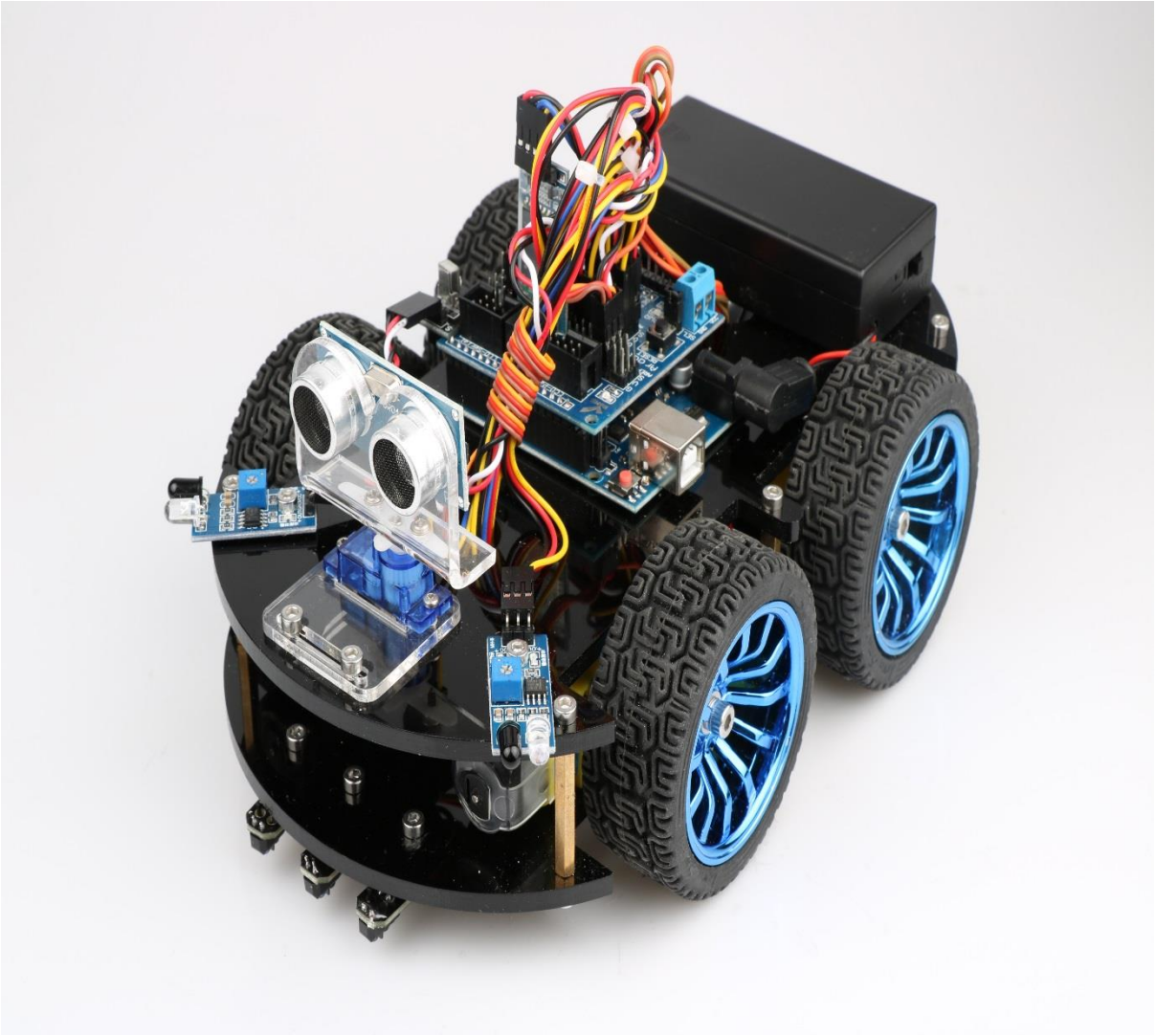
Hummer-Bot

Instruction Manual



Github https://github.com/keywish/keywish-hummer-bot

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Chapter1 Introduction

"Hummer-Bot" is a multi-function car based on Arduino UNO R3, which is composed of embedded micro-controller, sensor, mechanical movement, wireless communication module and other parts. Although it cannot sing and dance like the traditional robot, it is also very intelligent and a member of the family of intelligent robot. By virtue of the inherent talent, Hummer-Bot can run on every corner, automatically avoid obstacles and walk along the black and white lines freely, of course, people can also play it via such as Bluetooth, infrared ray, PS2 remote sensing control, with passion and all kinds of attitude.

In the robot-prevalent era, sensor, wireless and power technologies are indispensable parts of people's lives, such as infrared is widely used in industrial robot, ultrasonic wave is widely applied in the medical industry, as to the wireless technology, it is beyond count. WIFI, Bluetooth, infrared, and ZigBee are becoming irreplaceable parts in smart Home Furnishing. "Hummer-Bot" is a very product of the development of the robot by combing these technologies perfectly, it can be used conveniently, developed easily. In addition, "Hummer-Bot" has a variety of modes, can be switched freely and completed a variety of development on one platform, which is the best choice for every electronic enthusiasts.

"Hummer-Bot" is a car which combines machine and electric, people can feel like in a competition through wireless control, this is not only a test of endurance and confidence for enthusiasts, but also a training to their response. The core of the car’ walking is motor control, a good motor and drive are the necessary conditions for the car’ journey to success, "Hummer-Bot" contains 4 DC motors and a high power drive chip, which enable the driving force of the car to a higher level.

The key to judgment depends on the sensor, just like the five senses of human beings, which is always aware of everything around it, and avoids unnecessary mistakes, such as collision, migration and so on. The combination of power and sensor makes the car more flexible and data acquisition more accurate.

1.1 Writing Purpose

The purpose of this manual is to create a fast, practical and convenient development learning platform for the vast number of electronic enthusiasts and let them grasp the Arduino and its extended system design methods and design principles, as well as the corresponding hardware debugging methods.

This manual will lead you to learn every function of "Hummer-Bot" step by step and open a new "Hummer-Bot" journey for you. It is divided into two parts: 1, Preparation chapter, which mainly introduces the use of common Arduino development software and some downloading and debugging skills. 2, Experiment chapter, which contains hardware and software, the former mainly introduces the function and principle of each module; the latter mainly introduces each part of the program and leads you to understand and grasp the principle of Arduino and the car development through written examples step by step.

This manual is a specifications for "Hummer-Bot" , the file whose format is PDF which is in the CD along with our product requires the corresponding software to open. It contains detailed schematic diagrams and complete source codes for all instances, the codes won't have any mistake under our strict test. In addition, the library files used in the source codes are put into the corresponding path, you only need to see corresponding phenomenon of the car and personally experience the process of experiment by downloading the source codes to Arduino via the serial port emulator.

This manual is not only very suitable for students and electronic enthusiasts, but also a good reference for companies to develop products.

1.2 Product Introduction

"Hummer-Bot" is a multifunctional car based on the Arduino UNO and L298N motor. Compared with the traditional car, "Hummer-Bot" is also equipped with wireless control (Bluetooth, infrared, WIFI and so on); ultrasonic; infrared. It can trace and avoid obstacles automatically, of course, makers can also automatically control the car with wireless and make full use of each module, as well as integrate all kinds of related sensors to make the car more intelligent, which is more challenging. "Hummer-Bot" has various types of information, technical manuals, routines, etc.,

which can teach you step by step. Each electronic fan can use it easily to achieve their desired function.

Product Features

- Three groups of black line infrared tracing module
- Two group of infrared obstacle avoidance module
- Ultrasonic obstacle avoidance
- Four DC motor drive
- Two 3000mZh, 3.7V rechargeable lithium battery with longer endurance
- Remaining capacity of battery real-time detection
- Infrared remote control
- Bluetooth app control
- PS2 handle control (optional)

Product component inventory

Chapter2 Preparations

2.1 About Arduino

At the beginning of the study, let us read this little story: In the north of Italy, there is a picturesque town which across the blue green Dora Baltea River whose name is Ivrea, it is a place full of colorful history for it is where the king was born. In AD 1002, King Arduino became the ruler of the state, unfortunately two years later he was deposed by the German King Henry II and became an oppressed king. Today, in a street called cobblestone, there is a bar named di Re Arduino to commemorates the king appears in people's lives. The bar owner Massimo Banzi (there is a saying: Massimo Banzi often comes to this bar) is an electronics engineer in Italy, and later he named the electronic product Arduino in memory of this place. Arduino is a convenient, flexible, open source electronic prototype platform, including hardware (various types of Arduino board) and software (Arduino IDE). It is suitable for artists, designers, electronic lovers.

Arduino can perceive the environment through a variety of sensors, feedback, and influence the environment by controlling lights, motors, and other devices. The microcontroller on the board can write programs through Arduino programming language, compiled into binary files, burned into microcontroller. The programming of Arduino is realized by Arduino programming language (based on Wiring) and Arduino development environment (Based on Processing). Projects based on Arduino can either only contain Arduino or contain Arduino and some other software on the PC, they can communicate via such as Flash, Processing, MaxMSP.

You can do it yourself, or you can buy a finished kit, the software that Arduino uses can be downloaded for free. The hardware reference design (CAD file) also follows the available open-source protocol, and you can be very free to modify them according to your own requirements.

Arduino can not only use electronic components such as Switch or sensors or other controllers, LED, stepping motors or other output devices that are developed, but also operate independently as an interface that communicates with software, such as flash, processing, Max/MSP, VVVV, or other interactive software.

In addition, Arduino is based on the AVR platform and does second compilation and packaging for AVR library, the port is packaged, so you basically do not need to manage the register, address pointer and so on, the difficulty of software development

is greatly reduced, it is suitable for non professional enthusiasts. Advantages and disadvantages coexist due to the second compilation and packaging, the code is not conciser than original AVR code, and code execution efficiency and code volume is weaker than AVR direct compilation.

2.2 Why Choosing Arduino

There are many SCM and SCM platform suitable for interactive system design. For example: Parallax Basic Stamp, Netmedia 's BX-24, Phidgets, MIT' s Handyboard, and so on. All of these tools, you do not need to care about the cumbersome details of SCM programming, they provide you with a set of easy-to-use kit. Arduino also simplifies the working process of the microcontroller, but compared with other systems, Arduino is more advantageous in many places, especially for teachers, students and some amateurs:

1, Cheap - compared with other platforms, the Arduino board is pretty cheap. The cheapest version of Arduino can be made by hand, even if it's finished, the price will not exceed 200 yuan.

2, Cross platform - Arduino IDE can run in Windows, Macintosh, OSX, and Linux operating system. Most other SCM software can only run on Windows.

3, Simple programming environment - beginners can easily learn to use the Arduino programming environment, but it can also provide enough advanced applications for advanced users. As for the teachers, the Processing programming environment can be used easily, so if students have learned how to use Processing programming environment, then they will feel familiar when using the Arduino development environment.

4, Open source software and extensible - Arduino software is open source, experienced programmers can extend it. Arduino programming language can be extended through the C++ library, if someone wants to understand the technical details, you can skip the Arduino language and use AVR C programming language (because Arduino language is actually based on AVR C). Similarly, you can add AVR C code directly to your Arduino program if necessary.

5, Open source hardware can be extended - Arduino is based on the ATMEGA8 and ATMEGA168/328 MCU of Atmel, it is also based on the Creative Commons license agreement, so experienced circuit designers can design their own modules by extension or improvement according to their own requirements. Even for some

relatively less experienced users, they can also make a test board to understand how Arduino works, which is money-saving and time-saving .

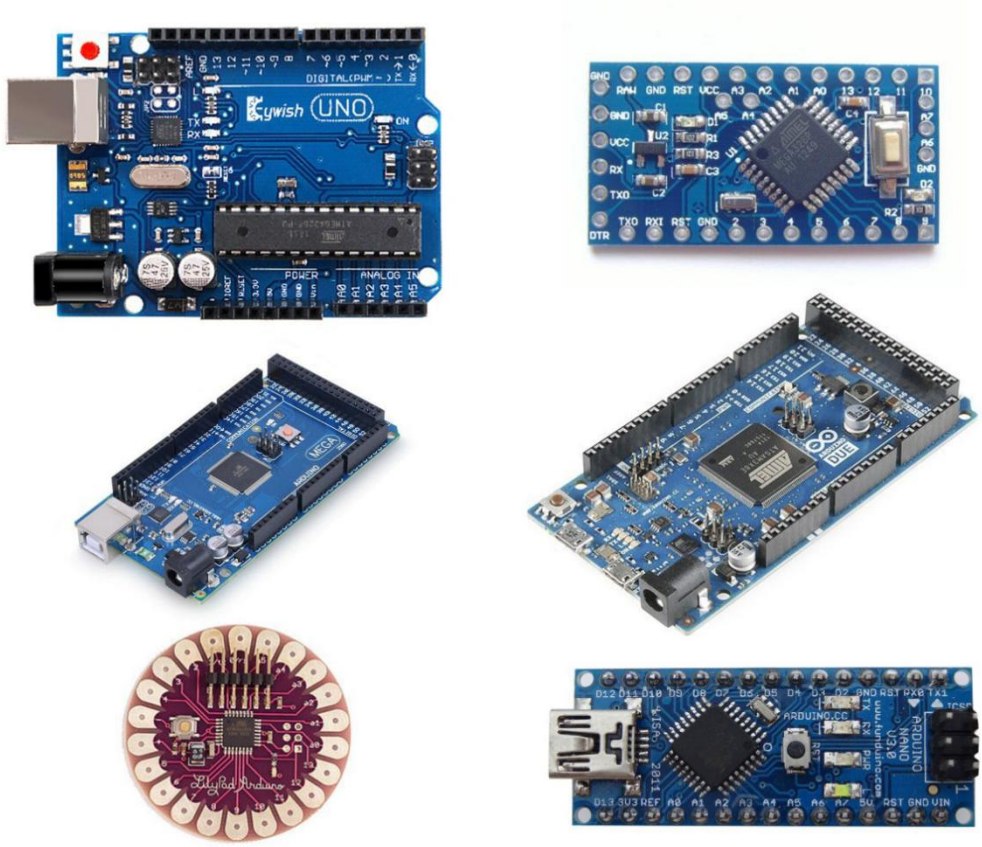

Fig 2.2 Several commonly usedArduino

3.1 Assembly of the Car

3.1.1 Bottom Mounting of the Car

First we open the box, take out the car body (two black acrylic), screwdriver, M4x12 screws, six angle coupling and matching set screws, four black&red welding wires and four motor and wheels.

The first step is to weld the black&red welding wires to the two copper plates of the motor. As shown in Fig.3.1.1

Fig.3.1.1 Diagram of Motor Welding Line

The second step is to fix the wire on the motor with tie tape.

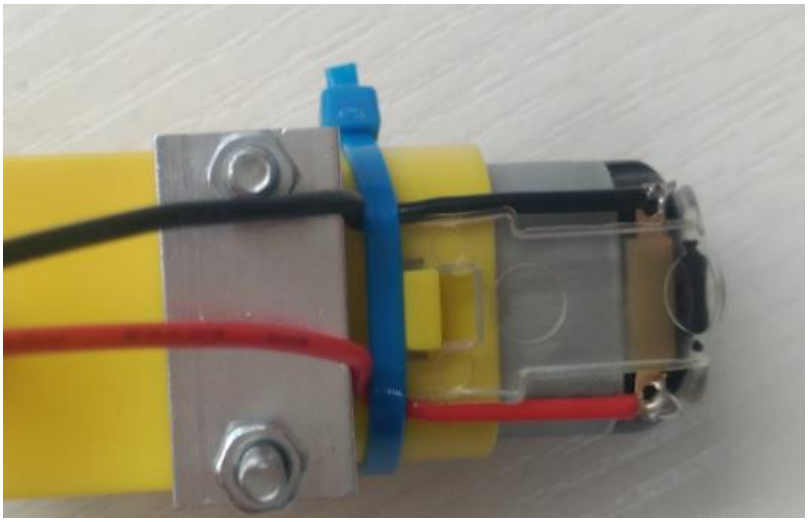

Fig.3.1.2 Diagram of Wire Fixing

The third step is to install aluminum alloy bracket for the motor. Note: the installation must ensure that the screw hole on the bracket aligns with the screw hole on the acrylic plate, aluminum alloy stent installation diagram is shown in Fig.3.1.3.

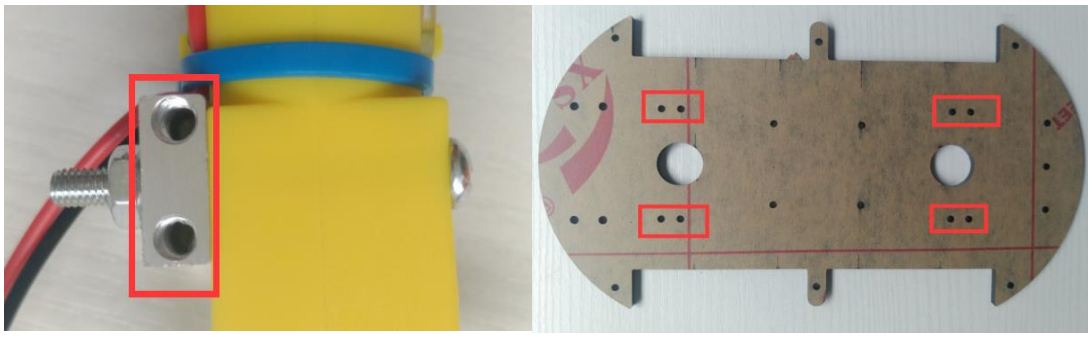

Fig.3.1.3 Diagram of Aluminum Alloy Bracket Installation

The fourth step is to fix the motor on the acrylic board, first removing the protective film on the acrylic, and then fixing it according to the corresponding space. After the installation, the front face is shown in Fig.3.1.4, and the back is shown in Fig.3.1.5.

Note: the screws in Fig.3.1.5 should not be screwed too tight, otherwise the wheels adjustment will be affected.

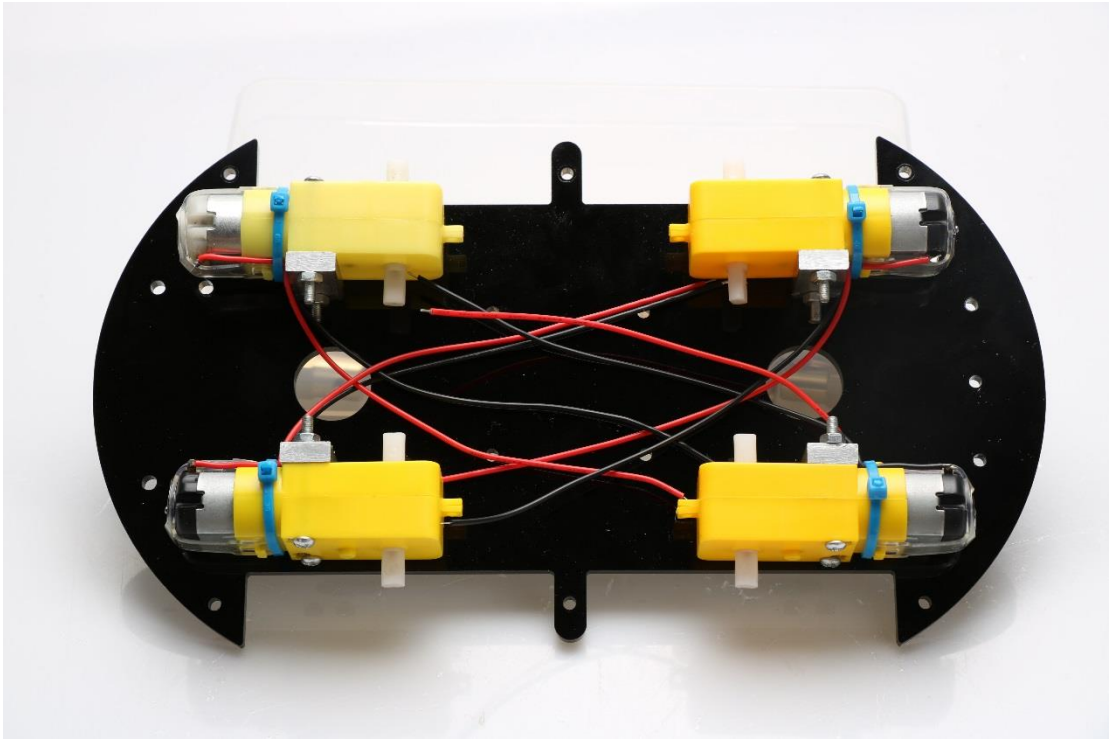

Fig.3.1.4 Diagram of Motor Installation

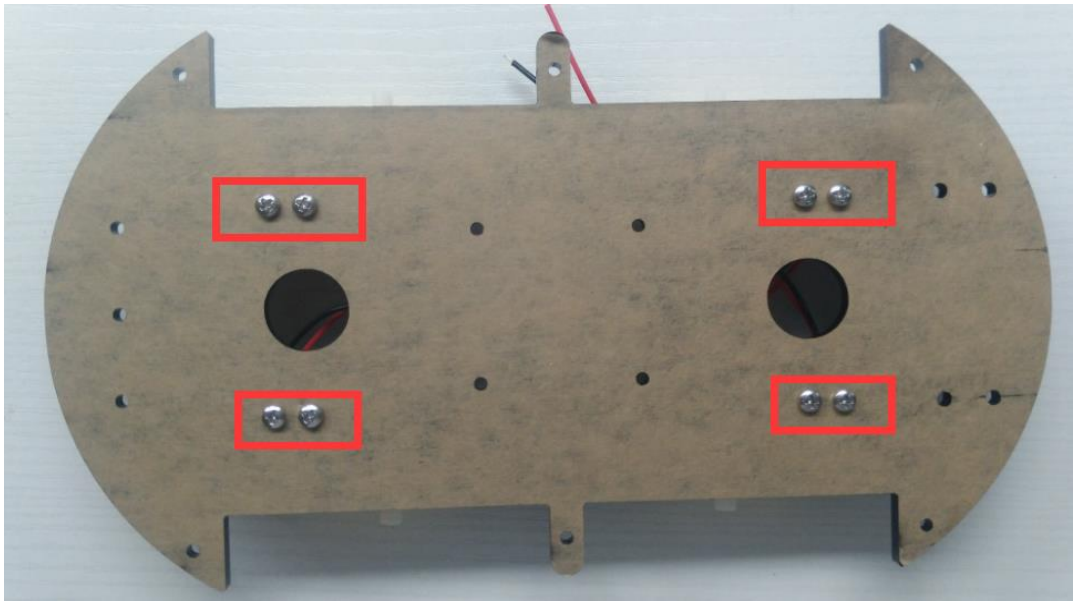

Fig.3.1.5 Fixing Screw for Motor

The fifth step is to install the connecting shaft for the purpose of fastening the connecting motor and the wheel, and use the connecting shaft as the power transmission link. Fig.3.1.6 shows the connecting shaft and the set screws, first screwing the screws into the connecting shaft (not too tight, otherwise the motor transmission shaft cannot be inserted into the connecting shaft), and then insert the smooth side of the motor transmission shaft into the set screws, as shown in Fig.3.1.7, rotating set screws to fasten a motor transmission shaft(not too tight)

Fig.3.1.6 Connecting Shaft Kit

Fig.3.1.7 Diagram of Connecting Shaft Installation

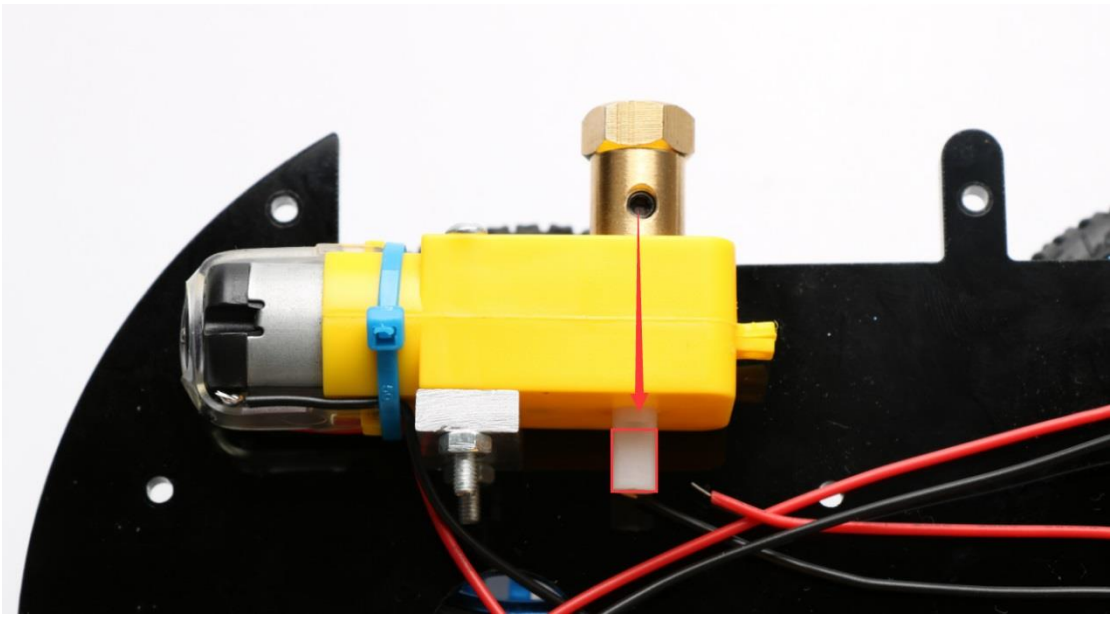

Fig.3.1.8 After Installation (set screws must be stuck in the smooth side)

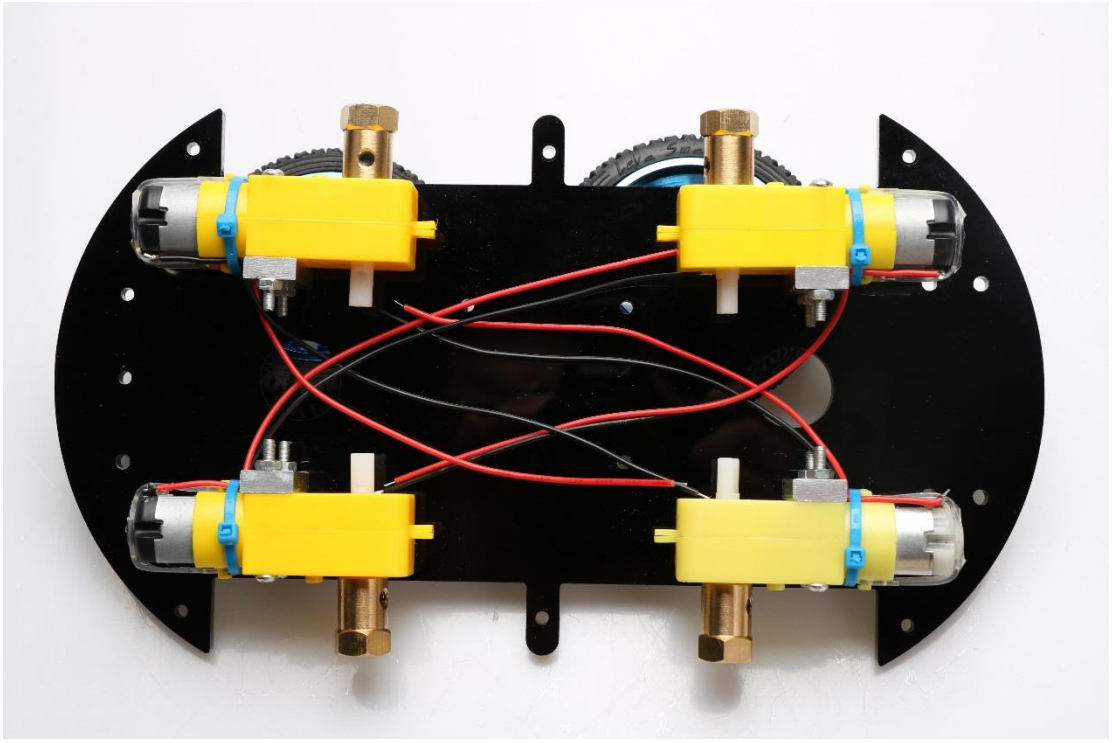

Fig.3.1.9 Diagram after Complete Installation

The sixth step is to install wheels, "Hummer-Bot" uses racing wheels which grip stronger, less friction, more stable than the traditional wheels. The wheel mounting method is relatively simple. Then inserting the connecting shafts into the wheels as shown in Fig.3.1.10 and screwing tightly as shown in Fig.3.1.11.

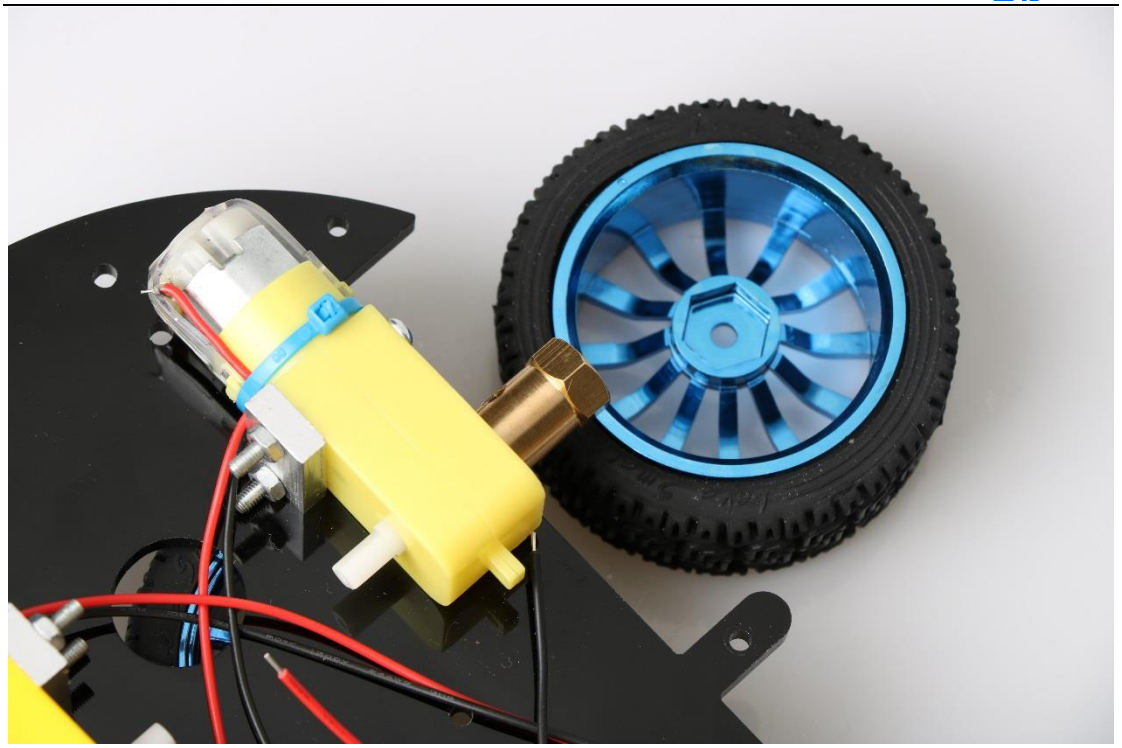

Fig.3.1.10 Diagram of Wheel Installation

Fig.3.1.10 Diagram of Wheel Screw Fixation

In the fourth step we said that don't screw too tight, because it is not convenient to adjust the wheels later. As shown in Fig.3.1.11,the installed wheels would have some tilt, then we need to adjust the motor by hand gently until the wheels and the acrylic become parallel, then tighten the screws.

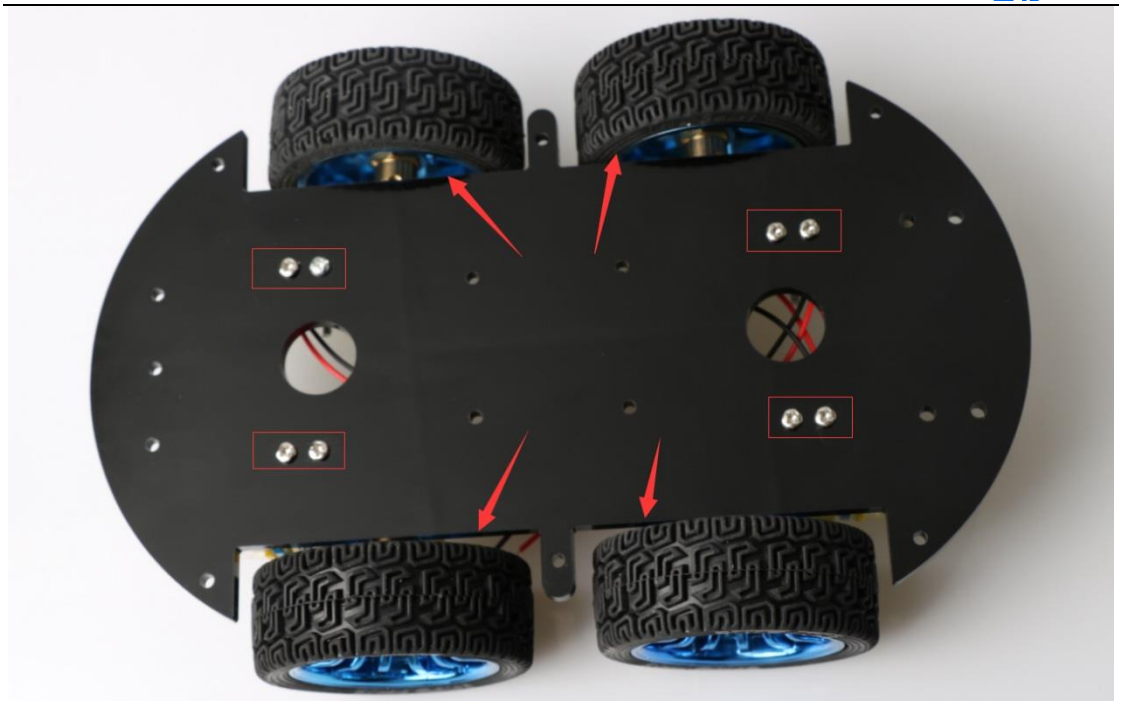

Fig.3.1.11 Adjusting Wheels and Tightening Screws

The seventh step is to install the motor drive. As shown in Fig.3.1.12, fixing the motor on the acrylic.

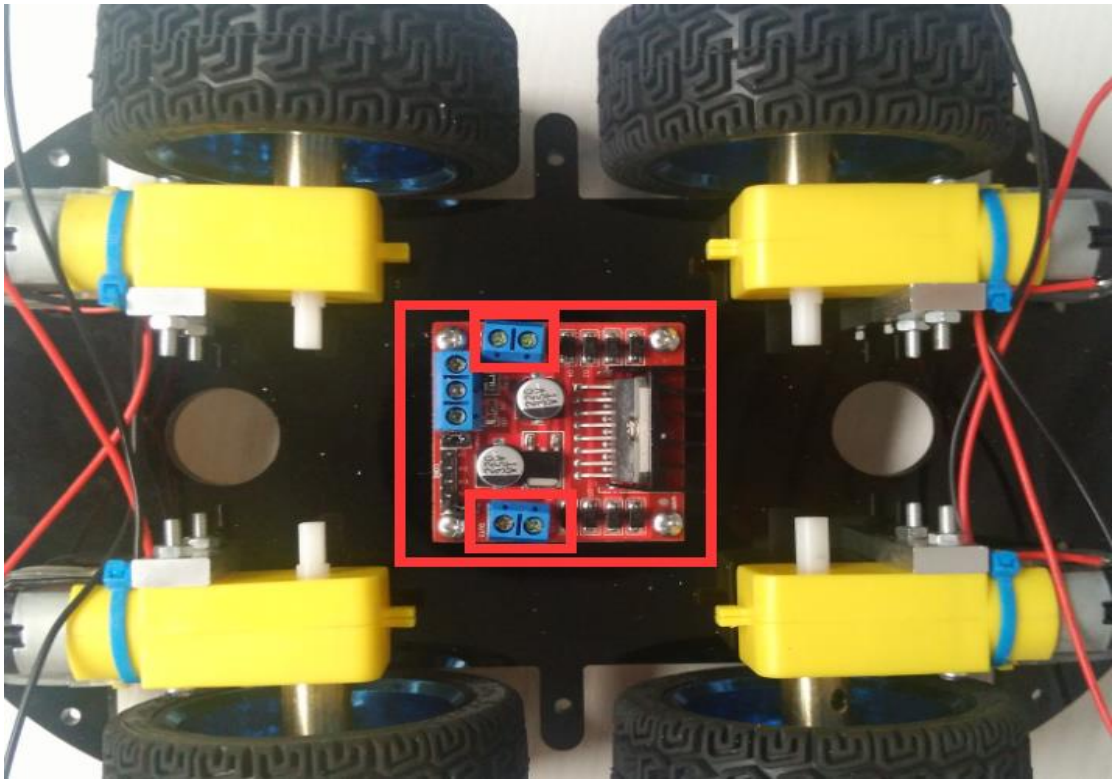

Fig.3.1.12 Diagram of Motor Drive Installation

The eighth step is to connect the motor wires to the drive, note that the rotation direction of the two motors require to be identical, so we should modify and debug the

program first when wiring. Connecting the motor to any motor driver board, as shown in Fig.3.1.13, then connecting the two wires on battery box to the motor drive +12v (red) and GND (black), and leading a wire from +5V to "3" or "4" in the figure(IN1&IN2 is a motor set, IN3&IN4 is another set). Observing rotation directions of the motors, if the rotation directions are not the same, you only need to change "1" and "2" in the figure. The physical map is shown in Fig.3.1.14.

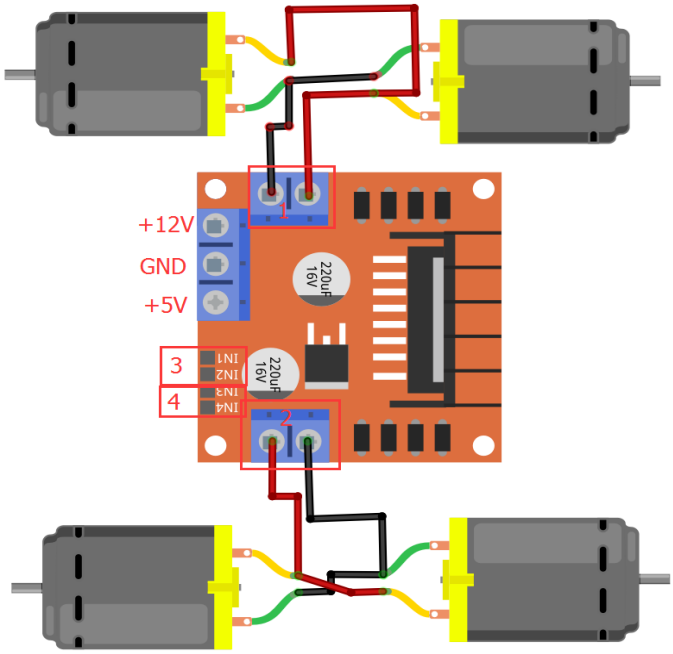

Fig.3.1.13 Diagram of Connection Between Motors and Drive Board

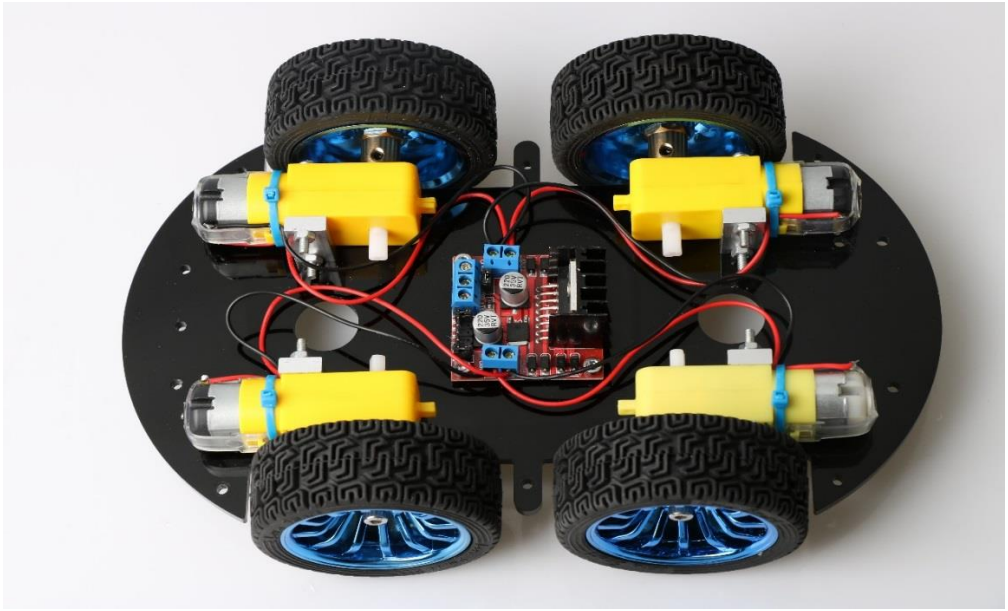

Fig.3.1.14 Diagram of Connection Between Motors and Drive Board

The ninth step is to install the tracing module and fix the module to the acrylic board according to the Fig.3.1.15. First, screwing the screws to the tracing module, as shown in Fig.3.1.16, and then connecting the 3Pin wire to the "1" in Fig.3.1.16. After the installation is completed, the back is shown in Fig 3.1.17 .

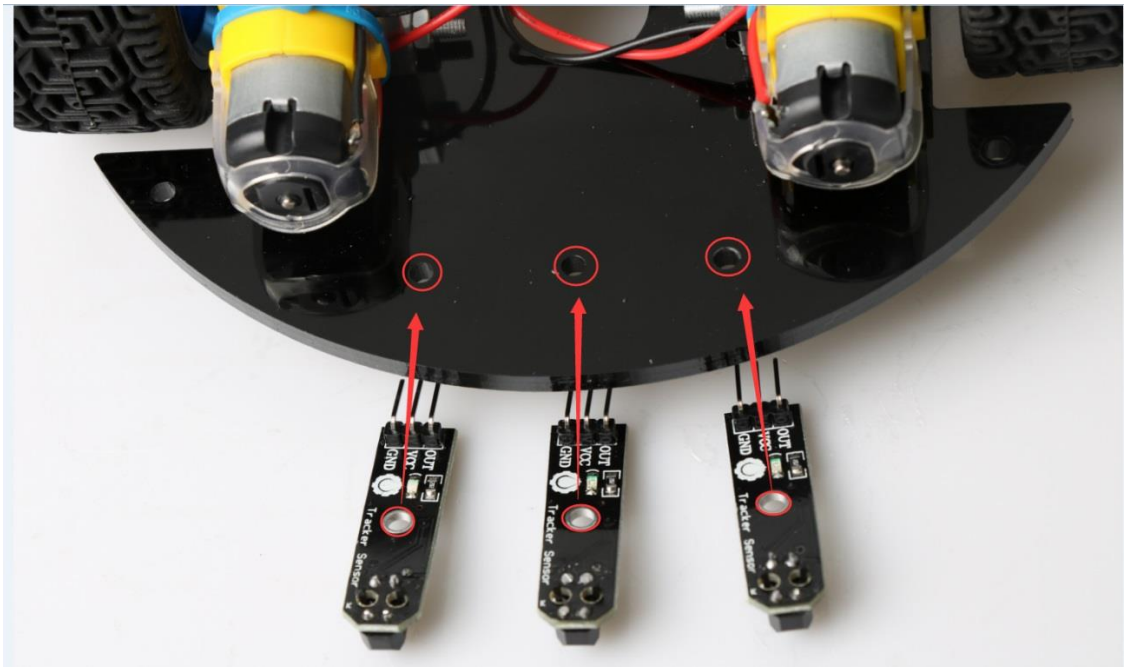

Fig.3.1.15 Diagram of Tracing Module Installation

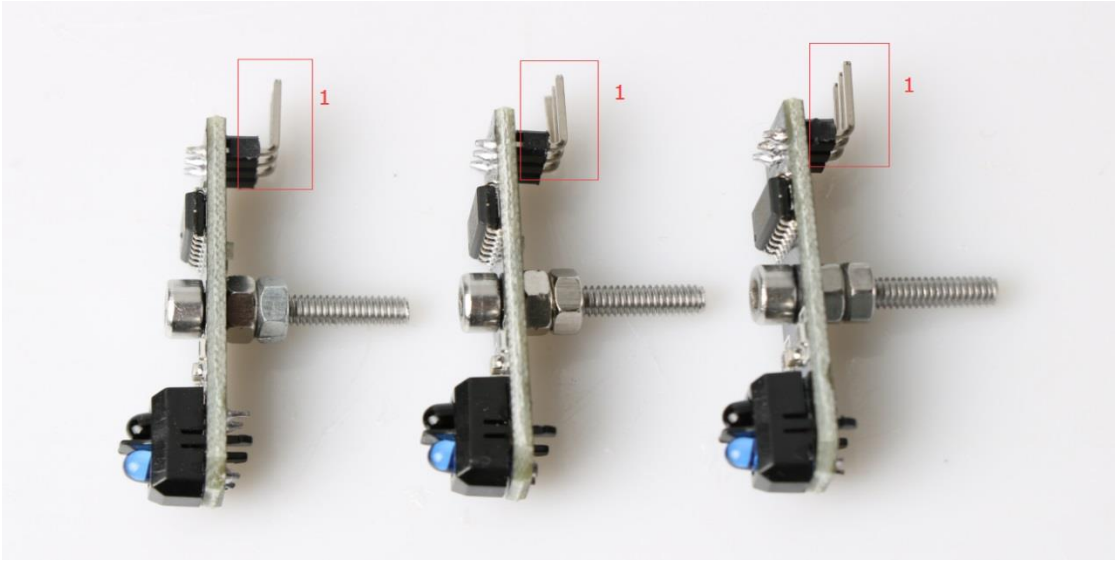

Fig.3.1.16 Diagram of Screw Brackets

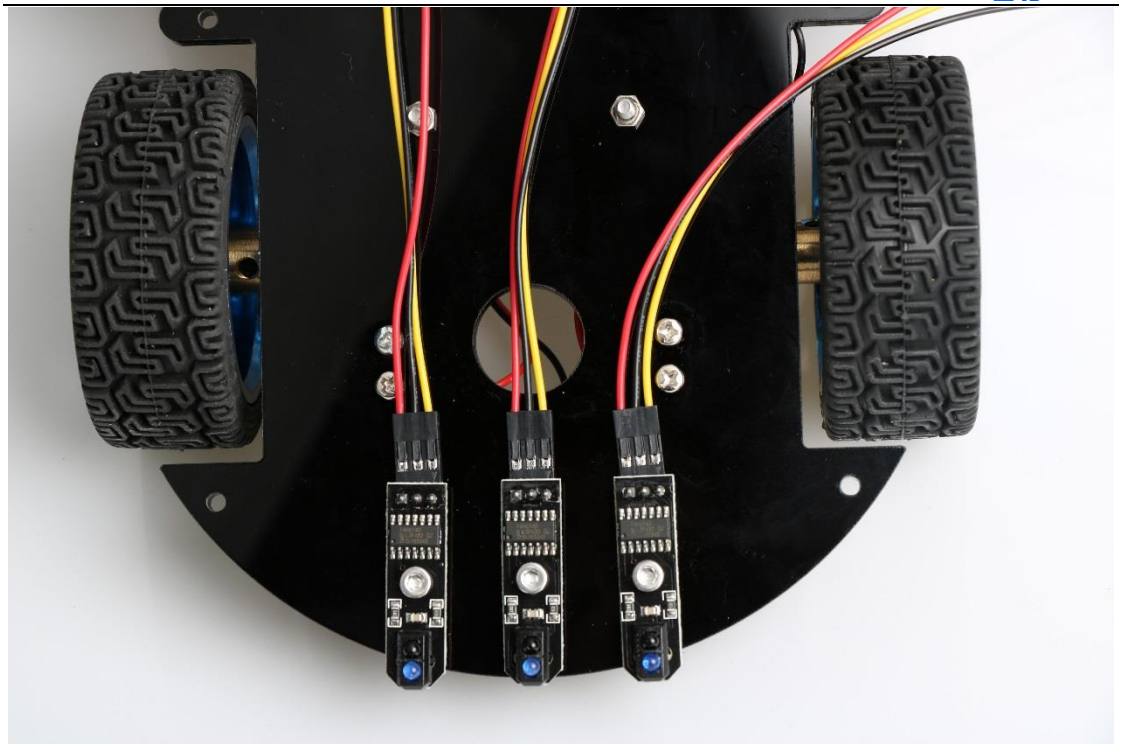

Fig.3.1.17 The Back of Complete Installation

3.1.2 Surface Mounting of the Car

The first step is to install the battery box and the Arduino mainboard, this step is quite simple, install the corresponding package to "3"and "2" in Fig.3.1.19, the complete installation is shown in Fig.3.1.20.

Fig.3.1.19 Diagram of Top Surface Device Installation

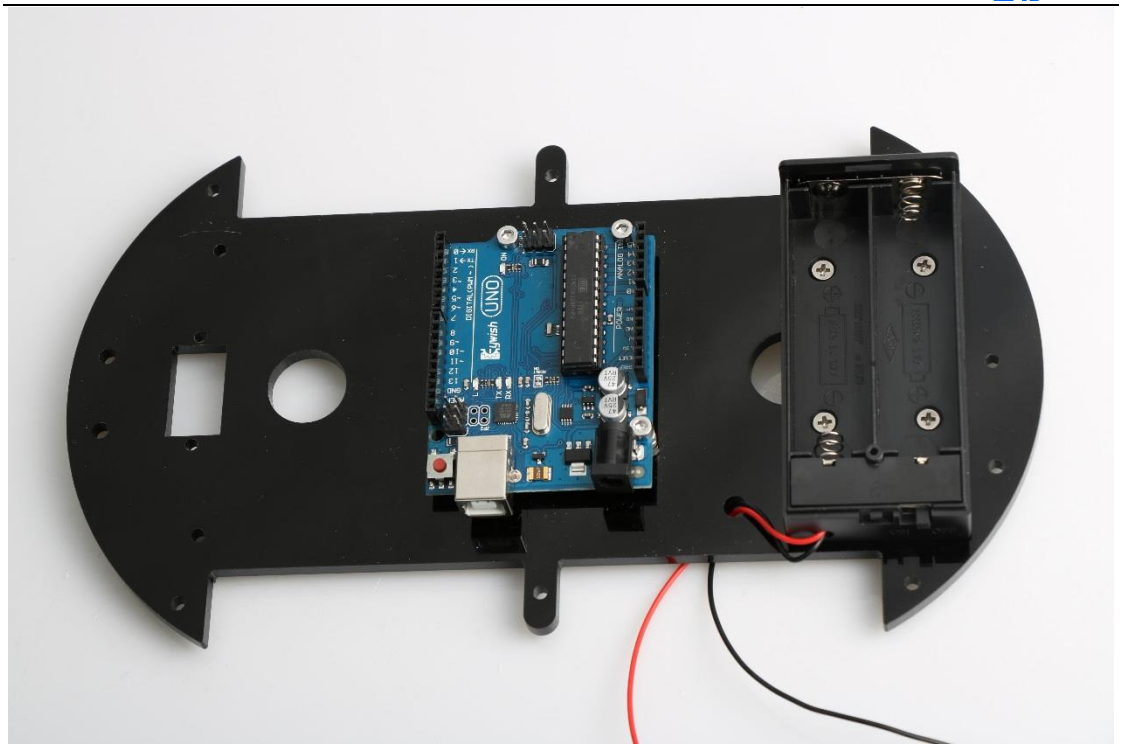

Fig.3.1.20 Diagram of Arduino Mainboard and Battery Box Installation

The second step is to install the total of 6 support screws which are mainly used to connect two piece acrylic board. In Fig.3.1.19, we can see the "1" logo where there are 6 holes, these are the screw fixing holes, The installation is shown in Fig.3.1.21and the complete installation is shown in Fig.3.1.22.

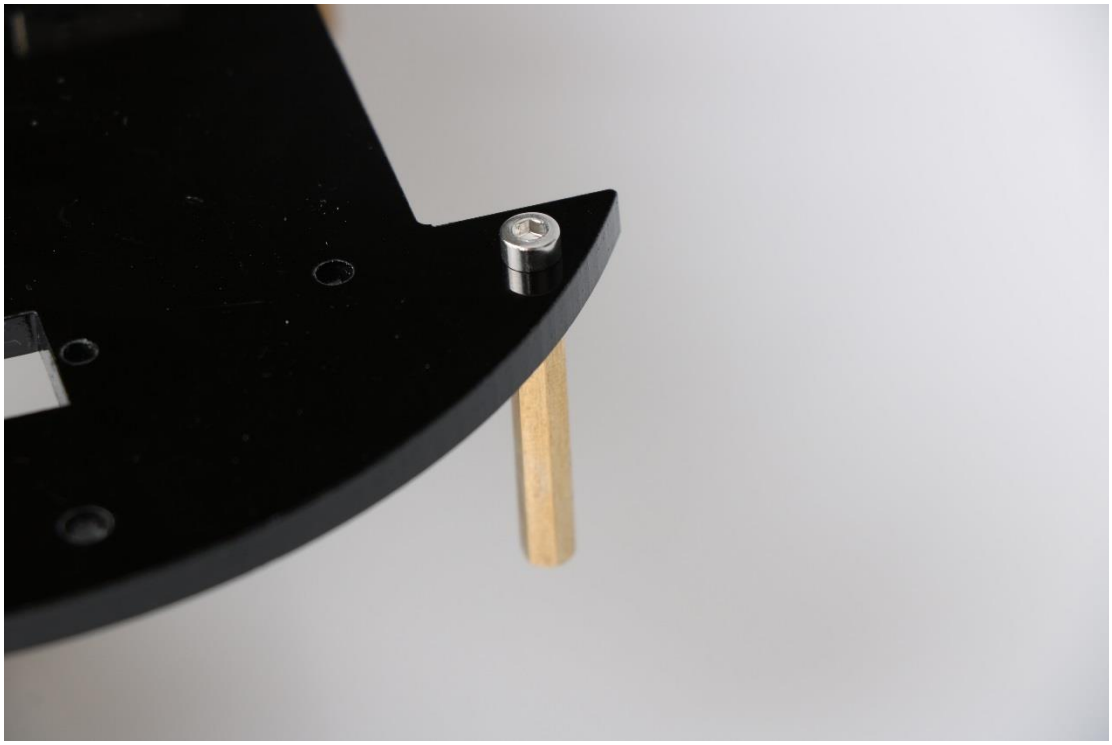

Fig.3.1.21 Installation diagram

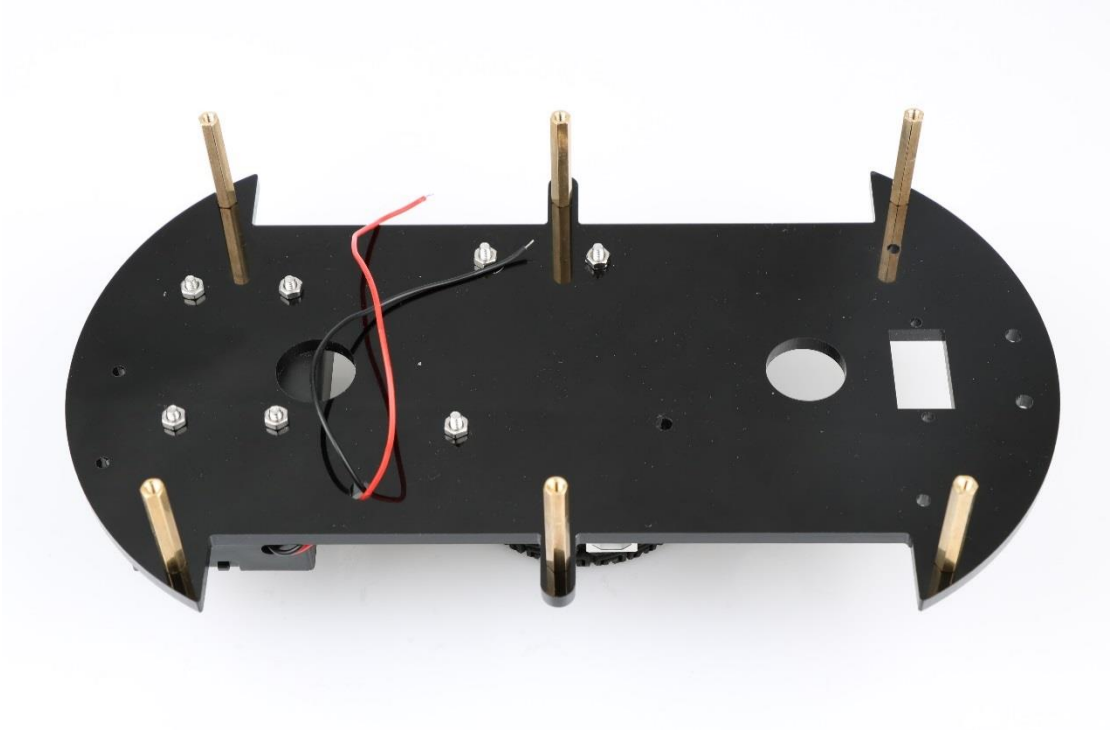

Fig.3.1.22 Diagram of the Pillars

The third step is to install the steering gear and the bracket. In Fig.3.1.19, the "4" logo is the actuator mounting position. The complete installation is shown in Fig.3.1.23.

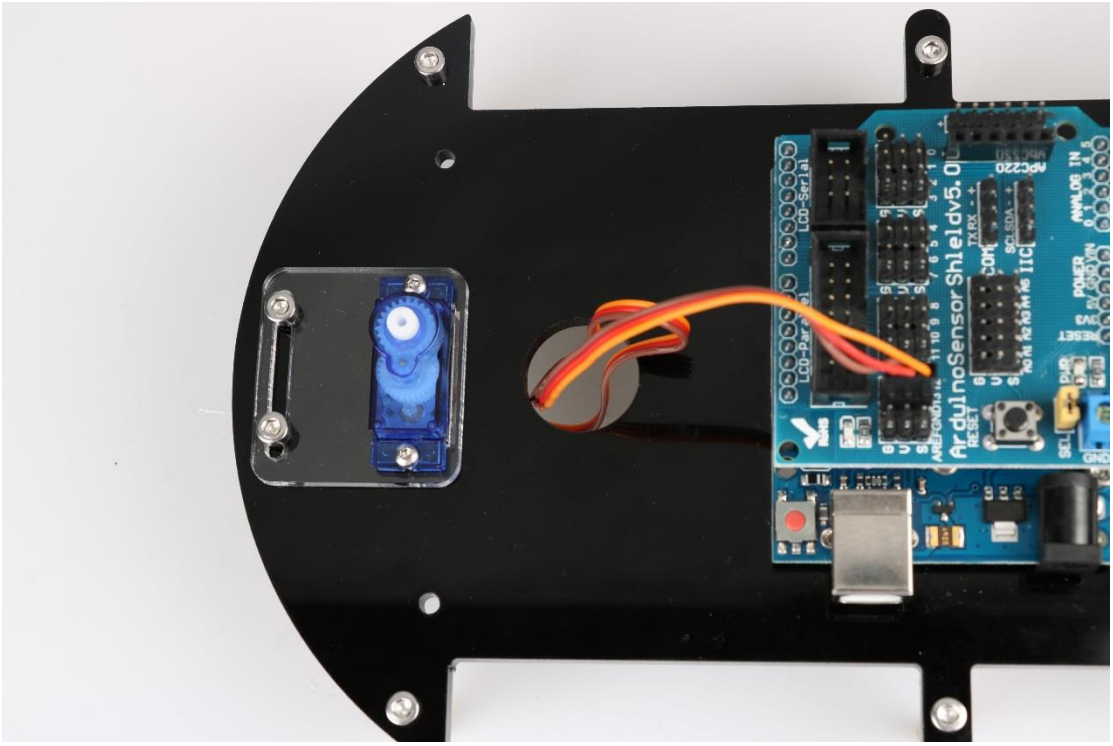

Fig.3.1.23 Diagram of Steering Gear Installation

After installing the steering gear, you can add the ultrasonic module on it. In order to reduce the later steering angle adjustment, we adjust the steering gear to 80 degrees, and copy the following program to the compiler environment (you can also directly open the program in the CD), then connect the signal line(Orange) on steering gear to the 13 IO port on Arduino, and fix it with a screw, the installation is shown in Fig.3.1.24.

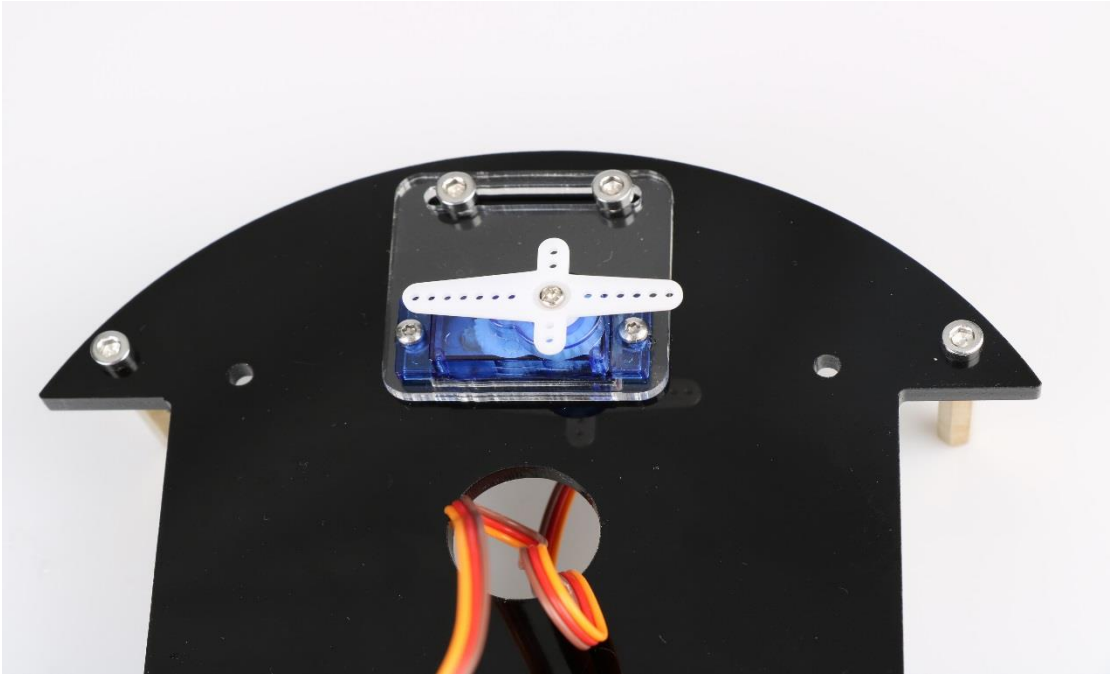

Fig.3.1.24 Diagram of Steering Gear Angle Adjustment

The fifth step is to install ultrasonic bracket, fix the bracket on the steering gear, as shown in Fig.3.1.25.

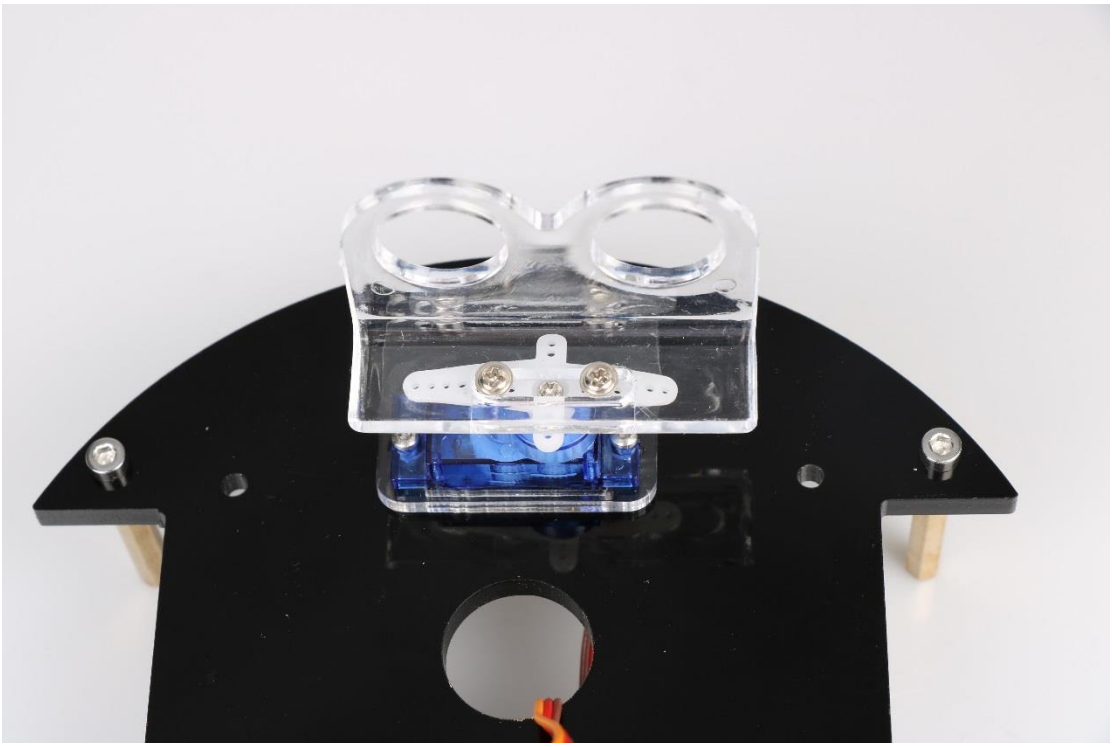

Fig.3.1.25 Diagram of Ultrasonic Bracket Installation

The sixth step is to install infrared obstacle avoidance module in the two holes marked as "6" in Fig.3.1.19, as shown in Fig.3.1.26.

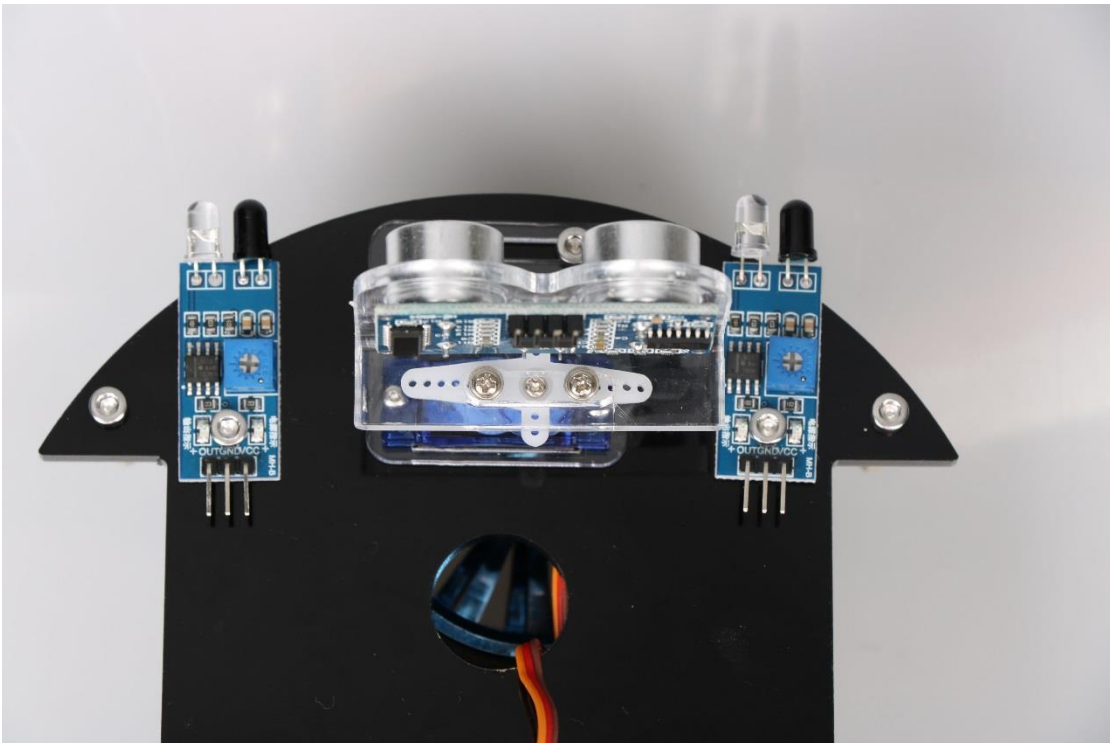

Fig.3.1.26 Diagram of Infrared Obstacle Avoidance Installation

The seventh step is to install infrared remote control receiving head on the Arduino extended board and fixed it with a screw, as shown in Fig.3.1.27. Pay attention to the installation direction.

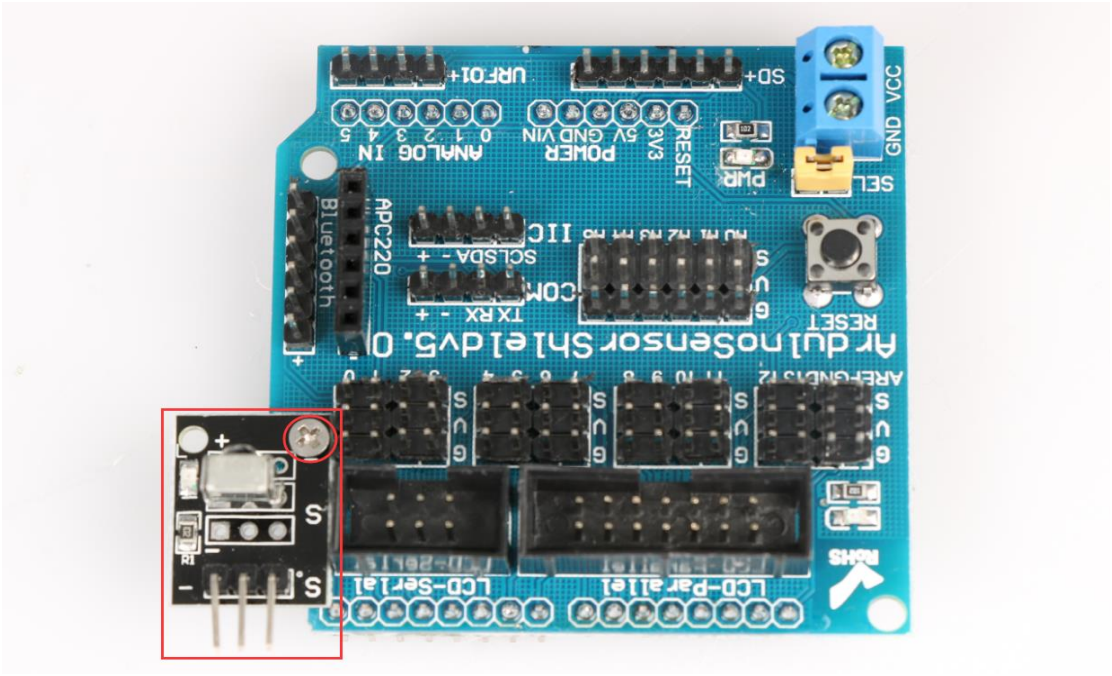

Fig.3.1.27 Diagram of Infrared Remote Control Receiving Head Installation

The eighth step is to install the voltage display module in the back of battery box to logo "A"marked in Fig.3.1.28, and insert the wire into the hole identified as "B" and out from the hole marked as "C". The complete installation is as shown in Fig.3.1.29.

Fig.3.1.28 Diagram of Voltage Display Module Installation

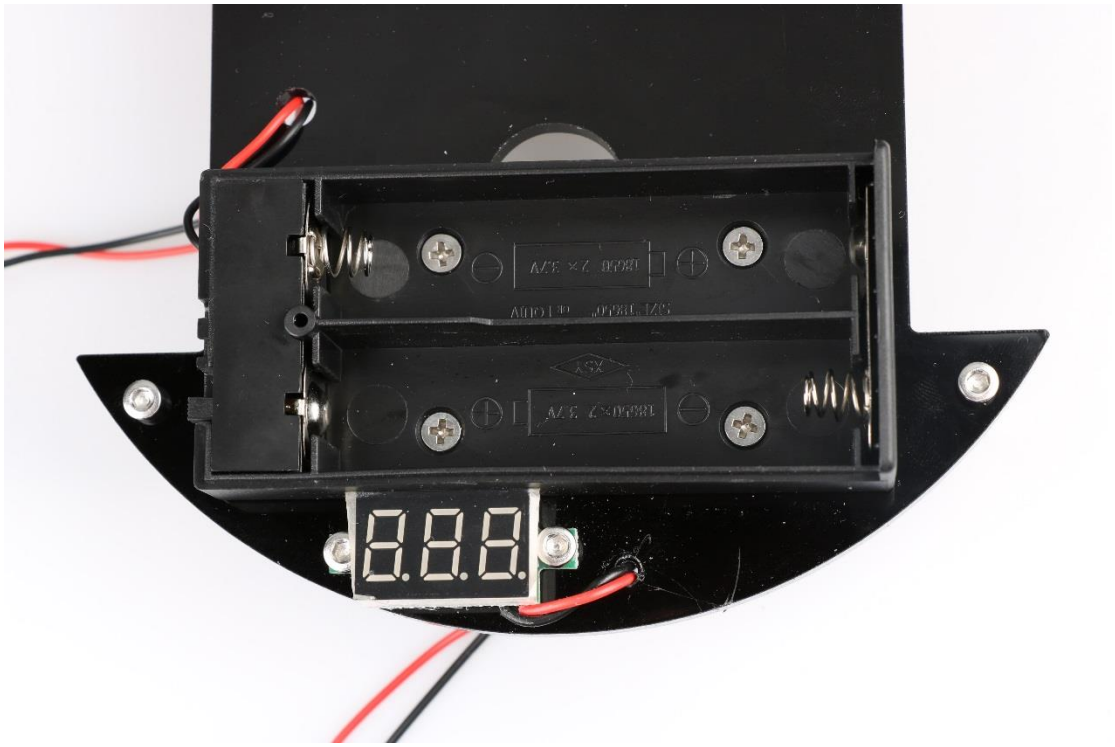

Fig.3.1.29 Diagram of Voltage Display Module Installation

The ninth step is to connect the power wires.This needs connect two wires to DC power head which is shown in Fig.3.1.30. The rubber ring marked as "1" can be removed to open the shell, as shown in Fig.3.1.31. Soldering the wires to the +12V and GND, as shown in Fig.3.1.32.

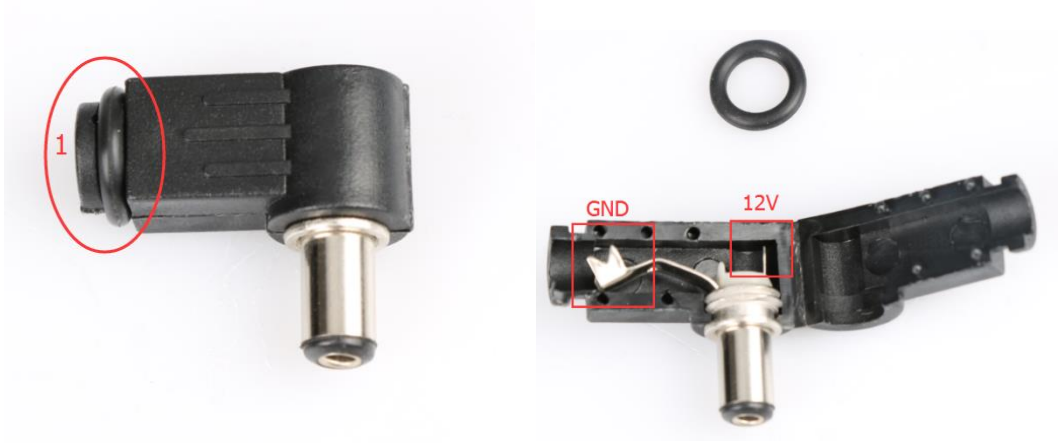

Fig.3.1.30&Fig.3.1.31 DC Power Head

Fig.3.1.32. Wire welding schematic

The tenth step is the whole assembly, first inserting the 4Pin wire into IN1-IN4 on the motor drive, and threading the other end wire of the tracing module from the bottom to the top of the car. Then connecting two wires of the battery box and the voltage display module 、DC power head to the +12V (red) and GND (black) on the motor drive board. At last, aligning the six columns with the six holes as shown in Fig.3.1.33, then screwing the screws tightly from the bottom and the assembly is completed which is shown in Fig3.1.34 and Fig3.1.35(details of wires connection will be introduced later).

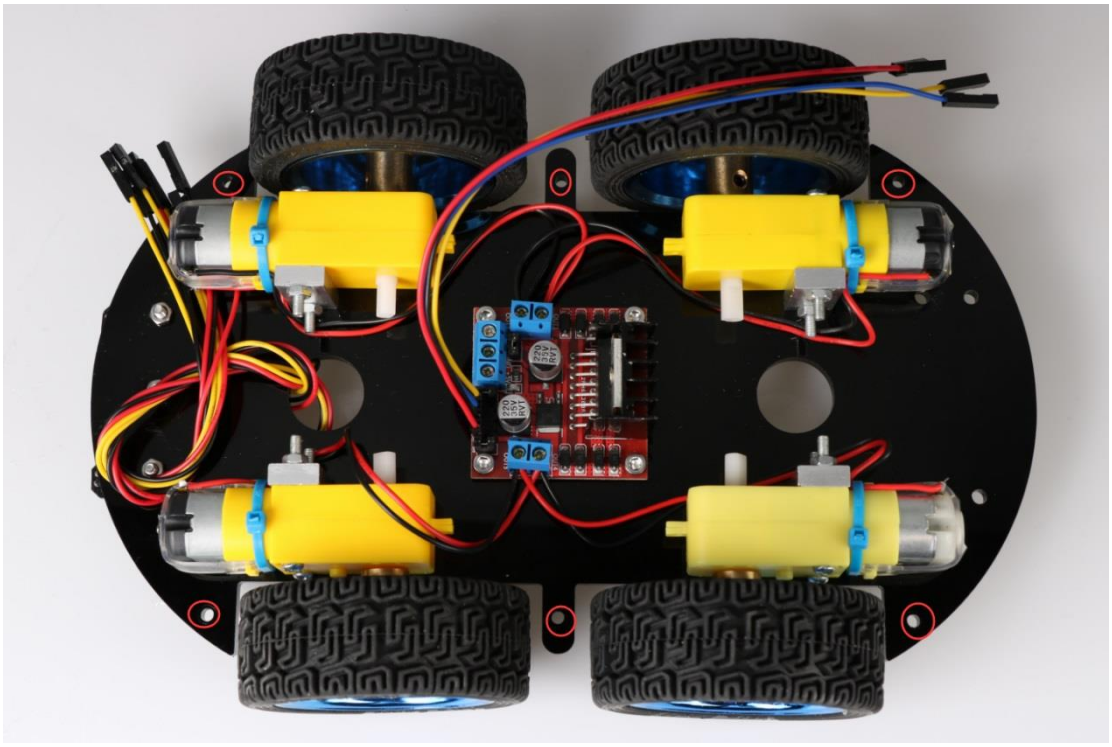

Fig.3.1.33 Diagram of Wires Arrangement

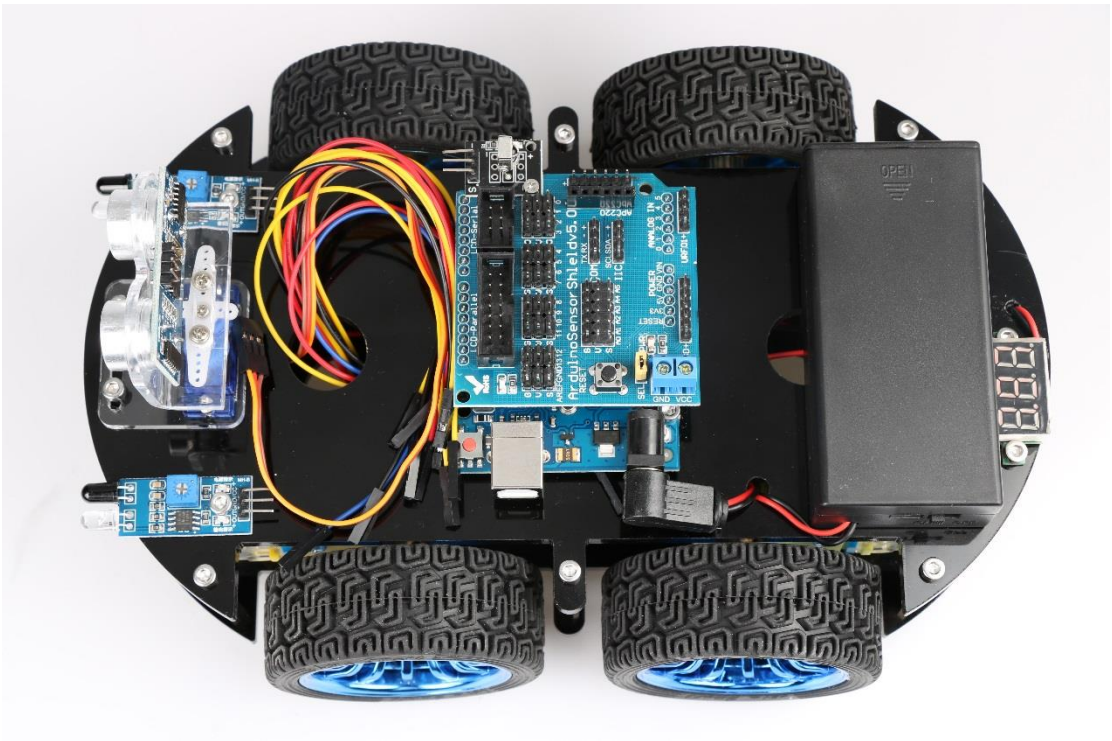

Fig3.1.34 the Effect of Whole Assembly

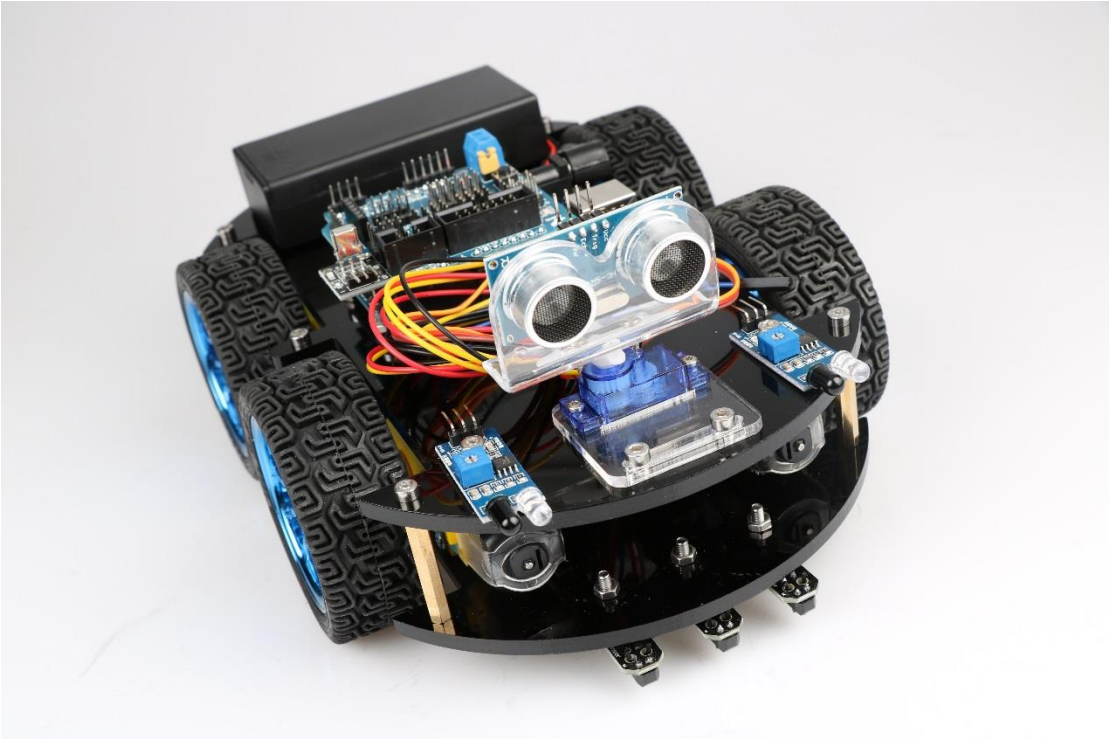

Fig3.1.35the Effect of Whole Assembly

So far, the basic assembly of car has been completed,we believe you have some basic knowledge of your car's structure, function and some modules through a short period of time, then you can achieve the corresponding functions only by downloading the program to the development board, each function has a corresponding program in CD , so please enjoy playing. However, if you can read the program and write your own program,there will be more fun, now let's go to the software section!

3.2 Development of the Car

3.2.1 Walking Principle of the Car

"Motor" - I believe it is universally acknowledged. In today' society, the power spreads every corner in of our lives, the motor is widely used in their respective posts. It is a kind of electromagnetic device which can achieve energy conversion or transfer according to electromagnetic induction, it has the advantages of good speed regulation performance, easy-to-start, quick response, large starting torque, small volume, light weight, easy-to-assemble which can server as power source for electrical appliances or machinery. Due to the internal high speed motor can provide the original power, drive speed (deceleration) gear set and produce greater torque,so it can meet the system

requirements. Combined with these advantages, in the "Hummer-Bot" car, we selected four DC motors as the power source.

Motor drive - it is a necessary condition for the motor to play its superior performance. Its main function is to provide sufficient current and power for the motor. In the "Hummer-Bot" car, we choose the L298N as the motor driver chip for it is a high voltage and current full-bridge driver chip, the chip uses 15 pins package. It is a special motor driven integrated circuit (two H bridges) with high voltage and current full-bridge driver.And it contains 4 channel logic drive circuit, basically belongs to a kind of two-phase and four-phase special motor drive which contains two H bridges of high voltage large current. The output current is 2A, the maximum current is 4A, the maximum working voltage is 50V, which can drive the load under 46V and 2A,such as high power DC motor, stepper motor, solenoid valve and so on. The chip with two enable control terminals uses the standard logic level to control signals, allows or prohibits the device to work when the input signal is not interfered, it has a logic power input terminal which can enable the internal logic circuit to work under low voltage, and feedback the variation to the control circuit. Especially, the input can be connected directly with the MCU and easily controlled. When the DC motor is driven, the stepper motor can be directly controlled, and it can be turned forward and reversely, which only needs to change the logic level of the input. The pin arrangement is shown in Fig.3.2.1. The pin 1 and 15 can separately connect to the current sampling resistor and form the current sensing signal.

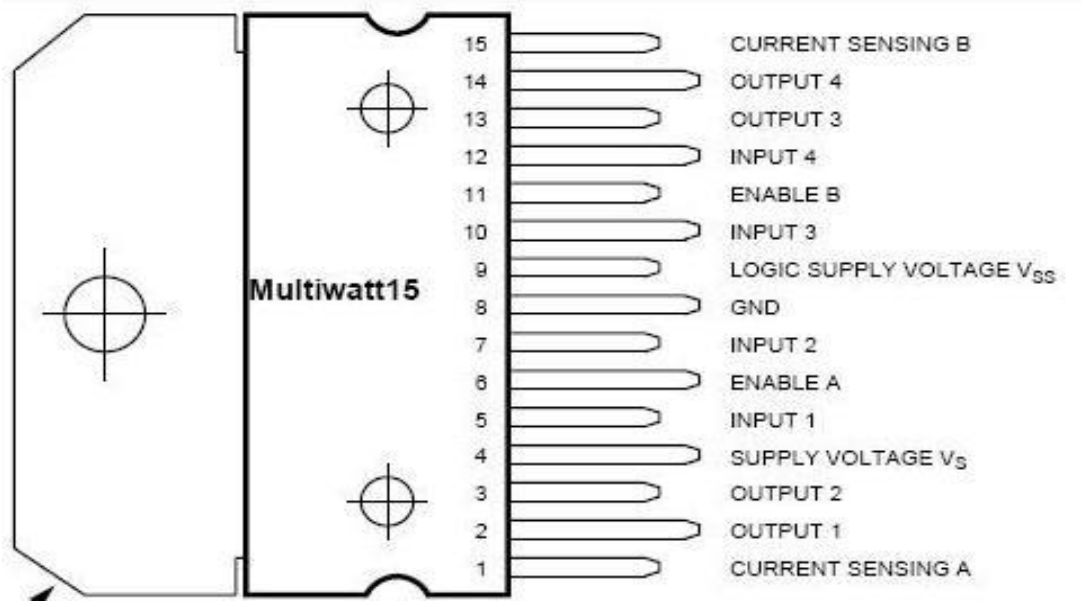

Fig.3.2.1 Arrangement of Chip Pins

L298N can drive 2 motors which are connected between OUTl, OUT2 and OUT3, OUT4. 5, 7, 10 and 12 pin are connected to input control level for controlling the positive and negative rotation of the motor, ENA, ENB are connected to control enable terminal for controlling the running and shutdown of the motor. Its characteristics:

- Signal indicator
- The speed is adjustable
- The strong anti-interference ability with photoelectric isolation
- Overvoltage and overcurrent protection
- Controlling of two motors separately
- Controlling the stepper motor
- The speed control with PWM pulse width
- Positive and negative rotation

ENA	IN1	IN2	Motor status
H	H	L	Forward
H	L	H	Reversal
H	IN2	IN1	Quick stop
L	X	X	Stop

Fig.3.2.2 Logic Function Chart

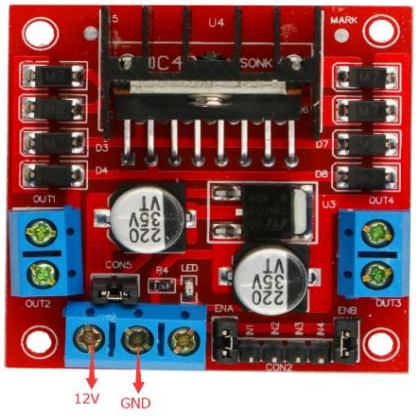

Fig.3.2.3 Module Physical Map

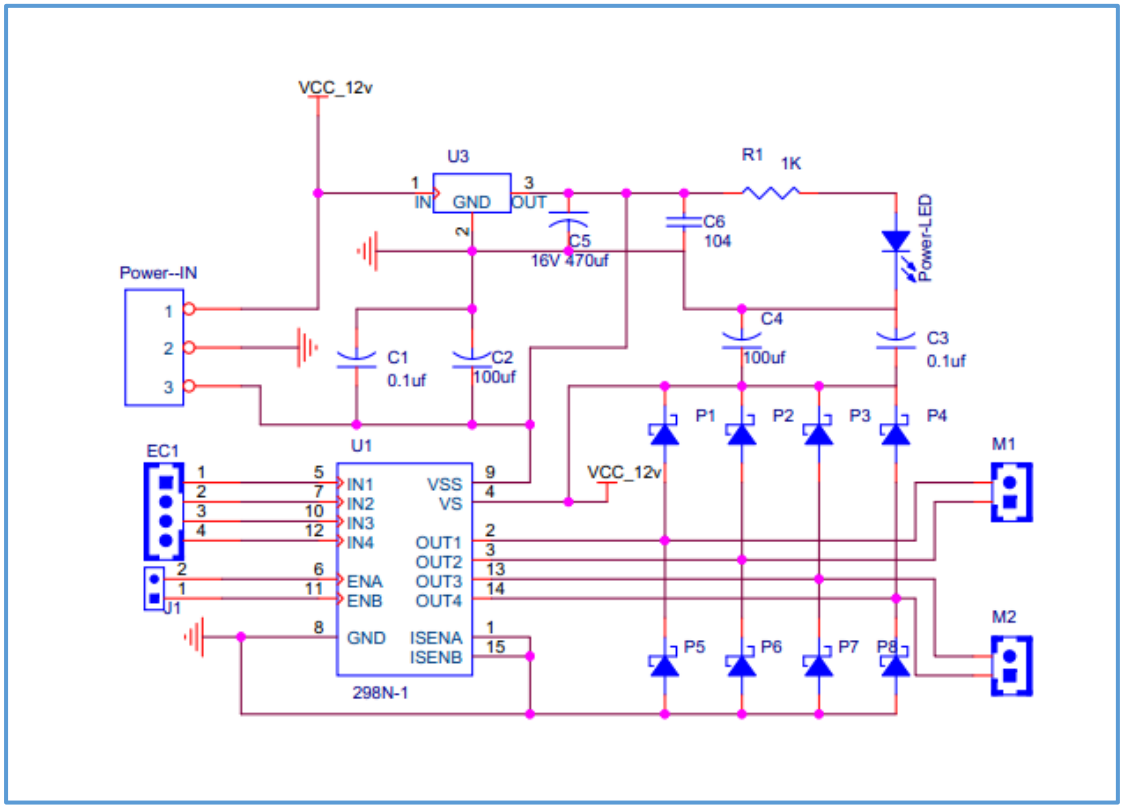

Fig.3.2.4 Schematic Diagram of Motor Drive

Four DC motors with high power L298N drive enable "Hummer-Bot" to run faster than conventional two-wheel car, the acceleration time is shorter and the structure is more stable. However, in the actual application, we need to adjust the speed of the car because of environmental or other factors, yet this does not affect the forward, backward, stop, flexible steering of the car, so we use PWM to control the speed of the motor(Note: PWM is a way to simulate the simulation output via square waves with different duty cycles.), Arduino PWM port outputs a series of square waves with fixed frequency, the power and current of the motor can be amplified after receiving the signal, thereby changing the motor's speed. The speed coordination of two motors on the right and left wheels can achieve the forward, backward, turning and other functions of the car. Figure 2.4.5 shows the sequence diagram of PWM duty cycles.

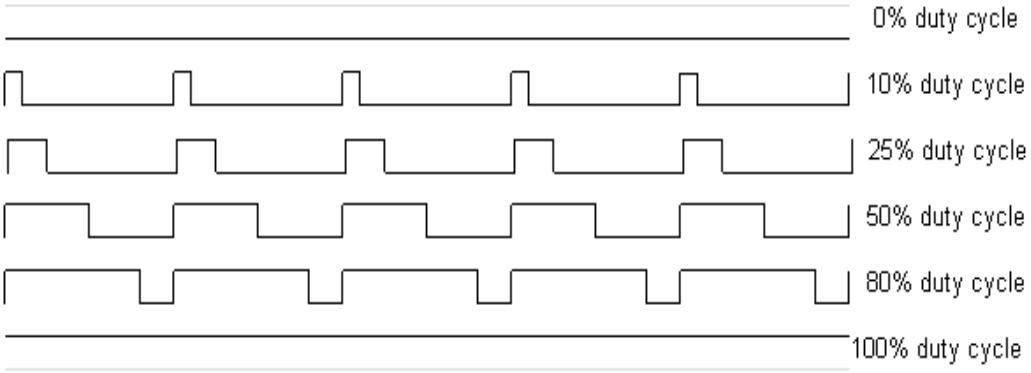

Fig.3.2.5 Sequence Diagram of PWM Duty Cycles

In Arduino, analog voltage can not be output, only 0 or 5V digital voltage value, we can use high resolution counter and the duty cycles of the square wave modulation method to encode a specific level of analog signal. The PWM signal is still digital, because at any given time, the full amplitude of DC power supply is either 5V (ON) or 0V (OFF). The voltage or current source is added to the analog load with a ON or OFF repetitive pulse sequence. When the DC power supply is added to the load, the power supply is on, otherwise the power supply is off. As long as the bandwidth is enough, any analog value can use PWM to encode. The output voltage value is calculated by the on and off time. Output voltage = (turn-on time / pulse time) * maximum voltage. Fig.2.4.6 shows the corresponding voltage to the pulse change.

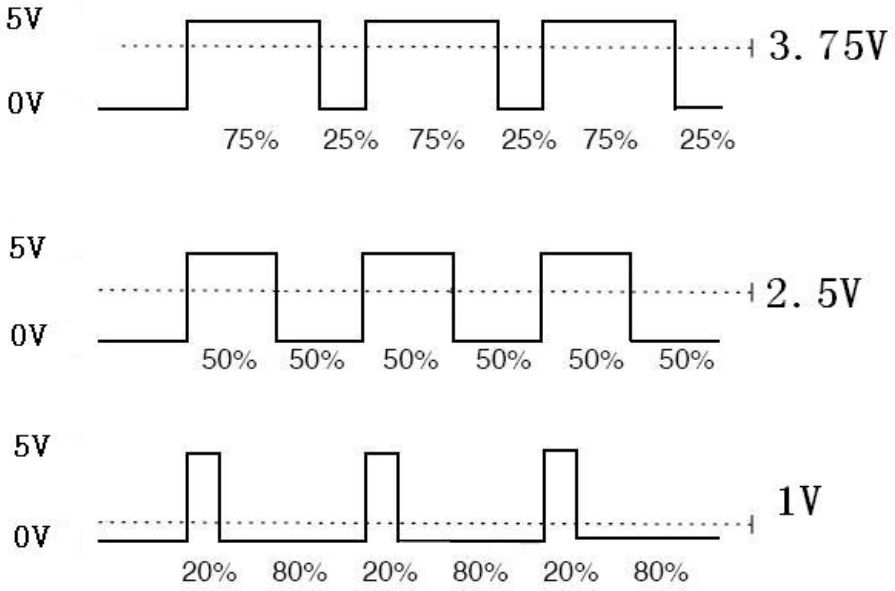

Fig.2.4.6 Relation between Pulse and Voltage

In the "Hummer-Bot" car experiment, we use Arduino UNO R3 as the main control board. By referring to the chip data, we will know that Arduino UNO has 6

PWM pins, namely digital interfaces 3, 5, 6, 9, 10, 11, and we select 5, 6, 9, 10 as the motor control IO, the connection is shown in Fig.2.4.7.

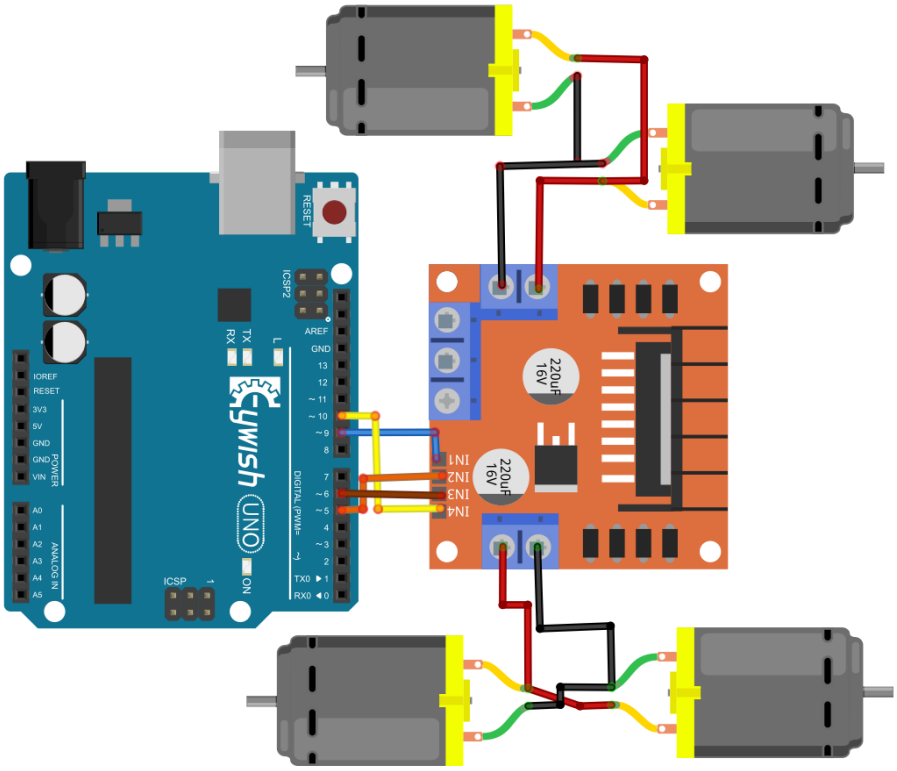

Fig.2.4.7 Connection between Arduino and L298N Drive Board

After the connection, we do not know whether the motor can work normally or not, so we need to do a simple test by copying the following code(you can also open the program in the CD directly) into the IDE development environment and downloading to the development board. And turning on the power(power connection is introduced the tenth and eleventh steps in 3.1.2) to observe the wheels rotation, if "going forward 5s----stopping 1s---- going back 5s---- stopping 1s----turning left 3s----stop 1s----turning right 3s" are normal,the connection is correct, otherwise the polarities of the motor may be reversed, then you need to adjust slightly.

Note: this test and IO selection are only for reference, you can choose other IO ports or use other wiring methods according to your own ideas.

```
int E1 = 5; //PWMA
int M1 = 9; //PWMA
int E2 = 6; //PWMB
int M2 = 10; //PWMB
void setup()
{
}
void loop()
{
  analogWrite(M1,0);
  analogWrite(E1, 150); //the speed value of motorA is 150
  analogWrite(M2,0);
  analogWrite(E2, 150); //the speed value of motorB is 150
  delay(5000);
  //******** ****************************//forward
  analogWrite(M1,0);
  analogWrite(E1, 0); //the speed value of motorA is 0
  analogWrite(M2,0);
  analogWrite(E2, 0); //the speed value of motorB is 0
  delay(1000);
//*****************************************//stop
  analogWrite(M1, 150); //the speed value of motorA is 150
  analogWrite(E1, 0);
  analogWrite(M2, 150);//the speed value of motorA is 150
  analogWrite(E2, 0);
  delay(5000);
//*****************************************//back
  analogWrite(M1,0);
  analogWrite(E1, 0); //the speed value of motorA is 0
  analogWrite(M2,0);
  analogWrite(E2, 0); //the speed value of motorB is 0
  delay(1000);
//******* ************************************//stop
  analogWrite(M1, 0);
  analogWrite(E1, 180); //the speed value of motorA is 180
  analogWrite(M2, 180); //the speed value of motorB is 180
  analogWrite(E2, 0);
  delay(3000);
```

```
//*****************************************//left
  analogWrite(M1, 0);
  analogWrite(E1, 0); //the speed value of motorA is 0
  analogWrite(M2, 0);
  analogWrite(E2, 0); //the speed value of motorB is 0
  delay(1000);
//***** ************************************//stop
  analogWrite (M1,200); //the speed value of motorA is 200
  analogWrite(E1, 0);
  analogWrite (M2,0);
  analogWrite(E2, 200); //the speed value of motorB is 200
  delay(3000);//***
************************************//right
}
```

By now, the car can move normally, are you happy and excited? But this is just the beginning, the car can just fool-turning without significance, there will be more fun if we add it some "organs".Now we will equip the car with several commonly-used sensors, so it will have a new understanding of the world.

3.2.2 Infrared Obstacle Avoidance

3.2.2.1 Introduction of Infrared Obstacle Avoidance Sensor

Infrared obstacle avoidance module is a pair of infrared transmitting and receiving tubes, the former launches a certain frequency infrared, the receiving tube will receive the reflected infrared when the infrared detects the obstacles.After the signal is processed by the comparator circuit, the green LED lights, and the signal output port outputs digital signal at the same time(a low level signal). The detection distance can be adjusted through the potentiometer knob, the effective distance range is 2-30cm, the working voltage is 3.3V-5V.Due to the sensor uses infrared, so the anti-interference ability is very strong, the measurement accuracy is very high when the distance is moderate. In addition, the module can be assembled easily and used conveniently, it can be widely used in robot obstacle avoidance,car obstacle avoidance and the black&white line tracing and many other occasions.

3.2.2.2 Working Principle

1, The module output port OUT can be directly connected with the IO port of the microcontroller, and directly drive a 5V relay; the connection mode is: VCC-VCC; GND-GND; OUT-IO (A3 and A4), as shown in Fig.3.2.9 and Chart 3.2.1.

2, The module uses the 3-5V DC power as power supply. When the power is on, the indicator will light.

3, The diameter of installation hole is 3mm, you can use the same size screws (screws in the kit).

Pin wiring definition (only for reference, you can define according to your own ideas):

arduino Uno	Infrared Obstacle Avoidance Module
VCC	VCC
GND	GND
A3	The left module
A4	The right module

Chart 3.2.1 Pin Wiring Definition

3.2.2.3 Module Parameters

The working principle of infrared obstacle avoidance sensor is very simple, that is the reflection property of objects. In a certain range, if there is no obstacle, the infrared ray emitted will gradually weaken because of the farther distance of transmission, and finally disappear. If there are obstacles, the infrared will be reflected to the receiving head. As soon as the sensor detects the signal, it can confirm that there are obstacles in front of the circuit board, the green indicator will light, the OUT port continuously outputs low level signal to MCU at the same time, the MCU conducts a series of analysis to ensure that the two wheels of car works properly and avoids the obstacle beautifully. The schematic diagram of the sensor is shown in Fig.3.2.8. Infrared detector can be divided into active and passive according to its working mode.

Active infrared detector is equipped with infrared light source, it can detect the location of the object through covering the light source, reflection, refraction and other optical means.

Passive infrared detector has no light source, and it can measure the position, temperature, or infrared imaging of the detected object by receiving the characteristic spectral radiation of the detected object.

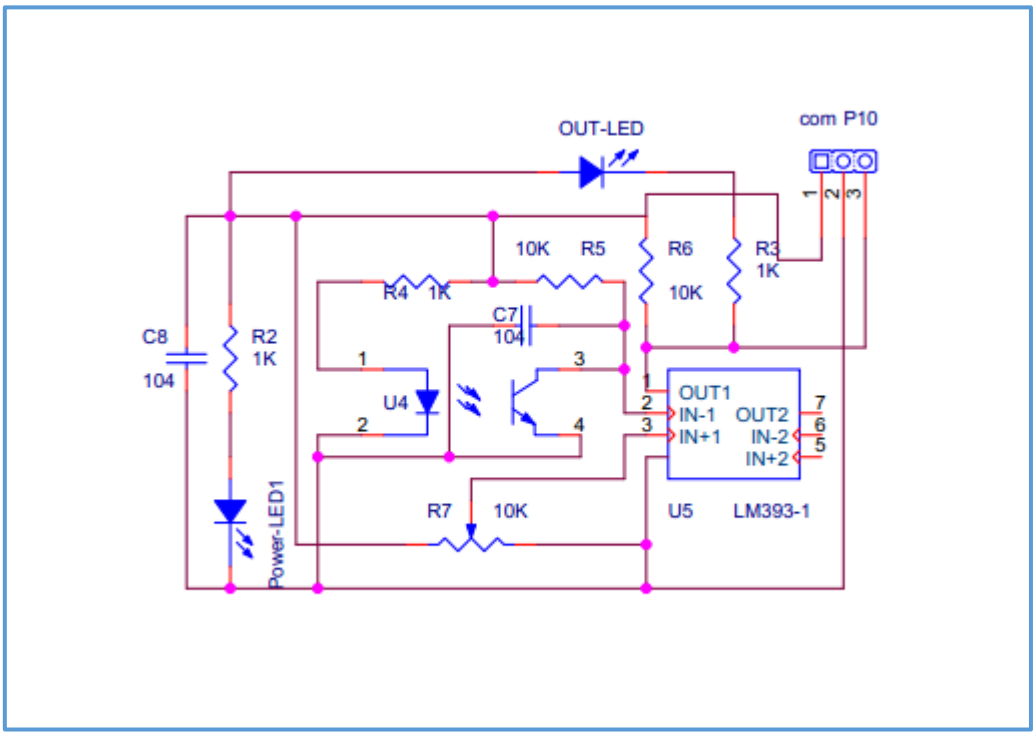

Fig.3.2.8 Infrared obstacle avoidance schematic diagram

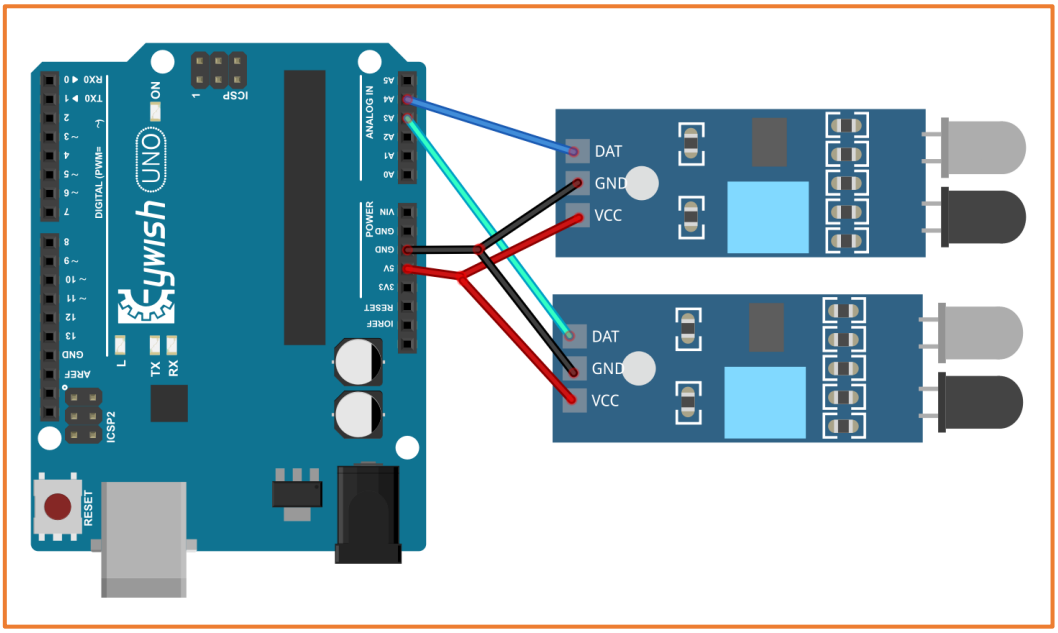

Fig.3.2.9 Connection of Arduino and Sensor

Note: This module can adjust the detection distance by the potentiometer, the detection distance is 2-30cm, if it is found that the distance detection is not very sensitive, you can use the potentiometer to achieve the desired results (rotating the potentiometer clockwise will increase the detection distance; counterclockwise will decrease), it is shown in Fig.3.2.10.

Manual adjustment is shown in the following diagram:

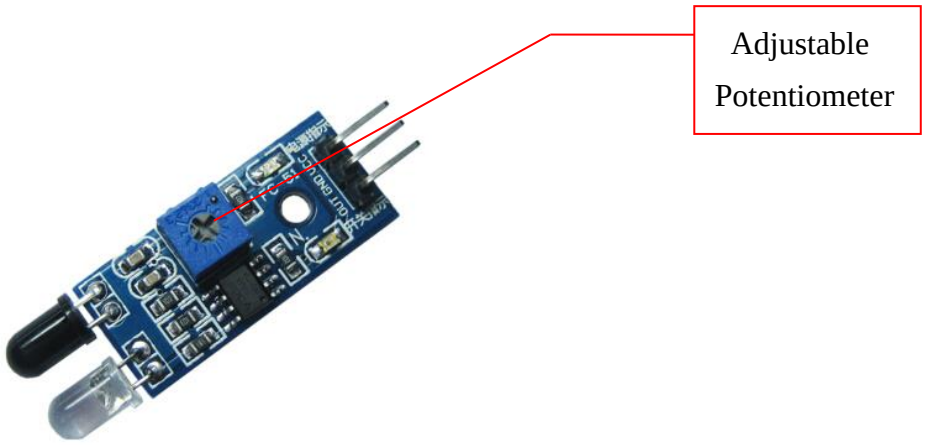

Fig.3.2.10 Diagram of Distance Detection Adjustment

3.2.2.4 Experimental Procedures

1, Fixing the two sensors on the car and connecting them to Arduino with wires.(Already done)

2, Testing the sensitivity of module, namely opening the switch on the battery box and the indicator will light, placing obstacles the 10cm away from the infrared tubes, adjusting the potentiometer until the output indicator lights up.

3, Module test.copying the following code to the IDE compiler environment (you can also open the program directly in the CD), downloading it to the development board, opening the serial port monitor (baud rate is 9600) and observing the changes of data when there is a obstacle (Figure 3.2.11) and no obstacle (Figure 3.2.12).

Note: Here we connect the infrared obstacle avoidance signal output port to the analog port on Arduino (A0-A5), so the serial port prints out analog value, you can connect it to digital port (2-13), and the serial port will only print out "0" and "1".

```
const int leftPin = A3;
const int rightPin = A4;
int dl;
int dr;
void setup()
{
  Serial.begin(9600);
  pinMode(leftPin, INPUT);
  pinMode(rightPin, INPUT);
```

```
  delay(1000);
}

void loop()
{
  dl = analogRead(leftPin);
  dr = analogRead(rightPin);

  Serial.print("left:");
  Serial.print(dl);
  Serial.print("   ");
  Serial.print("right:");
  Serial.println(dr);
}
```

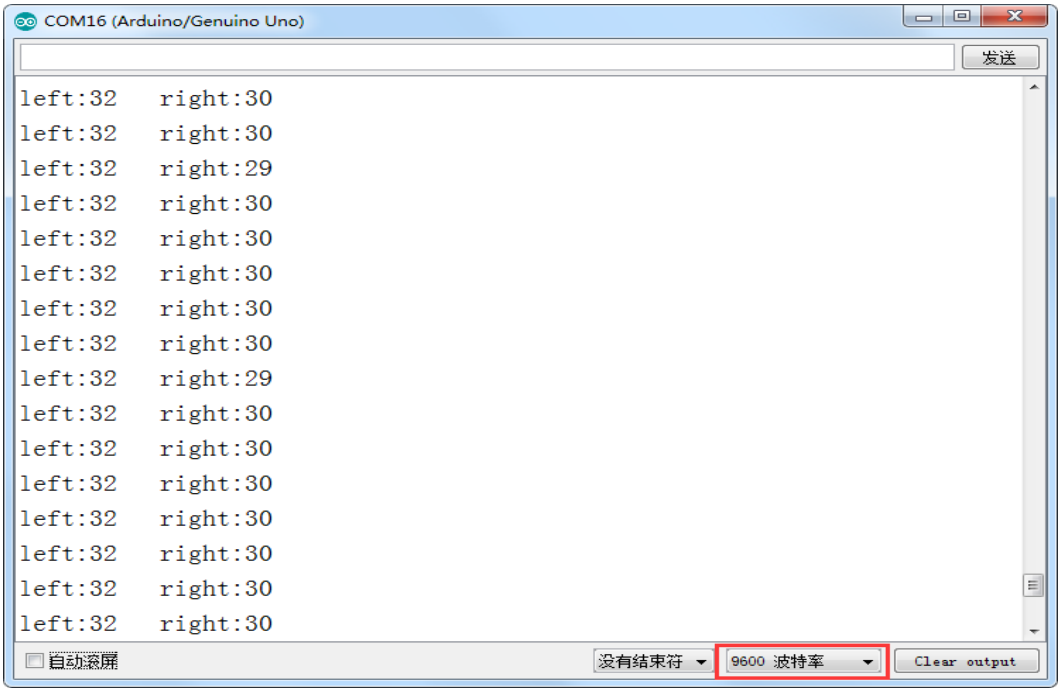

Fig.3.2.11 Diagram of Data with Obstacles

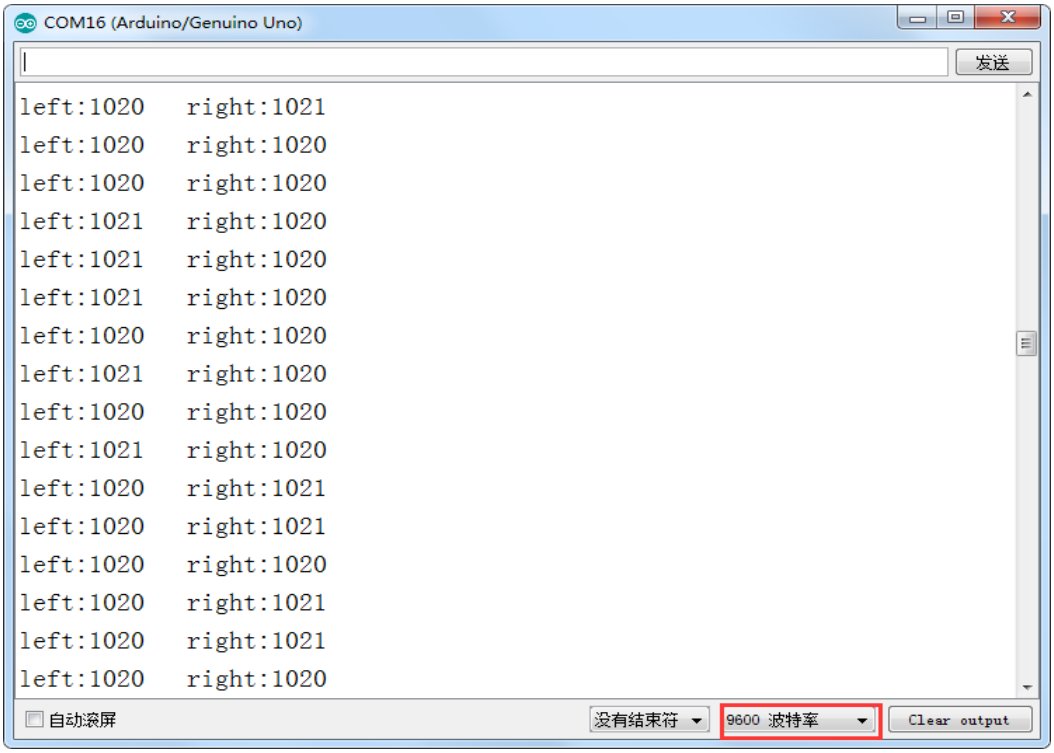

Fig.3.2.12 Diagram of Data without Obstacles

3.2.2.5 Software Design

In the above steps, we have tested the car's driving and obstacle avoidance module respectively, they have achieved the desired results, here the "infrared obstacle avoidance" actually has been explained in this section, but we have not put the programs of two parts together, so we now integrates the program of the two parts and complete this great "infrared obstacle avoidance" project. First, let's read the complete program:

```
int E1 = 5; //PWMA
int M1 = 9; //DIRA****************************************left
int E2 = 6; //PWMB
int M2 = 10; //DIRB****************************************right
/* Define 4 motor control terminals, connected to IN1-IN4 on the
motor drive board。*/
const int leftPin = A3;
const int rightPin = A4; // Define the two signal receiving ends of
the sensor
float dl;
```

```
float dr; // Define two margins to store the values read by both
sensors
void setup()
{
 Serial.begin(9600); // Set the serial port baud rate to 9600,
 pinMode(leftPin, INPUT);
 pinMode(rightPin, INPUT); // Set the working mode of two sensor
pins, namely "input"

 delay(1000);
}

void loop()
{
  dl = analogRead(leftPin);
  dr = analogRead(rightPin); // Read the values collected by both
sensors and assign them to the defined variables。

 if (dl >= 38 && dr <= 38) /* If the value collected by the left
sensor is greater than or equal to 38 and the right value is less
than or equal to 38, the following program in {} is executed (dl> =
38, there is no obstacle on the left, dr <= 38 shows that there is an
obstacle on the right, so at this time the car is turning to the side
without obstacles (ie, turning to the left). From Figure 3.2.11, we
know that the simulated value will drop below about 35 in the event
of an obstacle , But in order to reduce the error, we set the
threshold at 38 to prevent the car from judging the error because of
the error. We can also customize other values. If we use the digital
port to receive the value of the sensor, we only return "0" and "1"
", But the same way to judge. The reason why I did not use digital
IO, because we use the digital IO port in other places.*/
  {
   analogWrite (M1,0);
   analogWrite(E1, 180); //the speed value of motorA is 180
```

```
  analogWrite (M2,180); //the speed value of motorB is 180
  analogWrite(E2, 0); /* Set a PWM value, the maximum PWM is 255, but the speed of the car should not be too fast when walking, otherwise it can not hit the obstacle in time when the obstacles are suddenly encountered.*/
  Serial.print(dl);
  Serial.print("   ");
  Serial.print(dr);
  Serial.print("   ");
  Serial.println("Turning left"); /* Through the "Serial Monitor" print the current status of the car and the value collected by the sensor* /
  delay(300);
  analogWrite(M1, 0);
  analogWrite(E1, 0);
  analogWrite(M2, 0);
  analogWrite(E2, 0); /* As the car left after about 300ms stop, after measuring, 300ms time car just can rotate about 90 degrees, because the DC motor does not like the steering angle can be precisely controlled, so can only give a rough estimate, of course, different motor speed is not Similarly, the time used is not the same, so everyone in the experiment can be based on their own ideas, but the angle of 90, but also other values.*/
  delay(1000); //***********************************//Turning left
  }

  if (dl <= 38 && dr <= 38) /* If the value collected by the left sensor is less than or equal to 38 and the right value is less than or equal to 38, the following program in {} is executed (dl <= 38, indicating that there is an obstacle on the left and dr <= 38 shows that there is an obstacle on the right, so at this time the car is rotated 180 degrees backwards. In the experiment, the car can just turn around 180 degrees after 500ms of rotation. Because the DC motor can not precisely control the angle like the steering gear, An
```

```
approximate value, of course, different motor speed is not the same,
the time used is not the same, so everyone in the experiment can be
based on the circumstances may be.)*/
  {
   analogWrite(M1,255); //the speed value of motorA is 255
   analogWrite(E1, 0);
   analogWrite(M2, 0);
   analogWrite(E2, 255); //the speed value of motorB is 255
   Serial.print(dl);
   Serial.print("   ");
   Serial.print(dr);
   Serial.print("   ");
   Serial.println("Turning around");/* Through the "Serial Monitor"
print the current status of the car and the value collected by the
sensor.*/
   delay(500);
   analogWrite (M1,0);
   analogWrite (E1, 0);
   analogWrite (M2,0);
   analogWrite (E2, 0); /* Rotate 180 degrees and stop */
   delay(1000); //*********************************//Turning around
  }

  if (dl <= 38 && dr >= 38) /* If the left sensor is less than or
equal to 38 and the right value is greater than or equal to 38, the
following program in {} is executed (dl <= 38, indicating that there
is an obstacle on the left, dr> = 38 shows that there is no obstacle
on the left, so at this moment the car is turning to the side without
obstacle, that is, turning to the right)
 {
  analogWrite(M1, 180); //the speed value of motorA is val
  analogWrite(E1, 0);
  analogWrite(M2, 0);
  analogWrite(E2, 180); //the speed value of motorA is val
```

```
   Serial.print(dl);
   Serial.print("   ");
   Serial.print(dr);
   Serial.print("   ");
   Serial.println("Turning right");
   delay(300);
   analogWrite(M1, 0);
   analogWrite(E1, 0);
   analogWrite(M2, 0);
   analogWrite(E2, 0); /* Car must stop after each rotation, if you do
not stop there will be the phenomenon of rotating around. * /
delay(1000); //*********************************//Turning right
  }

   if (dl >= 38 && dr >= 38) / * Judge two values collected by the
sensor. If the value collected by the left sensor is greater than or
equal to 38 and the right value is greater than or equal to 38,
execute the following program in {} (dl> = 38, indicating that there
is no obstacle on the left and dr > = 38 that there is no obstacle on
the left, so the car at this time straight * /
 {
   int val=150; /* When the straight line has a PWM value of 150, if
the value is too large, the speed of the car will be very fast, which
may lead to the car can not hit the obstacle in time when it
encounters the obstacle. * /   analogWrite (M1,0);
   analogWrite(E1, val); //the speed value of motorA is val
   analogWrite (M2,0);
   analogWrite(E2, val); //the speed value of motorB is val
   Serial.print(dl);
   Serial.print("   ");
   Serial.print(dr);
   Serial.print("   ");
   Serial.println("go");//*********************************//forward
  }
```

```
}
```

In the above program, we made comments on some part of the program in order to make you to learn and understand the program easily, the program is relatively simple, you can write your own programs to give the car more skills. Of course, if you want to use it directly, we have the corresponding source program in the CD.

3.2.3 Infrared Tracing

3.2.3.1 Introduction of Infrared Tracing Sensor

After infrared obstacle avoidance, let us learn the infrared tracing, their nature of work are the same, using basically the same module, just in different ways, to achieve different functions. In this section when we study, we have to pay attention to the color of the line we trace(the black line or white line), if your floor is black, you should trace the white line (pasting white line on the floor); if it is white, then you should trace the black line (pasting black line on the floor); you just need to make a distinct difference between the track and the ground environment.

Black line tracking refers to the car drives along the black line on the white floor, it can know where to drive according to the received reflected light due to the different light reflection coefficient on the black and white floor.

White line tracking refers to the car drives along the white line on the black floor, it can know where to drive according to the received reflected light due to the different light reflection coefficient on the white and black floor.

In the "Hummer-Bot" car, we use the TCRT5000 sensor as tracing module, TCRT5000 infrared reflection sensor is a photoelectric sensor which consists of an infrared emitting diode and a NPN infrared photoelectric transistor. The detectable reflective distance is 1mm-25mm, the sensor is specially equipped with M3 fixed installation holes, so it is easy to adjust the direction, it also has the 74HC14 Schmidt trigger inverter which ensure the clean signal, the good wave shape and the strong driving ability. It can be applied to robot obstacle avoidance, robot tracing (detecting black line in white background and detecting white line in black background), which is the necessary sensor for tracing line robot and other occasions. The PCB size is 3.5cm*1cm, and the physical map is shown in Fig.3.2.13.

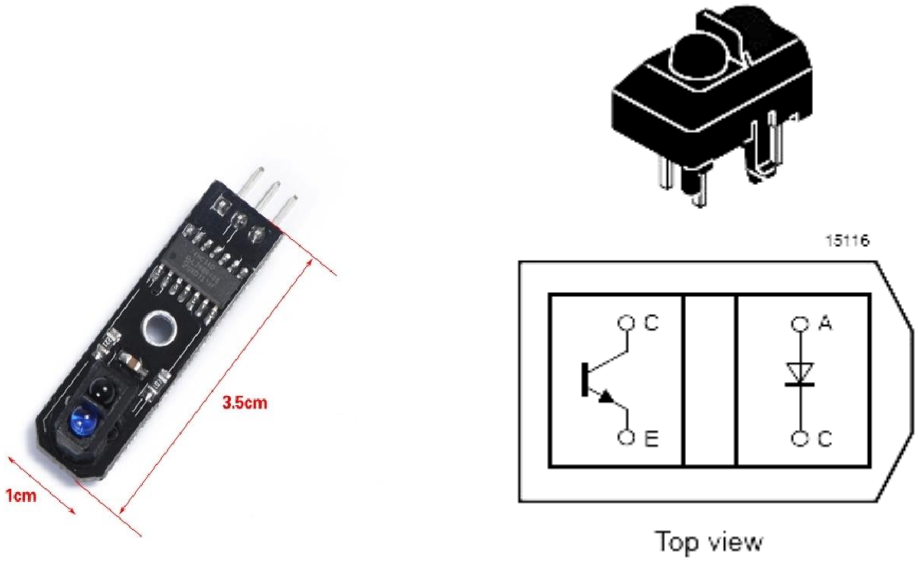

Fig.3.2.13 Physical Map of the Module

3.2.3.2 Working Principle

In the above, we talked about two patterns of tracing-the white line and the black line. In fact, either the black line or the white line, we usually adopt the infrared detection method.

Infrared detection method means that different objects with different colors have the different infrared reflection characteristics. The car launches the infrared to the ground continually during driving process, the infrared receiving tube will be in a shutdown state and the output of the module is low level when the emitted infrared is not reflected or the reflected infrared is not strong enough, and indicating diode will be off; when the diffuse reflection occurred on a white floor, the intense reflected infrared will be received by the receiving tube on the car, the photosensitive triode will be saturated, the output end of the module is high level and the indicating diode will light.

As is shown in the schematic diagram 3.2.14 (U1 is comparator, such as LM358, LM324, LM393, LM339 and a series of comparators, we use the 74HC14D comparator in TCRT5000), A and C are connected to the light emitting diode, C and E to the receiving diode, as shown in Fig.3.2.15. In the "Hummer-Bot" car, we use three modules, two in the left and right sides, one in the middle. Its installation is shown in Fig.3.2.16,the tracing sensors are in a straight line.

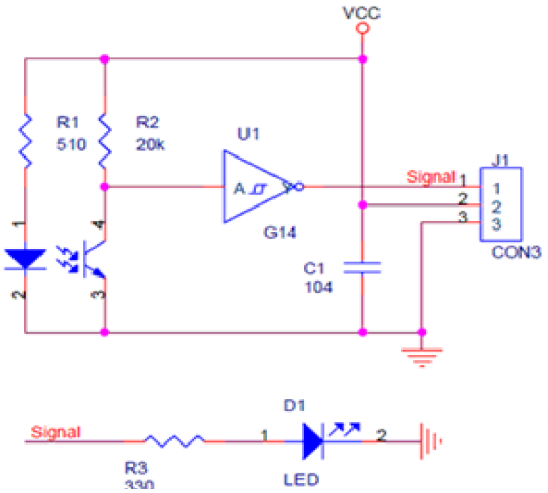

Fig.3.2.14 Schematic Diagram of Tracing Module

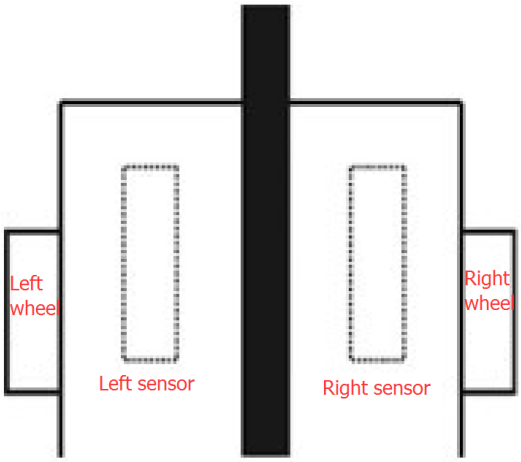

Fig.3.2.16 Diagram of Tracing Module Installation

The X1 and Y1 are the first direction control sensors, and the width of the two sensors on the same side of the black line must not be greater than the width of the black line. When the car is moving forward, the driving track is always between the two first level sensors X1 and Y1 (the black track as shown in Fig. 3.2.16), when the car deviates from the black line:

If the left X1 detects the black line which can not be detected by the right Y1 and intermediate sensors, the the car has shifted to the right, then the car will turn left slightly, and keeping intermediate sensor always detecting the black line; if the right Y1 detects the black line which can not be detected by the left X1 and intermediate sensors, the the car has shifted to the left, then the car will turn right slightly, and keeping intermediate sensor always detecting the black line; if the car turns back on the track driving along the black line, X1 and Y1 can all detect the white line, and send high level to the microcontroller.

3.2.3.3 Module Parameters

- Using TCRT5000 infrared reflection sensor
- The detection distance: 1mm~25mm, the focal distance is 2.5mm
- The comparator output signal waveform is clean, good-shape and it has more than 15mA strong drive ability.
- The working voltage: 3.3V-5V
- Using wide voltage comparator 74HC14D, digital output (0 and 1)
- Easy-to-install fixed bolt holes

Note:

Correct wiring! Do connect the positive and negative pins correctly, or the mainboard and electronic device may burn up. Connecting the VCC to 3.3V or 5V, the OUT output port to the microcontroller IO port directly. The I/O port on Arduino should be set for input mode / receiving mode, otherwise it can not be used. As for other MCU, such as ARM or more advanced control boards, if the I/O ports need to be used as the input and output mode, they have to be set to the input mode / receiving mode. The 51 series microcontrollers can be used directly, there is no need to set the input and output mode.

If you want to know more about TCRT5000, please refer to the file "TCRT5000.pdf" in the CD.

3.2.3.4 Experimental Procedures

1, Fixing the sensor on the car (the assembly is completed) and connecting it to the Arduino as shown in Fig.3.2.17.

2, Making the track. if your floor is white, then you could stick a black tape to form a loop, otherwise stick a white tape, the shape of track is based on your own desires, the best width of the tape is 13-18mm. In this manual, we use the black track, as shown in Fig.3.2.18.

3, Module test.Copying the following codes to the IDE compiler environment (you can also open the program in the CD directly) and downloading to the development board, opening the serial port monitor (baud rate is 9600) to observe the changes of data when there is the white line (Fig. 3.2.19) and is not the white line (Figure 3.2.20).

Note: Here we connect the signal output port of infrared obstacle avoidance to the analog port on Arduino (A0-A5), so the serial port monitor prints analog values, you can connect it to the digital port(2-13), then the serial port monitor will print out only "0" and "1".

```
void setup()
{
  Serial.begin(9600);
}
void loop()
{
  int left,centre,right;
```

```
  left=analogRead(A0);
  centre=analogRead(A1);
  right=analogRead(A2);
  Serial.print("right:");
  Serial.print(right);
  Serial.print("   ");
  Serial.print("centre:");
  Serial.print(centre);
  Serial.print("   ");
  Serial.print("left:");
  Serial.print(left);
  Serial.println("   ");
}
```

Fig.3.2.18 Example of the Black Track

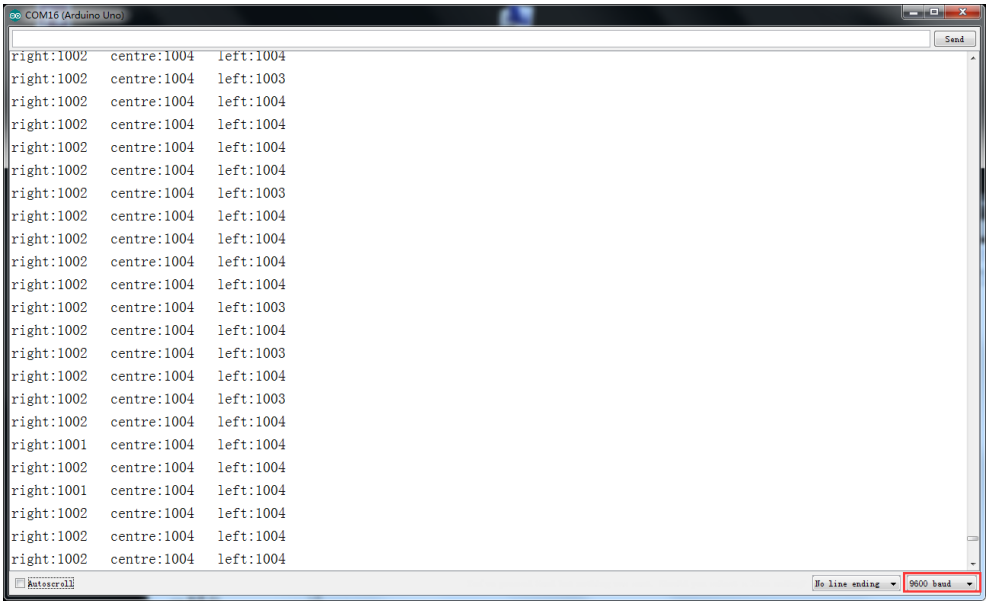

Fig. 3.2.19 The Data When the Sensor Does Not Detect the Black Line

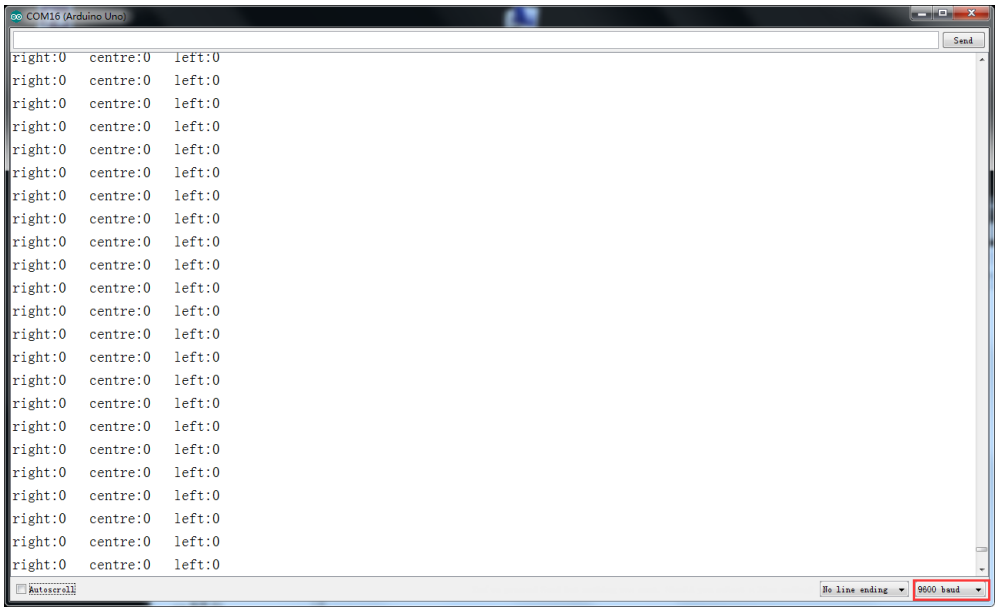

Figure 3.2.20 The Data When the Sensor Detects the Black Line

From Fig.3.2.19 and Fig.3.2.20 we can see that the output is high level when the sensor does not detect the black line, low level when detects the black line. We use the analog port to collect the sensor's signal, so the printed value is analog that, the high level is reaching 1024, the low level is 0. After we master the working principle of the sensor, our tracing car in this section comes to an end, then let us open a car journey.

3.2.3.5 Software Design

1. Overall software flow chart

When the car enters the tracing mode, it keeps scanning the I/O port of the MCU connected to the sensors, once detecting the changes in signal at the I/O port, the corresponding procedure will be implemented, the corresponding signal will be sent to the motor so as to correct the status of the car.

2. The car tracing flow chart

When the car enters the tracing mode, it keeps scanning the I/O port of the MCU connected to the sensors, once detecting the changes in signal at the I/O port, the corresponding procedure will be implemented. If the left sensor detects the black line(the left half of the car walked across the black line, the car body is trended right), the car should turn the left; If the right sensor detects the black line(the right half of the car walked across the black line, the car body is trended left), the car should turn the right. After the direction adjustment, the car walks forward, and continues to detect the black line repeatedly. The tracing flow chart is shown in Fig.3.2.21.

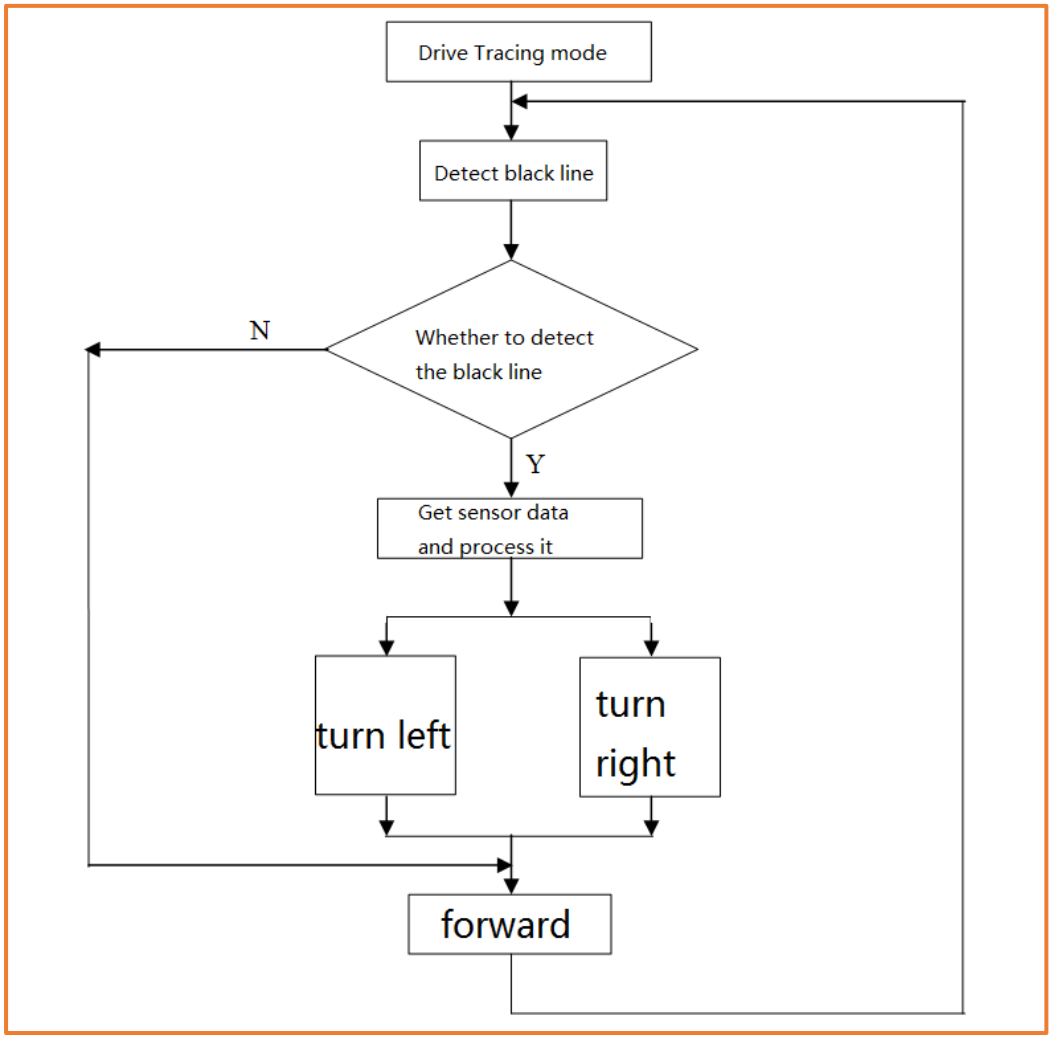

Fig.3.2.21 the Tracing Flow Chart

3. Program Explanation

```
int E1 = 5; //PWMA
int M1 = 9; //DIRA****************************************left
int E2 = 6; //PWMB
int M2 = 10; //DIRB***************************************right
/* Define 4 motor control terminals, connected to IN1-IN4 on the
motor drive board.*/

void setup()
{
  Serial.begin(9600); /* Set the baud rate to 9600 * /}

void loop()
{
  int left1,centre,right1; /* Define 3 sensors * /
  left1=analogRead(A0);
  centre=analogRead(A1);
  right1=analogRead(A2); /* Read the value collected by 3 sensors * /

  if((right1 >= 975)&&(centre <= 8)&&(left1 >= 975)) / * Judge the
collected value, if right1> = 975 and left1> = 975 are greater than
975, the left and right sensors do not detect the black line, the
center <= 8 shows that the middle sensor detects the black line, so
the car will Drive along the black line. From Figure 3.2.19 and
Figure 3.2.20, we know that when a black line is detected, the sensor
captures a value that is low and reads 0 after analog IO. However, to
reduce the error, we set the threshold In 8, to prevent the error
caused by the car to determine the wrong, we can customize the other
values, if the use of digital port to receive the value of the sensor
returns only "0" and "1", but to determine the same way. The reason
why I did not use digital IO, because we use the digital IO port in
other places. * /
{
```

```
   int val=150; /* Set a PWM value, the maximum value of PWM is 255,
but the speed should not be too fast when tracing the car, otherwise
the car will shake more in the tracing process.   analogWrite (M1,0);
   analogWrite(E1, val); //the speed value of motorA is val
   analogWrite (M2,0);
   analogWrite(E2, val); //the speed value of motorB is val
  }

  else  if((right1 <= 8)&&(centre >= 975)&&(left1 >= 975)) / * The
value collected to judge, if the center> = 975 and left1> = 975 are
greater than 975, indicating that the middle and left sensors did not
detect the black line, right1 <= 8 shows the right sensor detects a
black line, then the car Has left to the left, or the black line has
been turning to the right, so the car should turn to the right. * /
  {
    int val=150;
    analogWrite (E1,0);
    analogWrite(M1, val); //the speed value of motorA is val
    analogWrite (M2,0);
    analogWrite(E2, val); //the speed value of motorB is val
  }
   else  if((right1 >= 975)&&(centre >= 975)&&(left1 <= 8)) / * Judge
the collected value, if center> = 975 and right1> = 975 are greater
than 975, indicating that the middle and right sensors did not detect
the black line, left1 <= 8 shows that the left sensor detects the
black line, then the car Has been to the right deviation, or the
black line has turned to the left, so the car should turn left at
this time. * /   {
     int val=130;
     analogWrite (M1,0);
     analogWrite(E1, val); //the speed value of motorA is val
     analogWrite (E2,0);
     analogWrite(M2, val); //the speed value of motorB is val
    }
```

```
  if((right1 <= 8)&&(centre <= 8)&&(left1 <= 8)) / * The value
collected to judge, if the center <= 8, left1 <= 8 and right1 <= 8
are greater than 8, indicating 3 sensors have detected a black line,
then the car has reached the "ten" intersection, because We have only
3 sensors, no way to make more sophisticated judgments, so only let
the car choose to go straight. * /  {
   int val=130;
   analogWrite (M1,0);
   analogWrite(E1, val); //the speed value of motorA is val
   analogWrite (M2,0);
   analogWrite(E2, val); //the speed value of motorB is val
  }
}
```

3.2.4 Ultrasonic Obstacle Avoidance

In this product, we will integrate the ultrasonic module and steering engine together and make the two part working at the same time, which greatly increases the effectiveness of the data and the flexibility of the car, the main working flow: When the power is on, steering engine will automatically rotates to 90 degrees, the MCU will read data from the reflected ultrasonic. If the data is greater than the security value, the car will continue to drive forward, otherwise the car will stop, then the steering engine will rotate 90 degrees to the right. After that, the MCU reads data from the reflected ultrasonic again, the steering engine rotates 180 degrees to the left, then reading data again, the steering engine rotate 90 degrees, the MCU will contrast the two detected data, if the left data is greater than the right data, the car will turn left, otherwise turn right, if the two data are both less than the safety value, the car will turn around.

3.2.4.1 Suite Introduction

1. The steering gear

The steering gear is also called servo motor which is originally used in ships, since it can control the angle continuously through the program, so it has been widely used in intelligent steering robot to achieve all kinds of joint movement, the characteristics steering gear are small volume, large torque, high stability, simple

external mechanical design. Either in hardware or software design, the design of steering engine is an important part of car controlling, the steering gear is mainly composed of the following parts in general, steering wheels, gear group, position feedback potentiometer, DC motor and control circuit(shown in Fig.3.2.22, Fig.3.2.23). Fig.3.2.24 shows the most commonly used 9G steering gear now.

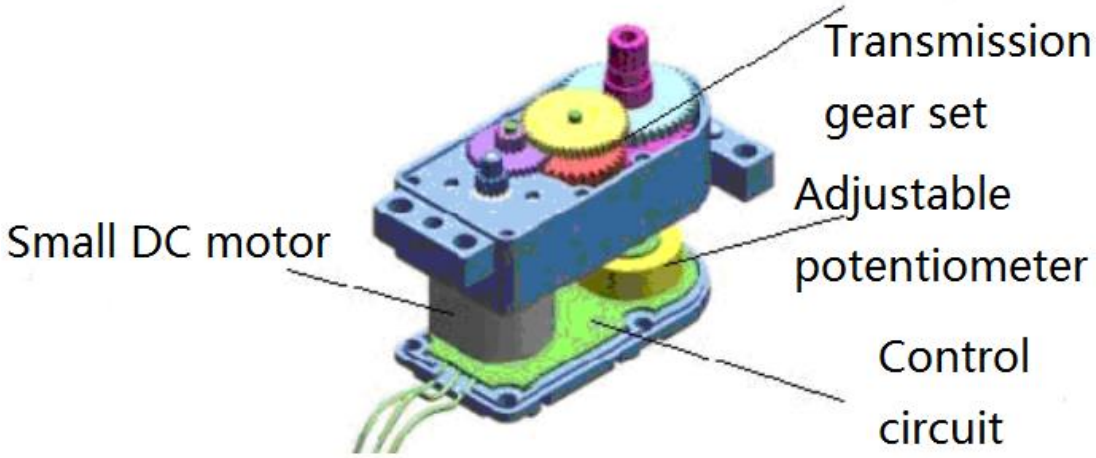

Fig.3.2.22 Diagram of Steering Gear

Fig.3.2.23 Composition of Steering Gear

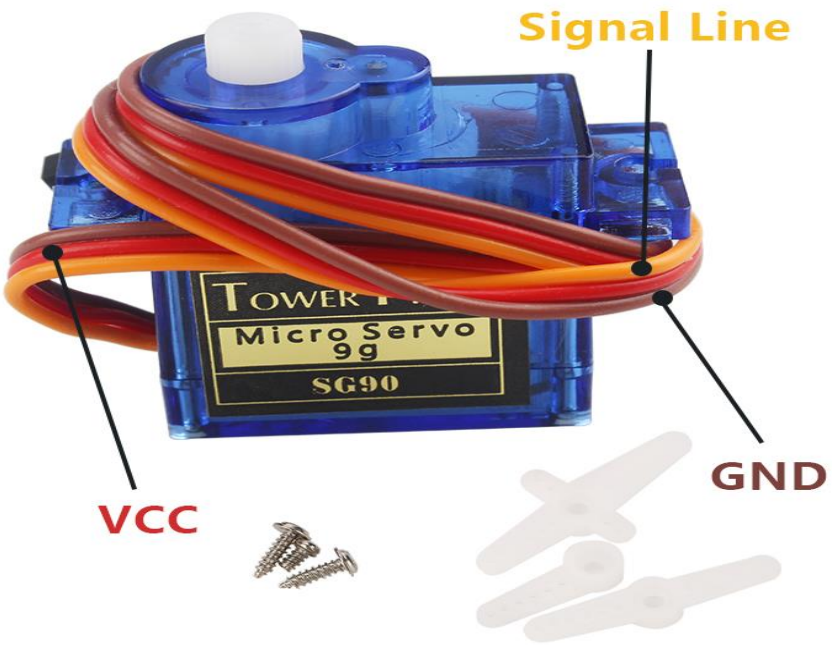

Fig.3.2.24 Physical Map of Steering Gear

2. The ultrasonic

An ultrasonic sensor is a device that transforms other forms of energies into ultrasonic energy with desired frequency, or transforms the ultrasonic energy into other forms of energy with the same frequency. The ultrasonic sensors are commonly classified into two categories, the acoustic type and the hydrodynamic type. Acoustic type mainly has: 1, piezoelectric sensor; 2, magnetostrictive sensor; 3, electrostatic sensor. The hydrodynamic type includes the gas whistle and the liquid whistle. At present most of the ultrasonic sensors are working using piezoelectric sensors. Distance measurement with the ultrasonic is also a hot spot.

In the "Hummer-Bot" car, we use HC-SR04 ultrasonic module which has the 2cm-400cm non-contact distance sensing function, the measurement accuracy can achieve to 3mm; the temperature sensor can correct the measured results using the GPIO communication mode, the module has a stable and reliable watchdog. The module includes an ultrasonic transmitter, receiver and control circuit, which can measure distance and steer like in some projects. The smart car can detect obstacles in front of itself, so that the smart car can change direction in time, avoid obstacles. A common ultrasonic sensor is shown in Fig.3.2.25.

Fig.3.2.25 Physical Map of Ultrasonic Module

3.2.4.2 Suite Parameters

1. Steering gear

The steering gear has three input wires as shown in Fig.3.2.25, the red is power wire, while the brown is the ground, which guarantee the basic energy supply for the steering gear. The power supply has two kinds of specifications (one is 4.8V, the other is 6.0V)which are corresponding to different torque standards, the 6.0V torque is higher than the 4.8V torque; and the another one is the signal control wire, which is generally white in Futaba, orange in JR. Noticing that some of the SANWA's power wires are on the edge rather than the middle which need to be identified, so you need to remember that the red is power wire, the brown is ground wire. The basic parameters of SG90 steering gear is shown in Fig.3.2.26.

Fig.3.2.26 Basic Parameters of SG90 Steering Gear

2. Ultrasonic wave

1, Working voltage: 4.5V~5.5V. In particular, voltage above 5.5V is not allowed definitely

2, Power consumption current: the minimum is 1mA, the maximum is 20mA

3, Resonant frequency: 40KHz;

4, Detection range: 4 mm to 4 meters. Error: 4%. In particular, the nearest distance is 4mm, the longest distance is 4 meters, and the data outputs continuously without setting anything. 5, Temperature measurement range: 0℃to +100℃; precision: 1℃

6, Illumination measurement range: bright and dark;

7, Data output mode: icc and uart (57600bps), users can choose any of them; UART mode uses 7 bytes as a group, and the 3 data stared with 0x55 are the distance values; the 2 data started with 0x66 are the temperature value; the 2 data started with 0x77 are the illumination values. 0x55\0x66\0x77 are the data headers in order to distinguish the 3 data;

8, Supporting the following 2 detection methods: 1, continuous detection; 2, controlled intermittent detection;

9, Distance data format: using mm as the smallest data unit, double byte 16 hexadecimal transmission;

10, Temperature data format: using Celsius degree as the smallest unit, single byte hexadecimal transmission;

11, Light data format: single byte 16 hexadecimal transmission; the value is big when it is dark, small when it is bright;

12, Working temperature: 0℃~+100℃

13, storage temperature: -40 to +120 degrees Celsius

14, Size: 48mm*39mm*22mm (H)

15, The size of fixing holes: 3*Φ3mm; Gap:10mm

3.2.4.3 Working Principle

1. Steering gear

The control signal enters the signal modulation chip by the receiver channel, gets the DC bias voltage. The steering gear has a reference circuit which generates a reference signal with a period of 20ms and a width of 1.5ms. Comparing the obtained DC bias voltage with the voltage of the potentiometer, and obtaining the output voltage difference. Finally, the positive and negative output voltage difference in the motor driver chip decide the positive and negative rotation of motor. When the speed of motor is certain, the cascade reducer gear will drive potentiometer to rotate so that the voltage difference is reducing to 0, the motor will stop rotating.

When the control circuit receives the control signal, the motor will rotate and drive a series of gear sets, the signal will move to the output steering wheel when the motor decelerates. The the output shaft of steering gear is connected with the position feedback potentiometer, the potentiometer will output a voltage signal to the control circuit board to feedback when the steering gear rotates, then the control circuit board

decides the rotation direction and speed of the motor according to the position, so as to achieve the goal. The working process is as follows: control signal→control circuit board→motor rotation→gear sets deceleration→steering wheel rotation→position feedback potentiometer→control circuit board feedback.

The control signal is 20MS pulse width modulation (PWM), in which the pulse width varies linearly from 0.5-2.5MS, the corresponding steering wheel position varies from 0-180 degrees, which means the output shaft will maintain a corresponding certain degrees if providing the steering gear with certain pulse width. No matter how the external torque changes, it only changes position until a signal with different is provided as shown in Fig.3.2.27. The steering gear has an internal reference circuit which can produce reference signal with 20MS period and 1.5MS width, there is a comparator which can detect the magnitude and direction of the external signal and the reference signal, thereby produce the motor rotation signal.

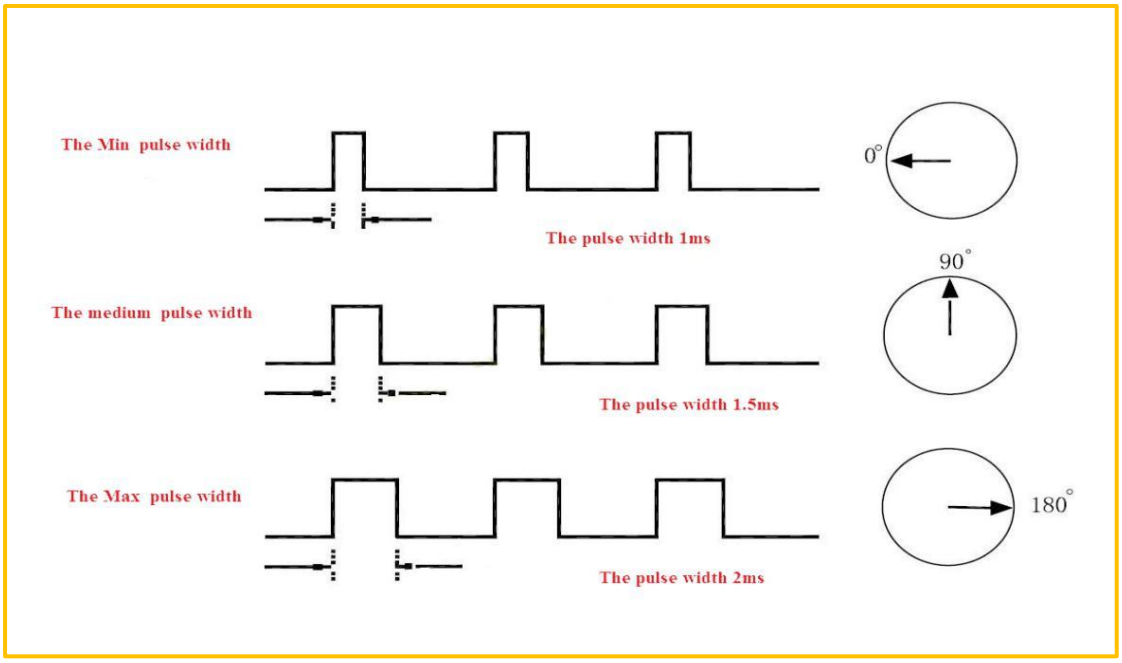

Fig.3.2.27 Relationship between the Motor Output Angle and Input Pulse

2. The ultrasonic

The most commonly used method of ultrasonic distance measurement is echo detection method, the ultrasonic transmitter launches ultrasonic toward a direction and starting the time counter at the same time, the ultrasonic will reflect back immediately when encountering a blocking obstacle, and stopping the counter immediately as soon as the reflected ultrasonic is received by the receiver. The working sequence diagram

is shown in Fig.3.2.28. The velocity of the ultrasonic in the air is 340m/s, we can calculate the distance between the transmitting position and the blocking obstacle according to the time t recorded by the time counters, that is: s=340*t/2.

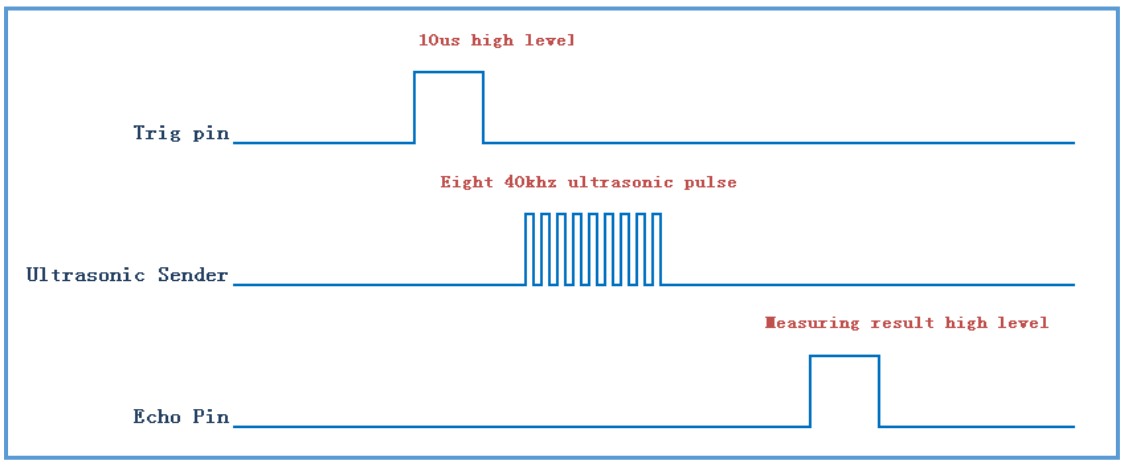

Fig.3.2.28 the Ultrasonic Working Sequence

Let us analyze the working sequence, first the trigger signal starts the HC-RS04 distance measurement module, which means the MCU sends an at least 10us high level to trigger the HC-RS04,the signal sent inside of the module is responded automatically by the module, so we do not have to manage it, the output signal is what we need to pay attention to. The output high level of the signal is the transmitting and receiving time interval of the ultrasonic, which can be recorded with the time counter, and don't forget to divided it with 2.

The ultrasonic is a sound wave which will be influenced by temperature. If the temperature changes little, it can be approximately considered that the ultrasonic velocity is almost unchanged in the transmission process. If the required accuracy of measurement is very high, the measurement results should be to corrected with the temperature compensation. Once the velocity is determined, the distance can be obtained. This is the basic principle of ultrasonic distance measurement module,which is shown in Fig.3.2.29:

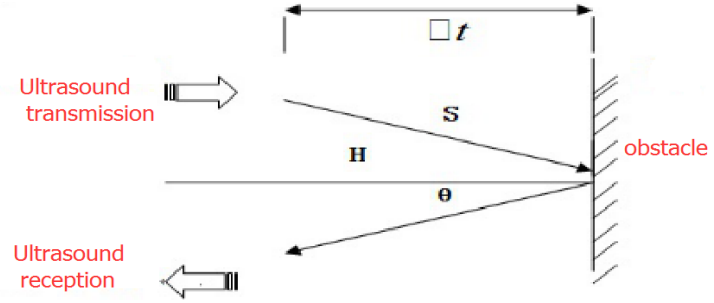

Fig.3.2.29 the Principle of Ultrasonic Distance Measurement Module

The ultrasonic is mainly divided into two parts, one is the transmitting circuit and the other is the receiving circuit, as shown in Fig.3.2.30. The transmitting circuit is mainly composed of by the inverter 74LS04 and ultrasonic transducer T40, the first 40kHz square wave from the Arduino port is transmitted through the reverser to the one electrode on the ultrasonic transducer, the second wave is transmitted to the another electrode on ultrasonic transducer, this will enhance the ultrasonic emission intensity. The output end adopts two parallel inverters in order to improve the driving ability. the resistance R1 and R2 on the one hand can improve the drive ability of the 74LS04 outputting high level, on the other hand, it can increase the damping effect of the ultrasonic transducer and shorten the free oscillation time.

The receiving circuit is composed of the ultrasonic sensor, two-stage amplifier circuit and a PLL circuit. The reflected signal received by the ultrasonic sensor is very weak, which can be and amplified by the two-stage amplifier. PLL circuit will send the interrupt request to the microcontroller when receiving the signal with required frequency. The center frequency of internal VCO in the PLL LM567 is $f_0 = 1/(1.1R_P 1C2)$, the locking bandwidth is associated with C3. Because the transmitted ultrasonic frequency is 40kHz, the center frequency of the PLL is 40kHz, which only respond to the frequency of the signal, so that the interference of other frequency signals can be avoided.

The ultrasonic sensor will send the received the signal to the two stage amplifier, the amplified signal will be sent into the PLL for demodulation, if the frequency is 40kHz, then the 8 pin will send a low level interrupt request signal to the microcontroller P3.3, the Arduino will stop the time counter when detecting low level.

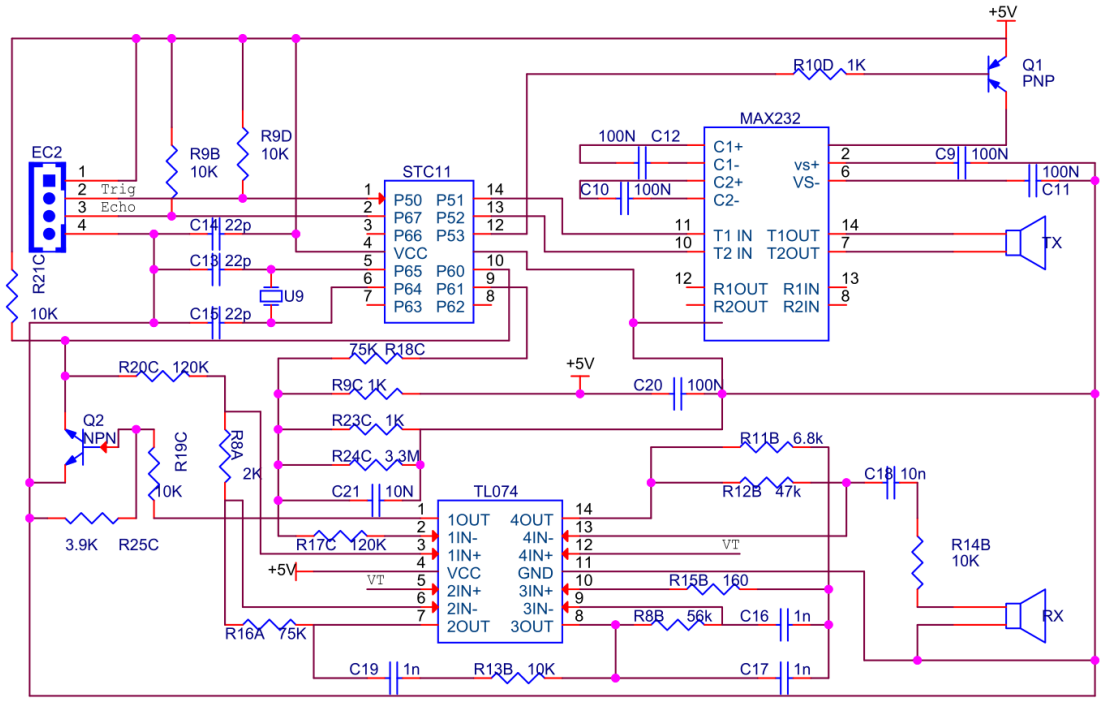

Fig.3.2.30 Schematic Diagram of Ultrasonic Transmitting and Receiving

3.2.4.4 Experimental Procedures

1, Installing the steering gear, ultrasonic module to the car which has been completed in fourth step to the seventh step in 3.1.2) as shown in Fig.3.2.31.

2. Connecting the steering gear and ultrasonic module to the Arduino motherboard as shown in Fig.3.2.32.(you can choose other IO ports according to your own ideas).

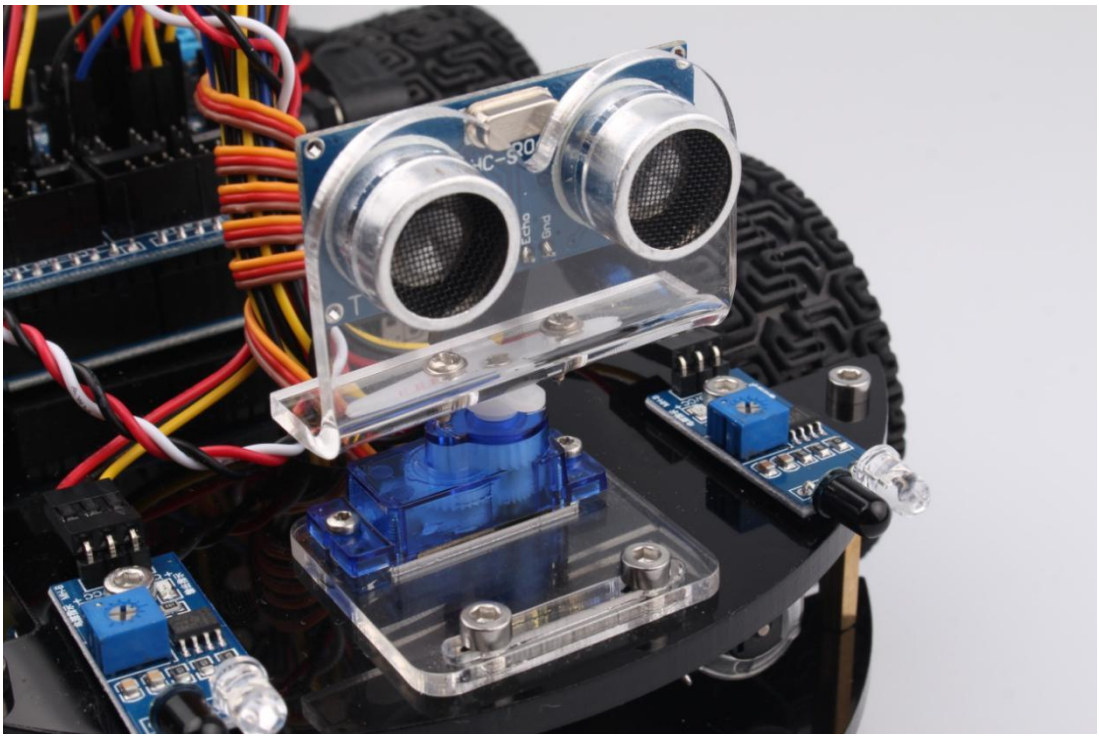

Fig.3.2.31 Installation Diagram of the Steering Gear and Ultrasonic Module

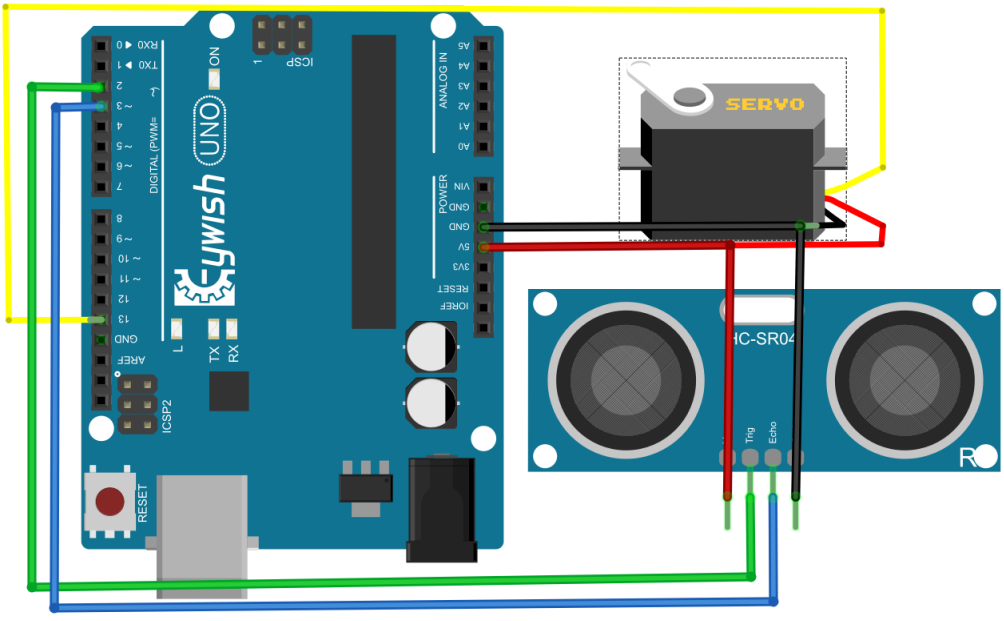

Fig.3.2.32 Wiring of the Steering Gear and Ultrasonic Module

3.2.4.5 Software Design

1. Diagram of the program
2. Introduction of the program

```
#include <Servo.h>/* In this section, we use the steering gear, so we
need to call the steering gear library file. As for what is in the
library file, we will not study it. Interested friends can drive for
research. We have put this library files on the CD-ROM, we need to
copy this folder to the Arduino IDE installation path "libraries"
folder, otherwise the program can not compile. * /
Servo head;

int E1 = 5; //PWMA
int M1 = 9; //DIRA****************************************left
int E2 = 6; //PWMB
int M2 = 10; //DIRB***************************************right
/* Define 4 motor control terminals, connected to IN1-IN4 on the
motor drive board. * /
const int TrigPin = 2;
const int EchoPin = 3; /* Define the sensor's 2 control pins to
connect to pins 2 and 3 on the Arduino. * /
float da;
float dl;
float dr; / * Define three variables, used to store the servo at
0,90,180 degrees, the value collected by the ultrasonic module, da is
the value collected by the ultrasonic 90 degrees servo, dl is the
steering servo 180 degrees ultrasonic acquisition To the value, at
this point the steering gear has turned to the left of the car. da
for the servo 0 degrees ultrasonic collected value, then the steering
gear has turned to the right side of the car. * /
void setup()
{
  Serial.begin(9600); / * Set the baud rate to 9600, use "Serial
Monitor" to check the data during debugging * /
  head.attach(13); / * Define the control pin of the servo as pin 13*
/
  pinMode(E2, OUTPUT);
  pinMode(E1, OUTPUT);
```

```
  pinMode(M1, OUTPUT);
  pinMode(M2, OUTPUT);
  pinMode(TrigPin, OUTPUT);
  pinMode(EchoPin, INPUT); / * Define two ultrasonic working mode. *
/
  head.write(80); / * The servos swivel to 90 (center) during
initialization, because some servos may have errors, so they are not
necessarily centered at 90 degrees, so be fine-tuned where the servos
are centered at 80 degrees. * /
  delay(1000);
}

void loop()
{
  analogWrite(TrigPin, 0); // Low high and low send a short pulse to
TrigPin)
  delayMicroseconds(2);
  analogWrite(TrigPin, 255);
  delayMicroseconds(10);
  analogWrite(TrigPin, 0);
  da = pulseIn(EchoPin, HIGH) / 58.0; // Convert the echo time to cm

  if (da >= 50 && da <= 2000) / * Judge the collected value, da> = 50
&& da <= 2000, meaning that when the distance between the current
obstacle and the car is greater than or equal to 50, and less than or
equal to 2000cm, execute the following program in {} * /
   {
     int val=150; / * When the straight line has a PWM value of 150,
if the value is too high, the speed of the car will be very fast,
which may lead to the car can not hit the obstacle in time when it
encounters the obstacle. * /     digitalWrite(M1,0);
     analogWrite(E1, val); //the speed value of motorA is val
     digitalWrite(M2,0);
     analogWrite(E2, val); //the speed value of motorB is val
```

```
    Serial.print("Distance = ");
    Serial.print(da);
    Serial.print("    ");
    Serial.println("Moving advance 50");
    delay(500); / * If the distance is more than 50cm, move forward
and output "Moving advance 50", indicating that the obstacle is more
than 50cm from the car
  }
  if (da <40 && da >30) / * Judge the collected value, da <50 && da>
30, meaning that when the distance between the frontal obstacle and
the car is greater than 30, and less than 40cm, execute the following
program in {} * /
  {
    int val=130;
    digitalWrite(M1,0);
    analogWrite(E1, val); //the speed value of motorA is val
    digitalWrite(M2,0);
    analogWrite(E2, val); //the speed value of motorB is val
    Serial.print("Distance = ");
    Serial.print(da);
    Serial.print("    ");
    Serial.println("Moving advance40");
    delay(500);  / * If the distance is more than 40cm, move forward
and output "Moving advance 40", indicating that the obstacle is more
than 40cm from the car


  }
  else if (da <= 20) / * The collected value is judged, da <= 20,
meaning that when the current obstacle and the car is less than 20cm,
execute the following program in {}, the distance between the car and
the obstacle has exceeded the safety value, So the car stopped
forward * /
  {
    int val=0;
```

```
    digitalWrite(M1,0);
    analogWrite(E1, val); //the speed value of motorA is 0
    digitalWrite(M2,0);
    analogWrite(E2, val); //the speed value of motorB is 0
    Serial.print("Distance = ");
    Serial.print(da);
    Serial.print("    ");
    Serial.println("Stopped");// If the distance is less than 20cm,
the car will stop and output "Stopped"
    delay(500);
    head.write(180); / * Servo rotated 90 degrees from the original
to 180 degrees, the left side of the car * /
    delay(1000);
    analogWrite(TrigPin, 0); // Low high and low send a short pulse
to TrigPin
    delayMicroseconds(2);
    analogWrite(TrigPin, 255);
    delayMicroseconds(10);
    analogWrite(TrigPin, 0);
    dl = pulseIn(EchoPin, HIGH) / 58.0; // Convert the echo time to
cm
    Serial.print("Left distance = ");
    Serial.print(dl);
    Serial.print("  "); / * Ultrasonic acquisition of the left side
of the car and obstacles distance, and then assigned to dl, then
print on the "Serial Monitor" * /
    head.write(0); / * Servo steering from the original 180 degrees
to 0 degrees, the right side of the car * /
    delay(1000);
    analogWrite(TrigPin, 0); // Low high and low send a short pulse
to TrigPin
    delayMicroseconds(2);
    analogWrite(TrigPin, 255);
    delayMicroseconds(10);
```

```
    analogWrite(TrigPin, 0);
    dr = pulseIn(EchoPin, HIGH) / 58.0; // Convert the echo time to
cm
    Serial.print("Right distance = ");
    Serial.print(dr);
    Serial.print("  ");
    Serial.println();/*Ultrasonic acquisition of the distance between
the right side of the car and the obstacle, and then assigned to dr,
and then print the distance on the "Serial Monitor" * /
    head.write(80);    // head steering back, that is, when the
initialization 80 degrees position
    if (dl >= 20 && dl <= 1000 && dl > dr)
    {
      digitalWrite(M1,0);
      analogWrite(E1, 180); //the speed value of motorA is 180
      digitalWrite(M2,180); //the speed value of motorB is 180
      analogWrite(E2, 0);
      Serial.println("Turning left1");
      delay(200);     // determine the left and right distance if the
left is larger than the left
     }
    else if (dl >= 1000)
   {
     digitalWrite(M1,180); //the speed value of motorA is 180
     analogWrite(E1, 0);
     digitalWrite(M2,0);
     analogWrite(E2, 180); //the speed value of motorB is 180
     Serial.println("Turning right1");
     delay(200);
    // Special case If the left return distance is greater than 1000,
the probe is blocked and turn right at this moment
     }
    else if (dr >= 20 && dr <= 1000 && dr > dl)
   {
```

```
      digitalWrite(M1,180); //the speed value of motorA is 180
      analogWrite(E1, 0);
      digitalWrite(M2,0);
      analogWrite(E2, 180); //the speed value of motorB is 180
      Serial.println("Turning right2");
      delay(200);      // Judge about the distance if the right side
then turn right
    }
     else if (dr >= 1000)
   {
     digitalWrite(M1,0);
     analogWrite(E1, 180); //the speed value of motorA is 180
     digitalWrite(M2,180); //the speed value of motorB is 180
     analogWrite(E2, 0);
     Serial.println("Turning left2");
     delay(200);
     // Special case If the return distance on the right is more than
1000, then the probe is blocked and turn left at this moment
    }
   else if (dr <= 20 && dl <= 20)
  {
    digitalWrite(M1,255); //the speed value of motorA is 255
    analogWrite(E1, 0);
    digitalWrite(M2,0);
    analogWrite(E2, 255); //the speed value of motorB is 255
    Serial.println("Turning around");
    delay(700);
    // turn around if both sides are less than 20cm in distance
   }
 }
}
```

In front the sections, we focus on the "automatic driving", and they are obstacle avoidance experiments. We didn't seem to have relationship with the car, it is lack of fun. So in the next few sections, we will develop the car from other aspects to make

sure that we are able to control the car personally, then we will start from the "infrared remote control", followed by "2.4G handle remote control" and the last is "mobile phone Bluetooth control".

3.2.5 Infrared Remote Control

3.2.5.1 Suite Introduction

Infrared remote control is widely used in every field which is known to everyone, since it can control other electrical appliances, naturally it can control the Hummer-Bot car. Let us take a look at the infrared remote control first:

Infrared wireless remote control kit includes Mini ultra-thin infrared remote controller and 38KHz infrared receiving module, the remote controller has 17 function keys, the transmission distance is up to 8 meters which is very suitable for controlling equipment indoor. The infrared receiving module can receive 38KHz modulation remote control signal. Through the Arduino programming, the decoding operation of the remote control signal can be realized so as to produce all kinds of remote control robot and interactive works. The suite is shown in Fig.3.2.33.

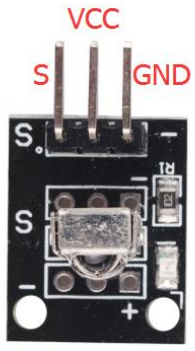

Fig.3.2.33 Physical Map of Remote Control Suite

Infrared remotecontrol system is mainly divided into modulation, transmitting and receiving parts. The transmitting part is mainly composed of keyboard, remote control specific integrated circuit, exciter and infrared light emitting diode. The integrated circuit is the core part of the launch system which consists internal oscillation circuit, timing circuit, scanning signal generator, key input encoder, instruction decoder, user code converter, digital modulation circuit and buffer amplifier and so on. It can produce a key scanning pulse signal, translate the key code, then obtain remote control commands of the keys by telecommand encoder (remote control encoding pulse). Through pulse amplitude modulation of the 38KHZ carrier signal, the infrared diode can transmit infrared remote control signal.

In the infrared receiver, photoelectric converter (usually a photodiode or photoelectric triode, here we use PIN photodiode) converts the received infrared light instruction signal into a corresponding electrical signal. The received signal is very weak and interference is particularly large, in order to achieve the accurate detection and signal conversion, in addition to the infrared photoelectric conversion device with high performance, choosing the reasonable circuit design with good performance is also required. The most common photoelectric conversion device is a photodiode. When the photosensitive surface of the PN junction is irradiated by light, the semiconductor material of PN junction absorbs light energy and converts the light energy into electric energy. When the reverse voltage is added to the photodiode, the reverse current in the diode will change with the change of the incident light intensity. The larger the radiation intensity is, the larger the reverse current will be, the reverse current of the photoelectric varies with the incident light pulse.

In the Hummer-Bot car, the integrated infrared receiving head has three pins, including the power supply pin, grounding and signal output pin. The circuit is shown in Fig.3.2.34. Ceramic capacitors is a decoupling capacitor which can filter the output signal interference. The 1 end is the output of the demodulation signal,which is directly connected to the number 2 port on the Arduino. When the infrared coded signal is transmitted, it will be processed by the infrared joint, then outputs the square wave signal, and directly supplied to the Arduino, and the corresponding operation is carried out to control the motor.

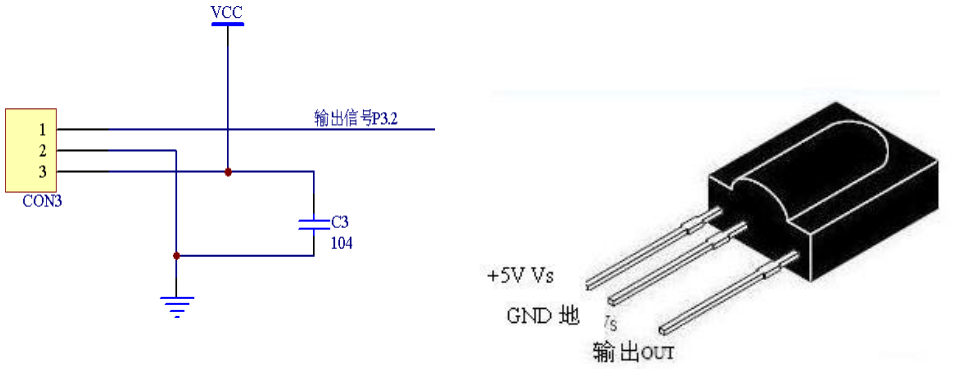

Fig.3.2.34 Circuit Diagram and Physical Map of Infrared Receiving Head

3.2.5.3 Working Principle

The remote control system in general composed of the remote controller (transmitter), and receiver, when you press any button on the remote control, it will generate the corresponding encoding pulse,and output various control pulse signals based on the infrared, infrared monitor diode sends the signal to the the amplifier and the pulse amplitude limiter, the limiter controls the pulse amplitude at a certain level, regardless of the distance of infrared transmitter and receiver. AC signal enters the band-pass filter which can pass the 30KHZ to the load wave 60KHZ, and enters the comparator through the demodulation circuit. The comparator outputs high or low level and restores the output signal waveform. The system procedure diagram is shown in Fig.3.2.35.

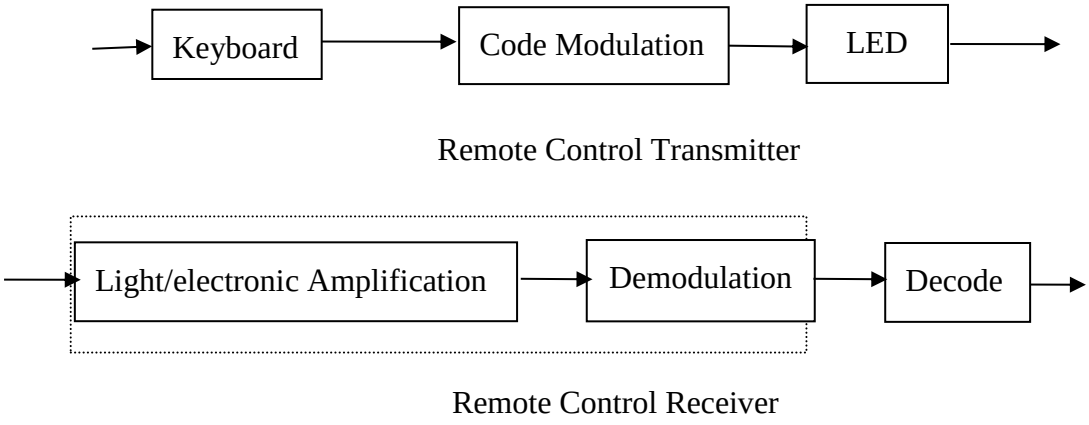

Fig.3.2.35 Remote Control System Diagram

3.2.5.4 Experimental Procedures

1, Installing the infrared receiving head on the development board (if it has been installed in the the eighth step in "3.1.2", please ignore. The complete installation is shown in Fig.3.1.26.

2, Referring to Fig.3.2.36 and connecting the infrared receiving module to the Arduino board (you can choose other IO ports according to your own ideas)

Note: Do not reverse power line, otherwise the receiving head will burn up.

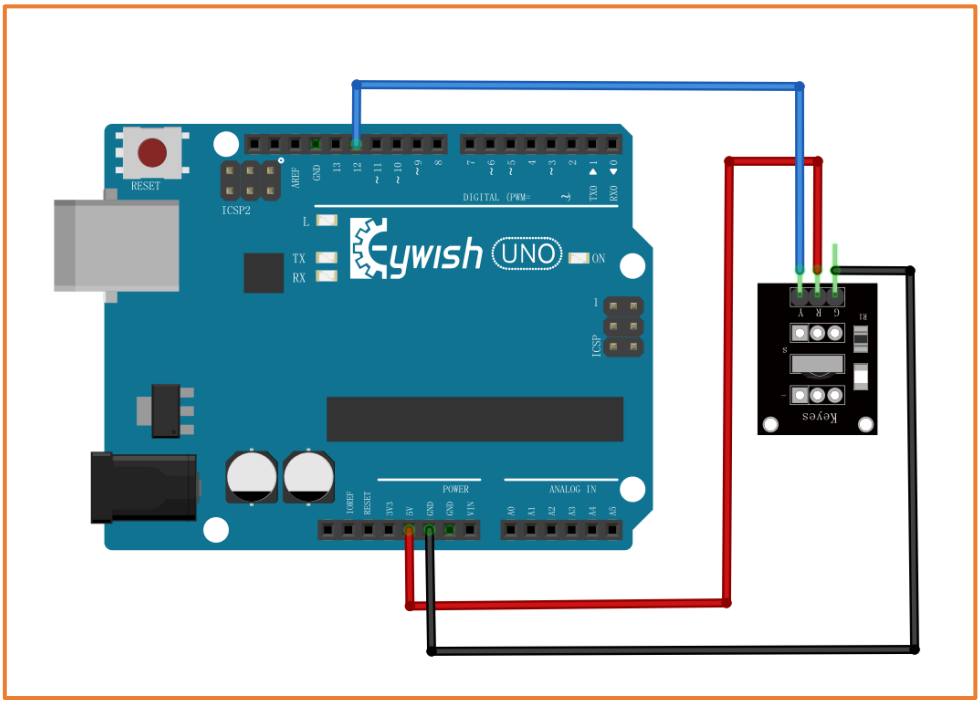

Fig.3.1.36 Infrared Module Connection Diagram

3, Copying the following program to IDE (you can also directly open the matching program in the CD), and downloading to the development board, pulled out the transparent plastic sheet marked as "1" in the Fig.3.2.33. Then opening the serial port monitor, observing and recording the values on it while pressing keys on the remote control towards the receiving head as shown in Fig.3.2.37.

```
#include <IRremote.h>
int RECV_PIN = 12; // Define the IR receiver pin to be 12
IRrecv irrecv(RECV_PIN);

decode_results results;
void setup()
```

```
{
  Serial.begin(9600);
  irrecv.enableIRIn(); // Initialize the infrared receiver
}
void loop() {
  if (irrecv.decode(&results))
{
    Serial.println(results.value, HEX); // Output the receive code in
hexadecimal
     Serial.println();// Add a blank line for easy viewing of the
output    irrecv.resume(); // Receive the next value  }
}
```

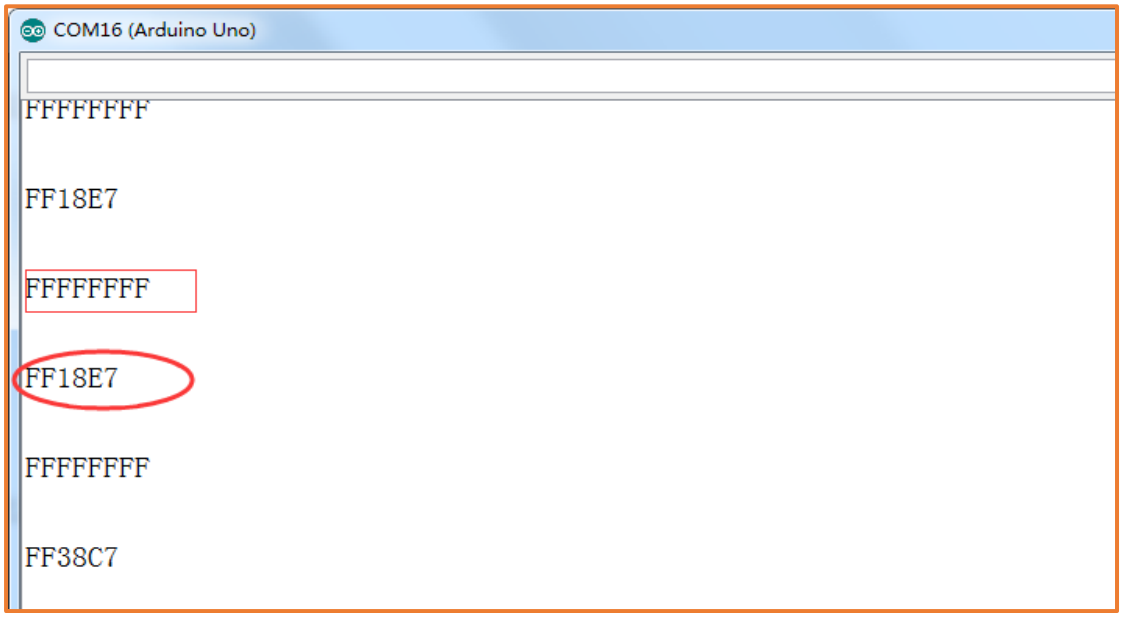

Fig.3.2.37 Remote Encoding Query

In Fig.3.2.37, we can see the two value "FFFFFFFF" and "FF18E7", "FF18E7" is the code of a key on the remote control, "FFFFFFFF" means that the code has been received, waiting to receive the next code.

3.2.5.5 Software Design

```
#include <IRremote.h>*/ In this section, we use infrared remote
control, so we need to call the corresponding library file, as for
what is in the library file, we will not study, and interested
friends can drive research. We have put this library files on the CD-
```

```
ROM, we need to copy this folder to the Arduino IDE installation path
"libraries" folder, otherwise the program can not compile. * /
int E1 = 5; //PWMA
int M1 = 9; //DIRA****************************************left
int E2 = 6; //PWMB
int M2 = 10; //DIRB***************************************right
int RECV_PIN = 12;
long expedite1 = 0xFF6897; / * Define a long integer expedite1
variable, and assign this variable 0xFF689, FF689 is the infrared
remote control button encoding * /
long expedite2 = 0xFFB04F;
long advence = 0xFF18E7;
long back = 0xFF4AB5;
long stop = 0xFF38C7;
long left = 0xFF10EF;
long right = 0xFF5AA5;

IRrecv irrecv(RECV_PIN);
decode_results results;

void setup()
{
  Serial.begin(9600);
  irrecv.enableIRIn(); // Initialize the infrared receiver
}

void loop()
{
  if (irrecv.decode(&results)) / * Read the value received by the
infrared * /  {
    if(results.value == advence) / * Judgment on the received value,
if this value is advence, execute the following {} command, here is
the forward instruction. * /
    {
```

```
      int val=150;
      analogWrite (M1,0);
      analogWrite(E1, val); //the speed value of motorA is val
      analogWrite (M2,0);
      analogWrite(E2, val); //the speed value of motorB is val
      irrecv.resume();  // Receive the next value
    }
    if(results.value == expedite1) / * Judgment on the value
received, if this value is expedite1, execute the command in {}
below, here is the acceleration 1 command. * /
        {
       int val=200;
       analogWrite (M1,0);
       analogWrite(E1, val);//the speed value of motorA is val
       analogWrite (M2,0);
       analogWrite(E2, val); //the speed value of motorB is val
       irrecv.resume();
     }
    if(results.value == expedite2) / * Judgment on the received
value, if the value is expedite2, execute the command {} below, here
for the acceleration 2 command. * /
        {
       int val=255;
       analogWrite (M1,0);
       analogWrite(E1, val); //the speed value of motorA is val
       analogWrite (M2,0);
       analogWrite(E2, val); //the speed value of motorB is val
       irrecv.resume();
     }
     if(results.value == stop) / * To judge the value received, if
this value is stop, execute the command in the following {}, here is
the stop instruction. * /
     {
       int val=0;
```

```
      analogWrite (M1,0);
      analogWrite(E1, val); //the speed value of motorA is val
      analogWrite (M2,0);
      analogWrite(E2, val);//the speed value of motorB is val
      delay(500);
      irrecv.resume();
    }
    if(results.value == left) / * Judgment on the received value, if
the value is left, execute the command in the following {}, here is
the instruction to the left. * /
   {
     int val=150;
     analogWrite (M1,0);
     analogWrite(E1, val); //the speed value of motorA is val
     analogWrite (E2,0);
     analogWrite(M2, val); //the speed value of motorB is val
     delay(500); / * Rotate 500ms to the left and stop, otherwise the
car will always be spinning around. * /
     analogWrite (M1,0);
     analogWrite(E1, 0); //the speed value of motorA is 0
     analogWrite (M2,0);
     analogWrite(E2, 0); //the speed value of motorB is 0
     analogWrite(A1,180);
     irrecv.resume();
   }
   if(results.value == right) / * Judgment on the received value, if
the value is right, execute the command in the following {}, here is
the command to the right. * /
      {
     int val=150;
     analogWrite (E1,0);
     analogWrite(M1, val); //the speed value of motorA is val
     analogWrite (M2,0);
     analogWrite(E2, val); //the speed value of motorA is val
```

```
      delay(500);
      analogWrite (M1,0);
      analogWrite(E1, 0); //the speed value of motorA is 0
      analogWrite (M2,0);
      analogWrite(E2, 0); //the speed value of motorB is 0
      analogWrite(A2,180);
      irrecv.resume();
    }
  if(results.value == back) / * Judgment on the received value, if
the value is back, execute the command {} below, here for the back
instruction. * /
  {
    int val=150;
    analogWrite (E1,0);
    analogWrite(M1, val); //the speed value of motorA is val
    analogWrite (E2,0);
    analogWrite(M2, val); //the speed value of motorA is val
    irrecv.resume(); // 接收下一个值
   }
   Serial.println(results.value, HEX); // Output the receive code in
hexadecimal
   Serial.println();// Add a blank line for easy viewing of the
output    irrecv.resume();
     }
}
```

The above is the infrared remote reference program, you can open it in the CD and download to the development board, the instructions of remote control in shown in Fig.3.2.38.

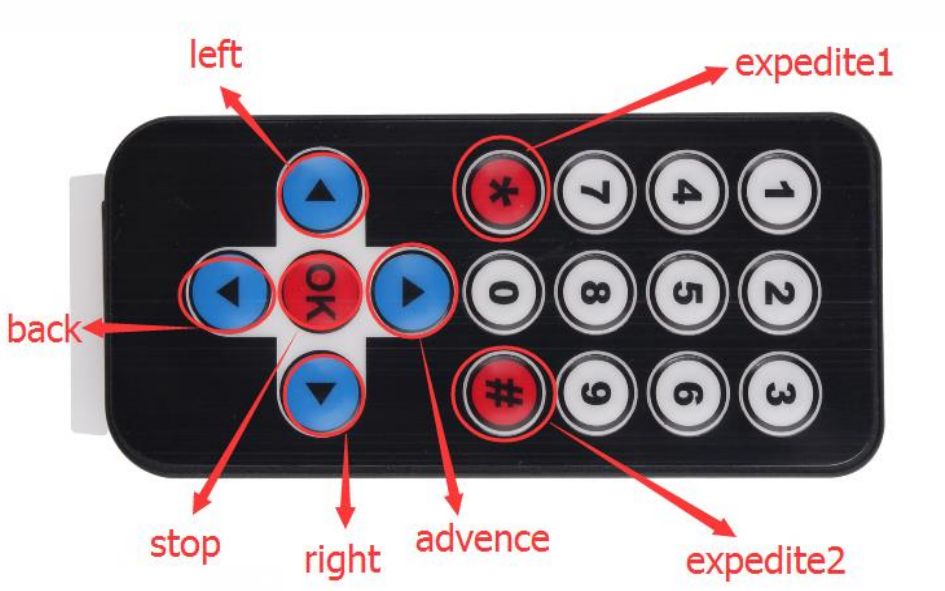

Fig.3.2.38. Infrared Remote Control Instructions

3.2.6 PS2 Handle (Optional)

3.2.6.1 Suite Introduction

PS2 handle is SONY game remote control handle, SONY series game host is very popular in the world. Someone has come up with the idea of the PS2 handle, cracked the communication protocol, so that the handle can be connected to other devices for remote control, such as remote control of our familiar four wheeled vehicles and robots. Its outstanding features are cost-effective,rich buttons and easy to extend to other applications, Fig.3.2.39 shows a commonly used PS2 wireless handle.

Fig.3.2.39 PS2 Wireless Handle

The PS2 handle is composed of the handle and the receiver, the handle uses two AAA batteries as power supply. The controller and receiver use the same power supply whose voltage range is 3~5V, overvoltage, reverse connection will cause the receiver to burn out. There is a power switch on the handle, ON /OFF, when you switch it to ON, the light on handle will not stop flashing until the receiver is searched. In a certain period of time, if the receiver can not be find, the handle will enter the standby mode and the light will burn out, you can press "START" button to wake up the handle.

The receiver is powered by the Arduino as shown in Fig.3.2.40, in the absence of pairing, the green light flashes. When the handle switch is opened, the handle and receiver will pair automatically, and the light will be always on, and the handle is matched successfully. Button "MODE" (The above logo may be "ANALOG" in different handles, but it will not affect the usefulness), you can choose "red light mode" or "green light mode".

Some users see that the handle and receiver cannot match properly! Most of the problems are the incorrect wiring of the receiver and the program problems.

Solution: The receiver should only be connected with power supply(power line must be connected correctly), not any data lines and clock lines. The handle light will be always on when pairing is successful. Then checking whether the wiring and program transplantation are correct again.

Fig.3.2.40 Remote Control Receiver Module

There are 9 interfaces at the end of the receiving head, each of which is shown in the following table:

1	2	3	4	5	6	7	8	9
DI/DAT	DO/CMD	NC	GND	VDD	CS/SEL	CLK	NC	ACK

Note: The appearance of the receiver will be different due to different batches, some with a power light, some without, but the use and definition of the pins are the same.
DI/DAT: The signal flows from the handle to the host. This signal is a serial 8-bit data which is transmitted synchronously to the falling edge of the clock. The read of the signal is completed in the process of clock changing from high to low;
DO/CMD: The signal flows from the host to the handle. The signal is similar to the DI, a serial 8-bit data, which is transmitted synchronously to the falling edge of the clock;
NC: Empty port; .

GND: Ground;

VDD: The 3~5V power supply;

CS/SEL: Providing trigger signals for handles, the level is low during communication;

CLK: The clock signal is sent by the host to maintain data synchronization;

NC: Empty port;

ACK: the response signal from the handle to the host. This signal changes to low in the last cycle of each 8-bit data sending, and the CS remains low. If the CS signal do not remain low, the PS host will try another device in about 60 microseconds. The ACK port is not used in programming.

3.2.6.4 Experimental Procedures

1, The wires are connected to the 1, 2, 4, 5, 6 and 7 pins of the receiving head respectively as shown in Fig.3.2.41.

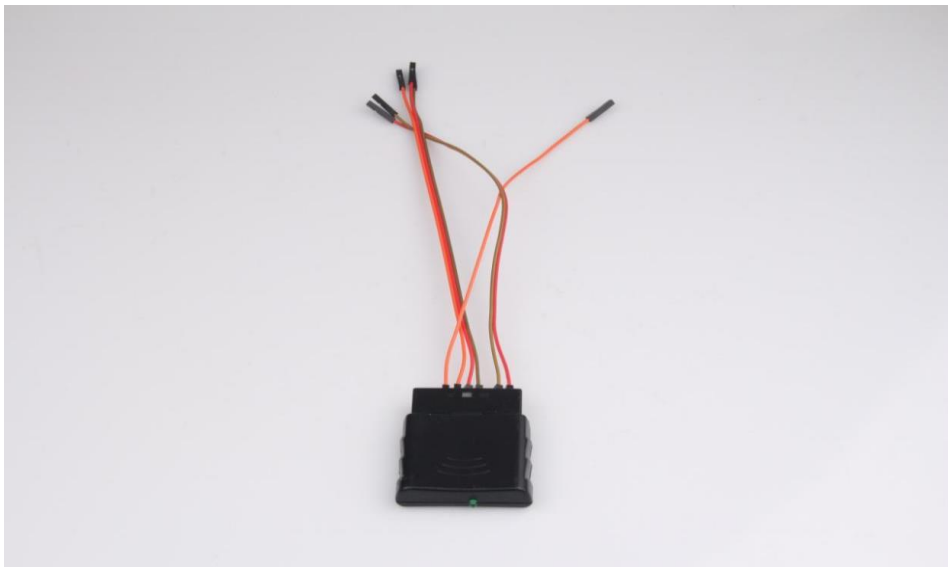

Fig.3.2.41 Wiring of the Receiver Head

2, Fixing the receiving head on the car with cable tie (the red frame area in Fig.3.2.42) as shown in Fig.2.3.43.

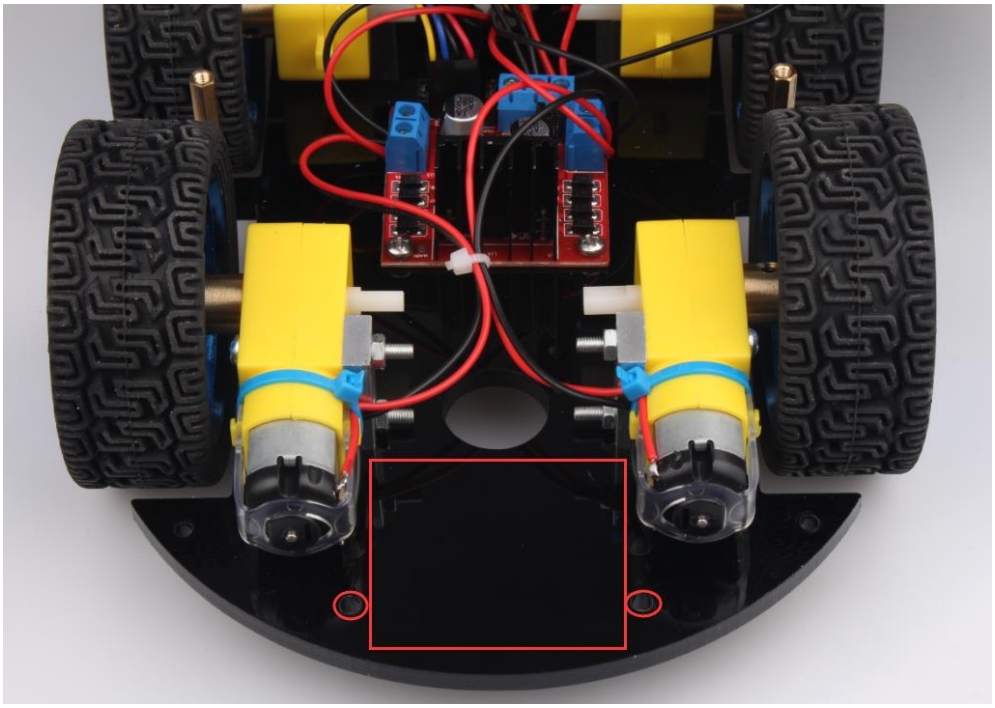

Fig.3.2.42 Receiving Head Position

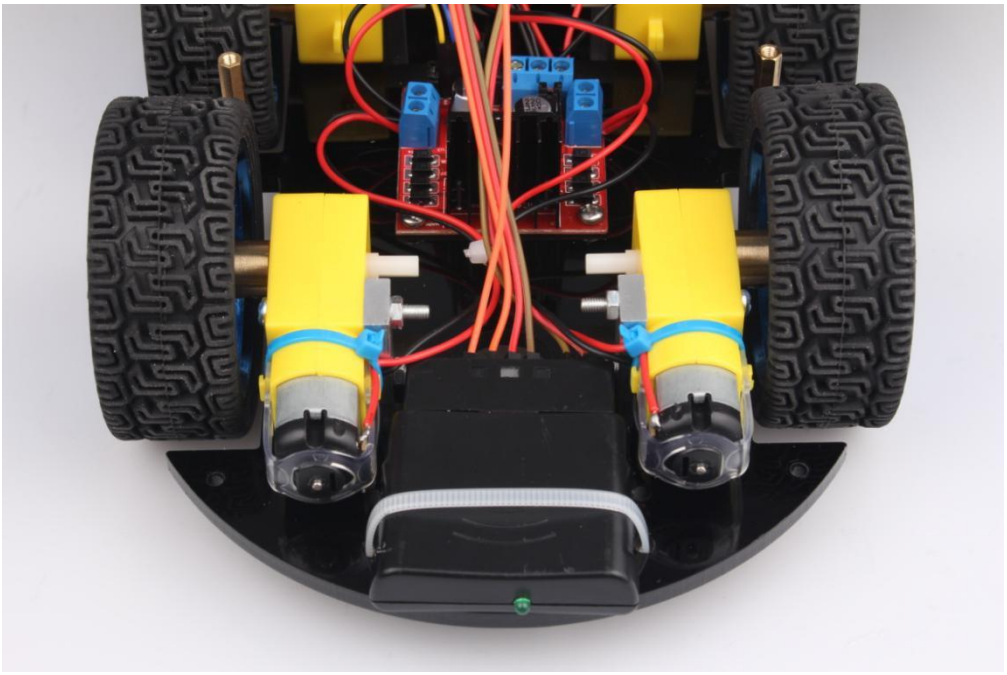

Fig.2.3.43 Installation of Receiving Head

3, Drawing the wire according to the hole at "1" in Fig.3.2.44, the connecting the wire to the Aruino extended board with reference to Fig.2.3.45 as shown in Fig.2.3.44.

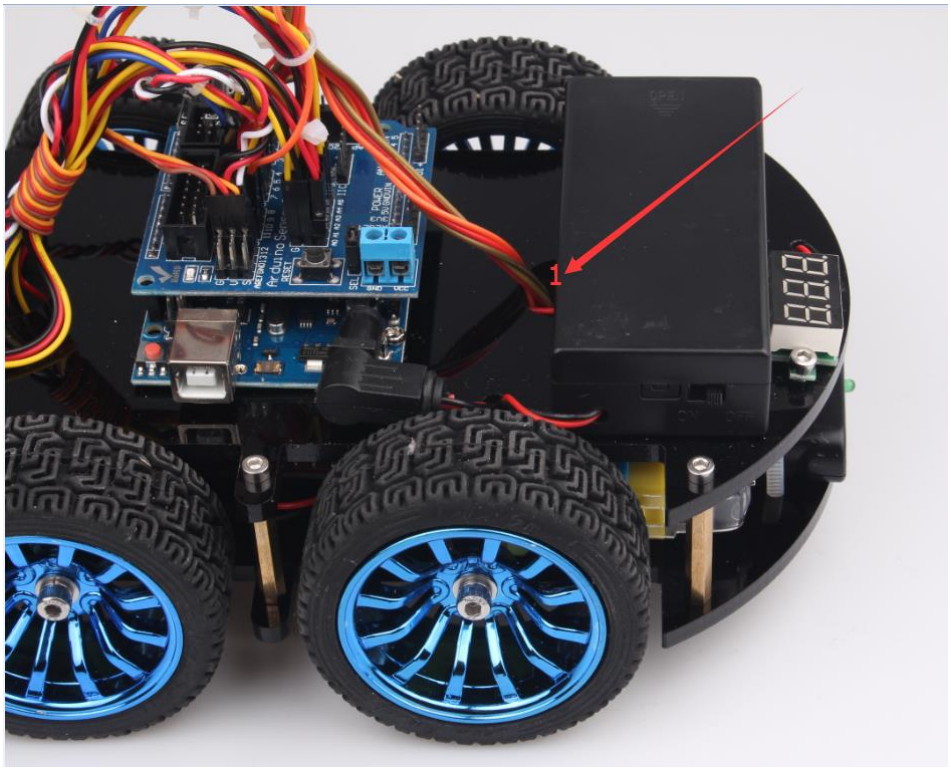

Fig.3.2.44 Physical Map of Wiring

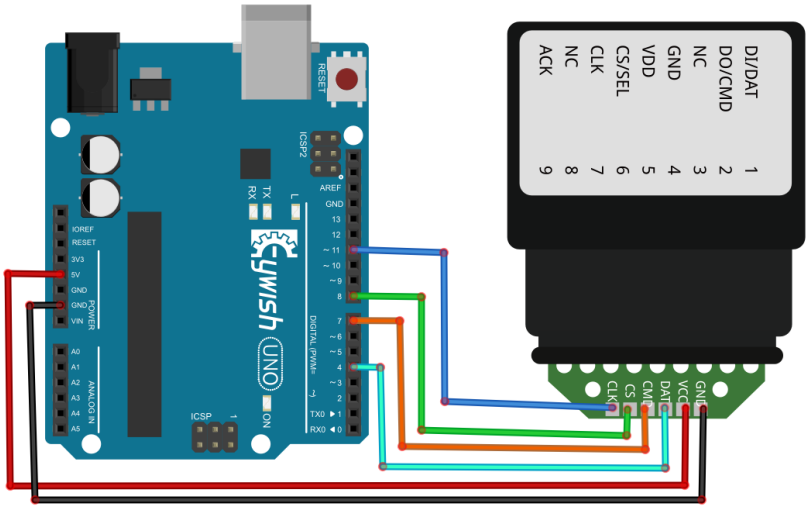

Fig.2.3.45 Diagram of Wiring between Arduino and Receiver Head

4, Opening the "remote control testing program" in the CD, and copying the library folder (PS2X_lib) to the "libraries"folder in the Arduino IDE installation path, as shown in Fig.2.4.14, otherwise the compiler cannot pass. In addition, downloading the program to the Arduino development board, opening the PS2 remote control, if the receiving head and remote control has been connected (or pairing successfully), the receiver head indicator will always be on, otherwise the LED lights will flash

constantly. Finally, we open the serial port monitor, press any button on the remote controller, and we can see the corresponding data on the serial port monitor, such as shown Fig.3.2.45.

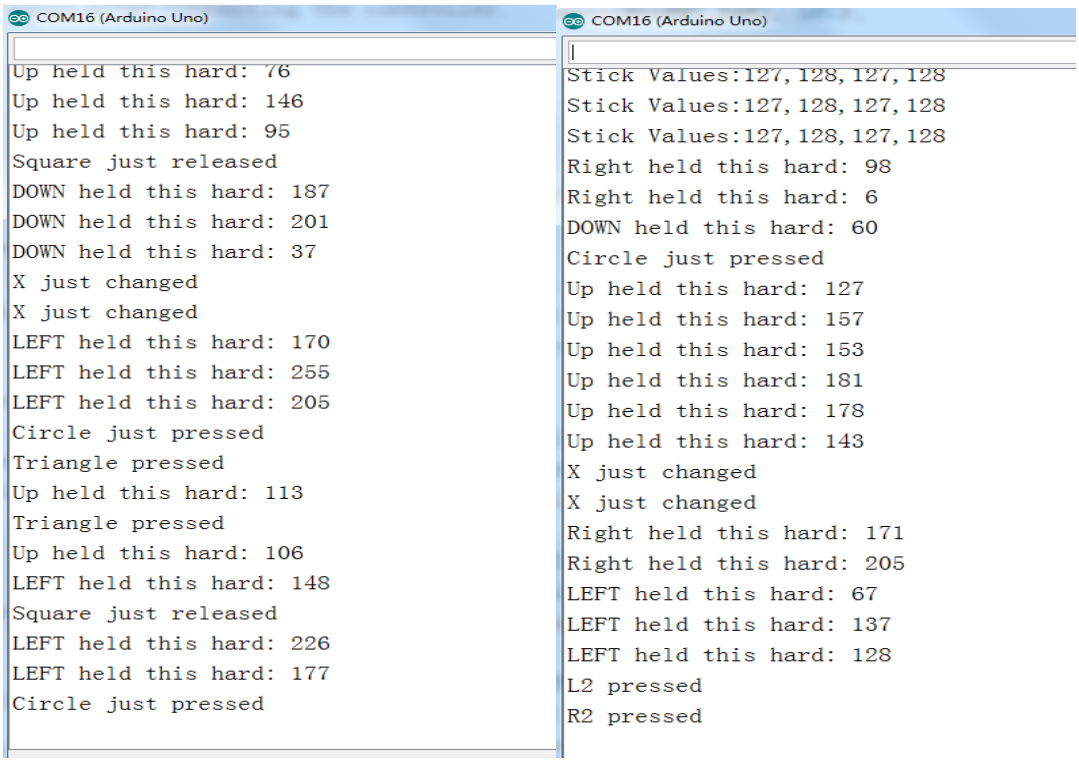

Fig.3.2.45 Data Display in Serial Port Monitor

3.2.6.5 Software Design

```
#include <PS2X_lib.h>/* Copy this file (PS2X_lib) folder to the
"libraries" folder under the Arduino IDE installation path or the
program will not compile. * /
int E1 = 5; //PWMA
int M1 = 9; //DIRA****************************************left
int E2 = 6; //PWMB
int M2 = 10; //DIRB****************************************right
PS2X ps2x;
int error = 0;
byte type = 0;
byte vibrate = 0;
int vb;
int KK;
```

```
void setup()
{
  Serial.begin(9600);
  error = ps2x.config_gamepad(11,7,8,4, true, true);
 / * Set the receiving port on the Arduino * /
}
void loop()
{
  ps2x.read_gamepad(false, vibrate); / * Read the signal received by
the receiver * /
  if(ps2x.Button(PSB_L3)) / * If the received signal is PSB_L3,
execute the command in {}, ie stop, "PSB_L3" is the code returned
when the button on the PS2 handle is pressed, and through the "fourth
step in the experimental step" we can get All key coding * /
  {
   int val=0    ;
   analogWrite (M1,0);
   analogWrite(E1, val); //the speed value of motorA is val
   analogWrite (M2,0);
   analogWrite(E2, val); //the speed value of motorA is val
  }
  if(ps2x.Button(PSB_PAD_UP)) / * If the received signal is
PSB_PAD_UP, execute the command in {}, ie forward, "PSB_PAD_UP" is
the code returned when the button on the PS2 handle is pressed, and
through the "fourth step in the experimental step" we can obtain All
key coding * /
  {
  int val=180    ;
  analogWrite (M1,0);
  analogWrite(E1, val); //the speed value of motorA is val
  analogWrite (M2,0);
  analogWrite(E2, val); //the speed value of motorA is val
   }
  if(ps2x.Button(PSB_R2)||(ps2x.Button(PSB_PAD_RIGHT)))
```

```
  / * If the received signal is PSB_R2 or PSB_PAD_RIGHT, execute the
command in {}, ie, turn right. The reason why two codes are used here
is because we have set two buttons on the PS2 handle for turning
right, Just press one of them to complete the right turn "PSB_R2 and
PSB_PAD_RIGHT" is the code that is returned when the button on the
PS2 handle is pressed. Through the "fourth step in the experimental
step" we can get the code of all the buttons * /
  {
  int val=200;
  analogWrite (E1,0);
  analogWrite(M1, val); //the speed value of motorA is val
  analogWrite (M2,0);
  analogWrite(E2, val); //the speed value of motorA is val
  delay(200);  analogWrite (M1,0);
  analogWrite(E1, 0);
  analogWrite (M2,0);
  analogWrite(E2, 0);
  }
  if(ps2x.Button(PSB_L2)||(ps2x.Button(PSB_PAD_LEFT)))
  / * If the received signal is PSB_L2 or PSB_PAD_LEFT, execute the
command in {}, ie turn left. The reason why two codes are used here
is because we have set two keys on the PS2 handle for turning left,
Just press one of them to complete the turn left * /
  {
    int val=200;
    analogWrite (M1,0);
    analogWrite(E1, val); //the speed value of motorA is val
    analogWrite (E2,0);
    analogWrite(M2, val); //the speed value of motorA is val
    delay(200);    analogWrite (M1,0);
    analogWrite(E1, 0);
    analogWrite (M2,0);
    analogWrite(E2, 0);
 }
```

```
  if(ps2x.Button(PSB_PAD_DOWN)) / * If the received signal is
PSB_PAD_DOWN, execute the command in {} to stop. * /
  {
    int val=180;
    analogWrite (E1,0);
    analogWrite(M1, val); //the speed value of motorA is val
    analogWrite (E2,0);
    analogWrite(M2, val); //the speed value of motorA is val
    }
  if(ps2x.Button(PSB_L1)) / * If the received signal is PSB_L1,
execute the command in {}. * /
  {
   vb = ps2x.Analog(PSS_LY); / * Read the value of PSS_LY, that is,
the joystick value, and assign this value to the variable vb. The
joystick range is 0-255. When you press L1, you can toggle the
joystick to generate the corresponding value. If L1 is not pressed,
dial rocker will not produce the corresponding value. Because PWM is
also 0-255, so we directly convert the value generated by the
joystick into PWM, so as to control the motor speed. Experimental
results are: Press the L1, dial the left rocker, the car can be
accelerated or slowed down in the process of progress. * /
analogWrite (M1,0);
   analogWrite(E1, vb); //the speed value of motorA is vb
   analogWrite (M2,0);
   analogWrite(E2, vb); //the speed value of motorB is vb
  }
  if(ps2x.Button(PSB_R1)) / * If the received signal is PSB_R1,
execute the command in {}. * /
  {
   KK = ps2x.Analog(PSS_RY); / * Read the value of PSS_RY, ie the
joystick value, and assign this value to the variable kk. The
joystick range is 0-255. When you press R1, you can toggle the
joystick to generate the corresponding value. If R1 is not pressed,
dial rocker will not produce the corresponding value. Because PWM is
```

```
also 0-255, so we directly convert the value generated by the
joystick into PWM, so as to control the motor speed. The experimental
result is: press R1, dial the right joystick, the car can be
accelerated or decelerated in the process of receding. * /
   analogWrite(M1,KK); //the speed value of motorA is kk
   analogWrite(E1, 0);
   analogWrite(M2,KK); //the speed value of motorA is kk
   analogWrite(E2,0);
  }
  delay(50);
}
```

In the above program, we used a lot of buttons, but they are all showed in code form and no details to any keys. Now we will know about these buttons, if you download the above program directly to the development board, you can control the car with PS2 handle in accordance with the instructions below as shown in Fig.3.2.46. Of course, we encourage users to write programs, set keys according to their own ideas, so the development of the car will be very meaningful.

Fig.3.2.46 Functions of PS2 Handle Buttons

PS2 handle description:

Mark 1: turn left

Mark 2: turn right

Mark 3: right joystick (Mark 5) control key. When the R1 is pressed, the right joystick will work.

Mark 4: left joystick (Mark 6) control key. When L1 is pressed, the left joystick will work.

Mark 5: right joystick

Mark 6: left joystick

Mark 7: move forward

Mark 8: move backward

Mark 9: power switch (if you do not use the handle, the power switch should be turned off as soon as possible to prevent the handle from sleep state)

3.2.7 Mobile Phone Bluetooth Control

3.2.7.1 Suite Introduction

Bluetooth is a wireless technology standard that enables short distance data exchange between fixed devices, mobile devices and building personal domain networks (using 2.4~2.485GHz ISM band UHF radio waves). Bluetooth technology was originally created by Ericsson in 1994 as an alternative to the RS232 data cable. It is the best choice of wireless transmission which has been applied to all walks of life now. Bluetooth module is mainly to realize the data transmission between host computer and slave computer, there are two kinds of communication methods, one is parallel communication, the other is serial communication.

Transmitting the data of each unit simultaneously is called parallel communication. Parallel communication of Arduino relies on parallel I/O. The biggest advantage of parallel communication is the fast speed of information transmission. The disadvantage is that every bit of the unit information needs a signal line. Therefore, parallel communication wastes materials.

Transmitting the data of each unit bit by bit is called serial communication. Serial communication can be realized by serial connection port. The outstanding advantage of serial communication is that only one pair of transmission lines is needed to transmit information. The disadvantage is that it is slower than parallel communication.

The design of the data transmission in this section is only for command transmission, the data volume is not large,so we will use serial communication to realize the wireless communication between host computer and slave computer, namely MCU serial communication.

Bluetooth module is the most important part of mobile phone Bluetooth control, it has the function of receiving remote control commands. The selection of Bluetooth module should be based on the design scheme, there are several hard demands in material selection: the reaction should be sensitive, easy to use, cost-effective, reliable communication. Through the online information, it is found that HC-05 Bluetooth module is more suitable for the design requirements, the purchase is also convenient and the effective distance is wide.

HC-05 Bluetooth wireless communication module has two working modes, one is command response mode, and the other is automatic connection mode. In the command response mode, the user sends the AT work instruction to the module to set the control parameters of the module and give the control instructions. In the automatic connection mode, the module has three working modes, namely the host(Master), the slave (Slave) and the loop (Loopback) mode. When the work mode is selected, the module will transmit data automatically according to the setting mode. The working state of the module can be dynamically converted by adjusting the input level of the external pin of the module. The physical diagram of module is shown in Fig.3.2.47.

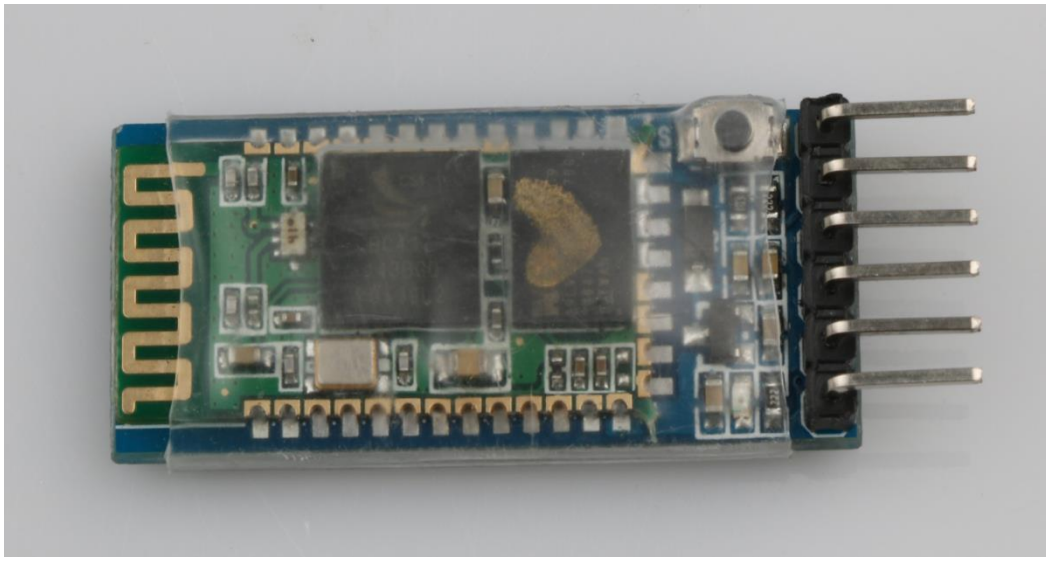

Fig.3.2.47 HC-06 Module

3.2.7.2 Suite Parameters (omitted)

3.2.7.3 Bluetooth protocol

Using Bluetooth to control the car means we use the Android app to control the Bluetooth sending instructions to the Arduino serial port, so as to control the motor's forwarding, reversing, speed and so on. Since the wireless communication is involved, one of the essential issues is the communication problem between the two terminals. But there is no common "language" between them, so designing communication protocols are required to ensure a perfect interaction between Android and Arduino. The main process is: the Android identification terminal packs the detected commands into the corresponding data packets, and then sends them to the Bluetooth module (HC-06). When HC-06 receives the packets, it will transmit them to Arduino through the serial port, then Arduino to analyze the data packets and execute the corresponding actions. The data format sent by the upper computer end (Android) is as follows, which mainly contains 6 fields, we use a structure to represent it

Start_code	Length	Type	Data	Checksum	Tail

```
typedef struct
{
    unsigned char start_code ;      // 8bit 0xAA
    unsigned char type;
    unsigned char addr;
    unsigned short int function;   // 16 bit
    unsigned char *data;           // n bit
    unsigned short int sum;        // check sum
    unsigned char end_code;        // 8bit 0x55
}ST_protocol;
```

The start_code is the beginning part of the packet, for example, the unification is designated as 0xAA.

The type represents the type of the slave device.

The addr is the address of the controlling device.

The function means the functional types of device which need to control, we are currently supporting the following functional types

```
typedef enum
{
    E_BATTERY = 1,
    E_LED = 2,
    E_BUZZER = 3,
    E_INFO = 4,
    E_ROBOT_CONTROL = 5,
    E_ROBOT_CONTROL_SPEED = 6,
    E_TEMPERATURE = 7,
    E_IR_TRACKING = 8,
    E_ULTRASONIC = 9,
    E_VERSION = 10,
    E_UPGRADE = 11,
}E_CONTOROL_FUNC ;
```

The data means the specific control value of a car, such as speed, angle.

The checksum is the xor result of each data bit.

The tail is the end part of the packet. When receiving this data, it means that the packet has been sent, the next packet is ready to be received. We uniformly designate it as 0x55. For example, a complete packet can be such as "AA 01 01 06 50 00 58 55", in which:

"06" is the "device type", such as motor, LED, buzzer and so on. The 06 here refers to the transmission speed, and the 05 refers to the transmission direction.

"50 (or 0050)" is the controlling data, 0x50 in hexadecimal is 80 when converted to binary, which means the speed value is 80. If the data is 05, it means the controlling direction, that is 80 degrees (forward).

"0058" is the check sum, that is, 0x01+0x01+0x06+0x50=0x58.

"55" is the tail of the protocol, indicating the end of data transmission.

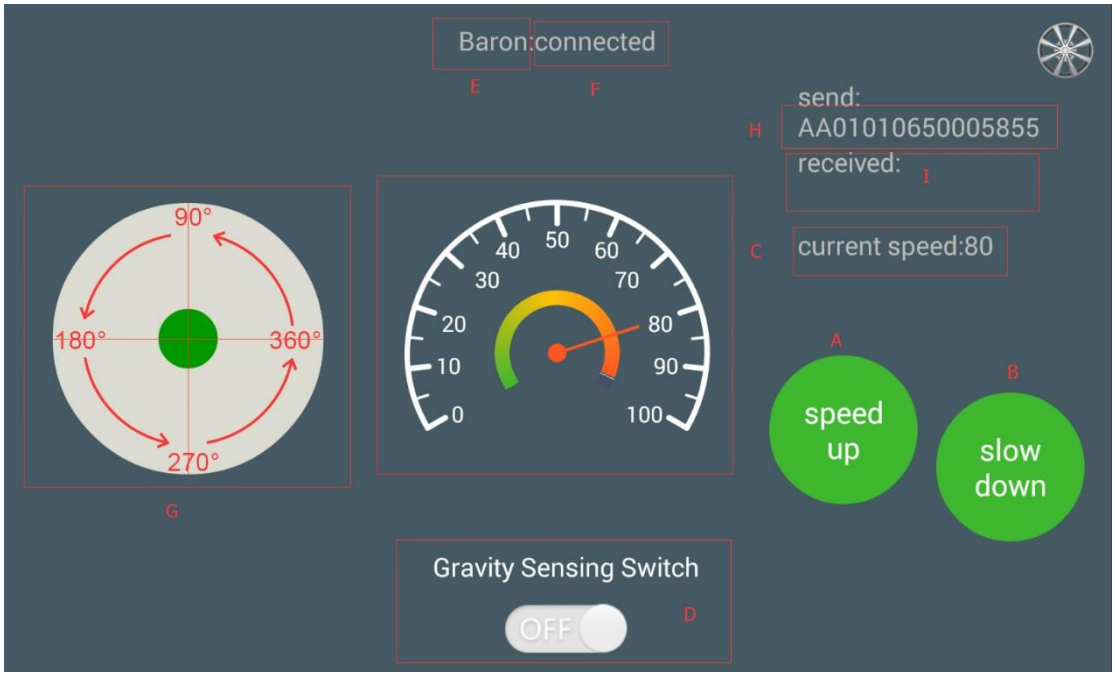

Fig.3.2.48 the Interface of Android APP

In the above Figure.3.2.48:

The "A, B" sections are the acceleration and deceleration buttons.

The "C" section includes the dashboard and the digital display area, and the two parts displaying synchronously. They represents the current speed.

The "D" section is a gravity remote sensing switch which can be switched to the gravity remote sensing mode.

The "E" section represents the Bluetooth name that is currently connected.

The "F" section indicates Bluetooth connection state. If the Bluetooth is not connected, the "disconnected" is displayed here.

The "G" section is a manual rocker, and sliding it allows the car to rotate.

The "I" section is a data return area, such as the current state, speed of the car, etc.

The "H" section is the data packet, for example, the data is "AA 01 01 06 23 00 2B

55". At this time, the speed is 35 (23 is 16 hexadecimal data, which means 35 when converted to 10 hexadecimal).

If the transmitted data is "AA 01 01 05 00 5B 00 62 55", it means that the car is moving forward (05 is the direction control instruction, and the 005B means 91 when converted to binary number. By the Figure.3.2.48 we can know that 91 degree means the car is moving forward).

3.2.7.4 Experimental Procedures

1, Connecting the wire to the Bluetooth module, as shown in Fig.3.2.49.
2, Connecting the other end of the wire to "1" marked in Fig.3.2.50 Connection mode: HC-05 VCC port on Bluetooth module is connected to Arduino 3.6V~6V DC power anode, GND port is connected to the cathode of the DC power, the RXD port is connected to the TXD port on Arduino extended board, TXD port is connected to RXD port on the board, as shown in Fig.3.2.51.
Note: Since Arduino UNO has only one serial port, the Bluetooth must be disconnected from the serial port when downloading the program, otherwise the download will fail.

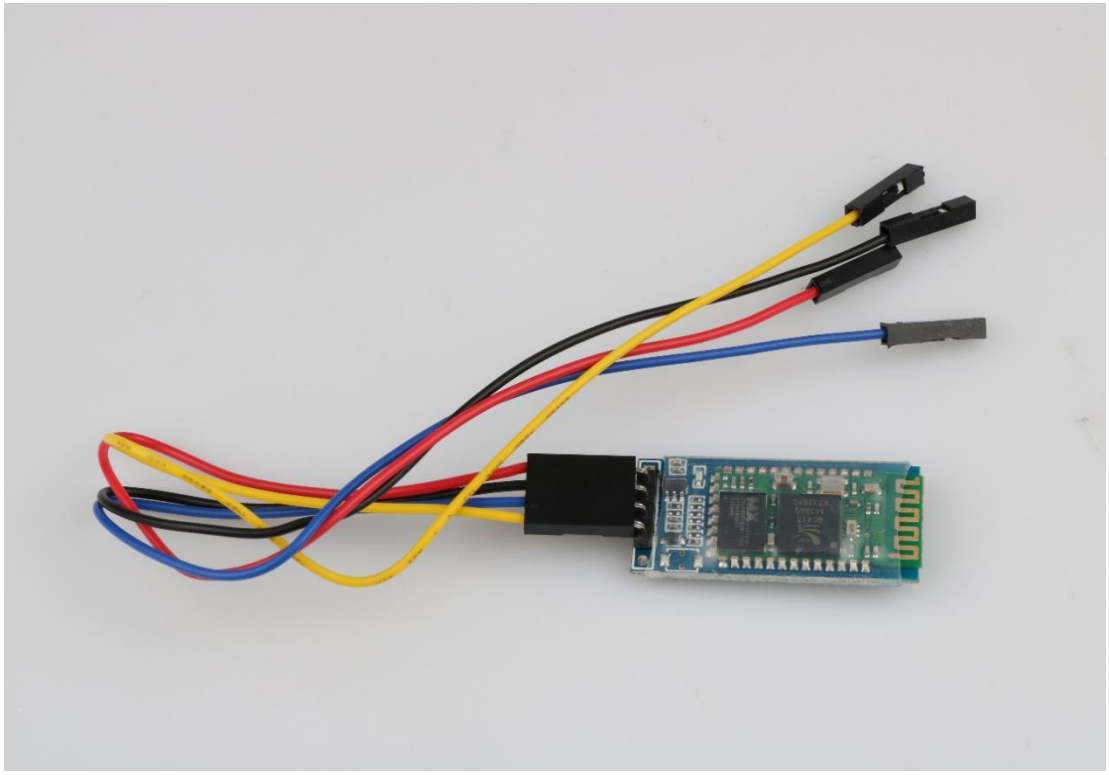

Fig.3.2.49 The Wiring of Bluetooth

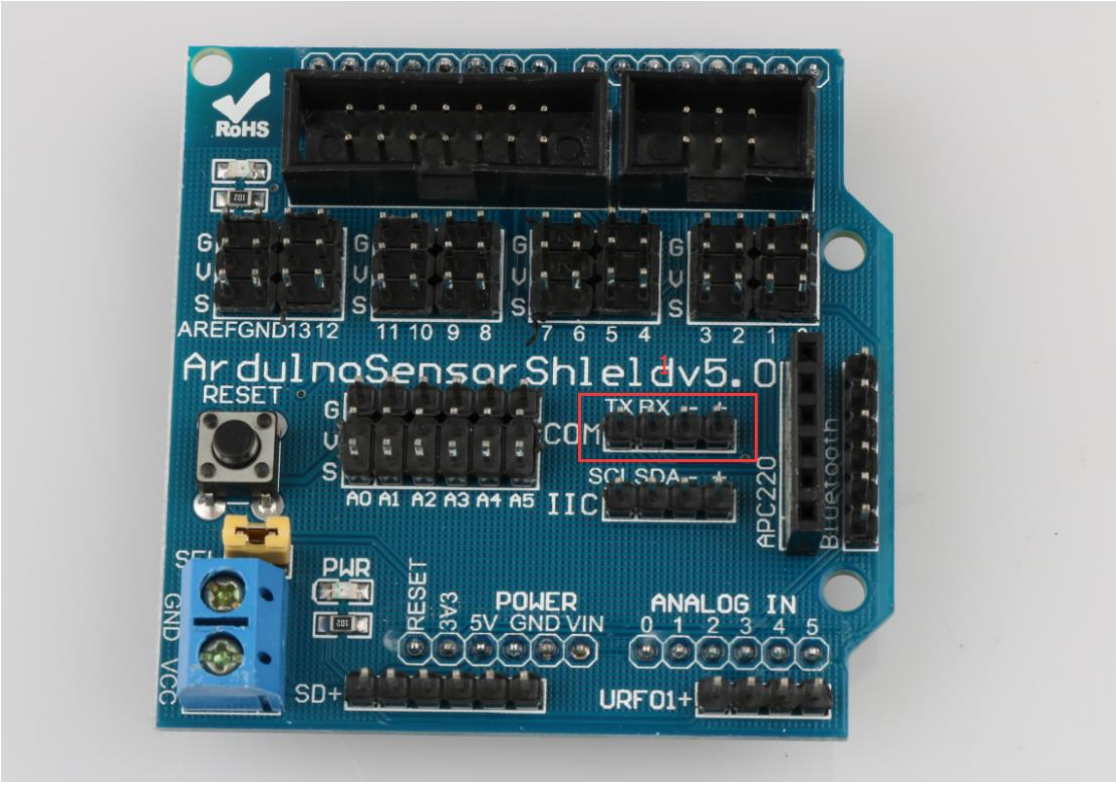

Fig.3.2.50 Wiring Positions of Bluetooth

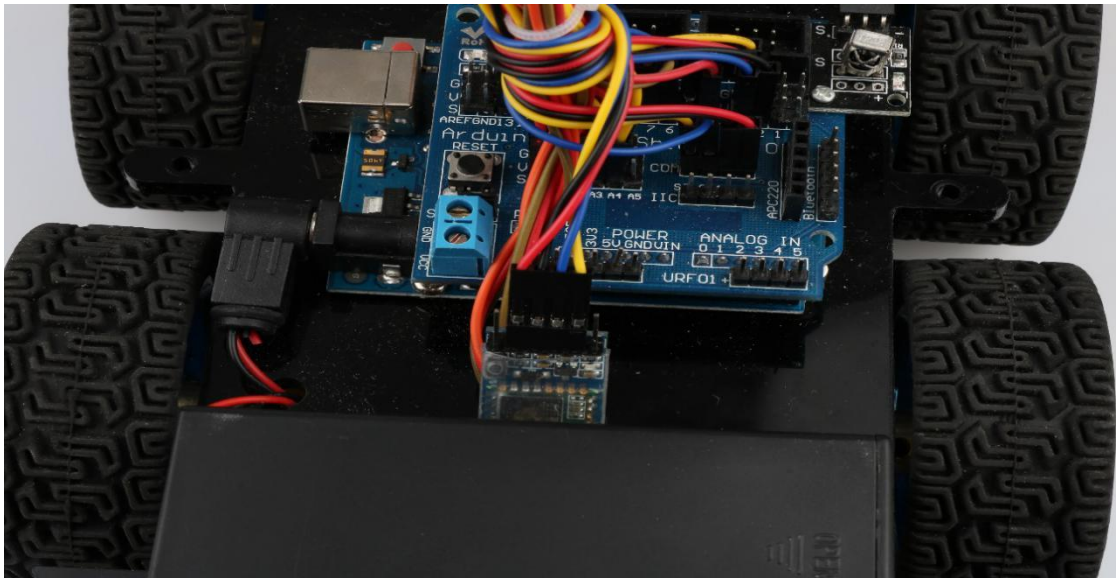

Fig.3.2.51 Installation of Bluetooth Module

3, Opening the mobile phone Bluetooth to find the Bluetooth name and connect (default Bluetooth name is HC-06, password is 1234). When the connection is successful, opening the APP (there is a software for Android mobile phone in the CD, latter we will launch the IOS version) and selecting Bluetooth name in APP and connecting as shown in Fig.3.2.52. You will see that the flashing of the Bluetooth

module indicator slows down, if you have downloaded the program to the development board before, you can use the phone to control the car directly, as shown in Fig.3.2.53.

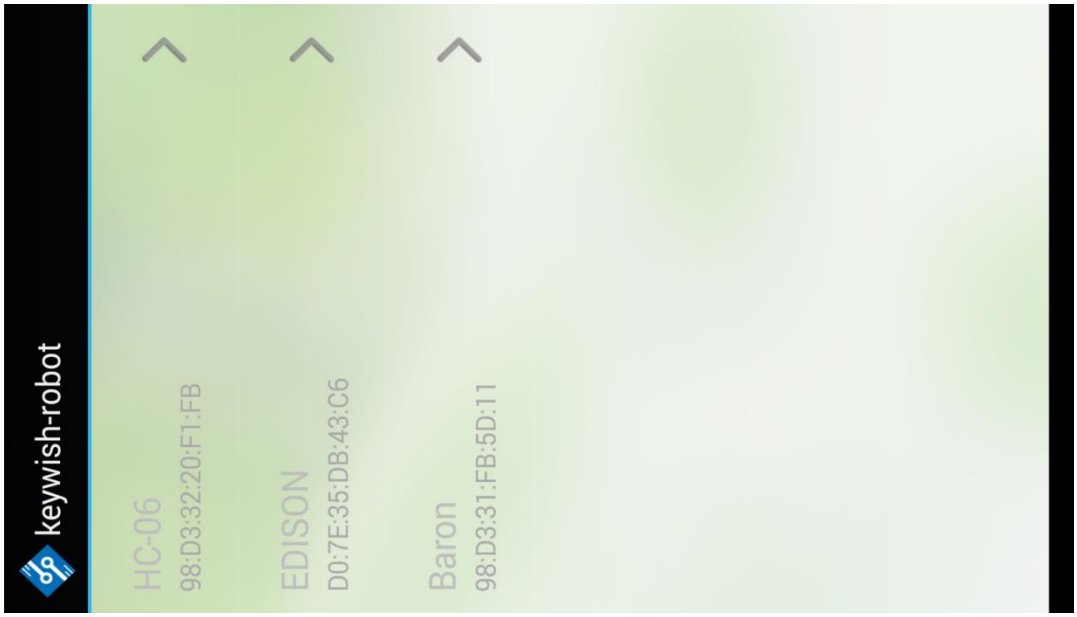

Fig.3.2.52 Connection of Mobile Phone APP

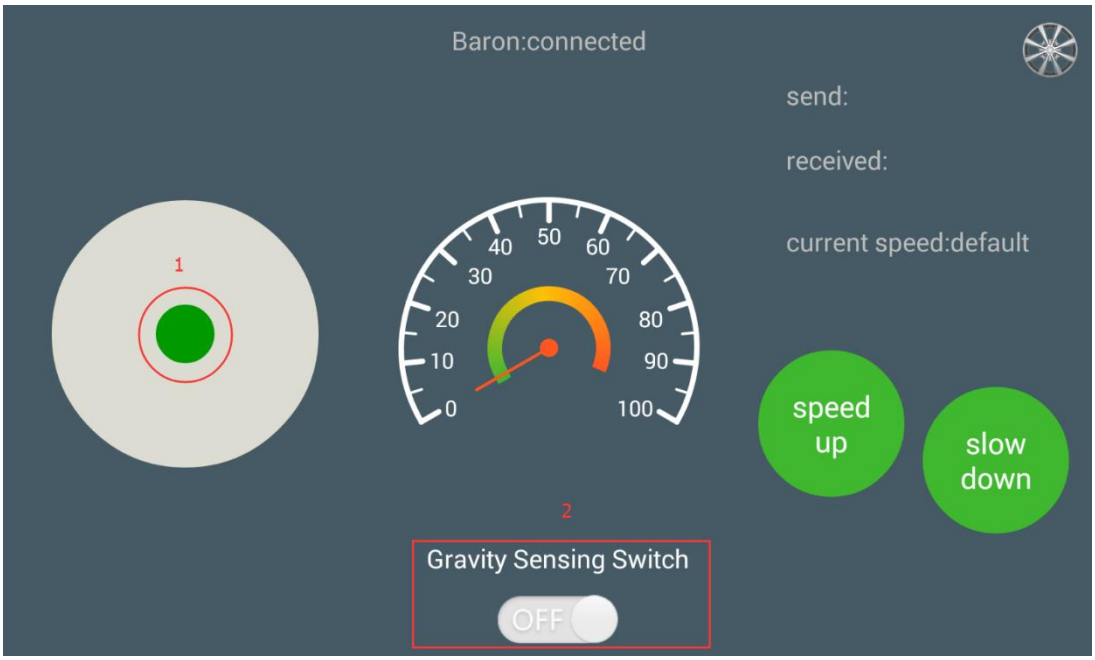

Fig.3.2.53. Diagram of APP Control

In Fig.3.2.53, we can see the logo "1" and "2". When the Bluetooth connection is successful, sliding green dot marked as "1" in any direction, the car will move towards the corresponding direction. Switching on the gravity sensor marked in "2", the APP is switched to the gravity induction mode, and you can control the movement direction of the car by shaking the mobile phone.

Of course, for some enthusiasts, you might want to modify Bluetooth parameters, such as Bluetooth name, password, or work mode, so how do you do that? It's really simple:

Bluetooth module parameter settings need USB-to-TTL module, the module can realize the connection between Bluetooth module and computer and download programs for the microcontroller. Through the USB-to-TTL module, Bluetooth module and the computer can exchange data, and you can set the basic parameters of the Bluetooth module by the computer, of course, you can also use Arduino to modify the Bluetooth directly, here we take USB serial port connecting Bluetooth for an example:

1, Connecting Bluetooth to USB-to-TTL module, connection mode: RXD-TX, TXD-RX, VCC-VCC, GND-GND, ATATE-VCC.

2, Inserting USB-to-TTL module into the computer's USB port, and then press the button as shown in the Fig.3.2.54 for 2 seconds. When the Bluetooth module indicator slows down (some Bluetooth doesn't occur) which means it has entered the AT mode, you can open the serial debugging assistant(the software in the CD)and start setting the AT mode.

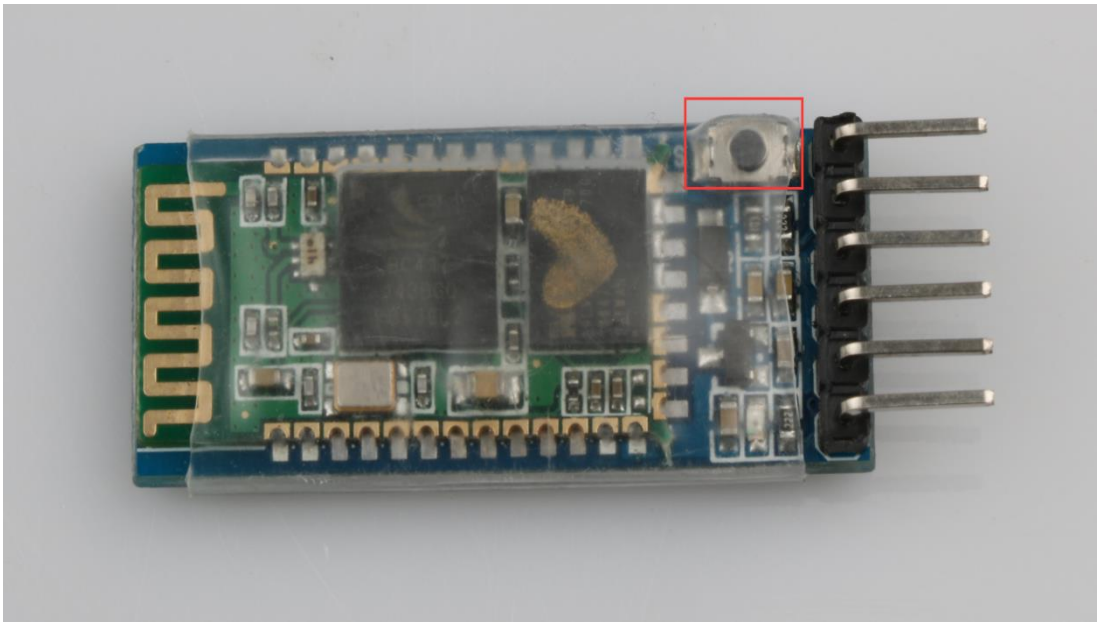

Fig.3.2.54 Bluetooth Button

Opening the serial debugging assistant as shown in Fig.3.2.55, first selecting the corresponding COM port (please refer to "2.4" if you do not know how to check the COM port), setting the baud rate which generally is 9600 as marked in logo "2", and

opening the serial port in logo "3", then selecting "send newline" in the mark "4". Finally, inputting the AT command in logo "1", and if the command succeeds, the "OK" will be returned in the blank. Parameter setting instructions of HC-05 Bluetooth module:

AT+NAME=Bluetooth-Slave The Bluetooth name is Bluetooth-Slave

AT+ROLE=0 The Bluetooth mode is slave mode

AT+CMODE=0 The Bluetooth connection mode is random address connection mode

AT+PSWD=1234 The Bluetooth pairing password is 1234

AT+UART=9600，0，0 The baud rate of Bluetooth communication serial port is 9600, the stop bit is 1 bit and there is no parity bit

AT+RMAAD Clear paired list

Fig.3.2.55 Display of Serial Port

3.2.7.5 Software Design

```
#include "protocol.h"
#include "hummerbot.h"
#include "process.h"
int E1 = 5;  //PWMA
int M1 = 9;  //DIRA  ---  left
int E2 = 6;  //PWMB
int M2 = 10; //DIRB  ---  right

byte readbuff[32] = {};
int readlen = 0;
ST_protocol recv;
hummerbot hbot(E1,M1,E2,M2,13,A0);

void setup()
{
    Serial.begin(9600);
    hbot.init();
}
```

```
void read_data(void)
{
  unsigned char avilable;
  byte *p = readbuff ;
  memset(p,0,32);
  readlen = 0;
  while (Serial.available()>0)
    {
        if(!avilable && Serial.peek()==START_CODE)
        {
            avilable = 1;
        }
        if (avilable)
        {
            if ((*p = Serial.read()) == END_CODE)
            {
               avilable =0;
               readlen++;
              //Serial.print(*p,HEX);
                break;
            }
         //  Serial.print(*p,HEX);
            p++;
            readlen++;
        }

    }
// Serial.print("\n");
}
```

```
 void loop()
{
     read_data();
     if (!protocol_prase(readbuff,readlen,&recv))
{
    switch(recv.function)
    {
        case E_BATTERY:
            break ;
        case E_LED:
            break;
        case E_INFO:
            break;
       case E_ROBOT_CONTROL:
       hbot.drive(protocol_prase_degree(&recv));
            break;
       case E_ROBOT_CONTROL_SPEED:
       hbot.setSpeed(protocol_prase_speed(&recv));
            break ;
        case E_VERSION:
            break;
    }
    }
}
```