Design of Intelligent Vehicle Based on NXP

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Abstract: This paper mainly introduces the design of intelligent vehicle based on nxp. The intelligent vehicle is powered by nickel-cadmium batteries. MC9S12XS128 MCU is used as the controller. Photoelectric sensors are used to differentiate the track, steering control is carried out by steering gear, speed control is realized by adjusting the speed of DC motor, debugging is carried out by the software of the host computer, and the operation information of the intelligent vehicle is sent to the host computer by wireless data transmission module to monitor the running state in real time. This design completed the design of the system, physical production, system debugging and other work. Through debugging, the design can accurately identify the location of the black line, guide according to the black line, and drive quickly. In the course of driving, the speed and direction are precisely controlled by the PID control algorithm.

1. Introduction

As a wheeled robot, intelligent vehicle has been widely used in many fields such as scientific research, military, transportation, industrial production and so on. In recent years, more and more research institutes and universities have devoted themselves to the research field of smart cars. In order to publicize the smart car, speed up the research of the smart car, promote the practical ability and engineering level of College students, and promote the reform of undergraduate education and teaching, under the guidance of the Department of Higher Education of the Ministry of Education, the Subcommittee of Automation Specialty Instruction of the Ministry of Education held the competition. This subject is based on the design of NXP Intelligent Vehicle Competition for National College Students, and has been made and debugged in accordance with the requirements and rules of the competition.

2. Overall Design of Intelligent Vehicles

2.1 Design task analysis

"Nxp" cup smart car race uses white KT board as the runway, with black guide line in the middle. The color of the floor laying the track is dark blue, requiring a clear distinction between the color of the floor and the color of the runway. The black guide line is made of black tape, which is directly attached to the center of the runway. The runway is 50 cm wide and the guide black line is 2.5 cm wide. The race track has a starting area of 1m in length. There is a 10cm black starting line on both sides of the starting point. The front end of the race car passes through the starting line as the start or end of the race time. It appears in the straight line part of the race track and is also the end line. In order to ensure the normal running of the car, the minimum curvature radius of the runway is 50 cm.

2.2 Design of the overall scheme of the system

In mechanical part, low density and high strength materials such as carbon fibre tube are used in the reinforcement part to reduce the weight as much as possible on the basis of ensuring stability; in order to improve the acceleration and deceleration performance of the car, the position of the center of gravity should be controlled in the center of the car and the height of the center of gravity should

be lowered as far as possible.

In the circuit part, we try to improve the sensor's forward-looking distance by various circuits, simplify the redundant part and improve the reliability of the circuit, and design the control circuit, driving circuit, interface circuit and other parts modularly, so as to ensure the stability and modifiability of the whole circuit. Especially in the design of power supply, the independent power supply is used to supply power for each module, which reduces the power interference between each other.

The software part improves the stability of the software, improves the robustness of the control algorithm, and makes good use of the foresight provided by the laser sensor to improve the strategy of bend prediction and path planning. In software design, it is necessary to control the sensor to scan circularly and detect the position of black line. At the same time, the scanned information is processed by digital filtering, and finally the speed and direction are controlled according to the processing results. In speed and direction control, PID control principle is adopted, and detection module is added to realize closed-loop control, so as to achieve fast and accurate control effect. The overall scheme is shown in Figure 1.
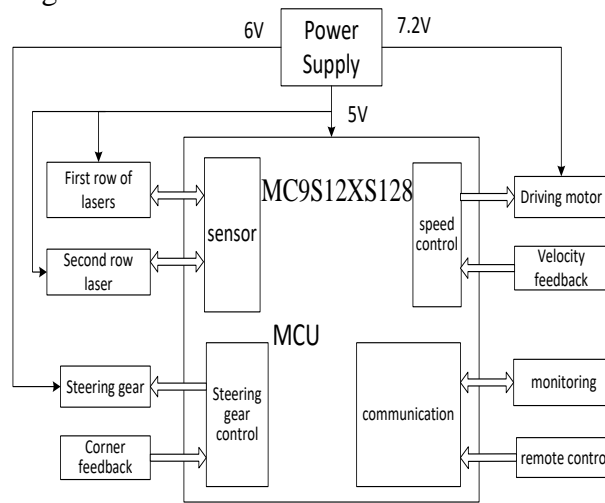

Fig. 1 Intelligent Vehicle Overall Structure Diagram

3. Mechanical Structure Design

The mechanical structure mainly refers to the parameters of the car body, the installation and fixing of components and modules, and the adjustment of the center of gravity. A good mechanical structure is the basis of improving the performance of the whole vehicle. Software is equivalent to the soul of the car, the commander of mechanical action, and the mechanical structure is the executor of the whole system. Without the good performance of the executor, the software can not play its good control performance.

3.1 Design of steering mechanism

The key section affecting the speed of intelligent vehicle is the bend, and the key mechanical structure design affecting the speed of the bend is the design of steering mechanism. Proper mechanical structure design will reduce the requirements of the program, improve the efficiency of debugging, and greatly improve the overall performance of the intelligent vehicle.

Ideally, the steering mechanism of intelligent vehicle is modeled. The wheel satisfies the steering principle, and the axes of the left and right wheels and the axes of the rear wheels must intersect at one point. Steering mechanism plays a very important role in the process of vehicle operation. Appropriate front axle and steering mechanism can ensure that the vehicle will not deviate in the straight-line driving process, and ensure the direction stability of the vehicle; while when the vehicle steering, the appropriate steering mechanism can make the vehicle return to the straight-line driving state, with good correctness. It is for these reasons that the optimization design of steering system has become the focus of mechanical structure in the design of intelligent vehicle, which

directly affects whether the racing car can successfully complete the race. In practice, we optimize the scheme of theoretical calculation, then make the actual structure to verify the theoretical data, and constantly improve in the actual debugging process.

3.2 Four-wheel positioning

During the debugging, it is found that the load of steering steering gear increases with the increase of the turning angle when the vehicle model is running in the bend. By adjusting the position and angle of the front wheel and changing the parameters of the front wheel positioning, the load of the steering gear can be reduced. Good front wheel alignment parameters can increase the stability of straight-line driving, make steering light, and help to reduce tire wear. Front wheel controls the direction of the whole car body. The four-wheel positioning of intelligent vehicle mainly considers the adjustment of front wheel parameters to determine the most appropriate front wheel parameters. Four-wheel positioning mainly includes four parameters: kingpin inward inclination, kingpin backward inclination, front wheel outward inclination and front wheel harness.

The functions of dumping and dumping are to make the automobile turn back automatically and keep a straight line. When the driver loosens the steering wheel after turning, the steering wheel of the car can be adjusted automatically, and the straight road driving is the function of the dumping of the main pin and the dumping of the dumping back.

In the model car, the front harness of the front wheel is realized by adjusting the left and right horizontal tie rods driven by the servo motor. After the position of the main pin in the vertical direction is determined, the size of the front harness of the front wheel can be changed by changing the length of the left and right horizontal tie rods. Adjusting the proper front wheel harness is beneficial to over-bending when steering, and can also improve the deceleration. Since the drag is greater than that without adjusting the front beam, the linear acceleration will slow down. Through the experimental verification, we adopt the strategy of straight high speed and slow bend speed, and adjust the front harness according to the experiment and debugging experience.

4. Hardware Circuit Design

4.1 Power supply design

The stable power supply is the basis of the stable operation of the system. Intelligent vehicle works stably. According to the selection of components, it needs to provide various power supply voltages. Different units have different requirements for the circuit, so the power supply of each part must be classified and designed to prevent crosstalk between each other.

For MCU, it is necessary to provide a stable 5V power supply, otherwise it is easy to cause the MCU to work abnormally and not suitable for LM2596 power supply, so LM2940-5 is chosen to supply power to it; for sensors and other devices, it is not sensitive to ripple voltage and needs to pass through large current, so LM2596 is chosen to supply power to them. In this way, separate power supply is chosen to prevent crosstalk between devices, which makes some parts work unstable. Because the power of the steering gear is small and does not need much power, LM2941 is chosen as the power supply of the steering gear. The test results show that this power supply mode achieves ideal power supply effect.

4.2 Design of detection circuit

The transmitting and receiving circuit of laser consists of transmitting and receiving parts. In the transmitting part, a oscillator emits a 180 KHZ frequency oscillation wave, which is amplified by a three-stage tube to light the laser tube. In the receiving part, the return light intensity is received by a matching 180 KHZ receiver, which is directly connected to the I/O port of the XS128 MCU after capacitance filtering to detect the return voltage. Because the laser sensor uses modulation principle, the receiver can only receive the same frequency of reflected light.

4.3 Driving circuit design

The driving design of the racing car is the precondition of influencing the high-speed driving

ability of the racing car. The motor drive must be stable and reliable, and the protection circuit should be perfect. The most important thing is to have a strong driving current. Only in this way can the racing car have sufficient power and complete the whole track operation excellently.

We use BTS7960 to drive the motor. Its driving current is very large. It can reach 68A theoretically. Moreover, its internal resistance is very small and its power consumption is very small. But the inner part of BTS7960 is a half-bridge. Therefore, two chips are used to construct the full-bridge driving circuit. This not only has the advantage of full-bridge driving circuit, but also reduces its heating. Finally, we decided to use two pieces of BTS7960 to build the motor driving circuit of the race car, and enhance the function of its protection circuit. We also designed the PCB diagram of the driving circuit in full accordance with the wiring requirements, so as to be more stable and reliable.

5. Software Design

5.1 Detection algorithm

In the design of intelligent vehicle, we adopt the way of one receiving tube corresponding to three transmitting tubes to design the circuit, so we need to use the working mode of cyclic scanning to detect in the process of signal acquisition, in order to distinguish different points.

This design uses a double-row laser structure to collect road information. The front row detects 15 points and the back row detects 8 points. The two rows of light spots on the runway are 20 centimeters apart. Two rows of sensors collect information at the same time. Finally, the information is aggregated and the direction control is carried out by weighted method.

During a scanning period, the CPU sequentially collects the states of each receiver and stores them in the array Daolu [15]. CPU first judges the number of laser tubes receiving black lines, if the number of heixianshu is greater than three, judges whether it is a parking line, if it is not considered as error detection, clears the array; if heixianshu is 1 or 2, it is easy to calculate the position of the black line Weizhi from the array. The front-row and back-row detection algorithms are similar. The number of front-row sensors and rear-row sensors are weizhi1 and weizhi2 respectively. This is conducive to data processing and can reduce interference to a certain extent.

5.2 Digital filtering algorithm

Because the car body will vibrate at high speed, with the interference of the track itself, or the laser tube irradiated on the curve outside the track, the sensor will have error detection. If not filtered, the direction or speed of the intelligent vehicle will be controlled incorrectly, and even cause the vibration of the car body, resulting in the unstable operation of the car or rush out of the track and so on. In order to prevent unstable operation caused by interference, we add smoothing filtering algorithm and limiting filtering algorithm in the process of information processing.

The purpose of smoothing filtering is to eliminate the vibration caused by the laser tube jitter, so as to make the position information more smoothly and reduce the vibration. Prevent control shocks caused by signal shocks. Smoothing filter can effectively prevent the position of black line from bouncing repeatedly when laser strikes the edge of the black line, and prevent the jitter of the steering gear.

5.3 Track discrimination algorithms

This design distinguishes straight, curved and S-type runway modes, which is the core algorithm of the program. Without recognition of track patterns, it is difficult to adapt a program to all tracks because of the complexity and diversity of track types. Because of the complex conditions of the track when the car is driving, it is impossible to judge the type of the track by collecting information once. We use the method of storing and analyzing the information of the track to distinguish the type of the track. In order to detect the type of track in advance, only the front sensor information is stored.

Store Black Line Position at regular intervals, and consecutively store a certain number. The

specific quantity should be determined according to the average speed. We test the vehicle speed according to 2.5 m/s. We select the acquisition time of 20 ms, 20 times and the distance of about one meter. Twenty groups of data are made into arrays and updated in real time. The latest data is always in the first place, and then the data is analyzed. According to the current detection value, the car can accurately identify the type of track which has passed about 1 m path.

5.4 Direction control algorithm

Intelligent vehicle controls the steering of front wheel by steering engine, and steering engine controls the angle by output pulse width of single chip computer. Because the intelligent vehicle pursues speed, the general fuzzy control algorithm can not meet the control accuracy and speed. We use the position-based piecewise PD control algorithm to control the direction, such as formula (1) (2). At the same time, weighted averaging is applied to the front and back sensors to achieve the optimal coordination of accuracy and speed, such as formula (3). The deviation error is calculated according to the detected position, and the calculation formula of output is as follows:

$$Speed\_f = Middle + Kp * error\_f(n) + Kd * d\_error\_f(n) \quad (1)$$

$$Speed\_d = Middle + Kp * error\_d(n) + Kd * d\_error\_d(n) \quad (2)$$

$$Speed = value\_f * Speed\_f + value\_d * Speed\_d \quad (3)$$

In the process of debugging, it is only necessary to set appropriate proportional parameter Kp and differential parameter Kd according to the length of the steering linkage of the car. Increasing the proportional parameter Kp can improve the response speed of the steering gear and make the turning more flexible. Excessive proportional parameter Kp can make the car oscillate and S-shaped path appear when driving on the straight road. Reducing the proportional parameter Kp will make the car run smoothly on the straight road, but the response of the bend is slow and it is prone to overshoot. Because the position and output are not linear, we segment the position and output. For the position and output angle of all kinds of track, we adopt the piecewise PD control algorithm.

In the calculation formula of position, there are two position parameters. By setting different value_f and value_d, the proportion of front sensor and rear sensor in direction control can be changed. By adjusting the weight of the front and rear rows, the tangential diameter or the tangential diameter of the car route can be effectively adjusted. The front row occupies a large proportion of the car route will move to the inside of the bend, and vice versa to the outside of the bend.

5.5 Speed control algorithms

The intelligent vehicle uses PWM mode to control the speed of the motor, and the square wave output by the single chip computer drives the motor through the driving chip BTS7960. In the process of car starting and turning into the straight road, the car is in the acceleration process. The single chip computer outputs large duty cycle PWM wave and detects the speed of the car. When the speed of the car reaches the set value, the constant speed control algorithm, namely the PID control algorithm, is adopted. In the braking process, the motor reverse braking is used to achieve the shortest braking time and prevent overshoot in the process of high-speed turning. When the speed drops to the bend speed, the constant speed control is enabled to smoothly pass through the bend.

6. System Debugging

After adjusting the parameters and debugging the intelligent vehicle all day, the design task is basically completed. From the scheme design, model making, car body assembly, debugging, the design can eventually independently detect the location of the black line, judge the type of track, adjust the speed and direction according to the road conditions, complete the line patrol and automatic parking, the final speed reaches 2.5m/s, which achieves the desired effect.

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