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Design of Intelligent Mobile Platform Control System

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Abstract: In response to the call of building a strong manufacturing country as mentioned in the document Made in China 2025, a control system for an intelligent mobile platform is designed. With its advantages demonstrated by omnidirectional movement capability, it provides a new direction for realizing remote control, dynamic path planning and multi-mode control.In this design, STM32F103 is used as the core processor, together with the DRV8833 motor driver module and N20 geared motors to achieve omnidirectional motion of the mobile robot. Mode selection is carried out through the OLED display on the remote controller. For remote control, two NRF24L01 modules are adopted to form a wireless communication link, so as to complete data transmission between the remote controller and the mobile robot.
Keywords: STM32 chip; wireless remote control; intelligent mobile robot; motor drive

Introduction

Inspired by the strategic goals of Made in China 2025, a remote-controlled Mecanum-wheel mobile robot is designed. By integrating multiple sensors, the Mecanum-wheel robot can perceive external environmental data and dynamically adjust its driving path according to the remote controller [1].This design adopts multi-sensor fusion technology and optimizes the weight of both the vehicle chassis and the remote controller chassis. On this basis, a two-layer integrated PCB design is implemented. The integration enables the Mecanum-wheel robot to achieve flexibility, stability and component replaceability in complex environments.

1 Overall System Design Scheme

This design mainly consists of two parts: the Mecanum-wheel robot and the remote controller. Control signals are input via the 3D aircraft model potentiometer on the remote controller, or ultrasonic signals reflected by obstacles are received by the ultrasonic module. After the CPU of the main control module on the remote controller receives and processes these inputs, it sends commands to the robot via the NRF24L01 wireless module. After the main control module of the robot parses the commands, it controls the motor driver module to adjust the rotational speed of the N20 geared motors, so that the robot can move forward, backward, and perform omnidirectional motion [2]. Autonomous obstacle avoidance is realized through the ultrasonic module, and remote control of the robot's movement is achieved via the remote controller. Finally, the main control module of the robot receives signals from the remote controller through the NRF24L01, analyzes them, and controls the operating state of the robot. The overall system block diagram is shown in Figure 1-1:

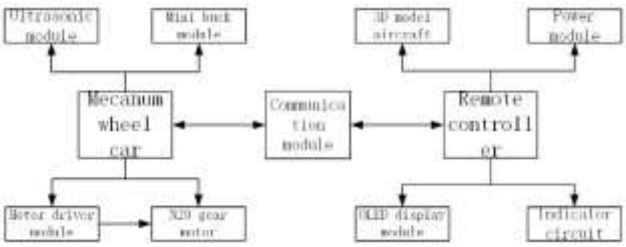

Figure 1-1 Overall System Block Diagram

2 System Hardware Circuit Design

2.1 Main Controller

This system adopts STM32F103C8T6 as the core processor, which has a main frequency of up to 72 MHz, integrates 64 KB of Flash memory and 20 KB of SRAM, and is equipped with 1 advanced timer,3 general-purpose timers,aswellas communication interfaces such as ADC DAC SPI I2C and CAN [3]. Its operating voltage is around 3.3 V, which effectively reduces the power consumption of the system — a crucial advantage for devices that require long-term operation and have strict power consumption requirements.

2.2 Wireless Transceiver Module

The NRF24L01 used in this design is a wireless transceiver module operating at 2.4 GHz, with a transmission distance ranging from 5 meters to 100 meters. It adopts GFSK modulation. In the 250 kbps low-speed mode, it can extend the communication distance and reduce power consumption. The module also integrates an automatic acknowledgment and automatic retransmission mechanism to improve the reliability of data transmission [4]. The physical diagram of the NRF24L01 is shown in Figure 2-1:

Figure 2-1 Physical Picture of NRF24L01

2.3 Motor Driver Module

The N20 geared motor is selected, which adopts an integrated package of a powder metallurgy gearbox and a micro DC motor. At an operating voltage of 3 V, it can provide a continuous torque of 0.6 N·cm. The motor is equipped with a D-shaped shaft, which can provide greater friction, so that the power of the Mecanum-wheel robot matches the desired value, making it more suitable for the omnidirectional movement requirements of the robot. In terms of driving mode, the N20 geared motor can be speed-regulated by PWM signals. Combined with the DRV8833 motor driver module, it achieves better speed control and direction adjustment. The physical picture is shown in Figure 2-2:

Figure 2-2 N20 Geared Motor

2.4 Ultrasonic Module

In the design of the remote-controlled Mecanum-wheel robot, the HC-SR04 is selected as the environmental perception sensor in this system to improve the robot's environmental awareness and realize obstacle avoidance. It features simple structure, accurate ranging and low cost. The measurable distance ranges from 2 cm to 400 cm, with a ranging accuracy of 3 mm, which can meet the requirements of the robot's obstacle avoidance function. The TRIG pin is controlled by the STM32F103. When the microcontroller outputs a high-level signal of at least 10 μs, the transmitter emits ultrasonic waves. When encountering an obstacle, the ultrasonic waves are reflected back as echoes. The receiver detects the reflected acoustic signal and converts the echo back into an electrical signal, making the ECHO pin high. The duration of the high level is proportional to the round-trip time of the ultrasonic waves [5]. The microcontroller captures the duration of the high-level ECHO signal via a timer, and calculates the distance to the obstacle combined with the propagation speed of sound waves in air. The physical picture is shown in Figure 2-3:

Figure 2-3 Ultrasonic Module

2.5 Circuit Design of the Joystick

In the remote control part of this system, a 3D aircraft model joystick potentiometer is used as the input device to realize mode selection and remote control of the Mecanum-wheel robot. The remote control potentiometer mainly consists of two variable resistors, which detect the displacements of the X-axis and Y-axis respectively, and integrates a key function to enhance control selection. The X-axis and Y-axis signals of the two joystick potentiometers are connected to the analog inputs of the microcontroller. The analog voltage output by the joystick is collected through the ADC, and then the direction and amplitude of the control are calculated, so as to realize the control of the robot. The circuit diagram of the 3D aircraft model joystick potentiometer is shown in Figure 2-4:

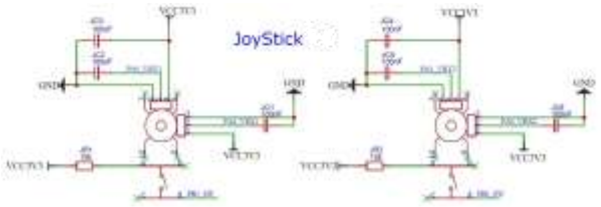

Figure 2-4 Circuit Diagram of the 3D Aircraft Model Joystick Potentiometer

3 System Software Design

3.1 Ultrasonic Module

The main function of the system is responsible for the overall control and task execution of the Mecanum-wheel robot. After power-on, it first initializes the delay function, NRF24L01 module, motors, ultrasonic module and RGB light. Meanwhile, the motors are set to stop mode during initialization. After a 1-second delay, the system turns off the LED light and enters a while loop to execute the robot's control logic. This enables the detection and response to the external environment, ensuring stable operation of the system. The program block diagram of the main program is shown in Figure 3-1:

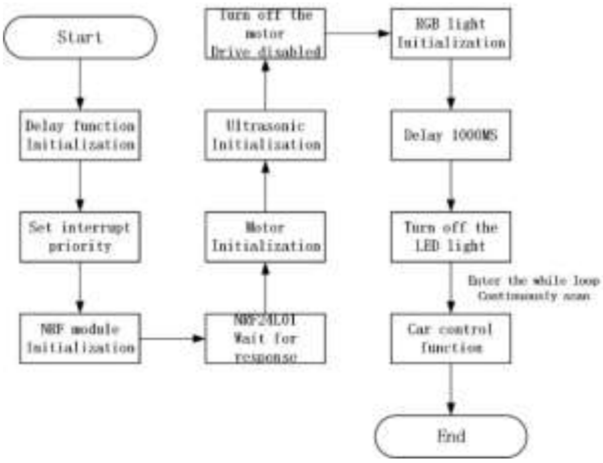

Figure 3-1 Program Block Diagram of the Main Program

3.2 Control Function Design

The Mecanum-wheel robot control function is based on the NRF24L01 wireless communication module, which parses the data packets sent by the remote controller and judges whether the data in the buffer is valid [6]. If the data is valid, the operating mode of the Mecanum-wheel robot is switched according to the commands sent by the remote controller. The robot has four motion states: free mode, follow mode, obstacle avoidance mode, and colorful light mode. After exiting the colorful light mode via the remote controller, the robot will maintain the exited mode in all subsequent states. In remote control mode, the robot is moved by the remote controller; in obstacle avoidance mode and follow mode, the ultrasonic module is used to detect obstacles, adjust direction and track the target. The program block diagram of the Mecanum-wheel robot control function is shown in Figure 3-2:

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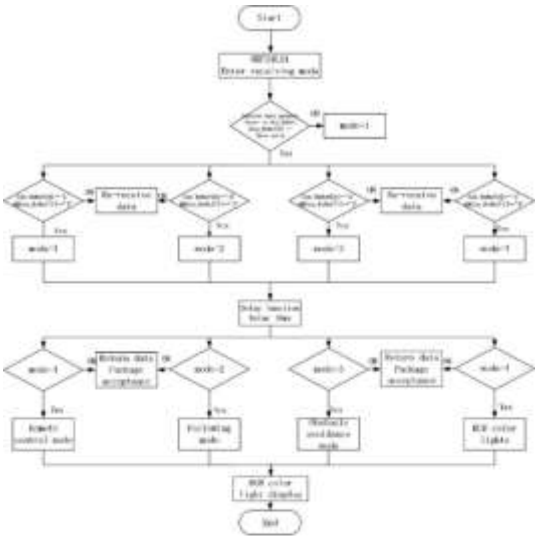
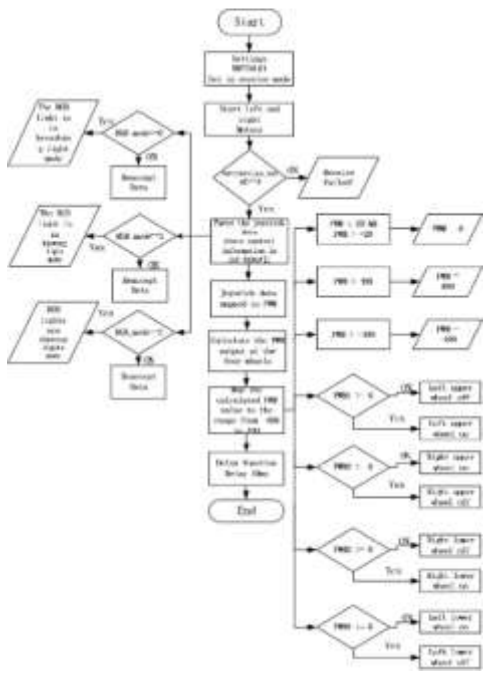


Figure 3-2 Program Block Diagram of the Mecanum-wheel Robot Control Function

3.3 Remote Control Function Design

After the system is powered on, data transmission is carried out through the NRF24L01 wireless communication module. The remote control function parses the commands from the remote controller and maps them to PWM signals for the four motors to drive the motors and achieve precise control. First, the system enters the wireless receiving mode, initializes the receiver of the NRF24L01 module on the Mecanum-wheel robot, and prepares to drive the robot. If a data packet is successfully received, the system parses the content in the data buffer received from the joystick and extracts the X and Y axis values of the left and right joysticks. Then the mapping function (Map()) maps the raw data to the range of -127 to 127. After that, PWM1, PWM2, PWM3 and PWM4 are calculated to meet the power requirements of the four motors. The program block diagram of the remote control function is shown in Figure 3-3:

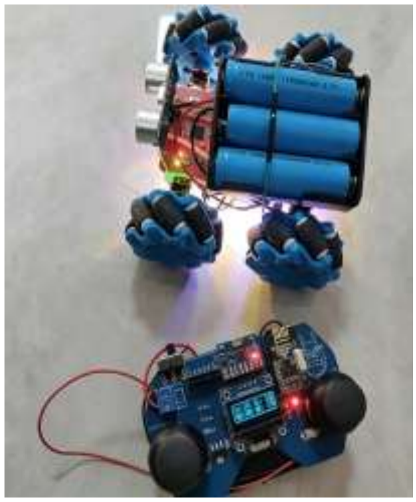


The program block diagram of the remote control function is shown in Figure 3-3.

4 Overall System Testing

4.1 Physical Picture

In this design, AD is used to draw the circuit diagram. To save space and weight on the vehicle body and reduce power consumption, two-layer PCB boards are fabricated for the chassis of the vehicle and the remote controller to replace the acrylic chassis. DuPont wires are used in part for power supply, connecting the motor interfaces to the corresponding interfaces on the PCB. The physical picture of the system hardware is shown in Figure 4-1:



The physical picture of the system hardware is shown in Figure 4-1

4.2 Experimental Testing

In this experiment, the forward and backward performance of the Mecanum-wheel robot in follow mode was mainly tested and verified. The front wheel of the robot was taken as the zero point, and the ultrasonic module was used to monitor the relative distance change to the obstacle in real time. In forward mode, when the measured distance between the obstacle and the robot reached 21 cm for the first time, the robot started to move forward and traveled 5.5 cm in the initial stage. Each subsequent movement distance varied slightly, ranging from 4 cm to 6 cm, indicating that the system has certain stability and response sensitivity. The forward data of the Mecanum-wheel robot in follow mode is shown in Table 4-1:\

Table 4-1 Forward Data in Follow Mode:

times	The relative forward distance of the Mecanum-wheel robot compared with the first time	The relative moving distance of the obstacle compared with the first time
The second time	6cm	5.5cm
The third time	5.5cm	4cm
The fourth time	5.5cm	4cm
The fifth time	6cm	7cm
The sixth time	5cm	4.5cm
The seventh time	5.5cm	5.5cm

In backward mode, the robot starts to move backward when the measured distance between the obstacle and the robot first reaches 7.5 cm. The first backward distance is 6.5 cm, and the subsequent movement distances are also between 5 cm and 6.5 cm, showing good repeatability and judgment accuracy. The backward data of the Mecanum-wheel robot in follow mode is shown in Table 4-2:

Table 4-2 Backward Data in Follow Mode

times	The relative backward distance of the Mecanum-wheel robot compared with the first time	The relative moving distance of the obstacle compared with the first time
The second time	6.5cm	6cm
The third time	6cm	5cm
The fourth time	6.5cm	7.5cm
The fifth time	6cm	6.5cm
The sixth time	5cm	6cm
The seventh time	5.5cm	6cm

5 Conclusion

The design of the control system for the intelligent mobile platform uses the NRF24L01 wireless module to transmit remote control signals, combines with the ultrasonic module to achieve follow mode and obstacle avoidance mode, and realizes remote control mode through the 3D model potentiometer on the remote controller. RGB lights are installed on the chassis of the Mecanum-wheel robot, providing rich visual feedback. The DRV8833 motor driver module and N20 gear motors enable the robot to run smoothly and achieve omnidirectional movement.

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