Design and implementation of temperature and humidity monitoring system for small cold storage of fruit and vegetable based on Arduino

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Abstract. At present, the utilization rate of small cold storage for fruit and vegetable in Yunnan is low, and it is necessary to carry out regional management of cold storage in order to save energy and improve the utilization rate. Because different fruits and vegetables need different refrigeration temperatures, so real-time temperature and humidity monitoring is particularly important. For meeting this requirement, this paper designs an arduino-based temperature and humidity monitoring system for small cold storage of fruit and vegetable. The system mainly includes hardware and software parts. Hardware component includes Arduino Mega2560, ESP8266, Zigbee, DHT11 temperature and humidity sensor, and OLED display and the software component includes the Arduino IDE, UartAssist serial debugging assistant, Lighting. Blinker. Finally, the whole system is tested, and the test results show that the system has the characteristics of remote viewing, high measuring accuracy and convenient use, and the system could meet the needs of temperature and humidity management for small cold storage.

1. Introduction
Yunnan is an important fruit and vegetable base in China, and its superior geographical environment is suitable for the growth of many vegetables and fruits. The suitable storage temperature and humidity of different fruits and vegetables are different. For example, the suitable storage temperature of apples is -1℃-5℃, and the humidity is 85-95%. Pomegranate is 3℃-5℃, relative humidity 85%-90%; Mango is 10℃-12℃, and the humidity is 95%-90%[1].According to the data of China Industry Information Network's cold storage demand forecast in 2020, the refrigerated rate of fruits and vegetables will reach 70% and continue to grow at a rate of 10% every year [2].

At present, there is a strong demand for cold storage in the multi-temperature area of small fruits and vegetables in Yunnan, but most researches on temperature and humidity monitoring system mainly focus on vegetable greenhouses [3-4], cold chain transportation [5]. Although the cold storage develops rapidly, the utilization rate of cold storage is low in many places. In order to save energy and improve the utilization rate, it is necessary to manage the cold storage in different areas. For meeting this requirement, this paper designs an arduino-based temperature and humidity acquisition system for small cold storage of fruit and vegetable, so as to solve the problem of real-time temperature and humidity monitoring in small cold storage.
2. Overall design of temperature and humidity acquisition system

The temperature and humidity acquisition system needs to meet the real-time monitoring of temperature and humidity, and can quickly query the temperature and humidity data at the mobile device terminal, and can store the historical data of temperature and humidity in the upper computer. Meanwhile, the system also satisfies the long-term stable, efficient and safe operation.

The hardware equipment used in this design includes Arduino base plate, temperature and humidity sensor, display screen, ZigBee wireless communication module, and serial port module. Arduino motherboard is the core of the system, controlling the work of each equipment. Temperature and humidity sensor is responsible for collecting the environment's temperature and humidity. The display screen directly displays the temperature and humidity collected by the temperature and humidity sensor. ZigBee wireless communication module connects each node to achieve real-time monitoring of each node. The serial port module is connected with the mobile APP, and uploads the temperature and humidity collected by the temperature and humidity sensor to the mobile APP(seeing Figure 1). The mobile APP is responsible for saving and displaying the current temperature and humidity, and displays the temperature and humidity change curve of each time period in combination with the historical temperature and humidity for analysis.

![Figure 1. Overall design scheme of the system](image)

3. Hardware and software design of temperature and humidity monitoring system

3.1. Hardware design

The hardware system, temperature and humidity monitoring system in multi-temperature area of cold storage, takes the Arduino MEGA2560 (Seeing Figure.2) and wifi module as an important part. The sub-control board uses the UNO substrate and the ZigBee module (Seeing Figure.3) to work together with the core unit, which reduces the design cost of the system and improves the data transmission rate between the main control board and sub-control board. The hardware part of the monitoring system mainly includes sensor unit circuit, display unit circuit, core unit and wireless network unit, including temperature and humidity sensor (Seeing Figure.4), wireless module (Seeing Figure.5), display screen (Seeing Figure.6) and baseplate and other components.

![Figure 2. Arduino MEGA2560](image)  
![Figure 3. ZigBee module](image)
3.2. Software design

All the programs in this design are written in the Arduino IDE environment, and the programming language is C language. The system is divided into temperature and humidity acquisition module, ZigBee wireless transmission module and OLED display module.

(1) Temperature and humidity acquisition module

The system selects one ESP8266DodeMCU module, one Arduino Mega2560 baseplate, one DHT11 temperature and humidity sensor, and dupont wires. VCC and GND of ESP8266DodeMCU module connect 3.3V and GND of Arduino Mega2560 baseplate, and D4 connected to the DATA of DHT11 temperature and humidity sensor, and the VCC, DATA and GND of THE DHT11 temperature and humidity sensor are connected with the 5V, Digital interface 2 and GND of the baseplate of Arduino Mega2560 using dupont wires. The system connects ESP8266 to the blinker mobile APP to transmit the temperature and humidity collected by the temperature and humidity sensor to the corresponding data stream in the Blinker mobile APP, so that the whole system can be remotely monitored.

(2) ZigBee wireless transmission module

This module includes four parts: Zigbee network communication between the main control board and the sub-control board; data transmission by the main control board connecting to the Internet through WIFI module; Function for monitoring display, real-time monitoring and display temperature and humidity data; the data collection.

(3) OLED display module

In this design, OLED display screen is used to display the temperature and humidity data collected by DHT11 digital temperature and humidity sensor. The circuit connection of DHT11, OLED and Arduino UNO base plate is shown in Figure 7. The circuit connection diagram of Arduino UNO, OLED and DHT11 is shown in Figure7.

4. System debugging and testing

Components of for hardware system assembly show as Figure 8.

The software system combines the three parts of the program and a one-time burn to the bottom plate. After debugging the program, the program can be verified. Compiling program of DHT11 is shown in Figure9. When clicking the serial port monitoring window, it proves that DHT11 is running normally (Seeing Figure10). Compiling program of ESP8266 is shown in Figure11.
Figure 7. Circuit connection diagram of Arduino UNO, OLED and DHT11

Figure 8. Hardware assembly diagram

Figure 9. Compiling program of DHT11
5. Conclusion

After testing, the whole monitoring system can run normally and achieve the expected function.

(1) Display unit test result

It can display the change of environment temperature and humidity in real time on the terminal display and output with digital signal. Where H refers to relative humidity; T is for temperature. The results are shown in Figure 8.
(2) Temperature and humidity remote monitoring results

The data collected by the temperature and humidity sensor can be sent to the main control board through ZigBee. The WIFI module on the main control board can package the data and upload it to the Internet of Things platform, and the temperature and humidity changes can be monitored in real time on the mobile phone. At the same time, the temperature curve and humidity curve produced according to the historical data can be viewed on the mobile phone. The test results of one-week temperature change are shown in Figure 12.

This system realizes the wireless monitoring of temperature and humidity of small cold storage through Zigbee technology. This system improves the degree of automation and reduces the cost of system development, maintenance and later upgrade.

![Figure 12. Display results of the lighting APP](image-url)

**Acknowledgements**

This work was supported by the Opening Fund of Key Lab of Process Analysis and Control of Sichuan Universities of China (2017001)

**References**

[1] Jiao Yan, Zhang Yan, Li Bao-guo, Hua Ze-zhao. Study on the influence of temperature and humidity changes on the storage quality of fruits and vegetables in refrigerators [J]. Low Temperature and Specialty Gases, 2001(06):18-21+30.

[2] Xin Xiu-rui, Niu Ji-kai, Bai Xin-yuan, Pan Chen-guang. Development Status of cold storage and Energy Saving and Environmental Protection [J]. Journal of Appliance Science & Technology, 2018(03):22-23.

[3] Zhang Li-ting, Yang Xi-wei. Automatic control system design of temperature and humidity for vegetable greenhouses based on Single Chip Microcomputer [J]. Wireless Internet Technology, 2016,15(24):41-42.

[4] Chen Peng. Design and research of temperature and humidity monitoring system for Vegetable Greenhouses [J]. Industrial Instrumentation and Automation ,2018(02):127-129+132.

[5] Yao Jun, Geng Xin-li, Zhang He-yun, etc.. Temperature and humidity monitoring of cold chain logistics system and fresh-keeping Control of Xinjiang Hami melon[J]. Jiangsu Agricultural Sciences, 2015,46(15):158-161.