

FREENOVE

FREE YOUR INNOVATION

Freenove is an open-source electronics platform.

www.freenove.com

Warning

When you purchase or use this product, please note the following:

- This product contains small parts. Swallowing or improper operation them can cause serious infections and death. Seek immediate medical attention when the accident happened.
- Do not allow children under 3 years old to play with or near this product. Please place this product in where children under 3 years of age cannot reach.
- Do not allow children lack of ability of safe to use this product alone without parental care.
- Never use this product and its parts near any AC electrical outlet or other circuits to avoid the potential risk of electric shock.
- Never use this product near any liquid and fire.
- Keep conductive materials away from this product.
- Never store or use this product in any extreme environments such as extreme hot or cold, high humidity and etc.
- Remember to turn off circuits when not in use this product or when left.
- Do not touch any moving and rotating parts of this product while they are operating.
- Some parts of this product may become warm to touch when used in certain circuit designs. This is normal. Improper operation may cause excessively overheating.
- Using this product not in accordance with the specification may cause damage to the product.

About

Freenove is an open-source electronics platform. Freenove is committed to helping customer quickly realize the creative idea and product prototypes, making it easy to get started for those enthusiasts of programing and electronics and launching innovative open source products. Our services include:

- Electronic components and modules
- Learning kits for Arduino
- Learning kits for Raspberry Pi
- Learning kits for Technology
- Robot kits
- Auxiliary tools for creations

Our code and circuit are open source. You can obtain the details and the latest information through visiting the following web sites:

<http://www.freenove.com>

<https://github.com/freenove>

Your comments and suggestions are warmly welcomed, please send them to the following email address:
support@freenove.com

References

You can download the sketches and references used in this product in the following websites:

<http://www.freenove.com>

<https://github.com/freenove>

If you have any difficulties, you can send email to technical support for help.

The references for this product is named Freenove Hexapod Robot Kit, which includes the following folders and files:

- Arduino Sketches and libraries for Arduino
- Processing Sketches and libraries for Processing
- AboutBattery.pdf Notes about battery
- CalibrationGraph.pdf Calibration graph
- Readme.txt Instructions
- Tutorial.pdf Tutorial

Support

Freenove provides free and quick technical support, including but not limited to:

- Quality problems of products
- Problems in using products
- Questions for learning and technology
- Opinions and suggestions
- Ideas and thoughts

Please send email to:

support@freenove.com

On working day, we usually reply to you within 24 hours.

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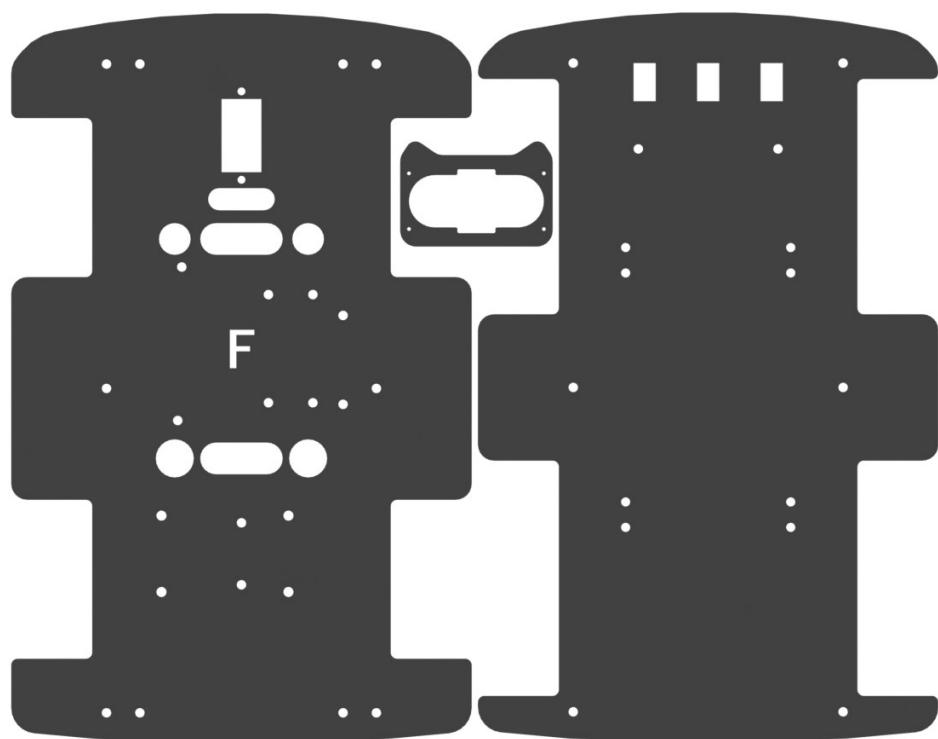
The code and circuit involved in this product are released as Creative Commons Attribution ShareAlike 3.0. This means you can use them on your own derived works, in part or completely, as long as you also adopt the same license. Freenove brand and Freenove logo are copyright of Freenove Creative Technology Co., Ltd and cannot be used without formal permission.

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List

Acrylic Parts



The surface of the acrylic parts is covered with a layer of protective film, you need to remove it first. Some holes in the acrylic parts may have residues, you also need to clean them before using.

Mechanical Parts



Dynamic Parts

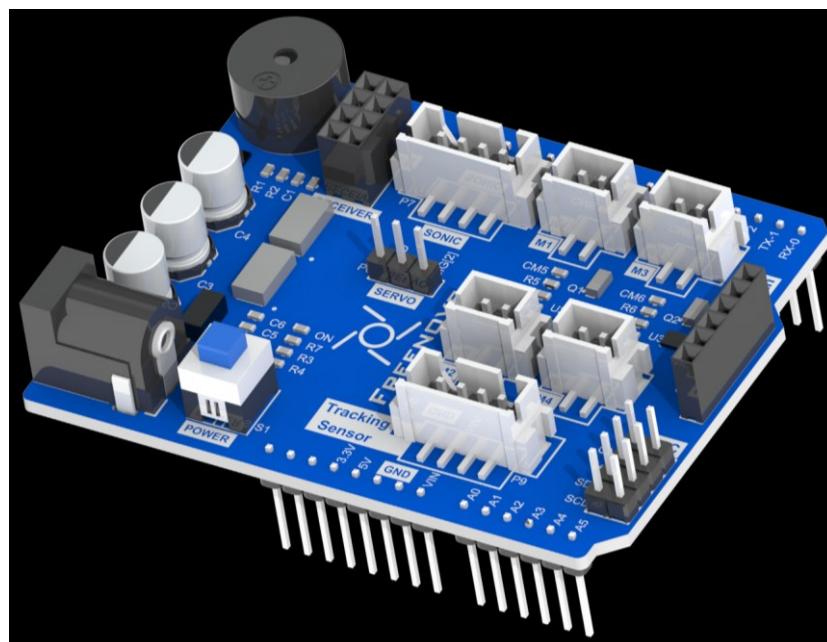
Servo x1 	Motor x4 
Driver wheel x 4 	Motor bracket package x 4 Screw M3*8 , Nut M3, Screw M3*30 

Electronic Parts

Freenove UNO



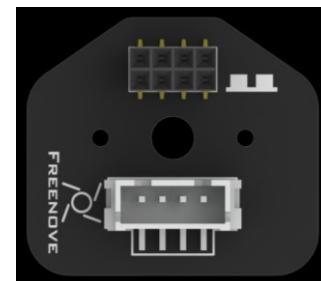
Freenove 4WD extension board



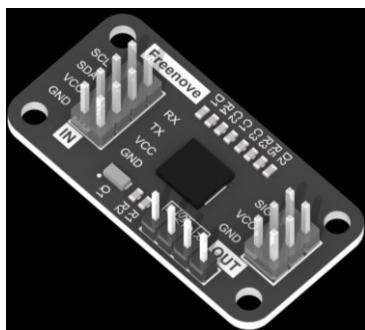
Line-tracking infrared sensor



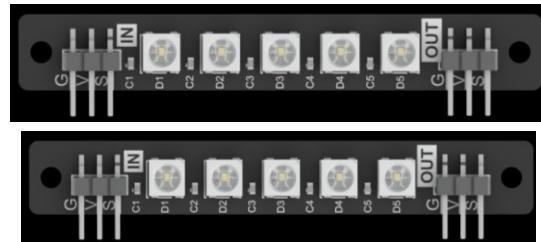
Ultrasonic module connector



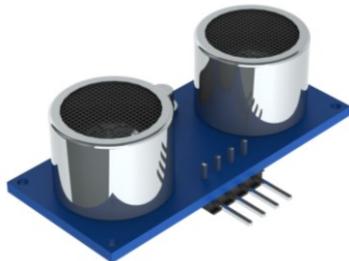
WS2812B_LED_controller



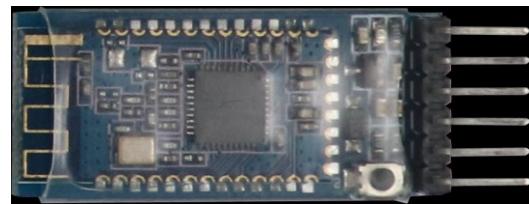
WS2812B_LED



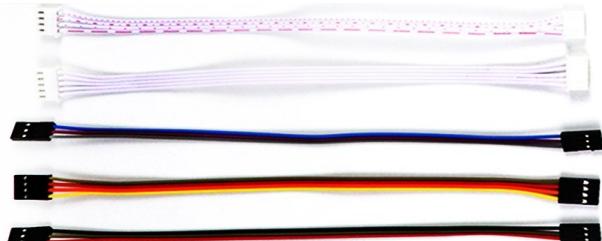
Ultrasonic module



Bluetooth



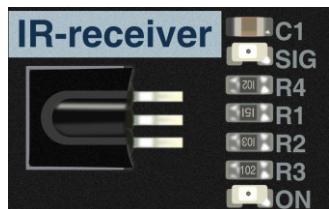
Wires



USB Cable



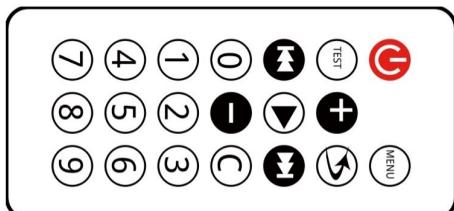
IRreceiver



Tape



IR remote



Battery holder

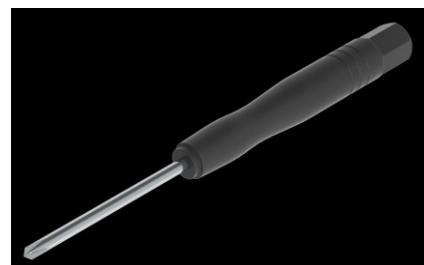


RF remote kit package (**only included in the smart car kit with RF remote control**)



Tools

Cross Screwdriver x1



Socket x1 (**only one is included in the kit**)



Self-prepared Parts

18650 3.7V rechargeable lithium battery x2



Preface

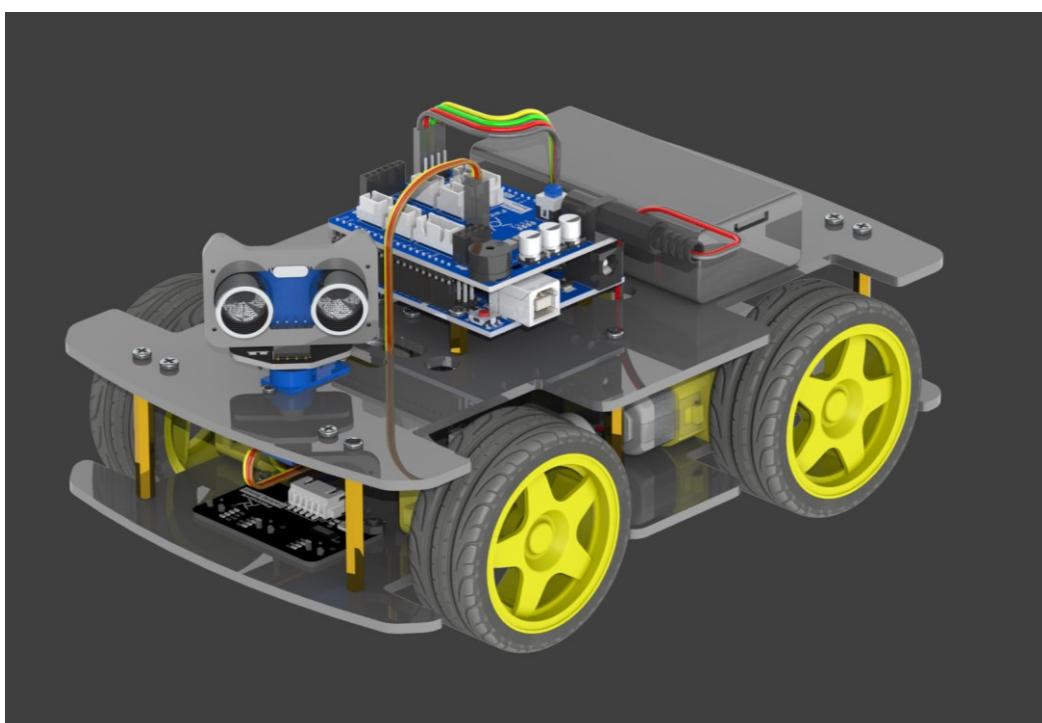
This 4WD Smart car is based on Arduino.

This tutorial will start from controlling electronic components such as LED, motor, servo, to building multifunctional car.

Please follow the tutorial step by step patiently.

If you have any concerns, please feel free to contact us. Our support team will provide great customer service.

support@freenove.com



Control board and Software

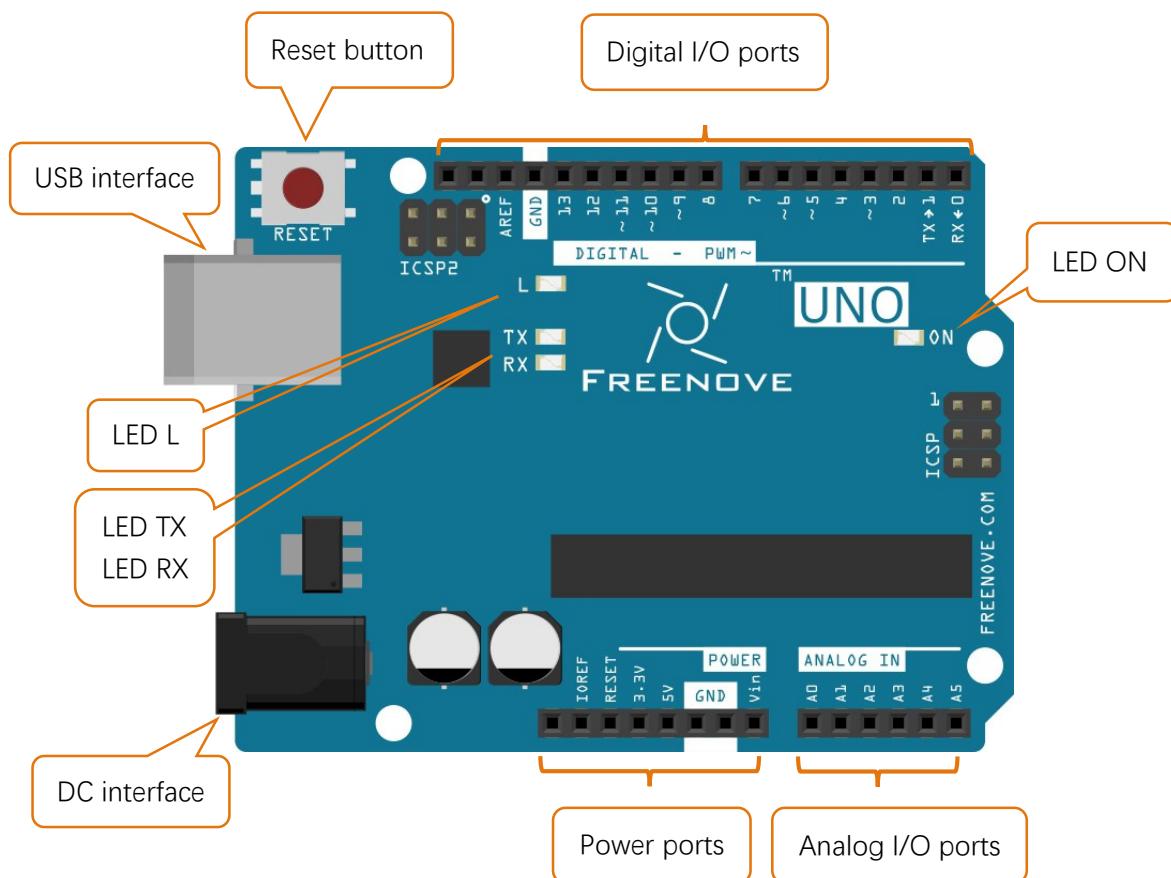
UNO Board

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive projects.

[Arduino boards](#) are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the [Arduino programming language](#) (based on C/C++), and [the Arduino software \(IDE\)](#).

The Arduino software is free and open source, and runs on the Mac, Windows, and GNU/Linux platforms.

The board used in this book is Freenove UNO, and it is fully compatible to Arduino UNO. Diagram of Freenove UNO board is shown below:



- Digital I/O ports is used to connect to other components or modules, to receive an input signal, or to send a control signal. Usually, we name it by adding a "D" in front of the number, such as D13.
- Only digital I/O ports with "~" can output PWM, Pin 3, 5, 6, 9, 10, 11.
- USB interface is used to provide power, upload code or communicate with PC.

- LED L is connected to digital I/O port 13 (D13).
- LED TX, RX is used to indicate the state of the serial communication.
- DC interface is connected DC power to provide power for the board.
- Power ports can provide power for electronic components and modules.
- Analog I/O ports can be used to measure analog signals.
- LED ON is used to indicate the power state.

Freenove UNO is the most suitable board to complete the experiments of this book. You can also choose to use Arduino UNO, Arduino MICRO, Arduino NANO, Arduino MEGA (or other boards compatible to them).

The Arduino programming language is based on C/C++.

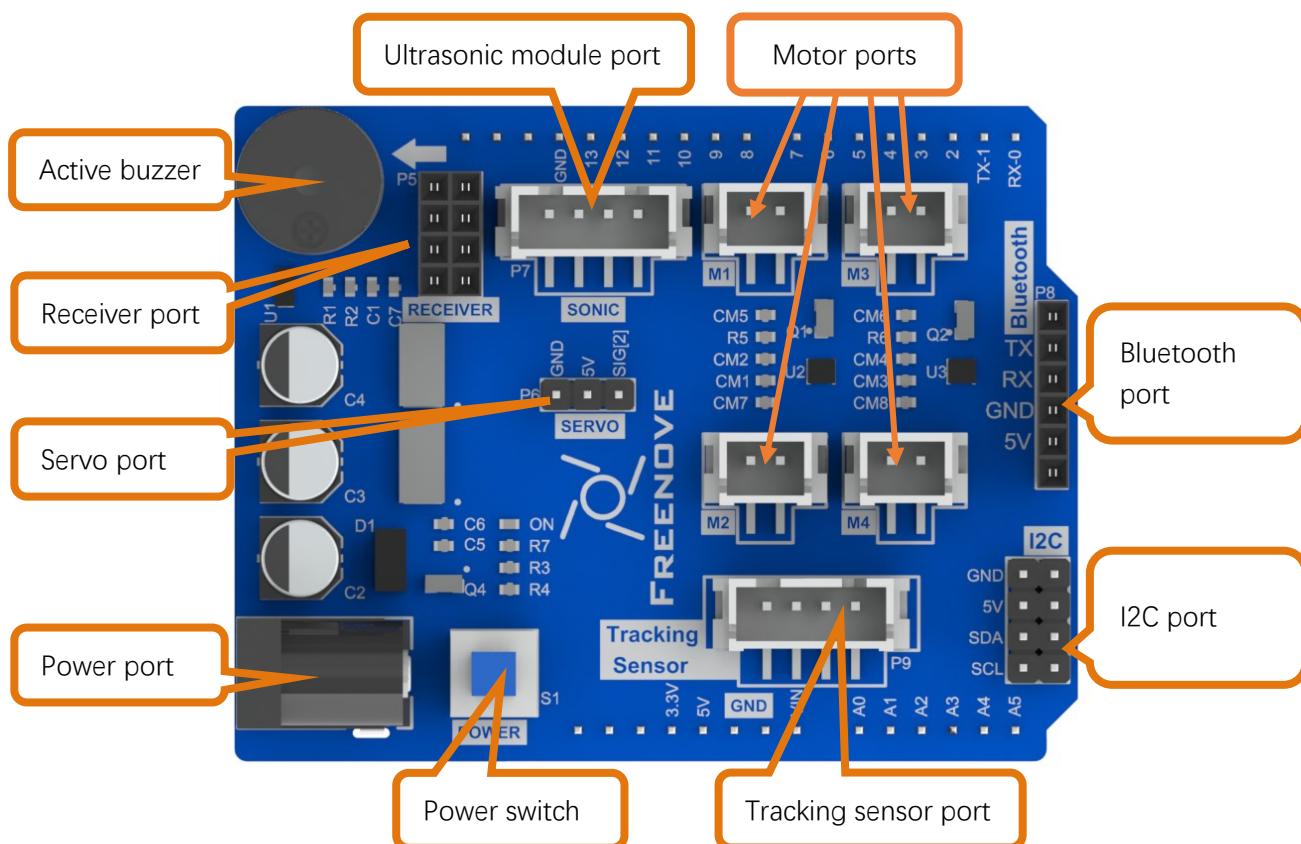
Please visit <https://www.arduino.cc>, click "resources" > "Reference" for details:

<https://www.arduino.cc/reference/en/>

If you want to learn more about how use Arduino to control electronic components to create interesting projects, please visit <http://www.freenove.com/store.html> for Arduino kits designed for beginners.

Extension Board

Freenove 4WD Extension board is below:



Receiver port can connect to RF module or IR module.

Relationship between extension board and the UNO board is below.

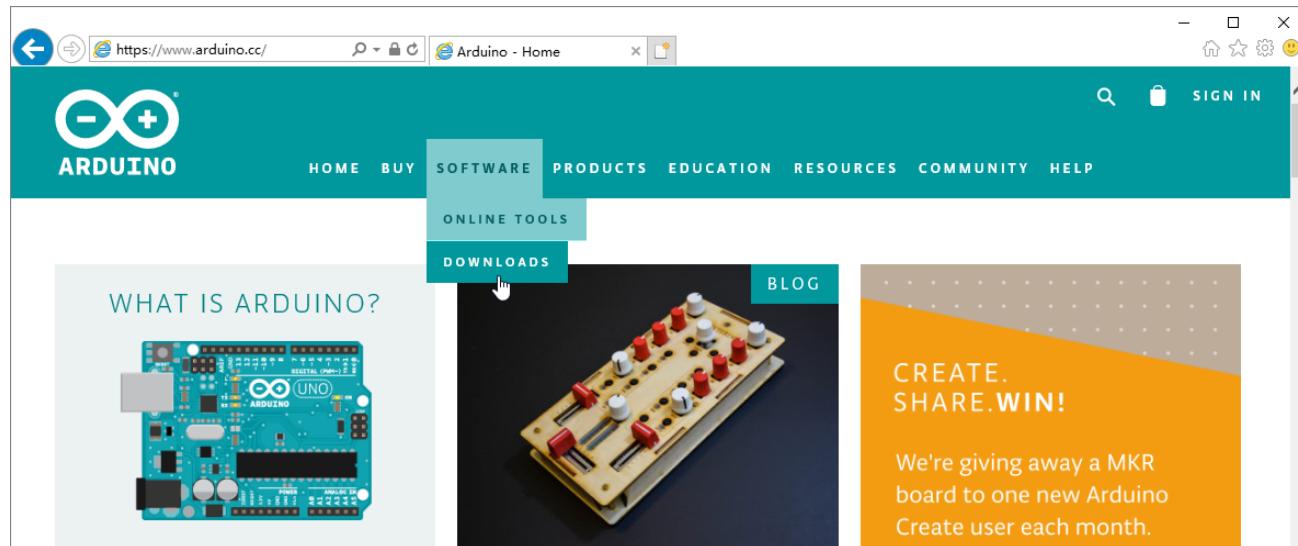
Pins of Arduino	Ports of extension	Pin multiplexing	Description
0	UART-Bluetooth		Bluetooth
1			
2	Servo		
3	Direction-Right		Direction of right motor
4	Direction-Left		Direction of left motor
5	Motor-Right		Speed of right motor -PWM
6	Motor-Left		Speed of right motor -PWM
7	Trig		Ultrasonic module
8	Echo		
9	SPI-NRF24L01	IR-remote	CE/IR-remote
10			CS
11	SPI-NRF24L01		MOSI
12			MISO
13			SCK
A0	Battery voltage	Buzzer	The ADC uses an internal 5V reference and the acquisition voltage is the battery voltage *1/4. Output to the Buzzer through the comparator. When higher than the 4.5V, output HIGH.
A1	Line-tracking sensor		Left
A2			Middle
A3			Right
A4	I2C		SDA
A5			SCL

Arduino Software

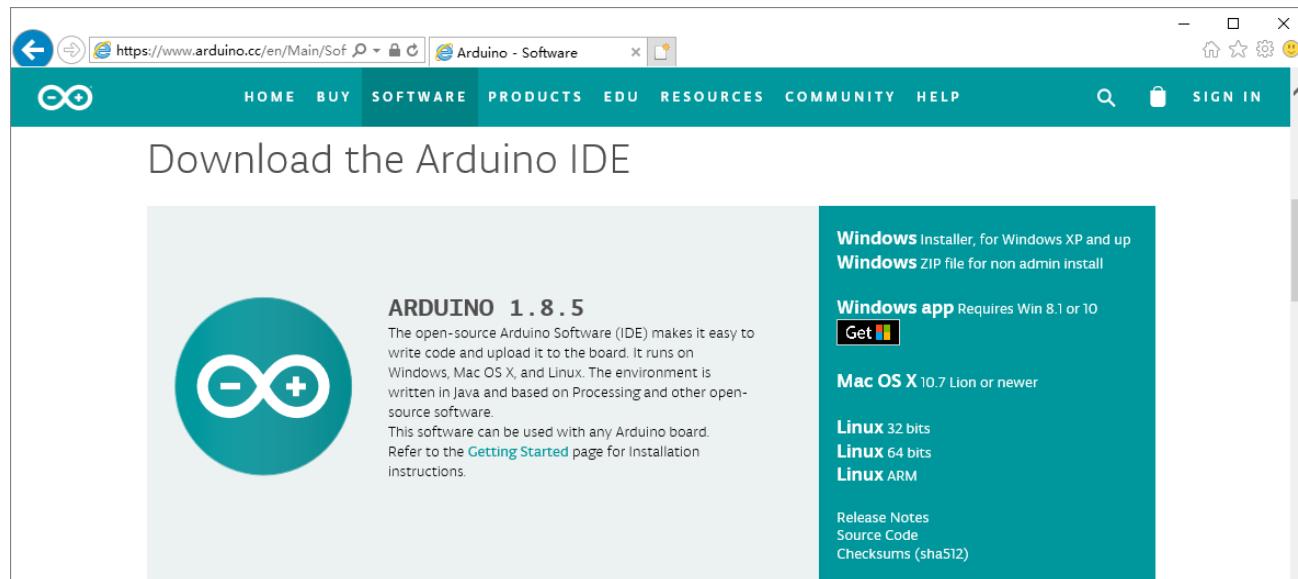
Download and install Arduino IDE

The Arduino Software (IDE) allows you to write code in the Arduino programming language and upload them to your board.

Please visit <https://www.arduino.cc>, then click "SOFTWARE" – "DOWNLOADS" to enter the downloads page.

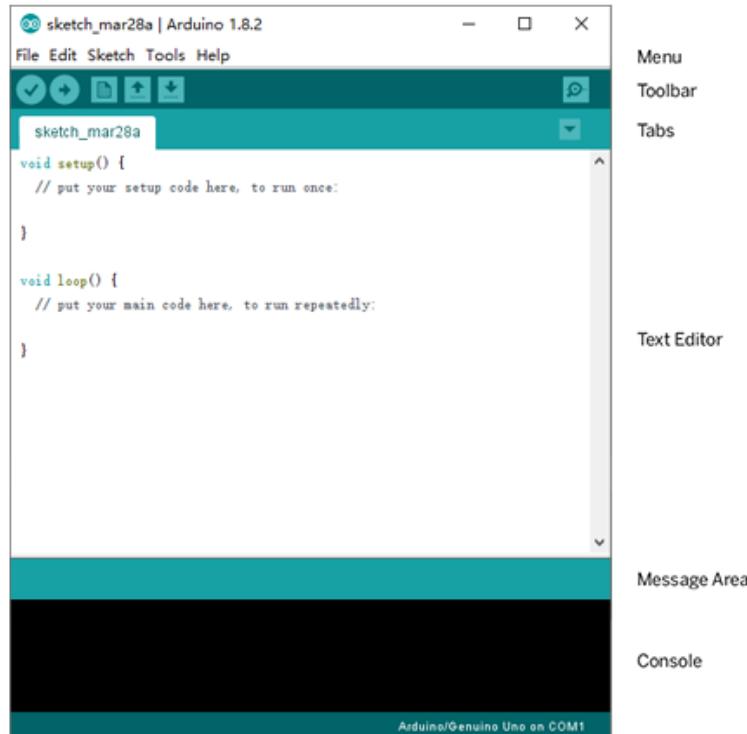


Find "Download the Arduino IDE". Microsoft Windows users please click the "Windows Installer".



After the download is complete, run the installer and complete the installation.

Open the Arduino Software, the interface of Arduino Software is as follows:



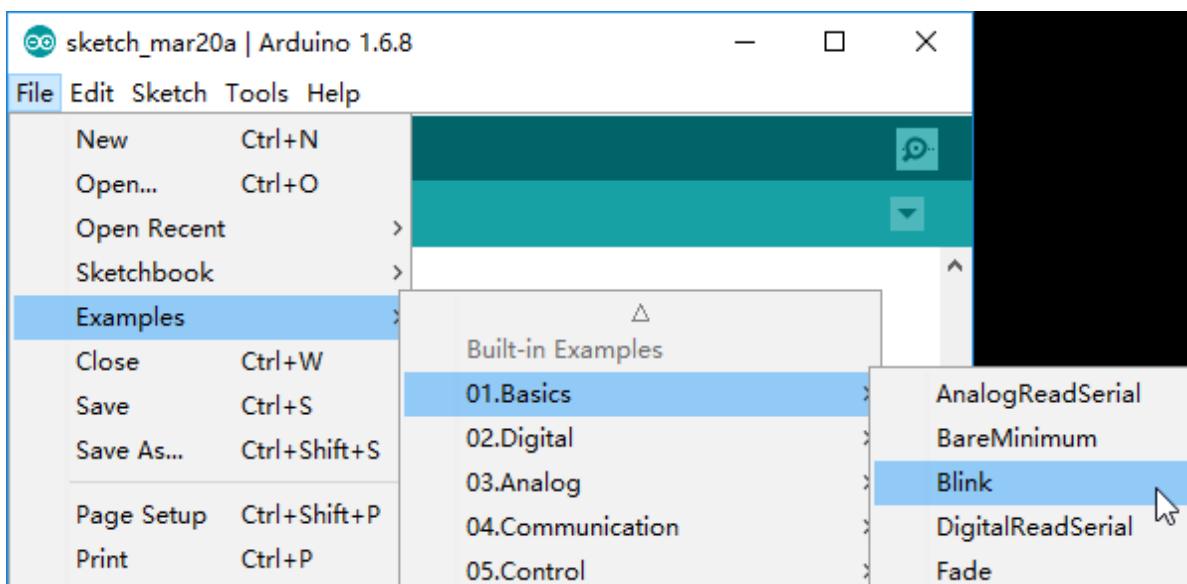
Programs written using Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and are saved with the file extension **.ino**. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

- Verify
Checks your code for errors compiling it.
- Upload
Compiles your code and uploads it to the configured board.
- New
Creates a new sketch.
- Open
Presents a menu of all the sketches in your sketchbook. Clicking one will open it within the current window overwriting its content.
- Save
Saves your sketch.
- Serial Monitor
Opens the serial monitor.

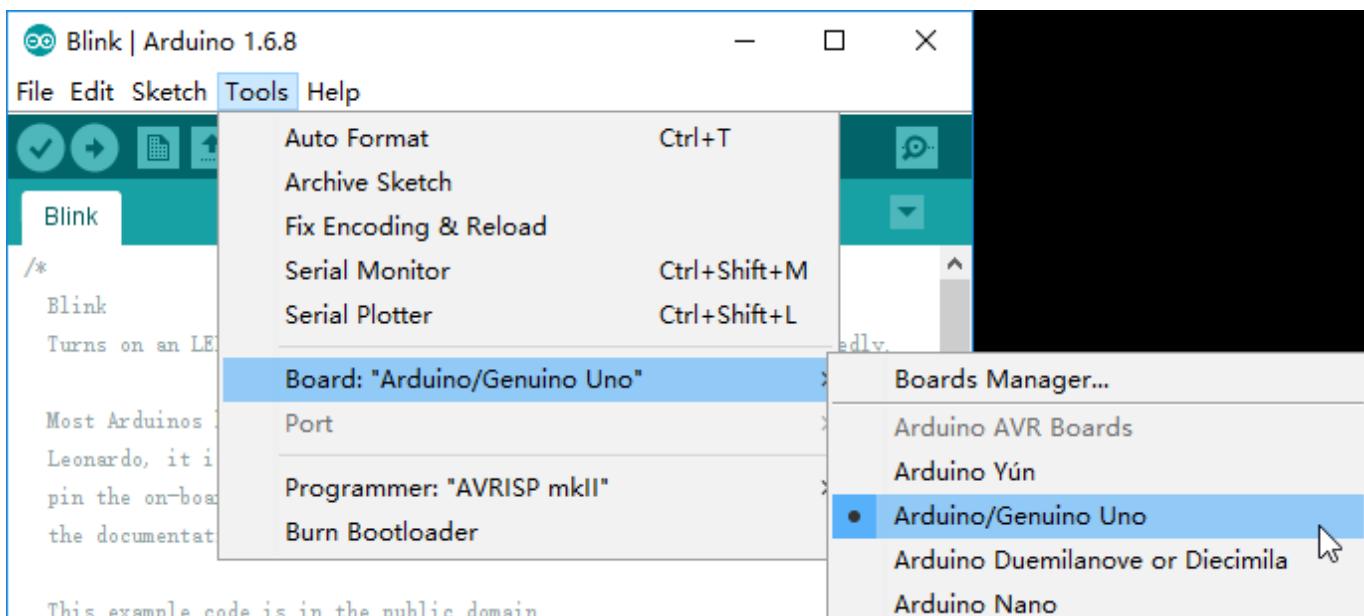
Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

First Use

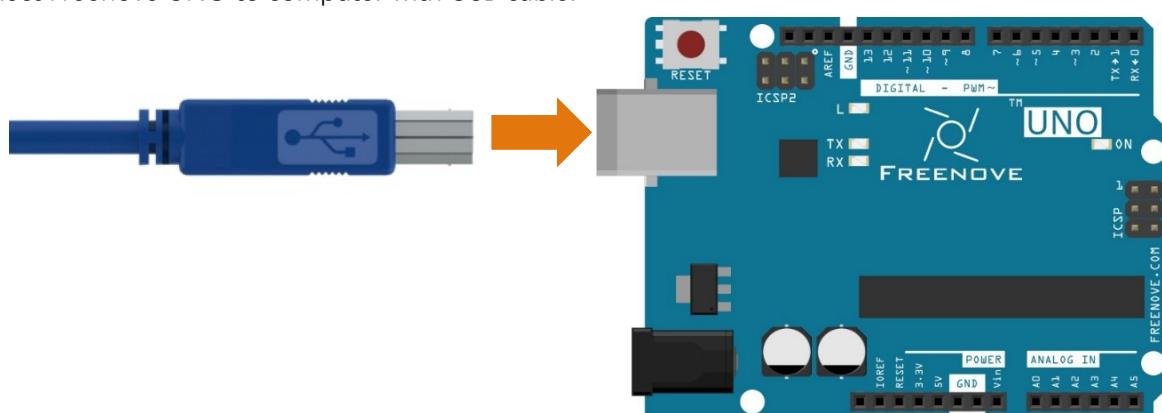
Open the example sketch "Blink" with Arduino Software.



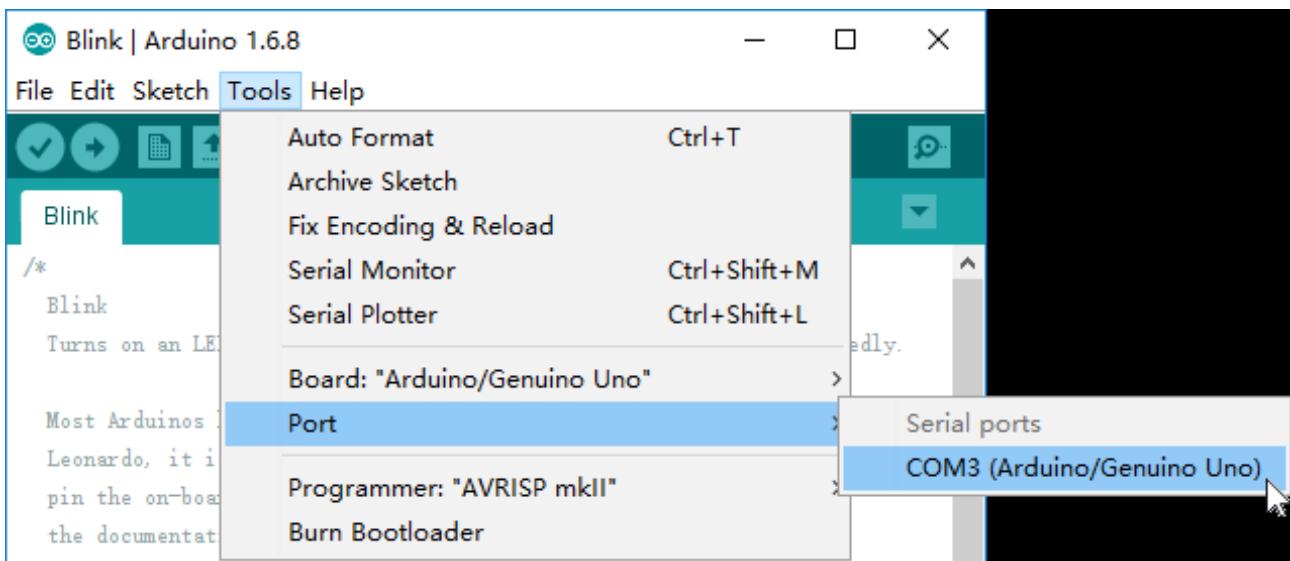
Select board "Arduino/Genuino Uno".



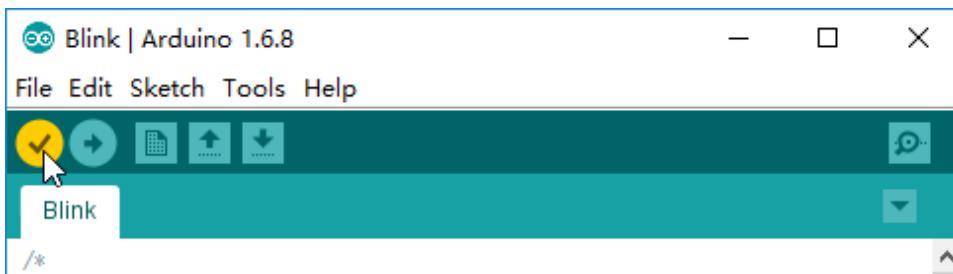
Connect Freenove UNO to computer with USB cable.



Select the serial port. Your serial number may be different from the following figure. If it is not detected immediately, please wait for a while, then click "Tools" to check again.



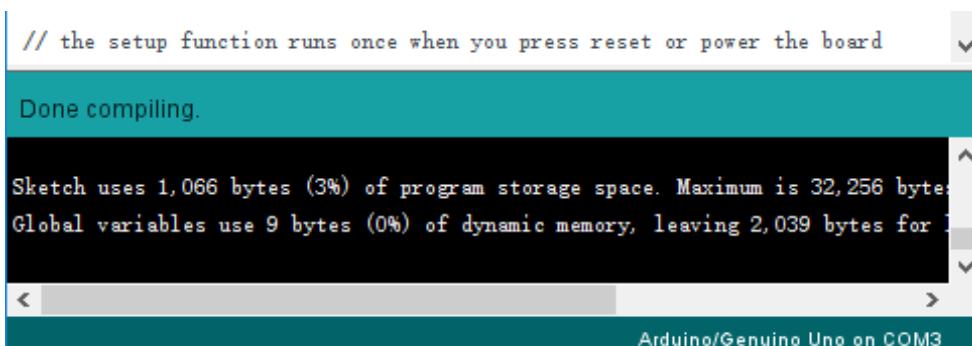
Click "Verify" button.



The following figure shows the code is being compiled.



Wait a moment for the compiling to be completed. Figure below shows the code size and percentage of space occupation.



Usually, when we write code, if it has a syntax error, the interface will prompt the error message. Then the

compiling can't be completed.

Click "Upload" button.

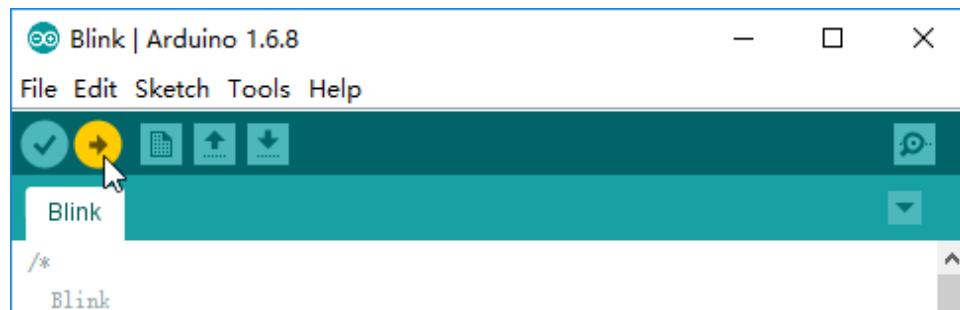
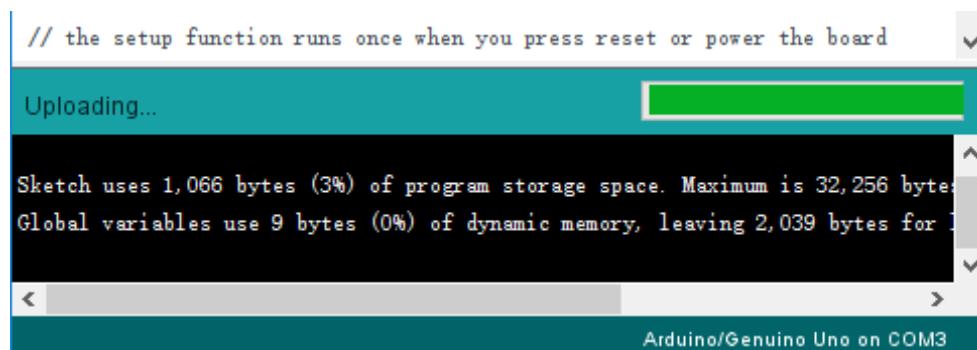
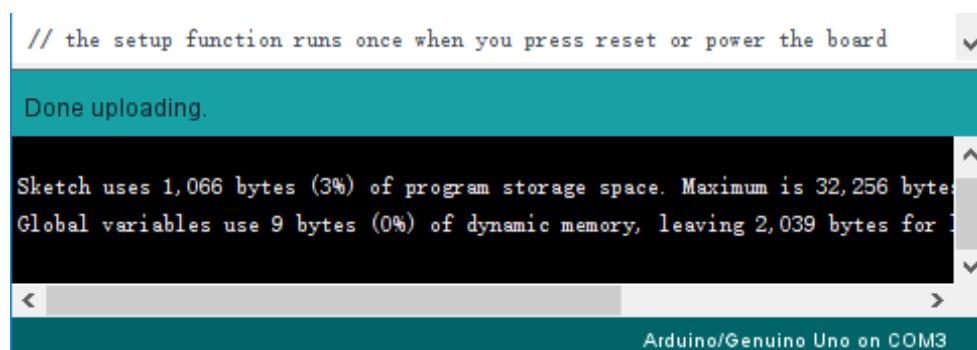


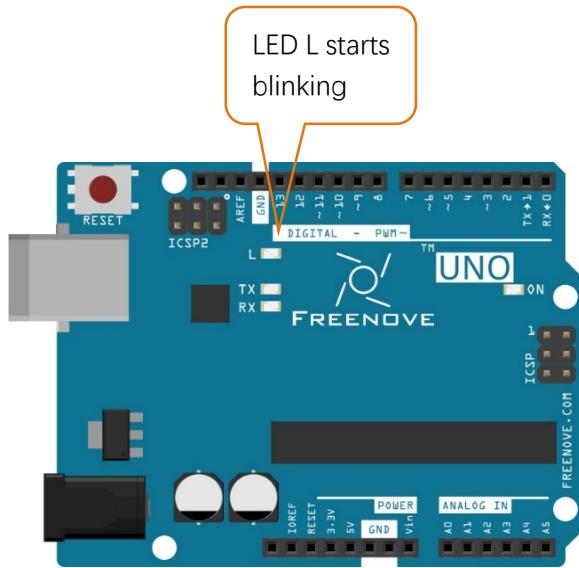
Figure below shows code are uploading.



Wait a moment, then the uploading is completed.



After that, we will see the LED marked with "L" on Freenove UNO starts blinking. It indicates that the code is running now!



So far, we have completed the first use. I believe you have felt the joy of it. Next, we will carry out a series of projects, from easy to difficult, taking you to learn the Arduino programming and the building of electronic circuit.

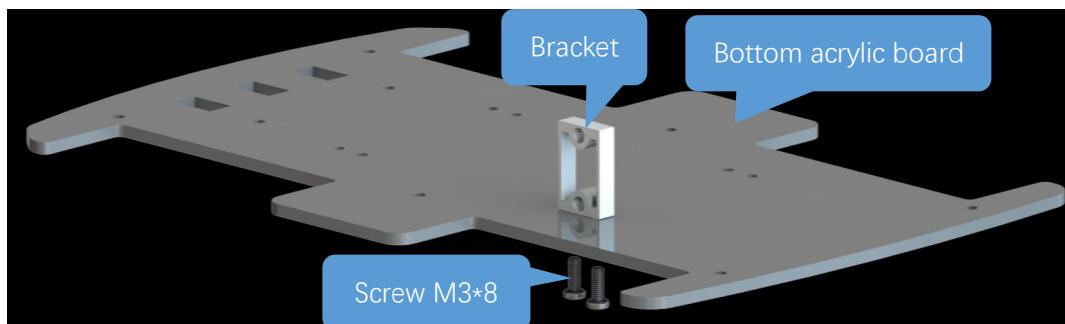
Upload Servo Code (Necessary)

In the directory of this kit, find and upload code in **Sketches\ 00.0_Servo_90** to Freenove UNO for car. This code will be used in assembly step. Do not neglect this step

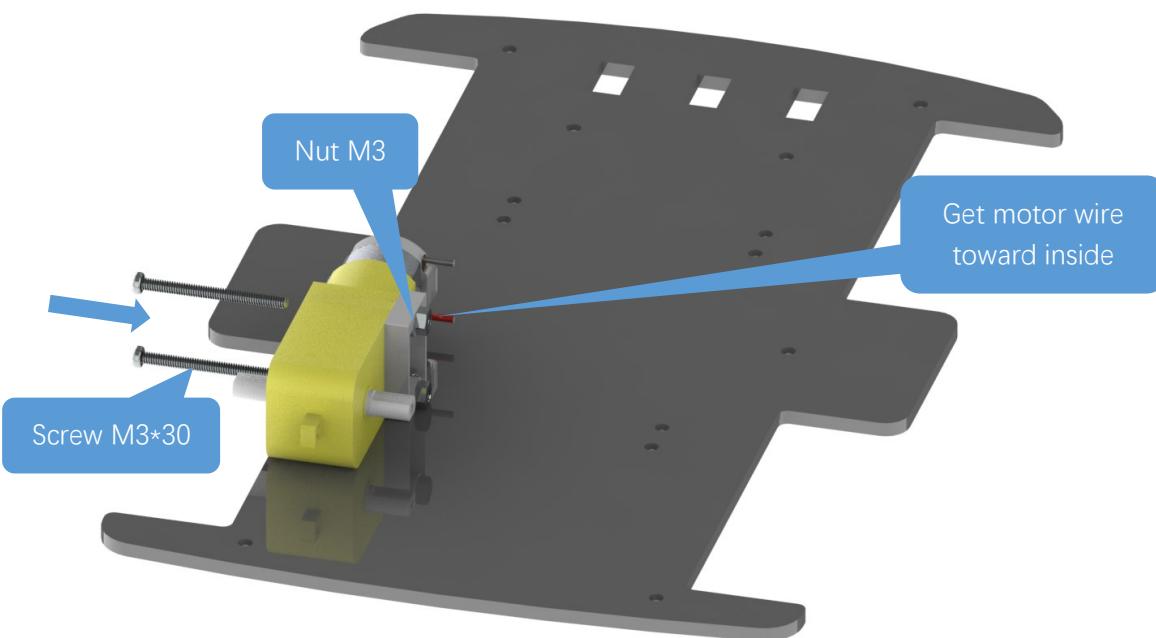
Assembly

In this chapter, we will learn how to assemble this car. This will spend some time. Please be patient.

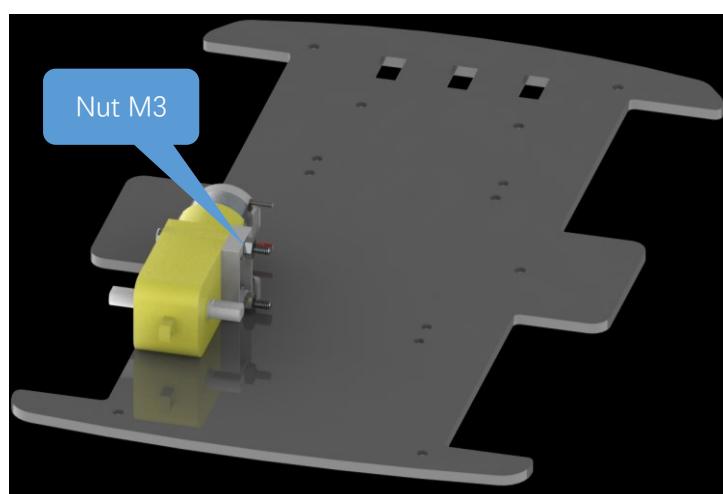
Install Motor Bracket on bottom acrylic board, with screw M3*8 **in the same bag**.



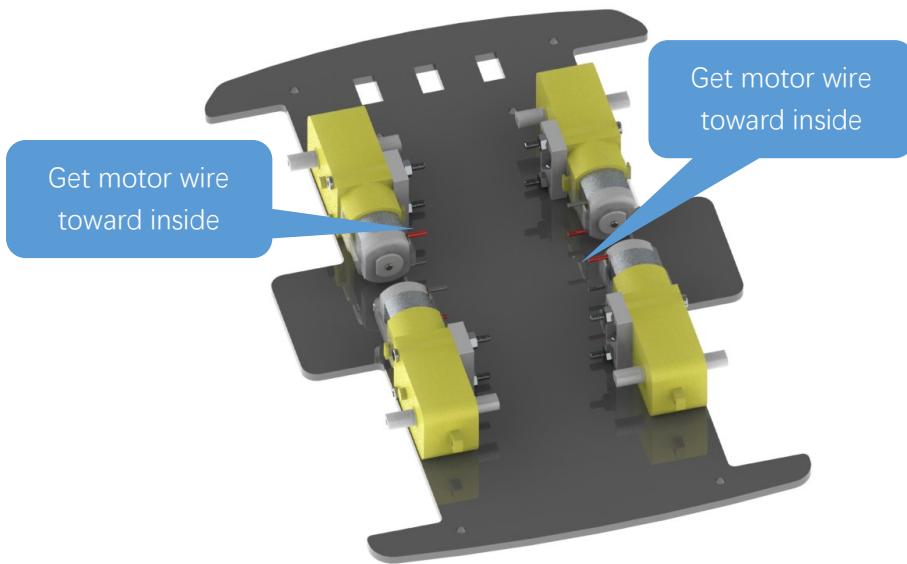
Install Motor Bracket on bottom acrylic board, with screw M3*30 and Nut M3 **in the same bag**.



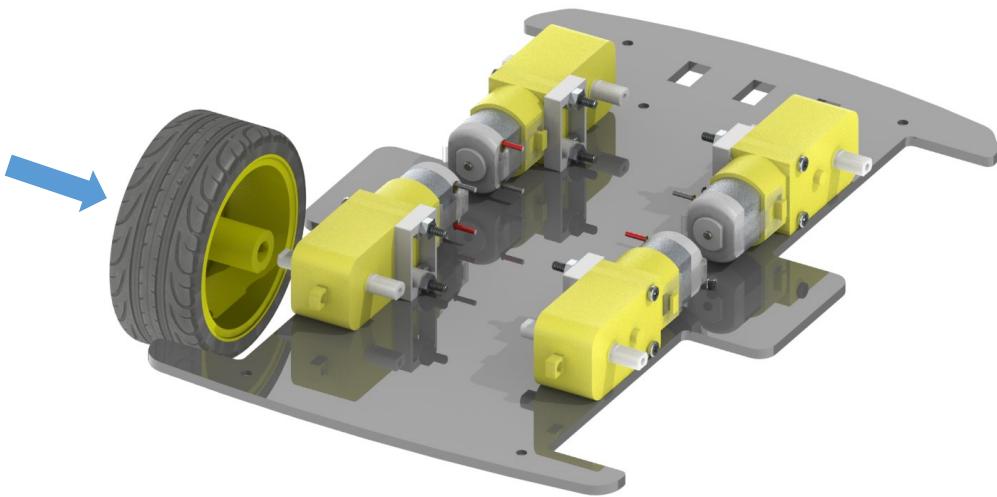
Then one motor has been installed successfully.



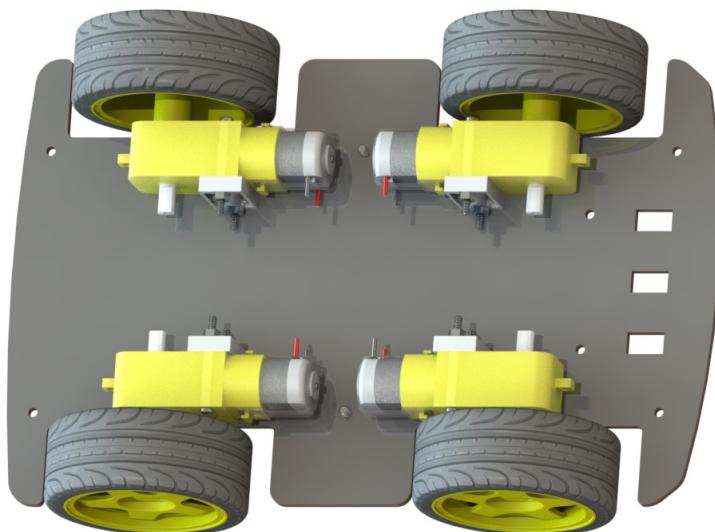
Install rest 3 sets of motors with same method.



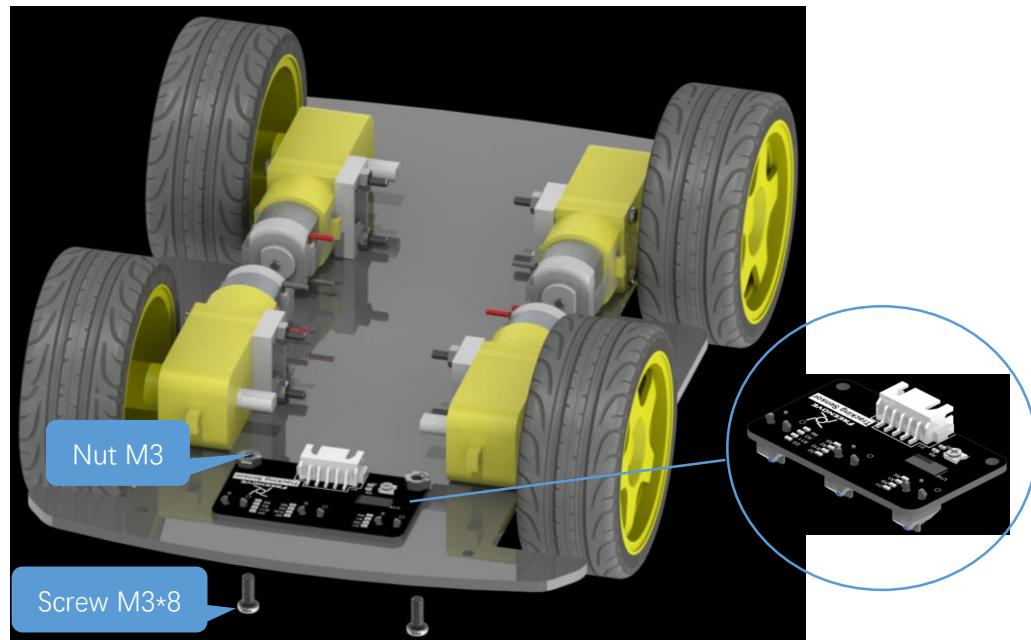
Install wheel. Note, the hole is not round.



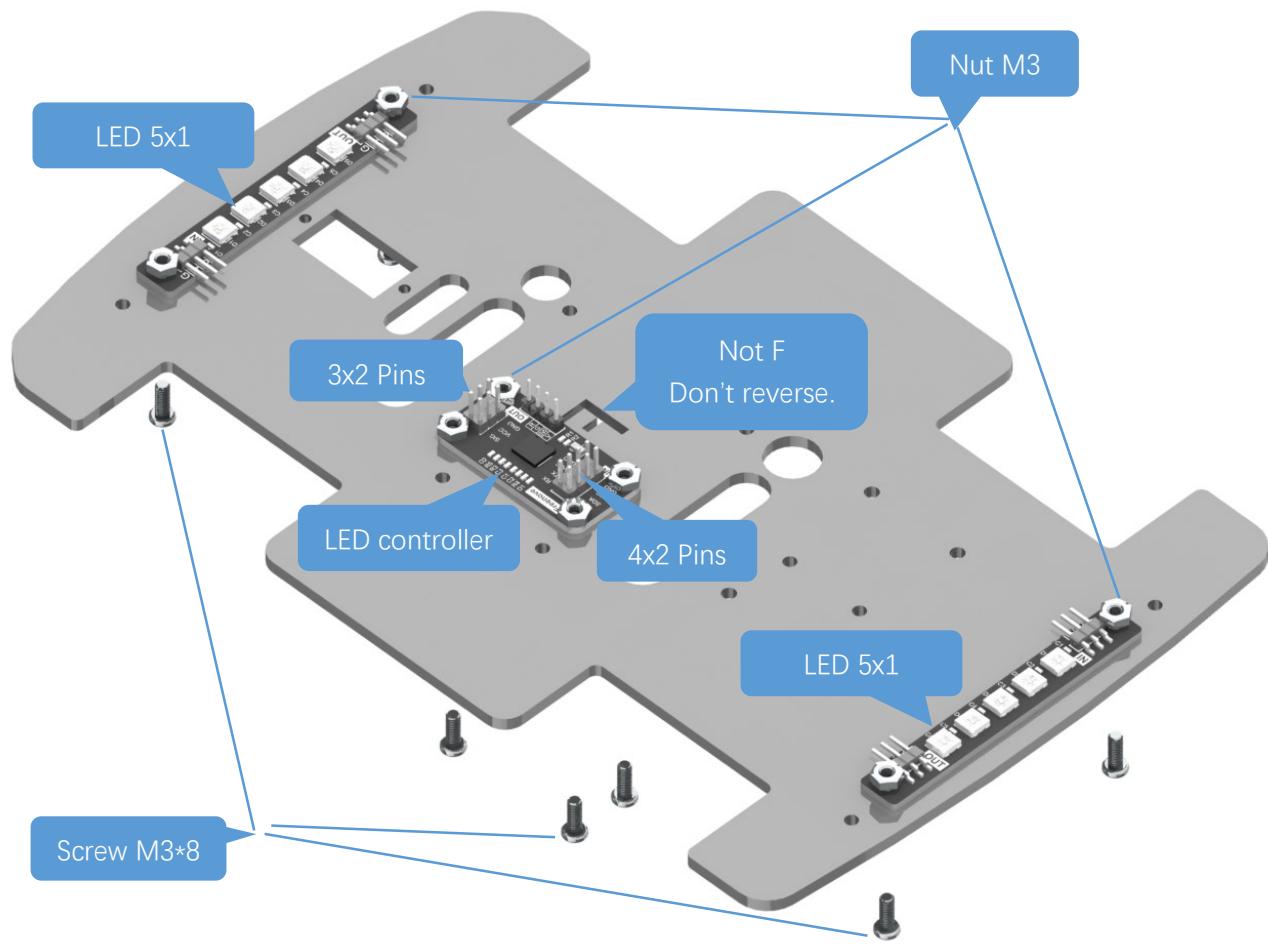
Install rest 3 wheels.



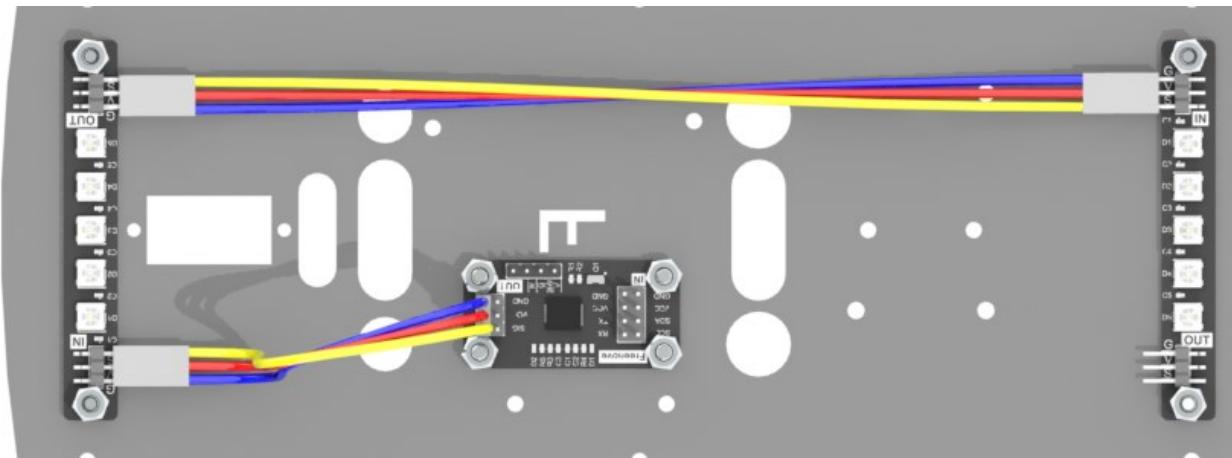
Install line tracking module with Screw M3*8 and Nut M3.



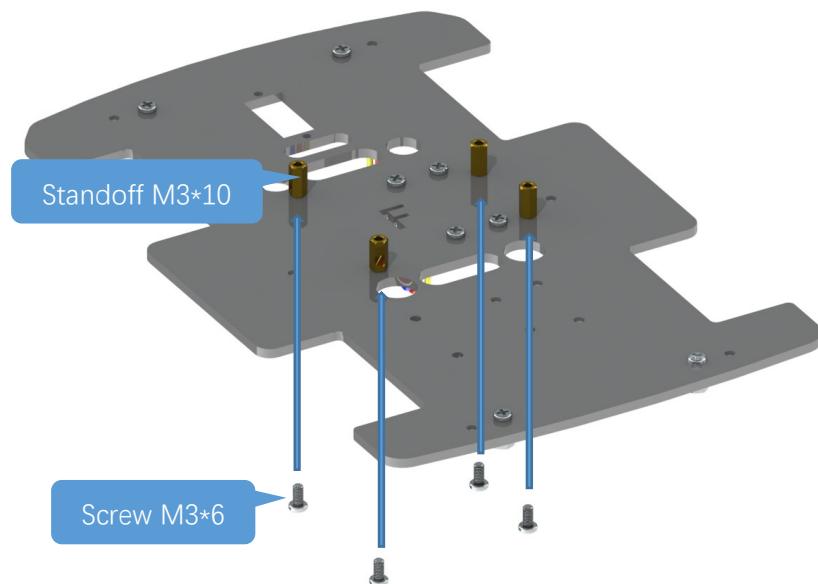
Install LED 5x1 and LED controller to top acrylic board.



Connect wiring of LED controller and LED 5X1. The wire need to be twisted 180°.

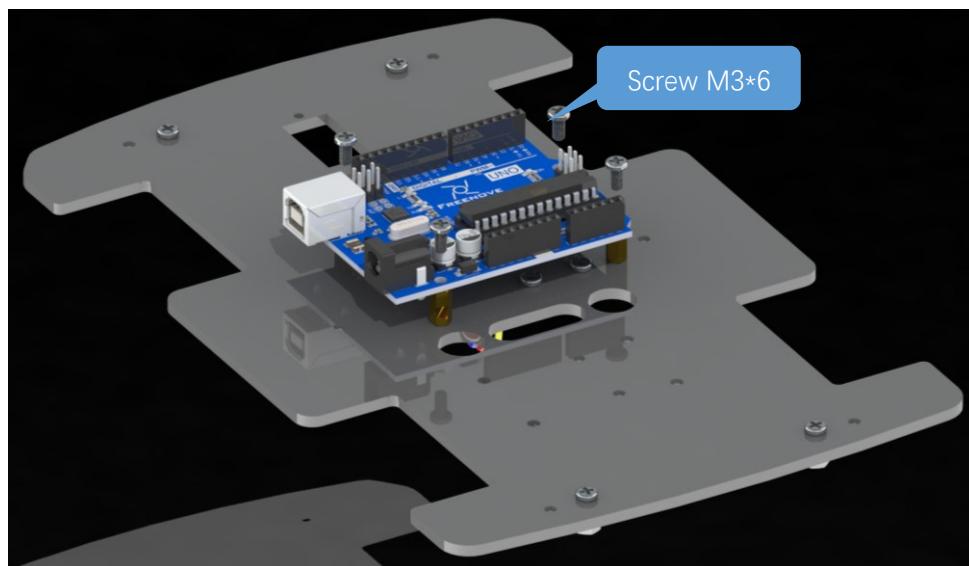


Install standoffs on top acrylic board.

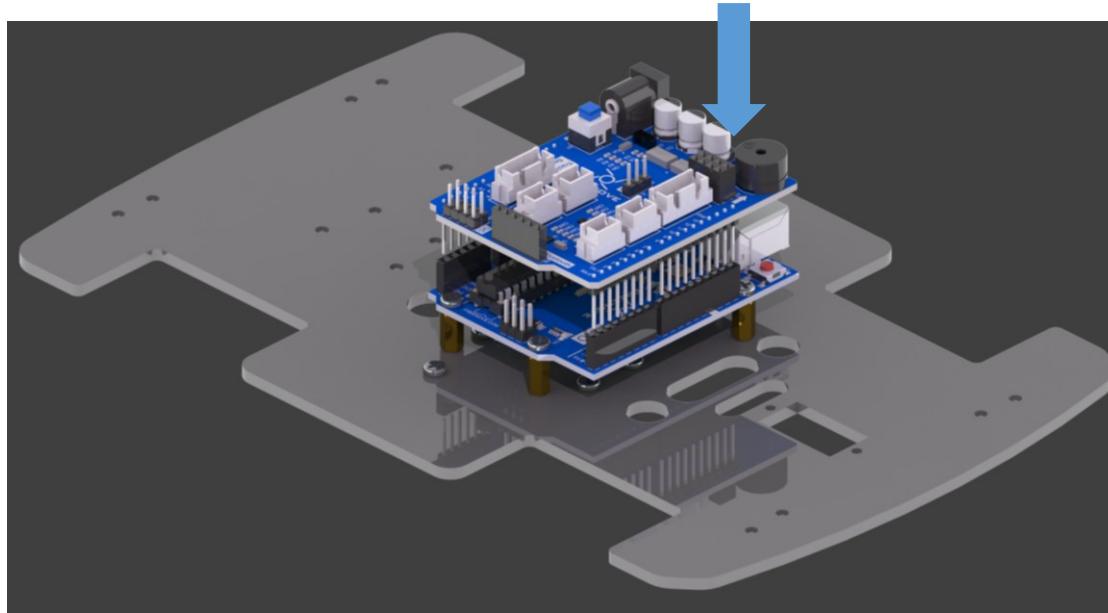


Install Freenove UNO board.

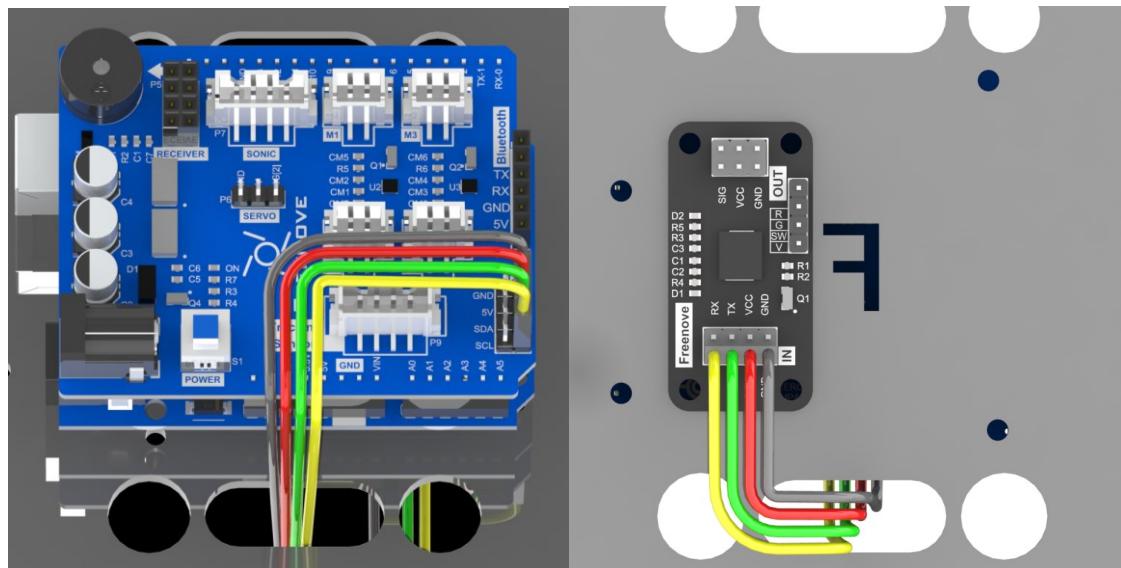
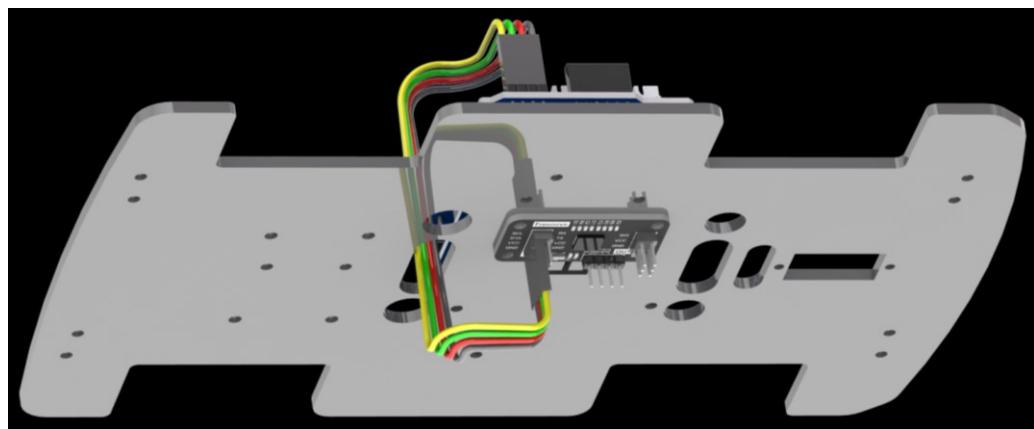
Note, our UNO is same with Arduino Uno board. Therefore, the install hole is not very proper. It is normal.



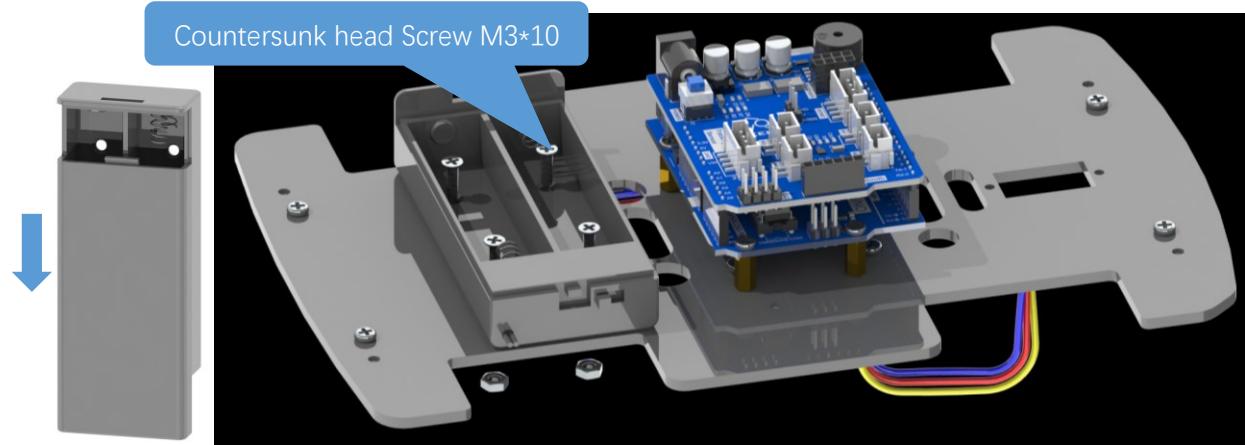
Plug extension into UNO board.



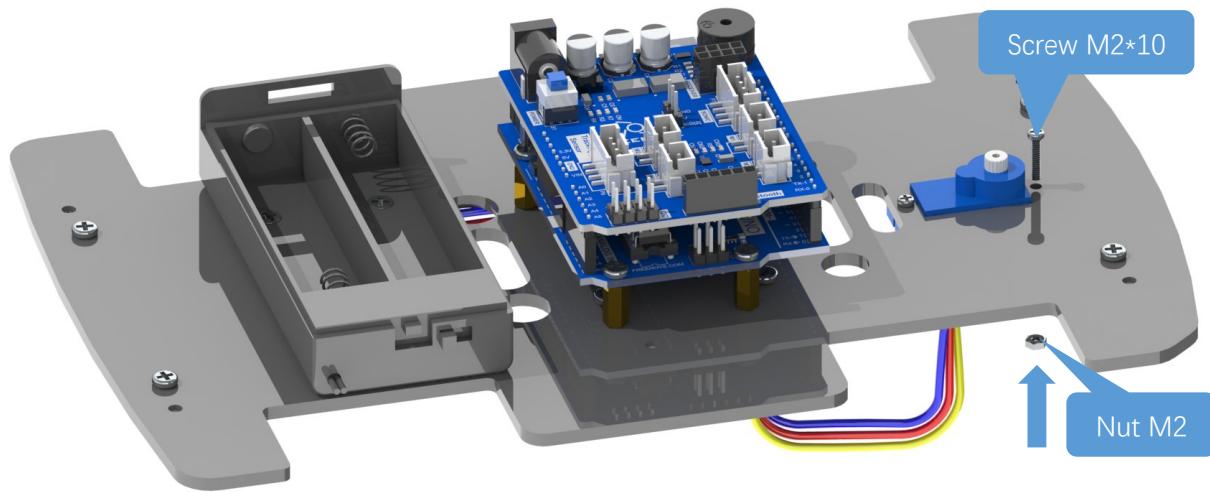
Connect LED controller with extension board with jumper wire F-F 4P. Wires of LED are hidden.
GND-GND, 5V-VCC, SCAL-RX, SDA-TX.



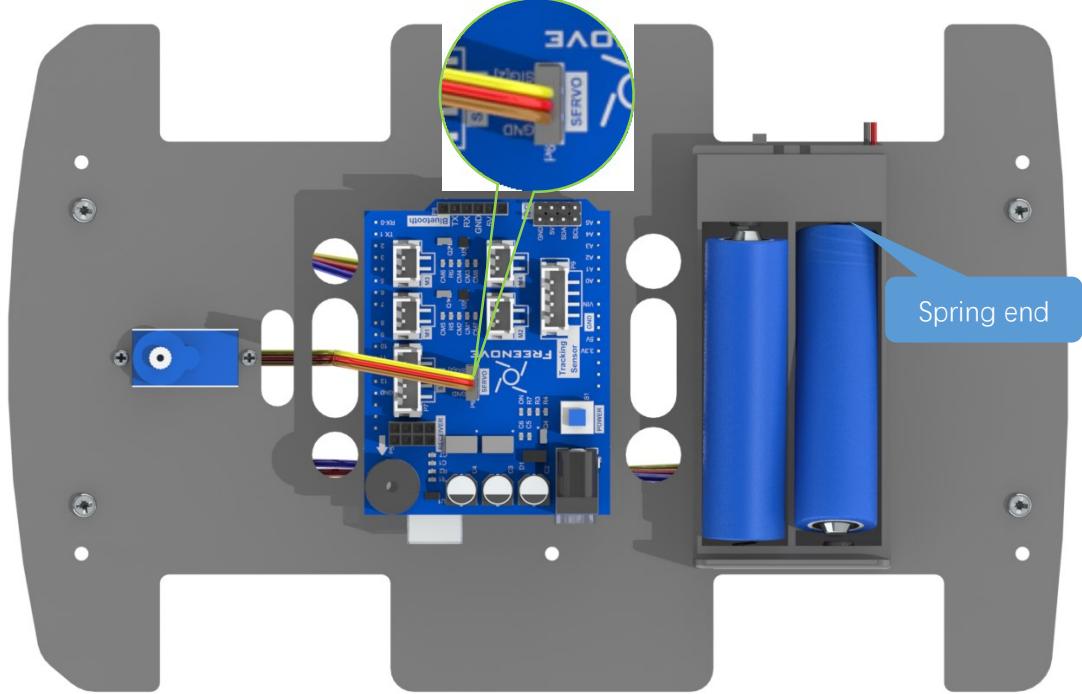
Install battery holder.



Install servo.



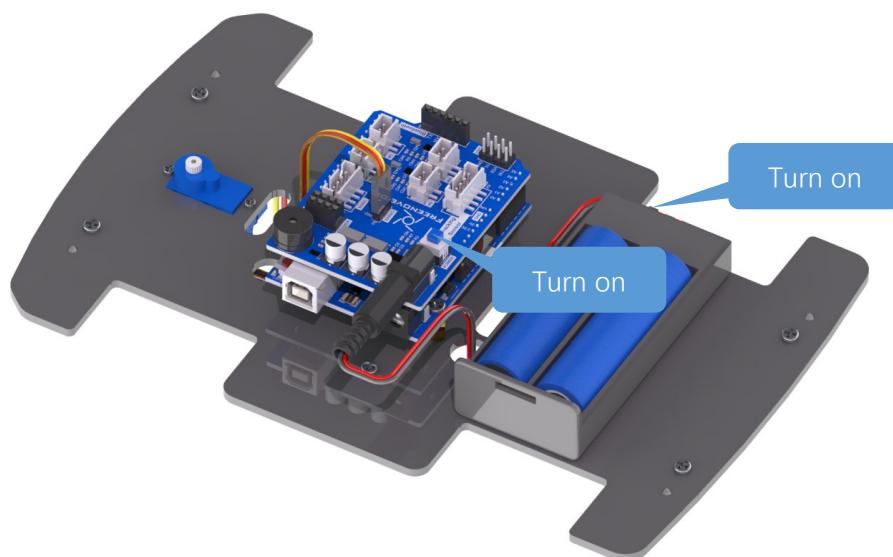
Install battery. And connect servo to servo port, yellow-SIG pin, red-5v, brown-GND.



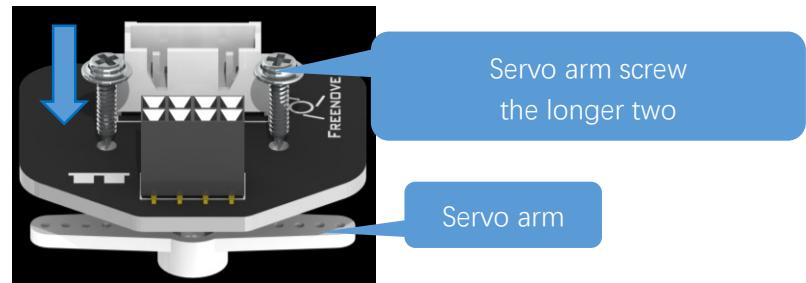
Connect power supply to extension board (the top board, not UNO board).

If you upload cod before, just turn on switch of extension board and battery holder.

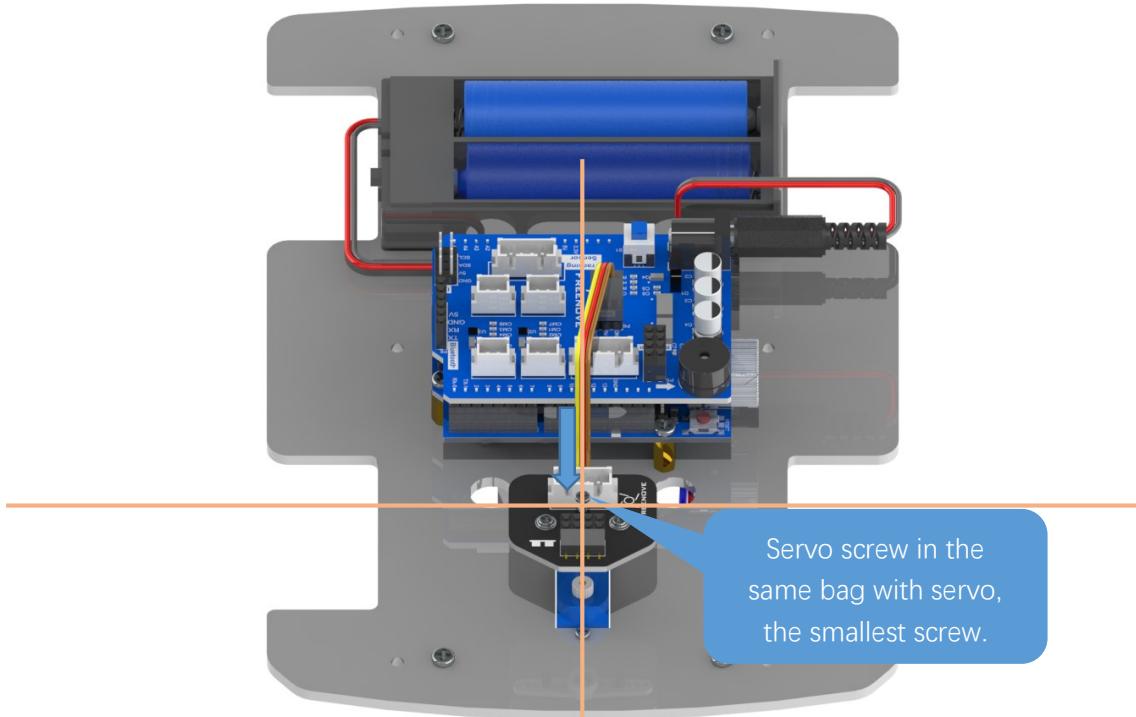
If not, you need [upload the code](#).



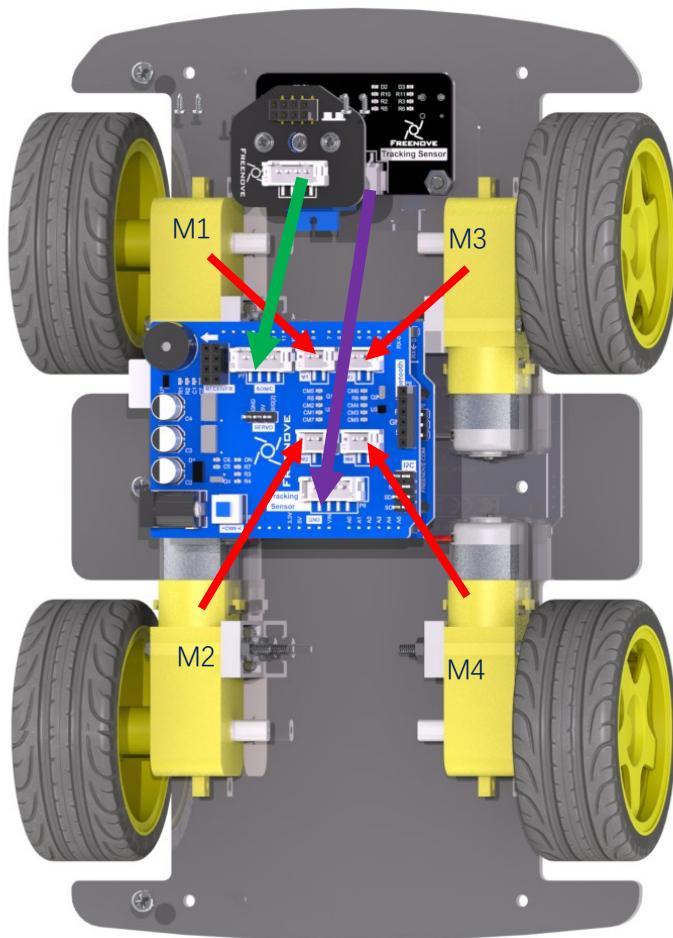
Install servo arm with sonic module connector. The screw and arm are in same bag with servo.



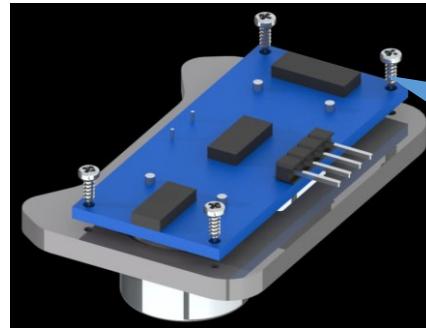
Connect servo arm to servo. Make sure servo arm is installed at 90 degrees.



Connect different components to corresponding port as below.

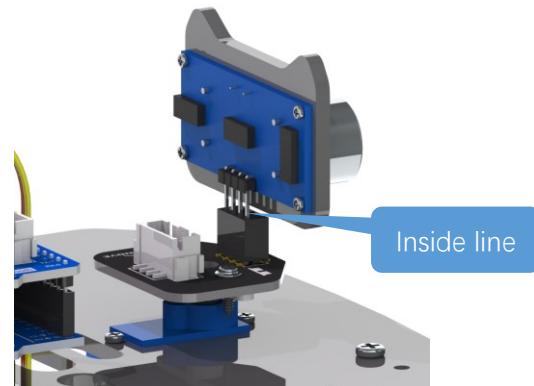


Install ultrasonic module to acrylic board.

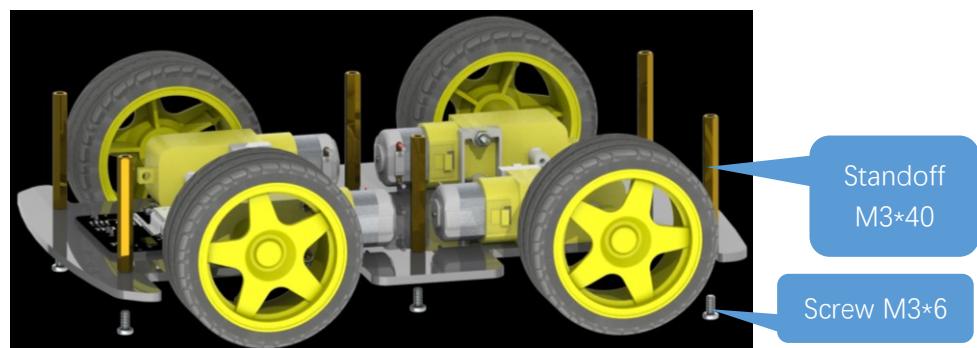


Self-taping screw
1.4*4

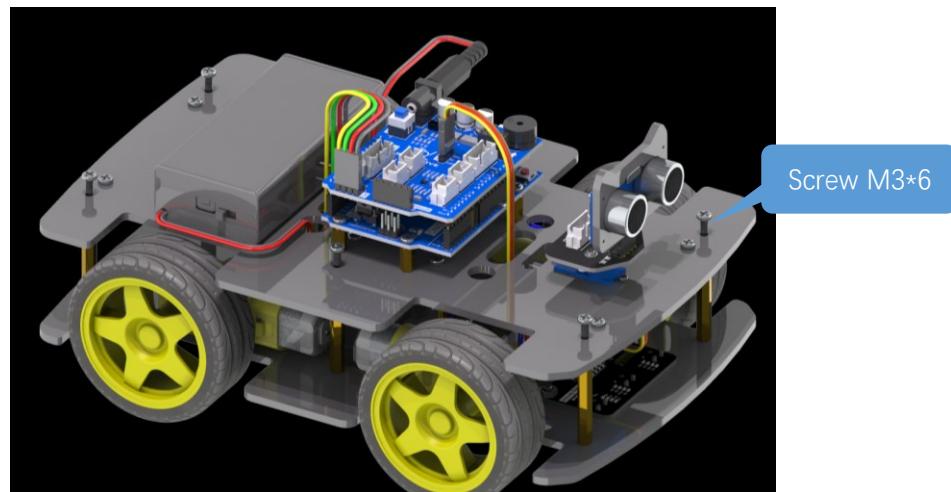
Plug ultrasonic module.



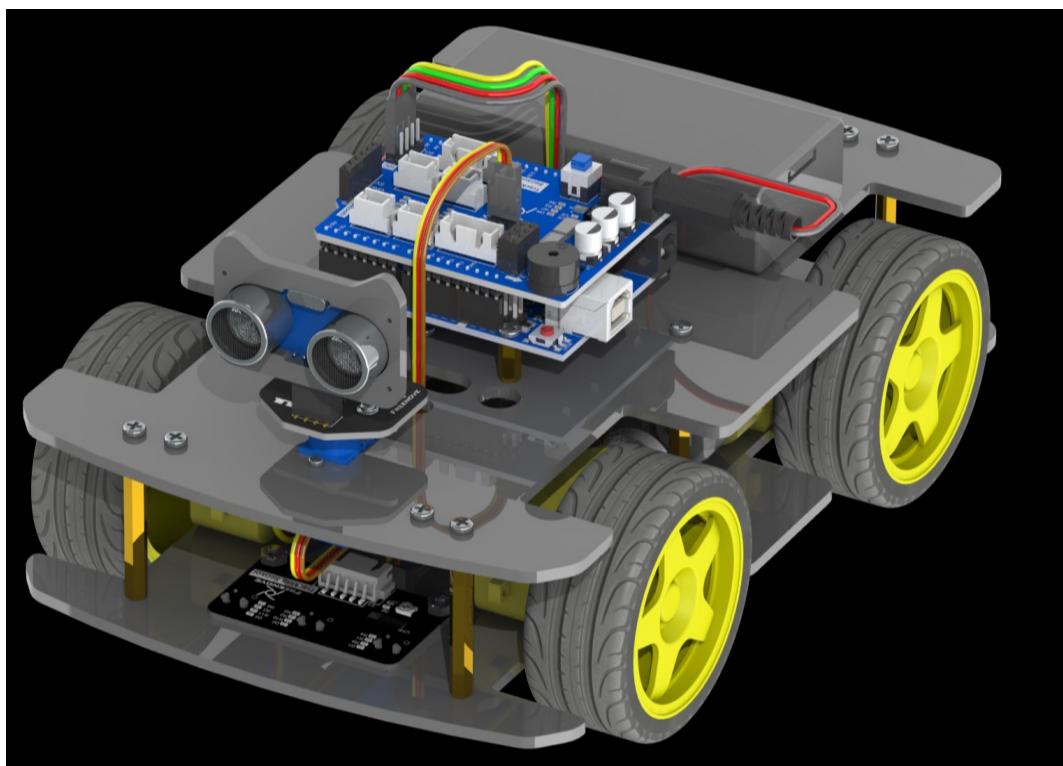
Install standoff M3*40 on bottom acrylic board.



Install top acrylic board to standoff.



Now the whole assembly is completed.



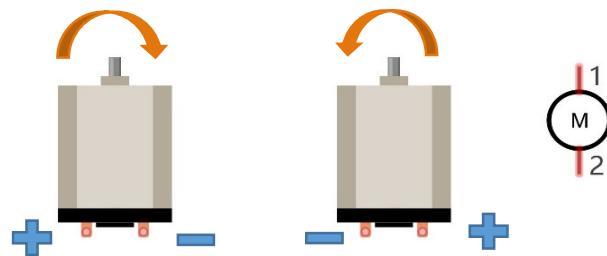
Chapter 1 Control Basic Components

This chapter will introduce how to control motor, buzzer, RGB LED and get battery level.

Motor

When motor get connected to the power supply, it will rotate in one direction. Reverse the polarity of power supply, then motor rotates in opposite direction.

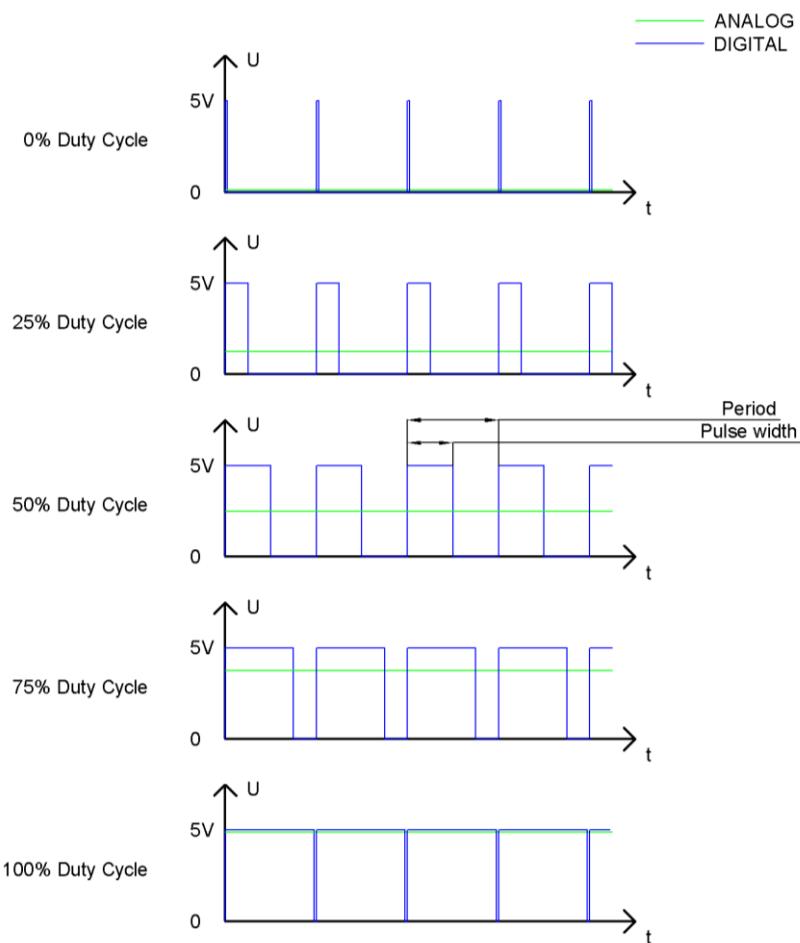
And the speed of motor depends on the voltage between two ends. The larger the voltage the larger the speed.



PWM

PWM, namely Pulse Width Modulation, uses digital pins to send certain frequency of square waves, that is, the output of high level and low level last for a period alternately. The total time for each set of high level and low level is generally fixed, which is called period (the reciprocal of the period is frequency). Output high time is generally called pulse width, and the percentage of pulse width is called duty cycle.

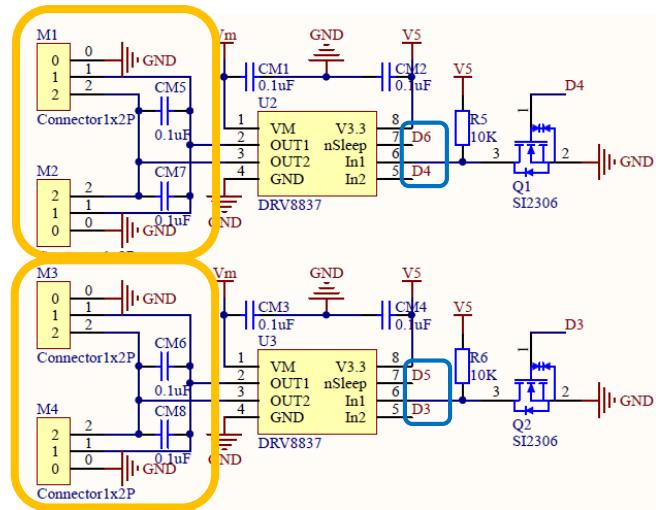
The longer the output of high level last, the larger the duty cycle and the larger the corresponding voltage in analog signal. The following figures show how the analog signal voltage vary between 0V-5V (high level is 5V) corresponding to the pulse width 0%-100%:



The larger PWM duty ratio, the larger the output power. So we can use PWM to control the brightness of LED, the speed of DC motor and so on.

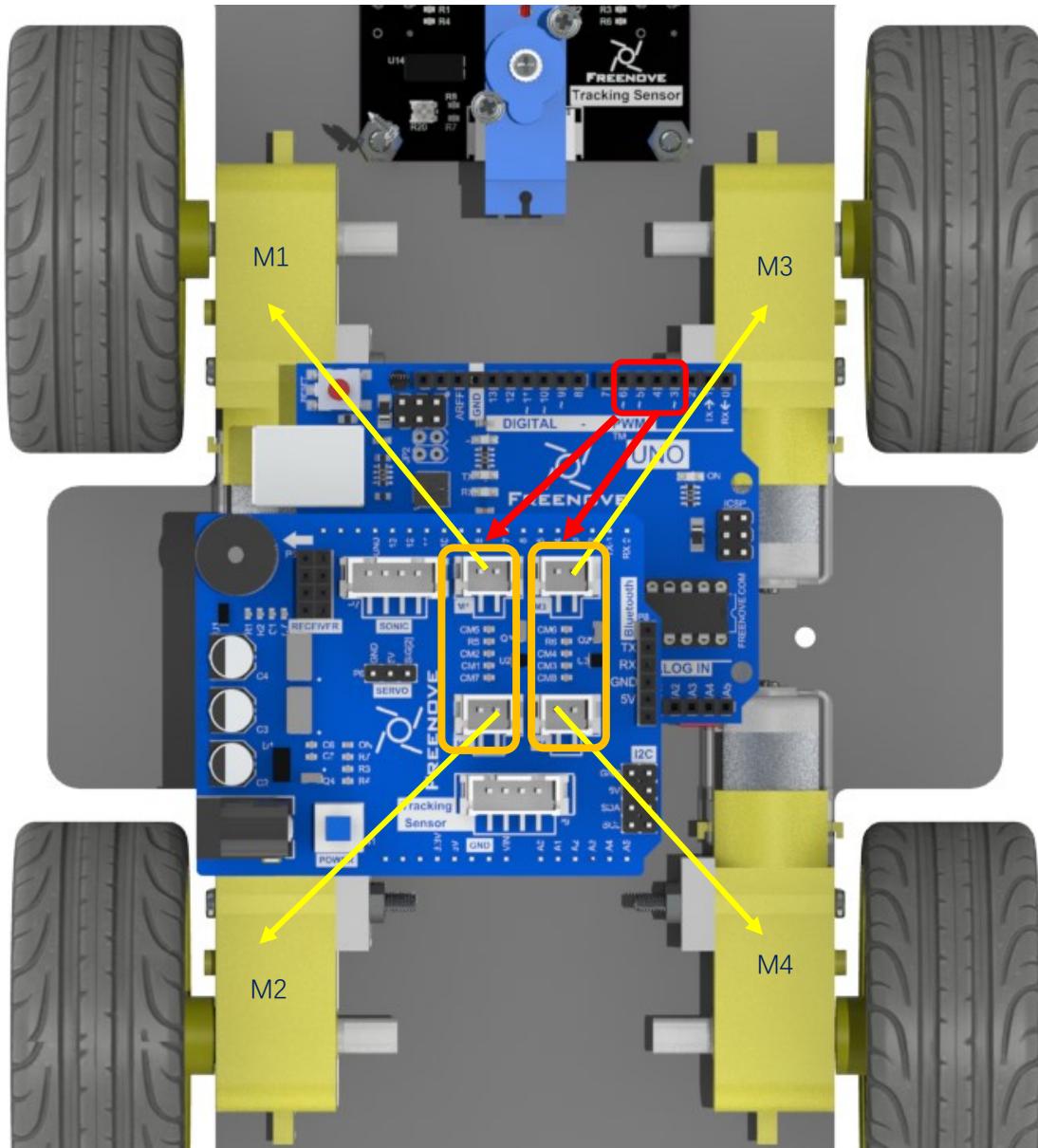


In this car, M1 and M2 are connected in parallel; M3 and M4 are connected in parallel. Schematic is below:



Motor [M1, M2, M3, M4]

D3 and D5 pin of UNO control M3 and M4. D4 and D6 pin of UNO board control M1 and M2.



Code

01.1.1_RunMotor_Left_Wheel

If you don't know how to upload code to Arduino, you can refer to [First Use](#).

Next turn off the power. And connect UNO to computer with USB cable. Upload code in folder: Sketches\01.1.1_RunMotor_Left_Wheel

Then disconnect USB cable and put your car in a place with enough space to move. Or make the car head stand up and observe the wheel. **Later code also need this step.**

Turn on the power of Car. Then the left motors and wheels of car will rotate forth and back. And you can see the speeds are different. You can turn off the power of car to stop that.

From last section, we have known M1 and M2 are connected in parallel, M3 and M4 are connected in parallel. It means that **you can only control motors in same side together**. We cannot control motors in same side separately. Usually, motors inside don't need to rotate with different directions.

The code is below:

```
1 #define PIN_DIRECTION_RIGHT 3
2 #define PIN_DIRECTION_LEFT 4
3 #define PIN_MOTOR_PWM_RIGHT 5
4 #define PIN_MOTOR_PWM_LEFT 6
5
6 void setup() {
7     pinMode(PIN_DIRECTION_LEFT, OUTPUT);
8     pinMode(PIN_MOTOR_PWM_LEFT, OUTPUT);
9     pinMode(PIN_DIRECTION_RIGHT, OUTPUT);
10    pinMode(PIN_MOTOR_PWM_RIGHT, OUTPUT);
11 }
12
13 void loop() {
14     //Left motors rotates to one direction
15     digitalWrite(PIN_DIRECTION_LEFT, HIGH);
16     analogWrite(PIN_MOTOR_PWM_LEFT, 100);
17     delay(1000);      //delay(ms), 1000ms=1s
18
19     analogWrite(PIN_MOTOR_PWM_LEFT, 0); //Stop
20     delay(1000);
21
22     //left motors rotates to opposite direction
23     digitalWrite(PIN_DIRECTION_LEFT, LOW);
24     analogWrite(PIN_MOTOR_PWM_LEFT, 255);
```

```

25   delay(1000);
26
27   analogWrite(PIN_MOTOR_PWM_LEFT, 0); //Stop
28   delay(1000);
29 }
30

```

In the code, following code is uses to define pins.

```

1 #define PIN_DIRECTION_RIGHT 3
2 #define PIN_DIRECTION_LEFT 4
3 #define PIN_MOTOR_PWM_RIGHT 5
4 #define PIN_MOTOR_PWM_LEFT 6

```

As you can see in schematic above. The pin for motors cannot be modified.

#define A B, it means A is B. Use A instead of B for easy maintenance and easy reading.

You can also define pins with int type, like int PIN_DIRECTION_RIGHT=3; But this need more RAM space.

Usually, there are two basic main functions for Arduino code, void setup() and void loop().

void setup(){ }

The setup() function is called when a sketch starts, which is used to initialize variables, pin modes, start using libraries, etc.

The setup() function will **only run once**, after each **power up** or **reset** of the Arduino board.

void loop(){ }

This function will loop consecutively. Code in this function will be executed again and again…

There are some other functions integrated by Arduino.

pinMode(pin, mode)

Configures the specified pin to behave either as an input or an output.

Parameters

pin: Arduino pin number to set the mode of.

mode: INPUT, OUTPUT, or INPUT_PULLUP.

digitalWrite(pin, value)

Write a HIGH or a LOW value to a digital pin.

If the pin has been configured as an OUTPUT with pinMode(), its voltage will be set to the corresponding value: 5V (or 3.3V on 3.3V boards) for HIGH, 0V (ground) for LOW.

Parameters

pin: Arduino pin number.

value: HIGH or LOW.

analogWrite(pin, value)

Writes an analog value (PWM wave) to a pin.

You do not need to call pinMode() to set the pin as an output before calling analogWrite().

Parameters

pin: Arduino pin to write to. Allowed data types: int.

value: the duty cycle: between 0 (always off) and 255 (always on). Allowed data types: int.

For more details, please refer to: <https://www.arduino.cc/reference/>

Note, as to analogWrite(pin, value) of motors for this car, and the maximum value is 255. Since motor need enough voltage to make the car move, **the maximum value is not 0**, which can make the car move depends on the battery level.

01.1.2_RunMotor_Right_Wheel

Upload code in folder: Sketches\01.1.2_RunMotor_Right_Wheel.

Then put your car in a place with enough space to move. Turn the power of car. Then the right motors and wheels of car will rotate forth and back. And you can see the speeds are different.

Because the left motors and right motors are mirrored. When the motors rotate with same direction, the car will react with reversed direction.

The code is below:

```
1 #define PIN_DIRECTION_RIGHT 3
2 #define PIN_DIRECTION_LEFT 4
3 #define PIN_MOTOR_PWM_RIGHT 5
4 #define PIN_MOTOR_PWM_LEFT 6
5
6 void setup() {
7     pinMode(PIN_DIRECTION_LEFT, OUTPUT);
8     pinMode(PIN_MOTOR_PWM_LEFT, OUTPUT);
9     pinMode(PIN_DIRECTION_RIGHT, OUTPUT);
10    pinMode(PIN_MOTOR_PWM_RIGHT, OUTPUT);
11 }
12
13 void loop() {
14     //Right motors rotate to one direction
15     digitalWrite(PIN_DIRECTION_RIGHT, HIGH);
16     analogWrite(PIN_MOTOR_PWM_RIGHT, 100);
17     delay(1000);
18     analogWrite(PIN_MOTOR_PWM_RIGHT, 0);
19     delay(1000);

20
21     //Right motors rotate to opposite direction
22     digitalWrite(PIN_DIRECTION_RIGHT, LOW);
23     analogWrite(PIN_MOTOR_PWM_RIGHT, 255);
24     delay(1000);
25     analogWrite(PIN_MOTOR_PWM_RIGHT, 0);
26     delay(1000);
27 }
28 }
```

01.1.3_Car_Move_and_Turn

Upload code in folder: Sketches\01.1.3_Car_Move_and_Turn.

Then put your car in a place with enough space to move. Turn the power of car. Then the car will move forth

and back, then turn left and turn right. The stop for 2 second. Then repeat the actions.

The code is below:

```
1 #define PIN_DIRECTION_RIGHT 3
2 #define PIN_DIRECTION_LEFT 4
3 #define PIN_MOTOR_PWM_RIGHT 5
4 #define PIN_MOTOR_PWM_LEFT 6
5
6 void setup() {
7     pinMode(PIN_DIRECTION_LEFT, OUTPUT);
8     pinMode(PIN_MOTOR_PWM_LEFT, OUTPUT);
9     pinMode(PIN_DIRECTION_RIGHT, OUTPUT);
10    pinMode(PIN_MOTOR_PWM_RIGHT, OUTPUT);
11 }
12
13 void loop() {
14     //Move forward
15     motorRun(200, 200);
16     delay(1000);
17
18     //Move back
19     motorRun(-200, -200);
20     delay(1000);
21
22     //Turn left
23     motorRun(-200, 200);
24     delay(1000);
25
26     //Turn right
27     motorRun(200, -200);
28     delay(1000);
29
30     //Stop
31     motorRun(0, 0);
32     delay(2000);
33 }
34
35 void motorRun(int speedl, int speedr) {
36     int dirL = 0, dirR = 0;
37     if (speedl > 0) {
38         dirL = 0;
39     }
40     else {
41         dirL = 1;
42         speedl = -speedl;
```

```

43 }
44 if (speedr > 0) {
45     dirR = 1;
46 }
47 else {
48     dirR = 0;
49     speedr = -speedr;
50 }
51 digitalWrite(PIN_DIRECTION_LEFT, dirL);
52 digitalWrite(PIN_DIRECTION_RIGHT, dirR);
53 analogWrite(PIN_MOTOR_PWM_LEFT, speedl);
54 analogWrite(PIN_MOTOR_PWM_RIGHT, speedr);
55 }
56

```

Now we will use `motorRun(200, -200)` as an example to introduce this function.

```

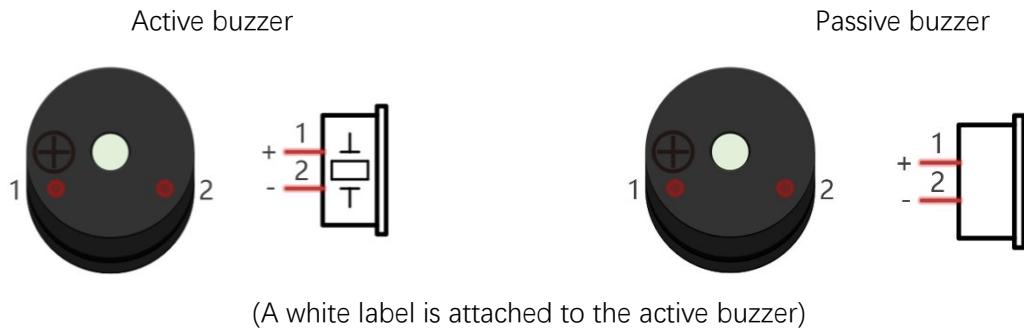
35 void motorRun(int speedl, int speedr) { //speedl=200, speedr=-200
36     int dirL = 0, dirR = 0;
37     if (speedl > 0) { //speedl=200>0, yes
38         dirL = 0; //so dirL =0
39     }
40     else {
41         dirL = 1;
42         speedl = -speedl;
43     }
44     if (speedr > 0) { //speedr=-200<0
45         dirR = 1;
46     }
47     else {
48         dirR = 0; //so dirR=0
49         speedr = -speedr; //then speedr=200
50     }
51     digitalWrite(PIN_DIRECTION_LEFT, dirL); // digitalWrite(PIN_DIRECTION_LEFT, 0);
52     digitalWrite(PIN_DIRECTION_RIGHT, dirR); // digitalWrite(PIN_DIRECTION_LEFT, 0);
53     analogWrite(PIN_MOTOR_PWM_LEFT, speedl); // analogWrite(PIN_MOTOR_PWM_LEFT, 200);
54     analogWrite(PIN_MOTOR_PWM_RIGHT, speedr); // analogWrite(PIN_MOTOR_PWM_RIGHT, 200)
55 }

```

The left motors and right motors are **mirrored**. When the motors on two sides rotate with the same direction, the car will turn. In order to make a car move forward or backward, we need to set the motor on two sides with different directions. So `motorRun(200, -200)` will make the car turn right.

Buzzer and Battery level

Buzzer is a sounding component. Buzzer has active and passive type. Active buzzer has oscillator inside, and it will make a sound as long as it is supplied with power. Passive buzzer requires external oscillator signal (generally use PWM with different frequency) to make a sound.



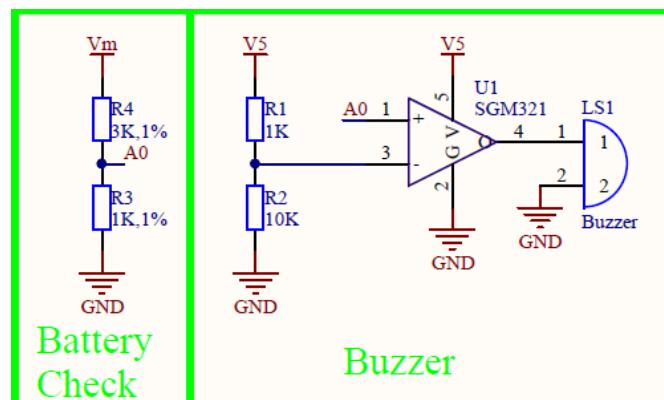
Active buzzer is easy to use. Generally, it can only make a specific frequency of sound.

Passive buzzer requires an external circuit to make a sound, but it can be controlled to make a sound with different frequency. The resonant frequency of the passive buzzer is 2kHz, which means the passive buzzer is loudest when resonant frequency is 2kHz.

In this car, the buzzer is active buzzer. So it can only make a specific frequency of sound. Function tone() of Arduino cannot be used for this kind of buzzer.

Since Arduino UNO has limited number of IOs. Buzzer and battery level are not used frequently. So we use one IO of UNO controlling buzzer and detect battery level in different time

The schematic of buzzer and battery is below:



As you can see they use same IO A0.

Battery level should be $V_m=4*V_0$. V_0 is the voltage detected by A0 of UNO.

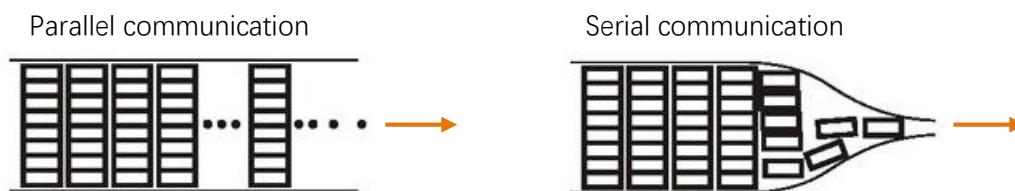
The maximum battery level is 8.4v ($V_0=2.1V$).

The right circuit means if $V_0>4.5V$, the buzzer will make sound.

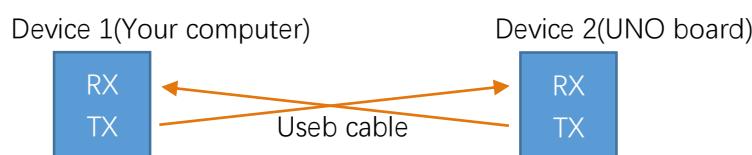
If V_0 is within(0~2.1v), it is used for battery. If $V_0>4.5V$, it used for buzzer.

Serial Communication

Serial communication uses one data cable to transfer data one bit by another in turn. Parallel communication means that the data is transmitted simultaneously on multiple cables. Serial communication takes only a few cables to exchange information between systems, especially suitable for computers to computer, long distance communication between computers and peripherals. Parallel communication is faster, but with more cables and the high cost, so it is not appropriate for long distance communication.



Serial communication generally refers to the Universal Asynchronous Receiver/Transmitter (UART). And it is commonly used in electronic circuit communication. It has two communication lines, one is responsible for sending data (TX line) and another for receiving data (RX line). The serial communication connections two devices use is as follows:



For serial communication, **baud rate in both sides must be the same**. The baud rates commonly used is 9600 and 115200.

Computer identifies serial devices connected to your computer as COMx. We can use the Serial Monitor window of Arduino Software to communicate with Freenove UNO.

Code

01.2.1_Buzzer

Upload code in Sketches\ 01.2.1_Buzzer. Then turn the switch of car.

You will hear b-bbbb----bbbb----bbbb----

The code in setup() is only executed once. Code in loop() will be executed circularly.

```

1 #define PIN_BATTERY      A0
2 #define PIN_BUZZER       A0
3
4 void setup() {
5   pinMode(PIN_BUZZER, OUTPUT);
6   digitalWrite(PIN_BUZZER, HIGH);
7   delay(100);
8   digitalWrite(PIN_BUZZER, LOW);
9 }
10
11 void loop() {
12   for (int i = 0; i < 4; i++) {
13     digitalWrite(PIN_BUZZER, HIGH); //turn on buzzer

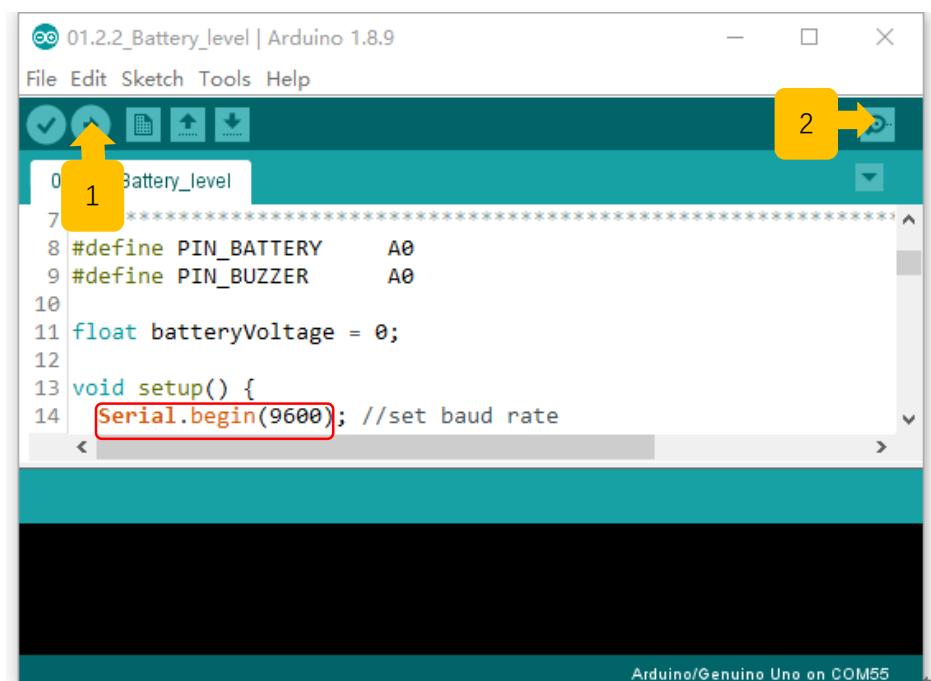
```

```

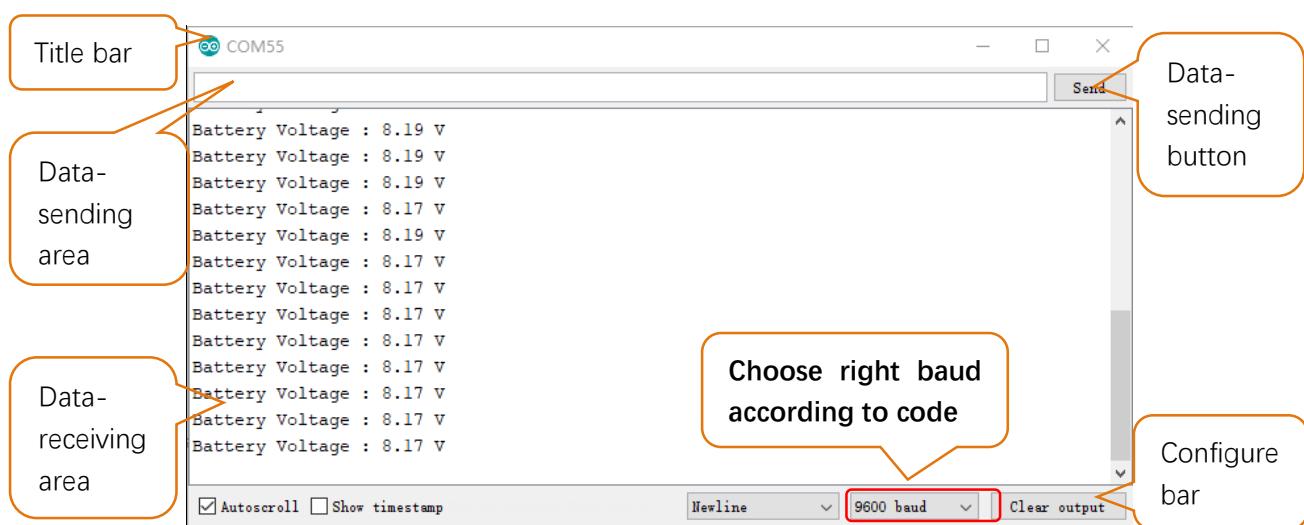
14     delay(100);
15     digitalWrite(PIN_BUZZER, LOW); //turn off buzzer
16     delay(100);
17 }
18 delay(500);
19 }
```

01.2.2_Battery_level

Upload code in Sketches\ 01.2.2_Battery_level. Don't disconnect the USB cable. Then turn the switch of car. And then click the Serial Monitor icon to open the Serial Monitor window.



Then you will hear buzzer make sound twice. And then see the Interface of Serial Monitor window is as follows. If you can't open it, make sure Freenove UNO had been connected to the computer, and choose the right serial port in the menu bar "Tools-Port".



The code is below:

```
1 #define PIN_BATTERY      A0
2 #define PIN_BUZZER        A0
3
4 float batteryVoltage = 0;
5
6 void setup() {
7     Serial.begin(9600); //set baud rate
8     pinMode(PIN_BUZZER, OUTPUT);
9
10    digitalWrite(PIN_BUZZER, HIGH);
11    delay(500);
12    digitalWrite(PIN_BUZZER, LOW);
13    delay(500);
14    digitalWrite(PIN_BUZZER, HIGH);
15    delay(500);
16    digitalWrite(PIN_BUZZER, LOW);
17 }
18
19 void loop() {
20     //Because the buzzer and battery voltage detection use A0 pin together,
21     //the buzzer must be turned off when reading battery voltage,
22     //otherwise the read battery voltage is incorrect.
23
24     //Turn off buzzer
25     pinMode(PIN_BUZZER, false);
26     digitalWrite(PIN_BUZZER, false);
27
28     //print battery voltage
29     if (getBatteryVoltage()) {
30         Serial.print("Battery Voltage : ");
31         Serial.print(batteryVoltage);
32         Serial.println(" V");
33     }
34     else {
35         Serial.print("Port busy! Please turn off buzzer before reading battery voltage.");
36     }
37     delay(1000);
38 }
39
40 bool getBatteryVoltage() {
41     pinMode(PIN_BATTERY, INPUT);
42     int batteryADC = analogRead(PIN_BATTERY);
43     if (batteryADC < 614)           // 614/1023* 5=3V, resonable Voltage:<2.1V
```

```

44     {
45         batteryVoltage = batteryADC / 1023.0 * 5.0 * 4;
46         return true;
47     } else {
48         return false;
49     }
50 }
```

In this code, different Data Types are mentioned: float, bool, void.

If you are not familiar data types, please refer to <https://www.arduino.cc/reference/>

VARIABLES

Arduino data types and constants.

Constants	Conversion	float	Variable Scope & Qualifiers
Floating Point Constants	(unsigned int)	int	const
Integer Constants	(unsigned long)	long	scope
HIGH LOW	byte()	short	static
INPUT OUTPUT INPUT_PULLUP	char()	size_t	volatile
LED_BUILTIN	float()	string	
true false	int()	unsigned char	Utilities
	long()	unsigned int	PROGMEM
	word()	unsigned long	sizeof()
		void	
		word	
	Data Types		
	String()		
	array		
	bool		
	boolean		
	byte		
	char		
	double		

The function is defined in form: **data type function name ()**.

If it is void function name(), after it is executed, it will return nothing.

```

28 //print battery voltage
29 if (getBatteryVoltage()) {
30     Serial.print("Battery Voltage : ");
31     Serial.print(batteryVoltage);
32     Serial.println(" V");
33 }
34 else {
35     Serial.print("Port busy Please turn off buzzer before reading battery voltage.");
36 }
37 delay(1000);
38 }
39
40 bool getBatteryVoltage() {
41     pinMode(PIN_BATTERY, INPUT);
42     int batteryADC = analogRead(PIN_BATTERY);
43     if (batteryADC < 614)           // 614/1023* 5=3V, resonable Voltage:<2.1V
44     {
45         batteryVoltage = batteryADC / 1023.0 * 5.0 * 4;
46         return true;
47     }else {
48         return false;
49     }
50 }
```

Code is always executed line by line. When `if (getBatteryVoltage())` is executed, the program will turn to execute `bool getBatteryVoltage(){ }.` After return, the program will execute code in `if { }.`

Serial.print()

Syntax is below:

`Serial.print(val)`

`Serial.print(val, format)`

Serial: serial port object. See the list of available serial ports for each board on the Serial main page.

val: the value to print. Allowed data types: any data type.

The only difference is that `Serial.println()` will send a "\n". content of next print() or println() will be shown in a new line.

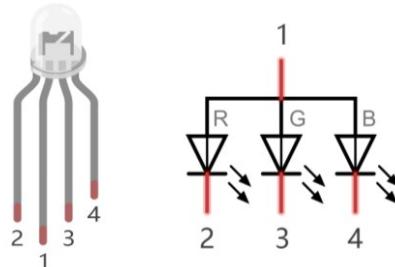
analogRead(pin)

It will map input voltages between 0 and the operating voltage(5V or 3.3V) into integer values between 0 and 1023. For 5v as an example, `ADCvalue= analogRead(pin)`

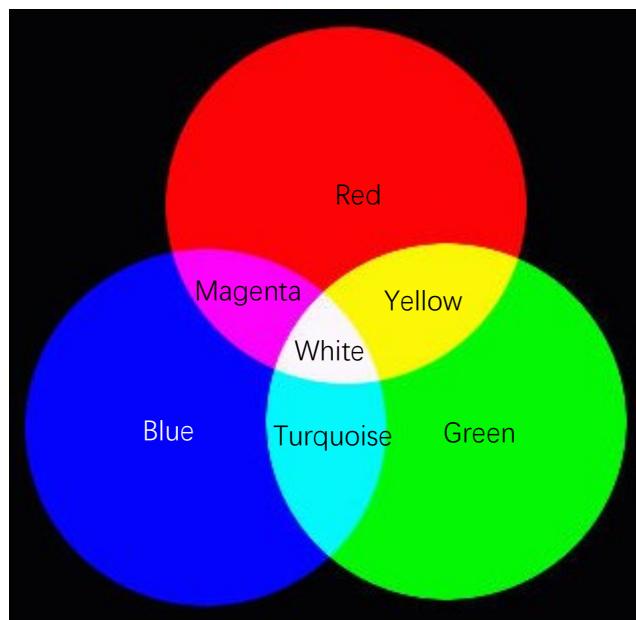
If you want to get the voltage value. It should be $V=ADCvalue/1023*5V$.

RGB

RGB LED has integrated 3 LEDs that can respectively emit red, green and blue light, and it has 4 pins. The long pin (1) is the common port, that is, 3 LED's cathode or anode. The RGB LED with common anode and its symbol are as follows. By controlling these 3 LED to emit light with different brightness, we can make RGB LED emit various colors of light.

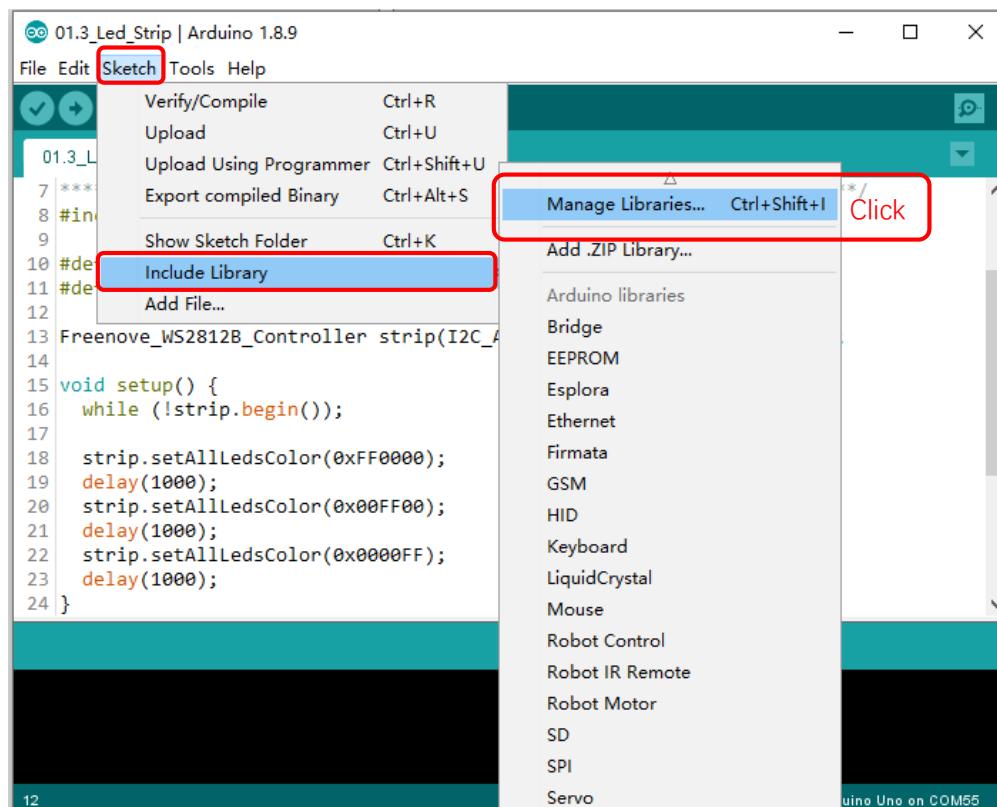


Red, green, and blue light are called tricolor light. When you combine these three primary-color light with different brightness, it can produce almost all visible light. Computer screens, single pixel of cell phone screen, neon, and etc. are working through this principle.



We know from previous section that, UNO controls LED to emit a total 256(0-255) different brightness by PWM. So, through the combination of three different colors of LED, RGB LED can emit $256^3=16777216$ Colors, 16Million colors.

Include Library



Enter "Freenove_WS2812B_RGBLED_Controller" and press "Enter" key to search.

Find and **install** the latest version (now it is version 1.0.0).



Then go back and upload the code.

Code

Upload code in Sketches\01.3_LED. Then turn the power of car.

You can find a proper view to observe LED color on the bottom acrylic board.





You will see. All LED show red, green, blue, yellow in turn. Then all LED get off.

Then first 5 LED show different color one by one. Then all LED show same color and color changes smoothly.

Then different LED show different color and color changes smoothly.

The code is below:

```
1 #include "Freenove_WS2812B_RGBLED_Controller.h"
2
3 #define I2C_ADDRESS 0x20
4 #define LEDS_COUNT 10 //it defines number of LEDs
5
6 Freenove_WS2812B_Controller strip(I2C_ADDRESS, LEDS_COUNT, TYPE_GRB); //initialization
7
8 void setup() {
9     while (!strip.begin()); //judge if initialization successs
10
11     strip.setAllLedsColor(0xFF0000); //Set all LED color to red
12     delay(2000);
13     strip.setAllLedsColor(0x00FF00); //set all LED color to green
14     delay(2000);
15     strip.setAllLedsColor(0x0000FF); //set all LED color to blue
16     delay(2000);
17     strip.setAllLedsColor(255, 255, 0); //set all LED color to yellow. This is just different
18     form of rgb value.
19     delay(2000);
20     strip.setAllLedsColor(0, 0, 0); //set all LED off.
21     delay(2000);
22
23     strip.setLedColor(0, 255, 0, 0); //set the N0.0 LED to red
24     delay(1000);
25     strip.setLedColor(1, 0, 255, 0); //set the N0.1 LED to green
26     delay(1000);
27     strip.setLedColor(2, 0, 0, 255); //set the N0.2 LED to blue
28     delay(1000);
29     strip.setLedColor(3, 255, 255, 0); //set the N0.3 LED to yellow
30     delay(1000);
31     strip.setLedColor(4, 255, 0, 255); //set the N0.4 LED to purple
32     delay(1000);
33 }
34
35 void loop() {
36     for (int k = 0; k < 255; k = k + 2) {
37         strip.setAllLedsColorData(strip.Wheel(k)); // set color data for all LED
38         strip.show(); // show the color set before
39         delay(50);
}
```

```

40 }
41 delay(3000);
42
43 for (int j = 0; j < 255; j += 2) {
44     for (int i = 0; i < LEDS_COUNT; i++) {
45         strip.setLedColorData(i, strip.Wheel(i * 256 / LEDS_COUNT + j)); //set color data for
46         LED one by one
47     }
48     strip.show(); // show the color set
49     delay(50);
50 }
51 }
```

First, you need install and include the library.

```
#include "Freenove_WS2812B_RGBLED_Controller.h"
```

Then set number of LED. The maximum is 255. But it is limited by power supply.

```
#define LEDS_COUNT 10 //it defines number of LEDs
```

There are two ways to set LED color.

A, set LED color directly.

1) set all LED color

```
strip.setAllLedsColor( rgb value)
```

rgb value should be Hexadecimal value, like `strip.setAllLedsColor(0x0000FF)`.

```
strip.setAllLedsColor( rvalue, gvalue, bvalue)
```

This is another form, Like `strip.setAllLedsColor(255, 255, 0)`.

You can find more rgb values and colors here https://www.rapidtables.com/web/color/RGB_Color.html

2) set color for one LED

```
strip.setLedColor( LED_Index, rgb_value) or strip.setLedColor(LED_Index, rvalue, gvalue, bvalue)
```

LED No. starts from 0, like `strip.setLedColor(0, 255, 0, 0)`.

B, Set color data first. Then use show function.

This is a more **efficient** way to set colors for many LEDs. It will make the code run faster than before.

1) set all LED color

```
strip.setAllLedsColorData( rgb value) or strip.setAllLedsColorData( rvalue, gvalue, bvalue)
```

After you complete set color, just add `strip.show()`

2) set color for one LED

```
strip.setLedColorData( LED_Index, rgb value) or strip.setLedColorData( LED_Index, rvalue, gvalue, bvalue)
```

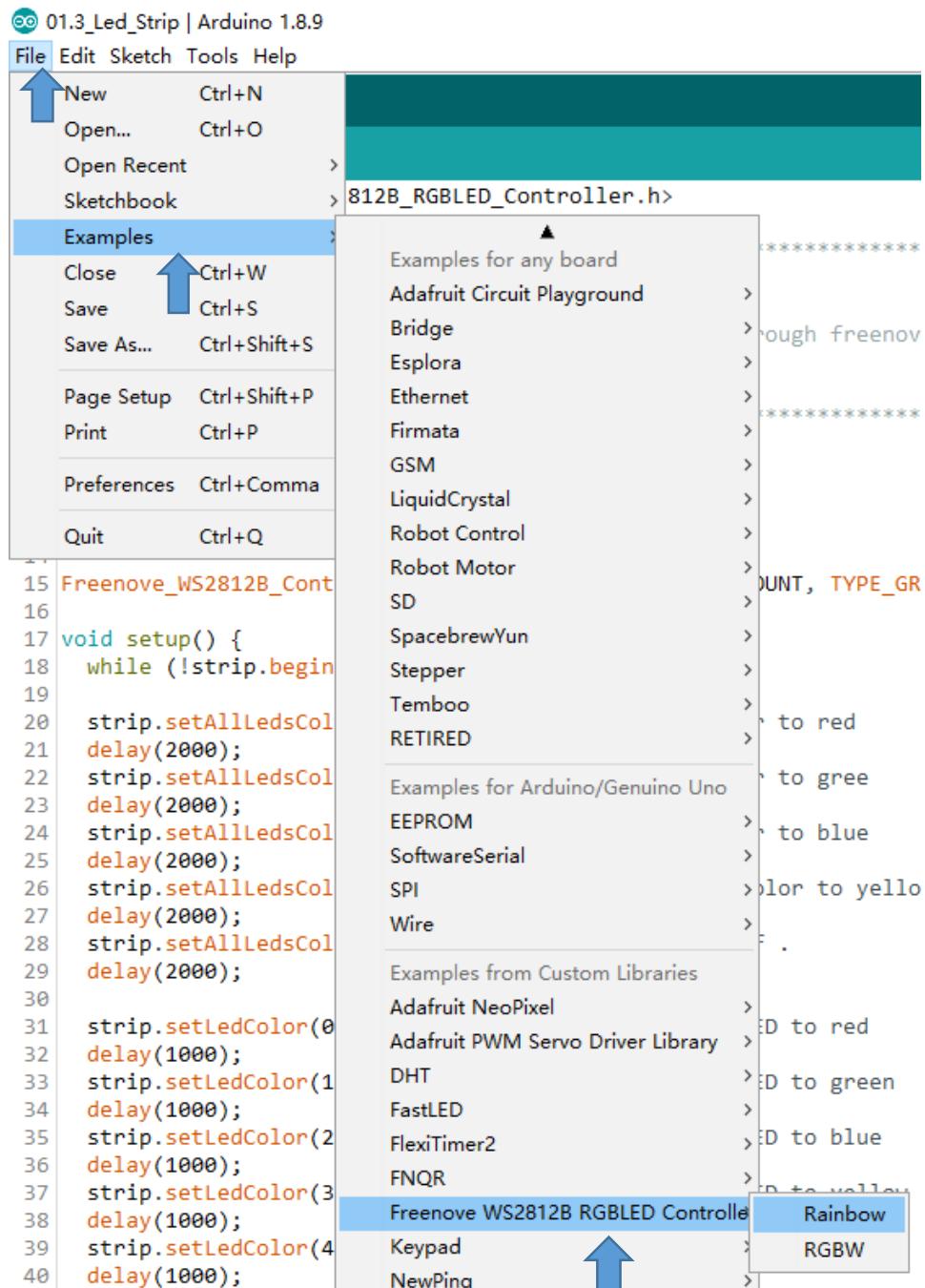
After you complete set color, just add `strip.show()`

strip.Wheel(value) value can be 0~255.

Different values correspond to different colors. You can take `strip.Wheel(value)` as a rgb value to use in the code, like `strip.setAllLedsColorData(strip.Wheel(k))`.



You can find some examples of the library below:



Integrate functions

Now we will write a code, which include all previous functions.

Code

01.4.1_Integrate_Functions

Upload code in sketches\ 01.4.1_Integrate_Functions.

Then put your car in a place with enough space to move. Turn the power of car.

```
1 #include "Freenove_WS2812B_RGBLED_Controller.h"
2
3 #define I2C_ADDRESS 0x20 //define I2C address of LEDs
4 #define LEDS_COUNT 10 //it defines number of LEDs
5 //define motor pins
6 #define PIN_DIRECTION_LEFT 4
7 #define PIN_DIRECTION_RIGHT 3
8 #define PIN_MOTOR_PWM_LEFT 6
9 #define PIN_MOTOR_PWM_RIGHT 5
10
11 #define PIN_BATTERY A0
12 #define PIN_BUZZER A0
13 #define MOTOR_PWM_DEAD 10
14 float batteryVoltage = 0;
15 bool isBuzzered = false;
16
17 Freenove_WS2812B_Controller strip(I2C_ADDRESS, LEDS_COUNT, TYPE_GRB); //initialization
18
19 void setup() {
20     while (!strip.begin()); //judge if initialization successes
21
22     Serial.begin(9600); //set baud rate
23     pinsSetup(); //set pin mode (output or input )
24
25     strip.setAllLedsColor(0x00FF00); //set all LED color to green
26     motorRun(100, 100); //Car move forward
27     alarm(4, 1); //4 beat, 1 repeat
28     resetCarAction(); //Stop the car and turn off the buzzer
29
30     strip.setAllLedsColor(0xFF0000); //Set all LED color to red
31     motorRun(-100, -100); //Car move back
32     setBuzzer(true); //turn on buzzer
33     delay(1000);
34     resetCarAction(); //Stop the car and turn off the buzzer
```

```
35 }
36
37 void loop() {
38     if (getBatteryVoltage() == true) {
39         Serial.print("voltage: ");
40         Serial.println(batteryVoltage);
41     }
42
43     int r = random(0, 255); //a random value between 0~255
44     int g = random(0, 255); //a random value between 0~255
45     int b = random(0, 255); //a random value between 0~255
46     strip.setAllLedsColor(r, g, b); //Set all LED color with current r, g, b value
47     delay(1000);
48 }
49
50 void pinsSetup() {
51     pinMode(PIN_DIRECTION_LEFT, OUTPUT);
52     pinMode(PIN_MOTOR_PWM_LEFT, OUTPUT);
53     pinMode(PIN_DIRECTION_RIGHT, OUTPUT);
54     pinMode(PIN_MOTOR_PWM_RIGHT, OUTPUT);
55     setBuzzer(false); //Turn off the Buzzer
56 }
57
58 void motorRun(int speedl, int speedr) {
59     int dirL = 0, dirR = 0;
60     if (speedl > 0) {
61         dirL = 0;
62     }
63     else {
64         dirL = 1;
65         speedl = -speedl;
66     }
67
68     if (speedr > 0) {
69         dirR = 1;
70     }
71     else {
72         dirR = 0;
73         speedr = -speedr;
74     }
75
76     speedl = constrain(speedl, 0, 255);
77     speedr = constrain(speedr, 0, 255);
78 }
```

```
79     if (abs(speedl) < MOTOR_PWM_DEAD && abs(speedr) < MOTOR_PWM_DEAD) {
80         speedl = 0;
81         speedr = 0;
82     }
83     digitalWrite(PIN_DIRECTION_LEFT, dirL);
84     digitalWrite(PIN_DIRECTION_RIGHT, dirR);
85     analogWrite(PIN_MOTOR_PWM_LEFT, speedl);
86     analogWrite(PIN_MOTOR_PWM_RIGHT, speedr);
87 }
88
89 bool getBatteryVoltage() {
90     if (!isBuzzered) {
91         pinMode(PIN_BATTERY, INPUT);
92         int batteryADC = analogRead(PIN_BATTERY);
93         if (batteryADC < 614) // 3V/12V , Voltage read: <2.1V/8.4V
94         {
95             batteryVoltage = batteryADC / 1023.0 * 5.0 * 4;
96             return true;
97         }
98     }
99     return false;
100 }
101
102 void setBuzzer(bool flag) {
103     isBuzzered = flag;
104     pinMode(PIN_BUZZER, flag);
105     digitalWrite(PIN_BUZZER, flag);
106 }
107
108 void alarm(u8 beat, u8 repeat) {
109     beat = constrain(beat, 1, 9);
110     repeat = constrain(repeat, 1, 255);
111     for (int j = 0; j < repeat; j++) {
112         for (int i = 0; i < beat; i++) {
113             setBuzzer(true);
114             delay(100);
115             setBuzzer(false);
116             delay(100);
117         }
118         delay(500);
119     }
120 }
121
122 void resetCarAction() {
```

```

123   motorRun(0, 0);
124   setBuzzer(false);
125 }
```

01.4.2_Library_Integrate_Functions

Upload code in sketches\01.4.2_Library_Integrate_Functions, which has same function with code 01.4.1_Integrate_Functions. The only difference is that we write some code into library. We will use this library later. Library will make programing more efficient.

 01.4.2_Library_Integrate_Functions | Arduino 1.8.9

File Edit Sketch Tools Help



```

01.4.2_Library_Integrate_Functions Freenove_4WD_Car_for_Arduino.cpp Freenove_4WD_Car_for_Arduino.h
1 #include "Freenove_4WD_Car_for_Arduino.h"
2 #include "Freenove_WS2812B_RGBLED_Controller.h"
3
4 #define I2C_ADDRESS 0x20 //define I2C address of LEDs
5 #define LEDS_COUNT    10 //it defines number of LEDs
6
7 Freenove_WS2812B_Controller strip(I2C_ADDRESS, LEDS_COUNT, TYPE_GRB); //initializat
8
9 void setup() {
10   while (!strip.begin()); //judge if initialization successss
11 }
```

The main code is as below. The Freenove_4WD_Car_for_Arduino.h has defined some pins, variables and functions. We can use them directly. We do not need redefine them again.

```

1 #include "Freenove_4WD_Car_for_Arduino.h"
2 #include "Freenove_WS2812B_RGBLED_Controller.h"
3
4 #define I2C_ADDRESS 0x20 //define I2C address of LEDs
5 #define LEDS_COUNT    10 //it defines number of LEDs
6 Freenove_WS2812B_Controller strip(I2C_ADDRESS, LEDS_COUNT, TYPE_GRB); //initialization
7
8 void setup() {
9   while (!strip.begin()); //judge if initialization successes
10  Serial.begin(9600); //set baud rate
11  pinsSetup(); //set pin mode (output or input )
12
13  strip.setAllLedsColor(0x00FF00); //set all LED color to green
14  motorRun(100, 100); //Car move forward
15  alarm(4, 1); //4 beat, 1 repeat
16  resetCarAction(); //Stop the car and turn off the buzzer
17
18  strip.setAllLedsColor(0xFF0000); //Set all LED color to red
19  motorRun(-100, -100); //Car move back
```

```

20     setBuzzer(true);      //turn on buzzer
21     delay(1000);
22     resetCarAction();    //Stop the car and turn off the buzzer
23 }
24
25 void loop() {
26   if (getBatteryVoltage() == true) {
27     Serial.print("voltage: ");
28     Serial.println(batteryVoltage);
29   }
30   int r = random(0, 255); //a random value between 0~255
31   int g = random(0, 255); //a random value between 0~255
32   int b = random(0, 255); //a random value between 0~255
33   strip.setAllLedsColor(r, g, b); //Set all LED color with current r, g, b value
34   delay(1000);
35 }
```

In this code, Freenove_4WD_Car_for_Arduino library is used.

```
#include "Freenove_4WD_Car_for_Arduino.h"
```

And you can see, we did not define pins and some functions in the main. But we can use them.

Now let's learn a new skill, using library.

Open the directory Sketches\ 01.4.2_Library_Integrate_Functions. You will see .cpp and .h file. They are **library files**.

When use the library in new code, you just need put this two files into the same directory of your code.

 01.4.2_Library_Integrate_Functions.ino
 Freenove_4WD_Car_for_Arduino.cpp
 Freenove_4WD_Car_for_Arduino.h

This library will be used latter. Library will make programing more efficient.

Now we will introduce content in the library.

First, check **Freenove_4WD_Car_for_Arduino.h**.

This file defines some pins and function.

After you write the code `#include "Freenove_4WD_Car_for_Arduino.h"`

You will be able to use the pins define and functions in Freenove_4WD_Car_for_Arduino.h. And you don't need to define the pins and build the functions any more in your code.

```

1 // Freenove_4WD_Car_for_Arduino.h
2 #ifndef _FREENOVE_4WD_CAR_FOR_ARDUINO_h
3 #define _FREENOVE_4WD_CAR_FOR_ARDUINO_h
4 #if defined(ARDUINO) && ARDUINO >= 100
5   #include "arduino.h"
6 #else
7   #include "WProgram.h"
```

```

8 #endif
9 #define PIN_SERVO          2
10 //define motor pin
11 #define PIN_DIRECTION_LEFT 4
12 #define PIN_DIRECTION_RIGHT 3
13 #define PIN_MOTOR_PWM_LEFT 6
14 #define PIN_MOTOR_PWM_RIGHT 5
15
16 //define ultrasonic module pin
17 #define PIN SONIC_TRIG      7
18 #define PIN SONIC_ECHO       8
19
20 #define PIN_IRREMOTE_RECV   9
21 //define SPI pin
22 #define PIN_SPI_CE          9
23 #define PIN_SPI_CSN         10
24 #define PIN_SPI_MOSI        11
25 #define PIN_SPI_MISO        12
26 #define PIN_SPI_SCK         13
27
28 #define PIN_BATTERY          A0
29 #define PIN_BUZZER           A0
30
31 //define tracking sensor pin
32 #define PIN_TRACKING_LEFT   A1
33 #define PIN_TRACKING_CENTER  A2
34 #define PIN_TRACKING_RIGHT   A3
35 #define MOTOR_PWM_DEAD      5
36
37 //define functions
38 // all following content are used in integrated code above
39 extern float batteryVoltage;
40 void pinsSetup();
41 void motorRun(int speedl, int speedr);
42 bool getBatteryVoltage();
43 void setBuzzer(bool flag);
44 void alarm(u8 beat, u8 repeat);
45 void resetCarAction();
46 #endif

```

Then check **Freenove_4WD_Car_for_Arduino.cpp**.

Its name should be same with .h file. We define functions in .h file and implement its content in .cpp.

You can see how the function work.

1	#include "Freenove_4WD_Car_for_Arduino.h"
---	---

```
2 float batteryVoltage = 0;
3 bool isBuzzered = false;
4
5 void pinsSetup() {
6     //define motor pin
7     pinMode(PIN_DIRECTION_LEFT, OUTPUT);
8     pinMode(PIN_MOTOR_PWM_LEFT, OUTPUT);
9     pinMode(PIN_DIRECTION_RIGHT, OUTPUT);
10    pinMode(PIN_MOTOR_PWM_RIGHT, OUTPUT);
11
12    //define ultrasonic module pin
13    pinMode(PIN SONIC TRIG, OUTPUT);
14    pinMode(PIN SONIC ECHO, INPUT);
15
16    //define tracking sensor pin
17    pinMode(PIN_TRACKING_LEFT, INPUT);
18    pinMode(PIN_TRACKING_RIGHT, INPUT);
19    pinMode(PIN_TRACKING_CENTER, INPUT);
20    setBuzzer(false); // turn off buzzer
21}
22
23 void motorRun(int speedl, int speedr) {
24     int dirL = 0, dirR = 0;
25     if (speedl > 0) {
26         dirL = 0;
27     }
28     else {
29         dirL = 1;
30         speedl = -speedl;
31     }
32
33     if (speedr > 0) {
34         dirR = 1;
35     }
36     else {
37         dirR = 0;
38         speedr = -speedr;
39     }
40
41     speedl = constrain(speedl, 0, 255); // speedl absolute value should be within 0~255
42     speedr = constrain(speedr, 0, 255); // speedr absolute value should be within 0~255
43     digitalWrite(PIN_DIRECTION_LEFT, dirL);
44     digitalWrite(PIN_DIRECTION_RIGHT, dirR);
45     analogWrite(PIN_MOTOR_PWM_LEFT, speedl);
46     analogWrite(PIN_MOTOR_PWM_RIGHT, speedr);
```

```
}

bool getBatteryVoltage() {
    if (!isBuzzered) {
        pinMode(PIN_BATTERY, INPUT);
        int batteryADC = analogRead(PIN_BATTERY);
        if (batteryADC < 614) // 3V/12V , Voltage read: <2.1V/8.4V
        {
            batteryVoltage = batteryADC / 1023.0 * 5.0 * 4;
            return true;
        }
    }
    return false;
}

void setBuzzer(bool flag) {
    isBuzzered = flag;
    pinMode(PIN_BUZZER, flag);
    digitalWrite(PIN_BUZZER, flag);
}

void alarm(u8 beat, u8 repeat) {
    beat = constrain(beat, 1, 9);
    repeat = constrain(repeat, 1, 255);
    for (int j = 0; j < repeat; j++) {
        for (int i = 0; i < beat; i++) {
            setBuzzer(true);
            delay(100);
            setBuzzer(false);
            delay(100);
        }
        delay(500);
    }
}

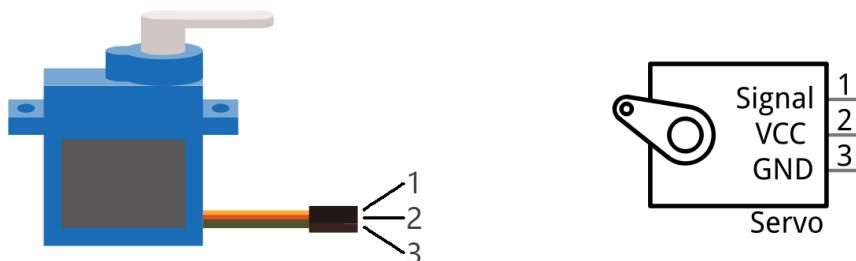
void resetCarAction() {
    motorRun(0, 0);
    setBuzzer(false);
}
```

Chapter 2 Obstacle avoidance

This chapter will introduce servo and ultrasonic module. Then make an automatic obstacle avoidance car.

Servo

Servo is an auto-control system, consisting of DC motor, reduction gear, sensor and control circuit. Usually, it can rotate in the range of 180 degrees. Servo can output larger torque and is widely used in model airplane, robot and so on. It has three lines, including two for electric power line positive (2-VCC, red), negative (3-GND, brown), and the signal line (1-Signal, orange).



We use 50Hz PWM signal with a duty cycle in a certain range to drive the servo. The lasting time 0.5ms~2.5ms of PWM single cycle high level corresponds to the servo angle 0 degrees - 180 degree linearly. Part of the corresponding values are as follows:

High level time	Servo angle
0.5ms	0 degree
1ms	45 degree
1.5ms	90 degree
2ms	135 degree
2.5ms	180 degree

When you change the servo signal, servo will rotate to the designated position.

Code

Upload code in Sketches\ 02.1_Servo. Then turn on the power of car.

Then you will see servo sweep between 45°, 90°, 135°.

```

1 #include "Servo.h"      //servo library
2
3 #define PIN_SERVO 2    //define servo pin
4
5 Servo;                  //create servo object to control a servo
6 byte servoOffset = 0;   // change the value to Calibrate servo
7
8 void setup() {

```

```
9  servo.attach(PIN_SERVO);           //initialize servo
10 servo.write(90 + servoOffset);   //Calibrate servo
11 }
12
13 void loop() {
14     servo.write(45);           //make servo rotate to 45°
15     delay(1000);             //delay 1000ms
16
17     servo.write(90);          //make servo rotate to 90°
18     delay(1000);
19
20     servo.write(135);         //make servo rotate to 135°
21     delay(1000);
22
23     servo.write(90);          //make servo rotate to 90°
24     delay(1000);
25 }
26 }
```

Servo library

There are some functions of this library:

servo.attach(pin)

Attach the Servo variable to a pin.

pin: servo pin it is an initialization step to control a servo.

servo.write(angle)

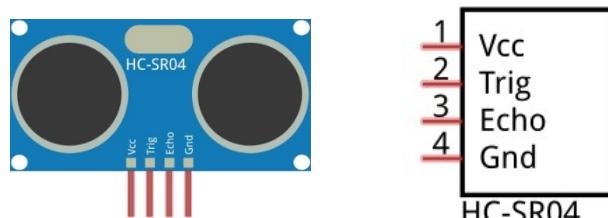
Writes a value to the servo, controlling the shaft accordingly.

angle: the value to write to the servo, from 0 to 180

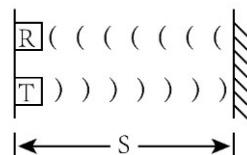
For more details, please refer to: <https://www.arduino.cc/en/Reference/Servo>

Ultrasonic ranging module

Ultrasonic ranging module use the principle that ultrasonic will reflect when it encounters obstacles. Ultrasonic module integrates a transmitter and a receiver. The transmitter is used to convert electrical signals (electrical energy) into sound waves (mechanical energy) and the function of the receiver is opposite.



Start counting the time when ultrasonic is transmitted. And when ultrasonic encounters an obstacle, it will reflect back. The counting will end after ultrasonic is received, and the time difference is the total time of ultrasonic from transmitting to receiving. Because the speed of sound in air is constant, and is about $v=340\text{m/s}$. So we can calculate the distance between the module and the obstacle: $S=vt/2$.

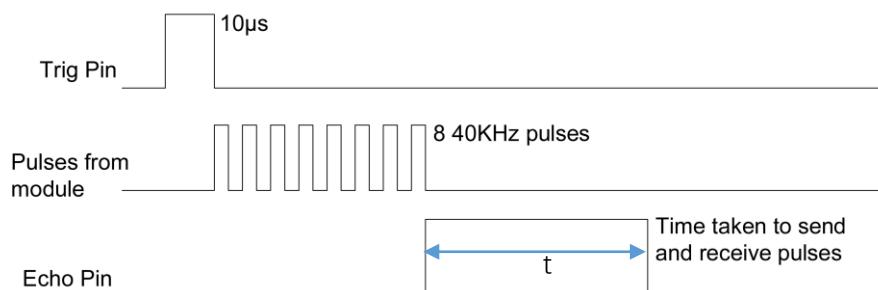


Pin description:

Pin name	Pin number	Description
Vcc	1	Positive electrode of power supply, the voltage is 5V
Trig	2	Triger pin
Echo	3	Echo pin
Gnd	4	Negative electrode of power supply

Instructions for use:

Output a high-level pulse in Trig pin lasting for at least 10us. Then the module begins to transmit ultrasonic. At the same time, the Echo pin will be pulled **High**. When the module receives the returned ultrasonic, the Echo pin will be pulled **Low**. The duration of high level in Echo pin is the total time of the ultrasonic from transmitting to receiving, $S=vt/2$, which is used to operate the HC-SR04 in Arduino.



Code

This project is used to set servo different angles and detect obstacle distance at each angle.

Upload code in Sketches\ 02.2_Ultrasonic_Ranging.

Then turn on the power of car. Then open the serial monitor.

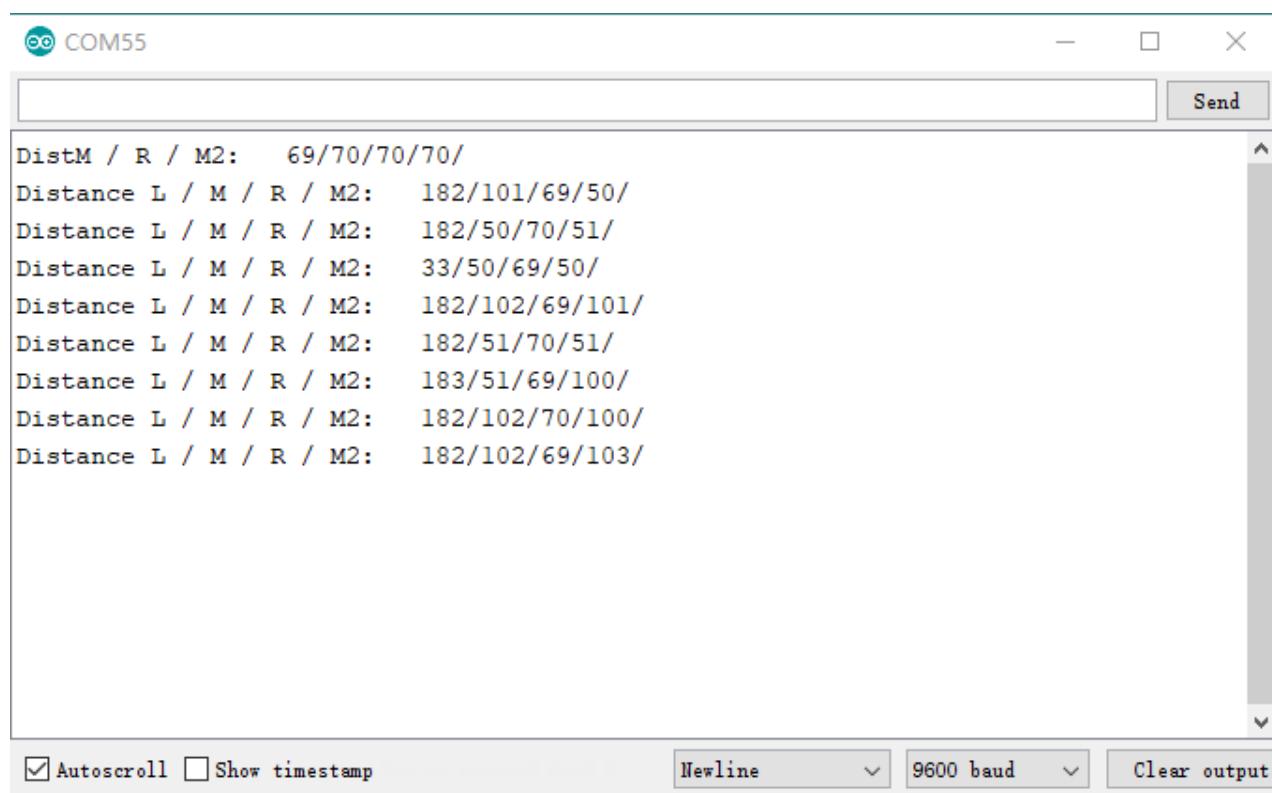


```

02.2_Ultrasonic_Ranging | Arduino 1.8.9
File Edit Sketch Tools Help
02.2_Ultrasonic_Ranging $ 
1 //*****
2 * Product      : Freenove 4WD Car for UNO
3 * Description  : Ultrasonic ranging and servo.
4 * Author       : www.freenove.com
5 * Modification: 2019/08/05
6 ****
7 #include "Servo.h"           //include servo library
8
9 #define PIN_SERVO      2      //define servo pin
10
11 #define PIN SONIC TRIG    7      //define Trig pin
12 #define PIN SONIC ECHO    8      //define Echo pin
13
14 #define MAX_DISTANCE    300    //cm
15 #define COUNT TIMEOUT   (MAX_DISTANCE*60) // calculate timeout

```

Then you will see servo sweep between 45°, 90°, 135°. And ultrasonic module detects different distance at different angles. All the distance values are printed below:



Sensor	Distance (cm)
L / M	69/70/70/70/
M	182/101/69/50/
R	182/50/70/51/
M2	33/50/69/50/
L / M	182/102/69/101/
M	182/51/70/51/
R	183/51/69/100/
M2	182/102/70/100/
L / M	182/102/69/103/

Autoscroll Show timestamp Newline 9600 baud Clear output

The code is below:

```

1 #include "Servo.h"           //include servo library
2
3 #define PIN_SERVO      2      //define servo pin
4

```

```
5 #define PIN SONIC TRIG    7 //define Trig pin
6 #define PIN SONIC ECHO     8 //define Echo pin
7
8 #define MAX_DISTANCE      300 //cm
9 #define SONIC_TIMEOUT      (MAX_DISTANCE*60) // calculate timeout
10 #define SOUND_VELOCITY     340 //sound Velocity: 340m/s
11
12 Servo servo;           //create servo object
13 byte servoOffset = 0;   //change the value to Calibrate servo
14 u8 distance[4];        //define an array with type u8(same to unsigned char)
15
16 void setup() {
17     Serial.begin(9600);
18     pinMode(PIN SONIC TRIG, OUTPUT); // set trigPin to output mode
19     pinMode(PIN SONIC ECHO, INPUT); // set echoPin to input mode
20     servo.attach(PIN SERVO); //initialize servo
21     servo.write(90 + servoOffset); // change servoOffset to Calibrate servo
22 }
23 void loop() {
24     servo.write(45);
25     delay(1000);
26     distance[0] = getSonar(); //get ultrasonic value and save it into distance[0]
27
28     servo.write(90);
29     delay(1000);
30     distance[1] = getSonar();
31
32     servo.write(135);
33     delay(1000);
34     distance[2] = getSonar();
35
36     servo.write(90);
37     delay(1000);
38     distance[3] = getSonar();
39
40     Serial.print("Distance L / M / R / M2: ");
41     for (int i = 0; i < 4; i++) {
42         Serial.print(distance[i]); //print ultrasonic in 45° , 90° , 135° , 90°
43         Serial.print("/");
44     }
45     Serial.print("\n"); //next content will be printed in new line
46 }
47
48 float getSonar() {
```

```

49     unsigned long pingTime;
50     float distance;
51     digitalWrite(PIN SONIC TRIG, HIGH); // make trigPin output high level lasting for 10 μs to
52     trigger HC_SR04,
53     delayMicroseconds(10);
54     digitalWrite(PIN SONIC TRIG, LOW);
55     pingTime = pulseIn(PIN SONIC ECHO, HIGH, SONIC_TIMEOUT); // Wait HC-SR04 returning to the
56     high level and measure out this waiting time
57     if (pingTime != 0)
58         distance = (float)pingTime * SOUND_VELOCITY / 2 / 10000; // calculate the distance
59     according to the time
60     else
61         distance = MAX_DISTANCE;
62     return distance; // return the distance value
63 }
```

```

#define MAX_DISTANCE    300    //cm
#define SONIC_TIMEOUT   (MAX_DISTANCE*60) // calculate timeout
#define SOUND_VELOCITY  340    //sound Velocity: 340m/s
```

First calculate t for max distance.

$340(t/10000000)/2 = \text{MAX_DISTANCE}/100 \quad t = 58.8 \times \text{MAX_DISTANCE}$ (Unit of t is μs)

We set timeout to $\text{MAX_DISTANCE} \times 60$, a little larger, since the maximum distance of ultrasonic module is larger.

`pingTime = pulseIn(PIN SONIC ECHO, HIGH, SONIC_TIMEOUT); // Wait HC-SR04 returning to the high level`
If time of high level lasting time of echo is larger than `SONIC_TIMEOUT`, it will return 0. Then `pingTime=0`.

`pulseIn(pin, value, timeout)`

pin: the number of the Arduino pin on which you want to read the pulse.

value: type of pulse to read: either HIGH or LOW.

timeout (optional): the number of microseconds to wait for the pulse to start; default is one second.

For more details, please refer to:

<https://www.arduino.cc/reference/en/language/functions/advanced-io/pulsein/>

Array

An array is a collection of variables that are accessed with an index number.

Define an array in Arduino.

`Data type Array name [Number of elements]`

`u8 distance[3];` define an array named `distance`, its data type is `u8`, which has 3 elements.

The index starts from 0.

`u8 = unsigned char` Its range is $0 \sim 2^8$, namely $0 \sim 255$.

Range of `u16` is $0 \sim 65535$.

For more details about array, please refer to:

<https://www.arduino.cc/reference/en/language/variables/data-types/array/>

Automatic Obstacle Avoidance Car

Code

02.3.1_Automatic_Obstacle_Avoidance

Upload code in Sketches\ 02.3.1_Automatic_Obstacle_Avoidance.

Then disconnect USB cable. Turn on the power of car. And put the car in a place with enough space to move.

The code is below:

```
1 #include <Servo.h>
2 #define PIN_SERVO 2
3
4 #define PIN_DIRECTION_LEFT 4
5 #define PIN_DIRECTION_RIGHT 3
6 #define PIN_MOTOR_PWM_LEFT 6
7 #define PIN_MOTOR_PWM_RIGHT 5
8
9 #define PIN SONIC_TRIG 7
10 #define PIN SONIC_ECHO 8
11
12 #define PIN_BATTERY A0
13
14 #define OBSTACLE_DISTANCE 40
15 #define OBSTACLE_DISTANCE_LOW 15
16
17 #define MAX_DISTANCE 300 //cm
18 #define SONIC_TIMEOUT (MAX_DISTANCE*60)
19 #define SOUND_VELOCITY 340 //soundVelocity: 340m/s
20
21 Servo servo;
22 byte servoOffset = 0;
23 int speedOffset;//batteryVoltageCompensationToSpeed
24
25 void setup() {
26   pinMode(PIN_DIRECTION_LEFT, OUTPUT);
27   pinMode(PIN_MOTOR_PWM_LEFT, OUTPUT);
28   pinMode(PIN_DIRECTION_RIGHT, OUTPUT);
29   pinMode(PIN_MOTOR_PWM_RIGHT, OUTPUT);
30
31   pinMode(PIN SONIC_TRIG, OUTPUT); // set trigPin to output mode
32   pinMode(PIN SONIC_ECHO, INPUT); // set echoPin to input mode
33   servo.attach(PIN_SERVO);
34   calculateVoltageCompensation();
35 }
```

```
36
37 void loop() {
38     updateAutomaticObstacleAvoidance();
39 }
40
41 void updateAutomaticObstacleAvoidance() {
42     int distance[3], tempDistance[3][5], sumDisntance;
43     static u8 leftToRight = 0, servoAngle = 0, lastServoAngle = 0; // 
44     const u8 scanAngle[2][3] = { {150, 90, 30}, {30, 90, 150} };
45
46     for (int i = 0; i < 3; i++)
47     {
48         servoAngle = scanAngle[leftToRight][i];
49         servo.write(servoAngle);
50         if (lastServoAngle != servoAngle) {
51             delay(130);
52         }
53         lastServoAngle = servoAngle;
54         for (int j = 0; j < 5; j++) {
55             tempDistance[i][j] = getSonar();
56             delayMicroseconds(2 * SONIC_TIMEOUT);
57             sumDisntance += tempDistance[i][j];
58         }
59         if (leftToRight == 0) {
60             distance[i] = sumDisntance / 5;
61         }
62         else {
63             distance[2 - i] = sumDisntance / 5;
64         }
65         sumDisntance = 0;
66     }
67     leftToRight = (leftToRight + 1) % 2;
68
69     if (distance[1] < OBSTACLE_DISTANCE) {           //Too little distance ahead
70         if (distance[0] > distance[2] && distance[0] > OBSTACLE_DISTANCE) {      //Left distance is
71             greater than right distance
72             motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back
73             delay(100);
74             motorRun(-(150 + speedOffset), (150 + speedOffset));
75         }
76         else if (distance[0] < distance[2] && distance[2] > OBSTACLE_DISTANCE)
77         {           //Right distance is greater than left distance
78             motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back
79             delay(100);}
```

```
80     motorRun((150 + speedOffset), -(150 + speedOffset));
81 }
82 else { //Get into the dead corner, move back, then turn.
83     motorRun(-(150 + speedOffset), -(150 + speedOffset));
84     delay(100);
85     motorRun(-(150 + speedOffset), (150 + speedOffset));
86 }
87 }
88 else { //No obstacles ahead
89     if (distance[0] < OBSTACLE_DISTANCE_LOW) { //Obstacles on the left front.
90         motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back
91         delay(100);
92         motorRun((180 + speedOffset), (50 + speedOffset));
93     }
94     else if (distance[2] < OBSTACLE_DISTANCE_LOW) { //Obstacles on the right front.
95         motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back
96         delay(100);
97         motorRun((50 + speedOffset), (180 + speedOffset));
98     }
99     else { //Cruising
100        motorRun((80 + speedOffset), (80 + speedOffset));
101    }
102 }
103 }
104
105 float getSonar() {
106     unsigned long pingTime;
107     float distance;
108     digitalWrite(PIN SONIC TRIG, HIGH); // make trigPin output high level lasting for 10 μs to
109     trigger HC_SR04,
110     delayMicroseconds(10);
111     digitalWrite(PIN SONIC TRIG, LOW);
112     pingTime = pulseIn(PIN SONIC ECHO, HIGH, SONIC_TIMEOUT); // Wait HC-SR04 returning to the
113     high level and measure out this waiting time
114     if (pingTime != 0)
115         distance = (float)pingTime * SOUND_VELOCITY / 2 / 10000; // calculate the distance
116     according to the time
117     else
118         distance = MAX_DISTANCE;
119     return distance; // return the distance value
120 }
121
122 void calculateVoltageCompensation() {
123     float voltageOffset = 8.4 - getBatteryVoltage();
```

```

124     speedOffset = voltageOffset * 20;
125 }
126
127 void motorRun(int speedl, int speedr) {
128     int dirL = 0, dirR = 0;
129     if (speedl > 0) {
130         dirL = 0;
131     }
132     else {
133         dirL = 1;
134         speedl = -speedl;
135     }
136
137     if (speedr > 0) {
138         dirR = 1;
139     }
140     else {
141         dirR = 0;
142         speedr = -speedr;
143     }
144     digitalWrite(PIN_DIRECTION_LEFT, dirL);
145     digitalWrite(PIN_DIRECTION_RIGHT, dirR);
146     analogWrite(PIN_MOTOR_PWM_LEFT, speedl);
147     analogWrite(PIN_MOTOR_PWM_RIGHT, speedr);
148 }
149
150
151 float getBatteryVoltage() {
152     pinMode(PIN_BATTERY, INPUT);
153     int batteryADC = analogRead(PIN_BATTERY);
154     float batteryVoltage = batteryADC / 1023.0 * 5.0 * 4;
155     return batteryVoltage;
156 }
```

We use analogWrite(PIN_MOTOR, PWM value) to make motor work. The PWM value represent different speed when the voltage of battery changes. So we set a speedOffset to compensate the difference.

```

1 void calculateVoltageCompensation() {
2     float voltageOffset = 8.4 - getBatteryVoltage();
3     speedOffset = voltageOffset * 20;
4 }
```

20 is tested value. You can try to test what is the most proper value.

We need control servo to 150°, 90°, 30°, 90°, 150°...

Get 5 ultrasonic module values (distance) at one angle. Then calculate the average distance.

```

1 int distance[3], tempDistance[3][5], sumDisntance;
2 static u8 leftToRight = 0, servoAngle = 0, lastServoAngle = 0; // 
3 const u8 scanAngle[2][3] = { {150, 90, 30}, {30, 90, 150} };
4 for (int i = 0; i < 3; i++)
{
5     servoAngle = scanAngle[leftToRight][i];
6     servo.write(servoAngle);
7     if (lastServoAngle != servoAngle) {
8         delay(130);
9     }
10    lastServoAngle = servoAngle;
11    for (int j = 0; j < 5; j++) {
12        tempDistance[i][j] = getSonar();
13        delayMicroseconds(2 * SONIC_TIMEOUT);
14        sumDisntance += tempDistance[i][j];
15    }
16    if (leftToRight == 0) {
17        distance[i] = sumDisntance / 5;
18    }
19    else {
20        distance[2 - i] = sumDisntance / 5;
21    }
22    sumDisntance = 0;
23}
24
25 leftToRight = (leftToRight + 1) % 2;
26

```

Then make the car react according to the distances above. About its logic, please refer to flow chart.

```

1 //make the car react according to the distances
2 if (distance[1] < OBSTACLE_DISTANCE) {           //obstacle in front
3     if (distance[0] > distance[2] && distance[0] > OBSTACLE_DISTANCE) {      //Left distance is
4         greater than right distance
5         motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back a little
6         delay(100);
7         motorRun(-(150 + speedOffset), (150 + speedOffset));
8         delay(50);
9     }
10    else if (distance[0] < distance[2] && distance[2] > OBSTACLE_DISTANCE)
11    {           //Right distance is greater than left distance
12        motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back a little
13        delay(100);
14        motorRun((150 + speedOffset), -(150 + speedOffset)); //Turn right
15        delay(50);
16    }

```

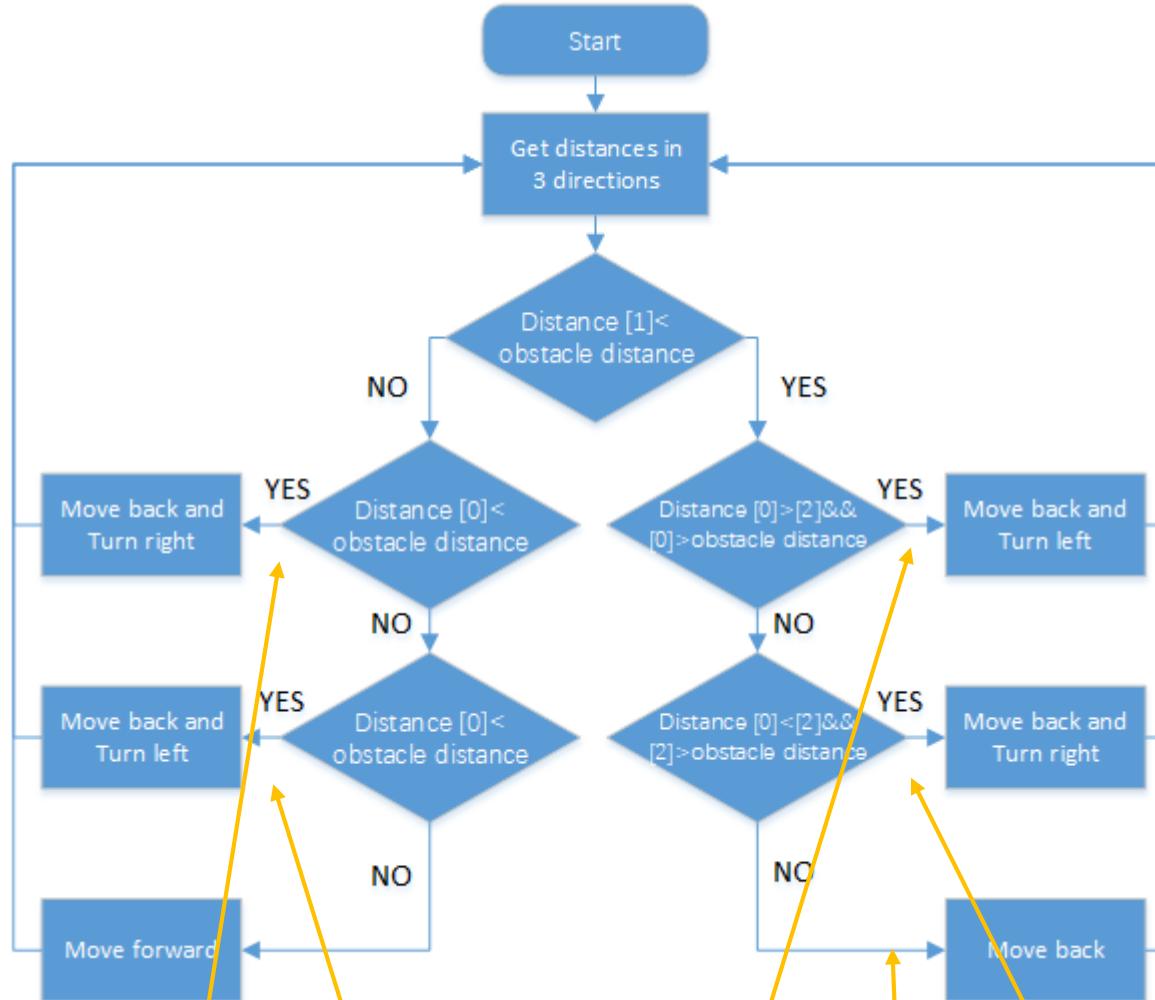
```
17     else {                                //Get into the dead corner, move back a little, then spin.  
18         motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back  
19         delay(100);  
20         motorRun(-(150 + speedOffset), (150 + speedOffset)); //Turn left  
21         delay(50);  
22     }  
23 }  
24 else {                                //No obstacles ahead  
25     if (distance[0] < OBSTACLE_DISTANCE_LOW) {      //Obstacles on the left front.  
26         motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back  
27         delay(100);  
28         motorRun((180 + speedOffset), (50 + speedOffset)); //Turn right with large radius  
29         delay(50);  
30     }  
31     else if (distance[2] < OBSTACLE_DISTANCE_LOW) {    //Obstacles on the right front.  
32         motorRun(-(150 + speedOffset), -(150 + speedOffset)); //Move back  
33         delay(100);  
34         motorRun((50 + speedOffset), (180 + speedOffset)); //Turn left with large radius  
35         delay(50);  
36     }  
37     else {                                //Cruising, no obstacle closed  
38         motorRun((80 + speedOffset), (80 + speedOffset));  
39     }  
40 }  
41 }  
42 }
```

Code logic is as flow chart below:

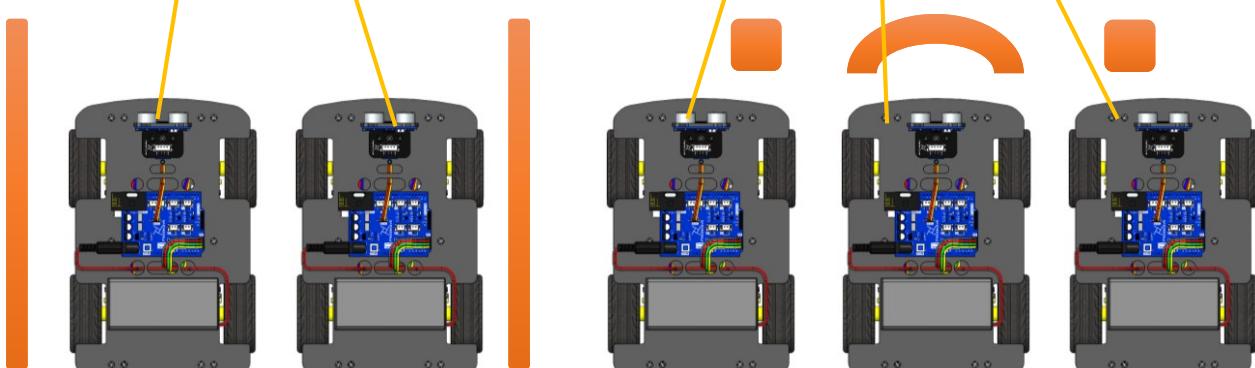
Distance[0] is the left distance to obstacle.

Distance[1] is the center distance to obstacle.

Distance[2] is the right distance to obstacle.



This project consider following



02.3.2_Libery_Automatic_Obstacle_Avoidance

Code in sketches\02.3.2_Libery_Automatic_Obstacle_Avoidance include a library

The code function and content is similar to previous section. There are little difference. Previous code is more simple.

```

1 //*****
2 * Filename    : Automatic_Obstacle_Avoidance.ino
3 * Product     : Freenove 4WD Car for UNO
4 * Description  : Automatic Obstacle Avoidance mode.
5 * Author      : www.freenove.com
6 * Modification: 2019/08/05
7 *****/
8
9 #include "Freenove_4WD_Car_for_Arduino.h"
10 #include "Automatic_Obstacle_Avoidance_Mode.h"
11
12 void setup() {
13     pinsSetup(); //from Freenove_4WD_Car_for_Arduino.h
14     servoSetup(); //from Automatic_Obstacle_Avoidance_Mode.h

```

There are 4 labels.

Freenove_4WD_Car_for_Arduino.h has introduced in section [01.4.2_Library_Integrate_Functions](#)

The main label is **02.3.2_Libery_Automatic_Obstacle_Avoidance.ino**

Its code is below.

```

1 #include "Freenove_4WD_Car_for_Arduino.h"
2 #include "Automatic_Obstacle_Avoidance_Mode.h"
3
4 void setup() {
5     pinsSetup(); //from Freenove_4WD_Car_for_Arduino.h
6     servoSetup(); //from Automatic_Obstacle_Avoidance_Mode.h
7     oa_CalculateVoltageCompensation(); //Automatic_Obstacle_Avoidance_Mode.h
8 }
9
10 void loop() {
11     updateAutomaticObstacleAvoidance(); //Automatic_Obstacle_Avoidance_Mode.h
12 }

```

The code is very simple. The function from other labels.

Code in label **Automatic_Obstacle_Avoidance_Mode.h**

```

1 ifndef _AUTOMATIC_OBSTACLE_AVOIDANCE_h
2 define _AUTOMATIC_OBSTACLE_AVOIDANCE_h
3
4 if defined(ARDUINO) && ARDUINO >= 100
5 include "arduino.h"
6 else
7 include "WProgram.h"
8 endif
9 include <EEPROM.h>
10 include "Servo.h"
11 include "Freenove_4WD_Car_for_Arduino.h"
12

```

```
13 #define OA_SERVO_CENTER (90)
14 #define OA_SCAN_ANGLE_INTERVAL 50
15 #define OA_SCAN_ANGLE_MIN (OA_SERVO_CENTER - OA_SCAN_ANGLE_INTERVAL)
16 #define OA_SCAN_ANGLE_MAX (OA_SERVO_CENTER + OA_SCAN_ANGLE_INTERVAL)
17 #define OA_WAITTING_SERVO_TIME 130
18
19 #define OA_CRUISE_SPEED (110 + oa_VoltageCompensationToSpeed)
20
21 #define OA_ROTATY_SPEED_LOW (120 + oa_VoltageCompensationToSpeed)
22 #define OA_ROTATY_SPEED_NORMAL (150 + oa_VoltageCompensationToSpeed)
23 #define OA_ROTATY_SPEED_HIGH (180 + oa_VoltageCompensationToSpeed)
24
25 #define OA_TURN_SPEED_LV4 (180 + oa_VoltageCompensationToSpeed)
26 #define OA_TURN_SPEED_LV1 (50 + oa_VoltageCompensationToSpeed )
27
28 #define OA_BACK_SPEED_LOW (110 + oa_VoltageCompensationToSpeed)
29 #define OA_BACK_SPEED_NORMAL (150 + oa_VoltageCompensationToSpeed)
30 #define OA_BACK_SPEED_HIGH (180 + oa_VoltageCompensationToSpeed)
31
32 #define OA_OBSTACLE_DISTANCE 40
33 #define OA_OBSTACLE_DISTANCE_LOW 15
34
35 #define OA_SPEED_OFFSET_PER_V 35
36
37 #define OA_SERVO_OFFSET_ADDR_IN_EEPROM 0
38
39 #define MAX_DISTANCE 300 //cm
40 #define SONIC_TIMEOUT (MAX_DISTANCE*60)
41 #define SOUND_VELOCITY 340 //soundVelocity: 340m/s
42
43
44 extern Servo servo;
45 extern byte servoOffset;
46
47 void servoSetup(); //initialize the servo
48 void setServoOffset(byte offset); //Set servo offset
49 void writeServo(u8 n); //set servo to an angle, offset has been considered
50 void writeServoOffsetToEEPROM();
51 void getServoOffsetFromEEPROM();
52
53 float getSonar();
54 void oa_CalculateVoltageCompensation(); // Calculate Voltage Compensation
55 void updateAutomaticObstacleAvoidance();
56 #endif
```

.h file used to define pins, variables and functions.

You can get information that what you can use from .h file.

The detailed implement code of the functions are include in .cpp file.

```
1 #include "Automatic_Obstacle_Avoidance_Mode.h"
2
3 Servo servo;
4 byte servoOffset = 0;
5 int oa_VoltageCompensationToSpeed;
6
7 void servoSetup() {
8     getServoOffsetFromEEPROM();
9     servo.attach(PIN_SERVO);
10    servo.write(90 + servoOffset);
11 }
12
13 void setServoOffset(byte offset) {
14     servoOffset = offset = constrain(offset, -10, 10);
15     servo.write(90 + offset);
16 }
17
18 void writeServo(u8 n)
19 {
20     servo.write(90 + servoOffset);
21 }
22
23 void writeServoOffsetToEEPROM() {
24     servo.write(90 + servoOffset);
25     EEPROM.write(OA_SERVO_OFFSET_ADDR_IN_EEPROM, servoOffset);
26 }
27
28 void getServoOffsetFromEEPROM() {
29     servoOffset = EEPROM.read(OA_SERVO_OFFSET_ADDR_IN_EEPROM);
30     servoOffset = constrain(servoOffset, -10, 10);
31 }
32
33 float getSonar() {
34     unsigned long pingTime;
35     float distance;
36     digitalWrite(PIN SONIC TRIG, HIGH); // make trigPin output high level lasting for 10µs
37     to triger HC_SR04,
38     delayMicroseconds(10);
39     digitalWrite(PIN SONIC TRIG, LOW);
40     pingTime = pulseIn(PIN SONIC ECHO, HIGH, SONIC_TIMEOUT); // Wait HC-SR04 returning to the
```

```
41     high level and measure out this waiting time
42     if (pingTime != 0)
43         distance = (float)pingTime * SOUND_VELOCITY / 2 / 10000; // calculate the distance
44 according to the time
45     else
46         distance = MAX_DISTANCE;
47     return distance; // return the distance value
48 }
49
50 void oa_CalculateVoltageCompensation() {
51     getBatteryVoltage();
52     float voltageOffset = BAT_VOL_STANDARD - batteryVoltage;
53     oa_VoltageCompensationToSpeed = voltageOffset * OA_SPEED_OFFSET_PER_V;
54 }
55
56 void updateAutomaticObstacleAvoidance() {
57     int distance[3], tempDistance[3][5], sumDisntance;
58     static u8 cnt = 0, servoAngle = 0, lastServoAngle = 0;    //
59     if (cnt == 0) {
60         for (int i = 0; i < 3; i++) {
61             servoAngle = OA_SCAN_ANGLE_MAX - i * OA_SCAN_ANGLE_INTERVAL + servoOffset;
62             servo.write(servoAngle);
63             if (lastServoAngle != servoAngle) {
64                 delay(OA_WAITTING_SERVO_TIME);
65             }
66             lastServoAngle = servoAngle;
67             for (int j = 0; j < 5; j++) {
68                 tempDistance[i][j] = getSonar();
69                 delayMicroseconds(2 * SONIC_TIMEOUT);
70                 sumDisntance += tempDistance[i][j];
71             }
72             distance[i] = sumDisntance / 5;
73             sumDisntance = 0;
74         }
75         cnt++;
76     }
77     else {
78         for (int i = 2; i > 0; i--) {
79             servoAngle = OA_SCAN_ANGLE_MAX - i * OA_SCAN_ANGLE_INTERVAL + servoOffset;
80             servo.write(servoAngle);
81             if (lastServoAngle != servoAngle) {
82                 delay(OA_WAITTING_SERVO_TIME);
83             }
84             lastServoAngle = servoAngle;
```

```

85         for (int j = 0; j < 5; j++) {
86             tempDistance[i][j] = getSonar();
87             delayMicroseconds(2 * SONIC_TIMEOUT);
88             sumDisntance += tempDistance[i][j];
89         }
90         distance[i] = sumDisntance / 5;
91         sumDisntance = 0;
92     }
93     cnt = 0;
94 }
95
96 if (distance[1] < OA_OBSTACLE_DISTANCE) { //Too little distance ahead
97     if (distance[0] > OA_OBSTACLE_DISTANCE || distance[2] > OA_OBSTACLE_DISTANCE) {
98         motorRun(-OA_BACK_SPEED_LOW, -OA_BACK_SPEED_LOW); //Move back a little
99         delay(100);
100        if (distance[0] > distance[2]) { //Left distance is greater than
101            right distance
102                motorRun(-OA_ROTATY_SPEED_LOW, OA_ROTATY_SPEED_LOW);
103            }
104        else { //Right distance is greater than
105            left distance
106                motorRun(OA_ROTATY_SPEED_LOW, -OA_ROTATY_SPEED_LOW);
107            }
108        }
109    else { //Get into the dead corner, move
110        back a little, then spin.
111            motorRun(-OA_BACK_SPEED_HIGH, -OA_BACK_SPEED_HIGH);
112            delay(100);
113            motorRun(-OA_ROTATY_SPEED_NORMAL, OA_ROTATY_SPEED_NORMAL);
114        }
115    }
116 // following code is different from last section. Last section is more simple
117 else { //No obstacles ahead
118     if (distance[0] < OA_OBSTACLE_DISTANCE) { //Obstacles on the left front.
119         if (distance[0] < OA_OBSTACLE_DISTANCE_LOW) { //Very close to the left front
120             obstacle.
121                 motorRun(-OA_BACK_SPEED_LOW, -OA_BACK_SPEED_LOW); //Move back
122                 delay(100);
123             }
124             motorRun(OA_TURN_SPEED_LV4, OA_TURN_SPEED_LV1);
125         }
126         else if (distance[2] < OA_OBSTACLE_DISTANCE) { //Obstacles on the right
127             front.
128                 if (distance[2] < OA_OBSTACLE_DISTANCE_LOW) { //Very close to the right

```

```

129     front obstacle.
130             motorRun(-OA_BACK_SPEED_LOW, -OA_BACK_SPEED_LOW);      //Move back
131             delay(100);
132         }
133         motorRun(OA_TURN_SPEED_LV1, OA_TURN_SPEED_LV4);
134     }
135     else {                                              //Cruising
136         motorRun(OA_CRUISE_SPEED, OA_CRUISE_SPEED);
137     }
138 }
139 }
```

Since the servo may not be installed to 90°, we need adjust it. But we don't want adjust it every time. so we can save the servoOffset in a place and next time just get it. The microcontroller on the Arduino and Genuino boards have 1024 bytes of EEPROM.

It is useful when we use remote control to calibrate the servo.

```

1 void writeServoOffsetToEEPROM() {
2     servo.write(90 + servoOffset);
3     EEPROM.write(OA_SERVO_OFFSET_ADDR_IN_EEPROM, servoOffset);
4 }
5
6 void getServoOffsetFromEEPROM() {
7     servoOffset = EEPROM.read(OA_SERVO_OFFSET_ADDR_IN_EEPROM);
8     servoOffset = constrain(servoOffset, -10, 10);
9 }
```

EEPROM

The microcontroller on the Arduino and Genuino boards have 1024 bytes of EEPROM.

EEPROM.write(address, val); write val to address

value = EEPROM.read(address); read the data saved in address

for example,

EEPROM.write(0, 3);

EEPROM.write(1, 5);

EEPROM.write(2, 8);

Value0= EEPROM.read(0); then Value0 = 3

Value1 = EEPROM.read(2); then Value2 = 8

For more information, refer to <https://www.arduino.cc/en/Reference/EEPROM>

Other code logic is similar to previous section.

Chapter 3 Line tracking

This chapter will introduce line-tracking sensor. Then make a line-tracking car.

Line tracking sensor

There are three Reflective Optical Sensors on this car. When the infrared light emitted by infrared diode shines on the surface of different objects, the sensor will receive light with different intensities after reflection.

As we know, black objects absorb light better. So when black lines are drawn on the white plane, the sensor can detect the difference. The sensor can also be called Line Tracking Sensor.

Warning:

Reflective Optical Sensor (including Line Tracking Sensor) should be avoided using in environment with infrared interference, like sunlight. Sunlight contains a lot of invisible light such as infrared and ultraviolet. Under environment with intense sunlight, Reflective Optical Sensor cannot work normally.

The following table shows the values of all cases when three Tracking Sensors detect objects of different colors. Among them, black objects or no objects were detected to represent 1, and white objects were detected to represent 0.

Left	Middle	Right	Value(binary)	Value(decimal)
0	0	0	000	0
0	0	1	001	1
0	1	0	010	2
0	1	1	011	3
1	0	0	100	4
1	0	1	101	5
1	1	0	110	6
1	1	1	111	7

Code

Upload code in Sketches\ 03.1_Tracking_Sensor. Then turn on the power. Then open the serial monitor. Put a black thing under the sensor. Move it you will see the different LED lights up.



The monitor is show below:

```

Sensor Value (L / M / R / ALL) : 0      1      1      3
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 1      0      0      4
Sensor Value (L / M / R / ALL) : 1      0      0      4
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1
Sensor Value (L / M / R / ALL) : 0      0      1      1

```

The code is below:

```

1 #define PIN_TRACKING_LEFT    A1
2 #define PIN_TRACKING_CENTER  A2
3 #define PIN_TRACKING_RIGHT   A3
4
5 u8 sensorValue[4]; //define a array, u8 = unsigned char, 0~255.
6
7 void setup() {
8     Serial.begin(9600); //set baud rate
9     pinMode(PIN_TRACKING_LEFT, INPUT); //
10    pinMode(PIN_TRACKING_RIGHT, INPUT); //
11    pinMode(PIN_TRACKING_CENTER, INPUT); //
12 }
13

```

```
14 void loop() {  
15     sensorValue[0] = digitalRead(PIN_TRACKING_LEFT);  
16     sensorValue[1] = digitalRead(PIN_TRACKING_CENTER);  
17     sensorValue[2] = digitalRead(PIN_TRACKING_RIGHT);  
18     sensorValue[3] = sensorValue[0] << 2 | sensorValue[1] << 1 | sensorValue[2];  
19     Serial.print("Sensor Value (L / M / R / ALL) : ");  
20     for (int i = 0; i < 4; i++) {  
21         Serial.print(sensorValue[i]);  
22         Serial.print(' \t'); //means Tab  
23     }  
24     Serial.print(' \n'); //means new line  
25     delay(500);  
26 }  
27 }
```

Bitwise Operators

There are some Bitwise Operators.

<< (bitshift left)

If `sensorValue[0] =1, sensorValue[1]= 1, sensorValue[2]=1`
`sensorValue[0] << 2` then `sensorValue[0]=100`, (Binary), namely 4(Decimal)
`sensorValue[1] << 1` then `sensorValue[0]=010`, (Binary), namely 2(Decimal)
`sensorValue[2]=001`(Binary)

| (bitwise or)

The code turns to: `100 | 010 | 001 =111`(Binary), namely 7(Decimal)

>> (bitshift right)

& (bitwise and)

^ (bitwise xor)

~ (bitwise not)

For more information, please refer to: <https://www.arduino.cc/reference/>

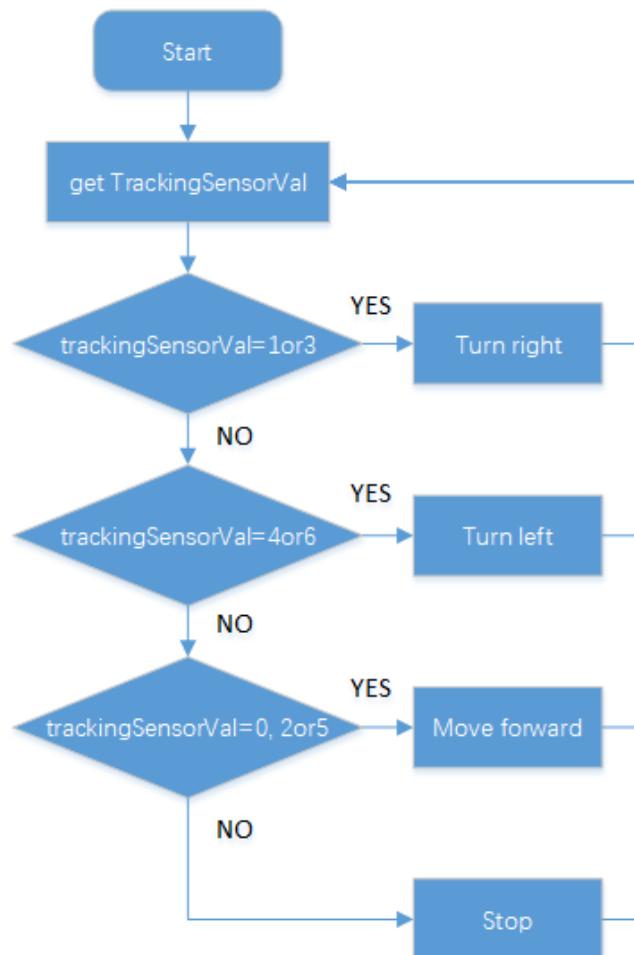
Line tracking car

The car will make different actions according to the value transmitted by the line tracking sensor.

When

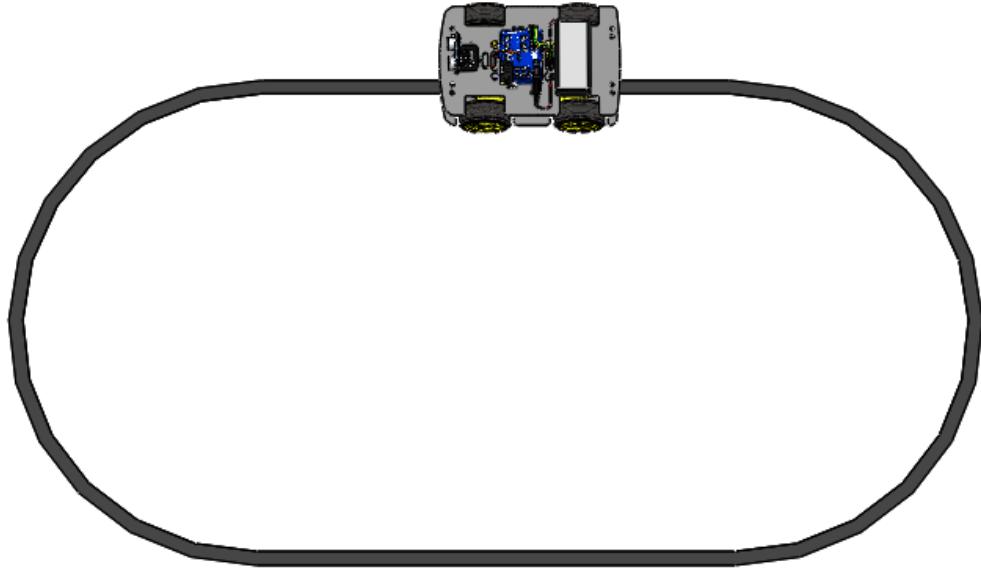
Left	Middle	Right	Value(binary)	Value(decimal)	Action
0	0	0	000	0	move forward
0	0	1	001	1	Turn Right
0	1	0	010	2	Move Forward
0	1	1	011	3	Turn Right
1	0	0	100	4	Turn Left
1	0	1	101	5	Move Forward
1	1	0	110	6	Turn Left
1	1	1	111	7	Stop

Flow chart of line tracking car is as below:



Code

Upload code in Sketches\ 03.2_Automatic_Tracking_Line. Then turn on the power. Use the black tape to build a line. Then put your car on it as below.



The code is below.

```
1 #include "Freenove_4WD_Car_for_Arduino.h"
2
3 #define TK_STOP_SPEED          0
4 #define TK_FORWARD_SPEED       (90 + tk_VoltageCompensationToSpeed)
5
6 //define different speed levels
7 #define TK_TURN_SPEED_LV4      (180 + tk_VoltageCompensationToSpeed)
8 #define TK_TURN_SPEED_LV3      (150 + tk_VoltageCompensationToSpeed)
9 #define TK_TURN_SPEED_LV2      (-140 + tk_VoltageCompensationToSpeed)
10 #define TK_TURN_SPEED_LV1     (-160 + tk_VoltageCompensationToSpeed)
11
12 int tk_VoltageCompensationToSpeed; //define Voltage Speed Compensation
13
14 void setup() {
15     pinsSetup(); //set up pins, from Freenove_4WD_Car_for_Arduino.h library
16     getTrackingSensorVal(); //Calculate Voltage speed Compensation
17 }
18
19 void loop() {
20     u8 trackingSensorVal = 0;
21     trackingSensorVal = getTrackingSensorVal(); //get sensor value
22
23     switch (trackingSensorVal)
```

```
24  {
25      case 0:    //000
26          motorRun(TK_FORWARD_SPEED, TK_FORWARD_SPEED); //car move forward
27          break;
28      case 7:    //111
29          motorRun(TK_STOP_SPEED, TK_STOP_SPEED); //car stop
30          break;
31      case 1:    //001
32          motorRun(TK_TURN_SPEED_LV4, TK_TURN_SPEED_LV1); //car turn
33          break;
34      case 3:    //011
35          motorRun(TK_TURN_SPEED_LV3, TK_TURN_SPEED_LV2); //car turn right
36          break;
37      case 2:    //010
38      case 5:    //101
39          motorRun(TK_FORWARD_SPEED, TK_FORWARD_SPEED); //car move forward
40          break;
41      case 6:    //110
42          motorRun(TK_TURN_SPEED_LV2, TK_TURN_SPEED_LV3); //car turn left
43          break;
44      case 4:    //100
45          motorRun(TK_TURN_SPEED_LV1, TK_TURN_SPEED_LV4); //car turn right
46          break;
47      default:
48          break;
49  }
50 }
51
52 void tk_CalculateVoltageCompensation() {
53     getBatteryVoltage(); //from Freenove_4WD_Car_for_Arduino.h library
54     float voltageOffset = 7 - batteryVoltage;
55     tk_VoltageCompensationToSpeed = 30 * voltageOffset;
56 }
57
58 //when black line on one side is detected, the value of the side will be 0, or the value is 1
59 u8 getTrackingSensorVal() {
60     u8 trackingSensorVal = 0;
61     trackingSensorVal = (digitalRead(PIN_TRACKING_LEFT) == 1 ? 1 : 0) << 2 |
62     (digitalRead(PIN_TRACKING_CENTER) == 1 ? 1 : 0) << 1 | (digitalRead(PIN_TRACKING_RIGHT) == 1 ?
63     1 : 0) << 0;
64     return trackingSensorVal;
65 }
```

Exp1 ? Exp2 : Exp3;

If Exp1 is true, the result of this code is Exp2.

If Exp1 is false, the result of this code is Exp3.

For example

If y=8;

var = (y < 10) ? 30 : 40; then var=30

If y=10

var = (y < 10) ? 30 : 40; then var=40

switch...case

```
switch (var) {  
    case 1:  
        //do something when var equals 1  
        break;  
    case 2:  
        //do something when var equals 2  
        break;  
    default:  
        // if nothing else matches, do the default  
        // default is optional  
        break;  
}
```

For more information, please refer to:

<https://www.arduino.cc/reference/en/language/structure/control-structure/switchcase/>

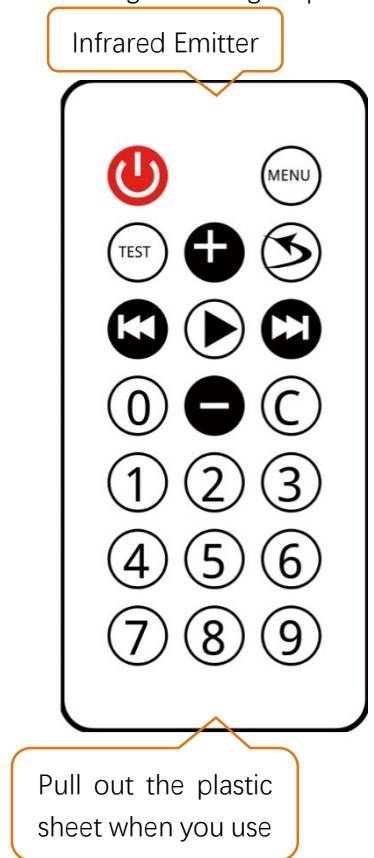
Chapter 4 IR control

This chapter will introduce infrared remote and receiver. Then make an IR remote control car.

Infrared remote and receiver

Infrared(IR) remote control is a device with a certain number of buttons. Pressing down different buttons will make the infrared emission tube, which is located in the front of the remote control, send infrared with different encoding. Infrared remote control technology is widely used, such as TV, air conditioning, etc. Thus, it makes it possible for you to switch TV programs and adjust the temperature of the air conditioning away from them. The remote control we use is shown below:

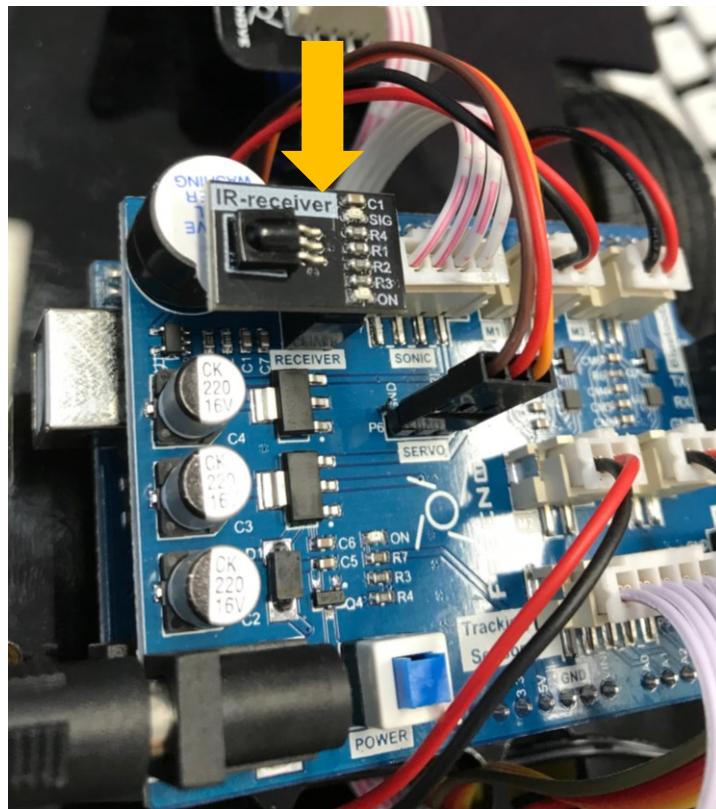
This infrared remote control uses NEC encoding with a signal period of 108ms.



Infrared(IR) receiver is a component which can receive the infrared light, so we can use it to detect the signal emitted by the infrared remote control. DATA pin here outputs the received infrared signal.

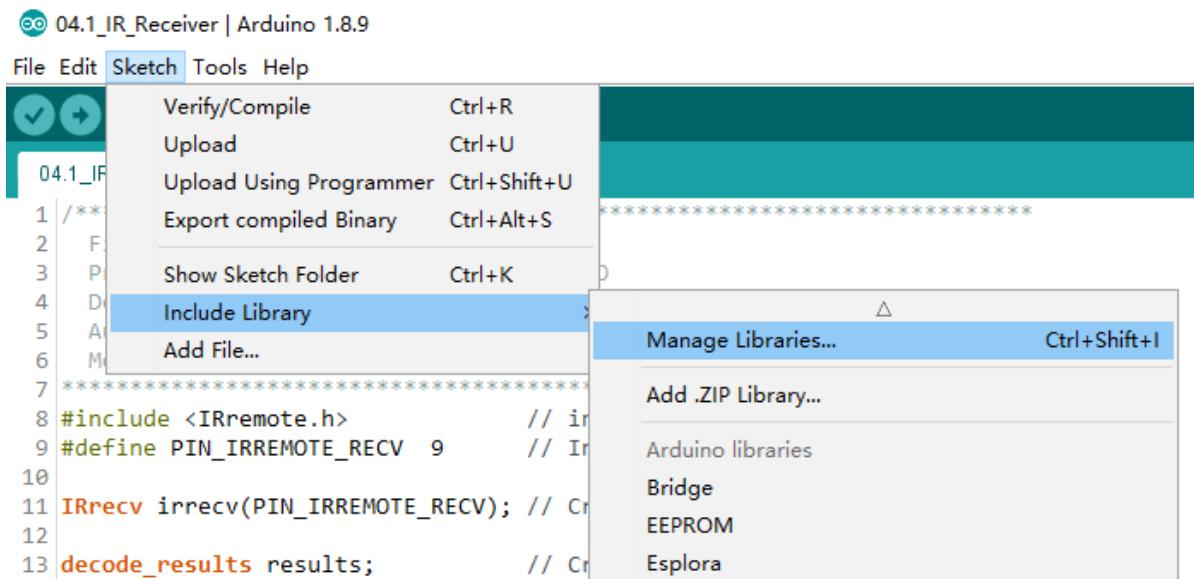


Install IR receiver on the car as below:

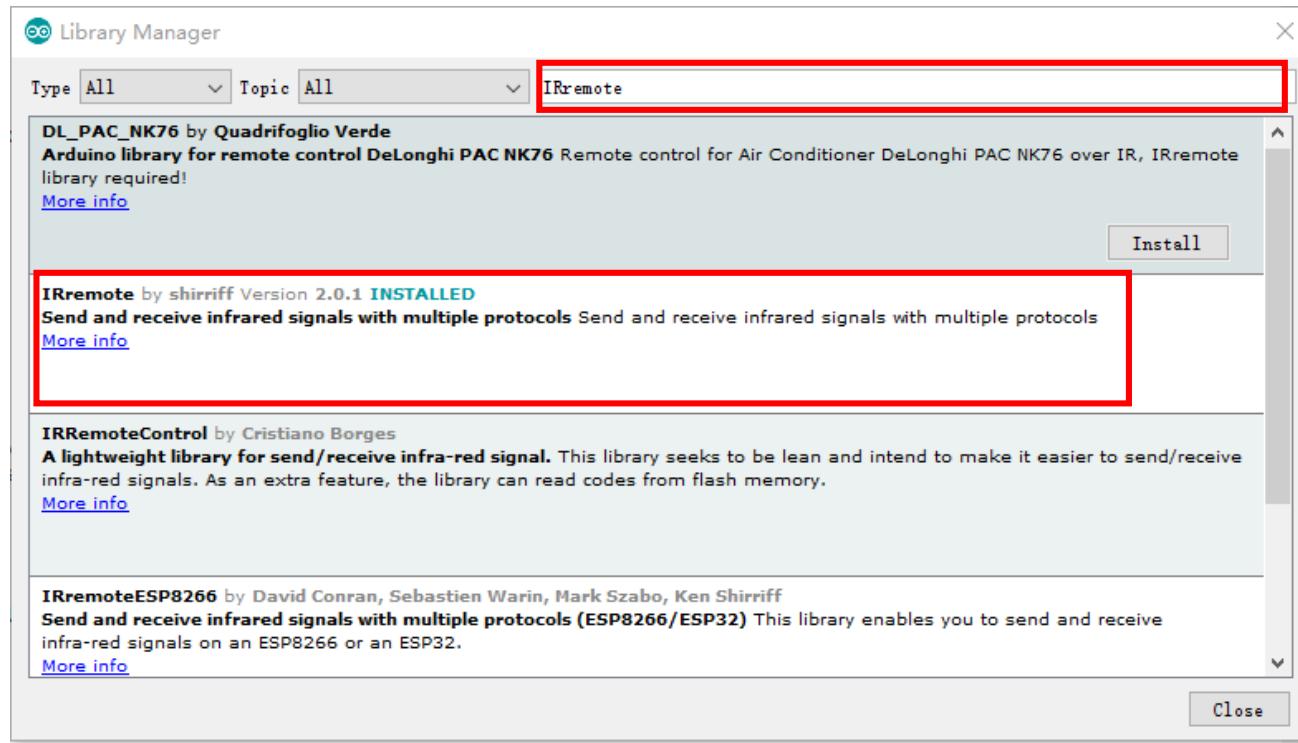


Code

An IRremote library will be used the code. Therefore, we need include it.

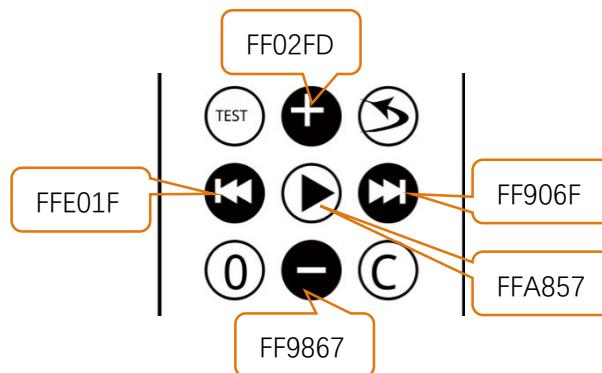


Search IRremote and install it.

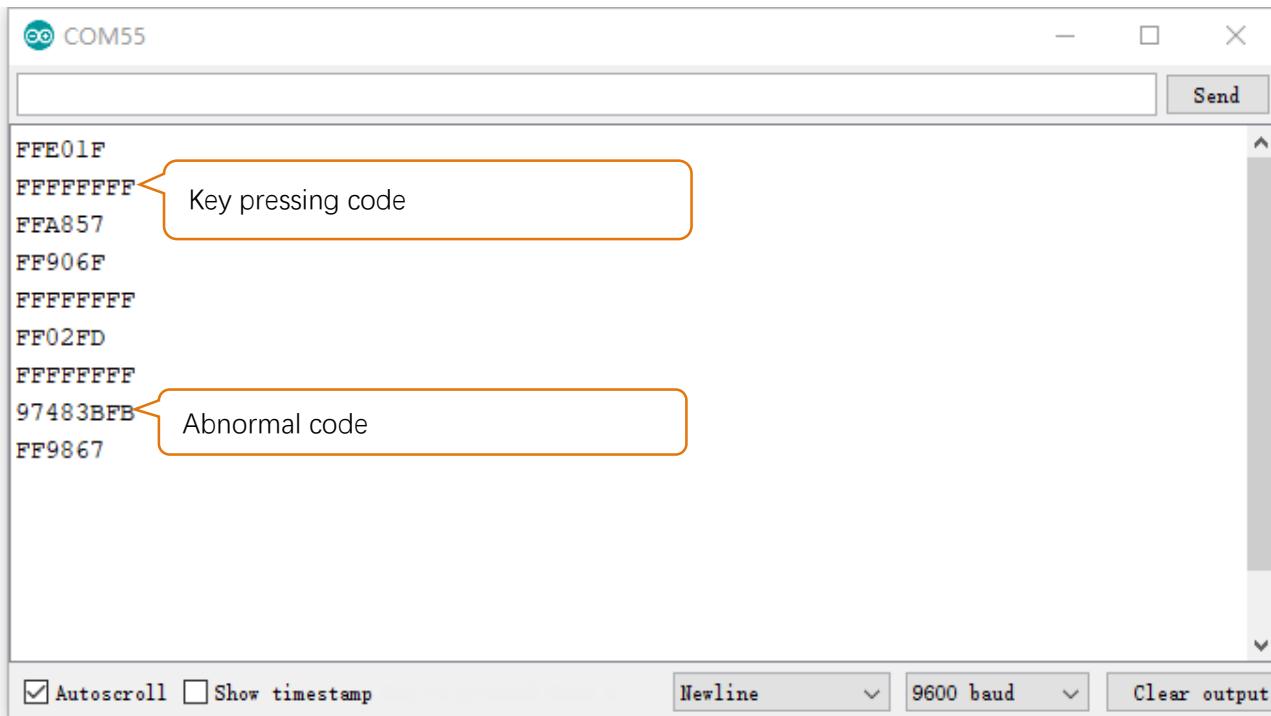


Then upload code in Sketches\ 04.1_IR_Receiver. Then turn on the power. Then open the serial monitor.

Then **pull off the plastic piece closed to the battery**. Then press following keys in IR remote.



After receiver the signal from Infrared Emitter. The controller will recognize which has been pressed. And print it in the monitor as below



When you press one key lasting for some time, FFFFFFFF will be shown. It indicate the key is in holding pressing state.

IR communication is not very stable. It is easily to interference. When using, the transmitting LED of remote control must be aimed at the receiver. Otherwise, it may result in no data being received or incorrect data being received.

In addition, sometime the code received is abnormal. Except key codes and FFFFFFFF, the rest codes received are abnormal. When we process the code, we need skip this kind of data.

Different key code corresponds to different key.

```

1 #include <IRremote.h>           // include IRremote library
2 #define PIN_IRREMOTE_RECV 9    // Infrared receiving pin
3 IRrecv irrecv(PIN_IRREMOTE_RECV); // Create a class object used to receive
4 decode_results results;        // Create a decoding results class object
5
6 void setup()
7 {
8     Serial.begin(9600);         // Initialize the serial port and set the baud rate to 9600
9     irrecv.enableIRIn();        // Start the receiver
10 }
11
12 void loop() {
13     if (irrecv.decode(&results)) { // Waiting for decoding
14         Serial.println(results.value, HEX); // Print out the decoded results
15         irrecv.resume();                // Receive the next value
16     }
17     delay(100);
18 }
```

IR Remote Car

We will use IR remote to control the car to make some actions.

Code

First, upload the code in Sketches\ 04.2_IR_Remote_Car. And turn on the power of car.

Key graph	Key define	Key code	Function
	IR_REMOTE_KEYCODE_UP	0xFF02FD	move forward
	IR_REMOTE_KEYCODE_DOWN	0xFF9867	move back
	IR_REMOTE_KEYCODE_LEFT	0xFFE01F	Turn left
	IR_REMOTE_KEYCODE_RIGHT	0xFF906F	Turn right
	IR_REMOTE_KEYCODE_CENTER	0xFFA857	Turn on buzzer

The code is below:

```

1 #include <IRremote.h>
2 #include "Freenove_4WD_Car_for_Arduino.h"
3
4 //define key, the code can not be changed.
5 #define IR_REMOTE_KEYCODE_UP      0xFF02FD
6 #define IR_REMOTE_KEYCODE_DOWN    0xFF9867
7 #define IR_REMOTE_KEYCODE_LEFT    0xFFE01F
8 #define IR_REMOTE_KEYCODE_RIGHT   0xFF906F
9 #define IR_REMOTE_KEYCODE_CENTER  0xFFA857
10
11 #define IR_UPDATE_TIMEOUT       120
12 #define IR_CAR_SPEED            180
13
14 IRrecv irrecv(PIN_IRREMOTE_RECV);
15 decode_results results;
16 u32 currentKeyCode, lastKeyCode;
17 bool isStopFromIR = false;
18 u32 lastIRUpdateTime = 0;
19
20 void setup() {
21     irrecv.enableIRIn(); // Start the receiver
22 }
```

```

23
24 void loop() {
25   if (irrecv.decode(&results)) {
26     isStopFromIR = false;
27     currentKeyCode = results.value;
28     if (currentKeyCode != 0xFFFFFFFF) {
29       lastKeyCode = currentKeyCode;
30     }
31     switch (lastKeyCode) {
32       case IR_REMOTE_KEYCODE_UP:
33         motorRun(IR_CAR_SPEED, IR_CAR_SPEED); //move forward
34         break;
35       case IR_REMOTE_KEYCODE_DOWN:
36         motorRun(-IR_CAR_SPEED, -IR_CAR_SPEED); //move back
37         break;
38       case IR_REMOTE_KEYCODE_LEFT:
39         motorRun(-IR_CAR_SPEED, IR_CAR_SPEED); //turn left
38         break;
39       case IR_REMOTE_KEYCODE_RIGHT:
40         motorRun(IR_CAR_SPEED, -IR_CAR_SPEED); //turn right
41         break;
42       case IR_REMOTE_KEYCODE_CENTER:
43         setBuzzer(true); //turn on buzzer
44         break;
45       default:
46         break;
47     }
48   }
49   irrecv.resume(); // Receive the next value
50   lastIRUpdateTime = millis(); //write down current time
51 }
52
53 else {
54   if (millis() - lastIRUpdateTime > IR_UPDATE_TIMEOUT) {
55     if (!isStopFromIR) {
56       isStopFromIR = true;
57       motorRun(0, 0);
58       setBuzzer(false);
59     }
60     lastIRUpdateTime = millis();
61   }
62 }
63 }
64

```

Since the emission period of the infrared remote control is 108 ms, the signal timeout time is set to a slightly value 120 ms. If the timeout is less than 108 ms, the data will be read ahead of time and cannot be read. It

will cause a misunderstanding that the signal is lost. If the timeout time is set too large, such as 1000ms, the delay of car action will be more serious.

```
11 #define IR_UPDATE_TIMEOUT 120
.....
54 if (millis() - lastIRUpdateTime > IR_UPDATE_TIMEOUT) {
55     if (!isStopFromIR) {
56         isStopFromIR = true;
57         motorRun(0, 0);
58         setBuzzer(false);
59     }
60     lastIRUpdateTime = millis();
61 }
....
```

You can change value of `IR_CAR_SPEED` to change speed of the car in range (0~255). In fact, since motor need enough voltage to make the car move so the maximum value is not 0.

```
12 #define IR_CAR_SPEED 180
```

millis()

Returns the number of milliseconds passed since the Arduino board began running the **current** program

```
lastIRUpdateTime = millis(); //write down current time
```

```
}
```

```
else {
```

```
    if (millis() - lastIRUpdateTime)
```

`millis() – lastIRUpdateTime` is the time from `lastIRUpdateTime` to current line.

For more details, please refer to:

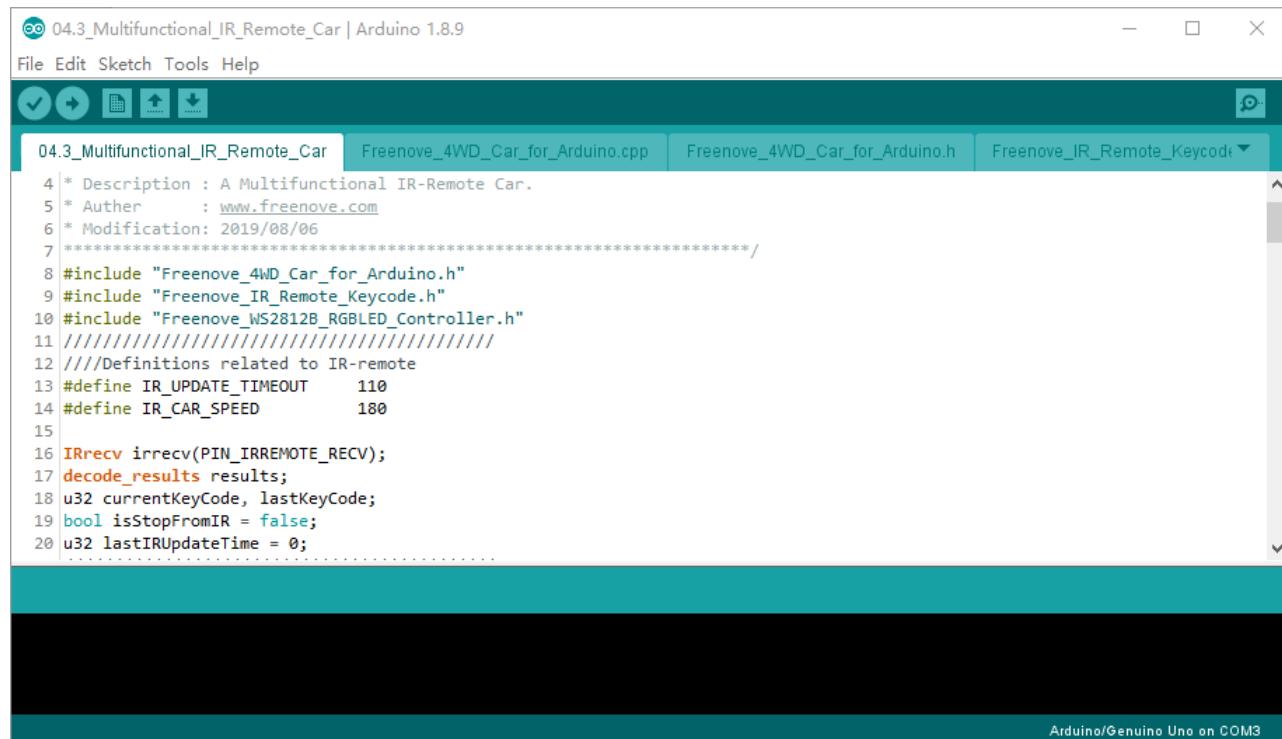
<https://www.arduino.cc/reference/en/language/functions/time/millis/>

Multifunctional IR Remote Car

This project will add the LED bar function that last section, so the infrared remote control car has more functions.

Upload Code and Running

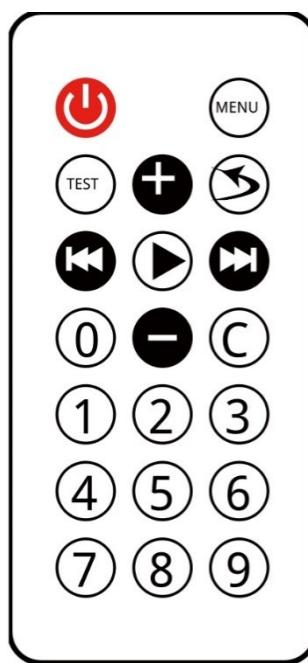
Open the code in Sketches\ 04.3_ Multifunctional_IR_Remote_Car.ino. Upload it into car.



```
04.3_Multifunctional_IR_Remote_Car | Arduino 1.8.9
File Edit Sketch Tools Help
04.3_Multifunctional_IR_Remote_Car Freenove_4WD_Car_for_Arduino.cpp Freenove_4WD_Car_for_Arduino.h Freenove_IR_Remote_Keycode.h
4 * Description : A Multifunctional IR-Remote Car.
5 * Author      : www.freenove.com
6 * Modification: 2019/08/06
7 ****
8 #include "Freenove_4WD_Car_for_Arduino.h"
9 #include "Freenove_IR_Remote_Keycode.h"
10 #include "Freenove_WS2812B_RGBLED_Controller.h"
11 ///////////////////////////////////////////////////
12 ///Definitions related to IR-remote
13 #define IR_UPDATE_TIMEOUT    110
14 #define IR_CAR_SPEED         180
15
16 IRrecv irrecv(PIN_IRREMOTE_RECV);
17 decode_results results;
18 u32 currentKeyCode, lastKeyCode;
19 bool isStopFromIR = false;
20 u32 lastIRUpdateTime = 0;
```

Arduino/Genuino Uno on COM3

After the code is successfully uploaded, turn on the power of the car and use the infrared remote control to control the car and other functions. The corresponding keys and functions is shown in the following table:



Key graph	Key define	Key code	Function
	IR_REMOTE_KEYCODE_UP	0xFF02FD	move forward
	IR_REMOTE_KEYCODE_DOWN	0xFF9867	move back
	IR_REMOTE_KEYCODE_LEFT	0xFFE01F	Turn left
	IR_REMOTE_KEYCODE_RIGHT	0xFF906F	Turn right
	IR_REMOTE_KEYCODE_CENTER	0xFFA857	Turn on buzzer
	IR_REMOTE_KEYCODE_1	0xFF30CF	Make the LED run mode 1 to scroll the rainbow color.
	IR_REMOTE_KEYCODE_4	0xFF10EF	Make LED run mode 2, changing the color of the water LED
	IR_REMOTE_KEYCODE_2	0xFF18E7	The color of the LED bar changes faster. The color is from ColorWheel.
	IR_REMOTE_KEYCODE_3	0xFF7A85	The color of the LED bar changes slower.
	IR_REMOTE_KEYCODE_5	0xFF38C7	The LED bar cycle period is decreased, and the LED bar changes at a faster speed
	IR_REMOTE_KEYCODE_6	0xFF5AA5	The LED bar cycle period is increased, and the LED bar changes at a slower speed

Code

This project has many labels.

"Freenove_IR_Remote_Keycode.h" is used to save key code of IR remote control.

Freenove_IR_Remote_Keycode.h

```
1 // Freenove_IR_Remote_Keycode.h
2 #ifndef _FREENOVE_IR_REMOTE_KEYCODE_h
3 #define _FREENOVE_IR_REMOTE_KEYCODE_h
4 #if defined(ARDUINO) && ARDUINO >= 100
5     #include "arduino.h"
6 #else
7     #include "WProgram.h"
8 #endif
9 #include <IRremote.h>
10
11 #define IR_REMOTE_KEYCODE_POWER      0xFFA25D
12 #define IR_REMOTE_KEYCODE_MENU       0xFF629D
13 #define IR_REMOTE_KEYCODE_MUTE       0FFE21D
14
15 #define IR_REMOTE_KEYCODE_MODE       0xFF22DD
16 #define IR_REMOTE_KEYCODE_UP         0xFF02FD
17 #define IR_REMOTE_KEYCODE_BACK       0FFC23D
18
19 #define IR_REMOTE_KEYCODE_LEFT        0FFE01F
20 #define IR_REMOTE_KEYCODE_CENTER      0FFA857
21 #define IR_REMOTE_KEYCODE_RIGHT       0FF906F
22
23 #define IR_REMOTE_KEYCODE_0           0FF6897
24 #define IR_REMOTE_KEYCODE_DOWN        0FF9867
25 #define IR_REMOTE_KEYCODE_OK          0FFB04F
26
27 #define IR_REMOTE_KEYCODE_1           0FF30CF
28 #define IR_REMOTE_KEYCODE_2           0FF18E7
29 #define IR_REMOTE_KEYCODE_3           0FF7A85
30
31 #define IR_REMOTE_KEYCODE_4           0FF10EF
32 #define IR_REMOTE_KEYCODE_5           0FF38C7
33 #define IR_REMOTE_KEYCODE_6           0FF5AA5
34
35 #define IR_REMOTE_KEYCODE_7           0FF42BD
36 #define IR_REMOTE_KEYCODE_8           0FF4AB5
37 #define IR_REMOTE_KEYCODE_9           0FF52AD
38#endif
```

04.3_Multifunctional_IR_Remote_Car.ino

```
1 #include "Freenove_4WD_Car_for_Arduino.h"
2 #include "Freenove_IR_Remote_Keycode.h"
3 #include "Freenove_WS2812B_RGBLED_Controller.h"
4 ///////////////////////////////////////////////////////////////////
5 ///Definitions related to IR-remote
6 #define IR_UPDATE_TIMEOUT      110
7 #define IR_CAR_SPEED           180
8
9 IRrecv irrecv(PIN_IRREMOTE_RECV);
10 decode_results results;
11 u32 currentKeyCode, lastKeyCode;
12 bool isStopFromIR = false;
13 u32 lastIRUpdateTime = 0;
14 ///////////////////////////////////////////////////////////////////
15 ///Definitions related to Led-strip
16 #define STRIP_I2C_ADDRESS 0x20
17 #define STRIP_LEDS_COUNT   10
18
19 u8 colorPos = 0;
20 u8 colorStep = 50;
21 u8 stripDisplayMode = 1;
22 u8 currentLedIndex = 0;
23 u16 stripDisplayDelay = 100;
24 u32 lastStripUpdateTime = 0;
25 Freenove_WS2812B_Controller strip(STRIP_I2C_ADDRESS, STRIP_LEDS_COUNT, TYPE_GRB);
26 ///////////////////////////////////////////////////////////////////
27
28 void setup() {
29     strip.begin();
30     irrecv.enableIRIn(); // Start the receiver
31 }
32
33 void loop() {
34     if (irrecv.decode(&results)) {
35         isStopFromIR = false;
36         currentKeyCode = results.value;
37         if (currentKeyCode != 0xFFFFFFFF) {
38             lastKeyCode = currentKeyCode;
39         }
40         switch (lastKeyCode) {
41             case IR_REMOTE_KEYCODE_UP:
42                 motorRun(IR_CAR_SPEED, IR_CAR_SPEED);
43                 break;
```

```
44     case IR_REMOTE_KEYCODE_DOWN:
45         motorRun(-IR_CAR_SPEED, -IR_CAR_SPEED);
46         break;
47     case IR_REMOTE_KEYCODE_LEFT:
48         motorRun(-IR_CAR_SPEED, IR_CAR_SPEED);
49         break;
50     case IR_REMOTE_KEYCODE_RIGHT:
51         motorRun(IR_CAR_SPEED, -IR_CAR_SPEED);
52         break;
53     case IR_REMOTE_KEYCODE_CENTER:
54         setBuzzer(true);
55         break;
56     case IR_REMOTE_KEYCODE_0:
57         break;
58     case IR_REMOTE_KEYCODE_1:
59         stripDisplayMode = 1;
60         break;
61     case IR_REMOTE_KEYCODE_2:
62         colorStep += 5;
63         if (colorStep > 100)
64         {
65             colorStep = 100;
66         }
67         break;
68     case IR_REMOTE_KEYCODE_3:
69         colorStep -= 5;
70         if (colorStep < 5)
71         {
72             colorStep = 5;
73         }
74         break;
75     case IR_REMOTE_KEYCODE_4:
76         stripDisplayMode = 0;
77         break;
78     case IR_REMOTE_KEYCODE_5:
79         stripDisplayDelay -= 20;
80         if (stripDisplayDelay < 20)
81         {
82             stripDisplayDelay = 20;
83         }
84         break;
85     case IR_REMOTE_KEYCODE_6:
86         stripDisplayDelay += 20;
87         if (stripDisplayDelay > 300)
```

```
88         {
89             stripDisplayDelay = 300;
90         }
91     break;
92 }
93 irrecv.resume(); // Receive the next value
94 lastIRUpdateTime = millis();
95 }
96 else {
97     if (millis() - lastIRUpdateTime > IR_UPDATE_TIMEOUT)
98     {
99         if (!isStopFromIR) {
100             isStopFromIR = true;
101             motorRun(0, 0);
102             setBuzzer(false);
103         }
104         lastIRUpdateTime = millis();
105     }
106 }
107 switch (stripDisplayMode)
108 {
109 case 0:
110     if (millis() - lastStripUpdateTime > stripDisplayDelay)
111     {
112         for (int i = 0; i < STRIP_LEDS_COUNT; i++) {
113             strip.setLedColorData(i, strip.Wheel(colorPos + i * 25));
114         }
115         strip.show();
116         colorPos += colorStep;
117         lastStripUpdateTime = millis();
118     }
119     break;
120 case 1:
121     if (millis() - lastStripUpdateTime > stripDisplayDelay)
122     {
123         strip.setLedColor(currentLedIndex, strip.Wheel(colorPos));
124         currentLedIndex++;
125         if (currentLedIndex == STRIP_LEDS_COUNT)
126         {
127             currentLedIndex = 0;
128             colorPos += colorStep;
129         }
130         lastStripUpdateTime = millis();
131     }
```

```
132         break;  
133     default:  
134         break;  
135     }  
136 }
```

Compared to the previous project, this code has more switch-case branch of the remote key code for controlling the light bar.

```
1 .....  
2     case IR_REMOTE_KEYCODE_1:  
3         stripDisplayMode = 1;  
4         break;  
5     case IR_REMOTE_KEYCODE_2:  
6         colorStep += 5;  
7         if (colorStep > 100)  
8         {  
9             colorStep = 100;  
10        }  
11        break;  
12    case IR_REMOTE_KEYCODE_3:  
13        colorStep -= 5;  
14        if (colorStep < 5)  
15        {  
16            colorStep = 5;  
17        }  
18        break;  
19    case IR_REMOTE_KEYCODE_4:  
20        stripDisplayMode = 0;  
21        break;  
22    case IR_REMOTE_KEYCODE_5:  
23        stripDisplayDelay -= 20;  
24        if (stripDisplayDelay < 20)  
25        {  
26            stripDisplayDelay = 20;  
27        }  
28        break;  
29    case IR_REMOTE_KEYCODE_6:  
30        stripDisplayDelay += 20;  
31        if (stripDisplayDelay > 300)  
32        {  
33            stripDisplayDelay = 300;  
34        }  
35        break;  
36 .....  
37
```

In the loop(), control the behavior of the light bar based on these variables above.

The variable **stripDisplayMode** is used to control the display mode of the LED.

The variable **stripDisplayDelay** is used to control the cycle time of the LED, that is, the speed of change.

The variable **colorStep** is used to control the color value change for each iteration.

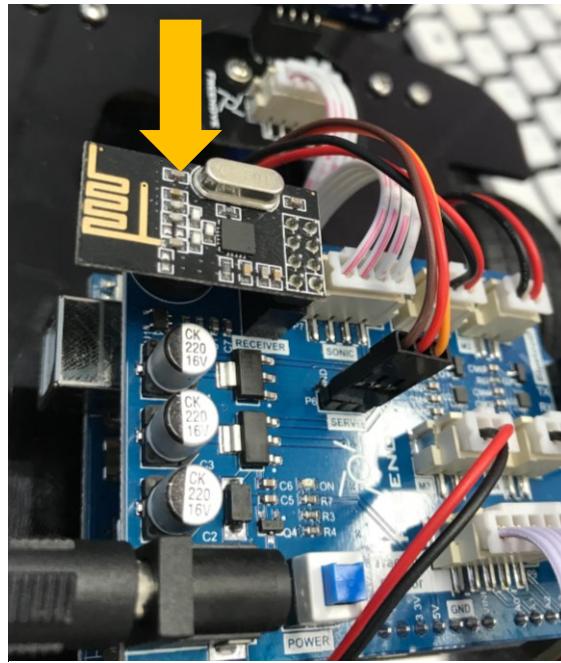
```
1  switch (stripDisplayMode)
2      {
3          case 0:
4              if (millis() - lastStripUpdateTime > stripDisplayDelay)
5              {
6                  for (int i = 0; i < STRIP_LEDS_COUNT; i++) {
7                      strip.setLedColorData(i, strip.Wheel(colorPos + i * 25));
8                  }
9                  strip.show();
10                 colorPos += colorStep;
11                 lastStripUpdateTime = millis();
12             }
13             break;
14         case 1:
15             if (millis() - lastStripUpdateTime > stripDisplayDelay)
16             {
17                 strip.setLedColor(currentLedIndex, strip.Wheel(colorPos));
18                 currentLedIndex++;
19                 if (currentLedIndex == STRIP_LEDS_COUNT)
20                 {
21                     currentLedIndex = 0;
22                     colorPos += colorStep;
23                 }
24                 lastStripUpdateTime = millis();
25             }
26             break;
27         default:
28             break;
29     }
```

Chapter 5 RF Remote Control

If you purchased the kit without RF remote control, you can skip this chapter.

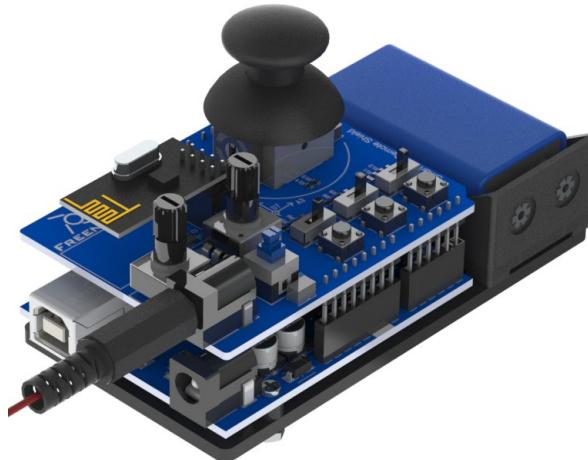
Receive RF Remote Control Data

Install RF module on the car. RF module and IR receiver use same receiver pins.



Then download tutorial and code to **assemble** remote controller.

https://github.com/Freenove/Freenove_Remote_Control_Kit/raw/master/Tutorial.pdf



For whole resources, please refer to https://github.com/Freenove/Freenove_Remote_Control_Kit

Upload Code and Running

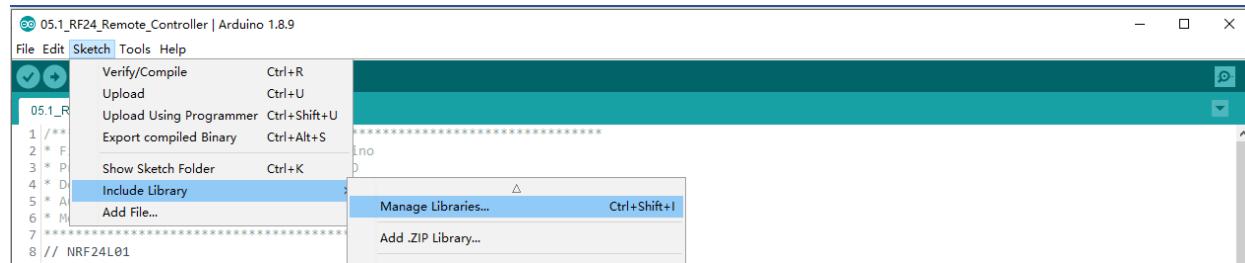
This project include two code:

Code 05.1_RF24_Remote_Controller.ino needs to be uploaded into RF Remote controller.

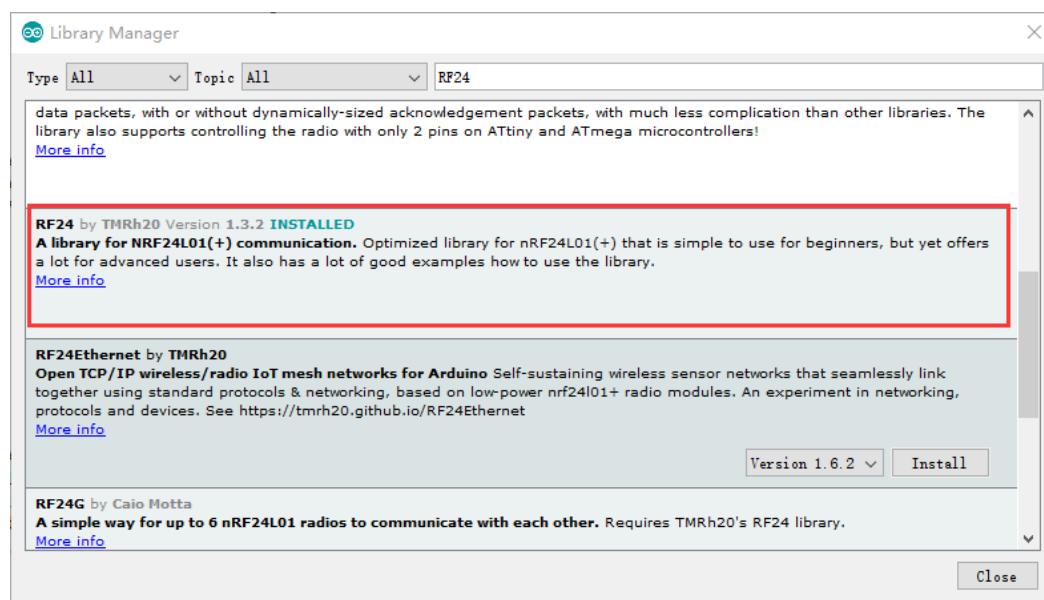
Code 05.2_Receive_Data.ino needs to be uploaded into Car.

First, install library. SPI is library of Arduino, which will be included automatically.

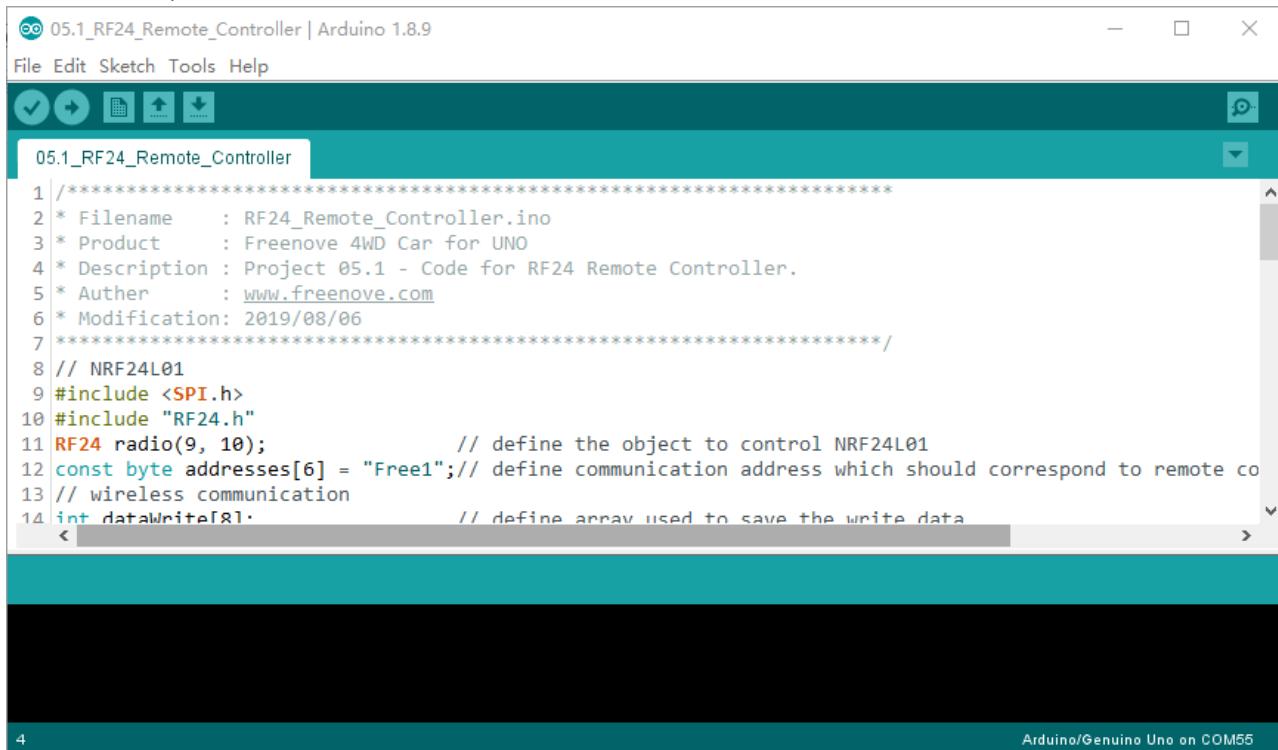
You only need to install RF24.



Find and install it.



Connect remote controller to computer. And upload code in Sketches\ 05.1_RF24_Remote_Controller. Then turn on power of RF remote control.

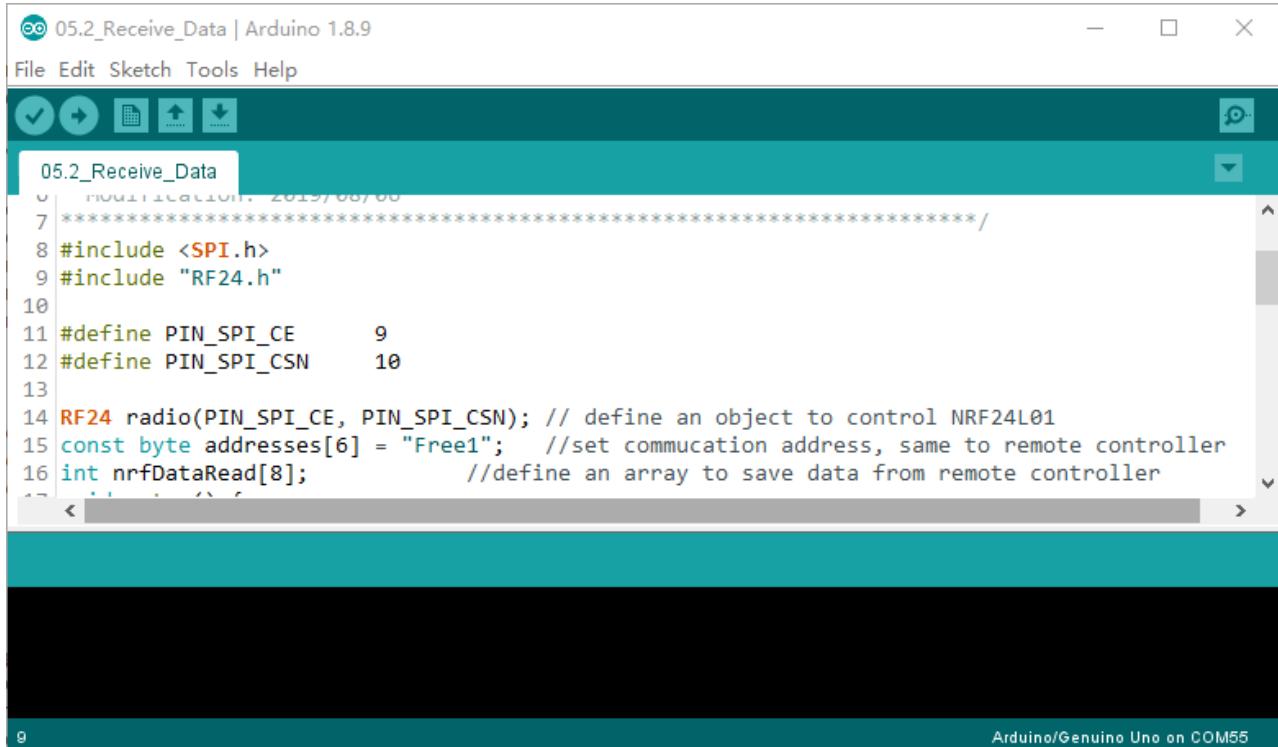


```

05.1_RF24_Remote_Controller | Arduino 1.8.9
File Edit Sketch Tools Help
05.1_RF24_Remote_Controller
1 /*****
2 * Filename      : RF24_Remote_Controller.ino
3 * Product       : Freenove 4WD Car for UNO
4 * Description   : Project 05.1 - Code for RF24 Remote Controller.
5 * Author        : www.freenove.com
6 * Modification  : 2019/08/06
7 *****/
8 // NRF24L01
9 #include <SPI.h>
10 #include "RF24.h"
11 RF24 radio(9, 10);           // define the object to control NRF24L01
12 const byte addresses[6] = "Free1"; // define communication address which should correspond to remote co
13 // wireless communication
14 int datawrite[8];           // define array used to save the write data

```

Then connect car to computer. And upload code in Sketches\ 05.2_Receive_Data.



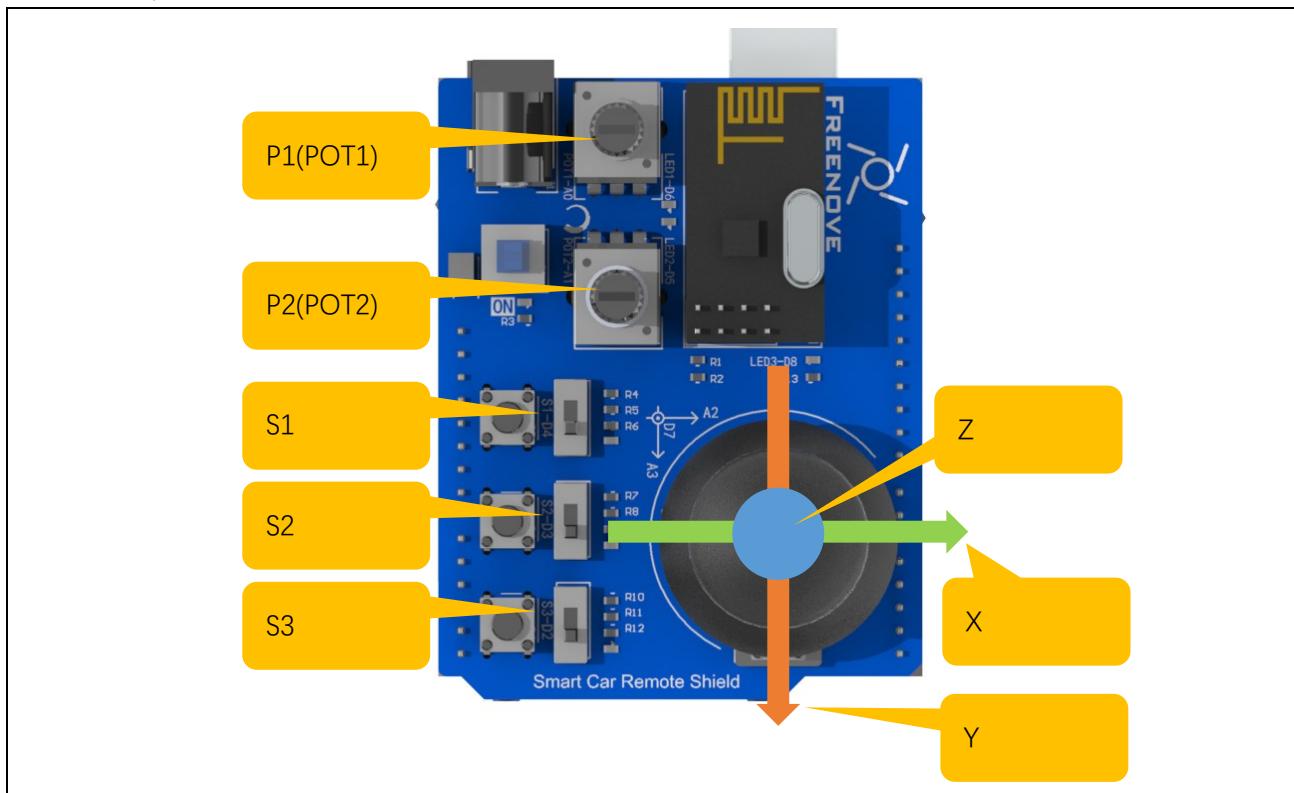
```

05.2_Receive_Data | Arduino 1.8.9
File Edit Sketch Tools Help
05.2_Receive_Data
1 //modification: 2019/08/06
2 *****/
3 #include <SPI.h>
4 #include "RF24.h"
5
6 #define PIN_SPI_CE      9
7 #define PIN_SPI_CSN     10
8
9 RF24 radio(PIN_SPI_CE, PIN_SPI_CSN); // define an object to control NRF24L01
10 const byte addresses[6] = "Free1";    //set communication address, same to remote controller
11 int nrfDataRead[8];                //define an array to save data from remote controller

```

Keep car connecting USB cable. Then open the serial monitor. You will see content as below. **Operate the remote controller and observe the data change.**

Data to components



Code

05.1_RF24_Remote_Controller

The code is below:

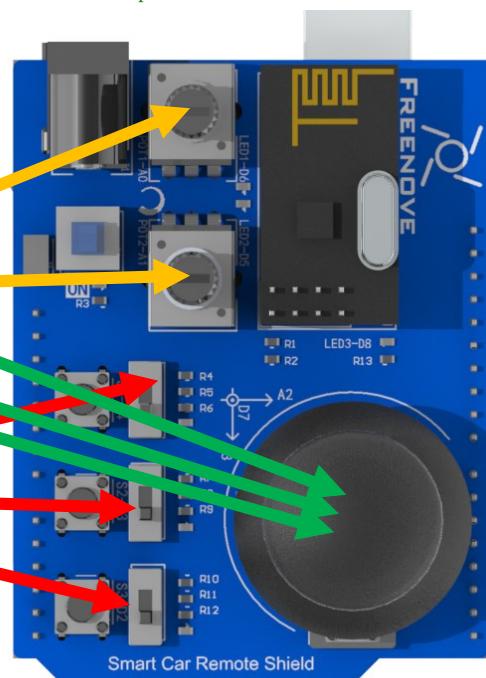
```
1 // RF24L01
2 #include <SPI.h>
3 #include "RF24.h"
4 RF24 radio(9, 10);           // define the object to control RF24L01
5 const byte addresses[6] = "Free1"; // define communication address which should correspond to
6 the control board of car
7 // wireless communication
8 int dataWrite[8];           // define array used to save the write data
9 // pin
10 const int pot1Pin = A0,        // define POT1 Potentiometer
11     pot2Pin = A1,        // define POT2 Potentiometer
12     joystickXPin = A2,      // define pin for direction X of joystick
13     joystickYPin = A3,      // define pin for direction Y of joystick
14     joystickZPin = 7,       // define pin for direction Z of joystick
15     s1Pin = 4,            // define pin for S1
16     s2Pin = 3,            // define pin for S2
17     s3Pin = 2,            // define pin for S3
18     led1Pin = 6,           // define pin for LED1 which is close to POT1 and used to
19 indicate the state of POT1
20     led2Pin = 5,           // define pin for LED2 which is close to POT2 and used to
21 indicate the state of POT2
22     led3Pin = 8;           // define pin for LED3 which is close to RF24L01 and used to
23 indicate the state of RF24L01
24
25 void setup() {
26     // RF24L01
27     radio.begin();           // initialize RF24
28     radio.setPALevel(RF24_PA_LOW); // set power amplifier (PA) level
29     radio.setDataRate(RF24_1MBPS); // set data rate through the air
30     radio.setRetries(0, 15);    // set the number and delay of retries
31     radio.openWritingPipe(addresses); // open a pipe for writing
32     radio.openReadingPipe(1, addresses); // open a pipe for reading
33     radio.stopListening();     // stop listening for incoming messages
34
35 // pin
36     pinMode(joystickZPin, INPUT); // set led1Pin to input mode
37     pinMode(s1Pin, INPUT);      // set s1Pin to input mode
38     pinMode(s2Pin, INPUT);      // set s2Pin to input mode
39     pinMode(s3Pin, INPUT);      // set s3Pin to input mode
```

```

40   pinMode(led1Pin, OUTPUT);           // set led1Pin to output mode
41   pinMode(led2Pin, OUTPUT);           // set led2Pin to output mode
42   pinMode(led3Pin, OUTPUT);           // set led3Pin to output mode
43 }
44
45 void loop()
46 {
47   // put the values of rocker, switch and pot
48   dataWrite[0] = analogRead(pot1Pin); // save
49   dataWrite[1] = analogRead(pot2Pin); // save
50   dataWrite[2] = analogRead(joystickXPin); //
51   dataWrite[3] = analogRead(joystickYPin); //
52   dataWrite[4] = digitalRead(joystickZPin); //
53   dataWrite[5] = digitalRead(s1Pin); //
54   dataWrite[6] = digitalRead(s2Pin); //
55   dataWrite[7] = digitalRead(s3Pin); //

56   // write radio data
57   if (radio.write(dataWrite, sizeof(dataWrite)
58   {
59     digitalWrite(led3Pin, HIGH);
60     delay(20);
61     digitalWrite(led3Pin, LOW);
62   }
63
64
65   // make LED emit different brightness of light according to analog of potentiometer
66   analogWrite(led1Pin, map(dataWrite[0], 0, 1023, 0, 255));
67   analogWrite(led2Pin, map(dataWrite[1], 0, 1023, 0, 255));
68 }

```



5 const byte addresses[6] = "Free1";

You can change the address if you have two freenove remote to control different cars, like Free2. But it is **necessary** to keep this same to the address in code in car.

```

48   dataWrite[0] = analogRead(pot1Pin); // (0~1023) save data of Potentiometer 1
49   dataWrite[1] = analogRead(pot2Pin); // (0~1023) save data of Potentiometer 2
50   dataWrite[2] = analogRead(joystickXPin); // (0~1023) save data of direction X of joystick
51   dataWrite[3] = analogRead(joystickYPin); // (0~1023) save data of direction Y of joystick
52   dataWrite[4] = digitalRead(joystickZPin); // (0,1) save data of direction Z of joystick
53   dataWrite[5] = digitalRead(s1Pin); // (0,1) save data of switch 1
54   dataWrite[6] = digitalRead(s2Pin); // (0,1) save data of switch 2
55   dataWrite[7] = digitalRead(s3Pin); // (0,1) save data of switch 3

```

When joystick in center place. Its value is about x=512, y=512

When joystick is pressed, z=0; when not pressed, z=1.

Swithes are the same, when swich on s=0; when swicht off, s=1.

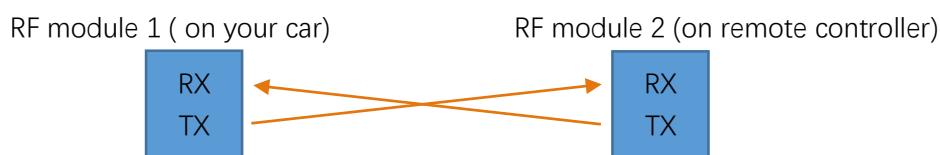
05.2_Receive_Data

The code is below.

```
1 #include <SPI.h>
2 #include "RF24.h"
3
4 #define PIN_SPI_CE      9
5 #define PIN_SPI_CSN     10
6
7 RF24 radio(PIN_SPI_CE, PIN_SPI_CSN); // define an object to control RF24L01
8 const byte addresses[6] = "Free1";   //set commutation address, same to remote controller
9 int RFDataRead[8];                  //define an array to save data from remote controller
10 void setup() {
11     Serial.begin(9600);
12
13     // RF24L01 initialization steps
14     if (radio.begin()) {           // initialize RF24
15         radio.setPALevel(RF24_PA_LOW); // set power amplifier (PA) level
16         radio.setDataRate(RF24_1MBPS); // set data rate through the air
17         radio.setRetries(0, 15);      // set the number and delay of retries
18         radio.openWritingPipe(addresses); // open a pipe for writing
19         radio.openReadingPipe(1, addresses); // open a pipe for reading
20         radio.startListening();       // start monitoringart listening on the pipes opened
21         Serial.println("Start listening remote data ... ");
22     }
23     else {
24         Serial.println("Not found the RF chip!");
25     }
26 }
27
28 void loop() {
29     if (radio.available()) {        // if receive the data
30         while (radio.available()) { // read all the data
31             radio.read(RFDataRead, sizeof(RFDataRead)); // read data
32         }
33         Serial.print("P1/P2/X/Y/Z/S1/S2/S3 : ");
34         for (int i = 0; i < sizeof(RFDataRead) / 2; i++) {
35             Serial.print(RFDataRead[i]);
36             Serial.print(' \t');
37         }
38         Serial.print(' \n');
39     }
40 }
```

41

The communicate is as follows:



radio.write(dataWrite, sizeof(dataWrite)) Transfer the data.

Both of the code for car and code for remote have following contents:

```
5   const byte addresses[6] = "Free1";
...
18   radio.openWritingPipe(addresses);    // open a pipe for writing
19   radio.openReadingPipe(1, addresses); // open a pipe for reading
```

This is used to set writing (transmitting) and reading (receiving) addresses of the RF24L01 module. Module B can receive the data of module A, only when the writing address of module A is the same as the reading address of module B. The module's own writing and reading addresses can be the same or different. When there are many RF modules in the around, the writing and reading addresses can be changed to avoid interference from other devices.

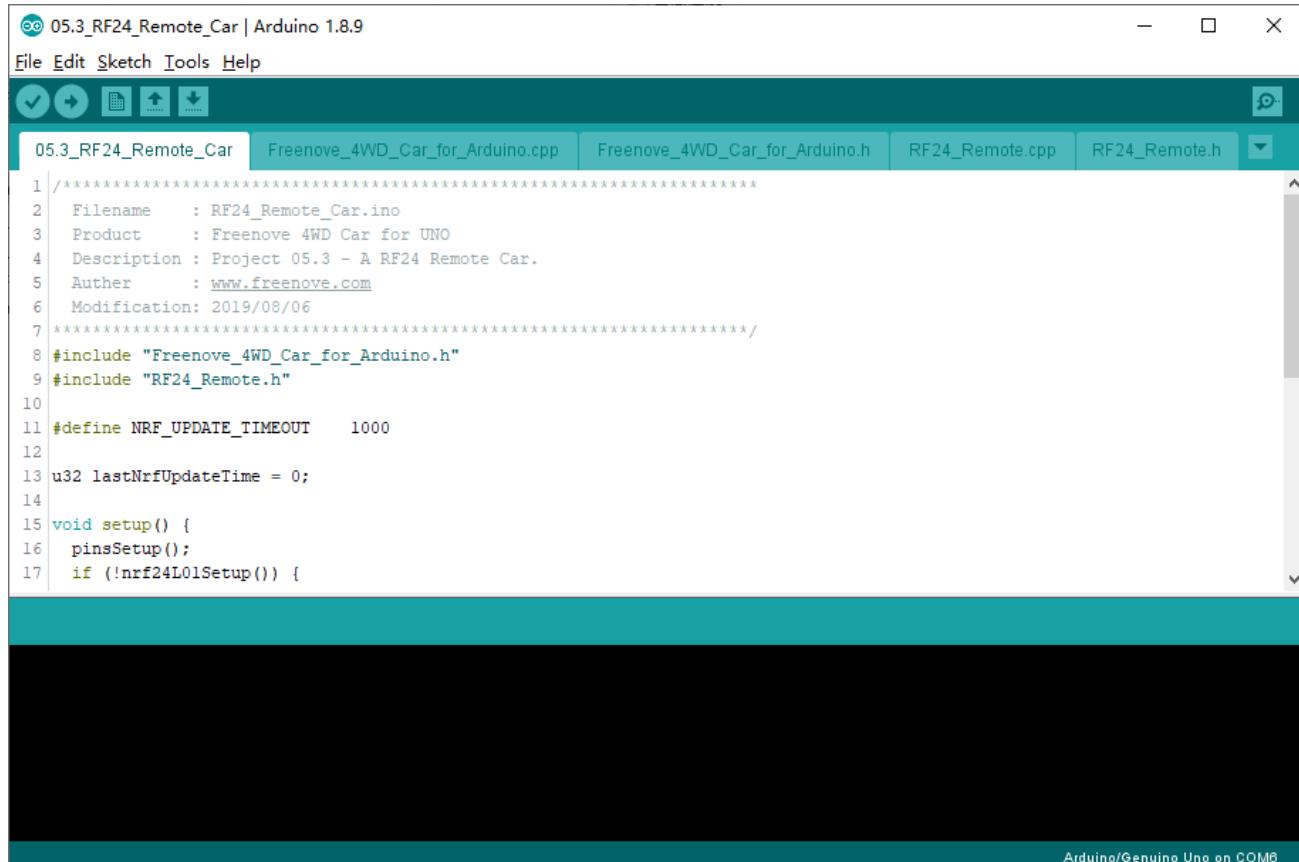
After we receive data from remote, we will recognize which component is operated according to the data change.

RF Remote Car

After successfully receiving the data sent by the RF remote control, we can use the data to control car movement, buzzer sounds, etc.

Upload Code and Running

Connect Car to computer with usb cable. And upload code in Sketches\ 05.3_RF24_Remote_Car.ino.



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** 05.3_RF24_Remote_Car | Arduino 1.8.9
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Standard toolbar icons for Open, Save, Print, and Upload.
- Sketch List:** 05.3_RF24_Remote_Car (selected), Freenove_4WD_Car_for_Arduino.cpp, Freenove_4WD_Car_for_Arduino.h, RF24_Remote.cpp, RF24_Remote.h
- Code Editor:** The main area displays the C++ code for the RF24 Remote Car sketch. The code includes comments, includes, defines, and setup functions.
- Status Bar:** Arduino/Genuino Uno on COM6

Then disconnect the USB cable and turn on the RF Remote Control and Car power switches. Operate the joystick to control the movement of the car. Press the joystick to turn on the buzzer.

Code

The project has five labels, of which "RF24_Remote.h" and "RF24_Remote.cpp" store contents about data reading and data processing for the RF24 remote control. These contents are called in "05.3_RF24_Remote_Car.ino".

RF24_Remote.h

```
1 #ifndef _RF_REMOTE_h
2 #define _RF_REMOTE_h
3
4 #include "Freenove_4WD_Car_for_Arduino.h"
5 #include "RF24.h"
6
7 extern RF24 radio;
8
9 enum RemoteData
10 {
11     POT1 = 0,
12     POT2 = 1,
13     JOYSTICK_X = 2,
14     JOYSTICK_Y = 3,
15     JOYSTICK_Z = 4,
16     S1 = 5,
17     S2 = 6,
18     S3 = 7
19 };
20 enum RemoteMode {
21     ON_ON_ON = 0,
22     ON_ON_OFF = 1,           //Servo calibration mode.
23     ON_OFF_ON = 2,
24     ON_OFF_OFF = 3,          //Ultrasonic obstacle avoidance mode.
25     OFF_ON_ON = 4,
26     OFF_ON_OFF = 5,          //Line tracking mode.
27     OFF_OFF_ON = 6,          //
28     OFF_OFF_OFF = 7          //Remote control mode.
29 };
30 enum RemoteModeSwitchState {
31     MODE_SWITCHING_IS_INITIALIZING = 0,
32     MODE_SWITCHING_IS_PROCESSING = 1,
33     MODE_SWITCHING_IS_CONFIRMING = 2,
34     MODE_SWITCHING_WAS_FINISHED = 3
35 };
36
37 #define MODE_REMOTE_CONTROL           OFF_OFF_OFF
```

```

38 #define MODE_LINE_TRACKING           OFF_ON_OFF
39 #define MODE_OBSTACLE_AVOIDANCE      ON_OFF_OFF
40
41 extern int RFDataRead[8];
42
43 bool RF24L01Setup();
44 bool getRF24L01Data();
45 void updateCarActionByRFRremote();
46 void resetRFDataBuf();
47 u8 updateRFCarMode();
48
49 #endif

```

Where enum RemoteData defines the order of the remote control data received, using more meaningful variable names instead of numbers. For example, if you want to use the X-axis data of the remote control, you can use RFDataRead[JOYSTICK_X] instead of the no meaningless RFDataRead[2]. It like define

```

enum RemoteData {
    POT1 = 0, // similar to #define POT1 0
    POT2 = 1,
    JOYSTICK_X = 2,
    JOYSTICK_Y = 3,
    JOYSTICK_Z = 4,
    S1 = 5,
    S2 = 6,
    S3 = 7
};

```

The enum RemoteMode defines all states of the remote control switches S1, S2, S3. The enum RemoteModeSwitchState defines the state when the remote control switches modes. These contents will also be used in the next project.

```

enum RemoteMode {
    ON_ON_ON = 0,
    ON_ON_OFF = 1,          //Servo calibration mode.
    ON_OFF_ON = 2,
    ON_OFF_OFF = 3,         //Ultrasonic obstacle avoidance mode.
    OFF_ON_ON = 4,
    OFF_ON_OFF = 5,         //Line tracking mode.
    OFF_OFF_ON = 6,         //
    OFF_OFF_OFF = 7,        //Remote control mode.
};

enum RemoteModeSwitchState {
    MODE_SWITCHING_IS_INITIALIZING = 0,
    MODE_SWITCHING_IS_PROCESSING = 1,
}

```

```

    MODE_SWITCHING_IS_CONFIRMING = 2,
    MODE_SWITCHING_WAS_FINISHED = 3
};
```

bool RF24L01Setup();

Initialize RF24L01. If success, return true, if not, return false.

bool getRF24L01Data();

Read data from remote control. If there is data read, return true; if not, return false.

void updateCarActionByRFRremote();

Control car actions (mainly for motor and buzzer) according to data received.

void resetRFDataBuf();

Set values of RFData array to default values.

u8 updateRFCarMode();

Combine data of S1 S2 S3 of remote control into one value and return it.

05.3_RF24_Remote_Car.ino

```

1 #include "Freenove_4WD_Car_for_Arduino.h"
2 #include "RF24_Remote.h"
3
4 #define RF_UPDATE_TIMEOUT      1000
5 u32 lastRFUpdateTime = 0;
6
7 void setup() {
8     pinsSetup();
9     if (!RF24L01Setup()) {
10         alarm(4, 2);
11     }
12 }
13
14 void loop() {
15     if (getRF24L01Data()) {
16         updateCarActionByRFRremote();
17         lastRFUpdateTime = millis();
18     }
19     if (millis() - lastRFUpdateTime > RF_UPDATE_TIMEOUT) {
20         lastRFUpdateTime = millis();
21         resetRFDataBuf();
22         updateCarActionByRFRremote();
23     }
24 }
```

In setup(), initialize pins and RF24L01. In loop(), receive data from the remote control and process the data. If receiving data is time out, the remote control signal is considered to be lost and the cart will be placed in the initialization state.

Multifunctional RF24 Remote Car

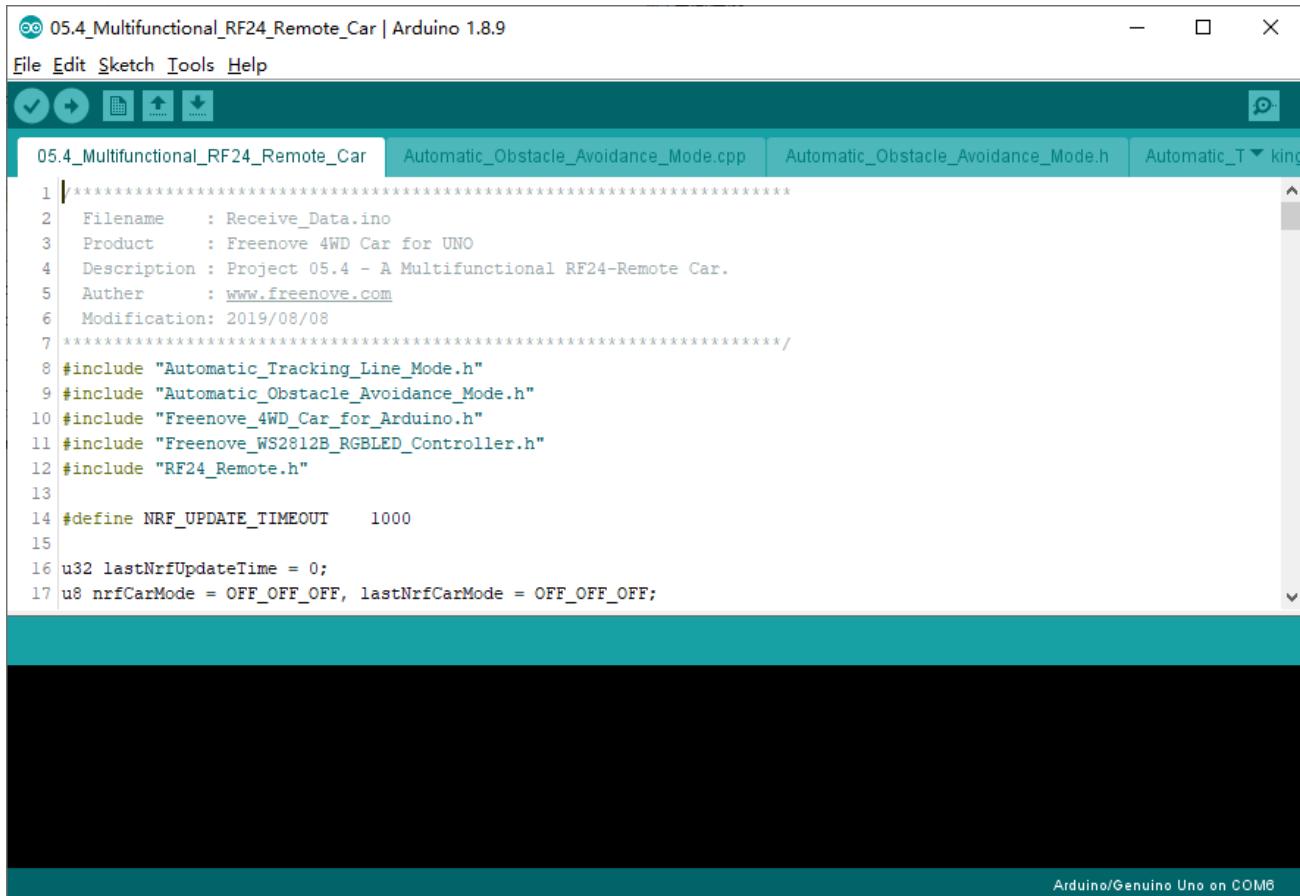
This project combines almost all functions of the car, such as obstacle avoidance mode, line tracking mode, remote control mode, RGB LED display mode, servo position calibration and so on. The switching between different functions is realized by switching the states of S1, S2, and S3 on the remote controller.

The project code is more complicated, but the components and knowledge used have been introduced in the previous project. The only difference is that they are integrated into one project, which is quite large.

Upload Code and Running

Connect Car to computer with usb cable.

And upload code in Sketches\ 05.4_Multifunctional_RF24_Remote_Car.ino.



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** 05.4_Multifunctional_RF24_Remote_Car | Arduino 1.8.9
- Menu Bar:** File Edit Sketch Tools Help
- Tool Buttons:** Checkmark, Run, Stop, Upload, Download, Serial Monitor, Schematic, Pinout, Help.
- Code Area:** The main code area displays the following C++ code:

```
1 // ****
2 Filename : Receive_Data.ino
3 Product : Freenove 4WD Car for UNO
4 Description : Project 05.4 - A Multifunctional RF24-Remote Car.
5 Author : www.freenove.com
6 Modification: 2019/08/08
7 ****
8 #include "Automatic_Tracking_Line_Mode.h"
9 #include "Automatic_Obstacle_Avoidance_Mode.h"
10 #include "Freenove_4WD_Car_for_Arduino.h"
11 #include "Freenove_WS2812B_RGBLED_Controller.h"
12 #include "RF24_Remote.h"
13
14 #define NRF_UPDATE_TIMEOUT 1000
15
16 u32 lastNrfUpdateTime = 0;
17 u8 nrfCarMode = OFF_OFF_OFF, lastNrfCarMode = OFF_OFF_OFF;
```

Status Bar: Arduino/Genuine Uno on COM6

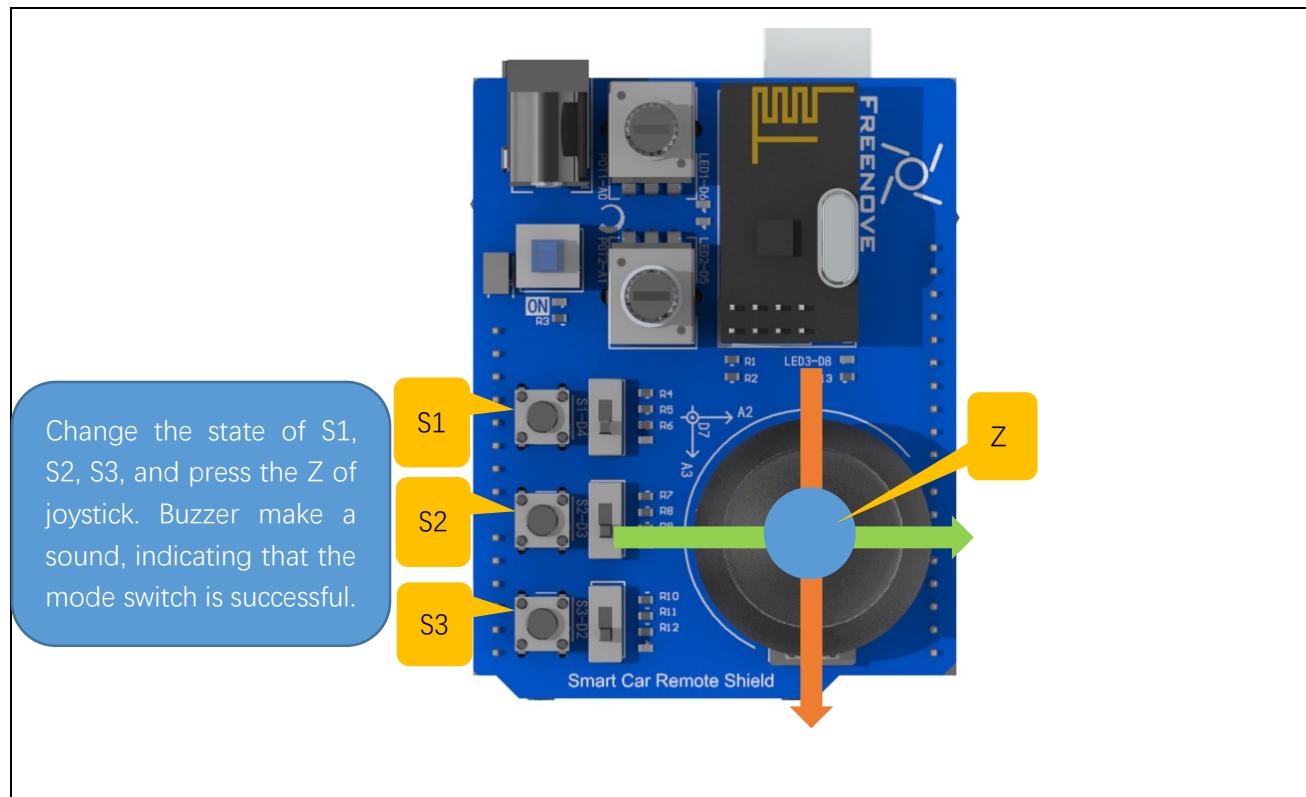
Disconnect the USB cable. Turn on the power of the remote control and the car. By default, the car is in manual remote control mode, and the S1, S2, and S3 switches on the remote control are off.

Switch different modes

- 1, Change the switch state of S1, S2, and S3, and the car will stop moving.
- 2, Press the Z axis of the joystick and the buzzer B sounds to indicate that the mode is successfully switched.

The following table shows the modes indicated by the different states of the three switches S1, S2, and S3. The LED next to the switch illumination to indicate ON and OFF state of switches. The three switches can form $2 \times 2 \times 2 = 8$ modes.

S1	S2	S3	Mode No.	Mode
ON	ON	ON	0	None
ON	ON	OFF	1	Calibrate servo mode
ON	OFF	ON	2	None
ON	OFF	OFF	3	Obstacle avoidance mode
OFF	ON	ON	4	None
OFF	ON	OFF	5	Line tracking mode
OFF	OFF	ON	6	Switch LED mode
OFF	OFF	OFF	7	Manuel control mode / Default mode



Mode 0, 2, 4

Reserved. We did not assign functions for them.

Mode 1-Calibrate servo

If your servo is not accurately mounted at 90 degrees, you can use this mode for fine adjustment (+ -10 degrees).

In this mode, you can adjust potentiometer 2 (POT2) to fine tune the angle of the servo. When you adjust the servo to the correct angle, press the Z-axis of joystick to save calibration data to EEPROM. It will be saved permanently unless it is modified.

Mode 3-obstical avoidance, Mode 5-line tracking mode

These two modes have been learned separately in the previous project, and the running logic and code are consistent with the previous project.

The difference is that in this project, the car can respond to commands from the remote control at any time. Therefore, in this project, it is still necessary to communicate with the remote controller in these two modes. When the remote control signal is disconnected, the car will stop. Therefore, the normal communication between the remote control and the car should be maintained at any time. Poor communication conditions may cause these two modes to work abnormally.

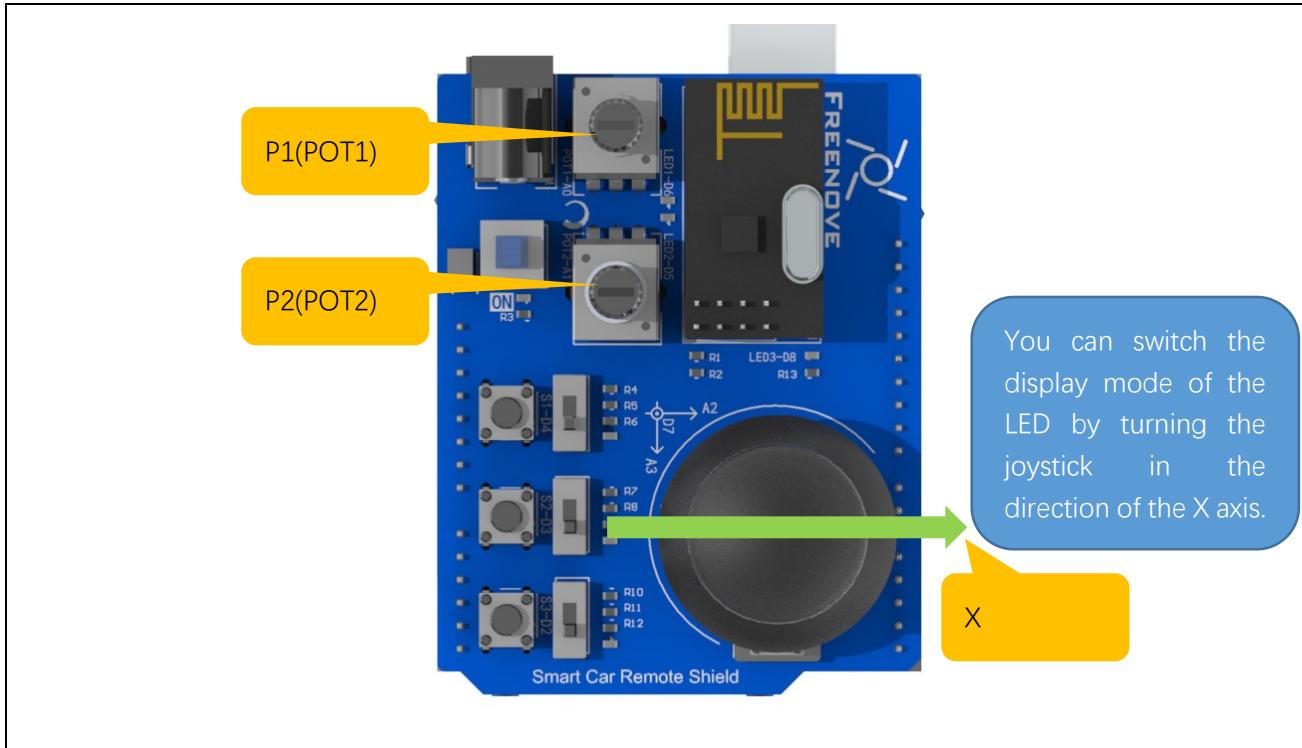
Mode 6-switch LED display mode

There are three display modes for the LEDs on the car, which are 0-flowing rainbow, 1-flowing water led, 2-Blink. In this mode, the display mode of the LED can be switched.

After entering this mode,

Move the joystick along the positive direction of the X-axis of the joystick to switch the LED to the next mode.
Move the joystick in the negative direction of the X-axis of the joystick to switch the LED to the previous mode.

In any mode, the LEDs can be adjusted with potentiometers P1 and P2. P1 is used to adjust the color change of the LED, and P2 is used to adjust the frequency of LED changes.



Mode 7- manual remote mode

This mode is manual remote mode and is the default mode. This mode is consistent with the previous project "RF_Remote_Car". Use the joystick to control to move forward, move back and turn left, turn right.

Code

There are 9 (file) labels for this project, 8 of which have appeared in previous projects. In the file "05.4_Multifunctional_RF24_Remote_Car.ino", it is mainly the logical management of each module function, such as switching of the car mode, switching of the LED display mode.

05.4_Multifunctional_RF24_Remote_Car.ino

```
1 #include "Automatic_Tracking_Line_Mode.h"
2 #include "Automatic_Obstacle_Avoidance_Mode.h"
3 #include "Freenove_4WD_Car_for_Arduino.h"
4 #include "Freenove_WS2812B_RGBLED_Controller.h"
5 #include "RF24_Remote.h"
6
7 #define RF_UPDATE_TIMEOUT    1000
8
9 u32 lastRFUpdateTime = 0;
10 u8 RFCarMode = OFF_OFF_OFF, lastRFCarMode = OFF_OFF_OFF;
11 u8 switchModeState = MODE_SWITCHING_WAS_FINISHED;
12 u8 joystickSwitchState = MODE_SWITCHING_WAS_FINISHED;
13
14 #define STRIP_I2C_ADDRESS 0x20
15 #define STRIP_LEDS_COUNT   10
16
17 #define MAX_NUMBER_OF_DISP_MODES 3
18
19 u8 colorPos = 0;
20 u8 colorStep = 50;
21 u8 stripDisplayMode = 1;
22 u8 currentLedIndex = 0;
23 u16 stripDisplayDelay = 100;
24 u32 lastStripUpdateTime = 0;
25 Freenove_WS2812B_Controller strip(STRIP_I2C_ADDRESS, STRIP_LEDS_COUNT, TYPE_GRB);
26
27 void setup() {
28     pinsSetup();
29     if (!RF24L01Setup()) {
30         alarm(4, 2);
31     }
32     servoSetup();
33     while (!strip.begin());
34     strip.setAllLedsColor(0xFF0000);
35 }
36
37 void loop() {
```

```
38     if (getRF24L01Data()) {
39         RFCarMode = updateRFCarMode();
40         if (RFCarMode != lastRFCarMode) {
41             if (switchModeState == MODE_SWITCHING_WAS_FINISHED) {
42                 switchModeState = MODE_SWITCHING_IS_INITIALIZING;
43             }
44             switch (switchModeState)
45             {
46                 case MODE_SWITCHING_IS_INITIALIZING:
47                     //Serial.println("Switching Mode Init... ");
48                     resetCarAction();
49                     writeServo(90);
50                     switchModeState = MODE_SWITCHING_IS_PROCESSING;
51                     break;
52                 case MODE_SWITCHING_IS_PROCESSING:
53                     if (RFDataRead[JOYSTICK_Z] == 0) {
54                         //Serial.println("Switching Mode ... ");
55                         setBuzzer(true);
56                         switchModeState = MODE_SWITCHING_IS_CONFIRMING;
57                     }
58                     break;
59                 case MODE_SWITCHING_IS_CONFIRMING:
60                     if (RFDataRead[JOYSTICK_Z] == 1) {
61                         //Serial.println("Comfirm Switched. ");
62                         setBuzzer(false);
63
64                         switchModeState = MODE_SWITCHING_WAS_FINISHED;
65                         lastRFCarMode = RFCarMode;
66                         switch (RFCarMode)
67                         {
68                             case MODE_OBSTACLE_AVOIDANCE:
69                                 oa_CalculateVoltageCompensation();
70                                 break;
71                             case MODE_LINE_TRACKING:
72                                 tk_CalculateVoltageCompensation();
73                                 break;
74                             default:
75                                 break;
76                         }
77                         //Serial.println("Switch mode finished !");
78                     }
79                     break;
80                 case MODE_SWITCHING_WAS_FINISHED:
81                     break;
```

```
82         default:
83             break;
84         }
85     }
86 else {
87     if (switchModeState != MODE_SWITCHING_WAS_FINISHED) {
88         switchModeState = MODE_SWITCHING_WAS_FINISHED;
89     }
90     switch (RFCarMode)
91     {
92     case ON_ON_ON:
93         break;
94     case ON_ON_OFF: //S1, S2 ON, S3 OFF
95         setServoOffset(RFDataRead[1] / 100);
96         if (RFDataRead[JOYSTICK_Z] == 0) {
97             setBuzzer(true);
98             writeServoOffsetToEEPROM();
99         }
100        else {
101            setBuzzer(false);
102        }
103        break;
104    case ON_OFF_ON:
105        break;
106    case ON_OFF_OFF: /////Sonic Obstacle Avoidance Mode, S1 is ON and S2, S3 are
107 OFF
108        updateAutomaticObstacleAvoidance();
109        break;
110    case OFF_ON_ON:
111        break;
112    case OFF_ON_OFF: //Tracking Mode, S2 is ON and S1, S3 are OFF.
113        updateAutomaticTrackingLine();
114        break;
115    case OFF_OFF_ON: //S3 is ON and S1, S2 are OFF
116        //stripDisplayMode = RFDataRead[POT2] / 512;
117        switch (joystickSwitchState)
118        {
119            static u8 switchCounter = 0;
120            case MODE_SWITCHING_IS_INITIALIZING:
121                if (RFDataRead[JOYSTICK_X] > 900)
122                {
123                    setBuzzer(true);
124                    switchCounter++;
125                    joystickSwitchState = MODE_SWITCHING_IS_PROCESSING;
```

```
126 }  
127     else if (RFDataRead[JOYSTICK_X] < 200)  
128     {  
129         setBuzzer(true);  
130         switchCounter--;  
131         joystickSwitchState = MODE_SWITCHING_IS_PROCESSING;  
132     }  
133     break;  
134 case MODE_SWITCHING_IS_PROCESSING:  
135     if ((RFDataRead[JOYSTICK_X] < 600) && (RFDataRead[JOYSTICK_X] > 400))  
136     {  
137         setBuzzer(false);  
138         joystickSwitchState = MODE_SWITCHING_IS_CONFIRMING;  
139     }  
140     break;  
141 case MODE_SWITCHING_IS_CONFIRMING:  
142     stripDisplayMode += switchCounter;  
143     if (stripDisplayMode == 0xff)  
144     {  
145         stripDisplayMode = MAX_NUMBER_OF_DISP_MODES - 1;  
146     }  
147     stripDisplayMode %= MAX_NUMBER_OF_DISP_MODES;  
148     joystickSwitchState = MODE_SWITCHING_WAS_FINISHED;  
149     break;  
150 case MODE_SWITCHING_WAS_FINISHED:  
151     switchCounter = 0;  
152     joystickSwitchState = MODE_SWITCHING_IS_INITIALIZING;  
153     break;  
154 default:  
155     break;  
156 }  
157 break;  
158 case OFF_OFF_OFF: //Remote Mode, all switch leds are OFF  
159     updateCarActionByRFRremote();  
160     break;  
161 default:  
162     break;  
163 }  
164 }  
165 colorStep = map(RFDataRead[POT1], 0, 1023, 0, 255);  
166 stripDisplayDelay = RFDataRead[POT2];  
167 lastRFUpdateTime = millis();  
168 }  
169 }
```

```
170     if (millis() - lastRFUpdateTime > RF_UPDATE_TIMEOUT) {
171         lastRFUpdateTime = millis();
172         resetRFDataBuf();
173         updateCarActionByRFRremote();
174         RFCarMode = lastRFCarMode = MODE_REMOTE_CONTROL;
175     }
176     switch (stripDisplayMode)
177     {
178     case 0:
179         if (millis() - lastStripUpdateTime > stripDisplayDelay)
180         {
181             for (int i = 0; i < STRIP_LEDS_COUNT; i++) {
182                 strip.setLedColorData(i, strip.Wheel(colorPos + i * 25));
183             }
184             strip.show();
185             colorPos += colorStep;
186             lastStripUpdateTime = millis();
187         }
188         break;
189     case 1:
190         if (millis() - lastStripUpdateTime > stripDisplayDelay)
191         {
192             strip.setLedColor(currentLedIndex, strip.Wheel(colorPos));
193             currentLedIndex++;
194             if (currentLedIndex == STRIP_LEDS_COUNT)
195             {
196                 currentLedIndex = 0;
197                 colorPos += colorStep; ///
198             }
199             lastStripUpdateTime = millis();
200         }
201         break;
202     case 2:
203         colorPos = colorStep;
204         if (millis() - lastStripUpdateTime > stripDisplayDelay)
205         {
206             static bool ledState = true;
207             if (ledState)
208             {
209                 strip.setAllLedsColor(strip.Wheel(colorPos));
210             }
211             else
212             {
213                 strip.setAllLedsColor(0x00);
```

```

214         }
215         ledState = !ledState;
216         lastStripUpdateTime = millis();
217     }
218     break;
219 default:
220     break;
221 }
222 }
```

In setup(), initialize pins and RF24L01 and LED module. In loop(), receive data from the remote control and process the data. If receiving data is time out, the remote control signal is considered to be lost. LED display code is added in this code, which is different from code in last project.

```

void setup() {
    pinsSetup();
    if (!RF24L01Setup()) {
        alarm(4, 2);
    }
    servoSetup();
    while (!strip.begin());
    strip.setAllLedsColor(0xFF0000);
}

void loop() {
    if (getRF24L01Data()) {
.....
    }

    if (millis() - lastRFUpdateTime > RF_UPDATE_TIMEOUT) {
        lastRFUpdateTime = millis();
        resetRFDataBuf();
        updateCarActionByRFRremote();
        RFCarMode = lastRFCarMode = MODE_REMOTE_CONTROL;
    }
    switch (stripDisplayMode)
    {
.....
    }
}
```

After reading the remote control data, judge whether the mode of the car has changed according to the state of S1, S2, S3. If the mode is changed, the code of the corresponding mode will be executed. Otherwise, the subsequent code will be executed.

```
if (getRF24L01Data()) {
    RFCarMode = updateRFCarMode();
    if (RFCarMode != lastRFCarMode) {
        if (switchModeState == MODE_SWITCHING_WAS_FINISHED) {
            switchModeState = MODE_SWITCHING_IS_INITIALIZING;
        }
        switch (switchModeState)
        {
        .....
        }
        .....
    }
    else {
    .....
    }
}
```

When the state of S1, S2, S3 changes, it means that the user wants to change the mode of the car, but in order to ensure that this change is not an erroneous operation, the user needs to press the Z axis of the joystick to confirm.

This series of actions can be implemented using the idea of a finite state machine. When the switch state changes, the state "MODE_SWITCHING_IS_INITIALIZING" is entered, the car's power module, motor and servo are initialized to prevent the car from running uncontrolled.

```
case MODE_SWITCHING_IS_INITIALIZING:
    //Serial.println("Switching Mode Init...");
    resetCarAction();
    writeServo(90);
    switchModeState = MODE_SWITCHING_IS_PROCESSING;
    break;
```

Then enter next state "MODE_SWITCHING_IS_PROCESSING" and wait for the user to press the rocker Z axis to confirm. If the user presses the Z axis of the joystick, then the buzzer sounds and enter the next state "MODE_SWITCHING_IS_CONFIRMING", waiting for the user to release the joystick. When the user releases the joystick, the buzzer stops sounding and changes the value of the variable switchModeState that holds the car mode. After the mode is switched, the completion status "MODE_SWITCHING_WAS_FINISHED" is entered.

```
case MODE_SWITCHING_IS_PROCESSING:
    if (RFDataRead[JOYSTICK_Z] == 0) {
        //Serial.println("Switching Mode ...");
        setBuzzer(true);
        switchModeState = MODE_SWITCHING_IS_CONFIRMING;
    }
    break;
```

```

case MODE_SWITCHING_IS_CONFIRMING:
    if (RFDataRead[JOYSTICK_Z] == 1) {
        //Serial.println("Comfirm Switched.");
        setBuzzer(false);
        switchModeState = MODE_SWITCHING_WAS_FINISHED;
        lastRFCarMode = RFCarMode;
        switch (RFCarMode)
        {
            case MODE_OBSTACLE_AVOIDANCE:
                oa_CalculateVoltageCompensation();
                break;
            case MODE_LINE_TRACKING:
                tk_CalculateVoltageCompensation();
                break;
            default:
                break;
        }
        //Serial.println("Switch mode finished !");
    }
    break;
case MODE_SWITCHING_WAS_FINISHED:
    break;
default:
    break;
}

```

Next, use the switch-case statement to let the car perform the corresponding function or action according to the value of the car mode variable RFCarMode.

```

switch (RFCarMode)
{
case ON_ON_ON:
    break;
case ON_ON_OFF: //S1, S2 ON, S3 OFF
.....//Set Servo offset
case ON_OFF_ON:
    break;
case ON_OFF_OFF: //Sonic Obstacle Avoidance Mode, S1 is ON and S2, S3 are OFF
    updateAutomaticObstacleAvoidance();
    break;
case OFF_ON_ON:
    break;
case OFF_ON_OFF: //Tracking Mode, S2 is ON and S1, S3 are OFF.
    updateAutomaticTrackingLine();
    break;
}

```

```

    case OFF_OFF_ON: //S3 is ON and S1, S2 are OFF
        .....//Change LED Mode
        break;
    case OFF_OFF_OFF: //Remote Mode, all switch leds are OFF
        updateCarActionByRFRremote();
        break;
    default:
        break;
}

```

In the calibration servo mode, the angle of the servo is adjusted according to the value of the potentiometer POT2. When the rocker Z-axis is pressed, the adjusted data is written into the EEPROM, and the buzzer will make a sound to confirm the writing.

```

case ON_ON_OFF: //S1, S2 ON, S3 OFF
    setServoOffset(RFDataRead[1] / 100);
    if (RFDataRead[JOYSTICK_Z] == 0) {
        setBuzzer(true);
        writeServoOffsetToEEPROM();
    }
    else {
        setBuzzer(false);
    }
    break;
}

```

In the mode of switching the LED display, the idea of finite state machine is still used.

First, enter the initialization state, waiting for the joystick to move in the direction of the X axis. If there is, the variable switchCounter will be self-added or self-decremented according to the positive and negative directions. Then enter next state, wait for the joystick to return to the middle. When the joystick returns to the middle, enter the next state, process the data, after the data processing is completed, enter the completion state.

```

switch (joystickSwitchState)
{
    static u8 switchCounter = 0;
    case MODE_SWITCHING_IS_INITIALIZING:
        if (RFDataRead[JOYSTICK_X] > 900)
        {
            setBuzzer(true);
            switchCounter++;
            joystickSwitchState = MODE_SWITCHING_IS_PROCESSING;
        }
        else if (RFDataRead[JOYSTICK_X] < 200)
        {
            setBuzzer(true);
            switchCounter--;
        }
}

```

```

        joystickSwitchState = MODE_SWITCHING_IS_PROCESSING;
    }
    break;
case MODE_SWITCHING_IS_PROCESSING:
    if ((RFDataRead[JOYSTICK_X] < 600) && (RFDataRead[JOYSTICK_X] > 400))
    {
        setBuzzer(false);
        joystickSwitchState = MODE_SWITCHING_IS_CONFIRMING;
    }
    break;
case MODE_SWITCHING_IS_CONFIRMING:
    stripDisplayStyle += switchCounter;
    if (stripDisplayStyle == 0xff)
    {
        stripDisplayStyle = MAX_NUMBER_OF_DISP_MODES - 1;
    }
    stripDisplayStyle %= MAX_NUMBER_OF_DISP_MODES;
    joystickSwitchState = MODE_SWITCHING_WAS_FINISHED;
    break;
case MODE_SWITCHING_WAS_FINISHED:
    switchCounter = 0;
    joystickSwitchState = MODE_SWITCHING_IS_INITIALIZING;
    break;
default:
    break;
}
break;

```

The variable that controls the LED display color change and the variable of the display frequency are updated every time according to remote control data.

```

colorStep = map(RFDataRead[POT1], 0, 1023, 0, 255);
stripDisplayDelay = RFDataRead[POT2];

```

Finally, the LED display mode variable stripDisplayStyle, the color change amplitude variable colorStep, the display period variable stripDisplayDelay.

```

switch (stripDisplayStyle)
{
case 0:
    if (millis() - lastStripUpdateTime > stripDisplayDelay)
    {
        for (int i = 0; i < STRIP_LEDS_COUNT; i++) {
            strip.setLedColorData(i, strip.Wheel(colorPos + i * 25));
        }
        strip.show();
    }
}

```

```
    colorPos += colorStep;
    lastStripUpdateTime = millis();
}
break;
case 1:
    if (millis() - lastStripUpdateTime > stripDisplayDelay)
    {
        strip.setLedColor(currentLedIndex, strip.Wheel(colorPos));
        currentLedIndex++;
        if (currentLedIndex == STRIP_LEDS_COUNT)
        {
            currentLedIndex = 0;
            colorPos += colorStep; // 
        }
        lastStripUpdateTime = millis();
    }
    break;
case 2:
    colorPos = colorStep;
    if (millis() - lastStripUpdateTime > stripDisplayDelay)
    {
        static bool ledState = true;
        if (ledState)
        {
            strip.setAllLedsColor(strip.Wheel(colorPos));
        }
        else
        {
            strip.setAllLedsColor(0x00);
        }
        ledState = !ledState;
        lastStripUpdateTime = millis();
    }
    break;
default:
    break;
}
```

Chapter 6 Bluetooth control

This section requires an Android device with Bluetooth to control the car. If you don't have such an Android device, you can not complete projects in this chapter.

Android App

Download and install app. You can use Android phone or tablet to control the robot.

You can download Freenove App through below ways:

View or download on Google Play:

<https://play.google.com/store/apps/details?id=com.freenove.suhayl.Freenove>

Download APK file directly

https://github.com/Freenove/Freenove_App_for_Android/raw/master/freenove.apk

Then install it on your android phone.



Bluetooth Module

Instructions for using the Bluetooth module

The Bluetooth module uses the serial port to communicate with the Arduino. The serial communication is also used to upload the program to Arduino. **Therefore, when uploading the program to Arduino, the Bluetooth module should be unplugged; otherwise, the program upload will fail!**

When the Bluetooth module is not connected by other device, the Bluetooth module can be configured using the AT command. Once connected, the Bluetooth module acts as a data pipe and cannot be configured.

By default, the Bluetooth module has a baud rate of 9600, no parity, 8 data bits, and 1 stop bit. Bluetooth name "BT05", role mode is slave mode.

Set name of bluetooth

If you have multiple Bluetooth modules with the same name around you, you will be confused when you connect. Which one is the Bluetooth module I want to connect to?

In the next project, I will introduce how to use the AT command to modify the name of the Bluetooth module and the master-slave role in the program.

For AT commands and more information about the Bluetooth module, refer to the documentation in the package for Datasheets/BT05-Instruction.pdf

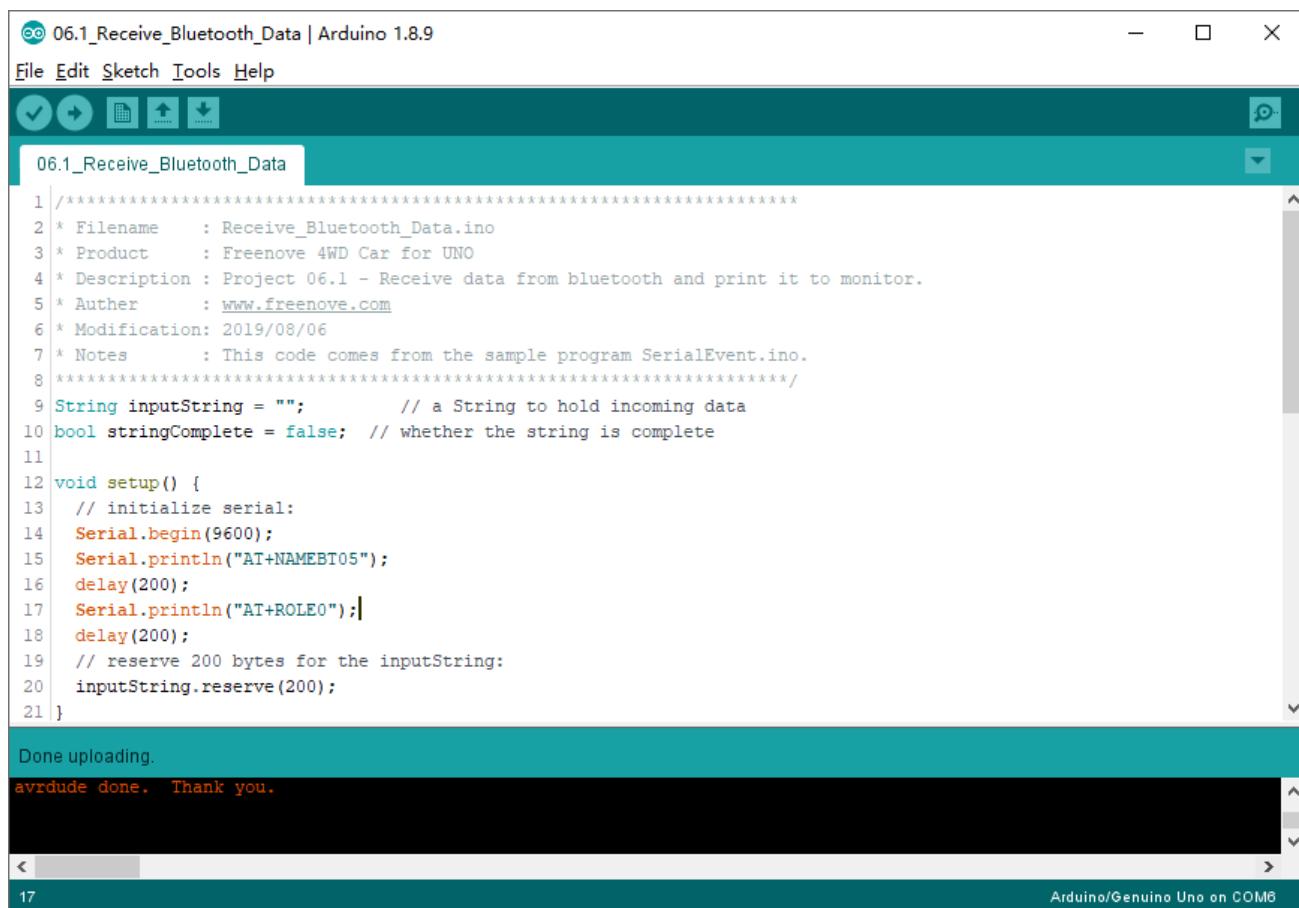
Set Bluetooth and Receive Data

This project uses the AT command to make some settings for the Bluetooth module, then uses the Bluetooth module to receive data from the app and print the data on the serial monitor.

Upload Code and Running

Unplug bluetooth. Then upload code in Sketches/06.1_Receive_Bluetooth_Data.ino.

Note, when upload code, we need unplug Bluetooth first. Or the uploading will fail.

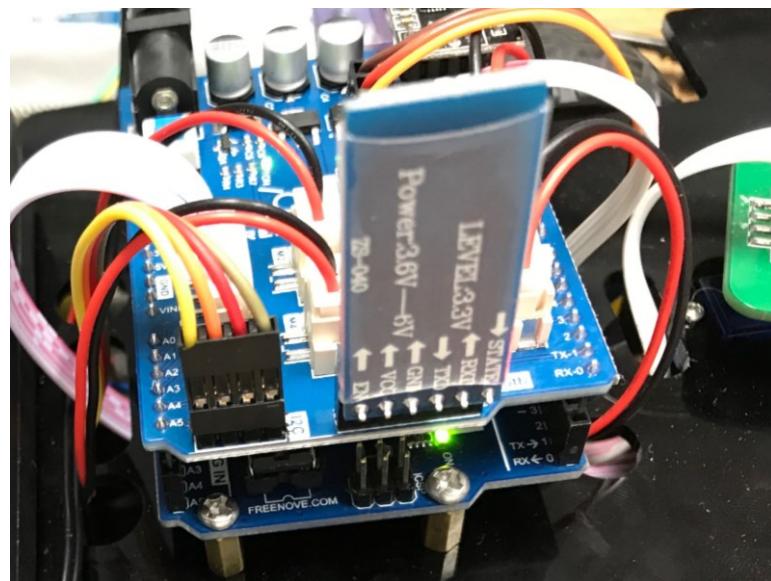


The screenshot shows the Arduino IDE interface. The title bar says "06.1_Receive_Bluetooth_Data | Arduino 1.8.9". The menu bar includes File, Edit, Sketch, Tools, and Help. Below the menu is a toolbar with icons for upload, refresh, and other functions. The main window displays the code for "06.1_Receive_Bluetooth_Data". The code is a C++ program with comments explaining its purpose. It initializes the serial port at 9600 baud, sends AT commands to set the Bluetooth module's name and role, and then enters a loop to receive data. The serial monitor at the bottom shows the message "Done uploading." followed by "avrduude done. Thank you.", indicating the upload was successful. The status bar at the bottom right shows "Arduino/Genuino Uno on COM6".

```
06.1_Receive_Bluetooth_Data | Arduino 1.8.9
File Edit Sketch Tools Help
06.1_Receive_Bluetooth_Data
1 //*****
2 * Filename : Receive_Bluetooth_Data.ino
3 * Product : Freenove 4WD Car for UNO
4 * Description : Project 06.1 - Receive data from bluetooth and print it to monitor.
5 * Author : www.freenove.com
6 * Modification: 2019/08/06
7 * Notes : This code comes from the sample program SerialEvent.ino.
8 *****/
9 String inputString = ""; // a String to hold incoming data
10 bool stringComplete = false; // whether the string is complete
11
12 void setup() {
13 // initialize serial:
14 Serial.begin(9600);
15 Serial.println("AT+NAMEBT05");
16 delay(200);
17 Serial.println("AT+ROLE0");
18 delay(200);
19 // reserve 200 bytes for the inputString:
20 inputString.reserve(200);
21 }
Done uploading.
avrduude done. Thank you.
17
Arduino/Genuino Uno on COM6
```

After the code is successfully uploaded, follow the steps below.

1. Plug the Bluetooth module on car as shown below. **Don't reverse it. The wrong connection may damage your hardware.**



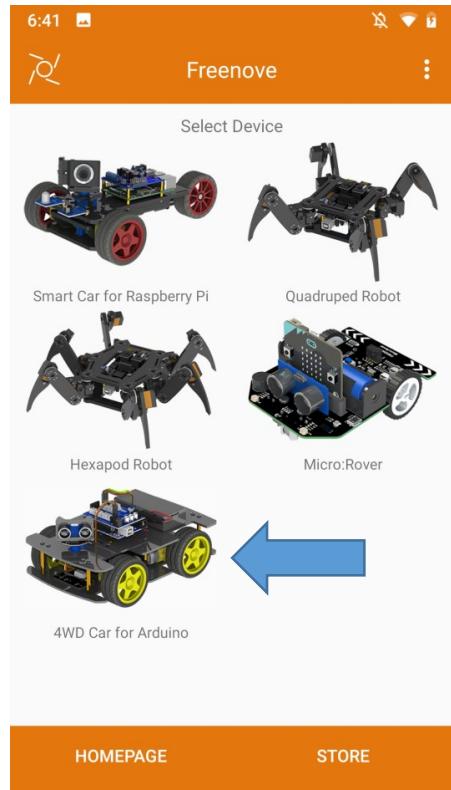
2. Open Arduino monitor.

As shown in the figure below, the Bluetooth name is set to "BT05" and the Bluetooth mode is slave mode (ROLE=0).

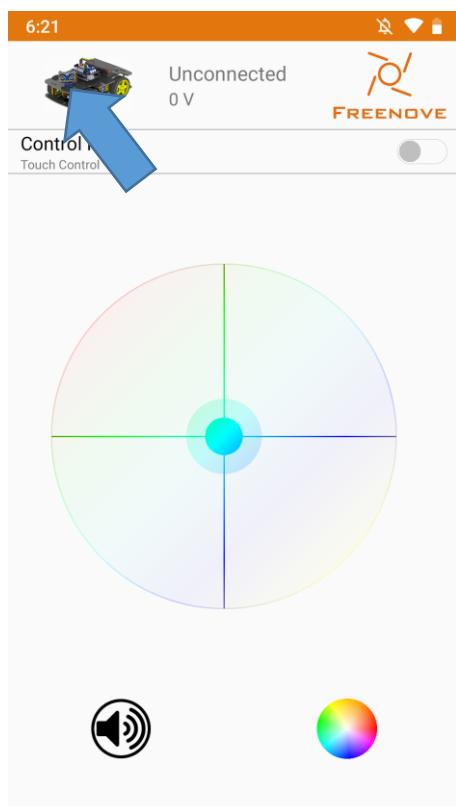
```
AT+NAMEBT05
AT+ROLE0
+NAME=BT05
OK
+ROLE=0
OK
```

Autoscroll Show timestamp Carriage return 9600 baud Clear output

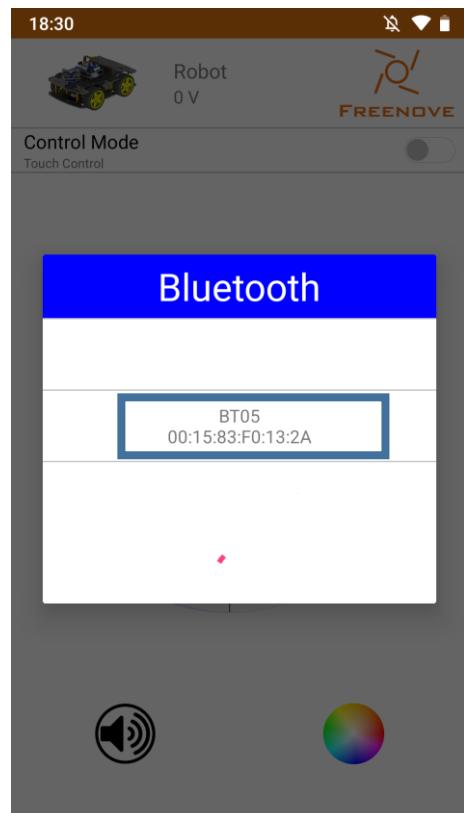
Next, open the app and click the 4WD Car for Arduino.



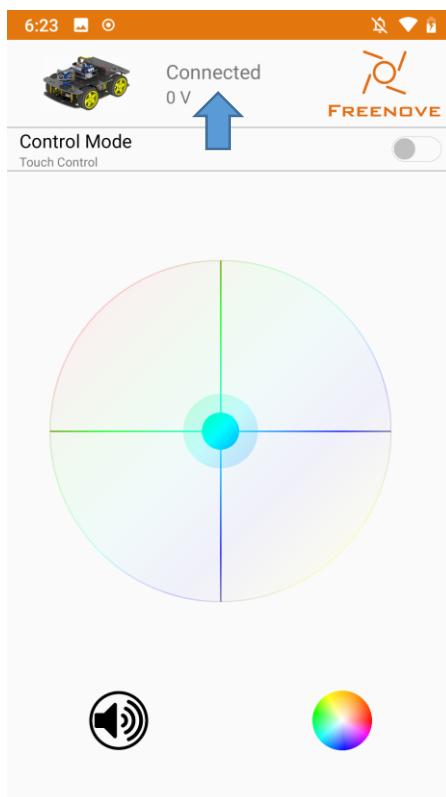
Click following icon.



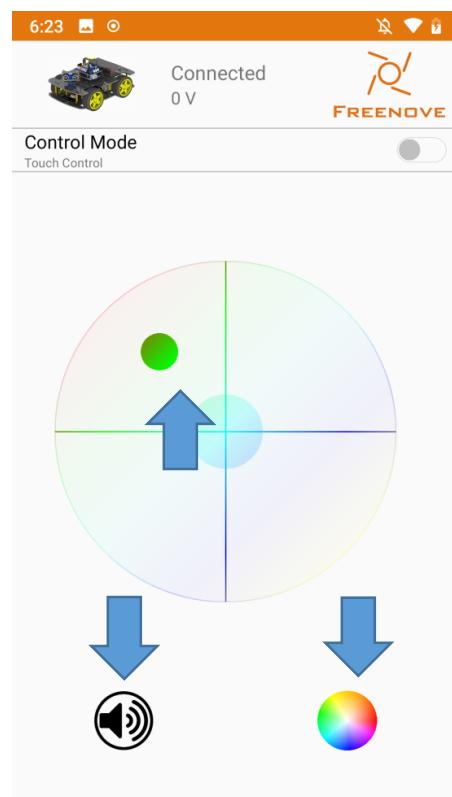
Click BT05.



If the connection successes, it will be connected.



Operate the app. And observe the monitor.



The monitor will show content below:

A screenshot of a terminal window titled "COM55". The window has a text input field at the top and a scrollable text area below. The scrollable text area displays the following serial port output:

```
A#262#210#
A#0#0#
A#-248#-214#
A#0#0#
D#2000#
D#0#
C#0#189#199#255#
C#0#189#199#255#
```

At the bottom of the terminal window, there are buttons for "Autoscroll" (checked), "Show timestamp" (unchecked), "Newline" (dropdown), "9600 baud" (dropdown), and "Clear output".

Bluetooth data- car action

The command format for communication between app and car is A#xxx#xxx#...xxx#, where # is a separator, the first character A represents the action command, it can be other character B, C, D...The xxx represents the parameters of the action command. And different commands carries different parameters. The command list is as below:

Action command	Description	Command character	Number of parameters (app send/receive)	Format example (app send/receive)
MOVE	Move, parameters are speeds of the two motors	A	2	A#100#100#
STOP	Stop moving	B	0	B#
LED_RGB	Control RGBLED, parameters respectively are serial number of LED mode, red value, green value, blue value.	C	3	C#2#100#150#200#
BUZZER	Control buzzer, and parameter is the frequency.	D	1	D#2000#
VOLTAGE	Get the battery voltage of Rover, parameter is the voltage value, unit mV	I	0/1	I# /I#4100#

Code

The data of the Bluetooth module is sent to the Arduino through the serial port. The project code comes from the Arduino example code "SerialEvent". Receive data from the serial port and print the data when '\n' is received.

The code is below:

```

1 String inputString = "";           // a String to hold incoming data
2 bool stringComplete = false;    // whether the string is complete
3
4 void setup() {
5     // initialize serial:
6     Serial.begin(9600); //default data transmission baud rate of the Bluetooth module is 9600
7     Serial.println("AT+NAMEBT05");// Or use Serial.print("AT+NAMEBT05\r\n");
8     delay(200);
9     Serial.println("AT+ROLE0");
10    delay(200);
11    // reserve 200 bytes for the inputString:
12    inputString.reserve(200);
13 }
14
15 void loop() {

```

```
16 // print the string when a newline arrives:
17 if (stringComplete) {
18     Serial.println(inputString);
19     // clear the string:
20     inputString = "";
21     stringComplete = false;
22 }
23 }
24
25 /*
26 SerialEvent occurs whenever a new data comes in the hardware serial RX. This
27 routine is run between each time loop() runs, so using delay inside loop can
28 delay response. Multiple bytes of data may be available.
29 */
30 void serialEvent() {
31     while (Serial.available()) {
32         // get the new byte:
33         char inChar = (char)Serial.read();
34         // add it to the inputString:
35         inputString += inChar;
36         // if the incoming character is a newline, set a flag so the main loop can
37         // do something about it:
38         if (inChar == '\n') {
39             stringComplete = true;
40         }
41     }
42 }
```

The default data transmission baud rate of the Bluetooth module is 9600, so set serial port baud rate to 9600.

```
Serial.begin(9600); //default data transmission baud rate of the Bluetooth module is 9600
```

Then use the AT command to set the name of the Bluetooth module to "BT05". The format of the command is "AT+NAMExxx\r\n", where "AT+NAME" is a fixed format, and the following "xxx" is the set name. The maximum length of the name is 18 characters. The command must be followed by "\r\n" ends. Since the Serial.println() function adds "\r\n" to the end, there is no need to add it in the program. The delay is 200ms to ensure that the Bluetooth module has enough time to complete the setup.

```
Serial.println("AT+NAMEBT05");// Or use Serial.print("AT+NAMEBT05\r\n");
delay(200);
```

Similarly, continue to use the AT command to set the Bluetooth module's role mode to slave mode. The Bluetooth module can be set to the master mode and the slave mode. In the mode, the Bluetooth module can actively search for and connect to other Bluetooth devices, but cannot be searched and connected by other devices. In order to be searched by the mobile app via Bluetooth, the Bluetooth role module needs to be set to the slave mode. According to the Bluetooth manufacturer's manual, 0 is the slave mode and 1 is the master mode.

```
Serial.println("AT+ROLE0");
delay(200);
```

In loop(), keep querying if stringComplete is true. If it is true, it indicates that the complete data has been received. The data will be printed on the serial monitor, and then the data is cleared. Then the array is ready to receive new data.

```
if (stringComplete) {
    Serial.println(inputString);
    // clear the string:
    inputString = "";
    stringComplete = false;
}
```

Function serialEvent() is used to receive the data transmitted by the serial port. When the newline character is received, the flag stringComplete is set to true, and the received data will be printed in loop().

```
void serialEvent() {
    while (Serial.available()) {
        // get the new byte:
        char inChar = (char)Serial.read();
        // add it to the inputString:
        inputString += inChar;
        // if the incoming character is a newline, set a flag so the main loop can
        // do something about it:
        if (inChar == '\n') {
            stringComplete = true;
        }
    }
}
```

Bluetooth AT Command

AT command mode when the module is not connected.

AT command, which belongs to the character line instruction, is parsed according to the line
(That is, AT command must be returned by carriage return or \r\n, hexadecimal number is 0D0A).

For more details about AT command, please refer to Datasheets/BT05-Instruction.pdf.

void serialEvent()

SerialEvent occurs whenever a new data comes in the hardware serial RX. This routine is run between each time loop() runs, so using delay inside loop can delay response. Multiple bytes of data may be available.

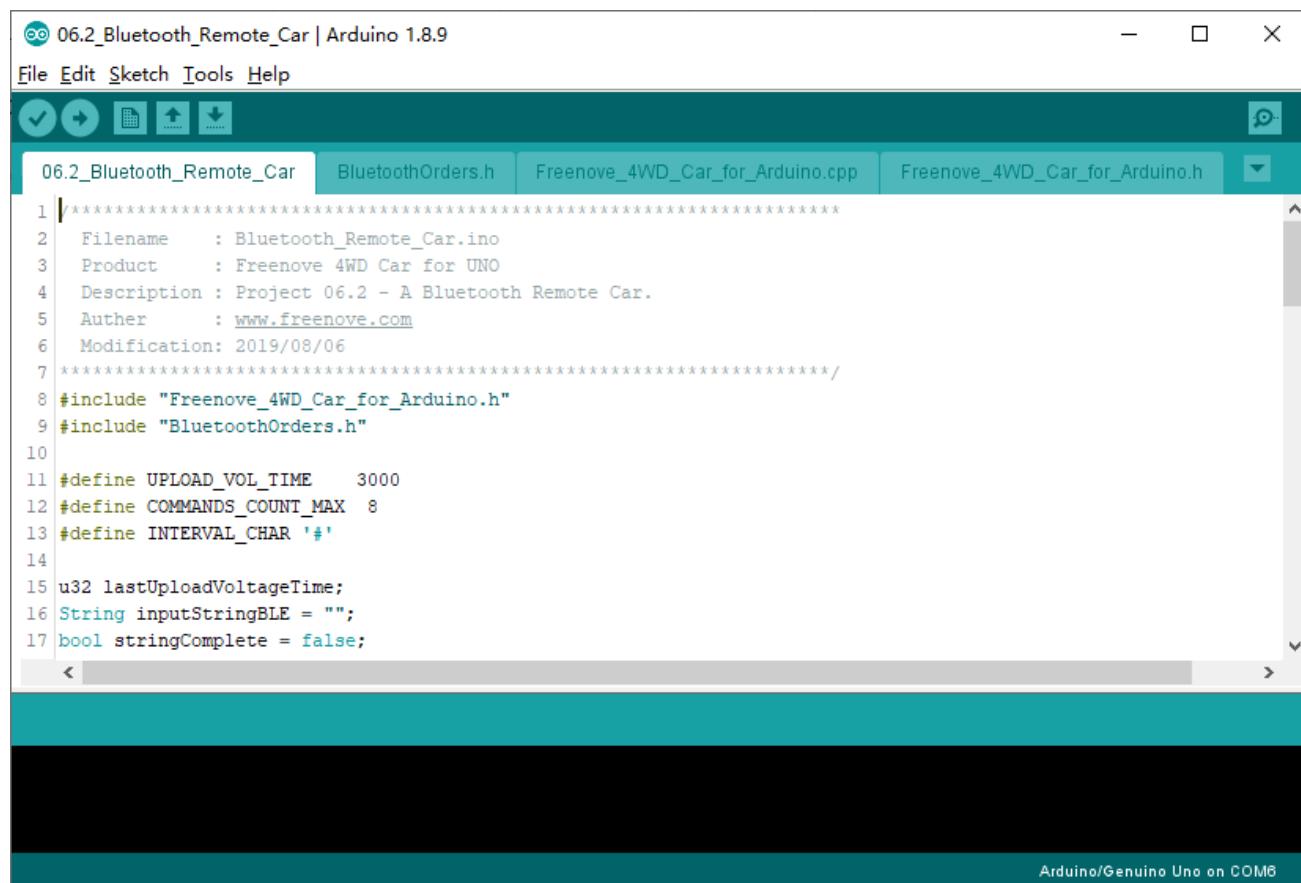
Bluetooth Remote Car

After learning how to receive the app's data via Bluetooth and the meaning of data formats, use the data to let the car do something. Control the car movement, the buzzer sounds, and the LED switches the display mode.

Upload Code and Running

Unplug Bluetooth. And connect car to computer with USB cable.

Then upload code in Sketches/06.2_Bluetooth_Remote_Car.ino.



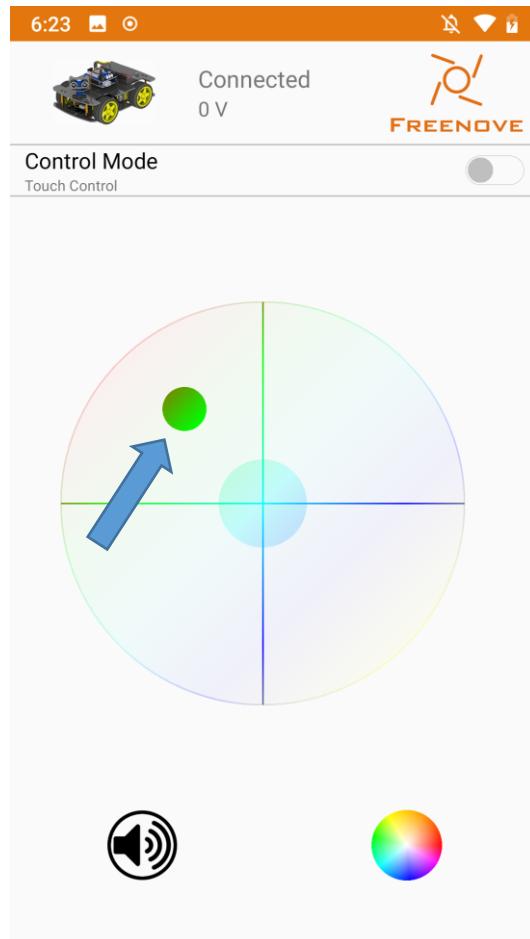
The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** 06.2_Bluetooth_Remote_Car | Arduino 1.8.9
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Standard toolbar icons for file operations.
- Sketch Area:** The main code editor window containing the `06.2_Bluetooth_Remote_Car.ino` sketch. The code includes comments, defines, and variable declarations. It also includes two header files: `BluetoothOrders.h` and `Freenove_4WD_Car_for_Arduino.h`.
- Status Bar:** Shows the message "Arduino/Genuino Uno on COM8".

```
06.2_Bluetooth_Remote_Car | Arduino 1.8.9
File Edit Sketch Tools Help
06.2_Bluetooth_Remote_Car  BluetoothOrders.h  Freenove_4WD_Car_for_Arduino.cpp  Freenove_4WD_Car_for_Arduino.h
1 // *****
2 Filename      : Bluetooth_Remote_Car.ino
3 Product       : Freenove 4WD Car for UNO
4 Description   : Project 06.2 - A Bluetooth Remote Car.
5 Author        : www.freenove.com
6 Modification: 2019/08/06
7 *****
8 #include "Freenove_4WD_Car_for_Arduino.h"
9 #include "BluetoothOrders.h"
10
11 #define UPLOAD_VOL_TIME    3000
12 #define COMMANDS_COUNT_MAX  8
13 #define INTERVAL_CHAR '#'
14
15 u32 lastUploadVoltageTime;
16 String inputStringBLE = "";
17 bool stringComplete = false;
```

After the code is successfully uploaded, unplug the USB cable and plug the Bluetooth module on car. Turn on the car power switch.

According to the previous way, the Bluetooth module of the car is connected through app, then the car can be controlled by clicking or sliding the operation panel on the APP.



Code

The project has 4 labels, the label "BluetoothOrders.h" stores Bluetooth communication, and command characters used to controls the car, only a part of which is used. The main label "06.2_Bluetooth_Remote_Car.ino" is the main content of this project.

BluetoothOrders.h

```

1 #ifndef _BLUETOOTHORDERS_h
2 #define _BLUETOOTHORDERS_h
3
4 #define ACTION_MOVE      'A'
5 #define ACTION_STOP     'B'
6 #define ACTION_RGB      'C'
7 #define ACTION_BUZZER    'D'
8 #define ACTION_ULTRASONIC  'E'
9 #define ACTION_LIGHT_TRACING 'F'
10 #define ACTION_TRACKING   'G'
11 #define ACTION_CAR_MODE    'H'
```

```
12 #define ACTION_GET_VOLTAGE    'I'  
13 #define ECHO_OK      'J'  
14 #define ACTION_NONE     'K'  
15  
16 #endif
```

06.2_Bluetooth_Remote_Car.ino

```
1 #include "Freenove_4WD_Car_for_Arduino.h"  
2 #include "BluetoothOrders.h"  
3  
4 #define UPLOAD_VOL_TIME    3000  
5 #define COMMANDS_COUNT_MAX 8  
6 #define INTERVAL_CHAR '#'  
7  
8 u32 lastUploadVoltageTime;  
9 String inputStringBLE = "";  
10 bool stringComplete = false;  
11  
12 void setup() {  
13     pinsSetup();  
14     Serial.begin(9600);  
15  
16 }  
17  
18 void loop() {  
19     if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {  
20         upLoadVoltageToApp();  
21         lastUploadVoltageTime = millis();  
22     }  
23     if (stringComplete) {  
24         String inputCommandArray[COMMANDS_COUNT_MAX];  
25         int paramters[COMMANDS_COUNT_MAX], paramterCount = 0;  
26         String inputStringTemp = inputStringBLE;  
27         for (u8 i = 0; i < COMMANDS_COUNT_MAX; i++) {  
28             int index = inputStringTemp.indexOf(INTERVAL_CHAR);  
29             if (index < 0) {  
30                 break;  
31             }  
32             paramterCount = i; //  
33             inputCommandArray[i] = inputStringTemp.substring(0, index);  
34             inputStringTemp = inputStringTemp.substring(index + 1);  
35             paramters[i] = inputCommandArray[i].toInt();  
36         }  
37         stringComplete = false;
```

```

38     inputStringBLE = "";
39
40     char commandChar = inputCommandArray[0].charAt(0);
41     switch (commandChar)
42     {
43     case ACTION_MOVE:
44         if (paramterCount == 2) {
45             motorRun(paramters[1], paramters[2]);
46         }
47         break;
48     case ACTION_BUZZER:
49         if (paramterCount == 1) {
50             setBuzzer(paramters[1]);
51         }
52         break;
53     default:
54         break;
55     }
56 }
57
58
59 void upLoadVoltageToApp() {
60     int voltage = 0;
61     if (getBatteryVoltage()) {
62         voltage = batteryVoltage * 1000;
63     }
64     String sendString = String(ACTION_GET_VOLTAGE) + String(INTERVAL_CHAR) +
65     String((voltage)) + String(INTERVAL_CHAR);
66     Serial.println(sendString);
67 }
68
69 void serialEvent() {
70     while (Serial.available()) {
71         char inChar = (char)Serial.read();
72         inputStringBLE += inChar;
73         if (inChar == '\n') {
74             stringComplete = true;
75         }
76     }
77 }
```

In loop (), the voltage value is uploaded to app at intervals.

	<pre> if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) { upLoadVoltageToApp();</pre>
--	--

```
lastUploadVoltageTime = millis();  
}
```

In the sub-function upLoadVoltageToApp(), first read the battery voltage, then convert the voltage unit to mv, and send it in the format of "I#xxx#". Use Serial.println() to send a Newline character '\n', after sending the previous data,

```
void upLoadVoltageToApp() {  
    int voltage = 0;  
    if (getBatteryVoltage()) {  
        voltage = batteryVoltage * 1000;  
    }  
    String sendString = String(ACTION_GET_VOLTAGE) + String(INTERVAL_CHAR) +  
String((voltage)) + String(INTERVAL_CHAR);  
    Serial.println(sendString);  
}
```

Then in `loop()`, if the required data is received, the data will be parsed into commands and parameters and will be saved in an array.

Suppose you receive a command string of "A#100#200#". First use the `String.indexOf()` function to find the position of the separator "#". And then use the `String.substring()` function to split the command string into "A" and "100#200#", and save the first element "A" that is split in the array "inputCommandArray".

Then continue to repeat this operation on the split string "100#200#". You can split the element "A", "100", and "200" are respectively and save them in arraies. Finally, convert these elements to integer types and save them in the parameter array paramters.

```
if (stringComplete) {  
    String inputCommandArray[COMMANDS_COUNT_MAX];  
    int paramters[COMMANDS_COUNT_MAX], paramterCount = 0;  
    String inputStringTemp = inputStringBLE;  
    for (u8 i = 0; i < COMMANDS_COUNT_MAX; i++) {  
        int index = inputStringTemp.indexOf(INTERVAL_CHAR);  
        if (index < 0) {  
            break;  
        }  
        paramterCount = i; //  
        inputCommandArray[i] = inputStringTemp.substring(0, index);  
        inputStringTemp = inputStringTemp.substring(index + 1);  
        paramters[i] = inputCommandArray[i].toInt();  
    }  
}*****
```

Finally, let the car perform different actions according to the commands and parameters.

```
char commandChar = inputCommandArray[0].charAt(0);  
switch (commandChar)  
{
```

```

        case ACTION_MOVE:
            if (paramterCount == 2) {
                motorRun(paramters[1], paramters[2]);
            }
            break;
        case ACTION_BUZZER:
            if (paramterCount == 1) {
                setBuzzer(paramters[1]);
            }
            break;
        default:
            break;
    }
}

```

indexOf()**Description**

Locates a character or String within another String. By default, searches from the beginning of the String, but can also start from a given index, allowing for the locating of all instances of the character or String.

Syntax

myString.indexOf(val)

myString.indexOf(val, from)

Parameters

myString: a variable of type String.

val: the value to search for. Allowed data types: char, String.

from: the index to start the search from.

Returns

The index of val within the String, or -1 if not found.

substring()**Description**

Get a substring of a String. The starting index is inclusive (the corresponding character is included in the substring), but the optional ending index is exclusive (the corresponding character is not included in the substring). If the ending index is omitted, the substring continues to the end of the String.

Syntax

myString.substring(from)

myString.substring(from, to)

Parameters

myString: a variable of type String.

from: the index to start the substring at.

to (optional): the index to end the substring before.

Returns

The substring.

toInt()**Description**

Converts a valid String to an integer. The input String should start with an integer number. If the String

contains non-integer numbers, the function will stop performing the conversion.

Syntax

myString.toInt()

Parameters

myString: a variable of type String.

Returns

If no valid conversion could be performed because the String doesn't start with a integer number, a zero is returned. Data type: long.

More information refer to: <https://www.arduino.cc/reference/en/language/variables/data-types/stringobject/>

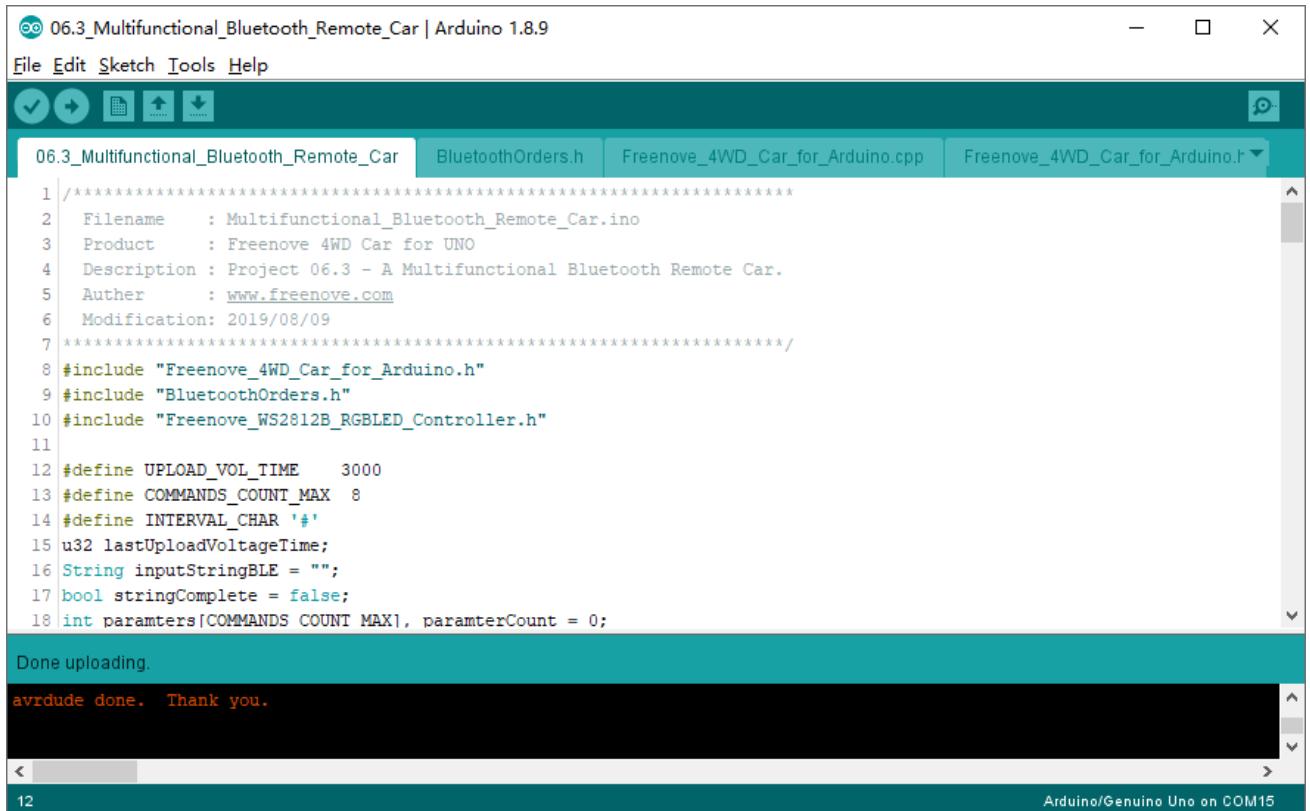
Multifunctional Bluetooth Remote Car

This project adds the function of LED display and the function of LED display mode switching on the basis of the previous project.

Upload Code and Running

Unplug Bluetooth. And connect car to computer with USB cable.

And upload code in Sketches/06.2_Bluetooth_Remote_Car.ino.



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** 06.3_Multifunctional_Bluetooth_Remote_Car | Arduino 1.8.9
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Checkmark, Run, Save, Upload, Download, Refresh
- Sketch List:** 06.3_Multifunctional_Bluetooth_Remote_Car (selected), BluetoothOrders.h, Freenove_4WD_Car_for_Arduino.cpp, Freenove_4WD_Car_for_Arduino.r
- Code Editor:** Displays the C++ code for the sketch, which includes comments, includes, defines, and variable declarations.
- Status Bar:** Done uploading.
avrduke done. Thank you.
12 Arduino/Genuino Uno on COM15

After the code is successfully uploaded, unplug the USB cable and plug the Bluetooth module on car. Turn on the car power switch.

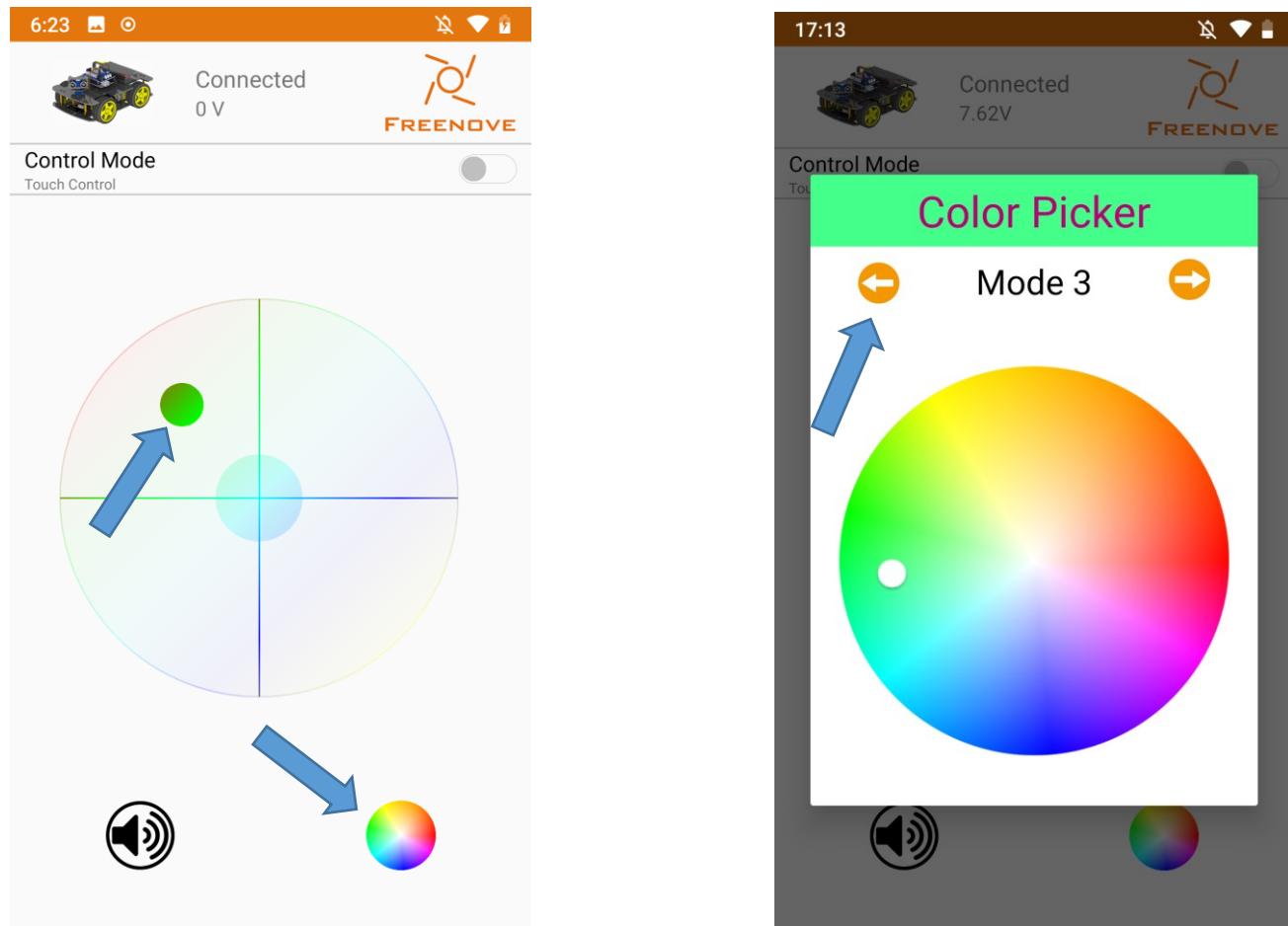
According to the previous method, connect Bluetooth module of the car with the app, and the operation panel of the APP can be clicked or swiped to control the movement of the car. And the color palette of the lower right corner can be clicked to control the display mode and color of the LED. Among them,

Mode 0 is a flowing rainbow,

Mode 1 is a flowing water led with color changing.

Mode 2 is a color-adjustable Blink.

Mode 3 displays the selected color of the current color picker for all LEDs.



Code

The code for this project is based on the previous engineering code, adding code related to LED control. Nothing else has changed.

06.3_Multifunctional_Bluetooth_Remote_Car

```

1 #include "Freenove_4WD_Car_for_Arduino.h"
2 #include "BluetoothOrders.h"
3 #include "Freenove_WS2812B_RGBLED_Controller.h"
4
5 #define UPLOAD_VOL_TIME    3000
6 #define COMMANDS_COUNT_MAX 8
7 #define INTERVAL_CHAR '#'

```

```
8  u32 lastUploadVoltageTime;
9  String inputStringBLE = "";
10 bool stringComplete = false;
11 int paramters[COMMANDS_COUNT_MAX], paramterCount = 0;
12
13 #define STRIP_I2C_ADDRESS 0x20
14 #define STRIP_LEDS_COUNT 10
15
16 u8 colorPos = 0;
17 u8 colorStep = 50;
18 u8 stripDisplayMode = 1;
19 u8 currentLedIndex = 0;
20 u16 stripDisplayDelay = 100;
21 u32 lastStripUpdateTime = 0;
22 Freenove_WS2812B_Controller strip(STRIP_I2C_ADDRESS, STRIP_LEDS_COUNT, TYPE_GRB);
23
24 void setup() {
25     pinsSetup();
26     Serial.begin(9600);
27     while (!strip.begin());
28     strip.setAllLedsColor(0xFF0000);
29 }
30
31 void loop() {
32     if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {
33         upLoadVoltageToApp();
34         lastUploadVoltageTime = millis();
35     }
36     if (stringComplete) {
37         String inputCommandArray[COMMANDS_COUNT_MAX];
38
39         String inputStringTemp = inputStringBLE;
40         for (u8 i = 0; i < COMMANDS_COUNT_MAX; i++) {
41             int index = inputStringTemp.indexOf(INTERVAL_CHAR);
42             if (index < 0) {
43                 break;
44             }
45             paramterCount = i; // 
46             inputCommandArray[i] = inputStringTemp.substring(0, index);
47             inputStringTemp = inputStringTemp.substring(index + 1);
48             paramters[i] = inputCommandArray[i].toInt();
49         }
50         stringComplete = false;
51         inputStringBLE = "";
```

```
52
53     char commandChar = inputCommandArray[0].charAt(0);
54     switch (commandChar)
55     {
56         case ACTION_MOVE:
57             if (paramterCount == 2) {
58                 motorRun(paramters[1], paramters[2]);
59             }
60             break;
61         case ACTION_BUZZER:
62             if (paramterCount == 1) {
63                 setBuzzer(paramters[1]);
64             }
65             break;
66         case ACTION_RGB:
67             if (paramterCount == 4) {
68                 stripDisplayMode = paramters[1];
69                 switch (stripDisplayMode)
70                 {
71                     case 0:
72                         colorStep = 5;
73                         stripDisplayDelay = 100;
74                         break;
75                     case 1:
76                         colorStep = 50;
77                         stripDisplayDelay = 50;
78                         break;
79                     case 2:
80                         colorStep = 5;
81                         stripDisplayDelay = 500;
82                         break;
83                     case 3:
84                         break;
85                     default:
86                         break;
87                 }
88             }
89             break;
90         default:
91             break;
92     }
93 }
94 static u8 lastColor[3];
95 switch (stripDisplayMode)
```

```
96  {
97  case 0:
98      if (millis() - lastStripUpdateTime > stripDisplayDelay)
99      {
100         for (int i = 0; i < STRIP_LEDS_COUNT; i++) {
101             strip.setLedColorData(i, strip.Wheel(colorPos + i * 25));
102         }
103         strip.show();
104         colorPos += colorStep;
105         lastStripUpdateTime = millis();
106     }
107     break;
108 case 1:
109     if (millis() - lastStripUpdateTime > stripDisplayDelay)
110     {
111         strip.setLedColor(currentLedIndex, strip.Wheel(colorPos));
112         currentLedIndex++;
113         if (currentLedIndex == STRIP_LEDS_COUNT)
114         {
115             currentLedIndex = 0;
116             colorPos += colorStep; ///
117         }
118         lastStripUpdateTime = millis();
119     }
120     break;
121 case 2:
122     colorPos = colorStep;
123     if (millis() - lastStripUpdateTime > stripDisplayDelay)
124     {
125         static bool ledState = true;
126         if (ledState)
127         {
128             strip.setAllLedsColor(paramters[2], paramters[3], paramters[4]);
129         }
130         else
131         {
132             strip.setAllLedsColor(0x00);
133         }
134         ledState = !ledState;
135         lastStripUpdateTime = millis();
136     }
137     break;
138 case 3:
139     if (lastColor[0] != paramters[2] || lastColor[1] != paramters[3] || lastColor[2] !=
```

```

140 paramters[4])
141     {
142         strip.setAllLedsColor(paramters[2], paramters[3], paramters[4]);
143         lastColor[0] = paramters[2];
144         lastColor[1] = paramters[3];
145         lastColor[2] = paramters[4];
146     }
147     break;
148 default:
149     break;
150 }
151 }

153 void upLoadVoltageToApp() {
154     int voltage = 0;
155     if (getBatteryVoltage()) {
156         voltage = batteryVoltage * 1000;
157     }
158     String sendString = String(ACTION_GET_VOLTAGE) + String(INTERVAL_CHAR) +
159     String((voltage)) + String(INTERVAL_CHAR);
160     Serial.println(sendString);
161 }

162 void serialEvent() {
163     while (Serial.available()) {
164         char inChar = (char)Serial.read();
165         inputStringBLE += inChar;
166         if (inChar == '\n') {
167             stringComplete = true;
168         }
169     }
170 }
171 }
```

In the app, four LED display modes can be sent, and different color change ranges and color change periods are set according to different modes. That is, the values of the variables colorStep and stripDisplayDelay.

```

case ACTION_RGB:
    if (paramterCount == 4) {
        stripDisplayMode = paramters[1];
        switch (stripDisplayMode)
        {
            case 0:
                colorStep = 5;
                stripDisplayDelay = 100;
                break;
```

```

        case 1:
            colorStep = 50;
            stripDisplayDelay = 50;
            break;
        case 2:
            colorStep = 5;
            stripDisplayDelay = 500;
            break;
        case 3:
            break;
        default:
            break;
    }
}
break;

```

In loop(), the LED is displayed based on the received mode and parameters.

```

static u8 lastColor[3];
switch (stripDisplayMode)
{
    case 0:
        if (millis() - lastStripUpdateTime > stripDisplayDelay)
        {
            for (int i = 0; i < STRIP_LEDS_COUNT; i++) {
                strip.setLedColorData(i, strip.Wheel(colorPos + i * 25));
            }
            strip.show();
            colorPos += colorStep;
            lastStripUpdateTime = millis();
        }
        break;
    case 1:
        if (millis() - lastStripUpdateTime > stripDisplayDelay)
        {
            strip.setLedColor(currentLedIndex, strip.Wheel(colorPos));
            currentLedIndex++;
            if (currentLedIndex == STRIP_LEDS_COUNT)
            {
                currentLedIndex = 0;
                colorPos += colorStep; ///
            }
            lastStripUpdateTime = millis();
        }
}

```

```
        break;
    case 2:
        colorPos = colorStep;
        if (millis() - lastStripUpdateTime > stripDisplayDelay)
        {
            static bool ledState = true;
            if (ledState)
            {
                strip.setAllLedsColor(paramters[2], paramters[3], paramters[4]);
            }
            else
            {
                strip.setAllLedsColor(0x00);
            }
            ledState = !ledState;
            lastStripUpdateTime = millis();
        }
        break;
    case 3:
        if (lastColor[0] != paramters[2] || lastColor[1] != paramters[3] || lastColor[2] != paramters[4])
        {
            strip.setAllLedsColor(paramters[2], paramters[3], paramters[4]);
            lastColor[0] = paramters[2];
            lastColor[1] = paramters[3];
            lastColor[2] = paramters[4];
        }
        break;
    default:
        break;
}
```

What is next?

Thanks for your reading.

This tutorial is all over here. If you find any mistakes, missions or you have other ideas and questions about contents of this tutorial or the kit and ect, please feel free to contact us via support@freenove.com, and we will check and correct it as soon as possible.

If you want to learn more about Arduino, Raspberry Pi, smart cars, robots and other interesting products in science and technology, please continue to focus on our website. We will continue to launch cost-effective, innovative and exciting products: www.freenove.com

Thank you again for choosing Freenove products.