Data Collecting to Volume Computing Using Digital Close Range Photogrammetry and Laser Technics

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SUMMARY

Photogrammetric techniques, measuring objects from photographs, have been utilized since the late 1800s. These methods are most commonly used for mapping large areas from aerial photographs. Digital close range photogrammetry is a technique for accurately measuring objects directly from photographs or digital images captured with a camera at close range. Multiple, overlapping images taken from different perspectives, produces measurements that can be used to create accurate 3D models of objects

With the development in technology, digital close range photogrammetry and laser scanning are affecting import degree, with the improvement of hardware and software products. Some studies can be made more economically, more accurately and faster. Digital close range photogrammetry and laser scanning can be apply very different disciplines. In this study, the situation of digital close range photogrammetry and laser scanning has been investigated in volume calculation. For this purpose, using both photogrammetric and laser scanning method in volume calculation have been used.

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1. INTRODUCTION

Cutting and filling volume calculation are important issues in many engineering and mining disciplines. Accurate 3D shape reconstruction and volume estimation are important in many applications, for example, erosion studies, estimation of ore removed from a mine face and terrain assessment for construction (Schulz and Schachter 1980).
Generally, classical methods have been used in volume computing. The trapezoidal method (rectangular or triangular prisms), classical cross sectioning (trapezoidal, Simpson, and average formula), and improved methods (Simpson-based, cubic spline, and cubic Hermite formula) have been presented in the literature (Yanalak 2005). Efficient volume computation in high accuracy is an important question both theoretically and practically (Soole and Poropat 2000).
The corrections of volume is direct proportional with the presentations of land surface in a best representation of land surface in best form is depend on the number of certain X,Y,Z coordinate points, point distributions and interpolation methods. Without doubt, in a convenient distributed and much more points provide better representation of land surface. However, much more points means much time and cost. Sometimes obtaining of geodetic points can be risky and also it can be impossible. Fort his reason, surface of land can not be represent correctly.
Geodetic surveying methods have been insufficient fort he volume calculation of the objects need to calculation of volume in a short time or in a risk areas, or unreachable areas. In this case digital close range photogrammetry and Laser Scanning technology are alternative methods to volume calculation.

In this study, the situation of digital close range photogrammetry and laser scanning has been investigated in volume calculation. An excavation area was selected for volume calculation. First surface of excavation area was defined by these two methods. Then, a mount excavation was done in excavation area. Finally, second surface of excavation area was defined by these two methods.

2. MATERIAL AND METHOD

In this study, close range photogrammetry and terrestrial laser scanning methods were used in volume calculation

2.1 Close Range Photogrammetry

Digital close range photogrammetry is a technique for accurately measuring objects directly from photographs or digital images captured with a camera at close range. Multiple, overlapping images taken from different perspectives, produces measurements that can be used to create accurate 3D models of objects (Kraus, 2007). Knowing the position of camera is not necessary because the geometry of the object is established directly from the images. Photogrammetry techniques allow you to convert images of an object into a 3D model. Using a digital camera with known characteristic (lens focal length, imager size and number of pixels), you need a minimum of two pictures of an object. If you can indicate the same three object points in the two images and you can indicate a known dimension you can determine other 3D points in the images (Atkinson 1996), (Cooper and Robson 1996).

The photogrammetric 3D coordinate determination is based on the co-linearity equation (Slama 1980) which simply states that object point, camera projective centre and image point lie on a straight line. The determination of the 3D coordinates from a definite point is achieved through the intersection of two or more straight lines. Therefore, each point of interest should appear in at least two photographs (Aguilar et al. 2005). Later, coordinates are measured from 3D model which is constituted by photogrammetric software

2.2 Terrestrial Laser Scanning

Laser scanners are optical measuring systems based on the transmission of laser light. The environment is illuminated on a point by point basis and then the light reflected by an object is detected. A laser scanner consists of a one-dimensional measuring system in combination with a mechanical beam-deflection system for spatial survey of the surroundings. The laser system measures range images which generates geometric dimensions of the environmental scenes whereas the reflectance image generates a photographic like impression of the scanned environment which can be used for feature extraction, visual inspection, object identification, surface classification and documentation purposes. The laser scanners thus provide an active illumination, non-contact measurement of the environment. This is advantageous in many situations, where operator access is limited or poor ambient lighting exists. In combination with passive CCD cameras colour information is mapped onto the geometry, leading to virtual reality. At the moment terrestrial laser scanners are used mainly in many engineering applications in order to digitize the 3D model of objects.

Surveying results must meet certain specifications in order to provide the necessary accuracy standards for a certain application. On the other hand, if instruments and methods are used which yield an accuracy far above the needed standard, this will result in unnecessary cost and expenditure. Therefore, any geometric surveying task comprises not only the derivation of the relative positions of points and objects but also an estimation of the accuracy of the results. Least squares adjustment based on overdetermination usually yields a reliable information concerning the accuracy of the results as well as the accuracy of the observations. If the number of observations is not sufficient for an adjustment, one may estimate the accuracy of the results by propagating the errors of the observation instruments to the results. In this case, the accuracy of the measurement device has to be known.

In the case of laser scanners, a large number of 3D coordinates on an object's surface is measured in a very short time. Important object features, such as corner points or edges, are not directly recorded; instead they have to be modeled from the point clouds in a separate process. While it is possible to record the same object several times from different observation points, it is impossible to record the very same points in these repeated surveys. Therefore, deviations can only be noticed after objects have been extracted from the point clouds and modeled. If the geometric properties of the object are known, however, the deviation of single points from the object's surface may be an indication for the accuracy [100].

The accuracy specifications given by laser scanner producers in their publications and pamphlets are not comparable. Experience shows that sometimes these should not be trusted and that the accuracy of these instruments which are built in small series varies from instrument to instrument and depends on the individual calibration and the care that has been taken in handling the instrument since. Many institutions have already published methods and results concerning accuracy tests with laser scanners (e.g. Balzani et. al. 2001, Johansson 2002, Kern 2003, Lichti et. al. 2000, 2002, [100]).

In the case of ranging scanners, range is computed using the time of flight or a phase comparison between the outgoing and the returning signal. Ranging scanners for distances up to 100 m show about the same range accuracy for any range. Triangulation scanners solve the range determination in a triangle formed by the instrument's laser signal deflector, the reflection point on the object's surface and the projection center of a camera, mounted at a certain distance from the deflector. The camera is used to determine the direction of the returning signal. In contrast to the ranging scanners, the accuracy of ranges acquired with triangulation scanners diminishes with the square of the distance between scanner and object (Boehler, Marbs, 2002).

3. STUDY AREA AND VOLUME CALCULATIONS

The study area is a sand heap (Figure 1). A truck was used to calculate volume of the sand. Because dimensions of the truck can be measure easily. The shape of the truck is rectangular prism. Width, length and height is sufficient to volume calculation. Volume of the truck body has been calculated as 17.4375 m^3 sand excavated and loaded to the truck. 5 truck sand have been excavated. The compression ratio of the sand have been calculated as %10. 78.4688 m^3 sand have been excavated of the study area

Figure 1, Study area

3.1 Volume Calculation by Close Range Photogrammetry

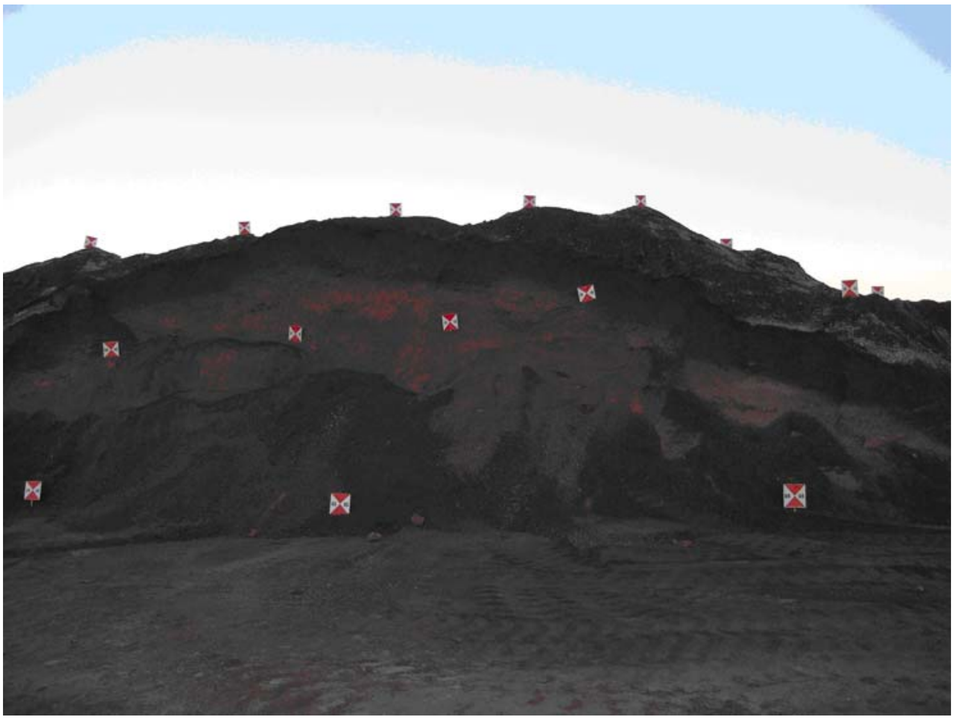

Figure 2, Post Excavation

Control targets have been placed before the excavation of study area (Figure 1) Local 3 dimensional coordinates have been measured using a electronic reflectorless total station.

Photographs of the excavation area have been taken by Canon 7.1 mega pixel digital camera. Later, 5 truck body sand have been excavated and converged. Control targets have been placed again (Figure 2) coordinates of the targets have been measured after the excavation. Photographs of the excavation area have been taken again after the excavation. Control target coordinates and photographs have been transferred to the photomodeller software. Photogrammetric evaluations have been completed. 616 field points have been measured for the non-excavated area. 569 field points have been measured after the excavation Obtained coordinate values transferred to the surfer software. Volume of the excavation have been calculated from two surface difference as 74.972 m3

3.2 Volume Calculation by Terrestrial Laser Scanning

Terrestrial laser scanning provides highly accurate, three-dimensional images to experience and work directly point-clouds in computer-aided design software.The laser scanners can record thousands of 3D points in seconds. That is, high speed data-acquisition in combination with high accuracy is possible.

In this study Optech ILRIS-3D Intelligent Laser Ranging and Imaging Systems were used to scan mining area.ILRIS-3D is a compact, fully portable and highly integrated package with digital image capture and sophisticated software tools, ideal for the commercial survey, engineering, mining and industrial applications(www.optech.ca)

Main Features of laser scanner

- High resolution and high accuracy
- Highest dynamic range available on the market: from 3 m to beyond 1 km
- Class 1 laser rating: completely eyesafe
- On-board 6-megapixel digital camera and large-format LCD viewfinder
- Ruggedly designed for demanding field applications
- Battery operated
- No leveling, retro-reflectors, or mirrors required
- Compact and easy to use
- Easily hand-carried and deployed by a single operator.

Figure 3 Field work

The field survey was carried out before excavation and after finishing excavation. The field survey was finished about ten minutes before and after excavation. Measurements were imported into the PolyWorks point cloud software. PolyWorks is a powerful point cloud software solution that processes data obtained from any 3D scanner. Originally developed to perform point-cloud-based inspection and reverse-engineering tasks for manufacturing applications, PolyWorks can now become the point cloud software system within surveying applications.(www.innovmetric.com) Measurements were imported into 3D application software PolyWorks and displayed on a computer monitor as a "point cloud" as one e-color, gray-scale, or true color.

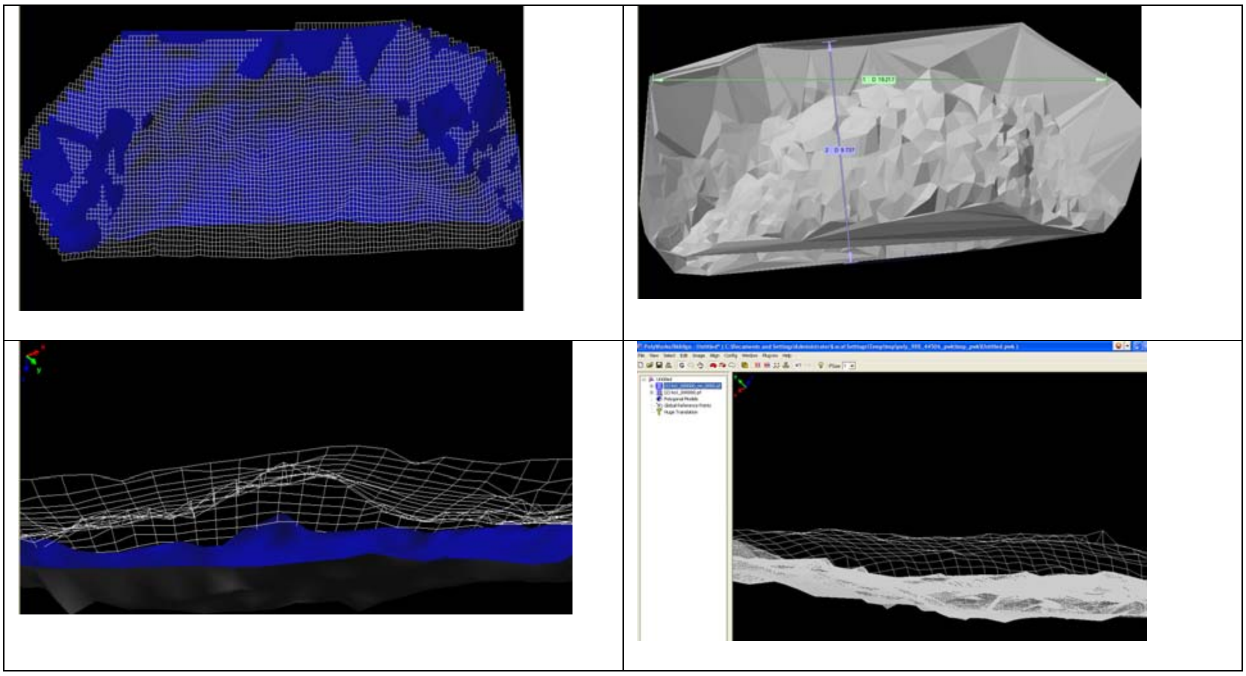

Figure 4: Point clouds on software and monitor screen

Volume calculation can be calculated either between a scanned surface and a user-defined plane or between two scanned surfaces. The scanned surface can be represented either by a point cloud or by a triangular mesh. The final calculated results can also be exported automatically generated cross-sections at desired intervals.

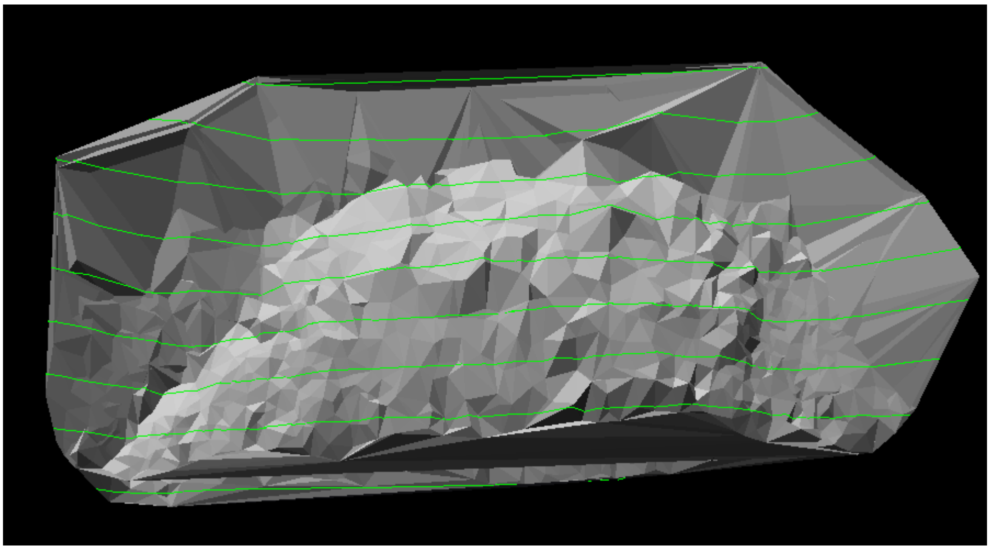

Figure 5: Cross- sections

Volume of the excavation have been calculated from two surface difference with PolyWorks software as 77.849 m3

4. CONCLUSION

Calculation of excavation and filling volumes is an important issue in many engineering and mining disciplines.In this study, the utility of digital close-range photogrammetry and laser scanner have been investigated for volume computation. Traditional survey methods used in capturing aggregate mine volume amounts usually involve a survey crew using a total station with man. Photogrammetric processing itself can be done by one person. Only control points have to be measured on the terrain by classical methods. However, it requires fewer points compared to evaluation of all points or lines in a quarry or a mine. Laser Scanners works similar to a total station; however, there are significant differences. With a laser scanner, only one man is enough to complete surveying.The scanner can be set up in a safe location away from unstable mining area and measurement can start to capture point clouds measurements at whatever increment the operator needs. With 3D laser scanning volume calculations are possible in a matter of minutes, compared to several hours with traditional methods. In addition, the amount of detail generated by thousands of points yields a more accurate representation of the real world surface. Data collection for current methods of mine volume calculations are long and often dangerous . Single point collection with a total station is labor intensive, costly, and most importantly, hazardous. Laser Scanning and photogrammetric methods eliminates these risks. Photogrammetric methods is more suitable method according to classical method. The end result with laser scanner is a more accurate,of volumes than photogrammetric methods.

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http://www.isprs.org/commission5/workshop/

Photomodeler 5.0 ……………

Surfer 8.0 ………………….

Url 1: www.optech.ca

Url 2 www.innovmetric.com

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