Design of Camera Type Handling Trolley based on Stm32

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Abstract: With the continuous advancement and development of industrial robots, research on handling robot control technology has become more and more extensive. When it is no longer stuck to traditional sensors, the more powerful camera has gradually become a hot spot for the relevant race-class intelligent handling models. This camera type handling trolley is designed based on the CHINA ROBOT COMPETITION sports camera type handling project. In this project, STM32F103RC was selected as the control processor. At the same time, in order to meet the black line and accurate color recognition of the camera tracking track required in the game, the CCD camera and openmv are respectively selected to realize the corresponding functions. In addition to this, controls such as the movement of the car through pwm, an OLED display module, and the like are applied.

1. Design and System Analysis

1.1 Design Analysis

The handling car designed according to the requirements of the competition needs to automatically carry and place the target. Compared with the traditional use of infrared sensors and ultrasonic sensors, the handling car designed in this paper needs to use the camera to collect road information, identify moving objects and place objects. Through the study of track information and competition rules, the following system is briefly analyzed:

First: Because the camera can only be used for line detection, and considering the black and white track and chip processing power, the use of CCD is the best choice. The CCD camera adopts a one-dimensional imaging mode, and the processor needs to process less data, which can respond to the track information more quickly and accurately.

Second: the car needs to identify the color of the block during the handling process. The CCD camera can only recognize the black and white track and cannot recognize the color. Therefore, the openmv camera with lower requirements for the main control computing capability can be easily completed by the provided routines.

Third: Because this competition pursues the stability of the car rather than the speed, it needs better braking performance during the driving of the car, so choose the DC motor based on the H-bridge driving PWM wave control speed. When the grab block is realized, because the mass of the block is small, the steering gear with small torque, high precision and high stability is selected.

1.2 Algorithm and Strategy Analysis

As we all know, Software algorithm is the core of the truck. The whole game is a procedural task., so it is especially important to design a suitable code and solution. So, the car needs to execute the relevant program code step by step. Once you make a mistake, the next steps will be messy,

First analyze the game strategy according to Fig 1 below:

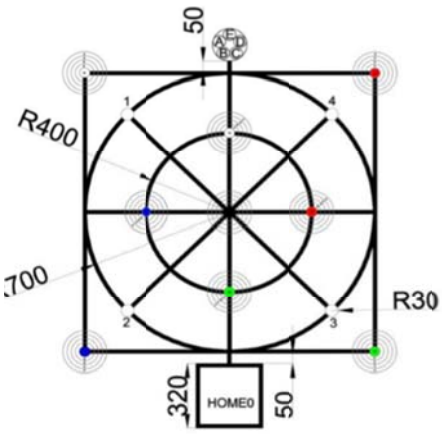

Fig 1. Competition drawings

According to the rules of the game, the sports strategy of the car is roughly defined as follows:

The car starts from HOME and reaches the center of the rice area to stop, then rotates counterclockwise 45 degrees and then goes straight to the 1st blank circle to identify the color. If it is not a black and white block, then the car returns to the center point and rotates in the corresponding direction and angle to go straight to the target area to place the object block; If it is a white or black block, place it on the corresponding position on the cloud disk after it is taken, and wait for the block in the four circles to be placed before placing it. The situation of the 2, 3, and 4 rings is similar to that of the 1st. After the start of the second task, the car sequentially grabs five blocks at B, C, A, D, and E, recognizes the color and stores it in a specified position on the cloud disk, and then places white, red, and green along the square boundary. Blue, and finally bring the black block back to HOME.

1.3 Hardware Control System Analysis

The hardware structure of the handling car has a very important influence on its performance on the track. Any control algorithm needs to be implemented and implemented by the hardware structure of the car. The system hardware structure of the car is introduced as shown in Fig 2 below:

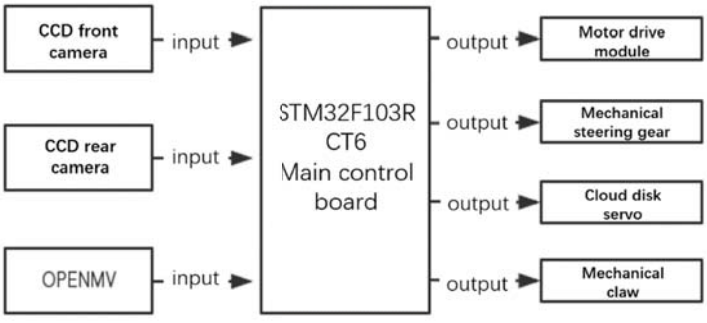

Fig 2. System hardware block diagram

As can be seen from the figure: stm32f103RCT is the core part of the whole system. It is responsible for receiving the information sent by the two CCD cameras and the openmv camera before and after processing, and generating appropriate control amount to control the motor and the steering gear according to the processed information. The CCD front camera is used for collecting road condition information in the forward direction of the car. The CCD rear camera is used for the car to back up the line, and the CCD camera sends the information to the processor through the ADC port; openmv recognizes the medium color information from the pictures taken by itself, and then sends it to the motherboard through the serial port; The power module mainly supplies a stable DC power supply for 32 single-chip microcomputers, cameras, motors, servos and display screens; The

two-way motor realizes the advancement, retreat and turning of the car; the steering gear realizes the grabbing block; the DC motor and the steering gear are controlled by PWM wave.

2. Hardware System Design

2.1 Car Frame Structure

The frame used according to the size requirements of the race committee is shown in Table 1 and Fig 3.

Table 1. Car frame parameters

Structural part	Size parameters
Car length	160mm
Car width	195mm
Front track	142mm
Wheel diameter	72mm
Frame height	88mm

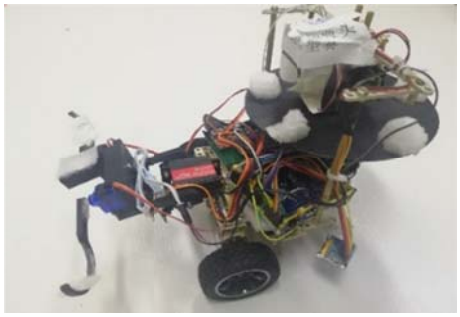

Fig 3. Car structure

2.2 Processor and Main Control Board

I choose to use Altium Designer to draw the main control board for the car and use the STM32F103RCT6 chip as the MCU. It has resources such as: 48KB SRAM, 256KB FLASH, 4 general-purpose timers, 5 serial ports, 3 12-bit ADCs, 51 general-purpose IO ports and other resources. At the same time, the main control board contains the minimum system circuit, the button circuit, and the OLED screen interface circuit. The circuit board is shown in Fig 4.

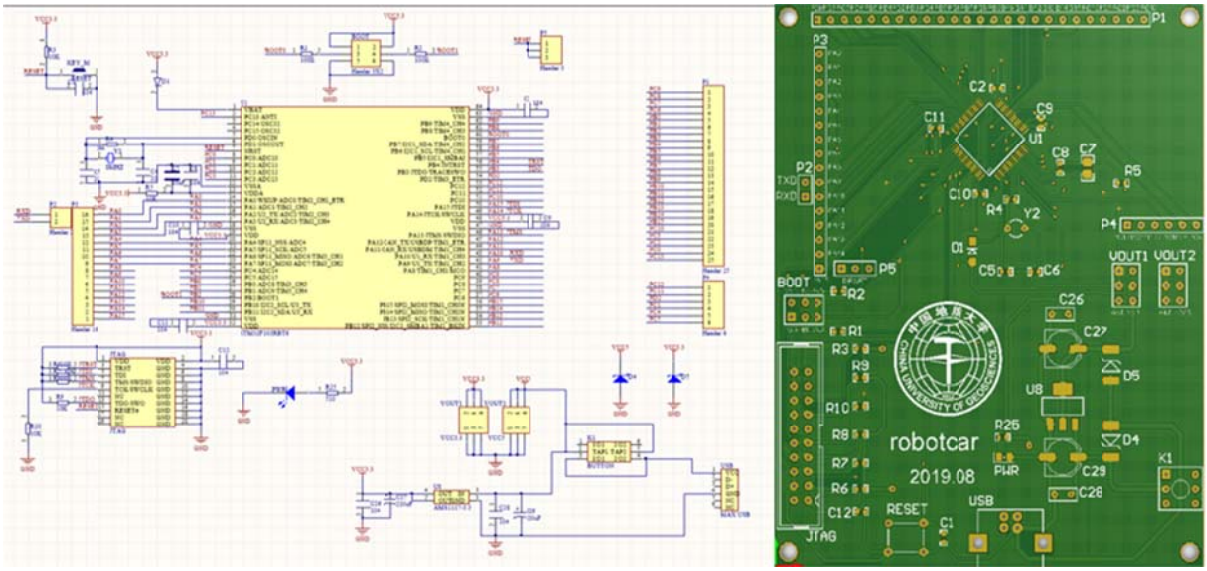

Fig 4. Homemade circuit board schematic and PCB

2.3 Car Power Module

The car power supply is provided by a 12V lithium battery. The battery power is directly connected to the transformer regulator board. The variable voltage regulator circuit board is equipped with an adjustable buck module, an adjustable buck regulator module, and a 12V drop 5V USB interface module. The two front-loading modules each have 8 sets of pin headers, which are suitable for multiple powered devices, but the long-term working current of the module should not exceed 2.5A, and the long-term power is not more than 10W, so it needs to be lowered. The electrical equipment used for pressure needs to be distributed on the two buck modules according to the power level.

2.4 DC Motor Module

The two-way motor consumes the most power in the entire car system. At the same time, the start of the motor will draw a large current from the power supply in a short time, which has a certain influence on other components, so the power supply voltage regulator module plays a very important role.

After comprehensive consideration, the TB6612FNG drive module is used to drive the motor. The TB6612FNG is a dedicated drive for two-way metal motors. It is undoubtedly the most suitable for a balance car with only two drive wheels, and the TB6612FNG module is small, and easy to install. Therefore, the structural advantages of this drive are also very obvious.

2.5 Steering Gear Module

The steering gear is mainly used to realize the functions of grabbing, storing and placing the block. The metal digital steering gear has large torque, fast response, high precision and no rudder. It is very suitable for driving large torque devices such as robot arms and cloud disks. As for the small torque servos required for the remaining two grippers, the SG90 9g is sufficient.

2.6 CCD Module

The CCD is the most important sensor in the handling of the car, and it plays a decisive role in the core of the entire task of the line. The handling car uses two CCD cameras, one for forward and the other for backward. The front camera is mounted on the arm. When the arm is lifted, the front camera illuminates the ground vertically. When the robot arm is lowered, the camera is placed under the frame. The installation position and the installation angle of the front camera are completely different from those of the racing car, because the racing car pays attention to the forward-looking image, and the image taken must be a certain distance ahead of the wheel, so that the body can be adjusted. But to the track, the distance is short, the road conditions are complex, in order to detect the position of the car body in real time, the camera collection point must be as close as possible to the front wheel position, and the installation angle of the camera is as perpendicular as possible to the ground. Then for the rear camera, the install idea is the same as the front camera.

2.7 Openmv Camera

In this project, the openmv camera is used for color block recognition. In fact, if you only want to achieve color block recognition, the GY-33 color sensor is the most suitable and the most error-prone choice, but because the official requirements of the event can only use the camera, so the openmv camera was chosen. Simply put, it's a programmable camera that implements logic through the Micro Python language and the camera itself has a lot of built-in image processing algorithms that are easy to use.

For openmv, the highest pixel size of the processed image is 300,000. The processor has limited computing power. It is not suitable for complex image processing, deep learning, etc., but it is more than enough for color recognition and processing. Obviously, the openmv camera is a small, low-power, low-cost board that makes basic machine vision applications easy.

3. System Testing and Overall Results

3.1 Test Results of Some Module

Before combining all the modules, some parts should be tested separately. The following is the result of the test.

(1) openmv: Even after the installation of the fill light, the requirements for light are relatively high, occasionally the error is recognized. In the case of ensuring that the color thresholds are not changed as much as possible, it is necessary to change the exposure according to the scene before each use.

(2) CCD camera: Because CCD will also be affected by relatively strong illumination, in order to solve the problem of stability of CCD work and realize accurate inspection line. Try to select more demanding conditions during debugging, such as nodes that are easier to identify. The feature recognition is carried out, and a scheme such as a simple inspection line is selected for an error-prone intersection in the inspection line, and the path recognition is basically realized without error.

(3) Power supply buck regulator board: Because of the welding problem, only one buck module can work normally. Finally, the 5V equipment (four-way servo) of the whole car can only rely on one buck regulator module, and the power supplied to the LEDs can only rely on the interface on the STM32.

(4) Motor: There is a gap between the two motor powers., the performance is that when the same PWM wave is given to the two motors, the speed of the wheels is not the same, so there will be some difference when PWM control is given to the motor.

3.2 Overall Test Results

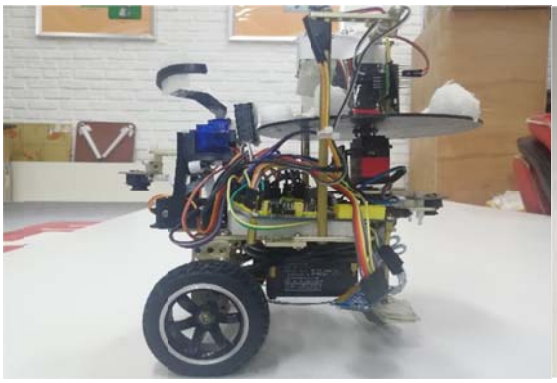

Fig 5. Car side view

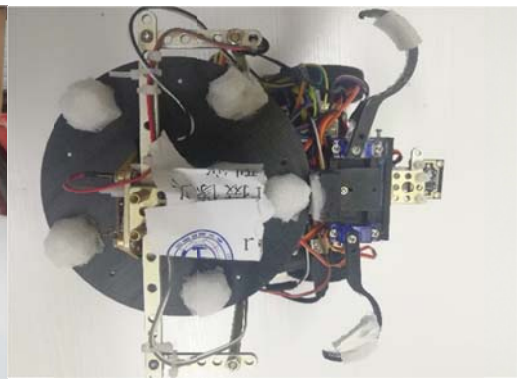

Fig 6. Car top view

Fig 5 and Fig 6 show the overall test results of the car. The car can fully execute the whole program, the tracking is relatively stable, the score point of each block is generally 6-8 points, and occasionally the block will be placed 10 points, so the accuracy of placing the block still needs to be improved.

Analysis of existed problems:

(1) The car may have a mistake in the first task. Once there are other colors recognized as black, then when the task 2 is executed, the wrong block will be identified in the task one, resulting in the loss of control of the car when taking the object in task two.

(2) At present, the whole vehicle is very heavy, and the track drawing is a little slippery, so the car will be slipped and the steering will fail. After the white paper is attached to the drawing, the situation is improved. When there is a ditch or bulge on the drawing, it will affect the movement and detection of the car because it is stuck with the bull's eye wheel, therefore the stability still needs to be improved.

4. Conclusion

The car is currently able to finish Task 1 and Task 2 in its entirety, but there is still room for improvement in scoring. Stability is the biggest problem facing the car nowadays, which is mainly caused by the tracking and color recognition involved in the task when the light changes. Due to the influence of light, the problem is mainly on the intensity, if the intensity is too large, the CCD camera will burst, and the output value cannot distinguish the black line and the gray line; if the intensity is too low, the output value of the CCD camera will be within 10, which is also difficult to distinguish. At the same time, when the light intensity is too strong or the light is not direct, the openmv recognition color will also be wrong. The above problems are currently not solved by algorithms., that is to say, the follow-up needs to design a better fill light structure to solve the influence of light on the camera recognition. This camera type handling trolley based on stm32 has just won the second prize in the CHINA ROBOT COMPETITION held in Qingdao in August 2019.

Acknowledgments

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