Visual Inspection Application of Substation Based on Internet of Things

Yu Yin¹*, Chen Gu¹

¹State Grid Jiangsu Electric power Co., LTD Yangzhou power supply branch, Yangzhou 225009, China

*Corresponding author e-mail: liutt_110@163.com

Abstract: After the Internet, the Internet of Things has become another innovative technology in recent years. In recent years, the Internet of Things technology has been applied to various industries, such as agricultural production, intelligent transportation, industrial production, etc., which also includes visual inspection of substations operating system. In the implementation of the Internet of Things visual inspection application system of the substation, the wireless data collection of the substation is a key part of the entire system. The system needs to use advanced wireless sensing technology, remote data transmission technology, Internet technology and other key technologies of the Internet of Things. Since the patrol inspection of substations in the domestic power system is still dominated by manual patrol inspection, due to the high intensity of the patrol inspection and the harsh operating environment, the work efficiency is insufficient. This article starts from the needs of the Internet of Things-based substation visual inspection application, integrates autonomous robots, sensor fusion technology, visual recognition technology and GPS positioning technology, builds a 24/7, all-round autonomous inspection visualization system, and initially achieves substation autonomy Patrol function. Secondly, it analyzes the principles of the autonomous robot inspection and visualization system, expounds infrared information collection and alarm functions, and analyzes a series of functions from information visualization and recognition to background operations. The research results show that the autonomous robot inspection visualization system can improve the inspection efficiency of the power station by more than 85%, and effectively reduce the strength and risk of workers.

Key words: Internet of Things Technology, Substation Inspection, Visual Inspection Application, Intelligent Robot

1. Introduction
The Internet of Things technology is a combination of Internet technology and embedded technology,
in which the embedded technology completes the data detection of the physical world and the control and regulation of the physical world [1-2]. Connect the actual physical world through Internet technology to realize the remote transmission of perception data and control information. Through the network interconnection, real-time monitoring and control of remote objects is achieved [3].

The safe and reliable operation of the power system is related to all aspects of our daily life. Any failure during its operation may have a huge impact [4]. As an important part of power system operation, substation operation management is also crucial. The traditional unmanned substation equipment inspection work is affected by the level of automation and human factors. The work efficiency and intelligence are low. It is impossible to find and deal with equipment defects in a timely and effective manner, which is a major safety hazard for substation operation [5-6]. In the cold winter period, it is often carried out by electric maintenance personnel to regularly check whether the heating system of the switchgear is normal. The efficiency of this inspection scheme is extremely low, and because of the wide geographical location of the substations, some of them are even in extremely remote mountains, which brings great inconvenience to the maintenance personnel's inspection work [7]. Moreover, regular inspections do not guarantee that there will be no failures in the two detection intervals, so that the safety of the entire power system cannot be truly guaranteed. Once a fault occurs, failure to find and deal with it in time will inevitably affect the operation of the entire unit and cause huge losses to the power system [8-9].

Based on the research of IoT wireless sensor network technology, this paper selects the wireless solution of sensor layer network. This article will introduce an improved PID control algorithm to complete the automatic control of the switchgear temperature. The design of the visualization system for the inspection of autonomous robots in substations is mainly to analyze the work process of the inspection and visualization of autonomous robots. This paper analyzes the operation effect of the autonomous robot inspection visualization system, and provides a theoretical basis for the later promotion of the inspection inspection visualization system. In this paper, based on the actual situation of the substation autonomous robot inspection visualization system, the corresponding reference data and case application are given.

2. Proposed Method

2.1 Substation Inspection Wireless Communication Technology in the Internet of Things

(1) NFC technology

NFC technology is a wireless high-frequency communication technology. NFC solves the same identification of all applications and services combined on a single device, and guarantees the security of data, and also simplifies complex operations.

(2) Infrared transmission (IrDA) technology

IrDA is the abbreviation of Infrared Data Association, and the widely used IrDA infrared connection technology is proposed by this organization. The IrDA data protocol consists of three basic layer protocols, including the physical layer, link access layer and link management layer. The IrDA stack supports IrLMP, IrLAP, IrIAS, IrLAN, IrOBEX, IrCOMM, IrLPT and IrAP and other functional protocols. The initial goal established when IrDA was established is that IrDA-enabled devices will be removable, and the price of this protocol is a cheap, inexpensive technology. Therefore, at the beginning of development, IrDA's communication model chose short-range, connectionless, point-to-point orientation.

(3) Analog PID controller

In the analog control system, PID control is the most commonly used control law of the controller. The set value of the system; u(t) is the output of the entire controller operation; e(t) is the deviation of the system set value r(t) and the actual value output c(t); e(t) = r(t) - c(t); the input and output relationship of the PID control part is:

\[ u(t) = K_P e(t) dt + T_d \frac{de(t)}{dt} \]  \hfill (1)
The transfer function is:

\[ G(s) = \frac{\mu(s)}{\epsilon(s)} = K_p\left[1 + \frac{1}{T_1s} + T_Ds\right] \quad (2) \]

In the formula, \(K_p\), \(T_I\), and \(T_D\) are the coefficients of each control item.

2.2 Basic Principles of Application of Visual Inspection for Secondary Circuit of Intelligent Station

At present, the visual display of SCD files in the XML text format is mainly based on the XML language according to its grammatical rules and the logical connection relationship between each device, and the connection between each device is displayed in a graphical form. Correspondence between SV and GOSE data sets among various devices. The main steps of secondary circuit visualization are as follows:

1) Parsing SCD files
2) Traverse the tree structure to build an IED linked list
3) Establish a virtual terminal connection relationship
4) Create drawing auxiliary variables for each IED
5) Draw IED virtual terminal connection diagram

2.3 Visualization Application of Autonomous Robot Inspection

(1) Isolation switch inspection point

Among the 397 defects found during the inspection, 16 were "dangerous" defects, 61 were "serious" defects, and 320 were "general" defects. Among the defects of the isolating switch, the number of component failures caused by external forces accounted for 129, accounting for 32.4% of the total, which was the highest proportion. Mainly include: the knife gate contacts fall off, the drive rod cracks, or the drive hoop breaks, hardware failure, and the indicator does not display. The reason for these failures is that the corresponding materials are not qualified, or the processing is poor, and the maintenance guarantee is not enough.

(2) Inspection of transformer oil level

Under normal circumstances, the oil level in the transformer is significantly affected by temperature, and there is a positive phase relationship between the two. If the oil level in the oil level tube changes abnormally, it means that the oil level is false.

1) The relevant pipeline of the oil pump valve is blocked;
2) The tubing respirator is damaged or blocked;
3) The vent hole of the explosion-proof pipe is blocked;
4) Residual air in the film protection device.

3. Experiments

3.1 The Content of Substation Inspection Mainly Includes the Following Aspects

(1) Routine inspection is to inspect the equipment and auxiliary facilities by maintenance personnel. The inspection content includes: exterior, sound, temperature, fire protection equipment, warning information, communication information, surrounding environment, equipment values, historical data, etc. Check the value and equipment, and strictly follow the relevant specifications to ensure that the inspection process is standardized and the inspection content is accurate.

(2) Special inspections are carried out on the basis of comprehensive inspections, in which the inspection cycle is: the inspection cycle for the second-type substation is 1 time / 15 days, the inspection time for the third-type substation is 1 time / 30 days, and the fourth type substation is 1 time / 60 days.

(3) Special inspections are inspections conducted by operation and maintenance personnel due to special circumstances or changes in modes.

3.2 Special Inspections are Inspections Conducted by O & M Personnel due to Special Circumstances
or Changes in Modes.

(1) After windy days, inspect the surrounding environment for floating objects, wind deflection problems, broken strands, terminal boxes, substation doors and windows closed.

(2) After the rainstorm, it is necessary to check the integrity of the equipment and whether it is loose or not;

(3) After the change of seasons, check whether the equipment is aging, whether the porcelain is cracked, and whether the air switch and oil pump need to be replaced.

4. Discussion

4.1 Visual Inspection Movement Verification of Autonomous Robots in Substations Based on Internet of Things

In order to check and ensure the effective inspection of the robot, the inspection work of the substation needs to be adjusted to make its design more reasonable. The inspection robot uses a combination of a driving mechanism and a clamping mechanism to make the driving mechanism and the clamping mechanism perform motion control relatively independently. Divide according to the type of equipment in the substation, and then combine the manual inspection method to evaluate the equipment status and determine the key points and general inspection points. At the same time, combined with the environmental factors of the substation, the inspection cycle is set. There are two types of inspection cycle settings, running cycle setting and initial cycle. Two types are set to shorten the period of the equipment with high failure level. The experimental results are shown in Table 1 below.

| Substation | Voltage | Condition evaluation | Defect score | Negative rate | Factors affecting safety | State evaluation results | Tour cycle |
|------------|---------|----------------------|--------------|--------------|-------------------------|-------------------------|------------|
| A1         | 220     | Normal               | 94           | 66%          | Floating object         | General                 | 32         |
| A2         | 220     | Normal               | 97           | 64%          | No                      | Good                    | 32         |
| A3         | 110     | Normal               | 92           | 51%          | No                      | Good                    | 32         |

As shown in Table 1 above, after the inspection of the autonomous robot is completed, manual inspection is required. Ensure the safe operation of the equipment. In the following special circumstances, the inspection environment is not suitable for manual inspections. It is necessary to use autonomous robots to conduct inspections. After the defects are found, notify the relevant personnel or perform simple maintenance to achieve controllable, controlled and controllable inspections.

4.2 Motion Analysis of Obstacle Course

Combined with the reasons of mechanical movement, the autonomous robot patrols the inspection model and analyzes the stability during the obstacle crossing. Establish an independent inspection robot model in Adams, and set the material characteristics of the parts in Adams according to the setting materials, and use the motor driving force, and the contact force between the inspection robot and the ground, according to the actual needs of the inspection Exert. During the obstacle crossing in the horizontal position, the preload of the clamping device and the ground is set to 20N, then the movement trajectory of the center of mass of the control box of the autonomous robot is shown in Figure 1 below.
5. Conclusions

This paper analyzes the current development of autonomous inspection robot technology by studying the application of autonomous robots in substations, and analyzes the possibility and necessity of autonomous robot inspection in combination with actual cases. The development of autonomous robot technology is relatively mature. By connecting with the background operating system, the inspection of the relevant equipment of the substation is realized. At the same time, auxiliary equipment equipped with autonomous robots, such as infrared and video, can transmit corresponding data in real time, collect equipment temperature and numerical information, and connect with local monitoring through wireless network communication system and remote centralized control background to achieve autonomy Equipment monitoring and intelligent analysis. Whether the operating conditions of the operating
equipment in the substation can be regularly observed by the autonomous robot, such as equipment corrosion, paint peeling, etc., the autonomous robot cannot perform autonomous recognition. Although the above problems are not directly related to the safety and stability of the equipment, they have a certain impact on the maintenance of the equipment, and need to be dealt with and maintained in a timely manner to eliminate the corresponding safety hazards. This shows that there is still room for further research and development of the autonomous robot inspection visualization system.

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