

Design of Intelligent Crawler Fire-Fighting Robot Control System

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Abstract: Based on STC89C52 microcontroller and mobile terminal as hardware platform, this paper designs a set of fire robot control system. The system consists of two parts: mobile platform control system and mobile terminal command system. The mobile platform control system is mounted in the mobile chassis of the fire-fighting robot. It enters the fire site or dangerous place with the fire-fighting robot. It is responsible for collecting the environmental data and video information such as the temperature, humidity, flame intensity, toxic gas concentration and so on, and sends them to the mobile terminal command system through the wireless transmission module, and can also receive the control instructions from the computer command system. The command system takes the PC terminal software as the control platform, and the operators use the software to control the fire robot. At the same time, the data and video information returned by the image transmission system are received and displayed on the user interface. The fire situation is identified by the flame sensor and the small water spray device. The system can identify the fire in the fire and automatically open the water spray device, It can realize close fire fighting and prevent fire spreading. The system has the advantages of small size, convenient control, high reliability, strong specificity, independent intelligence and so on. It can meet the control and emergency treatment of some high-risk occasions and meet the basic requirements of fire-fighting tasks to a large extent.

1. Introduction

With the advent of industry 4.0 era, the industry of various countries will usher in the era of rapid development. Due to the intelligence and flexibility of the fire-fighting robot itself, more and more are used in real life. Especially in the face of a merciless fire, firefighters can't predict the situation of the fire accident scene. In the face of unknown situations such as inflammable and explosive, easy collapse, chemical corrosion, toxic gas, etc., it will easily bring unnecessary casualties to the personal safety of firefighters^[1]. At present, the United States and Japan, especially the United States, have developed five kinds of fire-fighting robots with reconnaissance function, such as Pandor mobile robot and guardrobo D 1. The development of intelligent fire-fighting robots in China is just beginning. However, although the development of hardware and software of the existing fire-fighting robots is becoming more and more perfect, there are still some shortcomings, such as single function and poor independent intelligence. In order to meet the needs of practical application, a scheme of intelligent fire-fighting robot is proposed, which integrates fire-fighting, walking, reconnaissance and monitoring, climbing and obstacle crossing, data acquisition and image transmission.

2. Scheme Demonstration and Design

2.1 Overall System Design

In order to realize the monitoring of small places, this paper proposes a fire fighting and obstacle avoidance robot based on STC89C52 chip. It uses flame sensor and ultrasonic sensor to monitor the fire source and avoid obstacles respectively, and then uses water spray device to achieve the purpose of fire fighting. At the same time, through wireless image transmission control, remote data transmission and reception are realized. The robot has the advantages of simple structure, low cost and small volume^[2]. It can provide effective help for timely rescue and has certain practical

significance.

2.2 System Hardware Design

The design of the fire robot to STC89C52 chip as the main controller, and by the data acquisition module, drive module, sprinkler module, wireless transmission module (picture transmission module), power module, alarm module. The hardware structure diagram of the robot is shown in Fig. 1.

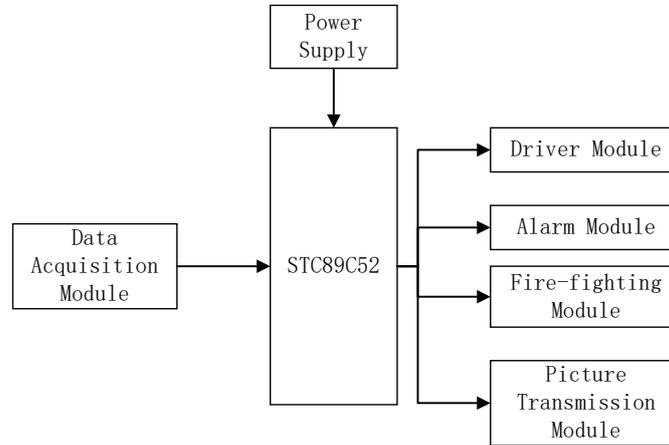


Fig.1 Block Diagram of Robot Hardware Structure

In the figure, data acquisition is divided into fire source data detected by flame sensor and obstacle data detected by obstacle avoidance sensor (us-015). In order to ensure the accurate position of fire source detection, far-infrared flame sensors are distributed in multiple directions of the robot. It can detect infrared light from 700 nm to 1000 nm, and its sensitivity is the highest when the wavelength is 880 nm. The driving module uses l2933d chip which can drive two motors as the driving core. When the enabling end is high level, the robot drive is started, and according to the detected obstacle data, the robot path is changed to achieve obstacle avoidance function^[3]. When the robot drives to the fire source, the fire extinguishing module can realize the function of sprinkling fire by the small water pump running at high speed in the sprinkler device. Considering the transmission distance, the wireless transmission module (image data transmission module) uses hc-12 chip for data transmission and reception. It is mainly composed of digital buzzer and alarm module.

3. Hardware Circuit Analysis and Design

The hardware circuit design takes STC89C52 as the core and uses two chips. One chip is used to drive two decelerating motors, the other is used to drive water pump and video part. First of all, according to the signal of detecting obstacle and flame^[4], the MCU can judge whether the robot is moving forward. If there is an obstacle, avoid the obstacle and enter the next working environment. When the signal is generated to drive the robot forward, the level signal generated by the direction control button in the mobile terminal is sent to the single-chip microcomputer through wireless network. According to the requirements of program design, the MCU makes corresponding judgment and sends it to the motor drive module, so that the robot can realize the basic functions of forward, left, right, parking and camera rotation. When reaching the fire site, the MCU controls the water pump to spray water to extinguish the fire source through the water pump drive module.

In the design of intelligent fire robot control system, STC89C52 single chip microcomputer is used as the main control chip of the control system^[5]. The hardware design module is divided into: power module, motor, obstacle avoidance module, water pump drive module, water pump module, WiFi video module.

3.1 Driving Circuit of Fire-Fighting Robot

The motor part is controlled by PWM mode of ordinary DC motor. PWM mode is easy to control motor speed and angle of turning, and double motor drive is used to facilitate the completion of in-situ

steering, backward and other actions of fire-fighting robot^[6]. Local left turn can be achieved by controlling the left motor to reverse and the right motor to forward transmission.

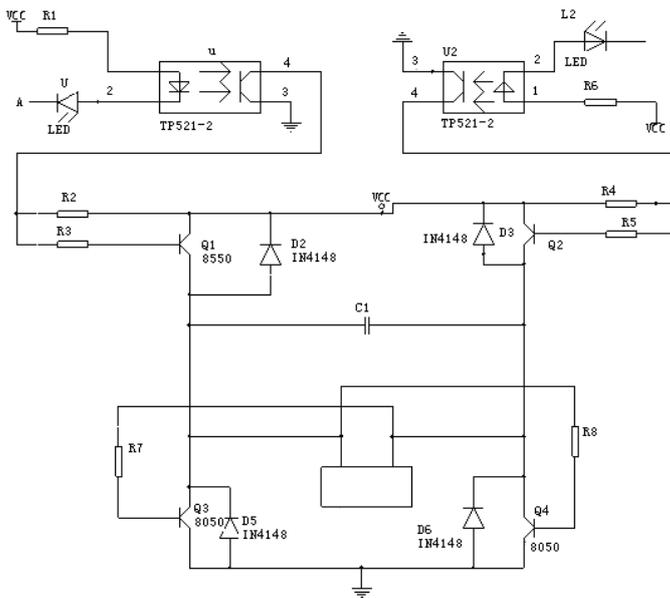


Fig.2 Rnal Circuit Diagram of Motor Drive

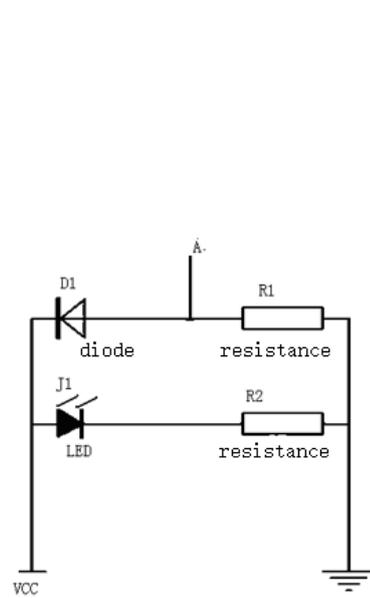


Figure 3. Obstacle Detection Circuit

There are four interfaces B0, B1, B2 and B3 on the control board to control the motor on the intelligent fire-fighting robot. First of all, put a universal wheel in front of and behind the external intelligent fire-fighting robot, with double power wheels on both sides. The internal circuit is shown in Figure 2. When input A is low level and input B is high level, the drive motor will rotate forward. When A input is high level and B input is low level, the drive motor reverses. A. When B is high level, the motor stops, A and B cannot be at low level at the same time^[7]. Four diodes can protect the transistor. The power transistor is driven by tp512 optocoupler to isolate the control part from the motor drive part. The four control ports B0, B1, B2 and B3 are respectively connected with port a, port B of the left motor, port a and port B of the right motor.

Table 1 Motor Rotation State Code

Left Motor		Right Motor		Left Motor	Right Motor	Motor Running Status
B0	B1	B2	B3			
0	1	0	1	Forward Rotation	Forward Rotation	Forward
0	1	1	0	Forward Rotation	Motor Reversal	Turn right
0	1	1	1	Forward Rotation	Motor Stalling	Turn right in place with the right motor as the center
1	0	0	1	Motor Reversal	Forward Rotation	Turn left
1	1	0	1	Motor Stalling	Forward Rotation	Turn left in place with the left motor as the center
1	0	1	0	Motor Reversal	Motor Reversal	Back off

It can be seen from table 1 that as long as different codes of four control ports B0, B1, B2 and B3 are set by software programming, different operation states of electric vehicle such as forward, backward and rotation can be obtained.

3.2 Obstacle Avoidance Sensor Circuit of Fire-Fighting Robot

For obstacle detection, we use photoelectric sensor, which adopts two-way obstacle avoidance sensor module. The detection distance is directly set at about 10 cm, and the level changes from low to high within 10 cm. Considering that the color gray difference between the site and the path is great, the reflection of the light source is also very different, which affects the output signal of the sensor. The single-chip microcomputer receives the signal of the line seeking sensor after that, it will control the motor to make corresponding action to avoid obstacles and complete the fire-fighting task.

In Figure 3, LED is the light-emitting diode, D1 diode is the receiving end, A is connected with the

single-chip microcomputer, and the resistance R1 and R2 play a protective role on the diode^[8]. The working principle is as follows: when D1 can't receive optical signal, the a-terminal of cut-off is equivalent to low-level grounding; when D1 receives the optical signal, it is broken down, which is equivalent to a high-level wire directly connected with VCC. The resistance of photodiode changes obviously with the light intensity. We use two-way obstacle avoidance sensors, the sensing distance is 10 cm, That is, as long as there are obstacles within 10 cm, the sensor output will change from low level to high level.

3.3 Water Pump Circuit of Fire-Fighting Robot

The control of the water pump is directly controlled by the pump motor. When the MCU judges that the fire source can be blown out, the program will judge the fire source, and then turn on the pump motor drive to control the water pump to spray water for fire extinguishing, as shown in Fig. 4.

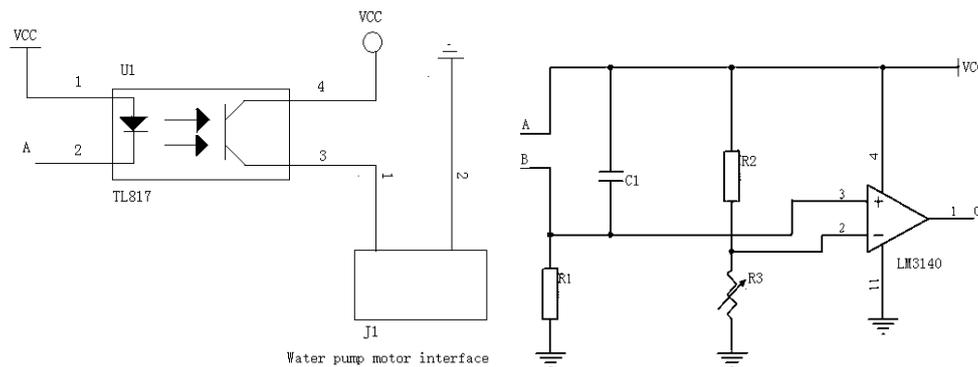


Fig.4 E Circuit Diagram of Water Pump Motor

Figure 5. Flame Signal Acquisition Circuit

3.4 Flame Sensor Detection Module

For flame detection, we make use of the influence of temperature change on the current of infrared sensor, and the distance also has obvious influence on the output of sensor. By comparing the comparator with the reference voltage, we can judge the direction and general distance of the fire source.

In the circuit shown in Figure 5, AB is the interface of the flame sensor, and the resistance R1 can not only protect the sensor but also raise the potential. In order to protect the sensor and meet the requirements of our voltage range, the resistance R1 is finally selected to be 120K, while the capacitor C1 is used to eliminate external interference and filter, which is about 0.1 μ F. by adjusting the rheostat R3, the reference voltage of the comparator can be adjusted, Then adjust the distance to the fire source. The test results show that when $R3=27\Omega$, the flame detector can sense the fire source within 25cm, which is regarded as close range. When R3 is very small, the fire source within 95cm can be sensed, which is regarded as a long-distance range. C is the output end of the comparator. The position of the fire source can be determined by detecting the voltage of the output terminal.

3.5 Video Capture Module

This paper uses a USB digital camera. The camera contains a digital signal processing chip, which can compress and encode the captured video stream information and convert the analog signal into digital signal. The design of the transmitter includes the collection of video information and data compression coding, which is mainly driven by the USB camera installed in the wireless router; in order to make the camera device work normally, it is necessary to load the USB video driver in the kernel.

According to the functional requirements of the video transmission system, the main task of the video capture terminal is to collect the video information of the environment where the fire robot is located, compress the video data, and send the compressed video stream. The function of video acquisition module is to collect video information through camera image sensor, and store the collected video data in random queue buffer of compression thread for real-time compression of

video data by compression thread. When the video capture thread successfully writes a frame of original video data to the compression thread queue buffer, the compression thread starts to work. The main task of compression thread is to compress the video transmitted by the capture thread into video stream data according to JPEG video compression standard, and then send the video stream data to the thread queue of buffer. The video acquisition terminal of the video transmission module and the video receiving module is the corresponding module, which is mainly responsible for receiving the video data sent by the video acquisition terminal in USB.

3.6 Wi-Fi Wireless Data Return Module

In the design of video module program, in addition to complete video acquisition and compression, it also needs to transmit real-time video signal for users to access, view and display^[9]. The wireless data transmission designed in this system is the transmission of control signal and video information, which is based on TCP / IP protocol. On the side of the server, the main application of TCP / IP protocol is to accept all kinds of requests from the remote client, and is responsible for establishing and canceling the connection with the remote client, and transferring the data required by the client to the remote client.

4. Summary

Based on the analysis of the development trend and control demand of intelligent fire-fighting robot control system, this system introduces the software and hardware composition of the intelligent fire-fighting robot control system based on STC89C52 single-chip microcomputer, and intelligently optimizes and improves the control system of fire-fighting robot. Its main characteristics are simple circuit structure, stable and reliable operation and low cost ratio. In addition, it also achieves satisfactory results in function, realizes the image transmission and display, and realizes the intelligent sprinkler function of the fire robot system.

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