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The Design of an Adaptive Obstacle Avoidance System for Intelligent Vehicle

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Abstract: ***With the continuous innovation and development of science and technology, the car is more and more intelligent and applied in various fields. For smart cars, it is very important to walk the route set by people correctly and avoid obstacles. This paper designs a kind of ultrasonic obstacle avoidance car with a complete structure, modular function and more sensitive response through software programming. Through the obstacle avoidance test experiment on the obstacle avoidance car, the experimental results show that the obstacle avoidance car can complete the obstacle avoidance action well as expected, and can move quickly and sensitively to avoid obstacles, with good effect and good running stability.***

Keywords: STC89C52; Obstacle avoidance car; The smart car

1. Introduction

With the development of modern information technology, the application of smart car not only involves transportation, military, industrial manufacturing and other industries, but also extends to life services and space exploration and other fields. Intelligent car is a kind of based on multi-sensor information fusion, wheeled robot, to be able to use their loading information of multiple sensors to collect the environment around, with functions of sense their work environment, and have certain adaptive ability, can according to the given instructions to complete the corresponding action of complex [1]. It can replace human beings to complete the task of cargo handling and equipment testing in harsh environment. For the intelligent car, it is very important to walk correctly on the route set by people and avoid obstacles. Therefore, it is particularly important to design and study the automatic obstacle avoidance system of the intelligent car.

Automatic obstacle avoidance technology has been regarded as a core content of intelligent car research. The automatic obstacle avoidance function of the intelligent car is to achieve autonomous, efficient and time-saving obstacle avoidance in a complex environment [2]. The key point is that in a certain environment, the smart car can efficiently identify and judge the location, shape, size and other information of obstacles, and then the obstacle avoidance system can make corresponding avoidance actions according to the obstacle information collected by the sensor. Intelligent vehicle automatic obstacle avoidance integrated application of a variety of cutting-edge technology, including multi-sensor information fusion technology, bluetooth, LAN, infrared data transmission and other wireless communication technology, mechanical technology and electronic technology. The automatic obstacle avoidance of the smart car reflects the level of automation and intelligence [3,4].

In the future, the automatic obstacle avoidance technology of intelligent car will adopt various sensors to collect information and develop towards information fusion. The development of a multi-sensor automatic obstacle avoidance system for intelligent vehicle, which is generally adapted to various operating environments, can not only improve the automatic obstacle avoidance performance of the intelligent vehicle itself, but also provide an important reference for the realization of intelligent automatic driving. Therefore, the study of automatic obstacle avoidance technology of intelligent vehicle has important theoretical research significance and practical application value.

System Design

On the basis of the existing intelligent car, equipped with reflective infrared sensor, ultrasonic detection sensor, speed sensor and photodiode array, the implementation of the speed of the car, the location, the running status of real time measurement, and will measure data transfer to the single chip microcomputer for processing, then the detection by the microcontroller based on various data to realize the intelligent control of the car. The overall design of the system is shown in figure 1:

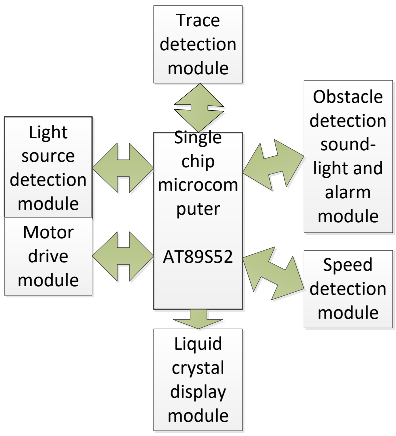

Figure 1: Overall design block diagram of the system

Obstacle avoidance mode, in front of the car left, front, right front, left, and right rear after the installation of a infrared sensor, when the car is in a state of forward, the front of an infrared sensor transmit signal detection analysis, when there are sensor detected signal, stop processing and according to detect the signal of the corresponding turning back, proceed automatically after back, in the process of back on after a infrared sensor signal detection, if the signal is detected, immediately after the brake. In the searching mode, the MCU makes corresponding turns according to the signal collected by the infrared sensors of the two rows of searching so that the car can keep moving in the middle of the black line. In the process of searching, the infrared sensor in front is turned on to detect constantly to prevent the car from touching the nearby wall.

1.1 Hardware design of obstacle avoidance system for intelligent vehicle

After the demonstration of the scheme, we have selected the scheme which only USES single chip microcomputer as the core component. The general block diagram of the system is shown in figure 2. Specific function Settings through the diagram intuitive description. The signal input of each sensor is controlled by the master control chip, and the control mode is realized by the software, including six infrared sensors to detect obstacles, four sensors to detect side obstacles, and two sensors to detect obstacles in front. There is also a hall sensor that detects signals associated with distance. In terms of function and function, it is divided into six parts: main control, drive, obstacle avoidance, display and system programming.

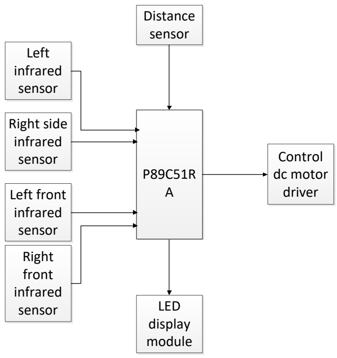

Figure 2: General principle of the system design block diagram

1.2 Software design of obstacle avoidance system for intelligent car

In the design of microcomputer control system, in addition to the system hardware design, a lot of work is how to design applications according to the actual needs of each production object.

In the SCM control system design, in addition to the system hardware design, a lot of work is how to design applications according to the actual needs of each production object. Therefore, the status of software design is relatively heavy, no matter in other system design or in the MCU control system design. But this topic USES the system design, it appears to be more important. In MCU control system, its type can be divided into two basic types: data processing and process control. Data processing includes: data collection, digital filtering, scale transformation and so on. Process control program is mainly to make the SCM according to a certain method to calculate, and then output, in order to control production. The software flow chart is shown in figure 3:

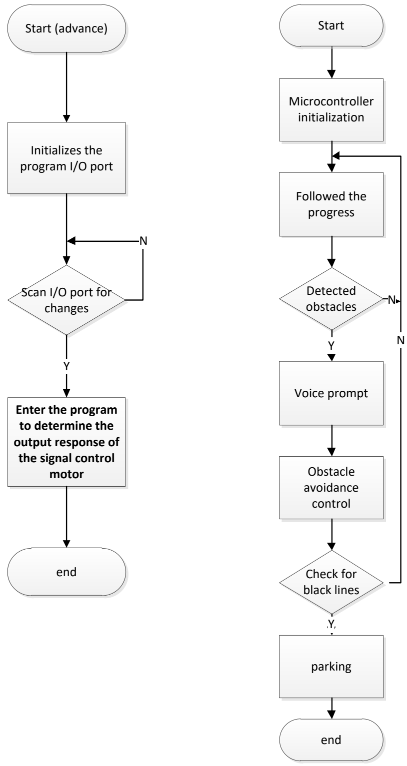

Figure 3: Control system flow chart

Using timed interrupts is to send ultrasonic waves at regular intervals to ensure accurate detection of obstacles. The guard is always waiting because it can't detect an obstacle. For convenience, the safety distance can be set according to the actual situation to make the system more perfect.

2. System Implementation

The controller module of the system adopts MCU as the control core of car movement. The module of line-finding and obstacle detection and avoidance adopts type infrared sensor for signal acquisition. The motor drive module of the car adopts the motor drive chip to control the motor. The direction adjustment module of trolley adopts the wave control of steering gear. The power module adopts the battery pack as the power supply of MCU, infrared sensor, steering gear and so on after voltage stabilization. The battery pack is directly used as the power supply of dc motor. Dc speed control system by the single chip microcomputer module generated waves control the speed of the motor. The schematic diagram of the system module is shown in figure 4:

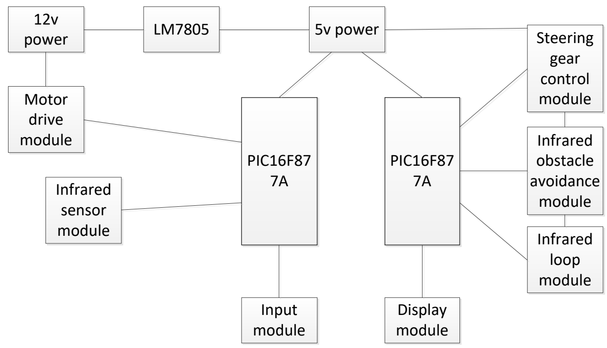

Figure 4: Schematic diagram of system module

2.1 Track detection system

Trace detection often USES sensors. According to the function requirements of the car, there are two schemes: one is to use the infrared photoelectric sensor, and the other is to use the sensor. Both of these two schemes can meet the requirements of tracking car. At present, the most common tracking detection method is infrared detection [6,7]. This system adopts double-row sensors as the signal collection of the line-finding system. At present, most intelligent cars adopt the road detection method of single-row sensors, which can obtain less road information and cannot distinguish the state of the intelligent car and the state of the road well, causing trouble on the control. In order to make up for the deficiency, a forward-looking single-row sensor road detection method has been formed, which can detect the road direction earlier with a longer detection distance and to some extent make up for the defect of low detection accuracy, but it cannot effectively distinguish the state of intelligent vehicle from the road condition.

2.2 Obstacle detection system

The car should be able to avoid the obstacles on the way accurately in the course of tracking, so there are certain requirements on the detection distance. In addition, considering the limitation of car speed and the speed of the obstacle avoidance reactor car in the process of obstacle test, the car should react within the range from the obstacle, so as to smoothly bypass the obstacle and find the best position and direction for driving into the garage [8]. If the range is too large, the judgment of obstacles may be wrong. The range is too small and it is easy to cause the car body to hit an obstacle or bypass the obstacle but can not achieve the ideal orientation scheme. Obstacles can be detected in a variety of ways: infrared light detection, ultrasonic detection, even mechanical contact. Compared with infrared detection, ultrasonic detection is far away and not easy to be disturbed by the external environment. Because the car needs to detect obstacles and bump and fatigue in the process of driving, light may affect the detection. So the need to choose better stability, so this design choose ultrasonic testing.

2.3 Light source detection system

The light source is detected using common photosensitive diodes during photosensitive. Photosensitive resistors are mainly used in light measurement, light control and radio and television conversion (converting light changes into electrical changes). [5] detect the external light source with the sensitive response of photodiode to the transformation of the light source. When there is light exposure, the photodiode shows a strong resistance, the comparator output a high level, otherwise output a low level. This change can be clearly observed by adding another external indicator light as the detection indicator. When there is light, and when there is no light.

2.4 Speed detection system

In the motor speed measurement, two schemes are considered: one is to use the photoelectric code plate, that is, the transmission photoelectric sensor. The infrared detection has the advantages of fast response speed, high positioning accuracy, strong reliability and incomparable advantages of the visible light sensor, so the infrared photoelectric code plate speed measurement scheme is adopted.

Speed measurement principle: we also install a grating next to the motor shaft. When the motor starts to rotate, the grating will also rotate. At this time, the infrared light-emitting diode installed on the side is lit up. At the same time, the other side of the grating is equipped with an infrared transistor, which is used to receive infrared signal emitted by the infrared light-emitting diode. As the grating rotates at high speed, driven by a motor, the infrared audion receives a series of pulse signals. The signal is transmitted to the internal counter of the microcontroller, and the speed of the car can be calculated according to the conversion relation of the measured data in advance.

2.5 Motor drive system

Scheme 1: use dc motor, plus appropriate speed reducer. Dc motor has good speed regulation performance and simple control. The dc motor can rotate continuously as long as it is connected to the dc power supply. The speed of the motor can be changed by adjusting the voltage. The drive circuit of a dc motor is essentially a power amplifier. The commonly used driving mode is the mode, that is, pulse width modulation mode. This method has good performance and simple circuit and control.

Plan 2: use stepper motor. Stepper motor has good control performance. When the stepper motor is fed an electrical pulse signal, the output shaft of the stepper motor rotates at an Angle, thus achieving precise position control. Different from dc motor, continuous rotation of stepping motor requires continuous input pulse signal, and the speed is determined by the external pulse frequency. Moreover, its rotation is not affected by voltage fluctuation, load change, temperature, air pressure and other environmental factors, and is only related to the control pulse. However, the driving of stepper motor is relatively complex and consists of controller and power amplifier.

It can be seen from the above table that both stepping motor and dc motor have their own advantages. Stepper motor can carry out precise position control, but drive circuit trouble, dc motor can meet the car requirements of precision and easy to control, drive circuit is very simple.

2.6 Single chip microcomputer control circuit system

This part is the core part of the whole car running, which plays the role of controlling all running states of the car. There are a lot of control methods, most of the use of single-chip microcomputer control. Microcontroller to complete motor control, line control, obstacle avoidance control metal detection control and light detection control. The main control of the car in this design USES the single chip microcomputer that we are most familiar with. Although this microcontroller itself does not have a module, but if the use of its own module microcontroller will produce a waste of resources. We can produce it through software programming, which can make full use of available resources without waste, and can well meet the design requirements.

As shown in figure 5, the microcontroller is adopted as the core of the whole system, and the moving car is controlled by the microcontroller to realize the established performance index. Full analysis of the system, the key is to achieve the automatic control of the car, and in this point, the single chip microcomputer control simple, convenient, fast advantage will appear. In this way, microcontroller can give full play to its rich resources, has a relatively strong control function and addressable operation function, low price and other advantages. This programme is therefore a more ideal one. For more complex program control switch input system, needs to be good at dealing with multiple switch quantity standard of single chip microcomputer, and can't use smaller mouth and small single chip microcomputer program storage, according to the analysis I selected the single chip microcomputer as the design of main control, single-chip microcomputer has a powerful operating instructions, bitwise addressable interfaces, application space up to for this design also swaps, more valuable is single chip price is very low. After comprehensive consideration of sensors, two motor drive, display and many other factors, we decided to use a single chip microcomputer, make full use of the resources of the single chip microcomputer.

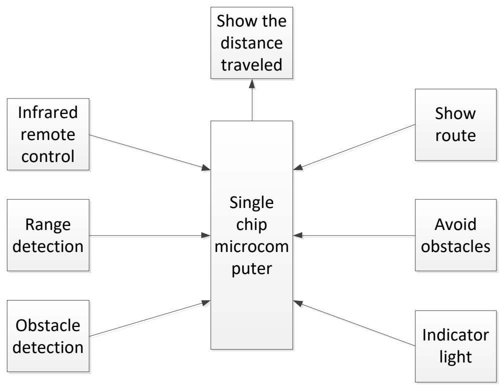

Figure 5: Principle block diagram with single chip microcomputer as the core

2.7 Tracing algorithm design

The flow of the tracking control algorithm is shown in figure 6.

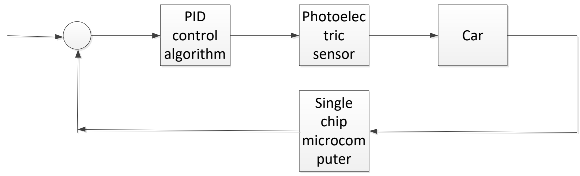

Figure 6: Trace Control

According to the layout of the sensor, the position of the sensor can be marked with a number. If the black line is detected, it is indicated by the number '0'; if the white line is detected, it is indicated by the number '1'. In order not to miss the states, we first considered all 16 states of the four sensors, which could be represented by four binary Numbers.

In the initial state, the black line should be located in the middle of the sensor. At this time, the 2 and 3 sensors detect the black line, that is, the state of the four sensors is 1, 0, 0 and 1 respectively, indicating that the binary number is 1001. At this time, the car moves forward.

When the car gradually deviates from the track black line from the middle to the left, that is, the black line is on the right of the car, and the corresponding states are 1000, 1100, 1110 and 1101. The car should turn left at this time.

When the car deviates to the right, the corresponding states are 0001, 0011, 0111 and 1011. The car should turn left at this time.

The last condition is that none of the four sensors can detect the black line, which means that the car has reached the end point, or it may have completely deviated from the track, which means that the track failed and the car stops.

In the actual driving process, due to the track design a lot of acute Angle, pure Angle, the car needs to turn the Angle is larger, in order to prevent the turning process car swing Angle is too large and out of the track, resulting in the car can not return, let the car back first, and then perform the turn. Practice has proved that this algorithm can realize the sensitive turning of the car.

2.8 Obstacle avoidance algorithm design

The problem of obstacle avoidance can be very complex. In order to simplify design, programming and debugging, it is advisable to use a relatively simple solution. Considering the speed of the car and the distance that the car can detect the obstacle, in order to avoid the car hitting the obstacle when turning, the car is designed to retreat after detecting the obstacle, then turn left, detect the obstacle again, and continue to adjust until the car circumacts the obstacle [9,10].

This obstacle avoidance procedure cannot guarantee smooth obstacle avoidance for all obstacle layout situations, but it can effectively avoid obstacles in most situations. The detection distance of obstacles and the turning radius of the car have a great influence on the effect of obstacle avoidance. According to the actual situation, better obstacle avoidance effect can be achieved by adjusting the turning Angle [11].

2.9 Speed measurement algorithm design

The speed of brushless dc motor can be controlled by either opening or closed loop. Compared with open loop control, the mechanical characteristics of speed control closed-loop system have the following advantages. When the ideal no-load speed is the same, the static difference of the closed-loop system (the ratio of motor speed fall to ideal no-load speed at rated load) is much smaller. When the required static difference is the same, the speed regulation range of the closed-loop speed regulation system can be greatly improved. The speed control scheme of the brushless dc motor is shown in figure7.

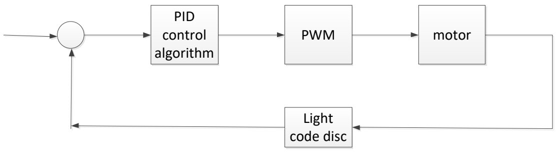

Figure 7: Motor speed control

2.10 PID control algorithm

As one of the earliest control strategies, control is widely used in process control and motion control due to its simple algorithm, good robustness and high reliability. Digital control algorithm is obtained by discretization of simulation. Each parameter has obvious physical meaning and is easy to adjust. Therefore, the controller is very popular among engineers and technicians. The digital control algorithm is shown in figure 8

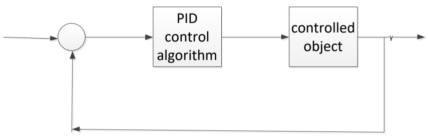

Figure 8: Simplified schematic diagram of PID control algorithm

3. Conclusion

This design USES bit MCU to control the dc motor. The pulse output through the mouth is used as the control signal of the dc motor. At the same time, sensors are used to detect the surrounding obstacles. The reflective photoelectric sensor is used to detect the black line of the car, and the ultrasonic sensor is used to detect the obstacles on the road to control the automatic obstacle avoidance of the intelligent car. It has automatic tracing and light finding function. The circuit structure of the whole system is simple and reliable. The actual test result is good.

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