Design of a Challenge Robot Based on Single-Chip Microcomputer

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Abstract. The Taiwanese robot is a robotic confrontation event that has emerged in recent years. This paper proposes a design scheme for the challenge robot. This new type of challenge robot was introduced from the control device, drive device, signal acquisition device and process design of the robot, and the mechanical analysis of the key parts of the robot was carried out. Through a large number of experimental tests and competition verification, the overall structure of the robot is reasonable and the stability is high, which can quickly knock down or push down the other robot.

1. Introduction

With the continuous popularization of intelligent concepts and the continuous development of intelligent technologies in recent years, more and more countries and regions have adopted the robot contest as an important platform for popularizing robot knowledge, selecting robotic technical talents and transforming robot technology [1]. A project of the robot competition came into being. Both sides of the challenge robot competition will fight on the platform, and the party who drops the platform will lose the game.

Challenge the rationality and stability of the robot's overall mechanism is an important prerequisite for the robot to win the game. It is of great significance to study the design of the challenge robot. Liu Yang and others from Inner Mongolia University of Technology proposed a new type of challenge robot, which added a 12-blade ducted fan at the center to increase the friction between the robot and the table [2, 3]. Zhang Heng, from Jinling College of Nanjing University, proposed a new design scheme for challenging robots, and introduced the robot from control strategy, motion planning, control system, sensing system, motion system and mechanical structure [4, 5]. Beijing University of Information Science and Technology Song Bofei and others have innovated the design of the challenge robot, and the overall use of laser-cut integrated stainless steel hollow steel plate with high-torque motor and infrared ranging sensor increases the stability of the robot [6]. The Xaiver developed by Carnegie Mellon University is the first autonomous mobile robot that can be controlled via the network [7, 8]. The robot is equipped with a camera for observing environmental information [9, 10]. It is also equipped with ultrasonic sensors and laser sensors, and has certain automatic navigation and obstacle avoidance capabilities. The WowWee company's intelligent robot Rovio is compatible with the global positioning system GPS and wifi. It is equipped with a network camera, which can transmit real-time video to users through wireless LAN, and users can remotely control it by using the network. It has a VGACMOS camera sensor, speakers and built-in microphone. The LED lighting on the whole body allows it to work
normally at night. The three omnidirectional wheels and the advanced intelligent identification system allow Rovio to patrol the house without any problems. Laboriously avoid obstacles [11, 12].

This paper designs the perfect combination of mechanical part, control part and driving part by using the single-chip control principle.

2. Design technical requirements

The robotic competition venue of the robot competition platform is shown in Figure 1. Length 2400mm, width 2400mm, wood material, countertop 100mm from the ground. The red wireframe is the competition area, the middle is black, and the periphery is a 50mm wide white border. The two initial departure areas A and B are in the middle of the front and the rear. The initial position area is 200mmX150mm, and the area border line width is 10mm, white.

![Figure 1. Schematic diagram of the site of the competition.](image)

Two-legged robot requirements for the competition.

1. The robot game biped robot has the following dimensions: length ≤150mm; width ≤200mm; height is not limited. The length of a single sole is not more than 150mm and the width is not more than 200mm. Weight ≤ 2.0Kg.

2. The way of travel must be alternately walking on both feet, and the contact with the ground cannot use wheels, tracks, other variant wheels or rotating rolling mechanisms.

3. The robot is made of any material, and the appearance and color are not limited.

4. The robot must be autonomous and cannot be controlled remotely or by wire. The robot startup can be a manual start.

3. Program

3.1. Mechanical Principle

The mechanical part of the robot is show in Fig.2. After the enemy position is found by the ultrasonic sensor, it is transmitted to the control part, driving the lower arm to drive the arm, moving itself to the attack range, and using the attack arm forearm to hit the enemy back and forth. The enemy knocked down.
Figure 2. 3D illustration of the challenge robot.

1. Attack arm; 2. Forearm; 3. Ultrasonic sensor; 4. Control box; 5. Body; 6. The lower arm; 7. The foot drive arm; 8. The foot

3.2. Control Principle
The overall design block diagram of the system of this design is show in Fig.3.

Figure 3. System overall design block diagram.

The whole system circuit takes the single-chip microcomputer as the control center, and externally connects the ultrasonic sensor, the motor drive and the power module. When the system is working, the ultrasonic sensor senses the enemy's position information and hands it over to the MCU for processing. When the ultrasonic sensor senses the position of the enemy, the buzzer alarms, and through a series of selection judgments, the corresponding operation is performed, and finally the enemy is successfully knocked down.

4. Theoretical analysis
In order to enable the robot to knock down the enemy, the speed of the arm swing is calculated, and the running time of the motor servo is obtained.

The LDX-227 motor can produce up to 15kg*cm of torque with an arm length of 10cm. By formula

\[ F = T \times L \]

The outermost end of the arm can generate 15N force. The robot weighs about 2kg. Formula for impulse calculation

\[ Ft = mv \]

It can be seen that the faster the speed, the shorter the contact time and the greater the impulse.
Take $F$ as the critical value of 20N and $m$ is 1.5kg.

$$v = \frac{20}{1.5}$$

The maximum angular velocity of the motor is $\omega = 94 \text{ rad/s}$.

$$v = \omega r = 9.4 \text{ m/s}$$

Therefore, the contact time $t \leq 0.705 \text{ s}$, for the convenience of design time $t = 0.5 \text{ s}$, speed $v = 8 \text{ m/s}$, angular velocity $\omega = 80 \text{ rad/s}$, the generated impulse is $F = 24\text{N}$, which can knock down the other robot.

5. Hardware parts

5.1. Single Chip Microcomputer
This design selects STC11F08XE in STC11Fxx series MCU.

Characteristics:
1. Enhanced 80C51 Central Processing Unit, 1T per machine cycle, faster 6~7 times than the rate of a standard 8051.
2. Operating voltage range: 5.5V~4.1V/3.7V
3. Operating frequency range: 0~35MHz, is equivalent to standard 8051:0~420MHZ
4. 6 vector-address, 2 level priority interrupt capability.
5. Three power management modes: idle mode, slow down mode and power-down mode.
6. Maximum 40 programmable I/O ports are available
7. Operating temperature: -40 ~ +85°C (industrial) / 0~75°C (commercial)

5.2. Ultrasonic Sensor
The ultrasonic sensor adopts HY-SRF05 as show in Fig. 4. The ultrasonic distance measuring module can provide 2cm-450cm non-contact distance sensing function, and the ranging accuracy can reach up to 3mm. The signal is received by HY-SRF05 ultrasonic sensor. Communicate to the master chip to control the steering gear to achieve fast and flexible motion, resulting in the most effective attack.

![Ultrasonic sensor](image)

**Figure 4.** Ultrasonic sensor.

The electrical parameters of the HY-SRF05 ultrasonic module are show in Table 1.
Table 1. Ultrasonic module parameters.

| Electrical parameters       | HY-SRF05 Ultrasonic module |
|-----------------------------|----------------------------|
| Operating Voltage           | DC5V                       |
| Working current             | 15mA                       |
| Working frequency           | 40Hz                       |
| Farthest range              | 4.5M                       |
| Recent range                | 2CM                        |
| Measuring angle             | 15°                        |
| Input trigger signal        | 10μS TTL pulse             |
| Output echo signal          | Output TTL level signal, proportional to range |
| Standard sizes              | 45*20*15mm                 |

5.3. LDX-227 Digital Motor
This design adopts LDX-227 digital motor as show in Fig. 5. The structure adopts a mixture of aluminum alloy and acrylic material to form a metal bracket to be reinforced, which is not only light in weight but also strong in strength and not easily deformed. The hardness and strength of the fiberglass board are very high, not easy to damage. Large torque (15KG/cm), 270 degree range rotation, high precision and long life.

The motor can provide 24N impulse to meet the demand of 19.6N, which can meet the attack requirements.

Figure 5. LDX-227 digital motor.

5.4. Hardware Connection
The sensor receives the signal and transmits it to the MCU. After processing by the MCU, it sends a command to the servo controller to make the corresponding action.

Figure 6. Hardware connection diagram.
6. Software flow

Set up a series of action groups through the interface shown in Fig. 7 to deal with enemies in different directions. When designing the action, you need to connect the motor control board to the computer first. After the indicator light turns green, you can design the action.

For the walking action, first decompose the walking action into two actions: lifting the leg and landing the foot. First reset the robot steering gear, then adjust the robot's leg steering gear to a suitable angle, input the running time according to the desired speed, and click Add move, you get the action of lifting your legs. Similarly, according to the above method, the robot landing action is added to the action group, and then the leg raising and landing action of the other leg is added, and the action group of walking one step can be obtained (Fig. 7). By clicking the button to run online, the robot can be moved one step, and the cycle can be walked all the time.

![Figure 7. Walking Action Group.](image)

The overall system flow chart is show in Fig. 8.

![Figure 8. System flow chart.](image)
7. Experiment analysis

7.1. Action Group Analysis
As shown in Fig. 9, the robot can complete the upright walking motion and advance in all directions.

![Upright action and Walking action]

Figure 9. Action analysis.

7.2. Process Analysis
As shown in Fig. 10, the robot can realize the position of the enemy through the ultrasonic sensor and approach the enemy, and swing the upper arm to attack the enemy a series of actions, in line with the design idea.

![Search for enemies and Attack the enemy]

Figure 10. Process analysis.

8. Conclusion
In this paper, a new humanoid challenge robot is proposed. The control device of the robot is designed. The action group of the drive device is designed to cope with different situations. The hardware is selected and connected, and the motion flow is designed. The structure of the robot was analyzed by theoretical analysis of the design and impact force. The analysis results show that the robot can meet the requirements of fierce confrontation in the competition.

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