Design and Development of Intelligent Fire-fighting Robot Based on STM32

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Abstract: With the rapid growth of economy, fires occur frequently in various dangerous places. According to the investigation, in the ancient tragic fire cases, the number of intelligent mobile fire-fighting equipment is very small, and ordinary fire extinguishers and fire-fighting trains can't put out the fire in time and quickly. As a kind of robot, intelligent fire-fighting robot plays an increasingly important role in fire-fighting and rescue. In this paper, the design of fire robot is studied. Intelligent fire-fighting robot is mainly composed of fire-fighting movement system, fire-fighting water spray system, fire-fighting control system and other components. All parts cooperate with each other and work together to complete the fire-fighting task.

1. Introduction
The concept of intelligent fire-fighting robot has been born, but it has not been popularized because of various difficulties. With the frequent occurrence of fire, there are more and more safety problems. Nowadays, with the increasing urbanization, a large number of basement buildings and petrochemical enterprises continue to be built[1]. However, ordinary fire extinguishers and fire-extinguishing trains can not be put out in time and quickly[2]. Sometimes, fire fighting operations may endanger the life safety of fire fighters. To solve this problem, the research of fire-fighting robot is urgent.

2. Overall Functional Design of Intelligent Fire-fighting Robot Based on STM32
The overall structure of the intelligent fire-fighting robot is shown in Figure 1. It is primarily composed of fire-fighting movement system, fire sprinkler system, fire control system and other parts. Each part is a whole to coordinate the activities and complete the fire-fighting task. The robot adopts the crawler type walking mode, driven by a pair of driving wheels at the rear of the car body, and turns on the principle of differential speed. The firearm is located above the car body, which can simulate the movement of human upper limbs and has better flexibility. The car body is also equipped with a camera, power supply system and other parts to assist the robot to complete the fire-fighting task. The control box is located at the rear part above the vehicle body, and an antenna is arranged on the control box for receiving signals. When the robot carries out fire-fighting work, it is supplied by an external water source.
The operation of the robot is mainly carried out by the robot body. It can run at a suitable speed under the control of the operator, and it is relatively stable. It can drive through the terrain with a certain slope smoothly and adapt to various types of fire environment. The robot power supply adopts battery, which is set inside the car body to supply power to the whole system.

Cameras are set in the center of the machine body and behind the fire arm, which can transmit the specific situation of the fire scene and the working condition of the fire arm to the operation screen. The camera is set above the pan tilt and can rotate 360° to observe the surrounding environment of the fire completely.

The fire arm system is composed of boom, middle boom, jib and its support. Among them, a series of transmission mechanism and water cutting gun are set inside the small arm. The water cutting gun aims at the fire source and emits high-pressure water flow to carry out fire-fighting and fire-fighting operation, and can be adjusted in the face of different working faces. It can adjust the position of the fire control arm flexibly and flexibly, and can complete the fire control task flexibly.

3. Functional Structure Design of Intelligent Fire-fighting Robot Based on STM32

3.1 Design of Fire-fighting Motion System
The fire-fighting motion system is mainly composed of a robot body and a DC motor. As the mobile carrier of the whole system, the car body of the fire robot can complete the front, rear, left, right and other actions under the control of the firefighters, and maintain the appropriate speed operation, and it is relatively stable, can drive through the terrain with a certain slope, and adapt to various complex fire rescue environment. The walking mechanism is driven by a pair of driving wheels, which is located in the car body back, turn using differential principle.

The fire-fighting environment of the fire-fighting robot is usually complex, and it needs suitable mobile carriers, and the center of gravity of the car body is required to be low to prevent rollover, and the weight of the car body is as light as possible, and it also needs to have a certain ability to cross obstacles, so it is suitable for the car body to adopt the crawler walking mode [3]. In the tension outer tube of the walking mechanism, there is a tension groove type. In front of the tension groove type, there is a small wheel shaft. The driven wheel is assembled on the small wheel shaft. By adjusting the screw, the extension length of the tension groove type can be adjusted. The distance between the driven wheel and the driving wheel will change accordingly, so that the tension degree of the track can be adjusted [4].
3.2 Design of Fire Sprinkler System

In order to improve the efficiency and quality of fire-fighting, it is a more ideal way to use a sprinkler to extinguish fire. The fire sprinkler system is mainly composed of the firearm and its internal parts, which are the core component of the whole fire robot. The design of the fire arm should be appropriate, and the space occupied by the mechanism should be reduced as much as possible to make the structure simple and light, which is conducive to manufacturing. According to the actual fire situation faced by the fire robot, the design of the fire arm should be considered from its structure and material to ensure the rationality and meet the requirements of special fire fighting. From the structure, it is necessary to calculate and design the size of each arm length of the fire arm. From the material point of view, the material used for the fire arm should not only have light weight, but also ensure the strength and stiffness requirements. Therefore, in the design of the fire arm, duralumin has better rigidity and lighter weight. The fire arm is welded with aluminum plate, and the center is hollow, which can facilitate the control line to pass through.

The fire arm system is composed of the big arm, the middle arm, the small arm and its support, and the control line is placed in the fire arm, which can avoid the breakage or winding of the line caused by the work when the control line is exposed outside, reduce its own weight, and properly improve the rigidity of the fire arm. A series of driving mechanisms and water cutting guns are set inside the jib, which can use the water cutting guns to spray out high-pressure water flow for fire-fighting, and can adjust adaptively, aim at the fire source, and complete the fire-fighting operation. The firearm system has four degrees of freedom, which can adjust the position and movement state flexibly. It plays an important role in the completion of the fire task and has a certain universality.

![Figure 2. Structure diagram of fire arm](image)

![Figure 3. Overall structure of fire arm](image)
3.3 Design of Fire Control Systems
The hardware of the fire control system is mainly composed of the upper computer and the lower computer. Both the upper computer and the lower computer use the control board with STM32F407 as the core to realize the function. The wireless communication technology is used to realize the signal transmission between the upper computer and the lower computer. In Keil environment, the control board is programmed with C language. Because STM32 chip integrates single cycle DSP instruction and floating-point unit to improve the calculation ability, it can greatly save time in actual calculation. At the same time, it also supports program execution and data transmission and processing. The data transmission rate is very fast [5]. In case of fire, fire officers and soldiers can control the robot to move into the fire scene, operate the robot remotely, control each part of the robot, and complete the fire-fighting task.

In the process of realizing the control, the fire robot transmits the detected field working conditions to the upper computer by wireless communication technology, and displays them on the screen of the control end. Firefighters control the robot. The upper computer reads the control signal of the control handle. After A/D conversion, the command is transmitted to the lower computer by using the wireless module NRF24L01. The control chip of the lower computer controls the operation of the robot and adjusts the working state of the fire arm through the driving module L298N, so as to complete the fire fighting task. In the working process, the lower computer not only receives and processes the instructions from the upper computer, but also timely feeds back the data and information of the actual working environment to the upper computer, so that the officers and soldiers of the fire brigade can formulate the fire control strategy in time and control the fire fighting robot to complete the fire fighting task.

3.4 Other Parts
Camera: A camera is set in the middle of the robot body, which can transmit the environmental conditions of the fire scene and the working conditions of the firearm to the upper computer. The camera is set above the platform and can rotate 360° to fully observe the surrounding environment.

24V Battery: The power supply of the robot is a 24V battery, which is set inside the car body to supply power to the whole system.

4. Innovation and practicability of intelligent fire-fighting robot based on STM32
- Setting the heavy parts on the chassis of the entire vehicle reduces the height of the mass center of the whole vehicle and improves the stability.
- STM32 is used as the control board, and the remote control handles is used to control the robot remotely, so as to reduce the risk of firefighters entering the fire scene.
- The Wi-Fi camera is used to monitor the scene remotely and collect data.
- The sprinkler can automatically expand, rotate and extinguish a fire in a wide range, with small space occupation and high stability.
- The protective cover can protect the equipment from damage.

5. Conclusion
Intelligent fire-fighting robot is mainly composed of three parts: fire-fighting movement system, fire-fighting water spray system and fire-fighting control system. Each part works together to complete the fire-fighting task. In case of fire, the fire fighters can remotely control the fire robot to enter the fire scene, and control the robot's movement and adjust the status of the fire arm to quickly extinguish the fire by observing the environmental conditions and the working conditions of the fire arm through the camera. Fire-fighting robot can replace human beings to participate in life-threatening things, to complete some difficult tasks and work; to enter the flammable and explosive hazard accident scene for data collection, processing and feedback. The robot can realize real-time remote monitoring operation and effectively extinguish the fire, ensuring people's life safety and property safety [6].
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