Application of electric meter in the smart distribution network

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Abstract: The purpose is to promote equipment automation in the smart distribution network and improve the electricity detection accuracy and reliability of power equipment. Here, electric meters in the smart distribution network are studied. Firstly, the current electricity detection methods are discussed. Secondly, the common electric meter fault mechanisms are summarized and analyzed. Finally, the GM (Grey Mole) (1,1) is optimized through ACO (Ant Colony Optimization) algorithm and is used for detection and investigation of the real-time electric meter monitoring system. Then, simulation experiments are conducted based on the user's electricity consumption data. The results indicate that the load correction value optimized by the ACO algorithm is closer to the actual load than the predicted value, and the absolute residual value is greatly reduced compared with the predicted value. At the same time, the prediction trend is more similar. This shows that the ACO-optimized GM can effectively improve the accuracy of the electric meter monitoring system.

1. Introduction
In recent years, with the gradual maturity of big data and Internet of Things technology, the construction of smart grid is also accelerating. As an important core part of smart grid, the intelligentization of distribution network has become a new trend in the modernization construction, which is of great significance for realizing the overall construction of smart grid [1]. In order to strengthen the construction of smart distribution network, it is necessary to construct a set of scientific and effective comprehensive electric evaluation indexes to realize the management and real-time monitoring of smart distribution network, so as to provide accurate real-time data for the distribution system and timely repair in case of failure. Therefore, in order to ensure the service life and accuracy of electric meters, digital electric meters are popularized in large scale, and at the same time, the detection technology of metering equipment is continuously updated to further improve the accuracy of detection. At present, although the popularity of smart distribution network system is high [2], the detection technology of electric meters is not fully mature. The main changes are now that the detection standard is unitary and there is no comprehensive overall evaluation index. Therefore, the detection technology needs to transit from theory to practice and accelerate the highly matching between theoretical technology and practical application. In today's high-speed economic development, both electric power companies and users pay more and more attention to the quality and experience of products. As the link between users and electric power companies, electric meters need to be tested in real time in order to improve the economic benefits of electric power enterprises, and equipment load is predicted according to the historical electricity consumption data. If there is a mismatch, faults can be reported in time to ensure the efficiency of
distribution network [3].

Based on the smart distribution network, this paper studies the accuracy and reliability of the electric meter monitoring system. After analyzing the common abnormal situation of electric meters, the grey GM (1,1) model is established, and the grey model is optimized by using ant colony algorithm. The theory is applied to the real-time data of a local user's electric meter as the research object, and the user's daily electricity consumption as the sample data is used to establish the grey prediction model, and then the predicted value is compared with the real data to verify the accuracy of the model, so as to realize real-time monitoring and abnormal processing of electric meters. It is very important to promote the automation construction of smart grid.

2 Analysis of Electric Meter Monitoring System of Smart distribution network

2.1 Status of smart distribution network data
At present, the data sources of smart distribution network can be mainly divided into three modules: the measured data of, the operation data of and the data outside the distribution network system. These three data sections serve the construction and operation of smart distribution network together. With the gradual maturity of Internet of Things and big data technology, people demand more and more electricity [4]. At the same time, the distribution system is more and more complex. For different types of users, their electricity consumption and time periods are different, and the changes of electricity consumption data of these users will tend to be regular to a large extent. For example, large holidays and normal working days will affect the user's electricity consumption, which will also affect the operation mode and development direction of the distribution network system. In recent years, with the continuous reform and upgrading of distribution network system, the measurement data of electric system has made great progress in terms of both method and processing technology. It is possible to use big data technology to mine the potential electricity consumption law of users from the historical electricity consumption situation, so as to deeply develop the database of distribution network system, provide continuous data for the intelligence of distribution system, and accelerate the database construction of distribution system [5].

2.2 Current situation of electric meter monitoring system
Power metering is an important work related to the power industry. This method and equipment with high efficiency, accuracy and stability can effectively maintain the interest relationship between electricity generation, transmission and distribution. In view of various abnormal problems caused by statistical methods, it is necessary to further study and propose the principle of abnormal monitoring of electric meters [6]. At present, the monitoring of electric meters is mainly realized through manual meter reading and auditing. However, on the one hand, due to the increase of the number of users, electric meters are also increasing, which makes the workload of manual meter reading increase sharply. On the other hand, the electric system is also developing continuously, and it is difficult to ensure the accuracy and convenience of manual measurement and monitoring methods [7].

Along with the construction speed of smart grid, various electric meters are constantly updating. Along with the development of the fully automatic operation mode of distribution system, various data of electric energy system show blowout growth. In the process of data collection of electric meters, a large number of abnormalities and faults will occur. In order to ensure the accuracy and stability of electric meters and maintain the real-time electric safety of distribution system, a scientific and effective prediction model of electric meter monitoring system must be established [8].

2.3 Cause of failure of electric meters
In general, there are three reasons for the failure of electric meters: the failure of the meter itself, the harmonic interference of the electric system, and the damage of the equipment caused by man-made stealing of electricity. Among them, the failure causes of the meter itself include quality, configuration, service life and working environment. Generally, if the electric meters are in a bad working environment...
for a long time, the equipment itself will be more prone to failure, resulting in serious deviation of data such as electricity consumption, resulting in electricity loss and even affecting the stability of the entire distribution system [9]. The harmonic interference of electric system is mainly due to the access of new electric equipments, which makes the whole distribution system structure tend to be diversified and complicated. The electromagnetic waves with different frequency are generated between different electronic equipments due to different working current and voltage. Although this harmonic phenomenon is not common, once it occurs, it will cause great interference to the electric meters and reduce the accuracy and sensitivity of the meters. The last is the act of human stealing electricity, which is the main and most common reason for the failure of the electric meters. For their personal selfish purposes, the wrongdoers tamper with the internal working structure of the electric meters, which makes the electric metering produce huge errors and directly affects the economic benefits of electric power enterprises [10].

2.4 Establishment of Grey Model and Ant Colony Optimization Algorithm
GM (1,1) is one of the gray model (GM), and it is widely used in the distribution system of smart grid. It is mainly used to predict the electric load. The main calculation principle of GM (1,1) is to accumulate the historical data as the original sequence one by one to get the new sequence continuously. The new sequence has the exponential law so it has a high fitting degree. The original sequence based on time can be accumulated to get the new time series. The regularity of the new time series can be fitted by linear differential equation, so the grey model is very suitable for the electric energy prediction with time series [11].

In this paper, based on the grey model, the optimization is carried out, and a bionic algorithm, the ant colony algorithm (Ant Colony Optimization, ACO), is used to simulate the transfer and communication between information elements. Because the algorithm has been used in the field of electronic calculation, it belongs to an advanced colony optimization algorithm, which can better realize the optimization of discrete problems in the grey model [12].

3. Case analysis of electric meter system test
3.1 Prediction effect analysis of electric metering under grey model
Taking the electricity consumption of a local resident user A in July 2020 as the sample data, the daily electricity consumption of 13th -26th was selected as the original sequence of the sample data to establish a grey model. The actual load and the predicted load and the absolute residual value between the two were shown in Figure 1 and 2.
Figure 1 Comparison 1 of the actual load of user A with the predicted load

It can be seen from the figure that the matching degree between the actual load and the predicted load was not very high, and the absolute residuals between the two fluctuated from high to low, which were not very stable. The precision and credibility of the prediction results of the grey model behind the data needs to be further improved.

Figure 2 Comparison 2 of actual load of user A with predicted load

3.2 Prediction effect analysis of grey model after ant colony algorithm optimization

In order to ensure the accuracy of the predicted load, the AM-GM (1,1) grey model optimized by ant colony algorithm was established according to the sample data, and the electricity consumption of 25th -27th was predicted and corrected, and the corrected value was compared with the actual data of 25th,
26th and 27th. The comparison results are shown in Fig.3.

![Comparison between predicted results of optimized grey model and actual load](image)

Figure 3 Comparison between the predicted results of the optimized grey model and the actual load.

It can be seen from the figure that the absolute residuals between the modified value of the grey model optimized by ant colony algorithm and the actual value was obviously reduced, and the modified load value was more consistent with the trend of the actual load. Compared with the large difference of the predicted load, the modified predicted load was more accurate. From this, it can be seen that the actual electricity consumption of the user was in good agreement with the predicted value without excessive deviation, and from the fluctuation between the upper and lower limits of the predicted threshold, it can be seen that the electric meter of the user had no fault and was basically normal.

4. Conclusion

In this paper, under the background of the gradual popularization of smart distribution network system, the reasons and performance of electric meters are studied. Taking the user's electric meter as the analysis object, the electricity consumption was predicted by establishing grey model and optimized by ant colony algorithm, and the defects and problems in the system were corrected. Finally, it was found that the AM-GM (1,1) model optimized by ant colony algorithm can effectively improve the prediction accuracy of electric energy load and find out the abnormal situation of power equipment in time. The shortcomings of this paper: only the data of normal functional equipment were collected as samples, and no power equipment under fault condition was found for comparative analysis, so further research is needed. It is believed that with the expansion and popularization of smart distribution network, the prediction and monitoring system of power equipments will be more and more perfected.

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