Design of Arena Robot Based on STM32 Control

Taoran Sun *, Gang Du *, Zhiming Cui b and Cheng Zeng c

School of Information Engineering, China University of Geosciences, Beijing 100083, China.

* Corresponding author email: 598138941@qq.com, 857510728@qq.com, 1213902597@qq.com, 3289173482@qq.com

Abstract. In order to design a small arena robot with stage, attack and defense, STM32F103ZET6 micro-controller is used as the main controller. Adopts the modular design thinking, the use of infrared ranging sensors, infrared photoelectric sensor, high-power motor relative to the implementation of the robot movement function; The hardware circuit, mechanical structure and software program are designed respectively. Synthesize the different situations encountered in robot competition, the hardware and software of the robot are optimized and the control strategy is put forward. In this way, the performance of the robot can be brought into full play and the winning rate of it in robot competition can be improved.

Key words: arena robot; STM32; sensors; control strategy.

1. Introduction

The Wushu Arena robot challenge which is a 1v1 confrontational competition is a project in China robot competition, intelligent robot competition in Chinese universities and robot competition for college students in five provinces of north China. According to the rules of the competition, the robots of both sides independently step onto a certain level of playing field and move around on it. The robot can take the initiative to find enemy robot, and quickly push the enemy robot down the platform. During a match, if the robot falls from the ring, the robot can quickly detect its own situation, and self-go to the arena to continue the match. If the robot fails to take the ring within the specified time, the opponent's robot is awarded points. At the end of the match, the winner with more points wins.

2. Robot Function Analysis

The design and research of small arena robot is a combination of mechanics, electronics, computer technology and artificial intelligence. Taking Wushu Arena robot project in Chinese robot competition as the background, the hardware and software of the robot are optimized, and the control strategy is studied.

The specific requirements of the robot are as follows:

(1) The movement mode of the robot is ordinary wheel movement;
(2) It can detect and judge whether the robot itself is in the arena or under the arena;
(3) When the robot is out of the ring, it can independently identify and step onto the 60mm high ring;
(4) When the robot is on the challenge stage, it can use infrared ranging sensor to find the enemy, and attack.

3. Robot Structure Design

3.1. Staging Structure Design
In order to bring down the center of gravity of the robot, and improve the flexibility and simplify the structure, this design is to make a bevel arm directly behind the robot. The blue structure in Fig. 1 is shown. According to the force decomposition and geometric size calculation of bevel arm, when the angle between the arm and the ground is more than 60 degrees, the force component of lifting the robot decreases, and it need more motor power to lift the robot to the ring. If the Angle is less than 45 degrees, the arm will have a large size, which may contact the arena in advance and lift the back wheel of the arena robot off the ground. As a result, the arena robot only relies on the front wheel to output power, reducing the total output power and making it difficult to stage. Therefore, the bevel arm was selected to be between 45 degrees and 60 degrees from the ground.

![Figure 1. Staging structure](image1)

3.2. Look For Enemy Robot Sensor Placement
One of the most important aspects of the robot is its perception of the enemy robot and its positioning. In order to obtain comprehensive and accurate detection, it is not enough to install as many infrared ranging sensors on arena robot as possible. There are two main reasons. First, the size requirements of arena robot are limited. Second, when a large number of sensors are installed on arena robot, it will consume a lot of resources of the controller of the robot to process these data, resulting in slow response of the robot and increasing the complexity of programming. Therefore, after analyzing the movement characteristics and possible detected states of arena robot, it is concluded that the layout shown in Fig. 2 is the optimal placement. Fig. 2 in the black for infrared ranging sensor, all installed on the chassis.

![Figure 2. Top view of sensor layout](image2)

3.3. Ring Edge Detection Sensor Placement
Four infrared photoelectric sensors are used as devices for the edge detection of arena robot, which are respectively installed in the left front, right front, left rear and right rear of it. In Fig. 3 and Fig. 4, the
dotted line represents the beam emitted by the sensors. During the movement of the robot, when the beam reaches the edge of the ring, the edge processing will be triggered and corresponding actions will be taken to avoid falling off the ring.

As shown in Fig. 4, the included angle between the beam represented by the dotted line and the arena plane is certain. The size of this included angle represents the distance between the arena robot and the edge of the arena. The larger the included angle is, the closer it is to the edge of the arena.

When arena robot moves at a high speed, it should be as far away from the edge of the challenge as possible. This is because after the robot moves at a high speed, it has less time to deal with the edge processing. In addition, due to the small inertia and the friction coefficient of the challenge surface, the robot will still slide forward for a certain distance after the motor brakes, and the wheel will skid after the motor reverses. However, this angle should not be too small. Although it is far away from the edge of the ring, it is easy to detect the opponent's robot in the process of confrontation with the enemy robot, so it cannot accurately detect the edge, resulting in a misjudgment of dropping off the ring.

3.4. Attack Structure Design

In the process of competition, the robot should not only attack the enemy robot, but also defend the enemy robot's attack. In this design, the shovel is used as the weapon of this robot. The shovel consists of two shovel arms and a horizontal shovel surface. One end of both shovel arms is fixed to the horizontal shovel surface, and the other end is fixed to the shaft of the chassis support. The shovel can rotate with the shaft as the center of circle, so as to ensure that the shovel is always close to the challenge plane and can not be scooped up by enemy robots during the confrontation. The shovel is shown in blue in Fig. 5:
4. Robot Hardware Circuit Design

4.1. Overall Project Plan
As shown in the hardware circuit schematic diagram in Fig.6, STM32F103ZET single-chip microcomputer is used as the main controller of the robot. The high-power DC brush-decelerating motor circuit drives the challenge robot to move, and infrared ranging sensor and infrared photoelectric sensor circuit are used to detect the enemy robot and its own position.

![Figure 6. Hardware circuit schematic diagram](image)

4.2. Function Module Selection

4.2.1. Main Controller
After a comprehensive analysis of arena robot, the core of the robot design lies in its efficient perception of the surrounding environment and flexible motion control. STM32F103ZET6 is very suitable for the robot controller, because it has powerful resources and rich peripherals and interfaces. Programming control is convenient, and online simulation debugging can be carried out by using SWD and JTAG interfaces. Fig.7 shows the master control PCB diagram and real object diagram drawn independently.

![Figure 7. the master control PCB diagram and real object](image)

4.2.2. Driving Scheme
The robot motion is common wheel movement. This design adopts "Z" type deceleration DC brushless motor and AQMH3615NS motor driver. Because when in sharp stop, sharp reversal, especially in the process of confrontation with enemy robots, low speed, large torque motor has a huge advantage. At the same time, the motor drive needs to bear a large amount of current under...
the above circumstances. The use of AQMH3615NS high-power dc motor driver, using PWM signal to speed the motor can well meet the above requirements.

4.2.3. Sensor Selection. The robot needs to be constantly aware of its surroundings. Since both robots are in motion, it is necessary to find enemy robots earlier in order to adopt better strategies. GP2Y0A02YK0F infrared ranging sensor can detect a relatively long distance. When the robot detects the edge of the ring, E18-D80NK infrared photoelectric switch obstacle avoidance sensor has a fast response speed, which can timely act to prevent falling off the ring.

5. Software Design

5.1. Programming Language Selection
Due to the robot using the STM32 multiple peripherals, programming complex for the control of the robot, the control program written in assembly language workload is too big, and more powerful C language function, the program structure, readability, portability, maintainability, etc have obvious advantages, so the robot control adopts modular programming ideas, through the C language implementation.

5.2. Overall Program Flow Chart
The control program of arena robot is written and debugged by Keil 5 Software produced by Keil Software of the United States. Through the analysis of the competition strategy, the flow chart of the control program is shown in Fig.8:

![Figure 8. Control program running flow](image)

6. Robot Construction and Debugging

6.1. Hardware Assembly
Before the overall test, the hardware should be assembled. Firstly, the controller should be welded, and each component should be welded to the printed PCB board according to the schematic design. Then, the overall structure of the robot is set up. The motor, motor driver, battery, sensor, stage mechanism, attack mechanism and controller are fixed in corresponding positions according to the order from bottom to top and from inside to outside. Finally, each module is connected to the corresponding port of the controller according to the schematic diagram. Build a small arena robot, as shown in Fig. 9.
6.2. **Debugging**

After the construction of the robot is completed, the software needs to be debugged to finally achieve the combination of software and hardware and maximize the performance of the robot. The debugging site is shown in the Fig.10.

Debugging is divided into two steps. The first step is to test whether each module is good and can work normally. In the sensor detection, you can write a program, with serial port, the sensor detection results output to the computer screen, can be very intuitive to judge the detection effect of the sensor. Sensor testing needs to pay attention to the accuracy and response speed of the returned results of the sensor. Motor detection is to control the positive and negative rotation, acceleration, deceleration of the motor through the program. In addition, it is necessary to judge whether the speed of the same side of the motor is the same when the program controls the same speed, allowing certain errors. The second step is to debug the program. First, each function module program is downloaded to the controller to conduct the test of a single function. After determining that each function module has no problem, each function is added to the main program for testing to avoid conflicts between each function module program.

6.3. **Test Results**

The test results show that after starting in a non-contact way, the robot can quickly find and mount a 60mm challenge. When moving on a ring at a speed below 50% of full speed, the detection of the edge of the ring is very sensitive, and the handling of the edge of the ring is very rapid, so that it don't fall off the ring; In the process of detecting enemy robots, the enemy within a radius of 400mm from its own can quickly determine the position of the enemy robot, and adjust itself to the enemy robot; After the robot falls off the ring, it can quickly determine its orientation and make adjustments to complete the
onstage movement in six seconds. Although it can meet the requirements of design well after debugging, there is still some room for improvement. In the process of confrontation, there is a small probability that the attacking structure of the robot will be lifted off the ring surface by the opponent robot, thus losing the attacking advantage. This can optimize the design of attack weapon mechanism, so as to increase the weight distribution in the structure.

7. Conclusion
In this paper, a small arena robot that can realize stage, attack and defense is designed and debugged. The robot is designed in three parts: hardware, structure and software. In the hardware part, low power consumption and high performance STM32F103ZET6 are used as the main control, and simple and high reliability motor drive circuit and sensor signal processing circuit are designed. In the structure part, the bevel arm stage structure of 45 degrees to 60 degrees is adopted, the sensor is arranged on the basis of the optimal theory, and the attack structure of both attack and defense is designed, which improves the flexibility and effectiveness of the robot. In the software part, the modular programming idea is adopted, and the C language is used to write the program to simplify the complexity and increase the readability, maintainability and portability of the program. We used this robot to participate in the second college intelligent robot competition in 2019 and won the second prize. Thanks for the support of the 2019 college student innovation and entrepreneurship project and 2018 Beijing practical training project.

Reference
[1] CHEN Wei-wei;ZHAN Yue-dong,Design of MCU-based PWM Speed Regulation System for DC Motor[J],Control and Instruments in Chemical Industry, P218-222.
[2] LIU Haihui;WANG Yajun;ZHU Chengrui,Intelligent motor control system based on single-chip microcomputer and Kingview,Modern Electronics Technique, P157-160.
[3] Song bofei;Yu runpeng;Xuxiaofei,The Innovative Design of Wushu Robot Structure and Competitive Strategy,Electronic Technology, P51-52.
[4] LIU Wei-bo;LI Ming-juan;LI Jin-bu,Arena Robot Control System Based on Single Chip Microcomputer,Journal of Binzhou University, P84-87.
[5] Wangxin;Xuxiaofei;jinchen,The Design of WUSHU Arts Arena Robot Self Staging,Electronic Technology, P69-70.