The Application of GOSLAM Technology in Campus Digital Surveying and Mapping

Huipeng Hong[1], Lingwei Kong[2]
[1]*Jilin Tiedao University, Jilin, China*;
[2]*China Railway Northwest Research Institute Co., Ltd., Lanzhou, China*

Abstract: Using the GOSLAM scanner for large-scale field measurement can significantly reduce the workload of fieldwork compared to traditional surveying methods, saving human and material resources. In this paper, the GOSLAM scanner was used for field measurement to obtain campus data images. The GOSLAM LidorWorks modeling software was utilized to establish a real-scene 3D point cloud, allowing for campus real-scene roaming. The CAD drawing software was used to draw the campus 2D topographic map. Through the process of campus panoramic scanning, digital storage, and conversion, the transformation path and implementation method of replacing the traditional surveying production system with a digital surveying production system were explored and practiced.

Keywords: GOSLAM Scanner; Zonal Scanning; 3D Point Cloud; CAD Format Conversion

1. Introduction

Surveying and mapping is one of the indispensable basic data in engineering projects. It provides information such as the elevation and slope of terrain and buildings, which is of guiding significance for the site selection, design and construction of engineering projects. With the in-depth application of digitalization in all walks of life, surveying and mapping has transformed from traditional paper-based form to electronic form, and the measurement method has shifted from conventional mobile measurement to digital multi-dimensional stereoscopic surveying and mapping.

Traditional surveying and mapping methods mainly rely on manual measurement and map drawing, with common tools including compasses, distance meters, theodolites and so on. These methods are relatively cumbersome and susceptible to subjective human factors, and the surveying and mapping results cannot realize 3D stereoscopic real-scene display. Campuses cover a large area and have numerous auxiliary facilities, so traditional surveying and mapping methods are time-consuming and labor-intensive, and cannot intuitively depict the topography, geomorphology and auxiliary buildings of the surveyed area. At present, unmanned aerial vehicles (UAVs) are widely used in the field of real-scene 3D surveying and mapping. However, UAV operations require GNSS signals and are affected by factors such as weather, altitude and surface cover, which impact operational efficiency and safety. In contrast, handheld scanners do not require GNSS signals or a large number of marked points, thus greatly improving operational efficiency and safety. They can better support urban construction and planning and promote the economical and intensive use of land [1]. As 3D laser scanning technology continues to develop and mature, its greatest advantage lies in the ability to rapidly scan measured objects in a non-contact manner. It can directly obtain high-precision planar point cloud data without the need for reflective prisms, and accurately acquire the 3D coordinates, color information and other data of the measured objects. Massive point cloud data can be used to construct 3D models of the measurement scene, truly achieving the effect of "what you see is what you get" [2]. Currently, scanners have been applied in various engineering projects such as indoor and underground space mapping, construction engineering, underground mine measurement, geological survey of water conservancy and hydropower projects, cultural relic protection and geological disaster assessment. They have greatly improved the efficiency and precision of surveying and mapping, simplified the measurement process to make it more accurate, and enhanced the usability of surveying and mapping results [3-9].

In this paper, the handheld SLAM (Simultaneous Location and Mapping) technology is adopted to break through the traditional single-point measurement method. It enables continuous mobile measurement and scanning, improves data acquisition efficiency, and accurately obtains the spatial geometric form of measured objects through non-contact measurement, which has broad application prospects in large-area topographic surveying and mapping. The practical operation of scanner fieldwork and post-processing software is studied by measuring the terrain and buildings of the existing campus of Jilin Railway Vocational and Technical College.

2. Project Introduction

2.1 Principles and Characteristics of GOSLAM Technology

SLAM (Simultaneous Localization and Mapping) refers to the technology of simultaneous localization and mapping. A SLAM scanner (see Figure 1) starts moving from an unknown position in an uncharted environment. During the movement, it performs self-localization based on position calculation and the generated map, while constructing an incremental map on the basis of self-localization, thus achieving autonomous positioning and navigation of the scanner [10].

Figure 1. GOSLAM T300Pro Scanner

The measurement method is simple and efficient. The total station is currently a commonly used technical means for real estate information surveying in China, which is divided into field surveying and mapping as well as indoor data editing and mapping. The total station measurement method is time-consuming and labor-intensive, and there are significant errors in data transmission between fieldwork and indoor work, which is not conducive to constructing accurate 3D models [11]. In contrast, the GoSLAM 3D scanner can easily address the above problems. It features a compact size, easy portability and operation, enabling scanning operations in diverse locations with high stability. By adopting reliable hardware and software technologies, the device ensures stability and reliability during long-term operation. It is not affected by factors such as the surface material and color of objects, and can meet scanning requirements in various complex environments. The user interface is intuitive and easy to learn, which lowers the threshold for operation. With low error and high precision, the GoSLAM scanner can accurately capture the 3D shape and details of objects, ensuring high accuracy of scanning data. It can complete the scanning of large-scale objects or scenes in a short time, thus improving work efficiency. During the scanning process, it can automatically perform data stitching, reducing manual intervention, improving stitching accuracy and efficiency, and displaying scanning results in real time to facilitate users to keep track of the scanning progress in a timely manner. Its large-scale scanning capability allows coverage of extensive areas, making it suitable for scanning needs of objects of various sizes. Moreover, it has high resolution, which can generate clear and detailed scanning data to present the subtle features of objects. With a wide range of applications and multiple scanning modes, it can be applied in various fields such as industrial manufacturing, underground mine measurement, architectural design, and cultural relic protection, boasting broad application prospects [12-13].

2.2 Collection of Measurement Data

The main preparatory work includes the following aspects: data collection, equipment debugging, and field reconnaissance.

(1) Collect the latest available data of Jilin Railway Vocational and Technical College, including the campus topographic maps and structural characteristics, to obtain a comprehensive understanding of the topographical features and location information of the college.

(2) Conduct equipment verification to check whether the components and batteries equipped on the GOSLAM scanner are in proper working condition.

(3) Verify whether the supporting software of GOSLAM has been upgraded to achieve system compatibility.

(4) Prior to the test, check in advance whether the weather on the day is suitable for field operations; carry out field reconnaissance and

divide Jilin Railway Vocational and Technical College into several sub-areas to be surveyed.

Data Acquisition Process: The data acquisition process of the GOSLAM scanner consists of pre-scanning equipment inspection, measurement route planning and execution, as well as measurement data processing and verification.

(1) Pre-scanning Equipment Inspection

Prior to operating the GOSLAM scanner, equipment inspection shall be carried out as follows: ① Check whether the battery power is sufficient to complete the operation. ② Verify that the instrument can be powered on normally and inspect the built-in memory card of the instrument. ③ Check whether the laser head of the instrument can rotate properly. ④ Verify that the handle can be connected to the instrument smoothly. ⑤ Clean the camera lens, check whether it can be mounted on the instrument, and ensure that the camera is turned on only after the instrument is activated. ⑥ Confirm that the instrument can be connected to the supporting software without errors. If all the above steps are verified to be normal, scanning can be initiated.

(2) Measurement Route Planning and Execution

① Planning: Before the start of work, it is necessary to plan the measurement route, schedule the measurement time and divide the survey area into sub-regions. During the measurement, ensure that the point clouds obtained from the second measurement have overlapping parts with those from the first measurement, so as to facilitate subsequent point cloud stitching. ② Execution: After the scanner is activated, perform data acquisition in accordance with the pre-planned measurement route, and use the supporting software to monitor the real-time working status of the scanner. The operator shall pay close attention to the point cloud acquisition progress. If any problem occurs, re-planning and re-measurement are required; if no abnormalities are detected, data acquisition shall be carried out according to the original plan, and the measurement shall be terminated upon completion.

Based on the campus area and building distribution, the survey area was divided into 34 sub-regions in this operation, with 34 data files collected in total.

(3) Data Collation and Verification

The measured data will be automatically saved to the built-in memory card of the instrument. The software GOSLAM Manager is used for data processing, including the following specific steps: ① Color video synthesis; ② Scanning data calculation; ③ Data export.

Rename the exported data files and store them in the designated folder, then import the data into another software, GOSLAM LidarWorks, to inspect the point clouds and corresponding images. If all requirements are met, the data acquisition task of this operation is completed.

3. Indoor Post-Processing of Measurement Data

After the completion of data acquisition using the GOSLAM scanner, indoor post-processing of the data is initiated. Software required for indoor data post-processing includes: GoSLAM LibarWorks (primary point cloud data processing software), GoSLAM Mapping Master, Autodesk ReCap (point cloud data format conversion software), and AutoCAD 2021 (the version of CAD required for importing point cloud data shall be 2021 or above). The main tasks of indoor data post-processing are as follows: collating field-collected data, point cloud clipping, point cloud slicing, point cloud denoising, accessing the 360° panoramic mode, converting point cloud data formats, stitching point clouds, and drawing CAD floor plans. Compared with traditional surveying and mapping post-processing, GOSLAM measurement technology reduces a substantial amount of workload and labor costs, while improving efficiency without compromising data accuracy. After exporting the point cloud data to the mobile graphics workstation, the data shall be inspected. If there are no issues such as data loss, corruption, format errors or incorrect renaming, the processing of the point cloud data can be started.

3.1 Point Cloud Import

Open the GoSLAM LibarWorks software, select Open and locate the saved path of the point cloud data. The files with the suffix _map.laz are monochrome point clouds, while those with the suffix colormap_[number].laz are colored point clouds. Monochrome point clouds generally exist as a single file and do not require merging. Colored point cloud files are usually larger in size and are often divided into multiple blocks; therefore, all files with the suffix colormap_[number].laz need to be selected when importing colored point clouds. After importing the colored point clouds, first select all the point cloud files by drawing a bounding box, then click Process → Merge to complete the point cloud merging. (After merging, the file should be saved separately to facilitate subsequent point cloud data conversion.)

3.2 Point Cloud Inspection and Processing Methods

After successful import, inspect the point cloud by focusing on the following four aspects:

(1) Presence of point cloud stratification

Use the built-in clipping box function of GoSLAM LibarWorks software to slice the point cloud. Exclude the stratified parts from the clipping box to eliminate stratification. After removal, click the prompt box in the upper left corner and select the option to export the selected area as a new point cloud. Finally, delete the originally imported point cloud data to complete the treatment of stratification.

(2) Normalcy of point cloud reflectivity

Point cloud reflectivity refers to the intensity of laser reflection from objects, which is mainly determined based on the RGB values of the point cloud data (see Figure 3). The higher the B-value, the higher the reflectivity; the lower the B-value, the lower the reflectivity. Drawing elevations based on the point cloud relies on reflectivity information (if the reflectivity information is accurate, elevations can also be drawn using this data).

(3) Point cloud accuracy requirements

Generally speaking, point cloud accuracy is divided into absolute accuracy and relative accuracy. Absolute accuracy refers to the precision of the absolute coordinate positions of the point cloud, while relative accuracy refers to the precision of dimensions. The default accuracy of the point cloud is 0.05 m. If stricter accuracy requirements are needed, adjustments can be made during the calculation process by editing parameters such as calculation mode, downsampling, scanning mode, high precision, and point cloud output density, then selecting the appropriate accuracy for calculation.

(4) Removal of point cloud noise points

GoSLAM LibarWorks software has a certain capability for noise point removal. The specific steps are: *Process → Denoising → Noise Filtering* for automatic denoising. However, for excessively dense noise (such as points from people, vehicles, and those affecting elevation drawing), manual removal is required. Manual removal can be achieved using the clipping and slicing functions of the software to eliminate unwanted dense noise points(see Figure 2).

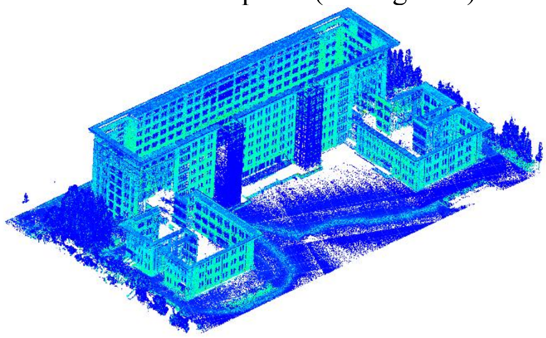

Figure 2. Point Cloud Map of a Single Building

3.3 Data 360° Panoramic Display of Point Clouds

Click the 360° Panorama option and select Import Panorama Points. The point files are located in the camera folder under the photo subfolder of the point cloud directory, and the photo path is the photo subfolder under the point cloud directory. After the import is completed, select the point cloud file and the panorama points folder, then click Enter Panorama Points at the top of the interface. Click a panorama point on the map and select Display Panorama in the upper right corner to enter the panoramic mode. You can then browse the entire campus from an immersive roaming perspective.

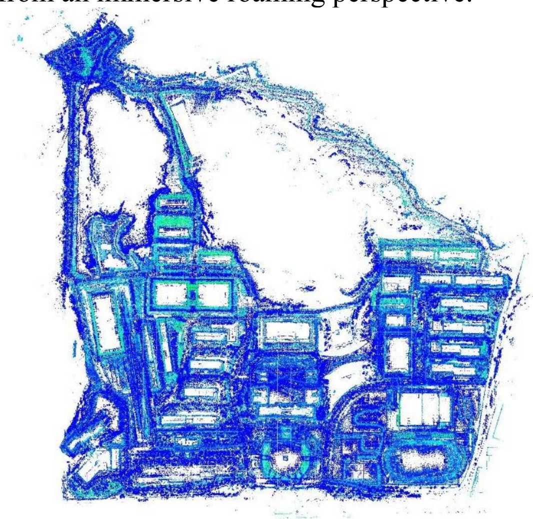

Figure 3. Point Cloud Map of the Entire Campus

3.4 Point Cloud Format Conversion and Connection with CAD Software

Export the LAS data. Neither the folder storing

LAS files nor the LAS filenames shall contain Chinese characters or symbols. Since AutoCAD is used for elevation drawing, Recap software is required to convert the point clouds into RCP or RCS format. RCP is an index file, which can be understood as a project for managing RCS files; RCS is the actual point cloud format compatible with CAD. The specific operations are as follows: Click Save As in the upper left corner and select the LAS file format. After saving, the file type will be AutoCAD layer state. Store the file in a dedicated folder for convenient management. Format conversion of the point cloud data can be performed after all files are exported. Open Autodesk ReCap software. Select New Project in the upper left corner, then import the point clouds. Enter the project name, modify the file save location, select the files to be imported, and locate the saved LAS files. Open and import the files. After loading is completed, click Index Unscanned Items and then Launch Project. No point cloud processing is required in this software; the file can be saved directly. Open AutoCAD 2021 software and create a new file. Select Insert → Attach, locate the file saved via ReCap software, click Open → OK. The point cloud file can then be imported into CAD for further processing.

4. Conclusion

In this paper, a 3D scanner based on SLAM measurement technology was adopted to acquire the image data of Jilin Railway Vocational and Technical College. The GoSLAM LidarWorks software was used for real-scene 3D modeling of the campus, with a model accuracy of 1–2 cm, to realize real-scene display of the campus topography, existing buildings, and land use conditions. The following conclusions were drawn from the research process of field surveying and instrument application.

(1) The GoSLAM 3D scanner can achieve self-localization and 3D mapping in complex environments without relying on external positioning aids such as GPS. Its work efficiency is far higher than that of traditional surveying and mapping as well as UAV-based surveying. The instrument is easy to operate, and its operational risk is much lower than that of UAVs.

(2) The real-scene display and roaming viewing angle of the surveying results generated by the scanner achieve visual effects that cannot be attained by traditional surveying and UAV aerial surveying.

(3) The workflow and precautions for the scanner were summarized through field surveying and indoor software post-processing, which can provide a reference for the application of the scanner in other projects.

Acknowledgments

This work was financially supported by Research on Key Technologies for Construction and Disease Prevention of Road Engineering in Plateau Cold RegionsProject No.: RI 2023-Major-01 fund.

References

[1] Yang M, Shi X W, Ge H R. Application research on UAV air-ground integrated 3D laser scanning technology[J]. Bulletin of Surveying and Mapping, 2020(3): 134-139.

[2] Wu X W, Shi H Y. Integrated surveying and mapping of surface and underground space based on 3D SLAM mobile laser scanning technology[J]. Surveying and Mapping of Geology and Mineral Resources, 2021, 37(3): 6-11.

[3] Qian Z Y, Sun Z L. Application of 3D laser scanning technology in urban underground space modeling[J]. Beijing Surveying and Mapping, 2019, 33(11): 134-1343.

[4] Guo R B. Research on 3D visual simultaneous localization and mapping technology for complex indoor scenes[D]. National University of Defense Technology, 2019.

[5] Liu Y Z, Wen W, Qian X Z. Analysis of fine topographic surveying and mapping based on terrestrial 3D laser scanning[J]. Journal of Engineering and Technical Research, 2018(6): 135-136.

[6] Huang H, Wang L, Jiang B, Luo D A. Accuracy verification of 3D SLAM laser image backpack surveying and mapping robot[J]. Bulletin of Surveying and Mapping, 2021(12): 68-73.

[7] Zeng Y. Research and application of GeoSLAM 3D laser scanner in underground mine surveying and mapping[J]. Management and Others, 2021: 115-119.

[8] Mu C, Peng Y P, Xie F. Application of Riegl VZ-1000 3D laser scanner in major geological hazard surveying and mapping[J]. Beijing Surveying and Mapping, 2021, 33(5): 575-578.

[9] Wang N. Application of terrestrial 3D laser

scanner in current situation surveying and mapping of ancient buildings[J]. Engineering Design, 2022: 79-80.
[10] Hu Y L. Application of terrestrial 3D laser scanner in 1:500 topographic map and cross-section surveying of Zhangjihuai Railway[J]. Railway Investigation and Surveying, 2018(1): 44-48.
[11] Zeng J F. Research on indoor environment surveying and mapping based on SLAM 3D reconstruction[D]. Zhejiang University of Technology, Zhejiang Province, 2020.
[12] Duan Y H. Application of Leica P50 3D laser scanner in building topographic map surveying and mapping[J]. Bulletin of Surveying and Mapping, 2020(6): 158-162.
[13] Kuang G Q, Zhang W J, Peng L C, et al. Application of handheld 3D laser scanner in underground space measurement[J]. Urban Geotechnical Investigation & Surveying, 2024(4): 146-149.