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Research on Digital Modeling and Life Cycle Information Management of Architectural Heritage Protection Based on BIM

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Abstract

Building information modelling (BIM) has been adopted in the architectural heritage industry. The digital protection method with BIM Technology as the core can introduce the information management workflow into the protection of architectural heritage, which can provide possibility for the complete preservation of all kinds of information related to the architectural heritage, improve the efficiency of protection, and meet the management needs of the whole life cycle of the architectural heritage. This paper is based on digital technology and combined with the characteristics of architectural heritage to create a BIM model of architectural heritage. The Autodesk Revit software, which is commonly used in China, is used as the entry point, and the C# language is used to develop Revit to make up for the shortcomings of traditional architectural heritage protection. At the same time, all kinds of information related to the architectural heritage are completely preserved, improving the efficiency of protection work, and meeting the information management needs in the process of building heritage maintenance and management.

Keywords

Building Information Modeling; Architectural heritage protection; Building components method; Information islands;

1. Introduction

With the development of information technology, the protection of architectural heritage has become more and more complex, and the traditional protection methods of architectural heritage have fallen behind the pace of The Times (Jing, 2017). Due to the lack of digital technology and information management methods, the protection of architectural heritage has encountered many obstacles at the technical level(Li & Liu, 2018). At the same time, the lack of more effective means to mine and store building information has made some data from previous studies difficult to use, and many tedious tasks have been repeated (Shi, 2014). In the face of these problems, BIM has more advantages in the field of architectural heritage protection and has a high degree of compatibility with architecture (Xing, 2017). The rapid development of digital technology has made it possible to create three-dimensional models, and the use of three-dimensional virtual reconstruction to record the spatial information of architectural heritage has gradually become the focus of research (Liu, 2016a). This enables most of the information management, monitoring, maintenance, and repair of the architectural heritage in the field of architectural heritage protection to effectively record, organize and track the relevant information of the entire life cycle of the architectural heritage(Zhao, 2014).

At present, architectural heritage information is often obtained by consulting historical documents, on-site surveying and mapping, interview recordings, and artisans' descriptions of local construction techniques (Jing, 2015. Liu,2013). This information is often kept by different institutions and individuals, and the information records are scattered.

Chen Yue (Yue, 2002) proposed the combination of parametric technology and CAD software, and applied parametric design to the three-dimensional modeling of architectural heritage. In his paper, he analyzed and explained the decomposition method and parameter setting of architectural heritage components. Wang and Xie (Wang & Xie, 2008) established an ancient architectural modeling system by writing CAD script files and combining database technology. Zhao and Yin (Zhao & Yi, 2011) proposed the acquisition approach of architectural heritage model data, elaborated the modeling steps in Sketchup and the modeling methods of components with different shapes. But this is still a relatively discrete way of recording information. Nowadays, with the development of digital technology, 3D models are used to record spatial information and graphic information simultaneously (Liu, 2016b. Chang, 2016). The architectural model is used as the carrier of information, and historical data, surveying and mapping data and research results are archived in the architectural model to facilitate the guidance of architectural heritage protection and research work and to improve the use value of the architectural heritage three-dimensional model(Sánchez et al., 2019; Hui et al., 2019).

As the carrier of information, the BIM model uses digital modeling technology to create a shared information environment to avoid information loss or misunderstanding(Wang,2015. Wei,2014). It's easy-to-operate information extraction method ensures efficient communication, reuse and sharing of information, and improves the decision-making efficiency of project participants(Zhi,2016). He (He, 2011) studied the parametric modeling method of ancient buildings based on the Revit platform, and elaborated the method of setting the family parameters and the modeling process of the main structure in detail. Sun (Sun, 2012) proposed the theoretical framework of architectural heritage information model based on Revit, and introduced the method of building the model in detail. Zhu (Zhu, 2012) proposed a BIM-based construction method for wooden structures and tried to plan the library of ancient building components.

The information management of architectural heritage protection is the foundation of all protection work, but the existing methods and means cannot adapt to the characteristics and challenges of the development of heritage records, such as traceability, sustainable multi-temporal, and diversification of information sources and objectives (Li,2014. Zhi, 2016). In order to solve the above problems, this paper proposes a BIM-based digital modeling and full life cycle information management method for architectural heritage protection. This method is based on the architectural component entity, combined with the architectural heritage characteristics to create the architectural heritage BIM model. In addition, this paper also proposes future research directions for digital modeling and the life cycle information management for researchers in this field. The main contributions of this paper include: (1) Record research, surveying and mapping, repair, protection, and monitoring information in different historical stages, (2) solve the problem of information transmission in the practice of architectural heritage protection, (3) improve the method system of architectural heritage protection, (4) explore the BIM technology and its application for architectural heritage protection in the new era, and (5) solve the problem of "information islands" in the information management of architectural heritage(Xin, 2013; Li, 2015 ; Fodli and AlSaeed, 2019; Gherardi ET AL., 2018).

2. Methodology

The digital protection of architectural heritage has gradually attracted social attention, and the parametric modeling technology of architectural heritage has become more mature. Figure 1 shows the framework of BIM-based digital modeling of architectural heritage protection and life cycle information management methods. Digital modeling and information management of architectural heritage based on the technical development of BIM software. Realize the transformation from two-dimensional graphic information to three-dimensional spatial information, from discrete information to composite information, and from information recording to information management.

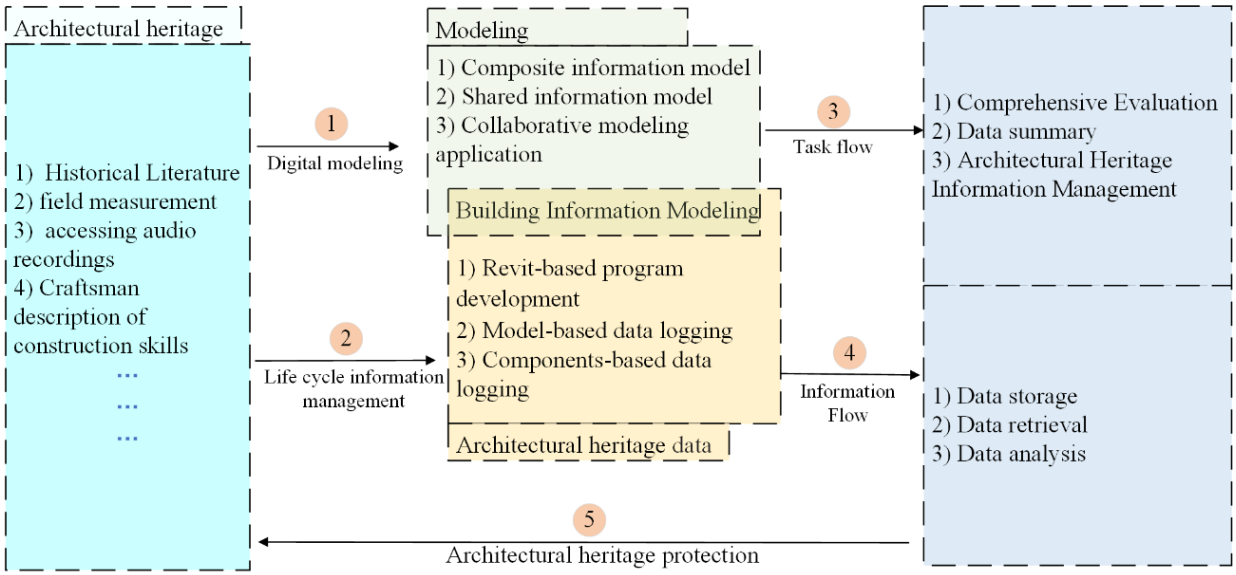

Figure 1: Framework of the method

2.1. Architecture Heritage Preservation and Protection

With the development of the computer level, the efficiency of the protection of architectural heritage has been improved to a certain extent(Stella, 2016; Makowska, 2019). However, graphical two-dimensional drawings cannot directly reflect the spatial characteristics of architectural heritage. Create a three-dimensional virtual architectural heritage model through digital technology, and use architectural components as the basic unit to record the detailed information of the architectural heritage in the process of design, construction, operation and maintenance and protection. At the same time, the BIM model is used as the carrier of information to record spatial information and graphic information.

Record discrete information such as historical data, surveying and mapping data, and research results into the components of the BIM model. The recorded information mainly includes: (1) Initial construction information. The basic description of the objective material level of the component, including the construction age, material, structure, and other information of different building components, reflecting the social craft and aesthetic conditions of the heritage construction time. (2) Social and humanistic information. Information about related events such as history and legends rooted in the building ontology. (3) Current status preservation information. Including the various changes of the components over the long history, such as cracking, insects and frogs, decay, etc., as well as the records of the damage caused by various natural and man-made damage factors after the establishment of the file. (4) Construct maintenance and file information. It mainly involves the chemical and physical treatment records of each maintenance.

2.2. Digitization of Architecture Heritage

This paper limits the application of BIM technology to the perspective of architectural heritage protection, and focuses on the application of BIM technology to the protection of architectural heritage information. The key point lies in the creation of the architectural heritage information model and the addition, deletion, modification, and checking of software applications based on the life cycle of the architectural heritage. In this paper, the Autodesk Revit software which is widely used in China is used as the starting point, and the.NET C# language is used for the secondary development of Revit, and the application plug-in is compiled. The application of BIM technology can make up for the shortcomings of traditional architectural heritage protection methods and solve the problems of transmission, storage, and management of architectural heritage information.

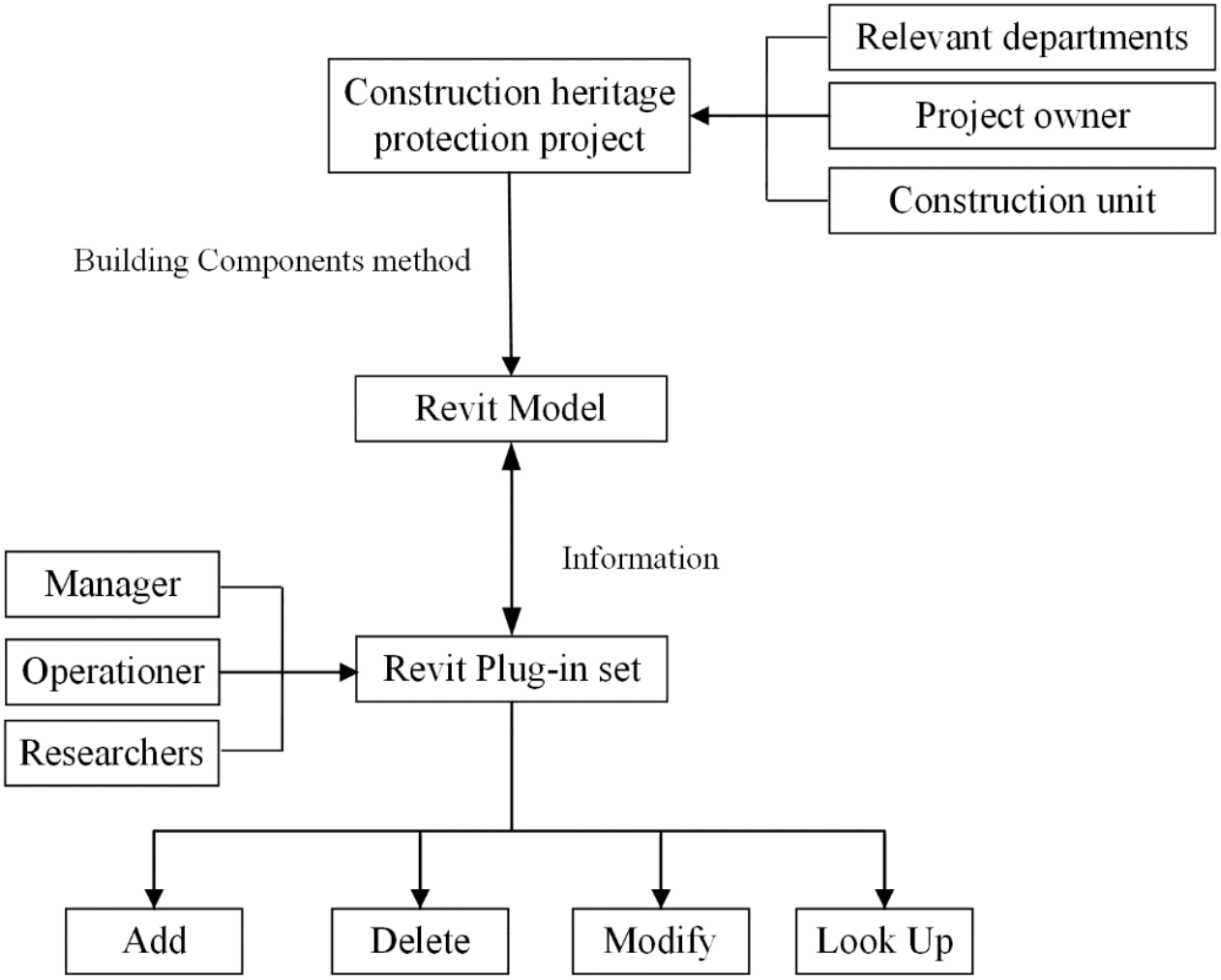

Figure 2 Project flow

As shown in Figure 2, after the approval of the architectural heritage protection project by the cultural relics protection department in China, the project owner and construction unit will use the component method to model the idea, and then give it to management, operation and maintenance and researchers, and develop through this study Revit plug-in for information recording, query, deletion, and modification.

2.3. BIM Tools

Modeling based on Revit can express and disseminate heritage information vividly, visually, and thematically. The secondary development based on Autodesk Revit software is a proprietary tool that realizes the input and output of BIM model information through storage expansion. Through the construction of software collaboration, retrieval, input and output platforms, the data collection, sharing and update of the records, maintenance, monitoring, and management behaviors of the heritage in different time periods have been successfully completed. Meanwhile, it can also speed up the process of architecture heritage protection, further assist in heritage protection and risk prevention, and form an effective information management method. The main development plug-ins and functions are mainly described as follows: (1) Project information: input/delete/modify the project information (information on research, surveying and mapping, repair, protection, and monitoring in different historical stages), (2) Component information: input/delete/modify component-related information (repair, protection, and update of components), (3) Information retrieval: query/modify the record information of the project/component (query related information recorded according to time and category), (4) Generate report: output the input information to generate report.

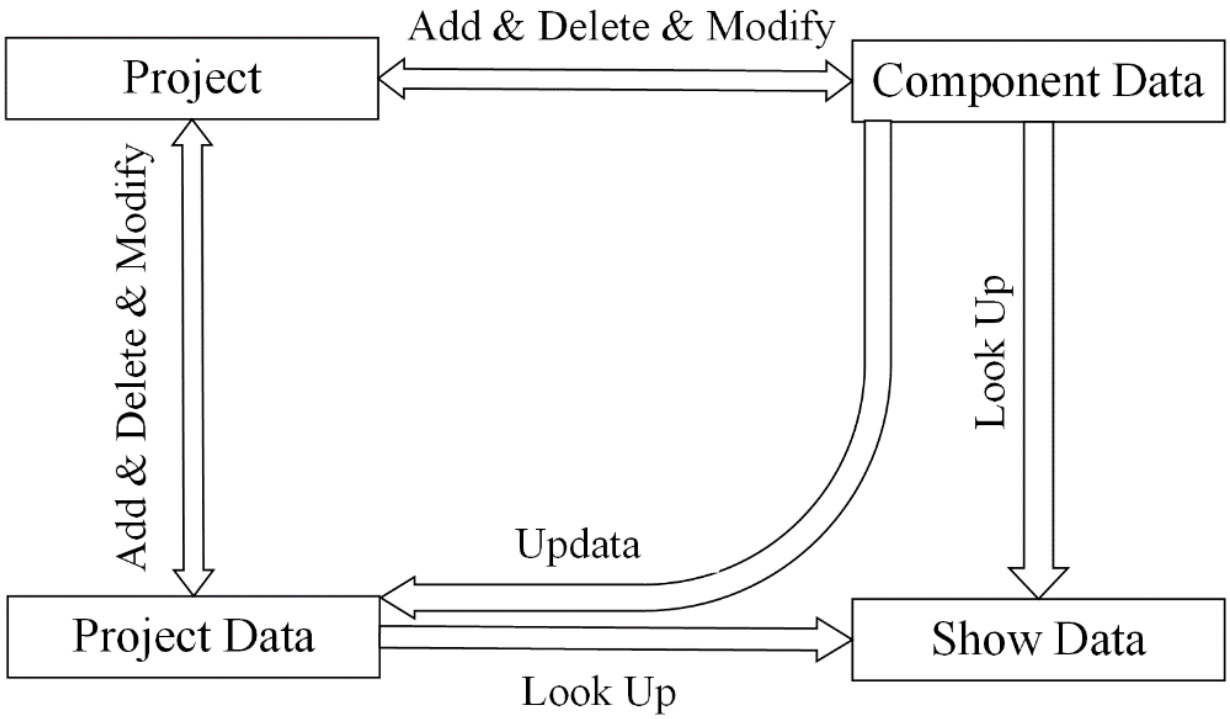

Figure 3: BIM Tools

As shown in Figure 3, both the components and project can realize the functions of adding, deleting, modifying and look up information; but when the component data is updated, the information of the corresponding project component can also be updated.

3. Results and Discussion

Using new technical methods to investigate, research and survey, further understand the situation of the architectural heritage itself, and then do a good preliminary work for its research evaluation. A BIM model created based on previous historical data and current surveying and mapping photos. Figure 7 shows the ancient tower

With the passage of time, when we study the noumenon of heritage, we should understand from its construction and construction, and record how it is used and changed. At the same time, we can explain the universal value and potential value of heritage to the historical celebrities, thoughts, aesthetic taste, consciousness and architecture technology system of the regional culture. Figure 7 shows a three-dimensional model of an ancient city building in China using the 'Building components method'. On the right is a plug-in developed based on Revit, which can add, delete, modify and loop up any component in the model, and can also perform information operations on the entire project.

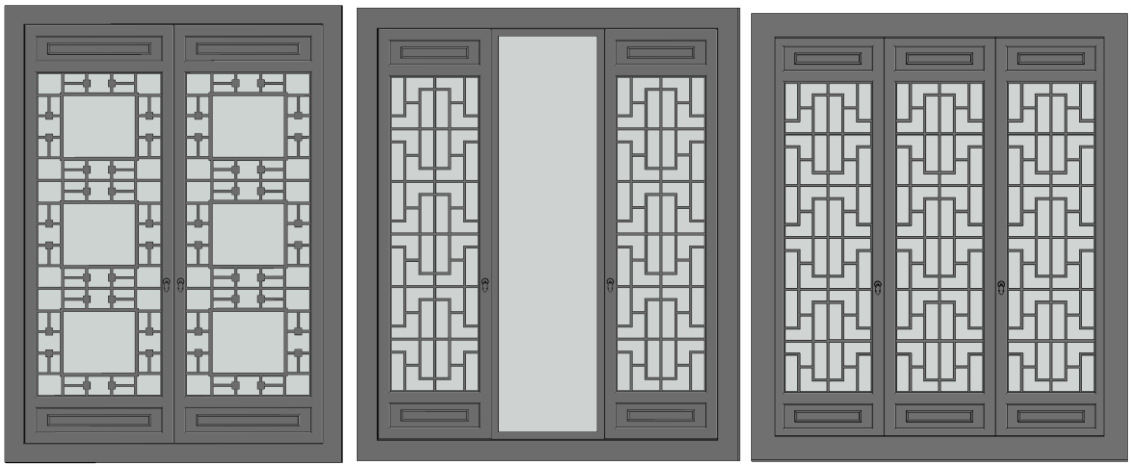

Figure 4 The window elements

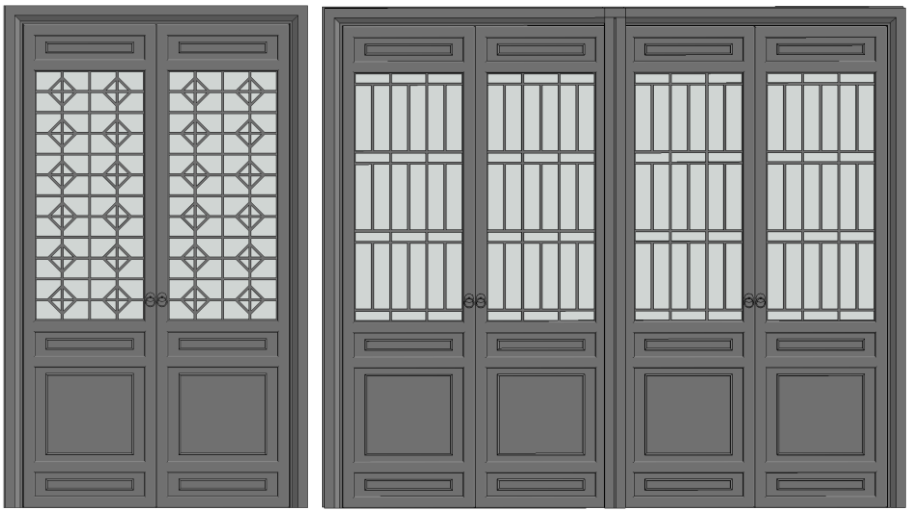

Figure 5 The door components

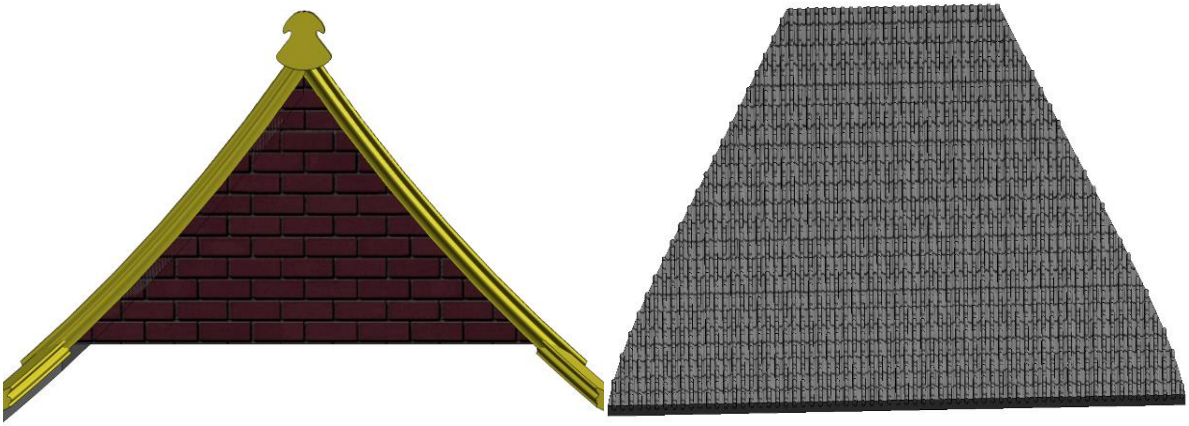

Figure 6 The roof components

Figure 7 Three-dimensional view of ancient tower

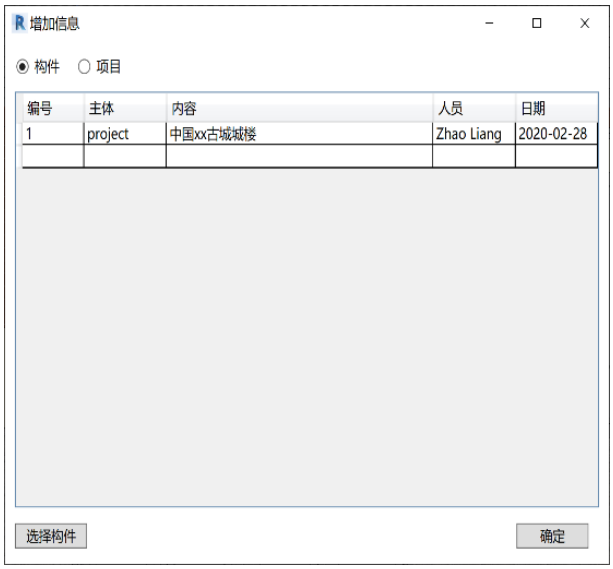

Figure 8 Revit plug-in interface

Figures 4 to 6 show the architectural components of the architectural heritage of this case study.The establishment of BIM model can enable architectural heritage researchers to obtain component-level fine architectural information. The convenient dissemination of architectural heritage information can enable the public to better understand the architectural heritage, consciously raise the awareness of architectural heritage protection, and realize the use of the past for the present in innovation.Compared with traditional two-dimensional drawings, BIM models can express the geometric features of buildings more intuitively. Compared with traditional three-dimensional building models, BIM models can record all the information related to construction projects, and this information processing capability has higher application value. In the past, the architectural heritage information generally exists in the database, and the model and the data are separated. This study uses the storage expansion method to read and write the data, so that the data and the model form a mapping relationship.

The damage of building components is usually recorded in the form of a report, which is convenient for a single repair of the building components. However, it failed to form a targeted and long-term maintenance record. The best way to classify information is to organize building components as a unit, rather than distributing maintenance records in different reports. The method provided in this study can record information on individual components, and can also record information on individual buildings. The communication between staff and researchers in different departments mainly relies on text for information transmission, which lacks intuitive positioning of building components. The situation of damaged components of the building is recorded in the form of pictures and text records. However, when the number of components is large, the recording method through the BIM model will provide a more intuitive location and record.The archival information of architectural heritage is usually recorded in different documents. When the staff or researchers need to know the archival information of one or more building components, they often need to check the documents once. The ideal way of requesting information should be to automatically search after entering the keywords, and to associate the information with the BIM model to provide graphical assistance. For example, in this case study, when it is necessary to know the historical information of a building component in a building, the computer can query according to the creation time of the building component (As shown Figure 8). While meeting the needs of architectural heritage protection, it enables researchers to intuitively understand the distribution of architectural components in different ages in architectural heritage.

Architectural heritage has important social value, which is also reflected in high research value. This study is mainly based on BIM technology to explore and study the information processing of architectural heritage. This paper aims to realize the sharing of architectural heritage data and the life-cycle management of architectural heritage information by means of digital modeling.

4. Conclusions

This paper proposes an application-oriented architectural heritage protection method, which describes the main relationship between digital modeling and the life cycle information management. This method is oriented towards the creation of BIM models for architectural heritage protection. First, through data surveys, on-site surveying and mapping and other geometric and non-geometric information of building components. Secondly, according to the needs of the life cycle information management of the architectural heritage, the BIM program developed in this research is used to record information. The information that needs to be recorded includes initial construction information, social and cultural information, current status preservation information, and construction, maintenance, and archive information.

This study provides an illustrative example to demonstrate the proposed method of "digital modeling of architectural heritage and the life cycle information management". The example is an as-is BIM model created for the protection of architectural heritage. By reading and writing the information of the reconstructed BIM model, it is verified that the proposed method can meet the expected application.

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