

Construction of Virtual Intelligent Construction Simulation System Based on BIM Technology

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Abstract: Although the appearance of BIM technology can greatly improve the visualization, informatization and three-dimensional of the architectural design process, it still lacks good display means for the construction effect, so that it is difficult for the constructor to grasp the design intention and the customer can't predict the real state of the building. In this paper, BIM virtual construction is taken as the research object, and the practical characteristics of virtual reality technology, network information technology and computer application technology are given full play to build a Web-based building virtual intelligent construction simulation system. Based on BIM technology, the system takes VR technology as the core, and transforms the parameterized, integrated and simulated 3D information model under BIM technology into a virtual scene object with immersion, visibility and interactivity through 3ds Max and Unity3D software, which greatly improves the application effect of BIM. In addition, the whole system is designed with B/S architecture, and the Web Server is built with the framework of Spring+SpringMVC+MyBatis in Java language environment, and a flexible and efficient front-end interactive interface is formed with the framework of Vue, which is convenient for users to log in and use through various channels, and promotes the digitalization and intelligent upgrade of modern building technology while taking into account the diverse needs of users, designers and builders.

Keywords: BIM; VR; building technology; virtual simulation; computer application

1 INTRODUCTION

At this stage, China has entered a new period of social development. Under this new historical position, profound changes have taken place in the internal and external environment. All industries and fields in the whole society will usher in new opportunities and new situations for development, and will also face new problems and challenges. In the context of economic development changing from high-speed growth stage to high-quality development stage, as an important industry of China's national economy, the construction industry will actively seek reform breakthroughs, conform to the development trend of the industry, accelerate the pace of information technology integration and innovation, fully realize digital transformation and upgrading, and achieve the important goal of high-quality development. ^[10] As the representative of building information technology, BIM has penetrated into the whole process and all aspects of the modern construction industry, continuously injecting new vitality into the high-quality development of the construction field, promoting the reform of the construction mode of construction projects and promoting the intelligent level of construction projects.

However, in the practical application process, BIM is used as a data-based tool for architectural engineering planning and design, construction and operation and maintenance management. [1] Although it has obvious rationality and scientific advantages in data display, data annotation and data integration, it has strong professional attributes, lacks concrete means of expression, and has a high threshold for use and understanding. It is only applicable to designers, so that it is difficult for builders to grasp the design intent and customers cannot predict the real state of the building. In view of this, this paper believes that on the basis of BIM technology, the three-dimensional information model of buildings is designed and processed twice, and it is introduced into Unity 3D software to complete virtual construction and scene fusion, forming a virtual intelligent construction simulation system that supports users to complete design display, construction simulation, panoramic roaming and data visualization analysis. In addition, Unity 3D software is used to release the system program according to WebGL standard, and the embedded display is completed by combining with the Web front-end design framework Vue, and the unified call and control of Web Server is completed to complete the design and development of building virtual intelligence construction simulation system based on Web. The system can support users, designers and constructors to log in, which effectively solves the communication problem during the period. At the same time, it can also carry out construction simulation drills in an immersive way to help the construction party understand the construction process and improve the level of the whole project management. [7]

2 INTRODUCTION OF KEY TECHNOLOGIES

2.1 BIM technology

BIM (Building Information Modeling) is the building information model. Its core function is to achieve a high degree of integration of various parameters and information by establishing a virtual and visible three-dimensional model of a building project, and to support the transmission and sharing of all links or processes in the whole life cycle of a building project, to achieve convenient and efficient collaborative management, and to improve the overall cost and schedule control of a building project. [6] As shown in Figure 1, the digital expression of physical characteristics and functional characteristics of construction projects by BIM technology covers all stages of construction projects.

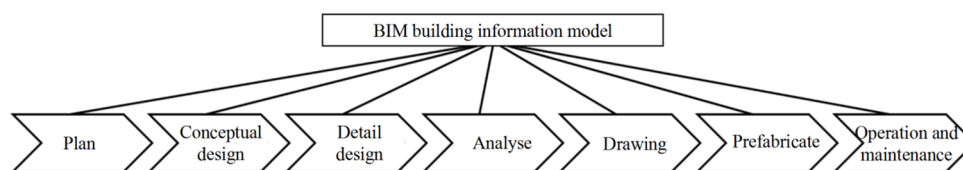


Figure 1: Application of BIM technology

BIM technology is obviously different from traditional architectural engineering design and management in practical application, which needs the support of a large number of computer application science and technology and software engineering. Under the BIM technology system, there are two parts: BIM platform and BIM tools. BIM platform tends to store, analyze, process and apply environmental data information of construction projects, while

BIM tools focus on the targeted solution of specific problems or the centralized display of some functions. At present, there are four common BIM software platforms: Autodesk, Bentley, Nemetschek Graphisoft and Gery Technology Dassault, and the platforms include design software, analysis and calculation software, engineering cost software and construction management software. (Yin, 2021) For the research object of this paper, virtual intelligence construction and design effect display mostly focus on the design stage, so Autodesk Revit is the main software selection.

2.2 VR technology

VR(Virtual Reality), that is, virtual reality technology. It aims to simulate and create a virtual environment through advanced computer application technology, network communication technology and graphic image processing technology, and support users to finish human-computer interaction through natural vision, hearing and touch, and finally give users feedback information similar to the real world, so as to obtain a relatively natural and real experience. [8] VR belongs to the frontier field of information technology, which brings together the research results of many disciplines and forms a unique technical system. As shown in Figure 2, it is a schematic diagram of virtual reality technology architecture. As the core of virtual reality technology, the simulation processor is mainly responsible for controlling human-computer interaction, the state and display effect of virtual scenes and objects. Rendering processor can transmit all kinds of feelings to users, while virtual database contains the main design content and auxiliary control program of virtual reality technology.

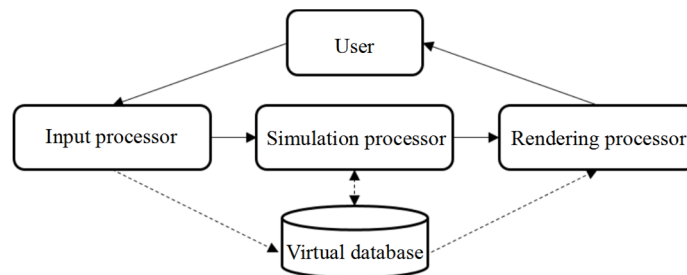


Figure 2: Virtual reality technology architecture

Virtual reality technology, with its unique immersion, interactivity and multi-perception, can be combined with practical application requirements. Through the steps of overall planning, data collection, material sorting, original modeling, scene dummy, interactive development, test release and so on, a virtual reality application system with computer system as the core and all hardware devices and software programs organically compatible is formed, which provides corresponding virtual reality services for many industries and fields.

2.3 Development process

According to the requirements of the above related application technologies, the configuration and deployment of the development environment of the building virtual intelligent construction simulation system are completed. The content of system development is divided into three parts. One is to complete the construction of building information model, the design of virtual simulation scene and the interactive function development of building model based

on Autodesk Revit, Unity 3D and other software. The second is to complete the design and development of front-end interactive interface based on Vue framework, and embed the files of virtual intelligence construction simulation system. The third is to complete the construction of the back-end Web Server in the Java language environment, and integrate and package all functional modules to form a standard Web application.

First of all, the virtual simulation design of building engineering mainly realizes the technical integration of BIM and VR, that is, the building information model under BIM is adapted to Unity 3D, which realizes the real-time embodiment and interaction of various data information and improves the user experience. The construction of BIM model will be completed in Autodesk Revit software according to AutoCad drawings, and the production content includes various types of architectural models and structural models, as shown in Figure 3, which is a comparative example of architectural models and structural models. When the BIM model is completed, FBX format will be selected for packaging and export, and such files will be introduced into Unity 3D.

Secondly, in Unity 3D software, the integration and assembly of models, the addition and optimization of dynamic effects, the construction of virtual scenes, the setting and processing of objects in the environment and the development of key interactive functions will be completed. The whole process will need a large number of functional components as support, such as the collision component (Collider) to detect whether there is a collision between moving objects, and it can also be used as an event trigger. The Emission, Shape and Renderer modules in the particle system respectively control how many particles are emitted, where they are emitted and their appearance, adding atomization effect to the model or scene and increasing dynamic special effects. [3] Among them, the design and development of interactive operation functions need to rely on a lot of script code writing. For example, users can independently change different perspectives to obtain different visual experiences when visiting indoors or outdoors in a building. The realization of this function requires Unity3D to define the MonoBehaviour event, that is, the user can control the rotation of the main camera by mouse or touch screen operation, and the key code is shown in Figure 4. After the script code is written, it is bound to the camera component in the virtual scene to complete the corresponding settings. After all the designs are completed, all the 3D data will be published to the Web by Unity 3D, that is, Unity3D will be selected and WebGL will be exported. After that project is exported, a specific file contain all the contents is generated.

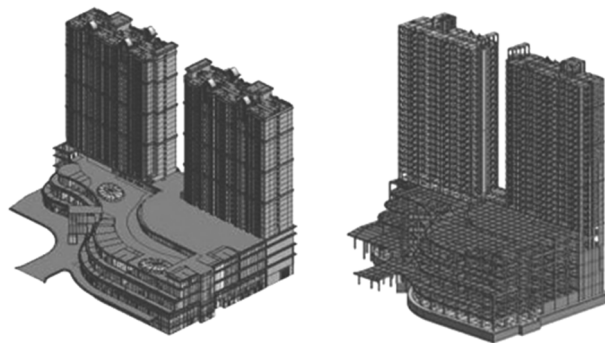


Figure 3: Comparison between architectural model and structural model under Revit software

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public class ThirdPCamC : MonoBehaviour {
    void Start () {
        thirdPCamAxe =
GameObject.FindGameObjectWithTag("3rdCameraAxe").transform;
        thirdPCamEuler = thirdPCamAxe.localEulerAngles;
        thirdPCam = Camera.main;    }
    void Update () {
        thirdPCamAxe.position = targetTrans.position;
        float mouseX = Input.GetAxis("Mouse X") * mouseSensitivity;
        float mouseY = Input.GetAxis("Mouse Y") * mouseSensitivity;
        thirdPCamEuler.y += mouseX;
        if (thirdPCamEuler.z <  && mouseY > ) { thirdPCamEuler.z += mouseY; }
        if (thirdPCamEuler.z > - && mouseY < ) { thirdPCamEuler.z += mouseY; }
        thirdPCamAxe.localEulerAngles = thirdPCamEuler;    }
}

```

Figure 4: User's independent conversion of visual angle function code

Finally, the exported specific files UnityLoader.js and *.json are embedded into the framework of Vue, and the interaction with the Web Server is realized by using two methods: SendMessage () and Application.ExternalCall (). For the construction of Web Server, Linux CentOS 7.7 is selected as the bottom operating system, Java is selected as the basic development environment, JDK version requires 1.8 and above, and IntelliJ IDEA Ultimate 2018 is selected as the Java development environment, Tomcat 8.5 is selected as the Web server, and MySQL 5.7 is used as the database server. In the process of building the overall development environment, Maven is used to manage the project structure, and the whole project is divided into several engineering modules. Based on SSM architecture, the integration of Spring-Spring MVC-MyBatis is completed. Through the introduction of the above key technical theories, the overall environment of system development, the configuration of related software and tools are determined, and the technical feasibility of the overall project of building virtual intelligence construction simulation system is also clarified.

3 DETAILED FUNCTION IMPLEMENTATION

3.1 Panoramic roaming

The system supports users, designers and constructors to log in and use the system through account registration and identity identification. Under the panoramic roaming function, users can make a comprehensive tour of the construction project through "naked-eye 3D". On the one hand, the realization of this function needs the support of Web3D visualization technology, on the other hand, it needs Unity3D to design and develop interactive functions. Thanks to the integration of the advantages of BIM and VR technology, users can not only feel the macro effect of architectural engineering in an immersive way, but also go deep into the room to have a more detailed experience of space layout, building materials, lighting and home decoration. At the same time, the system can also retrieve all kinds of BIM data information at any time, and view and mark it, which provides convenience for the communication and adjustment of architectural design schemes. [5] When using this function module, the builder can simulate the effect from different perspectives, different streamline directions and

different moving speeds, so as to strengthen the builder's grasp of architectural engineering design and improve the design quality.

3.2 Construction simulation

With the functional changes of modern architectural engineering, the architectural form is becoming more and more complex, and the construction difficulty is getting higher and higher. In addition, the construction process of architectural engineering involves many departments, personnel, equipment and materials, which easily leads to construction errors and production safety problems. When the builder logs into the system, under the construction simulation function, users can use VR to simulate all aspects of construction, predict the construction problems faced in the construction process in advance, and try various solutions through virtual construction simulation to improve the work efficiency of building construction. In addition, the virtual intelligent construction simulation can simulate the accident scene in the construction process, and the constructor can carry out safety education with the help of the system to reduce the accident rate, thus improving the management level of the whole construction project.

3.3 Data visualization analysis

In the system, users in three roles, namely, user, designer and constructor, all use the permission of this function. Under this function module, users can analyze and compare BIM data information according to their own needs. For example, when a user inquires about the floor area of a building project, the system will automatically list the BIM data area of each plot in the scene. At the same time, the system also supports users to call all kinds of statistical analysis algorithms to complete data processing, as shown in Table 1 for the floor area information of a residential district. As shown in Formula 1, it is a quick sort recursive formula, where p is the first place in the current array of all occupied areas, r is the last place, and q is a randomly selected distinguishing point. After array traversal, the value greater than q is placed on the left side and the value less than q is placed on the right side. After repeated operations of the algorithm formula, the array of occupied areas from large to small is obtained, and the sorting is completed. The time calculation formula of sorting operation is shown in Formula 2, and T stands for time complexity. [2]

Table 1: The floor area information of each building in a residential area

No.	Name	Number of plies	Design household	Floor area
1	3# residence, units 01, 02 and 03	32	128	1579.64m ²
2	7# Single family villa	3	1	337.56m ²
3	2-1, 2-2, 2-3 street shops	2	1	67.88m ²

$$F(x) = F(p \dots q - 1) + F(q + 1, r) \quad (1)$$

$$T(n) = 2(T/n) + n \quad (2)$$

When the operation is finished, the system can visually display the final data results. The realization of this function mainly depends on the Graph_Maker tool of Unity 3D, and it is convenient for Graph_Maker to obtain the corresponding data by presetting the data connection and calling interfaces in the database to complete the production of data charts. [4] As shown in Figure 5, it shows the floor area distribution of various types of buildings in a residential area.

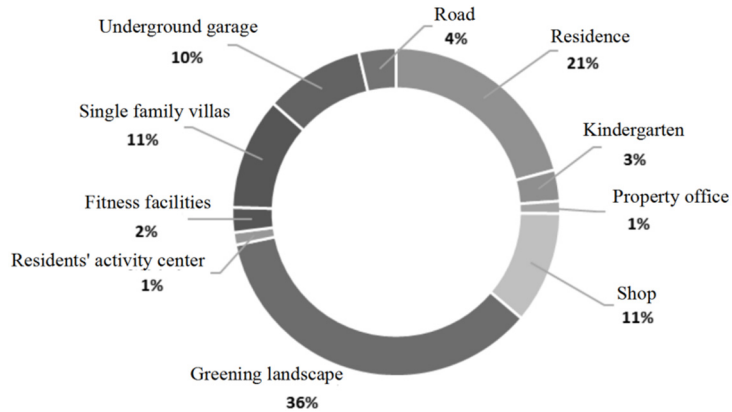


Figure 5: Distribution of floor area of various types of buildings

4 CONCLUSIONS

In order to improve the display effect of BIM data information model, this paper integrates the advantages of virtual reality technology, network information technology and computer application technology to build a Web-based building virtual intelligence construction simulation system. The system aims to realize the technical integration of BIM and VR, and carry out secondary design and processing on the three-dimensional information model of buildings, and introduce it into Unity 3D software to complete virtual construction and scene integration, thus forming an intelligent application program that supports users to complete design display, construction simulation, panoramic roaming and data visualization analysis. The system not only takes into account the diverse needs of users, designers and constructors, but also promotes the digitalization and intelligent upgrade of modern building technology.

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