USTB SMARTCAR Team
Technical Report

Team members: Cheng Gang

Wang Haonan

Fan Bin

Adviser: Yang Jue

2015.3.26 - 2015.9.10

1 Mechanical Structure

1.1 Modeling

According to rules, C-typed model car which has two motors for driving power is used in Worldwide Finals. This chapter is dealing with the mechanical structure and adjustment.

The car model is shown in figure 1.1.

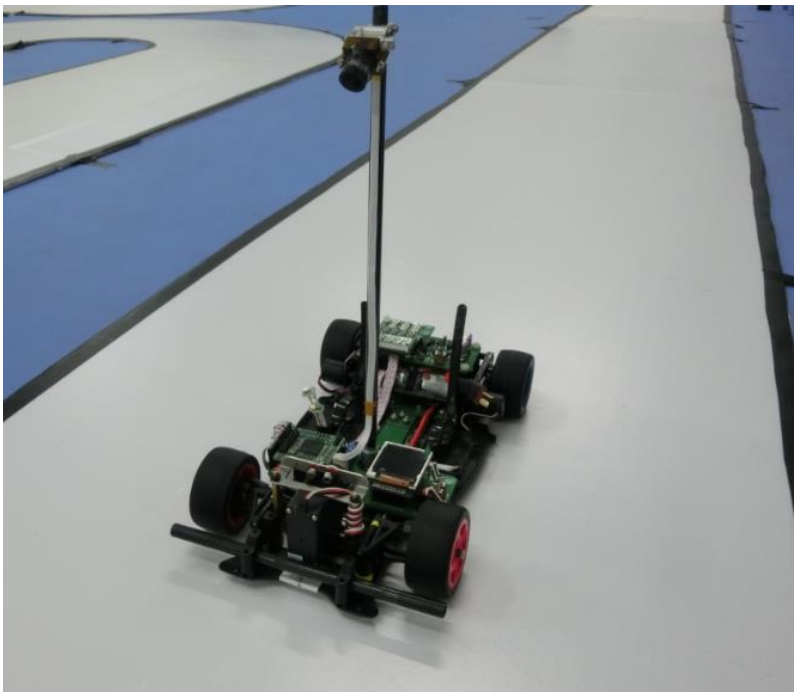


Figure 1.1 Car Model

1.2 Four wheel alignment

We just dealing with the basic angles including kingpin caster, kingpin inclination, camber and toe-in. Because only the front wheels can be adjusted, and we cannot change the camber, thus there are only three angles we can adjusted.

First is kingpin caster. According to theoretical analyses and experiments, kingpin caster acts like a damper in steering processing when there is an overshoot in steering.

The left and right kingpin inclination must be equal, or you will find a steering asymmetric phenomena. And a positive kingpin inclination is helpful to the opposite steering direction, in other words, when you have a bigger positive kingpin inclination in left side, your car will turn right easily.

Toe-in is an interesting part of the angles, because I cannot find an obvious conclusion of it. It seems that toe in too much or less have the same results and there is a exactly degree of it, and all you can do is to test all the time.

1.3 Center of gravity

The center of gravity impacts the distribution of wheels' weight. The ideal position is a little back of the center, and the height of center must be as low as possible.

1.4 Servo

We installation the servo in vertical (figure 1.2), and the oscillating arm is designed. This method will supply a fast response and less torque, because the power is fixed. But we find it is enough to turn.

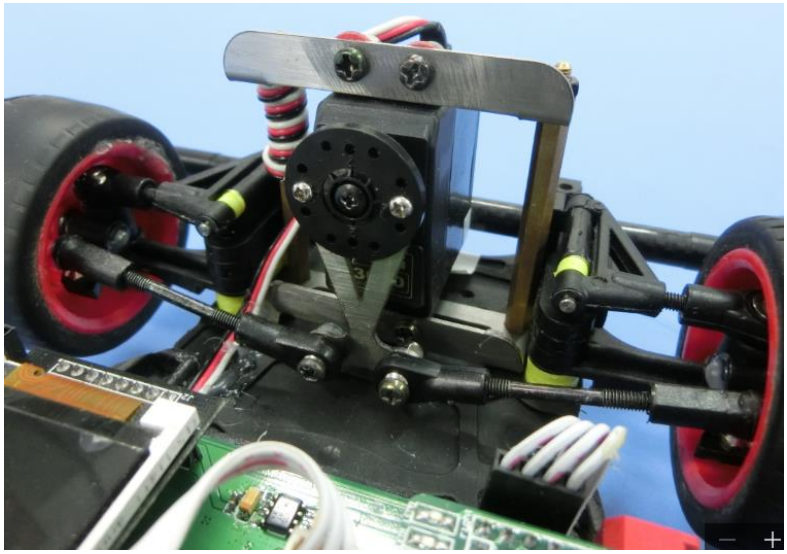


Figure 1.2 Servo

1.5 Camera

Using aluminium alloy to fix the camera on the bar made of carbon fibre(figure 1.3), which is easy to adjust and supply an relative stable position.

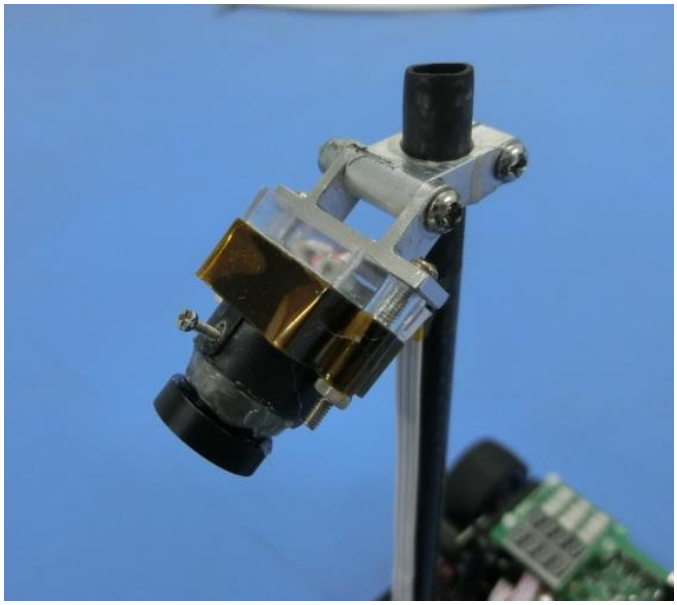


Figure 1.3 Cameral

2. Hardware

2.1 Introduction of Circuit Design

Considering the stability, reliability, efficiency, practicality, simplicity, we have designed our whole hardware.

1. There are generally three way of the acquisition of the analog camera signal, analog to digital conversion in MCU, analog to digital outside the MCU, hardware binarization. The efficiency of the first two plan is lower than the hardware binarization, so we designed the hardware binarization circuit to collect the analog camera signal.
2. We chose the MK60N512VL MCU, K60 series. It is Kinetis series, and it uses the Cortex-M4 kernel.
3. Our Motor Driver board is made by MC33883, which is a high performance H-bridge driver IC. The IC is used to drive the H-bridge circuit. We chose the MOSFET IR7843 to make our driver board. This MOSFET has low turn-on resistance, and it can provide high current. Also, its breakdown voltage is two times higher than the support voltage, it highly increase the driving ability.
4. The power-supply module is made by TPS7333 and TPS7350, which are Texas Instrument's power management IC. The power-supply module support 3.3V and 5.0V power for the hardware system. And the two IC are switching power IC, high efficacy and low ripple voltage.
5. For the purpose of close-cycle control, we use the rotary incremental encoder to measure the distance of the car. Comparing with the other sensor, the signal of encoder is more accurate, and more stable. The encoder has low power consumption, light weight, anti-shock, and anti-vibration. There is no pull-up resistor in an encoder, so the interface of the

encoder on the motherboard should be designed with pull-up resistor. Meanwhile, to make sure the waveform is stable, we use invertor to isolate with the mother board. Moreover, the K60 MCU has the function of Quadrature decoder, so there is no need of any other external auxiliary counter device, just need to be connected with the corresponding interface in MCU.

6. For the convenience of debugging, we have designed the Nixie tube keyboard with the ZLG7290. This chip uses IIC interface, supporting 8*8 keys and 8 Nixie tube, which is easy to use and saving the I/O resources of the MCU. In practice, we have designed the keyboard with 3*4 keys and 8 Nixie tube.

2.2 Function of the boards

1. Mother board

Power manager Hardware image processing Gyroscope

2. MCU core board

Basic function of the MCU including reset, download interface, USART interface, SPI interface.

3. Motor driver board

Drive two motors

4. Nixie tube Keyboard

Input and display parameter

2.3 Bill of materials（Not including resistor and capacitor, etc.）

1. Mother board

Name	Quantity	Manufacturer	Function
TPS7333	2	Texas Instruments	3.3V power supply
TPS7350	2	Texas Instruments	5.0V power supply
LM1881	1	Texas Instruments	Video Sync Separator
ADR441	1	Analog Devices	2.5V reference source
AD8032	2	Analog Devices	Operational amplifier
74HC14	1	NXP	6 input NAND gate
MPU9250	1	InvenSense	Gyroscope

2. MCU core board

Name	Quantity	Manufacture	Function
MK60DN512VL	1	Freescale	MCU

3. Motor driver board

Name	Quantity	Manufacturer	Function
MC33883	2	Freescale	H-bridge gate driver

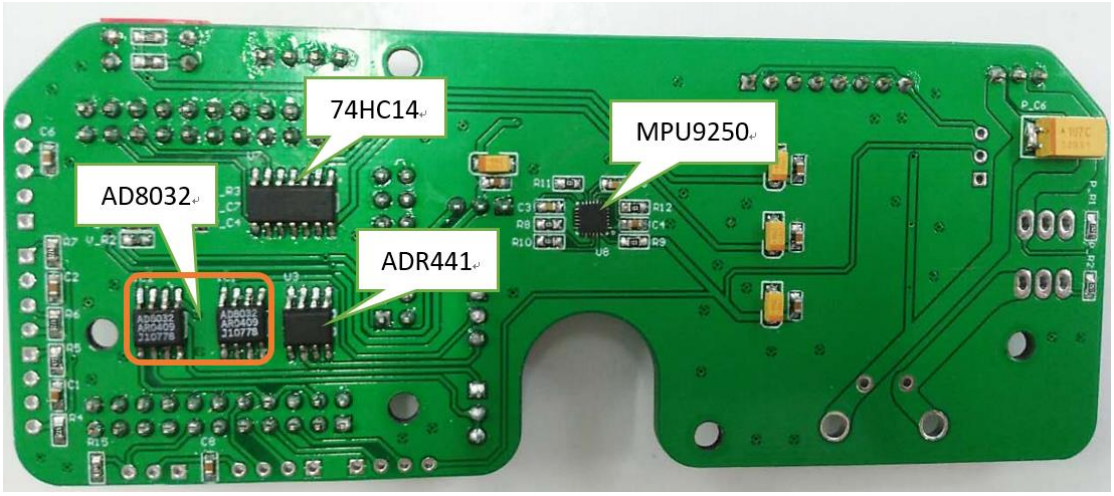
TPS7350	1	Texas Instruments	5.0V power supply
74HC14	1	NXP	6 input NAND gate
74HC00	1	NXP	Quad 2-input NAND gate
LR7843	8	International Rectifier	MOSFET

4. Nixie tube Keyboard

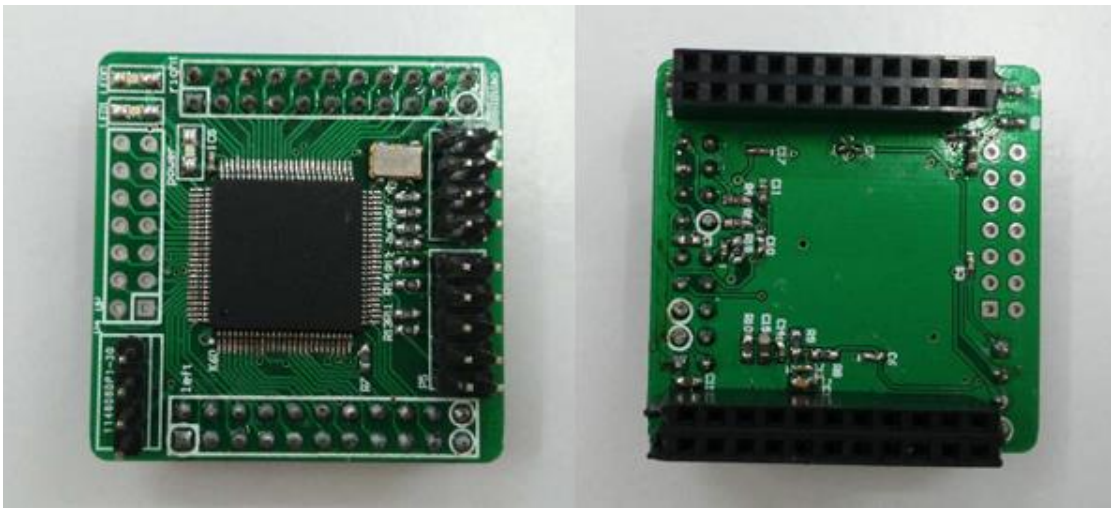
Name	Quantity	Manufacture	Function
ZLG7290	1	周立功单片机（ZLGMCU）	Drive the keyboard and Nixie tube

2.4 The Circuit Boards

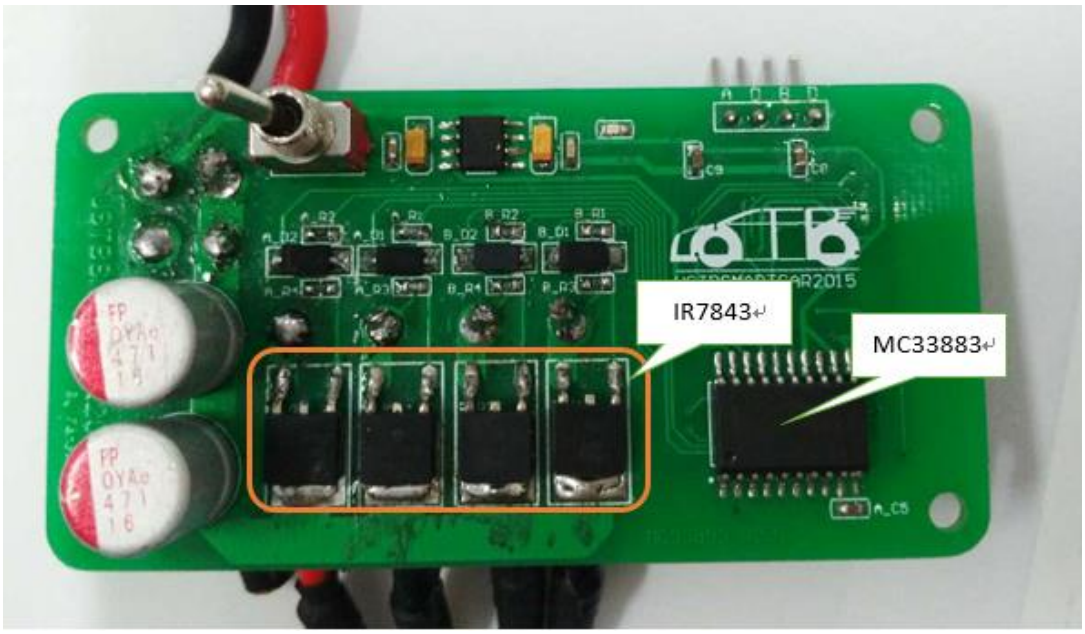
The Mother Board

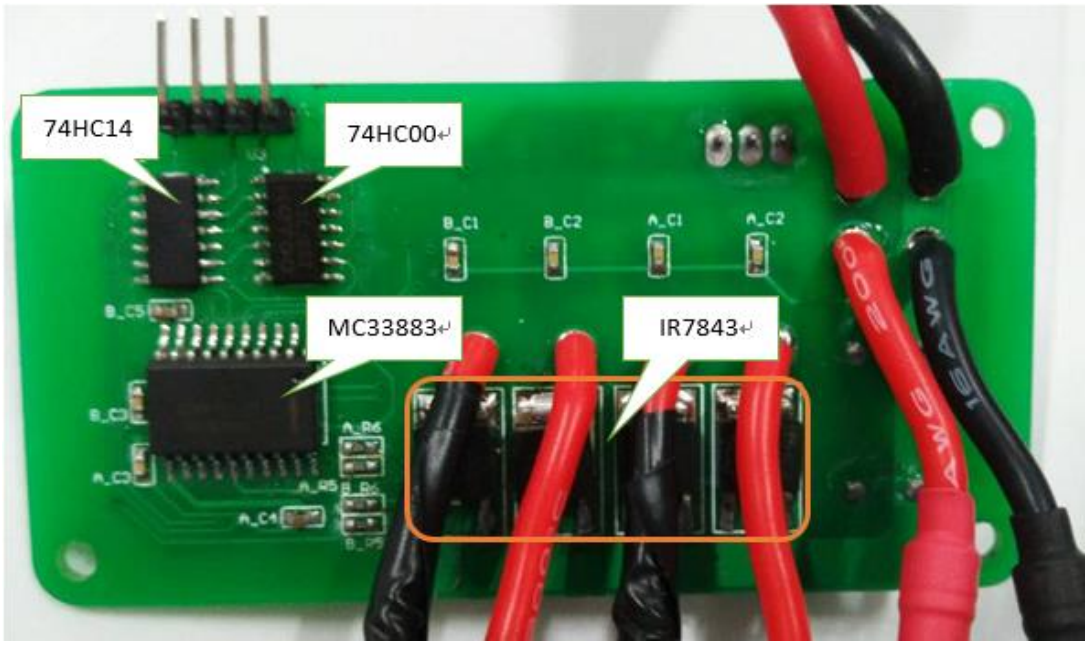


The MCU Core Board

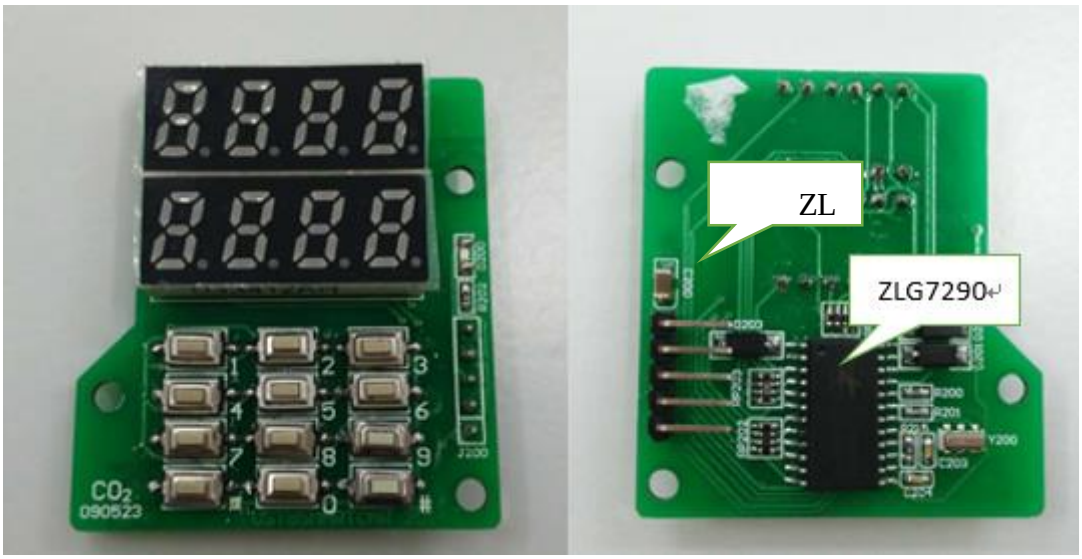


The Motor Driver Board





The Nixie tube keyboard



3. Software

High efficiency program is the basic of high speed. We use the CMOS camera to collect the image. The core content is image correction and track recognition. In the aspect of speed and turning control, we have used the classic PID algorithm. And with theoretical calculation and actual parameter compensation, the car can run fast and steadily.

3.1 The extraction and optimization of the track center line

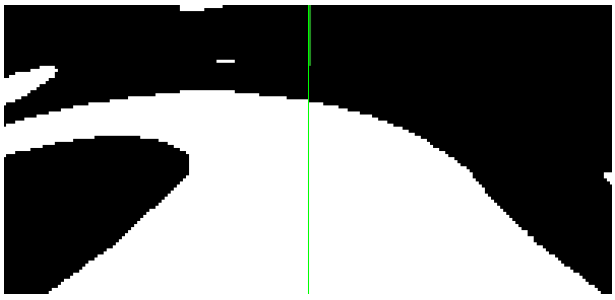
3.1.1 The Characteristics of Original Image

The information of track we extract in the image signal includes points position of both side of the track, the track center position after correction calculation, area planning of the center points, the variation range of the width of the track, type of the track element.

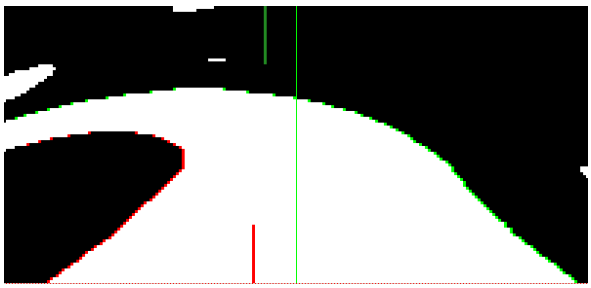
Because of self-designed feature, the image is distorted, so that the information the camera collected is not true. So we designed a function to recover the real track information. The origin information is a two dimensional matrix convert from the analog image. Every element of the matrix corresponds a pixel. The first row corresponds the furthest field of vision, about 220 cm. The bottom of the image corresponds the nearest field of vison, about 5 cm. The further, the smaller. The closer, the bigger. The black line is trapezoid.

MCU records all the jump point between black and white using the comparator (in right to left order). And the rising edge points and falling edge points are record in two arrays. Traversing the two array is the way to extract the track edge.

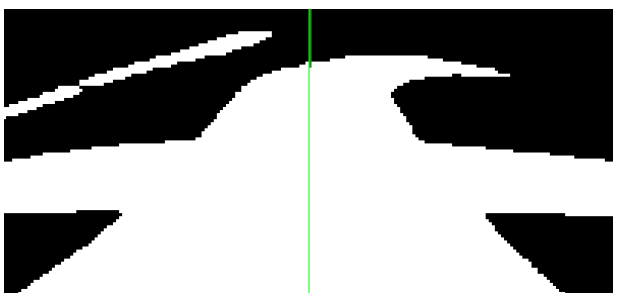
Several typical original and processed track images are show as follows.



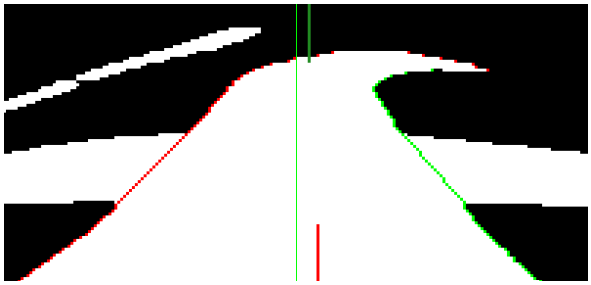
The original image of curve



Processed curve image



The original cross road image



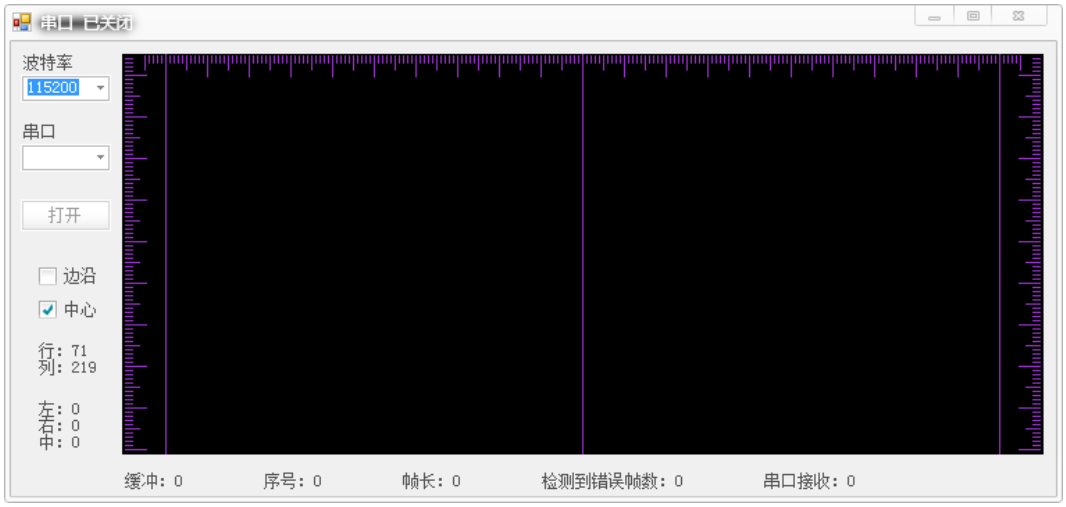
Processed cross road image

3.2 Introduction of Development and Debugging Tools

In order to better develop and debug, we have made two upper computer program.

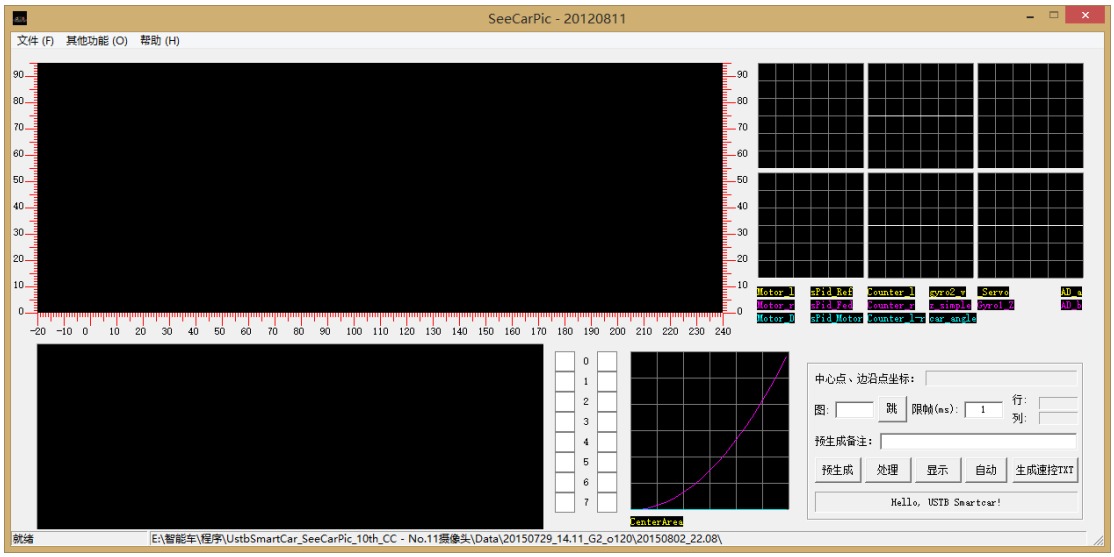
3.2.1 The C# static serial port upper computer program

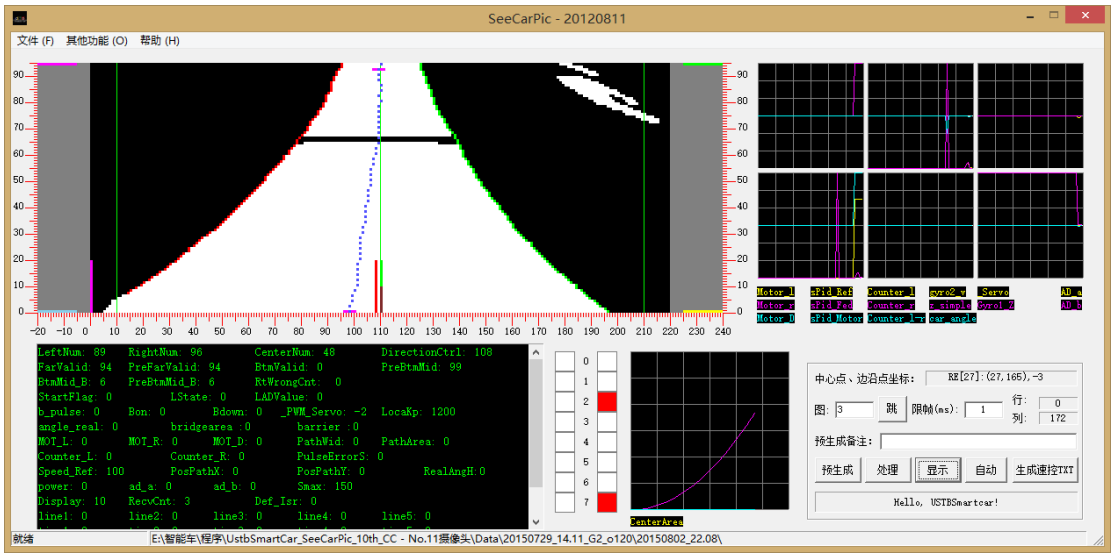
In order to observe the visual effect of the image acquisition, we also use the C# VS2008 as a secondary development and debugging tool.



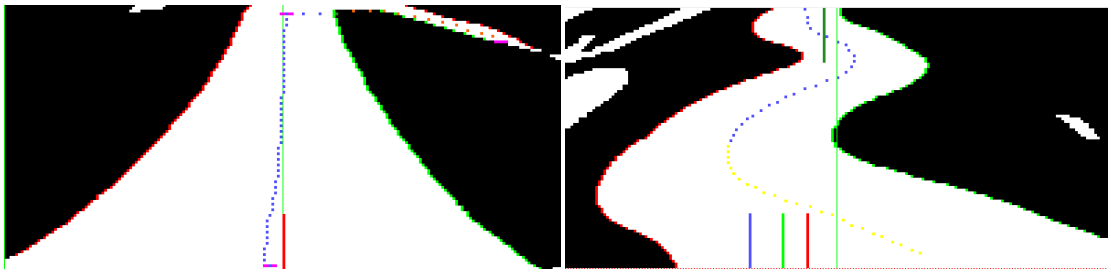
3.2.2 The MFC SD card upper computer program

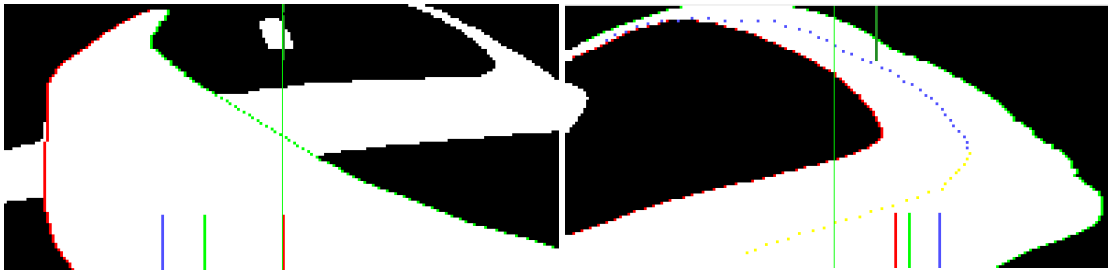
We use MFC to write the SD card host computer in C++ VS2008 environment. After the whole process of the model car, the upper computer program can get each image and related data and curve.

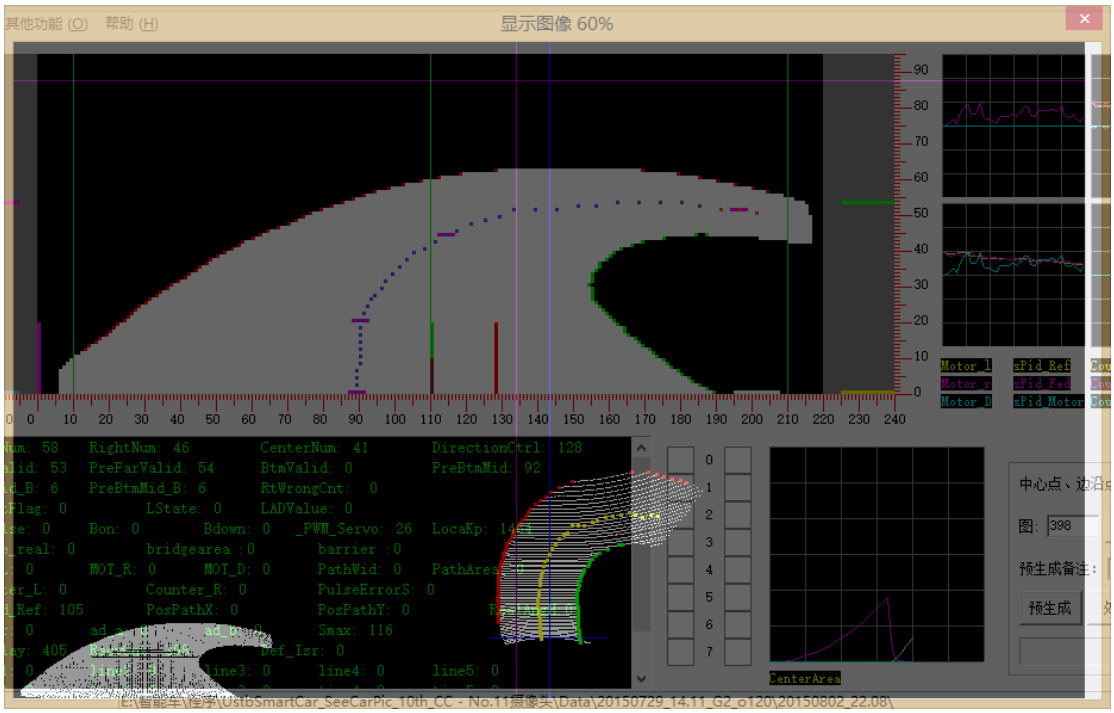




Model car in the course of the movement, the typical track record of the image, as shown in bellow.







The Corrected image

Appendix – The Hardware Circuit diagram