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Retraction

Retracted: Working Condition Monitoring System of Substation Robot Based on Video Monitoring

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1].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] C. Zhao and J. Li, "Working Condition Monitoring System of Substation Robot Based on Video Monitoring," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 7840507, 7 pages, 2022.

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Research Article

Working Condition Monitoring System of Substation Robot Based on Video Monitoring

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In order to realize intelligent video surveillance of substation, this paper presents a substation robot working state monitoring system based on video surveillance. In this paper, the intelligent monitoring system of substation robot working state is constructed by combining virtual reality technology. Through the cooperation of each unit in the system, the real-time monitoring of substation robot working state and the early warning of abnormal working state are realized. The system can transmit video data at a high frame rate to ensure the timeliness of video data transmission and clearly and smoothly present the virtual scene of substation robot work. It can realize the high-precision positioning measurement of the robot under different distances and speeds, obtain the working dynamic trajectory of the robot according to the measurement results, analyze its working state, and give an early warning in case of abnormal working state, so as to achieve the purpose of intelligently monitoring the working state of the substation robot. The experimental results show that each group of video data transmission frame rate of the system can reach 29 f/s and is relatively stable. The average transmission frame rate is 30.62 f/s. The video transmission frame rate is high, which can ensure the timeliness of video transmission. *Conclusion*. The designed substation intelligent video monitoring system has good output stability and reliability.

1. Introduction

With the continuous promotion of the construction of power video monitoring system and the continuous expansion of the construction scale of video monitoring, in the next stage, we should focus on using a large number of video monitoring systems to realize all-round inspection of substations without dead corners and use video intelligent analysis technology to improve the intelligent analysis and judgment of substation abnormal conditions. At the same time, data analysis technology is used to carry out statistical analysis, prediction, and early warning of equipment operation status according to equipment operation monitoring data, so as to replace manual patrol inspection to the greatest extent, reduce the workload of manual patrol inspection, improve the intelligent level of substation operation, and improve the sharing level of video data. Substation is an important equipment to realize high-voltage power transformation. In the transmission and distribution control, it is necessary to carry out intelligent video monitoring on the substation to improve the intelligent operation and maintenance management level of the substation. Using embedded control technology can improve the optimization level of substation intelligent video monitoring system. The research on its related design methods is of great significance in the optimal design of transmission and distribution and power grid [1–3].

Substation is the place that provides power distribution in the power grid system, and its stability and security of operation are directly related to the security of power system and power grid operation [4]. The safe and stable operation of the substation largely depends on the normal operation of the primary equipment in the substation. Therefore, increasing the research on the primary equipment monitoring will be of great significance for the stable operation of the substation and the basic guarantee of people's livelihood. The auxiliary equipment of substation is an important part to ensure the stable operation of primary equipment. Auxiliary equipment refers to the equipment that provides auxiliary support for substation monitoring, such as online monitoring of primary equipment, safety defense, fire fighting, moving ring system, intelligent locking control, voiceprint monitoring, video monitoring, and robots, in the substation. At present, substation is developing towards intelligence and unmanned. Substation auxiliary equipment monitoring is an important technical means to help substation realize unmanned. Auxiliary equipment monitoring includes dynamic loop system monitoring, security system monitoring, intelligent lock control system, fire protection system, primary equipment online monitoring, robot patrol monitoring, etc. The topology of auxiliary equipment is divided into station control layer, convergence layer, and sensor layer. The communication mode adopts DL/T860 standard. Dynamic loop system monitoring is to monitor the environmental conditions of the substation, including the monitoring of power cabinet, air conditioner, UPS, temperature and humidity, and other related parameters. Security system monitoring is to provide lighting, ventilation and heating, security alarm, access control identification, and other security environment for the substation. The lockable control system mainly solves the problems of many kinds and complex management of door locks in unattended substations, making the lock control management more reasonable and safe. The voiceprint monitors the operation status of the sound and vibration signal analysis device generated by the substation transformer and other equipment. The intelligent fire-fighting system mainly protects the complex building, power distribution equipment building, oil immersed transformer, etc., through various fire-fighting devices. Online monitoring of primary equipment is to conduct real-time monitoring of primary equipment of substation, ensure the operation safety of primary equipment, and provide guarantee for the safe operation of primary equipment [5–7]. Therefore, it is of great significance to strengthen the research of substation auxiliary equipment monitoring.

2. Literature Review

At present, substation patrol inspection is mainly conducted manually by substation operators to make sensory and simple qualitative judgment on operating equipment and mainly judge the operating status of equipment through senses such as seeing, touching, listening, and smelling [8, 9]. Manual inspection can timely find visible, audible, and smellable defects outside the equipment, such as oil level, oil temperature, pressure, oil leakage, external damage, rust, smoke, fire, odor, abnormal sound, and abnormal indication signal of secondary equipment. Manual patrol inspection is greatly influenced by the physical and psychological quality, sense of responsibility, external working environment, work experience, and technical skills of patrol inspectors, and there is the possibility of missing patrol inspection and defect discovery. Moreover, for the internal defects of the equipment, the operating personnel have no professional instruments or the accuracy of the instruments is too low, which cannot be found through simple inspection, such as excessive oil and gas test items, heating at special parts of the equipment, unqualified insulation, and other defects. Another kind of defects can only be found during operation, such as mechanical jamming, inadequate opening and closing of knife switch, and damage of box door of knife switch mechanism. On the other hand, due to the increase of unattended substations, many substations are far away. In the event of an accident in the station or the centralized control station can not patrol in time after the strong wind, snow, and thunderstorm, the attendant of the centralized control station can not understand the status of the on-site equipment in time, find hidden dangers in time, endanger the safe operation of the power grid, especially the substation with problems, and lose the opportunity to arrange treatment first. At the same time, inspectors need to stand close to the equipment when inspecting the equipment, which also poses a certain threat to the personal safety of inspectors, especially in the inspection of abnormal phenomena and special inspection in bad weather, and the risk is greater when finding the cause of the accident [10]. To sum up, the manual patrol inspection of unattended substation is poor in timeliness and reliability, costs a lot of manpower, has great traffic risk and patrol process risk, and has low patrol efficiency. Therefore, it is necessary to introduce substation patrol inspection robot [11].

The substation inspection robot is an important means of auxiliary system monitoring. It relies on a variety of sensors to complete the inspection task of inspecting the substation and assists the operation and maintenance personnel to inspect the knife switch, insulating insulator, oil level gauge, and other equipment that are difficult to monitor [12]. The inspection robot integrates environmental perception, dynamic decision planning, and behavior control and execution and completes the risk elimination work of the substation through remote control. It can be divided into outdoor wheeled robot, indoor rail lifting robot, and indoor two-dimensional code positioning robot. The earliest electric power inspection robot was applied to high-voltage transmission lines, equipped with a special camera, which reduced the workload of line inspectors [13, 14]. Using unmanned helicopter as inspection robot can realize inspection of high-voltage transmission lines and other equipment in substations. Chen and Wang proposed a design scheme of robot patrol monitoring system. The system can automatically record the data and operation data of the patrol robot in the process of patrol inspection and can also automatically identify the instrument readings and alarm abnormal data. The system is divided into robot management, motion mode control, image processing, database management, and patrol log, which can save some human resources and improve the troubleshooting ability of abnormal equipment [15]. The monitoring system of substation inspection robot shall also meet the image quality requirements of video transmission to ensure that remote personnel can clearly identify the target image [16]. The inspection robot should have certain intelligence, but the research in this direction is still scarce at present. It also needs to meet the requirements of human-computer interaction and analog instrument reading recognition, so as to avoid the problems such as unclear reading caused by complex site environment.

Facing the low inspection efficiency and poor information coordination of a single inspection robot, Kolodziej et al. proposed a hierarchical control system for inspection robots with two-level deployment and built a multiagent remote monitoring system based on distributed robots [17]. With the construction of unmanned substations, robot patrol monitoring has been widely used in more substations because of its flexible control and weather free.

This paper studies the design method of substation intelligent video monitoring system. First, the overall structure of substation intelligent video monitoring system is designed; then, the function modular development design of the system is carried out, and the design of substation intelligent video monitoring system is realized in combination with embedded development technology. Finally, the simulation test analysis is carried out, and the effectiveness conclusion is drawn [18].

3. Method

3.1. Overall Design Framework of the System. In order to realize the design of substation intelligent video monitoring system, firstly, the structural model of substation integrated intelligent monitoring system is analyzed, and the software of the system is developed by combining the embedded cross compilation method. Using the monitoring configuration software design technology, the program development control of substation intelligent video monitoring system is carried out. The embedded control module of substation intelligent video monitoring system is established. The integrated design of substation intelligent video monitoring system is carried out through function modular analysis and integrated video information processing method. The substation intelligent video monitoring system is built on the embedded control platform. The embedded b/s architecture method is used to control the program of the substation intelligent video monitoring system, so as to improve the intelligent control and integrated information processing ability of the substation intelligent video monitoring system. The main functional modules of the system include video information acquisition module, monitoring configuration software module, cross compilation module, program control module, remote information transmission module, human-computer interaction module, etc. [19]. According to the above overall design framework, the overall framework of the system is shown in Figure 1.

According to the overall structure analysis of substation intelligent video monitoring system, the monitoring configuration software controls the bottom layer, and the video information collector samples the video information of substation intelligent video monitoring. In this paper, the cross compilation control is implemented in the buffer, and the cache control of substation intelligent video monitoring is implemented in the cache component, so as to improve the process control ability of substation intelligent video monitoring.

3.2. Functional Module Analysis of the System. Based on the overall design of substation intelligent video monitoring system, the component design and hardware development environment analysis of substation intelligent video monitoring system are carried out. The dynamic range of multichannel data recording for substation control information collection is set to -10~10 dB, the amplification of Linux kernel configuration is 120 KB, and ISA/EISA/Micro Channel expansion bus is used.

For instruction loading of substation intelligent video monitoring, the integrated control method is used for hardware modular design of substation intelligent video monitoring, the expert system engine control method is used for program loading of substation intelligent video monitoring, the voltage impulse response control method is used for output bus control of substation intelligent video monitoring system, and the human-computer interaction interface module is constructed. The intelligent video monitoring and human-computer interaction of substation are designed in the data storage center, and the output bus control module is established to carry out the human-computer interaction and cross compilation of the intelligent video monitoring system of substation. The functional module structure of the system is shown in Figure 2.

3.3. System Development Design and Implementation. Through the overall architecture design and function modular analysis of substation intelligent video monitoring system, the components of substation intelligent video monitoring system are designed. This paper presents the design method of substation intelligent video monitoring system based on monitoring configuration software. The main functional modules include video information acquisition module, monitoring configuration software module, cross compilation module, program control module, and so on.

3.3.1. Video Information Acquisition Module. The video information acquisition module realizes the data information acquisition of the substation intelligent video monitoring system. The video information collector adopts the sensor device to collect the video information in the embedded bus. ADSP-BF537BBC-5A is used to realize the integrated information processing of substation intelligent video monitoring, and the relay protection control method is used to control the interruption protection in the process of video information acquisition. According to the DC transmission performance, combined with the coupling compensation method of capacitance, resistance, and inductance, the error disturbance in the video information acquisition process is suppressed, and the hardware design of the video information acquisition module is obtained, as shown in Figure 3.

3.3.2. Monitoring Configuration Software Module. The monitoring configuration software module realizes the bottom control function of substation intelligent video monitoring. In the process of equipment distribution and cable laying, the intelligent video monitoring and identification of substation are carried out, and the intelligent video feature quantity of substation is extracted. In the intelligent auxiliary

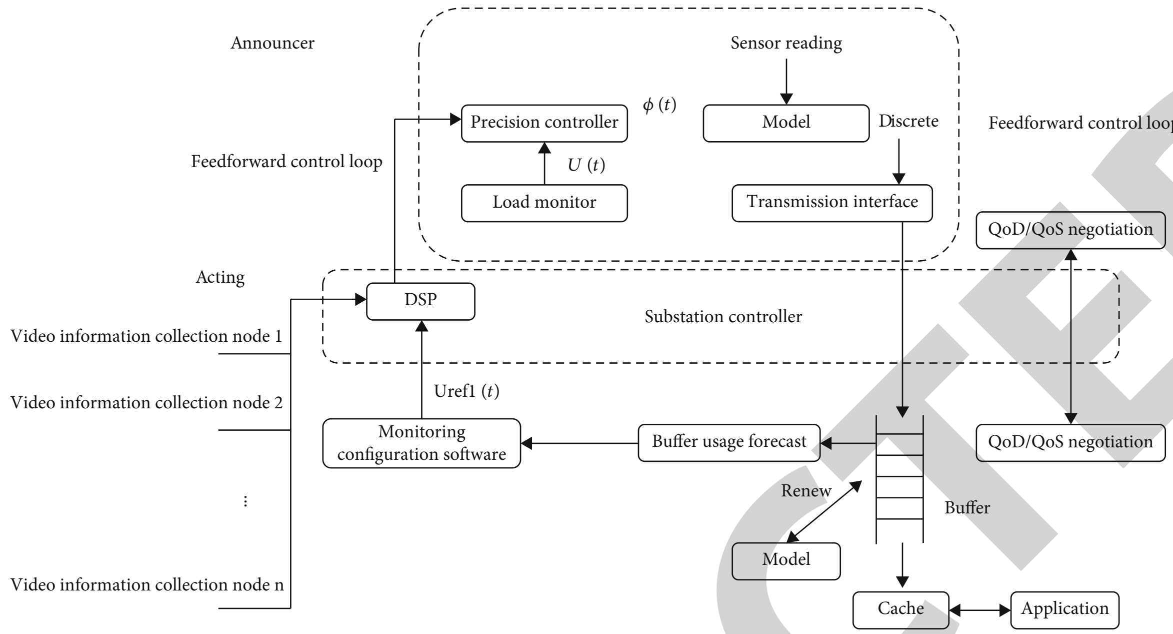

Figure 1: Overall structure of the system.

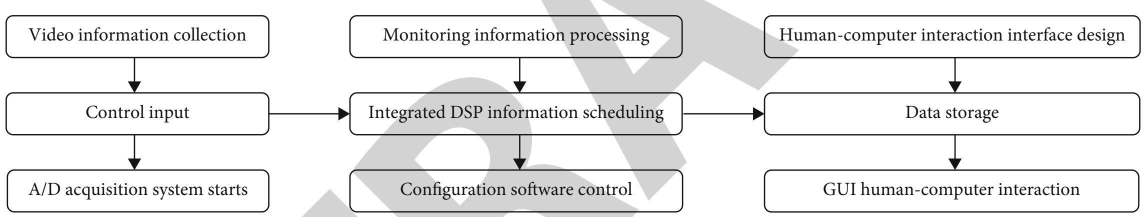

Figure 2: Functional module structure of the system.

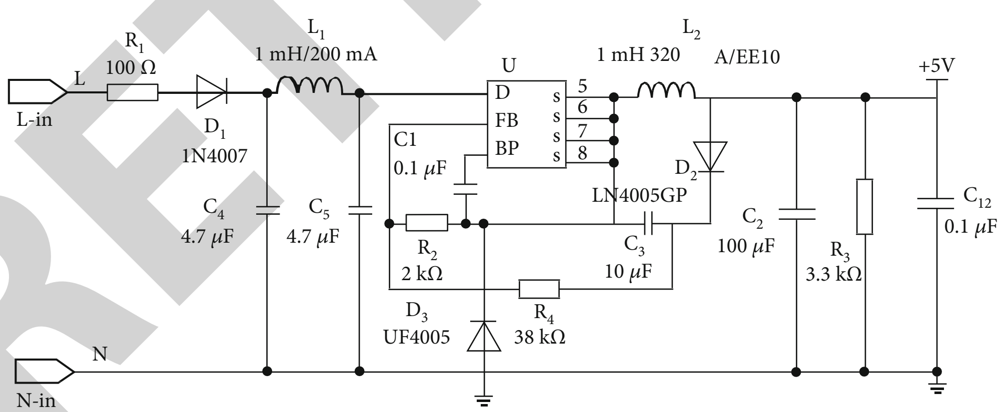

Figure 3: Hardware structure of video information acquisition module.

control system, the three-dimensional ICAD platform for substation intelligent video monitoring is designed. The monitoring configuration software is controlled according to the characteristics of each front-end equipment of the system, and the program of the monitoring configuration software module is obtained, which is transmitted to the ZigBee routing node through ZigBee. Upload to the server through GPRS, and the system uses adm706 chip to design the threshold detector. The system structure of the monitoring configuration software module obtained through the above design is shown in Figure 4.

3.3.3. Network Networking and Human-Computer Interaction. The imaging control and information transmission of substation intelligent video monitoring are carried out in the embedded Linux platform. The expert system engine control method is used to load the program of substation intelligent video monitoring, and the GPR module

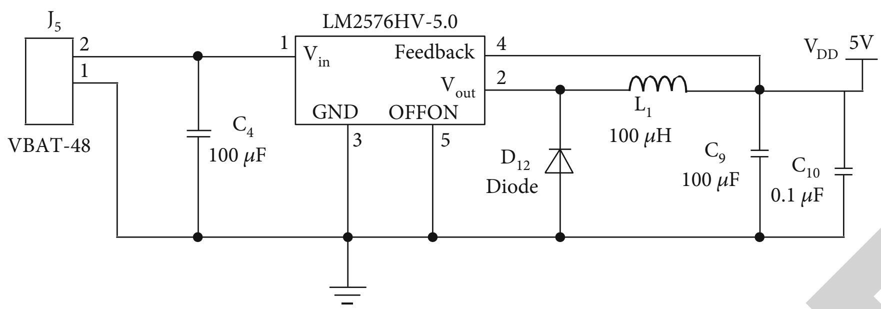

Figure 4: Design of monitoring configuration software module.

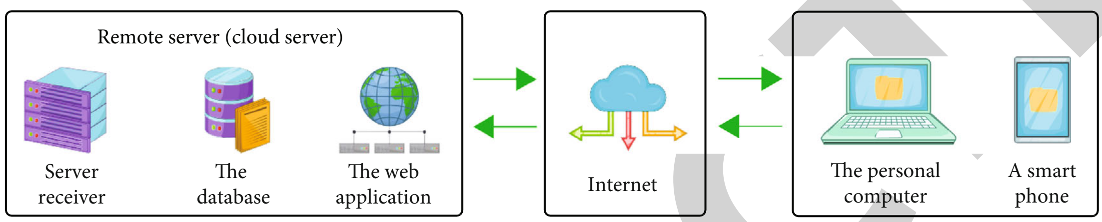

Figure 5: Network networking and human-computer interaction design of substation intelligent video monitoring.

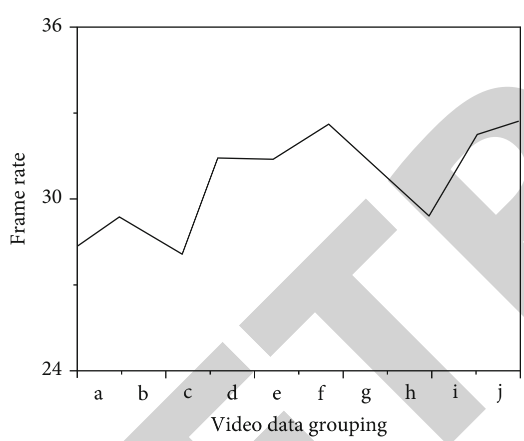

Figure 6: Video transmission frame rate statistics.

Table 1: Monitoring results and alarms of the system.

Task line number	Working condition	Alarm or not
A	No abnormality	No
B	There is an exception	Yes
C	No abnormality	No
D	There is an exception	Yes
E	There is an exception	Yes

is used for embedded human-computer interaction design [20]. Install the Windows Server 2012 R2 system for human-computer interaction and interface design, conduct cloud storage in the remote server, and obtain the network networking and human-computer interaction design of substation intelligent video monitoring, as shown in Figure 5.

3.4. System Positioning Measurement Algorithm Design. The operation process of the positioning and measurement algorithm mainly includes the creation of the robot 3D model library, the recognition of the robot in the real-time scene image, the acquisition of the scene 3D spatial information, and the acquisition of the robot position and scale. The specific process is described as follows:

(1) *Robot 3D Model Library Creation*. Manually select the three-dimensional model information of different operating robots in the working environment scene of substation robots. In order to distinguish different operating robots, number each operating robot, and successively store the three-dimensional model information of each operating robot in the database, so as to realize the creation of the model library of substation operating robots

(2) *Recognition of Working Robot in Real-Time Scene Image*. The template matching algorithm is used to identify the working robot in the real-time scene according to the robot model library. The template can be regarded as a known small image, and the template matching algorithm is used sad algorithm to find the target with the same template features in the large image and determine the detailed location information of the target at the same time. If template a belongs to an eight-bit image and its pixels are $M \times N$, move the template on the large image to be searched u, the pixels of the large image to be searched u are $X \times Y$, and the covered part of module a is set as the subimage U_{ij}. Among them, the coordinates of the upper left subgraph on the large image u are represented by i and j. As shown in formula (1), the search interval is set as

$$\begin{cases} 1 \leqslant i \leqslant X - M, \\ 1 \leqslant j \leqslant Y - N. \end{cases} \quad (1)$$

By comparing the similarity between template a and subgraph U_{ij}, the purpose of template matching is achieved. The criteria for measuring the matching degree between template a and subgraph U_{ij} are

$$D(i, j) = \sum_{m=1}^{M} \sum_{n=1}^{N} [U(i + m, j + n) - A(m - n)]^2. \quad (2)$$

In formula (2), $D(i, j)$ is a measure of the similarity between the (i, j) coordinate position in the image to be searched and the template, A is the template image function, U is the image function to be searched, i and m are image horizontal, j and n are the ordinate variables, and $A(m, n)$ represents the gray value of the image at the (m, n) coordinate position

4. Results and Discussion

The 3000 frames of video data collected by the system in this paper are divided into 10 groups (a-j) for video transmission, and the transmission frame rate of each group of video data transmitted by the system in this paper is counted to test the timeliness of video transmission of the system in this paper. The statistical results are shown in Figure 6. It can be seen from Figure 6 that the frame rate of each group of video data transmission of the system in this paper can reach 29 f/s and is relatively stable, with an average transmission frame rate of 30.62 f/s. The video transmission frame rate is high, which can ensure the timeliness of video transmission. The reason is that the system in this paper uses the video data collected by hardware M-JPEG coding, which improves the video acquisition and coding efficiency, and reduces the number of videos, so it improves the video transmission frame rate. See Table 1 for the monitoring results and abnormal alarms of the robot working state by the system in this paper.

5. Conclusion

This paper presents a video monitoring-based substation robot working state detection system. This paper presents the design method of substation intelligent video monitoring system based on monitoring configuration software. The main functional modules include video information acquisition module, monitoring configuration software module, cross compilation module, program control module, etc. The designed substation intelligent video monitoring system has good output stability and high reliability.

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 that they have no conflicts of interest.

Acknowledgments

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