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Research Paper

Design of an Intelligent Inspection Trolley Based on Photoelectric Sensor

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ABSTRACT:*This paper designs and researches an intelligent patrol car based on photoelectric sensor and MQ2 smoke sensor, which uses mature single-chip technology to realize the functions of obstacle avoidance, tracking and detection of dangerous gases, which is convenient for user operation and system management.The car can realize tracking and obstacle avoidance functions through photoelectric sensors, and use MQ2 smoke sensor to monitor dangerous gases in the surrounding environment. In this paper, STM32 single chip microcomputer is used as the main controller, combined with DC motor and infrared tracking and obstacle avoidance module, to realize the intelligent tracking and obstacle avoidance function of the car, the MQ2 sensor is used to realize the dangerous gas monitoring function, and the WIFI communication module is used to realize the connection with the upper computer. Through the design of hardware and software, the functions of autonomous tracking, obstacle avoidance and hazardous gas monitoring of the car are realized. At the same time, the upper computer can be connected to give real-time warning of the concentration of hazardous gas around the environment. The experimental results show that the design can effectively realize the tracking, obstacle avoidance and dangerous gas monitoring and alarm functions of the car, and has good performance and reliability in different environments, providing a valuable reference for practical applications.The subject adopts microcontroller to design intelligent inspection with low power consumption, low cost, short design cycle, simple and reliable system, perfect function, simple operation, and high degree of informatization with supporting upper computer management software. After hardware debugging the system can complete the expected functions.*

KEYWORDS: *Intelligent patrol car; STM32; Hazardous gas monitoring; ESP8266*

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I. INTRODUCTION

The intelligent inspection trolley designed in this paper mainly reflects the intelligent mode of the trolley, the design of the analytical methods, theoretical solutions and innovations for the intelligent fire fighting trolley, mining exploration robots and other automatic or semi-automatic machine design and popularization of a certain reference value, the intelligent inspection trolley in the presence of hazardous gases in the environment, the structure of the unusually complex terrain, the environment is not suitable for human work can play a huge role! Such as intelligent inspection trolley in the gas monitoring module, usually can be used in fire systems, security systems and other fields, in dangerous situations using intelligent inspection trolley for inspection, etc.; In recent years, environmental pollution and safety issues of concern, gas monitoring trolleys in which play an important role [1]. Intelligent inspection trolley as a new type of gas monitoring equipment, can realize automation, high efficiency, accurate gas monitoring, for improving environmental protection, safety, energy and other fields of work efficiency is of great significance. At the same time, the development of intelligent inspection gas monitoring trolley involves a number of disciplines, such as mechanical design, electronic control, sensor technology, etc., which is also of positive significance in promoting the technological development of related fields.

This paper mainly develops an intelligent patrol car that can automatically track, avoid obstacles and monitor whether the concentration of harmful gases in the environment exceeds the standard. The intelligent patrol car based on photoelectric sensor designed in this paper mainly uses the STM32 single chip microcomputer with powerful functions, superior performance, rich resources on the chip and low power

consumption as the main control chip, combined with the mature motor control and sensor technology and other related knowledge, so that various functions of the car can be fully realized [2]. The main modules of the intelligent patrol car are STM32 single chip microcomputer, tracking module, obstacle avoidance module, gas monitoring module, motor drive module, power module, buzzer module, WIFI wireless communication module, and upper computer. The STM32 single chip microcomputer controls each sensor of signal acquisition to achieve the functions required by the intelligent patrol car designed in this paper, The WIFI wireless communication module of the car can transmit the data collected by STM32 MCU to the upper computer, realizing the function of remote warning to users. The infrared photoelectric sensor converts the received infrared light with different intensities into high-low level signals through the sensor's internal conversion based on the principle that black and white objects with different colors have different reflective abilities to infrared light, so as to realize automatic tracking; In terms of obstacle avoidance, the working principle of the intelligent patrol car is the same as that of the track. If it encounters an obstacle, the infrared light emitted by the infrared photoelectric sensor will reflect back. If it does not, the infrared light will not be received, so as to realize the obstacle avoidance function; When the car is moving, the smoke sensor automatically monitors the harmful gas in the environment. If the concentration of harmful gas is detected to exceed the preset value, an alarm sound will be sent through the buzzer module, and the signal will be transmitted to the upper computer through the MCU and WIFI wireless communication module to warn the user[3]。

II. OVERALL DESIGN

The intelligent patrol car designed in this paper uses the front wheel drive to drive the whole car. It uses two DC reduction motors. The two front wheels of the car can use the same motor drive module. The motor drive module can adjust the speed of the two DC motors of the car through PWM waves, so as to control the car to adjust the travel direction, A Vientiane wheel needs to be installed at the rear of the trolley as the rear wheel, so that the trolley can be supported and balanced[4].The infrared photoelectric sensor tracking module is installed on the left, middle and right under the car body for tracking. Under normal circumstances, the tracking sensor in the middle of the car body detects the black line. When the other two do not detect the black line, the car is normal in the front. If the infrared photoelectric sensor tracking module on the left detects the black line, the main control chip controls the speed of two motors, The trolley can be properly corrected to achieve the purpose of tracking the trolley; Similarly, when the right infrared photoelectric sensor tracking module detects a black line, the car can also make appropriate corrections. The principle of car obstacle avoidance is consistent with that of car tracking. An infrared photoelectric obstacle avoidance sensor is installed in front of the car body. When the sensor detects that there is an obstacle in front of the car, the main control chip gives a signal, alarms through the buzzer and controls the car to stop. An MQ2 smoke sensor is placed at the rear of the car. In the environment where the car is running, if the concentration of harmful gas in the environment exceeds the standard, it will be detected by the MQ2 sensor, and alarm will be given by the buzzer. The car will stop moving, and transmitted to the upper computer through the WIFI wireless communication module, which can realize the function of sending a warning to the user remotely.

In order to realize normal connection and application between STM32 and each module, it is necessary to select the correct IO port to connect with each module. For example, STM32 is required to output PWM when the motor drive module regulates the speed of the motor, and TIM timer peripherals on the SCM are required when using STM32 MCU to realize PWM control. For example, the IO ports of STM32 corresponding to TIM3 are PA6 and PA7, Then the two IO ports PA6 and PA7 of STM32 are connected to the PWMA and PWMB of the motor drive module. The following figure is the overall circuit connection diagram.

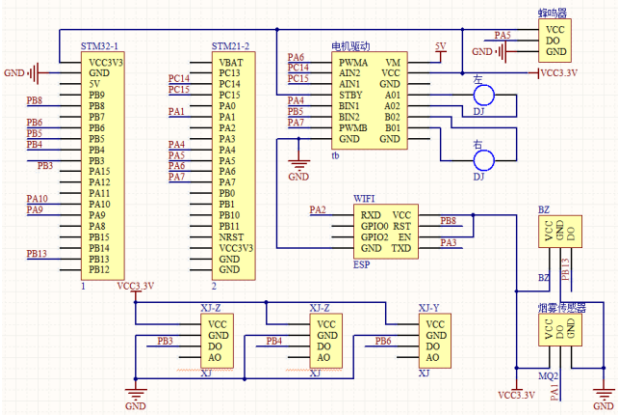

Figure 1: Circuit diagram of the general connection between the modules

III. HARDWARE DESIGN

3.1 Microcontroller system design

The core controller selected by the intelligent patrol car designed in this paper is the single chip microcomputer, whose function is to control the normal travel of the car to achieve the required functions and performance indicators of the car. The single chip microcomputer, which has the advantages of simple, convenient and fast control, is very suitable as the control chip of this design. In the intelligent patrol car designed in this paper, the single chip microcomputer can not only give full play to its advantages of rich resources, but also has more powerful control functions and addressable operation functions [5]. The SCM selected in this paper is STM32F103C8T6, which runs faster. Its own two AD converters enable us to design smoke sensors without adding external ADC for conversion; The smallest system module with STM32F103C8T6 chip as the core. The minimum system module includes clock oscillator circuit, power circuit, program download/debugging interface circuit, reset circuit, BOOT selection circuit and other parts. For convenience, lead the pins of the chip to both sides of the rectangular PCB, and then combine the above circuits to form the smallest system board.

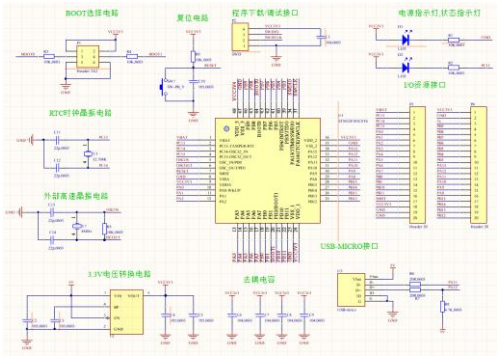

Figure 2: Schematic Diagram of STM32F103C8T6 Minimum System Board

3.2 Motors and motor drives

The power supply mode used by the intelligent patrol car designed in this paper is DC power supply. It needs to choose DC motor. The DC motor can not only bear large loads, but also work stably when the speed and signal are not constant. It also has obvious load characteristics, which greatly improves the stability of the car. When the system is in the no-load state, The torque of the motor is relatively large. When the trolley receives different commands, it will continue to move in the original state due to its inertia. In order to prevent the inertia movement, the DC motor can provide enough torque for the trolley, so the intelligent patrol trolley selects the DC reduction motor, The intelligent patrol car designed in this paper selects a motor drive chip to output PWM waves and change the voltage at both ends of the motor to realize the forward rotation, reverse rotation and stop of the motor. This paper selects a relatively new motor drive chip -- TB6612FNG drive integrated circuit to drive the motor. Its internal MOSFET-H bridge structure can not only withstand large current, It also has a dual channel output circuit [6] that can drive two motors at the same time.

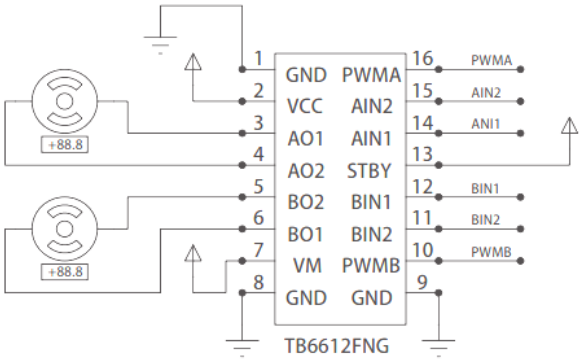

Figure 3: TB6612FNG Wiring Diagram

3.3 Tracking and Obstacle Avoidance (Infrared Photoelectric Sensors)

In this paper, the intelligent patrol car needs to realize independent tracking and obstacle avoidance in a specific environment. The principle of infrared photoelectric sensor tracking and obstacle avoidance is based on infrared reflection and reception. The infrared photoelectric sensor is usually composed of an infrared emitting

tube and an infrared receiving tube. The intelligent patrol car designed in this paper selects TCRT500 infrared photoelectric sensor module to realize the function of tracking and obstacle avoidance. TCRT5000 infrared photoelectric sensor module is an infrared reflective photoelectric switch designed based on TCRT5000 infrared photoelectric sensor, which contains an infrared light-emitting diode and a photosensitive triode.

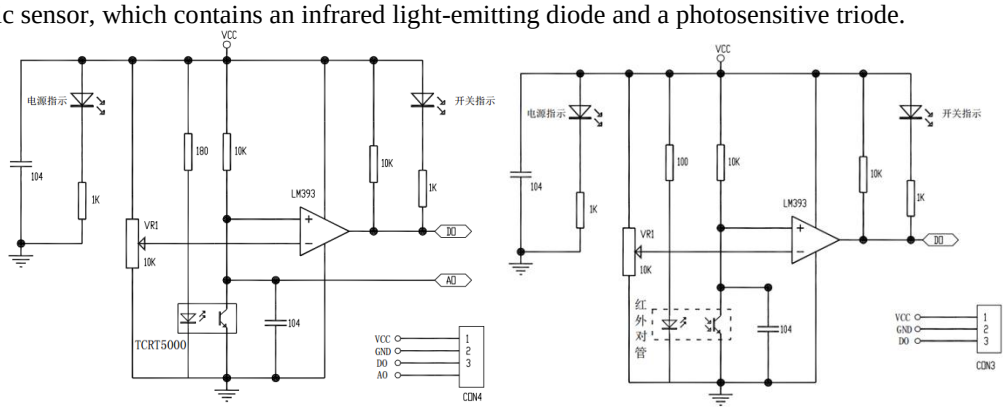

Figure 4: Internal Wiring Diagram of TCRT5000 Tracking and Obstacle Avoidance Module

3.4 Hazardous gas monitoring (MQ2 smoke sensor)

The intelligent patrol car designed in this paper not only has the functions of intelligent tracking and obstacle avoidance, but also has the function of harmful gas monitoring. The smoke sensor can be used to detect the concentration of certain gases in the current environmental places to prevent fire and other dangerous events. The sensor used to monitor harmful gases in the intelligent patrol car designed in this paper is not the MQ2 smoke sensor commonly seen in the market, The sensor has a long service life, extremely stable performance and extremely high sensitivity, especially for methane, butane and other alkyl smoke.

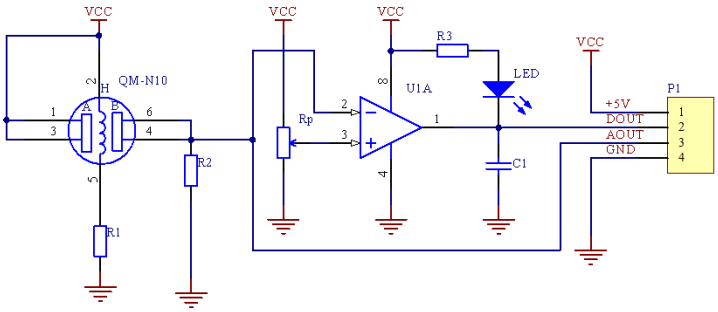

Figure 5: Circuit schematic of the smoke sensor module

3.5 WIFI wireless communication module

The intelligent patrol car designed in this paper can realize the function of remote notification to users after the concentration of the monitored harmful gas exceeds the standard. The most suitable choice is to use wireless communication. ESP8266-01S wireless communication module is used in the WIFI wireless communication part of this design. It has ultra-low power consumption, very powerful functions, long communication distance, low price, small size, supports three modes of AP, STA, AP+STA, and simple and efficient AT instructions. In this design, it is used for wireless communication between STM32 MCU and mobile phone. Through WIFI module, STM32 MCU sends the smoke concentration value collected by MQ2 smoke sensor to the upper computer.

IV. SOFTWARE DESIGN

4.1 Overview of the main software program

After the completion of the hardware part of the design of the intelligent inspection trolley, the microcontroller used in the design of this paper and the peripheral sensors that have been selected after the completion of the peripheral sensors, and for the trolley in this paper to realize the function, the software part of the design.

The intelligent patrol car designed in this paper is programmed in C language, and the selected software development environment is Keil μ Vision5。 In this paper, modular programming is used in the software design of the intelligent patrol car, and the GPIO port and ADC module of STM32 are used to collect

the data of the infrared photoelectric sensor and MQ2 sensor, so as to realize the vehicle's autonomous tracking, obstacle avoidance and harmful gas monitoring functions. At the same time, the WIFI wireless module is used to realize the connection between the intelligent patrol car and the upper computer, and realize the real-time data transmission and monitoring.

4.2 Motor drives

When using STM32 MCU to realize PWM control, TIM timer peripherals on the MCU are needed. Using the output comparison function of the timer, three key parameters of the timer need to be configured: prescaler value PSC (Prescaler), auto reload value ARR (AutoReload Register), and output comparison value CCR (Capture/Compare Register),The control of the three parameters of PWM control and the configuration of the three parameters of the timer need to be linked to realize the speed control of the DC motor by STM32 single-chip microcomputer. The TB6612FNG motor drive chip can drive two motors. The two channels (PA6 and PA7) of the timer 3 of the STM32 microcontroller generate two PWM waves to achieve speed control of the motor.

4.3 Tracking

In this paper, the tracking function of the intelligent inspection trolley adopts infrared photoelectric sensor, the principle is that the infrared photoelectric sensor infrared transmitter tube emits infrared rays, if the infrared rays encountered by the black line, then the infrared rays will be reflected back, in the infrared receiver tube to receive the infrared rays reflected back from the black line, which will produce an electrical signal, the electrical signal can be read by the controller, and then according to the written program The vehicle can complete the autonomous trajectory function.

4.4 Barrier avoidance and gas monitoring alarms

After the main function is executed, the MQ2 harmful gas monitoring module judges whether the concentration of harmful gas in the environment where the car is located exceeds the concentration value preset by the MCU. At the same time, the car's infrared obstacle avoidance photoelectric sensor senses obstacles. If the gas concentration value in the detected environment exceeds the preset concentration value or when the car's infrared obstacle avoidance photoelectric sensor senses obstacles, Alarm and stop the trolley through the buzzer to warn the people around the trolley to pay attention to safety.

4.5 WIFI wireless communication

ESP 8266-01S is usually pre installed with AT command firmware. This means that STM32 sends AT commands to ESP8266-01S through serial to control its Wi Fi connection and data transmission. The actual communication protocol and instruction format will vary according to specific applications and requirements. In most cases, you can send a string containing specific instructions (starting with AT) to tell ESP8266-01S to perform corresponding operations, such as connecting to the Wi Fi network, sending data, and so on.

In order to connect the STM32 with the ESP8266-01S module, the communication between the STM32 and the ESP8266-01S can only be realized through the connection between the STM32 serial port and the ESP8266-01S. The TX pin of the ESP8266-01S wireless communication module is connected to the RX pin of the STM32, and the RX pin of the ESP8266-01S wireless communication module is connected to the TX pin of the STM32. The intelligent patrol car designed in this paper selects the serial port 2 of the STM32 to connect with the ESP8266-01S wireless communication module. The corresponding pins of the serial port 2 are PA2 and PA3, to ensure that the ESP8266-01S is properly supplied with power, usually 3.3V, GND can be shared between STM32 and ESP8266-01S.

V. EXPERIMENRAL VALIDATION

The intelligent patrol car designed in this paper cannot be simulated and debugged in software, so Keil hardware debugging method is adopted. The debugging interface can choose serial port debugging, or you can choose to use the following four SWD pins for program debugging, and the four pins usually choose ST-LINK as the program downloader.

According to the intelligent inspection trolley designed in this paper need to realize the function, need to put black tape on the white floor as the trolley trajectory route, the trajectory route must have a straight line and turn route; for the trolley's obstacle avoidance function to achieve, you can directly find the nearby convenient objects as obstacles to check the trolley's obstacle avoidance function is normal, the trolley's obstacle avoidance function is normal[7]; For harmful gas monitoring, because it is difficult and expensive to obtain some harmful gases, the disposable lighter with low price and easy access is selected as the device for releasing

harmful gases, because the disposable lighter is filled with liquid butane, and MQ2 can just identify the gas butane emitted by the lighter.

5.1 Trolley tracking commissioning

Car in the front of the lower part of the body placed in three infrared photoelectric trajectory sensor, when the car position is appropriate, the car can be along the black line has been walking, as shown in Figure 5.2, the car along the black straight line trajectory walking.

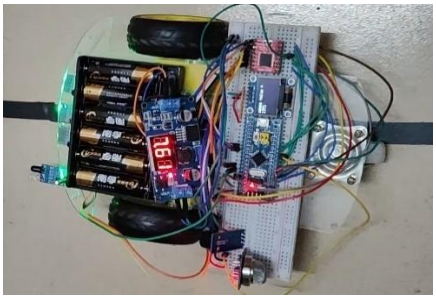

Figure 6: Trolley going in a straight line

Trolley walking along the black straight line trajectory, when the trolley walking to the turn, by the infrared photoelectric trajectory sensor to the microcontroller to send data, the microcontroller to respond to drive the motor to complete the corresponding turn, as shown in Figure 5.3, the trolley walking along the black straight line trajectory for the left turn and the right turn.

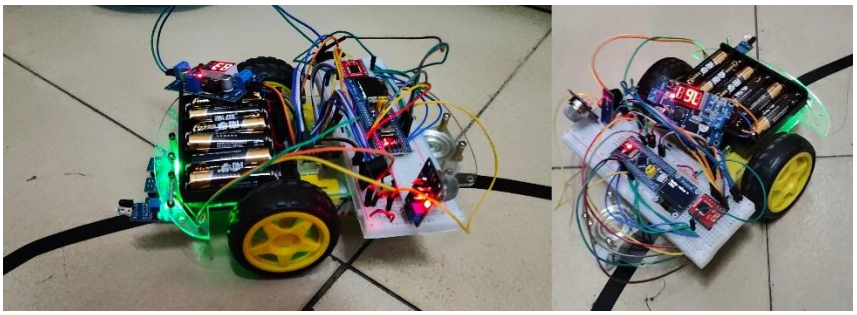

Figure 7: A trolley making a left turn versus a right turn

5.2 Trolley obstacle avoidance and gas detection debugging

Trolley body placed directly in front of an infrared photoelectric obstacle avoidance sensors, when the photoelectric obstacle avoidance sensors sense the existence of obstacles in front of the car, the car to stop the traveling action, if necessary according to the specific circumstances of the car can be carried out the next step of the operation, and at the same time through the buzzer to issue a warning, as shown in Figure 5.4, the car for the operation of obstacle avoidance.

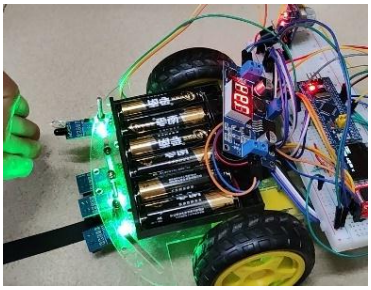

Figure 8: Trolley obstacle avoidance

An MQ2 smoke sensor is placed at the rear of the trolley to monitor whether the concentration of harmful gases in the environment where the trolley is located exceeds the standard. If the gas concentration exceeds the preset value, the trolley will stop and give an alarm through the buzzer. At the same time, a WIFI wireless communication module is placed on the trolley to complete the remote monitoring function. Because

some harmful gases are dangerous and the cost of obtaining them is high, a disposable lighter that can release butane gas can be selected to complete the commissioning of the harmful gas monitoring function of the trolley. As shown in Figure 5.5, the trolley detects that the concentration of harmful gases exceeds the standard.

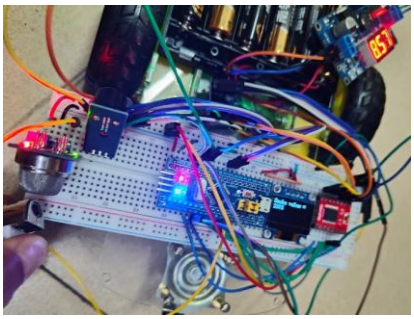

Figure 9: Hazardous gas detection in a cart

5.3 Upper computer debugging

The intelligent patrol designed in this paper directly uses the OneNET platform as the upper computer, uses the scene linkage function of the OneNET platform, and can choose to use the alarm mode of sending email to users to realize the remote alarm function when the concentration of harmful gases in the environment where the car is located exceeds the standard.

VI. SUMMARY

By having two swinging rods slowed by sticky friction, let us build a model, this model shows a driven double pendulum with stiction on both revolute joints. The angular velocity plots show the locking and unlocking of the joints. In diagram (1) is represented double pendulum [7].

The intelligent inspection trolley based on photoelectric sensing designed in this paper adopts the more mature microcontroller application technology, with the microcontroller as the control center, and at the same time using a variety of sensors, using a combination of hardware and software, successfully completed and realized the design of this paper based on photoelectric sensing intelligent inspection trolley, which is able to drive autonomously on the preset track, mainly manifested in the way of driving, can Through the infrared photoelectric sensor to the main control chip signal transmission, can make the car can automatically detect the user preset route. If the intelligent inspection off the sensor senses that the line has deviated, can be automatically corrected through the master control chip, so that the intelligent inspection trolley can return to the pre-set line up, when the intelligent inspection trolley detects obstacles in the forward direction of the presence of obstacles in the front, you can automatically start the alarm device alarm and stop in place, waiting for the intelligent inspection trolley users for its removal to continue to complete the work of the inspection. And the trolley can effectively monitor the concentration of harmful gases, in the environment where the trolley is located in the harmful gases exceeding the standard alarm action, for the application of related fields provides a valuable solution.

REFERENCES

[1]. Wu Zhilin. Design and research of hazardous gas patrol car system [D]. Chongqing University, 2022
[2]. Liu Peng, Sun Defan, Wang Tao, etc. Design of target seeking intelligent vehicle based on photoelectric sensor [J]. Electronic Design Engineering, 2021,29 (21):
[3]. Zhang Junpeng, Cui Zhitao, Sun Zhen, etc. Design of Arduino based gas monitoring intelligent patrol car [J]. Electronic Design Engineering, 2022,30 (06):
[4]. Yang Rong Design and Research of AGV Vehicle mounted Controller [D]. Xi'an University of Science and Technology, 2020
[5]. Qian Jinxing. Fire fighting trolley design based on STM32 [D]. Suzhou University, 2020
[6]. Hua Rong. Design of intelligent patrol car for safety parameters of chemical enterprises based on ARM [D]. Huaiyin Institute of Technology, 2020
[7]. Zhao Huandi, Tan Yufei, Qin Yunbai, etc. The design of intelligent patrol car tracking and obstacle avoidance based on STM32F407ZET6 [J]. Electronic Production, 2023,31 (13):