Development of a three-dimensional virtual monitoring system for a workshop

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Abstract: Aiming at the problems of poor applicability and development efficiency of the current manufacturing workshop monitoring system, a workshop monitoring system using the industrial Internet of Things platform as the system service platform is proposed. This article takes a seal automated production line as an example to illustrate the development process of a workshop monitoring system, including virtual scene construction, data acquisition and real-time model driving based on the industrial Internet of Things platform. The results show that the 3D virtual monitoring system has good real-time performance and realizes multi-level and visual monitoring. It has certain reference value for the development of the workshop 3D virtual monitoring system.

1. Introduction

With the development of information technology and the continuous progress of industrialization, the level of automation and informatization in manufacturing industry is constantly improved. More and more manufacturing enterprises are engaged in production and manufacturing activities in the way of automatic production line. However, due to the low level of information management, enterprises lack of fast and effective means to manage and monitor the operation of the workshop. The traditional workshop monitoring methods are mainly manual recording, two-dimensional reports, configuration monitoring, etc., So the transparency of production process is difficult to achieve.

In recent years, the workshop 3D virtual monitoring system based on real-time data-driven has attracted much attention. Many scholars at home and abroad have carried out research and practice on it and achieved certain results. However, there are common problems such as high threshold of system development, low development efficiency, poor portability and single monitoring mode. Toshiaki Kimura [1] developed a remote monitoring system for small and medium-sized enterprises, which used 3D hierarchical information visualization environment as the interactive interface of the monitoring system. Amos H.C.Ng [2] have developed a press production line monitoring and diagnosis system, which provides remote online monitoring and diagnosis functions and media playback functions. Li Zhi [3] designed a real-time monitoring system for the manufacturing workshop based on the analysis of the current status of workshop monitoring and the types of discrete enterprise workshop data. Cao Wei [4] proposed a real-time data collection and visual monitoring method for discrete manufacturing workshops based on radio frequency identification technology. Zhang Tao [5] studied the interventional 3D real-time monitoring system for digital workshops and established the demand framework,
architecture and operation mode of the monitoring system. In this paper, a three-dimensional visualization virtual monitoring system of workshop based on industrial Internet of things platform as data application bus is proposed to solve the problems of high threshold, low development efficiency and single monitoring mode. Taking seal workshop as an example, the development process of virtual monitoring system is introduced in detail.

2. Introduction to seal production system
A seal automatic production system is mainly composed of automatic warehouse unit, logistics unit, processing and manufacturing unit, assembly unit and control unit. The automatic warehouse is mainly used for storage of materials and finished products; the logistics unit is mainly used for the circulation of logistics, finished products and semi-finished products among various stations; the processing and manufacturing unit is mainly used for product processing; the assembly unit is mainly used for seal assembly; the control unit is composed of on-site general control PLC, CNC system and et al. There are two kinds of processed products: official seal and private seal. The production mode is a typical multi variety and small batch production mode.

3. Overall process of system development
The development of workshop 3D virtual monitoring system is a system engineering of multi software collaborative development and multi-functional modules mutual cooperation. In this paper, thingworx Internet of things platform is used as data application bus, and Creo, 3D Max, unity 3D multi software collaborative modeling is used to design and develop a personalized seal production workshop 3D visual monitoring system. The system development process is shown in figure 1. It mainly includes the following steps: (1) Using Creo 3D modeling software to build the 3D solid model of seal production workshop; (2) Equivalent modeling of workshop entities using 3dmax, rendering the model by giving materials and textures to make the three-dimensional model more realistic. In order to reduce the operating pressure of the hardware, the model is appropriately simplified, (3) Export 3dmax model to .FBX format file; (4) Import the .FBX model file into the unity3D engine, perform scene management, scene roaming, UI interface design, performance optimization, etc. in unity3D; (5) Collect equipment status information, material information, workpiece information, etc. in the workshop through sensors, IBOX, etc., and send the information to the Thingworx IoT platform for storage using the WebSocket protocol; (6) Divide the data into model driven data and non model driven data; (7) Non model driven information is further classified, stored in thingworx in datatable format and displayed in form format; (8) Model driven data unification: It is passed to unity3d engine in JSON string format for visual interactive simulation; (9) Data binding is implemented in unity3d to realize the driving of virtual scene model based on real-time data and the real-time updating of equipment status information; (10) Publish the simulation scene in unity3D as WebGL format and integrate it into thingworx platform. After the above steps, the kernel construction of the 3D virtual monitoring system is basically completed and then the system can be accessed through the website on the computer and mobile phones. The following is a detailed description of the development process of the system from five aspects: three-dimensional model construction, data acquisition, virtual scene construction, real-time model driving and system integration.
3.1. Three-dimensional model construction

According to the relevant data and on-site mapping provided by the equipment manufacturer, the physical parameters that can represent the seal production workshop are obtained and the geometric models of workshop, equipment, tooling, etc. can be established by using the three-dimensional modeling software Creo. At the same time, the models are simplified, given material, mapped and rendered in 3Dmax. Then the models are exported to FBX format. Scene management is carried out in Unity3D and model position, light, material, etc. are adjusted to make the virtual scene realistic.

3.2. Data acquisition

Data acquisition objects include PLC, CNC lathe, precision carving machine, industrial robot, AGV, etc. Taking PLC as an example, the process of data acquisition is explained. PLC data acquisition mainly includes the following contents: (1) Location, working status and current task name of stacker and warehousing platform; (2) Material information (including processed, unprocessed and to be processed); (3) RFID control information, etc. Siemens S7-1200-1215c is used as the main PLC, so the industrial connectivity module provided by thingworx Internet of things platform can be used to realize PLC data acquisition. Thingworx takes Postgre SQL database as the default standard database, based on the good scalability and compatibility of PostgreSQL database, so as to achieve the system load balance and good data performance balance.

3.3. Real-time model driving

The real-time model driving is the core of the three-dimensional virtual monitoring system for the workshop. On the basis of realizing the static mapping of the virtual scene, drive the model with real-time data on the workshop site and finally realize the virtual and real synchronization of the workshop manufacturing process. Based on the RESTFUL architecture, Thingworx provides the URL with the collected data resource. In Unity3D, the JSON string in the URL is continuously called by the GET method; Then the device name is used as an index to extract the device-related data from the JSON string for binding. In Unity3D, the D0tween plug-in is used to realize the real-time driving of the
operating status of the workshop. By calling the DoLocalRotate() function and the DoLocalMove() function, the model movement can achieve the effect of virtual and real synchronization.

3.4. Virtual scene construction

3.4.1. Scene roaming.
The 3D virtual monitoring system of seal production workshop realizes scene roaming in two ways: AGV fixed perspective and free perspective. AGV fixed perspective roaming is to take the forward direction of AGV as the first perspective to show every link of the workshop logistics so that managers can observe the whole production process. The effect of AGV fixed perspective observation is shown in figure 2. The free perspective refers to that the manager can see the forward, backward, left and right movement of the perspective by clicking the W, S, A, D buttons on the keyboard and controlling the perspective angle through the mouse to realize free roaming in the virtual scene. The effect of a free perspective is shown in figure 3.

3.4.2. Real-time data display.
In order to realize real-time and intuitive visualization of equipment operating status, a pop-up window of equipment operating information is added to the monitoring scene. Through the analysis of the JSON string, part of the running data is directly displayed in the form of text which realizes the intuitive visual monitoring of the device.

3.5. System integration and display
Using web pages as the main display platform of the production line 3D virtual monitoring system is an important part of the development process of the virtual monitoring system, which requires data interaction with integrated information and databases. Therefore, the Web front-end needs to complete the following two tasks: (1) Integrate WebGL files published by Unity3D; (2) Performing statistical analysis on the output of the personalized seal production workshop in the web page and forming a two-dimensional production report.

3.5.1. Unity3D release and Thingworx integration.
Unity3D can publish WebGL and supports web browsing and viewing. ThingWorx only needs to use the Web Frame plug-in and bind the URL where the WebGL file is located and adjust the interface layout to achieve the integration of the system's human-computer interaction interface.
3.5.2. Production report.
As shown in figure 6, based on the bar component provided by the Thingworx Internet of Things platform, a production report can be quickly created. And then the relevant data in the server can be bound to realize the statistics of the workshop capacity. Finally, it is displayed in the form of a histogram on the large screen of the workshop monitoring which is convenient for management personnel to make statistics.

3.5.3. Real time video monitoring.
The real-time monitoring video is used to show the workshop site status of two fixed perspectives. As a supplementary monitoring means of the virtual monitoring system, the real-time video monitoring can show the effectiveness of the virtual monitoring on the one hand, and on the other hand can be used as the basis for fault tracing. Also use the Web Frame plug-in to bind the URL where the surveillance video file is located, the display effect is shown in figure 7.
3.5.4. Augmented reality display.
In the augmented reality scene, the main monitoring objects are the three-axis movements of the CNC lathe spindle and tool library which are driven by the real-time data. As are shown in figure 8, part of the operation data are directly displayed in the form of text by using information pop-up windows.

![Figure 8. Augmented reality display effect](image)

4. System operation effect
The operation effect of the system is shown in figure 9. Through the combination of workshop monitoring screen and augmented reality technology, the production status of the whole workshop is presented in real time. After online, the system runs smoothly and has good real-time performance. After the actual running test, the virtual scene delay is about 0.5s. It can meet the monitoring requirements in the actual production process and achieve the expected design goal of the system.

![Figure 9. Overall operation effect of the system](image)

5. Conclusion
In order to solve the lack of effective monitoring methods in the current workshop, this article takes the seal production workshop as the example and introduces in detail the development process of the workshop 3D virtual monitoring system based on the industrial Internet of Things platform. The system realize the field equipment access, data acquisition, data management and data service; Through the way of multi software collaborative modeling, 3D virtual scene is built quickly and real-time model driving based on twin data is realized based on Unity3D; In order to solve the problems of single monitoring form, the system combines AR, desktop VR, real-time monitoring video and two-dimensional data charts to realize multi-level, real-time and visual monitoring of the operation status of the workshop. It has certain reference value for the application of virtual monitoring system.

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