AN UNDERGRADUATE PROJECT WITH TERRESTIAL LASER SCANNER FOR PURPOSE OF ARCHITECTURAL SURVEY

C.Ö. Kıvılcım
Istanbul Metropolitan Municipality, Department of Projects, Directorate of Historical Sites Protection

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ABSTRACT:

Photogrammetry and conventional geodetic survey methods are widely used for the restoration and conservation works, architectural, survey and documentation. With the developments in the laser technology, LIDAR systems are recently used in the survey of architectural structures. Although this is a promising futuristic technology, there are still problems to process the high-density point clouds of objects. To perform operations on point cloud data and extract 3-D surfaces are limited because of the hardware and software capacities. In this undergraduate project, an algorithm for the laser point clouds was used as an alternative to the classical methods for architectural purposes mentioned above. A fieldwork was carried out on the façade of a simple shaped building in order to analyse the application and compare the results. The point cloud data was described into 2-Dimension surfaces. Points within the same surfaces were used as reference and the façade of the building was produced by digitization of the surfaces. Today, similar techniques based on the same principle are in use for urban design, conservation works and archiving for the Istanbul historical heritage. Examples are introduced.

1. INTRODUCTION

With the recent developments in the Light Detection and Ranging (LIDAR) technology, laser scanner systems are used in industrial design projects, crash tests, risk mapping and further more. Among the other benefits of the use of LIDAR, architectural and 3-D applications are the recent topics of many scientific researches. Today, countries played significant roles in the history of civilizations such as Turkey, demand and need on very big numbers of architectural survey projects for restoration and other different applications like digital archives. This paper investigates and aims how a fast and accurate architectural survey can be produced.

2. MATERIALS AND METHOD

2.1 Equipment

A sample building façade in the campus of Yildiz Technical University was chosen for the application. The laser point clouds were acquired with a MENSI GS-100 Terrestrial Laser Scanner (TLS), which scans in horizontal direction (Figure1). The scanner specifications can be seen in the Table 1. During the fieldwork user is connected to the scanner's video camera by a laptop and easily controls the scan options including the area of interest to be captured. More, it is possible to see the sample point clouds nearly on the fly. Therefore, any gaps in the point clouds or wrong decisions can be easily recognized at the site of survey. Additionally, RGB images can be mapped onto the point clouds to get a virtual copy of the real object.

Figure 1. Mensi GS-100 Laser Scanner

Device Type	Long Range Mapping System
User Interface	PC, Windows NT/2000
Ideal Range	2-100 Meters
Max. Scan Rate	5000 points/second
Standard Deviation	6mm in one shot
Field of View (FOV)	360° in horizontal, 60° in vertical
Point Diameter	3mm (in 50m distance)
Radiance Dynamic	8 bits-256 Gray Scale
Laser Class	Class II laser (EN 60825:1994)
Distance Measurement	Time of Flight
Video Calibration	768x576 Colour Resolution On the fly video transmit
Camera Zoom Factor	Up to 5.5X

Table 1 Laser Scanner Technical Specifications

2.2 Method

The workflow of the method can be summarized as follow:

1. Target Selection and Laser Scanning
2. Registration of Point Clouds
3. Digitalization
4. Final Process

2.2.1 Target Selection and Laser Scanning

During the field work, point clouds were achieved from three different stations in order to prevent the gaps and to acquire all the important details from the façade of the building. To register the different point clouds in the same local coordinate system, totally 5 sphere-shaped Ground Control Points (GCP) provided with the TLS were used. The GCP's were placed such that at least 4 of them could be captured from each scan station. In the Figure 2, all reference points can be seen from the point cloud achieved from the first scan station.

Figure 2. Control Points seen in the point cloud from the first scan point.

The TLS is controlled by a laptop with the software PointScape from Mensi. In each station, to identify the possible GCPs, predefined settings from the software were used and a number of targets were introduced to the scanner. Number one GCP can be seen in the Figure 2 as in the point clouds and the determined volume in the reference space. After the first step, scan parameters are selected to start the scan session. The parameters provided are; the approximately distance to the object, number of signals to each point, distance between two points. For this application 10m distance to object, 1cm distance between two points of laser shots and 2 signals per a point were applied. To prevent the excessive point clouds, the software provides a maximum range offer, where 20 meters was for the this application. The scan time per station was taken 25 minutes including the time for setting the scanner in each station.

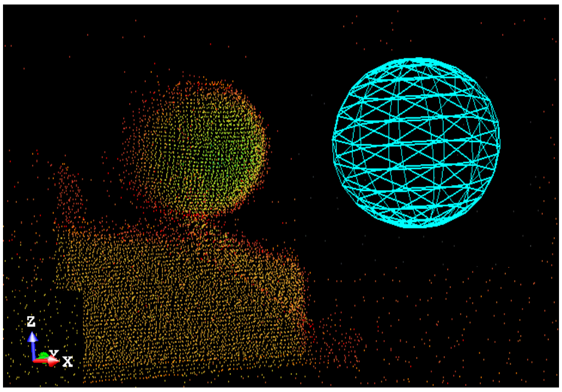

Figure 2. The recognized control point in the point cloud (on the left) and the identified volume of the predefined sphere in the reference space

2.2.2 Registering the Point Clouds

After the field work, different scans were registered by using the software RealWorks Survey. The process of the registration was mostly done automatically. Maximum GCP position error was computed from the second station's first control point which was in 12.571m distance to the scanner. This max error was computed as 1.40mm. All the other GCP locations were also found with position errors in mm.

2.2.3 Digitalization

The excessive parts of point clouds such as trees, bushes were deleted partially from the registered point cloud of the façade. In the next step, the registered 3-D point clouds were cut into surfaces as seen in the Figure 3. Points from the cloud within the similar surfaces were selected as reference points in order to determine the reference surfaces. This was archived with the toolbox of the RealWorks Survey where defined surfaces can be digitalized with the points in the characteristic parts of the structure with the use of line, poly line and arc functions.

2.2.4 Final Process

The final digitalized structure can be converted to CAD drawing seen in the Figure 4.

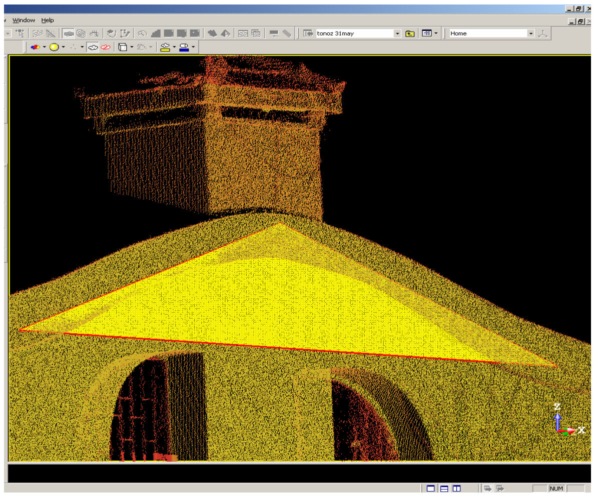

Figure 3. Describing reference surfaces by using points in the same surface

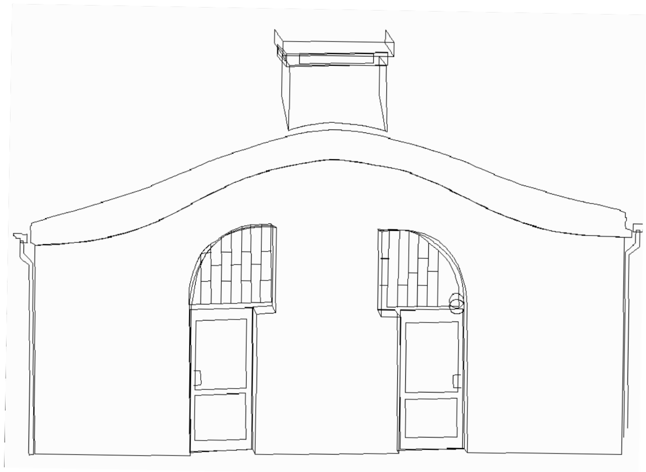

Figure 4. Sample building's digitalized façade as a final product for architects.

3. DISCUSSION AND RESULT

Laser point clouds provide an opportunity to work in 3-Dimensional Environment with the independence of scale. On the other hand during the whole workflow, the technology and the software played a major role for the production time. More, during the digitalization progress, it has seen that the reflected laser points and the low contrast areas in the point clouds have bad influence on determining the shapes. Therefore scan parameters such as distance to the object, radius of the laser signal, object materials and environmental conditions like shadows and bright surfaces are the means to improve the quality and accuracy of the point clouds which means a better product.

Still hardware and software technologies have disadvantages on very high density of point clouds.

The technique applied in this work, provides an easy way especially for the works of simple shaped buildings. Therefore an algorithm combined with rectification of building images and laser point clouds for better object orientation are used in different projects.

This undergraduate project is one of the very first projects where undergraduate students actively had the chance to use TLS in Yildiz Technical University, Turkey. With the help of such projects, the students get familiar with the recent technologies and meet the goals of update education contents of the department.

As an example to such use of the laser scanners in the architectural field is the project in progress of the Istanbul Metropolitan Municipality, The project of the econometric model project for the peninsula of the old Istanbul which covers 1500 ha². The project contains plans of façades and 3-D models of buildings for the different disciplines; urban planners, architects, restorer, engineers. Currently the project employs nearly 200 professionals.

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