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Design of Harmful Gas Detection System based on Quadcopter

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Abstract: Traditional harmful gas detection means can not achieve full range, high mobility, three-dimensional monitoring. Sometimes traditional harmful gas detection means need people to enter the harmful gas area, so it has a certain risk. This design proposes a method of hazardous gas detection based on the four-rotor aircraft, which combines the flight control and harmful gas detection. So this design is a good solution to the shortcomings of traditional harmful gas detection methods. Using the remote control let the four-rotor aircraft to fly into the harmful gas area. MQ135 sensor on the four-rotor aircraft outputs an analog voltage signal to the STM32 processor after detecting hazardous gas. The STM32 processor converts the analog voltage signal into digital signal and transmits it to the handheld terminal through the NRF24L01 wireless module. After receiving the digital signal, handheld terminal calculates the concentration of harmful gas in accordance with the formula and the concentration value is displayed in real time.
Keywords: quadcopter, harmful gas detection, STM32, MQ135

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1. INTRODUCTION

In personal life, safety production, environmental monitoring, petrochemical industry and other fields, the harmful gases detection is a crucial part. Harmful gas detection has a high risk, inconvenience and higher requirements for test equipment and personnel quality. there are two main ways of traditional harmful gas detection. A way, the harmful gases are detected by fixing the sensor to a certain position of the harmful gas area. The drawback of this approach is poor mobility, limited detection area, can not be stereo detection for the whole space. Second way, using the harmful gas detection handheld terminal detects the harmful gas. This method has a certain risk and the operation is inconvenient [1]. In view of the above situation, this design is put forward a kind of harmful gas detection method based on the four rotor, which combines flight control with harmful gas detection. Using the mobility, flexibility and convenience of four - axis aircraft make harmful gas detection technology is greatly improved [2].

2. THE OVERALL SYSTEM DESIGN

The overall train of thought of this design are as follows. By remote control, the four-rotor aircraft flies into the harmful gas area. MQ135 sensor on the four-rotor aircraft outputs an analog voltage signal to the STM32 processor after detecting hazardous gas. The STM32 processor converts this analog voltage signal into digital signal via the built-in ADC and then transmits this digital signal to the handheld terminal through the NRF24L01 wireless module. After receiving this digital signal, handheld terminal calculates the concentration of harmful gas through the corresponding algorithm. This concentration value is displayed on a TFTLCD screen in real time. The overall structure diagram of this design is shown in figure 1.

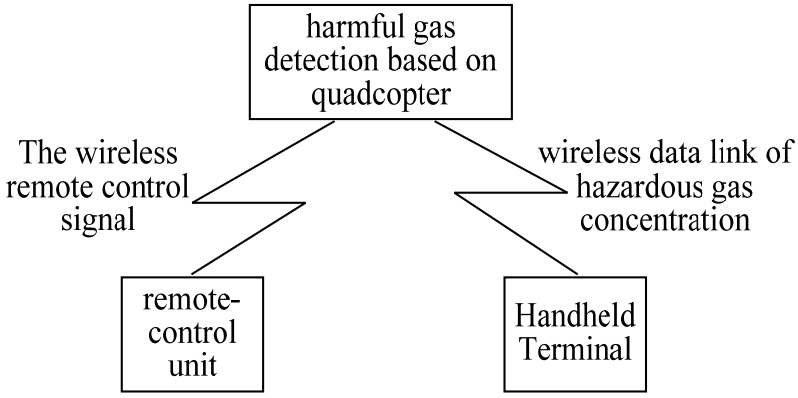

Fig. 1 Diagram of the system as a whole

3. THE SYSTEM HARDWARE CIRCUIT DESIGN

System hardware circuit is divided into three parts: remote control part, harmful gas detection part based on quadcopter, handheld terminal part.

3.1 The circuit design of remote control part

The main function of remote control part is to control the four axis aircraft fly to harmful gas area. The remote control is mainly composed of rocker potentiometer module, the core control module and the wireless module. The core controller scans the position of each rocker in turn through the built-in ADC and sends the scanned result to the four-axis aircraft via the wireless module NRF24L01[3]. The structure of the remote control is shown in figure 2.

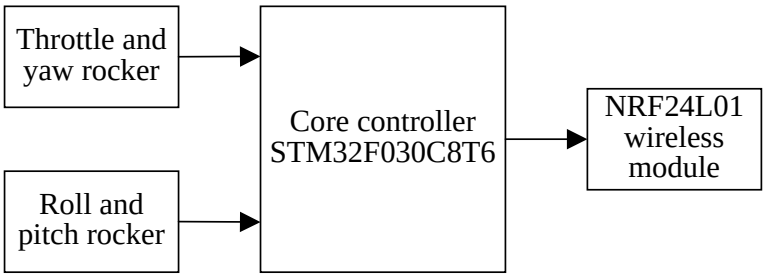

Fig. 2. The structure diagram of remote control

3.2 The circuit design of harmful gas detection part

The main function of the harmful gas detection part based on quadcopter is to achieve stable flight of the four rotors and to detect harmful gases. The test results are sent to the handheld terminal via the wireless module. Harmful gas detection part is mainly composed of STM32F103C8T6 processor, motor control module, harmful gas detection sensor MQ135, gyroscope and accelerometer sensors MPU-6050, NRF24L01 wireless modules.

This design adopts MQ135 sensor to test the harmful gas. The gas-sensing material used in the MQ135 is a tin oxide with a low conductivity in clean air. When there is harmful gases in the environment where the sensor is located, the conductivity of the sensor increases with the increase of hazardous gases concentration in the air. The conductivity changes can be converted to the corresponding output signal by a simple circuit. MQ135 gas sensor has a high sensitivity for ammonia, sulfide, benzene vapor and are also ideal for the detection of smog and other harmful gases. This sensor can detect a variety of harmful gases and is a low-cost sensor for a variety of applications [4]. The processor detects the state of the MPU-6050 to obtain the acceleration and angular velocity of the four rotor and then calculate attitude angle of the four-axis (including pitch angle, roll angle and yaw angle). The remote control unit transmits the control signals (including throttle, yaw, left and right, before and after) to the four rotor via the wireless communication module. After obtaining these control signals, the four rotor calculates the PWM value of the four motors by PID control algorithm to control the speed of the four motors. So that the four rotor will be able to complete a series of flight operations in the air [5].

The four rotor transmits the harmful gas concentration measured by the MQ135 sensor to the handheld terminal via the NRF24L01 wireless module during flight. The structure of the harmful gas detection section based on the four rotor is shown in figure 3.

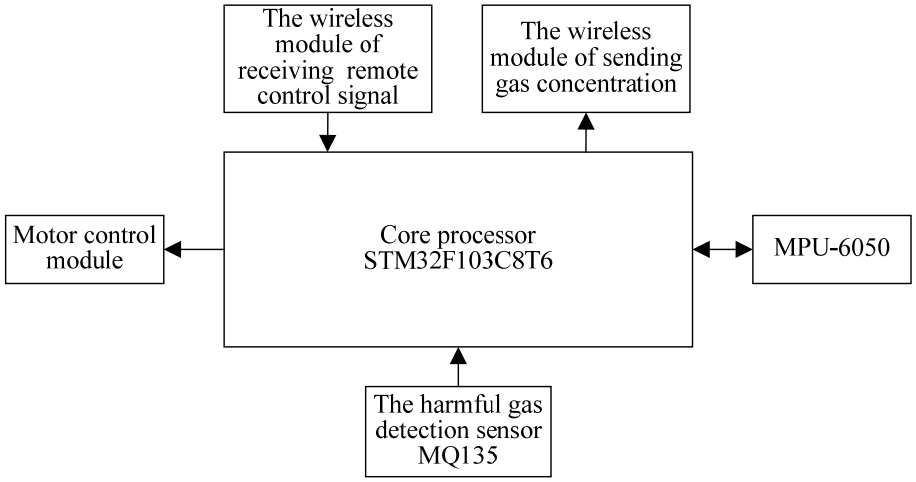

Fig. 3. The structure of the harmful gas detection part based on the four rotor

3.3 The circuit design of handheld terminal part

The main functions of the hand-held terminal part are to receive the harmful gas concentration measured by the four rotor and save it in the SD card and then display it in real time. Handheld terminal part is mainly composed of NRF24L01 wireless module, STM32F103C8T6 processor, TFTLCD display, SD card module. After receiving the harmful gas digital signal from the four rotor, the processor converts the received data into a hazardous gas concentration value according to the corresponding algorithm. This concentration value is not only saved to the SD card but also is displayed on the TFTLCD screen in real time. The structure of the hand-held terminal part is shown in figure 4.

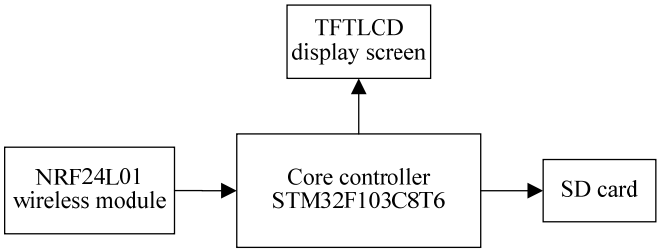

Fig. 4. The structure of the hand-held terminal part

4. SYSTEM SOFTWARE DESIGN

The system software design mainly divided into the software design of remote control part, the software design of harmful gas detection part based on quadcopter and the software design of handheld terminal part. The overall system program flow chart is shown in figure 5 [6].

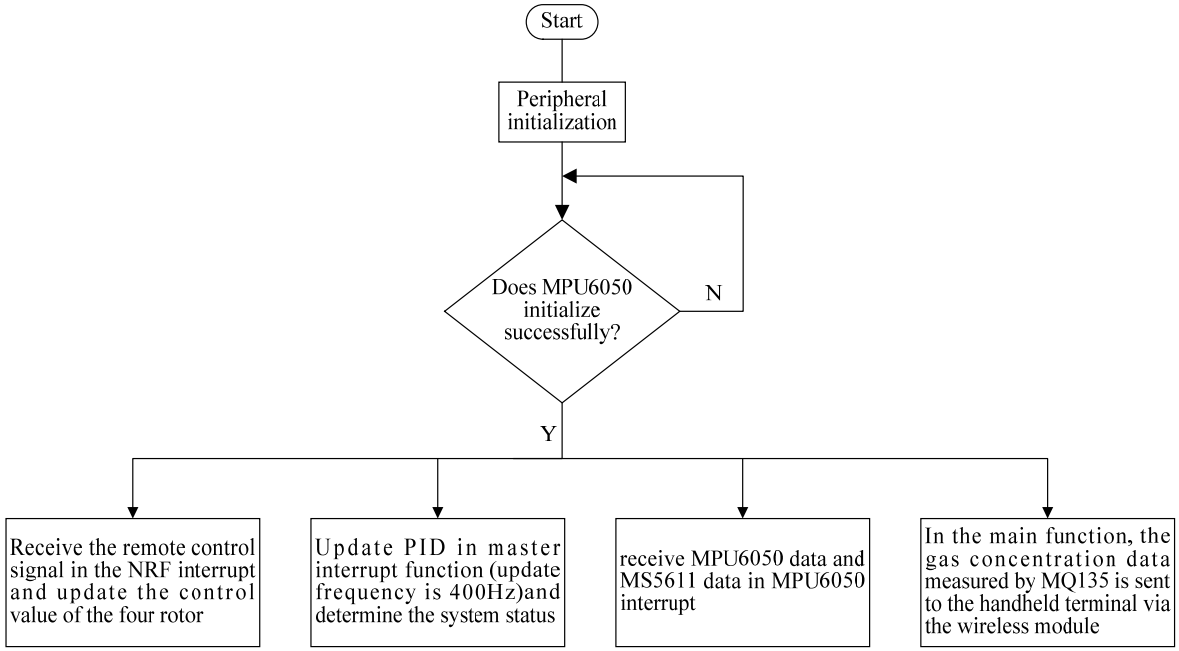

Fig. 5. The overall system program flow chart

5. SYSTEM DEBUGGING

After multiple PID parameter debugging, the four rotor realized a smooth flight. The four rotor can complete all kinds of flight movements, including vertical movement, pitching motion, roll motion, yaw movement, front and rear movement, lateral movement [7]. In order to verify the harmful gas detection performance, this design examined the methane, ammonia, hydrogen sulfide and smoke respectively, and then compared these test results with the test results of professional testing equipment KT-603. Comparison results are shown in table 1. Repeated tests show that the measurement error of the system is basically controlled within 10%, which meets the measurement requirements.

Table .1. The test results comparison of this design and KT-603.

Gas type	The test results of this design/(ppm)	The test results of KT-603/(ppm)	Error/(%)
Ammonia	184.6	195.4	5.9
Hydrogen sulfide	134.7	128.1	-4.8
Methane	89.2	95.3	6.8
Smoke	254.3	278.5	9.5

6. CONCLUSION

This paper puts forward a new harmful gas detection method based on the four rotor, which realizes a high mobility and three-dimensional detection of harmful gases. It solves the shortcomings of traditional harmful gas detection. This design combines the four rotor technology with harmful gas detection technology, which makes a qualitative leap in hazardous gas detection technology.

The test results show that the detection accuracies of ammonia, sulfide and benzene vapor are very high, and the detection results of smoke and other harmful gases are also very good. This system is suitable for home, workshop, mine, warehouse and other harmful gas detection occasions. This design realizes the rapid, accurate and real-time detection of harmful gases in hazardous environment, and ensures the safety of the person. In summary, this design has important practical value.

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