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STM32-based voice smart trash can

Bai Fenglin[1], Jiang Weibo[2]
Pingdingshan University

Abstract: *With the development of society and technology, in view of the increasingly serious environmental pollution and misclassification of garbage, this paper designs a voice intelligent trash can system developed by STM32 microcontroller, which combines voice broadcasting, motor drive, OLED screen display, voice recognition and button module to realize the functions of garbage delivery and automatic classification. The user activates the system through the wake-up word, speaks voice commands according to the type of garbage, and the system recognizes and opens the corresponding trash can, and broadcasts the garbage type. The button can also control the switch of the bucket, and the system has high stability, improving the efficiency and accuracy of garbage sorting management, and promoting a green and environmentally friendly lifestyle.*

Keywords: Smart trash can, STM32, Speech recognition, Automatic classification

I. INTRODUCTION

Garbage pollution is one of the environmental problems that urgently needs to be solved globally, and with the acceleration of urbanization, garbage production is increasing. Garbage contains a large amount of recyclable resources, such as paper, plastic, etc., and its effective use can reduce resource extraction and energy consumption. Traditional waste disposal methods are difficult to meet the demand, and garbage classification and management have become an inevitable choice. Smart trash cans can save energy and reduce consumption, promote scientific and technological innovation, and bring more benefits to society [1]. At home and abroad, smart trash cans have also attracted much attention. For example, in some areas of San Francisco and Chicago in the United States, smart trash cans called "Big Belly" have been widely used [2].

The development of smart trash can hardware technology mainly includes sensor technology, image recognition technology, RFID technology, communication technology, etc. Various technologies can be used to realize the information exchange between offline trash can data and cloud garbage operating system through the Internet and cloud computing platforms. Smart trash can software technology mainly includes data analysis, intelligent algorithms, garbage classification rule bases, etc. [3].

II. THE OVERALL DESIGN SCHEME OF THE SYSTEM

2.1 Functional requirements analysis

The purpose of this design is to design a voice intelligent trash can suitable for multiple scenarios, low cost, high feasibility, low power consumption, and long life to help people sort garbage, and the required functions are as follows:

1. Wake-up function. The function is realized by waking up the trash can with a specific voice, avoiding the trash can self-starting in a noisy environment, thereby reducing power consumption.

2. Speech recognition function. After waking up the trash can, you can open the lid of the "hazardous garbage" through a specific voice command, such as "battery".

3. Display function. Real-time detection of the opening and closing of the trash can and display it on the OLED screen.

4. Voice broadcast function. After identifying a specific voice command, the voice broadcasts the corresponding type of garbage, such as "hazardous garbage".

5. Button control function. Users can also open the corresponding trash can with the press of a button.

2.2 Overall scheme design

The control management system of this design supplies power to each module of the system through the 5V voltage provided by the power supply, STM32F103C8T6 as the core control system, through the voice recognition module LD3320

to recognize the audio signal to the smallest system, the OLED screen displays the corresponding information, and at the same time drives the servo to run, and at the same time can also control the servo through the button module.

III. MODULE SELECTION AND HARDWARE DESIGN SCHEME

3.1 Microcontroller module

This design uses a STM32F103C8T6 minimum core board as the microcontroller module, which has a variety of advantages and rich functional features [4]. The voltage range required by the microcontroller is 2~3.6V, and the system inputs 5V voltage through the USB port and then the voltage is reduced to 3.3V by the U2AMS117 chip, and the applicable temperature is -40~85°C, which has a wide range of application and stable performance. The number of IO ports of this microcontroller is moderate, and it can meet the needs of this system well under reasonable deployment and design. The chip pin diagram is shown in Figure 3-1.

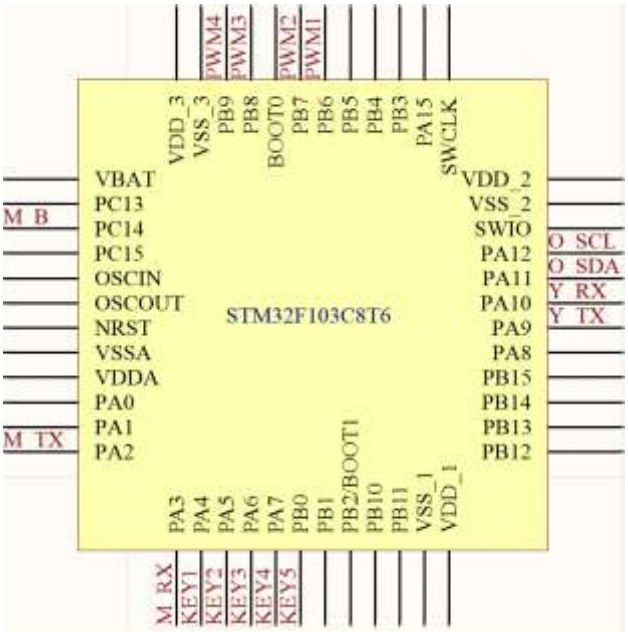

Figure 3-1 STM32F103C8T6 chip pin diagram

3.2 Speech recognition module

LD3320 is a speech recognition chip with a dual-core structure, one of which is used for audio processing and the other for speech recognition processing. Through this hierarchical architecture design, the complexity and power consumption of the entire system can be effectively reduced, and the operational efficiency and recognition accuracy of the system can be improved [5]. The built-in STC10L08X chip can control multiple signals of the LD3320 through the GPIO port to meet the needs of different applications [6]. The control of the signal can be achieved through STC10L08X program code STC10L08X and voice control and corresponding functions can be achieved through serial port communication with STM32 core modules. The speech recognition module and interface circuit are shown in Figure 3-2.

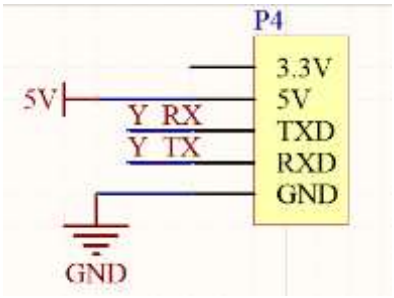

Figure 3-2 Speech recognition module

3.3 Voice broadcast module

The JQ8900-16P chip is a SOC solution that integrates MCU and audio decoder, which is suitable for audio processing applications such as voice broadcasting, which can eliminate tedious hardware circuit design work [7], and uses hard decoding to ensure the stability and sound quality of the system. For users, the system supports repeating at a specified time period and can achieve 30 levels of volume adjustment, which is conducive to better transmitting information to users [8]. The IO1~IO7 of its 16 pins are ground-trigger inputs, which can be used to trigger control recording.The audio broadcast module and interface circuit are shown in Figure 3-3.

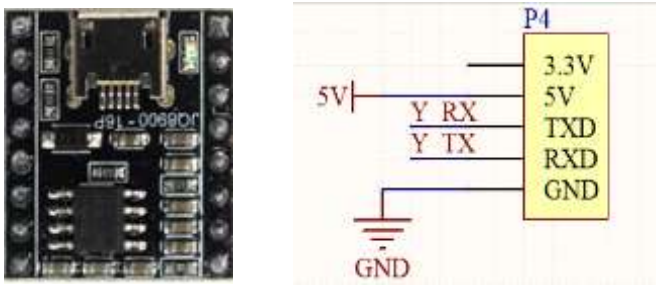

Figure 3-3 Voice broadcast module

3.4 Motor drive module

Designed to control the trash can lid using the SG90 servo. The servo controls the rotation angle and position by receiving PWM signals, where the length of the pulse width directly affects the position and angle of the steering disk. When the PWM signal enters the servo, it will go through processing steps such as demodulation and filtering to generate a DC bias voltage, which is compared with the reference voltage inside the servo to obtain the output voltage difference. This voltage difference is amplified and used to drive the chip, which determines the forward and reverse direction and angle of the servo [9], and for the application in this design, the SG90 servo can be securely attached to the trash can with hot melt adhesive. Thus, the purpose of using the SG90 servo to control the garbage can lid [10], and to complete its control and operation by controlling the operation of the servo [11].

The entire board is powered by a voltage of 5 V, where the servo power supply is directly connected to the main power supply, and the servo signal wire is connected to the PWM pin of the MCU [12]. The control of the servo requires an MCU to generate a pulse signal with a period of 20 ms, and the high level maintenance time of the signal is between 0.5 ms and 2.5 ms, and different high level durations correspond to different servo rotation angles [13]. The SG90 is an analog servo, and the MCU needs to constantly send signals at the corresponding angle to rotate it to the specified position. The servo and interface circuit diagram is shown in Figure 3-4.

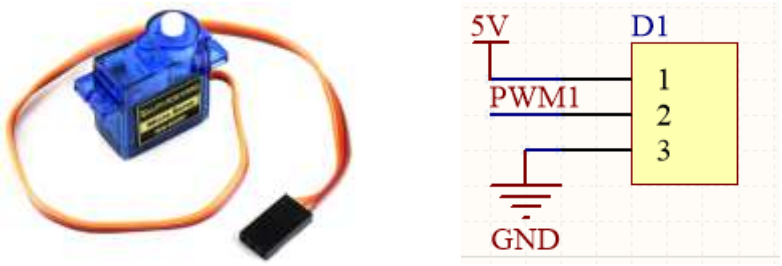

Figure 3-4 Motor drive module

3.5 Key Module

In this design, a touch button is used, and a structure with independent buttons is adopted. The advantage is that each button occupies an I/O port independently, avoiding the interference problem when pressing multiple buttons at the same time, and can achieve precise control and response to different buttons.

The key control circuit is mainly composed of pull-up resistors and buttons, and can be driven by the microcontroller in two ways: voice mode mode and manual mode. In manual mode, the microcontroller judges the pressing of different buttons through the input of the IO port, and then outputs different levels to drive the servo to switch the trash can lid.

3.6 Display Module

The design uses a 0.96-inch OLED display with a font (GT20L16S1Y Chinese character library chip) [14], which is easy to operate because it has its own coding table, which can be called up and displayed on the screen using ASCII code (Chinese Simplified encoding) when writing software programs to control it. The circuit diagram of the OLED display module and interface is shown in Figure 3-5.

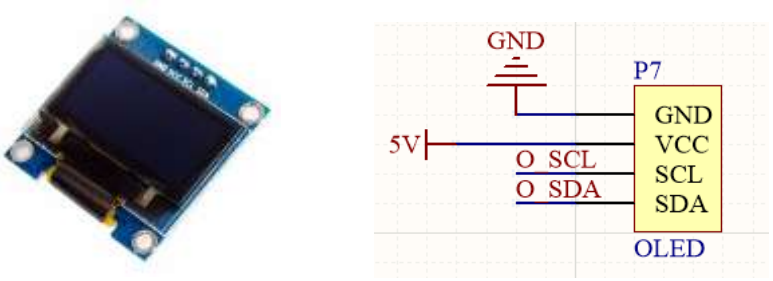

Figure 3-5 OLED display module

IV. Design and Implementation of Smart Trash Can Software

4.1 System software design process analysis

The system program is divided into four parts, namely voice recognition, motor drive, OLED and button modules, the whole system is powered by an external 5V power supply, each module is initialized after powering on, and the system runs for a cycle after the voice recognition module recognizes the wake-up word.

4.2 Subprogram design of voice broadcast module

This design uses the JQ8900 voice module, and the MP3 file needs to be named in the form of 01, 02, 03, etc. Set the voice file to be played and write it to Flash memory. In the main program, the MCU receives a voice signal or presses a button, and then calls the MP3_Star (u32 Number) function to play the corresponding audio. Number is the number of the audio file.

4.3 Whole machine test

Install each module on the board, connect the programming program to a 5V power supply, and complete the initialization of the system after reset. Detect the audio signal, the OLED screen displays the trash can switch status in real time, and after the test detects the audio signal or the corresponding button is pressed, the servo can be driven to accurately open the corresponding trash can, and the corresponding garbage type is broadcast by voice.

V. Conclusion

This design takes STM32 microcontroller as the control core, and designs an intelligent garbage classification control system based on voice recognition, which can realize intelligent and voice-based management of trash cans. The designed system is installed on the garbage container, which can collect speech, extract the keywords in the voice information through spectrum analysis and compare them with the keywords stored in the LD3320 chip, and issue corresponding control commands according to the comparison results to carry out voice broadcasting and trash can intelligent switch cover. At the same time, the trash can also has the function of automatically closing and displaying on the OLED screen, as well as the function of manually pressing a button to open the lid of the corresponding trash can. The entire system integrates various technologies such as voice recognition technology, mechanical control technology, and display technology to achieve smarter and more efficient waste sorting and treatment.

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