

LOW-COST PHOTOGRAMMETRY IN MINING

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Abstract: This paper presents practical creation of a 3D model of a quarry and its further applicability. The model was created using photos that were taken in the terrain. Further, using the software package, photos were processed and based on multi-pictures method, software assembled a 3D model. A completed 3D model has its own outer walls, bearing Photographic texture. Model has photo-realistic appearance. Based on a quality visible texture, a spatial information about the location of discontinuity has been acquired. Discontinuity has been given spatial elements. The emphasis is on low cost of the project, whereas for normal work required only camera, software and personal computer.

Key words: 3D model, quarry, photogrammetry, mining, photography, accuracy, PhotoModeler

1. INTRODUCTION

Something has been written about modeling in photogrammetry so far, but mostly described are theoretical models. There is no literature to describe the practical application and the extraction of useful information from photo-realistic painted surface.

Method of work has already been tested in mining industry and related branches, but not in such a large scale. By the quarry the longest distance that was watched was 61 m long (Hrib, 2011). The location of quarry is in western Slovenia where limestone is mined. Natural stone named Repen, which is partly recrystallised limestone, is produced and comes in a light gray color. Gray is from the perspective of identifying details in the photos very good, allowing faster work in labeling points. Since the quarry produce limestone, therefore its slopes can be vertical and flat. Reconstructing the facade with planes will therefore be easier and less time consuming. Large flat surfaces require fewer points for their determination.

A preview of the terrain has been done, which gave the first information about the size, brightness and other characteristics. The desire before a model creation was to provide an engineering accuracy, so the model can be applicable for later processing.

Normal camera Nikon D50 36x36 with 20 mm focal length, that is fixed, Leica Total Station TCRM1201+, dozen targets, a PhotoModeler 6 software package and a personal computer, were used for the project (Hrib, 2011). Before taking pictures, it is necessary to calibrate a camera. This is a procedure in which the camera captures images from multiple directions from calibration sheet given by the

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manufacturer of the software. Taken images are uploaded for processing by the software package, which then on the basis of photographs and shooting standing positions define internal camera orientation (EOS Systems Inc.). Calibration needs to be performed only once before shooting. On the terrain, before the shooting, targets are set. Those targets will serve a total station to determine basis points which will at the end of construction model be used to verify the results and deviations. Targets as points also need to be defined with the multi-photographic method for the model points determination.

2. METHOD

The focus of this article is the usefulness of developed 3D model for subsequent processing and information extraction from photo-realistic surface layers of quarry (model). The best way is to take picture over a pre-drawn plan that follows the preview of the terrain. The first visit of the terrain defines object, yet to be observed, outlines the direction of photographing and subsequent photography scenes.

For quality object visibility, illumination is important. Optimal illumination is in moderately cloudy day, because then is illumination the most even. With excessive light shadows appear on buildings and such photographs may be unusable. Shadows prevents good detail identification on the photos (Gorjup 1991, 2001). Furthermore, also the size of the object is very important. Size consequently affects on workload, that will later be performed and on the level of accuracy, because with increasing objects size, objects accuracy decreases.

Photographing is done by previously prepared plan. Photos should be photograph in two sets. In the first group are those photos that will be used to make the final facade image. In the second set are photos taken with a little more distant stalls. These second photos should in its scene include at least 2 or 3 scenes of first group photos. Second group photos covers larger area than first group photos. Scenes of these second photos should cover at least 2 and more scenes of first photos. Photos from the second package are important for future model orientation in the process with software (Hrib, 2011). All photos must with their scenes overlap with the previous up to 25%. This applies to both photography groups (EOS Systems Inc.).

When the photos are taken, they can be processed with Photomodeler software. On each photo same terrain details (stone, crack, stain, spot, ...) that appears in both photos are manually marked. For orientation of each following photos is necessary that it has with previous photo at least 6 common identical points (EOS Systems Inc.; Kosmatin 1996; Erwes et al. 2003). Marking and orientating identical points, can be seen on the figure 1. Figure is showing a crack on the outer wall of the quarry. The crack is because of its shape marked with identical points on two, three and more photographs. When identical points are marked on at least three photos they occur in 3D space of the model (Dobričić, 2006), which can be seen on the right side of figure 1. After marking all the points that were needed, the construction of the planes and their textures determination can begin, as illustrated in figure 2.

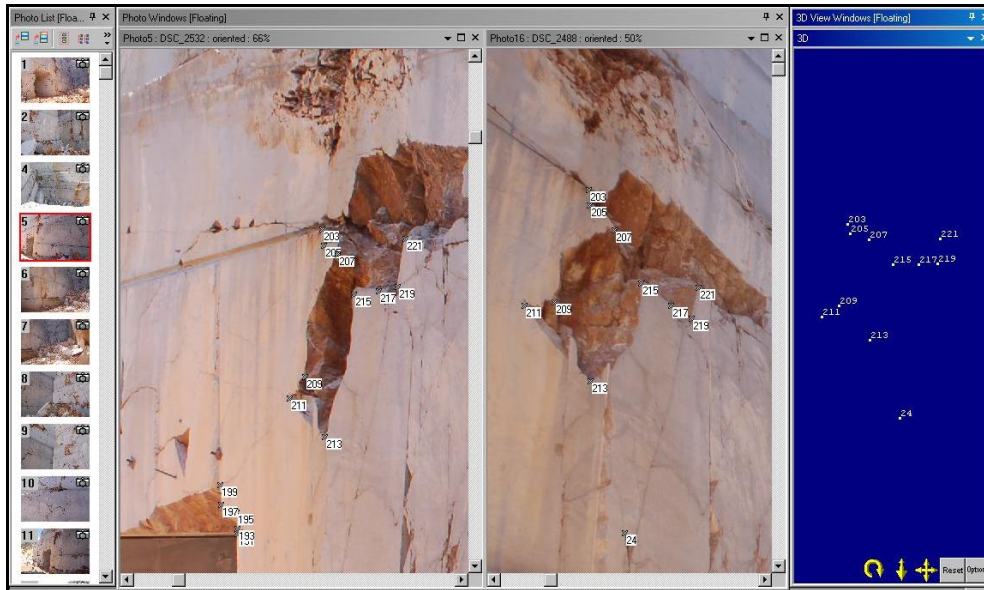


Figure 1 - Manual marking the points (Hrib, 2011)

If any part of the object is more important or if a center of observation is there, a larger amount of identical points, labeled in several photos, can be marked there. Progressive marking identical points, at the end results a 3D model formation with photo-realistic facade.

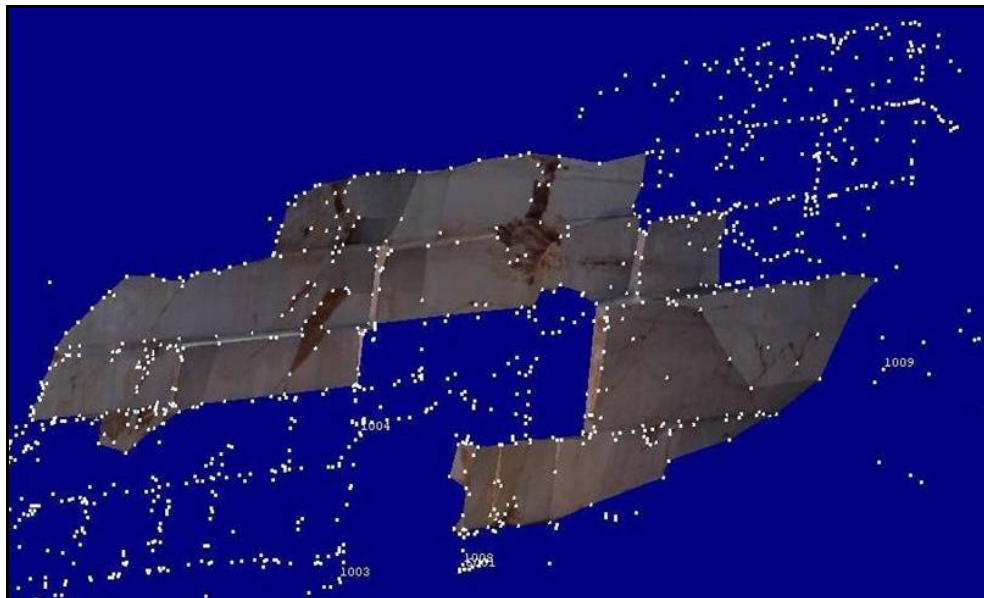


Figure 2 - Creation of a model (Hrib, 2011)

Finished 3D model in Photomodeler software was later on exported in CAD program, that is universally known. Having model transported in CAD program, further use and acquisition of qualitative model data can be made.

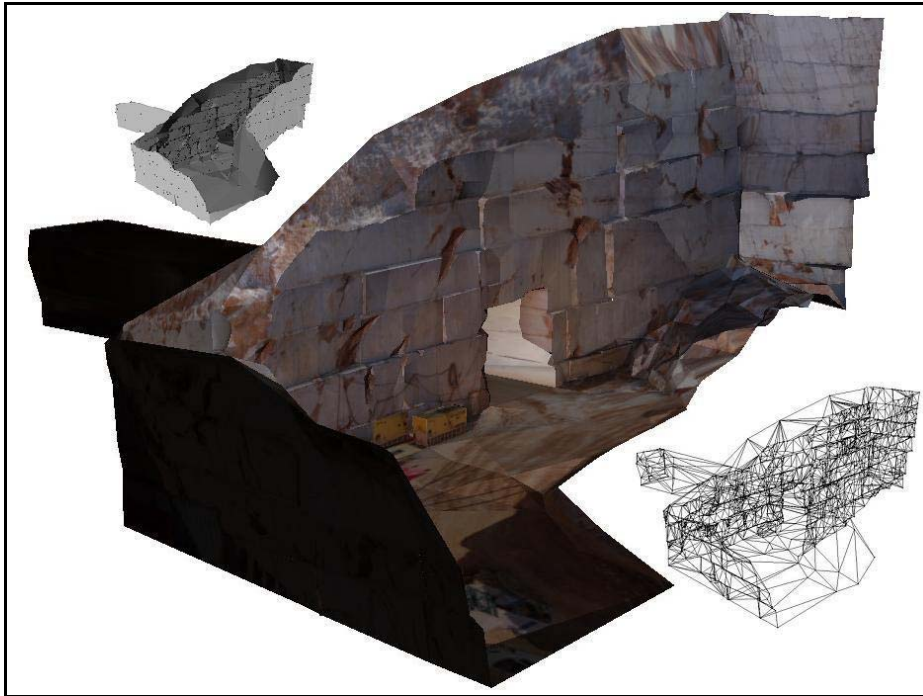


Figure 3 - Completed 3D model in shaded, render and wireframe view (Hrib, 2011)

The essence of this paper itself, is not in creation of a 3D model, but in its usefulness. Therefore, all detailed and more precise procedures for the development of the model are described in the help menu of Photomodeler 6 software. The model can be made in several different ways. Quantity of points may be reduced, thereby saving more time, but at the expense of quality and precision (Kosmatin 1996; www.photomodeler.com). The biggest savings are hidden in the quantity of points, that are manually marked. One of the possibilities is, that the creation of a model starts on the basis of already laid geodetic points, whose location and the coordinates are already known. This makes it possible to quickly photograph and update already created point model and therefore localizing the problem strictly to the focus area of observation. For accuracy verification, 12 points which were also marked on the model, were measured and specified with total station on the terrain.

3. APPLICATION

Possibilities of using a developed model are large. The first alternative is to obtain a quantitative metric information about individual details (cracks, shelves,

wedges, ...), which were on model marked as points or a group of points. Location of these points are already spatially defined on the model. A second option is to obtain data and thereby information from the photo-realistic surfaces (planes), which are defined by three points out of many that are forming the model.

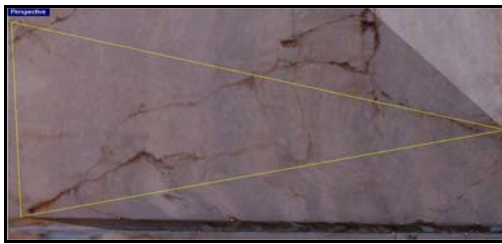


Figure 4 - Choosing observation planes (Hrib, 2011)



Figure 5 – Defining discontinuity (Hrib, 2011)

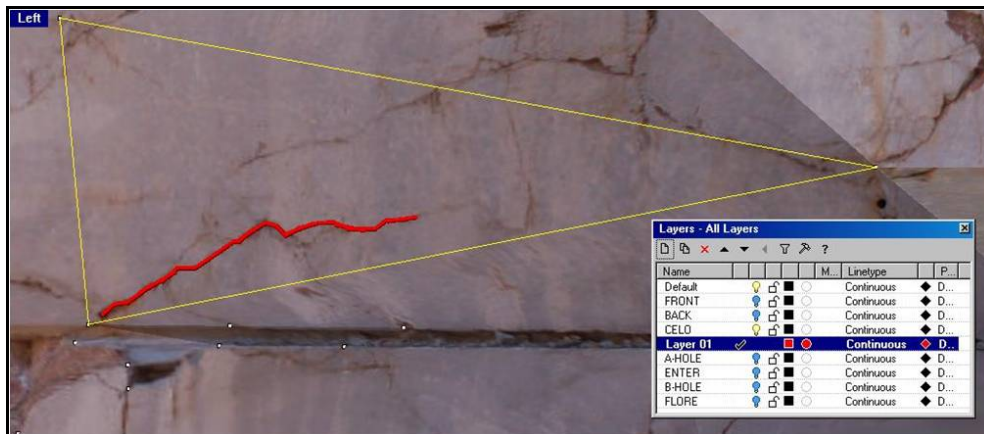


Figure 6 - Discontinuity defined in model space (Hrib, 2011)

As for further processing and data obtaining CAD program, Rhinoceros 4 was chosen. The procedure can be seen on figures 4, 5 and 6. All 3D models surface is made of triangular planes. All planes that are meant to be for further processing should have photo texture. All the planes can also be seen on the wireframe model view as shown on figure 3. If there is a crack, that is needed to be observed, chose the plane that is on (Figure 4). With *set 3point plane* command the triangular plane should be marked on their three corner points, before the markings of a crack begins. Crack marking has to have their own layer, that should be created. The layer colour is better to be contrast to surface texture. By choosing a new layer, a crack can now be recreated on a previously defined plane (Figure 5). Crack is redrawn with *Polyline* command, point by point. The more points that polyline has, the more accurate it is.

The method can be used for:

- determination of discontinuity, shear zones and fractures in the model;
- evaluation of breaks geometry and slope faults;

- the spatial positioning of cracks, discontinuities and fractures;
- acquisition of spatial elements;
- locating and determination of unstable wedges;
- identifying geotechnical and geological objects characteristics.

4. CONCLUSION

Most previous research in the field of photogrammetry was focused on observing and modeling medium or small objects up to 10 m per side. Quarry presents little larger object. Distance between the outermost points was 61 m, where engineering accuracy has been achieved. This means that the maximum deviation between the measured geodetic point and a specific model point was up to 1 cm. On average, the deviation was less than 4 cm between any two model points. The maximum deviation between two points was 20 cm. In modeling an average accuracy was achieved, according to rates provided by the software manufacturer.

When creating large objects, making compromises is unavoidable, because planes are only approximations of a real quarry wall surface. By approximation, the accuracy of the model decreases. I find that the method is not optimal for larger buildings over 90 m, but it is convenient for medium and small facilities. The advantage is shown, when quickly and promptly updating the object is required and where accuracy is not of the most importance. Transportation from software for modeling into the CAD software is fast and easy. The method is not difficult and it is easy for the beginner, to quickly acquire the necessary skills.

For obtaining large quantities of experimental data is the method quite time-consuming. It has the advantage in the obtaining qualitative data through observation and definition of discontinuity, that are created based on photographic textures of the models planes.

REFERENCES

- [1] DOBRIČIČ, L. (2006) Izdelava metričnih modelov stavb z nizkocenovnim orodjem. *Geodetski vestnik*, 50 (1), pp. 25–36, Ljubljana.
- [2] GORJUP, Z. (1991) *Fotogrametrija*. Ljubljana: University of Ljubljana, Faculty of Civil and Geodetic Engineering.
- [3] GORJUP, Z. (2001) *Temelji fotogrametrije in postopki izvedenja*. Ljubljana: University of Ljubljana, Faculty of Civil and Geodetic Engineering.
- [4] HRIB, Ž. (2011) *Možnost uporabe fotogrametrije v rudarstvu na primeru izdelave 3D modela kamnoloma*. Thesis, University of Ljubljana, Faculty of Natural Sciences and Engineering, Ljubljana. Available from: http://www.geo.ntf.uni-lj.si/mvulic/diplome/GRADUATION_THESIS/Hrib_FOTOGAMETRIJ_RUDARSTVo-3D%20MODEL_KAMENOLOMA.pdf

- [5] KOSMATIN, F. M. (1996) Arhitekturna fotogrametrija v spomeniškem varstvu – opis strokovnih metod in izdelkov za uporabnike. Fotogrametrija kot metoda dokumentiranja kulturne dediščine: sodobne tehnologije. *Vestnik*, XV, pp.19–39, Ljubljana.
- [6] ERWES, H. J. B. et al. (2003) Valuation of orthorectification by use of Photomodeler software. In: *Proceedings XIX CIPA symposium Antalya, Turkey, 30.Semptember-4.October*. Available from: <http://cipa.icomos.org/fileadmin/template/doc/antalya/75.pdf>
- [7] EOS SYSTEMS INC. 1992-2008 *Photomodeler 6.0*. [DVD-ROM], Canada.
- [8] EOS SYSTEMS INC. 1992-2008 *Measuring & Modeling the Real World in Geology and Mining*. [Online]. Available from: <http://www.photomodeler.com/applications/geology.htm>. [Accessed 10/12/2010].