Application and research of digital twin technology in power grid enterprises

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Abstract. With the diversified development of economy and society and the continuous progress of science and technology level, the innovation of marketing equipment field management method has become the inevitable trend of the development of electric power marketing in the new era. Intuitive and effective monitoring of the marketing field equipment and adjustment of marketing activities according to the operating status of the equipment can ensure that the marketing activities are always carried out safely and efficiently, so as to effectively promote the digital and intelligent transformation of marketing profession. In order to realize the real-time, accurate and intelligent management of community marketing equipment, this paper applies the digital twin technology to the management of power grid marketing equipment, focusing on the model construction, data transmission, system design methods are analyzed in detail. Through the process optimization, the establishment of digital twin, the design of real-time data acquisition module and the establishment of equipment entity layer, the construction of power grid field marketing equipment twin framework is completed. Finally, a prototype system is developed to verify the feasibility and effectiveness of the proposed method. The results prove that digital twinning technology can help realize the fine, visual and digital management of field equipment.

Keywords: Digital twin; Model building; Digital transmission; Equipment management system; Network marketing

1 Introduction

Data is an important resource for exploration and innovation. The development of modern enterprises, especially transition industries, must pay more attention to the accumulation and control of data innovation [1]. The effective use of data to explore new business forms and business models can help power grid enterprises break through the restrictions of traditional business models [2]. The emergence of digital twin technology provides a new idea for the management of power grid marketing equipment. In order

A. Rauf et al. (eds.), *Proceedings of the 3rd International Conference on Management Science and Software Engineering (ICMSSE 2023)*, Atlantis Highlights in Engineering 20,
https://doi.org/10.2991/978-94-6463-262-0_7

to increase the management of power station equipment, realize the digital management of the whole life cycle of power grid marketing field equipment, and reduce the operation and maintenance cost, the digital twin technology can be applied to the management of power grid power stations, and help the marketing specialty of power grid enterprises to transform to digital and intelligent [3].

In order to make the digital twin be used further, the first task is to create the digital twin model of the application object. The digital twin team of Beihang University expanded the 3D model by adding twin data and connecting two dimensions, and proposed the concept of digital twin five-dimensional model [4]. By establishing the digital transformation framework of power grid, Tanbochi Jan completed the mapping of digital twins and operation and maintenance entities, and completed the digital transformation of power grid after the integration and analysis of power grid data [5]. Yitao Liu et al. expounded the value and role of digital twin power grid in dispatching operation, equipment management, marketing operation, development planning, integrated energy and other business aspects [6]. Zaixing Peng et al. put forward the basic composition, quality characteristics, digital twin model, digital data model and test verification method of digital power equipment. According to the basic concept of digital power equipment put forward, the development path of digital power equipment was made clear [7].

This paper mainly explores the specific application of digital twin technology in power grid enterprise marketing equipment on the basis of predecessors, realizes intuitive and effective monitoring of districted field equipment, and can adjust marketing activities according to the operating status of the equipment, so as to ensure that marketing activities can always be carried out in an efficient environment and realize intelligent and refined control of infrastructure maintenance. Finally, it provides a more suitable management program for marketing field equipment, promotes management and service informatization, and expands and extends the scope of services.

2 Construction of model

Field scene construction is an important enabling technology to realize static mapping of virtual scene from physical scene, and virtual scene (VS) is the most important monitoring mode [8]. 3D modeling of virtual scene mainly includes modeling of a large number of devices in real scene and actual working scene, and virtual devices should be the complete mapping of physical devices. In reality, the number of equipment is large, including basic production equipment, transmission equipment and auxiliary equipment; in addition, the space size of general equipment is large, the structure is complex, and the materials among different equipment are not the same. In the modeling process, there will be many problems of 3D modeling, difficult to manage, poor rendering effect, slow running speed and so on, which directly affect the overall performance effect in the virtual scene. It is necessary to adopt a reasonable and effective way to plan the modeling work to avoid the above problems.

Firstly, the physical scene is segmented by scene block strategy. The block process mainly complies with the following three standards:

(1) problems with similar functions are grouped together, such as houses.

(2) In the scene, connectives with a certain connection order are classified as one kind, such as trees.

(3) With different functions, but basically belong to the same category and adjacent problems, such as pavilions, benches, etc. In the actual modeling work, it should be divided flexibly according to the actual situation.

After the scene is partitioned, the hierarchy needs to be adjusted, and the following strategies are used for hierarchical modeling:

(1) Before modeling, the complex object is decomposed according to a certain hierarchical structure as far as possible, and multiple simple objects are used to form a 3D model of the whole complex object.

(2) Avoid constructing 3D models with large space span as much as possible. When 3D modeling is carried out for objects with large volume, it is necessary to decompose them appropriately.

(3) When modeling the object with complex internal structure, only the shape can be modeled on the basis of not affecting the effect of expression.

(4) For objects with irregular shapes, simple shapes can be used to represent them according to their importance, such as cuboids and circles.

The virtual scene construction process is shown in Figure 1.

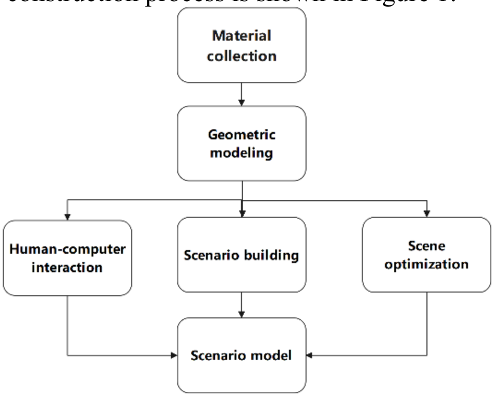

Fig. 1. Construction process of virtual scene of power grid marketing equipment

2.1 Methods-selection of virtual scene construction.

Scene 3D modeling work is mainly completed by 3DMAX software. In 3DMAX, the preliminary modeling work of the equipment is mainly completed by polygon modeling, two-dimensional transformation to three-dimensional and planar modeling.

2.1.1 Polygon modeling.

3DMAX mainly uses the commands of Editable Mesh and Editable Poly for polygon modeling. Editable polygons are improved based on editable network methods. The modeling method of editable network has many nice features: The model has good compatibility, less resources, faster running speed, and complex models can be built with fewer faces. Editable network methods usually divide polygons into trigonometric fundamentals, collapse the object into an editable grid by using the Edit Grid modifier or directly [9].

2.1.2 2D to 3D.

The transformation from 2D to 3D is mainly achieved by lofting, NURBS (Non-Uniform Rational B-Splines) modeling and some common editors. Lofting is mainly to take two-dimensional figures as sections and gradually depict complex three-dimensional objects along a fixed path. NURBS modeling is a modeling method based on mathematical formula, which can automatically calculate the surface accuracy. Compared with ordinary modeling methods, NURBS modeling requires fewer control points to build the same curve, so NURBS modeling can have excellent performance in surface modeling.

2.1.3 Patch modeling.

Patch modeling is developed on the basis of polygon modeling, which is a surface modeling method between network modeling and NURBS modeling. The patch modeling can change the curvature of the curved-surface by adjusting the parameters of the surface, and realize the modeling of complex curved-surface. Compared with network modeling, Curved-surface modeling can show the realistic effect of complex curved-surface with fewer surfaces, so it needs less control points. Compared with the NURBS modeling, the patch modeling has less computation, less demand on equipment resources, and can improve the computer running speed.

2.2 Production of 3D animation.

Using 3D animation software can realize 3D action display. By pre-designing various actions of the 3D model, such as rotation, translation, scaling, etc., 3D animation software is used for modeling, and pictures corresponding to various angles and poses of the control object are generated and numbered according to certain rules. In the display, only the corresponding picture number of the control object is calculated and call the display can achieve the purpose of real-time simulation. This method has a good effect when the action of the control object is simple. The demand for human-computer interaction is weak, and the action of the control object is known. However, due to the limitations of this method: Simple actions that control objects can only be animated within the knowable range, when the motion of the control object is complex and the motion trend is uncertain, using the 3D animation software to realize the virtual monitoring will often lead to the situation of huge system, poor real-time performance and the distortion of the control object's motion.

2.3 Collaborative development of multi-professional software.

Virtual scene construction involves geometric model construction, optimization, rendering, virtual scene construction, virtual scene management, viewpoint roaming, collision detection, particle effects, UI interface design and system integration, etc. If only one or two kinds of software are used to develop the virtual monitoring system, it will increase the difficulty of system development due to the shortcomings of the software itself, which is not conducive to the promotion of the virtual monitoring system. Therefore, when constructing the virtual scene, this paper adopts the virtual reality development engine Unity3D and IdeaVR, combined with the three-dimensional entity modeling software Solidworks and Creo, and the model rendering software Maya and 3dMax to realize the cooperation. The virtual scene is constructed by means of multi-professional software collaboration, which gives full play to the performance advantages of each professional software, reduces the workload of the underlying development of the system, reduces the development threshold of the system, and improves the development efficiency of the system. This paper uses multi-professional software to complete the construction of 3D virtual scene can well meet the development requirements of the system, and the system implementation is also relatively easy, can shorten the development cycle of the system, improve the efficiency of system development.

3 Transmission of power grid data

As one of the three core elements of the virtual monitoring system, how to collect twin data that can represent the real and complete operation state of the physical site from the massive, heterogeneous and multi-source data streams in the power grid marketing field equipment, and the interconnection of each dimension of the 3D visual monitoring system model is the problem to be solved in the connection of (CN) dimension. This paper first analyzes the data types of power grid marketing field equipment and the mainstream data collection technology in detail, and studies the causes of the difficulties in the underlying data collection of power grid marketing field equipment, and based on the Internet of things platform are put forward based on the present situation of network marketing field device virtual monitoring system of data acquisition and management scheme, finally, the key technology of the data acquisition scheme are studied.

3.1 Data Acquire.

Data acquisition is divided into two categories, one is the complete data contained in the original power grid system, the attribute data in the original model is processed and incorporated into the database, which is the first step of data processing in the operation and maintenance platform. The original data is sorted out, and then the interference data is removed to retain the required information. After the model is lightweight, it can be directly viewed and retrieved in the operation and maintenance management platform, giving full play to the value of the model in the operation and maintenance stage. The second is the data generated during the use of equipment, including equipment operating condition information, voltage information, equipment energy consumption information, power load information, temperature and humidity inside and outside the equipment and other major data information. Based on the original data, through a large number of sensors and monitoring systems, combined with the equipment use data, a series of operations such as data conversion and grouping, cleaning and sorting, finishing operation and analysis and extraction are carried out. Then, the data was integrated into the operation and maintenance interaction platform. The data from different data sources are integrated and classified, and applied to management according to requirements, and displayed as graphical and intelligent data to provide data sources for the digital twin engine.

3.2 Json-Based Text Data Transfer.

The 3D virtual monitoring system of power grid marketing field equipment is developed based on B/S architecture. Compared with the traditional C/S architecture, the advantages of B/S architecture are higher data security, better data consistency, better real-time data, convenient system maintenance and update, easy to realize cross-platform applications.

Therefore, the grid marketing field equipment management system using B/S architecture for development. As a result, the data has to go through three key points: the device side, the database side, and the WEB server side. For these three different application environments, a neutral data form should be used for data exchange. Based on the above analysis, using JSON format as the text data transmission format of the virtual monitoring system can make full use of the simple and easy advantages to reduce the complexity of the underlying code, improve the efficiency of data transmission, and ensure the real-time data of the power grid marketing field equipment management system.

4 Design of the System

4.1 The Overall Framework Design of the System.

With the continuous advancement of power grid digitalization and the continuous development of information technology, the field equipment management system of power grid marketing based on digital twin should be able to meet the needs of the company to continuously optimize and expand new service systems. Therefore, the microservice architecture is selected to design the field equipment management system of power grid marketing based on digital twin.

Based on the system architecture of microservices, the designed field equipment management system of power grid marketing mainly includes digital twin, data transmission, data acquisition services, equipment failure prediction services and other services. As shown in Figure 2.

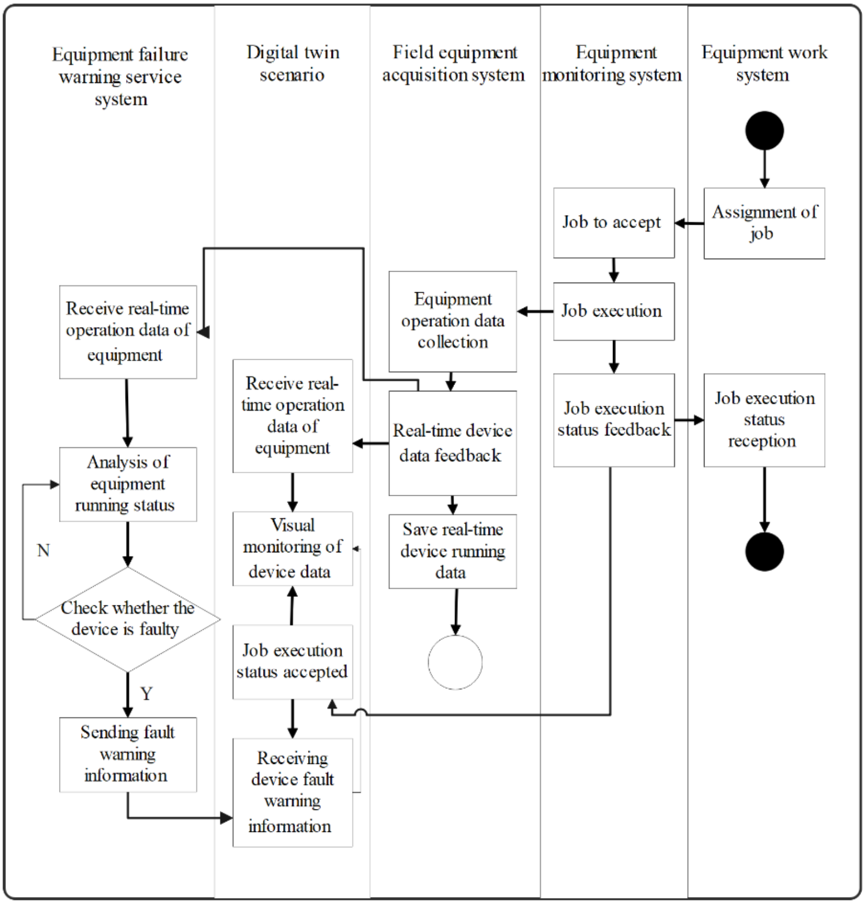

Fig. 2. Power grid marketing field equipment management system design

The whole system can be connected through the existing power grid LAN or the industrial Internet. The data interaction function between various parts can be realized through data transmission. Different from the traditional layered architecture, the system architecture based on microservices has the characteristics of flatness. System according to the function of each part is divided into different micro service module. Power grid for other software can be through an open interface for data transmission, and the system can be realized digital twins, data acquisition, data interaction between service and equipment failure prediction to ensure enterprise production data consistency and convenience. At the same time, with the construction of enterprise digitalization, new microservice modules can be continuously developed and added to the system according to actual needs to realize the horizontal expansion of the system.

4.2 Selection of the Framework.

In the traditional enterprise application development, the heavyweight framework EJB is used to develop. EJB framework is based on service-oriented architecture. It is an enterprise set framework developed in the early stage to solve the communication between heterogeneous systems. In essence, it uses RMI technology to use object serialization to complete the instantiation and invocation of remote objects, so as to realize the construction of distributed systems. However, the framework itself has the following drawbacks, such as the low efficiency of response performance and data processing caused by remote service invocation on the server side, too tedious programming work, and application code that is too dependent on the framework.

In order to achieve lightweight development and improve efficiency, this paper uses the Spring middleware platform as the core of the SSM or SSH framework to develop enterprise-level applications, and uses the mainstream SSM framework to build the field equipment management system of power grid marketing. The main advantages of the framework are to simplify the development work, to standardize the coding, and to be more safe and reliable.

In the lightweight mainstream development framework, whether it is SSH framework or SSM framework, it is based on Spring framework as the core middleware, and realizes rapid development through IoC (inversion of control) and AOP (Aspect-oriented programming).

4.3 Database Selection.

In this paper, Redis database is used as the cache database, and the data that needs to be frequently accessed is stored in the database. Because Redis is a memory-based persistent database, when a cache hit occurs, the IO speed of reading data from memory is faster than the IO speed of reading data from disk.

Data that is running in memory needs to be persisted in case it is lost due to power outages. In this paper, MySQL database is selected to complete the data persistence. Compared with SqlServer and Oracle relational database, MySQL database is open source and has low development cost. At the same time, MySQL database has good support for a variety of programming languages and large databases. And its core program uses multi-thread programming to make full use of system resources and improve the efficiency of reading and operating data.

5 Presentation of the system

Combined with the actual situation and demand of power grid enterprises, the field equipment management system of power grid marketing is developed, and the system is deployed to the community and simulated.

5.1 Display of the interface.

Using the more real characteristics of the virtual scene to describe the community not only brings a strong sense of immersion to users, but also more intuitively observe the layout and spatial level of the community. At the same time, it can understand the distribution of the field equipment and the equipment topology map, and help the staff to manage the field equipment of power grid marketing. The overall structure of the system is shown in Figure 3.

Fig. 3. The overall structure of the system

5.2 Display of device details.

In the process of using the cell equipment monitoring system, if the staff wants to know the equipment condition in a certain area or the operation and maintenance situation of the equipment in a certain area and other information, they can click the corresponding equipment in the equipment topology map by using the mouse. Detailed information about the operation of the device can be obtained from the pop-up display window of the device, as well as the electricity consumption and total amount of each household in the community. Monitoring of equipment is shown in Figure 4.

Fig. 4. Monitoring of equipment

The core function of the grid marketing field equipment management system based on digital twin is to monitor the actual state of the marketing field equipment through digital twin technology. When the field equipment is in working condition, the data transmission system will continuously send the running status of the equipment to the digital twin management system, and display the equipment status through the relevant display board. At the same time, the device data acquisition system will also collect the real-time operation data of the device, and send the real-time operation data of the device to the digital twin system in time, so as to feedback the device model in the virtual model. The equipment failure early warning service system will use the real-time operation data of the equipment to analyze the running status of the equipment. When there is an abnormality, the equipment failure early warning information will be released through the digital twin system in time, so as to realize the monitoring of the field equipment.

6 Conclusion

This paper introduces in detail how to use digital technology of twin in grid community site marketing equipment management, and through the twin body structures, process optimization, digital, real-time data acquisition and power grid digital transformation of physical layer framework, operational entities with the twin body digital mapping, to realize the field devices, visualization, digital management. The construction of smart grid digital twinning is an important way to realize the safe, stable and optimized operation of the future power system, so the research on the application of digital twinning in power grid enterprises is of great significance. In the next step, the linkage and fusion of virtual scene and real camera will be taken as the research direction to find the functional combination point.

Acknowledgments

This work was supported by Jiangsu Province key R & D Program on Industry Prospect and Core Technology (BE2020006-5).

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