Research on real-time scanning reconstruction control technology of 3D scene

Wenbo Du¹, Xingxing Li¹, Li Jiang¹*, Fei Lv² and Chang’an Hu¹

¹ National Institute of Measurement and Testing Technology, Chenghua District, Chengdu, Sichuan, 610021, China
² Chengdu Normal University, Wenjiang District, Chengdu, Sichuan, 611130, China
*Corresponding author’s e-mail: jixie@nimtt.com

Abstract: With the rapid development of society, the acquisition of basic data of many large engineering projects such as factories, power plants and large cultural relics protection has become an essential and valuable resource for reconstruction and expansion. However, the traditional method has many constraints such as large amount of data, difficulty in collection, low security and impact on production. This paper USES the ground type 3D laser scanning equipment combined with a handheld laser scanning equipment, USES the multi-channel data fusion technology, from the control survey, point cloud data acquisition, data preprocessing, and other aspects, in complex factory data model as the research object, a detailed study of 3D scene real-time scanning reconstruction technology.

1. Introduction

With the rapid development of society, the acquisition of basic data of many large engineering projects such as factories, power plants and large cultural relics protection has become an essential and valuable resource for reconstruction and expansion. However, the traditional method has many constraints such as large amount of data, difficulty in collection, low security and influence on production. In this paper, ground-based 3D scanning equipment and hand-held scanning equipment are combined, multi-channel data fusion technology is adopted, starting from control measurement, point cloud data acquisition, data pretreatment and other aspects, and the factory data model is taken as the research object to study the application of 3D scanning technology in detail.

As a 3D data acquisition tool, scanner has a wide range of applications [1-6]. Zhou Guokui et al. [7] established a 3D data information system for Jingjiang King's Mausoleum site by combining laser scanning with UAV. Foreign research on 3D reconstruction started early and the technology is relatively mature. In 2011, Professor Richard A. Newcombe of Microsoft Research Asia and others implemented A 3D reconstruction system for rapid indoor scene reconstruction based on the volume-space fusion registration algorithm and GPU technology. Domestic research in this area started late, so the technology is relatively backward for foreign countries, but it has also made some achievements in some areas. To a small range of indoor 3D scene reconstruction techniques to mature, the current domestic common 3D printing is a typical application example, for a wide range of outdoor 3D scene reconstruction also obtained the certain research success, is mainly used in cultural relics protection three-dimensional reconstruction of medieval buildings, open-air mining 3D scene reconstruction.
2. **3D reconstruction technique**

Early 3D scene reconstruction technology is based on 2D image information to construct 3D scene model. The 3D scene reconstruction technology based on 3D laser scanner can solve the shortcomings of the early 3D scene reconstruction technology of lack of stereoscopic and realistic sense, which makes the 3D scene reconstruction technology based on 3D laser scanning technology increasingly become a research hotspot. 3D laser can directly obtain the depth information of the scene to be measured, so the 3D scene reconstruction technology based on 3D laser scanning technology can accurately recover the 3d information of the scene and get the 3D real scene model.

The 3D scene reconstruction technology based on laser scanner mainly obtains the 3D point cloud data of the scene (i.e. the coordinate information of scene sampling points in the laser scanning Angle coordinate system) through 3D laser scanner. The 3D point cloud data is filtered and preprocessed, the surface features of point cloud such as normal vector extraction, the registration of point cloud data from different perspectives and the mesh surface reconstruction of registration results are realized. Different from the 3D scene reconstruction technology based on 2D image registration, the 3D scene reconstruction technology based on laser scanning can recover the geometric information of the real scene more accurately, which makes the 3D model more realistic and is more conducive to reproducing the objective real world in the computer.

3. **Data processing process**

3.1 **Data Acquisition**

The software platform is used to control the 3D laser scanner to scan the specific entity and reflection reference points and obtain as much information as possible about the entity. The 3D laser scanner finally obtains the geometric position information of the space entity, the emission density value of the point cloud, and the image information obtained by the built-in or external camera. These raw data are stored together in specific engineering files. Among them, the selected reflection reference points have high reflection characteristics, and its layout can choose different numbers and models according to different application purposes and needs. Usually, there should be four to five reflection reference points in two overlapping scans.

3.2 **Data Processing**

3.2.1 **Data Processing.** After data acquisition, the first step is to preprocess the obtained point cloud data and image data and apply filtering algorithm to eliminate the error points and points containing gross errors in the original point cloud. Recognition and classification of point cloud data, geometric correction of scanned images.

3.2.2 **Data Stitching and matching.** A complete entity with a scan picture is often cannot fully reflect the information on the entity, this needs us in a different position for multiple image scanning, since this will bow | multiple image stitching matching problem between the scan results. In the scanning process, the direction and position of the scanner are random and unknown. To realize the splicing of two or more scans, the conventional method is to select a common reference point to achieve this process. This process is also known as indirect geographic referencing. A specific reflection reference target is selected as a ground control point, and its high contrast characteristics are used to realize the positioning of the scanned image and the matching between the scanned image and the image. At the same time of scanning, traditional means such as total station measurement are used to obtain the coordinates and orientation of the control points in each scan, and then coordinate transformation is carried out to obtain the coordinates of the solid point cloud data in the unified - absolute coordinate system. This series of work involves manual participation and automatic processing by computers, which is semi-automated.
3.3 Modeling

3.3.1 Algorithm selection. After data processing is completed, the next work is to model the entity, and the primary work of modeling is the selection of mathematical algorithm. This is a process of geometric graph inversion. The accuracy of the final model and the correctness of the data expression are determined by the proper selection of the algorithm.

3.3.2 Model building and texture Mosaic. With proper algorithm, the entity can be modeled automatically directly by computer. The point cloud data guarantees the data of the surface model (DSM), while the image data guarantees the complete and accurate information of the Edges (Comer) and corners (Comer). Through the automatic software platform, the texture details of the model are described by the point cloud intensity information and the image information obtained by the camera.

3.3.3 Data output and evaluation. Based on different application purposes, the data can be output into different forms and directly provide data sources for spatial databases or engineering applications. However, the accuracy and quality of the data, whether it can meet the requirements of various applications, it is still an important step to comprehensively evaluate and analyze the results. The evaluation model and evaluation criteria should be determined according to different application purposes.

4. Case Analysis
Digital factory is a combination of modern digital manufacturing technology and computer simulation technology, and has its distinctive characteristics. Its appearance injects new vitality to the basic manufacturing industry, mainly as a bridge between product design and product manufacturing. Examples are shown in Figures 1 through 4.

![Figure 1. Site diagram of pipeline scanning in the factory.](image1)
![Figure 2. Factory corridor scan site map.](image2)
The development of 3D laser scanning technology can effectively improve the difficulties of data acquisition and large capacity of data processing in current factory reconstruction projects. Its emergence provides strong technical support for the quality control of enterprise transformation and expansion. It effectively solves the current measurement problem. It is expected that there will be a large number of factories in need of digital model every year, and of course, it will bring rich economic benefits. The completion of this project can effectively promote the technological progress in plant transformation and expansion, reduce the cost for enterprise factory transformation and expansion, and improve the technological progress for ourselves. This technology can be used not only in factories, but also in construction, archaeology, tunnels, police, water conservancy, aerospace, environmental protection, 3D printing and many other aspects.

5. Conclusions
The measurement of factory facilities is always a difficult problem in the field of measurement. And some factories are accompanied by toxic gases and explosive substances, these environmental factors restrict the measurement work. The emergence of a 3D scene scanning reconstruction technology suitable for factory reconstruction projects, its scanning process is simple, fast, non-contact, effectively solve the problem of factory facilities measurement, and is suitable for most of the factory reconstruction, expansion and other projects, the application prospect is broad. In this paper, the 3D laser scanning technology is applied to power plant expansion project, you can quickly get power plant two-dimensional topographic map, the status quo of the 3 d model, the profile of electrical equipment, etc., not only for the current situation of substation design personnel design provides a more accurate model of 2 d and 3 d data, but also for future deformation detection provides rich data support, has a certain practical significance. The 3D real-time reconstruction of the factory provides important basic data for the reconstruction and expansion of the factory, which can provide accurate size information. After the configuration of appropriate software, the time of data processing will be greatly reduced, and it will be paid more and more attention. In addition, 3D laser scanning technology will also be faster, more accurate and more portable. Coupled with the characteristics of scanning objects without limitation, 3D scanning technology will be applied to a wider range of fields.

References
[1]. Hu C A, Peng D K, Lv F, Sun H F, Zhao T, Li W Z. (2021) Application of Terrestrial Laser Scanner in engineering survey. IOP Conference Series: Earth and Environmental Science, Zhangjiajie, Vol.783 (1):012084, pp. 1-6.
[2]. Hu C A, Hu S , Sun H F, Zhao T. (2021) The application of geometric measurement equipment in industrial engineering measurement. Proceedings of SPIE - The International Society for Optical Engineering, Qingdao, Vol.11887:118871G, pp. 1-6.

[3]. Hu C A, Xing R , Hu S , Li J G. (2021) Application of portable measuring equipment in the field of industrial measurement. Journal of Physics: Conference Series, Dalian, Vol.1965: 012153, pp. 1-6.

[4]. Hu C A, Hu S , Kong L H, Liu J B. (2021) Application of ground laser scanner in surveying and mapping field. Journal of Physics: Conference Series, Chengdu, Vol. 2029: 012080, pp. 1-8.

[5]. Hu C A, Kong L H , Lv F . (2021) Application of 3D laser scanning technology in engineering field. E3S Web of Conferences, Guangzhou, Vol.233:04014, pp. 1-4.

[6]. Zhao T , Hu C A, Luo S T, Li W Z, Kong L H, Zhang R, Li J G. (2020) Big data analysis and server applications for Unmanned Aerial Vehicle/Drones . Proceedings - 2020 International Conference on Big Data and Artificial Intelligence and Software Engineering, Chengdu, pp.128-131.

[7]. Zhou G K, Zhang F, Zhang S M, Zeng X Z. (2015) Research on Design and Key Technology of 3D Digital System of Jiangjiang Vassal Mausoleums. Bulletin of Surveying and Mapping, 8:105-109.