An intelligent home security system based on STM32

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Abstract

Based on STM32F103C8T6 host control chip, this paper completes the design and development of an intelligent home security system combined with various hardware modules, cloud server and android app. The system integrates OLED display screen, buzzer, human infrared, Wifi and other modules. The serial port is connected with ZigBee coordinator. The terminal equipment with temperature, humidity and smoke sensors is adopted to monitor the environment, and the relays and stepping motors are designed to control the equipment at home by simulation. The access control system takes STC89C52 as the core, and integrates the functions of photographing module and steering gear simulation door opening. Android app uses socket technology to complete remote data communication through Alibaba cloud server and indoor security system. After testing, the system runs stably and has good performance.

Keywords: Smart home, Security, STM32,Zigbee, Wifi

1. Introduction

In recent years, smart home has developed rapidly. As an important part of smart home, smart home security is related to the safety of users' lives and property. Smart home security system can remotely monitor the home environment, accurately detect gas leakage, fire and other dangerous situations, and timely notify users through mobile app to strengthen the protection of users' lives and property. In addition, the access control system needs password to open the door, and the photographing function can take pictures when there are people in front of the door and save them to the memory card. The design of android app allows users to access the home security system by installing only one software, which greatly improves the convenience.

2. Overall system design

The overall design block diagram of smart home security system is shown in Fig. 1., which is composed of android app, server, indoor security system and access control security. The design of each part is as follows:

(1) This design uses Alibaba cloud server as the message transfer station of smart home security system to realize the connection between app and home security system in the wide area network. The main function is data forwarding.

(2) Users can remotely control their home devices and view their home conditions by operating the UI controls on the app. When an abnormal situation happens at home, app can send a warning notice to users.

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(3) The indoor security system uses Zigbee to realize home networking. The kitchen node monitors the home environment through temperature and humidity sensors and smoke sensors, and sends the monitoring data to the coordinator; The bedroom node controls the stepper motor and relay. STM32 displays the relevant information on the OLED display screen and monitors whether there are people at home.

(4) The access control system is designed with password lock and automatic photographing function.

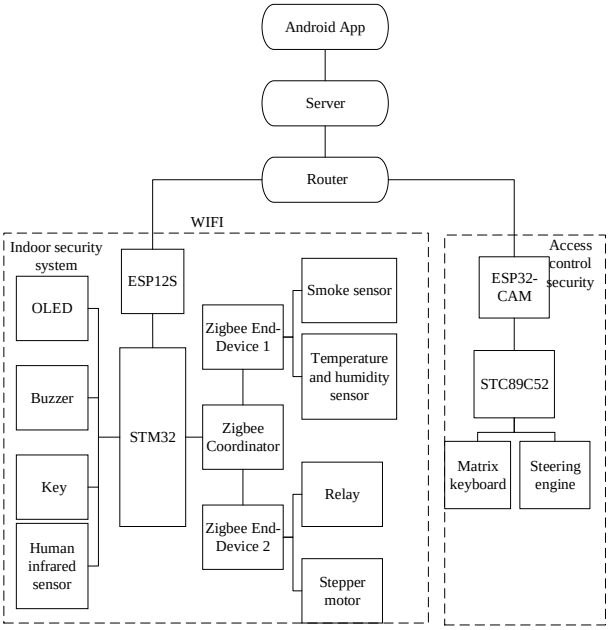

Fig. 1. The overall design block diagram of smart home security system

3. System hardware design

3.1. *Host Module*

The system needs a model that needs to be connected to human infrared sensor, OLED display, independent key, buzzer and other modules, and also to Zigbee coordinator. It needs to use multiple serial ports, IIC interfaces and multiple GPIO ports. Therefore, host module needs to be selected that its performance can meet the demand. In addition, low price and strong compatibility are also factors to be considered. Considering all aspects, the system uses STM32F103C8T6 as the host control chip.

3.2. *Communications module*

The wireless data communication scheme in this system is completed by Zigbee and Wifi. As the communication technology of indoor security system, Zigbee is mainly responsible for transmitting control commands and data collected by sensors. Wifi mainly provides external network access for the home security system, so that the system can transmit data with the cloud server.

3.3. *Various sensors*

The function of monitoring the home environment is realized through various sensors.

3.3.1. *Smoke monitoring module*

The system uses MQ-2 as the smoke monitoring module. The module converts the collected voltage analog signal into digital signal, and then converts it into combustible gas concentration according to formula[1] (1).

$$Rs/R0 = 11.5428 \times ppm^{(-0.6549)} \quad (1)$$

Where RS represents the current resistance value of the sensor, and R0 is the resistance value of the sensor in clean air.

3.3.2. *Intrusion monitoring module*

The system selects HC-SR501 to realize intrusion monitoring in home mode. The module can be placed at the porch to monitor intrusion. The working principle of HC-SR501 is to use infrared radiation. If the human body is detected, the sensor can generate a signal[2].

3.3.3. *water leakage monitoring module*

The system selects the raindrop sensor module to realize water leakage monitoring. The raindrop sensor is placed in places prone to water leakage such as kitchen and toilet. The sensor module has four pins, namely VCC, GND, DO and AC. DO is the digital signal output. The output high and low levels indicate whether there is water on the sensor surface.

3.3.4. *temperature and humidity monitoring module*

The system selects DHT11 temperature and humidity sensor to measure temperature and humidity. The sensor integrates temperature and humidity sensor elements, occupies less IO resources, and can read data with only one line. And the output is a digital signal with high accuracy[4].

3.4. *access control sub-system*

The access control system uses STC89C52 as the control core and uses the minimum system board to connect ESP32-CAM, HC-SR501, matrix keyboard and SG90 steering gear.

The system needs to capture the situation outside the door and save them. Therefore, the system selects ESP32-CAM as the access control camera module. ESP32-CAM uses serial port to receive data, connect OV2640 camera to take pictures, and insert SD card to store information. When the human body infrared sensor detects a person, it controls the camera to take pictures and save them.

4. System software design

4.1. *STM32*

The STM32 program flowchart is shown in Fig.2. After the STM32 is powered on, it first tests the relevant hardware such as OLED, keypad, LED and serial port, initializes the WIFI module, and then calls the function to send the AT instruction to the ESP-12SWIFI module through the serial port 3, so that it connects to the WIFI hotspot named Tom. After that, the single connection mode is set up to connect the Ali cloud server according to the server's external network address and port.Then judge whether it is home mode, and then process the data sent by the server and Zigbee. Since STM32 serial port 1 is connected to Zigbee coordinator and serial port 3 is connected to ESP-12S Wifi module, it needs to be handled separately.

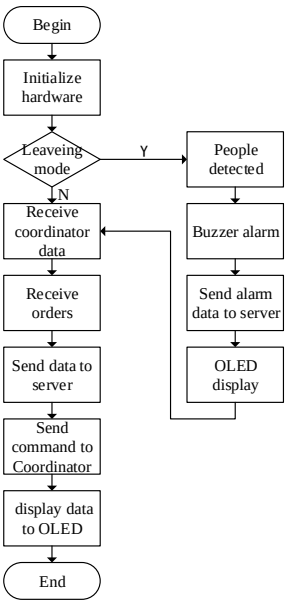

Fig. 2. The flow chart of STM32

4.2. *App*

App is initialized first and displayed on the interface after receiving the data. After receiving the alarm information, the app will be notified. You can also control home appliances through buttons. The App program flowchart is shown in Fig.3.

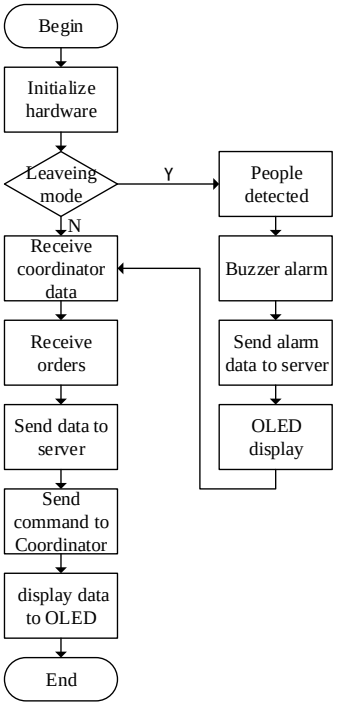

Fig. 3. The flow chart of App

4.3. *Zigbee*

After acquiring the environmental information data such as temperature, humidity and smoke, the terminal will call the data transmission function AF_ Datarequest(), you can set the sending mode to unicast, target address 0x00, target endpoint and cluster, and then send the data to the coordinator. The coordinator sends it to STM32 through the serial port.

4.4. *Server*

The server uses Python to write the socket server. In the initialization function init(), the socket object is first established in the function.Then the socket object is bound to the address that is the private address of the server. Every time a client connects to the server, a new thread will be opened to accept the new connection. When data is received, it will be forwarded to another terminal.

4.5. *Access control system*

The access control system monitors whether there are people outside the door through infrared sensors, and others control ESP32-CAM to take photos. Enter the password through the matrix keyboard, and if it is correct, System will control the steering gear to open the door. The access control system program flowchart is shown in Fig.4.

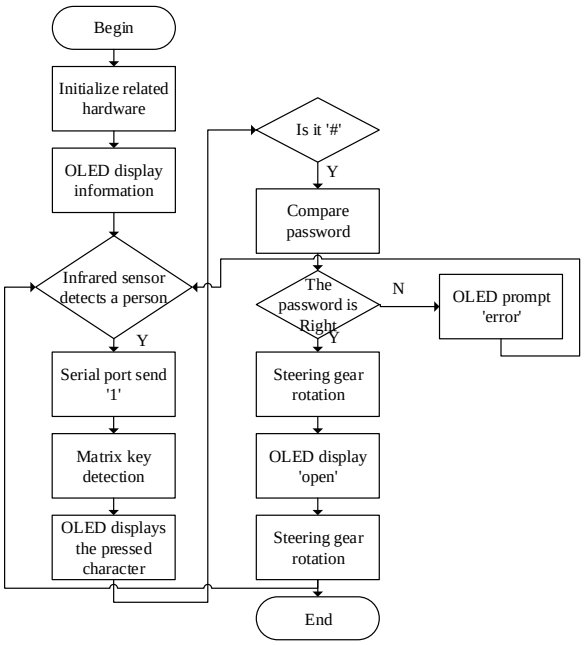

Fig. 4. The flow chart of access control system

5. System test

The appearance of the system is shown in the Fig.5. Start and build Zigbee wireless sensor network, preset Wifi hotspots, and connect open source hardware to the external network;

After that, open source hardware pushes various sensor data to Alibaba cloud platform through Wifi to realize real-time monitoring of home environment. Users can receive and process equipment management and alarm information through mobile app. For example, in case of flame, combustible gas detection or abnormal temperature and humidity, the system will push it to app for alarm.

App can display home environment information in real time, and can also control home devices through buttons. The app interface is shown in the Fig.6.

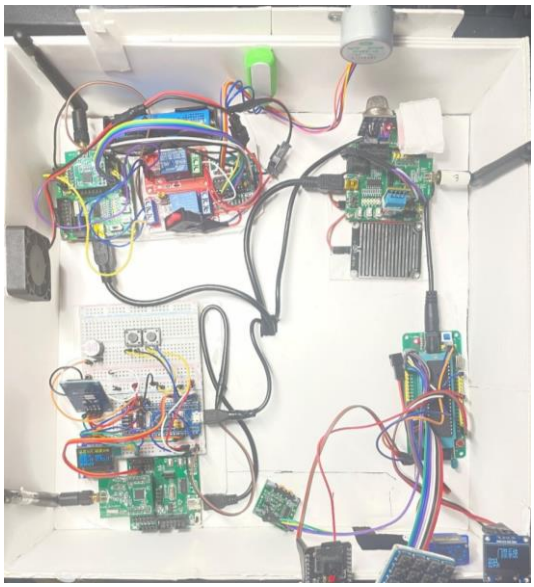

Fig. 5. The appearance of system

Fig. 6. The interface of App

The access control system has accurate password input and sensitive photography.

6. Conclusion

According to the long-term test,the intelligent home security system can monitor all kinds of sensor data in real time and upload them to the cloud platform of the Internet of things accurately and stably. Users can obtain home environment data through app to realize accurate monitoring and early warning. The system has the advantages of simple construction, convenient data query and strong scalability; It is not only applicable to the monitoring and management of home environment, but also can be used in office areas, venues and other fields.

The follow-up work focuses on the following two aspects: (1) strengthening the monitoring and early warning research on smart environment application scenarios;(2) studying artificial intelligence algorithm for the secondary development of the Internet of things cloud platform.

References

1. Trisnawan, I. K. N., Jati, A. N. , Istiqomah, N.et al., Detection of Gas Leaks Using The MQ-2 Gas Sensor on the Autonomous Mobile Sensor. *2019 International Conference on Computer, Control, Informatics and its Applications (IC3INA)*,2019,pp.177-180.
2. Y. Lihong,W. Jianxin, The Design of Intelligent Automatic-Door Based on AT89S52,*2016 International Conference on Robots & Intelligent System (ICRIS)*, 2016,pp. 428-431.
3. G. M. Debele and X. Qian, Automatic Room Temperature Control System Using Arduino UNO R3 and DHT11 Sensor, *2020 17th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP)*, 2020, pp. 428-432.

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