Research on Application in Intelligent Vehicle Automatic Control System

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Abstract. The traditional motor bridge circuit always has short circuit problems, and the smart car needs to be controlled by wire or remote control equipment. In order to study the application of automatic control technology in smart cars. Using the smart car model and simulation to study the smart car control system, with the mobile phone as the remote wireless control terminal, the smart car uses bluetooth communication and MCU as the intermediate bridge, the smart car achieves automatic direction control, voice control, gravity induction control, automatic tracking, automatic anti-collision and other functions. The motor circuit system is optimized by Simulation and experiment. It replaces the previous wired control and remote control equipment control, and effectively reduces the cost of equipment.

1. Introduction

With the development of society, more and more cars have brought a series of urgent problems to cities, including traffic accidents, road congestion, traffic equipment failures, etc. In this environment, the development of smart transportation and smart cars has become the future trend [1]. The autonomous control function of the smart car combined with the Internet of Vehicles will promote the global transportation and transportation network system to achieve high efficiency and low accident rate, so that the development of human transportation will reach a new level [2]. With the development of electronic technology and the Internet, higher requirements have been put forward for road recognition and autonomous control of smart cars [3]. The main research directions of vehicle networking technology in intelligent vehicle systems include full-body attitude monitoring, intelligent active collision avoidance, and automatic driving [4].

The thesis is based on automatic control technology, through proteus simulation principle and intelligent car model, to study the design and functional application of intelligent car control system. To simulate and optimize its structure, to find out the influencing factors of automatic control technology in road recognition, and analyze its advantages in car driving, thus to improve the performance of smart cars.

2. Function

The overall design of the intelligent car control system is divided into six modules, including the main control module, input module, output module, body structure module, and road automatic identification module. The main control module analyzes and processes the received front-end
information, channel data and smart car speed data through the MCU. The input module is the front end of receiving information composed of tracking sensor, infrared sensor, gravity sensor, speed sensor, radar, etc. It transmits the received environmental information and distance data to the control terminal. Output module includes mobile phone client and Bluetooth module. The Bluetooth module receives the work instruction sent by the mobile phone, and sends the work instruction to the single-chip MCU, MCU judges the content of the instruction. It also executes the corresponding function module according to the judgment. The body structure module mainly refers to the design of the body, it includes the steering gear control module, which drives the servo motor to complete the steering control of the smart car; the motor drive module, which drives the DC motor to play a key role in the car, which can control the acceleration and deceleration of the car. The auxiliary debugging module can be used for online debugging and status monitoring. The button module can change the speed and parameters of the smart car. The paper will introduce the key modules in detail.

3. Main Module Design of the System

3.1 Motor Drive Simulation Analysis

The most widely used drive circuit of the motor is the h-type full-bridge circuit, which can easily realize the four-quadrant operation of the DC motor, corresponding to forward rotation, forward braking, reverse rotation, and reverse braking [5]. As shown in Figure 1, during the movement of the smart car, the motor needs to be constantly switched between the four quadrants, that is, between forward rotation and reverse rotation, that is, S1, S2 are turned on and S3, S4 are turned off, S1, S2 are open and S3, S4 are open, and both states are open.

![Figure 1. Full bridge motor circuit diagram.](image)

In this case, two sets of control signals are theoretically required to complement each other [6]. However, in practice, there is a certain time error in the opening and closing of the switch [7], and the absolutely complementary control logic will inevitably lead to a short circuit between the upper and lower bridge arms [8]. In order to avoid direct short circuit and ensure coordination and synchronization between switch actions, it is theoretically necessary to invert the two control signals, but in practice there must be sufficient no-load time difference. The direct short circuit is easy to heat the switch tube and burn it badly. At the same time, it increases the energy loss of the switch tube and wastes the precious energy of the intelligent car.

Traditionally, the switch loss and heating can be reduced by adding a delay link device to the hardware circuit [9]. However, the complexity of the circuit will be increased, and problems such as equipment failure and instability will occur [10]. In order to solve this kind of hardware problem, it is realized through software programming during design. Inserting the delayed link program when the switch is suddenly reversed, and turn on the switch that should be turned on after the switch is closed, as shown in Figure 2. Every time the switch changes direction, it will not switch the direction immediately. It firstly turns off the switch for a period to make it completely closed, then it turns on another switch tube. The closing time is realized by a software delay controlled by the MCU.
The connection time of motor bridge arm can be corrected by increasing the delay between two control signals of upper and lower arms (Figure 3).

The system uses L298N as the drive module, which can directly drive 3-35V DC motors [11]. As shown in Figure 4, IN1, IN2, IN3, IN4 are L298N logic input ports, UT1, OUT2, OUT3, OUT4 are output ports. Because the output voltage is not stable enough, IN4007 diodes are used for voltage limiting protection. They make the output voltage of H3 and H5 reach close to ideal voltage value.
control the smart car and guide the direction of movement of the car. The actuator of the steering system of the smart car is a steering gear, which uses an adjustable PWM square wave to control the steering of the steering gear, that is, different duty ratios correspond to different angles, and the steering gear rotation angle is in a linear relationship with the duty ratio. The steering control of the steering gear uses PID control to control the steering of the steering gear. The formula is:

\[ \Delta \text{PWM} = Kp \epsilon_1 + Kd(\epsilon_1 - \epsilon_2) \]  

(1)

\( \Delta \text{PWM} \) represents the output servo PWM increment, \( \epsilon_1 \) and \( \epsilon_2 \) respectively represent the current and last position offset, \( Kp \) and \( Kd \) are the proportional coefficient and the differential coefficient respectively.

3.2 Bluetooth Module

The single-chip MCU directly controls the Bluetooth module. The bluetooth selected in the design can control the distance of the car up to about 50 meters. During the transmission of instructions, the intelligent car can be controlled in real time, it avoids the delay of work tasks since the car cannot receive data in real time [12]. Setting the character string in the MCU program. The given MCU and the Bluetooth module receive and send the same character string. When the Bluetooth module transmits the character to the MCU, the MCU recognizes it, when the set character is recognized. The MCU generates an interrupt and executes the corresponding program.

When the bluetooth mode of the mobile phone is turned on, and the bluetooth of the car is also turned on, the automatic search function of the hand will recognize the bluetooth that has been started around and conduct pairing. Once the pairing is successful, the Bluetooth module will send characters, then the bluetooth module of the MCU will receive the corresponding characters, the MCU will process and perform the corresponding functions. For example, the car forward function can be realized: press the button of "forward", and the start character "A" will be sent. The Car's Bluetooth module will receive the character "A" and send it to the MCU for processing. The MCU will execute the interrupt program corresponding to the character "A". When the button is released, the character "F" is sent. backward, left, right, stop, send the corresponding characters are: "B", "C", "D", "F", the implementation method is the same as the principle of forward. When the left turn and right turn buttons are released, the operation mode of the trolley is not to stop immediately, but to continue forward in the positive direction after turning. At the same time, the Bluetooth module can also cooperate with voice control to set the sentence that the car is going to say, then it realizes the automatic control of the smart car. The specific process is shown in Figure 5.
4. Automatic Tracking Module
Smart car has automatic tracking function, automatic tracking has three modes, through the button to switch mode. Mode 1: Tracking indicator light is on; Mode 2: Obstacle avoidance indicator light is on, indicating that this is the obstacle avoidance mode; Mode 3: Tracking light and obstacle avoidance indicator light are on at the same time, indicating that the tracking and obstacle avoidance are realized at the same time. The test run of the car model shows that the time of automatic tracking completion can be set by counting. As shown in Table 1.

| Counting interval | Timing time | Car track     |
|-------------------|-------------|---------------|
| 1-20              | 2s          | Go forward    |
| 21-30             | 1s          | Turn right    |
| 31-40             | 1s          | Stop          |
| 40-60             | 2s          | Go forward    |
| 61-70             | 1s          | Turn right    |
| 71-80             | 1s          | Stop          |
| 80-100            | 2s          | Go forward    |
| 101-110           | 1s          | Turn right    |
| 111-120           | 1s          | Stop          |

Figure 5. Flow chart of Bluetooth module control.
5. Smart Car Automatic Anti-collision Design

5.1 Analysis of Anti-collision Principle
The process from taking braking measures to stop the car has a great influence on the design of the anti-collision device [13]. There are five influencing factors in the process from braking to stop a car:

1) When the driver is aware of the danger, and is ready to take braking measures in his mind.
2) When the driver uses the brake measures, the brake device will affect the braking time.
3) The driver takes braking measures, and the pedal force is gradually increased until the braking effect is the best.
4) When the driver presses down the pedal, the force will not change for a long time. Currently, the effect is the best until the vehicle stops.
5) The braking force time when the maximum value of the vehicle decreases to zero after parking is also the time when the brake pedal under the driver is slowly lifted.

The first four times determine the braking distance of the vehicle, and the automobile anti-collision alarm system is also directly related to the distance and speed between the two vehicles. The principal diagram of vehicle collision is shown in Figure 6. In the figure, car B and car A keep a distance D, and the driver drives the car at a certain speed. When they are in danger respectively, the two cars take braking measures. The speeds of the two cars after braking are \( V_A \) and \( V_B \), and the corresponding distances after deceleration are \( D_A \) and \( D_B \). If the distance between two cars is not enough, it will often cause traffic accidents. In order to ensure the safety of A and B during service braking, the following requirements need to be met to maintain a safe driving distance between the two vehicles when braking: \( D_B + d_2 \) is less than or equal to \( d_1 + D_A \). After braking, the speed of the two cars must be satisfied: when the distance between the two cars is \( d \), \( V_A \) is greater than or equal to \( V_B \), otherwise the two cars will collide.

![Figure 6. Schematic diagram of car collision.](image)

5.2 Automatic Anti-collision Module
In the collision system designed by proteus simulation and smart car model, when the distance from the obstacle to the smart car is lower than the safety range of the set value [14], it will actively perform the collision avoidance function [15]. It mainly has functions such as detection distance, system information processing, and system alarm. The MCU processes the detected distance data, and compares the data information with the set dangerous alarm distance, determines whether to issue an alarm command, and controls whether the collision avoidance system alarms. The alarm module is an
audible and visual alarm device, which reminds by both voice and light flashing. And the distance between the vehicle and the obstacle is displayed on the display.

6. Conclusions
The paper focuses on the actual needs and problems of smart cars, and uses simulation and smart car models to complete the design of the smart car control system. The functions of the smart car have been debugged and all functions can be realized. The smart car can move forward, backward, turn left, turn right, climb hills, go downhill, and turn. It also has obstacle avoidance and anti-collision alarm functions. Research and development can be continued on this basis, and the system has good scalability and stability.

Innovation points of system design:
1. In the design of the motor, it breaks through the traditional form of bridge circuit, adds the delay time program to the software program, corrects the delay time of the upper and lower bridge arm, effectively changes the short circuit defect, and uses an adjustable PWM square wave to control the steering gear, which saves the cost of the motor.
2. The smart car is no longer controlled by the previous wired control or its own remote-control device. It uses the mobile phone network and Bluetooth to design, realizes the control of the smart car through the wireless smart phone combined with Bluetooth, and the car automatically performs corresponding actions and automatically avoids obstacle and tracking. The automatic control technology has been practically applied and verified on the smart car model.

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