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Retraction

Retracted: Connection Quality Prediction and Nonlinear Control of Power Grid Communication Wireless Network

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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) Peer-review manipulation

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.

References

[1] Z. Zhao, "Connection Quality Prediction and Nonlinear Control of Power Grid Communication Wireless Network," *Security and Communication Networks*, vol. 2022, Article ID 5239219, 7 pages, 2022.

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Research Article

Connection Quality Prediction and Nonlinear Control of Power Grid Communication Wireless Network

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Learn about effective and uncontrolled gambling on wireless networks. Firstly, according to the control purpose, considering the reliability requirement of microgrid for network communication, the characteristics of wireless sensor network communication quality of service in microgrid, the influence of wireless connection reliability, and the mathematical standard of wireless communication are determined. Then, according to the estimation of the occurrence time of wireless communication link reliability, the reliability of wireless sensor network communication link in a smart grid is improved based on a fuzzy nonlinear control algorithm. Finally, the security and reliability of the control system described in this paper are measured by simulation. The experimental results show that the reliability of the wireless communication estimation time estimation algorithm and the power control algorithm based on fuzzy control can estimate the reliability, shortsightedness, and accuracy of good connections in real time. By adjusting the output power of the node, the connection quality and reliability can be controlled stably.

1. Introduction

Electricity is an indispensable part of the modern energy system. With the increasing proportion of electric energy in the structure of the energy consumption system, the position of the power grid in the construction of the energy management system is becoming more and more important. In the future construction of the power grid, how to build a modern power system with high efficiency, low cost, high security, and flexible operation has become a problem of great concern to the power industry. Therefore, many countries and organizations unanimously proposed to build a high-performance smart grid with the combination of two-way power flow and two-way information flow and regarded it as an important strategy for the development of the power system in the twenty-first century [1]. In the smart grid (Figure 1), the communication network layer is an important layer, which includes access network, backbone network, service network, and support network. In these four parts, there is no complete and unified network form before the access network port. Compared with the communication requirements of a traditional power grid, the smart grid has higher complexity in the overall network structure, application technology, and equipment technology. Reliable network communication control technology is needed to complete the monitoring, operation control, and application of various communication equipment. Therefore, the network construction of a smart grid has high technical requirements for network reliability [2]. The transmission power of the wireless signal sensor in the network is a key factor that directly determines the reliability of the wireless transmission network. When other environmental parameters remain unchanged, the higher the transmitting node power, the higher the system reliability. However, only for the reliability of a link, the wireless network sensor nodes can greatly improve the transmission power for communication transmission. Although this can ensure the reliability of the adjusted communication, the electromagnetic interference generated by this link will also affect the communication of other links, resulting in the decline of the overall communication network quality. At the same time, in order to prevent mutual interference between adjacent links, excessively reducing the power of wireless sensor network transmitting nodes will reduce the reliability of a single link.

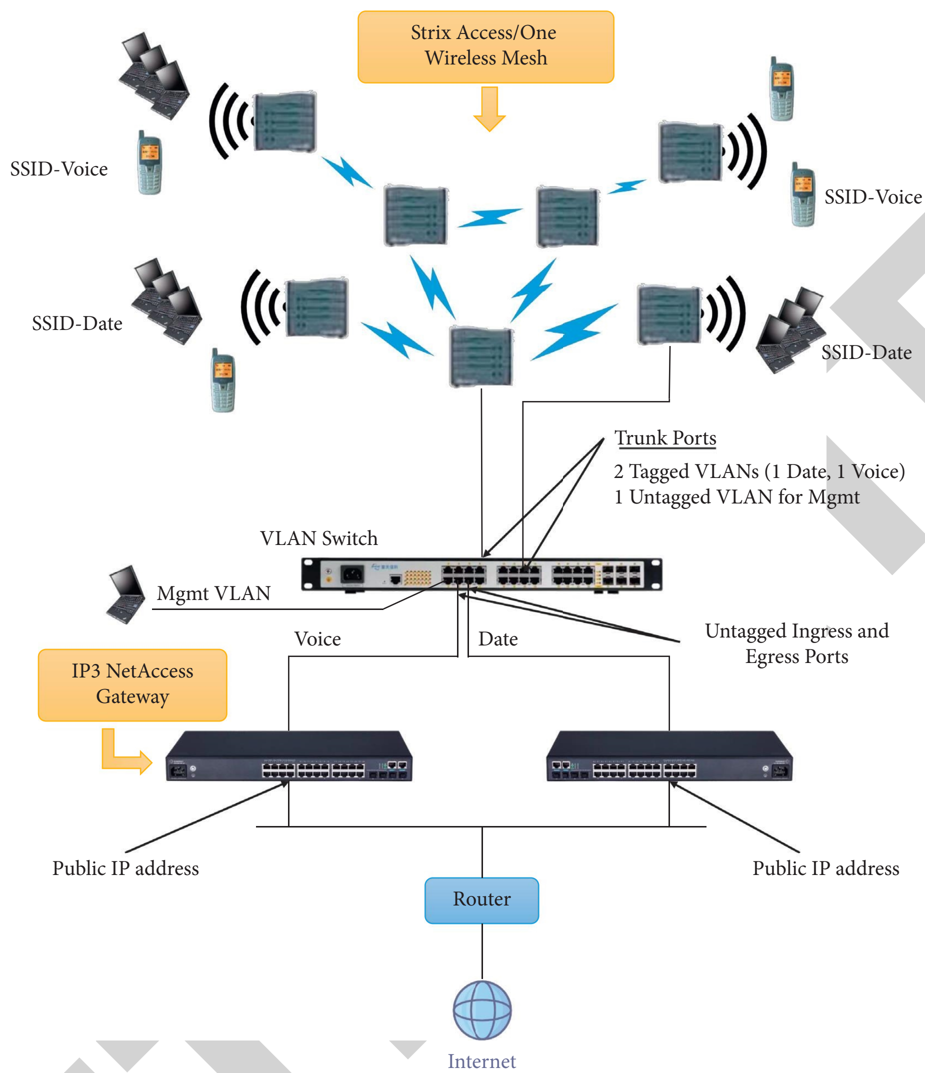

Figure 1: Wireless network coverage.

Based on the above analysis, in order to meet the reliability requirements of wireless data communication in smart grid and ensure the overall performance of wireless sensor network, the prediction of wireless communication links and the adjustment of the transmitted power of wireless sensor nodes through reliable power control methods are the main interface standards of this paper.

Therefore, this paper provides a method for estimating good communication reliability based on the analysis of the nonlinearity and randomness of wireless communication and uses a fuzzy nonlinear control algorithm to adjust the power transfer between nodes. First, the well-communicated historical time series is decomposed into stationary and noisy sequences by wavelet decomposition. The two standard design protocols are trained and predicted accordingly, and the reliability of intelligent wireless communication is calculated to determine whether it meets the standard reliability. Pre-export pressure on smart grid wireless communication links. Based on the concept of fuzzy nonlinear control, a powerful fuzzy nonlinear control system that can meet the intelligent planning environment is developed, resulting in low reliability time estimates through different design predictions and time requirements for wireless communication reliability system [3]. Therefore, the transmission power of the wireless sensor network is adjusted to ensure the reliability of wireless communication.

2. Literature Review

Zafari and others studied a method suitable for the long-term prediction of wireless link quality. This method uses a differential autoregressive mobile model (ARIMA) to effectively process autocorrelation data sequence and significantly improves the anti-interference of the communication link. However, due to a large amount of calculation of its model, it cannot meet the application of the smart grid in practical communication [4]. Ren and others proposed a time series prediction model based on a dynamic fuzzy neural network (DFNN). The model is improved on the basis of the ARIMA model. The DFNN model is used to simulate the nonlinear characteristics produced by the ARIMA model. And this method fully considers the error of the output signal, so the accuracy of the model is very high. However, this model requires input in a stable environment and is not suitable for communication link quality prediction with large changes [5]. Xing and others constructed the prediction model of wireless communication link with the BP neural network. The generalization and fault tolerance of this neural network make the prediction model get good prediction results. However, due to the different choice of network structure and slow convergence of the algorithm, this neural network cannot meet the reliability of the smart grid to wireless communication link [6]. Li et al. and others proposed a link quality confidence interval prediction method based on the random vector functional link neural network (RVFL) model. Although the prediction effect is good in the stable part of the data when the link parameters fluctuate greatly due to the interference of environmental factors, the accuracy is greatly reduced, and the establishment complexity of the model is high [7]. Tang et al. proposed an intelligent learning prediction method based on a correlation matching prediction mechanism. This method takes SNR as the evaluation index and obtains more accurate prediction results. However, because this method does not comprehensively analyze the characteristics of wireless transmission and communication, the practicability of this method is not high [8]. Wang et al. developed a good communication sample model based on the development of least squares vector regression (LS-SVR) to estimate communication quality. Although the game of these models is of high accuracy, the model design is complex, and the game cannot meet the intelligent communication standard in a harsh and flexible environment [9]. Ali et al. learned about new hybrid online machine learning algorithms for link quality estimation, training, and modeling based on relationship quality estimation (SNR) of verbal signals. This method has correct accuracy, but it is easy to cause early data loss in multiple data processing, resulting in low accuracy of long sequences [10]. Awan et al. believe that with the rapid development of the mobile communication industry and the integration of market competition, especially after China Mobile, China Telecom, and China Unicom became full-time employees, the products provided by traders became more and more common. And it is more uniform. The competition of business model has developed from the competition of network integration, coverage, scale, and business to that of service and speed. By leaning towards business, they can quickly provide different customers and new services [11].

3. Method

3.1. Power Grid Communication Reliability Demand Analysis. Due to the complex and changeable environment of electronic equipment, in order to ensure the stable operation of the smart grid, the equipment needs a certain communication power supply [12]. Countries around the world are now setting higher standards for the reliability of smart

Table 1: Reliability index requirements.

Range	Application	Reliability (%)
HAN	Home automation	>97.00
	Building automation	>97.00
	Meter reading	≥98.50
NAN	Prepayment for utility services	≥99.00
	Job changes	≥99.00
	Distribution automation	≥98.50
WAN	General protection	≥97.00
	Wide-area control	≥98.00
	Wide-area coverage	≥97.00

initiatives. Among them, the United States has reduced the reliability of measures shown in Table 1 in the areas of building network (HAND), community network (Nan), and wide-area network (WAN).

To achieve this goal, the communication reliability of the smart grid is set to a higher standard. In real communication, the smart distribution network is prone to external interference and cannot meet the communication reliability requirements of the smart grid. Therefore, in an environment with uncontrollable interference [13], it is difficult to ensure the reliability of wireless communication connections in the smart grid. It is an effective way to solve this problem by predicting the reliability of wireless communication links in smart power grid and taking measures to ensure the reliability of wireless sensor network communication in advance, which is also the research target of this paper.

3.1.1. Hardware-Based Reliability Evaluation Index. Hardware-based reliability evaluation index type is a parameter index type measured from the physical layer, including LQI, RSSI, and SNR.

LQI is the link quality indicator. In the IEE802.154 standard protocol, LQI is used to represent the energy and quality of received data. Its value ranges from 50 to 100. LQI can be read from the data packet at the receiving end. The larger the value, the higher the strength of the received data signal. LQI can also be applied in the network layer or application layer [14].

RSSI refers to the received signal strength. When the wireless sensor network node sends, it can directly read the RSSI value from the receiver. However, the RSSI evaluation index is only applicable to the communication links that are not often disturbed. For a smart grid with a complex environment, the RSSI value cannot reflect the fluctuation of wireless communication links in detail [15].

SNR is the signal-to-noise ratio, which represents the ratio of useful signal power value-to-noise signal power value (unit: dBm). The calculation formula is shown in the following formula:

$$\mathrm{SNR} = \mathrm{RSSI} - P_n, \quad (1)$$

where P_n is the background noise of the receiving node.

3.1.2. Reliability Evaluation Index Based on Software. Compared with the hardware-based reliability evaluation index that obtains parameter information through hardware, the parameter acquisition of software-based reliability evaluation index is independent of hardware [16]. The evaluation indicators of software are mainly composed of the following types:

Per is short for bit error rate, which is obtained by dividing the number of error bytes received by the total number of data bytes received. Per is calculated as follows:

$$\mathrm{Per} = \frac{R_e}{R_r}, \quad (2)$$

where R_e is the number of error packets received and R_r is the total number of packets received.

PSR refers to the success rate of data packet reception. The PSR calculation is shown in the following formula:

$$PSR = \frac{R_r}{R_s}, \quad (3)$$

where R_s represents the total number of packets sent in this period of time. Compared with other software-based reliability evaluation indexes, PSR is more intuitive and persuasive. Therefore, more and more researchers take PSR as the evaluation index of wireless communication link reliability.

3.1.3. Multi-Index Reliability Evaluation Index. In view of the limitations of a single reliability evaluation index on reliability evaluation, a reliability evaluation index based on multiple indexes has gradually become a research hotspot [17]. This method integrates the quality characteristics of four wireless communication links: channel quality, asymmetry, packet transmission loss rate, and stability, so as to evaluate the reliability of communication links; There is also a comprehensive reliability evaluation model of link quality based on the Kalman filter and fuzzy logic, which is constructed by using fuzzy rules, membership function, and other methods.

Since the smart grid is often affected by noise in wireless sensor network communication operation, the received signal power parameters RSSI and link negative L are few, which will not effectively affect the reliability of wireless sensor network communication in the smart grid. From the perspective of software-based testing, the security of the method is beneficial. However, in its calculation, it is difficult to ensure the accuracy of reliability measurement because a large number of encapsulated data are needed. Secondly, if the wireless sensor network is in a complex environment, resulting in constant changes in connectivity [18], the evaluation of a single sensor will be useless. Reliability, reliability test is combined with multiple indicators. It is very complicated.

3.2. Quality Prediction Model and Fuzzy Control. Because the signal-to-noise ratio of wireless communication is a temporary characteristic with the characteristics of position stability and noise superposition, the prediction model of time is not correct for the prediction of importance. Therefore, according to the complex environment of the smart grid and signal medium characteristics of wireless communication connection quality [19], a prediction algorithm of communication link reliability confidence interval based on LSTM is proposed. Figure 2 shows the algorithm structure.

As shown in the figure, this paper uses wavelet decomposition to decompose the SNR signal sequence into noise part and stationary part. For the relatively stable sequence after wavelet decomposition, it is predicted directly by LSTM neural network prediction model. For the noise sequence, the standard deviation sequence is calculated and then predicted by the LSTM neural network prediction model [20]. Finally, the prediction results of the two prediction models are integrated, and the predicted confidence interval of wireless sensor network communication link reliability is calculated.

In practical control, the controlled system is often not linear and time-invariant. Today's system models are mostly complex and changeable models, which have the characteristics of multi-input, uncertainty, and high complexity. The same is true for the wireless communication link of the smart grid. If the nonlinear control method is used, the nonlinear parameters in the model need to be adjusted continuously, and the fuzzy nonlinear control algorithm can just achieve this function. A fuzzy nonlinear control algorithm is a control algorithm that combines a nonlinear controller and a fuzzy controller. The fuzzy controller takes the signal-to-noise ratio error as the input and outputs the nonlinear controller to adjust the parameters through fuzzy rules and reasoning [21].

A fuzzy algorithm is an algorithm based on intelligent reasoning. It is an idea of gradual refinement. It is an innovation of applying the fuzzy algorithm to nonlinear control, so as to realize the parameter adjustment of the nonlinear controller.

The structure of the fuzzy controller is as follows:

(1) Input and blur. Defines the fuzzy subset of signal-to-noise ratio error and signal-to-noise ratio error change rate and converts it to the corresponding value of error and error change rate fuzzy universe through quantization factors [22]

(2) Fuzzy rule base. This part is the conditional rules obtained by using fuzzy language variables through expert experience and knowledge

(3) Fuzzy reasoning. The fuzzy input is input into the rule table and rule sentence, and then the corresponding output is obtained by the fuzzy reasoning algorithm

(4) Clarity. Based on the result of fuzzy reasoning, the accurate adjustment parameters of the nonlinear controller are calculated by the center of gravity method, which is transformed into the accurate output value in the base wood domain of the adjustment parameters of the nonlinear controller

The control flow of node transmit power is as follows:

(1) The LSTM prediction model predicts the reliability confidence interval of the next time based on the LSTM neural network reliability prediction model according to the SNR historical sequence of wireless communication link. The difference between the lower bound of the predicted confidence interval and the SNR corresponding to the given reliability expectation is input into the power fuzzy nonlinear control system, and the SNR error change rate is obtained.

(2) The error change rate watt outputs the corresponding parameter adjustment value after fuzzification, fuzzy rule reasoning, and clarity of the fuzzy controller to adjust the parameters of the nonlinear controller [23].

(3) The nonlinear controller outputs the precise power adjustment value and transmits it to the power control module of the transmitting node.

(4) The node communicates with the adjusted transmission power and collects the signal-to-noise ratio for the prediction of the confidence interval of the signal-to-noise ratio of the communication link at the next time. In this way, the power prediction and fuzzy control results are formed in the power feedback system.

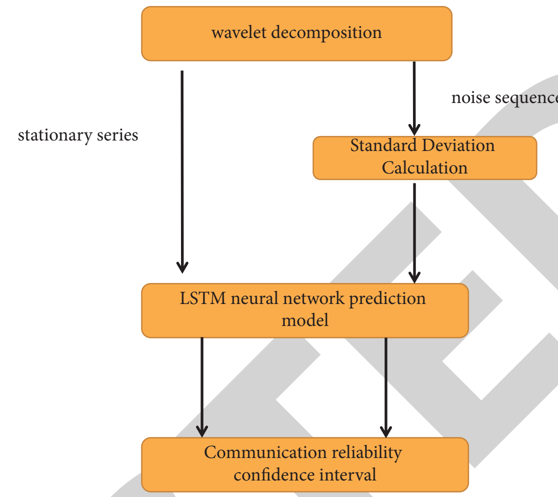

Figure 2: Confidence interval prediction algorithm of communication link reliability.

4. Experimental Analysis

In order to verify the superiority of the power fuzzy control algorithm, this paper establishes an experimental platform in the micro-grid environment and compares the communication performance of the link with that of the fixed power control algorithm by changing different parameters. In this experiment, the CC2530+CC2591 wireless sensor network node launched by TI company is used as the hardware platform for experiment. Two groups of WIRELESS sensor network nodes are sent, and each group has two communication channels [24]. One set is used for dimming control testing and the other for power control testing.

In this section, the dimming controller value of 0.98 in the same test environment is regarded as the input of the dimming controller, and the reliability of the lower level is regarded as the input of the dimming controller. Switching between tests compares the reliability of the relationship between uncertain power management and sustainable power management. The relevant parameter settings of the sensor node are shown in Table 2.

Table 2: The mainly parameters of simulation experiment.

Parameter name	Parameter values
Experimental area size	300 m × 300 m
Number of sensor nodes	Four
Each data packet size	45 bytes
Contract rate	At 300 ms/time
Communicating protocol	IEEE802.15.4

4.1. Change the Communication Distance. The experiment was divided into group A and group B. Group A was the uncertain energy control test group, and group B was the sustainability control group. In the two groups of tests, the transmission was adjusted to maximize the initial transmitting power; the receiving nodes moved at the same speed; and the communication distance gradually increased from 10 m to 200 m. Read the data of the receiving node to judge the efficiency of the two energy control methods.

Reliability analysis: Figure 3 shows the relationship between communication and reliability. It can be seen that the reliability of the two controls decreases with the increase of the connection distance, but the difference is that the connection reliability of the electric barrel dimmer control is higher than the power control, and the safety is very high [25].

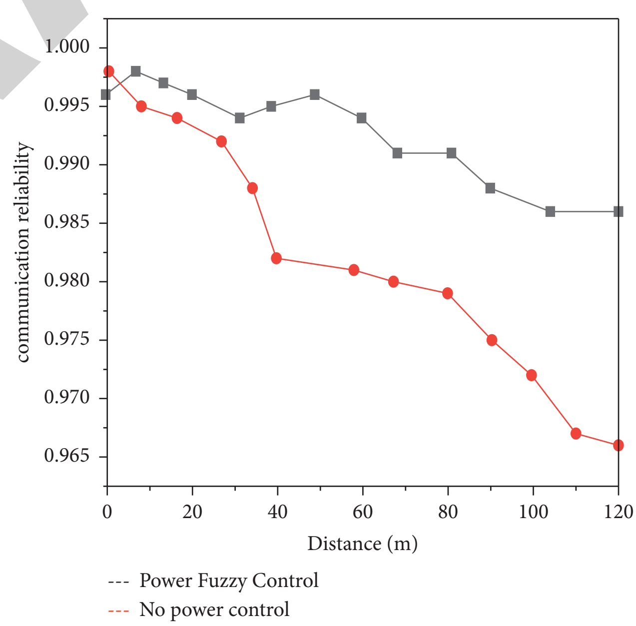

Figure 3: Reliability analysis under distance change.

4.2. Distraction. Two groups of communication nodes A and B are improved, and the communication problem of two

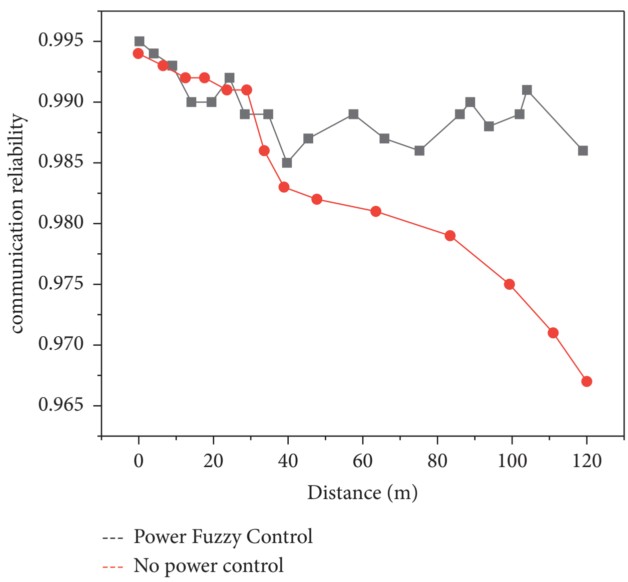

Figure 4: Comparative analysis of reliability under sheltered conditions.

groups of random communication is added. After the experiment is complete, the interaction between the two experimental connections is identified and compared.

Reliability analysis: Figure 4 shows the reliability comparison of fuzzy control power and stable power combination in the same transmission system. As can be seen from the figure, within 40 minutes, wireless communication settings have interference problems, and the reliability of the connection will be lost due to the influence of the environment. However, under fuzzy power management, the reliability of communication seems to stabilize gradually. For this kind of stable power management, communication reliability seems to make a difference. It can be seen that this link has a strong anti-interference function in the fuzzy control system.

An electric dimming controller is designed by using a dimming control algorithm to control the power supply of wireless nodes. To ensure the practicability of the control power algorithm, a simulation experiment is designed and compared with the simulation results under constant transmitting power. Experiments show that the proposed algorithm is more efficient, robust, and dynamic.

5. Conclusion

Firstly, the communication capability of wireless sensor networks in microgrid is investigated, and the influence of reliable communication is tested by the digital standard of wireless communication. The characteristics of wireless connection, which measures SNR quality, are important to the connection of nonlinear and nonstationary random sequences. A reliability model of the wireless communication link based on a predictive algorithm is established by decoupling nonlinear and nonstationary random sequences in SNR signals. In the energy industry microgrid environment, the reliability of wireless communication links is simulated and tested and compared with Kalman prediction, BP neural network, and ARIMA prediction algorithm to determine the feasibility and efficiency of the application process. Based on the estimation result of the wireless communication link reliability changing with time, the power management program of wireless sensor network node is planned, and the effective optimization control algorithm of wireless sensor network communication link reliability based on fuzzy control is studied. The security and reliability of the optimal control algorithm are determined by testing in a microgrid environment.

The next work will focus on how to further improve the link quality prediction algorithm. Because the wavelet neural network prediction algorithm adopts the online training method in the training, it increases the workload of nodes to a certain extent, resulting in a certain delay in the network. Therefore, in future work, we will improve the network learning mechanism and further improve the communication reliability of wireless sensor networks.

Data Availability

The data used to support the findings of this study are available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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