CREATION OF A QUARRY DIGITAL TERRAIN MODEL USING PHOTOS OBTAINED FROM UNMANNED AERIAL VEHICLE

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Abstract. This paper describes the method of creation of a quarry digital terrain model using photos obtained by digital camera from unmanned aerial vehicle. The following works were carried out in Leoben Mining University and supervised by Prof. G. Mayer, Prof. R. Pilgram and Dipl.-Ing. A. Tscharf. This paper describes field work and data processing. There are shown application area and an accuracy of the method, based on a comparison of control points obtained because of geodetic surveying and surveying using an unmanned aerial vehicle.

Keywords: quarry, point cloud, unmanned aerial vehicle, digital terrain model, camera, accuracy, analysis.

Introduction

Unmanned aerial vehicles (UAVs) together with consumer grade cameras are used for creation of 3D models. A growing number of mining companies are employing its. Equipped with digital cameras, such remote-controlled small aircraft generate high-resolution aerial imagery which can be further processed to produce highly precise orthophotos, point clouds and 3D models. Surveyors and engineers can use this data to make statements and forecasts about the development of the mine, document changes as well as calculate volumes of spoil and stockpiles [4].

UAVs have many advantages compared to traditional aerial surveying. The aircrafts are very small sized and compact packaging, consequently, the systems are transportable [7]. Moreover, there are very fast and cheap field work and automated data processing

Field work

Place of surveying is a quarry near Leoben called “Pronat Steinbruch Preg” (Fig. 1). Preg is located between Kraubath and St. Lorenzen. It is one of the leading quarries in Austria, which has hard stone. Size of the investigated area is about 160 x 180 and height is about 120 m [8].

Figure 1. Quarry “Preg”. Left: photo obtained from satellite of Google Maps and right: photo are taken at the Quarry

The first step of the field work was the creation of a reference point network. For this task total station and GNSS-system was used. Special Ground Control Points (GCPs) were created (Fig. 2) and are mounted on the reference points.

Figure 2. Left top: example of a marker created for I3D (Graz University of Technology) and right: a photo from UAV with these markers (Montanuniversität Leoben)

The second step was surveying using the UAV of the Chair of Mining Engineering and Mineral Economics (“Tarot Frame”, flight controller “DJI NAZA M V2” and camera “Sony Alpha 6000”) (Fig. 3) [5]. Before surveying camera was calibrated and needed parameters were defined and set.

Figure 3. UAV “Tarot Frame”, flight controller “DJI NAZA M V2” and camera “Sony Alpha 6000”

After these preparatory works, surveying can be started. While drone flew, camera took pictures every 3 seconds. Four flights were performed because battery time is about 7 minutes. The quarry was surveyed by UAV from several heights to mitigate the error propagation within the single height levels. Camera was set to nadir and was inclined for surveying of the highest points of the quarry surface. Duration of this step was about 2 hours. At last, all photos were transferred to computer for further processing.

Data processing

Images were processed in Agisoft PhotoScan Professional [6]. Algorithm of a dense cloud creation is shown on flowchart in Fig. 4.

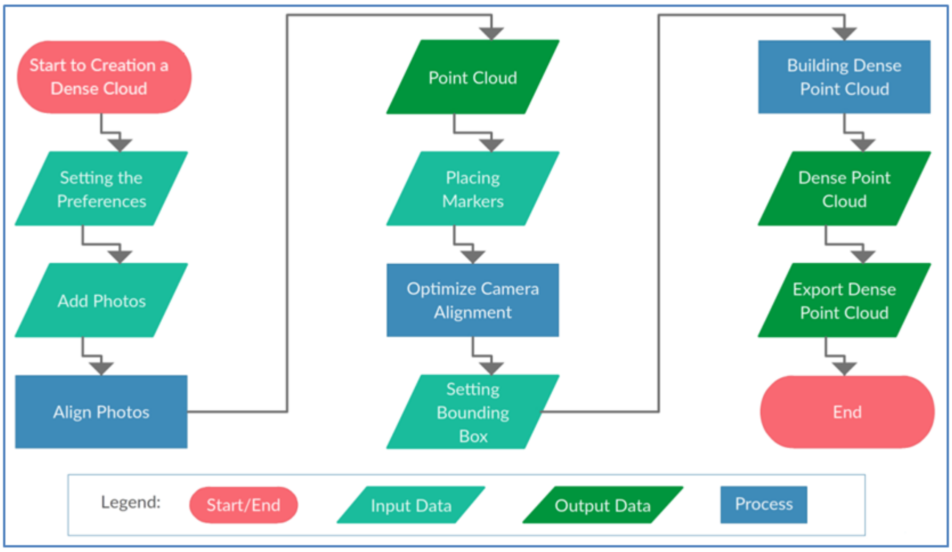

Figure 4. Flowchart of a dense cloud creation in PhotoScan

Manually placing of the markers is the biggest disadvantage of this software. PhotoScan can print and detect only own special markers (Fig. 5 left top).

PhotoScan markers have white border, consequently, in a sunny weather it is not possible to recognize them (Fig. 5 right). Furthermore, PhotoScan cannot recognize external markers, therefore, all markers were put manually, which is a very time-consuming step.

Figure 5. Left top: a marker created in Agisoft PhotoScan and right: a photo from UAV with these markers (Montanuniversitat Leoben)

In the experiment, quality of dense point cloud was chosen at a medium level. After processing, which took about 24 hours for computer with 4 Gb random access memory, 27.8 million points were created (Fig. 6). Comparison of GCPs coordinates obtained by geodetic measurements and by surveying with using UAV shows that Mean Square Error (MSE) is 7 cm [8].

The analogous surveying was carried out one year before. Comparing the two surveying the MSE is equal to 7 cm [7].

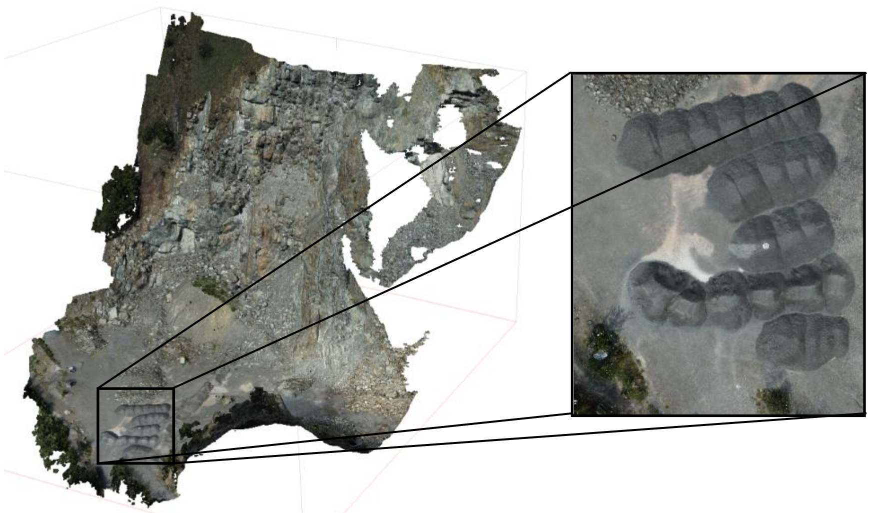

Figure 6. Left: dense point cloud of the quarry and right: dense point cloud of a bourock

The final step was the creation of a quarry digital terrain model (DTM) by obtained the dense point cloud (Fig. 7) [3].

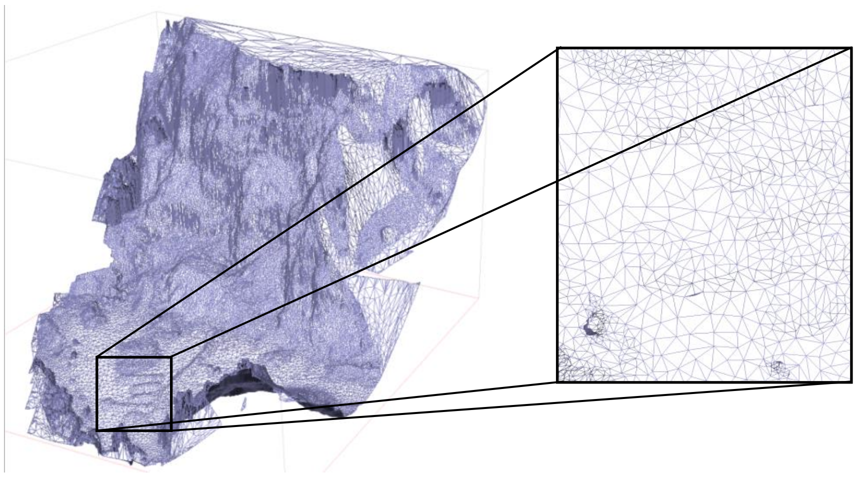

Figure 7. Left: Delaunay triangulation of the quarry and right: Delaunay triangulation of the bourock

Conclusions

In this way, DTM of the quarry including 27.8 million points was built. The MSE of a dense point cloud was 7 cm, which corresponds to a scale of 1:1000 and allows the design and planning work on quarries.

The demonstrated method is effectively suitable for the production of mining surveying works, such as: the creation of digital horizon-oriented plans, the calculation of work volumes, the replenishment of mining plans, etc. The main distinctive features of surveying using UAV are high automation of data processing and field works, low cost of equipment.

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