

# The Application of BIM in Artificial Intelligence Management of Construction Engineering Database Project

Yiqiao Li

Audit Dept, Jinan University, Guangzhou 510632, China

liyiqiao@jnu.edu.cn

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**Abstract:** In order to perfect the database system of building engineering and meet the demand of data processing and integration, a BIM - based artificial intelligence system integration research method of building engineering database was designed. The role of artificial intelligence integration method in building engineering database system was deeply analyzed, based on which the effectiveness of BIM based artificial intelligence integration method in building engineering database was further discussed. After experimental verification, the bim-based artificial intelligence integration method of building engineering database was more conducive to further improving the efficiency of architectural engineering, effectively reducing the design cycle of architectural engineering and realizing the optimization design of architectural engineering. And its integration efficiency was about 30% higher than the traditional integration method.

## 1. Introduction

For a long time, in the field of architectural engineering, in order to accurately analyze the performance and reaction of various engineering structures, various analysis theories and methods have been proposed and introduced, and constantly improved with The Times, making the numerical simulation analysis technology of structures represented by finite element become increasingly powerful. However, two obvious problems have been challenging the current theories and methods of structural analysis. Both the empirical formula and the widely used finite element analysis method are based on certain basic assumptions, which makes the numerical simulation results of the structure have a natural deficiency between the actual performance and reaction of the structure, and the error is too large and even fails in many complex engineering structure analysis [1]. The other is that the large amount of existing test data accumulated over a long period is only used for regression analysis or detection of numerical simulation accuracy, and the large amount of valuable information about structure performance and reaction contained in these data is not fully explored and utilized, which causes huge waste. Therefore, if we want to avoid errors introduced by basic assumptions and improve the accuracy and effectiveness of structural analysis, we need to find a structural analysis method that can directly predict the new structure's work behavior/reaction from the actual work behavior/reaction of the structure. To make full use of the experimental data, it is necessary to develop an effective method of knowledge mining from the existing experimental data [2].

Applying BIM technology into the field of architectural engineering design can not only realize the optimization of architectural engineering design, but also improve the work efficiency of the entire construction engineering. The application of BIM technology in the field of building engineering first requires scientific and reasonable analysis of all data before the design is started. On this basis, the dynamic management of engineering data is realized, so as to improve the construction efficiency of the entire construction project and further improve the design level of the construction project.

## **2. An artificial intelligence integration method of building engineering database based on BIM**

The artificial intelligence integration method is different from the traditional theoretical calculation method. It uses the computer to simulate human thinking mode for reasoning and analysis, so it can avoid the study of complex database information of architectural engineering and thus has unique advantages [3]. This paper mainly introduces the artificial intelligence integration method of building engineering database based on BIM.

The BIM - based artificial intelligence integration method of building engineering database consists of knowledge base, reasoning machine and interpretation mechanism. The knowledge of artificial intelligence is divided into original knowledge and empirical knowledge. The original knowledge is expressed in the parameter base of the knowledge base while the empirical knowledge is mainly embodied in the rule base. Reasoning machine is used for reasoning and solving problems according to knowledge in knowledge base. This paper adopts the positive and negative joint reasoning mechanism [4].

### **2.1 Artificial intelligence system integration**

The research system first needs to study the system architecture design. Architecture design is the core of the software system, which determines the structure of the system and defines all the software units of the integrated system. It is the description of the overall structure design of the software system. Whether the architecture design is reasonable or not directly determines the quality of the software. Therefore, the architecture design plays an important role in the software development process.

A successful architectural design must rely on clear system requirements and, on the basis of mastering the characteristics of the system application field, specifically build the overall system framework and organizational functional modules. And ensure the non-functional characteristics of the system, such as system scalability, maintainability, etc. [5]. Starting from the development strategic goal of the design enterprise, optimize the specific content according to the architectural engineering design and combine with the characteristics of domestic BIM market, based on actual requirements, the goal is to establish a set of comprehensive large-scale management software with complete functions and reliable performance [6]. In the system development process, 3D visualization technology, computer technology, database technology and advanced development platform are fully utilized. Based on reasonable hardware architecture and software architecture, the whole process information such as architectural engineering design optimization is integrated. At the same time, non-functional requirements such as system scalability, easy maintenance, data security, and good human-computer interaction interface also have certain requirements.

#### **2.1.1 Analysis of key technologies of platform architecture**

The architectures of the two most popular development models in the world are C/S (Client/Server, Client/Server) architecture and B/S (Browser/Server, Browser/Server) architecture.

#### **2.1.2 C/S architecture analysis**

The C/S architecture matured in the 1990s and usually adopts a two-tier structure, as shown in Fig.1. The purpose is to achieve resource sharing without resource equivalence. The C/S architecture divides the application into two parts: the foreground application and the background application. The server completes the background task processing; the client is mainly responsible for the foreground task processing, and the task is reasonably allocated to the server side or the client side for implementation. Most of the current software adopts the C/S architecture, because the C/S architecture can fully utilize the hardware resources of the client and server, which greatly reduces the communication overhead.

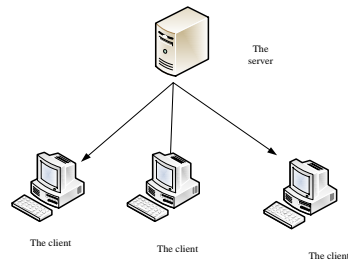


Fig.1 C / S mode structure

### 2.1.3 B/S architecture analysis

The B/S architecture was developed with the rise of Internet technology, usually a three-tier structure [2-20~2-21], as shown in Fig.2, which are the client, data server, and WEB server. The B/S architecture uses the standard TCP/IP protocol and is implemented on the WEB platform. The user interface is accessed through a browser (such as Internet Explorer). The business logic is mainly implemented by the data server, and only a small part is implemented in the client, so the load requirement of the client is smaller than that of the C/S architecture.

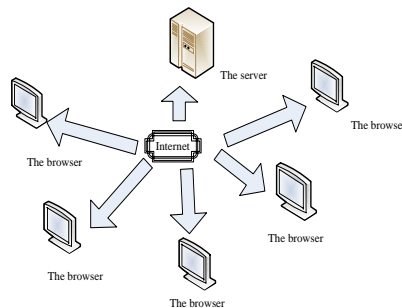


Fig.2 B/S mode structure

The C/S architecture and B/S architecture have their own advantages according to different needs and environments. Although the C/S architecture software is inferior to maintenance and upgrades compared to the B/S architecture, it has the following advantages:

First, most transaction logic is handled on the client side, with less load on the server side, and more importantly, less communication overhead between the client and the server. Usually, the transaction response time is the transaction time, the processing efficiency of the transaction and the response time are more satisfying than the B/S architecture. Second, the safety performance and overall performance are better. Because the C/S architecture-based software is aimed at a fixed user population and has different permissions depending on the identity level, the C/S architecture has high security requirements. Every C/S-based software performs transactions from data input, processing to output, and the hierarchy of each functional module is based on a framework. Therefore, the overall ratio of C/S architecture is better than B/. The overallity of the S architecture is much higher.

By analyzing the application of BIM in the field of building engineering, most of the work based on the BIM platform needs to rely on the local computer to complete, and the transaction processing for the three-dimensional information model, so the amount of data of the transaction is huge. If the B/S architecture is adopted, it will take a lot of time in the process of submitting and receiving data. Moreover, in the intricate Internet, the security of the project is not guaranteed, so the overall architecture of the platform is more suitable with C/S (Client/Server, client/server) structure.

A two-tier architecture is used on the C/S architecture, namely the integration layer and the database access layer (DAL) of the presentation layer (UI) and the business logic layer (BLL), as shown in Fig.3.

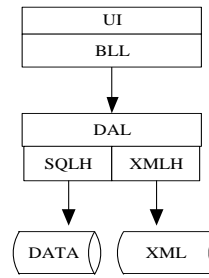


Fig.3 Schematic diagram of the platform architecture

The underlying data is stored separately by the relational database and the XML file. The integrated pipeline information is stored in the relational database, and the spatial information of each pipeline is stored by the XML file. Because relational databases are easier to handle business logic and facilitate functional extensions, attribute information (eg: frame beam type, pipeline name, device usage, maintenance cycle, etc.) is stored by the SQL database [7]. XML has a clear hierarchy and fast access. In the process of 3D information model processing, a large amount of data processing is required, and the data is required to be quickly read. Therefore, the spatial information data of the three-dimensional information model(eg: starting X coordinate of the wall, starting Y coordinate, starting Z coordinate, and end point X coordinate, end point Y coordinate, end point Z coordinate) is more suitable for storage by XML files.

## 2.2 Artificial intelligence system operation analysis

In the BIM platform, architectural design is expressed in three-dimensional visualization. The building model contains all the building model of the building model, the specific practices of each part, the exact dimensional relationship of each part, the design of the interior and exterior decoration, and the determination of various structures and materials. The structural content of the architectural design model is the main content of the structural designer's attention. How to quickly and accurately extract structural members from architectural design or how to design structural layout based on architectural design models is a concern of structural designers.

Structural members of reinforced concrete structures are usually columns, slabs, beams and shear walls. When architects design a building plan, they generally carry out the preliminary arrangement of structural columns and all building element components based on their own structural knowledge. So after the architect designed the preliminary architectural model, the structural designer can extract the structural columns in the architectural design model based on the data storage and artificial intelligence integration methods established in this paper or modify the vertical members such as columns and walls based on the architectural design model.

The BIM-based building model contains all the information about the model components, including the categories and types of components. The category information can be used to determine whether the model is a door, a window, a wall or the like, and the type information determines the type of the model, such as a brick wall or a concrete wall. The system designed in the foregoing has completely grouped and stored the above information. Therefore, the artificial intelligence integration method can quickly and effectively extract the attribute information, coordinate information, and geometric information of each model, and perform corresponding processing. According to the model category information and type information acquired by the data storage and access interface, the building parts such as doors, windows, and non-bearing walls are quickly filtered out, and structural members are extracted.

In addition to this, the layout of all the columns can be obtained by extracting the structural members. Then the projection of each column is a rectangle (in the structural design, the columns are mostly rectangular, and can also be designed as round or shaped). In this paper, a rectangular column is taken as an example to study, and the artificial intelligence integration method is used to select the center point of the rectangle. The coordinates of the center line point correspond to the space coordinates of the column. Then, the automatic arrangement of the frame beam in the three-dimensional space is converted into a spatial layout design in a two-dimensional plane space.

As shown in Fig.4, the layout information of all the columns is determined in a two-dimensional plane coordinate system XOY.

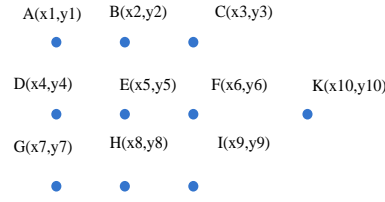


Fig. 4 Plane layout information for the column

After the column layout information is obtained through the artificial intelligence integration method, the topology constraint analysis is also performed to design a specific identification point. First, determine the spatial position of the frame beam. In the plane space shown in Fig.1, each node corresponds to a column and has a specific plane coordinate. Assuming that there are n nodes in this plane space, the plane coordinate of n nodes can determine the unique topology constraint scheme P, as shown in the formula:

$$P=F(A) \quad (1)$$

Where A is the set of coordinates of n nodes, which is determined by the topology constraints of each node, as shown in the formula:

$$A = \{(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)\} \quad (2)$$

Through the whole scene traversal, the adjacency and reachability between the nodes can be determined according to the coordinates of the nodes (the reachability can be judged by factors such as whether the line where the two nodes are located is parallel to the system axis, and the independent node is reachable to all neighboring nodes). When two nodes are both contiguous and reachable, the two nodes are connected. For example, the topology constraint of node a is as shown in the following formula:

$$Pa = \{(a,b), (a,b)\} \quad (3)$$

The topology constraints for node e are as follows:

$$pe = \{(e,b), (e,d), (e,f), (e,h)\} \quad (4)$$

Through the reachability between nodes,  $Pe$  can be reduced to  $Pe'$ , as shown in the formula:

$$pe' = \{(b,h), (d,f)\} \quad (5)$$

Through the traversal and decision research of the full scene node, an undirected connected graph composed of all nodes is finally obtained, as shown in Fig.5. In the undirected connected graph, if two nodes are connected, there is an undirected edge directly between the two nodes, indicating that there is a frame beam between the structural columns represented by the two nodes. As shown in Fig. 2, E0, E1……E14 are the positions of the determined frame beams.

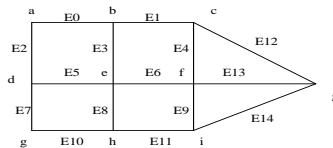


Fig. 5 Undirected connectivity diagram of the column nodes

### 3. Experimental research analysis

In order to verify the effectiveness of the BIM-based construction engineering database artificial intelligence system integration method, the following experiments were designed.

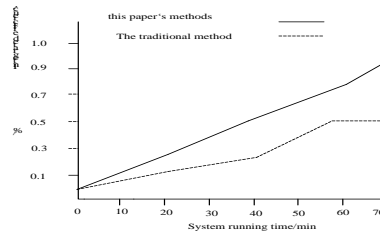


Fig. 6 System operation efficiency map

From the experimental data shown in Fig. 6, it can be seen that with the increasing system running time and data, the operating efficiency and data integration efficiency of BIM-based building engineering database artificial intelligence system is always higher than the operating efficiency of traditional systems. And the traditional system reached the highest point of its operating efficiency after 65 minutes. At this time, the integrated method designed in this paper is more efficient than the traditional 30%. The experimental analysis proves that the information integration and management efficiency of the BIM-based construction engineering database is improved, which can promote the design optimization of different construction projects, fully grasp the construction progress, and implement scientific deployment of resources. It can be seen that the implementation of BIM-based construction project database expert system integration method is of great significance to the long-term sustainable development of China's construction industry.

#### 4. Conclusion

All in all, the BIM-based artificial engineering integration method of the construction engineering database can further improve the overall work efficiency and achieve coordinated communication between different professions. For the construction industry, it is very important. Of course, we should also fully realize that the development of the construction industry is not a one-step process. It is a systematic, long-term process that requires our joint efforts to be finally realized.

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