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Smart Car Design Based on K60

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Abstract: The smart car system designed in this paper takes MK60FX512VLQ15 micro controller as the core control unit, detects track information through CMOS camera, inductance and infrared, and extracts the black edge line by using the binary camera of mountain eagle eye OV7725 hardware for track identification. The real-time speed of the model car is detected by the encoder, and the speed of the driving motor is adjusted by PID control algorithm to realize the closed-loop control of the speed and direction of the car. In order to improve the speed and stability of the model car, a large number of hardware and software tests were carried out by using small LCD and other debugging tools. Experimental results show that the design scheme is feasible.

1. Introduction

With the continuous development and progress of science and technology, the application of smart control is more and more extensive, almost permeating into all fields. Smart car technology, relying on smart control, has broad prospects and rapid development. At present, developed countries that have mastered the key technologies of the automobile industry have developed many experimental platforms for smart cars and commercial car-assisted driving systems [1-3]. Some researchers believe that smart car, as a brand-new automobile concept and product, will become the automobile production and automobile market in the near future. This article mainly includes the mechanical system, hardware system, software system and so on, elaborated our design party in detail, concrete manifestation in the hardware circuit innovation design and the control algorithm unique idea.

2. Overall System Design

Smart car mainly consists of three parts: detection system, control decision system and power system. Among them, the detection system is mainly completed by the OV7725 camera, assisted by the electromagnetic sensor through the circuit breaking area, and assisted by the infrared sensor to identify obstacles. The control decision-making system use MK60 as the main control chip, and the power system is responsible for providing stable working voltage for each module and driving the steering Angle and motor rotation. The overall working mode of the smart car system is as follows: eagle eye OV7725 hardware binary camera (CMOS image sensor) takes track images, inputs them into MK60FX512VLQ15 micro controller, and further processes to obtain main track information. Infrared module detects obstacles and electromagnetic sensor passes through the broken circuit area.

Speed is detected by encoder and pulse calculation is carried out with the input capture function of micro controller to obtain speed and distance. Steering gear adopts PD control; Drive motor PID control, through PWM control drive circuit to adjust the motor power.[4-6] The target value of car speed is controlled by default, operation safety scheme and optimization strategy based on image processing. The system block diagram is shown in Figure 1.

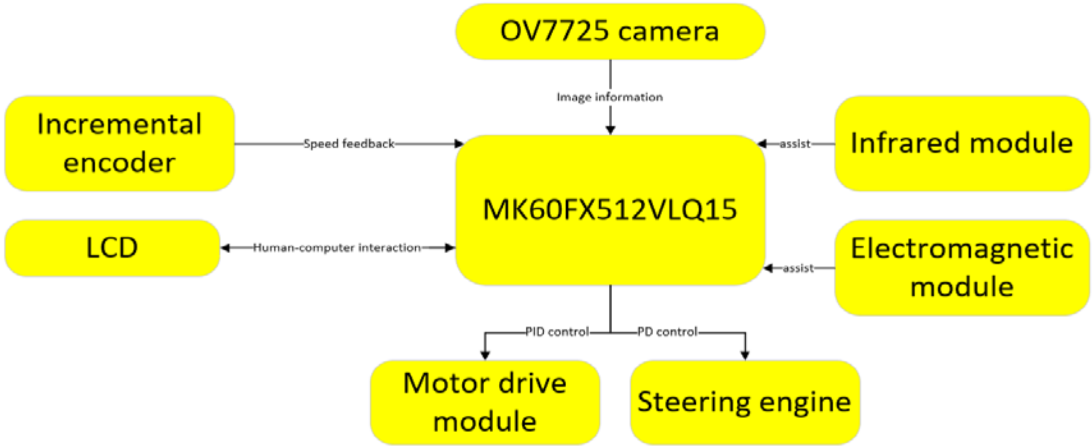


Figure 1: The system block diagram

3. Hardware Circuit Design

Smart car hardware circuit consists of six modules: main control module, power module, motor drive module, sensor module, speed detection module, auxiliary debugging module. The power module provides the required changes of current, voltage, current and other physical quantities for other modules of the car system, which also transmits the information between the single-chip microcomputer and the camera. Only when the power management module works steadily can it provide stable and appropriate voltage and current to other modules to ensure their normal operation. In the design, in addition to considering the voltage range and current capacity and other basic parameters, but also in the power conversion efficiency, reduce noise, prevent interference and circuit simplicity optimization. In the design process of schematic diagram and PCB, we consider the electrical characteristics of each functional module and the coupling between them. The vulnerable module is electromagnetic shielding, and the other parts are grounding, filtering, analog and digital circuit isolation.

3.1 Main Control Module

The main control module of this system adopts MK60FX512VLQ15, which is the kernel chip of K60 series Kinetis series microcontroller cortex-m4 series. The K60 memory space is scalable from 32KB of flash memory /8KB RAM to 1MB of flash memory /128KB RAM, with an optional 16KB cache for optimizing bus bandwidth and flash performance[7]. Pin diagram is shown in figure 2.

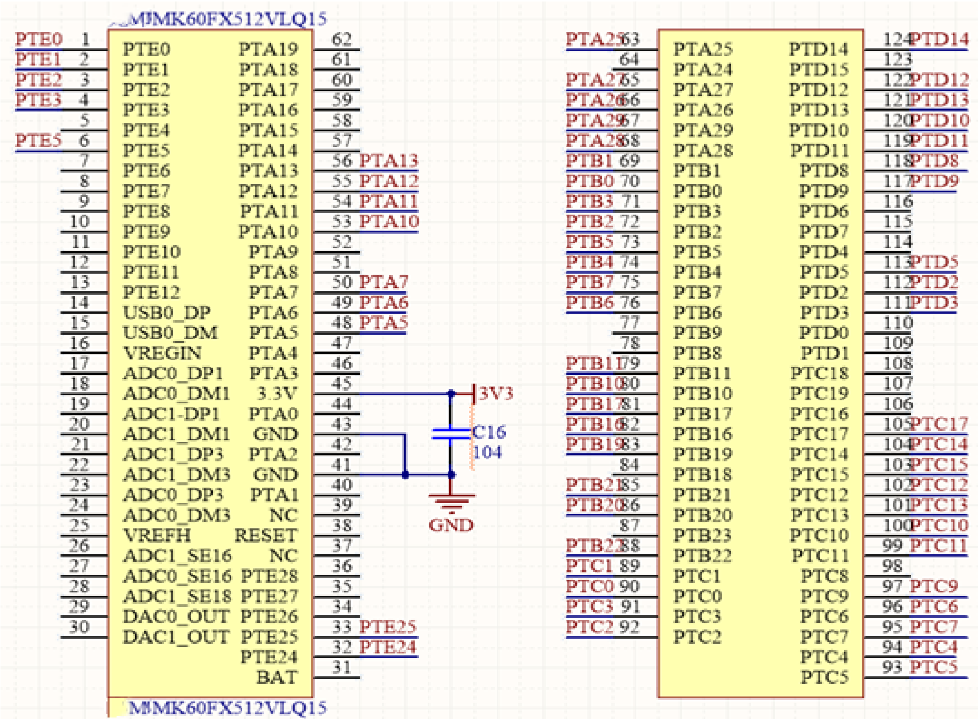


Figure 2: Master control module

3.2 Power Supply

3.2.1. 3.3 V Power Supply

Since the main control chip used by us supplies power to 3.3v, the battery voltage needs to be stabilized to 3 3v. There are many 3. 3v voltage regulator chips on the market, which can be divided into switch voltage regulator and linear voltage regulator according to the type[8]. The conversion efficiency of linear voltage regulator is low but the ripple is small, while K60 is sensitive to the power supply voltage and the voltage fluctuates greatly, which is likely to cause the chip low-voltage reset. Therefore, we choose the linear voltage regulator chip. In the linear voltage regulator chip containing LM and TPS series, in order to ensure the stable operation of the minimum system board, we finally adopted TPS7333 as the power supply chip of the minimum system, which is better than LM1117 in terms of its small ripple, only a few tens of mV, and better than LM1117 in terms of thermal protection and anti-static. The circuit diagram of TPS7333 is shown in figure 3.

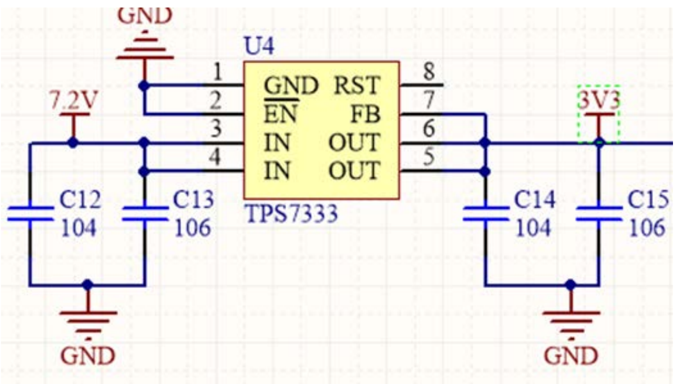


Figure 3: 3.3V voltage regulator module diagram

3.2.2. 5.0 V Power Supply

There are many linear 5V voltage regulator chips, such as LM1117-5.0, 7805, TPS76850, LM2940-5.0, LM1084-5.0, etc., according to the data manual: LM1117-5.0 output current 800mA, TPS7350 output current 500mA, TPS76850 output current 1A. Through practical use, it is found that TPS76850 has an ideal linearity, low pressure difference, simple circuit and good stability. Therefore, we choose TPS76850 for 5V voltage regulator chip. The circuit diagram of TPS76850 is shown in figure 4.

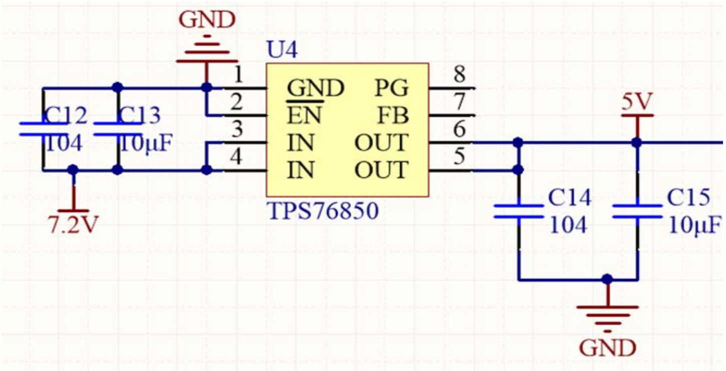


Figure 4: 5.0v voltage regulator module circuit diagram

3.2.3 6.0 V Power Supply

The steering gear is powered by AS1015, which is adjusted at a voltage of 6.0v or 5.5v. The higher voltage can improve the response speed of the steering gear, but the higher voltage will easily lead to the instability of the steering gear. The voltage regulating circuit schematic diagram of steering engine power supply is shown in figure 5.

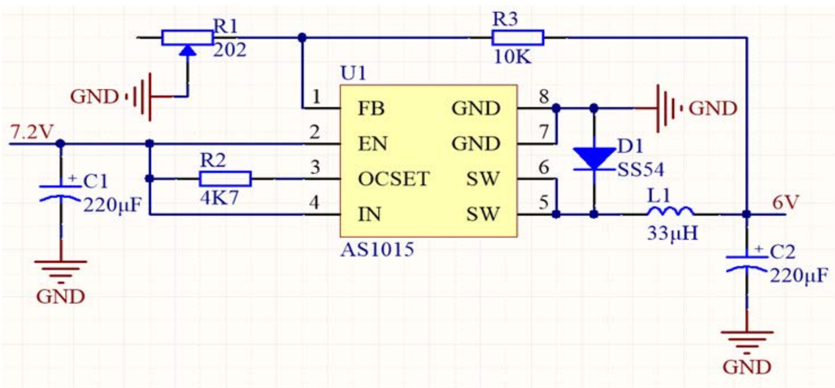
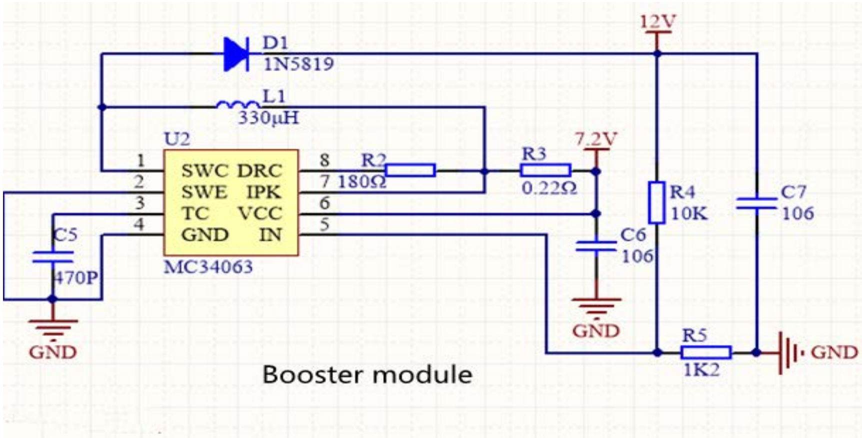


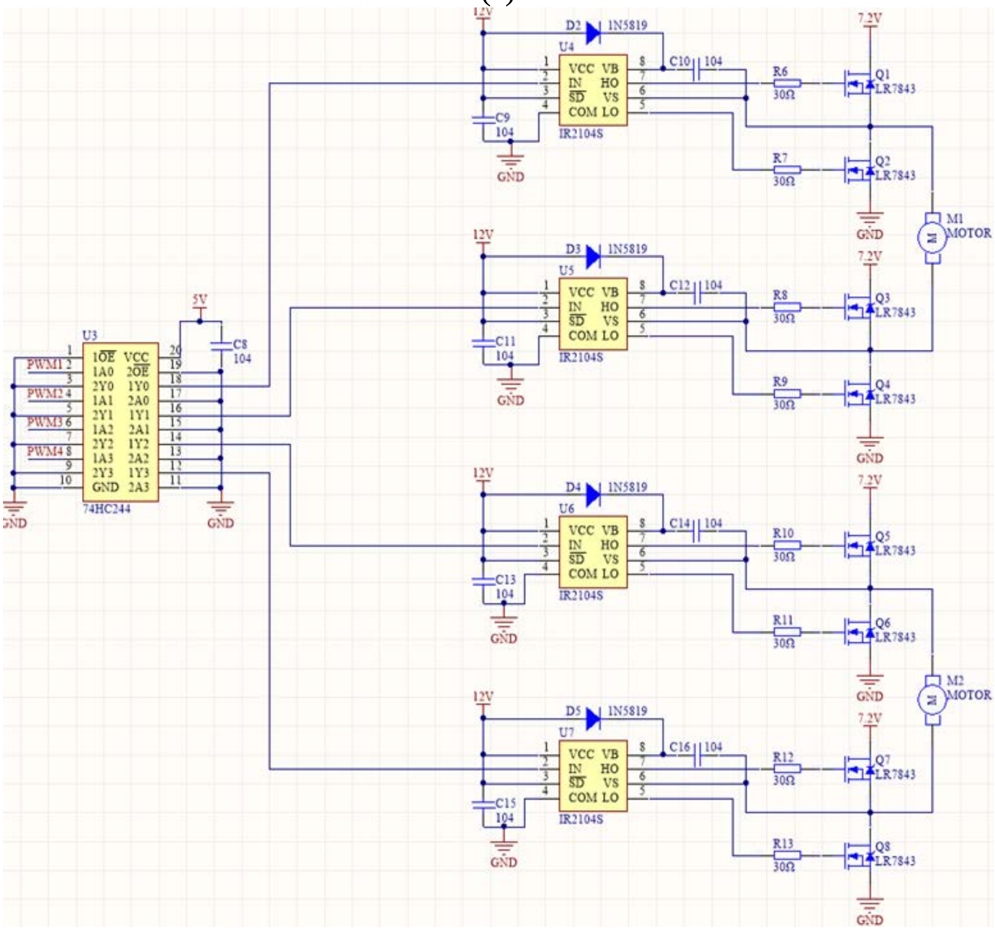
Figure 5: 6v voltage regulator module circuit diagram

3.3 Motor Drive Part

As a racing group, speed is the first element, and the car's speed and motor drive inseparable. Since the motor of the car is the only designated by the organizing committee of the competition, self-modification is forbidden, so we can only think of ways to improve the driving circuit of the car[9-11]. Our group use the classic H bridge driving circuit for control circuit, the circuit for four MOS tube control through the opened and shut off to control the motor operation, our group using the MOS tube for LR7843, the MOS RDS is 3.3 mΩ, the largest by current can achieve ID = 161 A, at the same time gate charge for Qg = 34 Nc, affects the switch of MOS gate charge rate, generally smaller, switch speed is faster. The main part of the drive circuit is an H-bridge-circuit composed of 4 MOS tubes, which is a reversible bipolar full bridge driver, and 4 MOS tubes are n-channel power MOSFET tubes. The rated working current can easily reach more than 100A, greatly improving the working torque and rotation speed of the motor[11-14]. The circuit diagram is shown in figure 6.



(a)



(b)

Figure 6: Circuit diagram of motor drive module

3.4 Camera Module

As a four-wheel group of the 14th session, the selection of photoelectric sensors is very important. In the market, there are mainly CCD and CMOS cameras, digital and analog cameras. CCD camera has the advantages of high contrast and good dynamic characteristics. However, it needs to work at the voltage of 12V, which is too power-consuming for the whole system. In addition, the large volume and heavy mass of CCD will raise the center of gravity of the car body, which is very unfavorable for the car driving at high speed. By contrast, CMOS camera has the advantages of small size, light quality, low power consumption, good image dynamic characteristics, etc. Since the car does not require high resolution of image clarity, our group chooses OV7725 digital camera. The advantages of this camera include: high frame rate of OV7725, which means more image data can be obtained per second, small size, digital signal output-data, strong anti-interference and simple hardware implementation. Digital image acquisition use the digital output characteristics of CMOS image sensor to directly read the digital output of the sensor. This method has stable performance and does not need A/D. The image acquisition work is done by parallel reading external data in a certain order in the single-chip microcomputer. Therefore, the program is simple and the acquisition speed is fast. Among the digital cameras, the series of cameras that adopt the OV7725 photosensitivity chip and output 8 pixels of information in one time through hardware binarization are very creative. They do not achieve higher frame rate by increasing PCLK frequency, which makes these cameras have higher output speed and more stable performance[15-17]. So, we thought twice before choosing this type of camera (typical: Shawnie eagle eye). The hardware circuit is shown in Figure 7.

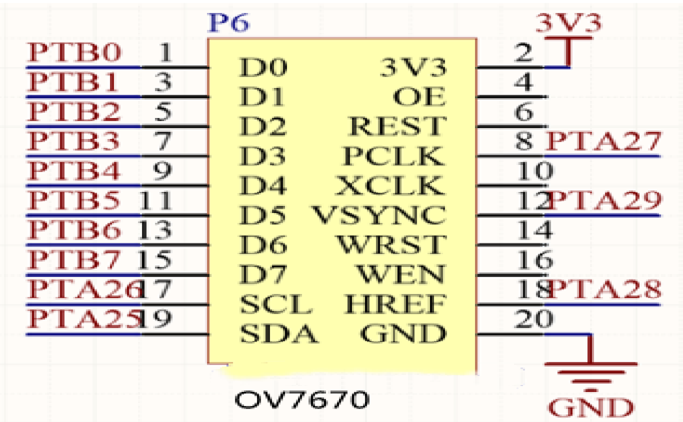


Figure 7: Circuit diagram of camera module

3.5 Speed Detection Module

This car used Long-Quiz's encoder to measure the car's speed, and TPS76850 provides its 5V working voltage. The processor detects the car speed by reading the pulse number of the encoder and detects the positive and negative rotation of the motor by reading the high and low level of the rotation pin of the encoder. Thus, realize the closed-loop control of smart car power system.

3.6 Auxiliary Debugging Module

Debugging is a necessary way to find the best parameters of smart car system. In the debugging process, we used modules, including: LCD screen, five-way key, dial code switch, infrared, buzzer, etc. LCD is used to display important parameters of the car, through the five-way button, these parameters can be changed, so as to avoid many times to write the program; Bluetooth module is used to send some information to the debugger in real time, so that the debugger can grasp the running situation of the car in real time. LED are used as indicators to indicate the status of the program [18]. The purpose of the buzzer is to display specific elements by changing the tone. The circuit diagram of the auxiliary debugging module is shown in Figure 8.

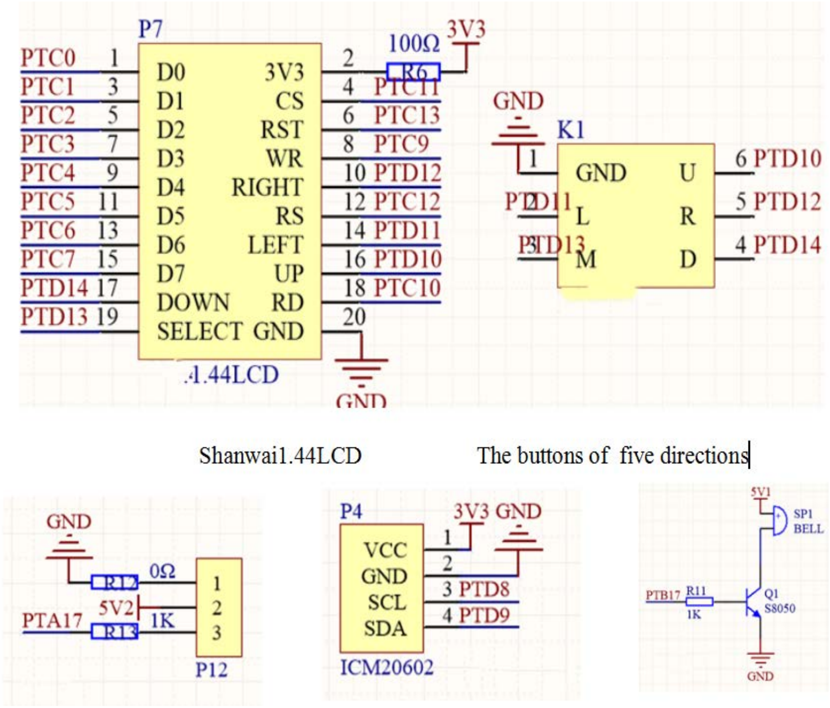


Figure 8: Auxiliary debugging module

4. Software System Design

The program of trolley mainly adopts the sequential structure, and use the nested control of interrupt vector to arrange the execution time between various tasks reasonably, so as to improve the stability and efficiency of the program. The software mainly includes the following functions[19-21]:

(1) Image acquisition and processing by camera;
(2) PWM signal output: PWM signals of steering gear and motor;
(3) Car mold operation control: speed control, direction control;
(4) Car model operation process control: program initialization, car model starts and end, car model state monitoring;
(5) The first category includes (1) - (3) functions, which need to be executed in precise time cycles. Therefore, a flag variable can be set in the timing interruption of a cycle as the symbol of the execution cycle.
(6) The second category includes (4) functions whose execution does not require precise time periods. This can be done in the main program of the program. The program structure flow chart is shown in figure 9.

4.1 The Main Program

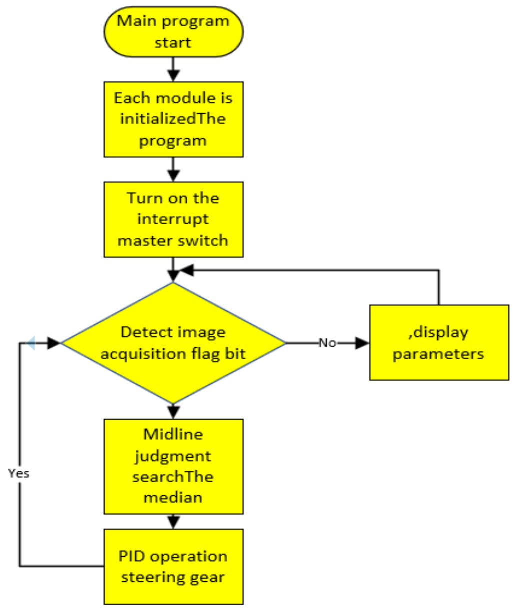


Figure 9: Main Software flow chart

4.2 Image Acquisition and Processing

Image acquisition using DMA way will get after binarization of hardware of the whole image data stored in memory, MCU by hardware binarization camera OV7725 collecting data from a group of eight representative eight pixels, you need to extract data from the camera, extract into 80 * 60 array, border on both sides by searching algorithm, to calculate the target path. The identification steps are as follows.

(1) The camera DMA stores compressed data.

(2) Data decompression.

(3) Find the sideline of the track and fit the median of the track.

(4) Calculate the deviation between the current car and the median. In order to facilitate us to observe the car movement, we extract and print the data collected by the camera.

On the small liquid crystal, we used a screen resolution of 128*128, so we printed an image size of 80*60.

Camera sensor information is very rich, image analysis algorithm directly determines the car motion path and state, camera field of vision is large, the blind area is small, information rich, forward-looking and other characteristics. According to the deviation of track center and image center, and the change rate of deviation to determine the type of track, such as: straight, curve. And do different calculations. The basic idea of looking for black lines on both sides is to start from the predicted middle line, look for each line on both sides until the black boundary is found, and do this from the first line to the end line. Calculate the median line directly from the boundary to average. Through the comparator circuit, the single-chip microcomputer records the black and white jump points of each line (the jump points are in the order from right to left) and saves them into two two-dimensional arrays. By traversing the rising and falling edges, the extraction of track edges can be completed. Several typical track images collected by the camera are shown in figure 10 ~figure 13.

The parking mode of smart car four-wheel group is to observe the parking of zebra crossing. The algorithm we used is to scan from one side of the runway to the other side in the effective path recognition interval of the car. If the black and white jumps (or white jumps to black) are more than six times, it can basically be judged as a zebra crossing. The standard zebra crossing has nine white stripes and eight black stripes in the center of the track. Considering the situation of stopping after turning, if eight black and white jumps are judged, it may be impossible to observe all the stripes, leading to the failure of stopping.

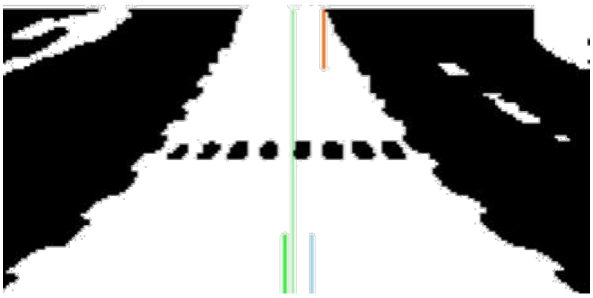


Figure 10: Starting point original image

The boundary characteristics of curve recognition are: the forward view is relatively close, the current deviation is large, the unilateral drop line, there is obvious jump, the near track is wide, the boundary near the end line is very narrow.

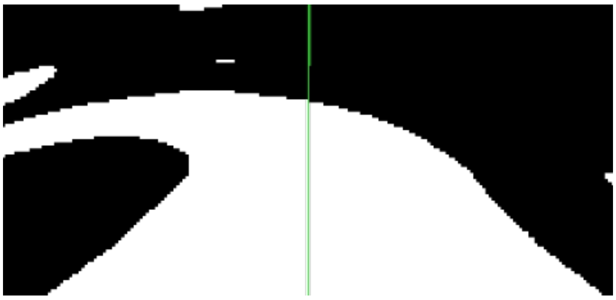


Figure 11: Original image of curve

The boundary feature identified by cross bending is that the calculated boundary shows the occurrence of losing lines on both sides of the continuous boundary, and the number of consecutive lines depends on the situation. The boundary features identified by right Angle bending are continuous on one side and line dropping on the other side.

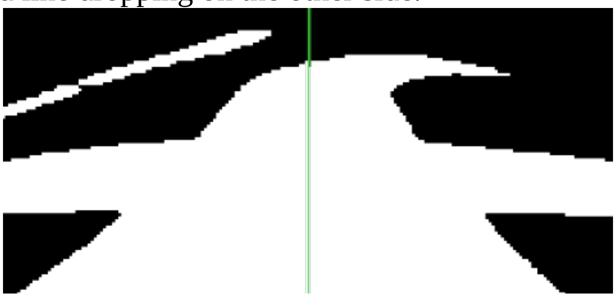


Figure 12: Cross original image

The boundary feature of obstacle recognition is that the current deviation is small and the boundary feature is far-sighted. There are no lines lost on both sides. One side of the boundary is continuous and the other side jumps to the middle. The boundary characteristic of the ramp identification is that it is far-sighted, the current deviation is small, there is no line loss on both sides, and there is no obvious jump. The nearby track is wide, and the boundary near the end line is narrow.

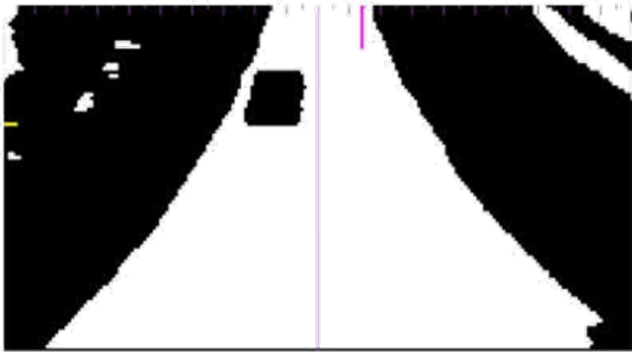


Figure 13: Original image of obstacle

The boundary feature identified by the circular island is that there are two obvious lost lines on one side of the circular island, and the two parts of the lost line show an arc state, while the other side is an edge of a straight road, which is approximately a straight line with shrinking boundary.

4.3 PID Control Algorithm for Steering and Speed

4.3.1 Steering Gear Control Task

According to the requirements of the competition rules, many schemes can be designed to maintain the car driving. The reference scheme assumes that the power to control the direction steering and maintain the operation comes from the servo motor of the car model, the motor of the rear wheel and the four wheels. The two rear wheels are driven by a dc motor and the steering of the two front wheels is controlled by a servo motor. Therefore, from the control point of view, as a control object, the car model's control input is the rotation degree of two dc motors and a servo motor. Car model motion control task can be divided into the following three basic control tasks.

(1) Control the direction of the car model: the steering of the two front wheels is driven by controlling the rotation Angle of the servo motor, so as to realize the steering control of the car model.

(2) Control the speed of the car model: the speed of the car model is controlled by adjusting the speed of the dc motor of the rear wheel, and the rear wheel is controlled by the mechanical differential of the left and right wheel. In fact, the most important thing is to control the wheel speed by controlling the speed of the motor.

4.3.2 Steering Gear Control Theory

Steering gear is a position servo system, which consists of steering wheel, reduction gear, position feedback potentiometer, dc motor and control circuit. Through internal position feedback, make its steering wheel output Angle proportional to the given control signal, so for its control can use the open loop control mode. When the load is less than its maximum output torque, its output Angle is proportional to a given pulse width. Steering gear control is one of the most important aspects of control algorithm. Once the steering gear control error, smart cars are likely to foul out of bounds. Therefore, one of the main tasks of switching is to observe the steering gear and make it control reasonably. The control of steering gear of our team adopts the traditional PD control. As for the knowledge of PID control, since PID control is a classic control, its theory is relatively mature, and there are many relevant books on the market, so it will not elaborate on PID control in depth.

The key codes are as follows:

```
  Dire-P-Value = dire-P Real-Warp;
  Dire-D-Value = dire-D (Real-Warp -Last_ Real-Warp);
  Servo-Control-Out  =  -(int)Dire-P-Value  -(int)  Dire-D-Value  +
Servo-Mid;
   // get the output of the steering gear
```

Among them, dire-P and dire-D two important parameters need to be adjusted constantly. In the actual debugging, it is found that the parameters given for the track type are more practical. For example, in straight and small S road corresponding dire-P can be given small, in case the steering gear Angle is too large. The parameter setting between segments should be continuous, otherwise, a big mutation of steering engine will occur after parameter switching, leading to poor path of smart cars. We set a mathematical function to control the output of parameters, reducing the workload of adjusting parameters. Of course, in order to prevent the gear of the steering gear from being damaged, the Angle of the steering gear should be limited.

4.3.3 Response Speed of Steering Gear

An important parameter that affects the control performance of steering gear is its response speed. The time delay is proportional to the rotation Angle and inversely proportional to the response speed of the steering gear. And the response speed of the steering engine is the factor that directly affects the performance and the maximum speed of the smart car, so improving the response speed of the steering engine is a key to improve the average speed of the smart car. There is a certain relationship between the working voltage and the response speed.

According to the principle of lever, a long output arm is installed on the output steering disc of the steering engine, and the steering drive rod is connected to the end of the output arm. This can be in the steering gear output smaller Angle, obtain a larger front wheel Angle, thereby improving the steering control speed of the car model. However, the longer the arm, the better. Lengthening the mounting arm will reduce the force added to the connecting rod. If the force is too small, it may be impossible to move the front wheel when turning, which will reduce the steering performance of the car model and get the opposite effect. Therefore, the pros and cons should be weighed.

In engineering practice, the most widely used regulator control law is proportional, integral, differential control: system, PID control for short, also known as PID regulation. PID controller has been developed for nearly 70 years. It has become one of the main industrial control technologies due to its simple structure, good stability, reliable operation and convenient adjustment. When the structure and parameters of the controlled object cannot be fully mastered or precise mathematical model cannot be obtained, it is difficult to adopt other techniques of control theory, and the structure and parameters of the system controller must be determined by experience and field debugging. At this time, it is most convenient to apply the PID-control technology. That is, when we do not fully understand a system and the controlled object, or cannot obtain system parameters through effective measurement means, the PID control technology is most suitable. PID control, PI and PD control are also available in practice. PID controller is a kind of linear controller, which constitutes the control deviation according to the given value and the actual output value. The proportion of deviation (P), integral (1) and differential (D) are formed into a control quantity through a linear combination to control the controlled object, so it is called PID.

Simply put, the PID controller of the calibration link as follows: Proportional link: reflect the deviation signal of the control system in a timely and proportional manner. Once the deviation occurs, the controller will be produced immediately194Generate control function to reduce deviation. Mainly used to eliminate static errors and improve the system's accuracy. The strength of integral function depends on the time constant of integration. Differential step: can reflect the variation trend (rate of change) of the deviation signal, and can introduce an effective early correction signal into the system before the deviation signal becomes too big, thus speeding up the system's operation speed and reducing the adjustment time. PID control algorithm is usually divided into position PID control algorithm and incremental PID control algorithm.

4.4 Direction Control Algorithm

For the closed-loop control of steering gear, we adopt the position PID control algorithm and fuzzy control algorithm. After referring to the steering gear control methods used in previous excellent technical reports, we made our own improvement and improvement on their basis. Combined with our road condition extraction algorithm, the traditional position PID algorithm and fuzzy control algorithm are used to control the direction of the steering gear, and finally satisfactory results are obtained. Angle of fuzzy control on the whole, with a bias decision direction algorithm, planning in advance good fuzzy interval division, set up fuzzy control rule table, the program run time deviation and deviation rate obtained by signal processing, according to the fuzzy interval get membership, finally according to the fuzzy membership degree with gravity method, get a certain P and definite D, and then used to calculate the steering Angle. The deviation and the variation rate of the deviation are divided into 7 intervals respectively, and the combination of the two can be divided into 49 segments to establish the two-dimensional fuzzy control table of steering gear. When the greater the deviation, the greater the variation rate of the deviation, the greater the steering gear Angle, the more urgent the Angle. The smaller the deviation, the smaller the variation rate of the deviation, the smaller the Angle of the steering gear, the slower the Angle of the steering gear.

```
  uint32 Angle (float32 Angle Offset)
  {
  error [0] = Angle Offset;
  error [1] = error [0] - old_ error [0];
  SERV Pram = Fuzzy_ Update (& Angle_ PD, error [0], error[1]) ;
  angle = SERV Pram * error [0] + severed *error [1] + serv Motor
Centore;
  old_ error [0] = error [0];
  return (uint32) angle;
  }
```

4.5 Speed Control Algorithm

For speed control, we use incremental PID control algorithm[21], the basic idea is straight acceleration, curve deceleration. After repeated debugging, the position of the black line obtained from each image and the speed PID. In the actual test, we found that the acceleration and deceleration of the car straight and curve transition is more sensitive, and the steering control with the steering gear is better. Speed control plays a crucial role in the rapid progress of the car and the deceleration when necessary. After the traditional PID method, we found that it could not meet our ideal speed control requirements. In addition, dimensional fuzzy control algorithm and incremental PID control algorithm are added to adjust the speed, and good results are found. On the whole, the fuzzy control of motor use the offset to determine the speed algorithm, and the offset and the rate of change of the offset are divided· 7 segments. The two-dimensional fuzzy table of the motor can be divided into 49 segments. The larger the offset, the higher the rate of change of the offset, the faster the speed decreases, the slower the speed, the smaller the offset, the lower the rate of change of the offset, the faster the speed increases, the faster the speed increases. Motor incremental PID control algorithm use PI control to determine the output PWM, according to the current speed and expected speed deviation and the accumulation of deviation to determine the pi-parameters, so as to determine the motor output PWM signal.

```
int32 Motor_ PID (float32 hope, float32 speed_ now)
{
spa_ error [0] = hope - speed_ now;
spa_ error [1] = spa_ error [0]-spa_ old error [0];
speed_ set+= speed_ I * spa_ error [0] + speed_ P * spa_ error[l];
spa_ old_ error [0] = spa_ error [0];
motor rate = speed set;
return (int32) motor_ rate;
}
Motor_ Gold=Fuzzy_ Update (&Speed_ Fuzzy_ Control, error [0], error [1]);
speed=Motor_ PID (Motor_ Gold, ch3_ pulse)
```

When the car starts running, the expected speed and actual speed change curves of the motor are shown in figure 14. The blue line is the expected speed and the purple line is the actual speed. It can be seen from the figure that the actual speed response is relatively fast. When the program gives a fast-expected speed, the actual speed accelerates very fast. When the actual speed reaches the expected speed, the overshoot will not be serious and can be stabilized at the expected speed.

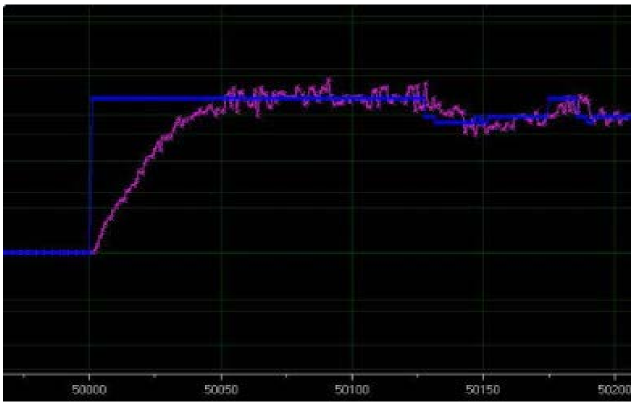


Figure 14 Curve of expected speed and actual speed of motor

5. Conclusion

Tested on the track by model cars, the designed system is better realized. It recognizes the basic elements of the road, such as straights, curves, roundabouts, obstacles, crossroads, and zebra crossings, and realizes the basic functions of automatic driving of smart cars. This model car won the second prize in the South China Division in the 2019 China University Student Smart Car Competition, with an average speed of 2.3M/S. The function of the whole system is relatively complete, the circuit design is simple, and the performance is stable. It has well exercised the practical ability of college students, and has certain teaching and popularization value.

References

[1] Gu, X.F. and Yu, M.L. (2020) Design of electromagnetic tracking obstacle avoidance car based on K60. Internet of Things, (03), 7-8.

[2] Teng, Y.F. (2014) Intelligent car control system based on K60 system board. Qingdao: Qingdao University of Technology.

[3]F.W. and Yao, X.L. (2020) Design of automatic tracking car based on CMOS camera. Journal of Ningbo University of Technology, (01).9-10.

[4] Zhang, S.Z. (2020) Image processing of intelligent vehicle based on CMOS camera. Journal of Ningbo University of Technology, (01).6-7.

[5] Li, L. (2019) Design of autonomous navigation system for intelligent vehicle based on multi-sensor fusion. Chengdu: SWJTU (Southwest Jiaotong University).

[6] Su, K. (2019) Study on active Collision avoidance Path Planning and Tracking control method for intelligent Vehicles. Dalian: Dalian University of Technology.

[7] Diao, Q.Q. (2019) Research and application of intelligent vehicle adaptive motion control system. Chongqing: Chongqing University of Technology.

[8] Ding, P. (2018) Research on PID control of self-tracking intelligent vehicle. Hengyang: University of South China.

[9] Chen, S.C. (2018) Research on Intelligent Vehicle Control System based on machine vision. Guangzhou: South China University of Technology.

[10] Li, Y. (2018) Research on Road and Vehicle Detection Technology based on machine vision. Beijing: Beijing University of Technology.

[11] Bi, S. (2019) Embedded artificial intelligence technology development and application. Electronic World, (05).5-7.

[12] Luo, Y.P. (2019) Design of embedded system based on ARM microcontroller. Equipment maintenance technology, 019(02), 3-6.

[13] Fan, C.P. and Chen, Z.H. (2016) Design and Implement of the Line Loss in the Curve of Intelligent Car Based on the 7725 Camera. Modern computer (pro). (28): 8-9.

[14] Fu, X.Y. (2017) Research on design and path planning of intelligent car software system. Zhejiang: Zhejiang Sci-Tech University.

[15] Wang, Y.Q. and Wang, G. (2013) A Design of Intelligent Car Based on STC89S52 Single Chip Microcomputer. 2095:666-670.

[16]Silva, T., Dias, L.S. and Nunes, M.L, et al. (2016) Simulation and economic analysis of an AGV system as a mean of transport of warehouse waste in an automotive OEM. IEEE International Conference on Intelligent Transportation Systems.

[17] Choe, R., Kim, Jeongmin, and Kwang Ryel Ryu. (2016) Online preference learning for adaptive dispatching of AGVs in an automated container terminal. Applied Soft Computing.

[18] Demirli, K. and Khoshnejad, M. (2008) Autonomous parallel parking of a car-like mobile robot by a neuro-fuzzy sensor-based controller. Fuzzy Sets and Systems, (19).

[19] Wang, Y.J. Zhao, C. P., and Gao, G.H. (2011) Design of an Intelligent Mini Car Based on AT80C5, 1043: 318-322.

[20] Yang, D.G. Liu, T.Y. and Hu, C.Y. (2015) DESIGN OF AN INTELLIGENT CAR FOR SEARCHING TRACK AND AVOIDING OBSTACLES, 8(2):1354-1378.

[21] Chen, J.J., Chen, Q.X., and Fan, Y.B. (2014) The Study of Intelligent Smart Car Based on msp430, 3382: 901-904.