Application of BIM + VR Technology in Immersed Tunnel Construction

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Abstract. As an important way to relieve the traffic pressure across rivers, immersed tunnel engineering has been gradually promoted. This paper introduces building information modeling and virtual reality technology into immersed tunnel engineering, analyzes its technical characteristics and advantages, expounds the application of BIM + VR technology in immersed tunnel engineering, and carries out practice in immersed tunnel engineering of Shenzhen-Zhongshan Bridge, which verifies the superiority and efficiency of the method.

1. Introduction

Urban traffic congestion has become an increasingly serious social problem, especially the traffic condition of the river crossing part is more severe, which often becomes the bottleneck affecting the smooth urban traffic. In order to solve this problem, all regions will strengthen the construction of cross river channel as an important part of traffic infrastructure construction, in order to alleviate the urban traffic pressure. As an important form of river crossing channel, immersed tunnel has the advantages of less land occupation, less navigation impact and fast construction speed. With the continuous maturity of its construction technology, the construction scale is becoming larger and larger, and the construction conditions are becoming more and more complex. Its requirements for survey and location service are also higher and higher, and the demand is also increasing. At present, in the construction of immersed tunnel engineering, especially in the docking, floating, docking and other key nodes, more sensors, artificial discrimination and two-dimensional sensor signal display tools are used for construction design and command. It is urgent to make full use of scientific and technological innovation and technological progress to improve quality and efficiency.

BIM (Building Information Modeling) Technology and VR (Virtual reality) technology are used to realize the visualization, refinement and intellectualization of immersed tunnel construction. Through the construction of three-dimensional engineering scene, the fine display of the function structure of immersed tunnel pipe section is supported, so that the construction commanders can immerse themselves in the virtual environment generated by computer in real time, and carry out the design drill, real-time construction situation and real-time construction plan of the real construction site Construction playback discussion can quickly and accurately simulate and monitor project related construction information on VR equipment, so as to effectively improve the accuracy and intuition of project implementation. In the application of Bim and VR technology integration, certain application research has been carried out at home and abroad, which has been verified in the design, construction,
operation and maintenance of road, subway, large-scale building and bridge engineering, making the engineering construction more specific, accurate and interactive. Due to the characteristics of underwater engineering, there are few related application cases [1-4]. By introducing BIM model into the floating and docking work of immersed tunnel, we can make full use of the terrain, geomorphology and hydrometeorological data of the floating route of GIS in the floating process of pipe section, and make more use of the high-precision pipe section 3D model of BIM in the docking stage of pipe section. Through the organic integration of GIS and BIM, we can give full play to their different scene scales based on their respective advantages, the multi-level construction management of immersed tunnel construction process can be realized by means of information technology. VR technology can make up for the defect that BIM lacks the combination with the actual environment in construction management, and realize the ingenious combination of virtual model and real environment. The joint application of BIM and VR in the project can not only make the construction management personnel have a "real sense of participation" in the environment to be constructed, but also help them to make correct and reasonable decisions. Moreover, the timely feedback of on-site information can continuously optimize the construction scheme, continuously improve the construction technology, and make forward-looking analysis of the project construction. It plays an important role in dealing with problems on site [1-3].

2. Technical design of auxiliary system for immersed tunnel construction based on BIM and VR

The combination of BIM and VR to support engineering application is a new application direction at present. It makes full use of BIM's high-precision and high information model structure, combines with computer simulation to produce a virtual world of three-dimensional space, and provides users with visual, auditory and other sensory simulation, so that users can get personal experience and observe things in three-dimensional space in time and at will [3-5].

The construction assistant system of Immersed Tunnel based on BIM and VR takes advanced computer 3D technology as the core, adopts virtual reality technology and augmented reality technology, combines extensible markup language (XML) technology, file processing technology, database technology and other related technologies, and comprehensively realizes the functions required by the system by adopting original extensible design mode; the system is based on 3D extensible technology Visual platform, for the application scenarios of docking, floating and docking of immersed tunnel, establishes a series of functional applications, including virtual roaming, network communication, construction simulation, real-time construction display, buoyancy warning, anchor cable tension warning and angle deviation warning.

For the auxiliary system of immersed tunnel construction, the implementation tools of this system mainly include modeling software, using 3ds max2014, Revit, SketchUp software; the main development language is Java Script or C#; the data storage mode adopts the storage form of external data files (XML, Oracle database), the development tool adopts unity3d5.5.0, and the system technology is realized from the aspects of BIM modeling, virtual reality scene construction, BIM + VR visual expression and system implementation. BIM modeling

The object of BIM modeling is immersed tunnel block, buried end and ancillary engineering equipment. BIM model is mainly based on the Revit platform to create the central file and working set by specialty. According to the design requirements, engineering entity properties, material properties, the project to be constructed is given to the model, and the visual model of building, structure, mechanical and electrical integration with full information coverage is established, which is synchronized to the fuzor management platform for verification and summary.

2.1. Virtual reality scene construction

The objects of virtual reality scene construction include general buildings, underwater terrain, water surface, tugboat and so on. Underwater topography is the focus of immersed tunnel engineering. With the help of GIS software and 3D MAX software, the high-precision and multi-level underwater three-dimensional terrain is established by using multi beam equipment to scan the data of water depth point cloud, constructing TIN model, using depth information rendering, baking mapping and other methods, as shown in Figure 1. The water terrain is constructed in the form of digital elevation model data and
high-definition image mapping. For general buildings, tugboats and other scene objects, SketchUp and 3DMAX are combined to build a highly restored 3D Engineering scene.

2.2. BIM + VR visual expression
In terms of 3D information model construction and scene visualization, the 3D application platform of immersed tunnel engineering reconstructs and transforms the model data of existing BIM road design software into 3D entity by using fast automatic network construction, UV optimized coordinate system generation technology and hierarchical optimization technology of image and model. Relying on the real-time rendering technology, light and shadow tracking system and global illumination real-time computing scene light source, the sampling rate of light source and the quality of rendering calculation are improved, and the reality of the scene is rapidly improved. Water efficiency, immersed tunnel, index information, underwater Hill shading and scene switching are the key elements in immersed tunnel engineering.

(1) Water surface effect
In the underwater engineering construction, due to the turbidity of the water body in the construction area, the actual construction process depends on various sensor indicators, and the construction process is not concrete. Through the development of water wave, perspective refraction, reflection and other effects, the visual expression of translucent water effect under sunlight is realized, as shown in Figure 2. The integration of construction scene, water surface effect and refined underwater terrain makes underwater construction clear at a glance.
(2) Flow visualization
The current hydrological situation is displayed in the form of vector arrow by preloading the hydrological data such as velocity and flow direction in the construction area obtained by numerical simulation. In order to avoid too messy hydrological information and distract the attention of the field personnel, the hydrological information is displayed in three levels according to the distance from the viewpoint, and combined with the true three-dimensional arrow and water effect, the three-dimensional visualization of different flow velocity and direction is realized, as shown in Figure 3.

Figure 2. Translucent water surface effect

Figure 3. Visualization of true 3D arrow of water flow velocity and direction

(3) Model display of main features in project area
The visualization of ground objects in the surrounding area of immersed tunnel project is an important component of 3D simulation scene, especially the landmark buildings along the floating transportation process of the pipe section, which can fully improve the expressiveness of the scene and bring the operator the feeling of being on the scene. Through the fine modeling, model simplification, 3D model slicing and other processing of the main buildings, terrain, greening, sketches in the immersed tunnel engineering area, the 3D simulation scene of immersed tunnel engineering is improved.

(4) Scene visualization scheduling by layers and levels
The system is designed for the docking, floating and docking stages of immersed tunnel construction. In the stage of floating transportation, the pipe segments are transported from the pipe segment prefabrication area or the storage area to the construction site, which needs to be visualized in a relatively macro large scene. More attention should be paid to the macro large-scale long-distance transportation scene, as shown in Figure 4, but less attention should be paid to the high-precision water
surface effects that consume GPU resources and physical interaction engine. In the docking and docking stage, the pipe joint needs to show the spatial relative relationship between its own structural details and the surrounding ground objects in the refined scene, such as sinking pipe fixed pile, docking buckle, Jack, positioning tower, as shown in Figure 5, but it does not pay much attention to the long-distance landscape and special effects. In the process of 3D scene model data production, the ground object type and spatial scale are divided into layers; the system carries out hierarchical visual scheduling of 3D scene model and special effects according to the relative relationship of layer type, visual distance of viewpoint and visual distance of elevation, taking into account the requirements of macro and high-precision underwater engineering construction.

3. Application of immersed tunnel engineering
Based on Unity3D engine, we independently developed a three-dimensional visualization application platform for the application scenarios of the docking, floating and docking stages of immersed tunnel. By laying relevant sensor equipment on the immersed tunnel equipment, we can monitor the spatial position, posture, river tide level, flow direction and other information of the pipe joint in real time, and support the smooth development of BIM model results and 3D MAX model results of immersed tunnel engineering 3D visualization display, supporting virtual roaming, network communication,
construction simulation, real-time construction display, construction playback, buoyancy warning, anchor cable tension warning, angle deviation warning.

(1) Construction simulation and real time display
Before the actual construction of immersed tunnel pipe joints in the stages of docking, floating and docking, it is necessary to carry out relevant construction design drills to identify the safety risks in the construction process and study the relevant disposal plans. The system provides the application of construction simulation, and the construction personnel can configure the scene parameters such as the construction plan axis, safety warning line, tide level, flow velocity and direction, so as to dynamically simulate the construction process in the three-dimensional simulation scene.

In the process of construction, the real-time monitoring data of sensors are obtained through a variety of network communication, and the data are calculated and adjusted. The construction process and index information are displayed dynamically in real time in the three-dimensional simulation scene, and the relevant construction progress is reported intuitively and real-time to the construction personnel, commanders and other engineering personnel. In the process of construction, the risk information concerned by the construction party is calculated, and the key risk information such as heeling, trim, head and tail offset, height difference, anchor cable tension and buoyancy are updated in real time and the threshold alarm is given, so as to avoid the safety risk in the construction process. See Figure 6.

(2) Immersed tube Transportation Exhibition
In the undocking and floating transportation stage of immersed tunnel pipe joints, the three-dimensional simulation scene is mainly displayed for the macroscopic transportation scene: the position relationship between the integrated ship and the channel, the speed and course, the velocity and direction, the wind speed and direction, the distance from the next turning point, the distance from the mooring point, the axis deviation between the integrated ship and the channel, the deviation trend of the integrated ship, the yaw angle, the design course of the current channel center line, and the navigation direction Thumbnails, for use by commanders and operators. In the process of operation, the measurement and control personnel monitor the positioning data, communication, data checking, system operation status of the system in real time, report the system failure to the commander in time, and do the corresponding emergency treatment. As shown in Figure 7, the immersed tube is fixed with the auxiliary transport vessel for floating transportation through the towing rope.
(3) Immersed tube docking Exhibition
In the pipe joint docking stage of immersed tunnel, the system has a variety of built-in calculation modes to support common real-time positioning measurement methods for pipe joint sinking, such as total station method, RTK-GPS method, sonar method, mechanical method and the combination method formed by these methods. In the docking process, the fine model of the immersed tube changes the spatial position and posture according to the real-time analysis and adjustment of the sensor data, as shown in Figure 8. According to the index feedback, the measurement and control personnel timely adjust the indexes of the hanging cable, traction cable, ballast water and other equipment systems, so as to realize the accurate Underwater Docking of the immersed tube.

4. Conclusion
In this paper, the self-developed three-dimensional application platform of immersed tunnel engineering is applied, BIM + VR technology is applied in immersed tunnel engineering, BIM modeling is carried out by using the design software of Revit BIM, 3D scene modeling is carried out by using 3DMAX and other software, and the concrete effect of BIM model and components is
realized based on virtual reality engine technology, so that BIM model can be used in the engineering application environment with VR immersive experience, perfect integration. Based on unity3d engine, the 3D application platform is constructed, and the 3D data is imported into the 3D application platform to realize the 3D real scene visualization of immersed tunnel engineering. A series of functional applications, including virtual roaming, network communication, construction simulation, real-time construction display, buoyancy warning and anchor cable tension, are designed and implemented for the application scenarios of the docking, floating and docking stages of immersed tunnel Warning, angle deviation warning. The immersion experience makes the three-dimensional dynamic display of docking, floating, docking and other key nodes more intuitive, the overall effect is more beautiful, and the efficiency of construction scheme research is significantly improved.

In this paper, BIM + VR technology is introduced into the immersed tunnel engineering. Facing the specific construction process of the immersed tunnel, such as docking, floating transportation, docking and so on, the specific technical implementation mode is explored, and the advantages and efficiency of the method are verified by the practice in the immersed tunnel engineering of the deep channel. In the future practice of immersed tunnel engineering, we will continue to make efforts to improve BIM + VR technology, continue to further apply and promote in this field, and constantly summarize important experience for exploring the development of BIM + VR technology in the future.

5. References

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