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Greenhouse Environment dynamic Monitoring system based on WIFI

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Abstract: Environmental factors such as temperature, relative humidity, and light intensity have a profound effect on the growth of greenhouse crops. At present, China's production greenhouses generally use artificial means to monitor environmental information, which wastes manpower and cannot accurately detect environmental information. In some greenhouse environment automatic monitoring systems, 485 bus or CAN bus are often used to realize remote monitoring of the greenhouse environment. The wiring method is complicated and the lines are easy to age. Based on the above problems, this paper proposes a method of dynamic monitoring of greenhouse environment based on WIFI, and realizes remote monitoring of greenhouse temperature, humidity and light intensity through the designed greenhouse sensor and the developed server software.

Keywords: Greenhouse environment, sensor, monitor, WIFI, server.

1. INTRODUCTION

With the development of facility agriculture technology, China's greenhouse construction has gradually evolved from simple sheds, single sunlight greenhouses to large multi-span greenhouses, and the scale of greenhouse construction has continued to expand. The cultivation area of greenhouse crops is raising fast these years(Haan,1998; Yoo,2002). The greenhouse is the main body in the facility agriculture industry. Through adjusting and controlling the environmental factors in the local area, the crops can be provided with suitable growth conditions to guarantee high quality and high yield of agricultural products. During the cultivation of greenhouse crops, temperature, humidity, light intensity, CO2 concentration, soil water and fertilizer all have an important impact on crop growth. It is difficult to rely on traditional monitoring methods for scientific and rational planting(Xiao,2017). In recent years, domestic and foreign greenhouse environmental monitoring systems have gradually replaced traditional manual monitoring methods. Lu Man proposed a scheme of greenhouse monitoring system based on the RS-485 bus. The monitoring system consists of a host computer, 232/485 conversion layer and on-site monitoring nodes(Lu,2013). In response to the need for intelligent monitoring of greenhouse environments, Yang Jing proposed an implementation plan for a greenhouse environmental monitoring system based on CAN bus and wireless sensor networks (WSNs) (Yang,2012). Li Li combined with embedded technology and wireless sensor network technology to achieve communication with remote management center through GPRS(Li,2009). Foreign scholars have made many achievements in greenhouse environmental monitoring research. Foughali Karim et al. used GPRS modules to implement remote monitoring of greenhouse environments(Foughali,2017). Min-Sheng Liao designed wireless greenhouse sensors based on ZigBee and CC2420(Liao,2017). Han et al. used DSP and 3G wireless communication technology to establish a remote diagnosis and recognition system for insect pests(Han,2012). However, in practical applications, most of the typical greenhouse monitoring systems in China use indoor cabling solutions. It is found that the indoor humidity is high and the light is strong, which can easily lead to the aging of the lines(Zhang,2013; Ma,2015; Gao,2013). At the same time, the complex wiring also increases the number of obstacles in greenhouse. In many wireless communication technologies such as GPRS, ZigBee, and Bluetooth, WIFI networks will become important for the monitoring system of agricultural greenhouses due to their advantages such as wide bandwidth, high transmission speed, strong compatibility, and strong anti-interference ability (He,2013), which is also an important research direction for greenhouse information transmission technologies (Lin,2014). In view of the above problems, this paper proposes a WIFI-based greenhouse environment remote monitoring system.

2. GREENHOUSE ENVIRONMENT DYNAMIC MONITORING PROGRAM

2.1 Design Program of Sensor

This section describes the system design and framework.The WIFI-based monitoring system converts the TTL signal on the sensor module into a wireless WIFI signal through a WIFI module, then realize network connection and data transmission with the server. The WIFI module uses the high performance WIFI module USR-WIFI232-A2 produced by YouRen networking company in Jinan. The module is used to implement bi-directional transparent transmission from serial port to WIFI data packets. The module internally completes protocol conversion. Through this module, physical devices can be connected to the WIFI network to implement control and management of the greenhouse environment.

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The WIFI module can work in AP mode and STA mode. It is connected to the sensor circuit board in this system, and works in STA mode. The WIFI module needs to establish a socket network connection with the server to achieve communication between the sensor and the server. The block diagram of the communication between the sensor and the server is shown in Figure 1. The server and the sensor each add into a wireless router, then we mapping the IP obtained by the server computer to the public IP of its router. At the same time, the WIFI module on the sensor is set to STA mode, and is added into a wireless router. The network parameter of the WIFI module is set to TCP Client mode.In the meanwhile, the WIFI module is added into the port opened by the server and the public IP mapped by the server. In this way, after a remote sensor is powered on, it can actively search for a server, waiting for the server to receive its request, and establish a socket network connection to perform data transmission.

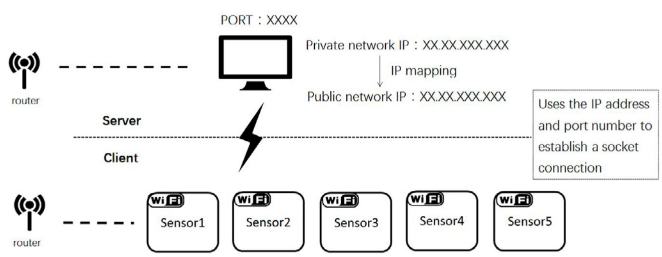

Fig.1 . Block diagram of the communication between the sensor and the server

2.2 Design Program of Server

The function implemented by the server program is to establish a TCP network connection with the sensor module, send commands to the sensor periodically, then receive, display, and store the environmental parameters returned by the sensor. This program is written in Visual Basic 6.0 , and it generates an .exe file when the program is debugged. The program structure shown in Fig.2.

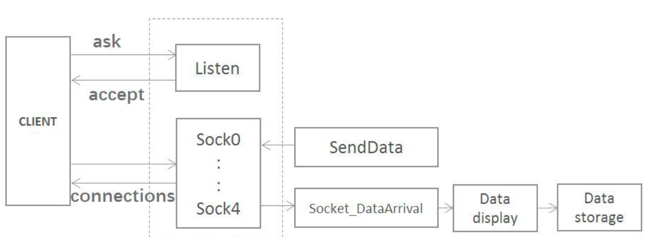

Fig.2 . Program structure of server

When the program runs, it first listens to the connection request sent by the clients (sensors).When the request is received, the request will be allowed and a SOCKET connection is established with it. When the Timer in the program expires, the server sends "$35T", "$35H", "$35E" to the currently connected client. When the returned data arrives, the received data is displayed in the "Received Content" text box and displayed in the temperature, humidity, and light intensity text boxes in turn. At this point, the data collection of a sensor is completed. After that, the server continues to collect the remaining sensors' data and display them. After all sensor data are collected and updated, they are stored in a text file. The format of storage is shown as follows:

Year/month/day Hour: minute: second

Sensor1: Temperature, Humidity, light intensity

Sensor2: Temperature, Humidity, light intensity

Sensor3: Temperature, Humidity, light intensity

Sensor4: Temperature, Humidity, light intensity

Sensor5: Temperature, Humidity, light intensity

3. SENSOR IMPLEMENTATION

3.1 Circuit and Principle of Greenhouse Environment Monitoring System Based on WIFI

The working principle of the sensor module is shown in Fig.3. The circuit board is powered by +5V DC, and is stepped down to +3.3V through the AMS1086-3.3 power module to power the WIFI module in the circuit. Temperature sensor, light sensor and humidity sensor send their corresponding signals to the SCM. The module communicates with the outside world via WIFI or the 485 bus. The program is wrote through JTAG into the C8051F020, which is the SCM of the sensor module. When needed, the SCM can be reset via the reset button.

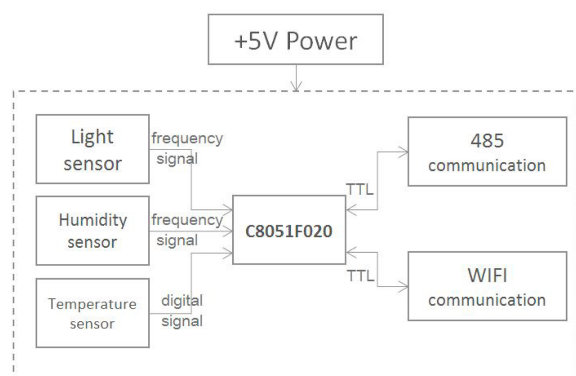

Fig.3 . Working principle of the sensor module

3.2 Sensor Software Design

The other major part of the sensor module is the design of its software. By programming the SCM C8051F020 on the sensor module, various functions of the sensor are realized, and the block diagram is shown in Fig.4. The software part of the sensor module consists mainly of the following contents:

System initialization: System initialization includes the declaration and definition of variables and functions in the program, watchdog initialization, clock initialization, Timer initialization, port initialization, and UART initialization.

Sending and receiving data: Sending and receiving data are accomplished by the functions sendBuf() and recBuf() respectively.

Timer settings: There are five Timers in the SCM: Timer0~Timer4 . Timer1 is used to generate the 9600 baud rate; Timer3 is used as the watchdog; Timer4 is set to the timing mode and is used for timing 20ms; Timer0 and Timer2 are set to the counting mode, which is used to count the output frequency of the light and humidity measurement circuit.

Commands and responses: After the program is run, it is initialized first, and then it enters the loop. In the loop, it queries whether there is data arriving. The specific commands and meanings are shown as follows:

‘$35T’ : Obtain greenhouse temperature;

‘$35H’ : Obtain greenhouse relative humidity;

‘$35E’ : Obtain greenhouse light intensity;

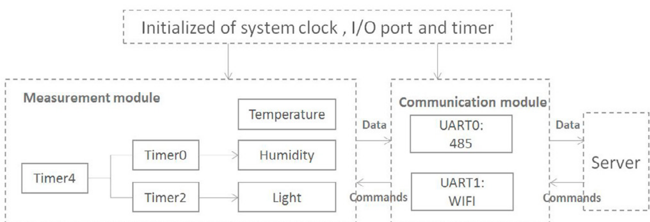

Fig.4 . Block diagram of sensor program

4. SERVER SOFTWARE DESIGN

Establishing a network connection is an important part of the server software. We add two winsock controls at first, one of which is used to monitor online request signals, named Listener; the other is the initial connection, named Sock. This control should be set as a dynamic array. In this software, server can connect with up to 15 clients at the same time. The process of establishing a socket connection is shown in Fig.5.

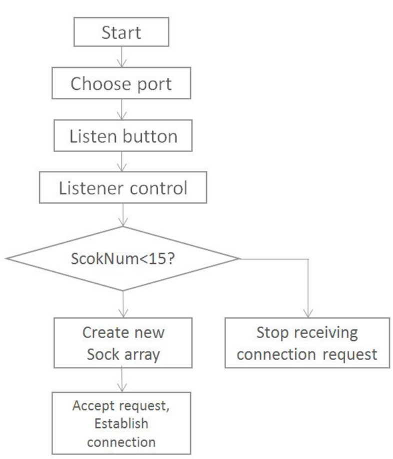

Fig.4 . The process of establishing socket connections

The initial welcome interface of the software is as shown in Fig.5. Then, it will automatically enter the environment monitoring interface after 3 seconds, which is shown in Fig.6. In the environment monitoring interface, as we can see, the default port opened is 2020, the default command is $35~$39, both of the above can be modified in the text boxes. In the process of establishing a connection, the client ID, the client connection request, and the acceptance of server are all recorded in the log area. In the meanwhile, the client's IP and remote port number are displayed in the client list. Text1~Text15 are used to display the current temperature, relative humidity, and light intensity of each sensor. Every time after all the data of 5 sensors are updated, the program will open the data storage text and write the data into it.

Fig.5 . Initial welcome interface of server

Fig.6 . Environment monitoring interface

5. TEST AND RESULTS

First, the computer where the server is running is added into a wireless router, and mapping the IP of the server to the router’s public IP address. Then configure the WIFI module into STA mode, and add into any wireless router. The baud rate is set to 9600, and the network parameter is set to TCP Client.The server IP is the public IP mapped to router. The above settings can be configured via web page configuration or AT command configuration, which are provided by the company of WIFI module. After the configuration is finished, the sensor module is powered on and the server software runs. At this time, the sensor module can actively send a connection request to the server. After receiving the request, the server establishes a connection with the server module and sends commands periodically.

We test the system after configuring the system according to the above process. The test cycle is 7 days, from 20th April，2018 to 27th April, 2018. The sensor was placed on the window facing east in author’s laboratory, in China Agricultural University, College of Information and Electronic Engineering, Beijing. The software during the test is shown in Figure 7, the sensor during the test is shown in Fig.8. The final measured data result is shown in Fig.9-11.

Fig.7. Testing interface

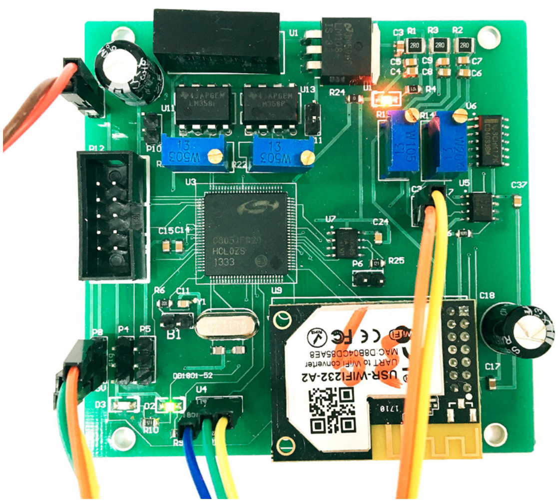

Fig.8. Physical map of sensor

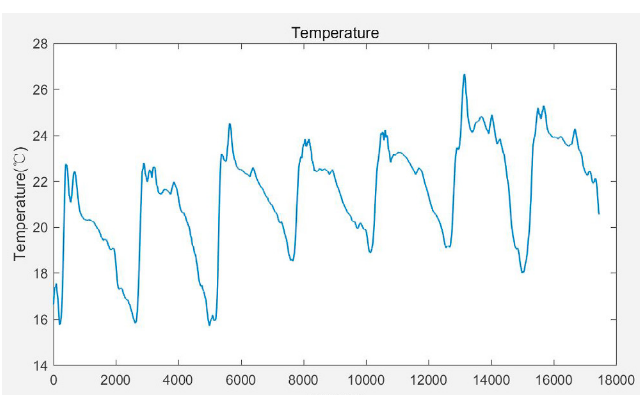

Fig.9 . Temperature result

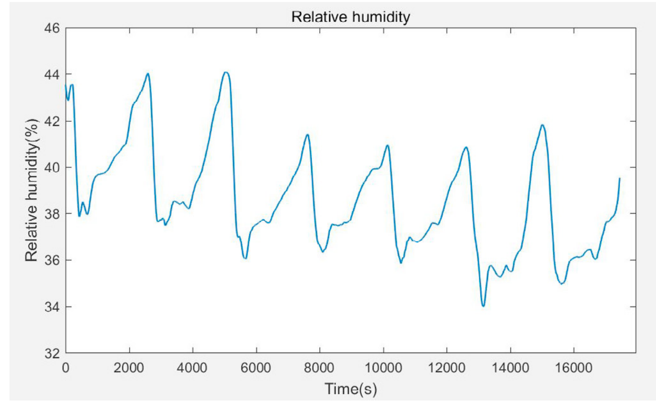

Fig.10.Relative humidity result

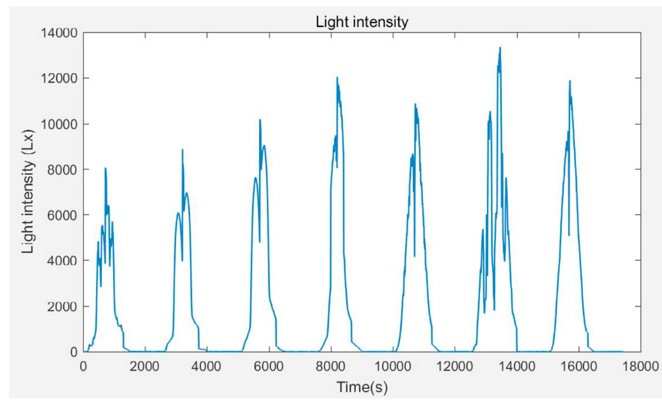

Fig.11.Light intensity result

6. CONCLUSIONS

This system performed software and hardware design of greenhouse environmental information collection based on the WIFI module. It can be seen from the above test results that during the 7-day test, the sensor module continued to work without crashes or abnormalities; the server software continued to run without interruption and other abnormal phenomena; the network connection between the server and the sensor was not interrupted, and the transmission performance is good. Because of the shadow of the buildings during the daytime, there may exist some sudden changes, especially the light intensity, which is a normal phenomenon. Besides, as we can see from the results, humidity and temperature tend to be inversely proportional, which is also a normal phenomenon during the days without rain or snow. Therefore, this system provides a feasible way for remote wireless dynamic monitoring of greenhouse temperature, humidity, light intensity and other environmental information, and provides a stable, feasible, and low-cost solution for greenhouse production management.

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