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Application of 3D Virtual Digital Visualization Technology in the Simulation and Modeling of Cross-Sea Network Engineering

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ABSTRACT

This paper analyzes the importance of cross-sea interconnection projects and delves into the application of 3D virtual digital visualization technology in the simulation of these projects. The system employs OpenGL technology to render 3D images and supports environmental configuration through dynamic link libraries. The internal design of the system is clear, featuring functionalities such as multi-scene dynamic focusing, multi-data port linkage, BIM information display, event tracing, and process simulation. Compared with traditional construction techniques, 3D virtual visualization technology exhibits significant advantages in graphic rendering, scheme selection, collaboration, and construction methods. The research presented in this paper provides valuable references for optimizing cross-sea interconnection projects and other major infrastructure constructions, demonstrating the immense potential of 3D virtual visualization technology in enhancing construction efficiency and reliability.

KEYWORDS

3D Virtual, Digital Visualization, Cross-Sea Network Engineering, Applied Simulation and Modelling

INTRODUCTION

Cross-sea network engineering, through the construction of cross-sea bridges and submarine cables, can effectively overcome geographical boundaries and strengthen transportation and power network connections between regions (Liu et al., 2023). This not only promotes the optimal allocation of resources but also drives industrial development and economic prosperity in the regions along the route. Cross-sea bridges are a crucial component of cross-sea network engineering (Zhang, 2021). The construction of these bridges not only overcomes challenges, such as harsh natural environments and high construction difficulty, but also shortens construction time and improves project quality through technological and management innovations. Submarine cable power transmission is another key component of cross-sea network engineering (Wang et al., 2021). It transmits electricity from the mainland to islands or across straits through submarine cables, achieving long-distance power transmission and supply. Submarine cable power transmission projects are characterized by high costs and complex construction and maintenance, which impose high demands on safety and reliability (Chen et al., 2023). Cross-sea network engineering plays a significant role in promoting regional economic

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integration, improving infrastructure levels, and driving technological advancement, making it the focus of this study. Despite the many benefits brought by cross-sea network engineering, there are also numerous challenges faced during its construction. For example, the construction of cross-sea bridges needs to overcome challenges, such as harsh natural environments and high construction difficulty, while submarine cable power transmission projects must address technical issues related to cable design, manufacturing, and construction (Li et al., 2022). As shown in Table 1, it is not uncommon for major cross-sea network projects to face delays exceeding one year. In recent years, the application of 3D virtual digital visualization technology in engineering has provided new solutions and methods for overcoming environmental and technical challenges (Sidani et al., 2021). At the same time, 3D virtual digital visualization technology is used to address practical problems in cross-sea network engineering, optimize project management, and enhance project quality, while also promoting technological innovation and the establishment of industry standards.

Table 1. Examples of construction delays in our country's cross-sea projects

Number	Project	Quantities of Work (km)	Projected Construction Timeline (year)	Completion Timeline
1	Hangzhou Bay Cross-Sea Bridge	36	2003–2007	2008
2	Jiaozhou Bay Cross-Sea Bridge	35.4	2007–2010	2011
3	Jia-Shou Cross-Sea Bridge	10.14	2008–2012	2013
4	Pingtan Strait Road-Rail Bridge	11.15	2014–2018	2020

LITERATURE REVIEW

In recent years, 3D visualization technology has become increasingly widespread in the field of construction engineering, bringing revolutionary changes to project planning, design, construction, and management (Safikhani et al., 2022). The use of three-dimensional virtual digital visualization technology transforms data or information into 3D visual models, allowing users to create virtual 3D environments or objects through computer graphics methods, enabling better understanding, analysis, and presentation of the data. Users can interact with the virtual environment through input devices, such as a mouse, keyboard, or gesture recognition, and immersive experiences can be provided using head-mounted displays or stereoscopic glasses. This technology creates 3D models, making the design, construction, and management processes of construction projects more intuitive, efficient, and precise. Currently, domestic research and application of 3D visualization technology are particularly prominent. Through building information modeling (BIM) technology, 3D mining models can be quickly constructed, providing technical support and assurance for mining operations. Additionally, BIM technology is widely used in the 3D visualization research of underground pipelines, effectively detecting collision issues between pipelines and between pipelines and underground facilities, thus improving the rationality of design and construction (Xu, 2021). In the fields of sponge city construction and geotechnical investigation, BIM technology also plays an important role. It establishes 3D visualization models to achieve comprehensive management of sponge city lifecycle data and provides 3D visualization of geotechnical investigation results. The application history of 3D visualization technology is longer abroad. As early as the 1970s, Western countries began using 3D visualization technology in engineering and applying it to construction plan optimization (Lin & Golparvar-Fard, 2020). The implementation process of 3D visualization technology includes acquiring spatial data, building spatial data models, and achieving 3D data visualization. The application fields of 3D visualization technology are also very broad, covering urban landscapes, education, underground urban spaces, and more. Foreign researchers have utilized modeling software, such as