Research of Intelligent Campus Design Based on Immersive BIM + VR Technology

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Abstract. With the maturity of virtual reality technology, more and more domestic colleges and universities have introduced virtual reality technology into the construction of the intelligent campus, establishing vivid and real three-dimensional virtual campuses, and achieving the goal of campus information, intelligence and visualization. This topic mainly studies the construction process of the smart campus based on BIM + VR technology. Taking the university buildings as the research area, the whole process from basic modeling to content innovation is discussed in detail. The VR smart campus is successfully established, and the innovative application of VR smart campus and campus sightseeing and VR fire simulation escape is realized.

1. Introduction
In the era of education informatization 2.0, with virtual reality, artificial intelligence, big data and other technologies as the core, it is vital to build a new type of smart campus and information campus and to solve the problem of insufficient integration of our country's higher education teaching and information technology and the construction of the safe campus and other new issues. We will promote the process of modernization and informatization of colleges and universities, improve the management level and efficiency, and realize the transition of university education from digital campus to intelligent campus in the context of the new era.

2. Overview of related technical theories

2.1 BIM technology
BIM technology is referred to as Building Information Modeling, and this technology has remarkable characteristics such as completeness, relevance and consistency[1]. According to the principles of self-management of buildings in the smart campus, combined with BIM technology modeling, engineering information, processes and resources at different stages in the whole life cycle of the project can be integrated into a model, so as to achieve scientific management and avoid problems such as a collision between pipe and ensemble.

2.2 VR technology
VR technology, namely virtual reality technology, is the integration of a variety of high-tech technology, which can stimulate people's hearing, vision, touch and other senses, giving people an immersive feeling. And at the same time, the participants can make a series of actions in real-time and accurate response. With the increasing maturity of VR technology, the technology has been widely used in education, training, construction, business, life and other aspects. The combination of BIM technology and VR technology has become an inevitable development.
2.3 Intelligent campus
Smart campus refers to the establishment of an intelligent learning environment with comprehensive perception and network collaboration, which is the further improvement and deepening of the construction of the digital campus[2]. BIM + VR technology is integrated into the construction of smart campus, three-dimensional modeling analysis is carried out by BIM technology in the early stage, and the virtual display of architectural information model is carried out in the later stage by VR technology. The three-dimensional virtual intelligent campus is established which is natural, dynamic and digital, to achieve the purpose of campus modernization and intelligence.

3. Intelligent campus design process of BIM + VR technology
This topic mainly studies the construction process of the smart campus based on BIM + VR technology. The preliminary study studies the results of BIM + VR technology in the design and research of smart campus system, clarifies the research direction and difficulties of the project, and establishes the overall research framework. Taking a certain university as the research area, the building group of the school is modeled based on BIM technology; as a virtual reality tool, Unity3D software develops the virtual campus system and interacts with scenes, and finally shows the interaction through the BIMVR display terminal. The flow of ideas for the overall design and research process of the smart campus is as follows:

![Diagram of BIM + VR Intelligent Campus Design Flow Chart](image.png)

4. Intelligent campus application of BIM + VR technology
This study takes the school complex as the research area and the gymnasium as an example relies on BIM technology, takes the essential modeling software Revit as the work platform. From elevation creation to model completion, a three-dimensional physical model is presented, showing the superiority of BIM technology. It provides basic guarantee and support for the establishment of a digital smart campus.

4.1 Building campus model based on BIM technology

4.1.1 Civil engineering part modeling. The first thing the refined model does in Revit is to draw the structural part of the gymnasium, including the foundation part, beams, structural columns and so on.
After the structural part of the stadium is finished, the civil portion is drawn. The civil sections include the placement of walls, floor slabs, ceilings, stairs, doors and windows, curtain walls, as well as the drawing of some special architectural models. When rendering the gymnasium building, the wall is drawn according to the axis net, then place the doors, windows and other components in sequence, and finally draw the floor slab. The gymnasium will be drawn in secondary order.

The architectural difficulties of sports hall comprise the drawing of stairs and curtain walls. There are so many staircases and curtain walls in the stadium that it takes plenty of time to paint. The staircases need to be modeled with lofting, and the curtain walls are restored and drawn according to the detail drawing with the curtain wall mesh in Revit.

![Civil model of gymnasium project](image)

**Figure 2. Civil model of gymnasium project**

### 4.1.2 Electromechanical part modeling

After the civil part of the stadium is accomplished, the mechanical and electrical part of the drawing begins. The electromechanical part mainly incorporates three major aspects: HVAC, water supply and sewage, and electrical engineering. The HVAC part is mainly the drawing of the air duct and the drawing of the fan coil unit. The illustration of various types of pipes for the water supply and sewage and the electrical aspect is the drawing of the strong and weak currents. The prime difficulties of the electromechanical part of the stadium are the placement of the Revit family and the intricate pipelines. Due to the high difficulty of the electromechanical part, it is necessary to achieve refinement, so each Revit family, each component and each pipeline should be relatively delicate.

After completion of the electromechanical part, the civil and electromechanical components are linked in Revit. When the link is completed, the collision analysis is conducted, and the collision place of the pipeline should be modified according to the principle of pipe comprehensive. That is to say, it is necessary to clarify the height of the structural beam, the distribution of the beams, the arrangement of the beam sockets according to the size, adjust the position of the electromechanical part of the width of the critical area, and priority to adjust the position of the HVAC, because the air duct part has the larger volume, which can be convenient later to adjust other systems.
4.1.3. Erection of steel structure. The steel structure of the gymnasium is drawn by Tekla steel structure design software, which can carry out a variety of structural modeling, including the drawing of beams, columns, plates, bolts and set a great diversity of changeable parameter values to facilitate modification and adjustment. Because of the large area of the gymnasium, there are a large number of steel structure grids on the top, which are composed of steel frames and fulcrums, so the project volume is relatively large.

The roof of the gymnasium is a bolt-sphere joint grid structure, a square quadrangular pyramid system, supported by the upper chord of the circular column points, and the projected area of the grid is 3,492 square meters. The steel structure on the top of the tennis hall and badminton hall in the gymnasium was drawn by Tekla software, a total of more than 5,000 steel beams, load-bearing steel beams more than a thousand. In the meantime, multi-directional design, measurement, analysis and production of nodes are carried out according to the detailed drawing of steel structure, which restores the authenticity of the model to a great extent, ensures the integrity of the model and guarantees the safety and feasibility of the building.

4.2 Integration and rendering of BIM models

4.2.1 Integration of models. The school building complex covers multiple teaching buildings, laboratory buildings, administration buildings, college student activity centers, gymnasiums, chemical engineering buildings and other buildings. After the buildings are drawn separately, the models are bound and integrated with Revit software.

The BIM modeler opens the stadium model in Revit and clicks the Draw Venue option to draw the real site. After checking correctly, click on the Link Model in the taskbar. First, import the model of the College Student Activity Center, put the whole model into its location in the field, and then click the Unbind option. The other buildings are also linked in accordance with the steps above, placing them in the correct position, from which the entire school building community is mapped.

4.2.2 Rendering of the model. Fuzor is an all-purpose software based on BIM, which has the advantages of simple interface, convenient use and flexible operation. It can be used as a VR plug-in on Revit to provide users with real-time virtual reality scenes while supporting real-time rendering and animation roaming of BIM models.

The model built in Revit was imported into Fuzor for rendering, and the rendered project was extremely lifelike. Then users can experience the VR effect through Fuzor, which realizes the roaming function of wearing VR devices, and roaming experience can also be carried out on the mobile terminal.
4.3 Application of fire simulation and escape based on VR technology
VR technology is highly maneuverable. The combination of BIM technology, Unity3D and VR technology enables the smart campus system to simulate the fire scene more realistically, which is conducive to enhancing students' interest and enabling students to understand the importance of standard escape actions and knowledge of fire prevention according to fire escape drills in a relaxed environment[3].

4.3.1 The selection of the system. In order to make the effect of the flame more realistic, we use the particle system to simulate the burning flame phenomenon when a fire occurs, the generated flame is more realistic and vivid, and the simulation effect is more authentic. The generated flame is more realistic and vivid, and the simulation effect is more authentic. The flame yielded by the particle system is the crux to simulate the occurrence of fire. In addition, the power supply is turned off and the fire extinguisher is picked up by the handle to simulate the process of a fire.

4.3.2 The establishment process of fire simulation
- Import the rendered BIM model into a suitable location in Unity3D, like a plugin a fire-prone circuit, or at the curtains where a fire is caused by tinder such as cigarette butts.
- Select the fire extinguisher model in the imported rendering model, select "Interactive-Replace Material" in the menu bar, the material properties appear in the property bar, enter the material panel title in the material properties, select the color, and replace the colors with red and green.
- Select the fire extinguisher, open the menu bar interactive-define pop-up window-text, you can set different pop-up positions in the property bar, enter text in the text content of the property bar, red is a dry powder fire extinguisher and green is a foam fire extinguisher, you can complete the pop-up text Interactive settings, after packaging and uploading, click in BIMVR to display text.
- The handle is operated to pick up the fire extinguisher. When encountering a flame, click on the trigger and the fire extinguisher will spray gas to extinguish the fire.
- When setting the escape path, select the imported character model, select Interaction—Define the movement path in the menu bar. The default object in the movement path properties of the property bar does not have a model. You need to drag the character model node to element 0 position to complete the object's designation.

4.3.3 Browsing of VR scenes. The completed virtual model scene needs to be opened in BIMVR2019, it cooperates with VR head-mounted display products to achieve an immersive experience of escape scenes through VR glasses and handles[4].
- When a fire occurs, the experiencer needs to choose the type of fire extinguisher by judging the size and kind of the fire. When the experiencer begins to interact, the initial model of the fire extinguisher is first clicked through the handle, and a text interaction is ejected indicating the type of fire extinguisher, and then the correct type of fire extinguisher is selected by interacting again to put out the fire. Until the flame particle is 0, the experience of fire fighting is over.
• When a fire is violent, the experiencer determines that it is not possible to extinguish the fire with a fire extinguisher on its own, click on the character model with the handle to interact with the escape path, at which point the character model will follow the predetermined safe route to escape.

In recent years, fire incidents in major colleges and universities in our country have gradually increased. Due to the large population flow on campus, the importance of fire education in colleges and universities has been highlighted. For the fire escape simulation of colleges and universities, the aim is to enable students to fully immerse themselves in the virtual campus environment created to perceive the real fire environment, through immersive experience to train fire escape skills, so that students really feel the threat and harm of fire[5]. This will increase public fire escape education and provide support for building a strong campus security line and improving the construction of a safe campus.

5. Conclusion
In today’s era of big data, the construction of smart campus conforms to the times and the overall situation of the national development strategy, which is beneficial to boosting the informatization, intelligence and sustainable development of universities, and promoting the progress of China’s education. This research uses BIM + VR technology to create a three-dimensional digital smart campus and realizes the integration of the overall modeling of the campus and VR technology, which promotes the construction of education information to a certain extent, and provides more convenient and more user-friendly services such as teaching activities, safety education, daily management and other aspects for the teachers and students of the whole school. China will realize the leap from education information 1.0 to 2.0!

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References
[1] Han C and Zhang Y and Guo Z L J 2018 Talk about the application of BIM in equipment upside down lifting vol Z1, (Beijing: Construction & Design for Project) pp 139-141
[2] Hao Y E and Zeng D H J 2014 The application and prospect of virtual reality (VR) technology in the construction of digital campus vol 5, (Beijing: Electronic test) pp 136-137
[3] Wang K B and Tao Z Q and Zhu J H and Su X H and Han Y J 2018 VR fire simulation escape simulation system vol 22, (Hei Longjiang:Science and Technology innovation) p64
[4] Chen L L and Su Y J and Wang Z and Ma T G J 2019 Unity3D is used to solve the problems and prospects of evacuation simulation vol 4, (Tianjin: Fire Science and Technology) pp 485-489
[5] Zhang J Z 2009 J Research on Fire Emergency System of High-rise Buildings Based on Virtual Reality Technology vol 23, (Hei Longjiang: Surveying and Spatial Geographic Information) pp 88-90