Design of Wireless Monitoring and Remote Control System for Multi-point and Multi-channel Temperature and Humidity Acquisition in Greenhouse

Fa Zhang[1], Zhinan Yuan[1], Hui Zhang [1]*, Su Zhang[2]
[1] Faculty of Computer and Software Engineering, Huaiyin Institute of Technology, Huai'an, 223001, China
[2]National Institute of Development Administration, Bangkok, 10700, Thailand

Abstract: The wireless monitoring and remote control system of conventional temperature and humidity collection is applied to the greenhouse environment, which has the deficiency of large monitoring error and low control accuracy. Based on system structure design and device selection, hardware circuit design of wireless monitoring and remote control system is realized by relying on peripheral design of chip module, design of temperature and humidity sensor and design of bluetooth module. Set up the software development platform for wireless monitoring, remote control system, complete the software design by relying on the system program design and user interaction module design, and realize the design of wireless monitoring and remote control system for greenhouse multi-point and multi-channel temperature and humidity collection. The test data show that the proposed wireless monitoring and remote control system has reduced the monitoring error by 13.17% and improved the control accuracy by 35.9% compared with the conventional wireless monitoring and remote control system. It is suitable for wireless monitoring and remote control of temperature and humidity collection in greenhouse.

Keywords: Greenhouse collection; Multipoint multiway; Temperature and humidity collection; Wireless monitoring; Remote control; System design

1. Introduction

Conventional remote control of the temperature and humidity acquisition wireless monitoring system, through the wireless monitoring of temperature and humidity sensors and actuators and remote control, suitable for outdoor applications with large temperature difference, but used in the greenhouse, due to the sensor and actuator limits, there of low error monitoring and control accuracy in[1], is not suitable for the greenhouse temperature and humidity acquisition wireless monitoring and remote control, therefore put forward more multiplex greenhouse temperature and humidity acquisition wireless monitoring of the remote control system design. Relying on the structure design and component selection of the wireless monitoring and remote control system, as well as the hardware circuit design and software design of the wireless monitoring and remote control system, the design of the wireless monitoring and remote control system for greenhouse multi-point multi-channel temperature and humidity collection is realized. In order to ensure the effectiveness of the designed wireless monitoring and remote control system and to simulate the greenhouse test environment, two different wireless monitoring and remote control systems are used to carry out simulation tests of greenhouse monitoring error and control accuracy.

2. Structure Design and Component Selection of Wireless Remote Control System

System structure design and component selection are mainly about system structure design and system module selection. The system structure is determined first, and then the type of each system module component is determined according to the type of the system structure. The model of each module selected is related to the type of circuit used in this design and the complexity of software programming. Therefore, it is necessary to consider the advantages and disadvantages of each device and reduce the burden for future work.

2.1. System structure design

If you want to design the system direction, it is necessary to divide the system into different modules. When different systems are divided into different modules, each small function can be clearly identified as which module should be responsible. The lack of any module can not

constitute the whole part of this temperature and humidity sensor. Without that function, it is impossible for the system to operate normally, and it is inevitable that problems will be exposed at some node or unnecessary risk to the system[2].

The so-called modular design, simple said is the product of certain elements together, form a specific function subsystem, the subsystem as a universal module and other products elements on a variety of combination, constitute the new system, produce a variety of different or the same functions and performance of products. Modular design has been widely used in the design fields of machine tools, electronic products, aviation and aerospace[3].

The wireless monitoring and remote control system designed in this paper is used to realize digital display of temperature and humidity of greenhouse crops, on-site alarm and remote control. The system is mainly composed of main control module, measurement module, power supply module, user interaction module and related software. The whole system takes the single chip microcomputer as the control core. When the system is running, the environmental data collected by the data collection module is first transmitted to the single chip microcomputer module and the collected data is displayed on the APP. In the future development, communication module can be added so that the collected data can be sent to the user regularly, or can be stored periodically. When the user requests it remotely via SMS, it can be sent to the user.

2.2. The device selection

In the process of designing the system, on the premise that all functions of the temperature and humidity sensor are fully realizable, the system should be made as green, energy-saving and environment-friendly as possible. Therefore, when selecting corresponding hardware equipment for the system, the hardware with lower power consumption should be selected as far as possible[4].

As the supporting point of the whole hardware system, the function of SCM cannot be neglected. If some partial doors or the actual operation of more difficult single - chip computer as the core of the hardware system module. Not only will it be more difficult to burn yourself into coding, but it is also easy to make all kinds of unsolvable errors, so it is crucial to choose a suitable microcontroller. Finally, STC89C52 microcontroller is selected as the hardware system of temperature and humidity sensor. First the microcontroller on the market is very wide, use all sorts of compatibility problems with upgrading is one step at a time, and this kind of single chip microcomputer to solve the problem of processing the actual speed is not common, is a popular one of common household items commonly used a single-chip microcomputer, the design of the interface number will also be able to support in this paper, the requirements of design, and 52 series of 51 series single chip microcomputer is also often used when learning microcontroller, prices are more affordable, can accept in the budget range, power consumption is low[5], already can be functions of the system needs to meet, Previous understanding of MCU can handle this design more easily.

About the single chip microcomputer STC89C52, it is produced and developed by the us listed company ATMEL. Machine cycle for a single clock, is a working byte for 4K, programmable memory. STC89C52 is very powerful, including 8k-byte read-only program memory, which can be erased repeatedly. When this single chip computer is fully engaged in the working state, the frequency is about 80MHz. The total control circuit of the single chip is shown in Figure 1[6].

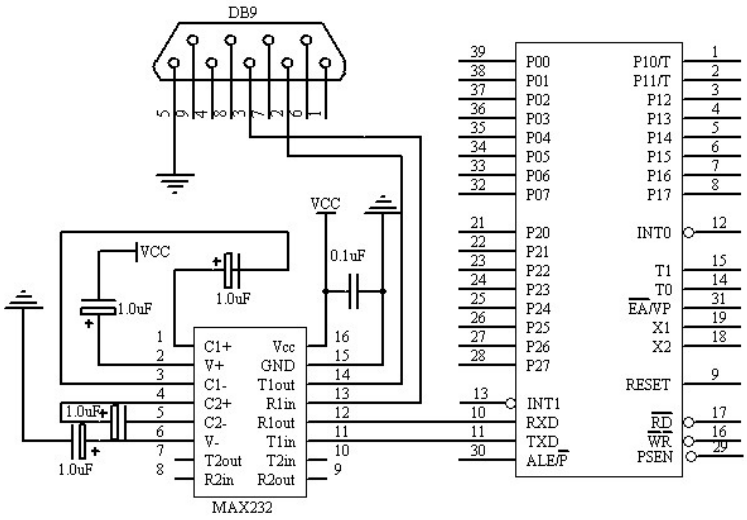

Figure 1. MCU control circuit

After several comparisons of references and searching relevant materials on the Internet to identify their advantages and disadvantages, it was decided to use STC89C52 as the core of the single chip module.

The temperature and humidity sensor system is mainly divided into the following modules. Is the main control operation on the STM89C52 microcontroller board module, the main function of temperature and humidity sensor system of DHT11 temperature and humidity sensor module, after will measure the results timely feedback to the android mobile phone application HC - 06 bluetooth processing module, and maintain the power source of the whole system has the function of the normal execution module[7].

DHT11 is used as the temperature and humidity sensor in the measurement module. However, in the data transmission module, the selection of a bluetooth processing module which can feed the measured results to the android mobile application in time does not have much choice but hc-06 bluetooth module.

3. Design of Hardware Circuit of Wireless Monitoring and Remote Control System

3.1. The peripheral design of the chip

In this MCU module, the main content is divided into STC89C52 MCU basic circuit and STC89C52 MCU debugging circuit. The port P1.0 and P1.1 of the STC89C52 MCU module based on ATMEL are used to download the program. The P0 port is used to connect the serial interface to the LCD screen, so that the data can be displayed directly. In addition, this port also has the function of timing. The two ports P1.4 and P1.3 are specifically connected to switches, controlling the maximum and minimum values of temperature and humidity measured by the system. The port of P0 is external with pull-up resistance[8]; The whole set of single-chip microcomputer above the electric self-reset way to work.

The hardware circuit of STC89C52 SCM module based on ATMEL is shown in figure 2[9].

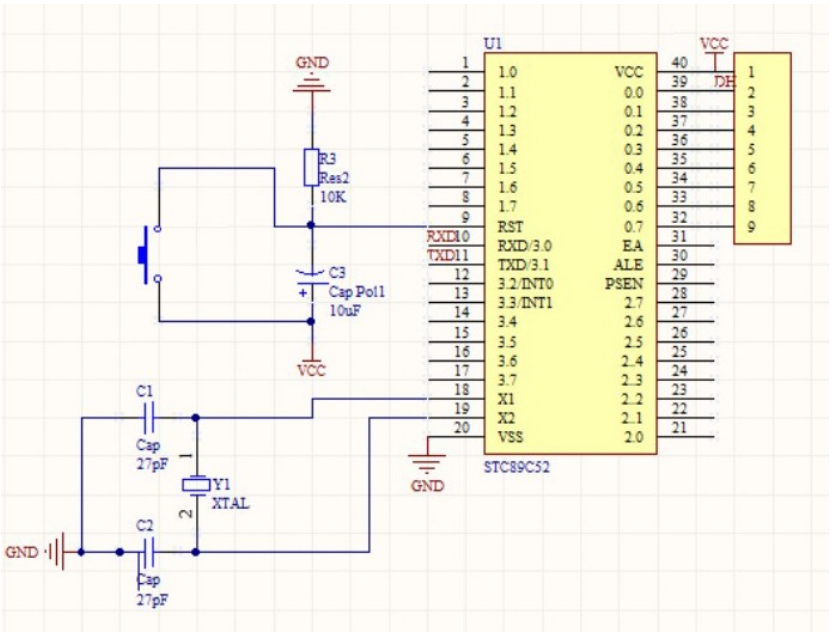

Figure 2. MCU peripheral circuit

3.2. Temperature and humidity sensor design

Model selection of measurement module. In this temperature and humidity sensor measurement module, sensor selection is the core component of the entire measurement module. Whether a suitable sensor can be selected directly determines whether the function of the system can be implemented smoothly.

The main parameters for the selection of sensor include: power supply voltage, measurement range, measurement accuracy, response time, bus type, output type, and cost. Combined with the application situation of the equipment and the measurement accuracy and range, the most widely used temperature and humidity on the market can be measured at the same time by the integrated temperature and humidity sensor dht-11. Dht-11 occupies a very small volume of single-chip microcomputer and does not require power, which is in line with the characteristics of low power consumption in mind[10].

At the same time, dht-11 can use digital signals, not just analog ones, to transmit data, making it less difficult to design and, unsurprisingly, less complex. Moreover, after several tests after the initial completion of the product, its accuracy is less than 0.1% different from the actual situa-

tion, and the accuracy accuracy of the product is effectively guaranteed.

Dht-11 is selected as the temperature and humidity sensor of the wireless remote control system designed in this paper. DHT11 is a digital sensor that monitors temperature and humidity together. As the integrated temperature and humidity sensor, the single-chip microcomputer of dht-11 is very small in volume and does not require electricity. The converter part of DHT11 is special, which is A/D converter in the form of I2C bus, which is 14 bits. The structural parameters of the temperature and humidity sensor can be expressed by formula (1) :

$$E = pE_0 + \log(a^n + ef) \quad (1)$$

Where, E_0 represents the initial state of the temperature and humidity sensor, p represents the structure coefficient, a represents the temperature range, n represents the maximum temperature difference, e represents the performance coefficient of the temperature and humidity sensor, and f represents the service life of the temperature and humidity sensor.

3.3. Bluetooth module design

Bluetooth module. It is important to select a bluetooth processing module that can feedback the measured results to android mobile application in time. However, I don't have much choice. But hc-06 bluetooth modules also have many features. The bluetooth module pin circuit of hc-06 is shown in figure 3.

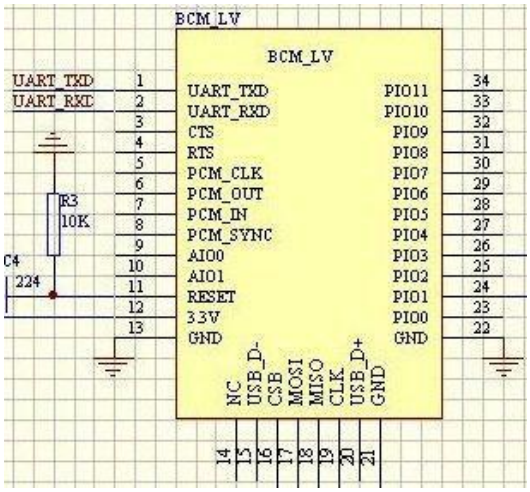

Figure 3. Hc-06 bluetooth module pin circuit diagram

4. Design of Wireless Remote Control System Software

4.1. Set up the software development platform of wireless monitoring and remote control system

As we all know, the Software Keil C51 is a Software development system that nobody knows about in the field of computer hardware. It is produced by Keil Software company in the United States. It uses the programming language C to develop the Software system, and is perfectly compatible with the series 51 single chip microcomputer. On this software development platform, it has its own advantages and characteristics with other software development platforms. First of all, in terms of functionality, there are many functions that can be implemented in the menu bar, resulting in compatibility with many different types of MCU. In addition, the overall layout of the compiled code looks neat and beautiful, and the typography and font can be adjusted accordingly according to their own needs. The algorithm of the software development platform of the wireless monitoring and remote control system is shown in figure 4:

```
public static void main(String[] args){
int[] arr = {5,3,5,2,8};
//new
int[] duiArr = new int[11];/
for (int i = 0;i<arr.length;i++){
  //duiArr[arr[i]] += 1;
  duiArr[arr[i]]++;
}
//fdgsduiArr,
for(int j = 0;j<duiArr.length;j++){
  if(duiArr[j] ==0){
    continue;
  for(int k = 0;k<duiArr[j];k++){
    System.out.println("gfdrgdfgd:  " + j);
  }
/**
 *
 * @param arr fdsg
 * @return
 */
public static int[] bubbleSort(int[] arr) {
  int n = arr.length;
  for (int i = 0; i < n - 1; i++) { //0 1 2 3.  dfgsdfas
    for (int j = 0; j < n - i - 1; j++) { //i=0,  adasd:  i=1,  asfdasf
      if (arr[j] > arr[j + 1]) {
        int temp = arr[j];
        arr[j] = arr[j + 1];
        arr[j + 1] = temp;
      }
    System.out.println(Arrays.toString(arr));
  }
  return arr;
}
public static void main(String[] args) {
  int[] arr = {35, 12, 99, 18, 76};
  System.out.println("fghfghdd:  ");
}
```

Figure 4. Wireless monitoring remote control system software development platform algorithm

4.2. System programming

First, after the user downloads, open the android phone app. Then the user can choose whether he or she has ever logged in to the android phone app to decide whether he or she should sign up for a user or simply log in with a registered account. When you register and log in the user information, you can click to check the temperature and humidity checkbox after logging in. The data is transmitted to the android mobile phone application via hc-06 bluetooth module in a single chip to check the temperature and humidity. The main functions include: sensor reading parameter subroutine, bluetooth transmission subroutine, key subroutine. System software flow chart is shown in figure 5:

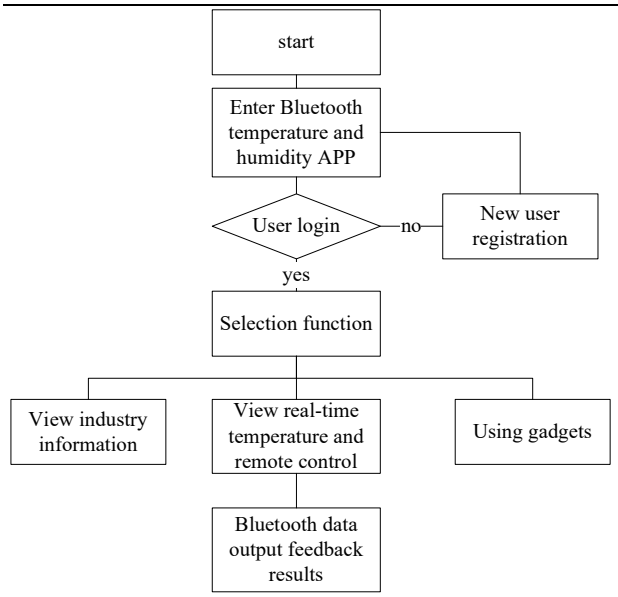

Figure 5. System software flow chart

To solve the problem of temperature and humidity data transmission of bluetooth sensor, the modification of parameters, data display and alarm of environmental changes should also be taken into account. Based on the hardware circuit, the software design of each functional module is completed, including the design of sensor reading parameter subroutine and bluetooth data transmission program. Finally complete the overall temperature and humidity system program design. Good software can make sure the android mobile phone application can run smoothly at the same time, also can greatly reduce the program to the mobile space, smooth and perfect run to catch the heart, let them take it for granted in their own phone this product, and even recommend to friends and relatives around you. Good software design is the lighthouse for the entire software architecture of the system, so that diligent programmers don't get lost in the hard work of editing code.

4.3. User interaction module design

The user interaction module completes the function of man-machine interaction through the APP produced by the android development environment of eclipse, and realizes the real-time check of bluetooth temperature and humidity on the mobile phone. At the same time, there are many other small features on the android phone app that allow users to check small information about their health at home, or their body mass index (bmi).

This chapter designs the hardware circuit of each functional module, including the hardware circuit design of single-chip computer module, the hardware circuit design of temperature and humidity sensor, the hardware circuit design of bluetooth module and the design of user interaction module. The MCU module adopts peripheral circuit design of STC89C52 MCU, the temperature and humidity sensor module adopts DHT11 type sensor circuit design, the bluetooth module USES hc-06, and the user interaction module USES APP developed in the android development environment of eclipse. The schematic diagram of Altium Designer09 circuit design software is made, which lays a foundation for PCB version production with software in the future. The design of wireless monitoring and remote control system for greenhouse multi-point and multi-channel temperature and humidity collection is realized.

5. Experimental Results and Analysis

In order to ensure the effectiveness of the design of the wireless monitoring remote control system for greenhouse multi-point and multi-channel temperature and humidity collection, the simulation experiment is carried out. In the test process, different greenhouses were used as test objects to carry out the simulation test of monitoring error and control accuracy. The environmental complexity, temperature and humidity range and environmental state of greenhouse were simulated. In order to ensure the effectiveness of the experiment, the conventional wireless monitoring remote control system was used as the object of comparison to compare the results of two simulation tests and present the test data in the same data chart.

5.1. Monitoring error comparison

In the test process, two different wireless monitoring remote control systems were used in the simulation environment to analyze the variation of monitoring error in the greenhouse. The comparison results are shown in Table 1.

Table 1. Monitoring error comparison

Case type number	Wireless monitoring remote control system proposed%	Conventional wireless monitoring and remote control system/%
1#	2.4	14.6
2#	3.1	13.5
3#	3.4	20.5
4#	6.1	18.5
5#	3.5	18.1
6#	5.2	17.5

According to table 1 monitoring error comparison table, the arithmetic mean value of the proposed wireless monitoring remote control system and the greenhouse monitoring error of the conventional wireless monitoring remote control system is processed. The average monitoring error of conventional wireless remote control system is 17.12%. The proposed wireless remote control system has an average monitoring error of 3.95%. Compared with the conventional wireless remote control system, the proposed wireless remote control system reduced the monitoring error by 13.17%.

5.2. Control accuracy comparison

During the test, two different wireless monitoring and remote control systems were also used in the simulation environment to analyze the variation of control accuracy of the greenhouse. The comparison curve of the test results is shown in FIG. 6.

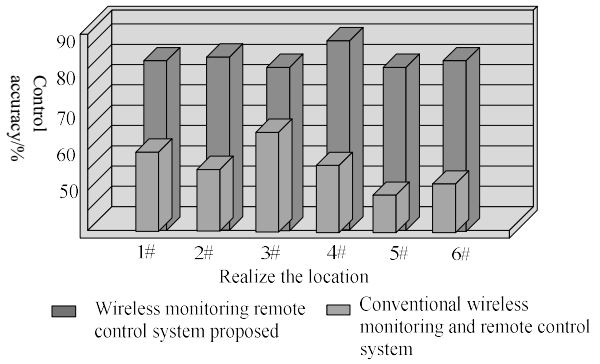

Figure 6. Control accuracy comparison chart

Fig.6 comparison of control accuracy, in which the abscissa is the number of test groups and the ordinate is the control accuracy, the arithmetic mean value of the proposed wireless monitoring and remote control system and the control precision of the conventional wireless monitoring and remote control system is processed. The control accuracy of the conventional wireless remote control system is 51.7%. The proposed wireless monitoring remote control system has a control accuracy of 87.3%. It is concluded that the proposed wireless monitoring and remote control system improves the control accuracy by 35.9% compared with the conventional wireless monitoring and remote control system. It is suitable for wireless monitoring and remote control of temperature and humidity collection in greenhouse.

6. Conclusions

In this paper, the design of wireless monitoring and remote control system for multi-point and multi-channel temperature and humidity acquisition in greenhouse is proposed. Relying on the structure design and component selection of wireless remote control system, as well as the hardware circuit design and software design of wireless remote control system, this paper realizes the research. Experimental data show that the wireless remote control system designed in this paper has high effectiveness. It is hoped that the research in this paper can provide theoretical basis for the wireless monitoring and remote control system.

7. Acknowledgment

2018125: Soft subject of Natural Science in Huaian City (Research on the factors affecting Information Technology Adoption of Retail Pharmacy in Huaian City)
201811049118X: Innovation Project of Jiangsu University students (Research and Development of traceability Management system based on Block chain Technology)

References

[1] Deng Weibin, Yang Can. Simulation Research on Temperature Optimization Control of Remote Indoor Air Conditioning[J]. Computer Simulation. 2016,33(8), 365-368.

[2] Chen Bangze, Yang Xiaobo. Simulation Research on Remote Optimal Control of Intelligent Home Indoor Temperature [J]. Computer Simulation. 2016,33(12), 286-290.

[3] Guan W. , Wang C. , Cai Y. , et al. Design and implementation of wireless monitoring network for temperature-humidity measurement[J]. Journal of Ambient Intelligence & Humanized Computing. 2016, 7(1), 131-138.

[4] Segura F. , Bartolucci V. , Andújar JM. Hardware/Software Data Acquisition System for Real Time Cell Temperature Monitoring in Air-Cooled Polymer Electrolyte Fuel Cells:[J]. Sensors. 2017, 17(7).

[5] Ling P . Based on the technology of ZigBee wireless greenhouse humidity monitoring system design and implementation[J]. Information Recording Materials, 2016.

[6] Jun B . Research and Design of Agricultural Production of Remote Monitoring System of Temperature and Humidity[J]. Journal of Agricultural Mechanization Research. 2016.

[7] Yang Jishou, Amp L.V. Temperature and Humidity Monitoring System for Base on IOT Technology[J]. Journal of Liuzhou Vocational & Technical College. 2016.

[8] Yang C., Wu ZhenJin, Yu Bencheng, et al. Design and Implementation of Wireless Temperature Monitoring and Alarm System for Cold Chain Logistics[J]. Computer Knowledge & Technology. 2018.

[9] Cai Jianhua, Xiong Rui, Huang Guoyu. Remote temperature and humidity monitoring system for flue-curing barn based on wireless transmission[J]. Tobacco Science & Technology. 2016, 49(11), 80-86.

[10] Duan Ping, Gao Xue, Zhu Zhihui. Research of greenhouse temperature and humidity remote monitoring system based on cloud service[J]. Modern Electronics Technique. 2018.