Design and Implementation of Water Saving Irrigation System Based on Zigbee Sensor Network

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Design and Implementation of Water Saving Irrigation System Based on Zigbee Sensor Network

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Abstract. This paper divides the water-saving irrigation system into five component modules: acquisition node module, control node module, aggregation node module, routing node module and host computer management software module. Design and analysis are carried out for each module. Finally, the design of the system is tested, mainly including sensor sensitivity test, reliable control of control equipment and the influence of weather conditions on system operation. This water-saving irrigation system is of great significance for saving water resources and improving the degree of automation control. In the longer term, it has improved the degree of mechanization of agriculture and realized the high efficiency of planting.

1. Introduction

In recent years, precision agriculture and the improvement of agricultural automation are the development trend of modern agriculture. Harvesters and rice transplanters in farmland have replaced the labor methods that people used to cultivate. Nowadays, it is not uncommon to use wireless sensors to measure crop ecological environment. To design a water-saving irrigation system, we must first start with its overall structure, analyze the overall design of the system from hardware and software, and select the appropriate chip and other hardware according to technical indicators, expected functions and design purposes.

2. Principle of water saving irrigation system

The system mainly uses the soil temperature and humidity sensor to detect the soil entropy information in the crop growth environment. By arranging a large number of micro-sensors in the field, according to the different demand for water in different growth stages of crops, watering is implemented by manual control or computer intelligent control of the switching state of the control device. The main control part is shown in Fig. 1.

Intelligent irrigation is reflected in the combination of software and hardware, as well as the temperature and humidity of the soil at that time, using reasonable watering methods, abandoning previous planting patterns relying on experience, furrow irrigation or flood irrigation, using wireless measurement and control methods to detect whether plants are in a state of water shortage, Rational use of natural precipitation or ditch water for irrigation. This will not only enable the plant to maintain a good growth state, increase the yield per mu, obtain the best economic benefits, but also reduce manpower waste and reduce production costs.

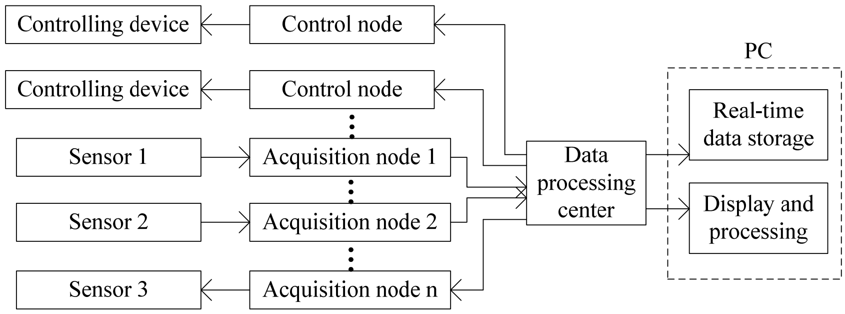

Figure 1. System function chart

The system is divided into three parts. The control node and the acquisition node are the terminals of the system. The control node is connected to the control device to control the working condition of the pump. Each collection node is connected with a sensor. The function is to collect the entropy information of the soil and transmit the information. To the data processing center, the PC is composed of a data storage module and a display processing module. The display module mainly displays the current temperature and humidity values of each terminal and the working state information of the control device.

3. Water saving irrigation system hardware solution

Considering the objective conditions of field planting, this paper designs a ZigBee-based intelligent irrigation system, which consists of two parts: the upper computer monitoring center and the monitored irrigation area. The coordinator is the aggregation node, and the router is responsible for controlling the node network. Joining, the collection node is responsible for the monitoring of soil temperature and humidity, and the control node is responsible for controlling the operation of the control equipment. The system mainly realizes the following functions: a large number of terminals are arranged in the irrigation area, and the sensors connected by the collection nodes detect the soil entropy information and the working state information of the control equipment at intervals. Because it is planted in the field, the plot is widely distributed and scattered, and the effective transmission distance of the ZigBee network is about 75 meters. Therefore, the routing node is added in the system. For the stable operation of the system and large-area data transmission, the mesh topology is adopted. The structure of the network is set up, the collection node can join the network in a multi-hop manner, and the information is processed and transmitted to the aggregation node. The RS-232 interface is used between the aggregation node and the upper computer for wired data transmission; the upper computer has three component modules. The temperature and humidity information display module, the soil humidity threshold setting module and the historical database module can see the real-time soil temperature and humidity value and the control device working state information in the display screen of the upper computer monitoring center, and compare with the preset threshold value, if Below the threshold, the host computer sends instructions to the control node through the sink node, so that the control device enters the working state. According to different plant demand for water in different periods, the threshold value can be flexibly set to keep the plant in good growth state; the machine will make the information of each transmission into a historical number. Library for users to understand the last few days of soil information and whether the system is working properly. The overall structure design of the system is shown in Figure 2:

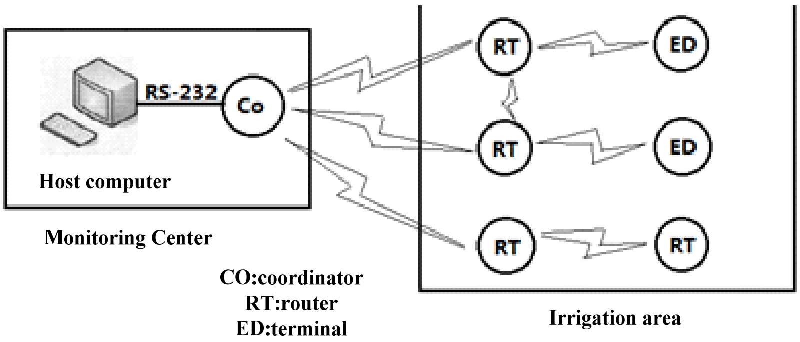

Figure 2. System overall hardware design diagram

The hardware design of this paper is mainly the aggregation node, the collection node and the control node. The aggregation node is responsible for the "bridge" of information exchange between the upper computer and the collection node, and maintains the ZigBee network; the collection node is responsible for collecting soil information and transmitting it to the upper computer for control. The node is responsible for controlling the operation of the device and executing the instructions sent by the host computer.

a). Aggregation node hardware

The aggregation node mainly refers to the ZigBee coordinator, which is responsible for maintaining the ZigBee network, performing bidirectional transmission with the host computer and the acquisition control node, and displaying the soil entropy information of the acquisition control node, since it is constantly receiving the Information exchange, so a stable power supply is required, and its structural block diagram is shown in Figure 3:

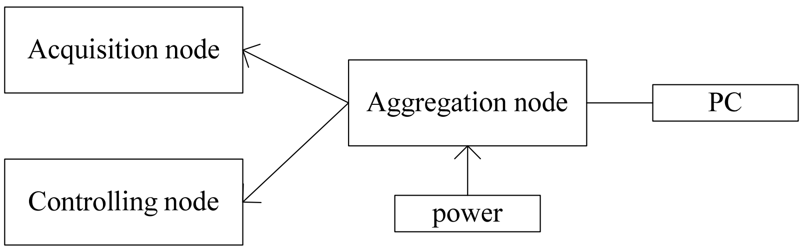

Figure 3. Convergence node composition block diagram

b). Acquisition node hardware

The collection node is responsible for the collection of soil temperature and humidity information in the system. When no information is collected, it enters the sleep mode, so its power consumption is small, and the dry battery is used as the power supply. The block diagram of the composition is shown in Figure 4:

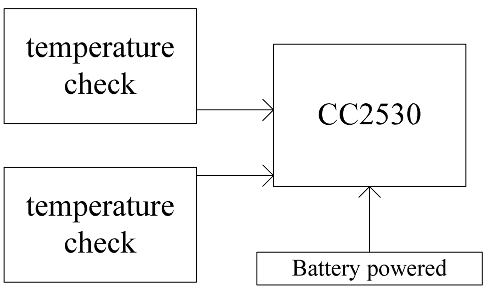

Figure 4. Acquisition node composition block diagram

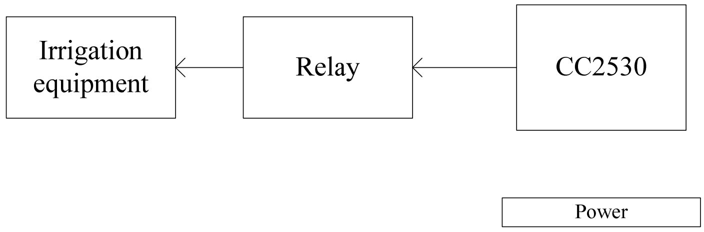

Figure 5. Control node composition block diagram

c). Control node hardware

The control node is composed of relay and irrigation equipment. The switch state of the relay determines the working condition of the irrigation equipment. Because the working energy of the relay is large, the normal power supply is adopted. At the same time, the relay can also automatically change the switch state according to the threshold change of the upper computer. The composition block diagram is shown in Figure 5:

4. Water saving irrigation system software program

The water-saving irrigation system designed in this paper is based on the information of soil temperature and humidity detected by the terminal, and makes corresponding judgments to realize intelligent control. The whole system is divided into communication protocol module, hardware control module and upper computer management software module. The overall design of system software is shown in Figure 6:

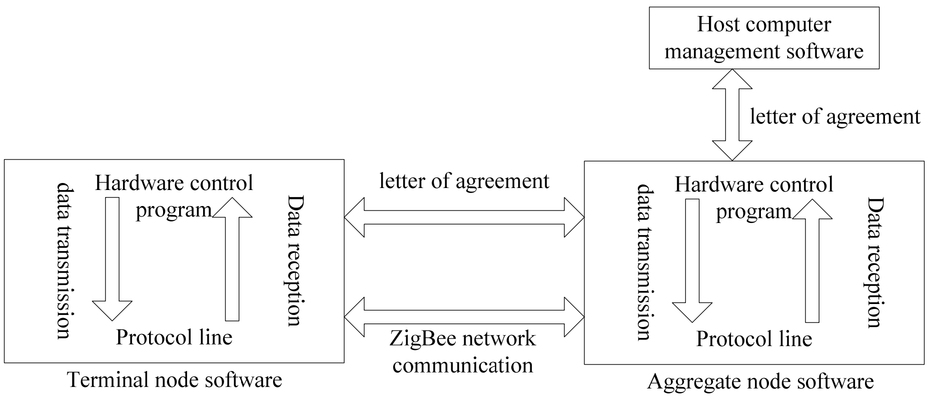

Figure 6. System overall software design diagram

The design of the protocol stack is the most basic design of the system. The establishment of ZigBee network, data transmission and reception, and the joining of terminal nodes are all based on this. On top of this, it is a hardware control module, which is mainly used to control the soil of the acquisition control node. Information detection, relay status detection, etc., the host computer provides a flexible user visual control interface to achieve remote supervision, the role of the communication protocol is to ensure the safe and reliable transmission of information.

5. Water saving irrigation system test

5.1. Temperature and humidity sensor sensitivity test

The system uses the lawn of the school as a test site. The lawn is planted with various trees and flowers, and the water content of the soil is different. The sensors carried by the terminal should be

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arranged next to different plants. It is vast, and because the soil quality of each piece is different, it is just that the accuracy of the test system is affected by the change of soil quality.

The function of the sensor is to detect the real-time temperature and humidity information of the soil. If the sensor is not sensitive enough, it may not perceive subtle changes in the surrounding area. Therefore, the sensitivity of the sensor needs to be tested. Figure 7 shows the temperature and humidity information under normal conditions:

Figure 7. Normally measured temperature and humidity information

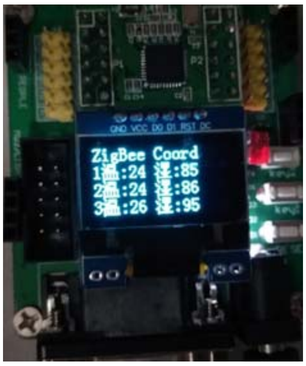

Figure 8. Test Results

In this paper, the sensor of terminal 3 is breathed and tested whether it will change. As a result, as shown in Fig. 8, it can be clearly seen that the humidity value of terminal three has changed due to the water molecules in the exhaled gas. In order to make the final measured humidity value larger, the DHT11 soil temperature and humidity detector has a very sensitive response.

5.2. System accessibility test

The terminal nodes of this system act on the field. Due to objective reasons, it is inevitable to withstand wind and rain, even lightning strikes, sun exposure, etc. are normal weather changes. After experimental observation, you can know when the weather is compared. In the worst case, the performance of the system will be affected, and the stability is not as stable as during normal operation. Since the wireless communication network is also interfered by electromagnetic waves, this is also inevitable. This is a shortage of this intelligent irrigation system. In the future work, I will continue to study to enhance its anti-jamming performance.

The barrier-free operation test is to verify the stability of the entire system. The whole system is turned on in the test field for one month, and the test system components can operate normally according to requirements, such as the battery life time, whether the relay can start and stop normally, whether the sensor can collect data normally, whether the host computer can send the corresponding command normally and Perform the appropriate function. Record the test results and make all the results in Figure 9.

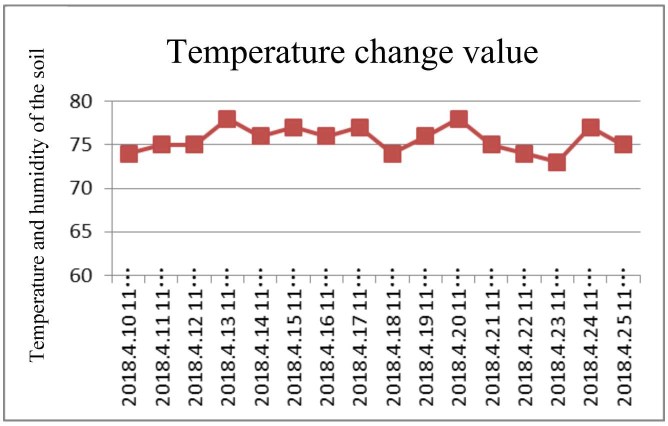

Figure 9. Soil moisture change

As can be seen from the above table, the system is stable in operation, and the monitoring of soil moisture is instantaneous and accurate, and the soil water content can be stabilized within a range.

By testing the integrity of the system, from the sensitivity of the sensor, the impact of the weather on the operation of the system and the system's accessibility time, the test results show that the sensor can also make sensitive response according to changes in the external environment; From the long-term system operation results, the system can reliably monitor the soil in the monitoring area, and the running time is long, so that timely and accurate detection can be achieved to achieve the expected goal.

6. Summary

This paper mainly completes the ZigBee-based intelligent water-saving irrigation system, and transmits the soil entropy information to the user through the sensor, and the user sends corresponding instructions to the terminal for execution. The system is divided into five parts: the collection node, the control node, the aggregation node, the routing node, and the upper computer monitoring center.

References

[1] Chen L J, Sun T, Liang N C. An Evaluation Study of Mobility Support in ZigBee Networks [J]. Journal of Signal Processing Systems, 2015, 59(1):111-122.
[2] Smart Grid Applications [J]. IEEE Transactions on Smart Grid, 2011, 2(1):110-120.
[3] Gislason D. Zigbee Wireless Networking[J]. Elsevier Ltd Oxford, 2016, 12(3):46-49.