Research on Building Measurement Technology Based on 3D Laser Scanning Technology

Hao Chen, Ting Xu, Yuxin Huang, Meng Sun, Jiayi Zheng, Yuhan Wu
School of Resources and Civil Engineering, Liaoning Institute of Science and Technology, Benxi 117004, Liaoning, China

Abstract: 3D laser scanning technology, with its characteristics of high efficiency, high precision and non-contact, has become an important tool in the field of building measurement. This paper takes the international student apartment of Liaoning Science and Technology University as the research object and uses the Southern SPL-500 3D laser scanner to conduct on-site point cloud scanning of the international student apartment. After field scanning, point cloud processing was carried out using SouthLidar Pro and Trimble RealWorks software. Subsequently, the accuracy of the building side length was inspected using the prismless mode of the 1 "total station. The experimental results show that multiple factors such as building characteristics, environmental factors, and human factors all have an impact on the measurement accuracy and need to be comprehensively considered. In the future, the measurement accuracy of buildings can be further enhanced by optimizing the accuracy assessment methods and improving the technical level.
***Keywords*:** 3D laser scanning technology, Building measurement, Point cloud data Processing, Accuracy evaluation

1. Introduction

With the continuous development of technology, traditional building measurement methods can no longer meet the requirements for accuracy and efficiency. 3D laser scanning technology, as an advanced measuring tool, has advantages such as high precision, high efficiency and non-contact, and is gradually becoming a popular technology in the field of building measurement.3D scanning technology is a method that measures the3D coordinate values of the surface points of spatial objects to obtain the point cloud information of the objects, thereby achieving accurate measurement and reconstruction of the external and internal structures of buildings. This study aims to explore the measurement accuracy of buildings based on 3D laser scanning technology and its application in the field of engineering surveying and mapping. As a rapid and precise measurement method, 3D laser scanning technology has significant advantages. In-depth research on its measurement accuracy is of great significance for promoting the development of engineering surveying and mapping technology [1].

2. 3D laser scanning technology

3D laser scanning technology, through precise laser ranging principles and data processing algorithms, achieves high-precision3D reconstruction and measurement of the surface of target objects. It features high efficiency, accuracy, automation, and strong adaptability, breaking through the limitations of traditional measurements. It can quickly obtain massive3D data in complex environments and is widely applied in fields such as topographic mapping, building maintenance, and urban planning.

This paper takes the international student apartment of Liaoning Science and Technology University as the research object. Field data acquisition is carried out using the Southern SPL-500 3D laser scanner. Point cloud processing is completed in combination with SouthLidar Pro and Trimble RealWorks software. Then, single-point and side length acquisition is conducted using a total station for accuracy verification. Subsequently, the role of this technology in improving the accuracy and efficiency of the building model was verified through actual cases. The coordinates and accuracy of the building were inspected using the prismless mode of the 1 "level total station to test the reliability of its3D laser scanning technology.

3. Data collection and data processing

3.1 Field Data Collection

Field data acquisition is one of the important steps in the research of building measurement accuracy based on 3D laser scanning technology. In order to ensure the reliability and stability of the application of3D laser technology in the measurement of building facades, the investigation work should be done in advance to grasp the true situation of the survey area. Based on the collected data, parameters such as instrument parameters, scanning intervals, scanning point cloud quality, and scanning angles are designed and set.

In this paper, a total of 14 stations were set up using the Southern SPL-500 3D laser scanner. The built-in 100m scene was applied. The scanning interval was set to 100 meters, the scanning point cloud quality was set, the horizontal scanning range was 0°-360°, and the vertical scanning range was 0°-150°. Photos were taken using the built-in camera, and a total of 8 photos were taken from different angles at each station.

3.2 Point Cloud Data Processing

This point cloud processing software uses SouthLidar Pro and Trimble RealWorks software provided by Southern Surveying and Mapping. It mainly includes the data preprocessing procedures such as point cloud data registration, coordinate system transformation, noise reduction and thinning, image data processing, and color point cloud production.

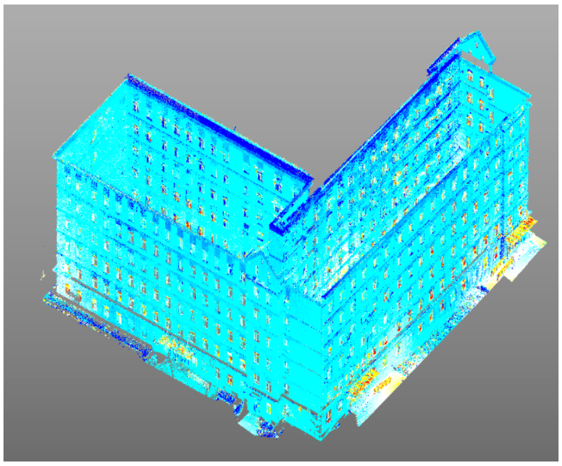

Figure 1. The registration results of the cloud data collected from the facad

Figure 2. The point cloud data after true color registration and cropping

Data preprocessing includes operations such as denoising, filtering and point cloud registration. Firstly, the collected point cloud data was denoised using the SouthLidar Pro software, effectively eliminating the noise points generated during the scanning process. If problems such as uneven point cloud distribution and large-scale occlusion occur during data processing, an external scan needs to be conducted again.

Point cloud registration is a key link in realizing the construction of the overall model of buildings. Since 3D laser scanners usually need to obtain data from multiple perspectives while ensuring the overlap rate, it is necessary to precisely align these scattered point cloud data. The registered data is shown in the Figure 1 and 2.

Subsequently, in the Timble RealWorks software, the analysis of point cloud data was carried out. In the "Analysis and Modeling" module of Timble RealWorks, the point cloud is first segmented, retaining only the main body of the building. Then, the point cloud data is classified. Through the precise extraction and filtering processing of the point cloud data, the fine features of the building are obtained, including walls, Windows, roofs, etc. During the model construction stage, point cloud data is usually transformed into a3D model. Finally, texture mapping is achieved by mapping high-resolution image data onto the surface of a3D model, which can reproduce the appearance details of buildings. The key to texture mapping lies in the precise alignment of the image with the model surface. Usually, a matching method based on feature points is adopted to ensure that the texture image can accurately cover the model surface.

4. Accuracy Evaluation

In this paper, a ground-based 3D laser scanner is used to conduct multi-station scanning of the target building to obtain a high-precision 3D model with a point cloud density of 5mm+100m. By comparing the point cloud data of 3D laser scanning with the measured data of the total station, the measurement accuracy and applicability of this technology were systematically evaluated. To verify its absolute accuracy, the prismless mode of the 1 "level total station was used simultaneously to measure the feature points of the building facade. Several typical feature points such as eave corners and window frame nodes were selected as the accuracy verification benchmarks. In the data processing stage, the coordinate system of the total station is first converted to the scanner coordinate system through the control points on the campus of Liaoning Science and Technology University, and the3D coordinates of the corresponding feature points are extracted in the Timble RealWorks software.

The comparative analysis shows that in the horizontal direction, the average deviation between the3D laser scanning point cloud and the measurement value of the total station is 3mm, and the maximum deviation is 5.2mm. 95% of the3D coordinate deviations of the comparison points are within ±6mm. In the vertical direction, the average deviation is 4.1mm and the maximum deviation is 6.3mm, all meeting the accuracy requirements in the "Code for Engineering Surveying" (GB50026-2020). Some of the selected coordinates are shown in Table 1.

Table 1. The coordinates of some feature points are poor

Number	Delta X	Delta Y	Delta H
G1	0.023	0.019	0.003
G2	0.032	-0.025	0.041
G3	-0.037	0.043	0.027
G4	0.027	0.033	0.025
G5	-0.017	0.009	-0.015

5. Factors influencing the measurement accuracy of buildings

The errors of sub-station scanning and data collection mainly include instrument errors, improper operation and laser ranging errors. The instrument errors mainly result from the precision limitations of the scanner and improper registration, etc. The laser ranging error is mainly affected by environmental conditions and the buildings themselves, such as atmospheric visibility, lighting conditions, impurity particle content, buildings, etc. [2]

The coordinate system of the point cloud data collected by scanning is defined with the geometric center of the instrument as the origin. Only by converting it into an absolute geodetic coordinate system can it be used for subsequent engineering analysis. Elements such as the accuracy of feature points and the length of the baseline during the conversion process will all have an impact on the data accuracy. The specific impact is manifested in the following three aspects: (1) Absolute positioning deviation of spatial points; (2) Distortion of the geometric form of buildings; (3) The spatial references among multi-source coordinate systems are inconsistent. For this purpose, the following optimization measures should be taken: The scanning range should be limited to enable the scanner to collect data within the optimal working distance, reduce the influence of laser beam divergence and air attenuation, minimize the scanning Angle as much as possible, reduce data distortion, and control the accuracy of feature points for coordinate transformation within 2 mm [3].

6. Conclusion

In this paper, the Southern SPL-500 3D laser scanner was used to conduct on-site measurements of the international student apartment of Liaoning Science and Technology University, analyze and process its point cloud, and use a total station to measure the feature points and lines. Through the comparison and analysis of accuracy, the high accuracy and reliability of 3D laser scanning technology in building measurement were verified.

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Author Bio

Hao Chen (2004-), male, undergraduate. Corresponding auther: Ting Xu (1988-), female, master's degree, associate professor.