Research on optimization method and system of power display data based on digital twin

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Abstract. With the development of science and technology and the progress of society, the electric power industry is gradually changing to the direction of intelligence and automation. In this process, a large amount of power data is generated and processed and analyzed. The data includes not only real-time data on electricity production, transmission and consumption, but also historical data, forecast data, and data derived from analysis through various algorithms. However, how to effectively display these power data so that people can intuitively and vividly understand and grasp them has always been a difficult problem facing the power industry. Traditional power data display methods, such as tables, charts, trend charts, etc., can reflect some characteristics of power data to a certain extent, but there are some inherent limitations, resulting in low efficiency in dealing with power business.

Keywords: digital twin; Power display data; Optimization method; System.

1 Introduction

1.1 Research Background and Significance

At present, the construction of electricity information acquisition system in electric power enterprises is developing rapidly, and iot products such as new intelligent energy meter acquisition terminal transformer [1] and customer-side metering perception are widely promoted and applied in metering devices, which greatly improves the intelligence level and effectively improves the company's lean management level [2]. As the key infrastructure of modern society, the power system's operating status and data information are of great significance for ensuring the reliability of power supply, optimizing resource allocation and promoting energy transformation. With the increasingly complex and intelligent power system, higher requirements are put forward for the accuracy, real-time and intuitiveness of power data display. However, the traditional power data display methods often have problems such as data dispersion, update lag, poor visualization effect, etc., which is difficult to meet the growing demand for

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fine management of power system. How to realize the efficient operation and accurate management of power system has become an urgent problem to be solved.

Digital twin technology, as a new digital means, provides a new idea and method to solve the above problems. Through the digital modeling of physical entity, digital twin realizes the real-time monitoring, simulation prediction and optimal management of power system.

1.2 Research Purpose and Problem Definition

However, in practical application, digital twin technology still faces many problems in the optimization of power display data. For example, the data quality is not high, the real-time data is poor, and the data visualization effect is not good.

The purpose of this study is to explore the method and system of power display data optimization based on digital twin, so as to improve the visualization effect and data quality of power system. Through in-depth research on the application of digital twin technology in power display, an effective data optimization method and system architecture are proposed. It is expected to provide an efficient and accurate power display data optimization method and system for the power industry, and help the intelligent development of the power system.

2 Related Work

2.1 The Application Status of Digital Twin Technology in the Field of Electric Power

1. Overview of digital twin technology

Digital Twin is a technology that synchronizes a virtual model of a physical object with its real state in real time [3]. By collecting sensor data and using analog analysis and machine learning algorithms, digital Twin simulates and analyzes the operating status, performance and environmental changes of physical objects or systems in the real world in the virtual world, so as to achieve real-time monitoring, prediction and optimization [4].

Digital twin technology realizes real-time synchronization between physical objects and virtual models through sensor data acquisition, analog analysis and machine learning algorithms, providing the basis for real-time monitoring, prediction and optimization. This technology has a wide range of application prospects in many industries and can provide more efficient, intelligent and sustainable solutions for various industries

The digital twin system includes five layers of physical domain, digital twin, measurement and control entity, user domain and cross-domain functional entity. The details are shown in the following figure 1:

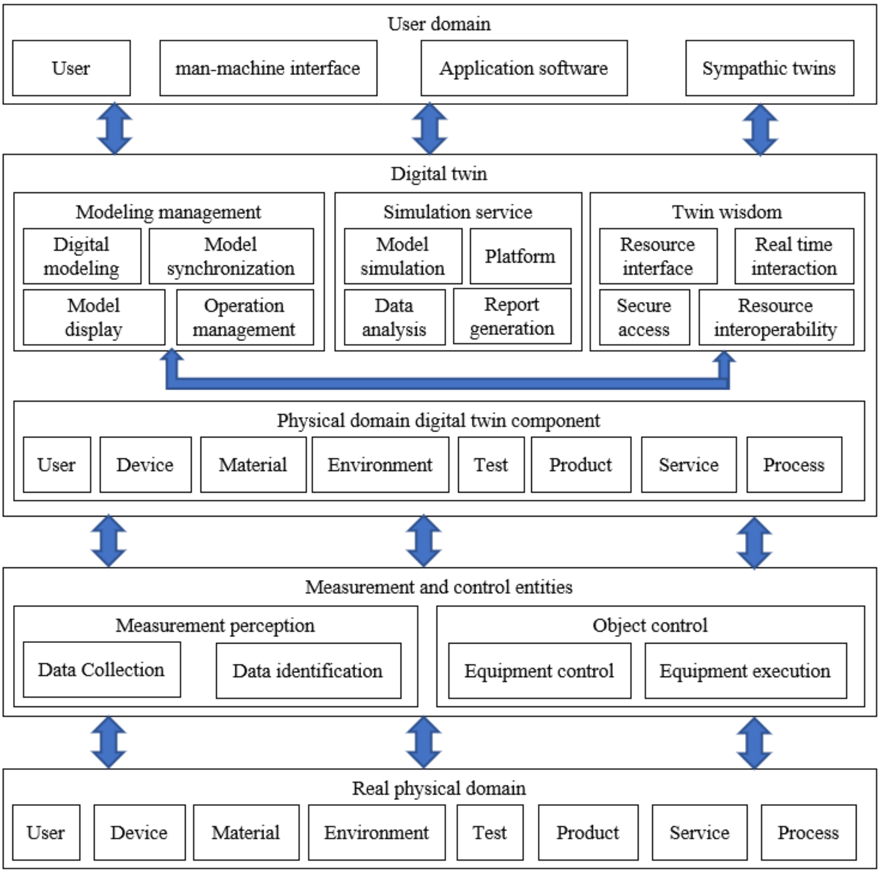

Fig. 1. The digital twin system

2. Digital twin technology, as a new technical means, has been widely concerned and applied in the field of electric power. At present, digital twin technology has been applied in many aspects of power system, such as the monitoring and maintenance of power equipment, the operation and management of power grid, etc.

1. Substation management: Through digital twin technology, real-time display of substation operating status, equipment parameters and other data, to help operation and maintenance personnel to carry out efficient management.

2.) Power grid dispatching: provide intuitive power grid topology and load distribution to assist dispatching personnel to make scientific decisions.

3.) Power equipment monitoring: real-time monitoring of equipment operating parameters, prediction of failures, maintenance and overhaul in advance.

4.) New energy power plant management: simulate the output of new energy power plants and optimize energy scheduling.

5.) Electric Power Business Hall display: to provide customers with intuitive power information display, improve service quality.

6.) Power emergency command: In an emergency, provide accurate power data support to assist in command decision-making.

7.) Distributed energy management: centralized management and optimal scheduling of distributed energy sources.

8.) Power load forecasting: Use historical data and real-time data to improve the accuracy of load forecasting.

9.) Power system simulation training: to provide students with a real operating environment to improve the training effect.

10.) Intelligent distribution network planning: show the effect of different planning schemes to help scientific planning.

And so on

3 Characteristics and Demand Analysis of Power Display Data

(1) Data characteristics

The power display data has the characteristics of large scale, multiple types and strong real-time performance. It includes the monitoring data of power equipment, the operation data of the power grid, the data of the user's electricity consumption, etc. These data sources are wide, the format is different, and the amount of data is increasing exponentially.

(2) Demand analysis

In order to realize the efficient operation management and scientific decision-making of the power system, it is necessary to conduct real-time collection, accurate analysis and intuitive visual display of the power display data. Specific requirements include: real-time update and synchronization of data, multi-source data fusion and correlation analysis, visualization of complex data and data security and reliability guarantee.

4 Power Display Data Optimization Method Based on Digital Twin

(1) Data acquisition and integration

The sensor network and communication technology are used to collect all kinds of data in the power system in real time, and the multi-source heterogeneous data is integrated into a unified format by means of data cleaning, conversion and fusion, so as to provide data basis for subsequent analysis and display.

(2) Construction of digital twin model

Build an accurate digital twin model based on the physical characteristics and operation rules of the power system. The model includes power equipment model, network topology model and power operation model, etc., which can reflect the running state and change trend of the power system in real time.

The collected data also need to be cleaned and pre-processed. It mainly includes data de-duplication, detecting and deleting duplicate data records, ensuring data uniqueness, processing missing values, detecting missing values in data, and filling in missing values with interpolation, the interpolation method selects the time dimension weighting interpolation in the missing position, as follows:

$$d_t = w_{t-2}d_{t-2} + w_{t-1}d_{t-1} + w_{t+1} d_{t+1} + w_{t+2}d_{t+2}$$

$$w_{t-2} + w_{t-1} + w_{t+1} + w_{t+2} = 1$$

Where d_t is the vacancy value at time t and $w_{t-2}, w_{t-1}, w_{t+1}, w_{t+2}$ is the weight coefficient, $d_{t-2}, d_{t-1}, d_{t+1}, d_{t+2}$ is the value of adjacent time at time t; Handling, identifying and handling outliers, which may be due to measurement errors, data entry errors or other causes, using statistical methods to detect outliers, and according to the specific situation to amend or delete; data standardization, data standardization processing, different scales or units of data into a unified scale, in order to better import the digital twinning model, make the data contrast of popular science process more intuitive.

(3) Data analysis and mining

Big data analysis and machine learning algorithms are used to conduct in-depth analysis and mining of the integrated power display data, and extract valuable information and knowledge, such as equipment failure prediction, power grid load prediction, power quality analysis, etc. [5]

(4) Visual display optimization

Using advanced visualization technologies, such as virtual reality (VR), augmented reality (AR) and three-dimensional animation, the power display data after analysis and processing will be presented to users in an intuitive and vivid form. At the same time, through the human-computer interactive interface, users can freely choose the display content and perspective to achieve personalized data display.

5 Power Display Data Optimization System Design based on Digital Twin

(1) System architecture

The system adopts hierarchical architecture design, including data acquisition layer, data processing layer, digital twin model layer, analysis application layer and visual display layer. The data interaction and function call between each layer are carried out through standardized interfaces to ensure the flexibility and scalability of the system. The details are shown in the following figure 2:

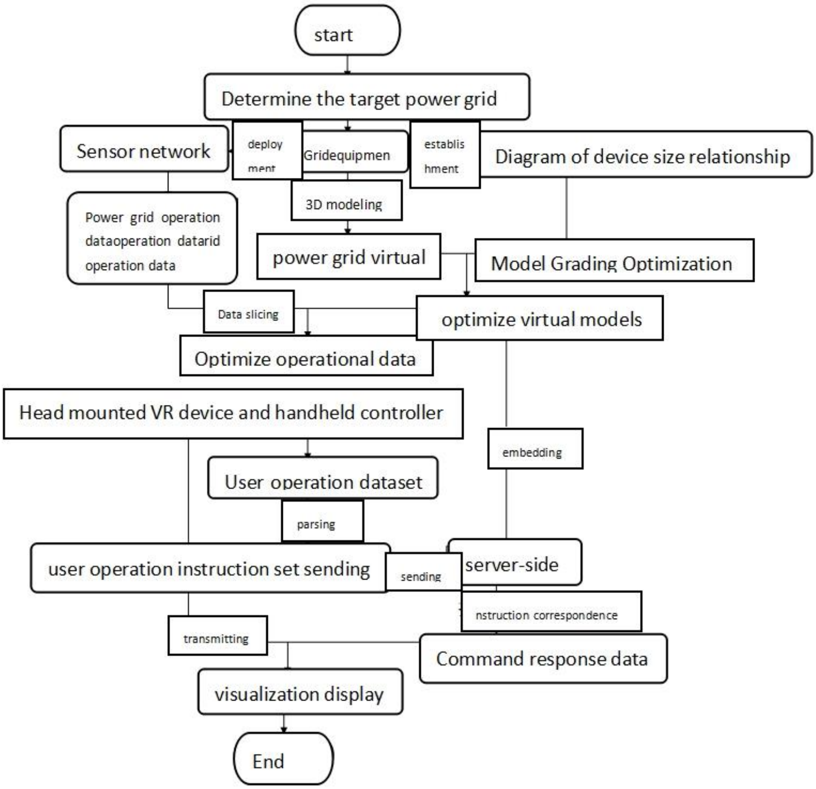

Fig. 2. Schematic diagram of power display data optimization method based on digital twin

(2) Function module

1. Data acquisition module: responsible for real-time collection of all kinds of data in the power system, and preliminary processing and transmission.

2. Data management module: storage, management and maintenance of the collected data to ensure the security and integrity of the data.

3. Digital twin modeling module: build and maintain the digital twin model of the power system to realize the dynamic update and optimization of the model.

4. Data analysis module: use data analysis algorithms and tools to analyze and mine the power display data and provide decision support.

5. Visual display module: the results of analysis and processing are displayed in an intuitive and vivid form, supporting a variety of display ways and interactive operations.

The details are shown in the following figure 3:

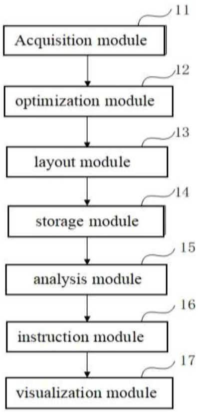

Fig. 3. Schematic diagram of power display data optimization system based on digital twin.

The picture marks the description: acquisition module 11, optimization module 12, layout module 13, storage module 14, analysis module 15, instruction module 16, visualization module 17.

(3) Technical realization

The system is based on cloud computing, big data, Internet of Things and artificial intelligence technologies, and makes full use of the powerful computing and storage capabilities of the cloud computing platform to realize efficient processing and analysis of massive power data; Through the Internet of Things technology to achieve the interconnection of power equipment and system, real-time data acquisition; And use big data and artificial intelligence technology to improve the accuracy and efficiency of data analysis and mining. [6] The details are shown in the following figure 4: Technology architecture.

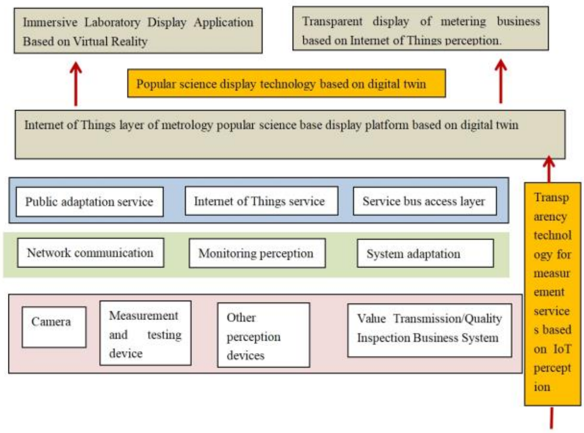

Fig. 4. Technology architecture

(4) System performance

1. The system supports the number of concurrent online users greater than 1000 and less than or equal to 2000, and the number of concurrent users greater than 100.

2. Application servers support horizontal scaling. When the load increases, the performance can be improved by increasing the number of application servers.

3. When multiple users are deployed concurrently, the system must meet the following requirements: The average response time for accessing the home page must not exceed 2 seconds. When performing simple query, adding and deleting services, the average response time should not exceed 3 seconds; When performing complex integrated services, the average response time should not exceed 5 seconds.

4. The average daily CPU usage of the system is less than 40%. The CPU usage is less than 85% and the memory usage is less than 80% when the system is subjected to the maximum concurrency.

The specific system performance indicators are shown in Table 1.

Table 1. System performance indicators

Serial number	**Index items**	**Specific requirements**	
		Number of concurrent users	**Average response time (seconds)**
1	Home Page Access	100	1.370
2	System login	100	2.149
3	Scene selection	100	1.450
4	Tour with Tour	50	1.378
5	Graphic loading	100	3.345
6	Video play	100	3.820
7	Leave feedback	50	1.923
8	Item details	100	1.256
9	Answer interactive	50	1.589

6 Evaluation of System Application Effect

Practical application case analysis

Combined with the actual power system operation management scenario, the application effect of the system in equipment monitoring, fault diagnosis, power grid optimization and other aspects of the case analysis, show the practical application value of the system.

Please refer to Figures 5-9 for details.

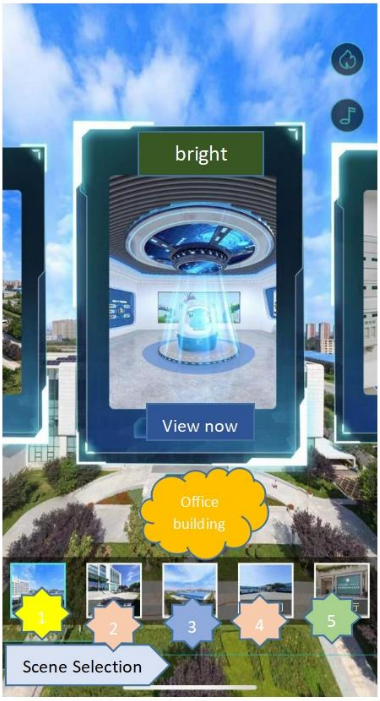

Fig. 5. Main page and scene selection

Fig. 6. Detail display-Graphic hotspot map

Fig. 7. Detail display --3D model display

Fig. 8. Currenttransformer laboratory application scenario

Fig. 9. Full performance laboratory application scenario

The stability and high efficiency of the system are verified by testing and evaluating the system's response time, data processing speed, visualization effect and other performance indicators.

Through the feedback and satisfaction survey of the staff, we can understand the evaluation of the system function, operation convenience and display effect, and constantly optimize and improve the system.

7 Conclusion

The optimization method and system of power display data based on digital twin can effectively improve the display effect and application value of power data, and provide strong technical support for the operation management and decision support of power system. In the future, with the continuous development and innovation of digital twin technology, as well as the deep integration with other emerging technologies, the system will play a more important role in the field of power, and promote the digital transformation and intelligent development of the power industry.

Acknowledgement

This paper proposes an optimization method and system of power display data based on digital twin, aiming to realize efficient integration, analysis and visual display of power

data through digital twin technology, so as to improve the level of operation management and decision support of power system.

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