Research on Digital Twin System of Stereo Warehouse based on WebGL

Jiankai Yan[1,2], Yuming Qi[1,2]

[1] Robot and Intelligent Equipment Research Institute of Tianjin University of Technology and Education, Tianjin 300222, China

[2] Tianjin Enterprise Key Laboratory of Intelligent Robot Technology and Application, Tianjin 300350, China

Abstract

With the great development of industrial IoT and computer technology, the human-computer interaction of IoT front-end webpage shows a 3D trend. Synchronized digital replica twinning of equipment such as stereo warehouses through 3D models of web pages can realize full-cycle synchronized monitoring, analysis and prediction of the production process. Based on Three.js, node.js, ajax and other Javascript web programming technologies to build a digital twin system for intelligent three-dimensional warehouses.

Keywords

Digital Twin; Virtual-real Interaction; WebGL.

1. Introduction

With the continuous progress of science and technology, digital transformation and intelligent upgrading have become increasingly urgent for the interaction and integration of the physical world and the virtual world. People hope to promote the interaction and integration of virtual and real space with the help of scientific and technological innovation, and realize the mutual benefit and win-win of human wisdom and social development. In this context, digital twins emerge as the times require, injecting new vitality into the interaction and fusion of virtual and real space[1]. Digital twins are composed of physical entities, digital twins, digital twin data, services, and connections and interactions between the above four parts[2]. Based on connection and interaction, digital-analog-driven digital twin can describe the attribute characteristics of physical entities, analyze the behavior rules of physical entities, predict the future state of physical entities, and then realize functional services such as state monitoring, operation maintenance, and decision optimization of physical entities[3],[4]. Through the interactive iteration of virtual and real information, the physical space and virtual space are enriched, integrated and perfected with each other, and finally the virtual and real symbiosis[5] and digital and analog co-prosperity are realized. Most of the current digital twin research direction mainly focuses on efficient algorithms and parallel computing methods to speed up the operation of digital twins, deep learning to make the digital twin system more intelligent, and edge computing and the Internet to improve security and privacy protection, etc., and there is little research on the interaction between the digital twin system and the user and the improvement of development efficiency.

In this paper, we model the three-dimensional warehouse by Three.js under the WebGL platform to improve the functionality of user interaction and the development efficiency of the digital twin system.

2. Traditional Digital Twins

Digital twin refers to the creation of a virtual model of an entity or system that corresponds to a real-world entity or system through digital technology. It is done by collecting various data about the entity or system and using computer simulation and analysis techniques to construct an accurate virtual copy. Digital twins can be used in a variety of fields, including industrial manufacturing, urban planning, healthcare, and more.

Traditional digital twins are based on computer-aided design (CAD) software or proprietary modeling and simulation tools. They use sophisticated 3D modeling techniques and physical simulation algorithms to create virtual physical objects and environments and display these virtual objects and environments through visual interfaces or outputs for understanding, analysis, and decision support of physical systems.

The digital twin system based on three.js can provide more realistic and accurate visualization. It utilizes advanced rendering techniques and graphical effects that can better reproduce the real physical environment and provide a more realistic feeling virtual experience. Compared to traditional systems, the three.js-based digital twin is implemented using Web technology, eliminating the need to install additional software or plug-ins. This allows the system to be accessed across platforms and devices, providing wider accessibility to users through their browsers. In addition, JavaScript and three.js-based digital twins are less expensive to develop, and this approach to development is also more flexible, allowing systems to be built and iterated on quickly, increasing development efficiency.

In summary, the digital twin system built based on three.js improves the shortcomings of the traditional digital twin system in terms of visualization effect, real-time interaction, cross-platform accessibility, as well as development cost and flexibility, making it more suitable for realizing realism, ease of use and practicality.

3. Warehouse Modeling and Environment Setup

3.1 Part and Overall Modelling

This topic with the help of three-dimensional warehouse to build a digital twin platform, in the use of SolidWorks software on the three-dimensional warehouse modeling before, first of all to determine the size of the warehouse, the layout and automation process. Then in SolidWorks software to create parts, assembly of the whole, the following figure for the three-dimensional warehouse part of the model diagram:
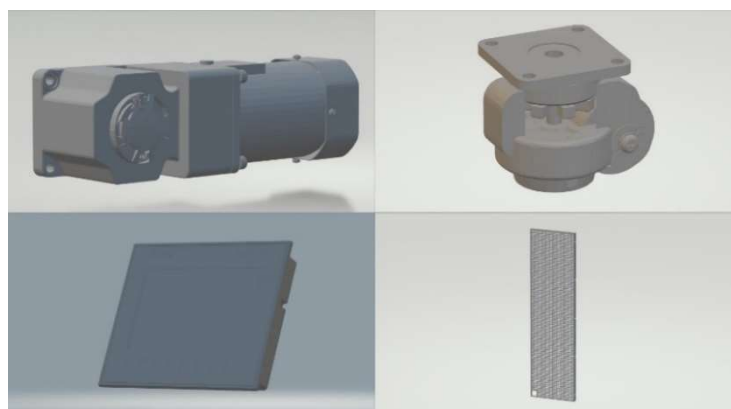

Fig. 1 Cubic Warehouse Parts Model Drawing

After completing the overall modeling of the three-dimensional warehouse, add model-dependent part attributes, features, constraints, and expression processes to improve the readability of the model,

so that it is closer to the actual use of the application scenarios. The following figure shows the overall model of the three-dimensional warehouse:
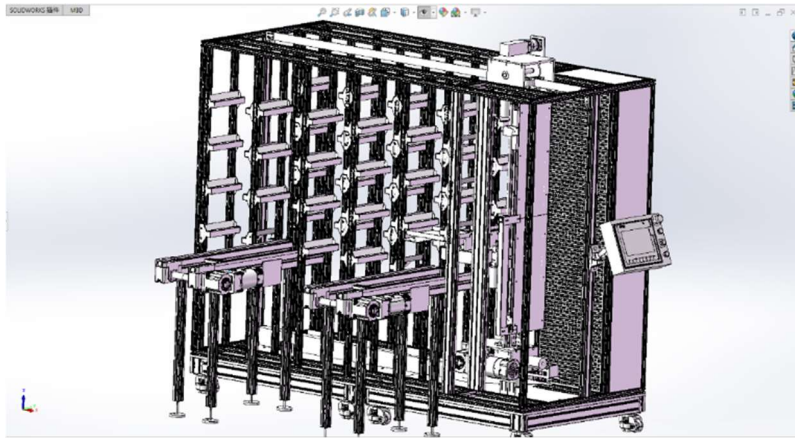

Fig. 2 Overall model diagram of the three-dimensional warehouse

3.2 WebGL Environment Setup

In this paper, we use WebGL to construct 3D models of web pages and build a digital twin platform. WebGL is a web drawing protocol based on OpenGLES2.0, which uses HTML5Canvas elements as rendering targets.

When modeling with Three.js, setting up the environment includes creating the scene, camera, and renderer, as well as setting up lighting and adding other necessary elements. Next the renderer object is created and attached to a container element in the HTML document and the dimensions of the renderer are set to provide the appropriate lighting effects by adding a light source such as AmbientLight, DirectionalLight or PointLight. Other elements such as ground, background texture, etc. can be added as required. Finally, the scene and camera are rendered to the screen using the renderer's render method in the animation loop, and animated by updating the model's properties. The following image shows the created scene:
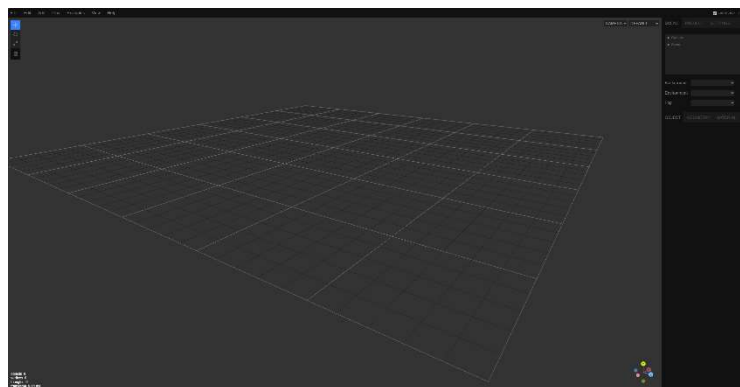

Fig. 3 Three.js scenario

3.3 SolidWorks Model Import

Lotka-Volterra model is a dynamic system model describing the interaction between predator and prey. It can be used to explain the periodic changes in the populations of prey and predators in some cases. and is suitable for solving the complex dynamic balance relationship between the two. Combined with the digital twin environment of this paper, three assumptions are given for the mathematical model:
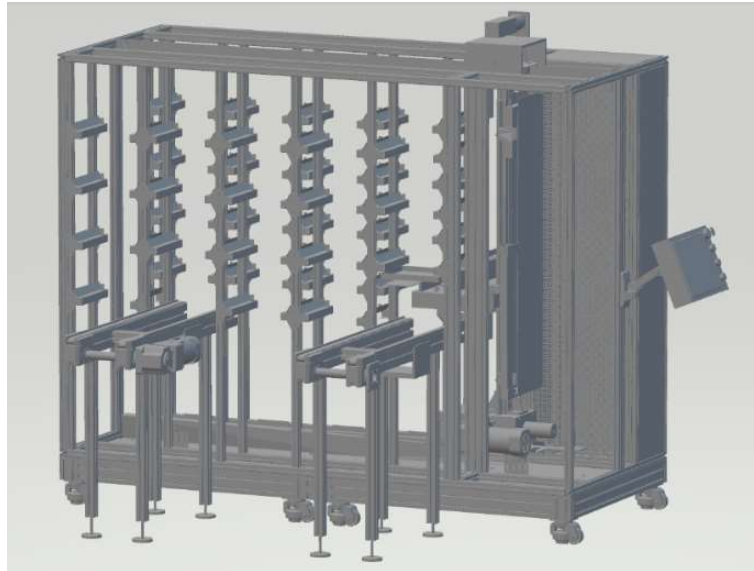
Fig. 4 Stereo warehouse model in GLTF format

4. Establishing Data Interactions

WebGL is the drawing standard of 3D graphics on the web page, which cannot be directly connected with external data such as sensors and PLC. The three-dimensional warehouse is equipped with corresponding warehouse management software (MES system), in which the MES system communicates with the three-dimensional warehouse PLC using Modbus protocol, so as to give instructions to the PLC, and the PLC also feeds back the sensor signal to the MES system. Therefore, the method adopted in this paper is to build a MySQL database, read the information of the warehouse in real time from the warehouse management software supporting the three-dimensional warehouse, and then read the MySQL database through the Node.js plug-in in WebGL, so as to complete the data interaction between the virtual model and the warehouse entity. The following figure shows the technical route of data interaction.
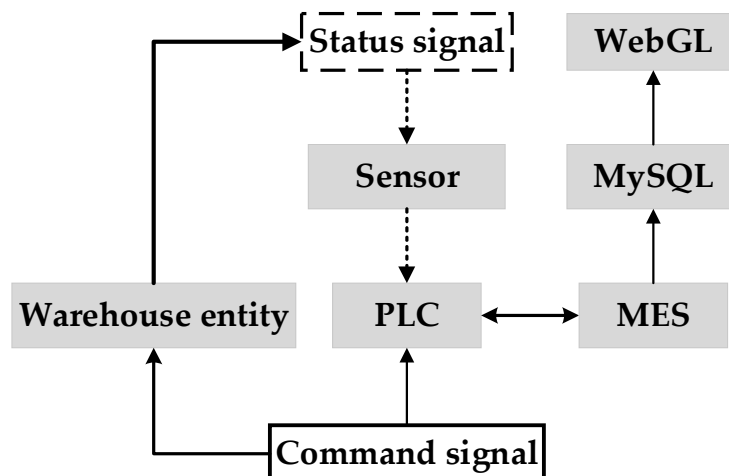

Fig. 5 Data interaction technology route

Three-dimensional warehouse management software will summarize the warehouse information to the management page, easy to later upload to the MySQL database for WebGL read signal. The following figure shows the interface diagram of the three-dimensional warehouse management software.
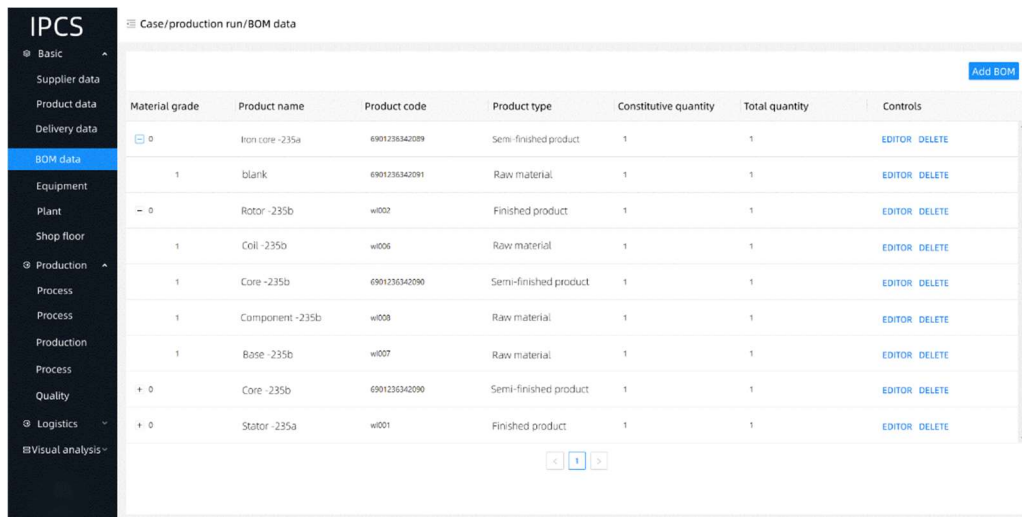
Fig. 6 Stereo Warehouse Management Software Interface

Build MySQL database, set MySQL user name, password, port number and other basic information. And through the 'Navicat' database visualization tool, against the stereo warehouse management software to read the information, run the "CREATEDATABASE storehouse;" statement to create a database named storehouse, and then corresponding to the information read by the management software to create the required table. Then create the required tables according to the information read by the management software. The following figure shows the MySQL database interface under Navicat.
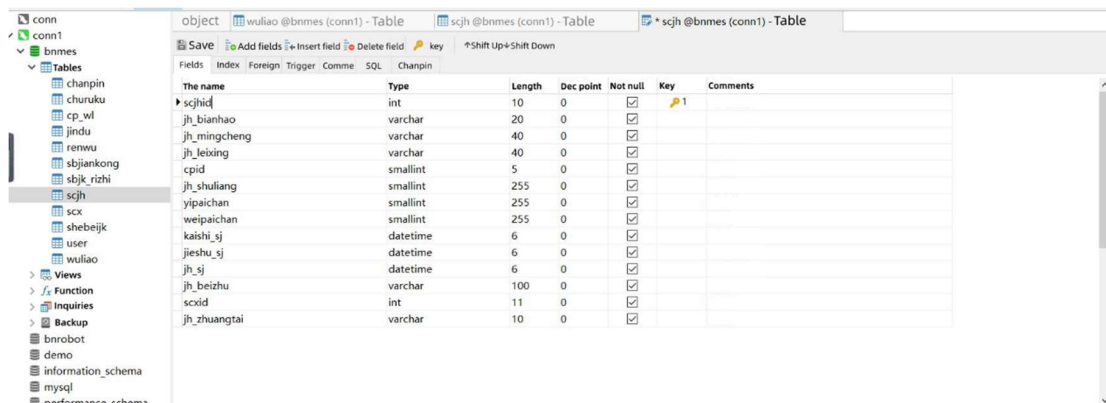

Fig. 7 Stereo Warehouse Management Software Interface

Install the MySQL module in WebGL via Node.js using the 'npm install MySQL' command, and connect to the database by setting connection parameters such as host, user, and password through the code after the successful installation, thus realizing the communication between the warehouse entity and the Three.js model communication.

5. Conclusion

This paper presents a WebGL-based digital twin system for three-dimensional warehouses, aiming at digital replication and full-cycle synchronized monitoring of three-dimensional warehouse equipment by exploiting the trend of industrial Internet of Things (IoT) and computer technology. The system uses web 3D models for real-virtual interaction, and is constructed through JavaScript web programming techniques such as Three.js, node.js, and ajax. Through the digital twin of the three-dimensional warehouse, it can realize the monitoring, analysis and prediction of the production

process. Through the system, users can monitor the three-dimensional warehouse in real time through the web interface to understand the equipment status, operation and other information. At the same time, the system also provides data analysis and prediction functions. By processing and analyzing the collected data, it can provide early warning and prediction of possible problems in the production process.

Compared with the traditional monitoring system, the digital twin system proposed in this paper has the following advantages. Firstly, WebGL technology is adopted to realize the virtual-real interaction of the three-dimensional warehouse on the webpage, so that users can understand the equipment more intuitively. Secondly, by digitally replicating the three-dimensional warehouse, more accurate and detailed monitoring data can be provided, which improves the effectiveness and precision of monitoring. Finally, the system also has data analysis and prediction functions, which can help users better understand the production process and take timely measures.

In summary, the WebGL-based digital twin system for three-dimensional warehouses proposed in this paper has a broad application prospect. By utilizing the latest computer technology and the development trend of IoT front-end web pages, it can realize the digital replica and full-cycle synchronous monitoring of the stereo warehouse equipment and provide reliable support and guidance for the production process.

References

[1] TAO Fei, QI Q. Make more digital twins[J]. Nature, 573: 490-491.

[2] TAO Fei, LIU Weiran, ZHANG Meng, et al. Five-dimension digital twin model and its ten applications[J]. Computer Integrated Manufacturing Systems, 2019, 25(1): 5-22 (in Chinese).

[3] TAO Fei, MA Xin, HU Tianliang, et al. Research on digital twin standard system[J]. Computer Integrated Manufacturing Systems, 2019, 25(10): 2405-2418 (in Chinese).

[4] GRIEVES M. Intelligent digital twins and the development and management of complex systems[J]. Digital Twin, 2022, 2:8.

[5] LI Peigen. Brief introduction to digital twin[EB/OL]. http://master.infosws.cn/20200818/38945.html, 2020-08-18 (in Chinese).

[6] Liao Wenjie. Research on Scientific Data Regulation from the Perspective of Symbiosis Theory [D]. Heilongjiang University,2022.

[7] Cheng Yongming. Symbiosis and Japanese Corporate Management [J]. Theory and modernization,2009.

[8] Zhang Xu. Research of City's Sustainable Development based on Symbiosis Theory [D]. Northeast Agricultural University,2004.