COMPARISON OF POINT CLOUDS PRODUCED FROM CLOSE-RANGE PHOTOGRAMMETRY AND LASER SCANNING TECHNIQUES

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ABSTRACT:

The currently the point clouds are the most preferred data type in diverse engineering projects and applications. The absence of detailed drawing operations is one of the most important factors for this demand. Additionally, the point cloud data in different formats can be used in different software without loss of data. The most common method to produce point cloud is to use laser scanners. These instruments produce 3D point cloud at regular intervals. However, point clouds can be produced with the help of photographs taken in appropriate conditions depending on the developing software and hardware technology. Today, it has become quite easy and many photogrammetric software provide the generation of point cloud support.

In this study, whether or not point cloud produced by photographs can be used instead of point cloud produced by laser scanner device is investigated. In accordance with this purpose, rock surfaces which have complex and irregular shape located in İstanbul Technical University Ayazaga Campus were selected as study object. Study object is mixture of different rock types and consists of both partly weathered and fresh parts. Study was performed on a part of 30m x 10m rock surface. 2D and 3D analysis were performed for several regions selected from the point clouds of the surface models. 2D analysis is area-based and 3D analysis is volume-based. Analysis conclusions showed that point clouds in both are similar and can be used as alternative to each other. This proved that point cloud produced using photographs which are both economical and enables to produce data in less time can be used in several studies instead of point cloud produced by laser scanner.

1. INTRODUCTION

Today, production of 3D models is the most effective method to show the current state of the modelled object. Several analysis can be made on model which has detailed information (Avsar et al., 2008). To produce 3D model of any object has become quite easy with the help of point clouds. Therefore, point cloud is the most preferred data type in diverse engineering projects and applications.

Laser scanner instruments which produces point clouds and 3D positioning information directly are often used for many applications about 3D modeling (Skarlatos and Kiparissi, 2012). These instruments produce 3D point cloud at regular intervals. These systems can be divided into two groups based on the usage as static and dynamic. In static method, laser scanner is in a fixed position and this is called terrestrial laser scanning. In dynamic method, scanning operation is performed by the scanner with a mobile platform which has an additional positioning system (Dapo et al., 2011). However, technology provides solutions in cheaper systems as in expensive ones such as laser scanners. Point cloud can be produced with the help of photographs taken in appropriate conditions depending on the developing hardware and software technology. Many photogrammetric software provide the generation of point cloud support. Unlike laser scanning technique, 3D positioning information is derived. Studies about which method is better than other among laser scanning, close-range photogrammetry and combination of both are in progress and will not and as long as the hardware and software technologies continues to develop (Jorda et al., 2011).

In this study, whether or not point cloud produced by photographs can be used instead of point cloud produced by laser scanner device is investigated. Only the presence of 3D object models produced by using two methods does not mean that methods are alternatives to each other. 2D and 3D analysis were made in order to demonstrate that point clouds produced from photographs are reliable data, as well.

2. STUDY AREA

Study was conducted on rock surfaces located in ITU Ayazaga Campus in order to evaluate point clouds obtained by laser scanner device and photographs. The rocks are the structures occurring by accumulation of a single mineral or combination of many mineral. Rocks in the study area showed in Figure 1, are the mixture of shale and sandstone rock types. Study object consists of both partly weathered and fresh parts. Some regions are covered by grass. Study was performed on a part of 30m x 10m rock surface.

Figure 1. Study area

The rocks in nature are weathered in course of time as in artificial structures like historical buildings. Weathering is deterioration of the original condition of the rocks due to erosion, water, wind and wave. Change in the mineral structure is called as chemical weathering. Physical weathering is the transformation of rocks to the ground by breaking up and going to pieces. Weathering actualizes both on the rock surfaces and under the rock surfaces (Bozkurtoglu, 1996). In geology science, some measurements in contact with the surfaces are made in order to prevent or control weathering. However, implementation of close-range photogrammetry and laser scanning methods for rocks is increasing day by day. Breaking angles as well as roughness relating to rock surface can be determined by creating sections at regular intervals (Kaya et al., 2011).

In scope of the study, firstly object which will be modelled was determined. Thereafter, camera calibrations were made in Photogrammetry Lab of Department of Geomatics Engineering at İstanbul Technical University. Papers for control points were prepared before the field work. During the field work, terrestrial measurements, taking terrestrial photographs and scanning operations were made on same day.

3. CLOSE-RANGE PHOTOGRAMMETRY

In close-range photogrammetry, Nikon D700 and Sony DSC-H9 digital cameras were used. Nikon D700 is fixed focus camera. Camera calibrations were made before the field work. 13 photographs of the calibration sheet consisting of 100 measurement points and 4 target points were taken by each camera. 12 of the 13 photos were taken from four sides of the sheet and 1 photographs was from the top. Calibrated principal distance of the cameras were determined as 52.54 mm for Nikon D700 and 5.34 mm for Sony DSC-H9. Principal distance is perpendicular distance between exposure center of the camera and image plane. Principal distance is associated with view captured in photograph. Principal distance value and view captured in photograph are inversely proportional to each other. Detailed specifications for cameras are given in Table 1.

Table 1. Camera specifications

SPECIFICATIONS	NIKON D700	SONY DSC-H9
Resolution (Mp)	12.1	8.1
Sensor Size (mm)	36 x 24	5.8 x 4.3
Max Image Size (pixel)	4256 x 2832	3264 x 2448
Dimensions (mm)	147 x 123 x 77	110 x 83 x 86
Weight (g)	1075	546

Papers in the size of 4 inch were used for control points marked on the surface. 24 control points showed in Figure 2, were marked on the surface as homogeneous as possible. It was not possible to mark control points on the upper part of the rock surfaces. Also, natural control points could not be selected because of complex structure of the area. Control points were measured by Pentax R-423 VN total station. Average values of the coordinates obtained from two polygons were used for object models. As seen in Figure 2, points 9 and 23 were extracted from the object model because of the fact that they are inconsistent.

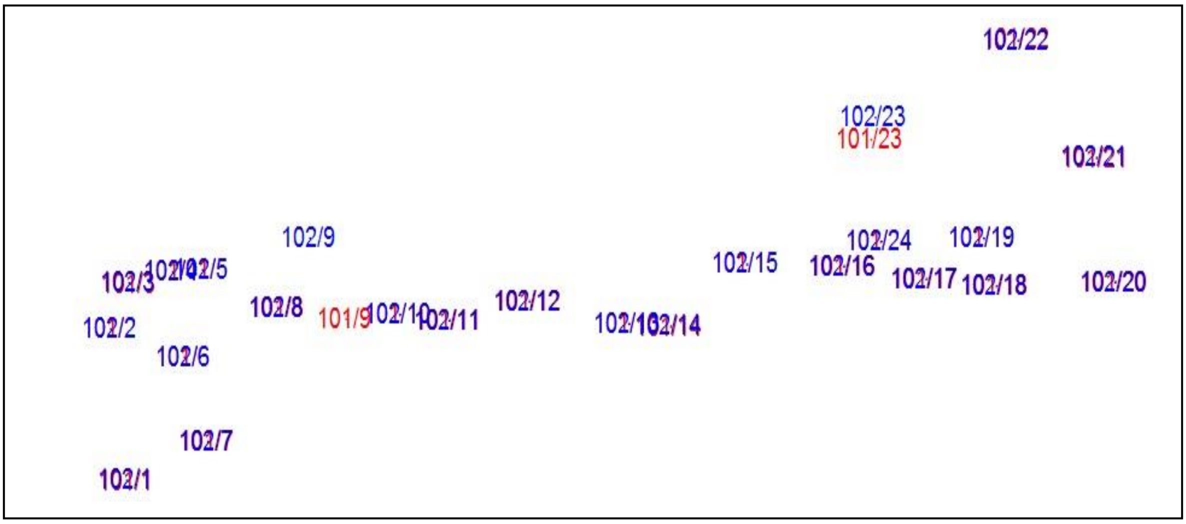

Figure 2. Distribution of markers

Thereafter, terrestrial photographs which have approximately %80 overlap in horizontal and %60 overlap in vertical were taken by each camera. Photographs were taken from a distance of 10 m for Nikon D700 and 6 m for Sony DSC H9. Agisoft Photoscan software was used to create 3D model from photographs. As seen in Figure 3, firstly weak point cloud was produced by aligning photos. The number of points after alignment of photographs are 62,543 for Nikon D700 and 23,175 for Sony DSC-H9. Then, weak point cloud was densified to obtain dense point cloud. The number of points after densification are 5.370,943 for Nikon D700 and 4.421,987 for Sony DSC-H9. Mesh model of the rock was created over dense point cloud. Control points must be visible in order to mark them in the software. They cannot be seen in mesh model. Therefore, mesh model was covered with photographs and textured model was obtained. A small part of 3D rock model produced with the help of photographs are given in Figure 4. The number of photographs used for 3D rock models are 44 for Nikon D700 and 55 for Sony DSC-H9.

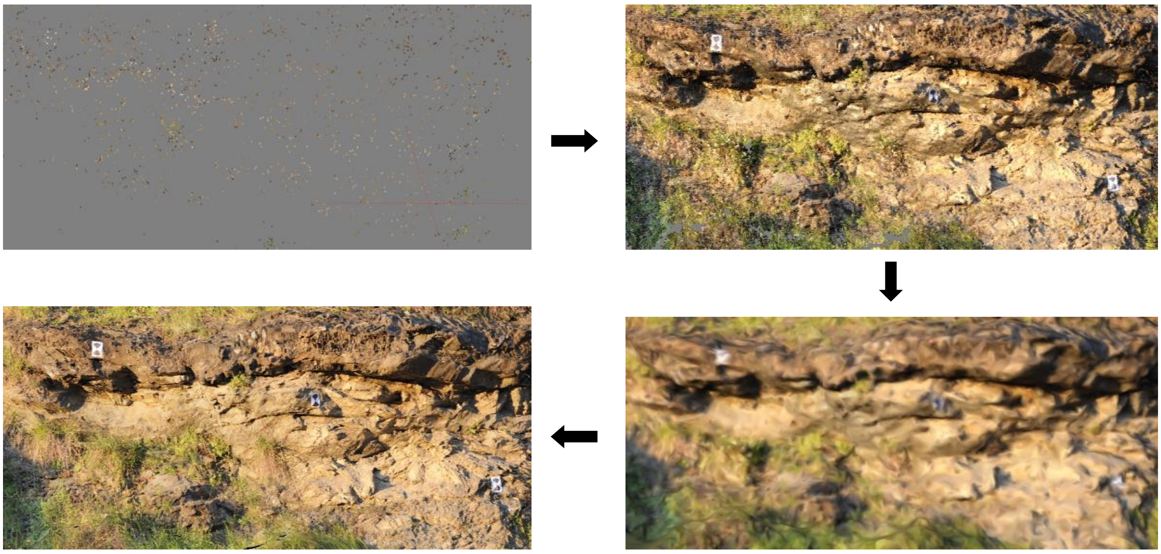

Figure 4. Creating of 3D model from point cloud generated from photographs of Nikon D700

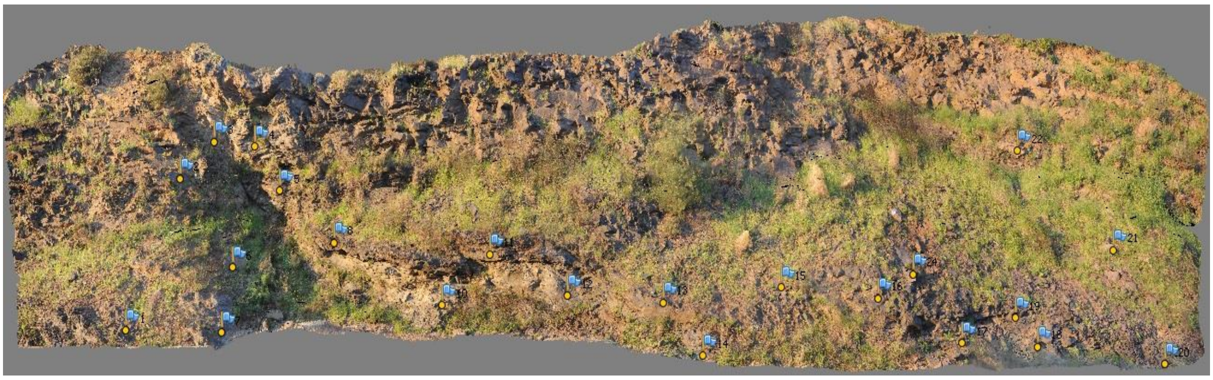

Figure 5. 3D rock model produced by Nikon D700

4. LASER SCANNING

In laser scanning technique, Leica ScanStation C10 terrestrial laser scanner was used. Three scanning in medium resolution were made for rock surfaces. One of the scanning was made from a point whose 3D coordinates has already known. The other two scanning were made from points closer than the surfaces. Cyclone software was used for registration of point clouds. Point clouds was registered with at least 3 common points between two point clouds. Scanning made from polygon point was referenced during the registration. CloudCompare software was used to mesh model from point cloud produced by laser scanner. Photographs were not taken by laser scanner after scanning. Therefore, coloring procedures was not applied for mesh model.

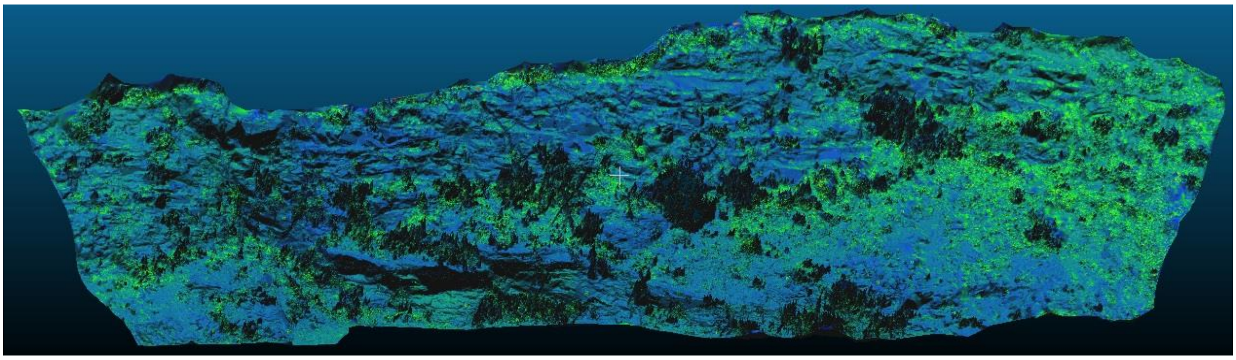

Figure 6. Mesh model produced by laser scanner

5. 2D AND 3D ANALYSIS

Analysis were made in order to compare point clouds produced by close-range photogrammetry and laser scanning technique. 2D analysis is area-based and 3D analysis is volume-based. Three regions representing the same area for three data sources (Nikon, Sony and Laser) were selected over point clouds for comparison. Selection was made from clean surfaces as far as possible. Region 2 is partly weathered unlike Region 1 and Region 3. Mesh models were separately produced for each data source.

In 2D analysis, sections were formed on mesh models. Two ends of contours were joined and area values were calculated using projections of the sections. Area values calculated are the values between line joining two ends and section. Area values are given in Table 2.

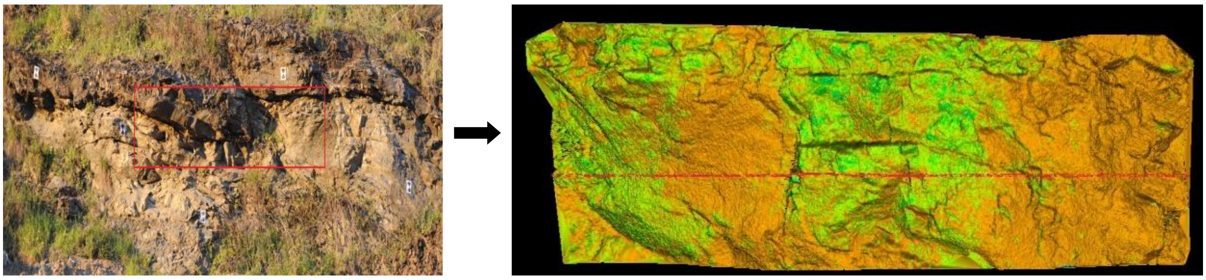

Figure 7. Region 1 and section on mesh model of Region 1 for laser data

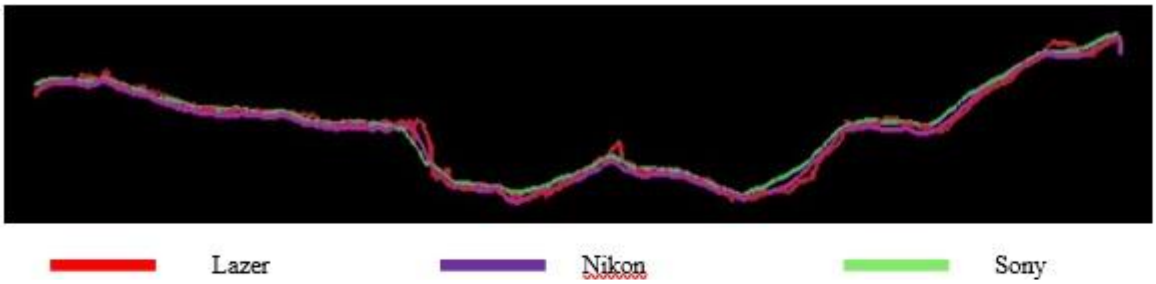

Figure 8. Three sections for Region 1

Table 2. Area Values (m²)

Source of Data	Region 1	Region 2	Region 3
Laser	0,3814	0,3015	0,6023
Nikon	0,3796	0,3008	0,5834
Sony	0,3773	0,2979	0,5613

In 3D analysis, volume calculations were made. Volume values calculated are the values between model on X-Z plane and a plane on Y axis which has the same distance for three mesh model. Volume values were calculated for the portion up to the plane of the space behind the objects.

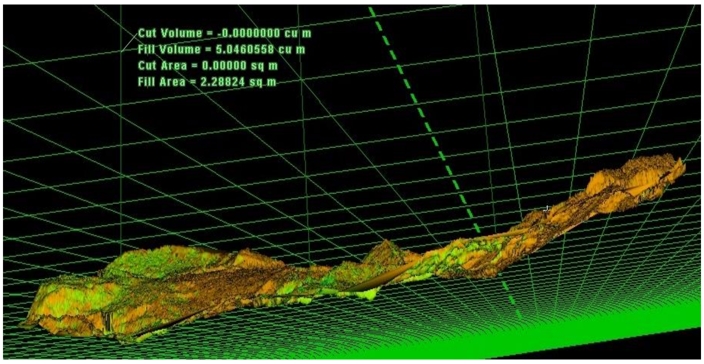

Figure 9. Region 1, volume calculation for laser data

Volume Values (m³)

Source of Data	Region 1	Region 2	Region 3
Laser	5,0461	13,3151	19,2265
Nikon	5,0435	13,0135	19,1777
Sony	5,0403	12,9994	19,1274

6. RESULT AND CONCLUSIONS

The use of point clouds are common in many engineering projects and applications. Point clouds can be produced with the help of photographs as well as laser scanners. However, laser scanners are being more preferred in order to produce point cloud. In this study, close range photogrammetry and laser scanning technique were compared with each other in order to show that point clouds produced by both methods can be used alternatively. 3D object models can be created using both methods but that's not enough to say that point cloud produced by photographs can be used instead of point cloud produced by laser scanner. Some analysis must be made to prove that data relating to photographs is reliable. 2D and 3D analysis made in this study showed that point clouds obtained by two methods are close to each other. Close-range photogrammetry which is more economical than laser scanning can be preferred in several studies.

Image matching algorithms are used to produce point clouds from photographs. These algorithms may not be adequate for all features. Suitable methods should be applied on different features in order to determine that point clouds produced by photographs can be used for what kind of studies.

7. REFERENCES

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