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Research on Control System of Intelligent Greenhouse of IoT Based on Zigbee

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Research on Control System of Intelligent Greenhouse of IoT Based on Zigbee

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Abstract: With the updating of science and technology, the development of modern agricultural technology in China is also progressing. The research of intelligent greenhouse control system has far-reaching significance. Greenhouse control system should meet the function demands of data acquisition, data transmission and remote monitoring. In this paper, the overall control structure of greenhouse is formulated within the framework of Internet of Things technology, which is divided into perception layer, transmission layer and application layer. Based on the architecture of Internet of Things and Zig Bee wireless sensor network technology, this paper designs four modules of the control system, including login management module, data display module, remote control module and system management module. The greenhouse control system of the Internet of Things is tested and analysed and the experimental results show that the system can achieve the expected effect of greenhouse.

1. Introduction

China is a big agricultural country. With the development of urbanization in China, a large number of migrant workers have entered cities and towns, and the number of rural farmers has been decreasing. The mode of farming has gradually changed from small-scale planting to large-scale planting. At present, the degree of informatization and intellectualization of agricultural greenhouse is low, and most of the management work still needs to be completed manually. We should make full use of intelligent and automated science and technology to improve agricultural production and efficiency. Greenhouse is mainly used for the seasonal period of unsuitable growth, which can provide the conditions needed for its growth cycle to increase its yield. Planting crops is very demanding to the environment. In the traditional manual control mode, most farmers rely on labour experience and individual feeling to control the indoor environment, without any scientific basis. After entering the era of agricultural information, agricultural environmental information such as temperature, humidity, carbon dioxide concentration and greenhouse lighting brightness has been more scientifically deliberated and the best standard has been obtained. As a result, the Internet of Things technology has been introduced into greenhouses.

Agricultural Internet of Things refers to a kind of network technology that applies wireless sensor network technology to connect the environmental monitoring equipment and control equipment in the agricultural system with the Internet of Things through the protocol designed to realize the monitoring, control and management of agricultural environmental information. ZigBee is one of the core technologies of the Internet of Things. Its communication distance is between radio frequency identification and Bluetooth. It has many advantages, such as complex structure, low energy consumption, low cost, medium transmission speed, short distance two-way communication and so on. Its transmission rate is 10 KB/s-250 KB/s and transmission distance is about 0m-75m. The frequency of device work is more selective, the sending and feedback of data information has the advantages of stability, low demand in power demand and very aspect in network construction. The communication mode chosen in this paper is ZigBee wireless communication mode.

2. Demand analysis of control system of intelligent greenhouse of IoT

The system should have stable function, simple operation and simple interface. It is convenient for managers and operators to deploy flexibly, access remotely and maintain automatically during the planting process. The monitoring system of greenhouse should have the features of reliability, ease of use and good expansibility.

2.1 Function demand of data acquisition

By collecting environmental parameters including temperature, humidity, illumination and soil moisture in different spatial positions of greenhouse, the plane distribution of various environmental characteristic parameters in greenhouse can be obtained in real time. Various functional sensors sampled the environmental parameters of fixed points according to a certain time and frequency, and packaged the sampled data. Sensor and controller nodes maintain a real-time link state with the base station, sending sampled data packets to the base station and base station regularly, while control nodes are on standby at any time, receiving and executing the base station to send action instructions. In order to know whether the working state is normal in time, each data acquisition node has a sign to show the normal working state of communication.

2.2 Function demand of data transmission

The data transmission of the Internet of Things system is the key to the realization of the system. Only a stable network can we use the developed system normally. We should keep on-line at all times and send the data packets of the acquisition nodes in time so as to ensure that the data can be transmitted safely and reliably in several different networks without causing the loss of data packets. A wireless sensor network node must be real-time on-line and transmit data through each other's network to form a stable interactive network. It can keep in touch with the monitoring terminal in real time and respond to the operation control instructions issued by the monitoring terminal immediately. We can keep in touch with the sensing layer in real time and see the real-time data in the monitoring terminal. The main function of the network transmission layer is that the W base station is a transit station, which can reliably and safely send all kinds of data received by the sensor nodes to the server through the Internet, and at the same time receive control instructions from the client at any time to realize the transmission of information data upstream and control data downstream.

2.3 Function demand of remote monitoring

The remote monitoring terminal is mainly for the convenience of managers and operators. Without reaching the site, it can clearly understand the crop growth and environment in greenhouse, and timely control and adjustment through remote operation. When users connect to the network, they can query all kinds of sensing data and remote-control functions of sensing nodes in greenhouse plantation park through terminal devices such as computers, mobile phones or tablets. Among them, the remote single computer monitoring system is directly connected with the remote gateway by running the software developed by the project, and monitors the remote sensing node data and the operation of the control node in real time. As smart phones have been widely used in our life, people's use of high-level smart phones is not only limited to the functions of communication and entertainment on mobile phones, but also can make use of the special changes of smart phones, which have many functions, strong practicability and flexible operation, to design an intelligent management and control system that can realize greenhouse planting, and to realize the control of greenhouse planting. Real-time monitoring of remote sensing nodes and control nodes, and diversified remote monitoring.

3. Overall structure of control system of intelligent greenhouse of IoT

The intelligent control system of greenhouse based on Zigbee can realize the comprehensive perception, reliable transmission and intelligent processing of greenhouse environmental parameters, and achieve the goal of greenhouse automation, intelligence, network and scientific production. The system is mainly composed of sensors, field controllers, centralized control computers and actuators. Sensors and actuators are connected with field controllers to form a field control system. Each greenhouse is equipped with a field control system. Each field control system is connected to the local area network through ethernet, and a distributed control structure is formed with the centralized control computer of the centralized control system.

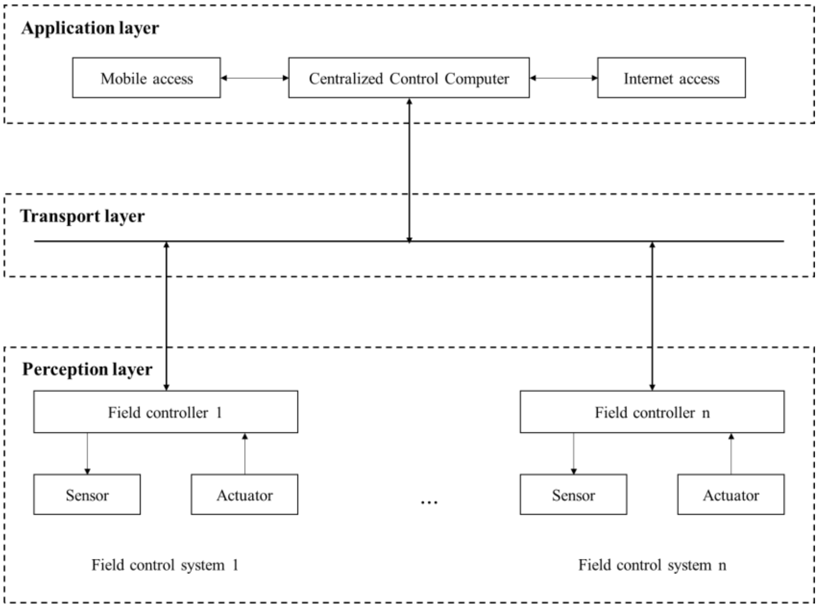

Figure 1. Overall structure of control system

The perception layer comprehensively perceives the microclimate environment information of greenhouse, provides accurate, scientific and comprehensive basis for automatic control and intelligent decision-making of greenhouse, and is the core and basic part of the agricultural Internet of Things. The field control system mainly includes field controllers and sensors. Through different kinds of sensors, the environmental parameters such as air temperature, air humidity, light intensity, CO_2 concentration and soil humidity inside and outside greenhouse are sensed. The field controller collects the information sensed by the sensor and sends it to the centralized control computer after preliminary processing for further processing. Transport layer is based on LAN, mobile communication network and Internet. It achieves data acquisition and decision-making command from application layer and remote user. The design of the network transmission layer of the system is based on the principle of safety, reliability and wide interconnection. The data transmission network includes the greenhouse field LAN and the remote WAN. There are many greenhouses in planting base, and the distance between field controller and centralized control computer is long. In order to realize reliable data transmission between them, the greenhouse field LAN adopts the wired transmission technology based on ethernet, which has the characteristics of large capacity, long networking distance, stability and strong anti-interference ability. The application layer obtains accurate and reliable environmental information by fusing, processing and sharing all kinds of information acquired in greenhouse, which provides decision-making guidance for automatic control and precise operation of greenhouse.

4. Modules design of control system of intelligent greenhouse of IoT

The greenhouse monitoring system consists of four modules: login management module, data display module, remote control module and system management module. The function modules of the system are shown in the Figure 2.

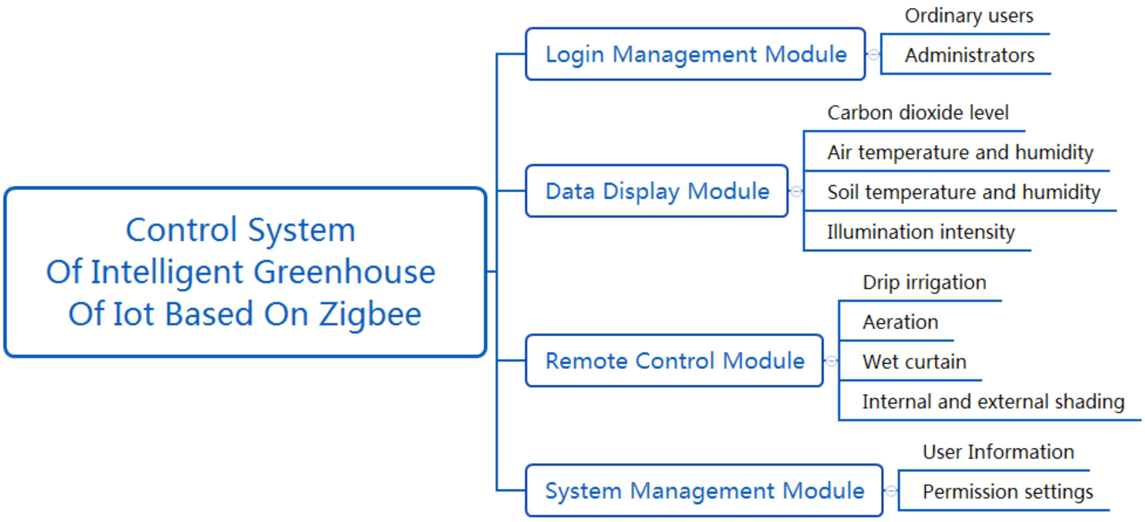

Figure 2. Modules design of control system of intelligent greenhouse of IoT

4.1 Login management module

In order to make the user interface friendly and make the system easier to use, the whole login interface layout is concise, easy to operate, and the prompt information is eye-catching. When the user enters the login interface and clicks on the login by entering the account password, a user login request will be sent to the server, which verifies the login information through the database. First, the account information will be verified to determine whether it is an administrator or an ordinary user. If the account does not exist, the system prompts the user not to exist and resets the authentication code; if the account is verified correctly, the next password matching is performed. The system has many environment parameters and configurations that are determined beforehand. Administrator account is set up in the system. Ordinary users need to check with the administrator for registration before they can log in. Administrators have the right to restrict access to ordinary users. The equipment that users of different nature can query is different. According to the function of the user set permissions. Functional privileges can be set not only to the last menu page, but also to the button operation in each page function, which ensures the refinement of system privileges.

4.2 Data display module

The data display module of greenhouse is mainly to visually display the environmental factors inside the greenhouse. There are two ways to display the environmental factors, namely, air temperature and humidity, soil temperature and humidity, light intensity, carbon dioxide concentration and so on. After the user successfully enters the main interface of the system, each user's terminal will automatically establish a long link with the server module. By default, the system collector sends data packets to the cloud platform server every sixty seconds. After the server parses the data packets, the allocated address is stored in the database. When users perform query operations, they are divided into real-time data query and historical data query. Real-time data is to send query instructions to the server according to user's needs. The server parses and matches the search in the database. After finding the corresponding data, the information is packaged and fed back to the server. In link management, the server looks at the mobile terminal connected with it at the moment and finds and pushes the data to the corresponding end. Different from real-time data, historical data refers to data information in a certain period of time. Its purpose is to determine whether the value of environmental factors in greenhouse is in the optimal growth state of crops, and to provide data basis for experts to analyse the limit value of environmental factors. The user clicks on the query history data during the input period and sends the data query request instruction to the server. The server receives the time information and the query instruction to parse and send the call data command to the database. The database extracts the corresponding environmental factor numerical information according to the time period and calculates the level according to the formula. After data sharing, the average data is packaged and fed back to the server, which feeds back to the user.

4.3 Remote control module
The remote control of greenhouse equipment is the core and part of the whole greenhouse monitoring system. The control methods are divided into user remote control and intelligent control. User remote control refers to opening or closing ventilation device, curtain rolling device, drip irrigation device and other equipment through experience judgment to keep crops in the best growing environment after users inquire or know that environmental parameters in greenhouse are not suitable for the growth of crops through alarm setting and push information. Data acquisition interface automatically collects information of greenhouse environment parameters and equipment status at a certain time interval, and automatically stores it in the established greenhouse environment database and equipment status database. Data acquisition and storage process continue in the process of centralized monitoring and management platform operation, without too much human-computer interaction process. The system can choose to stop the data storage process or hide the data acquisition interface in the data acquisition interface, and put the acquisition and storage process in the background of the program to execute the control process. After the server parses the instruction, it finds the number of the control box in the greenhouse and sends the control. Make orders. The control box parses the control commands from the server and activates the interface to complete the next action. The real-time monitoring interface of the system is used to display the environmental parameters and the running status of the equipment. After entering the real-time monitoring interface, the greenhouse status information is obtained by selecting the corresponding greenhouse number. The environmental parameters are displayed in the form of accurate values, histograms and real-time curves, and the operation status of the equipment is displayed in the form of indicator lights.

4.4 System management module
The system management module includes two parts: user information setting and permission setting. User information is composed of user name, display name and annotation information. Privilege setting is mainly for ordinary users. It is the administrator's operation setting of access rights for ordinary users. Access authority consists of two menus, including expert analysis, monitoring view, farming management, system management, real-time data and other options. User information settings also include password modification, password retrieval and other operations. When the user enters the modified password interface, the system will automatically send the data to the server platform by inputting the original password and clicking on the modified password. The server platform completes the modification and storage of the data information by matching the data information with the database. The realization process of retrieving the password is that the user will forget the secret. The account information of the number is sent to the server platform, and the matching information of the server platform is fed back to the user through the form of SMS. Privilege management function is based on login function, which provides a clear system of privilege allocation to prevent the overlapping of privileges between legitimate users. User management function mainly realizes the addition, deletion and modification of system user information. The logout function is designed to prevent illegal users from using the information stored in the browser when they log in to obtain the user's login information.

5. Performance testing and results analysis
We applied the pre-designed control system to the greenhouse for experiment. The control of temperature and humidity in greenhouse was monitored for a week. The test time was 09:00-16:00 per

day. Through the parameter setting module in the system, the temperature range of 19℃-23℃ and the humidity range of 60% RH - 90% RH are set for crops. According to the law of its change in the growth cycle, the ideal temperature setting value is 20℃ and the ideal humidity setting value is 80% RH. In the parameter setting module, the value of greenhouse degree is determined, and its value is input into the system. After corresponding preservation, the intelligent control module is operated. The error range between indoor temperature change trend and setting value can be kept within ±3℃, while the change of outdoor temperature has a certain influence on indoor temperature. The range of error between indoor humidity change and set value can be kept within ±10% RH, and the change of outdoor humidity also has some influence on indoor humidity. By recording and analysing the data, the error of temperature and humidity can be kept within the set ideal error range. Through the comparative analysis of experimental data, in the process of system operation, according to the range of setting values required by engineers, the change of environmental factors in greenhouse can be adjusted in real time to keep it between the standard error range.

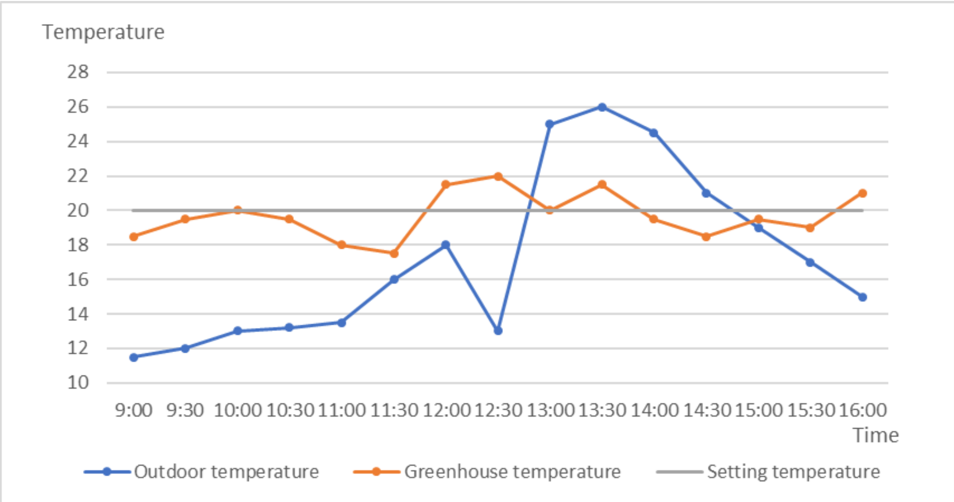

Figure 3. Temperature change curves indoor and outdoor

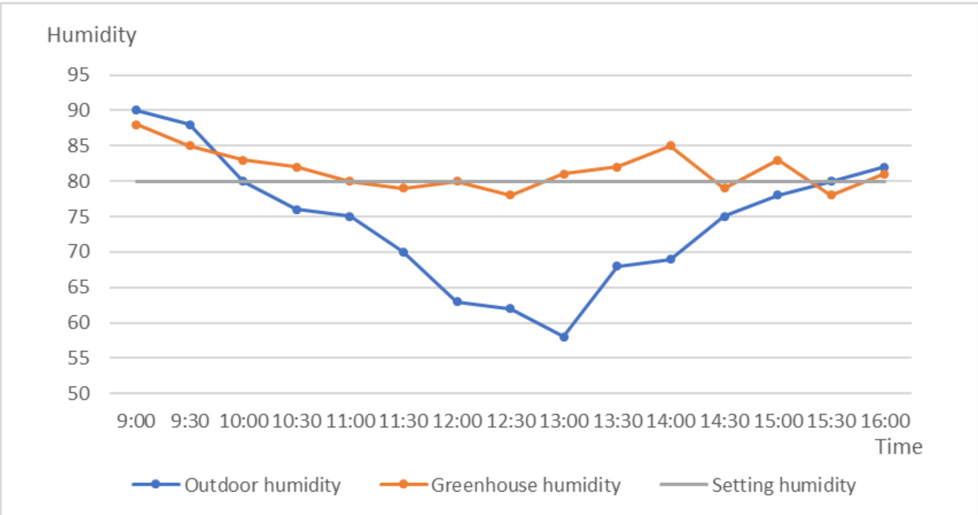

Figure 4. Humidity change curves indoor and outdoor

6. Conclusions

On the basis of in-depth analysis of the main environmental parameters in greenhouse, this paper defines the three-tier architecture of the control system within the framework of the Internet of Things technology, namely, the perception layer of the field control system, the transport layer of the communication network and the application layer of the centralized control system. The system consists of four modules, which are login management module, data display module, remote control module and system management module. The system has been tested for many times and the effect is obvious. The performance is stable and the use is convenient. Through the implementation of this system, it will be beneficial to the macro-control of greenhouse planting production management, make the whole planting process more intuitive, timely, scientific and comprehensive, which can improve the level of crops production and management.

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