Establishment and Application of Hospital BIM Based on Point Cloud and Image Fusion for Infectious Disease (Novel Coronavirus Pneumonia)

Guizhen He[1,2,*], Jun Yang[3], Qixiang Nie[2]

[1]State Key Laboratory of Surveying, Mapping and Remote Sensing Information Engineering, Wuhan University, Wuhan, 430079, China

[2]School of Civil Engineering and Architecture, East China Jiaotong University, Nanchang, 330013, China

[3]Dong Fureng Economic & Social Development School, Wuhan University, Wuhan, 430079, China

**Corresponding Author.*

Abstract

Since neither a single high-precision 3D coordinate laser point cloud nor a oblique image of high-precision spectral information can make the computer understand the data as human, in order to accurately and completely understand the object in the real world, in this paper, the fusion of the point cloud and the oblique image is studied for the understanding and application of the real object buildings by establishing a BIM model. Firstly, point cloud data and image data are acquired by different data acquisition methods. Laser point cloud and oblique image are fused by installation parameters so that geometric elements are consistent and benchmark is unified. Processing level is not limited to element level only, so as to ensure the integrity of information, and the fused mutual information remains consistent in scale, texture and direction. Secondly, under the condition of space-time synchronization, the relationship between point cloud and image in geometric space is established, and the alternating "energy transfer" is used for shape prediction and visual filling by matching under texture mapping constraints to enhance the semantic information of the 3D scene. Finally, a 3D building information model is established. Using the experimental results to track the whole life cycle (design, construction, operation) in real time saves the cost of building rework, reduces the building cycle, and improves the building accuracy. Especially based on BIM during Novel Coronavirus Pneumonia: analyze hospital space resource management and elastic function; construct medical unit model of infectious disease hospital; simulate and optimize medical process in infectious disease hospital; rapidly construct prefabricated infectious disease emergency hospital; simulate hospital infection path and dynamics; the auxiliary design and construction of infectious disease treatment in existing hospitals; The monitoring analysis and automatic control of hospital infection safety operation.

Keywords*: Point cloud data, UAV image, data fusion, hospital BIM for infectious disease (Novel Coronavirus Pneumonia), texture mapping*

I. Introduction

Although the acquired 3D information data can restore the original appearance of the building well in the form of digital information by building 3D models, 3D modeling of single data sources can only meet the need of modeling accuracy in a small range due to strong limitations, and it is difficult to precisely express the model of the scene in the case of complex local structure with diversity of local types. In addition, for some building models which need to retain a large amount of architectural texture details, higher precision measurement and more coordinate points are required because it is difficult to meet the measurement requirements with a single data acquisition method. As a result, multi-source data fusion is required, by which point cloud is detected by 3D laser scanning, building texture is measured by oblique photogrammetry, then point cloud data and image are fused together by multi-source data fusion, and finally a 3D model is established by the fused data. The established 3D data model can not only achieve the measurement accuracy, but also retain the

texture details of the building to the greatest extent.

Andrey V. Leonov et al. scanned the Moscow hyperbolic tower with a 3D laser scanner for 3D reconstruction [1]; Cezary Specht et al. constructed an accurate model of a typical building using data obtained by 3D laser scanning as a hypothetical reference for navigation of complex buildings [2]; Five sensors are used by Infoterra France and Pictometry USA to allow users to clearly see facade images of different angles of a building, giving the user a view of a real building [3]. Prandi et al. fused image and point cloud data to automatically generate texture in buildings.

Compared with relevant research abroad, domestic 3D model construction mainly focuses on large scenes, such as 3D scene representation of city and urban planning and design, and has been extensively studied by Tongji University, PLA Information Engineering University, Wuhan University, Nanjing Normal University, Remote Sensing Institute of Chinese Academy of Sciences, Chinese Academy of Surveying and Mapping and other domestic institutions. Lanzhou Jiaotong University uses 3D laser scanning technology on the ground to survey and map ancient buildings, and uses laser scanner to measure the building model of Five Spring Mountain in Lanzhou City with its advantages of fast speed and many coordinate points [4,5]. Yang Bisheng et al. proposed to extract building elevation information from vehicle-mounted laser scanning data [6]. Other universities in China use 3D laser scanning technology in Wuhan Greenland Center to establish steel structure BIM model in reverse direction and to carry out a series of on-site management such as real-time monitoring quality, which meets the requirements of fine management of on-site construction [7].

The outbreak of pneumonia fully exposed the weakness of flexible response ability of hospital space resources in China, resulting in insufficient treatment capacity and diagnosis and treatment capacity in a short time, thus missing the best opportunity for early prevention and control, and triggering the rapid spread of pneumonia. This requires us to establish a hospital space resource management system, analyze the functional elasticity and expansion feasibility of various spaces, and form the rapid adjustment and elastic expansion ability of the hospital functional unit system. However, there are many types of medical space, and the space cannot play an independent role. It needs to be equipped with the corresponding equipment and facilities system, and also has the corresponding physical environment requirements. Therefore, the spatial attribute is complex and the amount of information is large, and the traditional manual method cannot be used. In this process, BIM model has powerful digital and visual expression ability for space, and the rich spatial information data contained in BIM model provides an important support for spatial resource management. By constructing the elastic function index of space and developing the hospital elastic space resource management platform based on BIM, it is of great practical value to quickly find, analyze and formulate the transformation and expansion plan of infectious disease diagnosis and treatment space.

II. Fusion of Point Cloud and Image

Based on the accurate geometric information of point clouds and rich texture information of images, BIM can be established by fusing the two data sources. The flowchart is shown in Fig. 1.

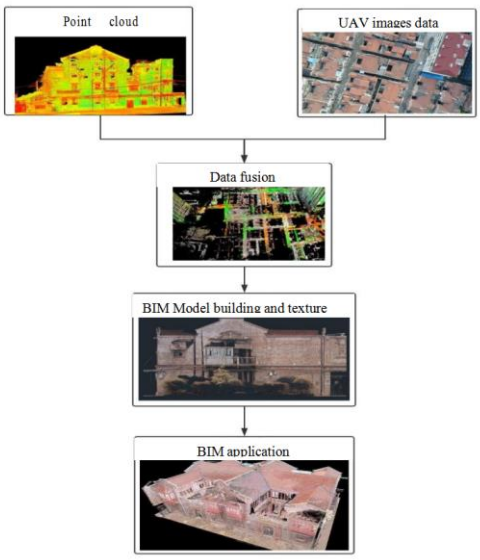

Fig 1: Flowchart for multi-source data-assisted BIM establishment

2.1.Collection of point cloud data

In order to effectively acquire experimental data, relevant data and instruments should be fully prepared. First, the 3D laser scanner is calibrated to verify whether its error meets the allowable error range. Site visits are conducted around the buildings to be measured with related measurement tools. According to the complexity of the surrounding environment, the stations to set up devices are set, whose number can be increased or decreased according to the environment factors. The control network is made around the building, as shown in Fig. 2. Field measurements are made after the control points are set up. Finally, the scanned data is exported for point cloud data processing.

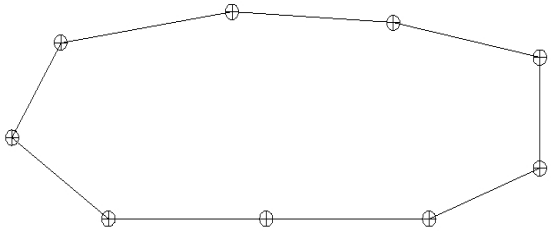

Fig 2: Layout of measuring stations

2.2. Point cloud data preprocessing

After the collected data going through the process of point cloud splicing, point cloud de-noising, point cloud simplification and missing data repair, the effect picture is shown in Fig. 3.

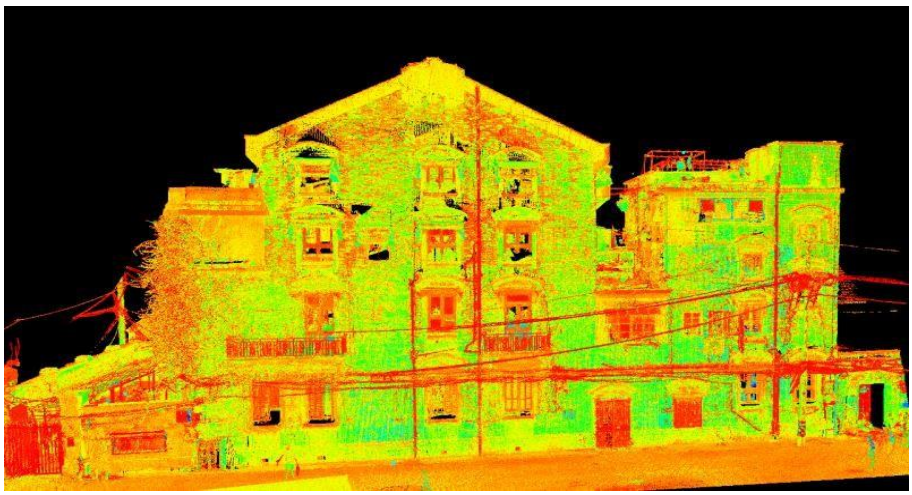

Fig 3: Effect after point cloud data pre-processing

2.3. Collection of UAV images

First, the elevation data, image data, etc. in the aerial photography area should be collected. After the image control points are laid by the eight-point method, the UAV image acquisition can be carried out, and the collected image can be exported by correcting it. The flow chart is shown in Table 1.

Table 1 UAV image acquisition flowchart

Related data collection	Setting of image control points	UAV shooting	Data correction	Data generation

The texture of Zhangyuan Building in Shanghai is very meticulous and the buildings are dense. Therefore, the eight-point method is used to set the control points. In addition, it should be noted when setting the control points that the image control points should be selected at a position which is easy to measure. Because of the long history of Zhang Yuan and the exposed facilities such as poles and wires, it is not appropriate to select the location near high voltage transmission lines, transformers and other places prone to electromagnetic interference. It is possible to set obvious and easily distinguishable marks on the ground as control points, which can improve the accuracy and enhance the reliability of control points. Layout of control points is shown in Fig. 4.

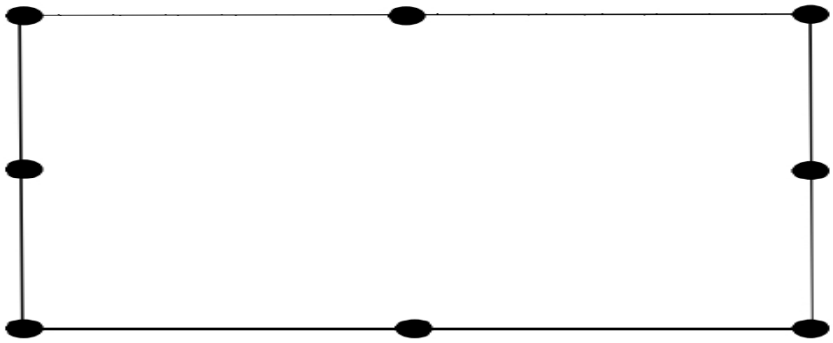

Fig 4: Layout of control points

2.4. Data fusion

In order to fully apply the geometric information of point cloud and the texture information of image, data

fusion method is adopted. The fusion will be completed in two stages. The first stage is implemented by point cloud registration in point cloud data processing, and the second stage is texture mapping after model establishment.

(1) Point cloud registration: point cloud is registered in the data processing stage. The registration method of camera installation parameters is used to make the UAV aerial camera and ground three-dimensional scanner closely connected during installation. Through calibration of camera installation parameters, the systematic errors between image and point cloud are corrected, and rough registration between image and point cloud is realized.

(2)Texture mapping: texture mapping is carried out at the BIM model establishment stage, and images are collated into the established 3D model. The resulting effect picture is shown in Fig. 5.

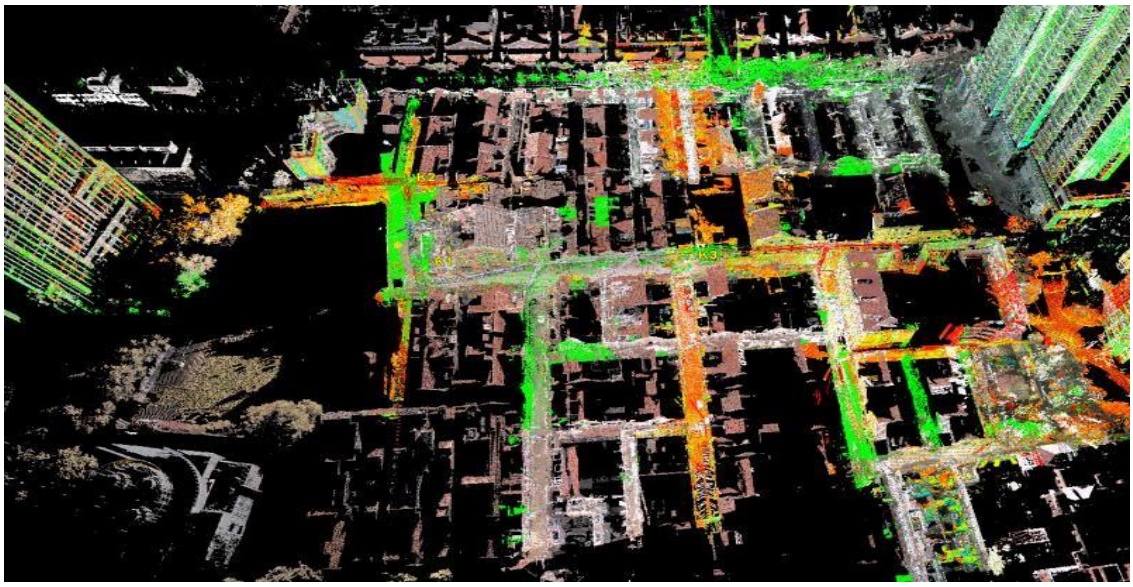

Fig 5: Effects after data fusion

2.5. Establishment of BIM and texture mapping

The texture of an image can be mapped into the model during 3D modeling. First, the model is initially established, and then imported into 3D Max for modification and processing. Modified BIM model is used for texture mapping to get a more visualized 3D building model. The essence of texture mapping is to establish the corresponding relationship between 2D texture spatial coordinate points and 3D spatial building surface coordinate points, map the corresponding color or gray value of 2D coordinate points to the 3D object surface, and get a 3D model that conforms to the true color. The interior orientation elements and object orientation coordinates of the image are solved by collinear equation, i.e. texture coordinates are generated. The model is shown in Fig. 6 below.

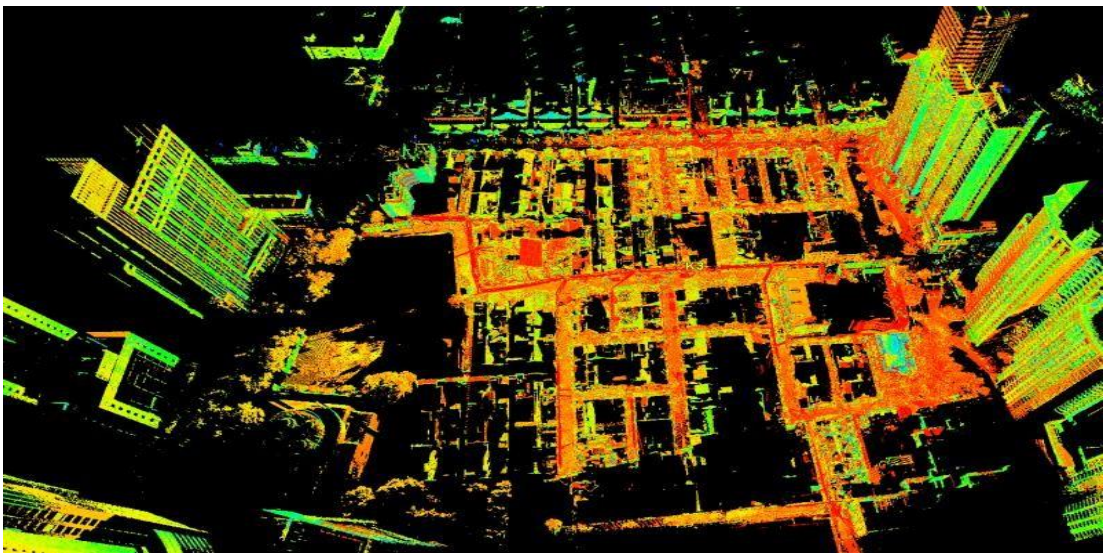

Fig 6: Effect of model establishment

III. Experimental Results and Application

The 3D model built by multi-source data fusion is more realistic and has accurate coordinates corresponding to each image point. During the construction phase, the buildings need to be repaired, expanded and renovated. Due to the complicated engineering data, it is difficult to achieve the fine management of the project, and it is impossible to obtain the accurate amount of funds, which leads to the waste of resources or the extension of the construction period due to the shortage of materials. The basic data of the project are obtained by establishing the model, which provides technical support for resource arrangement of the project. Secondly, collision inspection is carried out to forecast the problems that may be encountered during construction in advance by using the model, so as to reduce the errors and losses during construction and improve the quality of construction work.

During the operation and maintenance phase of a building, it is an effective tool for the government to conduct comprehensive stress analysis of the building, evaluate the building safety and enhance the safety analysis ability of relevant departments. Besides, BIM model can provide a complete database to manage various data, which facilitates the connection of engineering units and realizes the management of the whole life cycle of buildings. In addition, for some buildings of historical value, building digital model is a good protection for the ancient buildings by obtaining building data information comprehensively. Moreover, as the ancient buildings will be weathered and damaged when exposed outdoors for a long time, the preservation of digital models is of great significance to their later repair, reconstruction and academic research. The actual application of BIM is shown in Fig. 7.

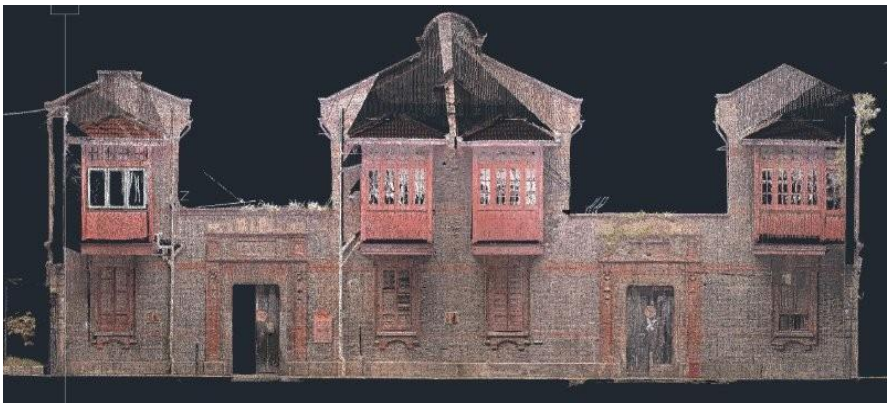

Fig 7: Application of BIM

IV. Conclusion

The combination of 3D laser scanning and tilt photography to build a BIM 3D model can complement the shortcomings of the two measurement methods, and the established model is more real and accurate compared with the traditional model established by using a single measurement method, and reduces a lot of work time in the field. Modeling by multi-source data fusion can not only meet the survey of complex buildings by construction units, but also meet the later requirements of building life cycle management, cultural relics protection and other aspects. The last but not the least is the lack of precision assessment due to the limitation of capability, which will be strengthened in the future measurement work. Building the medical unit model of infectious disease hospital based on BIM is very important, which can form a standardized unit model that meets various requirements and provide guidance for the construction or transformation of related hospitals. The transformation of infectious diseases in existing hospitals based on BIM can include rapid spatial analysis and transformation scheme formulation by using three-dimensional scanning, docking analysis of existing equipment, pipelines and new systems, scheme modeling and comparative analysis of various schemes, fine simulation analysis of field transformation construction, and infection risk analysis of transformation area and other areas.

References

[1] Leonov, N.A. Mikhail, V.I. Andrey, V.O. Stanislav, E.B. Alexander, M.B. Yuri, "Laser scanning and 3D modeling of the Shukhov hyperboloid tower in MoscowAndrey V," Center for Virtual History of Science and Technology, S.I. Vavilov Institute for the History of Science and Technology of the Russian Academy of Sciences, 109012 Moscow, Staropanskiy per., 1/5, RussiaTrimetari LLC, Russia, ul. Kronverkskaya, 5, BC "Troitskiy", of 250, 197101 Saint-Petersburg, Russia, pp. 551-559, 2015.

[2] S. Cezary, D. Pawel, D. Andrzej, H. Karolina, "Modeling 3D Objects for navigation purposes using laser scanning," pp. 301-306, 2016.

[3] Z. Penelop, A. Weinberger, G. Brian, "How Oblique Aerial Imagery is changing the Face of Transportation Planning," 10th National Conference on Transportation Planning for Small and Medium-Sized Communities, vol. 13, no. 25, pp. 85-105, 2006.

[4] F.L. Prandi, "Pictometry Images Intergrated use for 3D Model Generations," Remote Sensing and SpatialInformation Seiences, vol. 2008, no. 37, pp. 763-769.

[5] J. Wang, "The application of three-dimensional laser scanning technology on the ground in surveying and mapping of ancient buildings," Lanzhou Jiaotong University, 2018.

[6] B.S. Yang, F.X. Liang, R.G. Huang, "Advances, challenges and trends in data processing of 3D laser scanning point cloud," Acta Geodaetica et Cartographica Sinica, vol. 46, no. 10, 2017.

[7] X.H. Yao, X.Y. Xu, Z.M. Gao, "Application of BIM technology based on three-dimensional laser scanning in steel structure project of Wuhan Greenland Center," Steel Structure, vol. 33, no. 08, pp. 118-121, 2018.