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Design of Fire Extinguishing Robot

Yuan Chen, Dongshao Wang, Jiahui Yang, Xin Xv

School of Electrical Information and Engineering, Quzhou University, China

Abstract

In order to reduce the risk of fire extinguishing and protect the safety of people's lives and property. Design a trolley with fire warning, autonomous patrol, autonomous obstacle avoidance, and automatic fire extinguishing. The car can replace patrol personnel, carry out uninterrupted patrols in fire-prone situations, and alarm when dangerous gases or smoke are generated. When the robot detects a fire, it immediately performs intelligent fire extinguishing. The fire extinguishing robot of this paper mainly involves the application of STM32 single-chip microcomputer and multi-sensor, the design of steering mechanism of the servo, the position arrangement of sensors, and the writing of algorithms.

Keywords

Fire Extinguishing Robot; STM32; Sensor; Automatic Patrol.

1. Introduction

Many countries in the world have begun to invest in the research of intelligent fire extinguishing robots after the first use of firefighting robots in the Tokyo Fire Department in Japan in 1986. This paper intends to design an intelligent patrol fire extinguishing robot that autonomously extinguishes fires according to the set mode. First of all, it is necessary to complete the selection and structure of the entire mechanical structure, and then select the corresponding sensor and single-chip microcomputer to form a control trigger system, and finally form a complete fire extinguishing robot. The robot needs to have the following functions:

(1) It can replace security personnel to conduct uninterrupted patrols with set routes.

(2) With smoke alarm function, if smoke is generated in the set environment, timely alarm to attract attention.

(3) Flammable gas leakage detection, if flammable gas is produced (such as carbon monoxide), immediately alarm to attract attention.

(4) Photoelectric obstacle avoidance, when close to objects and people, the sensor feedback trolley immediately turns, so as to avoid accidents.

(5) Flame detection function, once the flame is detected, the flame sensor is fed back to the single-chip microcomputer to control the trolley to turn to the flame for fire extinguishing.

2. System Hardware Design

The hardware design of this system is divided into three parts: controller, sensor and motor speed regulation. Based on the functional design requirements of the system, it is mainly composed of the following ten modules: power module, step-down module, fire extinguishing module, gas detection module, flame detection module, smoke detection module, motor drive module, tracking module, obstacle avoidance module and alarm module. Among these hardware modules, the STM32 chip belongs to the controller part, which can accept sensor information and process it in real time, coordinate the operation of each module of the entire fire extinguishing trolley, and realize the normal operation of the system. This design is

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equipped with a 24V lithium battery power module to power the fire extinguishing car. The system hardware framework is simplified as shown in Figure 1 below.

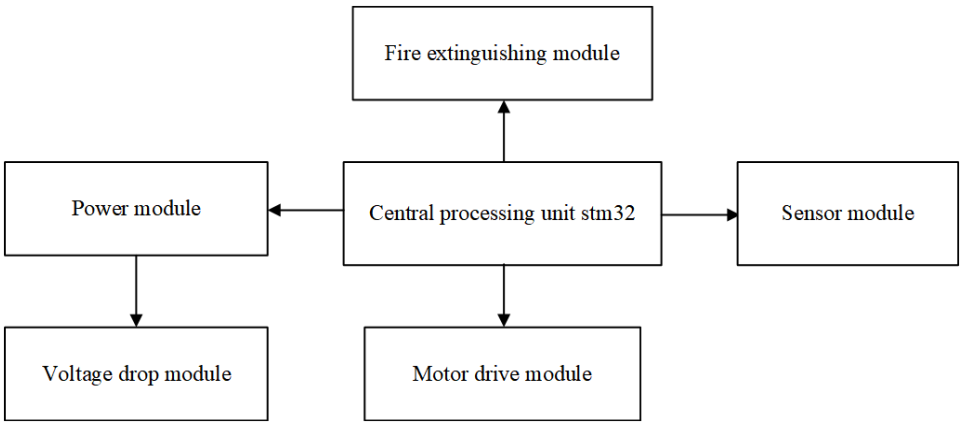

Figure 1. Simplified diagram of system hardware framework

2.1. Sensor Module Hardware Design:

2.1.1. Photoelectric Infrared Obstacle Avoidance Module

At present, the mainstream obstacle avoidance sensor has two ways: ultrasonic obstacle avoidance and infrared obstacle avoidance, but because ultrasonic obstacle avoidance has high requirements for on-site sound, it is easy to be affected by noise and thus affect judgment, so this robot adopts photoelectric infrared obstacle avoidance to achieve fire extinguishing and obstacle avoidance. This time, three E18-D80NK infrared photoelectric sensors are used, located directly in front and on both sides of the front of the car. When encountering obstacles, the sensor receives the signal, transmits it to the single-chip microcomputer through the signal line, and the programmed program receives and processes the signal of the three-way sensor, determines the direction of movement of the trolley, and realizes autonomous obstacle avoidance.

2.1.2. Infrared Tracing Module

This design adopts infrared tracking module to realize the patrol function of intelligent cars. Two tracking modules with adjustable sensitivity are installed under the front of the trolley, located on the left and right sides of the trolley, and the sensitivity of the sensor is adjusted through the adjustable resistance to achieve the effect of rapid response. The track is set to a black track, and it is difficult to reflect when the sensor meets black, and the output is high, so that only through the change of high and low levels, the track correction of the trolley can be controlled by a single-chip microcomputer, so that the trolley has been running along the black line to realize the function of autonomous patrol.

2.1.3. Gas (Smoke) Sensor Module

Install an MQ-2 model gas (smoke) sensor module on the roof of the trolley to fully contact the air and detect combustible gases and smoke in the air to the greatest extent. When the gas and smoke diffuse, the sensor is pulled up from the low level to the high level, so that only through the change of high and low levels can understand the gas in the air, when it is high, trigger the alarm system of the trolley, attract the attention of the surrounding personnel.

2.1.4. Flame Sensor Module

The flame sensor detects the flame by capturing the infrared wavelength in the flame through a special infrared receiving tube, and the wavelength of the detection flame is in the range of 800nm-1000nm, which can effectively realize flame detection. This system adopts a five-way fan-shaped flame extinguishing module, located at the front of the trolley, and the sector size of

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the sensor module is about 120°, which can realize a wide range of flame positioning. There is an LM393 comparator inside, when the flame is captured within the range, the output is converted from low level to high level and fed back to the microcomputer for fire extinguishing. The schematic of this flame sensor is shown in Figure 2.

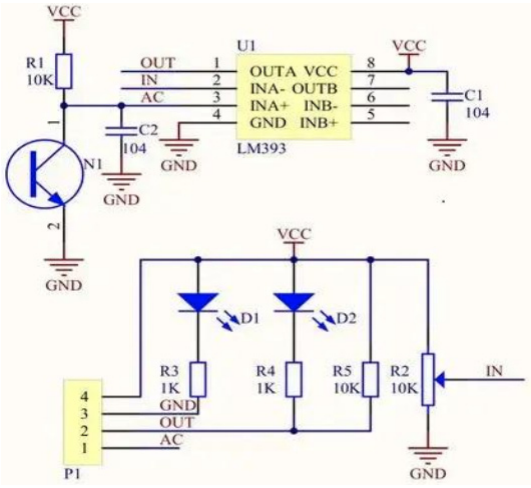

Figure 2. Schematic diagram of flame sensor

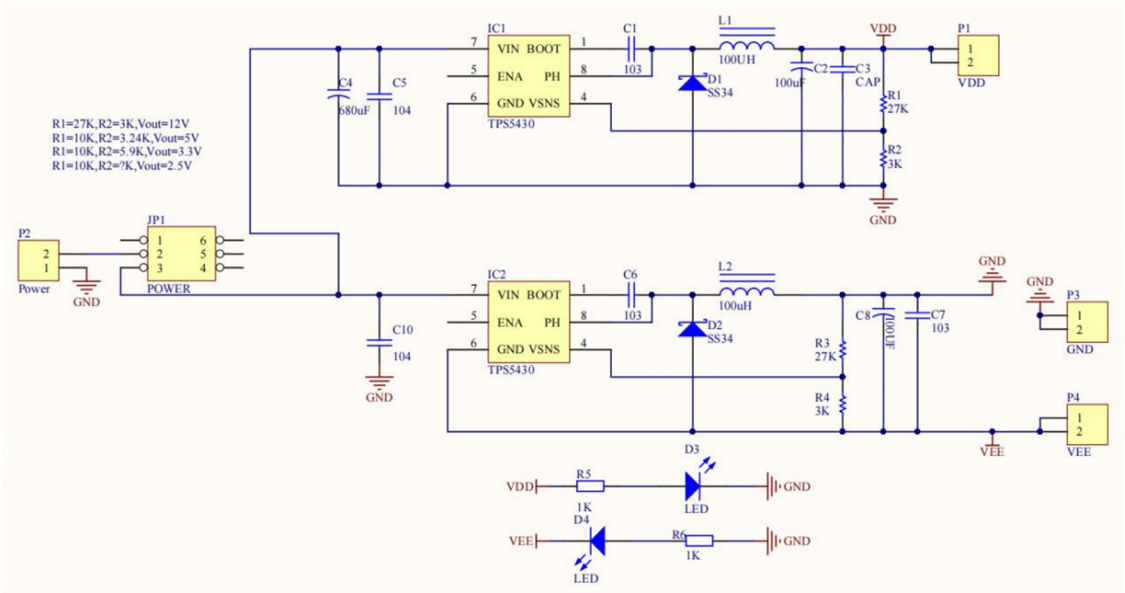

Figure 3. Schematic diagram of the step-down module

2.2. DC Geared Motor Speed Regulation

The car designed in this design adopts P6M37-520 DC geared motor, the reduction ratio is 1:56, the rated current is 1A, and the speed is 176RPM under 12V no load. This design uses the STM32F4 timer counting mode to generate PWM waves with a frequency of 2kHz, and controls the speed of the left and right wheels of the trolley through the generated two PWM waves input to the motor drive module. By adjusting the duty cycle (timer count value), you can control the average value of the output voltage of the module to achieve speed control of the motor.

2.3. Buck Module Design

Since the 24V lithium battery pack can not directly supply power to the sensor, servo and single-chip microcomputer, etc., DC-DC step-down module is required to achieve, so this design adopts TPS5430 buck module, the power supply size of this step-down module is 5.5V-32V, the output voltage is ±5V, and the maximum output current is 3A, which is in line with the system design.The schematic diagram of the step-down module is shown in Figure 3.

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3. System Programming

Main program design: The main program of the fire extinguishing robot adopts C language programming, and the main function is: initializing each hardware module and sub

The program, and is the starting point of the program operation, is particularly important for the writing of the main program, and its running steps are mainly as follows:

(1) Initialize each hardware module, configure relevant information, and complete the setting of interface baud rate.

(2) Initialize the subprogram, and the clock, interrupt and I/O port contained in the subprogram complete the initialization.

(3) The main program runs in a loop, detects signal changes and reacts. The flow chart of the main program is shown in Figure 4 below.

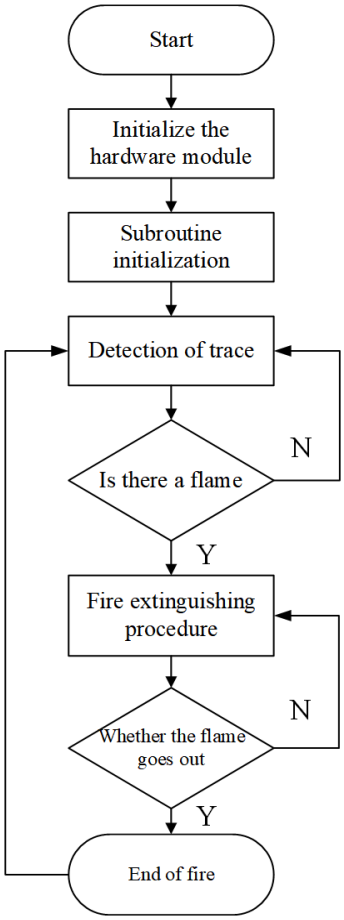

Figure 4. Main program flow chart

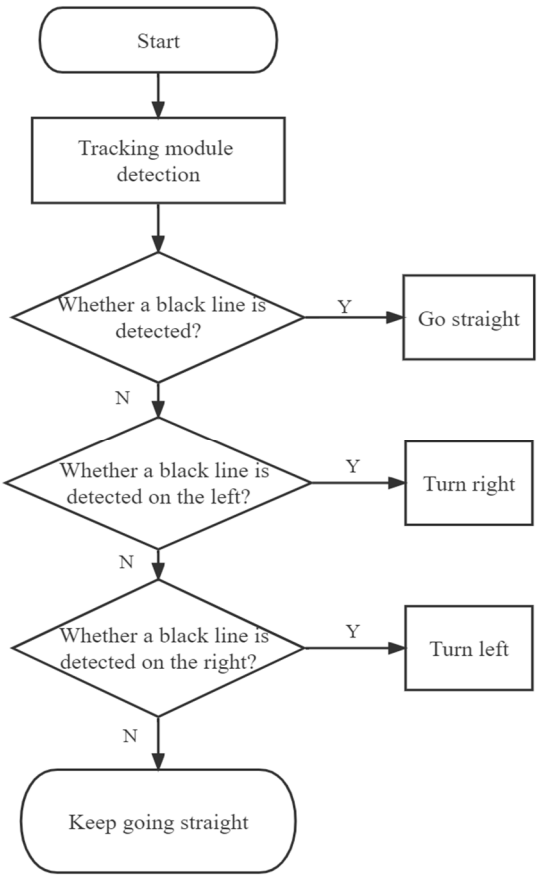

Figure 5. Flow chart of the tracing program

3.1. Trace Function Programming

The fire extinguishing trolley tracking function uses infrared reflection sensors, model TCRT5000, arranged on both sides of the front of the chassis of the trolley, which is used to adjust the steering route of the trolley and realize the patrol function. The sensor has an infrared transmitting tube and a receiving tube, and the output signal is selected as a digital signal. When the infrared light is reflected back, the infrared receiver tube is saturated with a low level, indicating that the diode is lit. Conversely, when the infrared reflection intensity is not enough, the infrared receiver tube is in the shutdown phase, and the level is high, indicating that the diode is off. Because infrared reflects black the weakest, the conversion of high and low levels can occur by laying a black line on the specified path, sending out a turning signal and realizing the cruising function of the car. The flowchart is shown in Figure 5.

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3.2. Obstacle Avoidance Function Programming

The obstacle avoidance function of the fire extinguishing trolley uses infrared photoelectric sensors, model E18-D80NK, arranged on both sides in front of the trolley, which is used to adjust the next direction of travel of the trolley to prevent collision with objects. The sensor is divided into NPN type and PNP type, and the output signal is a level (digital) signal. The sensor selected this time is an NPN-type sensor, and when approaching an object, the object reflects the infrared rays emitted by the photoelectric switch transmitter to the infrared receiver, and the received signal is processed by the circuit to generate a low-level signal. Conversely, the photoelectric switch maintains a high output. When the photoelectric sensor on the left side of the trolley detects the signal, the trolley turns to the right, and when the photoelectric sensor on the right detects the signal, the trolley turns to the left to realize the obstacle avoidance of the trolley. The flowchart is shown in Figure 6.

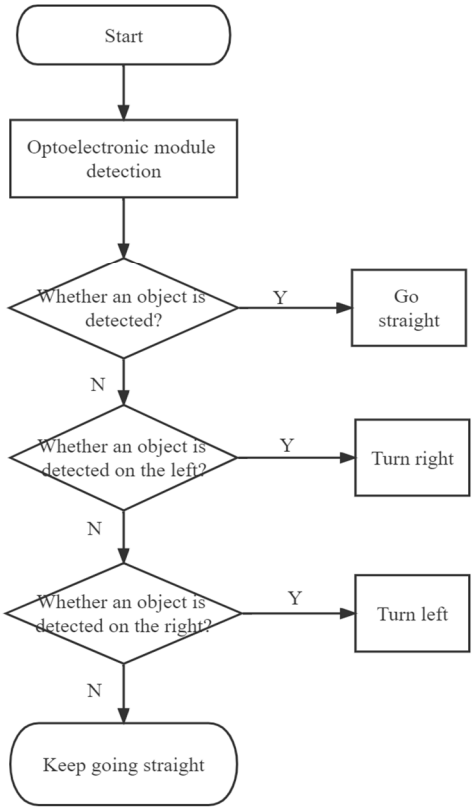

Figure 6. Obstacle avoidance procedure flow chart

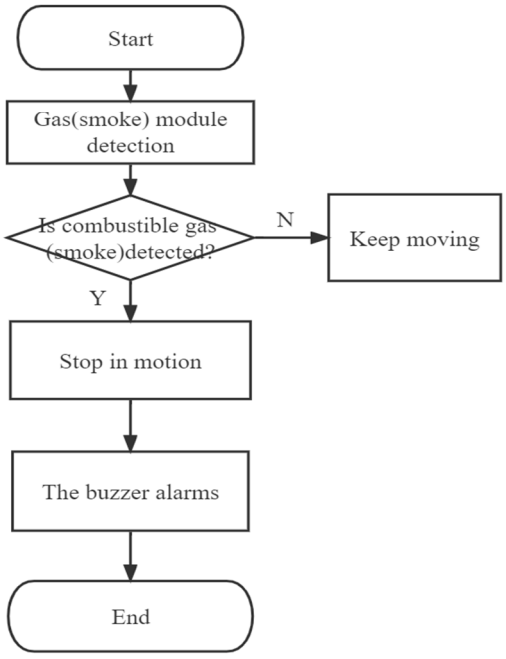

Figure 7. Gas(smoke) alarm flow chart

3.3. Gas (smoke) Alarm Function Programming

The smoke and gas alarm function of the fire extinguishing trolley uses the semiconductor gas sensor module MQ-2, which is very sensitive to smoke and combustible gases. Sensors are installed on the roof of the trolley to detect the presence of combustible gases and smoke in the air to prevent and warn of fires. As the concentration of combustible gas or smoke in the environment in which the sensor is located increases, the conductivity of the sensor increases, and the level signal is output through the TTL circuit. When the gas (smoke) concentration rises, the TTL output active level is low, the buzzer starts to alarm, and the trolley stops running. The flowchart is shown in Figure7.

3.4. Fire Extinguishing Function Programming

The fire extinguishing function of the fire extinguishing trolley uses a five-way flame sensor module, the flame sensor captures the infrared wavelength in the flame through the special

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infrared receiving tube to detect the flame, the wavelength of the detection flame is in the range of 800nm-1000nm, and the output is carried out by the voltage signal, and the measurement distance is adjustable.

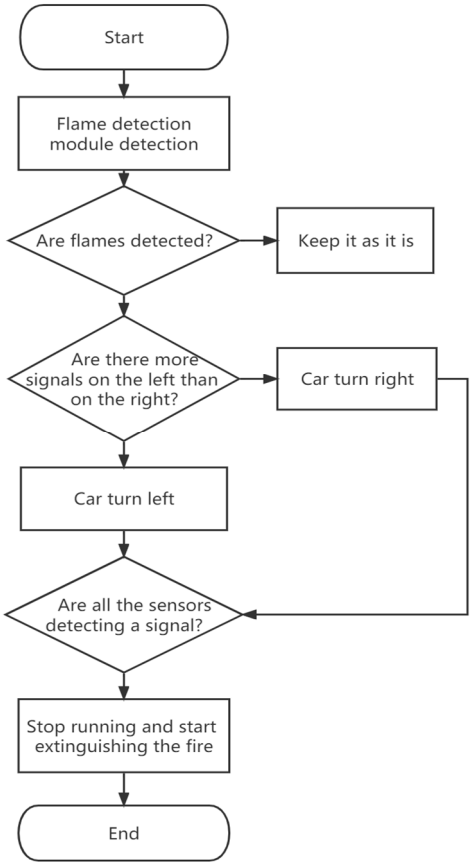

Figure 8. Fire extinguishing procedure flow chart

Sensors are installed at the very front of the trolley to detect the presence of flames in the environment. When the environment produces flames, the flame sensor controls the trolley to rotate to the way where the number of flames is detected according to the number of roads sensed by the left and right sides, and if the number of roads sensed by the sensors on both sides is the same, it means that the flame is in front, and then enable the fire extinguisher to extinguish the fire. The fire extinguishing function of the trolley is realized by the above algorithm, and the flow chart is shown in Figure 8.

4. Conclusion

In order to reduce the hazard of fire, it is necessary to develop a fire extinguishing robot with inspection function using intelligent technology. The intelligent fire extinguishing robot studied in this paper is based on the application of STM32 single-chip microcomputer and multi-sensor, the design of the steering mechanism of the servo, the position arrangement of the sensor, the writing of the algorithm, etc., with the functions of autonomous inspection, autonomous obstacle avoidance, fire warning, positioning and fire extinguishing, etc., in the day or night instead of patrol security for 24 hours of uninterrupted patrol, once the flame is detected during the patrol will immediately take action to extinguish. For the fire extinguishing robot, the following aspects of work are mainly done:

(1) Understand the development status of fire extinguishing robots at home and abroad, solve problems from the actual point of view, and design a fire extinguishing robot with patrol function, which can meet the needs of many occasions and have a wide range of applications.

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(2) According to the hardware needs, the controller based on the ARM chip is selected to control the action of the trolley, mainly including the control of the servo module, sensor module, fire extinguishing mechanism, etc.

(3) For modules such as sensors and servos, after fully understanding their principles and functions, subprograms are written through software and run with the main program.

Acknowledgments

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