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Design of Intelligent Wireless Picture Transfer Robot based on STM32

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Abstract

With the development of logistics industry, warehouse management also needs to realize information and intelligence, and the demand for real-time monitoring, data transmission, remote operation and other functions is increasing. Intelligent wireless graph transmission two-wheeled warehouse inspection robot is a robot that can autonomously inspect and monitor in the logistics warehouse environment. With STM32 single chip microcomputer as the control core, the robot includes environment acquisition, information processing, motion execution and remote control modules, and adopts no-line transmission technology, network control and PID balance algorithm, which can realize real-time video wireless image transmission, autonomous obstacle avoidance, environmental monitoring, path planning and patrol, information interaction and other functions. By using the robot to measure the environmental temperature, humidity and tracking route parameters, and comparing with the actual relevant parameters, the results show that the robot can detect images, temperature and humidity, flame and other warehouse environmental parameters in real time and accurately, and upload them to the mobile phone wirelessly, so as to detect environmental anomalies in time and give an alarm. The robot can improve the efficiency and intelligence level of warehouse management, and greatly save labor costs.

Keywords

Wireless Image Transmission; Network Control; PID Balance Algorithm; Information Interaction; Autonomous Line Patrol.

1. Introduction

In the field of warehousing and logistics, with the continuous expansion of business scale and the increasing variety of goods, warehouse management is facing unprecedented challenges. The traditional manual inspection method is not only inefficient, but also error-prone, which is difficult to meet the needs of efficient and accurate management of modern warehousing and logistics. In order to cope with these challenges, intelligent wireless picture transmission two-wheeled warehouse inspection robot came into being, which brings a new solution for warehouse management.

Intelligent wireless graph transmission two-wheeled warehouse patrol robot is a high-tech product that integrates advanced artificial intelligence, Internet of Things, wireless communication and autonomous navigation technologies. It uses a two-wheel drive design, with excellent mobility flexibility and stability, and can freely shuttle in the warehouse to complete a variety of complex patrol tasks. At the same time, the robot is also equipped with high-definition cameras and wireless picture transmission system, which can collect the image information in the warehouse in real time and transmit it to the remote control center through the wireless network, so that the warehouse manager can grasp the status of the goods in the warehouse in real time, the inventory situation and potential security risks.

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2. Overall Scheme Design

The design of this project adopts STM32 single chip microcomputer to realize the calculation and processing of maintaining the balance state of the two-wheeled robot and to obtain the data collected by temperature sensor, smoke alarm, ultrasonic sensor, etc., and adopts ESP32 single chip microcomputer to realize the WIFI remote control of the robot. The built-in camera module is used to obtain images in the warehouse in real time and the warehouse environment data collected by STM32 microcontroller is fed back to the mobile phone to realize remote inspection management. And the ultrasonic module can be used to realize automatic obstacle avoidance patrol, automatic detection of the warehouse environment, and timely feedback to the mobile phone when problems are found.

This design mainly uses MPU6050 gyroscope module, TB6612 drive module, OLED display, temperature sensor, smoke alarm, coded motor, ultrasonic module, flame sensor, 8-channel gray sensor, 28BYJ48 stepper motor, active buzzer, central processing module and ESP32 MCU wireless picture transmission control module. The basic system structure diagram is shown in Figure1

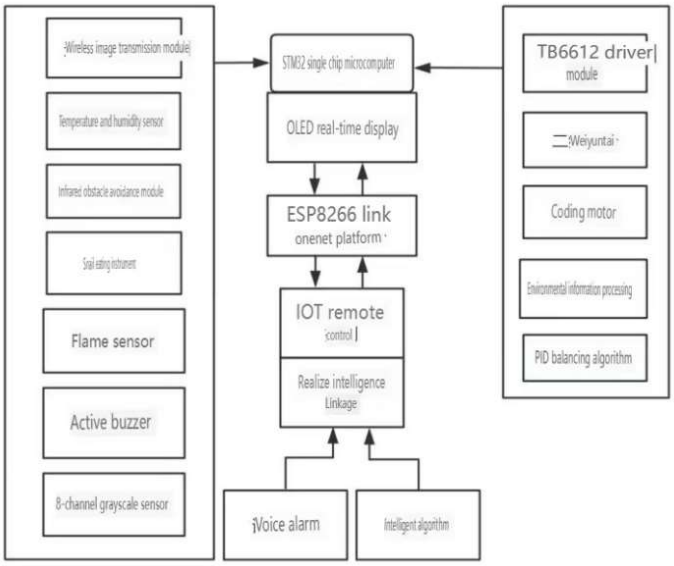

Figure 1. Basic system structure diagram

2.1 Hardware Design

The sensor circuit design is shown in Figure 2, and the control circuit design is shown in Figure 3:

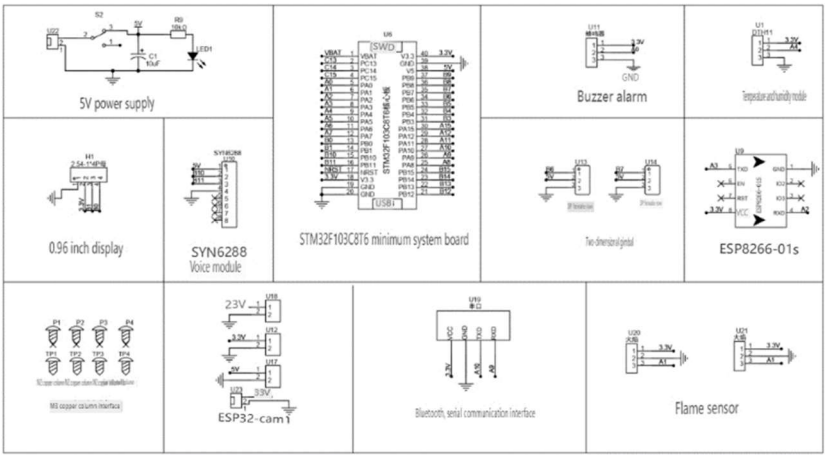

Figure 2. Circuit design diagram of the sensor control board for robot personage networking

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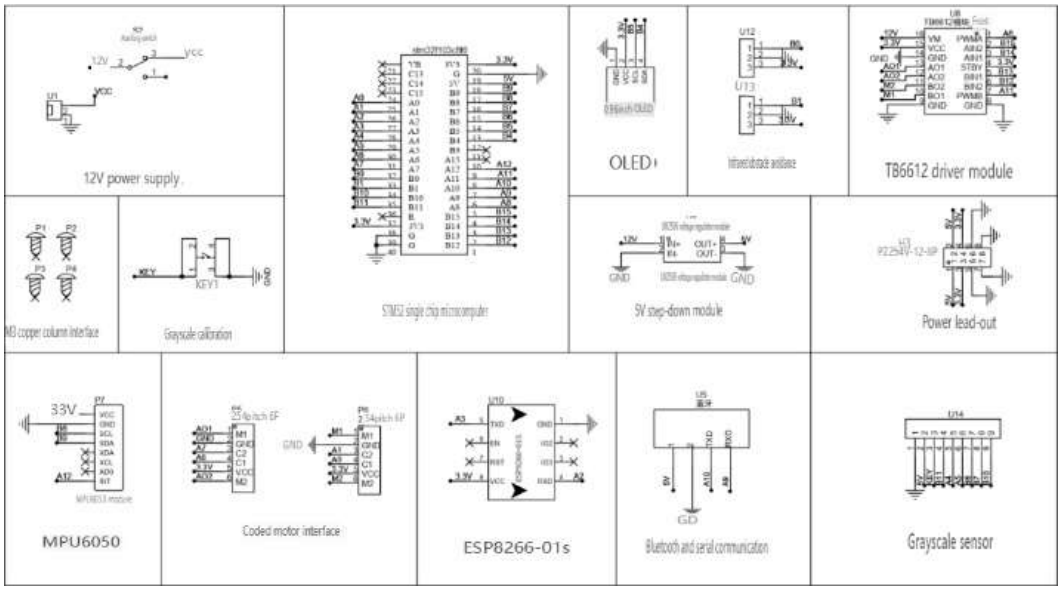

Figure 3. Robot motion control structure circuit principle design

2.1.1 Design of Motor Drive Module

The robot adopts the drive module TB6612, high integration, strong output capacity, PWM signal support, perfect protection function, power supply pin: including VM (motor drive voltage) and VCC (internal logic power supply voltage). The VM end is connected to the motor power supply, and the VCC end is connected to the logic power supply. Control pins: include PWMA, PWMB (speed control pin), AIN1, AIN2, BIN1, BIN2 (direction control pin), and STBY (standby control pin). By feeding corresponding signals to these pins, the speed, steering, and standby state of the motor can be controlled. Output pins: including AO1, AO2 and BO1, BO2, etc. These pins connect the positive and negative poles of the motor and are used to output drive current to drive the motor to rotate.

2.1.2 Design of Tracking Module

The robot uses 8 gray sensors. The 8-way grayscale sensor is a sensor specifically designed to detect black and white lines on the ground, and it plays a key role in many projects such as line patrol cars and autonomous robots. Typically consisting of eight infrared photodiodes and their corresponding photosensitive diodes, these sensors determine the position of the vehicle or robot relative to the line by measuring changes in ground reflectivity. Its working principle is based on the photoelectric effect, when the infrared photodiode emits infrared light, the black and white lines on the ground will produce different reflection effects on the light. A photodiode picks up this reflected light and converts it into an electrical signal, and the sensor analyzes the difference in the strength of these signals to identify black and white lines on the ground. Through the detection of the black and white line, the vehicle or robot can adjust the driving direction according to the pre-set control algorithm, so as to achieve the function of accurate driving along the line. The advantage of the 8-way grayscale sensor is its high precision and high sensitivity, which can accurately detect tiny black and white lines on the ground, thus ensuring that the vehicle or robot can stably travel along a predetermined path. In addition, because the sensor has 8 channels, it can provide more detection information, making the vehicle or robot more capable of patrolling the line in a complex environment.

2.1.3 Design of Wireless Image Transmission

Mainly using ESP32-CAM module, ESP32-CAM module is an integrated solution that integrates ESP32 chip and camera module to provide users with convenient iot and image processing functions. Good integration, strong image processing ability.

Esp32-cam module integrates the ESP32 chip and camera module, without additional connection of complex external hardware, so that users can quickly build a Wi-Fi-based image transmission system. At the same time, it is equipped with a high-definition camera sensor, which supports image acquisition, video streaming and simple image processing functions, such as face detection and

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motion detection. The ESP32CAM module captures images or videos, and transmits them to the server or mobile phone through WiFi to realize remote video surveillance function. The ESP32CAM module is used to collect images, and the pre-trained machine learning model is used for image recognition, face recognition and other applications.

2.1.4 Balanced Design of the Car

The robot is mainly balanced by the MPU6050, the world's first integrated 6-axis motion processing component launched by InvenSense, which perfectly combines 3-axis gyroscope and 3-axis acceleration sensor to provide excellent motion detection and attitude recognition capabilities for a variety of applications. It is unique in that it has a Digital Motion Processor (DMP) hardware acceleration engine, which outputs the full 9-axis attitude fusion data through the main I2C interface. This design allows the device to perform well in capturing and processing motion data, accurately capturing the motion, Angle, acceleration and other parameters of the object. The addition of DMP makes the MPU6050 more efficient when performing attitude calculation and motion processing, and it can complete a large number of computational tasks through the hardware acceleration engine, thus reducing the burden of the main processor. This advantage not only improves the operating efficiency of the system, but also reduces the pressure on the operating system, so that developers can focus more on the development of other functions by using its built-in DMP library to realize the attitude settlement and data processing of the two-wheeled robot, obtain the real-time motion state of the robot, and send it to the STM32 microcontroller.

2.1.5 Design of the Power Management Module

In order to ensure the stable operation of the robot, the robot adopts the LM2598 voltage regulator module. The LM2598 is a SIMPLE SWITCHER® step-down switching regulator from Texas Instruments (TI), part of the LM259x family. It is a monolithic integrated circuit that provides all active functions for buck switching regulators, is capable of driving 1A loads, and has excellent line and load regulation capabilities. Output voltage: The LM2598 is available in fixed output voltage versions of 3.3V, 5V, 12V, and adjustable output versions. The adjustable version has an output voltage range between 1.2V and 37V, with a maximum output current of 1A. Input voltage range: The LM2598 has an input voltage range of up to 40V, which makes it stable in a variety of power supply environments. Switching frequency: The LM2598 operates at 150kHz, allowing the use of smaller filter components, which reduces the size and cost of the board. Protection: The LM2598 has self-protection features such as overheat shutdown and two-stage current limit to provide complete protection under fault conditions. Package form: The LM2598 comes in a standard 7-pin TO-220 package with a variety of different pin bend options, as well as a 7-pin DDPAK surface mount package.

3. Software Design

This robot design uses STM32 single chip microcomputer to maintain the balance of the two-wheeled robot and to obtain the data collected by temperature and humidity sensors, infrared obstacle avoidance sensors, etc., and uses ESP8266-01S single chip microcomputer to realize WIFI remote control of the robot. The built-in camera module of ESP32-cam is used to obtain images in the warehouse in real time and the warehouse environment data collected by STM32 microcontroller is fed back to the mobile APP to realize remote inspection management. And the 8-channel gray line patrol module can be used to realize automatic obstacle avoidance patrol, automatic detection of warehouse environment, and timely feedback to the mobile APP when problems are found. As shown in Figure 4:

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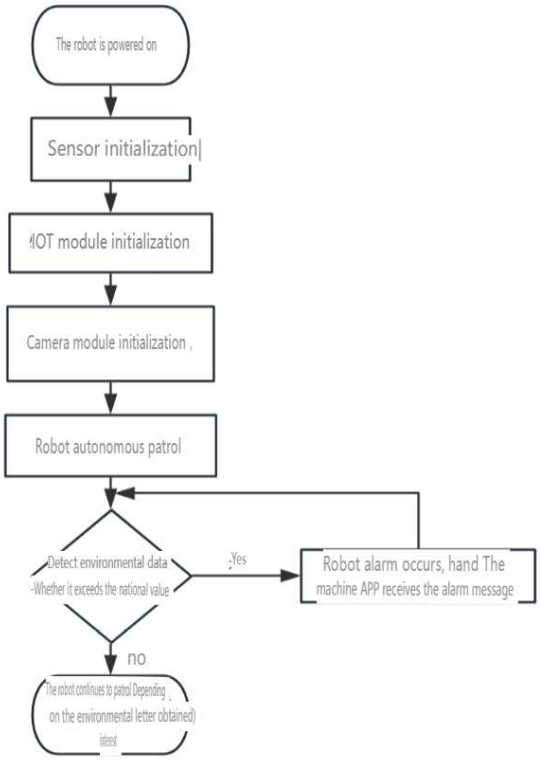

Figure 4. Software design flow chart

3.1 Balancing Program Design of Patrol Robot

During the driving process of the intelligent car, the on-board MCU is responsible for identifying and processing the data collected by the sensor in order to adjust the speed and direction of the car according to different road conditions (such as straight lines or turns). For example, when a specific task is not performed, the car will accelerate on a straight road and slow down on a turning road. In order to achieve this function, the drive motor needs to be equipped with an photoelectric encoder in order to feedback the current speed of the car in real time.

Then, PID (proportional-integral-differential) control algorithm is used to adjust the motor speed according to the deviation between the encoder feedback speed and the target speed, so as to achieve closed-loop control. In this closed-loop control system, the input signal is the speed and target speed fed back by the encoder, while the PID algorithm calculates the deviation and produces the output of the closed-loop speed. This output is converted into a PWM (pulse width modulation) signal that is sent to the encoder motor to perform the appropriate adjustment.

In short, the closed-loop control system of the intelligent car adjusts the motor speed through the PID algorithm, so that the car can travel at the appropriate speed and direction according to different road conditions. The encoder provides real-time speed feedback, while the PID algorithm calculates the amount of adjustment based on the deviation between the feedback and the target speed, and finally controls the execution of the motor through the PWM signal.

3.2 Design of iot APP

The acquired environmental information data is sent to the ONENeT Internet of Things cloud platform through the ESP8266-01S microcontroller, and then the cloud platform information is viewed through the mobile APP, and the control command can be sent through the mobile APP to realize wireless network control of the robot. When the monitored environmental information exceeds the self-defined threshold or the fire is detected, the alarm information can be quickly obtained on the mobile APP.

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4. Physical Function Display

The two-wheeled warehouse inspection robot designed in this paper is shown in Figure 5, and the measurement effect of ambient temperature is shown in Figure 6:

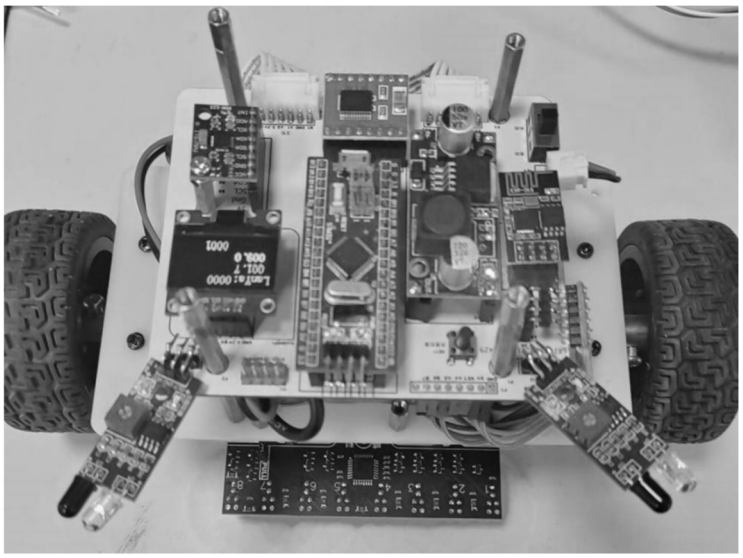

Figure 5. Physical display of the robot

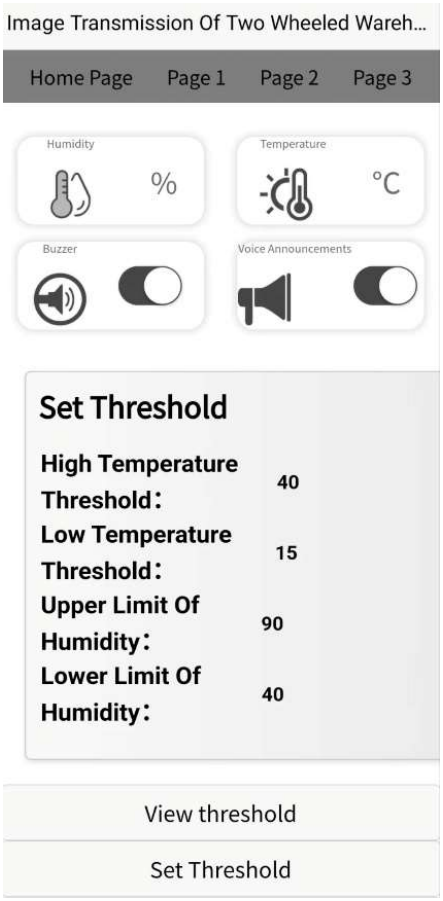

Figure 6. Data measurement effect of APP

Experimental measurement data are shown in Table 1:

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Table 1. Deviations between actual values and standard values of experimental measurement data

Measurement of temperature deviation	Deviation from measuring humidity	Distance from the tracking line	Whether the target location can be reached
0.2℃	0.5℃	2.1cm	Yes
0.4℃	0.3℃	1.9cm	Yes
0.1℃	0.2℃	1.5cm	Yes

Through the comparison of the experimental measurement data of the two-wheeled warehouse inspection robot and the annotated value, it is concluded that the robot has the ability of autonomous navigation and positioning, and can independently plan the inspection path in the complex warehouse environment and accurately reach the predetermined position.

5. Summary

As an important auxiliary tool of modern warehouse management, the development and application of intelligent wireless picture transmission two-wheel warehouse inspection robot greatly improve the efficiency and accuracy of warehouse management. In the early development process, the key technologies such as autonomous navigation and positioning technology, wireless image transmission technology, intelligent identification and data analysis technology are deeply studied, and these technologies are successfully integrated into the robot system.

Through wireless image transmission technology, the robot can transmit the collected data to the remote control center in real time to provide real-time warehouse information for the manager. At the same time, using intelligent identification and data analysis technology, the robot can intelligently identify the type, quantity, location and other information of the goods, analyze the congestion situation of the warehouse and the efficiency of the flow of goods, etc., and provide decision support for managers.

The development and application of intelligent wireless graph transmission two-wheeled warehouse inspection robot not only improves the efficiency and accuracy of warehouse management, but also reduces the labor cost and management difficulty. It can work continuously for 24 hours, reducing the labor intensity and time cost of manual inspection. At the same time, through real-time data transmission and intelligent analysis, the robot can help managers find problems in the warehouse in time and take appropriate measures to solve them, improving the safety and stability of the warehouse.

Acknowledgments

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