A Design of Intelligent Garbage Bin System

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Abstract: Garbage classification is more and more significant recent years. In order to promote the implementation of garbage classification and the improvement of intellectualization of urban sanitation work, a new type of intelligent garbage bin system is designed, which includes the bottom control part, android app and IOT cloud platform. Firstly, the system controls the inlets of intelligent garbage bin through interaction with android app, which realizes the function of ordinary garbage can. On top of that, the bottom control part collects all kinds of data of garbage bin by using some external sensors. And then the data will be reported to Android and Android will report that to cloud platform. Cloud platform server then transmits data to monitoring platform, which facilitates data statistics and the removing of garbage. By deploying the system, garbage classification can be promoted and the status of garbage can be effectively monitored, which will significantly improve garbage recovery efficiency and sanitation work level.

1. Introduction
With the rapid development of economy, the total amount of municipal solid waste is increasing year by year. From 2001 to 2019, it has increased by 59.7%, from 134.7 million tons to 215.21 million tons. People consume a lot of resources and expand production. They consume a lot and produce more waste, which makes contemporary society pay more and more attention to sustainable development of resources. Effective waste treatment can not only make our living environment better, but also promote the recycling of resources. Therefore, waste classification is imperative.

This paper designs an intelligent garbage can system, which not only has the function of traditional garbage can, but also makes up for the shortcomings of some intelligent garbage cans by endowing the garbage can with more functions. It will improve the work efficiency of sanitation workers and promote the sustainable development of resources, which has great economic and social benefits.

2. System design architecture
A complete intelligent trash can system includes four parts: bottom control part, android app, server and monitoring platform. The system framework is shown in Figure 1.
The bottom control part realizes functions like controlling motors to open and close nlets, weighing garbage, alarming for overflow, lighting with lamps and so on. Android and the bottom layer interact to control the whole garbage bin. People can log in and unlock the garbage bin through various ways. When residents drop garbage, the garbage classification is encouraged by adding corresponding environmental protection currency to the corresponding account according to the garbage weight. When receiving alarm information, Android will send it to cloud platform of the Internet of things. The cloud platform will connect devices to Internet and transmit the alarm information to the monitoring platform when receiving Android data stream. The monitoring platform visualizes the data and warns the abnormal information, which facilitates the timely conduct of environmental sanitation work.

3. Hardware design of the system
The hardware of the system is mainly composed of STM32F103 microprocessor, power module, 4-way motor module, 4-way weighing module, 4-way input event processing module, serial port module and 4-way lamp group module. The system hardware block diagram is shown in Figure 2. Following will introduce motor module and weighing module in details.

3.1. STM32 microprocessor selection
The bottom control part uses STM32F103 microprocessor. As an embedded ARM processor, it owns lots of advantages like providing a low-cost platform, reduced number of pins, reduced system power consumption, excellent computing performance and advanced interrupt response system. Abundant on-chip resources make STM32F103 microprocessor shows great development potential in many fields, such as motor drive, real-time control, handheld devices, PC game peripherals and air conditioning system.

3.2. Motor module
The motor module uses rz7889 bidirectional DC motor driver chip. The single motor drive circuit is shown in Figure 3. No.1 and No.2 pins of the chip are input pins, which are connected with the main control chip. No.5. and No.6 pins combined with No.7 and No.8 pins constitute two output pins, which are connected to a 2p connector and then connected with the external motor. The driving process is as follows: the two input pins of rz7889 chip which are connected to the main control chip output 3.3V or -3.3V to control the two output pins of rz7889 chip output 12V or -12V to drive the external motor.
forward, backward and brake. The motor status corresponding table is shown in Table 1, where h and l correspond to high level and low level respectively.

![Figure 3. Circuit of motor drive circuit](image)

Table 1. Corresponding table of motor status

| No.1 pin input | No.2 pin output | No.5 and No.6 pin output | No.7 and No.8 pin output | Motor status |
|---------------|----------------|--------------------------|--------------------------|-------------|
| L             | H              | H                        | L                        | forward     |
| H             | L              | L                        | H                        | backward    |
| H             | H              | L                        | L                        | braking     |
| L             | L              | L                        | L                        | braking     |

3.3. Weighing module

The weighing module uses the hx711 chip of Haixin technology. Hx711 is a 24 bit A/D conversion chip specially designed for high-precision electronic scale. The circuit of single channel weighing module is shown in Figure 4. No.11 and No.12 pins of hx711 chip are clock input pin and data output pin respectively, which are connected with MCU chip. MCU chip communicates with it by controlling the pin connected with No.11 pin of hx711 chip output high level or low level voltage and reads weighing data bit by bit from No.12 pin.

![Figure 4. Circuit of weighing module](image)

4. Software design of the system

The software design of the system mainly includes the development of embedded control system, the communication between the bottom layer and Android terminal, the development of android app, the construction of server and the design of monitoring platform.
4.1. Embedded control system

The embedded control system transplants μcos-II operating system to get rid of the traditional bare metal program, which will greatly improve the efficiency of the program and the real-time performance of the system. After the transplantation of the operating system, the development of the system mainly includes the formulation and implementation of the system workflow and the formulation of the serial communication protocol with Android.

The overall workflow of the system is shown in Figure 5. After the initialization of each module, the system will wait for the Android terminal to send commands through the serial port to enter the corresponding task. After the task is completed, it will wait for the next task and continue to cycle. There are four main kinds of tasks: login task, quit task, weighing task and overflow test task.

![Figure 5. Overall work flow of the system](image)

The login task is complex and its task flow is shown in Figure 6. After receiving the login command from the serial port, the system enters the login task and first judges whether it has exited at this time. If it has received the quit command to exit, it will check whether all the ports are closed and finish the task after ensuring that each port is closed. If the quit command is not received, the system will start to detect whether the door opening button is pressed. When a door opening button is detected to be pressed, the system will drive the corresponding motor to turn forward to open the port and set a timeout time for the motor through the timer to prevent the motor from being damaged when the limit switch fails. And then the system will detect whether the limit switch is pressed. When the motor rotates forward to drive the gate to the maximum extent, it will reach one end of the limit switch, which is called the opening limit switch here. If it is detected that a certain opening limit switch is pressed, the corresponding motor will be stopped. The timeout of the motor will be cleared and the closing timer of the gate will be turned on. When the timer arrives, the motor will be driven to reverse to close the gate and set the time-out time of the motor. Finally the system will detect whether the other end of the limit switch is pressed, which is called the closing limit switch here. If a certain closing limit switch is detected to be pressed, that is, when the port is completely closed, the system will stop the motor and clear the time-out time of the motor. At this time, the complete opening process ends and it will return to the beginning of the task and continue the loop. If no key is detected to be pressed, it will return to judge whether the exit command is received and continue the cycle.
Figure 6. Task flow of login task

Quit task will stop the detection of the gate opening button so as to prevent the residents from opening
the gate at will after logging out. But it will not affect the opened gate to carry out the following steps.
Weighing task will weigh the garbage in the bin and return the data to the Android terminal through the
serial port. The Android terminal will send a weighing instruction when the input port is opened or
closed and make a difference between the two return values to get the weight of the garbage. Overflow
test task will detect whether a garbage can has been filled through the infrared photoelectric sensor. For
the corresponding port of the garbage can which has been filled up with garbage, it can not be opened
again before the garbage is cleared. The information of overflow will be returned to the Android terminal
through the serial port.

4.2 Communication between bottom layer and Android terminal

The bottom layer and Android terminal adopt RS232 serial port communication. Baud rate is 9600 and
all data are high in front and low in the back. The basic structure of protocol frame is shown in Table 2
and the frame head, function code, data length, data, XOR check bits and frame tail are respectively
from left to right. Frame head and frame tail are used to distinguish commands. XOR check bits are used
to determine whether there is error code in the command. The function codes, data length, data and XOR
check bits of different commands are different. The function codes are shown in Table 3.

Table 2. Basic structure of protocol frame

| Description | 0   | 1   | 2   | 3   | 4   | 5   |
|-------------|-----|-----|-----|-----|-----|-----|
| HEX         | 0x55|     |     |     |     | 0xAA|
| Byte        | 1   | 1   | 1   | N   | 1   | 1   |
Table 3. Function code

| Serial number | Function description                                                                 | Function code (HEX) |
|---------------|--------------------------------------------------------------------------------------|---------------------|
| 1             | Android terminal sends port opening authority / The bottom layer returns the door opening permission has been authorized successfully | 0x10                |
| 2             | Android terminal sets the delay of closing the port / The bottom layer returns delay is set successfully | 0x11                |
| 3             | Android terminal reads weighing data of the port / Bottom layer returns weighing data | 0x12                |
| 4             | Android terminal controls the lamps / Bottom return lighting started successfully     | 0x13                |
| 5             | Android terminal reads the opening state of the device / Bottom layer returns the port status | 0x14                |
| 6             | Android reads overflow status / Bottom returns overflow status                       | 0x15                |

4.3. Android app
Android app interacts with the bottom layer to control the whole intelligent garbage bin and its front page is shown in Figure 7. Android app design mainly has four aspects, including the front-end page, the local function implementation, the hardware serial interface interaction and the server-side interaction. First is the basic page design. The general page is cut out and the layout is designed. The front-end page is realized. Then there are logical interaction between pages, dynamic face recognition and so on. Then there is interaction between Android and hardware. According to the basic serial Library of Android, the serial connection function is written. And then the interaction with camera, code scanner and garbage can hardware is designed one by one. Finally, network functions are implemented, such as basic weather acquisition, cloud face recognition, personal information recording and garbage can status upload.

![Image](image1.png)

Figure 7. Android app front end page

4.4. Server
The background adopts Java SSM framework technology, which is spring boot + Spring + mybatis
integration framework. It is a popular web application development framework at present. The system integrated SSM framework is divided into four layers: presentation layer, business logic layer, data persistence layer and domain module layer to help developers build web applications with clear structure, good reusability and easy maintenance in a short time. Controller controls business jump, uses mybatis framework to support persistence layer and uses mapper to manage interaction with database.

4.5.Monitoring platform
In order to improve the intellectualization of urban sanitation work, the monitoring platform visualizes the status of garbage cans. The monitoring platform is shown in Figure 8. After selecting the cell to be monitored, the user can monitor the intelligent trash can of the cell in real time to monitor whether it overflows and whether the outlets are abnormal. A, B, C and d represent kitchen waste, recyclable waste, hazardous waste and other waste respectively.

![Figure 8. Monitoring platform](image)

5. Conclusion
The intelligent garbage bin system designed in this paper provides an effective and reliable platform for garbage classification. It can not only monitor the status information of the trash can to improve the intellectualization of urban construction, but also add face recognition login and other functions to improve the user experience. I believe that this new type of intelligent trash can system will be welcomed by the market in the future and make a certain contribution to the garbage classification.

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