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Retraction

Retracted: Digital Reconstruction Method of Power Metering Production Data Based on Digital Twin Technology

Security and Communication Networks

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] H. Wang, H. Shen, C. Li et al., "Digital Reconstruction Method of Power Metering Production Data Based on Digital Twin Technology," *Security and Communication Networks*, vol. 2022, Article ID 6835371, 10 pages, 2022.

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Research Article

Digital Reconstruction Method of Power Metering Production Data Based on Digital Twin Technology

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With the continuous improvement of the integration and intelligence of ubiquitous power Internet of things system equipment, its cost in life cycle management such as data service, operation monitoring, and safety protection is becoming higher and higher. At the same time, the probability of power grid failure, reduced operation efficiency, and function failure will gradually increase with the development of its scale. Accurately evaluating the metering performance of distribution network digital metering system in the operation of power system and improving its accuracy, stability, and reliability are the key issues for its future use in power trade settlement. In this paper, a digital reconstruction method of power metering production data based on digital twin is proposed. The operation data of power system is collected in real time through the data acquisition module, the operation data is analysed, identified, and predicted, and then the analysis, identification, and prediction results are used to realize the visualization and digitization of operation data. Further, the operation data of the digital metering system are monitored and analysed to verify the effectiveness of the method. The advantages and disadvantages of the design scheme of the digital metering system are obtained by analysing the active power error, which provides the basis of practice and selection for the application of the digital metering system.

1. Introduction

Digital twin refers to a kind of digital reproduction of physical entities, processes, and systems. The digital model obtains and analyses the real-time information of the physical model through multiple means and can present a variety of elements in the physical model and the real-time dynamic operation in the whole life cycle, so as to realize the functions of system monitoring, operation and maintenance, process and system optimization, event prediction, and simulation [1]. An intelligent operation data automatic acquisition and monitoring system is proposed in the smart grid monitoring system used in the substation. It uses several acquisition terminals to obtain the operation data of the power system and then realizes the monitoring function through the host computer and central server. However, due to many types of operation data, including data collected by sensors, video monitoring data, and equipment operation status, the presentation of operation data and fault feedback are not intuitive enough to directly reflect the actual operation status of the built facilities [2]. Because the operation information is displayed and saved separately, there is a lack of shut connection between the records and the proper model; such a statistics administration mode will lead to low protection effectivity [3]. In addition, in terms of data analysis, there is a problem of insufficient integration of information, and it is difficult for the internal relationship between data to be deeply excavated, which seriously affects the efficiency of operation and maintenance.

Theoretical analysis and simulation calculation are carried out for typical influencing factors, such as truncation error, rounding error, signal frequency offset, signal harmonic component, DC offset, random interference, and so on. The check technique of size error verification is proposed, and some checks of digital watt hour meter are carried out with taking a look at tools to confirm the evaluation results. The influence on the measurement results and the treatment methods to reduce the measurement error are given [4]. By analysing the error factors of digital electric energy measurement, this paper puts forward some suggestions on reducing the error method, perfecting the function of electric energy meter, and putting forward constructive suggestions on the error verification method of digital electric energy measurement system [5].

The main organisational structure of this paper is as follows: Section 1 introduces the relevant background of power production measurement system and the current situation and problems of power measurement production data and explains the main problems discussed in this paper. Related work is discussed in Section 2. Section 3 analyses the power production system based on digital twin in detail. Section 4 analyses the method of digital reconstruction of raw tea according to data. Section 5 validates the operation data analysis method. Section 6 summarizes the full text.

2. Related Work

Digital twin refers to a kind of digital reproduction of physical entities, processes, and systems. The digital model obtains and analyses the real-time information of the physical model through multiple means and can present a variety of elements in the physical model and the real-time dynamic operation in the whole life cycle, to realize the functions of system monitoring, operation and maintenance, process and system optimization, event prediction, and simulation. In recent years, with the increasing acceleration of the intelligent process, to realize the interaction and integration of the physical world and the information world, the concept of digital twin came into being and continuously evolved and developed rapidly, which has played a great role in promoting many industries. However, drawing on its application in aerospace, automobile manufacturing, oil and gas pipeline, and other industries, the current application of digital twin in power industry has also made obvious progress. The main research on the application of digital twin is as follows.

In the process of the continuous improvement and development of the concept of digital twins, researchers have mainly carried out research on the modelling, physical information fusion, and service application of digital twins, focusing on the analysis of the relationship between digital twins and related industries, the establishment of virtual models, the analysis with the help of twin data fusion, service application criteria, and so on. The connotation of digital twin is to build a digital twin [6]. Its final manifestation is a complete and accurate digital description of physical entities, which can be used to simulate, monitor, diagnose, predict, and control physical entities [7]. With the in-depth improvement of synthetic brain software technology, in phrases of deepening the utility of twins, mixed with the parallel management theory, a digital quadruplet parallel evolution framework of parallel modelling, parallel prediction, and parallel execution of related structures has been formed, and energy power generation has been extended to the parallel system of social energy [8]. While researchers carried out in-depth research around digital twins, the concept of digital twins has gradually been accepted by American General Electric, German Siemens, and other enterprises and applied to technology development and production, forming digital twin development software tools such as Predix and scenter 3D, which has attracted extensive attention from academia, industry, and news media [9]. At the same time, many industries have carried out the application practice of digital twins. In BMW ding fen intelligent factory, manual monitoring is replaced by intelligent data analysis system based on digital twin. The US Air Force proposes to use the concept of digital twin to predict the structural life of aircraft; CNPC uses digital twins to promote the construction of smart pipe network; some literature also put forward the intelligent health management of power plant generator units based on the concept of digital twins [10].

Some scholars have studied the application of digital twin technology framework to power system online analysis. The implementation framework of digital twins in power system is designed, the key problems and core technologies faced in its construction are discussed, and the application status and prospect of digital twins in various fields of power system are clarified [11]. Others use digital twin technological know-how to construct the electricity tools enterprise net platform, centre of attention on the graph cloud, manufacturing cloud, check cloud, information cloud, and carrier cloud primarily based on the platform and talk about the software in the situations of strength gear design, manufacturing and operation, and protection administration [12]. Some scholars put forward the realization of perspective monitoring, fault prediction, and state optimization of generator unit operation and maintenance based on digital twin technology, which provides a new solution for the operation, maintenance, and management of power station units [13]. By organising a digital twin for simulation and early warning, firms can no longer solely minimize the nonfault shutdown time but additionally always decrease the work depth of employees. Intelligent power plants can also use digital twins to improve the intelligent level of power plants, to achieve the purpose of reducing personnel, increasing efficiency, energy conservation, and emission reduction. As a technology intensive and highly automated modern production enterprise, power plant has a good foundation in the application of digital twin [14]. From the connotation of digital twin and the architecture of DCS, the realization of local production process through DCs can also be regarded as a low-level digital twin.

3. Power Production System Based on Digital Twin

3.1. Overall Architecture of Digital Twin System. The modular production system based on digital twin is shown in Figure 1.

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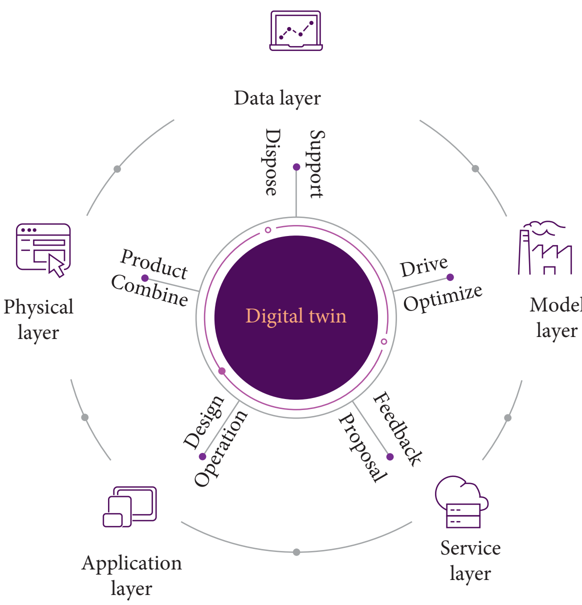

Figure 1: Model structure of digital twins.

(1) The physical layer includes modular production nodes and production units composed of modular production nodes. It is the carrier for the modular production system to perform production tasks. Modular production nodes can not only complete production tasks independently, but also form production units through combination to jointly execute production tasks [15]. The modular production node adopts standardized hardware design (circuit, network, and connection mechanism), which can quickly and cheaply combine into new production units according to production tasks, and the hardware equipment such as sensors, controllers, and effectors deployed in the modular node can enable it to have the ability of environment perception, computing decision-making, and manufacturing execution.

(2) The model layer is mainly responsible for modelling the modular production system in the information space and defining and describing the geometric attributes, physical rules, production operation logic, and operation knowledge of the digital twin workshop through the geometric model, physical model, behaviour model, and knowledge model, respectively; the intelligent negotiation mechanism is used to describe the system reconfiguration behaviour, such as negotiation and cooperation between modular production nodes, change of node type and number, and node reconfiguration [16]. The mannequin layer is the core of digital twin operation, the information layer, and the bodily layer, to map and describe the modular manufacturing device in the bodily house in the facts house, help the production managers understand the operation status of the production system, and support the functions of negotiation based dynamic reconstruction, simulation verification of reconstruction scheme, and model driven rapid reconstruction on the basis of real-time control function.

(3) The data layer is mainly used to store the basic configuration data and process data supporting the digital twin operation of modular production system. The data types include basic data, simulation data, and real-time data.

(4) The application layer mainly serves the design, operation, and simulation of modular production system. The reconfigurable application based on digital twin model includes model driven system design reconfiguration, operation scheme reconfiguration based on multiagent negotiation, and simulation verification of reconfiguration scheme. Model pushed machine diagram reconfiguration capacity that machine designers use the predefined mannequin factors in the mannequin layer to shortly diagram and reconstruct modular manufacturing nodes in the data area via visualization strategies; operation scheme reconfiguration based on multiagent negotiation refers to the generation of reconfiguration scheme through agent negotiation in the process of system operation to deal with external fluctuations of the system [17]. Simulation verification of reconfiguration scheme refers to verifying the effectiveness and rationality of reconfiguration scheme through the simulation results of model layer. The application layer aims to help system designers complete the tasks of design, verification, operation control, and reconstruction in the whole life cycle of modular production system through digital twin model, to improve the reconstruction efficiency [18].

3.2. Implementation Path and Foundation. Network flow digital twin is a systematic project integrating the technical achievements. Although its concept is still in the development stage, it has a certain technical foundation in related fields. Its core goal is to use the diversified modelling method based on mechanism and data to realize the panoramic image of the complex power metering and production system in the digital space and simulate the dynamic behaviour of the system in different scenarios through multiscale analysis and calculation, as well as support the flexible interaction with external elements. The technical framework is shown in Figure 2.

The modelling and simulation theory and method of physical energy system lay a foundation for the construction of digital twin core function of power metering and production system [19]. The existing research has carried out some research on the unified modelling and simulation method of electric, gas, and thermal multienergy flow under different time scales. For example, by transforming the partial differential equations of gas and thermal fluid into ordinary differential equations, the joint simulation of the dynamic characteristics of gas and thermal network can be

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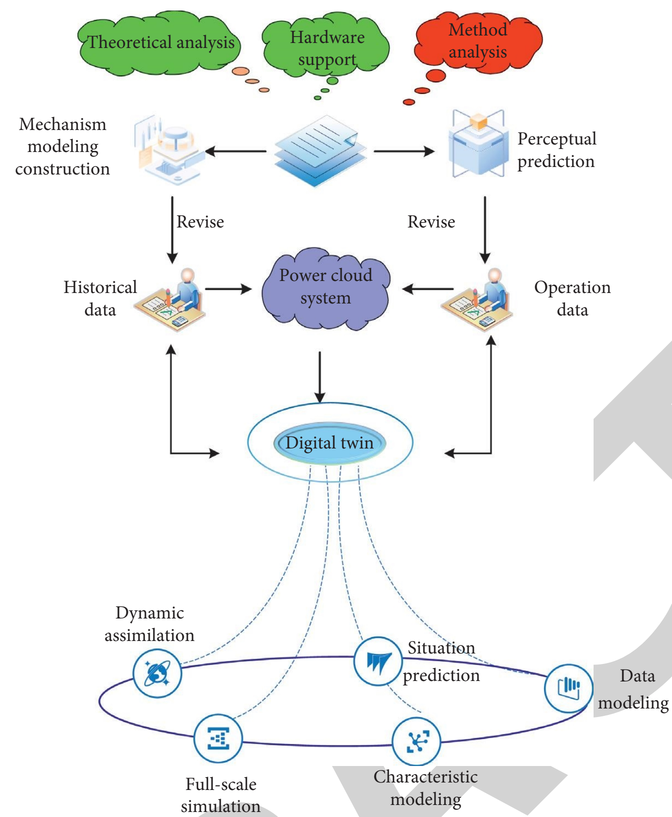

Figure 2: Composition of digital twin technology in power system.

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realized. By mapping the gasoline and warmness community mannequin in time area to frequency domain, the unified modelling of fuel network, warmness community, and electricity grid can be realized [20]. From the perspective of circuit, the components in gas network and heat network can be compared as circuit components, so an analysis method of power metering production system which is unified with circuit analysis method is proposed. By transforming the complex characteristics of multienergy network in time domain into algebraic problems in complex frequency domain, a unified distributed parameter circuit and network model of electric, gas, and thermal systems can be established.

The fusion and utilization of multisource data are the key to construct the digital twin of power metering and production system. Firstly, considering the complexity of power metering and production system, it is difficult for a large number of links with unclear mechanism and opaque state to construct analytical mathematical models, which will rely more on data-driven methods to reveal their operation characteristics. Secondly, as a direct reflection of the state and characteristics of physical system, multisource operation data can be used to drive the continuous improvement of digital twin model and parameters and the synchronous evolution of virtual real system. For the related problems, on the one hand, the existing research starts with the steady-state characteristics and uses the data-driven method to realize the power flow calculation of electric and thermal networks [21]. On the other hand, focusing on the dynamic characteristics, the multitime scale characteristics of key energy conversion equipment such as micro gas turbine are modelled based on data-driven method. The existing research has carried out some work in the above aspects and realized typical applications such as intelligent urban building energy efficiency management and energy Internet monitoring based on information physics system.

4. Digital Twin Digital Reconstruction Method of Power Metering Production Data

4.1. Planning and Design of Power Energy System Based on Digital Twin. Electricity metering can be used for planning, operation, control, optimization, etc. of production systems. Figure 3 shows the operation optimization based on digital twin.

The modular idea of digital twin is not only reflected in the flexible configuration ability of power metering production system, but also reflected in the modular combination ability of its optimal planning mathematical problems. Especially with the establishment of more unified digital twin standards and specifications in the future and their wide application in the manufacturing industry, the digital twin of various energy production, conversion, consumption links, and devices may have been established in the factory stage and provided to users as an additional product function or service. This will greatly improve the planning and design efficiency of power metering production system as a modular combination of complex products.

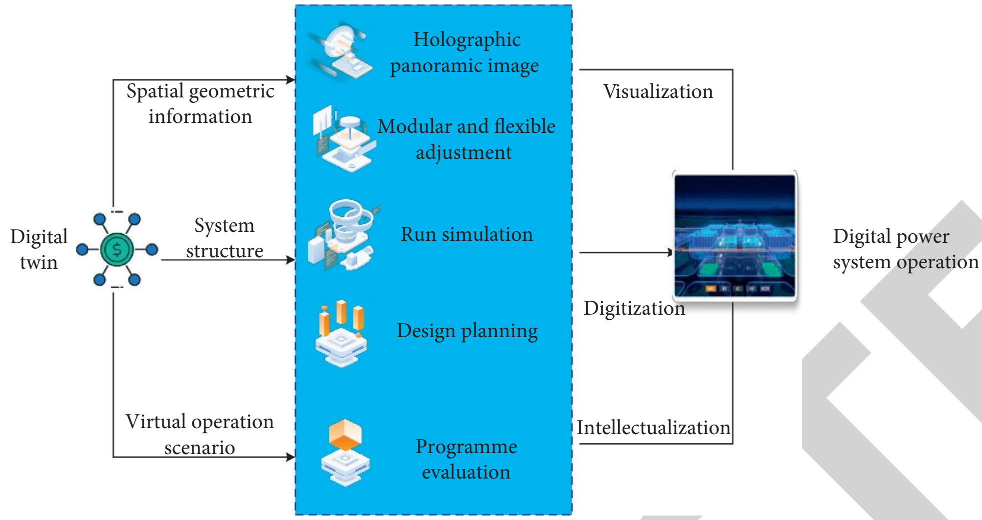

Figure 3: Power system design and operation optimization based on digital twin.

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In addition, the holographic mirror image including the spatial structure characteristics of the energy system through digital twinning can support the integration of the planning and design scheme and the construction implementation scheme; that is, in the planning and design stage, the matching relationship between the planning scheme and the energy pipe corridor, architectural space, and urban layout is considered, so as to make the planning scheme realizable in the real environment and the coordination with the overall urban construction scheme can be an important constraint for planning and design. Further, combining digital twin technology with 3D printing architecture and other technologies to realize the rapid construction of infrastructure such as power metering production station and distribution room will greatly shorten the cycle from planning and design to construction and operation. Finally, digital twin provides a more realistic testing environment for the evaluation of planning schemes. The uncertainty of source and load in the operation of power metering and production system will significantly affect the actual performance of the planning scheme.

4.2. Digital Twin Fault Early Warning and Predictive Maintenance. The ability to diagnose the operation risk of power metering and production system is still insufficient; in particular the condition monitoring of urban underground power, gas, and heat pipelines is more difficult. Regular inspection is still the main way of energy system operation and maintenance, which means that it is difficult to find the best balance between system operation and maintenance cost and safety and reliability level, which may even lead to serious fault loss [22]. At the system level, the risk characteristic information of each key equipment can be integrated in the system level digital twin, and the system risk status can be described by using the fault characteristic data of the same type of equipment, historical operation and maintenance data, energy system measurement data, etc., so as to provide support for more complete status monitoring.

4.3. Coordinated Control and Optimization of Power Metering and Production Based on Digital Twin. At present, the operation optimization of power metering production system is mostly based on specific steady-state model. However, the production, transmission, conversion, and consumption characteristics of multiple types of energy in the actual system are difficult to describe by a simple model but are closely related to the system operation environment, working conditions, and other factors. The realization of fine operation scheduling considering the real state of different devices is of great significance to the operation practice of power metering production system. In this regard, the digital twin's panoramic mirror image and behaviour characterization ability of the real-time state of the real system are used.

The state data fed back to the digital space can be used to comprehensively judge the control effect and modify the control strategy, so as to realize the fine closed-loop control coordinated by various energy supply devices and improve the overall regulation level of the system. The relationship between electric energy and active power is as follows:

$$W = \frac{\sum_{j=1}^{N} u(j*\Delta t)i(j*\Delta t)\Delta t}{\int_0^T u(t)i(t)dt}. \quad (1)$$

When the instantaneous value of voltage and current sampled by the electronic transformer is transmitted to the digital electric energy meter through the merging unit, the electric energy meter receives it and hands it to the microprocessor for multiplication according to the definition, so as to obtain the average power.

$$P = \frac{\sum_{n=1}^{N} u(n)i(n)}{\sum_{n=1}^{N} P_n}. \quad (2)$$

The product of voltage instantaneous value and current instantaneous value is the average value in one cycle, and the integral expression of reactive power is the average value in one cycle obtained by Hilbert transformation of voltage instantaneous value.

$$u(t) = \sum_{k=1}^{n} \sqrt{U_k \sin(k\omega t + \varphi_k)}, \tag{3}$$

where K and N are positive integers, and UK and IK are the effective values of the k-th harmonic of voltage and current, respectively.

$$v(t) = \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{\left[\sqrt{U_k \sin(k\omega t + \varphi_k)}\right]}{t - x} \mathrm{d}x. \tag{4}$$

The truncation error in the calculation of active power is analysed by a similar method, and the effective value of voltage obtained by trapezoidal method is

$$U = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} u_k^2 + \frac{u_0^2 + u_N^2}{N}}. \tag{5}$$

4.4. Multidomain Collaboration of Digital Twins. In the future, the smart city will have a higher level of informatization and digitization, to form the concept of digital twin city. At this time, the digital twin of power metering and production system can play an important role in supporting urban development and efficient operation. Using the digital twin data fusion and utilization capability of the power metering and production system can form the energy big data foundation for urban development and support various advanced data analysis applications. For example, the energy consumption data of electric power, hydraulic power, heat, and gas gathered by digital twins, combined with urban population, meteorology, geography, and other information, can be used to study and judge the trend of urban economic development and provide richer and accurate decision-making basis for urban planning and construction. The user side model and data provided by digital twin can describe users' living and consumption habits and help form new urban management and commercial operation modes. Energy security is an important part of urban security; the digital twin panoramic perception ability of power metering and production system can be used to find the system operation risk, judge the fault location, and improve the security and reliability of energy supply.

5. Validation of Operation Data Analysis Method

5.1. Multidomain Collaboration of Digital Twins. The metering performance of electronic transformer and digital metering system put into operation in digital metering pilot is analysed. See Figure 4 for the original collected data randomly selected.

The abnormal value range obtained after calculation of the original collected data is shown in Figure 5. The ratio difference and angle difference of 12 randomly selected operation data meet the requirements of error limit and can be used for subsequent data analysis.

5.2. Operation Data Measurement Performance Analysis. Randomly select 12 groups of operation data of a digital output electronic current transformer located in phase B in the pilot from August 2019 to July 2020, apply the operation data analysis method proposed in Section 2 to carry out the measurement performance analysis of distribution network electronic current transformer, and use the quadratic curve to analyse the influence of single factor on error. Through the quadratic curve, the influence of temperature and load changes on the error is analysed, as shown in Figure 6.

The error of digital output electronic current transformer is less affected by temperature change, the variation range of specific difference is 0.05%, and the variation range of angular difference is 3 degrees. It is greatly affected by the load change, with the variation range of specific difference of 0.12% and the variation range of angular difference of 5 degrees. However, when the load current exceeds 10a and about 2% of the rated current, the impact is significantly smaller. The influence of compound factors on error is analysed by three-dimensional surface. Through the three-dimensional surface, the influence of the change of temperature/humidity and temperature/load on the error is analysed, as shown in Figure 7.

Measurement error surface of digital output electronic current transformer is not smooth at low load, and the error fluctuation is large. With the increase of load, the error surface is gradually smooth, the error fluctuation is gradually reduced, and the operation of the transformer is more stable. The extreme point of the error of electronic current transformer often appears in the extreme point of the environment, that is, high temperature and high humidity, low temperature and low humidity, high temperature and low humidity, and low temperature and high humidity. From the analysis results of two-dimensional curve and three-dimensional surface, the calculated information gain of each influencing factor can accurately reflect its influence on the error.

5.3. Performance Analysis of Digital Electric Energy Metering System. This section analyses the metering characteristics of the digital metering system composed of analogy output electronic transformer and the digital metering system composed of digital output electronic transformer through the error data of the total active power of the two typical design schemes of distribution network digital metering system in the pilot within one year. The stability, advantages, and disadvantages in long-term operation are shown in Figure 8.

The maximum monthly active energy error of the digital output metering system is −0.48%, and the variation of monthly energy error within one year is 0.24%. For one year's operation, the overall metering performance is stable and can be preferentially applied to power trade settlement. Due to the ECT failure of phase α in the analogy output metering system, the maximum monthly active energy error is −6.0%. For phases α and γ in normal operation, the maximum monthly active energy error is −0.99% and −1.17%, respectively, but the variation of electric energy error within one year is only 0.28% and 0.41%. The analogy output metering system has high

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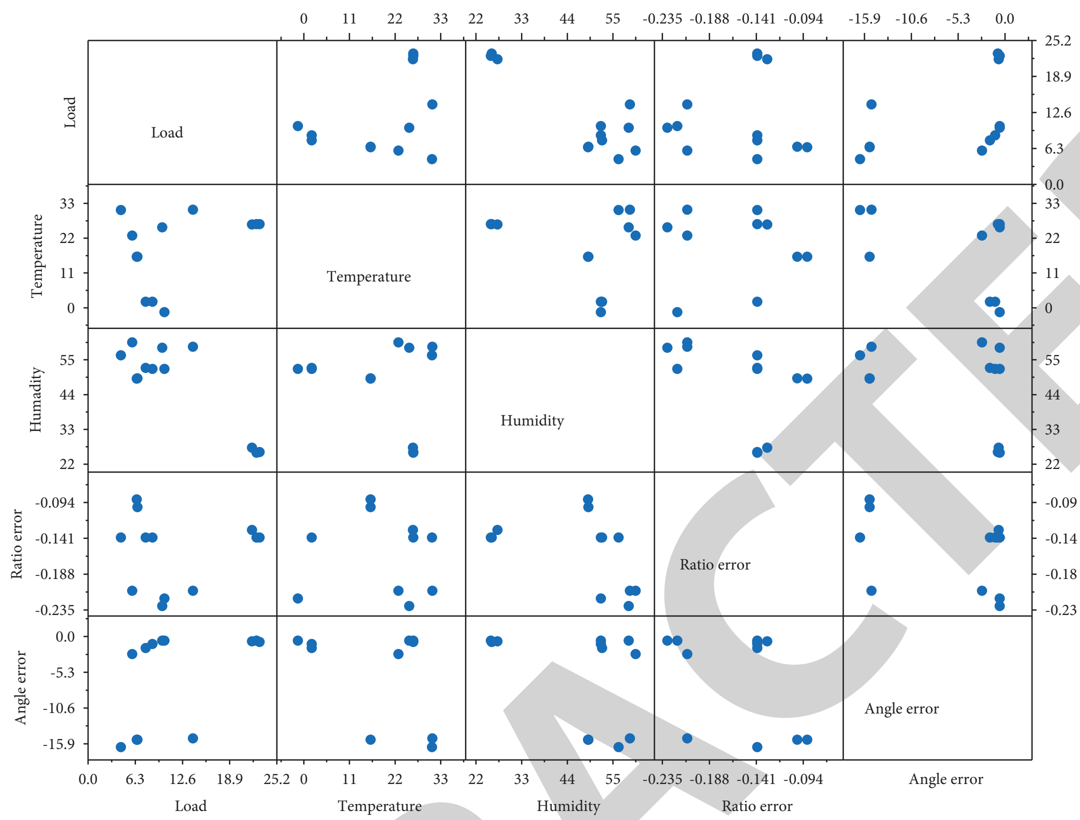

FIGURE 4: Raw data distribution of random sampling.

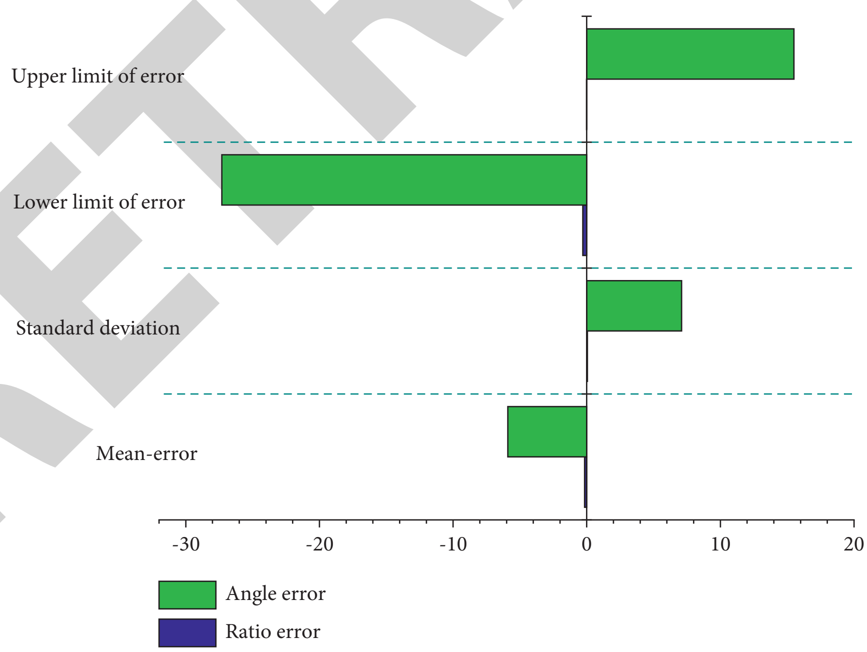

FIGURE 5: Calculation of outliers.

failure risk, and the metering equipment in normal operation also has large system error; before putting into operation, the system error can be eliminated through parameter configuration and then used for electric energy metering.

5.4. Power Parameter Monitoring Based on Digital Twin. The standard system is adopted, and the default admittance parameters are simulated with Manpower. In IEEE-9 system, node 1 is a balanced node, nodes 2 and 3 are PV nodes, and nodes 4, 5, and 6 are PQ nodes with load. It is

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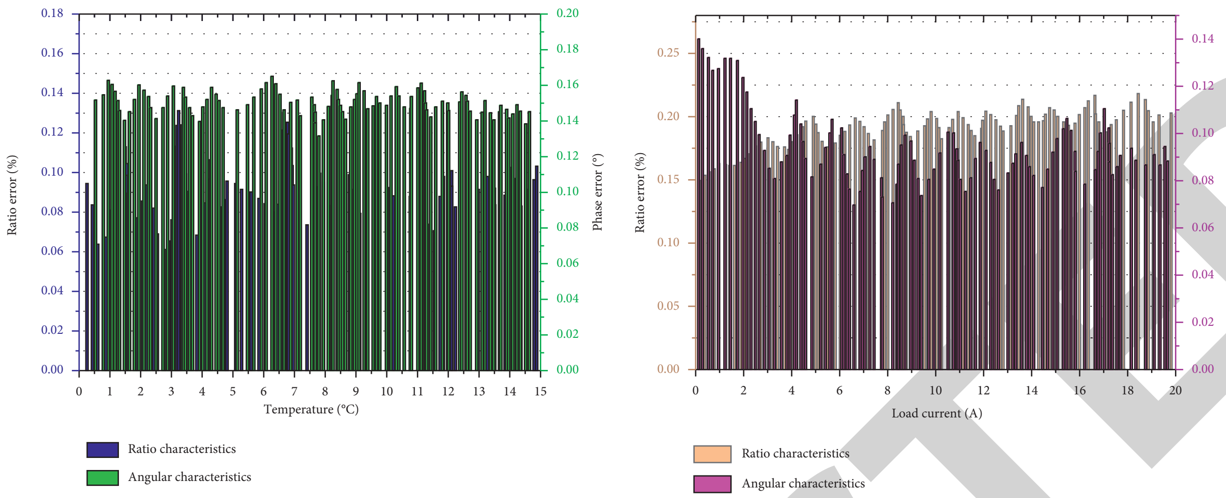
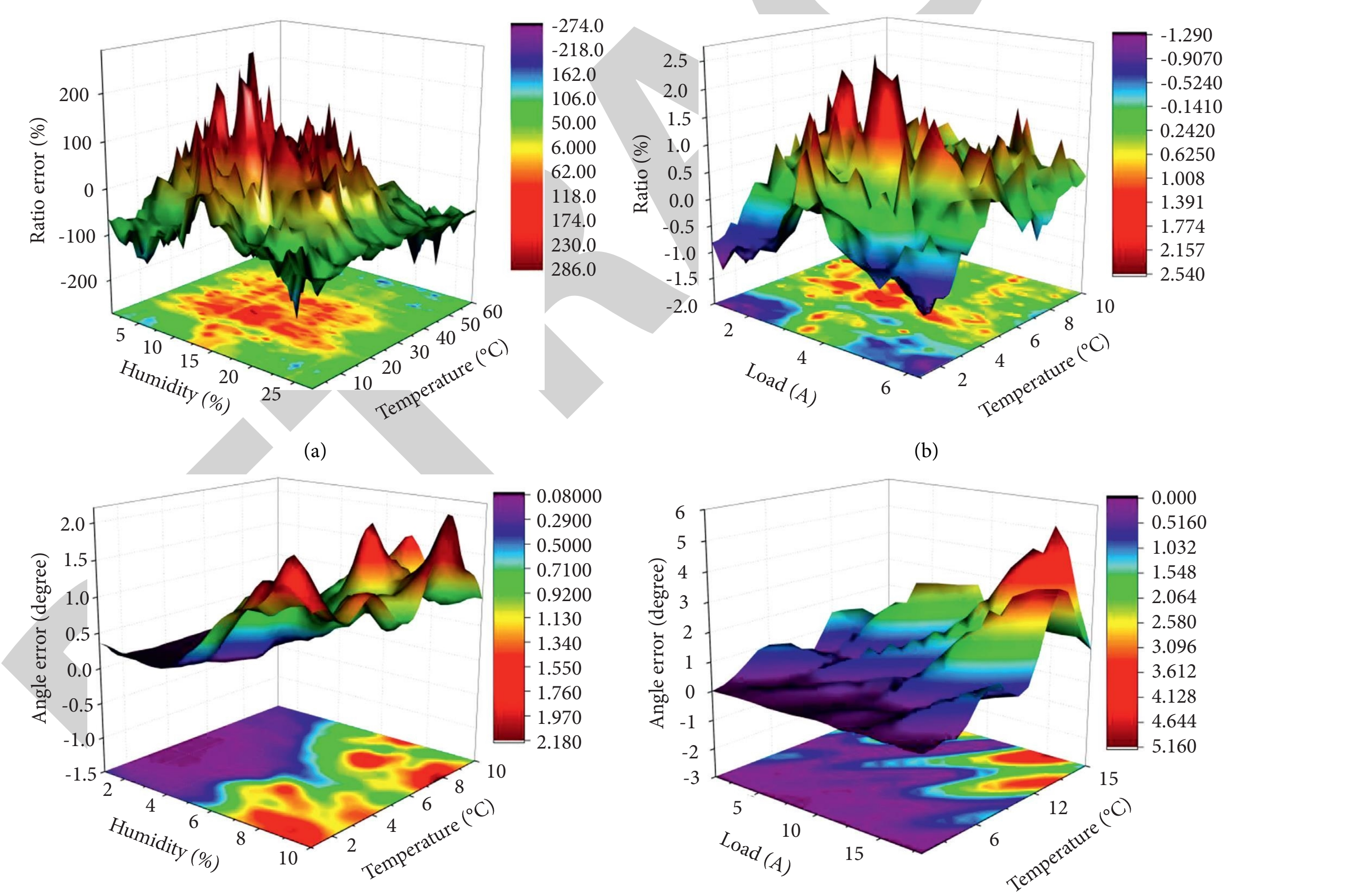


(a) (b)

Figure 6: Error characteristics of digital output. (a) Temperature characteristic. (b) Load characteristic.



(a) (b)

(c) (d)

Figure 7: Analysis of digital output error characteristics. (a) Ratio of temperature/humidity. (b) Ratio of temperature/load. (c) Angle error of temperature/humidity. (d) Angle error of temperature/load.

assumed that the normalized load fluctuation of 3, 4, and 5 in a certain day is shown in Figure 9(a), and its measurement frequency is 9600 points per day. At the same time, small fluctuations are introduced into the measured data of each node to simulate load fluctuations and measurement errors. It is substituted into the traditional

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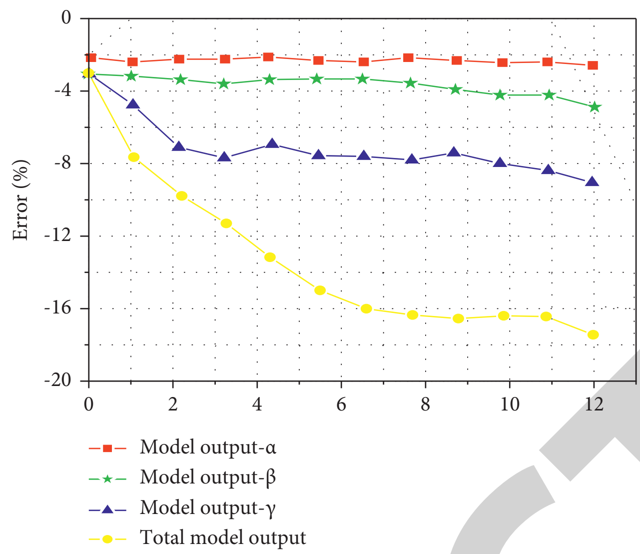
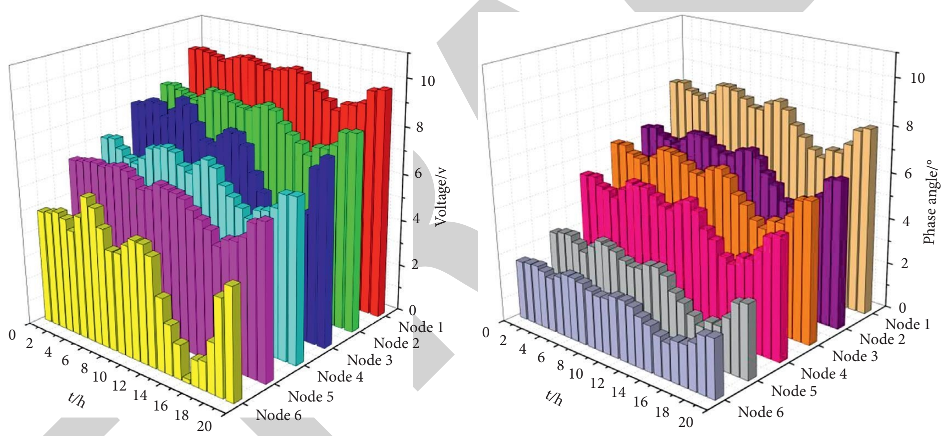


Figure 8: Error analysis of power data in digital metering system.



(a) (b)

Figure 9: Power flow calculation results of power production metering data. (a) Voltage amplitude. (b) Voltage phase angle.

power flow program to obtain the system state quantity, as shown in Figure 9(b). Train ANN network to simulate load active power value P and voltage amplitude u and voltage phase angle, add small artificial fluctuations to the parameters, and normalize them.

Similarly, the normalized voltage amplitude and phase angle can be obtained, and a 5-layer ANN network can be established to select the activation function. Time 1–8400 is used as the training set and time 8401–9600 is used as the test set. The predicted values of the three active load nodes in the system are very close to the actual values, which indicates that DT successfully represents the actual physical system. Different from the traditional way, the establishment of DT system does not depend on the information of topology but is realized through two links: training and testing based on artificial neural network, that is, training the historical data set to establish the neural network and using the network to test the sampled data set to obtain the results.

6. Conclusion

Digital twin can be used as an important means of integration and utilization of sea volume data and extensive connection in digital city, which will make it possible for the interconnection and cooperative operation of energy system and various fields of the city in digital space. Digital twin mannequin is developed and displayed primarily based on the analysis, identification, and prediction effects of energy machine operation facts via the digital twin mannequin building module, which realizes the visualization function of power system operation data. Operators can intuitively obtain the actual operation status and fault feedback of the current power system through the displayed three-dimensional digital model, improve the operation and preservation efficiency of the power system of the substation; use the digital twin for scientific construction, which can intuitively show the operation efficiency of the system.

Data Availability

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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