International Journal of Science and Engineering Applications
Volume 13-Issue 10, 01 – 04, 2024, ISSN:- 2319 - 7560
DOI: 10.7753/IJSEA1310.1001

Design of the Ultrasonic Ranging System based on the Internet of Things

Wen-Qiang Huang
School of Electronic Information and Electrical Engineering
Yangtze University
Jingzhou, China

Shi-ping sun
School of Electronic Information and Electrical Engineering
Yangtze University
Jingzhou, China

Abstract: This paper introduces an ultrasonic ranging system based on the Internet of Things, which uses STM32F407ZGT6 as the main control chip, uses HC-SR 04 ultrasonic sensor for distance measurement, DHT 11 temperature and humidity sensor monitors the environmental temperature and humidity, and communicates with Ali Cloud Internet of Things platform through ESP8266 Wi-Fi module. The system design aims to provide a low-cost and efficient real-time monitoring and remote control of environmental data, which is suitable for intelligent home, industrial automation, environmental monitoring and other application scenarios.

Keywords: STM 32; ultrasonic; temperature and humidity; ESP8266; Internet of Things

1. INTRODUCTON

The Internet of Things technology improves efficiency and intelligent decision-making capabilities by connecting sensors, devices, machines, and so on to the Internet, enabling data collection, exchange, and analysis. In the field of environmental monitoring, ultrasonic ranging technology is widely used because of its high precision and non-contact measurement characteristics[1]. Combined with temperature and humidity monitoring, it can provide comprehensive data support for environmental control. The system designed in this paper integrates HC-SR 04 and DHT 11 sensors to provide users with real-time environmental monitoring data[2].

2. SYSTEM DESIGN

The system design consists of hardware and software, which mainly includes the main control chip STM32F407ZET6, ultrasonic ranging detection module, temperature and humidity detection module, WIFI communication module, etc. The software section includes the ultrasonic ranging program, the temperature and humidity detection program, and the WIFI communication program. The block diagram of the overall system design is shown in Figure 1. The microcontroller sends the control signal, controls the ultrasonic module to transmit the ultrasonic signal, then the timer starts the timing; when the ultrasonic receiver receives the ultrasonic signal, the time is recorded as t, then the software program processes and corrects the data, and finally the output distance data is transmitted to Ali through WIFI wireless communication for real-time distance display.

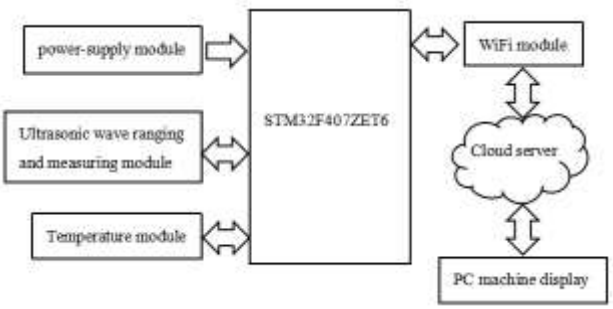

Figure 1. Block diagram of the system design

3. SYSTEM HARDWARE DASIGN

3.1 Main control unit

The main control chip of the system hardware is STM32F407ZGT6, the working frequency is 168 MHz, with high-speed processing capability and rich peripheral interface, convenient to connect with ultrasonic ranging module, temperature measurement module and communication module;

compared with other CM, it can meet the requirements for real-time and speed, and is suitable for the main control unit of the system [3].

3.2 Ultrasonic ranging

HC-SR 04 ultrasonic ranging module is designed. HC-SR 04 ultrasonic sensor measures the distance by transmitting ultrasonic wave and receiving reflected wave. Working principle: When the main control unit sends a pulse signal to the module Trig pin, the system will emit eight 40 KHz ultrasonic pulses, and then detect the echo signal. When the signal is detected, it is output through the Echo pin[4]. We can calculate the distance values based on the duration of the Echo output high level. The formula is: distance = high level time sound speed / 2. The timing diagram is shown in Figure 2.

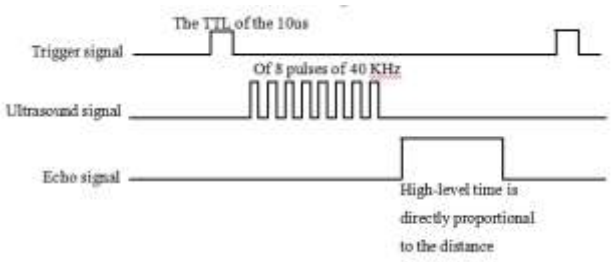

Figure 2 The timing diagram of ultrasonic ranging

3.3 Temperature and humidity detection

DHT 11 temperature and humidity sensor is a new temperature and humidity composite sensor with digital signal output. Its temperature measurement range is 0~50℃ and the error is ± 2℃; the humidity measurement range is 20 ~ 90% RH and the error is ± 5% RH. Sensors include NTC temperature measuring elements, resistance wet sensing elements, SCM, etc., which collects temperature and humidity in real time, and is stored in internal memory after AD conversion, and the data exchange and control in the system can be completed only through one data line. When using, it only needs to connect the DATA pin to an I / O of the MCU through a 5 K resistance, and the power supply voltage of DHT 11 is 3~5.5 . Through real-time detection of temperature, the speed of sound can be inferred to make temperature compensation for ultrasonic sounding[5][6].

3.4 ESP8266 Wireless communication

ESP8266 Is a low-cost, with complete Wi-Fi network function, the required power supply voltage of 3.3~5 V. ESP8266 The chip has built-in 32-bit processor, 80 MHz and 160 MHz frequency support, and integrated CP2101 chip to provide reliable USB to UART function, easy data transmission and programming with the computer. The transmission function of wireless transmission can transmit data and data through the AT command control module of serial port and save it. The functions in the system mainly include data transmission and remote display. In this system, ESP8266 module and STM 32 are connected by serial port, and the initialization of WiFi module is configured with serial port sending AT instruction. When the cloud data is parsed, the data will be sent to the microcontroller through the serial port[7]. SCM will send the real-time distance, temperature and humidity data to EP8266 through the serial port. After successful analysis, ESP8266 will upload the data to Ali Cloud Internet of Things, and the real-time data can be seen in the PC operation interface.

4. SOFTWARE DESIGN

4.1 Ultrasonic procedure design

First, the required measurement distance can be calculated by transmitting the ultrasonic wave at the ultrasonic transmitting end and detecting the time that the receiver receives the ultrasonic wave. The ultrasonic ranging process is shown in Figure Figure 3.

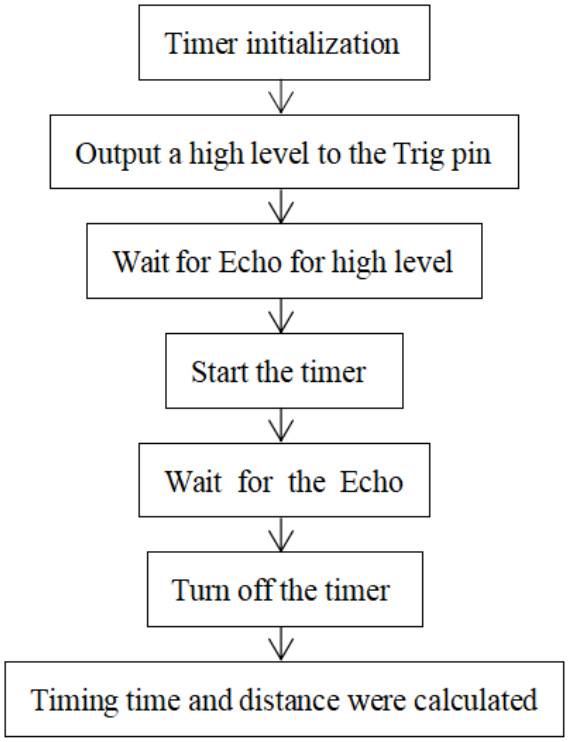

Figure 3 Flow block diagram of ultrasonic ranging

4.2 Temperature measurement design

Connect to the MCU PG 9 port through the data pin of the DHT

11 module. First, PG 9 outputs a low level of 20ms for the output mode, and then PG 9 outputs a high level of 30us. Change PG 9 to the input mode, DHT 11 will send a response signal, and then send data to the microcontroller, with a complete data transmission of 40bit. The checkbit is used to determine whether the transmitted data is correct. If the data is correct, then the checksum data is equal to the last 8 bits of the addition result of the first four data.

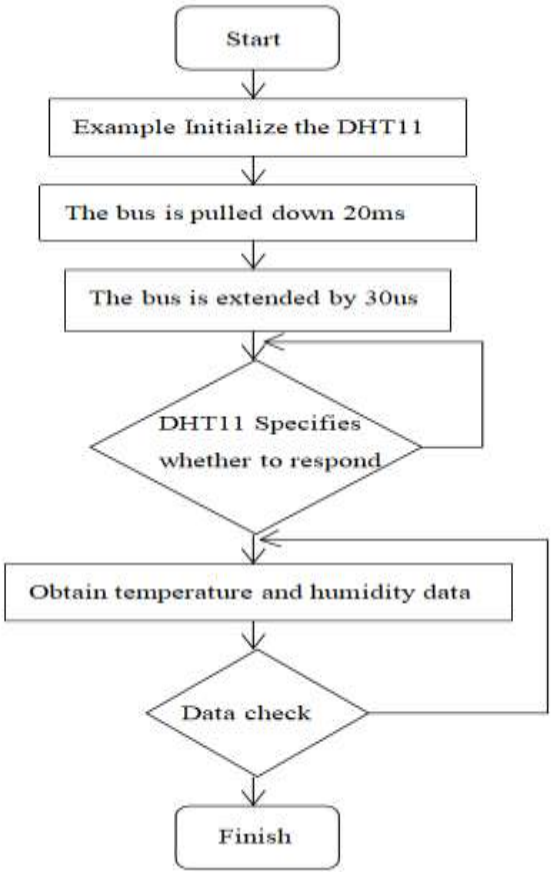

Figure 4 Flowchart of temperature and humidity programming

4.3 Wireless communication programming

In order to realize the remote interaction between the data communication module and the cloud platform, the system ensures the information exchange between the system and the cloud platform by using the connection with the ESP8266 module and using the MQTT protocol, including the establishment of TCP connection and data transmission and receiving operations[8]. The ESP8266 module needs to be initialized through serial communication before entering the transtransmission mode. The initialization process begins by sending the AT + RST instruction that is used to reset the ESP8266 module. Before data transmission, the ESP8266 WiFi module must be connected to the wireless network. This can be achieved by sending the AT + CWJAP instruction to connect to the specified WiFi network. Once the network connection is established, the AT + CIPSTART instruction can be used to create the TCP connections. Subsequently, the data is sent via the AT + CIPSEND instruction. When the data is successfully sent, the module will return the "SEND OK" response, indicating that the data transmission is complete, and then you can continue to use the AT + CIPSEND instruction to send more data.

Figure 5 Physical diagram of the esp8266 module

5. System test and operation results

The system hardware assembly, power system, WIFI module will connect ali cloud, all kinds of sensors began to work and get all kinds of data, and through the single chip microcomputer data analysis, calculate the accurate distance, and then open the ali cloud Internet configuration product ID, device name, equipment function, through ESP8266WIFI module data upload to the cloud server, and through the ali cloud Internet of things platform for real-time data display. Remote monitoring and control are realized. The interface of Ali Cloud platform is shown in the figure.

Figure 6 Cloud platform display interface

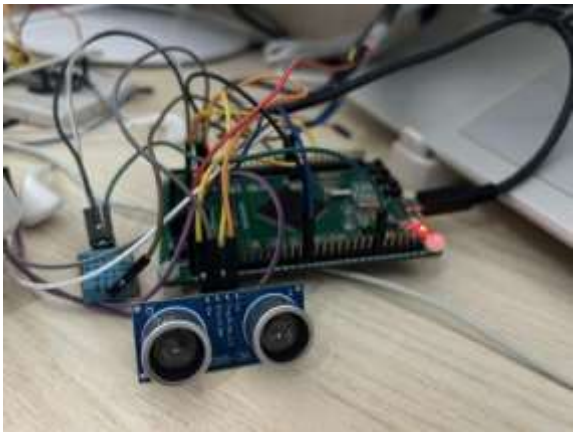

Figure 7. Physical picture of the system

6. CONCLUSION

This paper studies an IoT-based system capable of acquiring temperature and distance in real time. The system can collect the temperature and distance data in real time, and upload the data to the Ali Cloud server through the wireless communication module, and then display the data in real time through the Ali Cloud Internet of Things platform. After many debugging and testing, the system operation is reliable, strong scalability. A variety of sensors can be added to obtain data, and the remote monitoring and control of devices can be realized through the cloud platform, which can be widely used in various scenarios.

7. REFERENCES

[1] Zhao Jie. Smart Home System Design based on the Internet of Things technology [J]. Toy World, 2024, (07): 169-171.

[2] Xing Lingling. Design of automatic parking control system based on microcontroller [J]. Electronic production, 2021, (17): 31-35.

[3] He Liyuan. Design and implementation of an embedded smart home control system [J]. Electronics Production, 2024,32 (04): 44-48.

[4] Su Lin. Design of an ultrasonic rangefinder based on HC-SR 04 [J]. Science and Technology Information, 2012, (09): 125 + 124.

[5] Li Zhiwei, Dong Wei, Huang Shuangcheng. Design of agricultural greenhouse temperature and humidity monitoring system based on DHT 11 [J]. Industrial instrumentation and automation devices, 2021, (01): 39-43.

[6] Tao Feifang. Design of ultrasonic ranging system based on temperature and humidity compensation [J]. Electronic production, 2024,32 (16): 83-85 + 79.

[7] Chang Xin, Wang Qi. Extensible Iot system implemented with STM 32 and ESP8266 [J]. SCM and embedded system application, 2018,18 (12): 58-61.

[8] Cao Zhenmin, Chen Nian, Ma Qiang, et al. Wireless control circuit design based on ESP8266 [J]. Industrial Control Computer, 2017,30 (01): 68-69.