Greenhouse Monitoring and Control System Based on Zigbee

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***Abstract*—A greenhouse monitoring and control system based on Zigbee networks was developed. This system consists of greenhouse data acquisition controller and greenhouse remote monitoring and control software. The system could monitor temperature and humidity, soil water content and concentration of carbon dioxide in greenhouse and could save these greenhouse data to database. Greenhouse acquisition controller had two kinds of control modes, including local manual control mode and remote wireless control mode in monitoring center. Greenhouse remote monitoring and control software can collect, display and record the collected data, also can control greenhouse environment. According to the current indoor temperature, the target temperature and the offset temperature, PID control method is used for temperature control in greenhouse. The system is implemented using low power wireless components, and easy to be installed. A good wireless solution is provided by this system for centralized management of the greenhouse group.**

***Keywords*[1]- Zigbee; carbon dioxide enrichment; intelligent greenhouse; PID control**

I. INTRODUCTION

At present, China is in the process of transformation from the traditional agriculture to high quality, efficient and productive modern agriculture. Greenhouse cultivation reflects the development direction of modern agriculture [1,2]. With the continuous development of facilities for agriculture, the requirements of the greenhouse control system are also increasing. The greenhouse monitoring and control system not only can monitor many environmental factors such as temperature, atmospheric humidity, soil moisture and CO_2 concentration, but also can store, manage and analyze the collected greenhouse data. So the greenhouse monitoring system is a multi-tasking system.

Greenhouse cultivation aims basically to protect the plantations from bad weather, and becomes a mean to achieve controlled agricultural production in recent years [3]. Most of the greenhouse control system adopted PLC greenhouse control and field bus control system. These systems have the shortcomings of wiring time-consuming and high cost. Zigbee technology is a new wireless communication technology. Relative to Bluetooth and WIFI, Zigbee technology has the characteristics of low complexity, low power consumption, low data rate, low cost and ad hoc networks, et al. [4][5]. Zigbee technology is suitable for the field of automatic control system and implementing devices [6].

In our case, greenhouse monitoring and control system based on Zigbee network was developed. The system can collect environmental information inside greenhouse by using temperature sensor，humidity sensor and CO_2 sensor. The system can also realize manual control and automatic control of greenhouse.

II. SYSTEM OVERALL DESIGN

Greenhouse monitoring and control system was made up of host system, the central node, wireless collection nodes, winder reel, CO_2 enriching device and solenoid valves. The host system connects the central node through a serial port. Wireless collection nodes connect the central node through Zigbee wireless network. Input terminal of wireless collection node connects the air temperature and humidity sensors, CO_2 sensor and soil moisture sensor. Wireless collection node can collect greenhouse temperature and humidity data and CO_2 concentration data. These data are sent to the host system through the Zigbee wireless network. Greenhouse monitoring and control system mainly includes greenhouse remote monitoring and control software and greenhouse data acquisition controller. Greenhouse data acquisition controller is mainly composed of a Zigbee wireless acquisition module, CO_2 sensor, soil moisture sensor, air temperature and humidity sensor.

Zigbee wireless acquisition module includes four channels of 4-20mA current signal inputs, four channels of high and low voltage outputs. Two channels of high and low voltage outputs are used for controlling of opening insulation film and closing insulation film. One channel is used for CO_2 enrichment control, another channel is used for irrigation control in greenhouse. A wireless acquisition module with an 8-bit address is used to identify the controller.

The CO_2, air temperature and humidity integrated sensor selects TGP-CO_2 sensor. This carbon dioxide sensor is a fast, low power NDIR sensor. The sensor can output 4-20mA analog signal for CO_2 concentration, air temperature and humidity.

The interval time of the data acquisition controller should be set primarily when the controller works. The greenhouse data acquisition controllers periodically send the collected

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data to the central node. The data formats are as follows: the data header + data length + terminal address + port number + function code + valid data.

III. GREENHOUSE REMOTE MONITORING SOFTWARE DESIGN

The greenhouse remote monitoring and control software has three function modules, such as greenhouse environmental information collection, environmental control and meteorological information collection. The greenhouse environmental information collection can collect greenhouse air temperature, humidity, CO_2 concentration and soil water content inside greenhouse. Greenhouse environment control includes remote control of greenhouse winder reel, greenhouse irrigation and CO_2 enrichment. Meteorological information collection includes the acquisition of outdoor temperature and humidity, daily rainfall, wind speed and wind direction. The software can realize manual control and intelligent control for greenhouse environment. When the user double-click the icon of greenhouse manually control in the main system interface, the greenhouse CO_2 enrichment and the irrigation manual control interface can be entered. In this interface the manual control of greenhouse CO_2 enrichment can be realized by clicking the enrichment button.

The control parameters should be set in greenhouse intelligent control. The setting parameters include the varieties of greenhouse planting crop as well as the appropriate range of temperature. Figure 1 shows the setting interface of greenhouse intelligent control. After a greenhouse is selected, the parameters of this greenhouse can be set.

A. *Data protocol analysis*

The host computer in greenhouse monitoring center connects the central node SZ02 of Zigbee wireless network through the serial port. The data of each greenhouse will be regularly sent to the central node SZ02.

The data of greenhouse environment is transmitted through character format. A complete statement includes data head, data length and environmental data. Fig. 2 shows the process flow of serial port interrupt function.

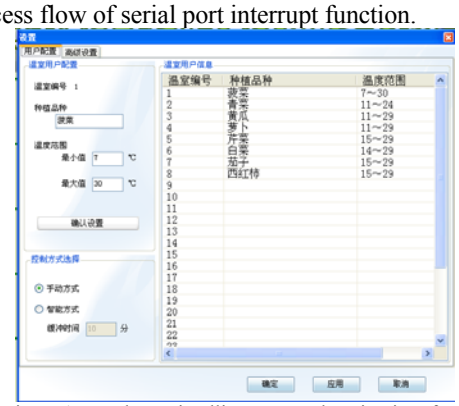


Figure 1 greenhouse intelligent control setting interface

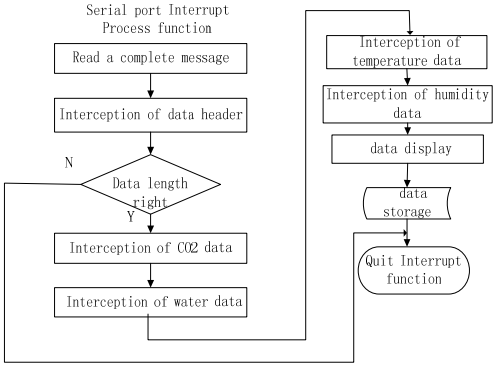
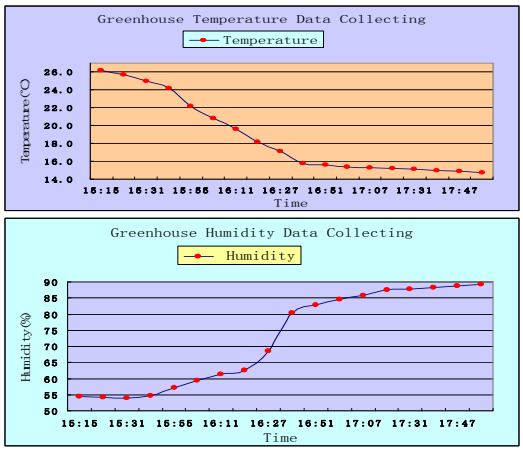


Figure 2 Serial port processing flow

B. *Data acquisition*

The greenhouse monitoring and control system could real-time monitor the greenhouse interior environment and exterior meteorological conditions. The collected data of interior greenhouse environment includes temperature, humidity, CO_2 concentration and soil moisture. The collected data of outside meteorological conditions consists of temperature and humidity. Greenhouse remote monitoring and control software achieves serial communication by the serial communication control. When the serial port receives the data which are reported by greenhouse acquisition controller, the system can receive and process the collected data, and then save and display the data. Fig.3 shows the collected data change with time in greenhouse. Fig. 4 represents a comparison chart of inside and outside temperature and humidity.

This system saves data every 8 minutes. The received temperature, humidity, CO_2 concentration and soil moisture data are the voltage and current value but not available for using directly, this data need to be processed effectively.



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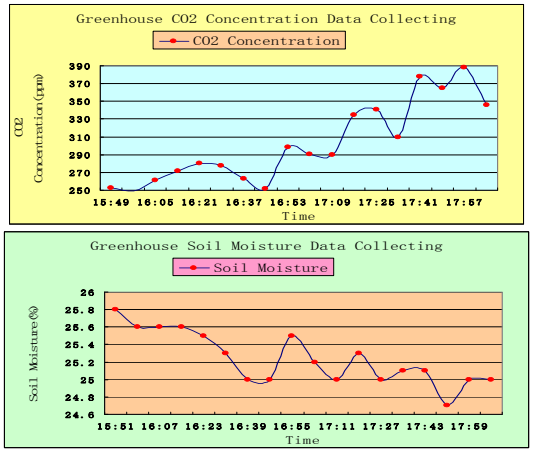

Figure 3 Collected data change with time in greenhouse

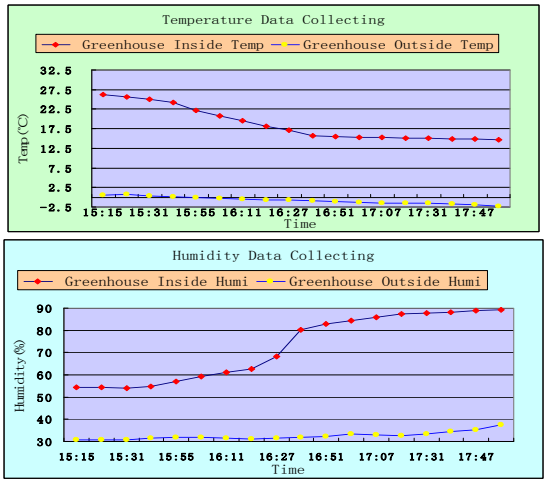

Figure 4 Comparison of inside and outside temperature and humidity

So the environmental parameters processing function (GH_Data_UpdataFourPara) is needed to be called in the data receiving function. Fig. 5 is processing flow chart for the environmental parameters.

C. *Greenhouse temperature intelligent control*

According to the requirements of the crop-growing periods, the settings of target temperature, offset temperature, continued time and hysteresis band should be carried out. These settings can be set through the program or through the man-machine interface. If the current value of indoor temperature (temperature pv) is greater than or equal to the sum of the target temperature (setting temperature sv) and the offset temperature, meanwhile, this state continues for 60s, PID controller output digital control command. The output can drive winder reel to open film, through the D/A module that can convert digital signal to analog signal.

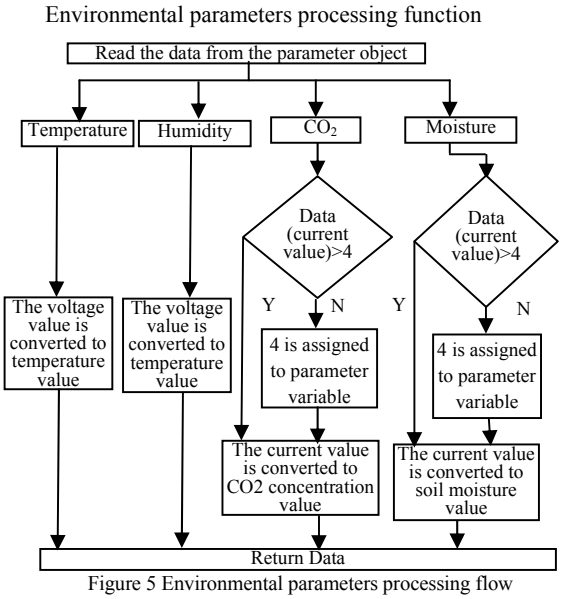

Figure 5 Environmental parameters processing flow

When the value that the sum of the target temperature and the offset temperature subtracts the hysteresis band value of the temperature is greater than the indoor temperature (pv), meanwhile, this state continues for 60s, PID regulator output digital control command consequently. The digital output can control roll film device to close film, through the D/A module that can convert digital signal to analog signal. In this system PID sampling period T is 20s, the input filter constant α is 50%, the proportional gain K_P is 85%, the integral time T_I is 210 s, the differential gain K_D is 50%, the derivative time T_D is 40s.

IV. EXPERIMENTS AND ANALYSIS

Testing and application were preceded in the national precision agriculture demonstration base. The greenhouse environment parameters were collected through Zigbee wireless network. The maximum distance is 1.5 km between the monitoring center and the greenhouse controller. Zigbee antenna is fixed on the greenhouse back wall through a bracket. Zigbee antenna connects the greenhouse controller through three meters of extension line. Remote operation test of opening film and closing film in the monitoring center was good. Figure 6 shows the greenhouse temperature comparisons between temperature control operation and without control operation. In the PID control the target temperature is 17℃, the offset temperature is 1℃. After using the PID control, the greenhouse temperature is steady relatively.

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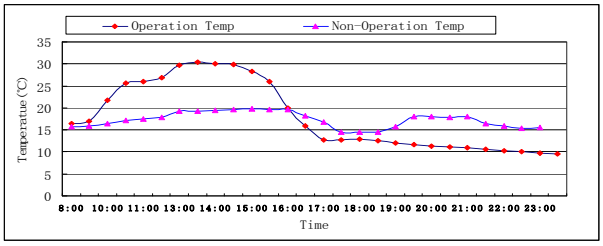

Figure 6 Greenhouse temperature comparisons of control operation and non operation

V. CONCLUSION

A greenhouse environment monitoring and control system based on Zigbee wireless network was developed.

The system could monitor temperature and humidity, soil water content and CO_2 concentration in greenhouse. The obtained data by using the system will be able to provide the data support for vegetable planting in greenhouse. The system is reliable and runs stably. The man-machine interface of the software system is friendly. This system provides a good solution for centralized management of the greenhouse group.

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