Design and Realization of Garage Access Control System Based on STM32 microcontroller minimum system technology

Yuanyuan Wang *
School of Management, Tianjin University of Technology, Tianjin, China

*Corresponding author e-mail: wangyuanyuan@tjut.edu.cn

Abstract. This paper designs and implements a community access control system based on STM32 microcontroller minimum system technology. A power unit composed of steering gear and simple lifting rod device is designed. According to the actual demand, a display device composed of buzzer alarm device and display screen is designed. Considering the need of camera recognition, the program of camera recognition process is designed, the database is written, and the license plate of this area is stored in advance. The system can make the license plate can be recognized by the camera automatically, and through the comparison with the database, the lifting rod or the buzzer alarm is realized. The access control system is of great significance to the control of vehicle entering and leaving and the safety of the community.

1. The research status
In recent years, most of the vehicle management is used by the camera license plate recognition system, with the increase of vehicles, China's work efficiency of vehicle management is constantly improving, but there are also some problems, The most common is when we meet fog weather or heavy rain and snow weather, visibility becomes very low, license plate recognition system is very difficult to license plate shooting, leading to the failure of this method of license plate recognition, so at present, the management of residential area garage applied license plate recognition system has yet to be improved. [1] The real significance of using camera for license plate recognition lies in that it can effectively change the current situation of vehicle management in China's residential areas. License plate recognition technology can provide help for the management of vehicles in China's residential areas. The design can ensure the safety of the community vehicle driving, can effectively monitor the non-community vehicle, to ensure the safety of the community.

With the rapid development of society, more and more families have cars, and cars have become one of the main tools for people to travel, especially in cold winter and hot summer, so that people can enjoy better services [2]. However, the problems also appeared, such as other vehicles disorderly into their own community, disorderly parking. In order to better solve these difficulties, the access control system of intelligent residential area emerged at the right moment [3].

2. Overall system design scheme
This chapter has carried on the design to the district garage access control system overall plan, including the system structure design, the system overall workflow brief introduction and the control core chip brief introduction.[4]
2.1. System structure design
Community garage entrance guard system is divided into the hardware design and software design part. The hardware part includes the single chip microcomputer minimum module, used to identify the camera module, used to display to recognize license plate image display module, used to prompt not vehicle alarm buzzer module, this area is used to control the lifting rod and steering gear module. The software part mainly includes initial processing of various devices, camera acquisition and image processing, display screen processing, alarm device processing, and steering gear power device processing. The design framework of the garage access control system is shown in Figure 1.

![Figure 1. Design frame diagram of access control system.](image1)

2.2. Overall workflow
The procedure flow of entrance control system of residential garage mainly refers to the operation of private cars entering the door. The operation of entering the door first determines whether the car is a vehicle in the community. The operation is completed through the identification process of the camera and the comparison with the database. The license plate recognized by the camera is displayed on a TFT-LCD screen. After the result of license plate recognition is compared with the database, if it is the vehicle of this community, a signal is transmitted to the steering gear module, so that the steering gear starts to control the lifting rod at the door of the community, and the vehicle enters; The result of comparison is not the vehicle in this community, so the CPU gives a signal to the buzzer, so that the buzzer emits sound as an alarm signal, to remind the staff. The operation of going out is much simpler. It only needs to detect the signal of vehicle entering through the camera, and then lift the lever. This paper will not discuss it.

2.3. Control core chip
STM32F103RBT MCU is used in the garage access control system of the residential area. The MCU is shown in figure 2. It operates from 2.0V to 3.6V with integrated Flash memory and three 12-bit A/D converters. It can be seen from above that compared with the traditional 51 microcontroller, it has been improved in running speed and program storage. More importantly, the MCU used in this paper has its own AD converter, so it does not need external AD conversion module, and has the characteristics of low power consumption. Therefore, choose STM32F103RBT MCU as the control core of this system.

STM32F103RBT single chip microcomputer except AD conversion part, other parts, in the pin level and software operation level, and the traditional 51 single chip microcomputer.

![Figure 2. STM32F103RBT real figure.](image2)
3. Hardware design and production

Hardware part design, including camera recognition device design, lifting rod power device design, buzzer alarm device design, display display device design and other hardware part production.

The recognition device consists of a single chip microcomputer minimum system, a camera module and a STM32 minimum system module.[5] Microcontroller minimum system and buzzer module, display module, steering engine module, camera module four modules connected. The camera module is used to collect information, which is then processed to achieve the effect of license plate recognition, so as to facilitate the comparison of subsequent license plates and control the rise and fall of the lifting rod or the buzzer alarm.

3.1. SCM introduction and design

STM32F103RBT is used in the control core chip of the garage entrance control system. The microcontroller is installed on the minimum system and the pin welding, so that it can be well connected with the outside display, steering gear and other hardware. The entrance control system of the garage in the residential area uses STM32 module directly, and chooses the minimum system of the single chip microcomputer which can be disassembled repeatedly to work with the single chip microcomputer, instead of welding peripheral devices, so as to achieve the purpose of convenient and reusable hardware.

The specific parameters and features of the module are as follows: After welding, all IO ports are drawn out, which is easy to connect with other devices. Integrated ISP download interface, easy to download programs; It has a power switch, which is convenient for the experiment. The reset mode is external button reset, and the external size of the SCM module is 5cm*5cm. The chip is based on ARM's latest Cortex-M3 architecture. The product features an ARM32-bit core product, 128KB Flash, 12bit AD, 20K RAM, and a 64-pin STM32F103RBT6 main chip with an active buzzer.

Microcontroller up to 64 pins, most of the pins will be used in the district garage access control system, MCU PC8 to PC12 and PB0 to PB15 pins are connected with the LCD module; The pins of PC0 to PC7 and PA0 to PA7 are connected with the camera module; Any peripheral pin of the single chip is connected with the signal line interface of the steering gear. The specific wiring of the STM32 microcontroller in the access control system of the garage in the community is shown in Figure 3.

Figure 3. Microcontroller wiring diagram.

3.2. Liquid crystal display module

The entrance control system of the garage in the residential area adopts TFT_LCD LCD display module, which is an LCD display module. As an input/output device, it can display the license plate image scanned by the camera to the LCD screen through a specific transmission device, and finally reflect to the human eye.

TFT_LCD is a thin film transistor liquid crystal display. The CS pin of the LCD module is connected with the PC9 pin of the single chip microcomputer, so that the TFT_LCD LCD module can complete the chip selection signal function; The WR pin is connected with the MCU pin PC11 to complete the
task of sending license plate information to TFTLCD. RD pin and MCU pin PC10 connected, so that the MCU can read information from TFTLCD; DB0 to DB15 pin and MCU pin PB0 to PB15 pin connection, so that the MCU can be two-way data communication with the LCD display; RES pin and MCU pin PC8, equivalent to liquid crystal display module; RS pin and MCU pin PC12 connected, TFTLCD LCD display module to perform the task of reading and writing commands or data; BL and VDD pins are connected to 3.3V voltage, and GND pins are connected to the bottom line, so that the LCD module can work normally. Specific wiring is shown in Figure 4.

![Figure 4. LCD module wiring diagram.](image)

### 3.3. Camera module

The garage access control system of the residential area adopts OV7670 camera module. The camera, as a video input device, plays an important role in the image collection of license plate recognition system. [6]The high-quality license plate image collected by the high-quality camera can provide great convenience for the operation of the subsequent links.

OV7670 camera module pin D0–D7 is connected with MCU pin PA0–7, OV7670 camera module pin SIO_C is connected with MCU pin PC6, OV7670 camera module pin SIO_D and MCU pin PC6 are connected to PC7 to simulate SCCB communication clock and data signal, providing conditions for data transmission. OV7670 camera module pin OV_VSYNC is connected to MCU pin PC0 to realize OV7670 frame synchronization signal. The PIN RRST of OV7670 camera module is connected with the pin PC2 of single chip microcomputer, so that the FIFO realizes the reset of reading pointer. OV7670 camera module pin FIFO_OE and MCU pin PC3 connected to enable FIFO output selection; OV7670 camera module pin FIFO_WRST and MCU pin PC5 are connected, so that THE FIFO to achieve reading pointer reset; OV7670 camera module pin FIFO_WR is connected with MCU pin PC1 to enable FIFO to write. OV7670 camera module pin FIFO_RCK is connected with MCU pin PC4 to achieve the task of reading FIFO clock. Connection diagram of OV7670 and STM32 is shown in Figure 5.

![Figure 5. OV7670 and STM32 connection circuit diagram.](image)
3.4. Steering gear module
The steering gear model of the garage access control system in the residential area is SG90, and its rotation angle is 0-180 degrees. The lifting rod of the access control system in the residential area needs to change the angle and keep the control of a certain angle, so the steering gear is used for control. The steering gear is essentially a servo motor. STM32 MCU to control SG90 steering gear drive, need to use the MCU output a PWM signal, steering gear angle rotation also drives the lifting rod up and down, so as to control the community lifting rod switch, in order to achieve the function of access control system.

Power device includes steering gear, simple lifting rod lifting device. If the license plate information collected by the camera matches that in the database, then the steering gear drives the lever to lift through a simple device, lifting the lever to a vertical position of 90°, and after the vehicle passes, the steering gear controls the lever to restore to the original position.

4. Software design
This chapter designs part of the garage access control system software, mainly through STM32F103RBT chip 0V7670 model camera (with FFO) to send instructions to control, and then to complete the camera recognition process of image acquisition, according to the results of pattern recognition on the LCD plate number[7]. In order to greatly improve the processing speed, STM32 MCU uses 16 times frequency to improve the processing speed. Other software parts also include the process of matching the license plate recognized and the preset value of the license plate set in the microcontroller. After comparison, the microcontroller sends instructions to the steering engine or the buzzer. This chapter describes the main part, that is, the part of the camera recognition.

4.1. Design of camera recognition system
The core of the access control system is the license plate recognition. The license plate recognition adopts pattern recognition technology and image processing technology. When the vehicle enters the detection area, the tracking and recognition of the license plate is the main work of the camera.

Camera on the license plate recognition system working principle: when the car license plate in the tested range, calculate the opportunity to receive detection device capture the license plate images, then computer photos about cars began to identify operation, the final output on the screen the identified results, and the results compared with the database of the existing license plate for this area. The signal is then transmitted to the steering gear module or the buzzer module. The flow of license plate recognition system is shown in Figure 6.

![Figure 6. Flow chart of license plate recognition system.](image)

4.2. Image acquisition and preprocessing
When the system starts normally, STM32, LCD and camera are initialized first. After that, the system starts to capture the license plate picture after KEY1 is pressed.

In order to make some features of the license plate image, such as color and texture, can be effectively saved and enhanced, we need to preprocess the image of the license plate before taking photos. This is because in the process of acquisition, the license plate image taken may be interfered by other noises. Image preprocessing this step includes a number of processes, mainly image balance and image gray conversion, image filtering, but also includes the image effect enhancement process and image binarization process.

4.3. Binary analysis
Grayscale image contains 256 grayscale levels, which can be very good to display the brightness of the image. When we were in the treatment of the license plate image, in order to present the information we
need, so we will target information and image background is divided into two parts, this can avoid the interference of background pixels, to the goal of the information we need perfection, to process the image analysis of the process is called image binarization. The camera needs to binarize the collected information (pixels). After the binarization processing, the pixels will become two kinds of all-black 0x0000 and all-white FXFFF, so the processed image will become black and white image with only 0 and 255 gray levels, namely the binary image. The set of images is only related to the location where the pixel value is 0 or 255, and the multi-level value of the pixel does not need to be considered, which effectively simplifies the process of processing. In addition, the binary image with small storage space and fast operation speed can greatly improve the processing efficiency.

The core of binarization processing of license plate image is to select the appropriate threshold T to separate the target information of the license plate image, such as Arabic numerals, Chinese characters and English letters from the background image. After such division, the license plate image will be clearly displayed. If the gray graph function of the input is \( f(a,b) \) and the binary graph function of the output is \( G(a,b) \), the classification of binarization is as follows:

\[
g(a,b) = \begin{cases} 
0 & f(a,b) < T \\
255 & f(a,b) \geq T 
\end{cases}
\]

The global threshold method of binarization processing can complete the binarization operation well. Except under some adverse conditions, such as strong noise or unequal illumination, the simple global threshold method can display the bimodal image of histogram distribution well and clearly separate the background and target of the image. However, the local threshold method is more extensive, and is often applied to the image with uneven background or a larger change rate of target gray level. However, this method also has disadvantages, which are quite obvious, such as low processing efficiency and inability to ensure the stroke connectivity of characters.

4.4. License plate recognition area

Whether the license plate can be successfully detected in the recognition area is the top priority of the whole system, so it is necessary to choose the appropriate algorithm to achieve the stability of the function.

But these series of methods are inseparable from the license plate texture information, image color information, geometric shape information. At present, the commonly used positioning methods are based on mathematical morphology, texture feature analysis and edge detection.

Firstly, the rough location of the license plate is determined by the expansion corrosion calculation. The way to accurately locate the license plate of the vehicle in the district is to scan the column and column, which is a horizontal scan in a top-down way. We first statistics the number of white pixels in each row, expressing it in \( \text{White}_y(I, 1) \), if the bank point of pixel value is 1, since 1, after progressive scan \( \text{PY1} \) to assign the maximum row of values to variables, set judgment conditions, starting from the \( \text{PY1} \) cycle, meet the conditions of \( \text{PY1} \) do since the subtract 1, until the conditions are not set up, Exit the loop. The value of \( \text{PY1} \) is the upper boundary of the license plate area. Follow the same method to get the lower boundary of the license plate area.

Plate boundary was determined, up and down or so to get from left to right and scanning way, choose \( \text{White}_x(1, j) \) to statistics the j column white pixel number, scanning from the left, then the \( \text{PX1} = 1 \), according to the judgment of the conditions, circulating operation, conditions are not exit is established, get \( \text{PX1} \) value is to the left of the plate region boundary; Similarly, if the scanning starts from the right, that is, \( \text{PX2}=X \), the value of \( \text{PX2} \) can also be obtained according to the additional determination conditions. At this time, the value of \( \text{PX2} \) is the right boundary of the license plate area.

After identifying the upper boundary, lower boundary, left boundary and right boundary of the license plate area, it can accurately locate the license plate area of vehicles entering the community and obtain accurate boundary.
4.5. Character segmentation and normalization
After the accurate location of license plate area, we also need to carry out character segmentation. Because the recognition effect of the recognition method based on the unit of string is not good, and we know that if the recognition method is based on the unit of single character, this effect is very good, and it is a more reliable algorithm in today's character recognition method, so we want to carry out character segmentation. Accurate extraction of Chinese characters, English letters and numbers on the license plate, and make them exist alone, can provide guarantee for the normalization processing and character matching work better. In this way, the effect of character segmentation is closely related to the final recognition result. Therefore, we should choose the most appropriate segmentation algorithm to normalize the segmentation of a single character.

4.6. Character match
After character segmentation and normalization, we have processed the image of the license plate into a unified character image in terms of size and size, and then we need to match each character one by one.

Character recognition and matching is the last step of the system, which determines whether the system runs successfully or not. In the development process of recent decades, character recognition in daily life is more and more popular, and his technology is becoming more and more mature. In the field of license plate recognition system, character recognition methods are various, commonly used recognition algorithms are template matching method, statistical analysis based on feature, neural network method. Because the license plate character recognition is realized on STM32 in this paper, the template matching algorithm is adopted, which can effectively realize the character recognition.

The template matching algorithm actually compares the character image with the sample template and takes the sample with the highest similarity to the input character image as the input character image. We should first create a template library, store it in the program, a single 24*50 pixel size, and size the characters to the same size as the templates in the character template library. After the match, the characters corresponding to the maximum similarity are displayed as the output result. This method has the characteristics of fast recognition speed, especially when processing binary images, this advantage is more prominent. Template matching is shown in Figure 7:

![Figure 7. Template matching diagram.](image)

5. Conclusion
This paper summarizes the research and application of single chip microcomputer, camera, display screen and steering gear. Design and manufacture of a residential access control system, used to solve the problem of other vehicles into the residential area. The main conclusions are as follows:

The hardware part of access control system is designed. The acquisition device, which is composed of the minimum system of single chip microcomputer and the camera module, is designed to make the camera collect images effectively. The power device composed of steering gear and simple lifting rod device is designed to lift the rod of the vehicle in this district. The alarm device composed of buzzer module is designed to alarm the vehicles that are not in this community. A display module composed of display module is designed to display the scanned license plate image effectively.

The software part of the entrance control system of the garage in the residential area is designed, so that the entrance control system can accurately judge the foreign vehicles and the vehicles in the residential area, and realize the operation of some functions. The hardware part and software part of the garage access control system are designed and made, so that the system can control the rise and fall of the buzzer alarm or the lifting rod through the camera recognition and processing.
The system of access control based on camera license plate recognition is relatively complex. The main research object of this paper is image recognition system. Although the expected goal has been achieved, many follow-up work has not been carried out due to some objective factors. At the same time, the research object of this paper has some limitations, the lack of non-standard license plate research, only the common license plate positioning, segmentation, recognition.

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