

Research on Greenhouse Lighting Monitoring System based on Wireless Sensor Network

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Abstract: Agriculture is the main pillar industry of a country, and China is the world's largest agricultural country. Agriculture plays a crucial role in the economic and social development of the entire country. However, in the process of continuously advancing modernization construction, there are obvious shortcomings in the issues of agriculture, rural areas, and farmers. The research of this paper is based on the wireless sensor network to monitor the light intensity parameters in the greenhouse. Combined with the crop growth environment, ZigBee technology is used to realize the two-way communication between the sensor and the control system, and realize the automatic real-time monitoring of the light intensity that affects the growth of crops in the greenhouse. Through experiments, it has been shown that using ZigBee technology to construct a wireless sensor network monitoring system for greenhouse lighting monitoring is feasible. It meets the needs of wireless monitoring and provides a new solution for the implementation of intelligent control of greenhouses.

Keywords: ZigBee Technology; Wireless Sensor Network; Greenhouse Lighting Monitoring System.

1. Introduction

Agriculture is the main pillar industry of a country, and China is also the world's largest agricultural country. Agriculture plays a crucial role in the economic and social development of the entire country. However, compared to developed countries where the overall monitoring system for agriculture has been developed relatively well, China has obvious shortcomings. Currently, there are two main methods for monitoring greenhouse environment in China. One is manual monitoring, which has problems such as low work efficiency, high labor costs, and inability to achieve real-time monitoring. The second is to monitor through wired methods, but this monitoring method is more cumbersome in wiring and has higher installation costs. Furthermore, most agricultural production bases are located in remote and vast areas, so the management of greenhouses is mainly done manually, relying on manual experience, which to some extent leads to resource waste.

With the rapid development and progress of socio-economic and scientific technology, the scientific and technological level of agriculture has also improved. At present, China has become the country with the largest planting area of greenhouse, and the planting area of greenhouse is still rising year by year. How to research and design an efficient light intensity monitoring system suitable for greenhouse in China, solve the rising demand for food, improve crop yield, and develop modern agricultural production is an important issue related to people's lives and the fate of the country. Based on this, this research monitors the light intensity parameters in the greenhouse based on the wireless sensor network, combines the crop growth environment, and uses ZigBee technology to achieve two-way communication between the sensor and the control system, so as to achieve automatic real-time monitoring of the light intensity that affects the growth of crops in the greenhouse. And use MATLAB and SPSS19.0 to analyze the data and compare it with the actual situation, providing a new

solution for the implementation of intelligent control of greenhouses.

In recent years, Chinese universities and social researchers have conducted extensive research on information collection in agricultural greenhouses. Jin Yu of Beijing University of Technology applied the industrial control computer in the greenhouse, mainly using the industrial computer as the core controller, to realize the collection of environmental parameters and the control of the actuator. The system has problems such as high overall construction and maintenance costs, complex wiring, and large size. Sun Zhongfu et al. applied GPRS technology to remote data collection to address the bottleneck issue of agricultural network communication due to the complexity of agriculture. Wang Xinzhong and others applied wireless sensor network and other technologies to orchard irrigation to collect greenhouse environmental parameters, and upload the collected data to the database on the PC end for storage. Pan Heli et al. designed a distributed environmental monitoring system using a combination of ZigBee technology and 3G/4G communication technology to achieve data collection and transmission. Wu Huangda and others combined CAN bus and wireless sensor network to achieve a temperature and humidity monitoring system applied in agricultural greenhouses. Wang Maoli and others designed a farmland information monitoring system based on Internet of Things technology using LoRa and MSP430 microcontroller, and conducted in-depth research on the application of LoRa technology in farmland.

2. Development Status of Intelligent Agricultural Greenhouse Lighting Monitoring System

The development of information science and technology has triggered an economic and industrial transformation worldwide, changing the pattern of economic development in various countries and ushering in a new era of economic development. The level of information technology innovation

has become a benchmark for measuring the economic strength and modernization comprehensive level of each country. In foreign greenhouse cultivation techniques, Rome's use of mica sheets to ripen cucumbers became the earliest greenhouse cultivation technique to emerge abroad. With the advancement of technology, the scale of greenhouse horticulture in Europe and America, led by the Netherlands, continues to expand, and the level of automation is becoming higher and higher, achieving information and intelligent greenhouse environmental monitoring. With the continuous emergence of innovative talents in technology, Israel has utilized advanced computer recognition technology to achieve 24-hour monitoring of greenhouse cultivation techniques based on different growth environments of crops. In recent years, with the continuous improvement of network technology, developed countries such as the United States and Japan have implemented remote monitoring and video diagnosis of greenhouses, using robotic arms for cultivation, transplantation, and other operations in greenhouses, becoming a model of advanced closed production systems. In the early 21st century, the United States began a new era of wireless communication technology in agriculture by applying wireless sensor technology to vineyards. With the improvement of wireless sensing technology and internet system, the market share of wireless sensing technology in greenhouse cultivation will increase, and the precise management system of data will greatly improve crop yield.

There is still a significant gap in the construction of agricultural greenhouses in China compared to developed countries. However, China attaches great importance to the development of agricultural modernization, especially since the beginning of the 21st century. China has entered a new stage in agricultural modernization construction, with investment in agricultural construction increasing year by year, accelerating the upgrading and transformation of agricultural industrial structure, developing facility agriculture in some areas, and applying modern advanced technologies to China's modern agricultural construction. At first, China's development of smart agriculture mainly relied on equipment and technology imported from abroad. However, due to high costs, most of the achievements were difficult to adapt to the needs of China's agricultural development and were difficult to popularize in agricultural planting. In the late 1980s, with the introduction of greenhouse cultivation technology, China's research on greenhouse cultivation technology gradually deepened. Under the joint promotion of national policies and macroeconomic situation, China paid sufficient attention to the development of greenhouse cultivation technology and its development status, thus achieving a series of successes in the research of smart agriculture and gradually maturing the technology.

3. Architecture of Greenhouse Lighting Monitoring System Based on Wireless Sensor Network

The environment measurement and control system of greenhouse with wireless sensor network consists of three parts, namely, wireless sensor measurement and control network terminal node, ZigBee gateway (coordinator) and host computer data center. In the wireless sensor measurement and control network, each terminal node is composed of a ZigBee communication module and a specific

functional sensor, which measures the environmental parameters of light intensity in the greenhouse. Moreover, each ZigBee terminal node (FFD) can wirelessly connect with multiple isolated sub nodes (RFDs) that do not undertake network information transfer tasks within its signal coverage range.

The hardware structure of ZigBee gateway (coordinator) used in the greenhouse lighting monitoring system based on wireless sensor network includes transceiver chip CC2430, Ethernet controller DM9000, microcontroller S3C2440, RS232, JTAG, SDRAM, RJ45 interface and 320 MHz crystal oscillator. Its main function is as follows: to complete the conversion of data transmission format and remote transmission of data, achieve communication connection between ZigBee network and Intranet network, and also interact with remote servers and manage ZigBee network.

4. Software Design of Wireless Sensor Measurement and Control Network Terminal Nodes

The main tasks of sensor terminal nodes include data information collection and network connection, responsible for partial routing, maintaining communication with adjacent nodes, and detecting link status. In order to reduce the average power consumption of the network, when designing terminal node module application software, it is necessary to keep each module in a dormant state as much as possible and minimize the number of times the ZigBee module is awakened. The program flow of the terminal node for wireless transmission testing control network is as follows: after device initialization, first detect whether a network already exists. If the network status is determined to be normal, request to join the network, otherwise return to retest. After successfully joining the network, simply wait for the command. When receiving the command for gateway data collection, AD collects voltage data from each sensor. Otherwise, enter the power saving mode to continue waiting. After the data collection is completed, it is weighted and sent to the gateway. Once completed, it can enter the power saving mode to continue waiting.

5. Research Results of Greenhouse Lighting Monitoring System Based on Wireless Sensor Network

5.1. Method of Testing Greenhouse Lighting Monitoring System based on Wireless Sensor Network

In this study, the simulation test method is used to test the system, and the network simulation software platform NS2 is used to organize and combine the sensor nodes in a free way to form a wireless sensor network to achieve data collection.

5.2. Process of Testing the Simulation System

After analyzing the data obtained through simulation testing with MATLAB and SPSS19.0 and comparing it with actual data, it was found that the system has good performance, low error rate, strong mobility, and the measured data can be recorded in real-time. In order to verify the dynamic change performance of the system, some abnormal indicators such as interference operations such as occlusion were artificially added during the testing process.

From the experimental results, it can be seen that these interferences have responded, indicating a faster response speed.

5.3. Wireless Sensor Network Greenhouse Lighting Monitoring System based on ZigBee Technology

In general, in recent years, based on the continuous exploration and research of greenhouse monitoring technology, China has committed itself to research and design achievements suitable for greenhouse in China on the basis of local natural environment conditions. Although some breakthroughs have been made in the development of smart agriculture, there is still a gap compared to developed countries. China has a vast territory and complex terrain, with planting areas generally located in remote areas. Many environments have brought great constraints to the use of intelligent devices, and there are problems such as difficulty in installation and easy damage during use. In addition, many smart agricultural greenhouse monitoring systems are currently only in the experimental stage, and many technologies cannot be directly applied in practical applications. Therefore, combined with advanced wireless sensor network technology and computer control technology, a set of universally applicable greenhouse lighting monitoring system can be developed, which can be applied in the actual agricultural planting process to increase production and income of agricultural planting.

In summary, it can be found that existing research fully recognizes the importance of smart agriculture for the development of enterprises and the national economy. There is relatively rich research on greenhouse monitoring systems, but most of them are based on wired monitoring. Considering the regional characteristics of China, there are restrictions on their actual use. The research on greenhouse lighting monitoring based on wireless sensor network is relatively rare, but this project collects data based on wireless sensor network, and uses ZigBee technology to achieve two-way

communication between sensors and control systems. Through testing, it is found that its effect is relatively good.

6. Conclusion

This project uses wireless sensor network and ZigBee technology to research the greenhouse lighting monitoring system. The simulation test shows that the system has better flexibility, reduces costs and has certain versatility. It shows that it is feasible to use ZigBee technology to build a wireless sensor network monitoring system for greenhouse lighting monitoring, which meets the needs of wireless monitoring, and provides a new solution for the realization of intelligent control of the greenhouse.

Acknowledgments

This research is funded by 2023 Anhui University of Finance and Economics Undergraduate Research Innovation Fund Project (No.: XSKY23030ZD).

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