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Master of Environmental Engineering

Environmental Monitoring

ENVIRONMENTAL MONITORING OF RIVER PRIEßNITZ USING 3D-MODEL WITH
AGISOFT PHOTOSCAN

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Abstract

The general aim of the project is to make a basis for a future assessment in environmental monitoring using a 3D model of a small tributary which is modified and created in AgiSoft PhotoScan software. There is no sampling involved in this project and no monitoring assessment will be done yet after the project. It is inferred that 3D modelling could help in doing future study when there is a need of evaluating and monitoring the river bank and surrounding environment. This report has successfully demonstrated the importance and the versatility of using Agisoft for 3D modelling for the purpose of environmental monitoring. The experiment has been done using digital camera with a conventional lens and neither ground control points or GPS were used. Despite that and the low quality was used in some of the sequences, results were achieved in quite fast amount of time.

KEYWORDS : Agisoft Photoscan; Environmental Monitoring; 3D Model Construction; River Monitoring

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1. Introduction

In the last few years, the advancement of technology has shed a new development to the 3D modelling with regards to environmental monitoring. Such technology for example, is the processing of digital data such as photogrammetric images through a software. Hence, a 3D model is a process in which a mathematical representation of an object is developed using specialized software. Using AgiSoft PhotoScan, one can manipulate still photos and make a good textured 3D model by reconstructing the overlapping photos. The important feature in using this software is to retrieve considerably high quality of overlapping images (Li, Chen, Zhang, & Jia, 2016). As the images contain data points in 3D coordinate system, through succession of progress, Agisoft can produce a mesh based on the adjoining of point clouds.

As one of the design of environmental monitoring, 3D model can be useful in determining the elevation model from which further analysis for hydrological assessment can be done. Despite that, it cannot be used as a basis to determine water parameters in terms of chemical, biological, microbiological, and radiological. This is very important since the local residence also depends on the source of water from the river. One example is pollution from either heavy metals or contamination of pathogen as has been shown before by several authors in the same location (Schaller, Brackhage, & Dudel, 2011). For the purpose of detecting a point or diffuse source of contamination, it is limited only to the visual aspect and flow visualization.

2. Experimental Method

2.1. River Prieβnitz for Environmental Monitoring

In this particular project, river Prieβnitz is used as an object for the 3D modelling. It is a small tributary in Dresden that flows towards the river Elbe. The total length of the river is around 25.4 km as has been archived by Umweltamt Dresden. It is distributed over the whole city of Dresden, with its short stretch in the protected area of Heide.

As once excursion has been done by the author, river Prieβnitz is a good example for many hydrologists since it is useful to visit the upstream part and downstream as well where the erosion and sedimentation occurrences often happen (Feistel, 2016). During the capturing of images, ice formation was evidenced near the river bank which is favorably true due to the presence of dead zones, whereby velocity is said to be the minimum, hence less energy for water to flow, and ice formation is formed.

Due to its location inside the protected area of Heide and raised about 240 m above sea level, debris from the local vegetation can be seen in many stretches of the river, which flow along the river until they reach downstream near the main river Elbe. Some parts of the river also flow in the main city of Dresden, which could have an influence from anthropogenic activities along the river banks. One example would be a discharge from household, it was to be witnessed during excursion where white color from an unknown pollutant affected the aesthetics of the river. Although the usage of river Prieβnitz has not yet been thoroughly researched in this report, the model could be very useful as a basis for using the river for the object of 3D modelling and future assessment and monitoring.

2.2. 3D Modelling Using AgiSoft PhotoScan – General Workflow

In order to work with Agisoft Photoscan, one needs to have a general workflow to ensure the success of the project (Agisoft Photoscan, 2016). As can be defined in the manual, there are several steps needed to be taken in the given general workflow, for the sake of simplicity, in this report, it is assumed to be only several main points, which as follow :

1. Capturing high quality overlapping images based on the rules from the manual. As a general rule of thumb, more images are better.
2. Preselecting the images based on quality.
3. Alignment of the images. The purpose of this step is to create sparse point clouds from the overlapping images.
4. Creating the dense point cloud.
5. Creating the mesh or the basic geometry of the 3D model.
6. Creating the textured model.
7. Creating orthomosaic images and export the result.

It has been said previously on the introduction, that in order to use the software, one needs to take high quality overlapping photos. One possible device is using digital camera. As can also be read from the manual, it is better to avoid fish lenses and wide lenses camera as it can distort the images, however, it is also possible to use it as long as camera calibration is undertaken during the image processing. Some authors have demonstrated the use of wide lens in Agisoft Photoscan (Hastedt, Luhmann, & Ekkel, 2016).

2.3. Image Capturing

For this purpose, the images capturing was performed using Canon EOS 600D camera on Monday, 23rd of January 2017 at 14:54. The ground temperature was -4^0 C with wind velocity to be 25 km/h averagely in Dresden. However, there was no wind disturbance during the time. Weather was slightly overcast, which was a suitable condition in capturing the images as diffused light is needed and less shadow was present during the time.

The property of the images was taken using focal length of 18 mm, with the minimum ISO available in the camera which was 100 (this is also due to the outdoor photography where light source is abundant), aperture was F/3.5 for all images. One problem was that, some images were taken using shutter speed of 1/60 s, and others were taken using 1/125s, 1/40 s, or 1/250 s this could arise problem whereby images will be distorted. In total, there were 149 images. It is unfortunate however, that there was no geo-referenced imagery nor ground control points and GPS.

Figure 1 Environment of the River Bank in the middle stretch of Prieβnitz for the current project

In this report, the author tried to demonstrate the 3D model of a small tributary river in Dresden, which is called river Prieβnitz. The location of images was in the middle stretch of the river, which is neither too far upstream nor downstream, because as it goes either more to either location, the width between each site is greater, making the accuracy of the 3D model not reliable.

As it happened to be a struck of fortune, there was a small connecting bridge between each site which helped during images capturing. The location as exactly under the Carola bridge, exactly around the coordinates of 51^0 04’ 27.7” N and 13^0 45’ 46.1” E. The surrounding environment was not thoroughly taken as it was also quite uniform due to heavy presence of snow. The location was also located not far from local residency, which was approximately around 100-200 m. The short stretch was not curved, although further upstream the river widens and is curvier than the location.

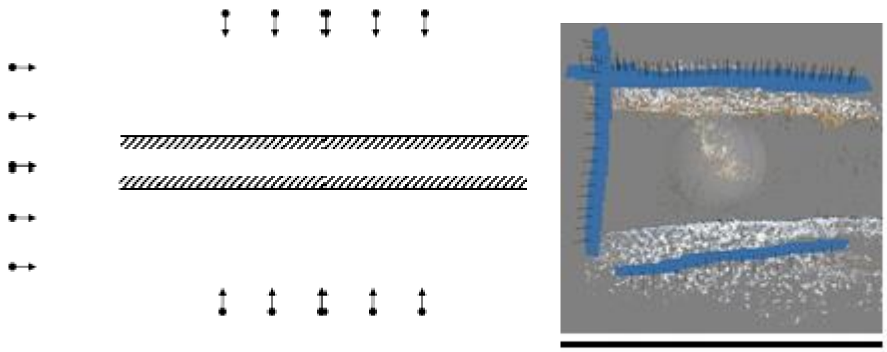

Figure 2 Facade used in capturing the images, points with arrow correspond to the direction of capturing (a) and blue squares were the actual capturing position

Figure 3 Carola Bridge near the location (Geo-Loge, 2006)

Figure 2 shows the façade positions in which the images were captured. It was very unfortunate that the author could not do the measurement of the rough river dimensions used during the images capturing. However, rough estimations are approximately to be 4 m in x-direction and 3 m in y-direction.

2.4. Image Processing

The images captured were processed using the aforementioned software. There are various steps in the image processing before the 3D model can be achieved. At first, the total of images taken were loaded into the photos pane of the software. A total of 149 images were loaded. In order to remove the unwanted images thereby reducing the amount of work, quality of each image was determined using image quality estimation feature. The range of values is from 0.1 to 1, which correspond to very low and very high quality respectively. For this project, it is defined that if the qualities of the images are below 0.50, they were all to be removed. At least there were 30 photos indicated that have quality lower than 0.50. The low quality is due to a lot of reasons, for example, poorly focused images, vague images, and poor lighting.

Before the images were to be aligned, several steps were done to reduce the workload. It is better if the computer device has the latest extra graphic card or higher RAM capacity (16-32 GB is preferable). Furthermore, one can also uses the feature camera optimization. In addition, different filtering options were used to remove unreliable points from the images, such as using the features of reprojection error, reconstruction uncertainty, image count, and projection accuracy.

In the next step, the pre-set quality images were to be aligned. The accuracy of the alignment was set to be at highest quality. It should be noted, that there will be a trade-off for every quality to be chosen. As such, highest quality uses the original images without having to be downscaled by a factor of 4 (2 on each side) in return to increasing of working time. Masking feature was not used as it is desirable to actually capture the surrounding environment. Other parameters such as the pair preselection was also not used.

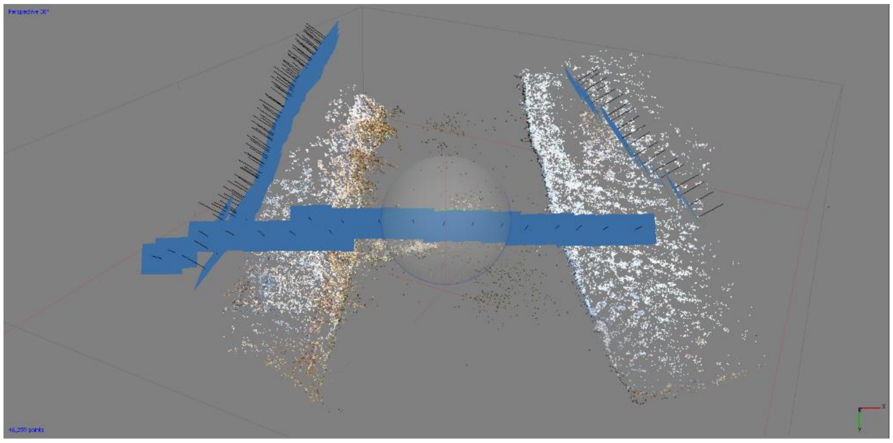

Figure 4 Alignment of the images with the resulting sparse point clouds

Each image contains data points, and these data points are compared to each other to check whether there are matching points. The matching points are then to be used to determine the position and orientation with regards to one another. The resulting points are called as sparse point clouds. Sparse point clouds can be used to directly build the mesh and thus a 3D model without having to build the dense cloud, but it is rather unfavorable as the quality of the 3D model will be compromised. On the contrary, sparse point cloud are to be used as a basis for the building of the dense point clouds. As can be seen from figure 3, the resulting sparse point clouds were built according to the overlapping images.

The next step is the building of dense point cloud. It is to be notified that deleting some sparse point clouds prior to making dense point clouds can alter the result. During the depth reconstruction, the sparse point clouds are used to determine the projection and extrapolation of the dense point clouds. If there are noticeably deleted sparse points, the reconstruction process can therefore be hampered as there are not enough data points to be reconstructed, thereby producing a broken dense point clouds. However, for the sake of simplicity, during Gradual Selection, filtering options were used and manually deleting points was done too in order to reduce the processing time.

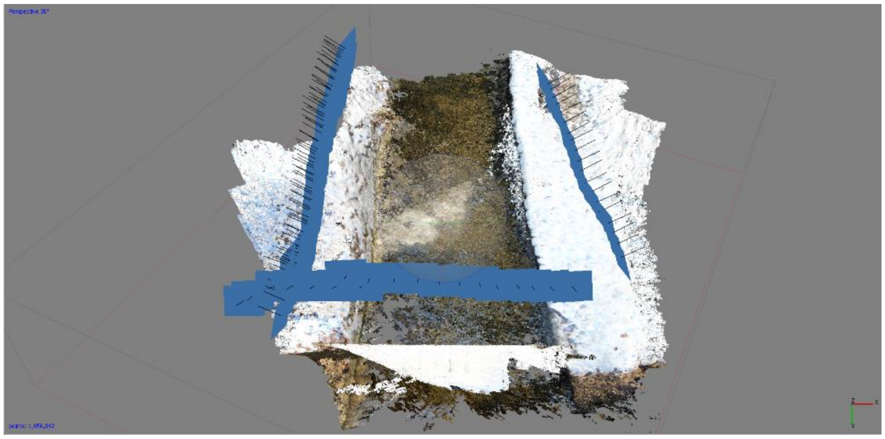

Figure 5 Dense Point Cloud

As the images processing reaches its final step, a polygonal mesh is to be built before different 3D models can be achieved. As the source data, selected points in the dense point clouds were used for the polygonal mesh. The option 'arbitrary' is chosen for the type of surfaces, as it is more suitable to the project since the images are of terrestrial image. Furthermore, 'arbitrary' option is usable to almost any other object besides planar surfaces which uses the other mode. 'Height Field' is particularly used for an elevation images, such as satellites or UAV. For this purpose, polygon count to be used was in the medium quality.

3. Main Results

3.2. Results and Discussion

With the polygonal mesh had been built, there were only several finishing steps before the model was complete. To showcase the results, several options can be made. In figure 5, the solid model has been successfully created. As can be seen from the figure 5, there is uneven roughness in the surface of the model which is expected. Using the same mesh, textured model can then be created. Although some texture data were missing and considering the low-quality option was used during the dense point cloud reconstruction and medium polygon count, the detail is considerably high as can be witnessed from figure 6. As a final result, orthomosaic image was created and exported as can be seen in figure 8.

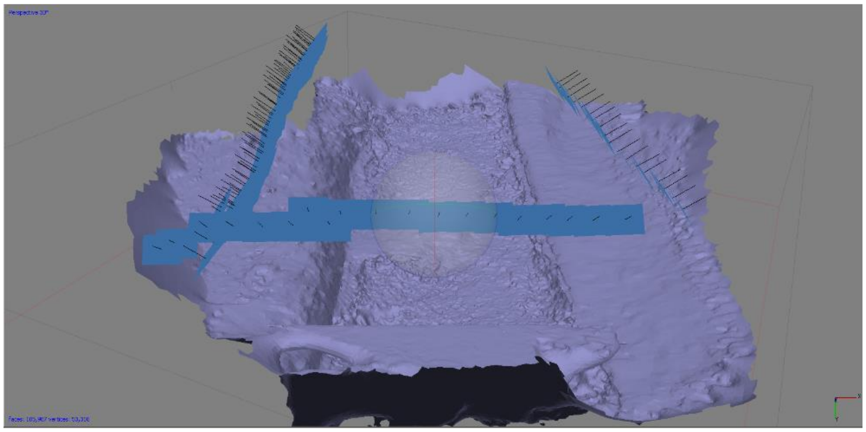

Figure 6 Solid model of the river Prieβnitz short stretch

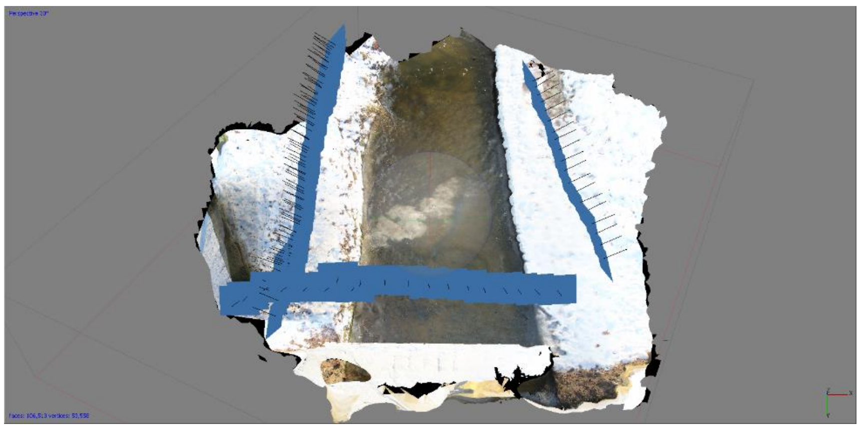

Figure 7 Textured model of river Prieβnitz built from the solid model

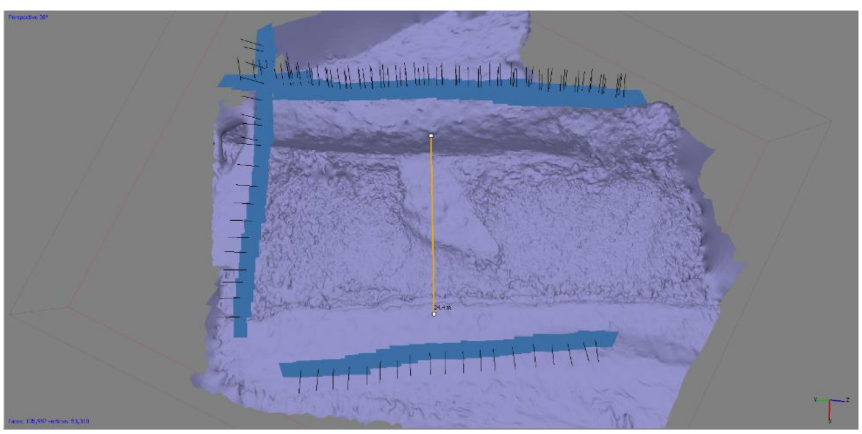

Figure 8 River bank measurement

There are few things that should be pointed out. First, as it has been said before, this 3D model has shown to be promising and useful in terms of its purpose. In figure 8, it is noticeable that ice formation was present in the river bank and 3D model has successfully shown it. In addition, the detailed surrounding can also be seen as some vegetation that were not covered by snow present.

However, as the author tried to do measurement to assess whether the accuracy of the model should also be high, it was found that there seemed to be an off-measurement as the distance between the river bank accounted to be 24.4 m which is evidently shown in figure 7 below. This would not be the correct value.

Furthermore, during the process, mistakes were made as the author tried to explore using the ultra-high quality. As the complexity increases, so is the working load and processing time. After five days using the batch process, there was still approximately 180 hours left until the dense point clouds are finished. As the time does not allow for such long process, compromising the quality into low is taken instead in order to reduce the processing time. As a consequence, only 45 minutes was needed for the whole process. As can be seen, even though the low quality was chosen, the resulting dense point cloud was surprisingly better than it would be expected.

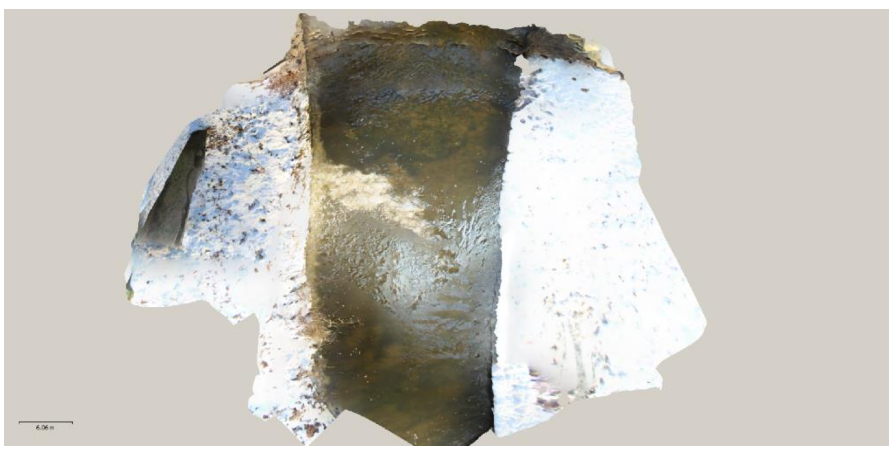

Figure 9 Orthomosaic Image of River Prieβnitz

Despite the fact that the author did not try to measure the actual distance during the observation and image capturing, however, it is to be assumed that the distance is not more than 4 m. Nevertheless, the author should have demonstrated more procedures during the image capturing, as to use the geo-referencing using GPS could prove useful to determine the actual dimensions as has been shown by other authors (Taufik, Okamoto, & H., 2016). The authors had also demonstrated further development by translating the 3D model into an actual 3D map using 3D printer. In addition, Digital Elevation Model (DEM) can also be used if geo-referenced imagery was captured instead.

4. Conclusion

This report has successfully demonstrated that environmental monitoring of an object using 3D model can be done rather simplistic, low cost, and fast. The experiment of image capturing using digital camera with conventional lens of 18 mm focal length has also been done to showcase that this process was rather fast. This model can be used as further study of the river itself in the future as there are still a lot if improvement that can be done.

A more advanced exploration should also be done to increase the accuracy of the model as there seemed to be an off measurement shown by 24.4 m distance between each river banks. This could be improved using a more thorough planning such as the addition of GPS to record each coordinate during capturing of the images.

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