Application of Point Cloud Data in the Construction and Management of Interior Design

Minyong Li 1 and Jianwen Liu 2

1 College of art and architecture, Xiamen Xingcai Vocational &Technical College, Xiamen, China
2 College of Landscape Architecture, Fujian Agriculture and Forestry University, Fuzhou, China
E-mail: 329094365@qq.com

Abstract. There are many defects in the construction and management of the previous interior design, which leads to the problems of inaccuracy, waste of materials, high labor cost and low efficiency in the actual construction and management. The application of three-dimensional scanning technology with high precision and high rate of point cloud data in construction and management of interior design is put forward. Through the three-dimensional laser scanning of the building body, the vector set of the building body in the set of three-dimensional coordinate system is obtained, and the data collected by the methods of multi frame data fusion and noise reduction are used to collect the data from the point cloud. Through processing, accurate indoor information data can be obtained and analyzed, and the foreseeable problems can be solved ahead of schedule. The extraction of indoor scene information by point cloud data improves the efficiency, accuracy and labor cost of the previous data collection, and improves the efficiency of construction and the ability to solve the problem.

1. Introduction
In recent years, the economic development of our country is in good condition, society enters a new economic era which is high integration of the knowledge economy and the information economy, and the interior design industry is further developed under the impetus of this new economic era. But this also puts forward higher requirements for the construction and management of the interior design engineering, and it has been applied in the past. The defects of construction and management in the past hindered the development of interior design. Point cloud data is a wide application of non-contact 3D scanning technology, which breaks through the traditional method of measurement, uses 3D laser scanner to obtain the point cloud data of target objects and processing into three-dimensional information. This makes this technology emerge in many fields, such as target recognition, ground mapping, building modeling and so on. In some complex and irregular building bodies and conditions which the traditional measurement methods can't measure accurately, three-dimensional laser scanning technology can still carry out rapid and accurate measurement and construct three-dimensional model, providing new technical support for the complex interior environment design. The technology optimizes the defects of traditional measurement methods, and it can obtain the required indoor scene information quickly and accurately. The point cloud data after splicing and noise reduction are very practical, speeding up the development of indoor information. After processing, the point cloud data can get the accurate three-dimensional data of the indoor scene, and the point cloud data model can be imported into the HD Modeling for CAD2013 software to drawing each two-dimensional plane, and extract the accurate and effective size and pipeline information. Therefore, according to the
characteristics of the 3D laser scanning technology, it can also make the interior design optimize and deal with the predictable problem in the process of construction and management in advance.

In this paper, commercial houses in new intercity plaza of xiamen city are taken as the research object, and a study on indoor scene 3D information based on high accuracy and high speed 3D laser point cloud data is proposed. Through 3D laser scanning, the collected point cloud data were preprocessed by splicing and denoising. Based on the point cloud data of algorithm, the brick and pipeline information can be extracted accurately to draw the interior plan and two-dimensional line drawing, and realize the effective acquisition and analysis of indoor information data. The application results show that the 3D laser scanning technology is efficient in the extraction of indoor 3D data, which greatly reduces the time cost and labor cost of data acquisition and improves the efficiency of generating practice.

2. The current situation of the construction and management in interior design

With the continuous development of interior design, the requirements for construction and management are getting higher and higher. The main work of construction and management of interior design is to design and decorate the indoor environment. In the process of construction, the required tool is various, construction technology is complex, and the construction link is repetitive, in some more complex engineering, there are many uncertain factors, so it will affect the construction and management of the interior design, construction quality will directly affect the quality of the buildings and the effect of the expected design. The importance of construction and management of interior design has been paid attention to, but there are still many problems in the process of construction and management, which need to be improved and solved. The following are the main problems of construction and management in interior design.

2.1. Low accuracy and efficiency

In interior design, it is necessary to measure the interior wall, ground, beam position, water and electricity road, which is called measuring room. There are three ways in the traditional measuring room: 1. Quantitative measurement: mainly measure the length, width and height of each space and calculate the area, and then put forward reasonable suggestions according to the daily needs of the owner. 2. Positioning measurement: in the positioning measurement, the position of the door, window and air conditioning hole is mainly marked, and the window requires scalar quantity. In the measurement of kitchen bathroom, the position of the downpipe, hole distance, toilet pit hole distance, distance from the wall, position of smoke pipe, position of gas pipe, distance under the pipe, and location of floor drain all need to make accurate measurement, so as to accurately locate in the future design. 3. Height measurement: generally, the height of the floor should be relatively fixed. However, because the construction of each building will be different, there may also be a certain drop. During the height measurement of the designer, the height of each area of the room should be carefully checked to ensure the accuracy in the future design drawings. The traditional manual measurement method has too many variables to accurately control the precision of complex building or space measurement, and the measuring efficiency will also follow the changes of the proficiency of the surveyor and the environment.

2.2. Waste materials and not environmental protection

In the construction process, because of the characteristics of the traditional measurement method, the measurement results will inevitably be error, and there may be data omission and loss. The deviation of the data can also be deviated in calculating the area of each space and the amount of material. In this case, the majority of construction personnel will choose to exceed the amount of billing documents for materials, and did not deal with returns, resulting in waste of materials. Inaccurate hydro-electric route positioning will also lead to material waste, not environmental protection. These situations have not been well solved due to technical problems. Most of the construction personnel only listed the materials needed in the construction based on their previous experience. In the current huge market of interior construction in China, the waste caused is conceivable. These problems of
excessive material consumption due to technical defects can be better solved through technical renewal.

2.3. Lack of safety awareness
In the process of construction, the awareness of construction safety should not only be reflected in the design of engineering drawings, but also permeate the whole construction process and the minds of the construction personnel. In the process of construction, it is more important to raise the safety awareness of the construction personnel while improving the construction efficiency. At present, in the design of interior design construction drawings, the interior designers lack of security considerations for the construction aspect. For example: in the early stage of the design drawings, there are some potential safety hazard in indoor fire protection, earthquake zone and secure channel design. In use process, if there was an accident, will threaten the life in the space. The safety awareness of the construction personnel is not high, for example: the construction process is not in accordance with the construction standards; The decorative materials are not orderly and piled up at will. Some construction techniques will produce open fire, which is easy to cause accidents, the safety of construction workers will be threatened. Due to inaccurate positioning, it is easy to lead to damage of hydropower pipes, water leakage and electricity leakage, and there are safety risks.

2.4. Lack of Standard Indoor Construction Work System
Without a standard indoor construction work system, it is difficult to guarantee the safety of construction. Most of the interior decoration construction teams in China lack a sound management system in the process of interior design construction and management. In the construction process, there is no unified management concept and practical experience, which leads to insufficient construction progress and quality assurance. In the review stage of the construction project, if there is no sound management system, the construction supervision work cannot be effectively connected. Without effective management system, the construction cost will increase. Therefore, it can be seen that a perfect standard construction system is great importance to construction and management. In traditional construction, most of the methods used by managers are based on feelings, experience and not strictly in accordance with the construction standards and norms, which leads to many avoidable problems in construction.
Most of the above construction status can be optimized by using point cloud data, such as: the traditional manual measurement method is not accurate and the budget is not accurate, which leads to the waste of materials, safety hazards and unnecessary economic losses caused by improper operation damage the pipeline equipment. This also reflects the advantages of the application of point cloud data in interior design construction and management from the side.

3. Comparison between traditional technology and new technology

3.1. Traditional construction methods
Although the traditional construction method has advantages in operation difficulty, price and other aspects, there are many defects and problems in the traditional construction method. First, it is difficult for traditional construction methods to accurately measure complex buildings or irregular Spaces when measuring buildings. Second, it will take a lot of time for the construction personnel. This is especially true for complex buildings and Spaces, where labor costs are high and efficiency is low. Most surveying and mapping tasks will have a certain time limit, and this measurement method will cost a lot of manpower and material resources. Third, the cost budget is not accurate. Fourth, there are safety hazards in the construction process. The failure to accurately measure the exact dimensions of complex buildings or irregular Spaces will lead to the deviation of material consumption in the later period. In the long run, many unnecessary wastes will be caused, which will increase many costs and reduce profit space. In indoor construction cost, labor costs account for a large proportion. Because inaccurate measurement in complex building or alien space cause the increased construction time, it will increase labor costs, it is unfavorable to control construction cost. When the construction is completed, the expenditure and the budget differ greatly, increasing the burden of the owner, bringing adverse impact on their own professionalism. At the same time, the safety hazards caused by
inaccurate measurement are fatal to the whole construction process, which will not only cause many unnecessary rework, but also threaten the physical and mental health of the owner. It can be seen that the improper traditional measurement method not only brings about the increase of construction cost, but also includes many problems that are closely related to safety. Therefore, the upgrading and updating of traditional technology can bring essential changes to the construction.

3.2. 3D Laser scanning technology

3D laser scanning technology is a non-contact measurement method with a wide range of applications, which can obtain the 3D information of objects without contact. This technology breaks through the traditional measurement method and has a far-reaching development prospect in many fields [1]. 3D laser scanning technology can realize rapid and accurate 3D model construction for various large irregular and complex buildings and environments with insufficient light, providing important technical support for complex interior environment design [2]. This technology enables the acquisition of indoor space information to get rid of the traditional bottleneck and accelerate the development of indoor informatization. The processed point cloud data has a strong practicability and a breakthrough in the acquisition of architectural information [3]. Based on this expression in the form of point cloud image, access to the indoor complete 3D data, reduce the amount of data registration, point cloud data model into HD Modeling for CAD 2013 software can draw two-dimensional Digital Line Graphic of each surface, and extract the effective information, pipe sizes, complete measurement and design of indoor scene information accurately [4]. The efficiency of 3D laser scanning technology is several times compare to traditional measurement, and the intuitiveness of point cloud data can greatly reduce the error rate of the internal and external industries, so as to avoid the external industry again, reduce labor cost, and the source data volume is more complete and rich.

From the above, it can be seen that the 3D laser scanning technology has a good performance in accuracy of measurement, safety degree before and after construction, material budget and other aspects. It has got rid of the bottleneck of traditional technology and made a breakthrough in the acquisition of information in various aspects of indoor environment.

4. Application of point cloud data in the construction and management of interior design

4.1. Drawing of the building survey plan

FARO Focus3D X130 3D laser scanning system was adopted to obtain high resolution 3D coordinate spatial point position information of the surface of the object under test in a large area through the measurement method of high precision, high speed and high density laser point cloud scanning [5]. Through the laser 3D scanner, the object is scanned in many dimensions, so as to obtain the point cloud data collection of the object. Using FAROscene software, the original point cloud data collected can be processed by splicing registration and de-noising. Only by splicing the points and data after pre-noise reduction can the complete indoor 3D model be obtained and the two-dimensional Digital Line Graphic information of the target object be obtained. Denoising process, the removal of the original point cloud data of useless information, will be left point cloud information of hole on the target object and it will affect the creation of a late model. Aiming at this problem, you can use the HD Modeling for CAD 2013 software layering slicing technology to carry on curve fitting for hollow point cloud information, thus completing the empty part of the point cloud data. Extract the required 3D data from the model, and draw the geometric contour lines of the interior facade and plane, such as walls, doors, Windows and balconies. The floor plan clearly shows the layout of the house and counts the total area of the house and calculates the area of each room [6]. According to the point cloud data, the two-dimensional Digital Line Graphic can be completed, and the dimensions can be measured in FAROscene software, and the accurate original plan can be obtained. The original plan is the first step of interior design, and whether it is accurate or not is vital importance, which affects the authenticity and validity of the whole interior design, and has a significant impact on the later construction. The following figure is the original plan obtained by the measurement of a commercial house in Xiamen city, the area size of each space can be accurately obtained. Using software layering, slicing point cloud data model, with HD Modeling for CAD 2013 area statistics to calculate house construction area is 90.4919 m$^2$. As shown in figure 1, the specific area of each room is the living room 36.4781 m$^2$, hall
3.7452 m², balcony 4.5021 m², master bedroom 13.0127 m², master bathroom 2.6321 m², guest bathroom 2.5378 m², daughter room 9.5802 m², study 8.1737 m². Compared with the data obtained by the traditional measurement method, the accuracy can be better guaranteed, and the accurate size of each indoor space can provide effective control of material budget, material use, carbon emission and construction period in each process of indoor construction. According to the building survey plan obtained by stratifying and slicing the point cloud data model, we can clearly and intuitively understand the indoor layout. If the layout of building survey plan is not reasonable, we can rearrange it directly according to point cloud data model. Drawing accurate building survey plan is the basis of design and construction.

**Figure 1. Building survey plan**

4.2. Positioning of pipeline equipment

The point cloud data is imported into FAROscene software for scanning to locate the precise location of pipeline equipment. Because after the completion of hydropower positioning and wiring, the pipeline equipment is usually buried in the wall, and when other ancillary facilities are installed, the pipeline equipment may be damaged due to inaccurate positioning. Using the scanned point cloud data to accurately locate the pipeline equipment can effectively avoid the problem of damaging the pipeline equipment. Using software to stratify and slice the point cloud data, the area information, the location of the pipeline equipment, the location and size of the door, window and all kinds of communication facilities can be extracted, it can effectively avoid the damage to pipeline equipment and communications facilities caused by the wrong operation in the construction process, ensure the construction safety and avoid unnecessary loss. As shown in figure 2 that the extraction of window and pipeline information can accurately show the distance between the top and the bottom of the pipe to the wall and the height above the ground, which brings convenience to the installation of socket and electrical equipment. At the same time, the non-contact 3D scanning technology of point cloud data is used to facilitate us to extract and analyze information from all aspects of the interior accurately and efficiently, providing new technical support for the construction, management and maintenance of interior design.

**Figure 2. Extraction of information from pipeline equipment**
4.3. Measurement of space dimensions
In interior design, the design is mainly aimed at a closed space formed by three surround surfaces, whose shape and size are determined by the ground, top surface and wall [7]. Interior design mainly covers wall design, ground design and ceiling decoration, and the basis of these designs is the measurement of space size. It is difficult to meet the requirement of complex building house measurement by manual measurement. With the high precision 3d scanning technology, the collection point cloud data of the device can be collected without arriving at the site, and then a two-dimensional Digital Line Graphic can be drawn according to the collection of point cloud data, which can be imported into FAROscene software for measurement after completion. Figure 3 shows some of the living room dimensions accurately measured by a three-dimensional laser. They are 1.953 m in height, 0.856 m in width, 2.837 m in height and 0.654 m in distance from the door to the post. Through the processing of point cloud data collection, the detailed space dimension information, doors and Windows, ground, wall and roof specific shape and size can be extracted. Every progress of interior design is measured by point cloud data technology, which can greatly reduce labor and time cost and improve work efficiency. For construction and management, these can not only reduce the budget and improve the profit space, but also substantially improve the quality of construction, so that construction can be carried out more effectively. This is incomparable to the traditional measurement.

![Figure 3. Precise measurement of part size in the living room](image1)

![Figure 4. Positioning of bricks](image2)

4.4. Positioning of bricks and cracks
After painting the indoor walls, it is easy to encounter obstacles of bricks when installing equipment such as electrical appliances. FAROscene software can be used to process the point cloud data obtained by scanning, extract the location information of bricks and cracks, and quickly find concrete cracks to facilitate the installation of the equipment. The extracted 2D line drawing can provide reliable information source for later information management. Setting the origin coordinates (0, 0), it
can be accurately extracted from point cloud data: brick boundary point A (0.509, 0.181); brick boundary point B (0.747, 0.234). As shown in figure 4 is the precise positioning of the brick and seam of the original point cloud. After importing the scanned point cloud data into the HD Modeling for CAD2013 drawing software, the point cloud data of the wall surface are extracted for fine drawing of two-dimensional line drawing. After the house walls are painted, they can be precisely lofted by locating the cracks and bricks that have already been positioned in the software. If the position of the brick and brick joints cannot be accurately located, the electrical equipment installed on the wall is likely to be a safety hazard, and it may take many attempts to install the equipment in place. To the walls which have been painted, it will bring adverse effect to the integrity and beauty, and increase cost, reduce efficiency either. This technology can avoid such problems.

4.5. Construction cost budget
The interior design is mainly designed for the interior floor, wall and roof, and the construction is also decorated for the three surrounding surfaces. Before the construction, 3D laser is used to scan the interior space, and registering and removing noise points from the point cloud data set are achieved. If the point cloud data volume is still large after the unified registration and denoising of the software, the data need to be filtered and simplified [8]. After the software is used for stratified sections and the accurate area of each room is calculated, the required materials can be calculated accurately according to the requirements of decoration. For example, Bricks, white latex, cement, etc. Traditional manual measurement methods not only have low efficiency, low time cost and high labor cost, there are also problems of data loss, omission and inaccuracy, which will increase the difficulty of on-site construction and require on-site coordination between designers and construction managers, so as to affect the effect of decoration construction period and design [9]. Compared to traditional manual measuring way, the point cloud data is a kind of non-contact 3D scanning technology. Scanning with a 3D laser, the point cloud data collected only need a single scan, which can accurately calculated the information needed for space by the relevant software, and not need to be back for measuring again, it can reduce time costs, labor costs, labor costs, reduce the waste of materials, increase the speed of construction decoration.

The standard sizes of brick used in house decoration are 300*300 mm, 500*500 mm, 600*600 mm and 800*800, which are mainly used to decorate the floor and wall of living room, kitchen, toilet and other rooms. Through three-dimensional laser measurement and using layered slicing technology calculate each elevation area of the house and according to the size of decoration needs, as well as the calculation of the house plan, elevation, design decoration drawings, accurate calculation of the size and quantity of bricks to be purchased. Part of the building decoration materials statistics as shown in Figure 5.

![Figure 5. Material data statistics](image)

5. Conclusions
In view of the existing problems in the construction, management of interior design in China, the application of point cloud data in the construction, management of interior design is discussed and its feasibility is proved [10]. The breakthrough of point cloud data in the construction, management of interior design lies in the fact that the point cloud data collected is comprehensive three-dimensional spatial data. In addition to its advantages of high precision and high efficiency, it can help us to better
complete interior design and optimize some problems in the previous construction process. The application of new technology enables us to better control the construction progress and cost, improve the safety factor of construction, and reduce the difficulty of early measurement and late maintenance. Further development and application of 3D laser scanning technology, away from the bottleneck of traditional construction, management of interior design, and accelerate the development of indoor informatization [11].

6. Acknowledgment
Fund program: this paper is the research result of "the application of tilt photography technology in the protection and management of ancient buildings" for the science and technology project of the Fujian provincial education department. The project number: JAT171185.

7. References
[1] Liu Jia. 3D modeling of indoor scene laser point cloud data [A]. Mapping press. Bulletin of surveying and mapping. BBS abstract set of frontier technology of surveying and mapping science [C]. Mapping publishing house: 2008:7.
[2] Chen Ping. Research on 3D laser scanning in mobile interior based on SLAM [D]. China University of Geosciences (Beijing), 2016.
[3] He Yuanrong, Zheng Yuanmao, Pan Huoping, Chen Jianzhi. True 3D modeling and application of complex architecture based on point cloud data [J]. Remote Sensing Technology and Application, 2016, 31(06):1091-1099.
[4] Zhang Weiqiang. 3D laser scanning technology on the ground and its application in the mapping of ancient buildings [D]. Chang’an University, 2014.
[5] Chen Yunbo, Feng Yafei, Ji Xiaobo. Research and practice of using 3ds Max and 3D laser scanning technology to generate 3D building models [J]. Survey Report, 2016(12):77-80.
[6] Chen Huwei. Three-dimensional model construction and application research of open-pit coal mining [D]. Liaoning University of Engineering and Technology, 2012.
[7] Zheng Peijun. Interior decoration design and construction management [D]. Shanghai Construction Engineering Design Research Institute co. LTD, 2018.
[8] Huang Chengliang. Research on the application of indoor mobile measurement technology in completion measurement [J]. Urban Survey, 2017(05):133-135.
[9] Li Lin. 3D reconstruction system of indoor environment based on laser scanning [D]. Harbin Institute of Technology, 2016.
[10] Chen Huwei. Three-dimensional model construction and application research of open-pit coal mining [D]. Liaoning University of Engineering and Technology, 2012.
[11] Yang Lin. Application research of 3D laser scanning technology in deformation monitoring of construction engineering [D]. Tianjin University, 2016.