Research on Online Monitoring of Power Supply Reliability of Distribution Network Based on Mobile Communication Technology

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Abstract. The distribution network plays an important role in distributing electric energy in the power network. Because of the huge and complex structure of the distribution network, the power supply effect is affected. Therefore, an on-line monitoring method for power supply reliability of distribution network based on mobile communication technology is proposed. Use mobile communication technology to collect fault information in distribution network. Through the reliability evaluation algorithm, the reliability management system is constructed and the monitoring process is designed. The overall detection system is divided into four modules, and online detection is realized through communication interconnection. The experimental analysis results show that the online monitoring method of power supply reliability of distribution network based on mobile communication technology has high accuracy and practicability, and fully meets the research requirements.

Keywords: Mobile communication technology · Distribution network · Power supply reliability · Online monitoring

1 Introduction

With the rapid development of modern society and the popularization of high technology, the application of electric power has been fully popularized in the society. However, the improvement of social benefits also makes social development and people's life have higher requirements for the reliability of power supply. According to the incomplete statistical data of power grid monitoring and management, most of the power outages currently occur in the distribution network, and the power loss generated by the distribution network accounts for nearly half of the power loss of the power grid. Relatively speaking, the research on the reliability of distribution network has not attracted the

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strong attention of scholars. The biggest reason for this phenomenon is that the facilities of the power generation system are concentrated compared with the distribution network, the original investment in the facilities is large, the establishment takes a long time, and the degree and scope of the impact of power failure caused by insufficient power supply on society and ecology are easy to attract people's attention. Compared with many foreign countries, although the research on the reliability of distribution network in China started late, after a long time of hard exploration, it also pays more and more attention to the research on the power supply reliability of distribution network. A series of reliability evaluation algorithms are proposed, the corresponding evaluation and calculation software is developed, a relatively perfect database of power grid basic parameters and accident records is established, and a system for efficient monitoring and management of power grid power supply capacity and power quality is established.

Reference [1] proposes a study on power supply reliability monitoring of active distribution network based on load characteristics. Select the collection equipment with load characteristics, and transmit the collected data using optical fiber network; Combining the power consumption in different time periods, a load probability model is established to obtain the time series characteristics of all load points in the distribution network; Analyze the reliability indexes of the load points of the series and parallel structures respectively, and evaluate the reliability of the distribution system by using the outage frequency, outage time and other indexes; Take these indicators as the monitoring basis, obtain the probability formula of normal operation of the distribution network, input basic information into the network, set the iteration times and sampling density, and judge whether the power supply can meet the power supply demand of all loads during the power outage The algorithm has high accuracy, but the calculation process is complicated. Reference [2] proposes a study on reliability of distribution network with DG based on load optimality. First, a load importance measurement index system is established. Secondly, each index in the load is subjectively weighted based on AHP. Then, each index is objectively weighted using entropy weight method. Finally, kender harmony coefficient is introduced to obtain the comprehensive weight of the index. This algorithm has high detection efficiency, but the accuracy of detection needs to be improved.

At present, there are two kinds of quantitative calculation methods of reliability indexes: analytical method and simulation method. The analytical method is based on the structural characteristics of the network and carries out reliability calculation through mathematical modeling [3]. Simulation method is an experimental method. On the premise that the original parameters of equipment reliability in the distribution network are known, the possible operating states of the system are determined by sampling from the probability distribution function of the equipment, and then the operating states of various systems are analyzed and calculated, and the reliability indexes are obtained according to the statistics of the results of the simulation experiment. The method of reliability analysis mainly adopts the minimum path method, which is to seek the shortest power supply path for all user points in the network, and equivalent the equipment with non shortest power supply path to the shortest power supply path. Therefore, only the influence of nodes and load nodes on the shortest power supply path on network reliability needs to be considered, and the methods and evaluation indexes suitable for power supply reliability statistics, calculation and analysis of distribution network users are formulated. The shortest path algorithm is applied to the theoretical analysis of the actual calculation example, and the reliability improvement measures are analyzed one by one by calculating the reliability index and using the income increment/cost increment evaluation method, so as to find the reliability improvement measures suitable for the actual power network. Therefore, an on-line monitoring method of power supply reliability of distribution network based on mobile communication technology is proposed.

2 Research on Online Monitoring of Power Supply Reliability of Distribution Network

2.1 Identification of Power Supply Fault Information of Distribution Network

Due to the complex and changeable operation of the actual distribution network system, there are still many problems in the production and operation process, and the practical value of these algorithms is limited. Using mobile communication technology to collect fault information, construct fault judgment matrix or locate the distribution network through hot arc search is also affected by the collected information to a great extent, and the fault tolerance is poor. In case of distorted information or mistransmission of information, it will cause misjudgment and missing judgment. Mobile communication technology has good interpolation results, while extrapolation may have large error and slow convergence speed. The monitoring method based on mobile communication technology can effectively simulate the process of fault diagnosis, but there are many defects in practical application. With the development of hardware technology and integrated intelligent technology, as well as the in-depth research on the principle of fault location by more experts and scholars, and the comprehensive use of various advanced and optimized intelligent methods, the electrical quantity after fault can be collected more efficiently and accurately, which will make the fault location of distribution network achieve better development. The advantages and disadvantages of various fault location algorithms are shown in Table 1.

Reliability mainly refers to the ability of a certain element, a certain equipment or a certain system to realize the specified functions under normal specified conditions during the predetermined operation period. Its measure is called reliability or reliability. Reliability represents the ratio or probability of equipment and system success. The reliability research of power system involves all links, coupled with the rapid progress of computer information technology, at present, many power grids have realized the supervision and management under the computer system. Therefore, it is the general trend to carry out the system reliability analysis through the computer. Due to the wide range of power system, comprehensive reliability evaluation is difficult to achieve. It is usually discussed and studied after the subsystem is divided. According to the composition of power system, it can include the reliability evaluation of power generation, transmission, distribution and other systems. The reliability index of distribution network can be divided into load point index and system index, in which the system index can be further divided into frequency time index and load electricity index [4]. The load point index describes the reliability of

Table 1. Comparison of advantages and disadvantages of various fault location algorithms

Fault location method	Advantage	Shortcoming
Matrix algorithm	Strong adaptability, high system storage efficiency and good engineering practicability	It takes a long time to judge the fault, and it is easy to miss and misjudge
Overheated arc search algorithm	The principle is simple and the detailed fault degree can be obtained	It has high requirements for the completeness of fault information and complex processing of special switches contained in distribution network
Expert system	Avoid limitations and be more careful and accurate; Strong applicability, not affected by environment, time and space and human factors; Analyze the problem objectively, comprehensively and logically	It is difficult to acquire knowledge and verify its completeness; The diagnosis speed of large system is very slow; Difficult maintenance; Lack of learning ability; Poor fault tolerance
Wavelet neural network	Have certain generalization ability; Strong fault tolerance; Fast execution speed	Learning convergence speed is generally slow; The error of extrapolation is large

a single load point, and the system index is used to describe the reliability of the whole system. The system reliability index can be calculated through the load point index. The commonly used load point reliability index mainly includes the average failure rate of load point, the average annual outage time of load point and the average outage duration of each fault of load point. Its specific meaning is:

$$r = \frac{U}{s\lambda} \tag{1}$$

In formula (1), the average failure rate of load point λ the average failure rate of load point is the expected value of the number of power outages at load point within the statistical time (usually one year), and the unit is generally the next year (Times). Average annual outage time of load point U average annual outage time of load point refers to the expected value of outage duration of load point within the statistical time (usually one year), and the unit is generally hour/year (h/a3). The average power outage duration s per fault at the load point, the average power outage duration of each fault at the load point can be calculated from the first two indicators by the formula. Point-of-load reliability metrics do not always fully characterize the system. In order to reflect the severity and importance of system outage, its reliability needs to be evaluated from the perspective of the whole system. All system reliability indexes can be calculated from the average failure rate λ_i and average outage time U_i of load point. The reliability indexes of load point can be calculated from the following formula:

$$\begin{cases} \lambda_i = r \sum_k \lambda_{i,k} \\ U_i = t \sum_k U_{i,k} \end{cases} \tag{2}$$

In formula (2), $\lambda_{i,k}$ and $U_{i,k}$ represent the average failure rate and outage time caused by the failure of component k at the load point, respectively.

2.2 Power Supply Reliability Evaluation Algorithm of Distribution Network

When studying the reliability of power system, the research object is generally divided into two levels: component and system. Component is the basic unit of the system, and it cannot be divided in the system. The system is made up of components, and it is the whole of components. The main components of the distribution network are: overhead lines, buried cables, air switches, voltage regulators, distribution transformers, cables, isolating switches, fuses, etc. [5]. Their reliability is directly related to the reliability of distribution system and even the reliability of power system. From the perspective of reliability theory, the electrical equipment or components used in power system can be divided into two types: Repairable components and non repairable components. If the component is put into use, once it fails, it cannot be repaired, or although it can be repaired but it is not economical, this kind of equipment is called non-repairable component. A component fails after a period of use. Reliability and unreliability Reliability refers to the probability that a component can perform a specified function under specified conditions and within a predetermined period of time. It is a function of time and is recorded as R(). It can also be said that reliability is the probability that the lifetime T is greater than the time t, that is, the probability that the element can still work reliably at the time t:

$$R(t) = P[T\lambda_i > t], \quad t \geq 0 \tag{3}$$

The probability of failure (failure) of the component from the start of use to time t, or the probability that the life T of the component is less than or equal to time t, is called the unreliability (or failure function), which is also a function of time, denoted as F(t), that is:

$$F(t) = P[U_i T > t], \quad t \geq 0 \tag{4}$$

The data exchange of the mobile communication architecture is shown in Fig. 1.

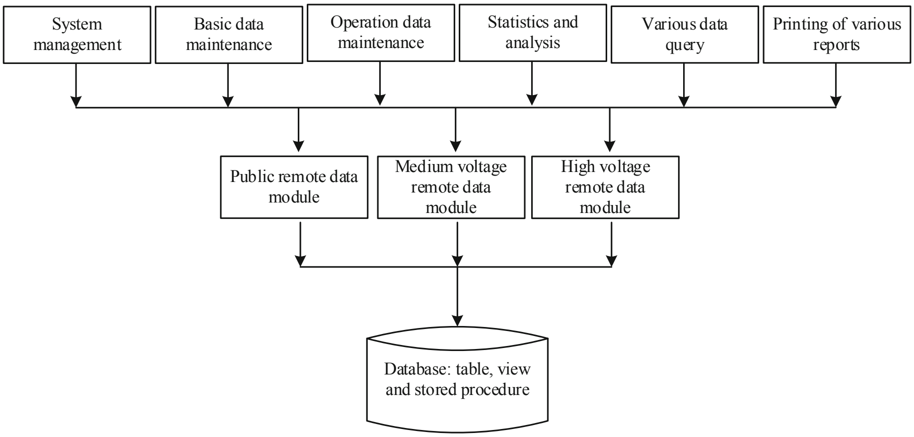

Fig. 1. Data exchange of mobile communication architecture

The system consists of client, middle layer and database server. The client interacts with the database through the remote data module of the middle layer. The remote data module not only provides an intermediary for clients to access the database, but also encapsulates a large number of business logic. Among them, the public remote data module includes parts other than the data table and business logic for medium voltage data and high voltage data, such as various coding data, system management part and application server initialization. The medium voltage remote data module and the high voltage remote data module respectively encapsulate the medium/high voltage basic data, operation data, statistical analysis data and corresponding business rules. The work of the database server includes the maintenance of the database structure, that is, tables, indexes, views, stored procedures, etc. [6]. The collected information is preprocessed, and the relationship between the information output and the input components is analyzed according to the processing results. The specific calculation formula is as follows:

$$f(x_n, y_m) = \frac{R(t)l(x_n, y_m)}{F(t)\sqrt{(x_n)(y_m)}} \tag{5}$$

In formula (5), $l(x_n, y_m)$ represents the covariance between the input information x_n and the output information y_m; k represents the total information quantity. According to the formula, the normalized calculation formula of input information x_n and output information y_m can be obtained:

$$x_n' = \frac{\mathrm{x}_n - x_{\min}}{x_{\max} - x_{\min}}, \quad y_n' = \frac{\mathrm{y}_n - y_{\min}}{y_{\max} - y_{\min}} \tag{6}$$

The formula is weighted to obtain the input data vector expression, as shown in the formula:

$$x = \left(f_1\left(x_1', y'\right)x_i', f_2\left(x_2', y'\right)x_{i-1}', \ldots, f_1\left(x_j', y'\right)x'\right)^T \tag{7}$$

In formula (7), T represents a period, and the weighted input information vector can be obtained by this formula. According to the above weighted processing results, the monitoring process is designed, as shown in Fig. 2.

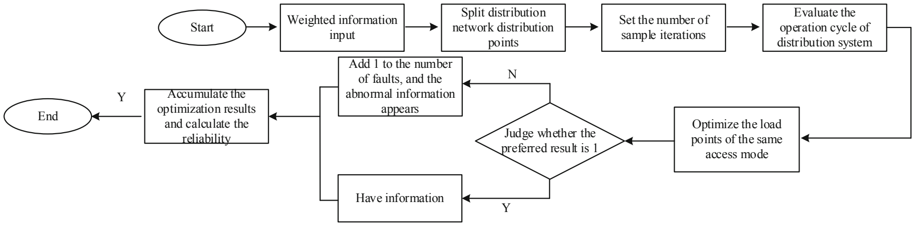

Fig. 2. Monitoring process design

The specific monitoring process is as follows: input the weighted information, divide the distribution points of the distribution network in the set, count the number of power sources, and read the corresponding loads. Set the initial number of sample iterations and evaluate the distribution network operation. In normal operation, judge whether the power supply is connected correctly. If the access is correct, the load points of different access modes are optimized, and then it is judged whether the preferred result is 1. If it is 1, it means that there is correct access information; otherwise, abnormal information occurs. If the access is wrong, the same access mode load point needs to be optimized, and then judge whether the preferred result is 1, if it is 1, it means that there is correct access information; otherwise, abnormal information occurs. Count the optimization results twice, and use this as an index to determine whether the number of optimizations is greater than the preset number of times. If so, output the correct access information, and the process ends; if not, return to step (2). According to the above monitoring process, a monitoring implementation scheme is designed.

2.3 Realization of Online Reliability Detection of Distribution Network

The overall structure of the online monitoring system is divided into system data acquisition module, system data storage module, system operation analysis module and graphical interface display module. In order to realize the communication interconnection of hardware equipment between each module and within the module, different interfaces need to be designed to realize the online collection of system power data, the monitoring and analysis of reliability information and the storage and management of data [7]. The sample data of the power supply bureau and its subordinate district and county-level power supply bureaus in a two-year power grid are collected. Through the analysis of the impact indicators of power supply reliability, the indicators affecting power supply reliability are summarized as shown in Table 2.

Table 2. Impact indicators of power supply reliability

Indicator type	Specific indicators
Grid structure	Ring network rate, switchable rate, average length of each line, network connection standardization rate, inter station connection rate and average number of sections of the line
Equipment quality	Average life value of scrapped distribution transformer, average life value of scrapped switch cabinet, failure rate of bare conductor medium voltage line tread, medium voltage failure rate of insulated wire and medium voltage cable failure rate
Technical equipment level	Insulation rate, wire rate, number of timely data connected to EMS system by master station, number of quasi real-time data connected to metering front by master station, number of equipment accounts connected to GIS system
Cause of failure	Failure times caused by natural factors, failure times caused by external factors, failure times caused by operation and maintenance construction factors
Operation and maintenance capability	Average continuous duration of medium voltage fault outage, fault emergency repair in place, positioning, average duration of power restoration, number of live work, households during power outage, number of live work optimization, and total number of pre trial and regular inspection

In order to establish the JDBC connection mode between the master station system and the database, read the power data information collected by the terminal and the power failure event information actively reported, and establish the original data table of power failure event, the combined power failure event data table and the relationship table between the original event and power failure event in the database [8]. Secondly, through the collected voltage information of metering points, the shutdown and power supply status of users are discriminated and analyzed according to the calculation model of medium voltage users, so as to realize the calculation of RS-1, aihc-1 and aitc-1 indicators. For the outage event information, the outage event merging algorithm is used to judge whether to merge the outage event. If the outage event can be merged, the last outage event information is written into the merged outage event data table. At the same time, the last power failure event information is overwritten with the original power failure event information in the relationship table between the original event and power failure event. If the power failure event cannot be merged, the last power failure event information is directly written into the relationship table between the original event and power failure event, and the data information in the relationship table between the original event and power failure event is statistically calculated to obtain the regional power failure frequency index [9]. Finally, the JDBC connection mode is established again, and the calculation results of power supply reliability index are written into the database for storage and management. The calculation function flow of system power supply reliability index is shown in Fig. 3.

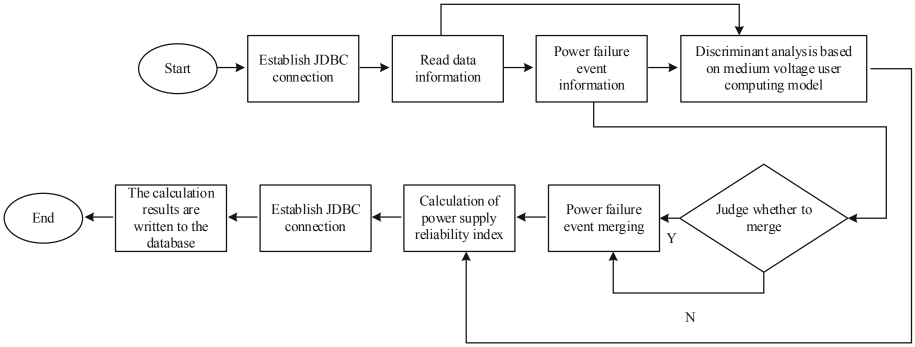

Fig. 3. Function flow chart of system power supply reliability index calculation

The query date and query type combo boxes in the power supply reliability index calculation interface are combobox controls based on Ajax technology to realize the data display of the page without refresh. Users can select different query conditions in different combo boxes according to their needs to realize the online calculation and query of power supply reliability indexes with different monthly values and cumulative values. The evaluation index can reflect whether the distribution system is reliable or not, and provide data basis for reference decision-making. In terms of reliability data statistics of distribution network, it is mainly divided into two categories: reliability data statistics of components and operation reliability data statistics of power supply system. The power supply reliability index for distribution network has a long history. Its earliest proponents are Edison Electric Power Research Institute (EEI), American Public Power Association (APA) and Canadian Electric Power Association (CEA). Among them, the most important index is the reliability index of each load point, ENS, SAF1, CAIF1, CAID and SAIDI. Their specific definition is 2nsaifi, which represents the average outage frequency of the power supply system. It mainly refers to the average outage times of power customers in the power supply system within a year. Its calculation formula is as follows:

$$SAIFI - \frac{\sum_{i} \lambda \mathrm{i} Ni}{f(x_n, y_m) - \sum_{\mathrm{i}} N_i} \tag{8}$$

In formula (8), A and N respectively represent the user outage rate and the number of users at the load point, and ID represents the duration index of the average outage of the power supply system. In its main system, the monitoring master station and terminal for the average duration of power outage within the time range of one year constitute an intelligent condition monitoring system. Its terminal is installed on the distribution network site and is mainly responsible for the transmission of line operation status information. The monitoring master station can receive and upload terminal information and provide visual display information for the system. Therefore, it is also necessary to monitor the main station and terminal line. The principle of short circuit fault monitoring is shown in Fig. 4.

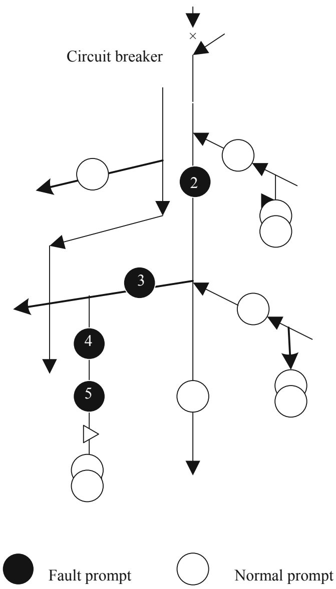

Fig. 4. Principle of short-circuit fault monitoring

The principle of short-circuit fault is shown in Fig. 4. There are three forms of fault judgment for phase-to-phase short-circuit faults in the distribution network, namely self-positioning, local-positioning and re-positioning fault judgment. When phase to phase short-circuit fault occurs in the monitoring system line, the intelligent distribution network monitoring system collects the fault waveform. Through this waveform, we can see the sudden change of short-circuit fault current, accurately monitor the fault location and the working state of electrical equipment (components), which can generally be divided into operation state and shutdown state. The running state is also known as the available state, that is, the element is in the state in which it can perform its specified function. Shutdown state is also called unavailable state, that is, it is unable to perform its specified function due to component failure. The whole life of an element is in the alternation of "operation" and "shutdown", which is a cycle. Both continuous working time t and continuous shutdown time t are random variable reliability (R), which refers to the probability of no failure in the time interval [0, n] under normal operation conditions at the starting time. During the operation of the transmission line, the reliability calculation can be expressed by the formula:

$$R(t) = \frac{T_U}{NT_S} = 1 - \frac{T_D}{NT_S} \tag{9}$$

In formula (9), T is the operation cycle and N is the annual average number of transmission lines. The reliability evaluation of distribution network under complex conditions is carried out on the basis of single load. Count the abnormal values monitored by the distribution grid within 1 min, and design the sliding window processing model, so as to reduce the memory occupied by big data in the sliding window. The design of the sliding window processing model is shown in Fig. 5.

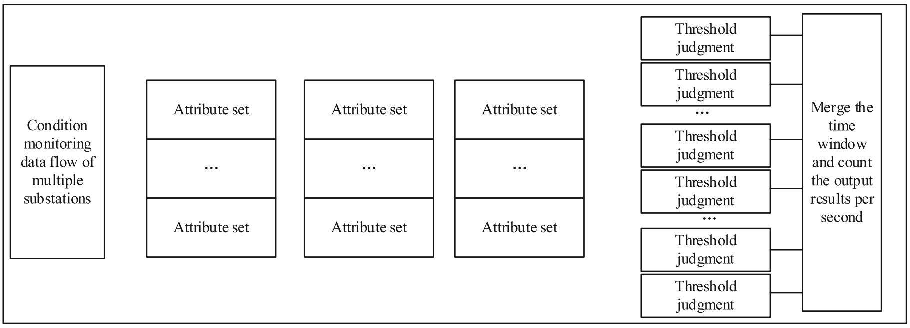

Fig. 5. Sliding window processing model

According to the processing model, the sliding window topology is task programmed and cluster processed, the window structure is designed by using storm programming model, the program is developed by using programming language, and the data flow is processed in batches within the specified time to ensure data continuity. The specific implementation process is shown in Fig. 6.

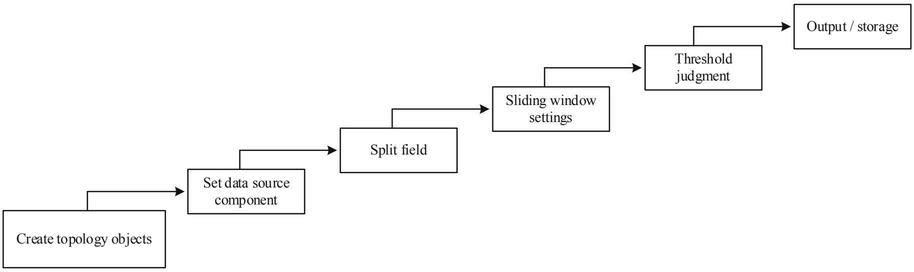

Fig. 6. Implementation process of sliding window topology

In the model, the data source component and logic processing component are topologies formed by data flow. According to the needs of distribution business, the distribution system is directly connected with users, so its voltage quality and power supply reliability are easy to change due to load changes. Especially when the difference between peak and valley of load curve is large, it will restrict the reliability evaluation under constant load. Therefore, in the process of reliability research of most distribution systems, when calculating the power consumption and outage cost of power customers, it is usually assumed that the load of power customers is constant, and then these reliability indexes are calculated through average load or peak load. However, the load of the power supply system is actually a function of changing time and is affected by factors such as the type of power customers and seasons. Therefore, the application of average load or peak load as parameters is bound to affect the accuracy of reliability calculation. If the variation range of load is large, the error interval of the index will also increase, which will affect the accuracy of reliability evaluation. Therefore, it is necessary to analyze the reliability of complex distribution network under load curve.

3 Analysis of Experimental Results

In order to fully verify the accuracy of the algorithm established in this paper, the model is used to verify the actual data of a municipal power supply bureau respectively, and to detect whether the algorithm has certain applicability and effectiveness for the reliability evaluation and prediction effect of the actual situation in this area. The statistics of the verification results of power supply reliability are shown in Table 3.

Table 3. Statistical results of power supply reliability

Power Supply Bureau No	Power supply reliability (%)	BP network prediction results			Paper method		
		Estimate	Absolute error	Relative error	Estimate	Absolute error	Relative error
A	99.1468	106.3256	7.1788	7.241%	96.6589	2.4879	2.509%
B	99.9868	93.6523	6.3345	6.335%	95.6582	4.3286	4.329%
C	99.1625	105.6528	6.4903	6.545%	95.6259	3.5366	3.566%
D	99.2685	93.6526	5.6159	5.657%	95.6523	3.6162	3.643%
E	99.6985	92.6523	7.0462	7.068%	**102.3256**	2.6271	2.635%
F	99.1685	**108.6528**	**9.4843**	**9.564%**	95.6523	3.5162	3.646%
G	**99.9951**	93.6528	6.3426	6.343%	94.9856	**5.0095**	**5.100%**
H	99.3656	92.3658	6.9998	7.044%	96.0568	3.3088	3.330%
I	99.9863	92.9875	6.9988	7.000%	95.6482	4.3381	4.339%
J	99.7156	90.4518	9.2638	9.290%	94.9649	4.7507	4.764%

The statistics of the verification results of the average outage time of users are shown in Table 4.

Table 4. Statistics of user average outage time verification results

Power Supply Bureau No	Power supply reliability (%)	BP network prediction results			Paper method		
		Estimate	Absolute error	Relative error	Estimate	Absolute error	Relative error
A	11.49	12.11	0.62	5.396%	11.98	0.49	4.426%
B	10.49	11.85	1.36	12.965%	9.86	**0.63**	6.001%
C	11.49	10.03	1.46	12.707%	11.87	0.38	3.307%
D	12.93	12.18	0.75	5.800%	13.42	0.49	3.790%
E	6.48	5.82	0.66	10.185%	6.89	0.41	6.327%
F	10.18	12.05	1.87	**18.369%**	10.65	0.47	4.617%
G	9.43	10.02	0.59	6.257%	9.59	0.16	1.697%
H	14.99	15.58	0.59	3.936%	15.52	0.53	3.536%
I	**15.25**	**17.03**	1.78	11.672%	**15.66**	0.41	2.689%
J	8.18	10.49	**2.31**	18.240%	8.85	0.67	**8.191%**

The comparison between Table 3 and Table 4 shows that the training error of this method is lower and the number of iterations is less. In order to further verify the fitting degree and efficiency of the two evaluation algorithms, this paper continues to use the determination coefficient R2 in the neural network algorithm for comparative analysis, which can analyze the fitting effect between independent variables and dependent variables. Generally, the calculation result of R2 is between 0 and 1, and the closer it is to 1, the better the fitting degree of the algorithm can be obtained. The statistical results of the determination coefficient R2 of BP algorithm and the method in this paper are shown in Table 5.

Table 5. Statistical results of determination coefficient R2

Decision coefficient	BP algorithm		Paper method	
	Training sample set	Test sample set	Training sample set	Test sample set
R2	0.763	0.866	0.905	0.958

The training time of monitoring data is shown in Table 6.

Table 6. Training time of monitoring data

	BP algorithm	Paper method
Training time (s)	426.28	199.68

When the working process remains unchanged, change the data source component and logic processing component to test the system throughput. The data source components are set in two cases. The first group is: keep the number of data source components unchanged, add logical components, and set them to (4,4), (4,5), (4,6); The second group is: the number of logical processing components remains unchanged, and the data source components are added, which are set to (4,4), (5,4), (6,4). The six groups of topologies are tested experimentally, and the system throughput under different conditions is counted. The results are shown in Table 7.

Table 7. System throughput of different components

Number of components	System throughput/(10000 pieces/s)		
	50000 pieces of data	150000 data	250000 data
(4,4)	1.02	1.07	1.13
(4,5)	1.05	1.11	1.10
(4,6)	**1.13**	**1.16**	**1.14**
(5,4)	0.89	0.91	1.01
(6,4)	0.83	0.86	0.87

It can be seen from Table 7 that the system throughput shows different characteristics by changing the number of concurrent logical processing components. The experimental group in the comparison table can fix the data source components. With the increase of logical components, the processing of condition monitoring data components can be accelerated, so as to improve the processing throughput of the system. Under the condition of fixed throughput, the monitoring efficiency of traditional system and automatic monitoring system is compared and analyzed, and the results are shown in Fig. 7.

According to Fig. 7, when the weight value and threshold parameters achieve the best effect, this method will further increase the training efficiency, reduce the number and degree of blind training, ensure the training efficiency, reduce the correlation between various variables to a certain extent, fully improve the effectiveness and adaptability of data, and ensure the reliability and stability in the training process. Therefore, as a new, reliable and stable prediction model, this method can be fully applied to the reliability evaluation of distribution network, ensure the safe and reliable operation of distribution network, and even provide an effective technical support for the safe and reliable development of distribution network in various cities across the country.

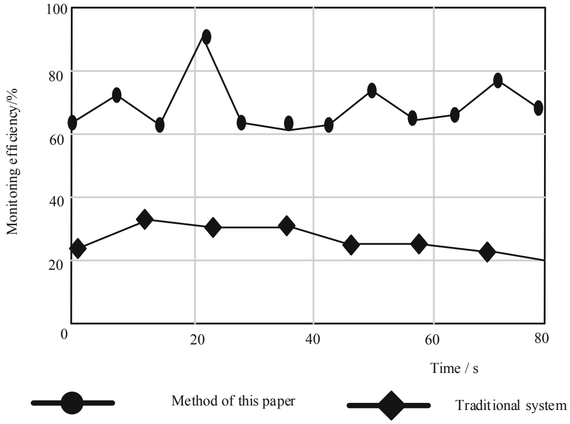

Fig. 7. Comparative analysis of monitoring efficiency of two systems

4 Conclusion

In order to improve the reliability of power supply network, the research on on-line monitoring of power supply reliability of distribution network based on mobile communication technology is proposed. Using mobile communication technology and reliability evaluation algorithm to identify fault information in power supply network. According to the processing model, the sliding window topology is subject to task programming and cluster processing to ensure data continuity. By expounding the relationship between reliability and cost, this paper puts forward the evaluation method of income increment and cost increment to evaluate the reliability improvement measures. The relationship between cost and reliability improvement is comprehensively considered, and expressed by drawing Pareto curve. Finally, some basic grid structures of a city power supply bureau are selected as research examples for reliability improvement and quantitative calculation and analysis. The historical reliability statistics and basic parameters of the city are selected, and the best reliability improvement scheme is obtained by using this method, which verifies the effectiveness of the algorithm.

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