Design of Wireless Monitoring System for Tea Garden

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Design of Wireless Monitoring System for Tea Garden

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Abstract. In view of the poor management of tea gardens in our country, this article designs a wireless transmission technology-based tea garden monitoring system. This system consists of parameter acquisition module, wireless communication module, end device control unit, irrigation & fertilization device, and upper computer, it uses Zigbee technology to transmit parameters and uses WIFI technology to transmit images, by which the soil temperature, humidity, and tea plant growth in tea garden can be monitored in real-time. The test and inspection results show that the system can irrigate a tea garden of 60m² within just 4 minutes, it provides a highly efficient and accurate wireless monitoring system for the tea garden and provides the technical guarantee for improving tea garden's management level.

1. Introduction

Tea planting is one of the important industries in China's agriculture. The quality of fresh tea leaves is directly determined by the ecological environment in which it is grown [1-3]. Tea plant are originally subtropical plants, the suitable temperature for its growth is 17-25 °C, excessively high or low temperatures can cause the decreasing in tea production and affect the quality of tea [4-6]. At present, China's tea production and export volume ranks first in the world, but the management level of tea garden is not high [7-8]. At present, tea gardens in China is mainly depends on manual cultivation, and management is time-consuming and inefficient. With the rapid development of agricultural Internet of Things technology, some tea gardens have begun to introduce management systems based on wireless sensor networks[9-10], which can basically realize the monitoring of monitoring of soil temperature and humidity, pH, etc.

This paper designs a wireless tea garden monitoring system, it uses Zigbee network and WIFI transmission technology to respectively provide wireless monitoring of the soil temperature and humidity and the growth of tea trees; in addition, an excellent man-machine monitoring interface is designed for the upper computer to facilitate the supervision and regulation by tea farmer.

2. Design of System Structure

Tea garden wireless monitoring system mainly consists of parameter acquisition module (including soil temperature and humidity sensors and WIFI camera), wireless communication module (including ST-MW-09S module, CC2530 router and CC2530 coordinator), end device control unit (i.e. end device CC2530), irrigation and Fertilizer device and upper computer, the overall structure of this
system is shown in Fig.1.

![System Structure](image)

**Figure 1. System Structure**

The working principle of this system is described as follows: (1) The parameter acquisition module collects the soil temperature and humidity and the image of tea garden in real time; the soil temperature and humidity data is transmitted to the upper computer via the end device, router and coordinator. The image of tea garden is wirelessly transmitted by the WIFI camera via the ST-MW-09S module to the upper computer; (2) The upper computer analyzes and processes the collected data, if the parameter value exceeds the normal value range, an alarm will be sent; tea garden's image is displayed on the man-machine interface of the upper computer; (3) The upper computer's control command is sent to the end device CC2530 via the coordinator CC2530 and the router CC2530 to control the irrigation actions of the irrigation and fertilization device.

The end device adopts 8-bit single chip CC2530 as its microprocessor; the control command of the upper computer is transmitted to the coordinator through the RS232 serial port, then the coordinator sent it to the end device CC2530 via the router CC2530 through the ZigBee wireless network. After the end device CC2530 receives the control command transmitted by the upper computer, it can perform identification analysis and make corresponding actions.

3. **Parameter Acquisition and Wireless Network Design**

Temperature, humidity data and tea garden images are respectively transmitted to the upper computer through the wireless communication network composed of CC2530 and Zigbee modules and the WIFI signal sent by ST-MW-09S wireless communication module. The Zigbee wireless network is also responsible for transmitting control commands from the upper computer to the end device CC2530 to control the irrigation and fertilization device. The upper computer is connected to the coordinator CC2530 through the USB serial port; the serial port is initialized to 19200 baud rate, 8 data bits, and 0 parity bit.

3.1. **Parameter Acquisition**

3.1.1. Acquisition of Temperature and Humidity The soil sensor uses the digital temperature and humidity sensor SHT11. The data collected by this sensor is transmitted to the end device CC2530 and finally transmitted to the upper computer via the Zigbee wireless network. The communication between them is IIC communication.

3.1.2. Acquisition of Tea Garden Image This system uses the CS-R5110 wireless high-definition web camera, which is composed of lens, image sensor, acoustic sensor and encoder, compared with wired camera, it avoids the disadvantages of complicated wiring. After the CS-R5110 camera captured the
image of tea garden, the video data was compressed and encrypted using built-in digital compression controller and web-based operating system, and transmitted to the human-machine interactive interface of the upper computer through WIFI wireless network.

3.2. Wireless Transmission Technology

The ZigBee transmission technology is composed of end device CC2530 (End Device), router CC2530 (Router) and coordinator CC2530 (Coordinator), of which the end device CC2530 sends the collected soil temperature and humidity data to the coordinator CC2530 via the router CC2530. The coordinator CC2530 transmits the received data to the upper computer via the USB serial port and display it on the man-machine monitoring interface. The upper computer analyzes the temperature and humidity parameters and sends out control instruction information to the coordinator; the coordinator sends the control command information to the end device node through the ZigBee wireless network via the router, thereby realizes the wireless collection and control of the tea garden's temperature and humidity data.

This system's video image information is transmitted to the upper computer through the WIFI signal of the wireless communication module ST-MW-09S. The WIFI connection module of the camera CS-R5110 is set as the ST-MW-09S module, and its IP address is set to the IP address corresponding to the ST-MW-09S gateway, meanwhile, the ST-MW-09S module is directly connected to the upper computer. The upper computer can access the IP address of the camera to view the image of the tea garden taken by camera CS-R5110 on the monitoring interface, thereby achieving the wireless transmission of tea garden's image.

4. Monitoring Design of Upper Computer

4.1. Design of Upper Computer's Function Area

The upper computer's monitoring interface is designed with display area, functional area and spraying area, as shown in Fig.2.

![Figure 2. Function Area of Upper Computer](image)

In Fig.2, the display area includes temperature, humidity, video images and alarm information; the soil temperature and humidity values received from the coordinator CC2530 are displayed in both numerical value and dynamic graph way, allowing the user to directly check soil parameters of tea garden in real time; the tea garden image is to reflect the site conditions of the tea garden in video form, so that tea growers can accurately understand the growth condition of tea tree; the alarm information is displayed in the form of indicator and table, when the system collects a certain
parameter that exceeds the preset upper and lower limit values, the alarm indicator is on; the function zone includes the upper and lower limits setting for humidity, fertilizer and water irrigation, clear water irrigation and manual irrigation modes; according to their own experience, tea growers can design suitable upper and lower humidity limits for the growth of tea tree; when necessary, tea grower can send control instructions via the upper computer to perform fertilizer water irrigation or fresh water irrigation for tea tree; the tea garden is divided into multiple areas, each area is correspondingly installed with one sensor node, which is composed of two SHT11 temperature and humidity sensors to carry out the wireless monitoring and management of tea gardens’ sub-areas based on the data actually measured by each sensor node.

4.2. Control Method of Upper Computer

The control commands of the upper computer are mainly designed based on soil moisture and tea tree's image information. The upper computer sends control commands to the end device CC2530 according to the humidity value provided by real-time monitoring. The control process in each area is shown in Fig.3.

![Control Flow Chart of Upper Computer](image)  

**Figure 3. Control Flow Chart of Upper Computer**
There are nine types of control command information including a, b, c, d, e, f, m, x, y, etc., of which “m”, “e” and “f” control commands respectively mean the fertilization for the current area, fertilization for area 1 and fertilization for area 2; the “c”, “b”, and “d” control commands respectively mean that irrigation for all areas, watering for area 1 and irrigation for area 2; The “a”, “x”, and “y” control commands mean that stop irrigation for all areas, stop watering for area 1, and stop irrigation for area 2. If the tea tree in area 1 is lack of water or fertilizer, the upper computer sends command “b” or “e” to initiate the fresh water drip irrigation or fertilizer water drip irrigation for the area 1; when the humidity and fertility of the area 1 reach the suitable growth value range for tea tree, the upper computer then sends command "x" to terminate the irrigation in the area 1. If all areas are lack of water or fertilizer, the upper computer sends command “c” or “m” to start operations for all areas; when the moisture and fertility of all areas reach the suitable growth value range for the tea tree, then the upper computer sends command "a" to terminate the operations for all area actions.

5. Test and Measurement

5.1. Test Conditions

A tea garden with an area of 60m² was equipped with the wireless monitoring system designed by this article, this tea garden is equally divided into two areas, each area is equipped with three SHT11 temperature and humidity sensors. The fertilizer and water proportioning device is designed to be 60cm long, 30cm wide and 120cm high and placed between two areas; WIFI camera CS-R5110 is placed in the middle of the tea garden. The two tea gardens were respectively equipped with a drip irrigation main pipe and its branch pipes, so that the pipes just covered all the tea tree. Three kinds of operation modes including manual irrigation, fertilizer irrigation and fresh water irrigation, were available on the upper computer to test and verify the test results of these three types of operation modes in turn.

5.2. Test Results

In the manual irrigation mode, the initial humidity of tea garden soil is 42%, and the upper humidity limit is set to 70%, in this mode, there have four buttons including all zones, zone 1, zone 2, and stop. When manually pressing the zone 1 button, zone 2 and all zone buttons, the upper computer sends the drip control command to the end device CC2530; when the humidity acquired by the sensor is higher than humidity’s set upper limit 70%, the upper limit light of the alarm system is on; manually press the stop button, the upper computer sends stop command to the end device CC2530 to terminate the drip irrigation in the corresponding area.

For fertilizer and water irrigation, the time of drip irrigation and discharging is respectively set to 60s and 30s. When reaching the set time point, the upper computer automatically sends commands to conduct fertilizer and water drip irrigation based on three different situations: Command m indicates fertilization for all areas, Command e indicates fertilization for area 1, and command f indicates fertilization for area 2; When the time is up, the upper computer automatically sends a stop command to terminate the drip irrigation for the corresponding area.

For fresh water irrigation, the lower limit of humidity is set to 35% and the upper limit is set to 70%. When the humidity acquired by the sensor is lower than the set lower limit for three consecutive times, the upper computer automatically sends the drip command to performs the drip irrigation for corresponding area; when the humidity acquired by the sensor is higher than the set upper limit for three consecutive times, the upper computer automatically sends stop command to terminate the drip irrigation for the corresponding area.

The test results of the manual irrigation model and clear water irrigation model are shown in Table 1. From Table 1, it can be seen that it takes manual irrigation for 2 minutes before the humidity reaches the set value; based on several tests of the system, after the fertilizer and water irrigation button is pressed or the set time point of fertilizer and water drip irrigation is reached, the irrigation and fertilization device works; it takes fresh water irrigation for 4 minutes before the humidity reaches the set value. The manual switching window can be used to check tea tree growth and diseases and pests in the tea gardens. This shows that the system has strong wireless monitoring capabilities.
Table 1. Humidity Compensation Time Table

| Work Area         | Button   | Stable Time          |
|-------------------|----------|----------------------|
|                   | All nodes watering | 2 minutes and 21 seconds 00 |
| Artificial Irrigation | Node 1 watering | 1 minutes and 53 seconds 02 |
|                   | Node 2 watering | 2 minutes and 09 seconds 08 |
| Fresh Water Irrigation | All nodes watering | 4 minutes and 09 seconds 00 |
|                   | Node 1 watering | 4 minutes and 05 seconds 00 |
|                   | Node 2 watering | 4 minutes and 20 seconds 00 |

6. Conclusion

The tea garden wireless monitoring system designed in this article provides the real-time wireless monitoring of tea garden's temperature, humidity and growth, which are displayed in real time on the Labview monitoring interface of the upper computer. The self-designed irrigation and fertilization device has a simple structure and is easy to control, which improves the irrigation efficiency. This system can automatically detect the environmental parameters for analysis and processing; and automatically adjust and control according to the results; this system can provide water and nutrients to the tea garden in a timely manner and can significantly improve the efficiency.

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