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Evaluation of point cloud software in terms of 3D architectural drawings

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Abstract

In 3D reconstruction, the point cloud is crucial for preserving the geometric data of the target object. Following the acquisition of data by 3D laser scanner or image-based techniques, several software options are available for analyzing and processing the point cloud. In this investigation, terrestrial laser scanning was employed for point cloud acquisition, with subsequent analysis being carried out using Sketchub and Pointcab software. Ultimately, a web-based application, Sketchfab, was utilized to create a virtual reality simulation.

1. Introduction

Local laser scanning technology is an accelerating field, known for its ability to quickly create point clouds that render realistic 3D models of objects at a low cost. Nowadays, obtaining fast, comprehensive, and cost-effective 3D models and visual information is crucial. Terrestrial laser scanning has introduced a new era in surveying techniques (Atik & Duran, 2020). Thousands of points per second are obtained instantaneously, reflecting the scanned object or object surface (Yakar et al. 2010; Karataş et al. 2022a). These points enable the construction of precise 3D models through careful evaluation of the data (Dustin et al., 2016). The created models allow for access to critical information such as point position, object size, surface area, and volume. Prior to commencing scanning, a measurement plan must be developed, and scanning parameters must be established according to the desired precision. This technique is cost-effective and speedy compared to other measuring methods (Suchocki et al., 2020). The fundamental operating principle is the emission of a light beam (laser) that gets reflected from the object surface and is subsequently detected by the receiver (Yılmaz and Yakar, 2006). Laser scanning systems utilize three distinct measurement principles - Time-of-Flight, Phase Shift, and Triangulation - to assess the sensor-target distance (Ulvi et al. 2014).

The TLS data obtained from terrestrial laser scanning were processed using Scene software. Regular scans are crucial in data processing, allowing automatic merging of scans. The resulting point clouds can be employed to generate precise drawings. Point clouds obtained from laser scanning are more precise and denser than those obtained from photogrammetry, making them more useful (Alptekin et al. 2019).

This study involved using TLS data to create drawings in two different software programs. The resulting drawings were used to generate a 3D model, which was presented in a virtual reality environment. The study highlights the strengths and weaknesses of the software programs used for creating the drawings.

2. Material and Method

The data for the historical building was obtained using the TLS technique (Kanun et al. 2021). Terrestrial laser scanners can be classified into three categories, based on their length measurement principles: time-of-flight, triangulation, and phase difference scanners (Karataş et al. 2022b). Time-of-flight scanners have an extensive scanning range (Alptekin and Yakar, 2020a). Phase-difference scanners can measure shorter distances, but their measurement accuracy is more precise than that of time-of-flight scanners (Alptekin and Yakar, 2020b). Furthermore, while triangulation laser scanners exhibit increased sensitivity and accuracy in comparison to phase-difference laser scanners, they are more suited for smaller objects (Ogawa & Hori, 2019; Karataş et al. 2022c).

The phase difference method was employed in the FARO Focus3D S350 laser scanner used in this research, which boasts a range of 0.6-350 m and a data collection capacity of 976,000 points per second using the phase comparison technique. This laser scanner has the ability to perform scans ranging from 60 cm to 330 m with a

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precision of ± 2 mm. The scanner is capable of collecting up to 976,000 points per second (Figure 1).

Figure 1. Faro Focus 3D X330 Laser scanner (URL 1)

Point clouds were obtained for the study at a spatial resolution of 1 cm. This resolution was chosen as a suitable balancing point between the final 3D model's level of detail and the computer resources required for data processing. The scans were conducted in 48 sessions on the same day. At the required spatial resolution, a survey design must first establish the locations of the TLS stations to ensure complete object coverage. The laser scanner is capable of generating measurements with an accuracy of approximately 1-2 mm at close range. The quantity of dots on a surface is contingent upon the scanner's resolution (Liscio and Le, 2022). Many manufacturers of laser scanners provide a function that indicates the quantity of dots at a predefined distance. For instance, when the FARO laser scanner is set to a resolution of 14, it produces dots spaced approximately 6 mm apart when scanning at a distance of 10 m. At this resolution, the dot density would be 3 mm on an object that is 5 m away and 0.6 mm on an object that is 1 m away. In contrast, the accuracy of the scanned data is determined by the number of times the spot is sampled. The more samples taken, the closer the data should be to the true value. However, increasing the quality setting leads to longer scanning times. For instance, a ¼ resolution and 1x quality scan takes 1 minute 30 seconds, whereas a scan with the same resolution but 4x quality takes 7 minutes 46 seconds. In this investigation, a ¼ resolution setting and 3x quality setting were utilized (Liscio & Le, 2022). The scanner distance from the wall was approximately 1 meter, resulting in a point spacing of less than 1 mm.

During the positioning of the scanning positions, we ensured a minimum overlap of 60% between the previously scanned area and the subsequent scan region. Some of the test areas featured reflective surfaces. The study aimed to evaluate laser scanning technology efficacy in various areas and we did not take any additional measures designed for reflective surfaces. The study was conducted in four distinct areas, each with its own unique structural features. Relevant details regarding each area have been outlined in the respective sections. The TLS data was collected, and scan data from all locations were merged using a cloud-to-cloud approach before being georeferenced with the aid of target points. Before georeferencing, the point cloud data for each location underwent filtering through the Deviation, Dark-scan and Distance filters. Also, the TLS point cloud data was cleaned and resampled before starting the image processing stage. In the domain of image processing, 3D models can be created and of high quality using Triangular Network and Texture Matching techniques.

3. Results

The point cloud obtained with TLS was transferred to Sketchub software and 3D drawings of the study area (Figure 3) were made.
Drawings of the study area were also made in Pointcab software, a different drawing software (Figure 4).

After the drawings were made, a solid model of the study area (Figure 5) was mounted on the Virtual Reality (VR) system and introduced to the users by offering virtual navigation within the model (Figure 6).

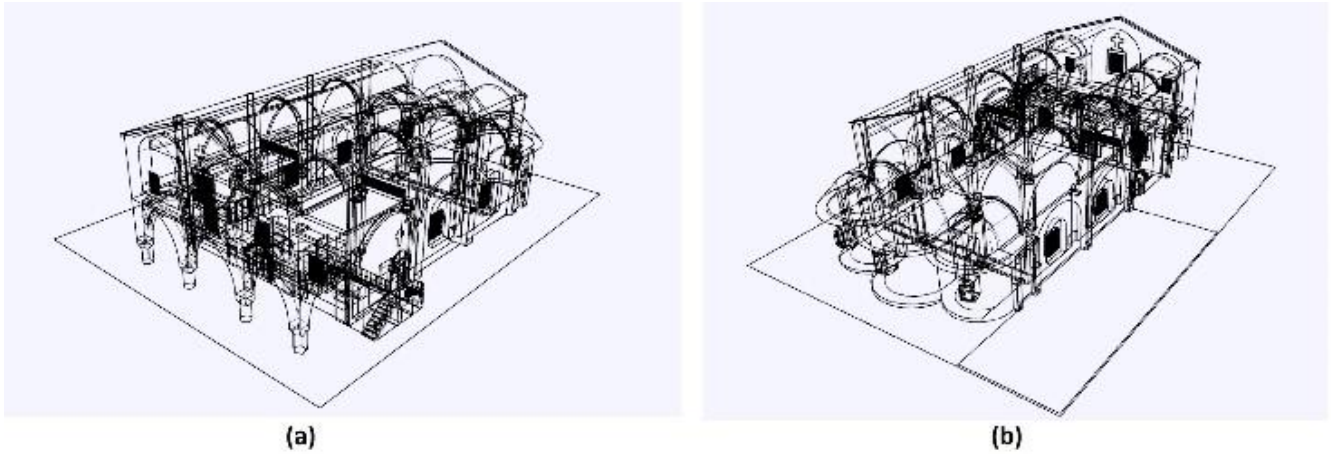

Figure 3. Sketchhub draws (a) South façades, (b) north façades

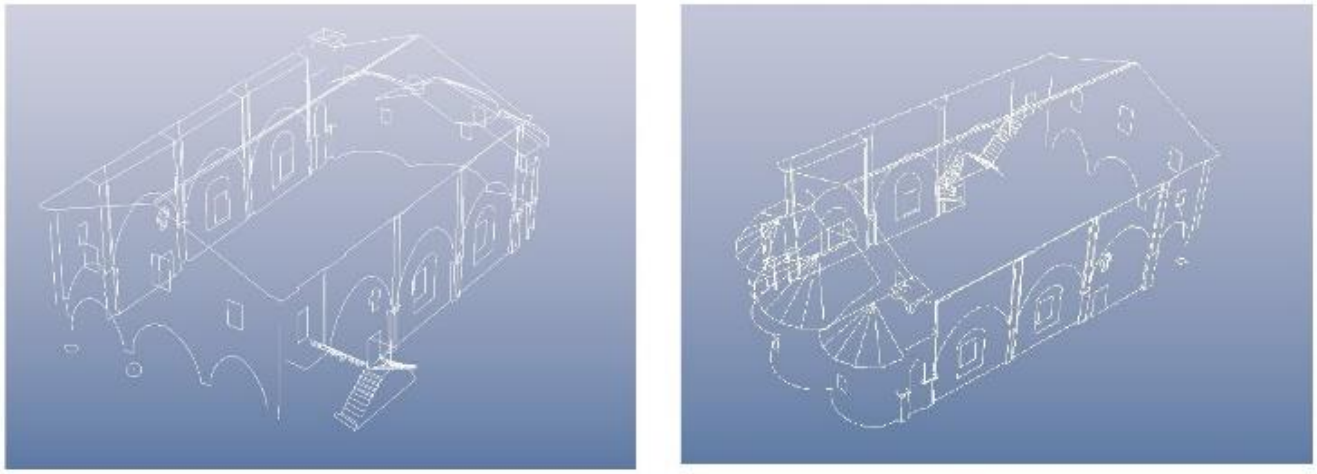

Figure 4. Pointcab drawings (a) South Facade, (b) North Facade

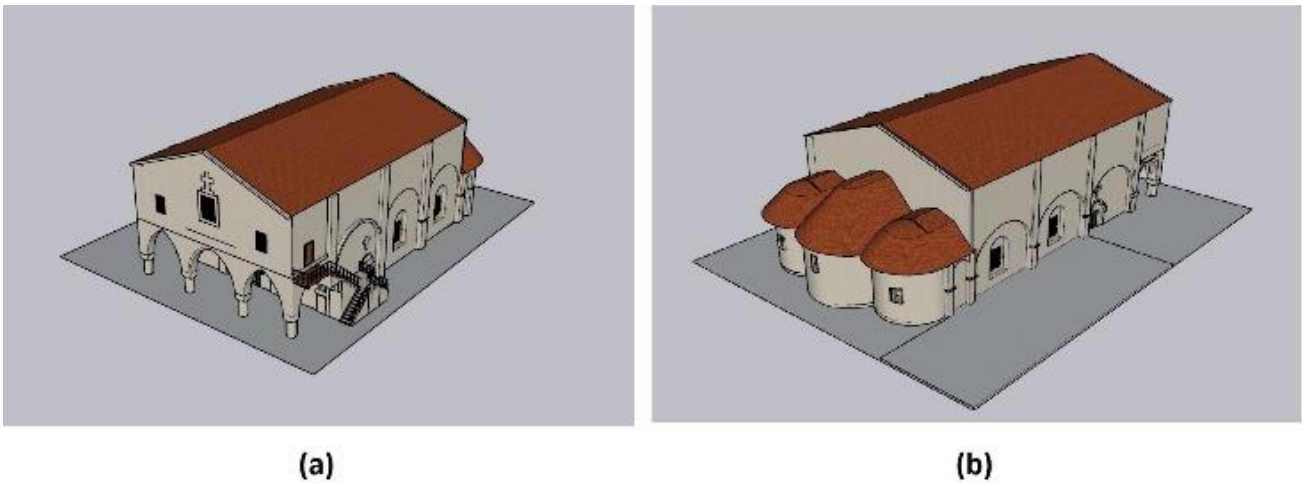

Figure 5. Solid model. South façade (a), North façade (b)

Figure 6. Virtual Reality through a 3D model

4. Discussion

The accuracy of the local laser scanning in this study is in the range of approximately 0.4-0.7 cm.

The observations obtained as a result of the study are as follows:

Sketchub

- Plans, views, sections can be drawn.
- It provides 3D models for interior spaces.
- It allows use in construction projects.
- It is used in the design of urbanisation and landscape areas.

Pointcab;

- Floor plans and measurements can be made.
- Point cloud data from all commonly used 3D scanners can be processed.
- There is the possibility of output in the extension required by all commonly used CAD software.
- It contains plugins for Autocad, Archicad, Revit and etc. software.

The main advantage of the Laser Scanning technique is the direct generation of point clouds that define the object or scene.

5. Conclusion

Building Inspection has proposed a methodology to establish a comprehensive and accurate data source through Terrestrial Laser Scanning for building inspection, in addition to developing a TLS-derived inspection. The resulting database can be a valuable resource for diverse applications, such as asset management and structural assessment of heritage buildings. The 3D model derived from TLS, which is proposed in this study, has the potential to save time for asset managers and structural engineers as it removes the need for frequent in-person revisits to a structure. Furthermore, it can aid document management through the use of digital models instead of physical ones. Linking additional information, such as structure reports or building inspection data, to a digital copy of a bridge can improve understanding and communication among relevant personnel.

The study area was successfully represented in a 3D model and CAD drawings using TLS point clouds. The study employed two different drawing programs. Both programs have pros and cons that are discussed in detail. Those wishing to undertake similar work should choose their drawing software based on their project requirements. If presenting drawings and solid models in a virtual environment is the aim, VR systems should be utilized. The WEB-based Sketchfab platform, which supports both augmented and virtual reality, was utilized as the VR platform (https://skfb.ly/oNYNq). The use of WEB-based platforms significantly assists with the transfer of such studies to users.

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