Orientation and Calibration of land Photogrammetry

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ABSTRACT

Photogrammetry is the developing direction of long distance measurement. Improving the accuracy of measurement is a key step in photogrammetry. This paper studies the the methods of photogrammetric calibration.

We are responsible for reconstructing the parts of the stone pit's slope, which are the remaining buildings of the former stone quarry and a so-called "Schauwand", using terrestrial images captured with close range photogrammetry. The images are oriented and calibrated using different methods.

1. Two check

a) Calibration with Matlab using checkerboard target

b) Calibration using coded target and orientation with PhotoScan
After the steps above the processing of dense surface reconstruction are performed again with PhotoScan.

The reference points, whose coordinates are measured with free stationing, was manually defined for every image. The exterior orientation is estimated and after the computation of the reference point, the georeferenced point cloud is obtained.

The cloud model are then exported from PhotoScan, and imported to software CloudCompare. The clouds obtained from aerial photogrammetry (WP11) and laser scanning (WP10) were also imported into CloudCompare, and compared with our point clouds.

2. On-site measurement

2.1 Calibration

Pictures were taken of 2 different types of targets (coded target and checkerboard). It worked well with the method of the brief description.

2.2. Free Stationing for the georeferencing

On the first time, 4 pass points were measured and then 10 targets and 2 natural points on the wall. There were 2 natural points needed, because the targets on the wall were all on the same height and for a good 3D result there were higher points needed. It was no problem to find the points in the pictures, because there were taken some additional pictures to remember these natural points.

On the second time, 4 pass points and 7 targets on the wall were measured.

2.3. Object's Geometry Acquisition

a) shooting from an angle, a wall on the west part of the quarry is captured. The measurements were done in 3 sets with different capturing distance and the last set was done in portrait configuration. A part of the wall was

taken in two different directions and with different distances. The total amounts of image are 406. To get one part of the wall with a really good result, there were taken extra pictures of this part with a distance of around 5 meters to the wall. These pictures were taken near the ground and also from a higher position, to get a nice 3D result. It worked well, which shows the result of this part, it is like standing next to the wall when you look at the model in Photoscan.

b) shooting from another angle, the "Schauwand" on the north part of the quarry was captured in 3 sets of data, which were taken in various move directions with an small angle between capture direction and the direction to the "Schauwand". The amounts of images are 124. The house beneath the "Schauwand" was taken in 89 images. The images in both times were taken with 80% overlap.

3. Post-processing / Results

3.1. Model No.1 - The Wall

In Photoscan computing was done, there were no problem occurred. Also the georeferencing worked well and the errors are acceptable. The points were calculated with the Helmert transformation and only 3 of the 4 pass points available were used. To measure 4 points was just for safety if some measurement is wrong of one point.

Comparison of the georeferencing with laser scanning group was done and it looked fine. So the next step was to compute the mesh and the texture of the model.

Pictures showing the steps in Photoscan:

- Sparse point cloud generation;
- Dense point cloud generation;
- Meshed model generated based on the dense point cloud;
- Textured model.

Computation of the mesh model was only done of a smaller part from the wall, because this was the part where we took more pictures and it would have taken too much time to compute the mesh of the whole wall. Due to the fact that there was only a mesh model of a smaller part available, the textured model can be only from this part aswell.

The pictures 1 are showing a good result, also a good 3D alignment of the cliffs in the wall. This good result was possible, because there were so many additional pictures made of this part of the wall (around 200). In the model there is a ground pixel size of 0.7-2.25 cm, which depends on how far away pictures were taken.

Figure 1. Meshed and textured model of the wall from different points of view.

3.2 Calibration

The calibration was done in 2 different methods, in-situ/field calibration and plate calibration. The plate calibration was done with 2 different targets, which are coded target (processed using Photoscan) and checkerboard (processed using Matlab). There were no problems to compute the camera calibration in both ways with the pictures of the first week. To export the data in matlab with the self-written matlab file which was made before the pictures were taken on field worked exactly as expected so it was easy to import the calibration parameters into Photoscan. In the second week there was only the method with the coded targets used, because a new and better camera was used in this week and this method was enough calibration.

The comparison was done using the sparse point cloud. The pictures 2-3 show that the differences between the point clouds from in-situ and coded target calibration are smaller compared to the differences between checkerboard and coded target calibration. A reason therefore could be that the checkerboard calibration parameters are not that good as the coded target and the in-situ parameters.

The point cloud from terrestrial and airborne were also compared, and the result is shown below.

For the distance difference of the points between laser scanning and terrestrial photogrammetry. The highest difference is around 5 meter but the majority are below 1.3 meter. A reason for the high difference therefore is the vegetation above the wall, but also there is some vegetation on the wall. This is not good for the laserscanner but also not good for the point matching in Photoscan. Without the vegetation, there would be a better result.

3.3. Model No.2 - The House

a) Processing

A total number of 88 Photos were taken for the house and were used to create a 3D point cloud. 10 points were measured from the UAV flight Photos and there coordinates were estimated, to be used as control points for georeferencing. For both, WP 9 & WP 10. See Figure 5.

After georeferencing was performed a dense point cloud was created. See Figure 6.

From the UAV images a dense point cloud was created for the same area. See Figure 7.

Both point clouds were uploaded to cloud compare for comparison.

Analysing results we notice big errors up to 2.5 m caused by the difference in perspective of both methods, while the UAV can see the roof and grounds the terrestrial photogrammetry cannot see the roof but can see inside the house. That's why we notice big errors inside the rooms and smaller errors on the walls, land and rock surrounding the building.

b) Comparison of the different calibrations

The second task was comparing the point clouds constructed from the same images of the house but with two scenarios, with and without considering the pre estimated camera calibration parameters.

First we estimate the interior and exterior orientation parameters. And use the estimated parameters to create a point cloud.

Second we estimate the calibration parameters by means of a coded calibration board. And load the parameters and fix the calibration.

By looking at the comparison we find a mean distance of 2,5 cm, and this is due to the effect of the lens distortion which was not high quality.

Figure 2. Comparison of in-situ and coded target calibration

Figure 3. Comparison of checkerboard and coded target calibration

Figure 4. dense point cloud was created

Figure 5. the UAV images a dense point cloud was created

3.4. Model No.3 - Schauwand

a) Computing

As for Schauwand in Week 2 we captured 124 pictures in different directions and input them into Agisoft PhotoScan to generate point clouds in both sparse and dense mode of the structure.

We add some markers to the targets, which are shown in previous screenshot. Since we did not get reliable coordinates of the targets the generated point cloud would not be georeferenced. The coordinates of each point would not be filled in marker sheet right site of the screenshot. However the reconstruction of the point cloud would not be influenced and the geometry of the structure is produced with high quality.

Figure 8 represents the generated sparse point cloud and the location of each camera as well.

Based on the result of the sparse point cloud we also create a dense point cloud, which shows textures of the Schauwand in detail. See Figure 9. This dense cloud is generated without georeference.

We also tried other ways to get georeference from other sources:

Picking up stable nature points on the ground or hillside which can be located by WP11. Since most of the hillside is covered by unstable vegetation we are unable to identify reliable equivalent points in 2 point clouds, which cause the problem that our point cloud cannot be georeferenced.

Without identical reference coordinate system we can still compare two point clouds using Tool "Registration" directly in software CloudCompare.

b) Comparison

After generation of the point cloud starts the comparison of different results from other groups.

Firstly we choose the result from Laser scanning as a reference cloud, in which the grasses on both side of the road are also included. Aligning of 2 point clouds without using the global coordinate would be realized by picking up several identical point pairs.

Picking up equivalent points in two separated clouds and align them with adjusted scale.

Figure 6. the generated sparse point cloud

Figure 7. dense point cloud

4. The result of aligning:

Because of the same reason we can rarely find reliable nature points, so

the accuracy of this kind of aligning is critical. At least for visualization the result is acceptable such as the road level fit well to each other and both scales are well adjusted. For Analysis of accuracy we compute the cloud to cloud distance.

It's clear that the most part of the clouds fit to each other with absolute distance below 1m (area highlighted in blue). Some areas in blue seem to be caused by the lack of points in those areas such as under trees or shaded parts. The border parts with the biggest difference till 10m are some noise or caused by the distortion of the lens while capture.

5. Comparison with the UAV model

Since the different capturing direction of Schauwand and pictures from UAV group. Even though we did do some comparison between those clouds.

It appears the same effect as the house because of the capture direction. The difference seems very significant especially in border area of objects.

6. Comparison with the laserscanning model

Sparse point cloud of coded target calibration with laser scanning data. Point cloud that used coded target calibration is compared with the point cloud from laser scanner. The maximum distance is stated 48 meter for overall point cloud data, which is caused by the vegetation around the wall and with minimum distance of 0 cm.

For comparison figures, the scale on the right is in meter and the colors represent the distance between two point clouds that are compared. From blue to red shows the shortest distance and the furthest distance respectively. Point cloud that used self-calibration method is compared with the point cloud from laser scanner. The maximum distance is stated 53 meter for overall point cloud data, which is caused by the vegetation around the wall and with minimum distance of 0 cm. A dense point cloud that used coded target calibration method is compared with the point cloud from laser scanner. The maximum distance is stated 31 meter for overall point cloud data, which is caused by the vegetation around the wall, which is a problem for the laser scanner, and with minimum distance of 0 cm.

Dense point clouds for laser scanning. Dense point clouds for laser scanning. A dense point cloud that used coded target calibration method is compared with the point cloud from laser scanner. The maximum distance is stated 43 meter for overall point cloud data, which is caused by the vegetation around the wall, which is a problem for the laser scanner, and with minimum distance of 0 cm.

Figure 8. sparse point cloud of self-calibration

Figure 9. Comparison of laser scanning calibration

Figure 10. Dense point clouds for laser scanning

Figure 11. the whole distortion of the area

7. Conclusion

The calibration is really important for a project in photogrammetry, because it calculates the lenses' distortion parameters. A bad calibration can destroy a whole project, that can be seen in Cloud Compare while comparing the different models of the checkerboard calibration and the coded target calibration.

The georeferencing worked well, but chosen more natural points might get better results.

Because of the measurements lost, the project had some problems with the georeferencing. So we used the measurements from the UAV to georeference, which contains 5-10cm errors.

The vegetation in the 'Schauwand' part affected the quality of the 3D reconstruction.

Before the on-site measurement we had to export the calibration parameters.

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