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Design of Greenhouse Detection and Control System Based On Zigbee Wireless Network

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Abstract. In order to overcome the difficulty of control and the inaccuracy of the traditional greenhouse, this paper combines the Zigbee technology with various wireless network sensors and control system to design the software and hardware of the system, which avoids the problem of wiring difficulties when detecting traditional greenhouses, and the advantages of the control system is easy operation, accurate detection and easy control management. So it has greater reference value for increasing crop yield and agricultural development.

1. Introduction

As we all known, China is the world's most populous country, So the cultivated crop yields currently owned do not meet the growing population demand. Therefore, improving the utilization rate of cultivated land and crop yields to improve the quality of production is an important issue that the country needs to solve. With the development of modern technology and information technology, the gricultural intelligent control has developed rapidly. When traditional agricultural sheds are planted to detect important environmental factors such as light, CO2 concentration, soil temperature and humidity needed for crop growth, there are not only a lot problems with complicated wiring and difficult protection measures, but also the factor of human and material resources. So it has great limitations in the control method. However, the study of the intelligent greenhouse control system in this paper uses the wireless sensor network of the Zigbee module [1-4], which can not only solve the problems existing in the traditional greenhouse control, but also monitor the growth of crops by cameras effectively. The monitoring information can be fed back to the server in a timely manner [5-7]. And according to the environmental factors collected by the sensors in the greenhouse, the server can make corresponding orders to the control mechanism, so that the execution mechanism can control the fan, heater, sprinkler watering equipment, and many more. In our present work, the control system not only improves the accuracy of environmental factor detection in the greenhouse and increases crop yield, but also reduces the burden on growers and input costs.

2. Overall design of the system

2.1. Zigbee technology and CC2530

At present, there are several wireless communication network technologies such as Bluetooth, Wifi, NFC, and Zigbee. But Zigbee has given people greater expectations in industrial monitoring, wireless sensor networks, and security system monitoring on various occasions [8-10]. Zigbee technology has the advantages of close range, low cost, low power consumption, short delay, high security, Mesh network, and so on, which can expand the transmission range and improve the reliability of transmission information [11-13]. Therefore, in this work, Zigbee technology is selected. Zigbee Gateway is the core of the detection system in designing of the smart shed, which formed a bridge to complete the communication dissemination between the Zigbee network and the Internet network [14-16]. To enable users can make decisions and take response measures, it can not only convert the data transmission format, but also deliver the data information to the server for analysis and display on the screen or user's mobile phone.

CC2530 is a SOC chip produced by TI that supports IEEE 802.15.4 / Zigbee agreement/Zigbee R adaptation of 2.4-GHz IEEE 802.F4CE protocol. CC2530 has the advantages of low power consumption, low cost, anti-interference performance, and low complexity. [4] The CC2530 includes an enhanced 8051 kernel. And the debugging interface can program Flash on the chip and does not interfere with the external I/O pin. The chip is equipped with a DMA controller that can reduce the load of the 8051 CPU kernel during data transmission. At the same time, the chip requires very few external components to form the Zigbee coordinator and each node. Two CPU modules are used in this system, and the main CPU can completes network connection, data conversion, and data processing. The other CC2530 module is used as a coordinator to connect the sensors of each collecting environment factor through Zigbee, constantly detecting each sensor information and transfer to the main CPU for processing.

2.2. Overall structural design of the system

The analysis and design of the system are mainly based on several main factors that affect the growth of crops in the greenhouse. And the main influencing factors include light intensity, carbon dioxide concentration, air temperature humidity, and soil humidity. As shown in Figure 1, the structure of the system mainly includes the following six parts: air temperature and humidity sensor, carbon dioxide sensor, soil humidity sensor and light intensity sensor composed of distributed nodes; Control mechanism that composed of ventilator, heater, sprinkling watering equipment, light adjusting equipment; Zigbee gateway; Camera; Server; Cell phone and computer.

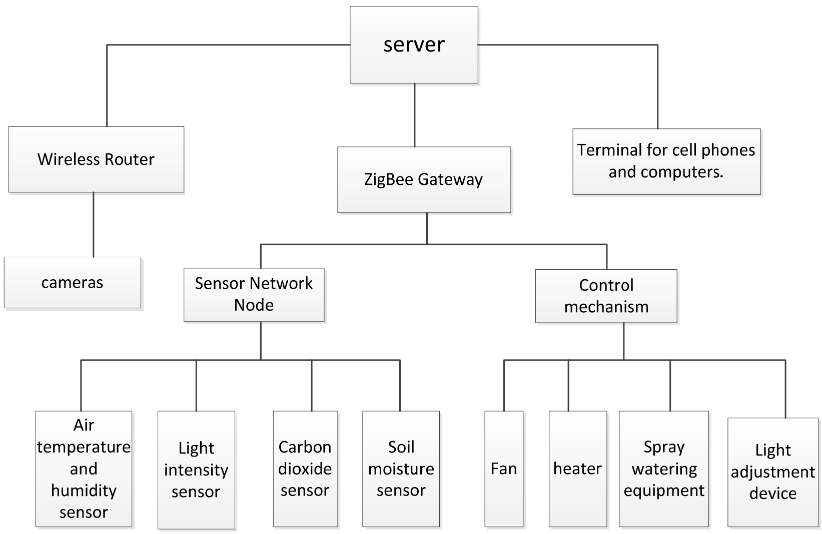

Figure 1. Overall structure of the system

The responsible of the sensor node is not only collecting the growth status information of the crops in the greenhouse, but also integrating the environmental factors collected by various sensors into the

Zigbee gateway. The Zigbee gateway extracts valid information and uploads it to the server. Then the server is equipped with a database and web service, so users can view the growth information of crops in real time using a computer or mobile terminal device. The environmental factors collected by the sensors include: air temperature and humidity, light intensity, carbon dioxide concentration, and soil moisture. At the same time, the server compares the collected environmental factor data with the preset value of the set environmental factor, and issues the corresponding automatic control commands to the control mechanism. When the control mechanism receives an order from the server, it will activate or turn off the ventilators, heaters, sprinkler watering equipment, and lighting adjustment devices, and adjust the temperature, carbon dioxide concentration, soil moisture, and light intensity in the greenhouse accordingly. Make these factors within a certain range, which is the most conducive to the growth of plants. The camera is installed inside and outside the greenhouse respectively, and video images are collected through the movement and rotation of the camera, which can ensure the safety of the greenhouse against theft and monitor the growth of crops. The user can propose countermeasures and solutions in time to complete the intelligent control of the greenhouse according to the information provided by the video image.

3. System hardware design

The hardware design is the basic part of the entire intelligent system, and it mainly includes the design of wireless routers, cameras, Zigbee gateways, various sensor devices, and control system.

(1) To carry out real-time collection inside and outside the greenhouse, the intelligent system uses a wireless network camera, which connected the wireless router through the Wi-Fi, and it transmits the video image information from the monitored area to the user remotely. The collected video information is also continuous and clear. The wireless network camera is easily installed and does not require wiring and area restrictions, which can change the installation location according to the user's needs. Therefore, it has a high degree of flexibility. The connection of the wireless camera is shown in Figure 2 below.

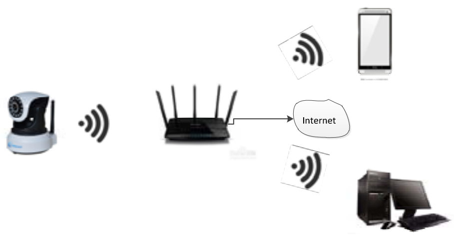

Figure 2. The connection of the wireless camera

(2) The Temperature and Humidity Sensor

The temperature and humidity sensor was selected the SHT11 digital temperature and humidity sensor. This type of digital temperature and humidity sensor is superior to the traditional analog sensor. The main capability is that the SHT11 digital temperature and humidity sensor can avoid complex debugging, calibration. It also has the advantages of high measurement accuracy, fast response speed, high anti-interference ability and so on. The internal structure of SHT11 is shown in Figure 3 below.

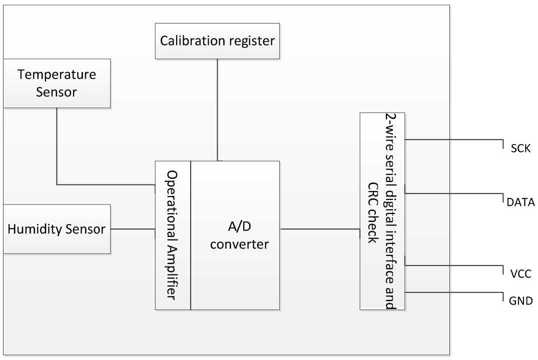

Figure 3. The internal structure of SHT11

In addition, the SHT11 interface is simple and encapsulated with SMD surface patches, as is shown in Figure 4, the pin diagram include: GND: land; DATA: Data line; SCK: clock line VDD: power line NC: not connected.

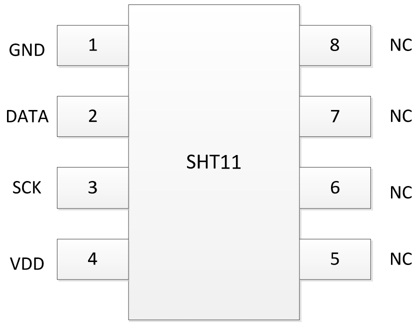

Figure 4. Pin diagram

(3) The Light Intensity Sensor Selected HA2003 Light Sensor.

The HA2003 sensor uses a photoelectric conversion module to convert the collected light intensity into a voltage value with a conditioning circuit to a 0-2V or 4-20mA output. The sensor collects sunlight or artificially set light under natural conditions. In the greenhouse, the HA2003 sensor with waterproof and measured in small size, high measurement accuracy and corrosion resistance, which beneficial to the life length of the sensor.

(4) Carbon dioxide concentrations are measured by the MG811 carbon dioxide sensor. The changes of the temperature and humidity inside the greenhouse have less impact on the MG811 carbon dioxide sensor. The sensor has better sensitivity and selectivity to the carbon dioxide with the stable measurement process.

(5) The FC-28 soil moisture sensor is a resistive sensor, whose sensitive component is a hygroresistor. The size of the resistance depends on the amount of moisture in the soil, which is indicated by the resistivity. After the A/D conversion, soil moisture can be read, and data can be visually output digital signals after compared with the comparator LM393. The circuit diagram is shown in Figure 5.

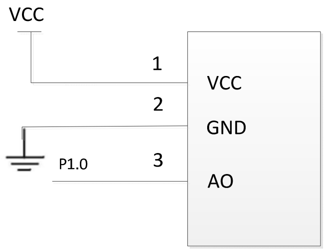

Figure 5. FC-28 Soil moisture sensor circuit diagram

(6) To control the fans, heaters, sprinklers, and lighting regulators, the electromagnetic relays was used as control device. Firstly, the electromagnetic relay is added to the Zigbee network, and the server control it by issuing corresponding instructions, and completted the start-up or closure of various equipment in the greenhouse.

4. System software design

The software design of the system mainly includes: Zigbee gateway; various sensors, and the design of the entire control system circuit. The overall design flow chartbelow is shown in Figure 6. The gateway obtains the preset range of each acquisition sensor according to the actual environment of crop growth. The collected data was compared with the preset value by the sensor in real time, and send real-time informations or alarms to the server. And the server will feed back the information to the user.

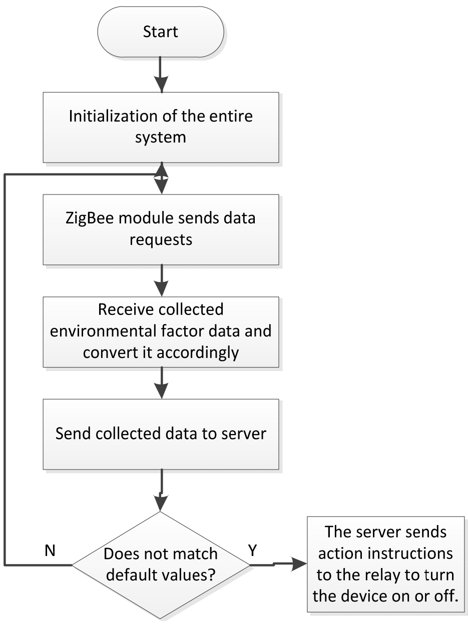

Figure 6. The main programming of the control system

4.1. Software Design of the Zigbee Gateway

The Zigbee gateway interacts with the server by the network and processes the corresponding instructions which issued by the server, then it will process the data and transmit them to each sensor and control mechanism, which was feed back to the server by the Zigbee gatewayand transmitted by terminal sensors and control mechanisms. The work flow of the Zigbee module is shown in Figure 7 below.

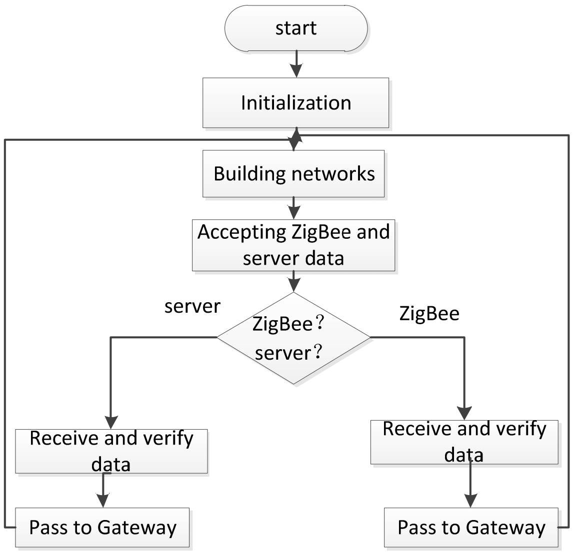

Figure 7. The work flow of the Zigbee module

4.2. *Design of temperature and humidity sensors*

The SHT11 sensor was added to the established Zigbee network, which transmits the collected temperature and humidity information to the server. Firstly, the Zigbee gateway sends an boot command to initialize the SHT11 after sends a control command, then there is a data transmission request for the acquisition information, at the same time, the SHT11 begin to work which including receiving and sending temperature and humidity information. SHT11 entered a dormant state when it finished collecting information and sending information. SHT11 Collection Data Flow Chart as shown in Figure 8 below.

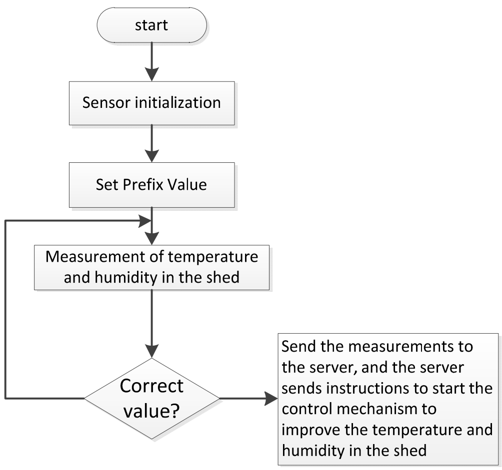

Figure 8. SHT11 Collection Data Flow Chart

4.3. *Design of carbon dioxide sensors and light intensity sensors*

Firstly, the carbon dioxide sensor and the light intensity sensor was added to the established Zigbee network, and they accept and calculate the carbon dioxide and light intensity information after receiving the command from the terminal. And then, the data is sent to the server after the A/D conversion of the information. The server will send the corresponding adjustment instructions to the executor for reconciliation. The instructions don’t continue to circulate and the two sensors continue to collect carbon dioxide concentrations and light intensity until their measurements is in a predetermined range. The programming process is shown in Figure 9 below:

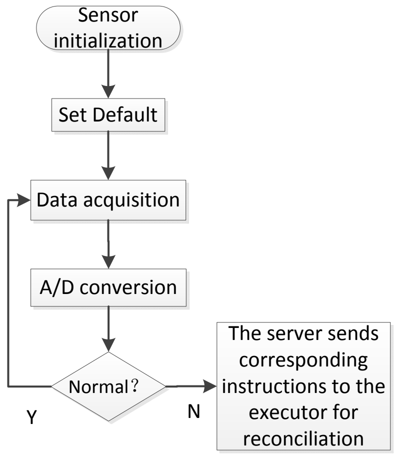

Figure 9. Carbon dioxide and light intensity sensor programming process

5. Conclusion

In conclusion, it is difficult to detect environmental factors and people urgently that improve the growing environment of crops in the traditional greenhouse. However, research on a wireless network detection and control system based on the Zigbee wireless network can overcome the difficulty of control and the inaccuracy of the traditional greenhouse. In our work, in order to monitor the internal and external safety of the greenhouse, the wireless network camera was used in this design. In addtion, it is also combined with temperature and humidity, carbon dioxide, soil moisture, and light intensity sensors perfectly. And the environmental factors in the greenhouse was regulated to the control system. Its advantages lies in that it can not only guarantee the accuracy of the system measurement, but also it can make effective environmental improvements, provides good conditions for the development of agriculture, and increases the yield of crops.

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