A COMPARISON OF CLOSE-RANGE PHOTOGRAMMETRY USING A NON-PROFESSIONAL CAMERA WITH FIELD SURVEYING FOR VPLUME ESTIMATION

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ABSTRACT:

Rapid and accurate volume calculation is one of the most important requirements in many applications such as construction and mining industries. The accuracy of a calculated volume depends on the number of collected points on the object. Increasing the number of measured points undoubtedly requires higher cost and time. On the other hand, collecting surveying points might sometimes be difficult, dangerous or impossible. The aim of this study is to evaluate the close range photogrammetry (CRP) using a non-professional camera for DEM generation in comparison to the traditional field surveying technique (TST). For this purpose, a test area in Deralok hydropower planet site was considered and the process of DEM extraction in both methods was compared. The obtained results showed that although the CRP method in contrast with TST method was more time consuming, however, this method was able to successfully measure negative slops and berms and, consequently, calculated more accurate volume. Moreover, the relative error of 0.2% was reported.

1. INTRODUCTION

The volume calculations are an important requirement of the construction and mining industry (Fawzy 2015). The accurate volume estimation is important in many applications, for example, dam project, road project, and building applications (P. L. Raeva 2016). The traditional methods such as the trapezoidal method, traditional cross sectioning, and improved methods (Simpson-based, cubic spline, and cubic Hermite formula) have been used in volume computing. The main elements of these methods are to collect the points that appropriate distribution and density (M. Uysal 2015). These methods need more mathematical processes and take more time. Although, the high accuracy dependent on the number of collected points on the object(Karami 2014). More points require higher cost and time. In addition, collecting surveying points might be difficult, dangerous or impossible sometimes. (C. Arango 2015) Therefore, the classic surveying method is not always applicable to calculate excavation volume.

There are high accuracy requirements as far as heights are concerned due to volume calculations and therefore high resolution images. However, very precise terrestrial measurements could be extremely time-consuming process. On the other hand, by photogrammetric techniques, large areas can be covered in high details in less than an hour. (Patikova 2004)

In comparison to classical geodetic methods, close range photogrammetry is an efficient and fast method. It can significantly reduce the time required for collecting terrestrial data. The accuracy of the volume calculation is proportional to the presentation of the land surface. The presentation of the surface, on the other hand, is dependent on the number of coordinated points, their distribution, and its interpolation. (Yilmaz 2010)

The estimated accuracy of the comparison is up to 3% - 4%. In some countries, the legislation states that the volume should be calculated with a precision of ±3% of the whole material (P. L. Raeva 2016). However, this value depends on many factors such as the type of material being excavated in the quarry, the atmospheric conditions, etc. (M.Mazhdrakov 2007)

2. STUDY AREA

The study site is situated in the power house excavation of Deralok Hydropower Plant project in Iraqi Kurdistan and is located 80 kilometres northeast of Dohuk and the area is more than 1 hectare (lon 43.6562 °, lat 37.0689 °). (Figure 1).

Figure 1. Deralok hydropower planet site, red boundary is power house

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3. METHODOLOGY

Volume calculation is usually performed in two main steps: data acquisition and volume estimation. Time, cost and accuracy are very important parameters in volume estimation techniques. In this paper, the close range photogrammetry (CRP) using a non-professional camera and the traditional field surveying technique (TST) have been executed for estimation the volume in a sample project. In the following section, the details of these steps for both methods are described.

3.1 Data Acquisition

Data acquisition is an important step for volume estimation. The more accurate the collected data results in more accurate the estimated volume.

For the data acquisition in the field surveying method, a Leica TS-09 total station, with the specifications 1" angular accuracy and Enhanced measurement accuracy to prism 1.5 mm + 2 ppm was used and all the necessary points to estimate the volume were observed. In this case, around the excavation area with a prism and surveying characteristics break lines many points have been observed and, surveying trench wall with the total station non-prism tool was done.

In the CRP method a non-metric camera was used. We have been trying to use the camera at low prices with a high efficiency. The Table 1 shows the camera specifications.

Camera Specification	
camera model	DSLR-A700
Dimensions	4272×2400
Horizontal & vertical resolution	72 dpi
Focal length	35 mm
F-stop	f/11

Table 1. SONY- DSLR-A700 camera specifications.

For the study area, we walk around the power house excavation top of the trench and acquired 3-6 images in each station in differed view for increase overlap (Figure 2).

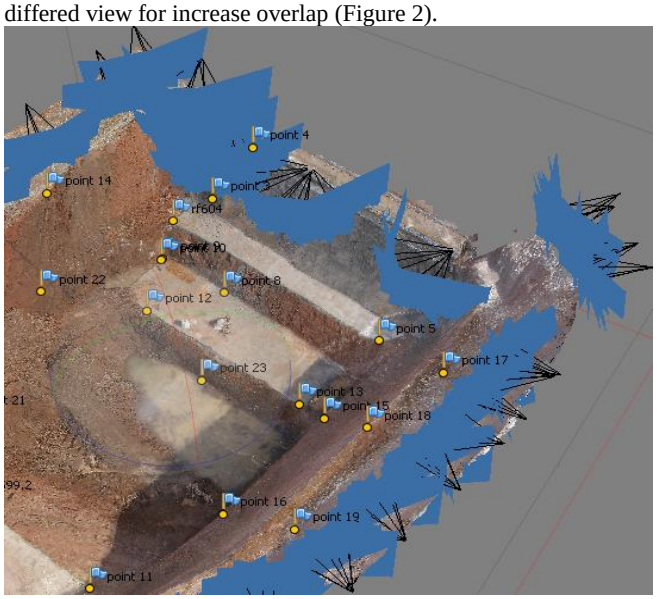

Figure 2. Camera locations and image network

3.2 Volume Estimation

To estimate the volume excavation many methods can be used. I.e. trapezoidal method for rectangular or triangular prism, Simpson's and improve methods using Simpson-based, cubic spline and cubic Hermite formula used for conventional method calculation (M.Yakar 2008).

3.2.2 Volume Estimation in TST Method

After obtaining the field data with the TST, the data was export to the TST with flash memory and saved in .idx format, after editing point and create a .txt file, this point is ready to import into Civil 3D software.

After import data, we fit a surface to points. In this step, editing the surface is an important step in volume computing because as long as we do not have a correct surface with all break lines, and etc. we cannot compute a correct volume. Figure 3 shows the flowchart of the volume calculation using Civil 3D software.

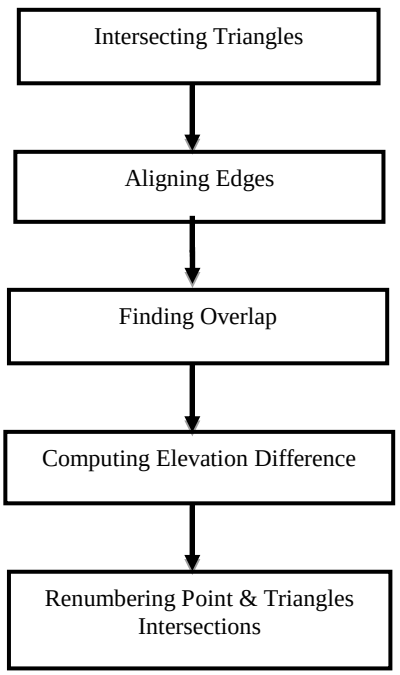

Figure 3. Volume computation flowchart

3.2.2 Volume Estimation with CRP Method

To obtain the values of the excavation volume, we adjust the image first with the GCP, these points was the same geo-referenced points around and into the excavation that we survey by TST, after that, we use AgiSoft software to process image, to generation an exact DSM we following this steps:

- Align photos
- Create dense cloud
- Build mesh
- Build tiled model
- Build DEM

4. RESULTS & DISCUSSION

Figure 4 show the number of images that cover the study area, as we see all of the excavation bottom, trench wall, berms exist in more than 9 Photos.

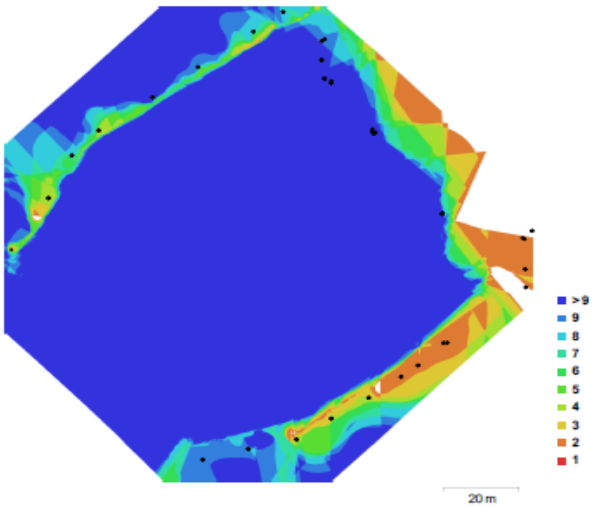

Figure 4.Camera locations and image overlap

In order to images georeferencing and assess the geometric accuracy (plane and height), a local network of control and cheek points have been considered according to Figure 5, and the coordinates of these points have been reading.

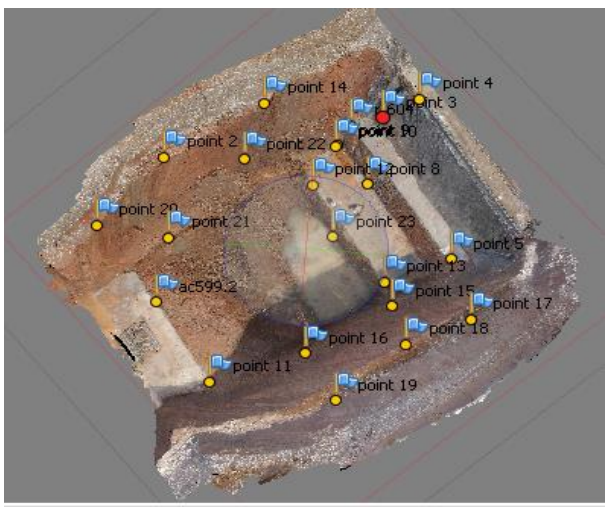

Figure 5. GCP locations

Basically, the principles of calculating the volume of an object in any kind of photogrammetric software slightly differ from the conventional methods. Unless a Point Cloud Densification is created. Agisoft output DSM include this negative slope, and TST method cannot modeling this negative slops as shown in Figure 6 DSM from Agisoft and Figure 7 shows Civil 3D DEM. After converting the agisoft DSM to DEM the volume was computed.

In both digital elevation models use contour line with 2.5 meters interval

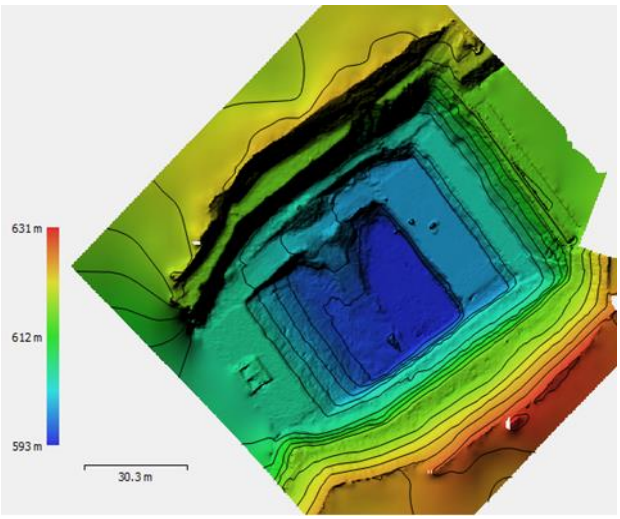

Figure 6.CRP Reconstructed digital elevation model with 2.5 contour line AgiSoft output

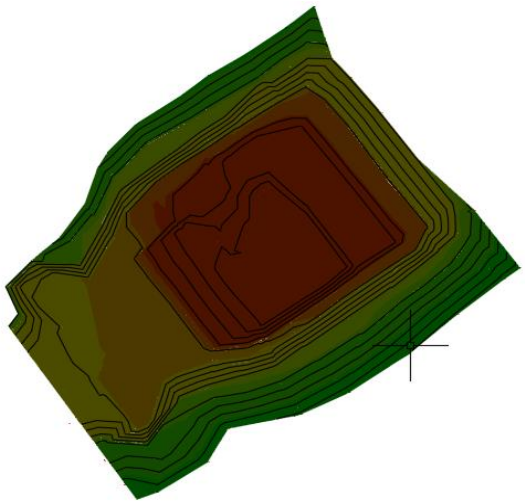

Figure 7. Land survey Reconstructed digital elevation model with 2.5 contour line Civil 3D output

4.1 Comparison of excavation Volumes

In this study, the traditional method with TST to estimate volumes of excavation were compared with CRP, data from the same site were taken and the post processing was done in civil 3D with a DEM that generated by AgiSoft with TST.

In this comparison, because we do not have the actual value of the volume excavated, our goal was to compare these two methods together only values compared and examine how close the numbers obtained.

4.2 Time spent & cost for data acquisition

The Table 1 shows a clear difference between the two methods of data collection, the CRP is about 3.5 times faster than the TST, in addition, the risks of obtaining the data with the camera are much lower, this because people are not exposed to unstable locations.

Time taken for	Land Survey by TST	CRP by Camera
Preparation Equipment	10 minutes	5 minutes
Data collection	4 hours	35 minutes
Data processing to obtain DTM	30 minutes	1 hours
Create sections-calculate volume	25 minutes	25 minutes

Table 2. Time comparison between both methods

Following CRP method is much less expensive than TST because the method requires fewer people and the device used to rent or buy cheaper.

4. CONCLUSION

In this study, we evaluated the CRP method using non-professional camera to generate excavation DEM in comparison to traditional field surveying method. We get 121 images around the study area and applied 23 control and check points.

The volume that obtained by the traditional method and CRP was 198424.48 m^3 and 198047.29 m3, respectively. The relative error of 0.2% can conclude that the estimated volume using CRP data was more accurate. The ability of the CRP method in considering negative slope due to loss right in the trenches, which cannot be measured by TST method, was promising.

REFERENCES

C. Arango , C. A. M. (2015). "Comparison Between Multicopter Uav And Total Station For Estimating Stockpile Volumes." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

H. E.-D. Fawzy, "The Accuracy of Determining the Volumes Using Close Range Photogrammetry." IOSR Journal of Mechanical and Civil Engineering

Karami, A., sousouni, B. , Hosseininaveh, A. (2014). "A novel contactless approach for calculating volumes of objects." The 1st National Conference on Geospatial Information Technology.

M. Uysal , A. S. T., N. Polat a (2015). "DEM generation with UAV Photogrammetry and accuracy analysis in Sahitler hill."
M.Mazhdrakov (2007). "Mine engineering in open-pit quarries."

M.Yakar , H. M. Y. (2008). "Using In Volume Computing Of Digital Close Range Photogrammetry." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

P. L. Raeva, S. L. F., D. G. Filipov (2016). "Volume Computation Of A Stockpile – A Study Case Comparing Gps And Uav Measurements In An Open Pit Quarry." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences.

Patikova, A. (2004). Digital photogrammetry in the practice of open pit mining. Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci, 34, 1-4.

Yilmaz, H. M. (2010). Close range photogrammetry in volume computing. Experimental Techniques, 34(1), 48-54.

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