Retraction

Retracted: Safety Monitoring System and Method for Unmanned Operation of Unmanned Aerial Vehicle Distribution Network Based on Learning Control Robot Technology

Journal of Robotics

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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.

References

[1] B. Jia, Y. Jiang, T. Ma et al., "Safety Monitoring System and Method for Unmanned Operation of Unmanned Aerial Vehicle Distribution Network Based on Learning Control Robot Technology," *Journal of Robotics*, vol. 2022, Article ID 8559153, 10 pages, 2022.

Research Article

Safety Monitoring System and Method for Unmanned Operation of Unmanned Aerial Vehicle Distribution Network Based on Learning Control Robot Technology

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The continuous expansion of the scale of power grid construction has led to the emergence and development of the uninterrupted operation of the unmanned aerial vehicle (UAV) distribution network. However, in the actual power production process, due to the limitations of operating conditions and environment, power safety accidents are inevitable. With the support of intelligent technology, the monitoring effect and application level of the safety monitoring system for the uninterrupted operation of the UAV distribution network have been improved. Unified planning and scheduling were carried out throughout the job implementation process. The efficiency of equipment safety management has been strengthened, which is of great practical significance to the safe production of electric power. Based on the analysis of the environmental characteristics and implementation difficulties of the unmanned aerial vehicle distribution network, this paper studied the safety monitoring system and method by combining the high intelligence and high-efficiency characteristics of the learning control robot technology. The designed unmanned aerial vehicle distribution network safety monitoring system and method were tested. In order to understand the effect of the system intuitively, this paper analyzed from three aspects: system sensitivity, anti-interference, and data acquisition and management. It also contrasted with traditional monitoring systems. The test data showed that the sensitivity test value of the traditional monitoring system in the R1 circuit with the lowest voltage intensity was 71.3%. In the R4 circuit with the strongest voltage intensity, the test value only reached 84.4%. The test values of the system in this paper in the two types of circuits were 85.6% and 93.3%, respectively. In the data acquisition and management test, the acquisition and management rates under the highest numerical information could reach more than 97%. It can be seen that it has strong feasibility in actual operation.

1. Introduction

With the improvement of the level of economic development and material living conditions, the market demand for power supply continues to expand. Power supply stability and safety have become the focus of attention of the public. As an important technical means to ensure the stable operation of power supply equipment and improve the power quality of users, the emergence of unmanned aerial vehicles (UAVs) has improved the reliability of uninterrupted operation of the distribution network, which is of great significance to the automation construction of the power grid.

However, the main target of traditional UAV operations is high-voltage transmission lines, which generally exist in residential power areas. The environment where it is located is generally narrow, and there are many obstacles around it. The difficulty of signal acquisition and the lack of real-time and precision seriously affect the implementation of the operation. To this end, an effective safety monitoring system and method must be established. In today's highly developed science and technology, the learning and control robot technology is becoming increasingly intelligent and systematic, contributing to the development efficiency, as well as the efficiency of major industries. For example, it has

exerted its application value in medical, manufacturing, sports, astronomy, and other professional fields. It can continuously test the repetitive control tasks and correct the control quantity within a limited time range to achieve high-precision tracking of the target task. It plays an important role in establishing the safety monitoring system and method for the uninterrupted operation of the UAV distribution network.

The safety monitoring of the UAV distribution network without power outage has always been an important issue in power grid development. Sun proposed an adaptive unscented Kalman filter algorithm for the safety monitoring of the distribution network without power outages. It was proved by simulation experiments that it could reduce the influence of prediction errors on estimation accuracy [1]. Guoqiang proposed a network reconfiguration model based on the distribution system security domain. This model also achieved better power loss and safety monitoring compared to the load balancing model [2]. Zhuang proposed a wireless sensor network based on the Internet of Things technology for the safety monitoring of the UAV distribution network, which was used for insulation state perception [3]. Tao proposed a method for detecting the capacity of distributed photovoltaic power generation integrated into the distribution network based on the fusion of multiple data sources, which can realize real-time detection when the UAV distribution network is not powered off [4]. To reduce the occurrence of safety accidents, Zhang proposed a live installation tool for the uninterrupted operation of the UAV distribution network. Through different structures and sensor combinations, grid data monitoring could be achieved [5]. To effectively identify the electric shock current in the uninterrupted operation of the distribution network, Liu proposed a support vector machine method to classify and monitor it [6]. These monitoring systems and methods can identify and monitor the security risks of the power grid to a certain extent. However, as the scale of the uninterrupted operation of the distribution network expands, the complexity of its implementation environment continues to rise. The real-time performance and accuracy of safety monitoring systems and methods should also be improved. This is where learning-to-control robotics offers unique advantages.

The learning control robot technology has made great progress in recent years. It has important research and application value. To improve the acquisition of real samples, Cutler proposed an efficient learning-controlled robotics framework in a multi-simulator-available scenario for a target task [7]. Turan incorporated learning-controlled robotic technology into minimally invasive intestinal diagnosis and treatment, which enabled high-precision diagnosis [8]. Clever proposed a dynamic model based on learning-controlled robotics to create feasible and optimal motion primitives [9]. Lim computed mutual information by approximate computation of nonparametric methods. He also detected the network's largest number of objects by learning-controlled robotics [10]. Perico believed that programming based on learning-controlled robotics allowed complex tasks with input from different types of sensors and

could adapt complex tasks to new environments and objects [11]. Kim proposed a learning-controlled robotic technology with a tactile sensing mechanism, which changed the limitations in performance and efficiency of robotic teleoperation [12]. It can be seen that the learning and control robot technology has exerted its value in many fields. However, its integration with power grid development has not been deeply explored. In order to promote the safe and effective operation of the distribution network without power failure, it is very important to study the safety monitoring system and method of the unmanned power distribution network operation based on the learning control robot technology.

In this paper, combined with the learning control robot technology, effective research was carried out on the safety monitoring system and method for the unmanned operation of the UAV distribution network. The system test data showed that the sensitivity test value of the system in the R1 circuit with the lowest voltage intensity was 85.6%. In the R4 circuit with the strongest voltage intensity, the test value reached 93.3%, which was highly sensitive. The traditional monitoring system was only 71.3% and 84.4% in the R1 and R4 circuits, respectively. In the anti-interference test, the noise frequency range of the system in this paper was reduced from $20\ dB\ \mu A \sim 60\ d\beta\ \mu A$ to $-40\ dB$ $\mu A \sim 0\ d\beta\ \mu A$, which could shield a large amount of electromagnetic interference. In the data collection and management test, the collection rates under different numerical information were 99.2%, 98.6%, 98.2%, and 97.4%. The corresponding management rates were 98.7%, 98.3%, 97.8%, and 97.1%, respectively, which had good applicability.

2. Establishment of the Safety Monitoring System and Method

2.1. Overview of the Uninterrupted Operation of the UAV Distribution Network. The distribution network refers to the power network that receives electricity from the transmission system or regional power stations and then distributes it on-site or sequentially according to different voltage levels to users. It is located at the terminal of the power grid and is directly connected to the power system where each user is located. Its main function is to realize power distribution and ensure that every user can get a power supply [13]. The uninterrupted operation is to use the live operation method, which uses professional power equipment, such as insulation tools, arc suppression devices, and bypass equipment. A reasonable operation plan is adopted to reduce the scope of power outages as much as possible. In the state of a partial power outage or complete power outage, electric construction can be realized. Before the unmanned operation of the UAV distribution network is implemented, the safety monitoring system can detect the abnormality and fault of the power system in time, which can accurately locate the fault point in the power grid. Then, the purpose of eliminating hidden dangers of power safety and reducing power outages for users is achieved.

However, the uninterrupted operation of the UAV distribution network is often hindered by line environment problems because the surrounding environment of most distribution lines is relatively complex. Overall, its operating environment has the following characteristics:

(1) Most of the distribution network lines are located in areas with complex terrain, dangerous terrain, inconvenient traffic, and insufficient signals. Many standardized work practices cannot be implemented effectively.

(2) The height of the tower structure is low, and the wiring structure is relatively simple.

(3) The operating life of distribution network lines is generally long, resulting in weak towers and poor load-bearing capacity.

(4) Part of the power equipment in the distribution network area is scattered. It is difficult to implement the operation without a power outage in the distribution network.

After a power accident, many places are affected by environmental problems. It is difficult for electrical equipment such as insulated bucket trucks to reach the operating point. It is necessary to use the operating lever method or use an insulating platform for operation. In addition, due to the existence of some hidden problems in the construction and maintenance process, the operation site equipment is complicated. At the same time, the large equipment required for the traditional bypass operation cannot be transported to the designated location for installation. This adds great difficulty to implementing the existing unmanned aerial vehicle distribution network without power outages.

Therefore, only by establishing a high-precision power monitoring system and mastering the operation status of the distribution network can it be adjusted in time to reduce the line loss caused by environmental factors, thereby improving the economic benefits of electricity [14]. However, the current power system generally has a large capacity. The unstable operation of the voltage makes the distribution structure more complicated. The traditional approach to safety monitoring systems is increasingly inapplicable. This changing trend has correspondingly increased the requirements for the accuracy and implementation of safety monitoring systems.

2.2. Learning Controlled Robotics. With the continuous progress of human cognitive ability and the development of science and technology, the learning and control robot technology plays an important role in modern human life and production [15]. It effectively combines deep learning, iterative learning control algorithms, and robotics. At present, in the field of robot control, the service-oriented learning control robot technology can improve the reusability and scalability of the control system [16]. The application of learning control robot technology to the safety monitoring system for the uninterrupted operation of the UAV distribution network can improve the development

efficiency of the system and ensure its performance requirements. Through the continuous learning and correction of the technology itself, the data information generated during the iterative operation of the monitoring system is used. Constantly correcting its control behavior, the system finally achieves complete tracking of the reference signal set for the uninterrupted operation of the UAV distribution network after a limited number of iterations. Its technical principle is shown in Figure 1.

The optimization problem of the safety monitoring system is attributed to

$$\min_{u_k}\left\{e_k^2\right\}. \tag{1}$$

Among them, u_k is the control term and e_k is the error term. y_k is represented as an output item. Considering the single-input single-output form in the learning control robot technology, the dynamic monitoring of the unmanned operation of the UAV distribution network is described as a supervector form using this technology:

$$y_k = Gu_k + d_0. \tag{2}$$

Among them, the calculation basis of each parameter is shown in Table 1.

In order not to lose generality, $x_k(0) = 0$ is usually taken and $CB \neq 0$ is satisfied. The minimization of system monitoring errors should be considered when designing monitoring performance indicators to optimize the safety monitoring system. It is also necessary to make the changes of the control items not too drastic to ensure the stability of the control variables, which enables the system output to be monitored smoothly [17]. The problem can be optimized as

$$\min_{u_{k+1}} J_{k+1}\left(u_{k+1}\right) = e_{k+1}^2 + u_{k+1} - u_k^2. \tag{3}$$

Among them, the error constraint is

$$e_{k+1} = y_d - Gu_{k+1}. \tag{4}$$

By finding the optimal solution for control item u_{k+1} in the performance index formula, the optimized safety monitoring system controller can be expressed as

$$u_{k+1}^* = u_k + G^T e_{k+1}. \tag{5}$$

In order to further improve the monitoring performance, the optimization problem can be expressed as

$$\min_{u_{k+1}} J_{k+1,N}\left(u_{k+1}\right) = \sum_{i=1}^{N} \lambda^{i-1}\left(e_{k+1}^2 + u_{k+i} - u_{k+i-1}^2\right). \tag{6}$$

By learning the theory of control robot technology, the optimal solution is given as

$$
\begin{aligned}
u_{k+1}^* &= u_k + G^T\left(I + \lambda Q_{N-1}\right)e_{k+1}, \\
e_{k+1} &= \left[I + GG^T\left(I + \lambda Q_{N-1}\right)\right]^{-1}e_k, \\
Q_N &= \left[I + GG^T\left(I + \lambda Q_{N-1}\right)\right]^{-1}\left(I + \lambda Q_{N-1}\right).
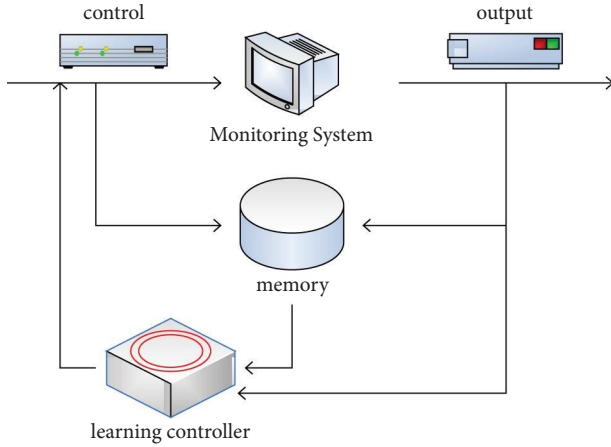\end{aligned}
\tag{7}
$$

Figure 1: Principles of learning-controlled robotics.

Table 1: Calculation basis of each parameter.

Sequence	Parameter	Calculation basis
1	u_k	$[u_k(0), u_k(1), \cdots, u_k(T-1)]^T$
2	y_k	$[y_k(1), y_k(2), \cdots, y_k(T)]^T$
3	d_k	$[CA, CA^2, \cdots, CA^T]^T x_k(0)$
4	G	$\begin{bmatrix} CB & 0 & \cdots & 0 \\ CAB & CB & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ CA^{T-1}B & CA^{T-2}B & \cdots & CB \end{bmatrix}$

Among them, N is the number of predicted items and I is the identity matrix. $\lambda > 0$ is the weight parameter.

In fact, in this process, the learning control robot technology can effectively increase the initial control input and improve signal reception. It can also improve the real-time performance of the monitoring system and improve the convergence speed of the system.

2.3. Establishment of the Safety Monitoring System and Method. Under the guidance of learning control robot technology, a new UAV distribution network safety monitoring system was established. It can reflect the actual situation in real time when the distribution network is not powered off. According to the actual voltage of the monitoring power equipment, the monitoring of various parameters is completed, and real judgment is made. Its system structure is shown in Figure 2.

In the functional module, the safety monitoring system based on the learning control robot technology can not only measure the insulation performance parameters of the live device in real time, but also analyze and process the obtained values. Its specific functions include the following:

(1) The changes in resistance and capacitive current in the operation of the distribution network are measured to analyze the damp condition of the internal insulating device and the aging state of the valve plate.

(2) The leakage current of the corresponding capacitive equipment and the specific condition of the dielectric loss are measured to determine the state of the internal equipment (such as moisture state and insulation aging degree) and whether there is damage.

(3) During the implementation of the operation, the condition of the flammable gas inside the insulating oil of the device is verified to monitor whether there are problems such as discharge caused by excessive temperature.

(4) The quality of the signal transmitted by the UAV is judged, which makes the transmitted signal not distorted. While not affected by other signals, it does not affect other surrounding signals.

The user organization structure is the basis for building the system's functions, which is related to the system's role, user authority, and user unit structure, among others. After the user's organizational structure is determined, the units, departments, and personnel involved in the entire system can be determined [18]. In other words, the basic scope of the construction of the system is delineated and formally determined. The user organization structure of this system is shown in Figure 3.

The safety monitoring of the uninterrupted operation of the UAV distribution network includes four links: power transmission, substation, distribution, and power consumption. There are many departments involved. In this paper, the system is divided into two major structures: the monitoring department and the electric power bureau. In Figure 3, there are four categories of user roles. The first category is the system administrator, who is responsible for the establishment and maintenance of the system organizational structure, the user's authority management, and the configuration of the system's basic data. The second category is safety monitoring personnel. The main responsibility of the safety monitoring personnel in the division of user roles is to perform system security monitoring and analyze the monitoring data. The third category is equipment managers. After the monitoring personnel makes an unqualified judgment on the monitoring content, the equipment manager needs to make corrections. The fourth category is the system query user. They are the managers of the general power supply department, the staff of various departments of the Electric Power Bureau, and some other authorized browsing users. When the authority is assigned, the staff of each department of the Electric Power Bureau or other authorized browsing users can only view or operate the security monitoring process of the department. The managers of the power supply department have the right to view or operate the monitoring data of the entire system. According to the management requirements of power safety monitoring standardization, its configuration requirements are shown in Figure 4.

The system database design is divided into four parts: standardized content of safety monitoring, basic data, monitoring process management table, and operation log.
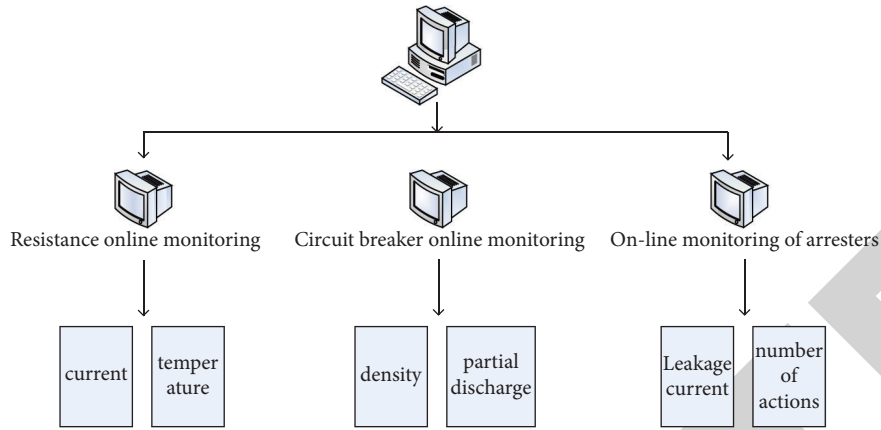
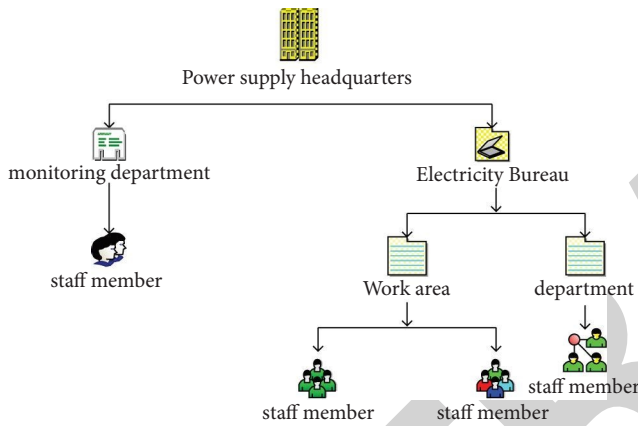Figure 2: Safety monitoring system structure.

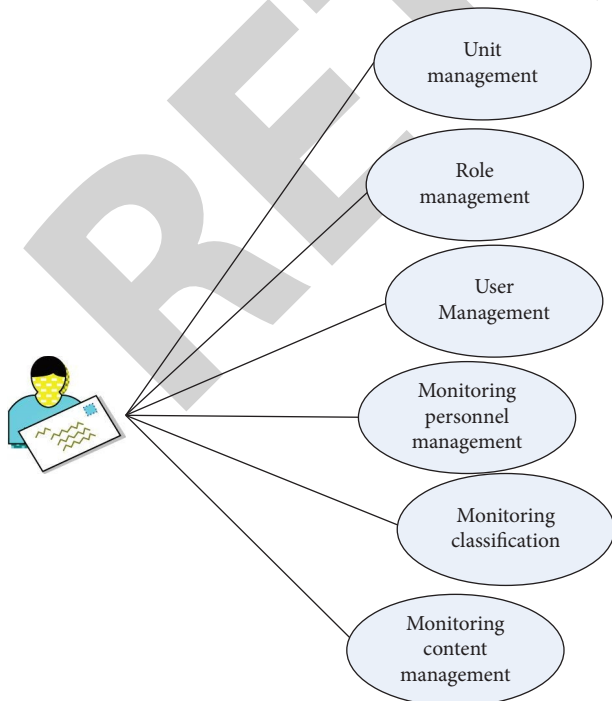Figure 3: User organization structure.

Figure 4: Configuration requirements for managers.

Among them, the safety monitoring standardization content includes the following: the standard directory structure is used to divide the safety monitoring standard content structure directory. The content of monitoring standardization is used to record the scope of standardized monitoring, monitoring basis, and monitoring focus, among others. The basic data includes the organizational structure of the departments involved in safety monitoring and supervision, monitoring personnel information, user information, and authority management. The monitoring process management table records the data of the whole process of safety monitoring, including the safety monitoring plan and its plan decomposition, distribution information, supervision and execution time, execution personnel, and execution results, which is based on the rectification process and results of the problems found in the monitoring process. The operation log is to improve the security of the system. Through system operation, relevant personnel can view the data recording log, such as user login time and data type records. The monitoring task and monitoring record data dictionary are shown in Tables 2 and 3.

The monitoring task is a task assignment table formulated according to the monitoring plan. The main user of this table records the task creation time and completion time. Among them, ID is the unique identification of the monitoring task to ensure the uniqueness of the task in the system [19]. The plan ID is to record the plan associated with this task, which can realize the tracking management of the monitoring plan through the plan ID.

The monitoring record data dictionary includes the creator, name, creation time, and other information. The table associated with it is the catalog classification table. Associated with it is the monitoring task, which can operate or understand the monitoring content through the data dictionary [20].

3. Test of Safety Monitoring System for Unmanned Operation

In order to verify the efficiency of the UAV distribution network uninterrupted operation safety monitoring system and method based on the learning-controlled robotics

TABLE 2: Monitoring task data dictionary.

Field name	Field description	Type of data	Length
ID	Unique ID of the row	VARCHAR2 (50)	50
PLAN-ID	Plan number	VARCHAR2 (50)	50
CARD-ID	Supervision card number	VARCHAR2 (50)	50
USER-ID	Executor number	VARCHAR2 (50)	50
ORG-ID	Supervised unit number	VARCHAR2 (50)	50
LEADER-ID	Accompanying leader number	VARCHAR2 (50)	50
EXCUTEDATE	Executive supervision time	DATE	8
NOTE	Remark	VARCHAR2 (500)	500

TABLE 3: Monitoring record data dictionary.

Field name	Field description	Type of data	Length
ID	Unique ID of the row	VARCHAR2 (50)	50
USER-ID	Creator number	VARCHAR2 (50)	50
CLASSIFY-ID	Catalog number	VARCHAR2 (50)	50
NAME	Supervision card name	VARCHAR2 (50)	50
CREATEDATE	Creation time	DATE	8
NOTE	Other instructions	VARCHAR2 (500)	500

technology, it was tested from three aspects: system sensitivity, anti-interference, and data acquisition and management. The test results were compared with those of traditional safety monitoring systems to confirm their feasibility. The experimental environment of this paper is shown in Table 4.

3.1. Sensitivity Test. In the initial stage of uninterrupted operation of the UAV distribution network, the monitoring system needs to receive the signal from the voltage divider circuit (VDC). The operating environment was determined accordingly. If the numerical signal conditions specified by the operation were met, the operation could be performed. However, the voltage divider circuit in actual operation is often in an unstable state, which affects the reception of the monitoring system signal. In this paper, the sensitivity of the two types of systems was tested with four different voltage divider circuits. The voltage intensity from low to high was divided into R1, R2, R3, and R4. The results are shown in Figure 5.

Generally speaking, the lower the voltage of the voltage divider circuit, the lower the sensitivity of the system and the weaker the received signal, as shown in Figure 5. The sensitivity of the two monitoring systems increased with the voltage increase, but the test values were quite different. Figure 5(a) shows that the sensitivity test value of the system in this paper in the R1 circuit with the lowest voltage intensity was 85.6%. In the R4 circuit with the strongest voltage intensity, the test value reached 93.3%. The sensitivity of the system in this paper was high. With the support of the learning control robot technology, the system control quantity was stable. It enabled the system to ensure signal reception even in a weaker operating environment. In contrast, the traditional monitoring system in Figure 5(b) had the lowest sensitivity of 71.3% and the highest of only 84.4% in the four circuit tests. Under this condition, the

strength of the signal received by the system varies. The authenticity and reference of its judgment were also weak, which affected the implementation of the uninterrupted operation of the UAV distribution network.

3.2. Anti-Interference Test. There are electronic circuits interconnecting various units in the equipment inside and outside the monitoring system. Due to the influence of system structure design, component selection, wiring, installation, and other processes, electromagnetic energy may be transmitted in the form of current between the equipment and unit lines along with wires (such as power supply wires, signal transmission lines, and common ground wires), resulting in interference and affecting monitoring results. In this paper, the anti-interference test of the system was carried out under the noise of different frequencies, as shown in Figure 6.

In the monitoring process, in the face of electromagnetic interference, the system needs to shield the noise well to realize real-time monitoring smoothly. Figure 6(a) shows that the preset standard based on the monitoring system in this paper did not meet the required noise filtering, which completed the diagnosis of electromagnetic interference well. Its noise frequency changed from high-frequency to low-frequency regions. Under the learning control robot technology, the noise superscalar collected by the system in the specified frequency range could be basically consistent with the actual measurement value of the interference measurement module. The antijamming performance of the monitoring system was used to analyze the time-frequency characteristics of the processing results. It has high accuracy, which can well assist the implementation of uninterrupted operation of the UAV distribution network. Figure 6(b) shows that the noise frequency of the traditional system before and after antijamming did not change significantly. The noise frequency was still mostly concentrated in the

TABLE 4: Safety monitoring system test environment.

Attributes	Item	Specification
Hardware	CPU	Intel Xeon E5-4650 2.70 GHz
	RAM	4G
	Hard disk	300G SATA2 16M
	Network	Dual-port gigabit local area network
Software	Operating system	Windows 2019
	Middleware	Apache Tomcat 7.0.109
	Database	Oracle 11 g
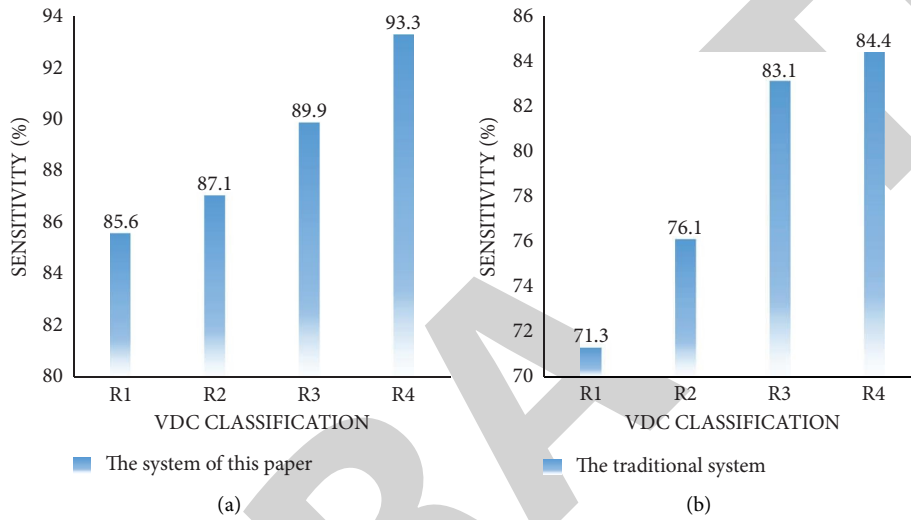
FIGURE 5: Sensitivity test results. (a) The monitoring system of this study. (b) The traditional monitoring system.

high-frequency region. In this state, electromagnetism causes continuous interference to the system, which not only affects the normal operation of the monitoring system, but also makes it unable to operate for a long time. A comparison of the two clearly shows that the interference measurement and suppression functions of the system in this paper are well designed, meeting the requirements of the operation indicators.

3.3. *Data Collection and Management.* The data collection and management of the monitoring system mainly focus on the data collection and management of the actual operating state of the electrical equipment. This is also an important indicator to measure the practicability of the monitoring system. In this paper, the data collection rate and management efficiency of the two types of systems were investigated under different amounts of numerical information (500, 1,000, 1,500, and 2,000), as shown in Figure 7.

In Figure 7, the two types of systems show different levels of collection rate and management rate under different numerical information. Generally speaking, the larger the numerical information, the lower the collection and management rates. However, Figure 7(a) shows that this trend

had less impact. Under different numerical information, the acquisition rates were 99.2%, 98.6%, 98.2%, and 97.4%, respectively. The corresponding management rates were 98.7%, 98.3%, 97.8%, and 97.1%, respectively. Under the highest digit value of 2,000, the collection and management rates still reached more than 97%. It shows that the system can perform autonomous collection work. The system can display various information parameters of electrical equipment on the main wiring, which provides data support for the uninterrupted operation of the UAV distribution network. The learning control robot technology uses the actual situation value collected by the system to input and change the setting value. The status information query of the equipment and the specific data analysis, calculation, and diagnosis functions are completed, which brings great convenience to the actual operation of the system. Figure 7(b) shows that the acquisition rates of the traditional monitoring system under different numerical information are 89.2%, 82.1%, 79.5%, and 71.1%, respectively. The corresponding management rates are 83.4%, 78.5%, 74.3%, and 65.8%, respectively. Collection efficiency is easily affected by numerical information. The management efficiency also cannot match the collection efficiency, which brings great problems and challenges to subsequent information transmission.
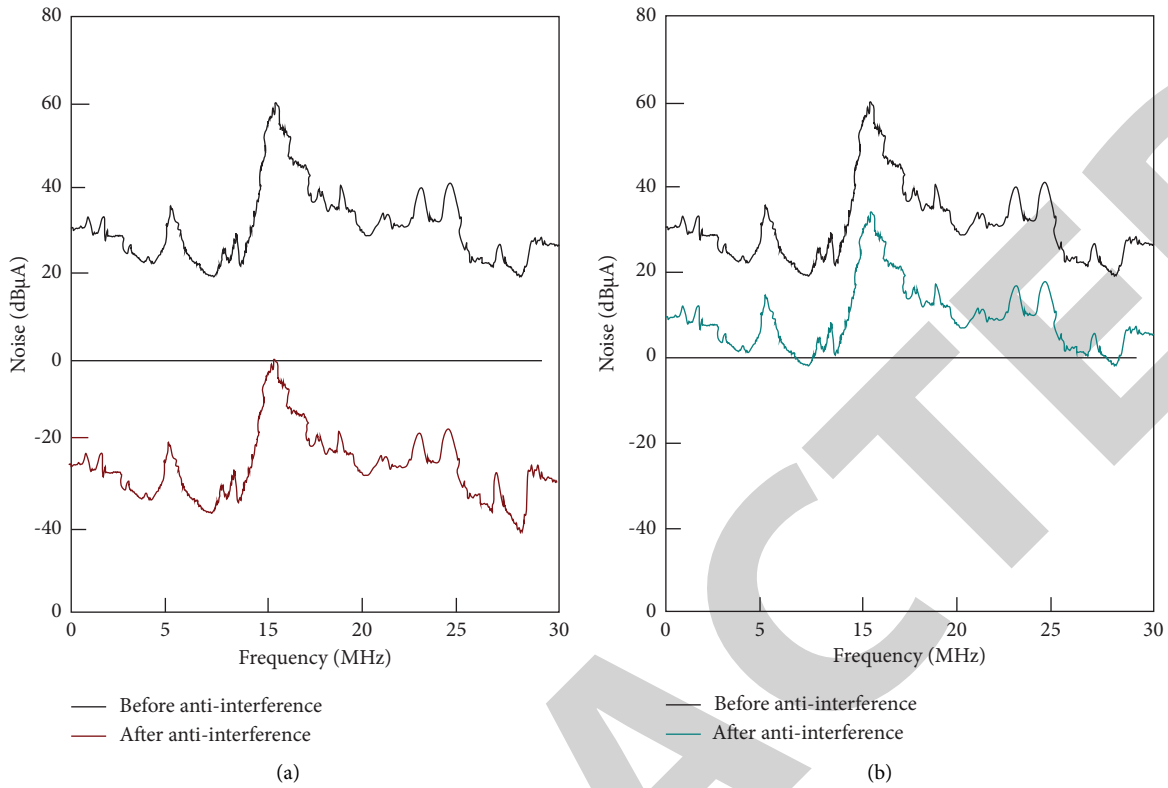
Figure 6: Immunity test results. (a) The monitoring system of this study. (b) A traditional monitoring system.
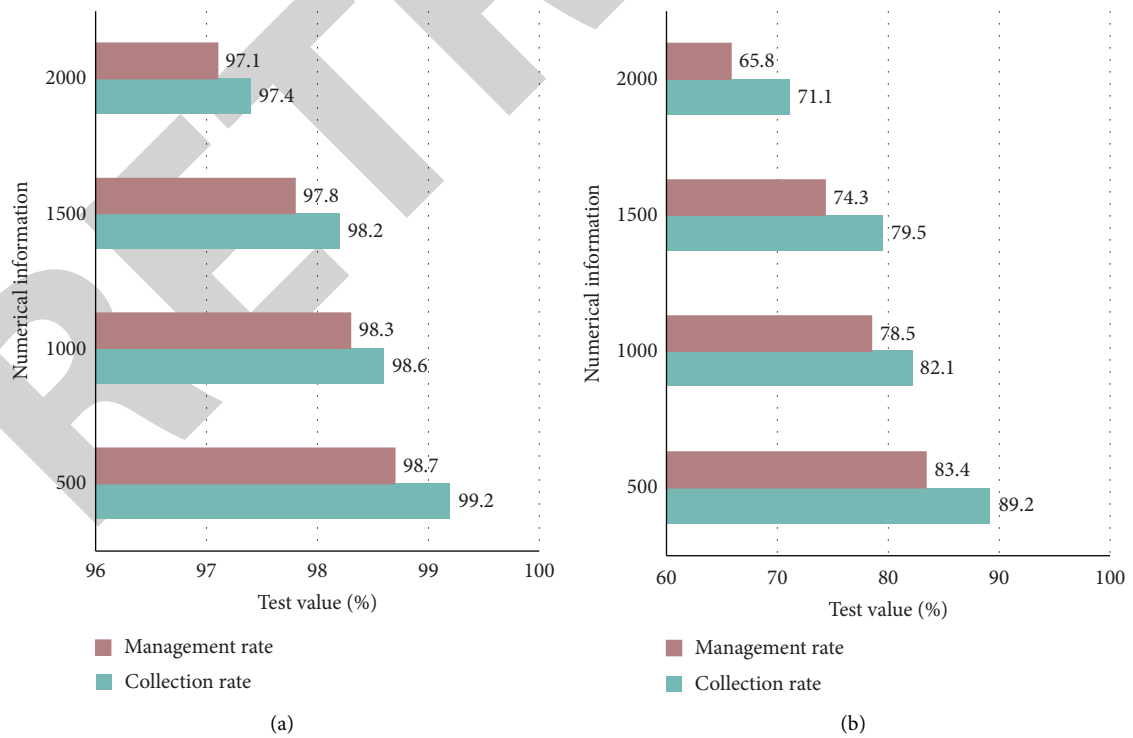

Figure 7: Data collection and management results. (a) The monitoring system of this study. (b) A traditional monitoring system.

4. Conclusion

The most important thing in the implementation process of the uninterrupted operation of the UAV distribution network is to ensure safety. The monitoring system is a key part of ensuring the safe production of electricity, which plays a key supporting role in the reliable operation of the operation. In this paper, combined with the learning control robot technology, the safety monitoring system and method for unmanned operation of the UAV distribution network were studied. With the support of the technical theory, the sensitivity and anti-interference of the monitoring system have been improved so that the system could still ensure signal reception in the operating environment with weak voltage. The electromagnetic signal was effectively shielded, which provided a more reliable guarantee for the implementation of the operation. Since the research on the safety monitoring system and method for uninterrupted operation of UAV distribution network based on learning control robot technology is still in the exploratory stage, some problems need to be further solved in the operation process. This paper only studies the development of the safety monitoring system and method and does not think about the later operation and maintenance services of the system. Power grid construction covers a wide range. Therefore, the system's universality in this paper needs to be continuously verified. These questions are also the main directions of follow-up research. In future research, the reliability of the safety monitoring system and method for the uninterrupted operation of the UAV distribution network can be more effectively improved.

Data Availability

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

Conflicts of Interest

The authors declare no conflicts of interest.

Acknowledgments

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