Research on the Construction of Traditional Village Intelligent Model based on CIM

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Abstract. With the development of BIM, GIS and IoT technologies, CIM technology is becoming increasingly mature. CIM technology provides new ideas to address the preservation and renewal of traditional villages. Taking Beishan Village of Zhuhai City as the research object, this paper sorted out its CIM construction ideas, and divided its CIM construction process into three parts: information data board, online platform boardand offline equipment board. In the information data board this paper will improve the geometric information collection process based on TLS technology; In the online platform board this paper will design four user layers: government, professionals, enterprises and institutions, and the public; and in the offline equipment board this paper will set up an external sensing system to provide real-time dynamic data for CIM. It is hoped that these studies can provide some references for the realization of comprehensive intelligent systems in the future.

Keywords: CIM, Village Protection, Intelligent Model, Traditional Village.

1 Introduction

With the continuous development of modern information technology, the protection and renewal of traditional villages have ushered in an opportunity for transformation. BIM (Building Information Modeling), GIS (Geographic Information System) and IoT (Internet of Things) technologies are widely used as CIM (City) Intelligent Model) laid the foundation. Among them, BIM is a component of CIM, GIS provides an operating environment for CIM, and IoT provides CIM with the ability to interact with the real world. CIM expands on these three elements and provides new ideas for the protection and renewal of traditional villages [3].

Beishan Village in Zhuhai was announced as a Famous Historical and Cultural Village of Guangdong Province in 2009, and is a typical Lingnan traditional village of high value. It is rumored that the Yang Clan has been living here since the Song Dynasty, and the village was already quite large in the Qing Dynasty. Beishan Village is still facing difficulties in heritage protection, management of the current situation, planning

G. Zhao et al. (eds.), *Proceedings of the 2023 5th International Conference on Civil Architecture and Urban Engineering (ICCAUE 2023)*, Atlantis Highlights in Engineering 25,
https://doi.org/10.2991/978-94-6463-372-6_38

and updating, as well as difficulties in coordinating protection, management and updating.

CIM can provide comprehensive data and information on traditional village-related issues, conduct simulation and prediction, promote multi-stakeholder cooperation, and enhance the scientific impartiality of decision-making. Thus, it can help planners and managers to better understand and solve the problems of protection, management and renewal of historical and cultural villages, and ultimately realize the improvement of the quality of life of local residents. Therefore, based on CIM, this paper focuses on the protection and renewal of traditional villages, and takes Beishan Village of Zhuhai City as the research object to explore the construction strategy of traditional village intelligent model.

2 Research status

2.1 Research status of protection and renewal of traditional villages

The international research on traditional villages probably originated in the middle of the 19th century, and experienced a process of transformation from focusing on the study of material cultural heritage to gradually paying attention to the protection of regional values[1]. The research on traditional villages in China started relatively late, but now presents a prosperous scene of collaborative research of multiple disciplines, perspectives and theoretical methods. In 2002, China clearly put forward the concept of historical and cultural towns (villages), formulated the Measures for the Management of Historical and Cultural Towns (villages) and the Measures for the Selection of Chinese Historical and Cultural Towns (villages), and promoted the protection and renewal of traditional villages by means of laws and regulations. Historical and cultural villages are special categories of traditional villages, which are selected by the Ministry of Housing and Urban-Rural Development of the People's Republic of China. Traditional villages with special protection and management requirements[2].

2.2 Research status of CIM

CIM (city intelligent model) is a concept proposed by Professor Wu Zhiqiang of China in 2011. It originates from the Campus Intelligent Model of Shanghai World Expo which is an organic complex of urban information based on three-dimensional digital space[3] and is an intelligent model to realize simulation prediction, auxiliary decision making and interaction between people and urabn information. In 2017, Farid Javadnejad et al argued that CIM is an extension of BIM[4]; In 2018, TA Valkanova implemented the integration of a large amount of building information using CIM to support decision making[5];In 2019, Melo, HC realized the use of CIM to assist in decision-making related to the sewage system in Piumhi, Brazil[6]; In 2022, Guangzhou Zhujiang Industrial Group Co., Ltd. issued a document saying that it has established a multi-dimensional regional renewal and transformation CIM that includes approval, negotiation, opinion consultation, cost accounting, and resettlement, basically realizing the opening up of the CIM platform and the core work at all stages of urban renewal[7].

CIM has been applied in the whole process management of engineering projects, prefabricated buildings, community construction, urban integrated management and other fields. However, there is still a gap in the application research of CIM in the field of traditional village protection and renewal protection. Therefore, this paper takes Beishan Village of Zhuhai City as the research object to explore the application of CIM in the field of traditional village protection and renewal protection.

3 Overview of Beishan Village

Beishan Village is located in southern China and belongs to Xiangzhou District, Zhuhai City, Guangdong Province, China. Beishan village is in the South Asian tropical monsoon Marine climate zone, with high temperatures throughout the year, abundant rainfall, and often affected by the South Asian tropical monsoon, with many thunderstorms. Beishan Village is a traditional village rich in Lingnan culture. Beishan Village, facing Beishan Mountain in the south, was originally developed in a "comb style", and later in a "grid style". 2020, the "Zhuhai Beishan Village Protection Plan (2020-2027)" was completed. The document stipulates the planning principles, protection zoning, protection requirements, protection measures and so on, which is an important foundation for the construction of the CIM of Beishan Village[8].

4 CIM construction Ideas

The construction of CIM in Beishancun needs to first delineate the problem domain and abstract the essential features of things in the problem domain into system objects. The problem domain refers to the business scope involved in the development goal problem, which becomes the basic unit of building the CIM system. The fundamental issues of the problem domain of Beishan Village CIM platform includes three aspects: heritage protection, current management and planning update.

In the aspect of Beishan Village heritage protection, the corresponding objects of this problem are: 1 item of intangible cultural heritage; 9 immovable cultural relics; 17 historical building and conservation planning recommended historical building clues; 12 historic streets; 7 ancient and famous trees; Ancient Wells, stone monuments and 4 other places. There is also a need to identify core protection areas, construction control zones. The purpose of heritage protection is to protect valuable heritage, which can be broken down into the following ways: the classification and classification of heritage, the formulation of classification and classification protection strategies, the implementation of protection strategies and the evaluation and feedback mechanism. The corresponding objects of the current management of Beishan Village include land, buildings, structures, roads, public facilities, park squares, plants, people, vehicles and so on[9]. The corresponding objects of Beishan village planning renewal include protection structures, repair structures, improvement structures, transformation structures and new structures. Through the classification of the structures within the scope of protection, the classification protection and remediation measures are carried out.

The "object" obtained from the above analysis of the three fundamental problems of the problem domain is actually the class of concrete objects. For example, "immovable cultural relic" is actually the class name of nine concrete objects. "Immovable cultural property" is a special category, i.e. subcategory, of "protected structures". "Protected structures" is the general class of "immovable cultural relics", that is, the parent class.

5 CIM Construction Process

Based on Biagini C's classification of CIM stages[10], CIM construction can be divided into three parts: 1. Information data section: information collection, information transformation, information integration; 2. Online platform section: platform analysis, platform design, platform programming, platform testing, platform maintenance[11]; 3. Offline equipment segment: central equipment, node equipment, sensing equipment.

5.1 Information data

The information data in the information data section can be divided into physical data and non-physical data. Physical data includes: geometric data, thermal data, optical data, acoustic data, etc., and non-physical data includes: functional information, population information, historical information, cultural information, etc. In the construction process of Beishancun CIM, the current geometric data is mainly collected through the three-dimensional laser scanning technology TLS (terrestrial laser scanning) (Figure 1).

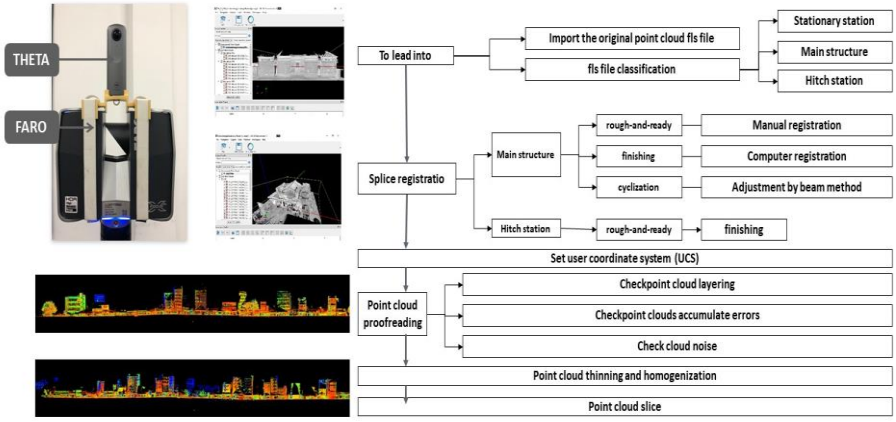

Fig. 1. TLS device, point cloud model, modeling process (Self-drawn by the author, data source: Guangzhou Si Survey and Drawing Technology Co., LTD).

It is necessary to determine the working time, content and order before the field scanning to collect the current geometric data by 3D laser scanning technology, and then determine the scanning process according to the field conditions. The FARO X330 device was used for 3D laser scanning, and the THETA device was used to take panoramic photos to assist with colour matching in post. According to the requirements of

the site and the results, set the parameters of the scanner: resolution, quality, point distance (mm/10m), scanning size (Pt), point number (MPts), ultra-clear distance (m), limit distance (m) and so on. And according to a certain flow line and order as far as possible to set the scanning sites evenly. In the case of ensuring that each position is covered and there are additional stations at key locations, the number of stations should be reduced and the overall scanning time should be reduced.

After the field scan is completed, the JRC 3D Reconstructor software can combine the data obtained by all brands of scanners into a single project file. Import all the original point cloud files into the software, and classify them by fixed station, main structure station, and hanging station. In the process of registration, the main structure is first spliced, and on this basis, the station is spliced to improve the accuracy. In splicing, the first rough splicing is performed for manual alignment, which relies on the congruent alignment of the two point clouds to ensure that the error is less than 0.1m. Secondly, precision spelling, computer registration is carried out to ensure that the error is less than 0.003m.Then use the beam method to further reduce the error, to ensure that the error is less than 0.002m. After the registration is completed, the point cloud proofreading is continued to deal with the layering, accumulated error and noise of the point cloud. Finally, the point cloud is extracted and homogenized to make the model lightweight.

5.2 Online platform

Due to the unique characteristics of the famous historical and cultural village in Beishan Village, compared with the existing large-scale urban center CIM, the construction of the CIM in Beishan village should focus on solving the problems related to the protection and renewal of traditional villages. The user layer of Guangzhou CIM platform includes: government, enterprises and institutions, and the public[12]. The user layer design of the CIM platform in Beishan Village includes: government, professionals, enterprises and institutions, and the public. The government user layer is based on the current situation of government management. The municipal government is mainly responsible for coordination and supervision; The district government is mainly responsible for the protection and administration of historical and cultural towns (villages) under its jurisdiction; The town government and sub-district office are mainly responsible for daily inspection and on-site protection; The administrative department of natural resources is mainly responsible for the planning and management of famous historical and cultural towns (villages); The administrative departments of housing and urban-rural construction are mainly responsible for the supervision and administration of the structural safety, use and repair of buildings and structures in historic and cultural towns (villages); The administrative department for cultural relics shall be responsible for the supervision and administration of the protection of cultural relics and intangible cultural heritage in famous historical and cultural towns (villages)[13]. Tthe professional user layer includes: town and country planners, architects, environmental planners, geographic information system (GIS) experts, economists, sociologists, etc., which is an expert committee formed to improve the scientific nature of the whole process and avoid potential risks, and make suggestions and review various decisions. The

user layer of enterprises and institutions includes the design unit and the construction unit, and the completed design scheme and construction organization scheme need to be submitted to the relevant departments for application and review in accordance with relevant regulations. The public user layer includes: property owners, tenants, merchants, tourists, mainly with data feedback function. In order to realize the data cycle of data entry, decision making, decision entry and public feedback, the information and functions of each user layer are interexchanged.

5.3 Offline equipment

CIM is not only a software platform, but also includes hardware devices, physical environments, networks, and external awareness systems[14]. The external perception system enhances the connection between CIM and reality. Fangyu Technologies Monitoring System is an external sensing system jointly developed by Guangzhou Fangyu Technology Co., LTD., South China University of Technology and Guangzhou Si Surveying and Mapping Technology Co., LTD. Based on mature 4G/5G network, NB-IoT, LoRa and other Internet of Things technologies, the system makes full use of the digital achievements of historical buildings and integrates advanced artificial intelligence algorithms to select and analyze data. It can conduct comprehensive real-time monitoring of the protection status of the value parts of historical buildings, structural safety and water and electricity safety, and give early warning of potential risks[15].

The system includes device system, cloud platform and data browsing terminal. Equipment system covers: wireless collector, vibration sensor, biaxial tilt sensor, HD camera ball machine, temperature and humidity sensor and so on. The cloud platform is used to realize data storage, algorithm correction, data analysis and other functions. Data browsing terminal includes: monitoring data visualization interface, early warning system, report system and geographic information system, which makes the monitoring platform operationhumanized.

6 Specific results and innovations

The geometric data acquisition part of the current information data plate, based on TLS (terrestrial laser scanning), has a relatively perfect scientific acquisition process, which can be faster and more efficient to obtain a more highly accurate model. The specific acquisition process includes: on-site scanning, point cloud splicing, point cloud slicing, point cloud coloring, and each process stage has a more detailed method, which can be promoted on a large scale. However, the collection of non-physical data is often realized through various types of census and access to multi-source big data, and there is still more room for intelligence. And the conversion of information and the integration of information has to be followed by further exploration.

The online platform board has now realized the construction of a single-function platform for historical building management, building inspection, point cloud data management, and management of historical and cultural cities. Historical and cultural city management platform has realized: 1.GIS information management, display; 2. basic

information, mapping file management, display; 3. repair, property rights, construction records management; 4. 360-degree panoramic data presentation; 5. positioning inspection, maintenance records management and other functions. But to really realize the government, professionals, enterprises and institutions, the public's comprehensive needs integration is still a long way to go.

Now the offline equipment board has now realized the initial construction of the building monitoring system, as the entire CIM perception equipment, to provide real-time dynamic data for CIM. The team of Guangzhou Fangpi Technology Co., Ltd. has carried out pilot experiments on the building at No. 24, 918 Road, Tianhe District, Guangzhou City, and has installed vibration chord transmitters and biaxial inclination sensors for building structural monitoring; has installed power leveling instruments for settlement monitoring; has installed vibration sensors, temperature and humidity sensors, and flooding sensors for building environment monitoring; and has installed cameras for wind monitoring. At present, the monitoring equipment of single building is running normally, and the building monitoring system is running normally, but the experiment of simultaneous operation of multiple buildings has not been carried out for the time being, and the pivotal equipment and node equipment of the monitoring system have not been perfected yet.

Through the above experiments, the efficiency of basic data collection as well as the quantity and accuracy of basic data have been successfully improved; the efficiency of the government's management of traditional villages and historical buildings has been enhanced; and public participation has been promoted. The prototype of an intelligent model for traditional villages has been established, but there is still a long way to go before the establishment of an intelligent platform with comprehensive integration and unified standards.

7 Conclusion

The protection, management and renewal of traditional villages are important issues of practical relevance to the interests of the people, and the development of technology provides new opportunities for solving related problems and optimizing related processes. Taking Beishan Village, a typical traditional village, as an example, the author explores the feasibility of CIM in the field of traditional village conservation and renewal protection. Based on the CIM technology and analyzed in combination with real cases, the construction process of CIM is divided into information data plate, online platform plate and offline equipment plate. The independent operation of each board has been realized, but it needs long-term efforts to establish a unified and perfect traditional village intelligence model and promote its generalization.

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