Design of Intelligent Inspection System for Distribution Network Based on Circular Multi-Agent Structure

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Abstract. With the rapid development of power system, distribution network inspection is becoming more and more important. The inspection work of the distribution network can effectively monitor and master the operation of power lines and power equipment, find equipment defects and hidden dangers, and propose specific maintenance plans to ensure power supply reliability. In the past, the distribution network inspection was generally carried out by manual means, which was inefficient and heavy in operation. In order to improve the efficiency of inspection, this paper proposes an intelligent distribution network inspection system based on the circular multi-agent structure. Firstly, the structure of the circular multi-agent is analysed, and then the macro structure of the intelligent inspection system for distribution network is designed. Finally, its micro architecture with different modules is designed. The proposed intelligent inspection system can effectively improve the inspection efficiency and enhance the intelligence level of the power system.

1. Introduction

The construction of low-voltage distribution network occupies a considerable proportion in the whole city. The long-term outside exposure of power lines and power equipment will bring a great challenge to the safe and stable operation of the power system[1]. The stable operation of the distribution network is related to the stable supply of electricity throughout the region and the daily life of the people[2][3].

In summary, the inspection work of the distribution network is becoming more and more important. The role of the distribution network inspection work is to timely monitor and master the operation status of power lines and power equipment, find equipment defects and equipment hidden dangers, and propose specific maintenance programs to eliminate defects in time to achieve the operational goals of "safe, economic, multi-supply, and less-damage"[4][5]. In the past, most of the distribution network inspections were manual, with low efficiency, heavy work, and large resource consumption[6]. Therefore, it is very meaningful to design an intelligent distribution network inspection system.

Regarding the issues above, this paper proposes an intelligent distribution network inspection system based on the circular multi-agent structure. The main contents of the remaining chapters of this paper are: the second section analyses the structure of the circular multi-agent; the third section designs the macro-architecture of the distribution network intelligent inspection system; the fourth

section designs the intelligent inspection system in a micro level; the fifth section concludes the full text.

2. Circular multi-agent structure analysis

Multi-agent system is a new type of distributed computing technology. It has developed rapidly since its emergence in the 1970s. It has become a method of complex systems analysis[7][8].

The research of multi-agent collaborative technology is a frontier research topic in the control field. Intuitively speaking, multi-agent is a certain number of autonomous individuals through mutual cooperation and self-organization, at the collective level to show an orderly collaborative movement and behaviour. This kind of behaviour can enable the group system to achieve certain complex functions and show a clear collective "intention" or "purpose". The rapid development of multi-agent provides the model and analysis method for the study of complex systems, and also provides the theoretical basis for the wide range of practical applications. In particular, with the increasing demand for biological population decision-making, computer distributed applications, military defence, environmental monitoring, industrial manufacturing, and special terrain rescue, multi-agent collaborative technology has attracted more and more interest and attention from scholars. Compared with the traditional single system application, the ability of multi-agent to work together improves the efficiency of task execution. The redundancy of multi-agent improves the robustness of the task application. Multi-agent is easy to expand and upgrade, and also can complete distributed tasks that a single system cannot complete.

In summary, the advantages of multi-agent structure can effectively improve the intelligent level of the distribution network inspection system, so this paper will design a distribution network intelligent inspection system based on the multi-agent structure.

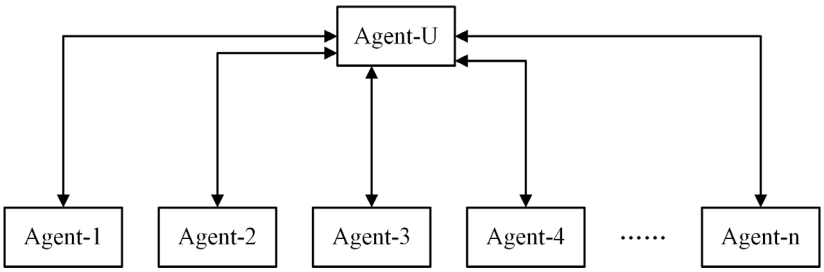

Figure 1. Layered multi-agent structure.

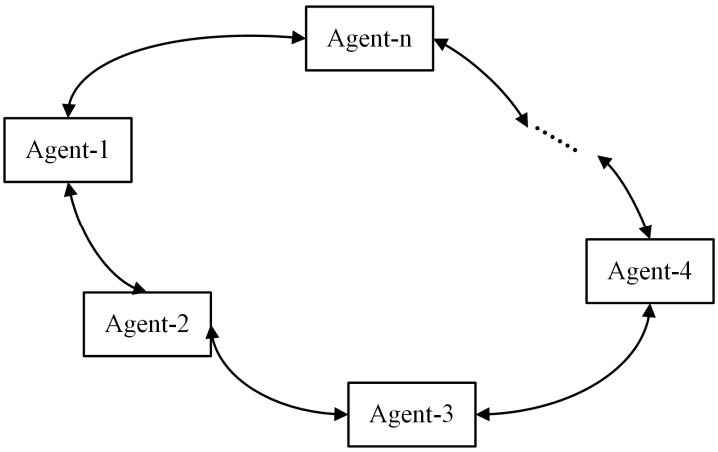

Figure 2. Circular multi-agent structure.

Multi-agent structure commonly used at present is a layered structure, as shown in Figure 1[9][10]. Among them, Agent-U is the upper layer of the agent, and Agent-1 ~ n is the lower layer of the agent. Information interaction and instruction transferring are realized between the upper and lower layers through communication links. The upper agent coordinates the cooperative operation of all the agents according to the real-time information of the lower agents.

However, the layered structure shown in Figure 1 has a low reliability defect. When the upper Agent-U fails, the communication links between the various agents will be completely disconnected and the entire multi-agent structure will be paralyzed. To solve this problem, the circular multi-agent structure is used in this paper, as shown in Figure 2.

As shown in Figure 2, in the circular multi-agent structure, there are two communication links between any two agents. Therefore, if any one agent fails, the entire multi-agent structure can still maintain the connection state and continue to work effectively.

3. Macro design of intelligent inspection system

The intelligent power inspection system for distribution network designed in this paper mainly consists of distribution network GIS sub-module, distribution network data acquisition and monitoring system sub-module, distribution network information inspection and acquisition system sub-module, distribution network production management system sub-module, distribution network patrol vehicle GPS positioning monitoring system sub-module, and distribution network remote video monitoring system sub-module. These six modules have functions such as remote real-time support, remote real-time acquisition control, inspection information collection, inspection work management, inspection vehicle positioning, and remote video surveillance, which enable the distribution network intelligent inspection system to play a huge role of improving the efficiency of daily inspections, saving labour costs, and truly achieving intelligent, digital and automated distribution network management.

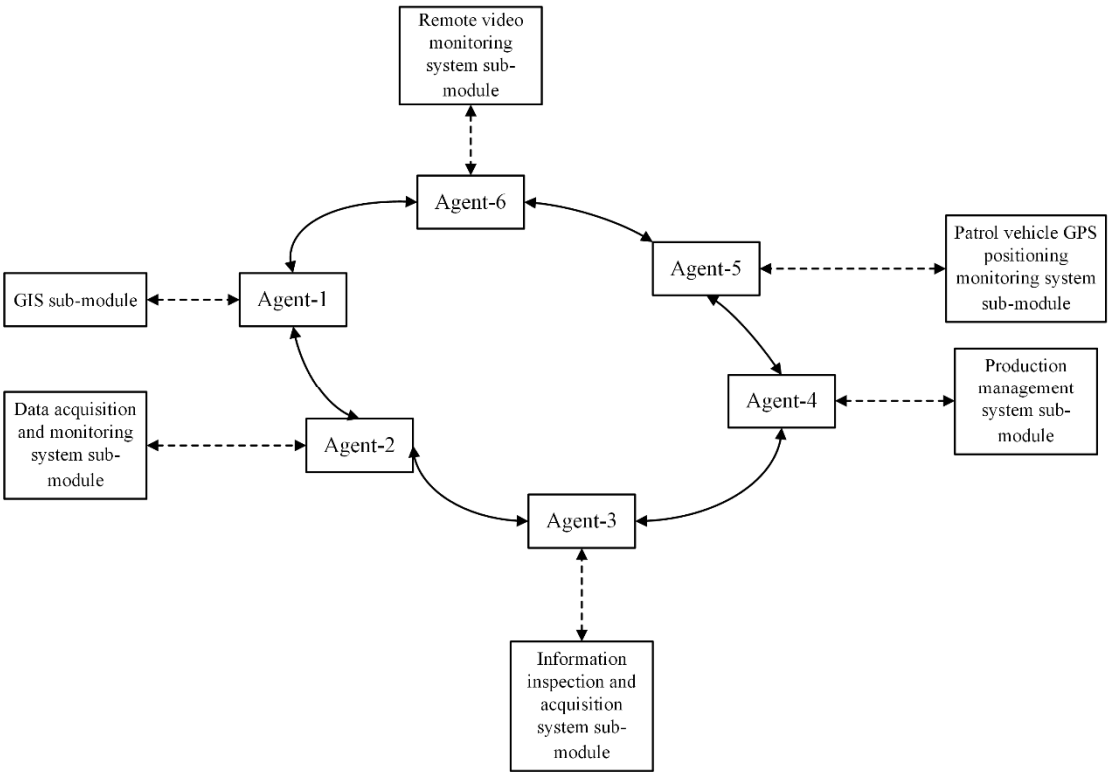

Figure 3. Macro structure of intelligent inspection system for distribution network.

As shown in Figure 3, based on the circular multi-agent structure, each of the six modules has an agent responsible for transmitting and receiving information, and these agents realizes the communication coupling of the six modules through a circular communication link. Thus, the intelligent inspection system of distribution network can be effectively coordinated.

4. Micro design of intelligent inspection system

4.1. GIS sub-module

The GIS module of distribution network can realize the functions of management, maintenance, display, operation, analysis and model of geospatial data. It is one of the important bases for remote real-time support of distribution network intelligent inspection system.

The entire GIS sub-module can be divided into three parts: the basic data platform system, the application system and the interface system. The core functions of the sub-modules include GIS basic functions, GIS application functions, and geographic information release functions. They have a standard unified equipment model and are seamlessly integrated with other sub-module data. And through the common data exchange platform, the information is shared interactively with the external system.

4.2. Data acquisition and monitoring system sub-module

As an important part of the intelligent inspection system, the distribution network data acquisition and monitoring sub-module is also one of the important bases of remote real-time support. The module is mainly composed of a master station control system, a substation system and an automation terminal. The three-layer structure is used to construct an automation system to realize hierarchical control of data.

The distribution network data acquisition and monitoring sub-module has functions such as data acquisition, event alarm processing, human-machine interface, analogue screen control, system internal monitoring and switching, operation ticket, and device statistics. It realizes low-voltage side monitoring of the main substation through the main station dispatching system, as well as remote data acquisition and monitoring through the feeder automation and switching stations.

4.3. Information inspection and acquisition system sub-module

The distribution network information inspection and collection system is the daily working platform of the distribution network inspection personnel. It is the most important module in the inspection system. It is used to collect information about the power lines and electrical equipment obtained by the distribution network inspection. And the transmission of related information is completed through a wireless communication network.

The information collector is the core equipment of the whole module. It plays a professional and intelligent role in the information collection, recording and transmission. The information collector should be developed based on the most convenient handheld mobile terminal in the current informational office field, and should include three parts: powerful hardware configuration, mature system software and convenient application software.

4.4. Production management system sub-module

The distribution network production management sub-module is established on the basis of the data of GIS sub-module. It is the platform for the daily power distribution production management of the regional power supply department's transportation management centre, production technology department, and operation inspection team. The functions of the module include the file management of the distribution network equipment, the formulation of the inspection work plan, the release of work tasks, and the inspection of work conditions. This module can be combined with the GIS sub-module to facilitate the implementation of the graphic and text integration inspection mode.

4.5. Patrol vehicle GPS positioning monitoring system sub-module

The GPS positioning monitoring module of the distribution network inspection vehicle can perform positioning monitoring and track query on the inspection vehicle equipped with the GPS vehicle terminal in the execution of the inspection task, and can play the role of auxiliary monitoring and visual management for the inspection work. GPS global positioning function can calculate the three-dimensional position and speed of the positioning point in real time. In the past, such systems were mainly applied in urban management, financial security, tourism and other aspects, and should be a new bright spot in power inspection work. It has strong practical significance and value.

4.6. Remote video monitoring system sub-module

The remote video monitoring module of the distribution network is a new function of the intelligent inspection system of the distribution network. It can grasp the situation of important lines and power equipment of the regional distribution network in real time. It is a new way for data collection of the entire distribution network intelligent inspection system, which can provide real-time and intuitive video information for global distribution network management. The video surveillance system can be integrated into the system through the interface provided by the digital city management system. It can also be added to the system through its own power equipment, and the data source can be obtained through optical cable transmission and realize various video monitoring functions.

5. Conclusion

Based on the circular multi-agent structure, this paper proposes an intelligent distribution network inspection system. Firstly, the circular multi-agent structure is analysed, and then the intelligent inspection system of the distribution network is analysed and designed in detail from both macro and micro perspectives. The intelligent power inspection system of the distribution network proposed in this paper can solve the problems of low efficiency, heavy operation and large resource consumption of the traditional distribution network inspection method, and effectively improve the intelligent level of the power system.

Acknowledgments

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