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Creation of a point cloud of a historical structure using the terrestrial laser scanning method – The Example of Bezmialem Valide Sultan Fountain

Berkan Sarıtaş [*1], **Umut Aydar** [2], **Beyza Karademir** [2]

[1]*Eskisehir Technical University, Graduate School of Science, Türkiye, berkansrts@gmail.com*
[2]*Canakkale Onsekiz Mart University, Department of Geomatics Engineering, Türkiye, umutaydar@comu.edu.tr; beyza3992@gmail.com*

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Abstract

In order to ensure that the structures are repaired again as a result of possible natural disasters and day-to-day wear and tear of historical structures, it is necessary to create 3-dimensional models. One of the methods used in the realization of this model is terrestrial laser scanning. As a result of scanning the historical structures in question in different sessions with the terrestrial laser scanning method, a point cloud is obtained and used in relay studies. The filtering process is performed first for the use of point clouds. The filtering process was carried out by removing the point data found in the environment during the scanning of the structure to be studied and which were considered noise in our study. In our study, CloudCompare software was used in order to turn the point clouds obtained as a result of different sessions and the filtering process completed into a single structure. In order to combine the point clouds, control points established before the scanning process started and natural points located on the structure were used.

Introduction

In order to be used for repairing damages that may occur as a result of damage to historical structures, terrestrial laser scanning (TLS) technology can be used to create substrates for creating sections of 3-dimensional (3D) models.

Traditional geodetic measurement methods, whole ground measurement or real-time (RTK) GPS measurements are not very suitable for quickly accessing geometric and visual information of the object. These allow only individual point measurement. For this reason, these methods are usually slow. Modern reflector-free total stations and other developing technologies also have point-based scanning functions. However, the excessive scanning time, the low number of points obtained, the inability to obtain sets of points suitable for the actual model of the scanned object have brought the terrestrial laser scanning technology to the forefront [1].

Laser scanners provide imaging in the form of a point cloud by scanning the object to be measured in the form of arrays of dots under a certain angle in the horizontal and vertical directions. For each laser point, the scanner instrument-centered polar coordinates are measured. These are; the inclined distance to the measured point, the angle that the measuring line makes in the horizontal plane with the x-axis, and the angle of inclination that the measuring line makes with the horizontal plane [2].

If the external surfaces of a building are to be scanned for architectural relay, the tool is installed at any point and the area seen on the building surface is scanned. Then, the scanning is performed by installing the instrument in a suitable place so that it scans the adjacent area of the first scan. Each scan is performed in such a way as to create common scanned areas at a certain rate with the previous scan. These common scanned areas are necessary for the joining of point sets. [3].

The aim of my study is to create 3D models as base data for use in repair operations in case of destruction and damage caused by possible natural disasters and day-to-day wear of historical structures.

Study Area

Bezmialem Valide Sultan Fountain was built by Bezmialem Valide Sultan on Besiktas Sports Street on the Rumeli side of the Bosphorus in Istanbul in 1839. It is a square fountain with four facades. The fountain was built with the empirical style [4].

Material and Method

TLS was used to create a 3D point cloud of Bezmialem Valide Sultan Fountain. First of all, control points have been established on the structure in order to be able to use it during the merging of scanning data. The scans were performed in the local coordinate system and eight different scanning operations were performed. During the scanning operations, it was taken into account that there were overlays between consecutive scans, that is, there were common control points Decoupled in the scanning data.

During the scanning of the structure, objects in the environment are included in the scanning data. Points other than the structure should be cleaned both because of the high size of the data and because it causes difficulties to the operator during the processing of the data. The filtering operations were carried out manually with the help of CloudCompare, a free software. After only the data belonging to the structure remains in each session, the registration process is performed using CloudCompare software again so that a 3D model of the object can be created. During sequential scanning, the control points common to both scans are matched.

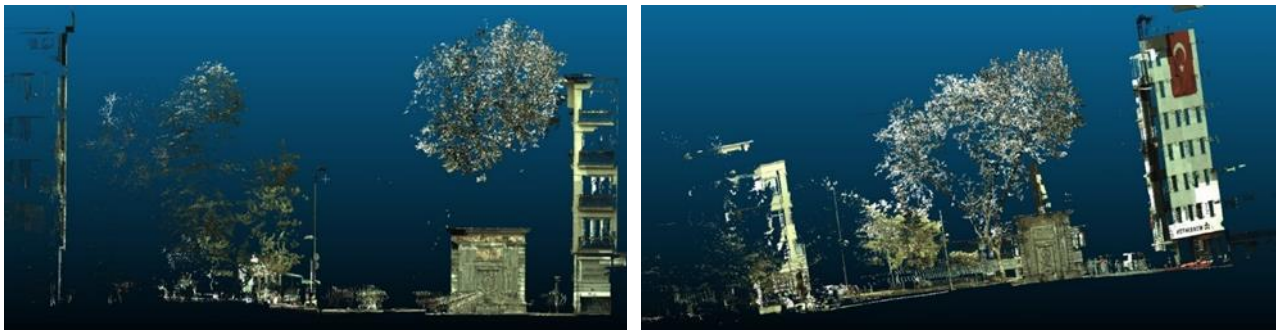
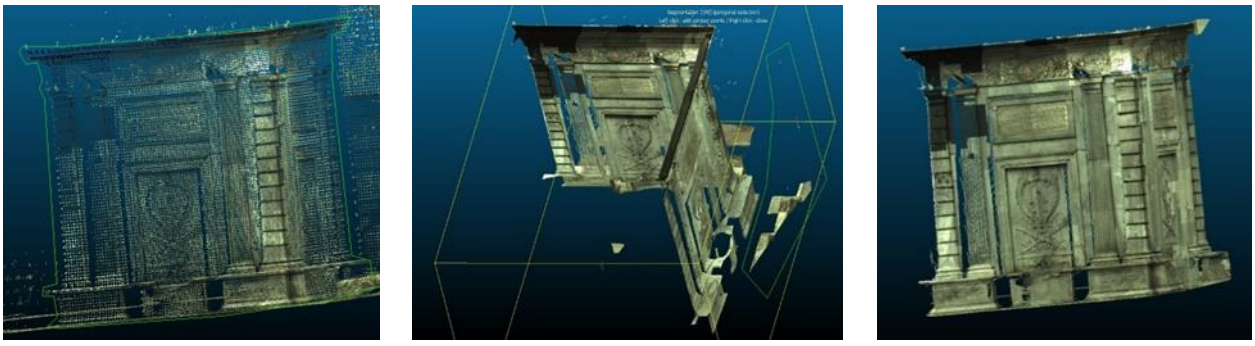


Figure 1. An example of the scanning data obtained with different sessions

Filtering the noise from point cloud

The point cloud data for each scan goes through the filtering process separately. After the data is transferred to the CloudCompare environment, the segment button is selected and the points belonging to the structure that want to be filtering of noise points are surrounded in such a way as to form a closed polyline. By deleting the points remaining outside the selected parts, it is ensured that the noise points remaining around the structure are filtered. In the same way, it is possible to delete the selected parts by selecting noise points. The point cloud is examined from different angles and the filtering process continues until the noise points are detected and only the points belonging to the structure are left. This process is repeated for scanning data for all fronts.



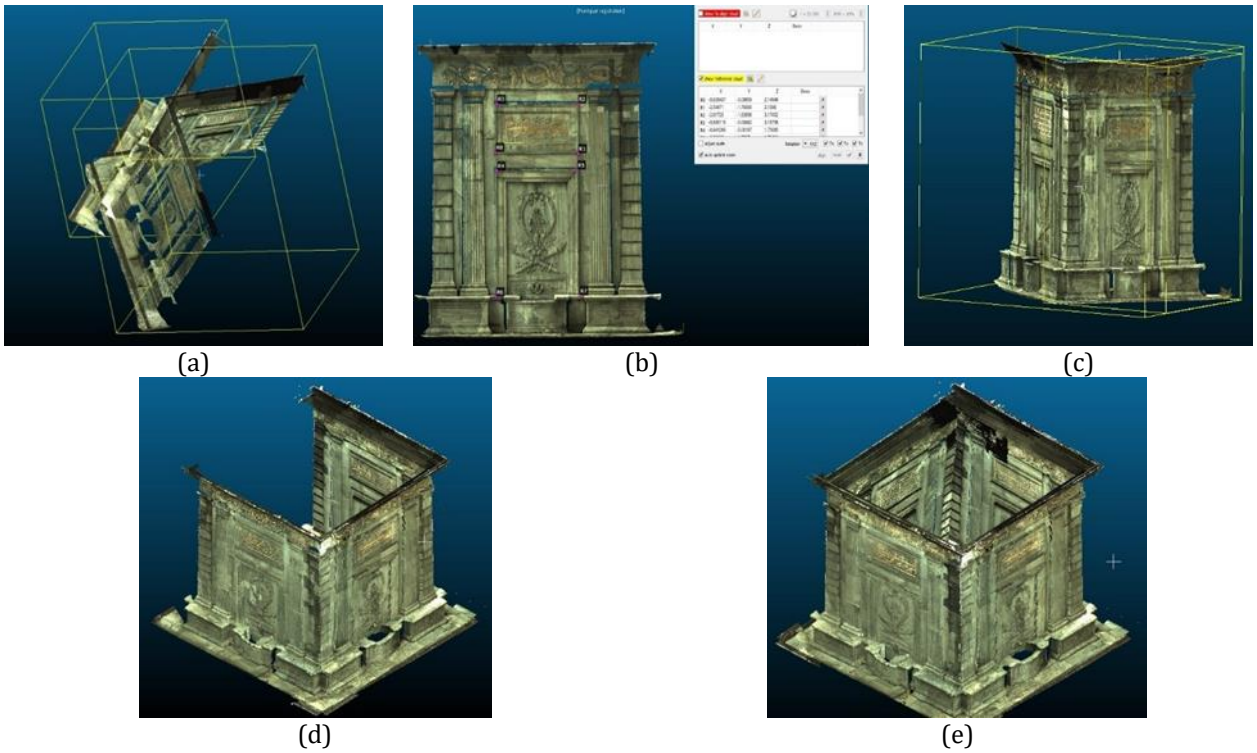
(a) (b) (c)

Figure 2. (a) selection of points belonging to the structure, (b) detection of noise points, (c) point cloud formed by filtering noise points

Merging the point cloud

The registration process is performed in order to Decouple the data obtained in all scans and to ensure that all the details of the structure are contained in a single point cloud. In order for the 3D model to be created precisely,

the common surfaces are combined with the matching of control points. Since each successive front screening is carried out by having common control points with each other, matching common control points allows a more accurate model to be created.



(a) (b) (c)

(d) (e)

Figure 3. (a) displaying the scan data to be matched in local coordinates, (b) selection of control points located on the structure, (c) two fronts mapped using the control points, (d) three fronts mapped using the control points, (e) mapping all the facades of the structure and creating a 3D model

Conclusion

With the 3D point cloud created, Bezmialem Valide Sultan Fountain will be able to be used as base data in the restoration work that will be carried out to restore it to its former state if it is damaged in any case. When we look at the advantageous side of the process performed, it is ensured that data can be obtained faster and with more precise accuracy compared to classical methods. The roof of the structure was not included in the model because it was not scanned. In order for the roof part to be included in the model, the scanning process can be performed with the help of a drone, and the obtained scanning data can be integrated into the model in the point cloud belonging to the roof. It can be determined how sensitive a model has been created by performing an accuracy analysis of the operations performed. The accuracy of the created model can be determined in future studies.

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