

Welcome

Thank you for choosing Freenove products!

About Battery

First, read the document [About_Battery.pdf](#) in the unzipped folder.

If you did not download the zip file, please download it and unzip it via link below:

https://github.com/Freenove/Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico

Get Support and Offer Input

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

- Product quality issues
- Product use and build issues
- Questions regarding the technology employed in our products for learning and education
- Your input and opinions are always welcome
- We also encourage your ideas and suggestions for new products and product improvements

For any of the above, you may send us an email to:

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Safety and Precautions

Please follow the following safety precautions when using or storing this product:

- Keep this product out of the reach of children under 6 years old.
- This product should be used only when there is adult supervision present as young children lack necessary judgment regarding safety and the consequences of product misuse.
- This product contains small parts and parts, which are sharp. This product contains electrically conductive parts. Use caution with electrically conductive parts near or around power supplies, batteries and powered (live) circuits.
- When the product is turned ON, activated or tested, some parts will move or rotate. To avoid injuries to hands and fingers, keep them away from any moving parts!
- It is possible that an improperly connected or shorted circuit may cause overheating. Should this happen, immediately disconnect the power supply or remove the batteries and do not touch anything until it cools down! When everything is safe and cool, review the product tutorial to identify the cause.
- Only operate the product in accordance with the instructions and guidelines of this tutorial, otherwise parts may be damaged or you could be injured.
- Store the product in a cool dry place and avoid exposing the product to direct sunlight.
- After use, always turn the power OFF and remove or unplug the batteries before storing.

About Freenove

Freenove provides open source electronic products and services worldwide.

Freenove is committed to assist customers in their education of robotics, programming and electronic circuits so that they may transform their creative ideas into prototypes and new and innovative products. To this end, our services include but are not limited to:

- Educational and Entertaining Project Kits for Robots, Smart Cars and Drones
- Educational Kits to Learn Robotic Software Systems for Arduino, Raspberry Pi, micro:bit and Raspberry Pi Pico W.
- Electronic Component Assortments, Electronic Modules and Specialized Tools
- **Product Development and Customization Services**

You can find more about Freenove and get our latest news and updates through our website:

<http://www.freenove.com>

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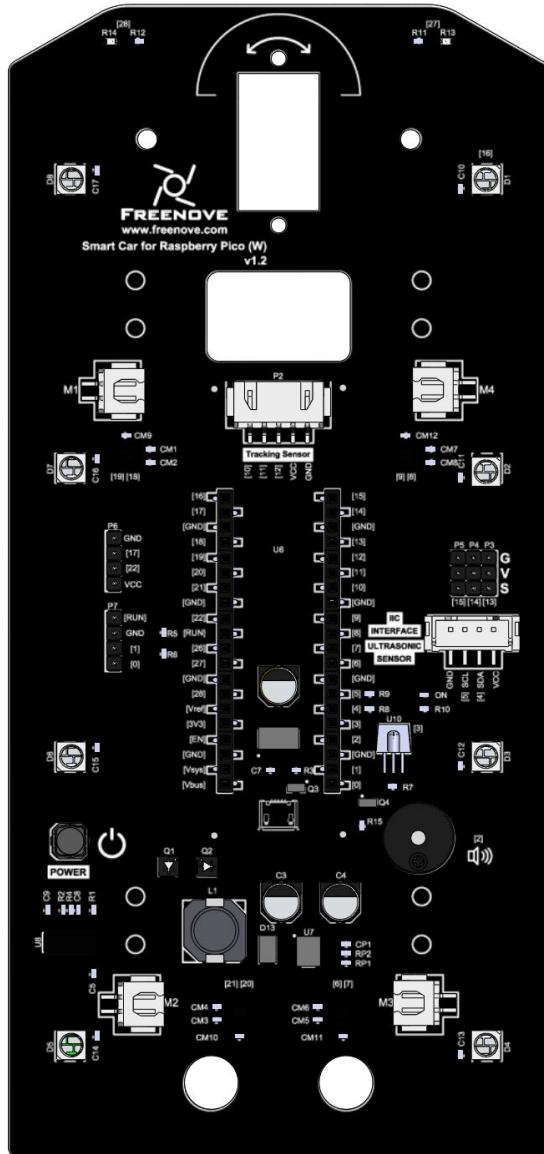
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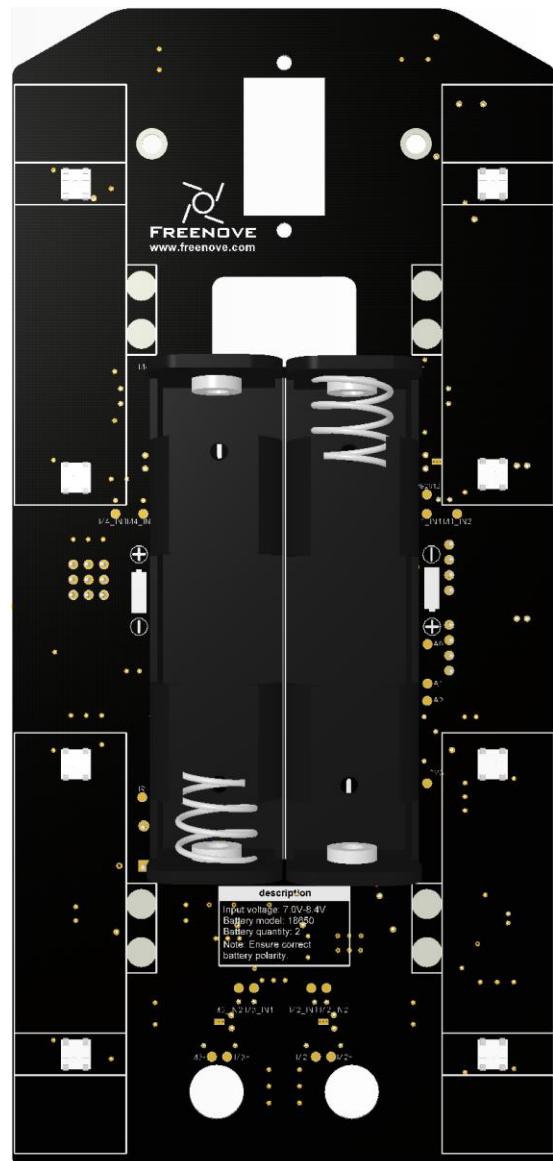
If you have any concerns, please feel free to contact us via support@freenove.com

Raspberry Pi Pico (W) Car Shield

Top



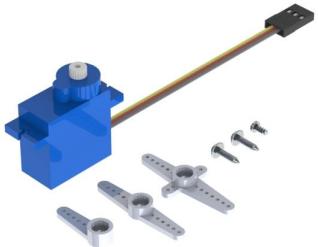
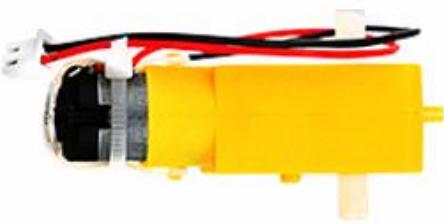
Bottom



Machinery Parts



Transmission Parts

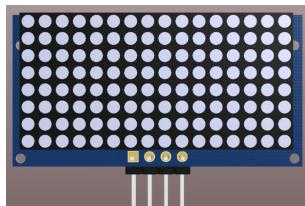
Servo package x1 	Driven wheel x4 
DC speed reduction motor x4  Caution: Do not remove the cable tie from the motor; otherwise, the motor cable may become detached.	Motor bracket package x4 

Electronic Parts

Line tracking module x1



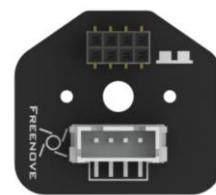
Dot Matrix Module x1



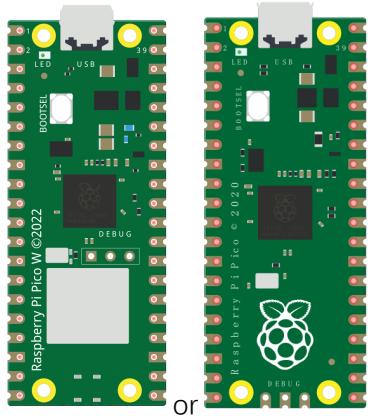
Ultrasonic Module x1



Ultrasonic module connector



Raspberry Pi Pico W x1 or Raspberry Pi Pico x1



or

Infrared emitter x1

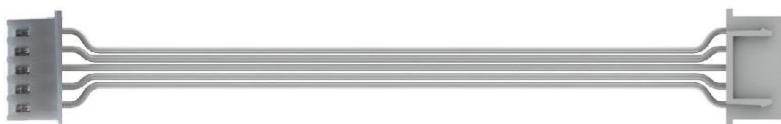


Wires

XH-2.54-4Pin cable x1



XH-2.54-5Pin cable x1



Tools

Cross screwdriver (3mm) x1



Black tape x1



Required but NOT Contained Parts

2 x 3.7V 18650 lithium **rechargeable** batteries with continuous discharge current >3A.

It is easier to find proper battery on eBay than Amazon. Search “18650 high drain” on eBay.



Preface

Welcome to use Freenove 4WD Car Kit for Raspberry Pi Pico (W). Following this tutorial, you can make a very cool car with many functions.

Based on the Raspberry Pi Pico (W) development board, a popular IoT control board, this kit uses the very popular Arduino IDE for programming, so you can share and exchange your experience and design ideas with enthusiasts all over the world. The parts in the kit include all electronic components, modules, and mechanical components required for making the car. They are all individually packaged. There are detailed assembly and debugging instructions in this book. If you encounter any problems, please feel free to contact us for fast and free technical support.

support@freenove.com

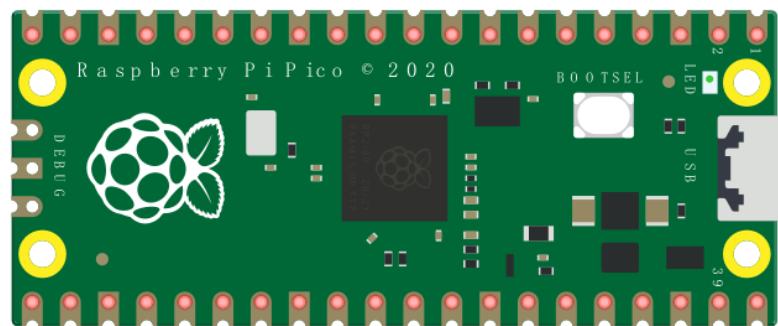
This car does not require a high threshold for users. Even if you know little professional knowledge, you can make your own smart car easily with the guidance of the tutorial. If you're really interested in Raspberry Pi Pico (W) and hope to learn how to program and build circuits, please visit our website: www.freenove.com

or contact us to buy our kit designed for beginners: **Freenove Ultimate Kit for Raspberry Pi Pico.**

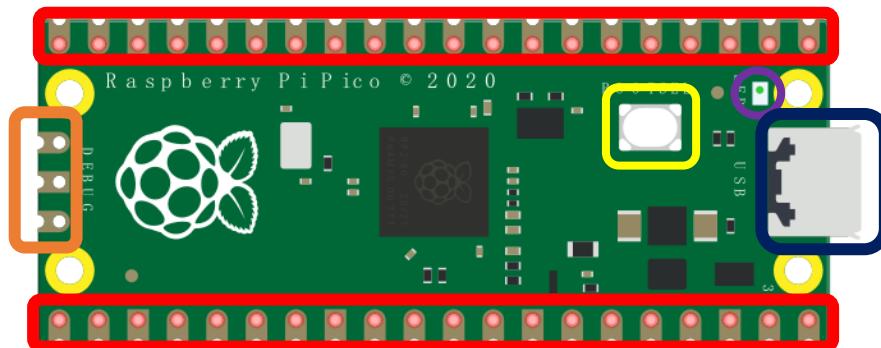
Raspberry Pi Pico

Raspberry Pi Pico applies to all chapters except Wireless in this tutorial.

Before learning Pico, we need to know about it. Here we use an imitated diagram of Pico, which ressembles the actual Pico.

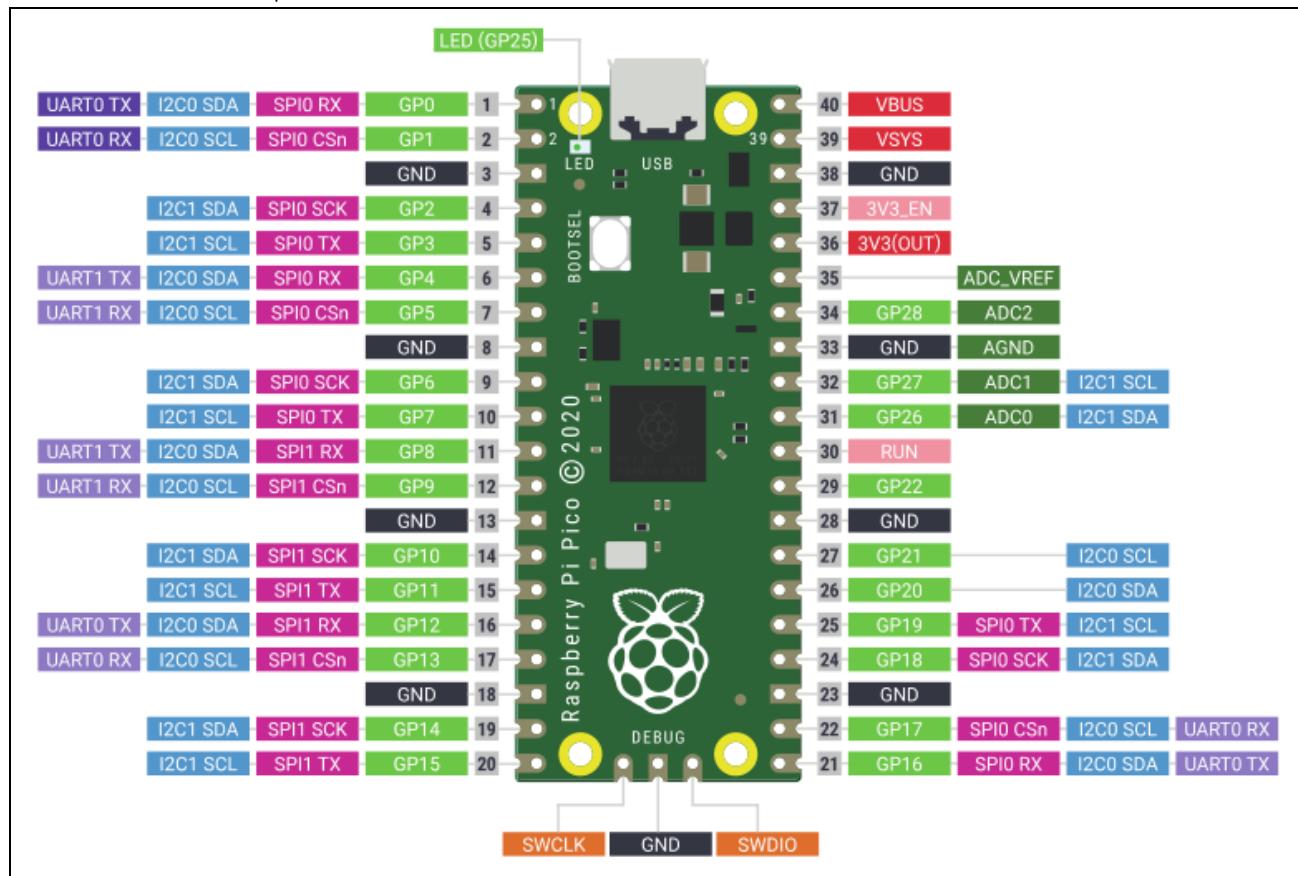


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging

Function definition of pins:



Color	Pins	Color	Pins
Black	GND	Red	Power
Green	GPIO	Green	ADC
Purple	UART(defualt)	Lavender	UART
Magenta	SPI	Blue	I2C
Light Red	System Control	Orange	Debugging

For details: <https://datasheets.raspberrypi.org/pico/pico-datasheet.pdf>

UART, I2C, SPI Default Pin

In Arduino IDE, the default pins of serial port are Pin0 and Pin1.

Note: Serial port is virtualized by RP2040. Therefore, when using the serial port, please enable the verification function of DTR. It can work under any baud rate.

UART

Function	Default
UART_BAUDRATE	X
UART_BITS	8
UART_STOP	1
UART_TX	Pin 0
UART_RX	Pin 1

I2C

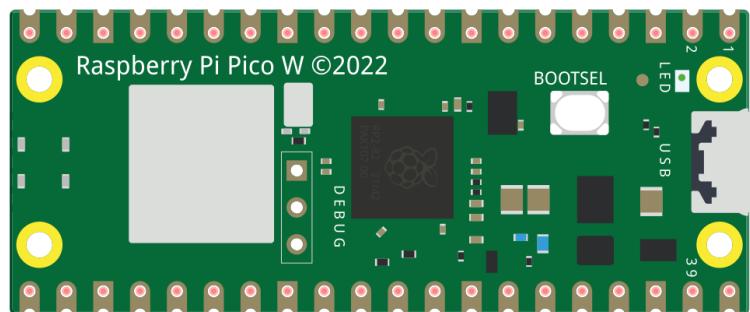
Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

SPI

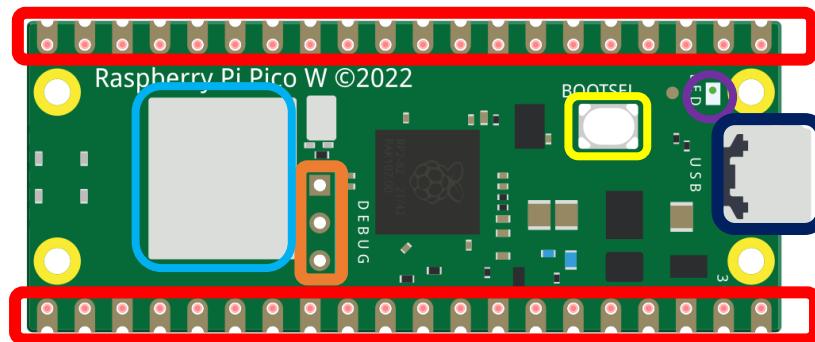
Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

Raspberry Pi Pico W

Raspberry Pi Pico W adds CYW43439 as the WiFi function on the basis of Raspberry Pi Pico. It is connected to RP2040 chip through SPI interface.

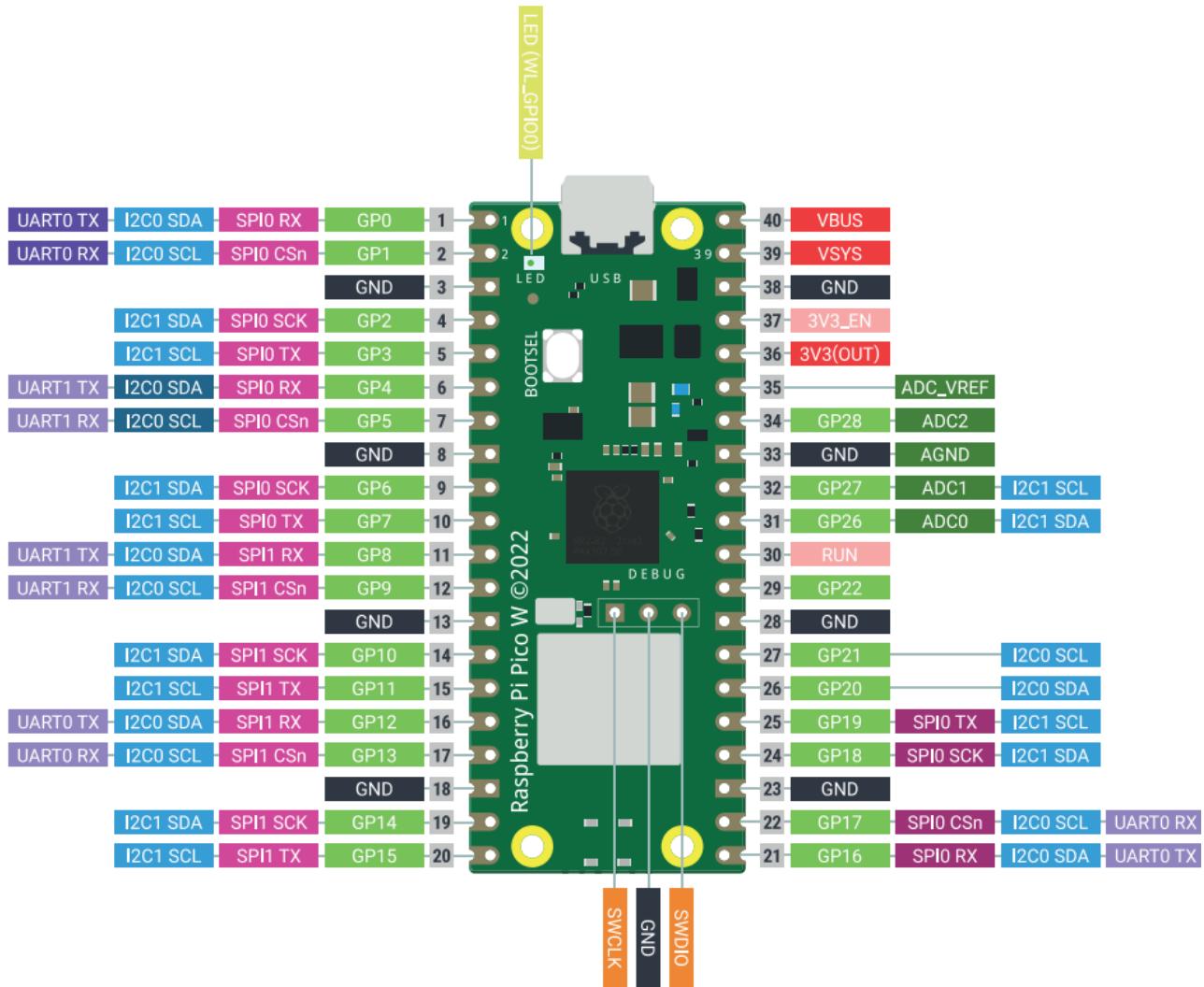


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging
	Wireless

Function definition of pins:



Color	Pins	Color	Pins
Black	GND	Red	Power
Green	GPIO	Dark Green	ADC
Purple	UART(defualt)	Lavender	UART
Magenta	SPI	Cyan	I2C
Light Red	System Control	Orange	Debugging

For details: <https://datasheets.raspberrypi.com/picow/pico-w-datasheet.pdf>

UART, I2C, SPI, Wireless Default Pin

In Arduino IDE, the default pins of serial port are Pin0 and Pin1.

Note: Serial port is virtualized by RP2040. Therefore, when using the serial port, please enable the verification function of DTR. It can work under any baud rate.

UART

Function	Default
UART_BAUDRATE	X
UART_BITS	8
UART_STOP	1
UART_TX	Pin 0
UART_RX	Pin 1

I2C

Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

SPI

Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

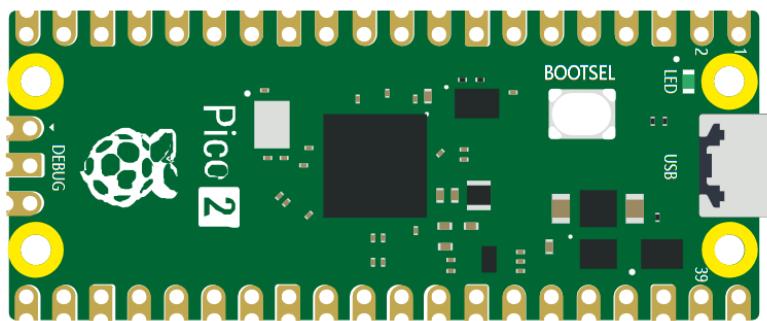
Wireless

Function	Default
WL_ON	GPIO23
WL_D	GPIO24
WL_CLK	GPIO29_ADC
WL_CS	GPIO25

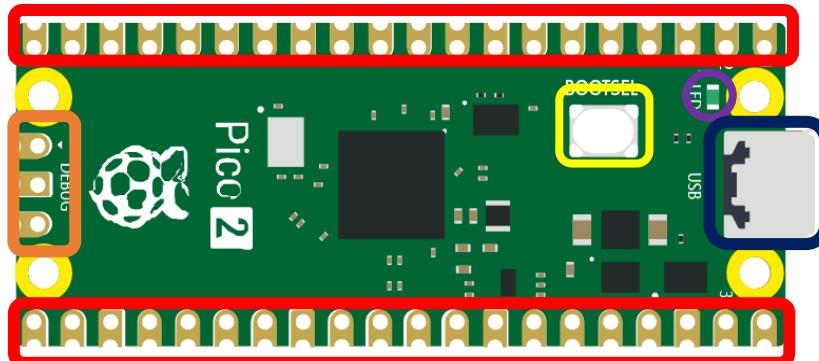
Raspberry Pi Pico 2

Raspberry Pi Pico 2 is applicable to all chapters in this tutorial except RFID and those involving WiFi.

Raspberry Pi Pico 2 uses RP2350 chip as the main controller, which equipped with dual Cortex-M33 or Hazard3 processors, capable of running up to 150 MHz, providing a significant boost in processing power, compared with the original Pico. It also doubles the memory with 520KB of SRAM and 4MB of onboard flash memory, with the ADC sampling frequency increasing to up to 500ksps. In addition, it adds 8 more PWM channels, and features additional interfaces like 2× Timer with 4 alarms, 1× AON Timer and 4 x PIO.

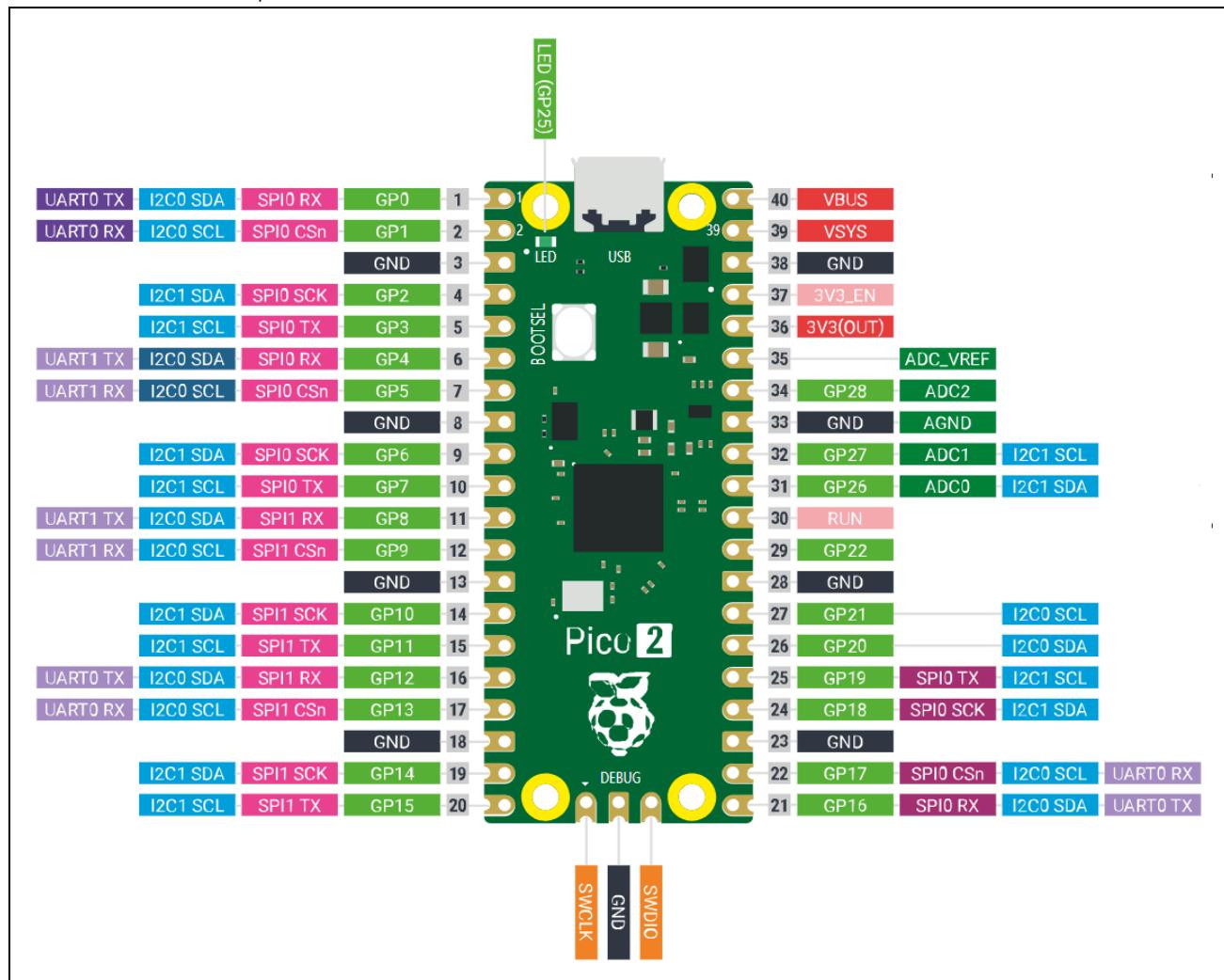


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging

Function definition of pins:



Color	Pins	Color	Pins
Black	GND	Red	Power
Green	GPIO	Dark Green	ADC
Purple	UART(default)	Lavender	UART
Magenta	SPI	Blue	I2C
Pink	System Control	Orange	Debugging

For details: <https://datasheets.raspberrypi.com/pico/pico-2-datasheet.pdf>



UART, I2C, SPI Default Pin

In Arduino IDE, the default pins of serial port are Pin0 and Pin1.

Note: Serial port is virtualized by RP2350. Therefore, when using the serial port, please enable the verification function of DTR. It can work under any baud rate.

UART

Function	Default
UART_BAUDRATE	X
UART_BITS	8
UART_STOP	1
UART_TX	Pin 0
UART_RX	Pin 1

I2C

Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

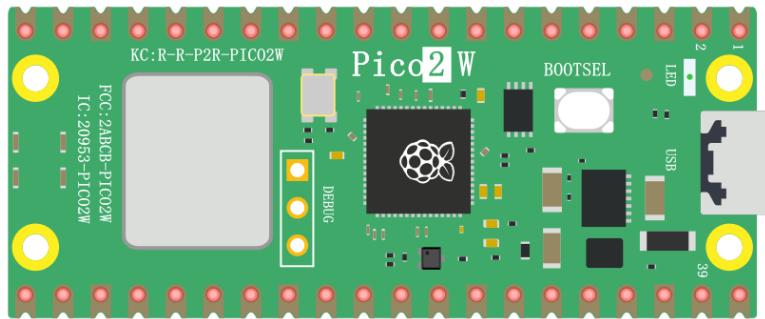
SPI

Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

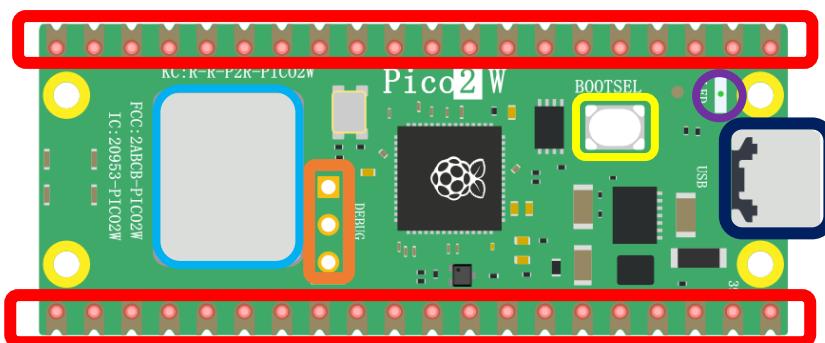
Raspberry Pi Pico 2W

Raspberry Pi Pico 2W applies to all chapters in this tutorial.

The Raspberry Pi Pico 2W adds WiFi functionality based on the Raspberry Pi Pico 2 by incorporating the CYW43439 module, which connects to the RP2350 chip via an SPI interface.

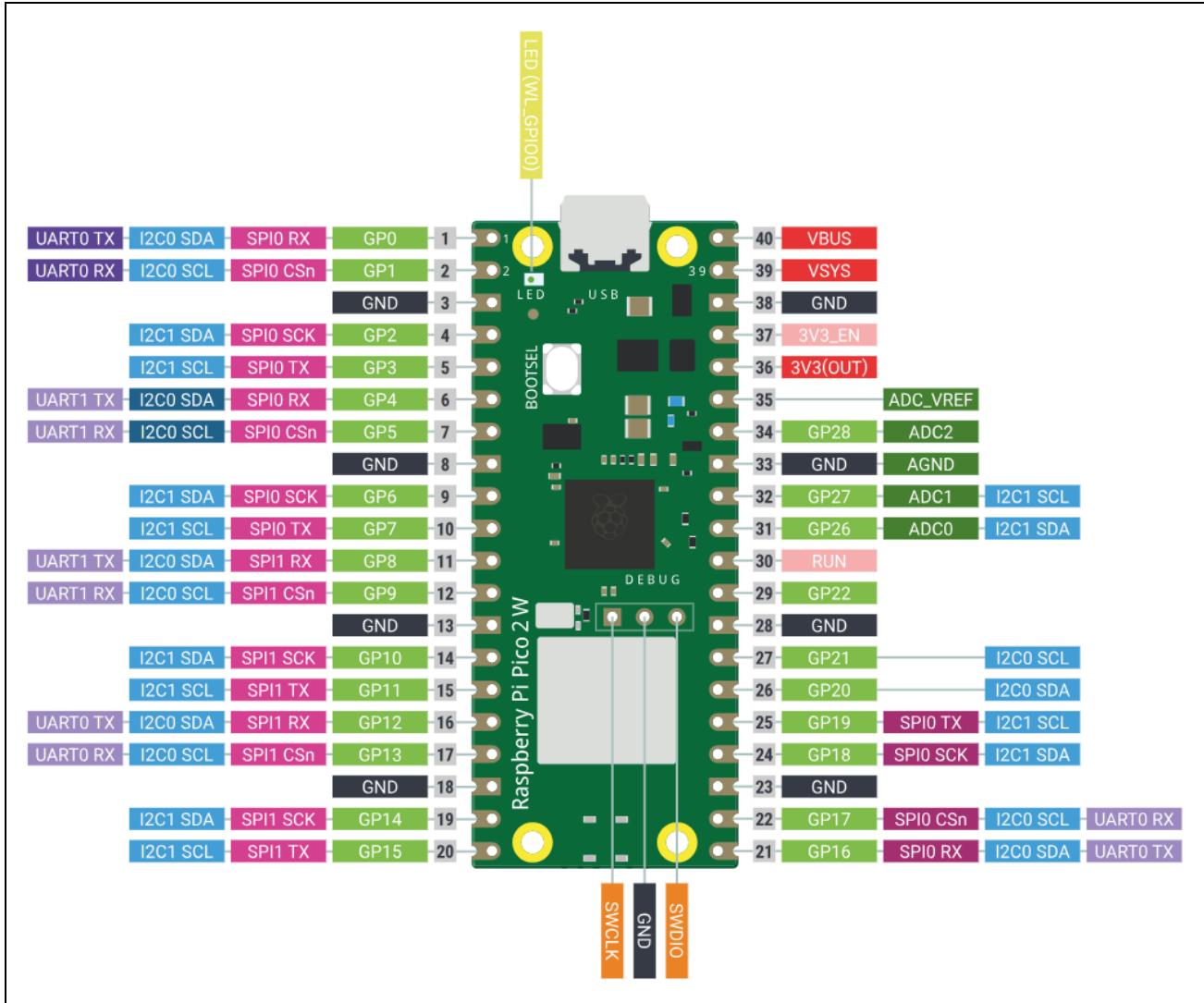


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging
	Wireless

Function definition of pins:



Color	Pins	Color	Pins
Black	GND	Red	Power
Green	GPIO	Dark Green	ADC
Purple	UART(default)	Lavender	UART
Magenta	SPI	Blue	I2C
Pink	System Control	Orange	Debugging

For details: <https://datasheets.raspberrypi.com/picow/pico-2-w-datasheet.pdf>

UART, I2C, SPI, Wireless Default Pin

In Arduino IDE, the default pins of serial port are Pin0 and Pin1.

Note: Serial port is virtualized by RP2350. Therefore, when using the serial port, please enable the verification function of DTR. It can work under any baud rate.

UART

Function	Default
UART_BAUDRATE	X
UART_BITS	8
UART_STOP	1
UART_TX	Pin 0
UART_RX	Pin 1

I2C

Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

SPI

Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

Wireless

Function	Default
WL_ON	GPIO23
WL_D	GPIO24
WL_CLK	GPIO29_ADC
WL_CS	GPIO25

Pins of the Car

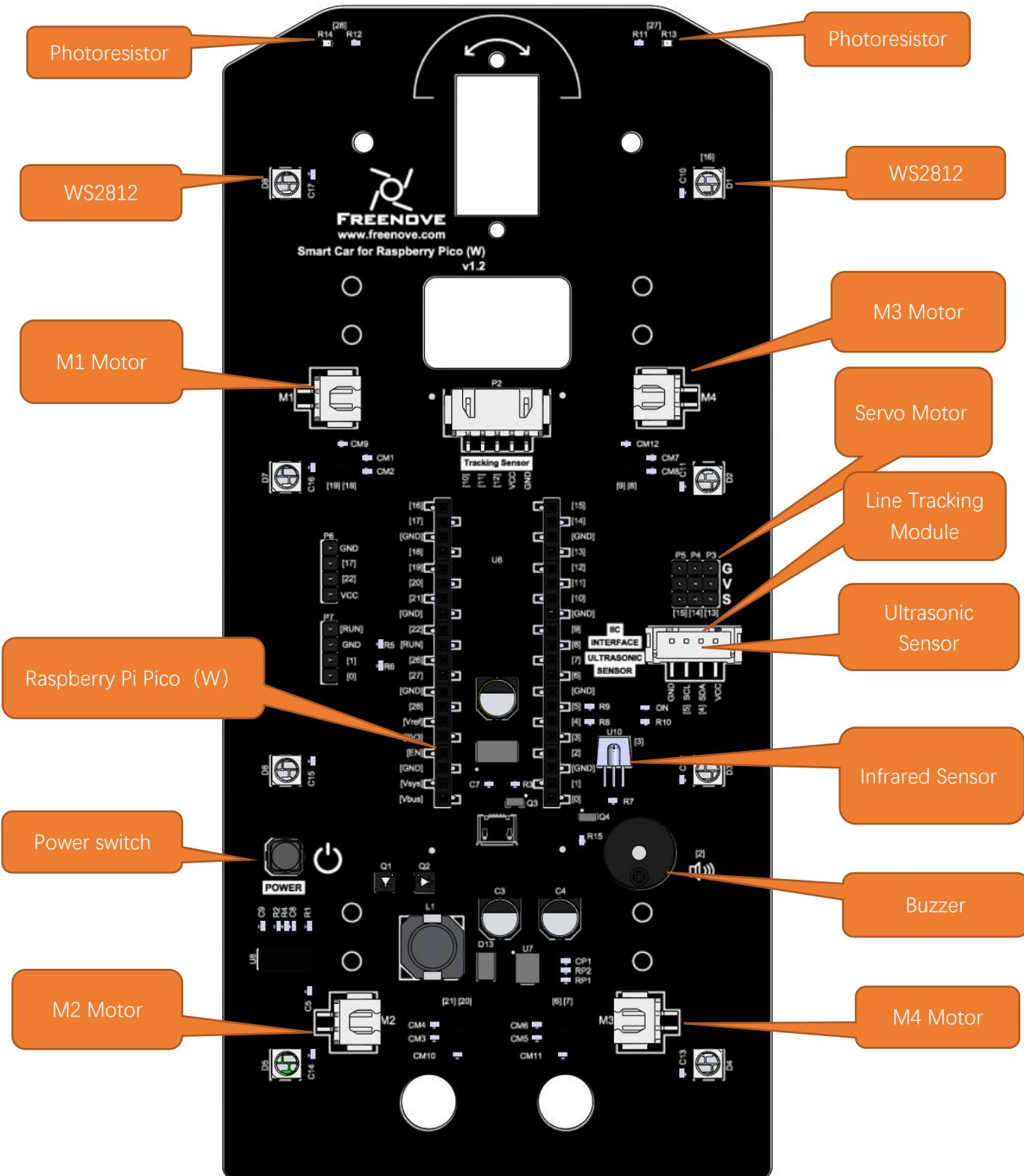
To learn what each GPIO corresponds to, please refer to the following table.

The functions of the pins are allocated as follows:

Pins of Raspberry Pi Pico W	Funtons	Description
GPIO18	Motor	M1_IN1
GPIO19		M1_IN2
GPIO20		M2_IN1
GPIO21		M2_IN2
GPIO6		M3_IN1
GPIO7		M3_IN2
GPIO8		M4_IN1
GPIO9		M4_IN2
GPIO13	Servo	Servo1
GPIO14		Servo2
GPIO15		Servo3
GPIO10	Tracking module	Track1
GPIO11		Track2
GPIO12		Track3
GPIO4	I2C port/Ultrasonic module interface	SDA/Trig
GPIO5		SCL/Echo
GPIO16	WS2812	WS2812
GPIO26	Battery detection	A0
GPIO27	Search light ADC port	A1
GPIO28	Search light ADC port	A2
GPIO22	Unused GPIO	GPIO22
GPIO17		GPIO17
GPIO3	Infrared receiver port	IR
GPIO2	Buzzer port	Buzzer
GPIO1	Serial port	RX
GPIO0		TX

Introduction to the Car

The function diagram of the Raspberry Pi Pico W car is as follows:

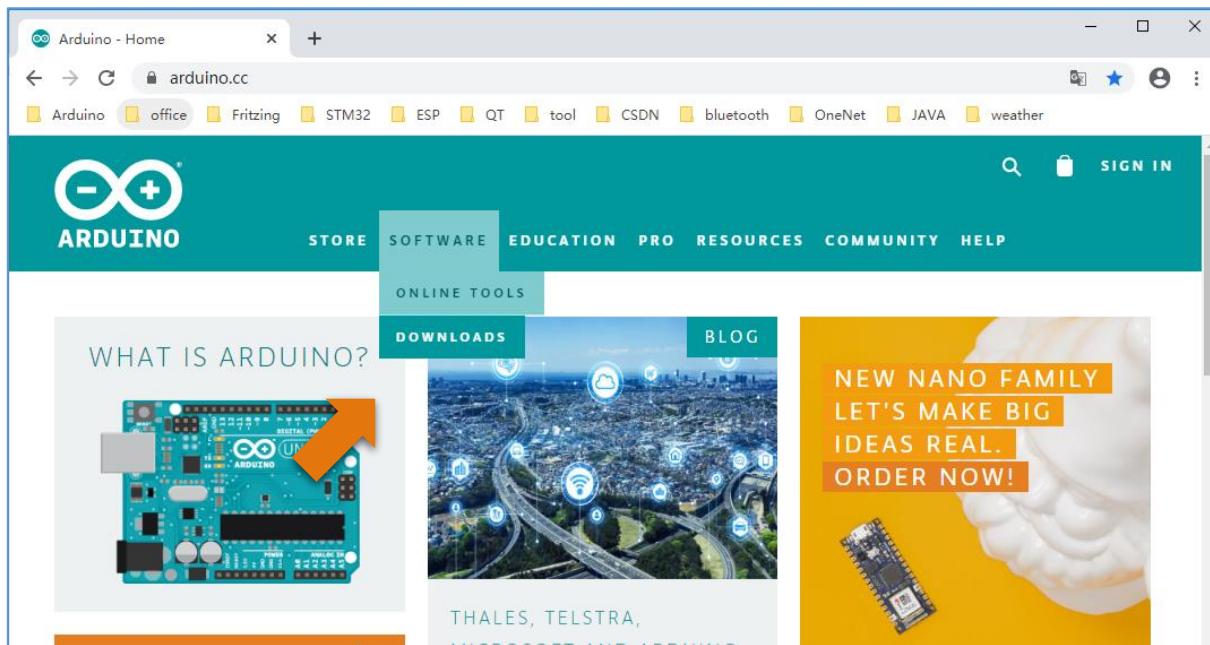


Chapter 0 Installation of Arduino IDE

Arduino Software

Arduino Software (IDE) is used to write and upload the code for Arduino Board.

First, install Arduino Software (IDE): visit <https://www.arduino.cc>, click "Download" to enter the download page.



Select and download corresponding installer based on your operating system. If you are a Windows user, please select the "Windows Installer" to download and install the driver correctly.

Downloads

A screenshot of the Arduino IDE 2.0.3 download page. The page features the Arduino logo and the text 'Arduino IDE 2.0.3'. It describes the new release as faster and more powerful, mentioning features like autocompletion, code navigation, and a live debugger. It includes a link to the 'Arduino IDE 2.0 documentation'. Below this, there's a section for 'Nightly builds' and a link to the 'SOURCE CODE' on GitHub. To the right, a teal sidebar titled 'DOWNLOAD OPTIONS' lists download links for Windows (Win 10 and newer, 64 bits; MSI installer; ZIP file), Linux (AppImage 64 bits (X86-64); ZIP file 64 bits (X86-64)), and macOS (Intel, 10.14: "Mojave" or newer, 64 bits; Apple Silicon, 11: "Big Sur" or newer, 64 bits).

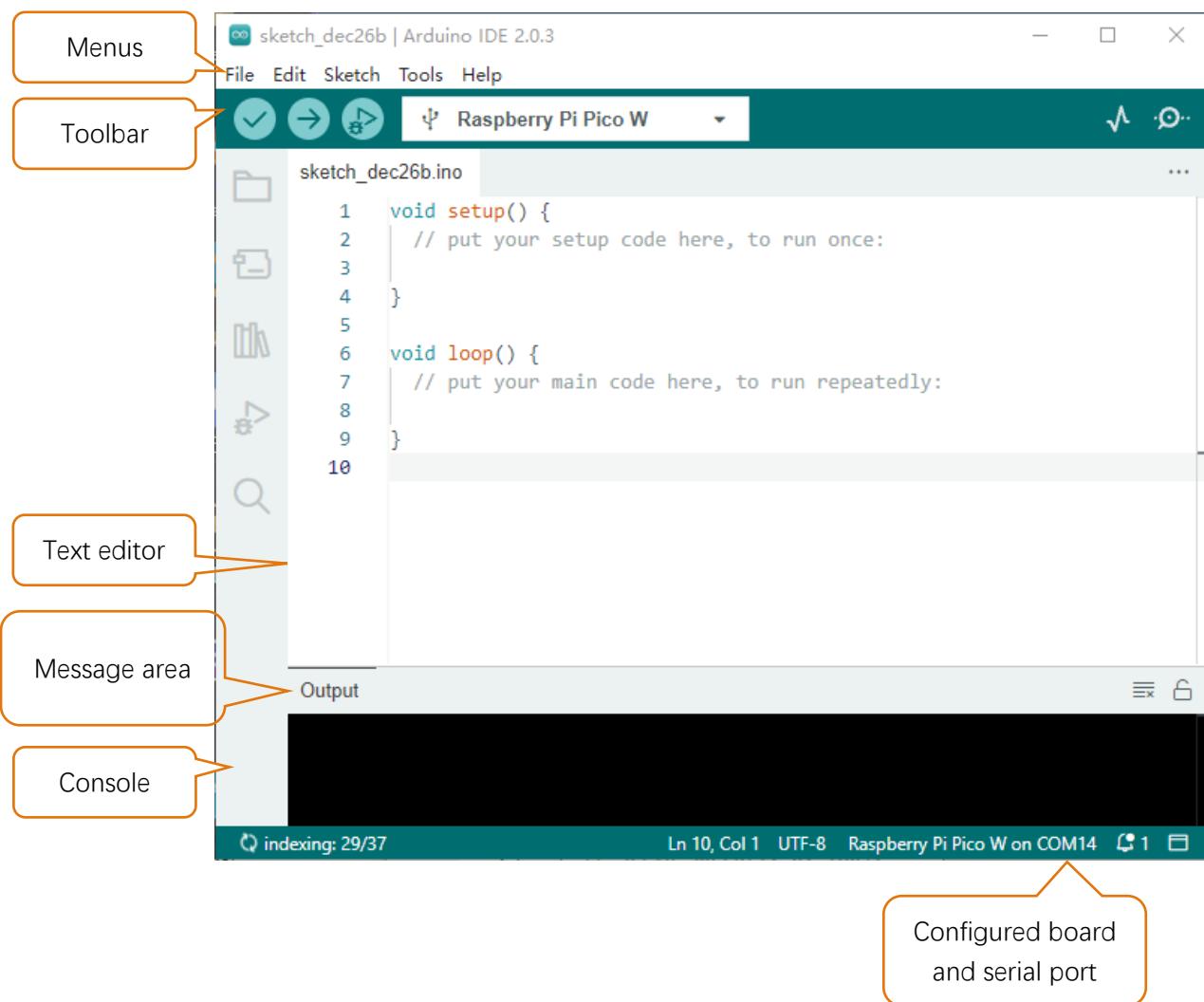
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After the download completes, run the installer. For Windows users, there may pop up an installation dialog during the installation. When it comes up, please allow the installation.

After installation is completed, an Arduino Software shortcut will be generated on the desktop. Run the Arduino Software.



The interface of Arduino Software is as follows:



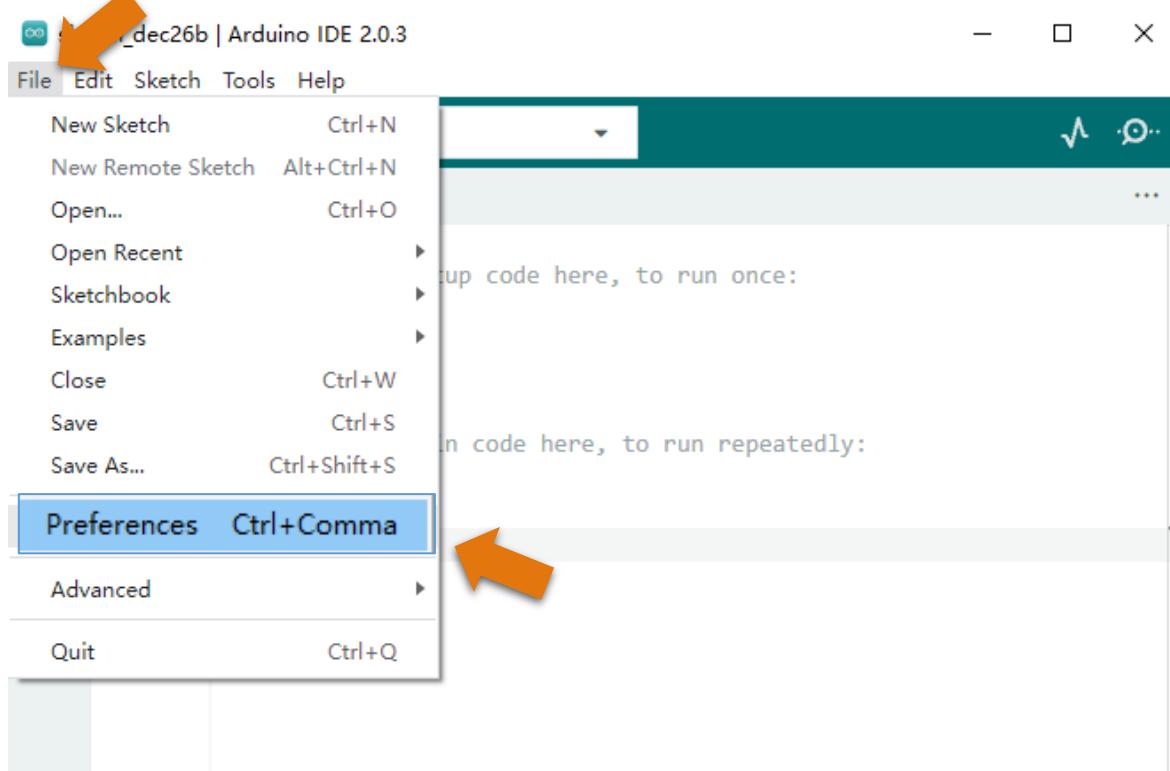
Programs written with Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and saved with the file extension.**.ino**. The editor has features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand 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	Check your code for compile errors .
	Upload	Compile your code and upload them to the configured board.
	New	Create a new sketch.
	Open	Present a menu of all the sketches in your sketchbook. Clicking one will open it within the current window and overwrite its content.
	Save	Save your sketch.
	Serial Monitor	Open the serial monitor.

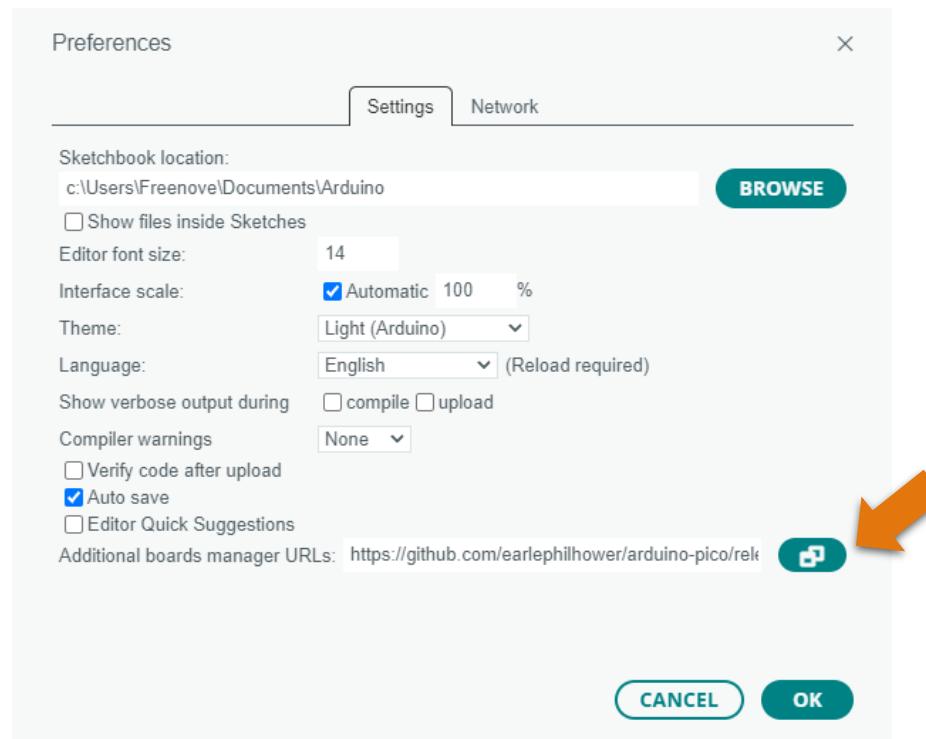
Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

Environment Configuration

First, open the software platform arduino, and then click File in Menus and select Preferences.

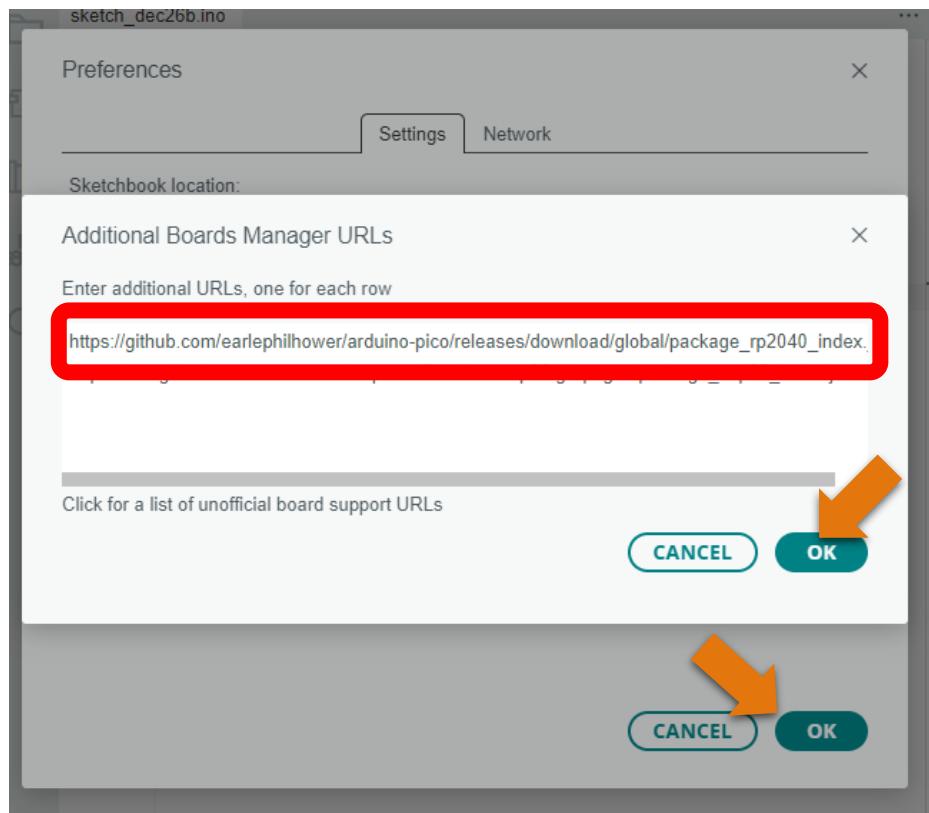


Second, click on the symbol behind "Additional Boards Manager URLs"

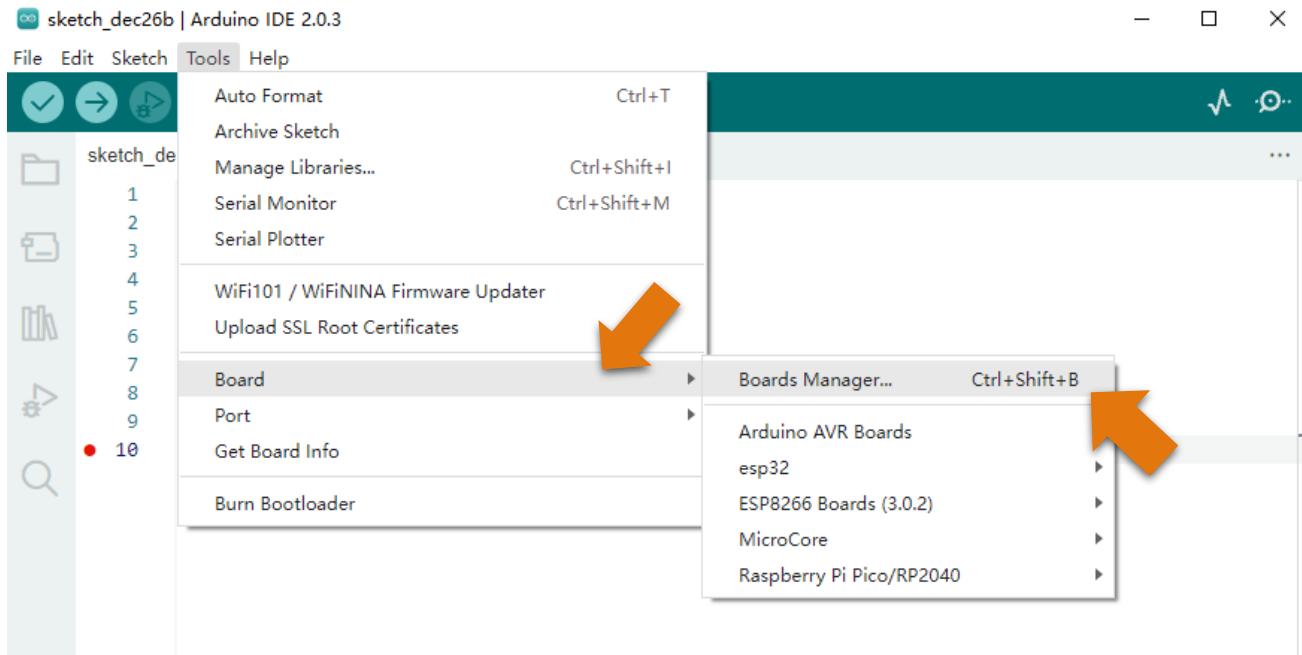


Third, fill in

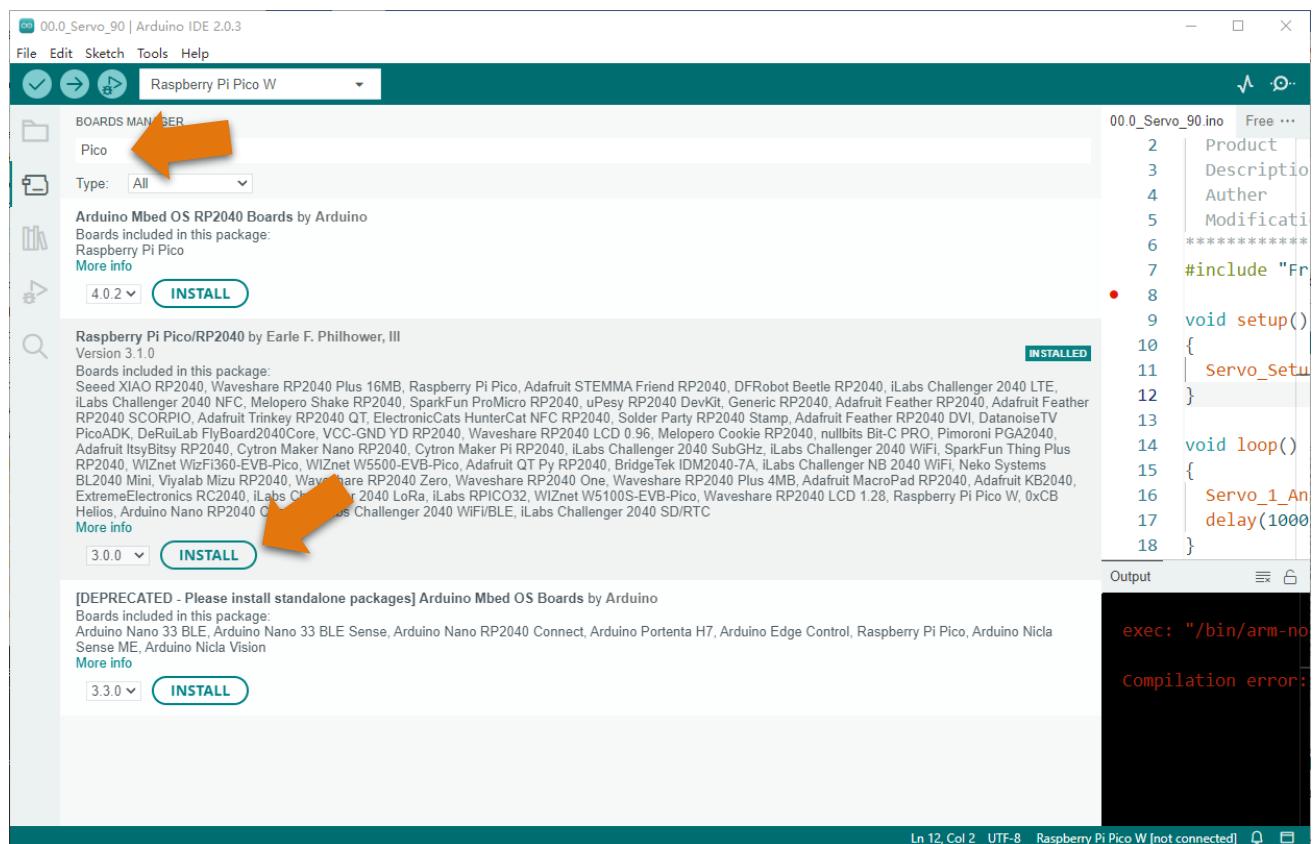
https://github.com/earlephilhower/arduino-pico/releases/download/global/package_rp2040_index.json in the new window, click OK, and click OK on the Preferences window again.



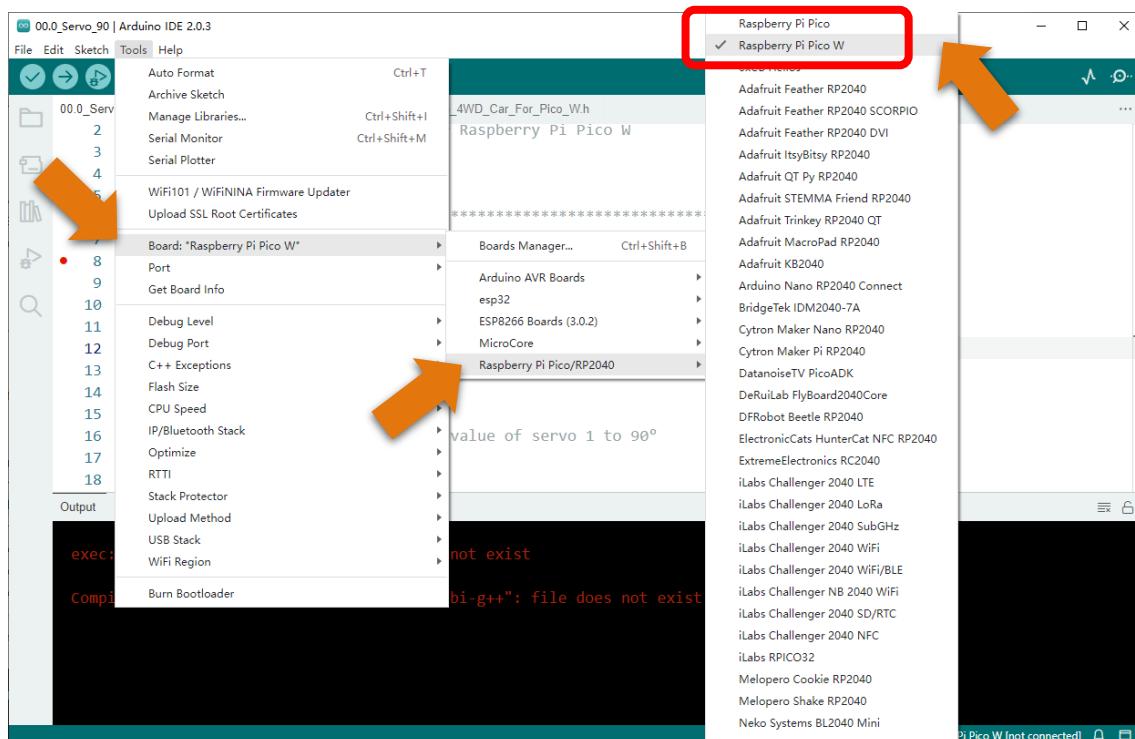
Fourth, click Tools in Menus, select Board:"ArduinoUno", and then select "Boards Manager".



Fifth, input "Pico" in the window below, and press Enter. click "Install" to install.



When finishing installation, click Tools in the Menus again and select Board: "Raspberry Pi Pico/RP2040", and then you can see information of Raspberry Pi Pico (W). Click "Raspberry Pi Pico W" so that the Raspberry Pi Pico W programming development environment is configured.



Additional Remarks

To finish this tutorial, you can use a Raspberry Pi Pico W or a Raspberry Pi Pico. The two boards have the same form factor, and their only difference is that Pico W features with an onboard single-band 4.802GHz wireless interface using Infineon CYW2. That is to say, the hardware Raspberry Pi Pico W is almost the same as the normal pico except for the wireless interface, which enables Pico W to work with WiFi (see chapter 7). If you use a normal Pico, you will not be able to finish the experiments in chapter 7. You can just skip that chapter.

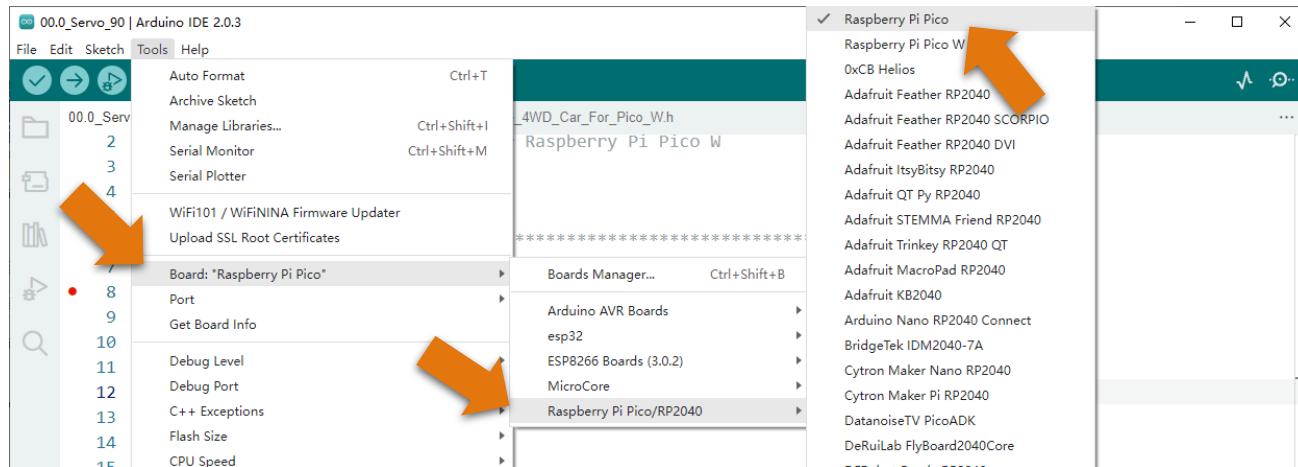
No matter which board you use, the procedure for each project is the same. You only need to select the correct board and upload the corresponding code based on the board you use.

In this book, we use Raspberry Pi Pico W to illustrate the operation.

The followings show the configuration on Arduino for the use of each board.

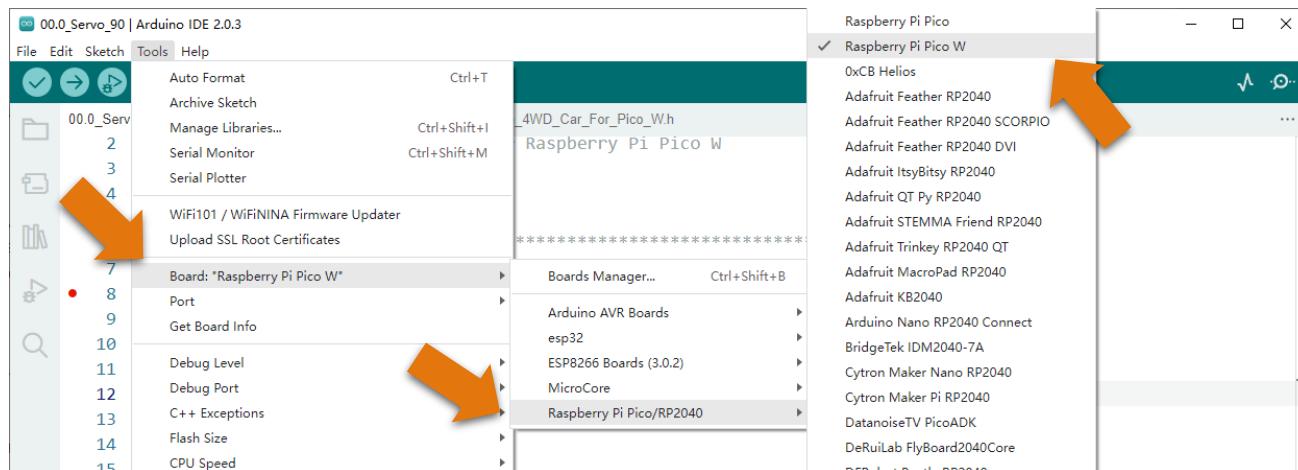
For Raspberry Pi Pico:

Click Tools on Menu bar, click Board, select “Raspberry Pi Pico/RP2040”, and select Raspberry Pi Pico.



For Raspberry Pi Pico W:

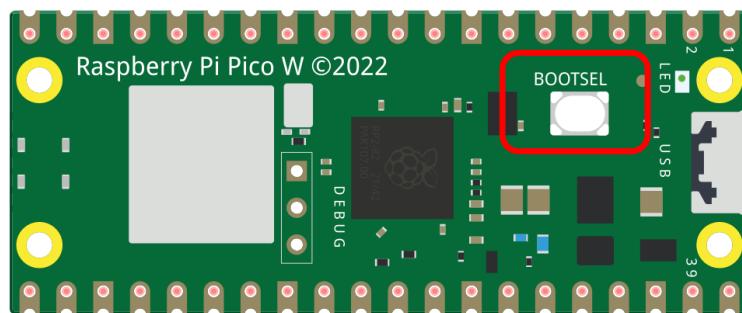
Click Tools on Menu bar, click Board, select “Raspberry Pi Pico/RP2040”, and select Raspberry Pi Pico W.



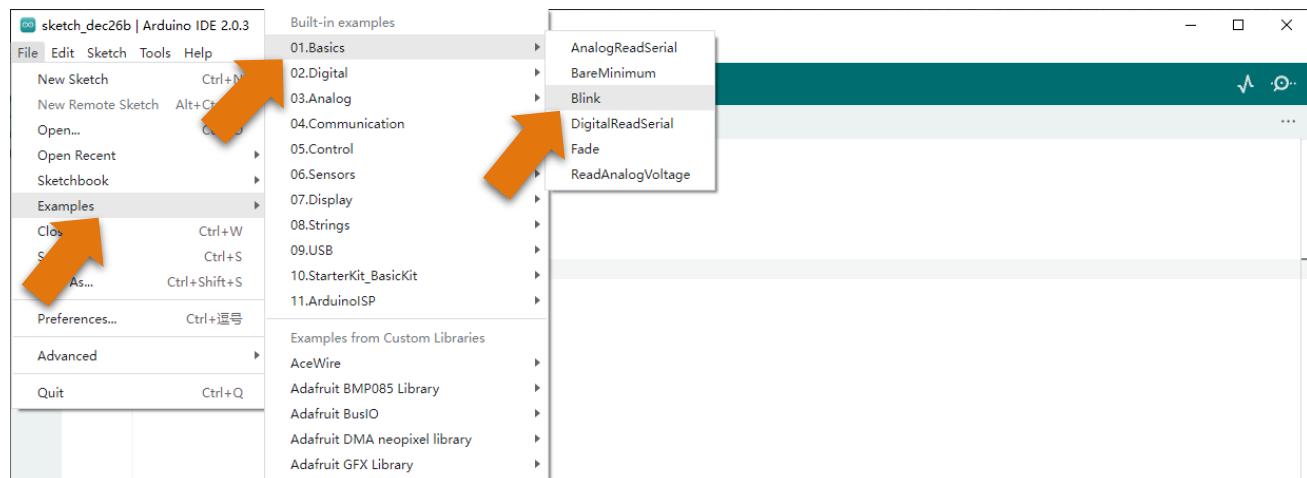
Uploading Arduino-compatible Firmware for Raspberry Pi Pico (W)

To program a new Raspberry Pi Pico (W) with Arduino, you need to upload an Arduino-compatible Firmware for it. Please refer to the following steps to configure.

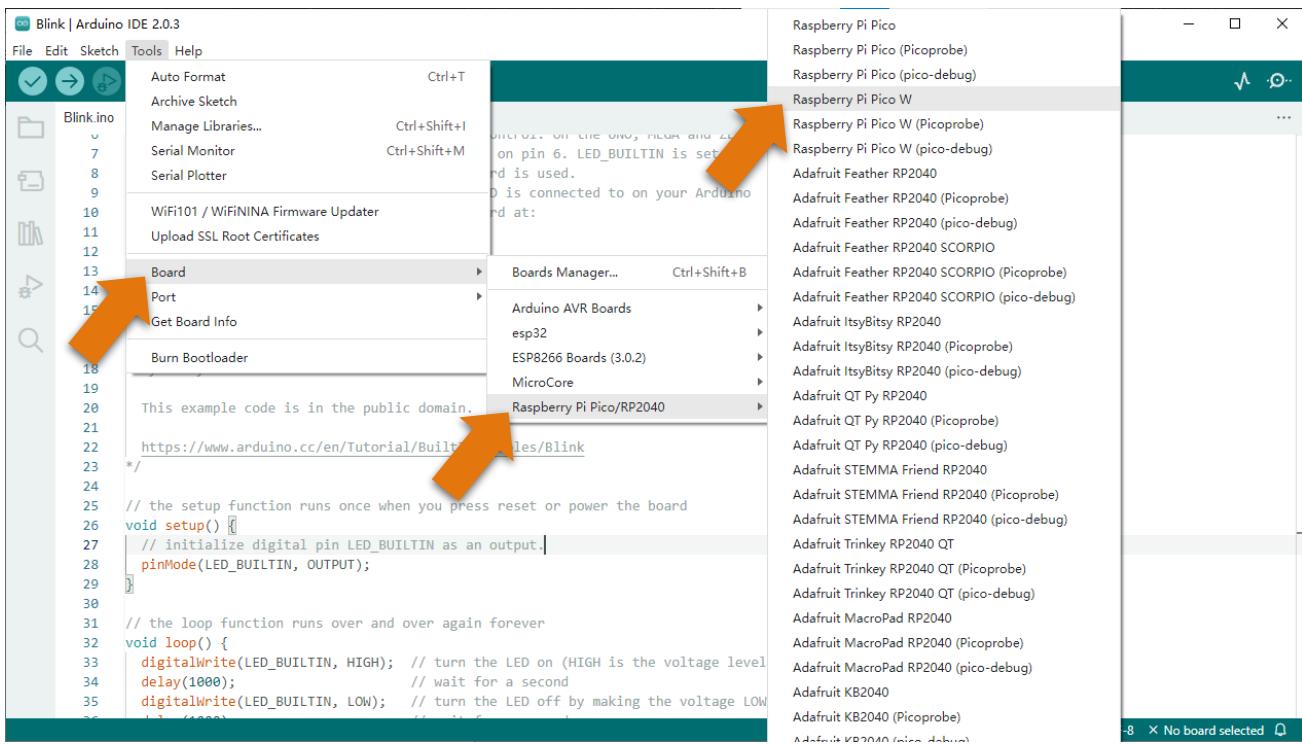
1. Disconnect Pico (W) from your computer. Press and hold the white button (BOOTSEL) on Pico (W) while connecting it to your computer. (Note: Be sure to hold the button before powering the Pico, otherwise the firmware will not download successfully.)



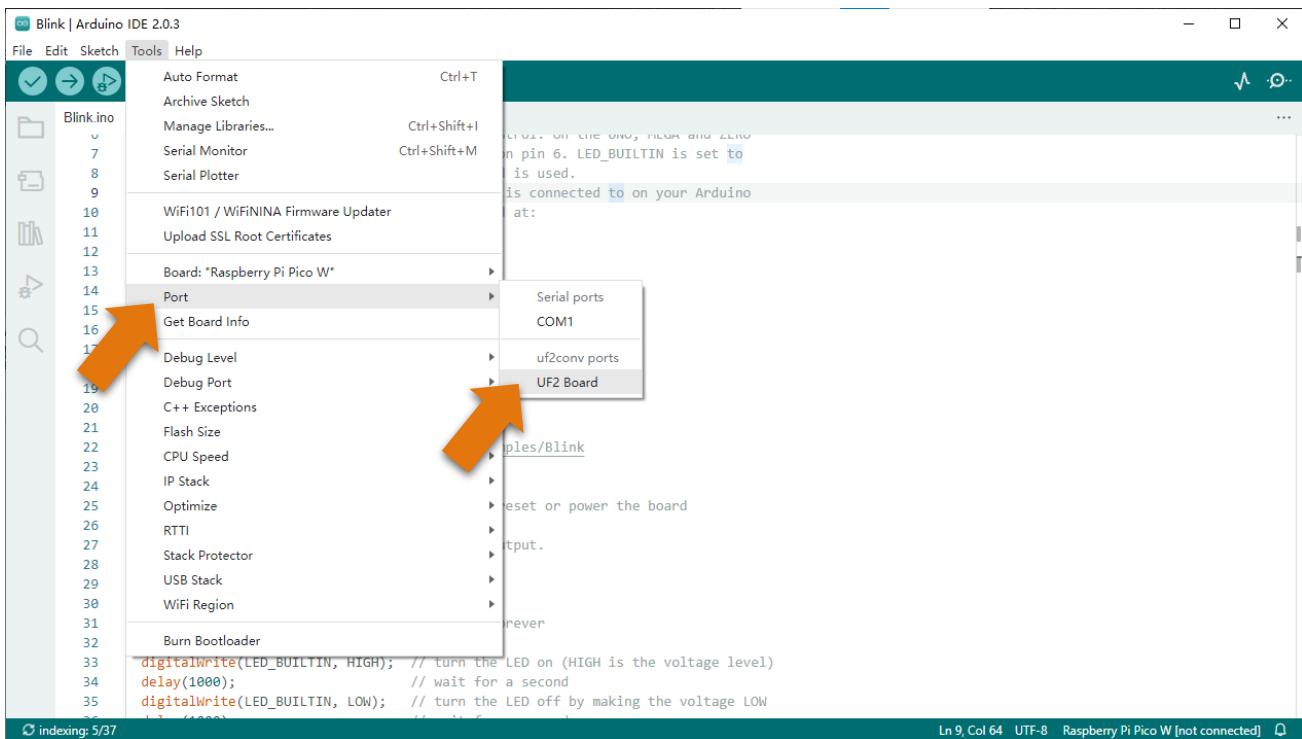
2. Open Arduino IDE. Click File>Examples>01.Basics>Blink.



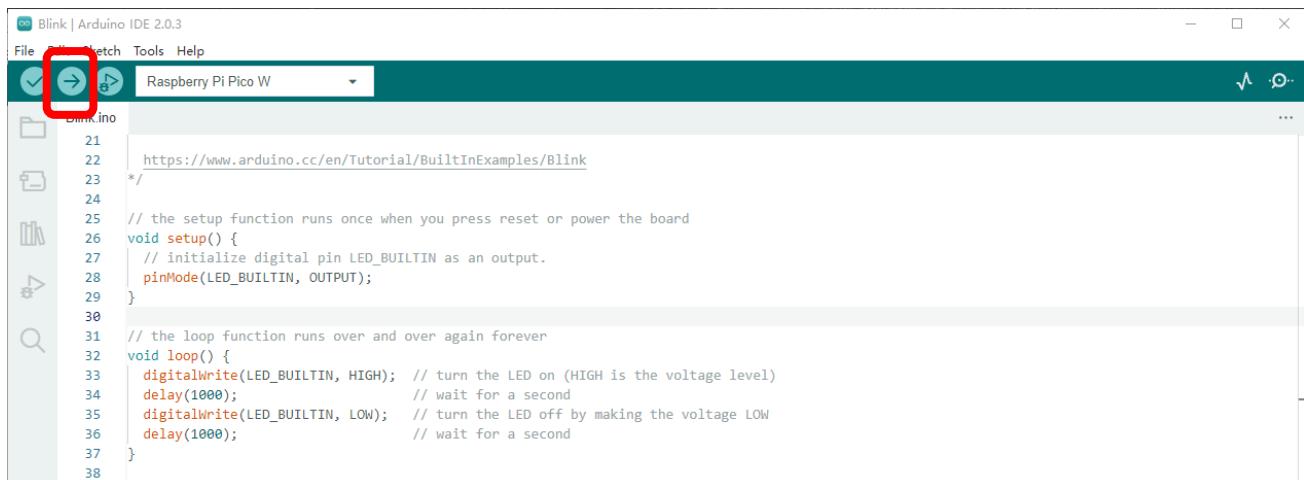
3. Click Tools>Board>Raspberry Pi RP2040 Boards>Raspberry Pi Pico W.



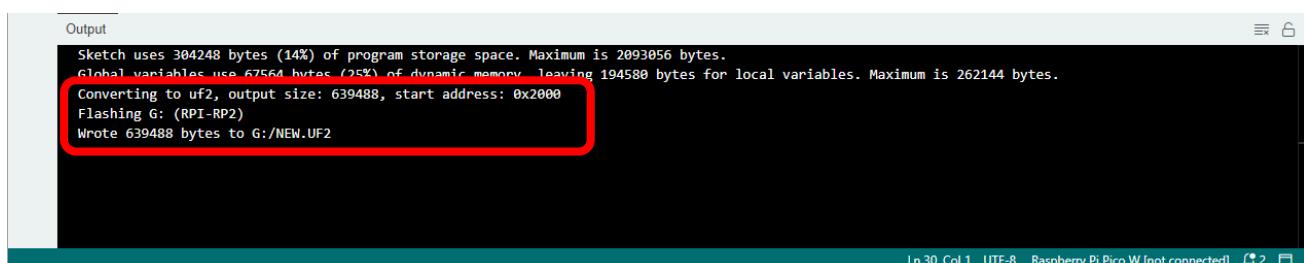
4. Click Tools>Port>UF2 Board.



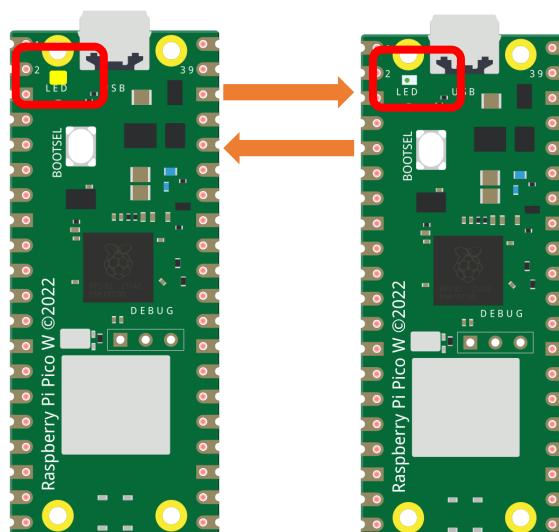
5. Upload sketch to Raspberry Pi Pico W.



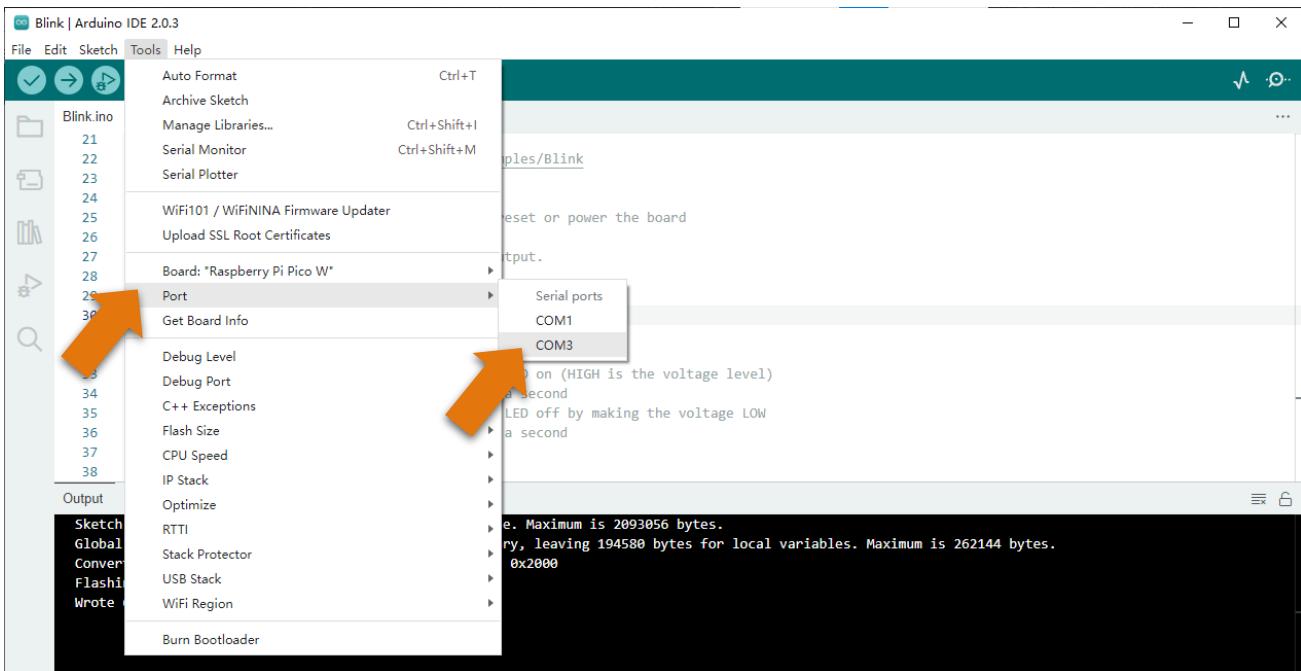
When the sketch finishes uploading, you can see messages as below.



The indicator on Pico W starts to flash.

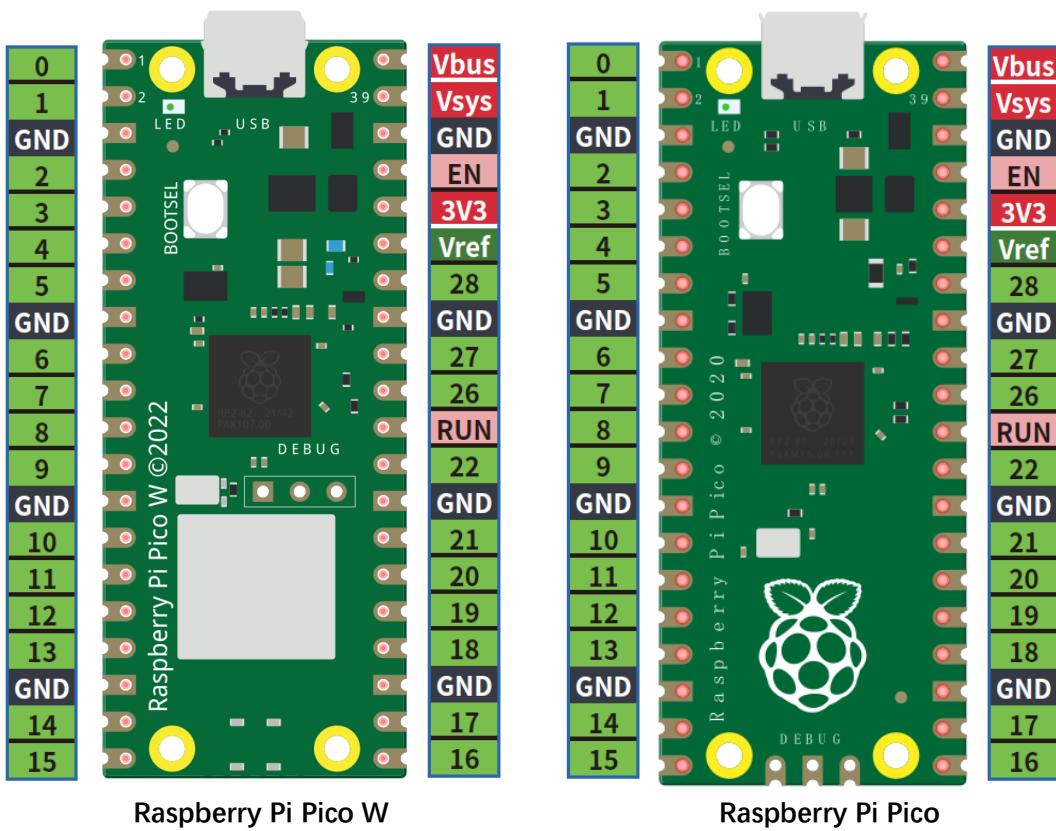


5, Click **Tools>Port>COMx (Raspberry Pi Pico W)**. X of COMx varies from different computers. Please select the correct one on your computer. In our case, it is COM3.

**Note:**

1. At the first use of Arduino to upload sketch for Pico (W), you need to select a port on the UF2 board. After that, each time before uploading sketch, please check whether the port has been selected; otherwise, the downloading may fail.
2. Sometimes when used, Pico (W) may lose firmware due to the code and fail to work. At this point, you can upload firmware for Pico (W) as mentioned above.

To facilitate your learning, the pins of Pico W and Pico are shown below:



Uploading the First Code

Here we take "00.0_Servo_90" in

"**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches**" as an example.

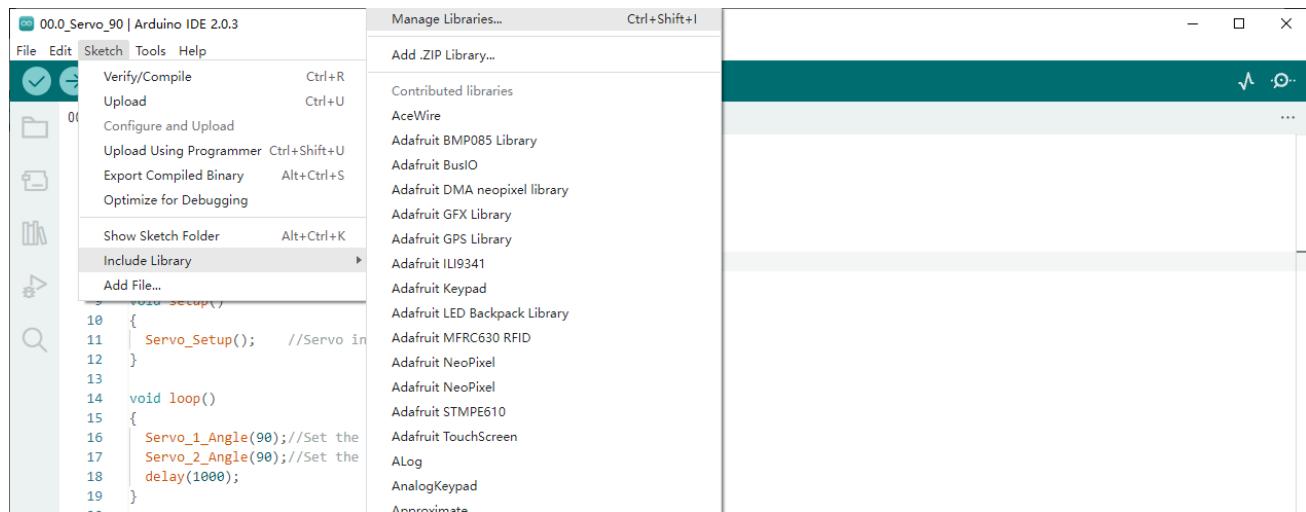
The servo on the car is controlled by RP2040_PWM. Therefore, it is necessary to add the related libraries to Arduino IDE first.

How to Add Libraries

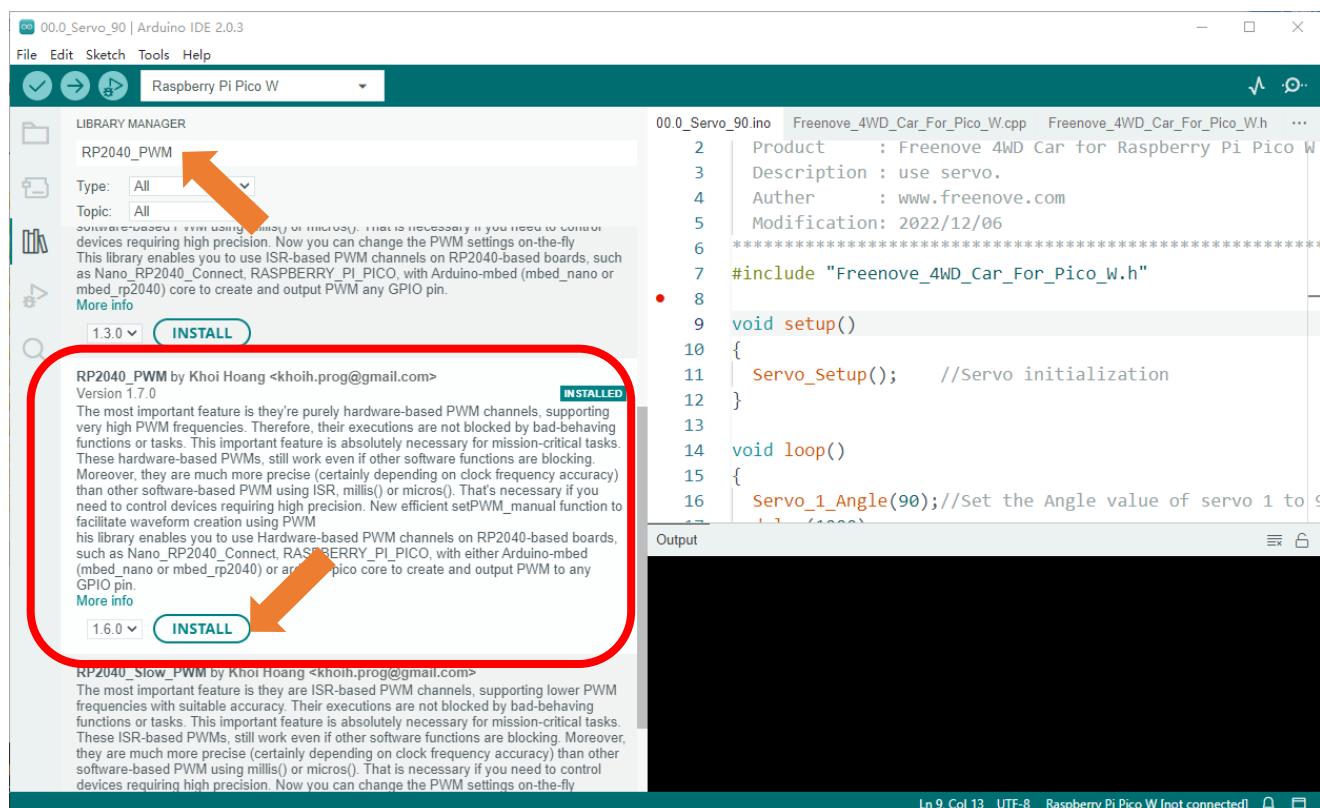
Method 2 is preferred.

Method 1

Open Arduino IDE, click Sketch on Menu bar ->Include Library -> Manage Libraries.



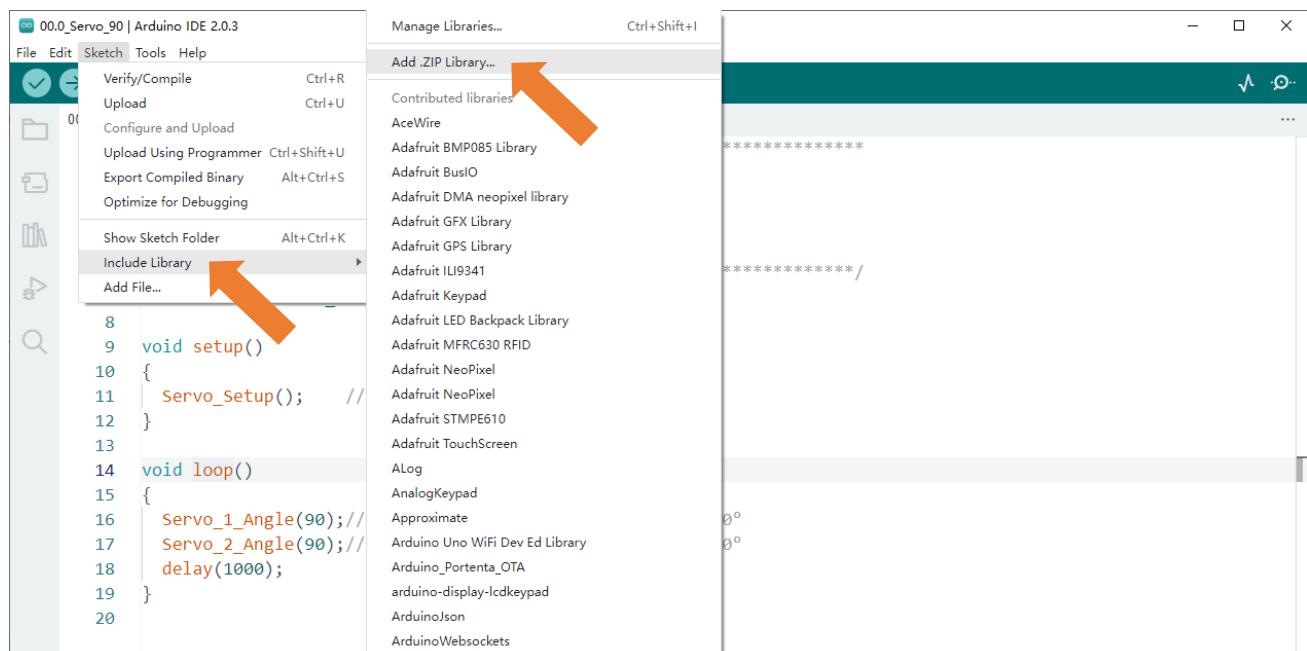
There is an input field on the right top of the pop-up window. Enter RP2040_PWM there and click to install the library boxed in the following figure.



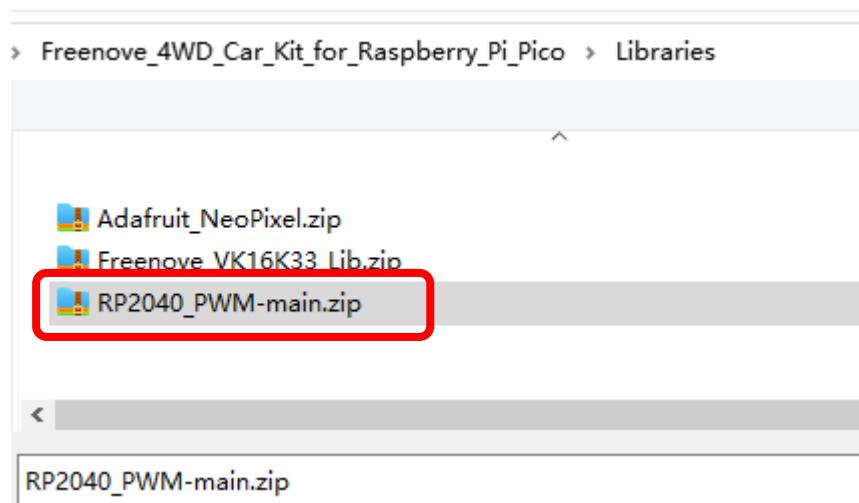
Wait for the installation to finish.

Method 2

Open Arduino IDE, click Sketch on Menu bar->Include Library ->Add .ZIP library.

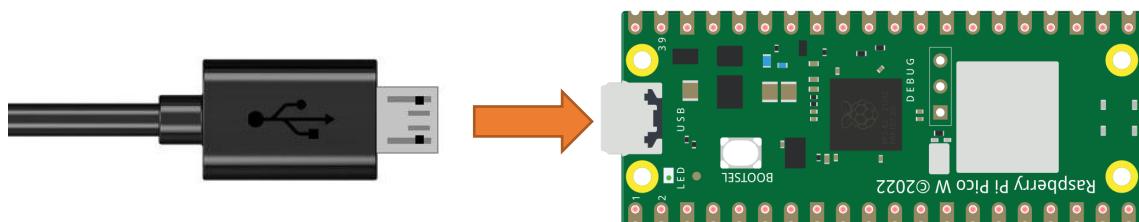


On the pop-up window, select RP2040_PWM-main.zip in Libraries folder under "Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Libraries", and then click Open.



How to Compile and Upload Code

Step 1. Connect your computer and Raspberry Pi Pico W with a USB cable.



Step 2. Open “00.0_Servo_90” folder in

“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches”, and double-click “00.0_Servo_90.ino”. The code is to rotate the servo motors to 90°.

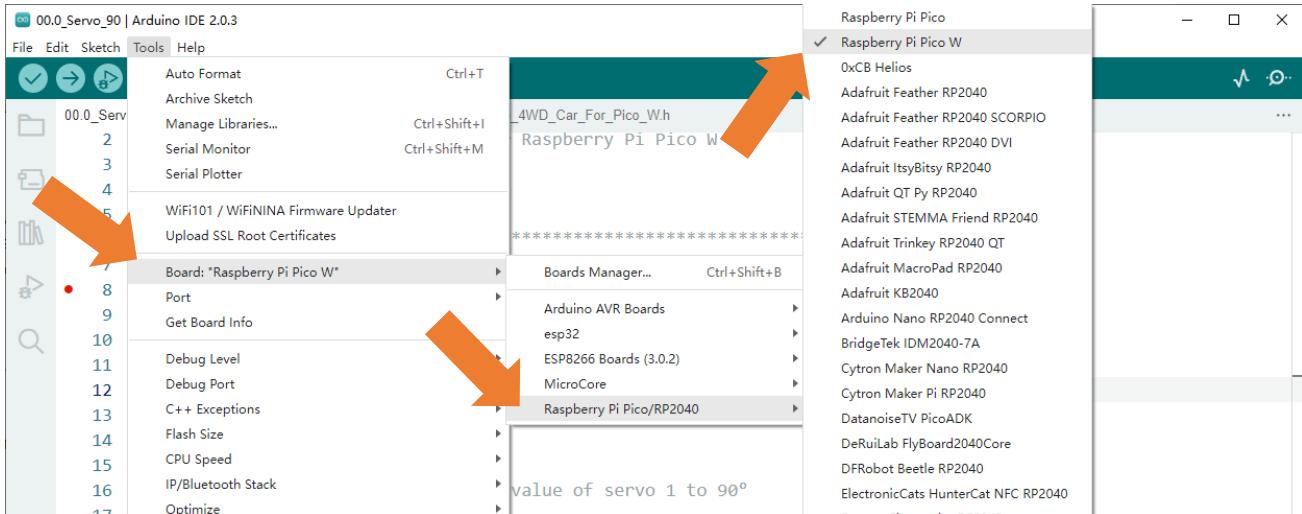
The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** 00.0_Servo_90 | Arduino IDE 2.0.3
- Menu Bar:** File Edit Sketch Tools Help
- Sketch Selection:** Raspberry Pi Pico W
- File List:** 00.0_Servo_90.ino Freenove_4WD_Car_For_Pico_W.cpp Freenove_4WD_Car_For_Pico_W.h
- Code Editor:**

```
1 // ****
2 Product      : Freenove 4WD Car for Raspberry Pi Pico W
3 Description   : use servo.
4 Author        : www.freenove.com
5 Modification  : 2022/12/06
6 ****
7 #include "Freenove_4WD_Car_For_Pico_W.h"
8
9 void setup()
10 {
11     Servo_Setup();    //Servo initialization
12 }
13
14 void loop()
15 {
16     Servo_1_Angle(90); //Set the Angle value of servo 1 to 90°
17     delay(1000);
18 }
19
```
- Output Panel:** A large black area labeled "Output".
- Status Bar:** Ln 1, Col 3 UTF-8 Raspberry Pi Pico W [not connected]

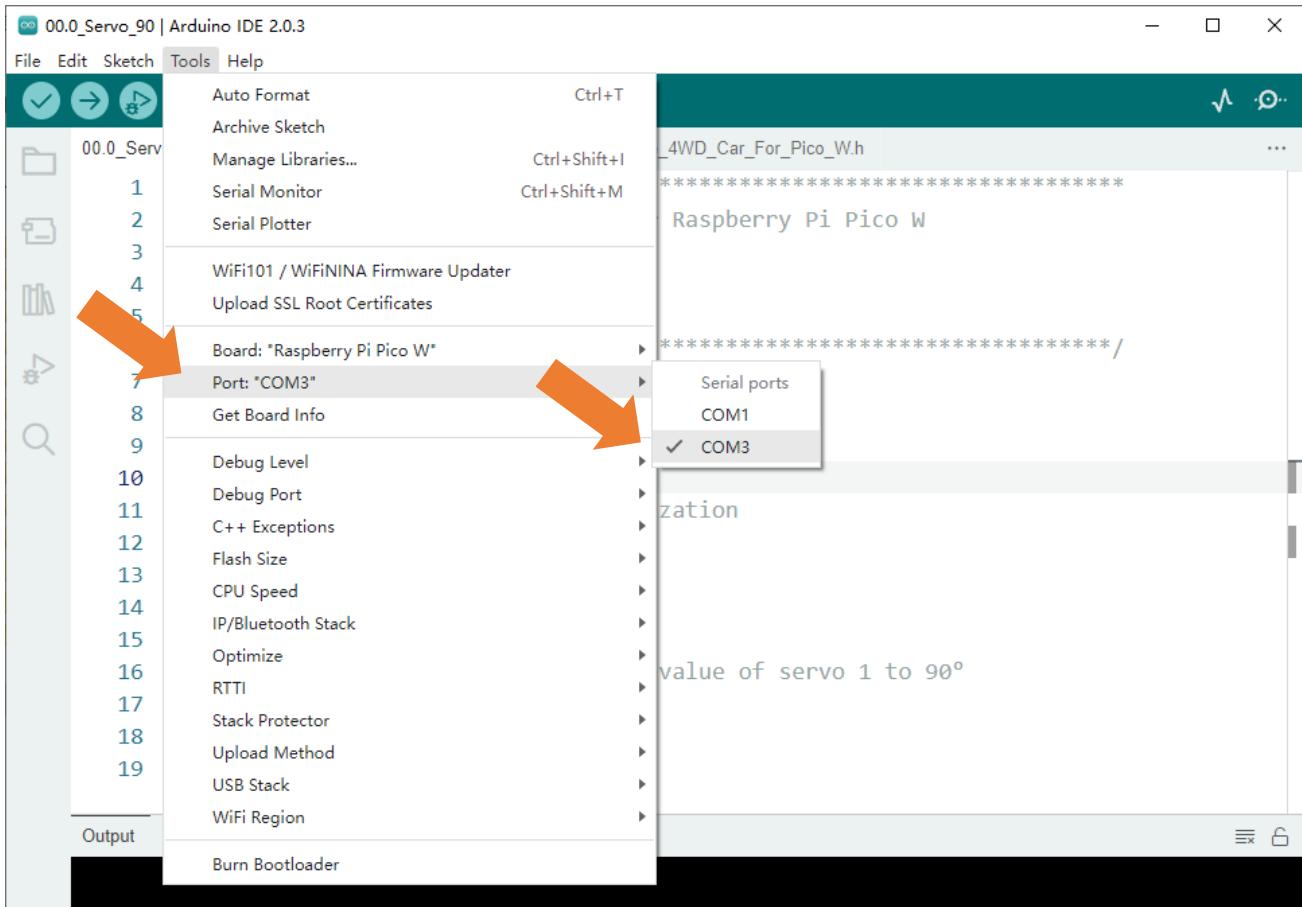
Step 3. Select development board.

Click Tools on Menu bar, click Board -> “Raspberry Pi Pico/RP2040” -> Raspberry Pi Pico W.



Step 4. Select serial port.

Click Tools on Menu bar, navigate your mouse to Port and select COMx on your computer. The value of COMx varies in different computers, but it will not affect the download function of Raspberry Pi Pico (W), as long as you select the correct one.



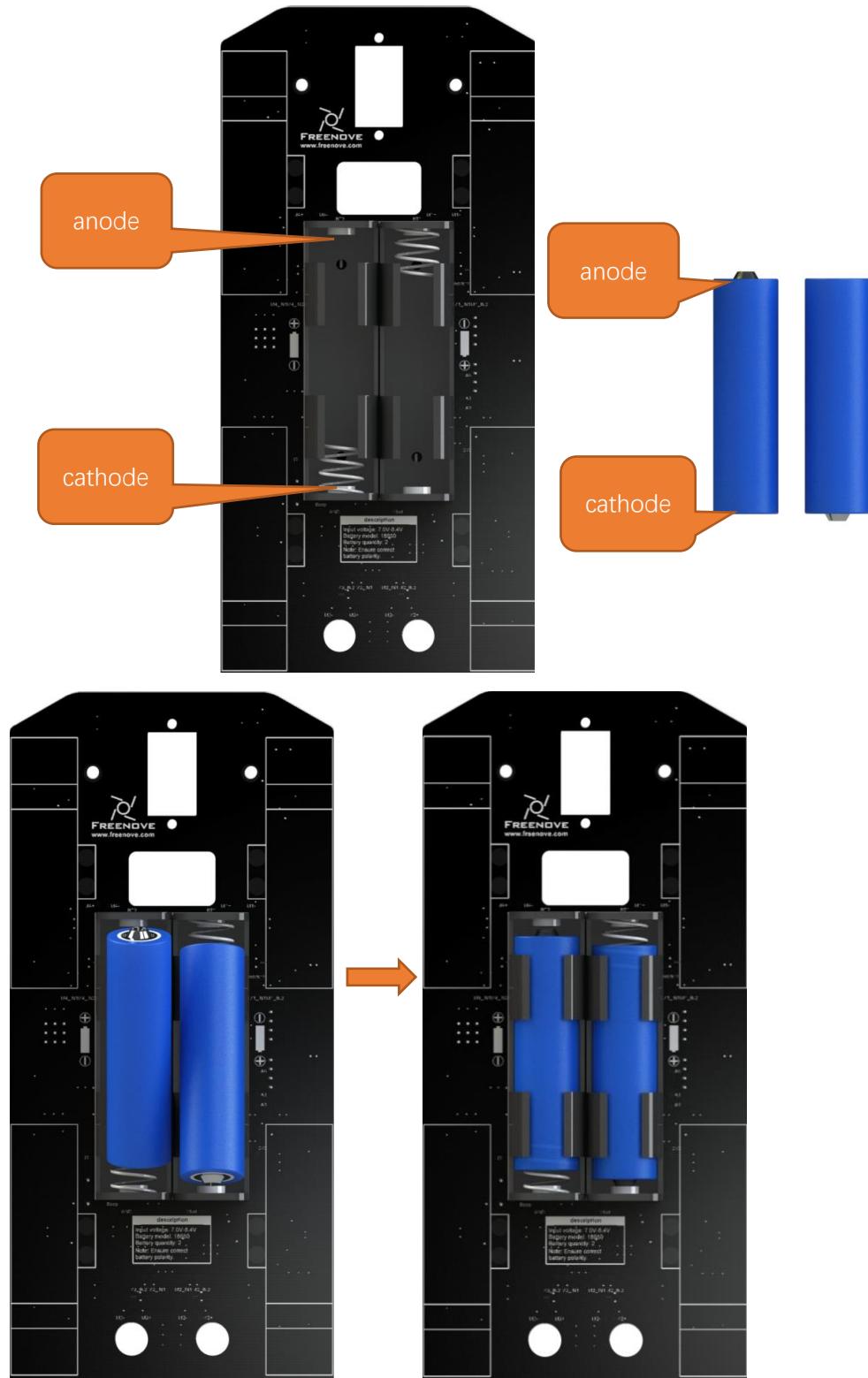
Click “Upload Using Programmer” and the program will be downloaded to Raspberry Pi Pico (W).

The screenshot shows the Arduino IDE interface. The top menu bar includes File, Edit, Sketch, Tools, Help, and a dropdown for "Raspberry Pi Pico W". A red box highlights the "Upload" button in the toolbar. The central workspace displays the code for "00_0_Servo_90.ino", which includes an include statement for "Freenove_4WD_Car_For_Pico_W.h" and two function definitions: setup() and loop(). The setup() function initializes a servo. The loop() function sets servo 1 to 90 degrees and delays for 1000ms. Below the code is the "Output" window, which shows the upload progress and final message: "Sketch uses 80220 bytes (3%) of program storage space. Maximum is 2093056 bytes. Global variables use 69532 bytes (26%) of dynamic memory, leaving 192612 bytes for local variables. Maximum is 262144 bytes. Resetting COM3. Converting to uf2, output size: 194560, start address: 0x2000. Scanning for RP2040 devices. Flashing G: (RPI-RP2). Wrote 194560 bytes to G:/NEW.UF2". The status bar at the bottom indicates "Ln 14, Col 11 UTF-8 Raspberry Pi Pico W on COM3".

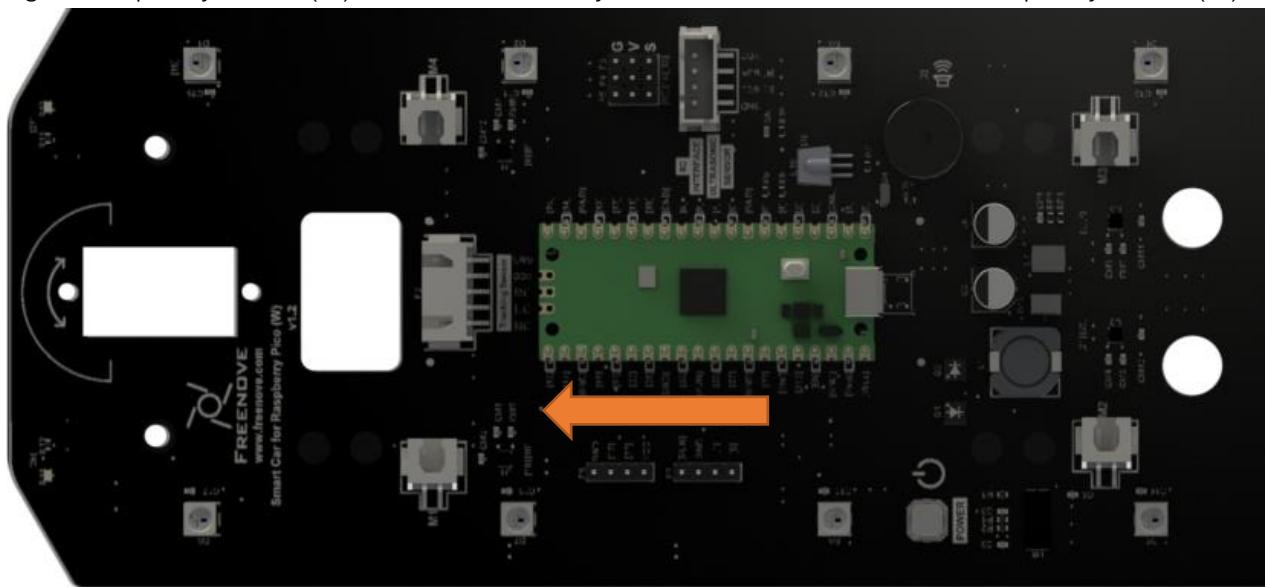
When you see the following content, it indicates that the program has been uploaded to Raspberry Pi Pico (W).

The screenshot shows the Arduino IDE Output window. It displays the same upload log as the previous screenshot, but with a red box highlighting the final message: "Sketch uses 72496 bytes (3%) of program storage space. Maximum is 2093056 bytes. Global variables use 67520 bytes (25%) of dynamic memory, leaving 194624 bytes for local variables. Maximum is 262144 bytes. Resetting COM3. Converting to uf2, output size: 175616, start address: 0x2000. Flashing G: (RPI-RP2). Wrote 175616 bytes to G:/NEW.UF2". The status bar at the bottom indicates "Ln 18, Col 15 UTF-8 Raspberry Pi Pico W on COM3".

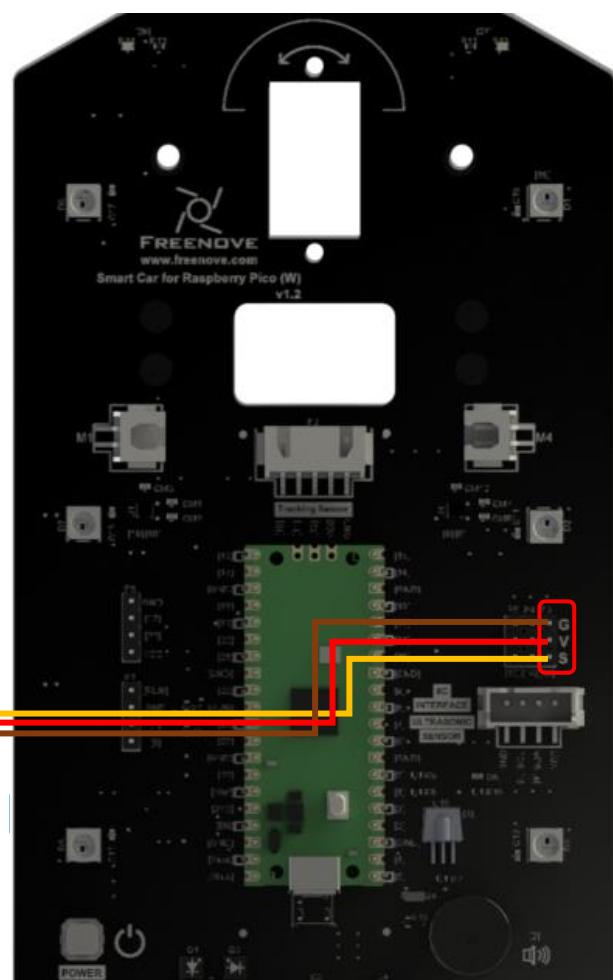
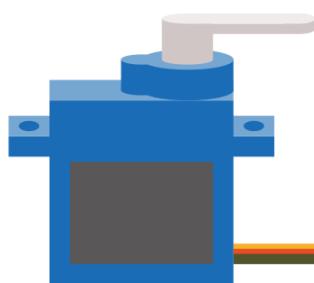
The car needs to be assembled with batteries installed. When installing them, please follow the silk print on the board.



Plug the Raspberry Pi Pico (W) to the car shield. Pay attention to the orientation of Raspberry Pi Pico (W).



Make sure Raspberry Pi Pico (W) is plugged into the shield correctly. Take out two servo motors and plug them into the car shield. Please note the color of the wires. Do NOT connect them wrongly.



Turn ON the switch and the servo will keep at 90°.

Chapter 1 Assembling Smart Car

If you have any concerns, please feel free to contact us via support@freenove.com

Assembling the Car

Installing Motor and Wheels

There are 4 bracket packages to fix motors, each containing an aluminum bracket, two M3*30 screws, two M3*8 screws and two M3 nuts, as shown below:



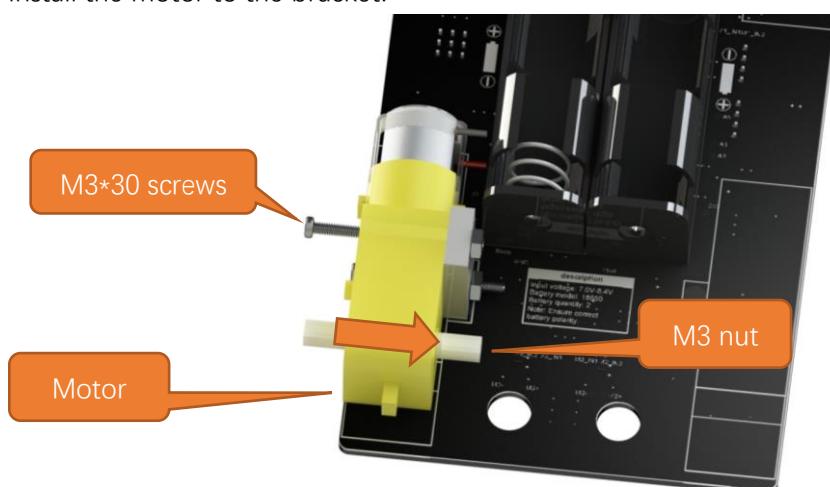
Installation steps:

Step 1 Fix the bracket on the shield.



Put the bottom of the car up, use two M3*8 screws to fix the bracket on the shield.

Step 2 Install the motor to the bracket.



Use two M3*30 screws and two M3 nuts to fix the motor on the bracket.

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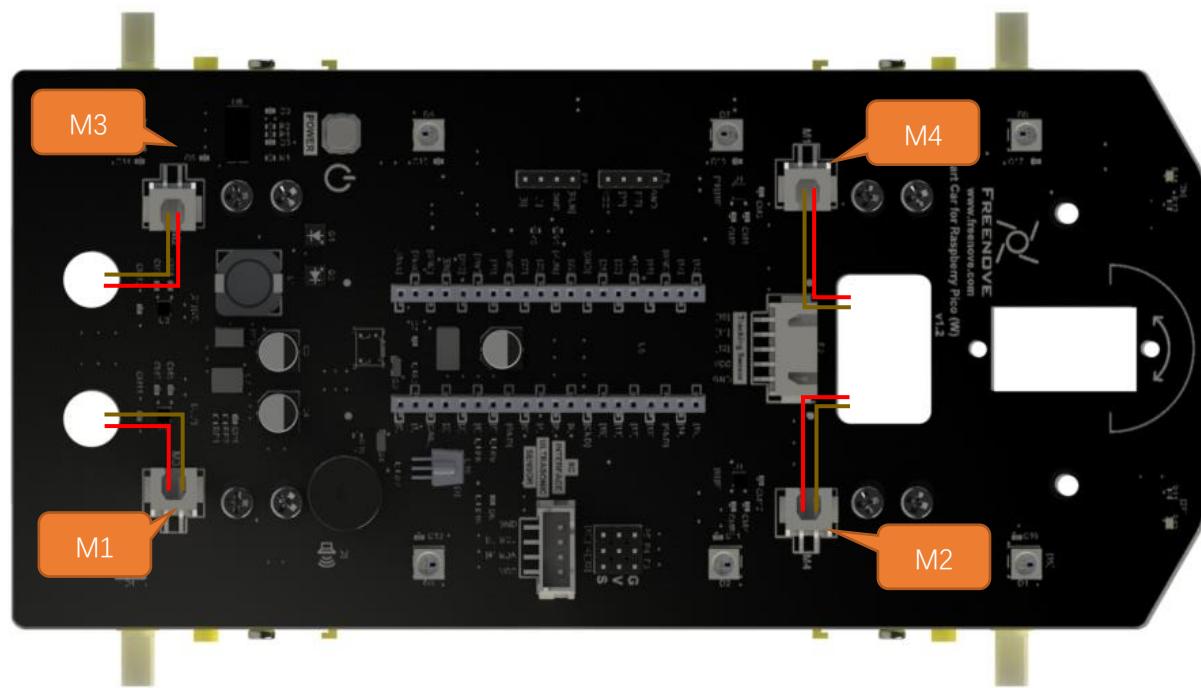
Caution: Do not remove the cable tie from the motor; otherwise, the motor cable may become detached.

If you perform step 2 before step 1, please check whether the M3 nut located under the motor in step 2 is at the same level as the bracket.

If the M3 nut below is not horizontal, it may easily cause damage to the PCB surface during installation step 1, resulting in a short circuit on the control board.

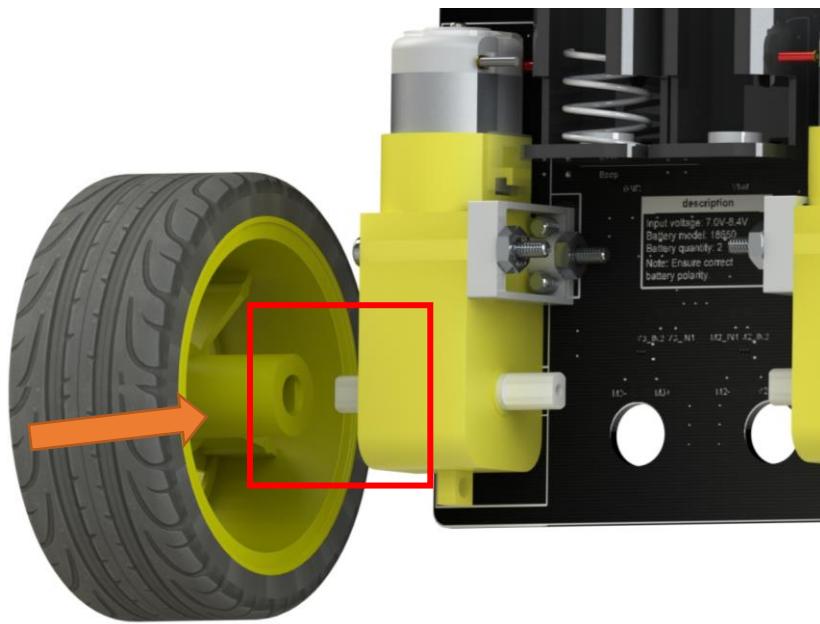


Step 3 Connect the motor wire to the corresponding socket.

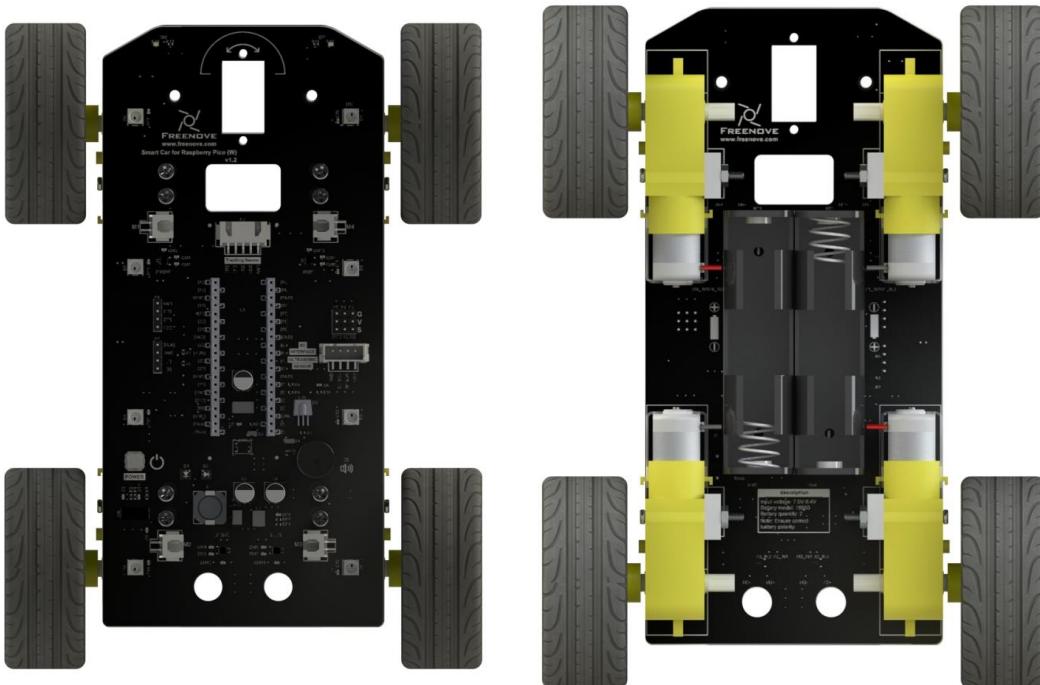


Put the motor wires through the holes on the shield and connect them to the corresponding sockets on the top.

Step 4 Install the wheel to the motor.



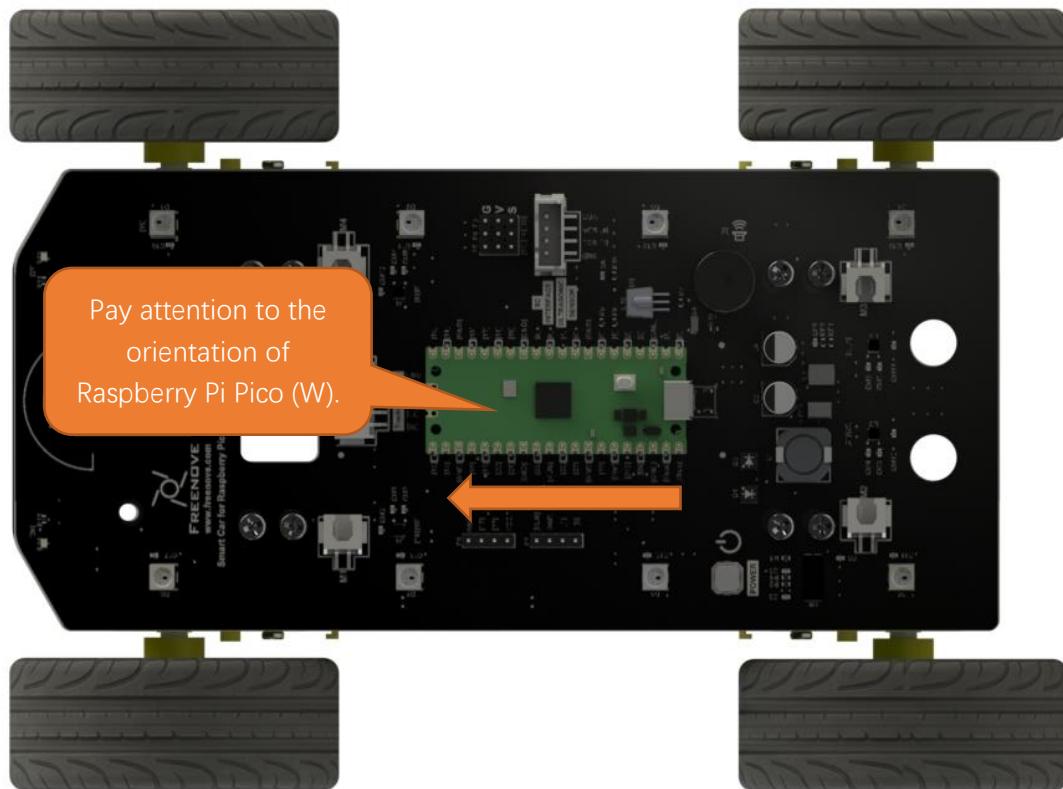
Note: The hole is not round. Please align the hole and fix the wheel to the motor.



The installation of the four wheels is similar. Repeat the above installation steps to complete the installation.

Plugging in Raspberry Pi Pico (W)

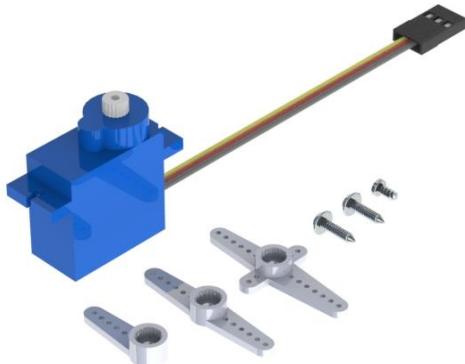
Plug Raspberry Pi Pico (W) into the shield.



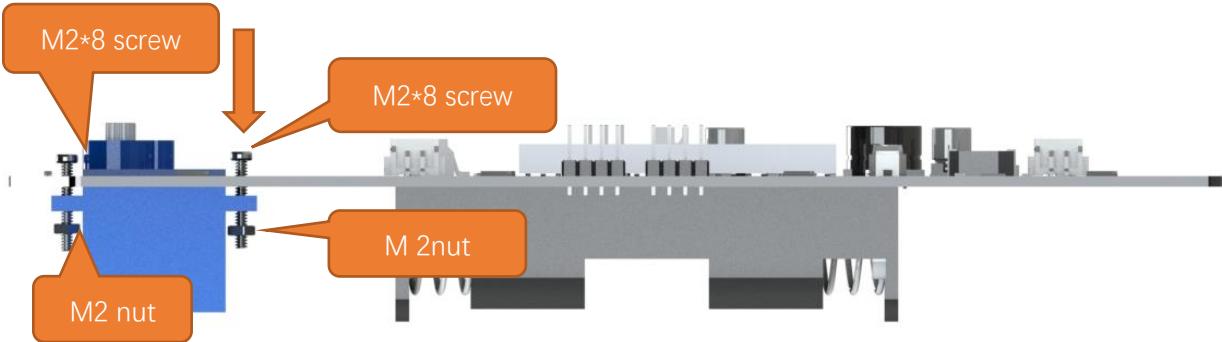
Please pay attention to the orientation of Raspberry Pi Pico (W). Do NOT reverse it; Otherwise, it may burn the Raspberry Pi Pico (W).

Installing Servo

Servo package: one servo, three rocker arms, two M2*8 screws and one M2*4 screw.

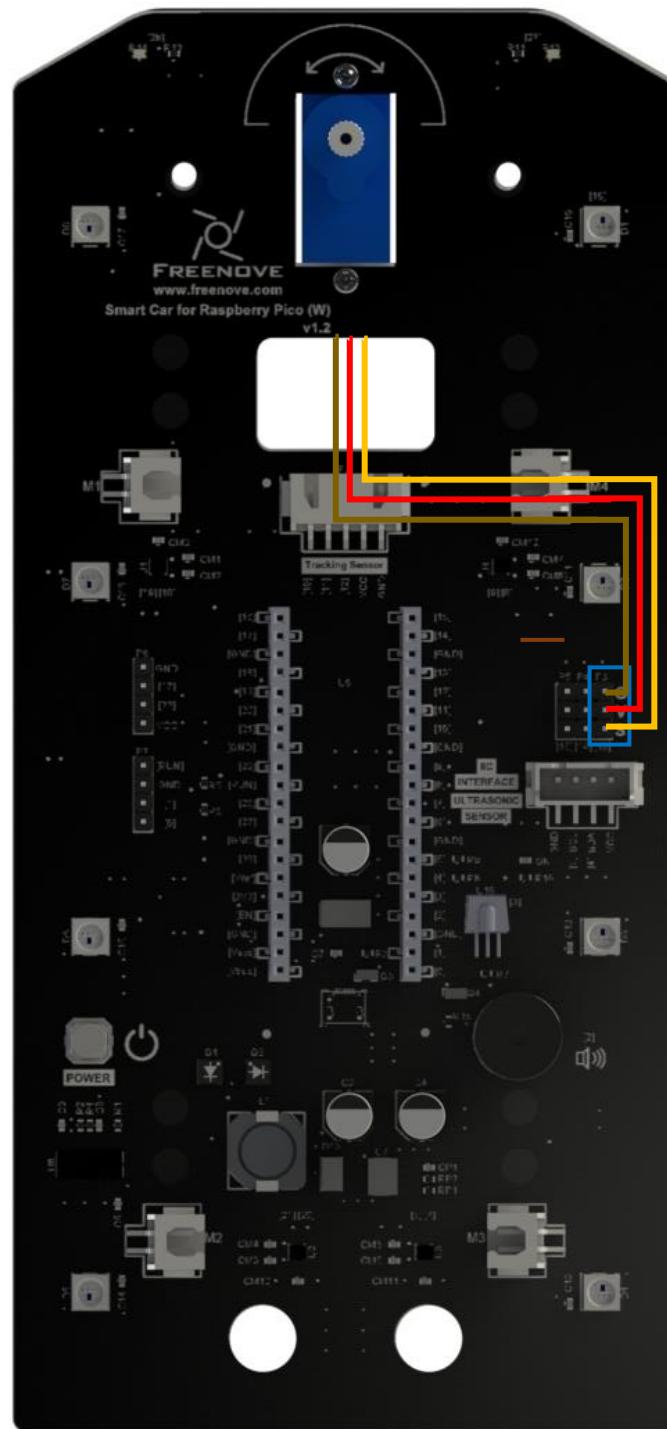


Step 1 Fix servo1 to the shield.



Use two M2*8 screws and two M2 nuts to mount the servo1 on the shield. Pay attention to the servo's direction.

Step 5 Wiring of the servor motor



Connect servo1 to P3 interfaces on the shield.

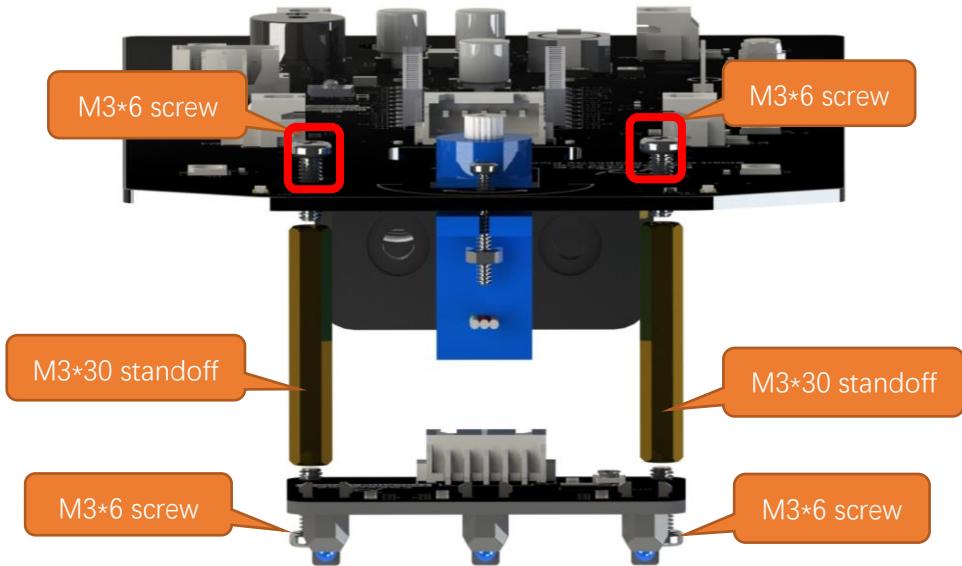
Pay attention to the color of the wires.
Do not connect them wrongly.

Connect servo to P3 interfaces on the shield respectively.

Pay attention to the color of the wires. Do not connect them wrongly.

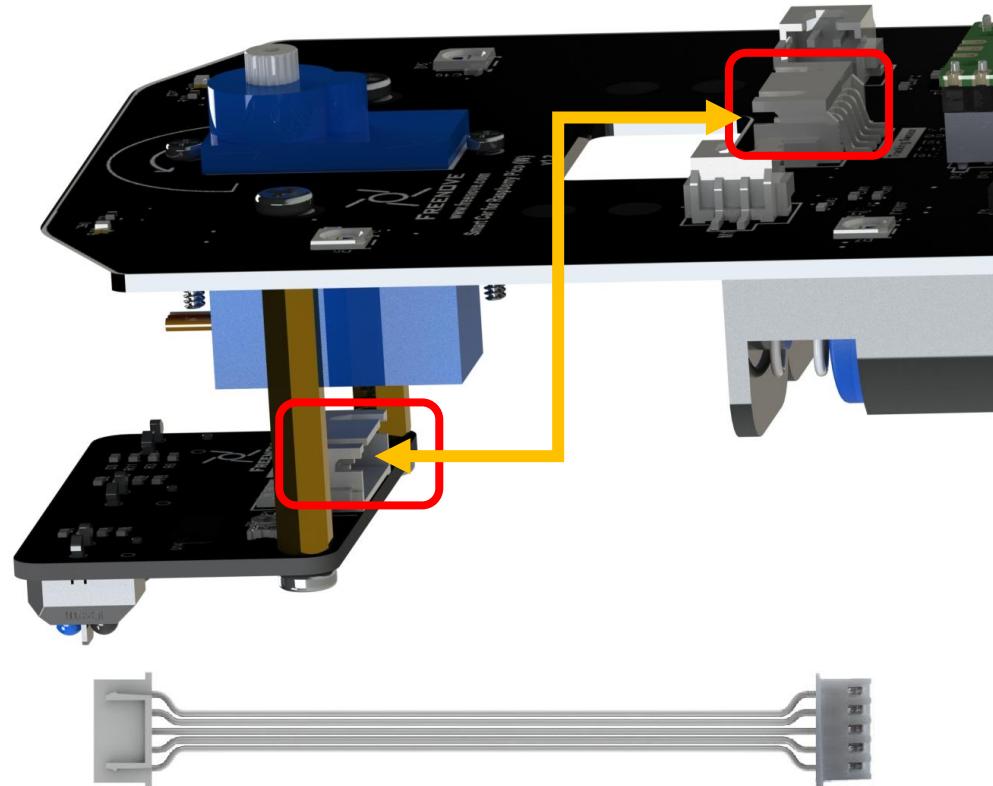
Installing Line Tracking Module

Step 1 Installing line tracking module



First, use two M3*6 screws to fix two M3*30 standoffs to the bottom of the car, and then use two M3*6 screws to fix the line tracking module to the standoffs.

Step 2 Connect the cable to the tracking module



Use cable to connect the two connectors marked above.

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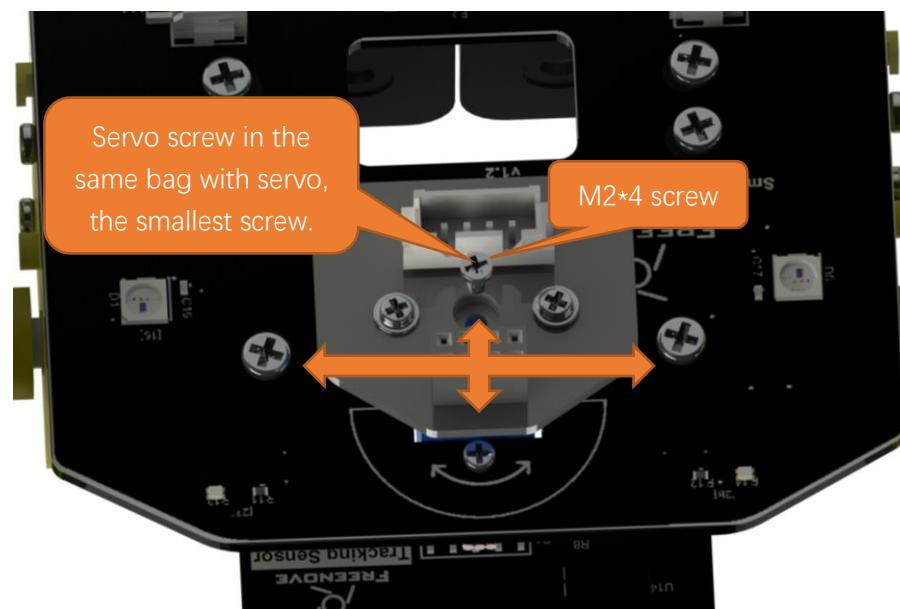
Mounting the Servo Arm to Module Connector.

Step 1 Mount the servo arm to acoustic wave module or expression module connector. The screw and arm are in the same bag with servo.

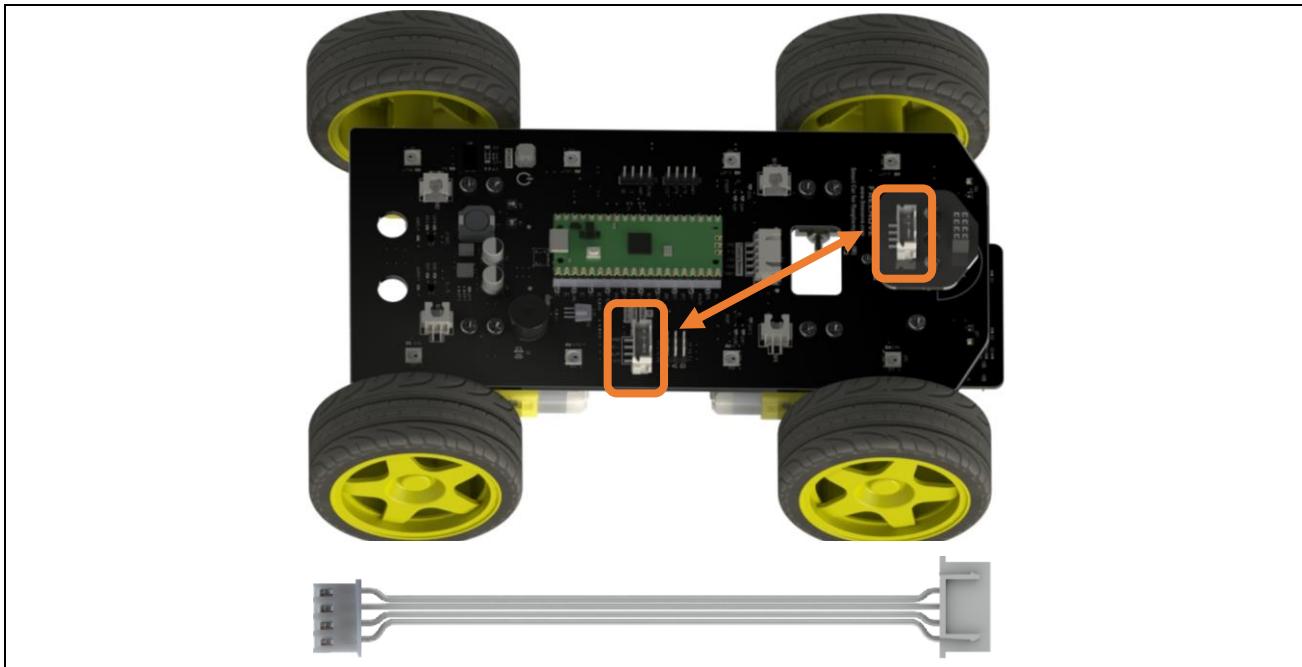


Step 2 Connect servo arm to servo. Make sure servo is installed at 90 degrees.

Note: Before attache the rocker arm to servo, please adjust the servo at 90°. You can refer to [here](#).

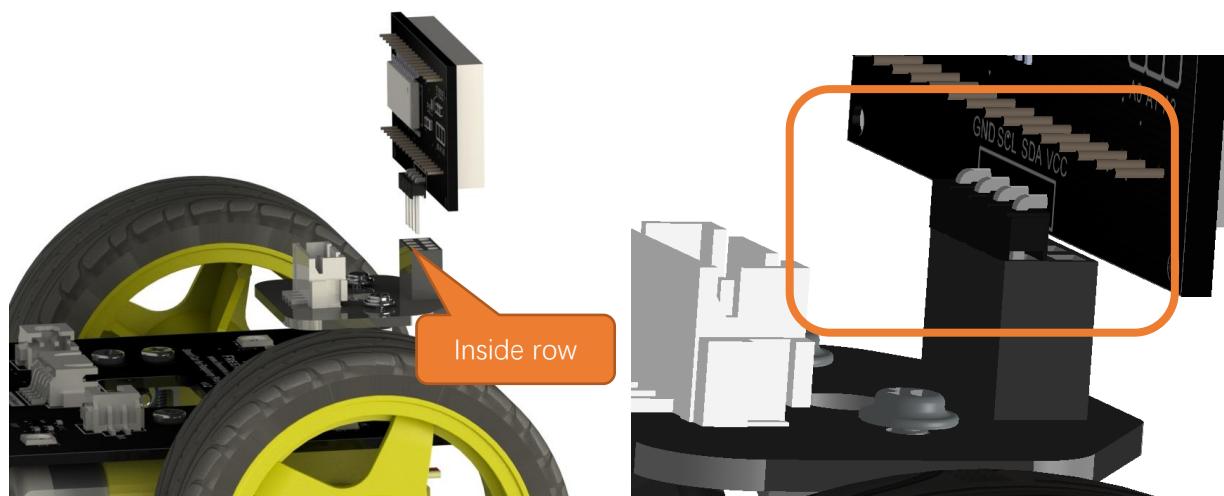


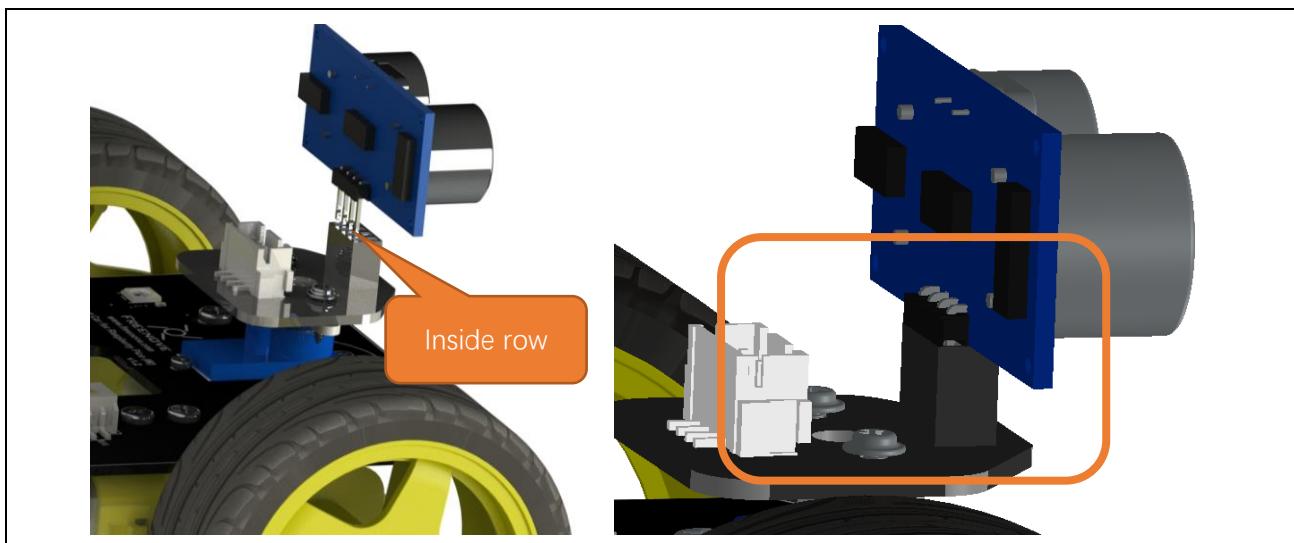
Step 3 Connect the two connectors marked below with a cable.



Plugging in LED Matrix or ultrasonic module.

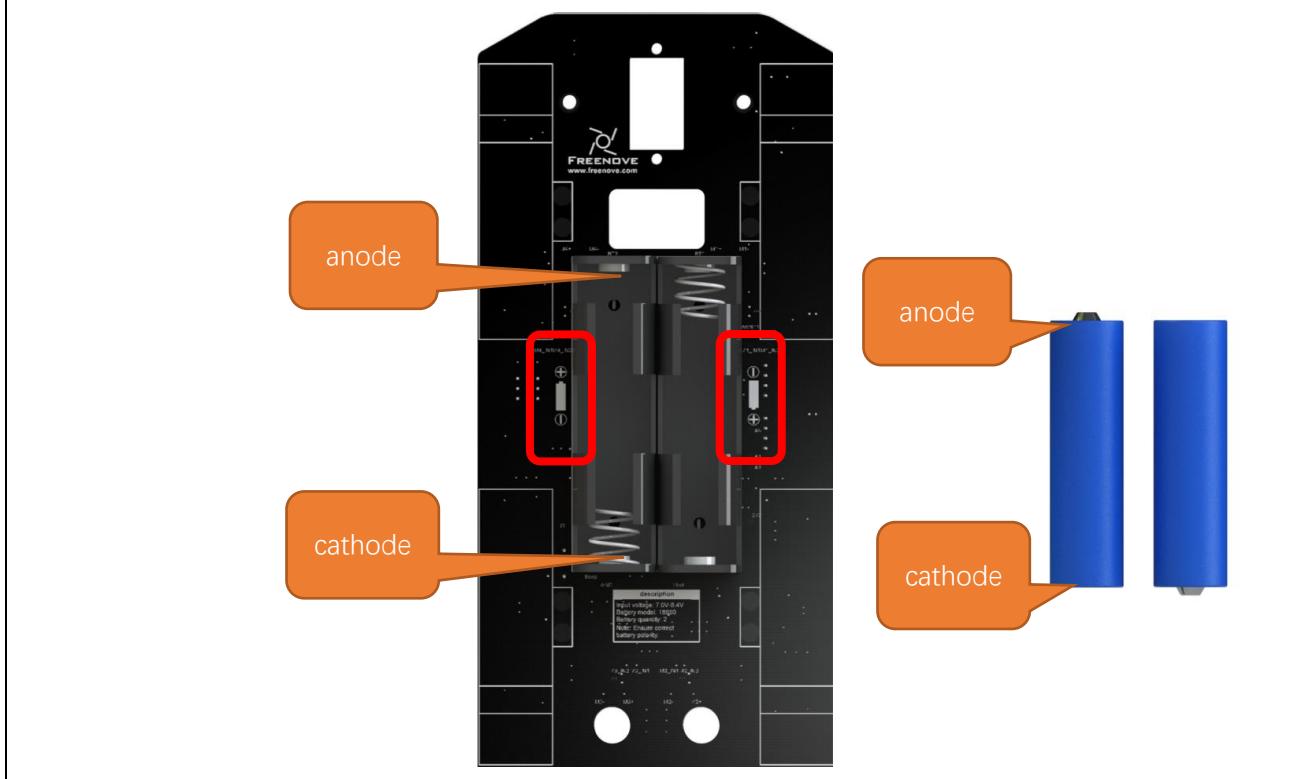
Step 1 Install LED Matrix or ultrasonic module.

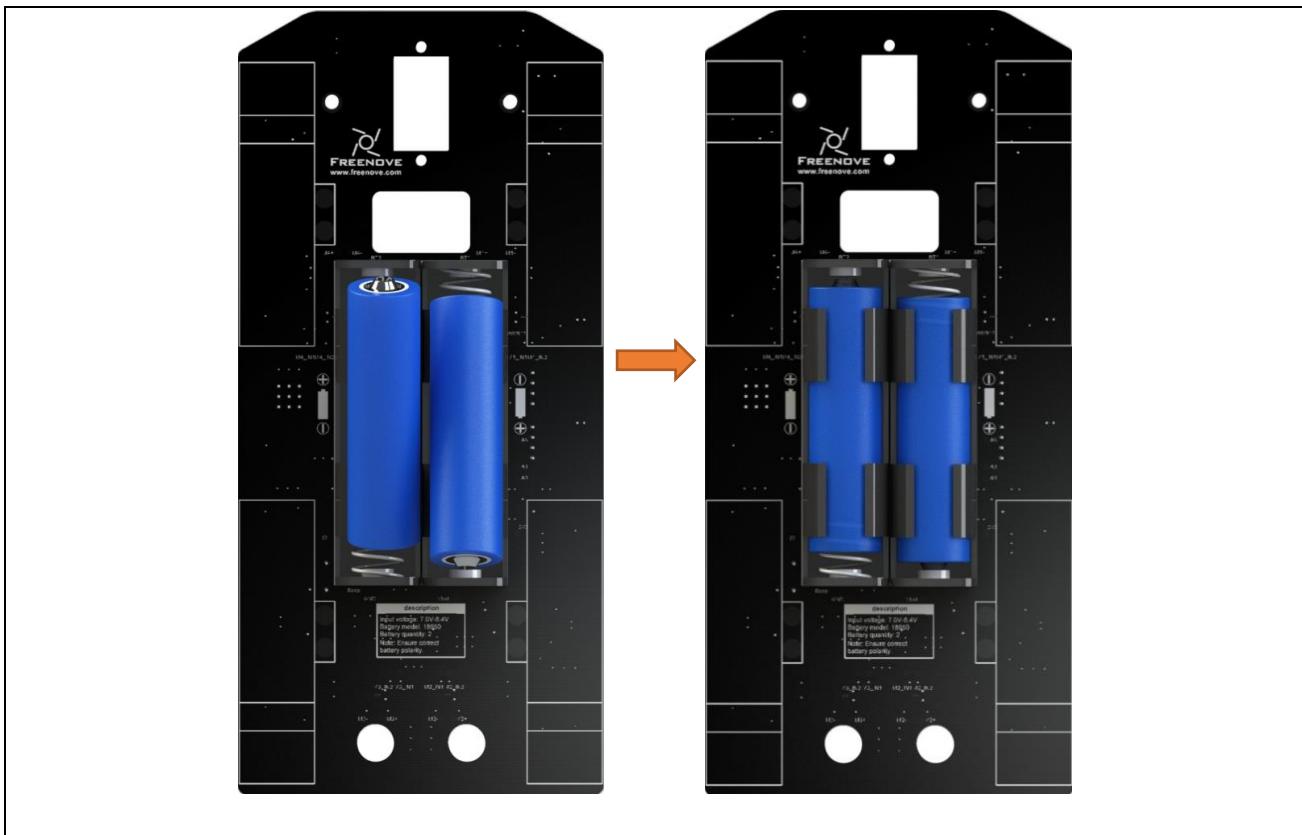




Installing two 18650 batteries

Step 1 Installed with batteries. When installing them, please following the silk print on the board.

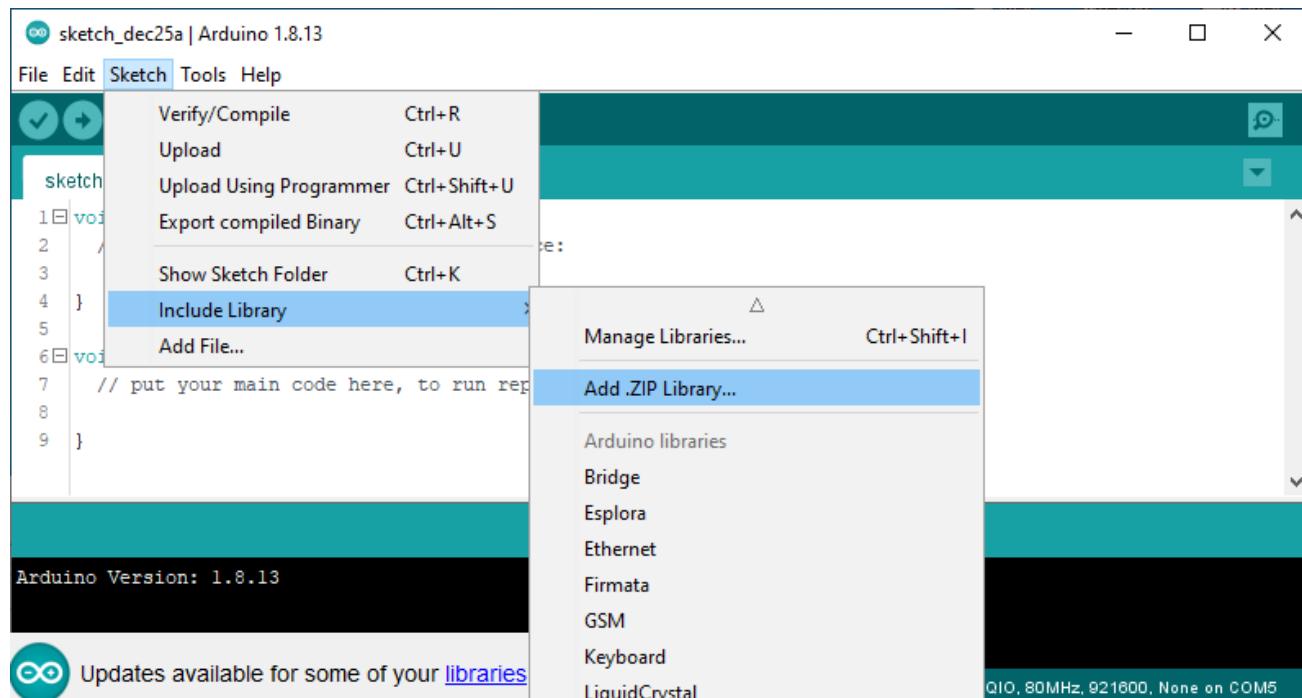




How to Play

Add libraries

Open the **Arduino IDE**, Click **Sketch** on the menu bar ->**Include Library** -> **Add .ZIP Library...**



In the new pop-up window, select **Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico_W\Libraries**, select every Library, click **Open**, and repeat this process until you have installed all six Libraries into the Arduino.

› Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico › Libraries

- Adafruit_NeoPixel.zip
- Freenove_VK16K33_Lib.zip
- IRremote.zip
- RP2040_PWM-main.zip

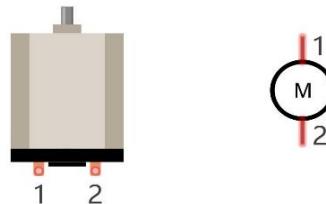
Chapter 2 Module test

If you have any concerns, please feel free to contact us via support@freenove.com

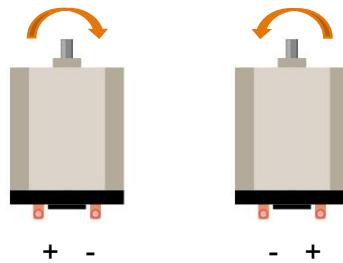
2.1 Motor

Motor

A motor is a device that converts electrical energy into mechanical energy. Motor consists of two parts: stator and rotor. When motor works, the stationary part is stator, and the rotating part is rotor. Stator is usually the outer case of motor, and it has terminals to connect to the power. Rotor is usually the shaft of motor, and can drive other mechanical devices to run. Diagram below is a small DC motor with two pins.



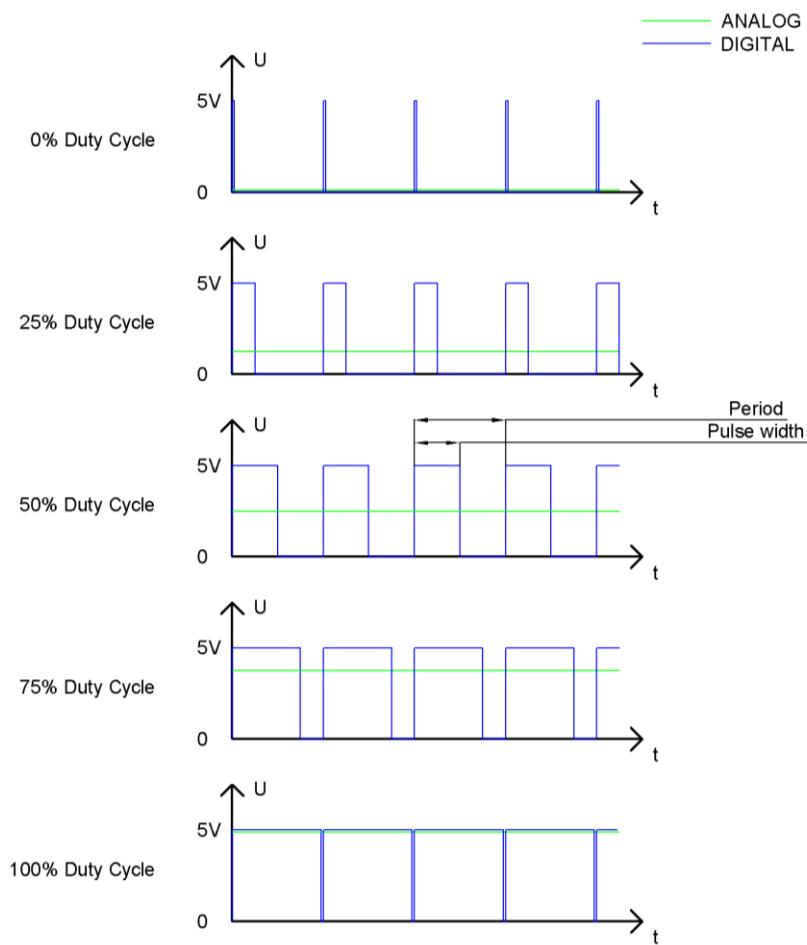
When a motor is connected to the power supply, it will rotate in one direction. Reverse the polarity of power supply, then the motor rotates in opposite direction.



PWM

PWM, Pulse Width Modulation, uses digital pins to send certain frequencies of square waves, that is, the output of high levels and low levels, which alternately last for a while. The total time for each set of high levels and low levels is generally fixed, which is called the period (the reciprocal of the period is frequency). The time of high level outputs are generally called "pulse width", and the duty cycle is the percentage of the ratio of pulse duration, or pulse width (PW) to the total period (T) of the waveform.

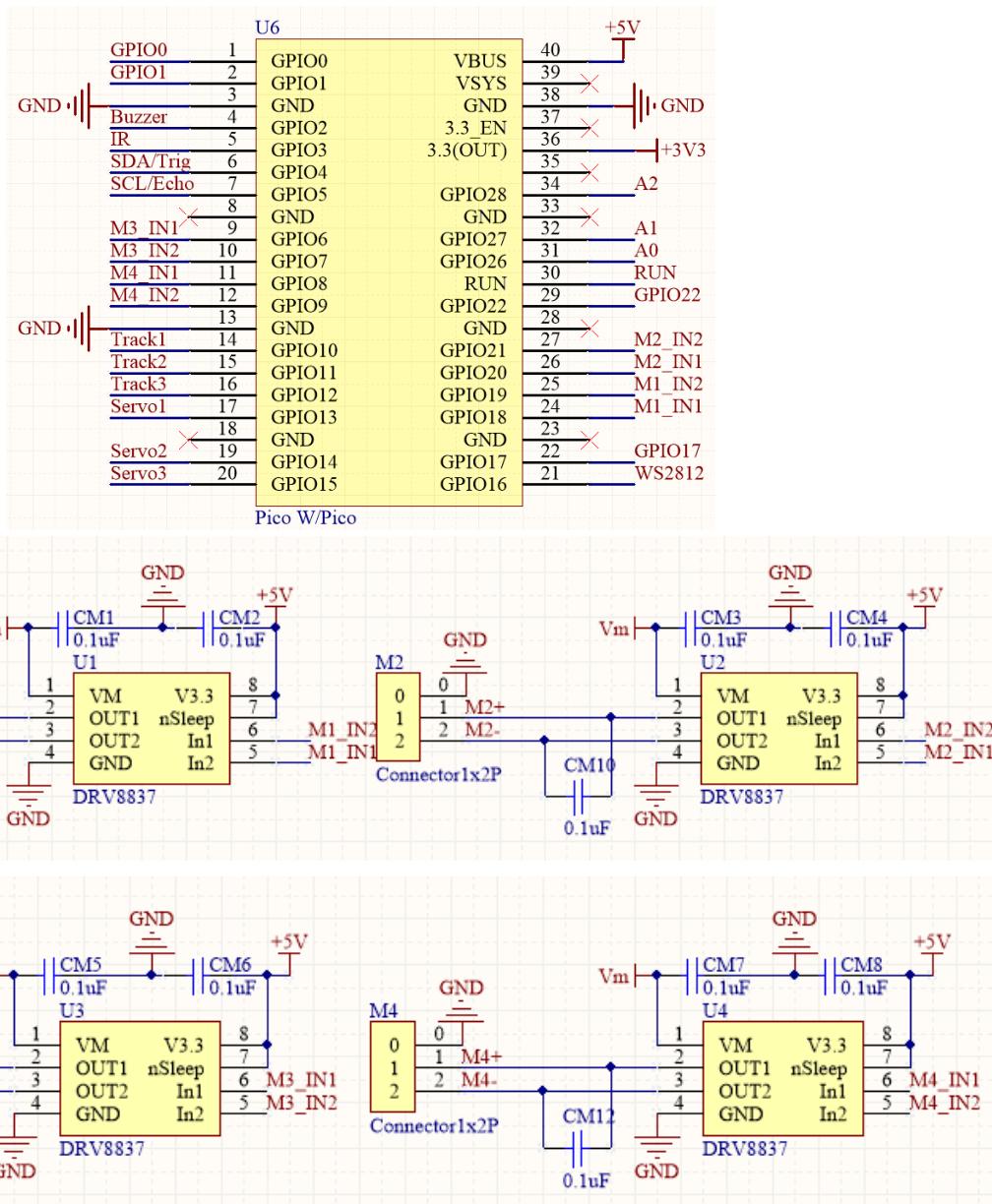
The longer the output of high levels last, the larger the duty cycle and the higher the corresponding voltage in analog signal will be. The following figures show how the analogs signal voltage vary between 0V-5V (high level is 5V) corresponding to the pulse width 0%-100%:



The longer the PWM duty cycle is, the higher the output power will be. Now that we understand this relationship, we can use PWM to control the brightness of an LED or the speed of DC motor and so on.

Schematic

The PWM control signal of this car is provided by Pico (W) with the RP2040_PWM library. RP2040_PWM library, the PWM library of Pico (W), uses Hardware-PWM module on RP2040-based boards to create and output the PWM of any GPIO pin. These purely hardware-based PWM channels can generate from very low (lowest is 7.5Hz * (F_CPU/125)) to very high PWM frequencies (in the MHz range, up to (F_CPU/2) or 62.5MHz). The reason why we use this library is that it is based on hardware-PWM channels, so its operation will not be blocked by bad-behaving software functions / tasks.



Pins of Raspberry Pi Pico W	Funtons	Description
GPIO18	Motor	M1_IN1
GPIO19		M1_IN2
GPIO20		M2_IN1
GPIO21		M2_IN2
GPIO6		M3_IN1
GPIO7		M3_IN2
GPIO8		M4_IN1
GPIO9		M4_IN2

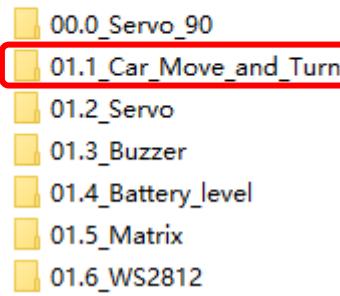
As can be seen from the figure above, pins 18 and 19 are configured to control motor M1, pins 20 and 21 to control M2, pins 6 and 7 to control M3, and pins 8 and 9 to control M4.

Mx_IN1	Mx_IN2	Rotating direction of the wheels
1	0	Forward
0	1	backward

Sketch

Next, we download the code to Raspberry Pi Pico (W) to test the motor. Open “01.1_Car_Move_and_Turn” folder under “**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches**” and double-click “01.1_Car_Move_and_Turn.ino”.

Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico > Sketches



Code

```
1 #include "Freenove_4WD_Car_For_Pico_W.h"
2 void setup()
3 {
4     Servo_Setup();
5     Motor_Setup();      // Motor initialization
6 }
7
8 void loop()
9 {
10    Motor_Move(50 , 50);    //go forward
11    delay(1000);
12    Motor_Move(0 , 0);      //stop
13    delay(1000);
14    Motor_Move(-50 , -50); //go back
15    delay(1000);
16    Motor_Move(0 , 0);      //stop
17    delay(1000);
18    Motor_Move(-50 , 50);   //turn left
19    delay(1000);
20    Motor_Move(0 , 0);      //stop
21    delay(1000);
22    Motor_Move(50 , -50);   //turn right
23    delay(1000);
24    Motor_Move(0 , 0);      //stop
25    delay(1000);
```

	26 }
--	------

After downloading the code, please place the car to a relatively open area. Turn on the power switch and you can see the car go forward, backward, turn left and turn right repeatedly.

Code Explanation

If you are not familiar with Arduino IDE, you can visit <https://www.arduino.cc/reference/en/> to learn more.

Add the header file of the car. Each time before controlling the car, please add header file first.

1	#include "Freenove_4WD_Car_For_Pico_W.h"
---	--

Motor_Setup function, initialize the driver chip of the motor.

5	5 Motor_Setup() ; // Motor initialization
---	---

Loop function can be used repeatedly in the program. Here we call Motor_Move function to control the car to move forward, backward, turn left and turn right repeatedly.

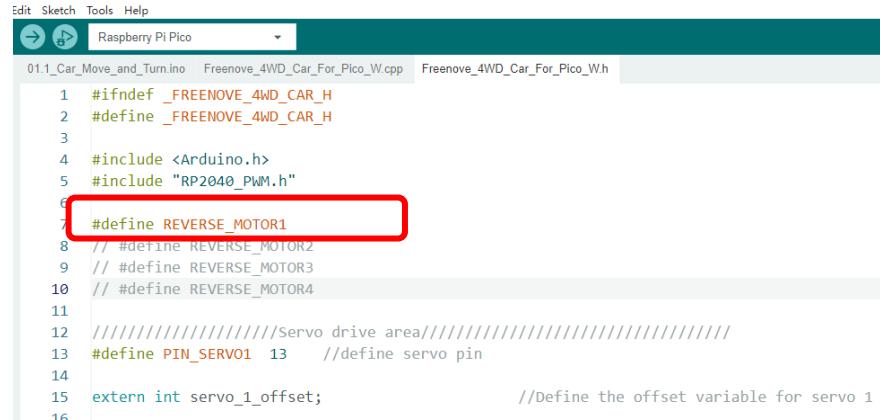
8	8 void loop()
9	{
10	10 Motor_Move(50 , 50) ; //go forward
11	11 delay(1000) ;
12	12 Motor_Move(0 , 0) ; //stop
13	13 delay(1000) ;
14	14 Motor_Move(-50 , -50) ; //go back
15	15 delay(1000) ;
16	16 Motor_Move(0 , 0) ; //stop
17	17 delay(1000) ;
18	18 Motor_Move(-50 , 50) ; //turn left
19	19 delay(1000) ;
20	20 Motor_Move(0 , 0) ; //stop
21	21 delay(1000) ;
22	22 Motor_Move(50 , -50) ; //turn right
23	23 delay(1000) ;
24	24 Motor_Move(0 , 0) ; //stop
25	25 delay(1000) ;
26	26 }

Motor_Move_Init function is to control the car. The four parameters m1_speed, m2_speed, m3_speed, m4_speed range from -100 to 100. When the value is positive number, the motors move forward. Otherwise, they move backwards. m1_speed, m2_speed represent the two motors on the left and m3_speed, m4_speed embody those on the right.

	void Motor_Move_Init(int m1_speed, int m2_speed, int m3_speed, int m4_speed);
--	---

The Motor_Move function is used to control the car, which sets the left two motors as one group and the right two motors as the other, with the motors in the same group featuring the same speed.

If your car is moving in the opposite direction of the programmed direction, you can change the motor rotation direction of the motors through micro definition. Take the motor M1 as an example, modify the macro definition in the "Freenove_4WD_Car_For_Pico_W.h" file to "#define REVERSE_MOTOR1".



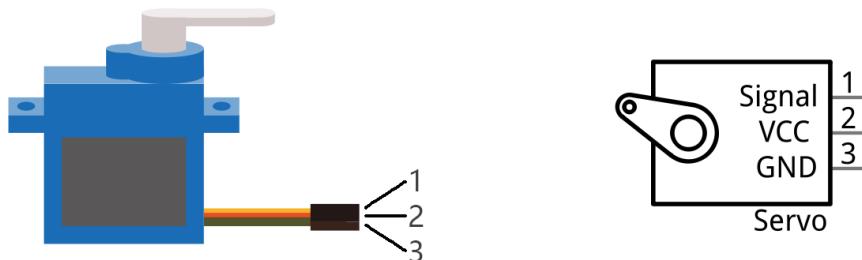
```
01.1_Car_Move_and_Turn.ino  Freenove_4WD_Car_For_Pico_W.cpp  Freenove_4WD_Car_For_Pico_W.h
1 #ifndef _FREENOVE_4WD_CAR_H
2 #define _FREENOVE_4WD_CAR_H
3
4 #include <Arduino.h>
5 #include "RP2040_PWM.h"
6
7 #define REVERSE_MOTOR1
8 // #define REVERSE_MOTOR2
9 // #define REVERSE_MOTOR3
10 // #define REVERSE_MOTOR4
11
12 ////////////////////Servo drive area///////////////////////////////
13 #define PIN_SERVO1 13 //define servo pin
14
15 extern int servo_1_offset; //Define the offset variable for servo 1
16
```

```
void Motor_Move(int Left_speed, int Right_speed) {
    int lf, lb, rf, rb;
    lf = lb = Left_speed;
    rf = rb = Right_speed;
#ifdef REVERSE_MOTOR1
    lf = -Left_speed;
#endif
#ifdef REVERSE_MOTOR2
    lb = -Left_speed;
#endif
#ifdef REVERSE_MOTOR3
    rf = -Right_speed;
#endif
#ifdef REVERSE_MOTOR4
    rb = -Right_speed;
#endif
    Motor_Move_Init(lf, lb, rf, rb);
}
```

2.2 Servo

Servo

Servo is a compact package, which consists of a DC motor, a set of reduction gears to provide torque, a sensor and control circuit board. Most servos only have a 180-degree range of motion via their "horn". Servos can output higher torque than a simple DC motor alone and they are widely used to control motion in model cars, model airplanes, robots, etc. Servos have three wire leads that usually terminate to a male or female 3-pin plug. Two leads are for electric power: positive (2-VCC, Red wire), negative (3-GND, Brown wire), and the signal line (1-Signal, Orange wire), as represented in the Servo provided in your Kit.



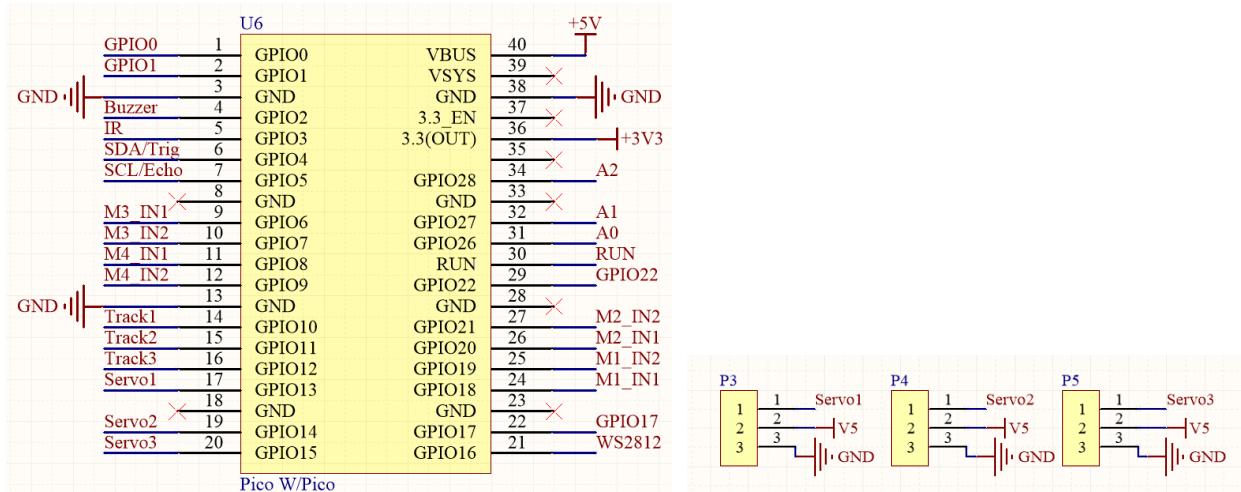
We will use a 50Hz PWM signal with a duty cycle in a certain range to drive the Servo. The lasting time of 0.5ms-2.5ms of PWM single cycle high level corresponds to the servo angle 0 degrees - 180 degree linearly. Part of the corresponding values are as follows:

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

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

Schematic

Pico (W), based on the RP2040_PWM library, provides the servos' driving signals.



Sketch

Download the code to Raspberry Pi Pico (W) to make servo sweep back and forth.

Open “01.2_Servo” in “**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches**” and double-click “01.2_Servo.ino”.

Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico > Sketches

- 00.0_Servo_90
- 01.1_Car_Move_and_Turn
- 01.2_Servo**
- 01.3_Buzzer
- 01.4_Battery_level
- 01.5_Matrix
- 01.6_WS2812
- 02.1_Ultrasonic_Ranging
- 02.2_Ultrasonic_Ranging_Car
- 03.1_Photosensitive
- 03.2_Photosensitive_Car

Code

```
1 #include "Freenove_4WD_Car_For_Pico_W.h"
2 void setup()
3 {
4     Servo_Setup();          //Servo initialization
5     Servo_1_Angle(90);    //Set servo 1 Angle
6     delay(1000);
7 }
8
9 void loop()
10 {
11     // Servo 1 motion path; 90°- 30°- 150°- 90°
12     Servo_Sweep(1, 90, 30);
13     Servo_Sweep(1, 30, 150);
14     Servo_Sweep(1, 150, 90);
15 }
```

Code Explanation

Add header file of servos. Each time before controlling servos, please add header file first.

```
1 #include "Freenove_4WD_Car_For_Pico_W.h"
```

Initialize the servo driven chip.

```
4 Servo_Setup();          //Servo initialization
```

Set the angle of the two servos to 90°.

```
5     Servo_1_Angle(90);    //Set servo 1 Angle
```

Sweep function of the servos. Servo_id stands for the servo number. Angle_start represents the starting position of the servo when sweeping while angle_end is the ending position. Note: the sweeping range of servo1 is 30-150°.

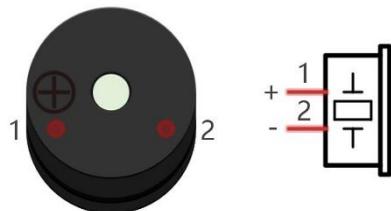
```
void Servo_Sweep(int servo_id, int angle_start, int angle_end);
```

2.3 Buzzer

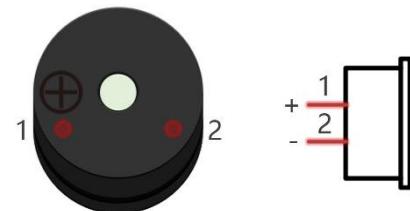
Buzzer

Buzzer is a sounding component, which is widely used in electronic devices such as calculator, electronic warning clock and alarm. Buzzer has two types: active and passive. Active buzzer has oscillator inside, which will 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



Passive buzzer



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 its resonant frequency is 2kHz.

How to identify active and passive buzzer

1. Usually, there is a label on the surface of active buzzer covering the vocal hole, but this is not an absolute judgment method.
2. Active buzzers are more complex than passive buzzers in their manufacture. There are many circuits and crystal oscillator elements inside active buzzers; all of this is usually protected with a waterproof coating (and a housing) exposing only its pins from the underside. On the other hand, passive buzzers do not have protective coatings on their underside. From the pin holes viewing of a passive buzzer, you can see the circuit board, coils, and a permanent magnet (all or any combination of these components depending on the model).

Active buzzer



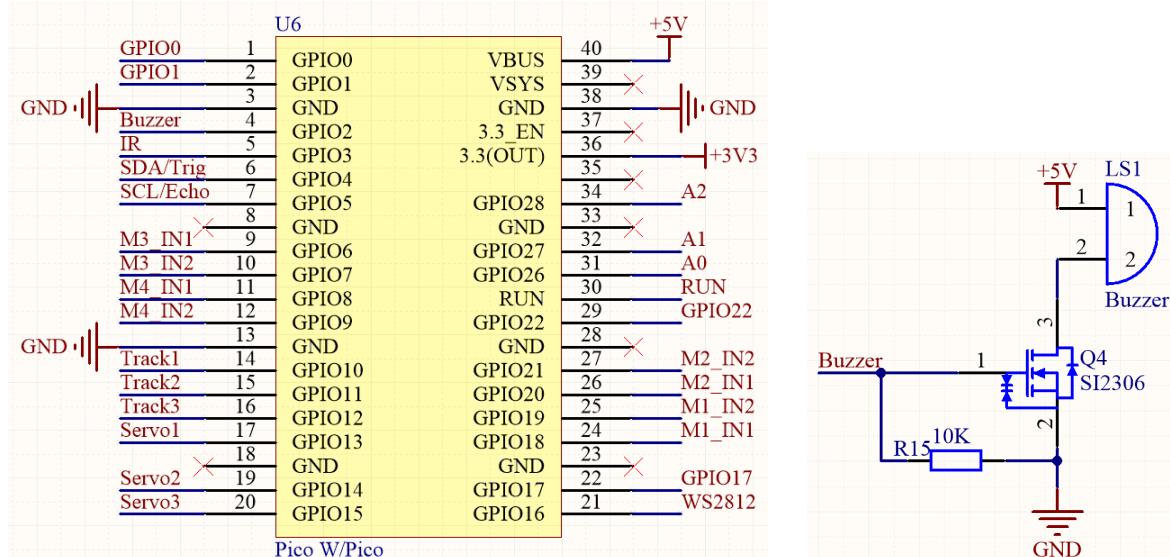
Passive buzzer



The buzzer used in this car is a passive buzzer that can make sounds with different frequency.

Schematic

As we can see, the buzzer is controlled by GPIO2 of Raspberry Pi Pico W. When the buzzer receives PWM signal, NPN will be activated to make the buzzer sound. When the buzzer receives no signal, it will be controlled at low level by R2 and NPN will not be activated, so the buzzer will not make any sounds.



Sketch

In this section, we will test the buzzer to make it sound like an alarm.

Open “01.3_Buzzer” folder in the

“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches”, and then double-click “01.3_Buzzer.ino”.

Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico > Sketches

- 00.0_Servo_90
- 01.1_Car_Move_and_Turn
- 01.2_Servo
- 01.3_Buzzer**
- 01.4_Battery_level
- 01.5_Matrix
- 01.6_WS2812
- 02.1_Ultrasonic_Ranging
- 02.2_Ultrasonic_Ranging_Car

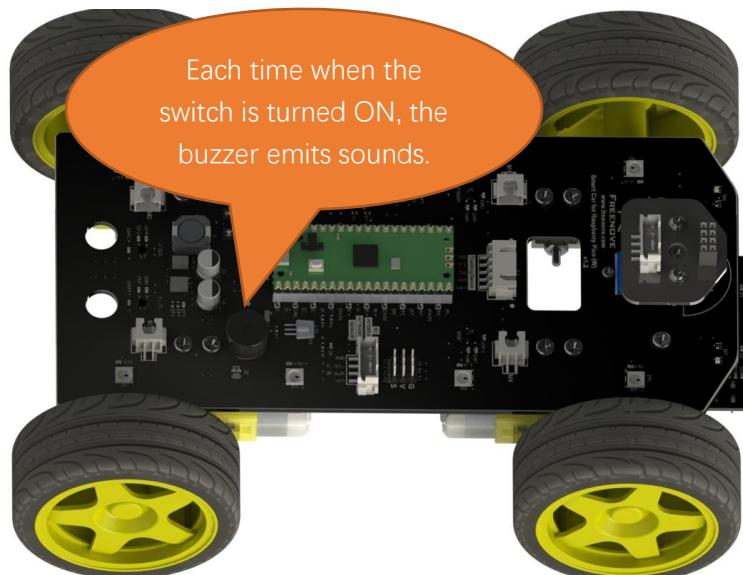
Code

```

1 #include "Freenove_4WD_Car_For_Pico_W.h"
2
3 void setup() {
4     Buzzer_Setup();      //Buzzer initialization function
5     Buzzer_Alert(4, 3); //Control the buzzer to sound
6 }
7
8 void loop() {
9     delay(1000);
10}

```

After the program is downloaded to Raspberry Pi Pico (W), the buzzer emits four short beeps, repeating for three times.



Code Explanation

Configure the PWM of Raspberry Pi Pico (W) to associate it with GPIO2 pin to control the buzzer to make sounds.

	void Buzzer_Setup(void);	//Buzzer initialization
--	--------------------------	-------------------------

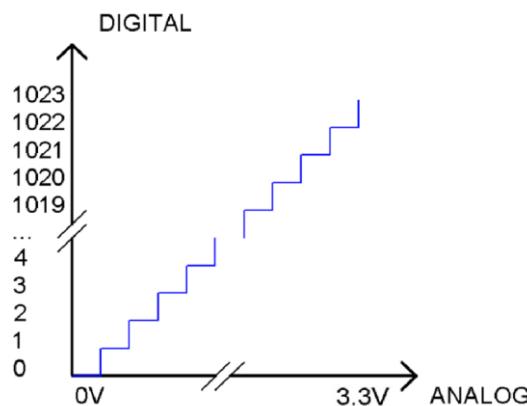
Control the buzzer to sound regularly. Parameter beat represents the number of times the buzzer sounds in each sounding cycle and rebeat represents how many cycles the buzzer sounds.

	void Buzzer_Alert(int beat, int rebeat); //Buzzer alarm function
--	--

2.4 ADC Module

ADC

ADC is an electronic integrated circuit used to convert analog signals such as voltages to digital or binary form consisting of 1s and 0s. The range of our ADC on Raspberry Pi Pico (W) is 10 bits, that means the resolution is $2^{10}=1024$, and it represents a range (at 3.3V) will be divided equally to 1024 parts. The range of analog values corresponds to ADC values. So the more bits the ADC has, the denser the partition of analog will be and the greater the precision of the resulting conversion.



Subsection 1: the analog in range of 0V---3.3/1023 V corresponds to digital 0;

Subsection 2: the analog in range of 3.3/1023 V---2*3.3 /1023V corresponds to digital 1;

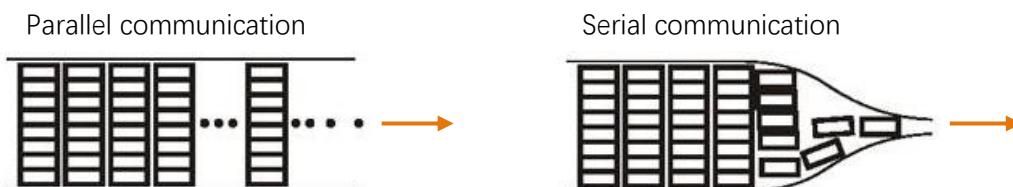
The following analog will be divided accordingly.

The conversion formula is as follows:

$$ADC\ Value = \frac{\text{Analog\ Voltage}}{3.3} * 1023$$

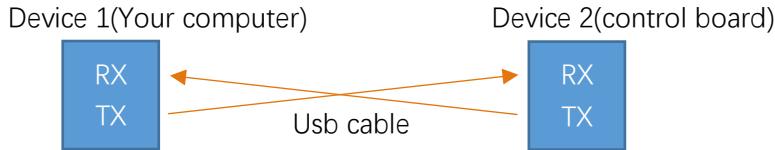
Serial Communication

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, which is especially suitable for computers to computers, long distance communication between computers and peripherals. Parallel communication is faster, but it requires more cables and higher cost, so it is not appropriate for long distance communication.



Serial communication generally refers to the Universal Asynchronous Receiver/Transmitter (UART), which is commonly used in electronic circuit communication. It has two communication lines; one is responsible for

sending data (TX line) and the other for receiving data (RX line). The serial communication connections of two devices use is as follows:

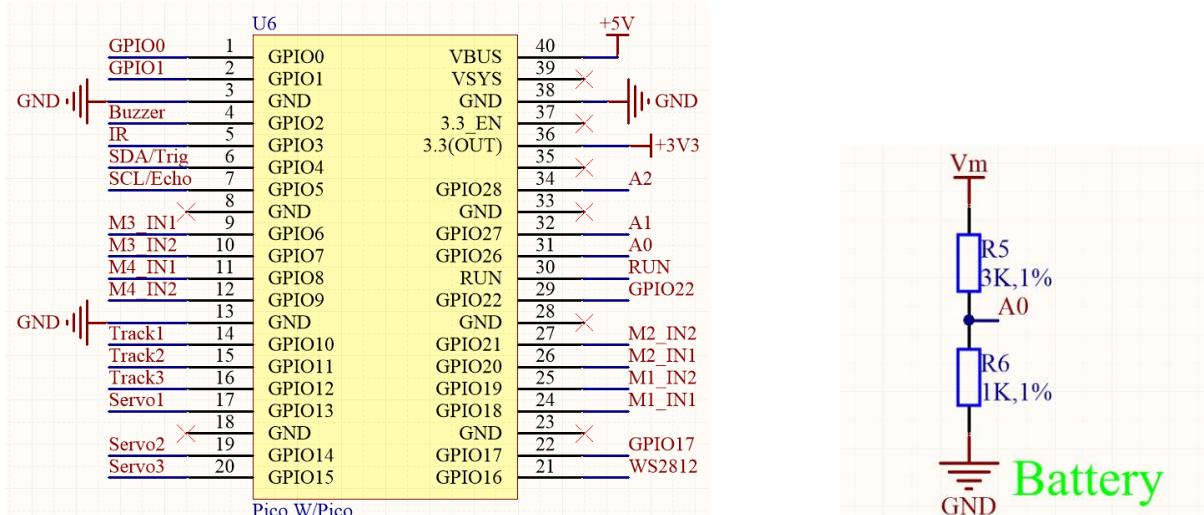


For serial communication, the **baud rate in both sides must be the same**. The baud rates commonly used are 9600 and 115200.

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

Schematic

As we can see, the car reads the voltage of the batteries through GPIO26 of Raspberry Pi Pico (W).



The voltage acquisition range of GPIO26 on Raspberry Pi Pico W is 0-3.3V, while the car is powered by two 18650-lithium batteries, whose voltage is 8.4V when they are fully charged, which exceeds the acquisition range of Raspberry Pi Pico (W). Therefore, after passing through the voltage divider circuit composed of R3 and R4, the voltage at A0 will be about 1/4 of the battery voltage, $8.4/4=2.1V$, which is within the voltage collection range of GPIO26.

Sketch

In this section, we will use GPIO26 of Raspberry Pi Pico (W) to read the voltage value of the batteries and print it on serial monitor. Open “01.4_Battery_level” folder in “Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches” and then double-click “01.4_Battery_level.ino”.

Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico > Sketches

- 00.0_Servo_90
- 01.1_Car_Move_and_Turn
- 01.2_Servo
- 01.3_Buzzer
- 01.4_Battery_level**
- 01.5_Matrix
- 01.6_WS2812
- 02.1_Ultrasonic_Ranging
- 02.2_Ultrasonic_Ranging_Car
- 03.1_Photosensitive
- 03.2_Photosensitive_Car

Code

```

1 #include "Freenove_4WD_Car_For_Pico_W.h"
2
3 void setup() {
4     Serial.begin(115200); //Set the Serial Baud rate
5 }
6 void loop() {
7     Serial.print("Battery ADC : ");
8     Serial.println(Get_Battery_Voltage_ADC()); //Gets the battery ADC value
9     Serial.print("Battery Voltage : ");
10    Serial.print(Get_Battery_Voltage()); //Get the battery voltage value
11    Serial.println("V");
12    delay(300);
13 }
```

Code Explanation

Activate the serial port and set the baud rate to 115200.

4	Serial.begin(115200); //Set the Serial Baud rate
---	--

Get ADC sampling value of GPIO26 and return it. The ADC has a range of 0-1023. The voltage range collected is 0-3.3V.

	int Get_Battery_Voltage_ADC(void); //Gets the battery ADC value
--	---

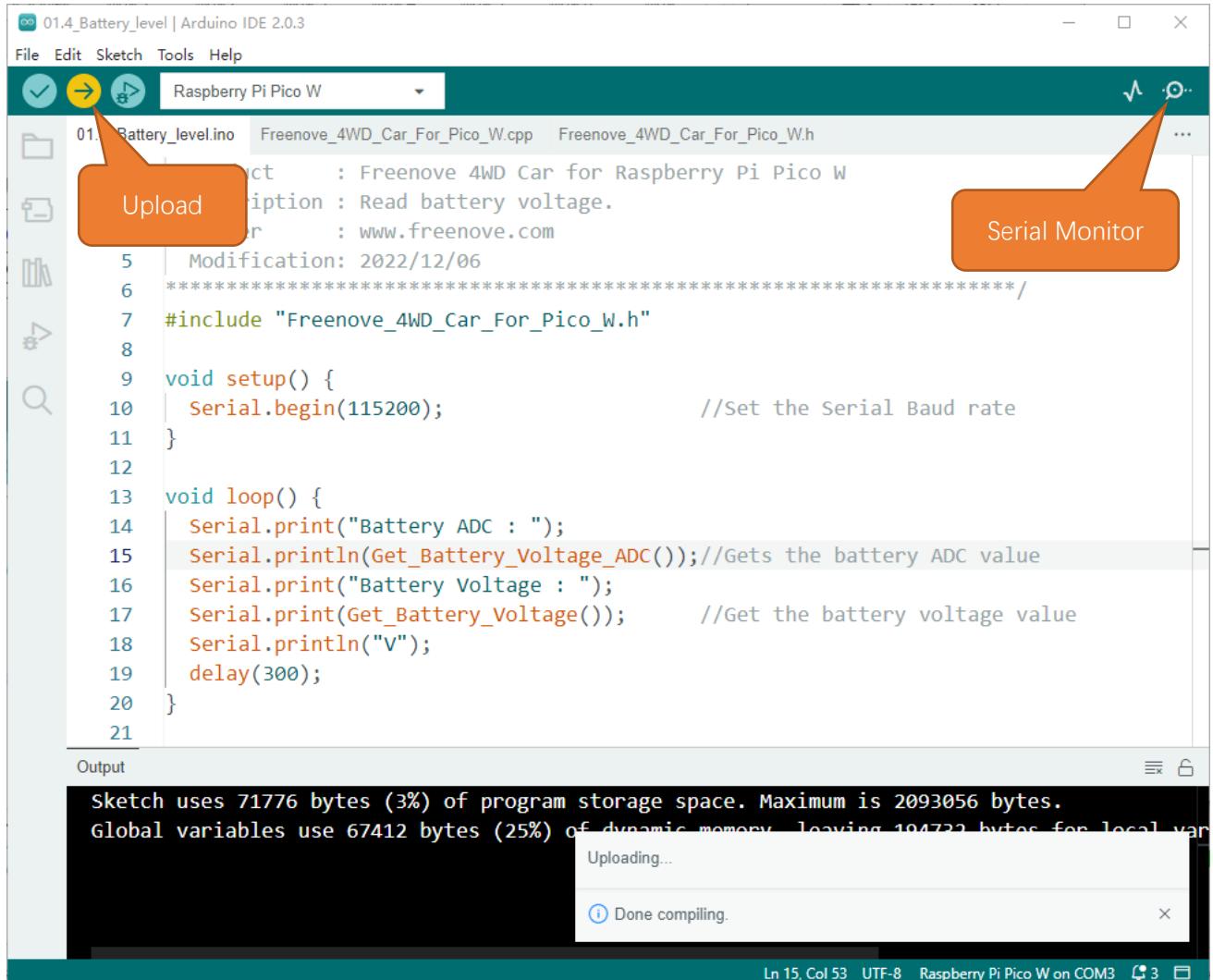
Calculate the voltage of batteries and return it.

```
float Get_Battery_Voltage(void); //Get the battery voltage value
```

The default battery voltage coefficient is 3. Users can modify it by calling this function.

```
void Set_Battery_Coefficient(float coefficient); //Set the partial pressure coefficient
```

Click "Upload" to upload the code to Pico (W). After uploading successfully, click Serial Monitor



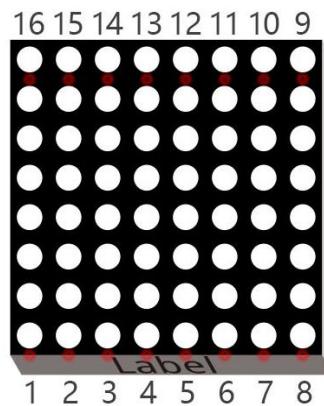
Set baud rate to 115200.



2.5 LED Matrix

LED Matrix

A LED matrix is a rectangular display module that consists of a uniform grid of LEDs. The following is an 8X8 monochrome LED matrix containing 64 LEDs (8 rows by 8 columns).

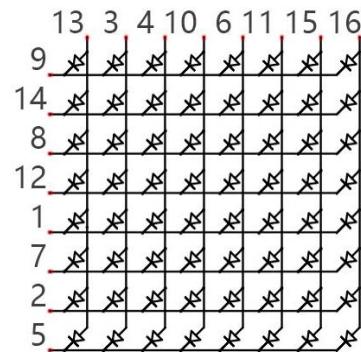


In order to facilitate the operation and reduce the number of ports required to drive this component, the positive poles of the LEDs in each row and negative poles of the LEDs in each column are respectively connected together inside the LED matrix module, which is called a common anode. There is another arrangement type. Negative poles of the LEDs in each row and the positive poles of the LEDs in each column are respectively connected together, which is called a common cathode.

Connection mode of common anode

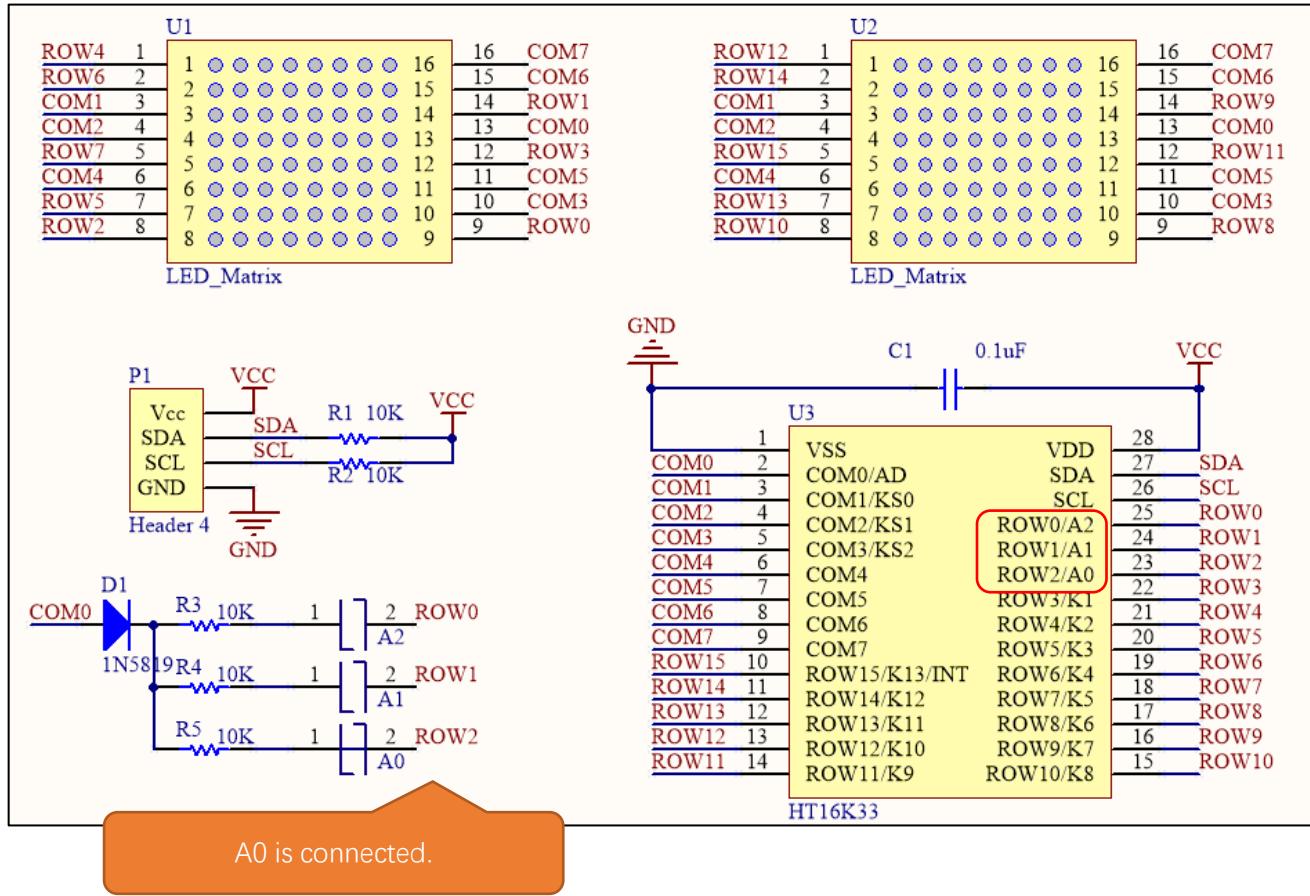


Connection mode of common cathode

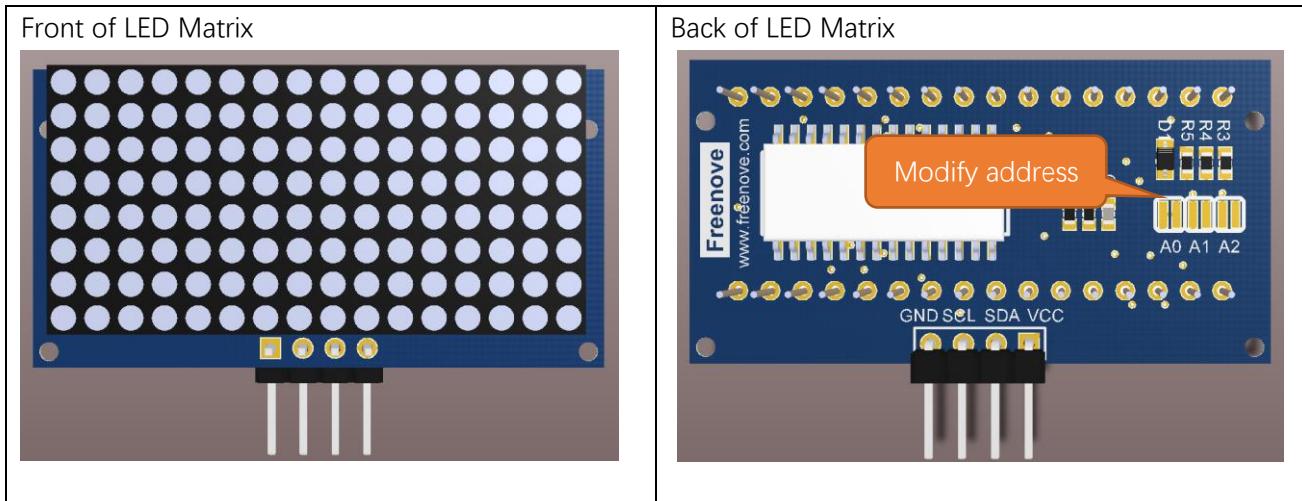


Schematic

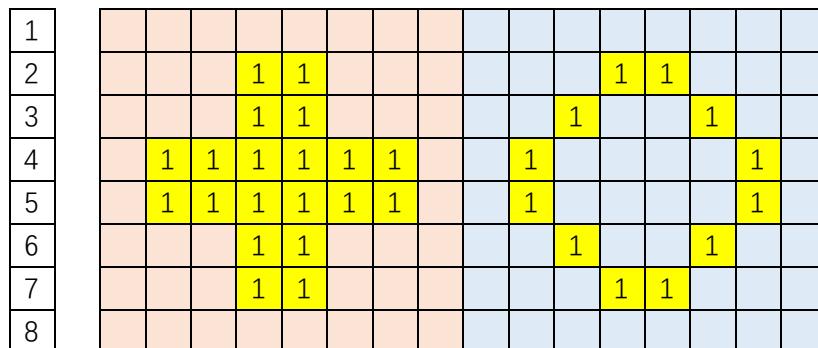
For this tutorial, the LED matrix module is individual and it is driven by IIC chip.



The LED matrix is common anode. As we can see from the schematic above, the anode of LED matrix is connected to ROWx of HT16K33 chip, and the cathode is connected to COMx. The address of HT16K33 chip is $(0x70 + [A2:A0])$, and the default address of LED matrix is 0x71. If you want to change the address, you can use a knife to cut the connecting line in the middle of A0, or connect A1/A2.



We divide the LED matrix into two sides and display “+” on the left and “o” on the right. As shown below, yellow stands for lit LED while other colors represent the OFF LED.



Below, the table on the left corresponds to the "+" above, and the table on the right corresponds to the "o" above.

Row	Binary	Hexadecimal
1	0000 0000	0x00
2	0001 1000	0x18
3	0001 1000	0x18
4	0111 1110	0x7e
5	0111 1110	0x7e
6	0001 1000	0x18
7	0001 1000	0x18
8	0000 0000	0x00

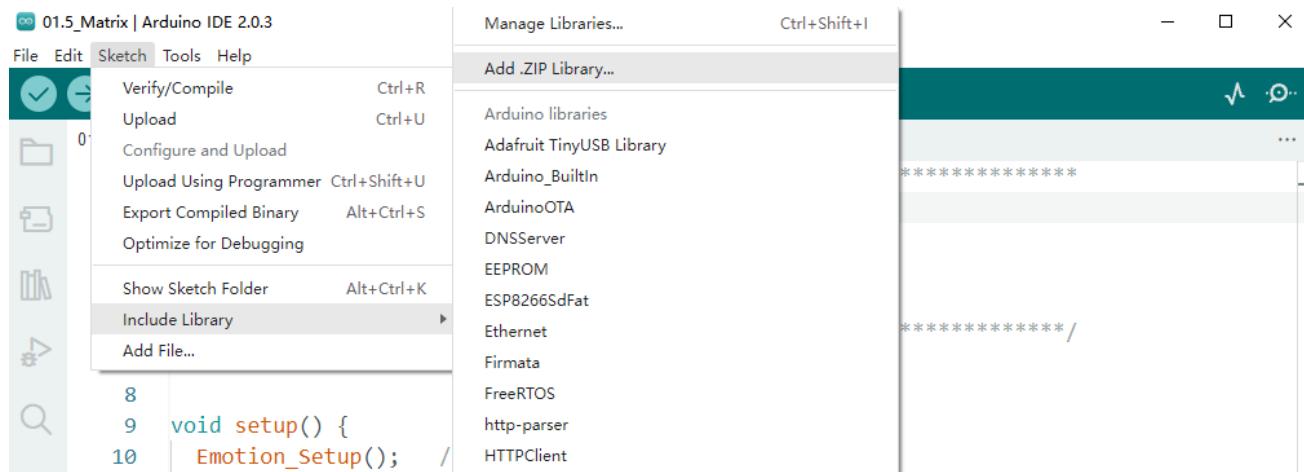
Row	Binary	Hexadecimal
1	0000 0000	0x00
2	0001 1000	0x18
3	0010 0100	0x24
4	0100 0010	0x42
5	0100 0010	0x42
6	0010 0100	0x24
7	0001 1000	0x18
8	0000 0000	0x00

Sketch

The LED matrix is controlled by HT16K33 chip. Therefore, before opening the program, we need to install Freenove_VK16K33_Lib library in advance.

Install Freenove_VK16K33_Lib Library

Click Sketch and select Add .ZIP Library in Include.



Select "Freenove_VK16K33_Lib.zip" in the folder Libraries of the folder

"Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico".

Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico > Libraries

- Adafruit_NeoPixel.zip
- Freenove_VK16K33_Lib.zip
- IRremote.zip
- RP2040_PWM-main.zip

Install Processing

In this tutorial, we use Processing to build a simple Led Matrix platform.

If you have not installed Processing, you can download it by clicking <https://processing.org/download/>. You can choose an appropriate version to download according to your PC system.

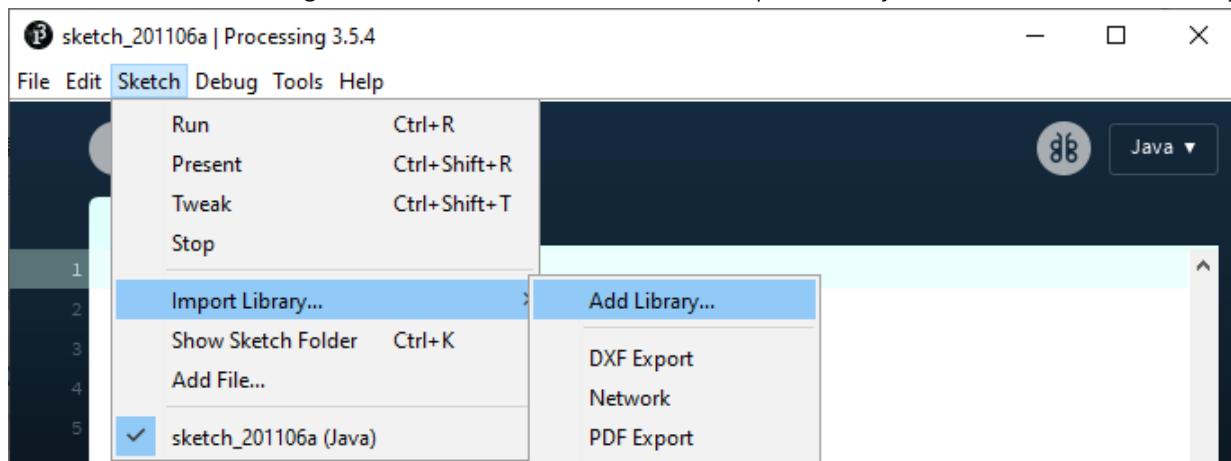
The screenshot shows the official Processing website. At the top, there's a navigation bar with links for "Processing", "p5.js", "Processing.py", "Processing for Android", "Processing for Pi", and "Processing Foundation". Below the navigation is a large "Processing" logo with a geometric background. To the right is a search bar. On the left, there's a sidebar with links like "Cover", "Download", "Donate", "Exhibition", "Reference", "Libraries", "Tools", "Environment", "Tutorials", "Examples", "Books", "Overview", and "People". The main content area has a heading "Download Processing. Processing is available for Linux, Mac OS X, and Windows. Select your choice to download the software below." It shows a large "3" logo and the text "3.5.4 (17 January 2020)". Below this are download links for "Windows 64-bit", "Windows 32-bit", "Linux 64-bit", and "Mac OS X". Further down, there's a section about changes in version 3.0 and links for "Github", "Report Bugs", "Wiki", "Supported Platforms", and "Platforms".

Unzip the downloaded file to your computer. Click "processing.exe" as the figure below to run this software.

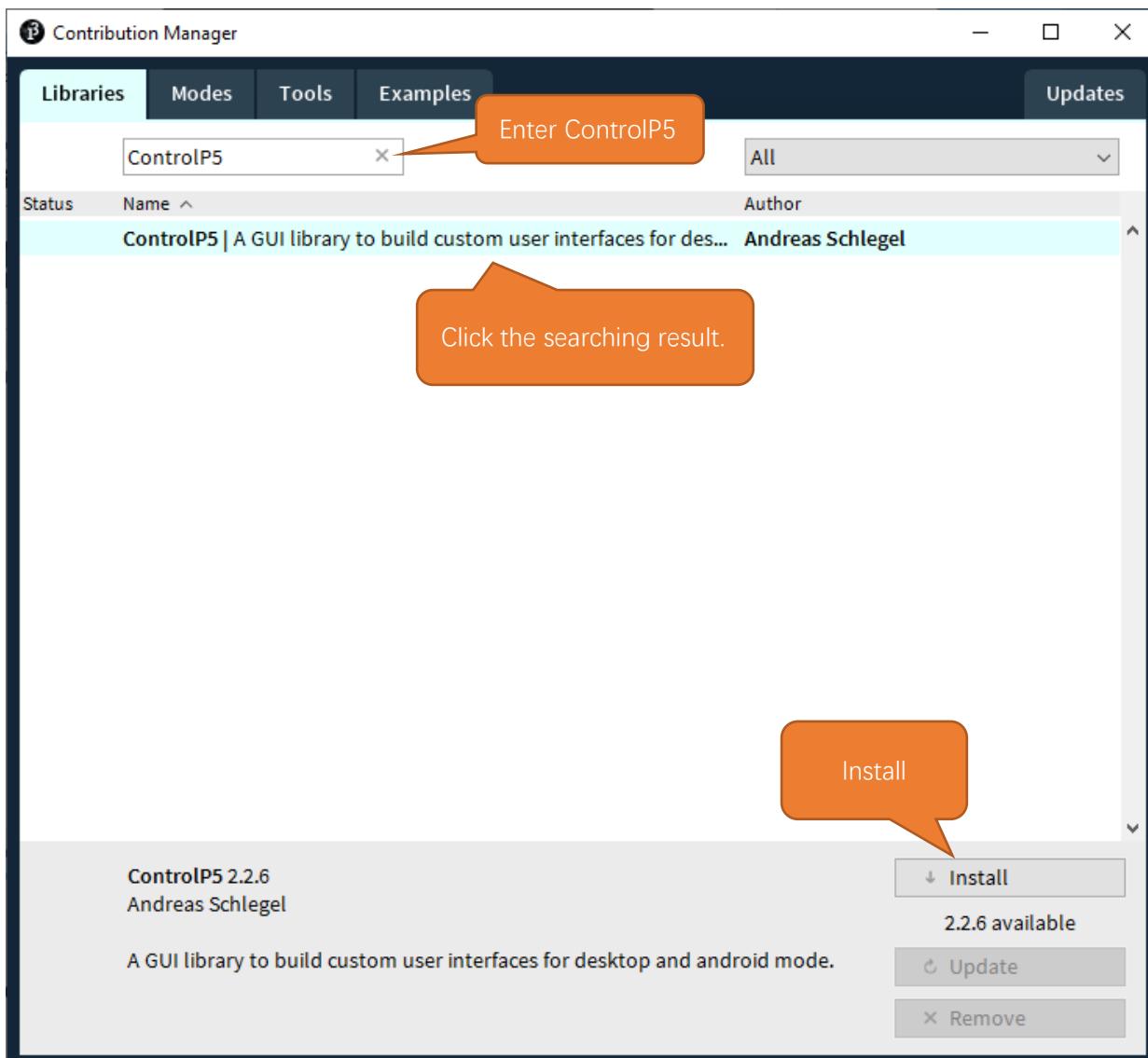
	core	2020/1/17 12:16
	java	2020/1/17 12:17
	lib	2020/1/17 12:16
	modes	2020/1/17 12:16
	tools	2020/1/17 12:16
	processing.exe	2020/1/17 12:16
	processing-java.exe	2020/1/17 12:16
	revisions.txt	2020/1/17 12:16

Need support? support.freenove.com

In the interface of Processing, click Sketch on Menu bar, select "Import Library..." and then click "Add Library..." .

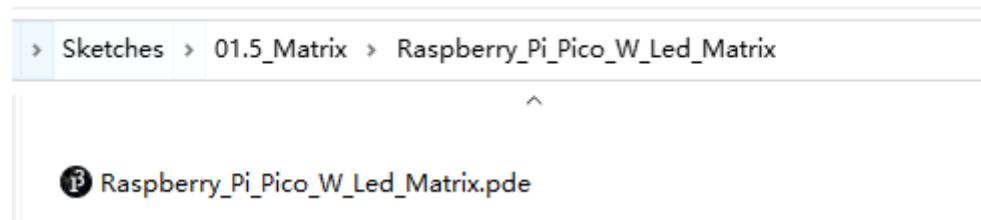


Enter "ControlP5" in the input field of the pop-up window. Click the searching result and then click "install"

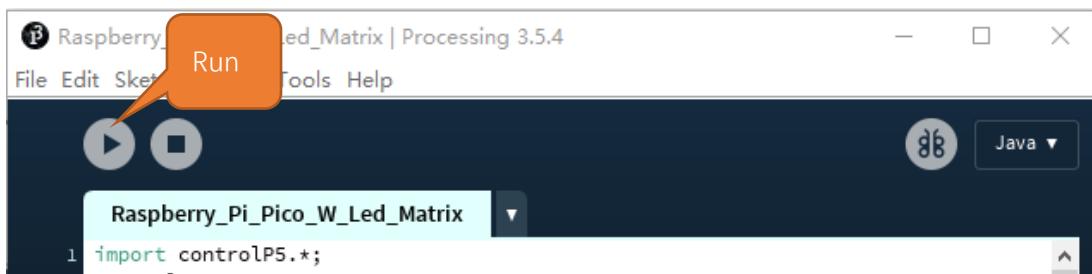


When the installation finishes, restart Processing.

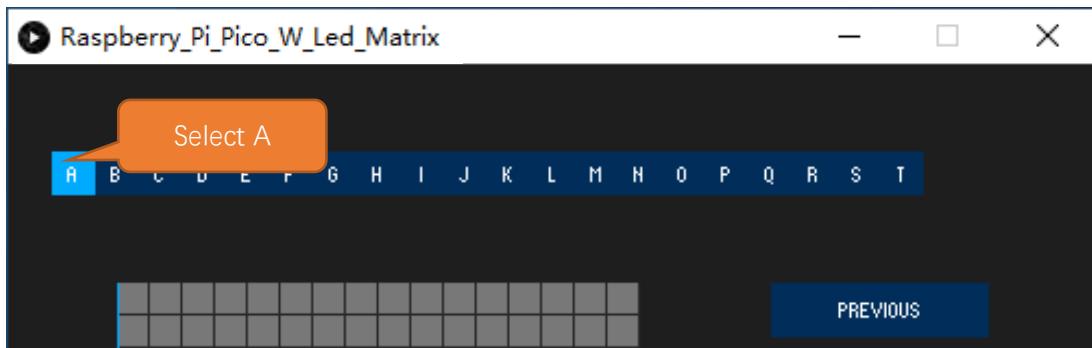
Open the folder Raspberry_Pi_Pico_W_Led_Matrix in 01.5_Matrix of the “Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches”. Here we take Windows as an example. Click to open Raspberry_Pi_Pico_W_Led_Matrix.pde.



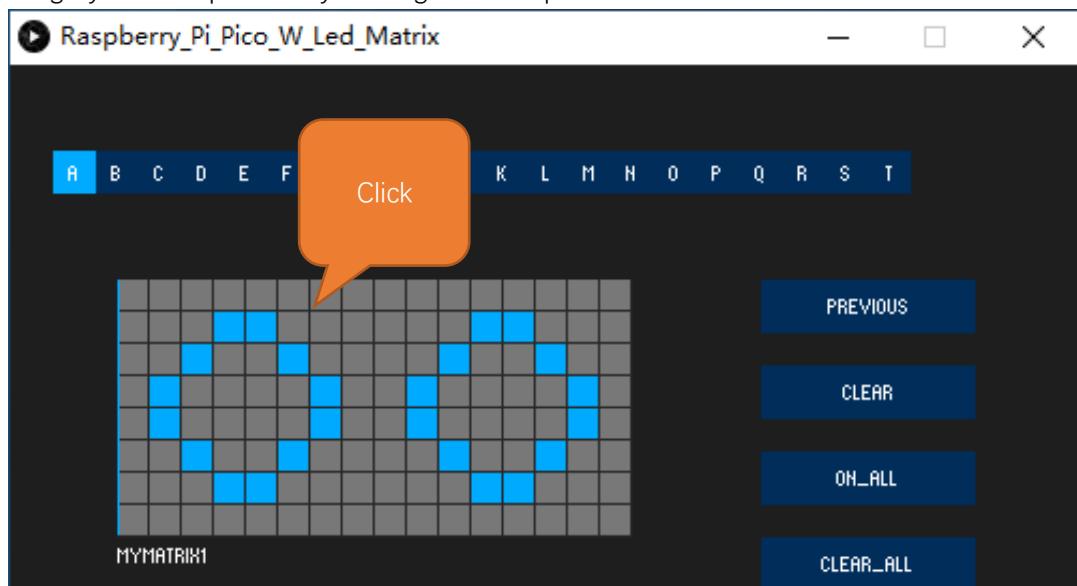
Click “Run”



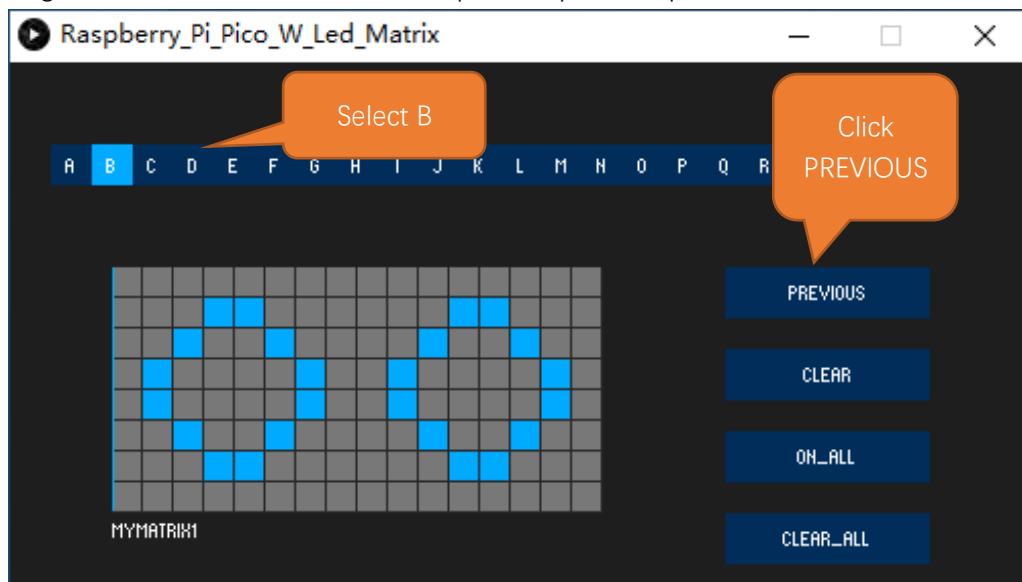
There are 20 pages from A to T. Select Page A.



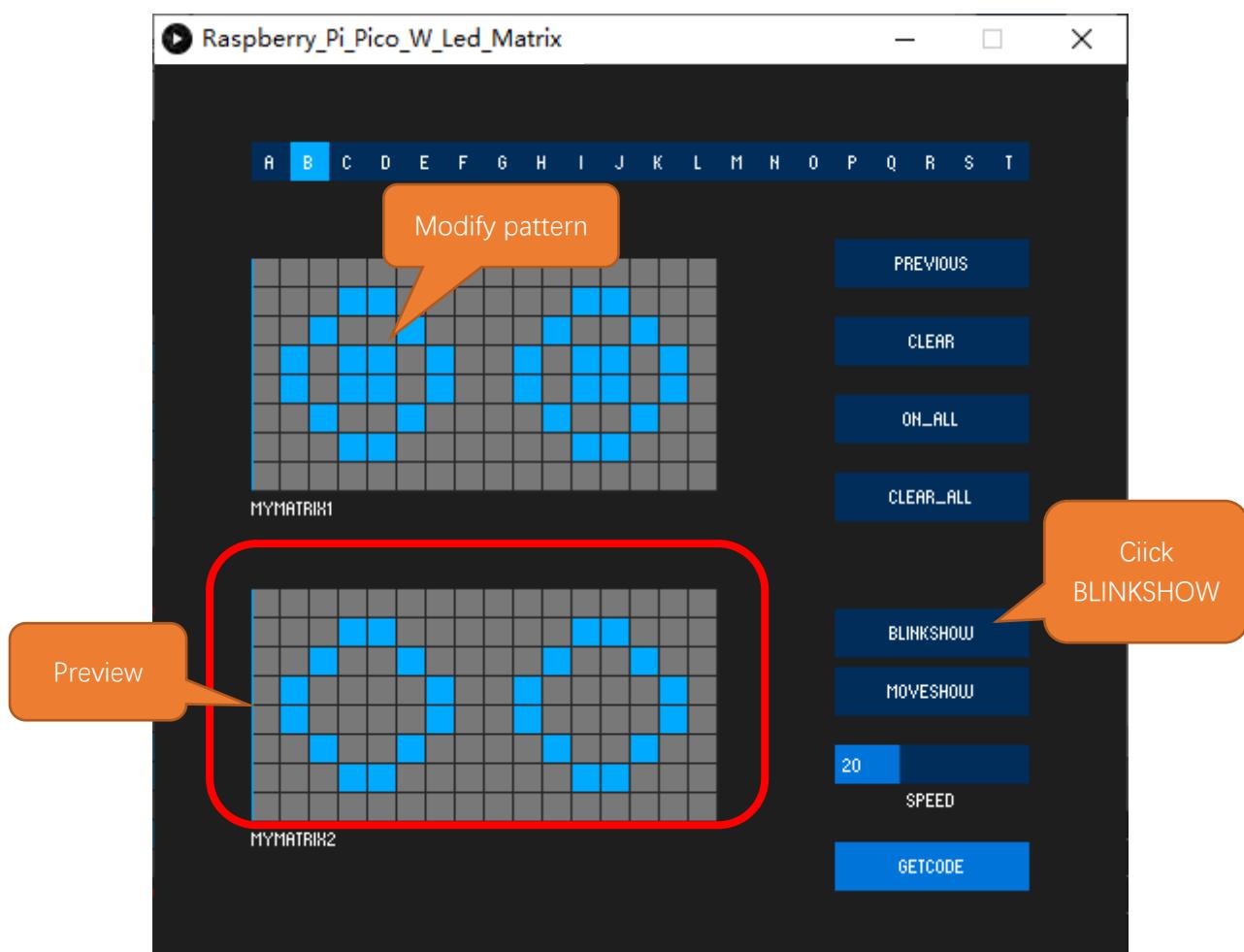
You can design your own pattern by clicking on the squares.



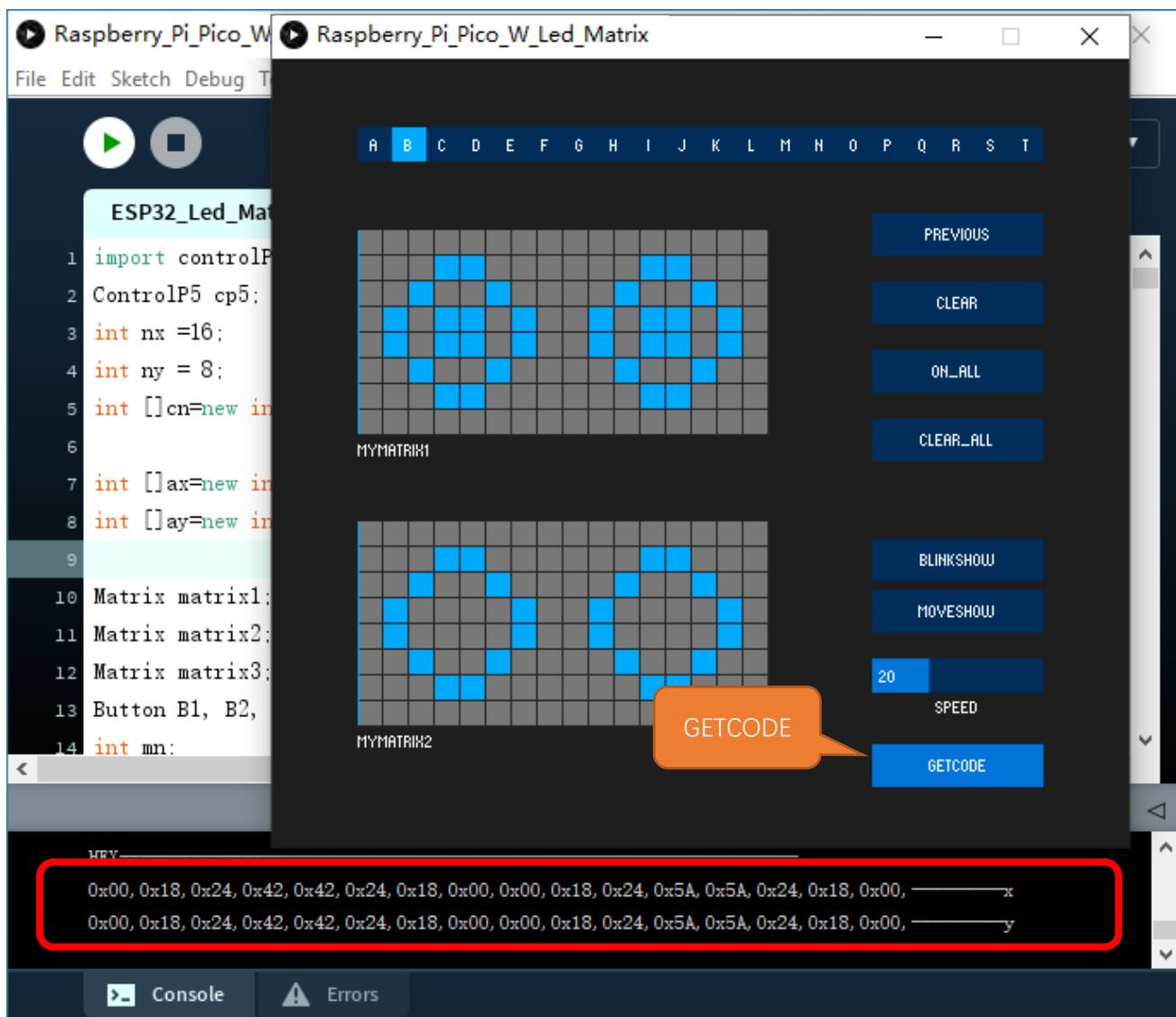
Next select Page B and click PREVIOUS, which copies the previous pattern to B.



Click the squares to modify the pattern, and then click BLINKSHOW, you can browse the overlay effect of different pages.



Click GETCODE to generate array.



The data on the left of the LED matrix are stored together and end with "----x", and the data on the right are stored together and end with "----y". Copy these two sets of dot matrix data and replace the array content in "01.5_Matrix.ino".

Open the folder “01.5_Matrix” in the “**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches**” and double click “01.5_Matrix.ino”

Code

```
1 #include "Freenove_VK16K33_Lib.h"
2
3 Freenove_VK16K33 matrix = Freenove_VK16K33();
4
5 byte x_array[][8] = { //Put the data into the left LED matrix
6     /////////////////////////////////
7     0x00, 0x18, 0x24, 0x42, 0x42, 0x24, 0x18, 0x00,
8     0x00, 0x18, 0x24, 0x5A, 0x5A, 0x24, 0x18, 0x00,
9     /////////////////////////////////
10    };
11
12 byte y_array[][8] = { //Put the data into the right LED matrix
13     /////////////////////////////////
14     0x00, 0x18, 0x24, 0x42, 0x42, 0x24, 0x18, 0x00,
15     0x00, 0x18, 0x24, 0x5A, 0x5A, 0x24, 0x18, 0x00,
16     /////////////////////////////////
17    };
18
19 void setup()
20 {
21     matrix.init(0x71);
22     matrix.setBlink(VK16K33_BLINK_OFF);
23 }
24
25 void loop()
26 {
27     showArray(500);
28 }
29
30 void showArray(int delay_ms)
31 {
32     int count = sizeof(x_array) / sizeof(x_array[0]);
33     for (int i = 0; i < count; i++)
34     {
35         matrix.showStaticArray(x_array[i], y_array[i]);
36         delay(delay_ms);
37     }
38 }
```

Replace the x array on the left

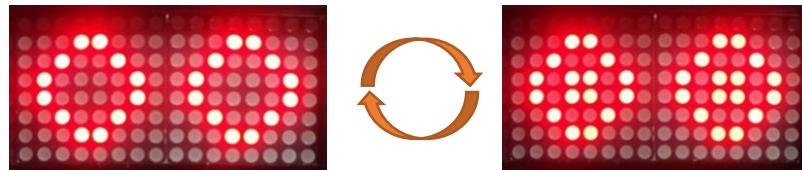
Replace the y array on the right

Copy and paste the array generated by the auxiliary applet to the program, and then click upload.



```
01.5_Matrix | Arduino IDE 2.0.3
File Edit Sketch
Upload
01.5_Matrix.ino
29 }
30
31 void loop()
32 {
33     showArray(500);
34 }
35
36 void showArray(int delay_ms)
37 {
38     int count = sizeof(x_array) / sizeof(x_array[0]);
39     for (int i = 0; i < count; i++)
40     {
41         ...
42     }
43 }
```

You can see the LED matrix keep blinking.



Code Explanation

Add the header file of LED matrix. Each time before controlling LED matrix, please add its header file first.

```
1 #include "Freenove_VK16K33_Lib.h"
```

Apply for an Freenove_VK16K33 object and name it matrix.

```
3 Freenove_VK16K33 matrix = Freenove_VK16K33();
```

Define IIC address and IIC pins of HT16K33 chip. Call init() function to initialize it and call setBlink() to set the LED matrix not blink.

```
3 Freenove_VK16K33 matrix = Freenove_VK16K33();
...
21     matrix.init(0x71);
22     matrix.setBlink(VK16K33_BLINK_OFF);
```

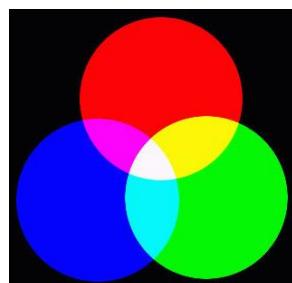
Define count to calculate the number of one-dimensional arrays contained in the two-dimensional x_array, and use the for loop to call the showStaticArray() function to continuously display the content of LED matrix.

```
32     int count = sizeof(x_array) / sizeof(x_array[0]);
33     for (int i = 0; i < count; i++)
34     {
35         matrix.showStaticArray(x_array[i], y_array[i]);
36         delay(delay_ms);
37     }
```

2.6 LED

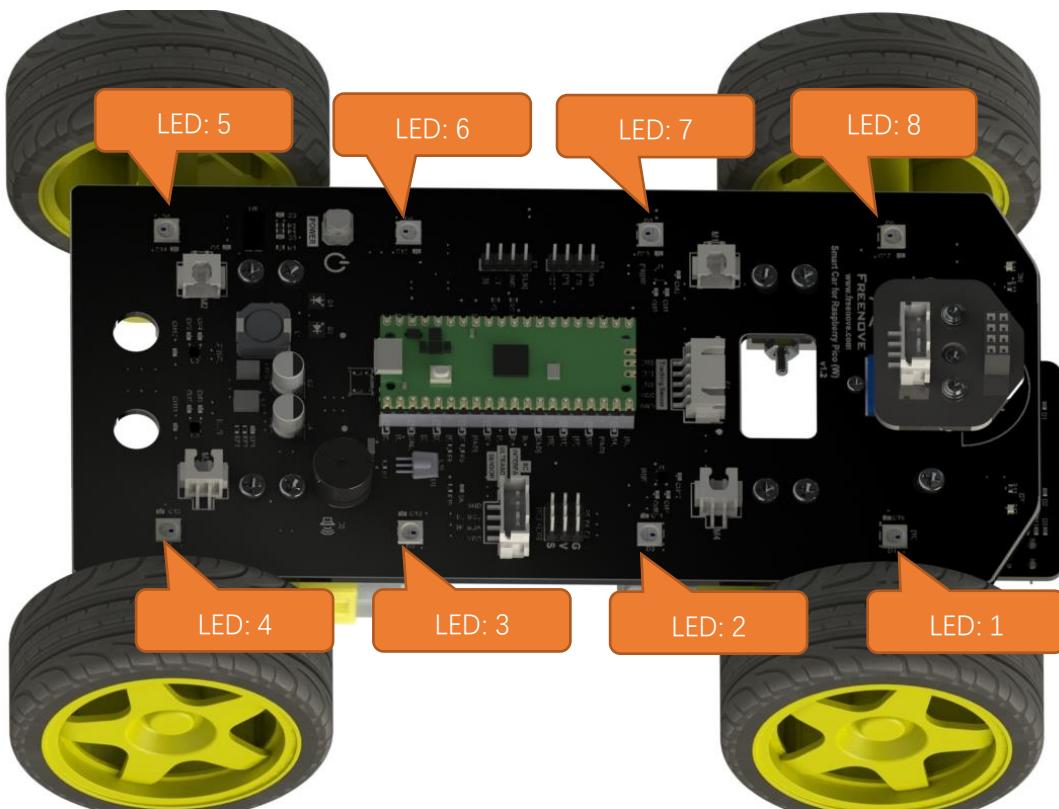
LED

Red, green, and blue are called the three primary colors. When you combine these three primary colors of different brightness, it can produce almost all kinds of visible light.



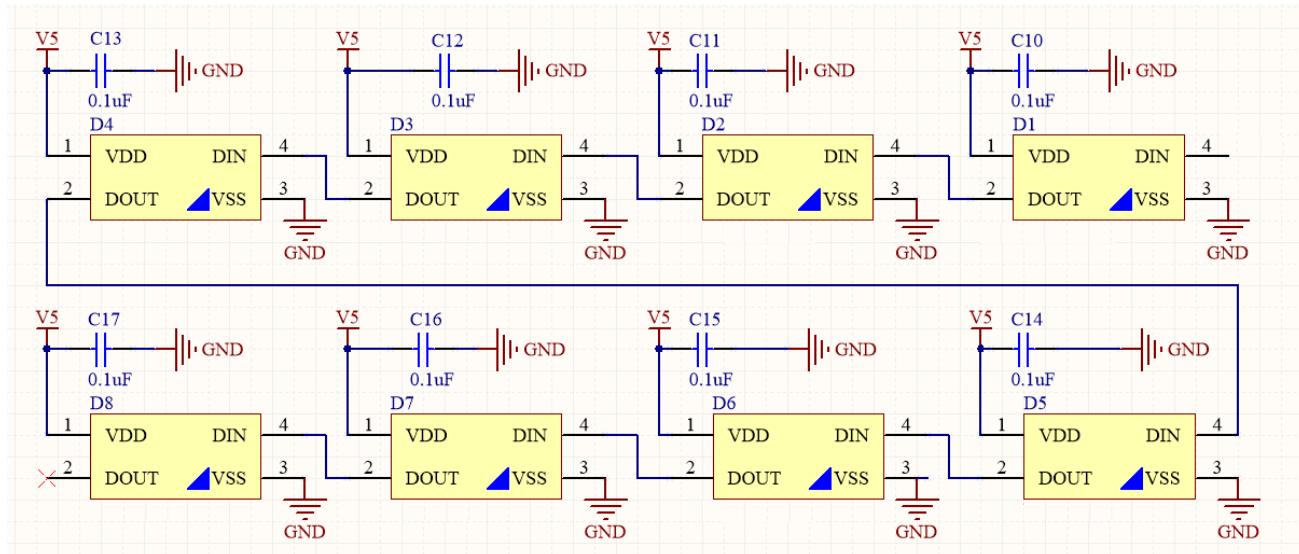
RGB

The LED of the car is composed of eight LED, each of which is controlled by one pin and supports cascading. Each LED can emit three basic colors of red, green and blue, and supports 256-level brightness adjustment, which means that each LED can emit $2^{24}=16,777,216$ different colors.



Schematic

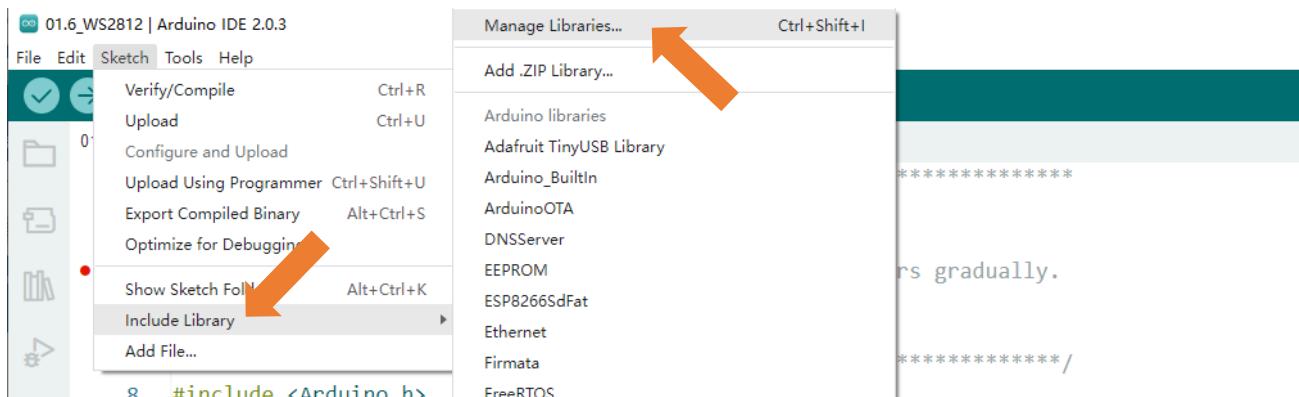
As shown below, the DOUT of each LED is connected with DIN of the next LED, and the 8 LED can be controlled to emit colorful colors by inputting control signals through LED.



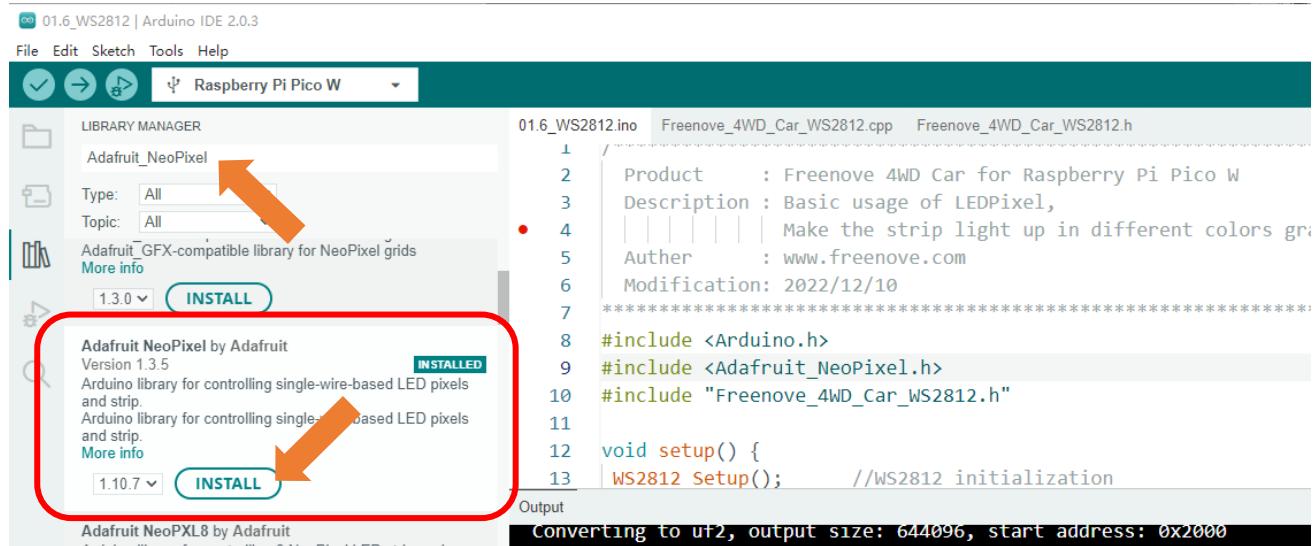
Sketch

Before programming, please make sure the LED driver library has been installed. If not, please install it as follows.

Open Arduino IDE, select Sketch on Menu bar, navigate the mouse to Include library and click Manage Libraries.

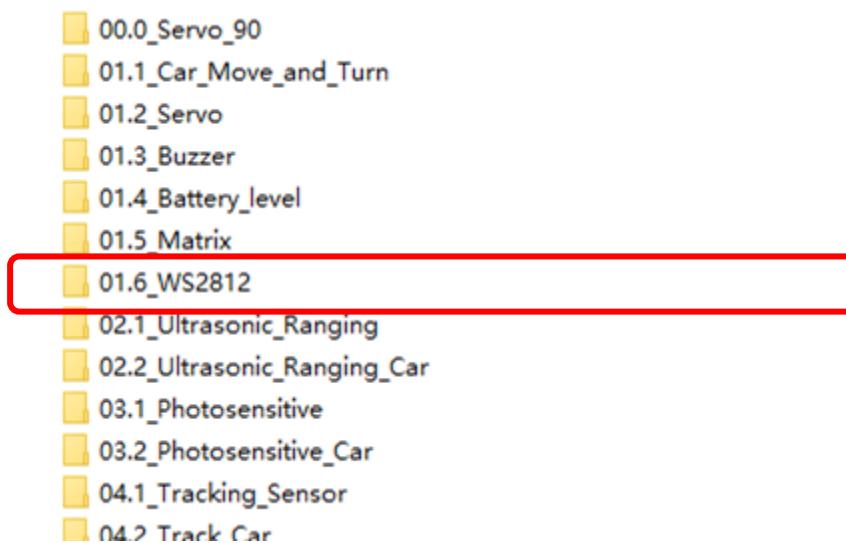


Enter "Adafruit_NeoPixel" in the input field of the pop-up window, find it and then click Install.



Wait for the installation to finish.

Next, we will download the code to Raspberry Pi Pico W to test the LED. Open the folder "01.6_WS2812" in the "Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches" and then double click "01.6_WS2812".



Code

```

1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include "Freenove_4WD_Car_WS2812.h"
4
5 void setup() {
6     WS2812_Setup();      //WS2812 initialization
7 }
8
9 void loop() {
10    WS2812_Show(5);
11 }
```

Another part of the code

```

1 #define WS2812_PIN 16      //Control pins for Pico W
2 #define LEDS_COUNT 8
3 Adafruit_NeoPixel ws2812_strip(LEDs_Count, WS2812_PIN, NEO_GRB + NEO_KHZ800);
4 //WS2812 initialization function
5 void WS2812_Setup(void)
6 {
7     ws2812_strip.begin();
8     ws2812_strip.setBrightness(20);
9     ws2812_close();
10 }
11 //WS2812 non-blocking display function
12 void WS2812_Show(int mode)
13 {
14     switch (mode)
15     {
16         case 0://Close the WS2812
17             ws2812_close();
18             break;
19         case 1:
20             ws2812_rgb();
21             break;
22         case 2:
23             ws2812_following();
24             break;
25         case 3:
26             ws2812_blink();
27             break;
28         case 4:
29             ws2812_breathe();
30             break;
31         case 5:
```

```

32     ws2812_rainbow();
33     break;
34     default:
35     break;
36   }
37 }
38 int rainbow_count = 0;
39 //WS2812 rainbow display
40 void ws2812_rainbow(void)
41 {
42   ws2812_strip.setBrightness(20);
43   ws2812_strip_time_next = millis();
44   if (ws2812_strip_time_next - ws2812_strip_time_now > 5)
45   {
46     ws2812_strip_time_now = ws2812_strip_time_next;
47     rainbow_count++;
48     for (int i = 0; i < 12; i++)
49       ws2812_strip.setPixelColor(11 - i, Wheel((i * 256 / 12 + rainbow_count) & 255));
50   ws2812_strip.show();
51   if (rainbow_count > 255)
52     rainbow_count = 0;
53 }
54 }
```

Download the code to the Raspberry Pi Pico W, turn ON the power switch and the LED on the car will emit lights like rainbow.

Code Explanation:

Add the header file of LED. Each time before controlling LED, please add its header file.

2	#include <Adafruit_NeoPixel.h>
---	--------------------------------

Set the number of LED, define the control pin and channel. Instantiate a LED object and name it strip.

	#define WS2812_PIN 16 //Control pins for Pico W #define LEDS_COUNT 8 Adafruit_NeoPixel ws2812_strip(LEDS_COUNT, WS2812_PIN, NEO_GRB + NEO_KHZ800);
--	---

Initialize LED, set their brightness to be 10. The range of brightness is 0-255.

	ws2812_strip.begin(); //Initialize LED ws2812_strip.setBrightness(10); //Set the brightness of LED
--	---

Set the color of LED. Note: The color will not be displayed immediately after it is set.

	ws2812_strip.setPixelColor(11 - i, Wheel((i * 256 / 12 + rainbow_count) & 255));
--	--

Display the color of LED. After setting the color, you need to call show function to display it.

	ws2812_strip.show();
--	----------------------

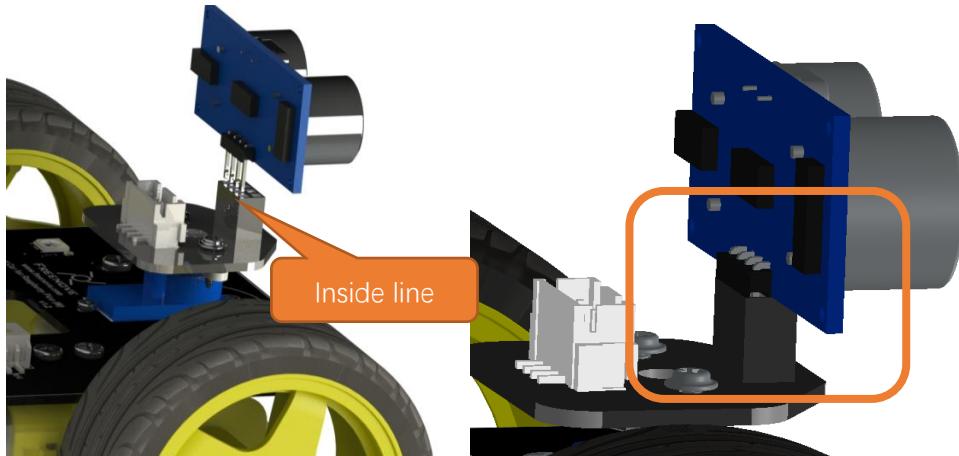
Chapter 3 Ultrasonic Obstacle Avoidance Car

This chapter requires replacing the LED matrix with the ultrasonic module. Please follow the tutorial to replace it first. In this tutorial, only chapters 3, 6, and 7 apply the ultrasonic module. When work on other chapters, please change to use the LED matrix.

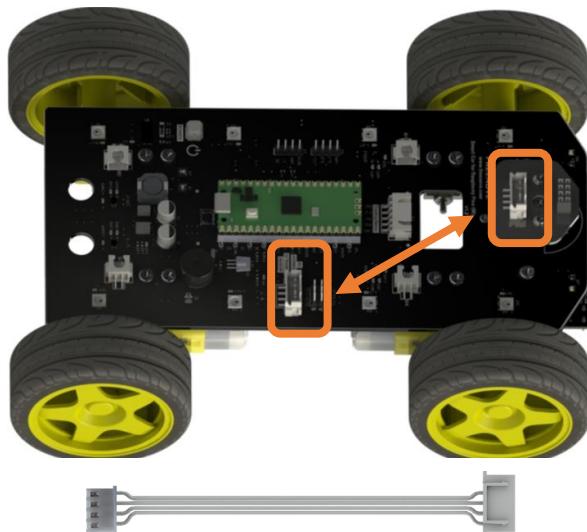
3.1 Ultrasonic Module

Replace the ultrasonic module.

Step 1 Installing the ultrasonic module.



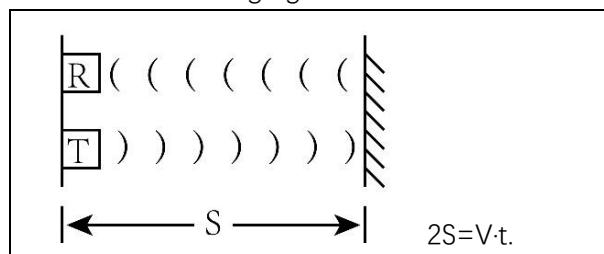
Use cable to connect the two connectors marked below.



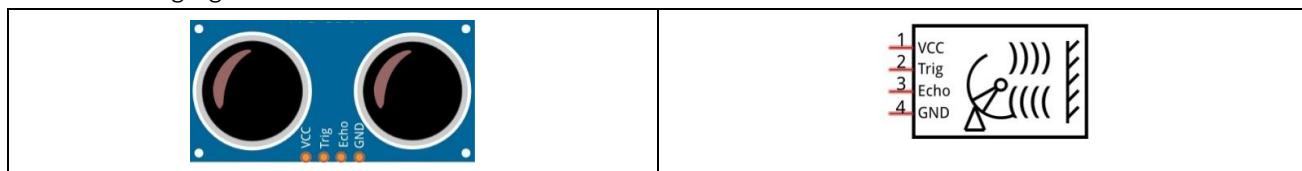
Module	Gnd	Echo	Trig	Vcc
Car	GND	ECHO	TRIG	VCC
	GND	5	4	VCC

Ultrasonic Module

The ultrasonic ranging module uses the principle that ultrasonic waves will be sent back when encounter obstacles. We can measure the distance by counting the time interval between sending and receiving of the ultrasonic waves, and the time difference is the total time of the ultrasonic wave's journey from being transmitted to being received. Because the speed of sound in air is a constant, about $v=340\text{m/s}$, we can calculate the distance between the ultrasonic ranging module and the obstacle: $s=vt/2$.



The ultrasonic ranging module integrates both an ultrasonic transmitter and a receiver. The transmitter is used to convert electrical signals (electrical energy) into high frequency (beyond human hearing) sound waves (mechanical energy) and the function of the receiver is opposite of this. The picture and the diagram of the ultrasonic ranging module are shown below:



Pin description:

Pin	Description
VCC	Power supply pin
Trig	Trigger pin
Echo	Echo pin
GND	GND

Technical specs:

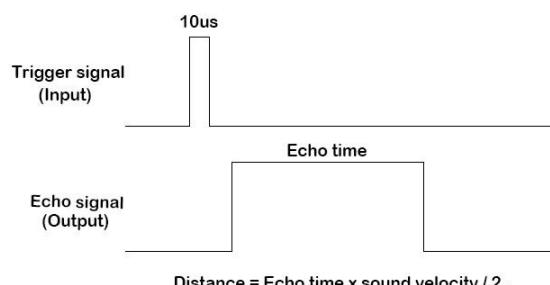
Working voltage: 5V

Working current: 12mA

Minimum measured distance: 2cm

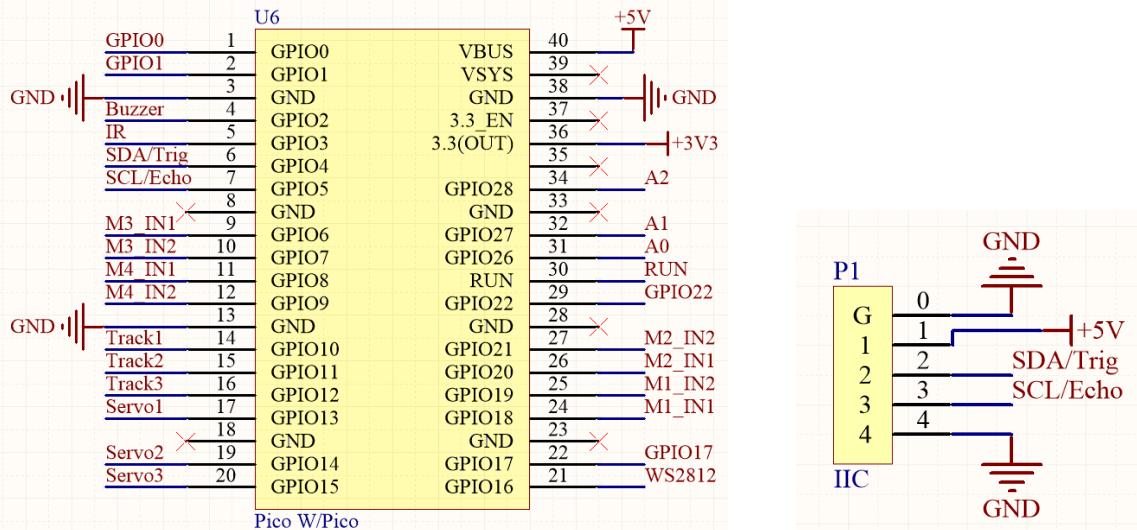
Maximum measured distance: 200cm

Instructions for use: output a high-level pulse in Trig pin lasting for least 10us, the module begins to transmit ultrasonic waves. At the same time, the Echo pin is pulled up. When the module receives the returned ultrasonic waves from encountering an obstacle, the Echo pin will be pulled down. The duration of high level in the Echo pin is the total time of the ultrasonic wave from transmitting to receiving, $s=vt/2$.



Schematic

The ultrasonic module is plugged in the front of the car and is connected to the Raspberry Pi Pico (W) development board by means of wiring. As can be seen from the figure below, Raspberry Pi Pico (W) uses GPIO4 and GPIO5 to control the Trig and Echo pins of the ultrasonic module.



Sketch

When the power of the car is turned ON, every module will be initialized and the servo motor will rotate to 90°. The ultrasonic data will be obtained and printed through serial port as the servo motor rotates.

Open the folder “02.1_Ultrasonic_Ranging” in

“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches” and double click “02.1_Ultrasonic_Ranging.ino”

Code

```

1 #include <Arduino.h>
2 #include "Freenove_4WD_Car_For_Pico_W.h"
3
4 void setup() {
5   Serial.begin(115200); //Open the serial port and set the baud rate to 115200
6   Ultrasonic_Setup(); //Ultrasonic module initialization
7   Servo_Setup(); //Servo initialization
8   Servo_1_Angle(90); //Set the initial value of Servo 1 to 90 degrees
9   delay(500); //Wait for the servo to arrive at the specified location
10 }
11
12 void loop() {
13   Servo_1_Angle(150); //Turn servo 1 to 150 degrees
14   Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
15   delay(500);

```

```
16 Servo_1_Angle(90); //Turn servo 1 to 90 degrees
17 Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
18 delay(500);
19
20
21 Servo_1_Angle(30); //Turn servo 1 to 30 degrees
22 Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
23 delay(500);
24
25 Servo_1_Angle(90); //Turn servo 1 to 90 degrees
26 Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
27 delay(500);
28 }
```

Code Explanation:

Initialize ultrasonic module and Servo.

```
6 Ultrasonic_Setup(); //Ultrasonic module initialization
7 Servo_Setup(); // initialization
```

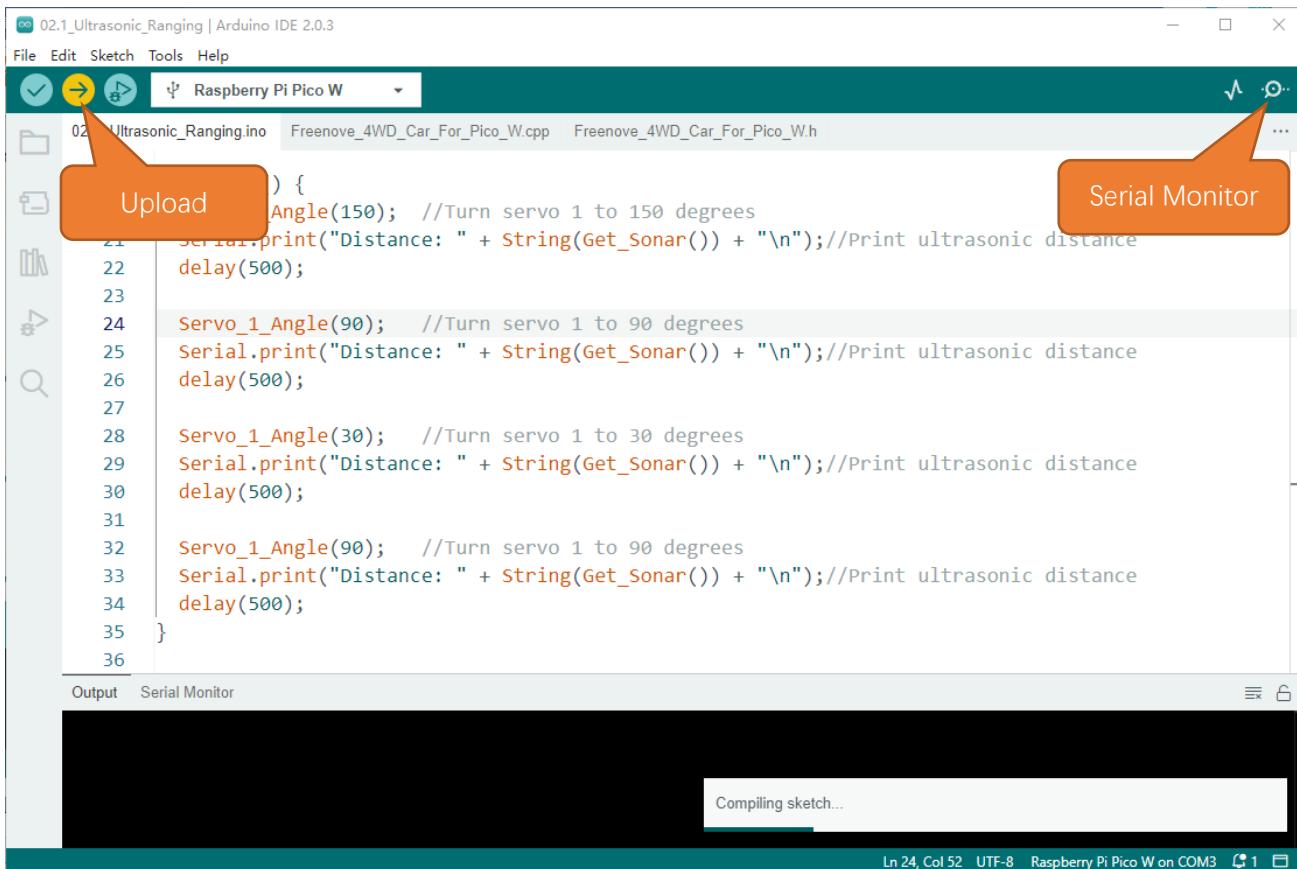
Obtain the distance between ultrasonic module and the obstacle and return a real number data in cm.

```
15 Get_Sonar()
```

Rotate the angle of the servo motor 1 and cooperate with the ultrasonic module to obtain distance data.

```
13 Servo_1_Angle(150); //Turn servo 1 to 150 degrees
...
17 Servo_1_Angle(90); //Turn servo 1 to 90 degrees
...
21 Servo_1_Angle(30); //Turn servo 1 to 30 degrees
...
25 Servo_1_Angle(90); //Turn servo 1 to 90 degrees
```

Click “Upload” to upload the code to Raspberry Pi Pico (W). After uploading successfully, open Serial Monitor.



Set the baud rate as 115200.



3.2 Ultrasonic car

After starting the car, the ultrasound acquires data in various directions, makes judgments based on the data in each direction, and controls the car to avoid obstacles.

Sketch

Open the folder “02.2_Ultrasonic_Ranging_Car” in

“**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches**” and double click
“02.2_Ultrasonic_Ranging_Car.ino”.

Code

```

1 #include <Arduino.h>
2 #include "Freenove_4WD_Car_For_Pico_W.h"
3
4 void setup() {
5     Ultrasonic_Setup();           //Initialize the ultrasonic module
6     Motor_Setup();               //motor initialization
7     Servo_Setup();               //servo initialization
8 }
9 void loop()
10 {
11     Ultrasonic_Car();
12 }
```

The code of automatic obstacle avoidance vehicle is as follows:

```

1 void Ultrasonic_Car() {
2     int distance[3], tempDistance[3][5], sumDisntance;
3     static u8 leftToRight = 0, servoAngle = 0, lastServoAngle = 0; ///
4     const u8 scanAngle[2][3] = { { 150, 90, 30 }, { 30, 90, 150 } };
5     int speedOffset = oa_VoltageCompensationToSpeed;
6     for (int i = 0; i < 3; i++) {
7         servoAngle = scanAngle[leftToRight][i];
8         Servo_1_Angle(servoAngle);
9         if (lastServoAngle != servoAngle) {
10             delay(100);
11         }
12         lastServoAngle = servoAngle;
13         for (int j = 0; j < COUNT_GET SONAR; j++) {
14             tempDistance[i][j] = Get_Sonar();
15             delayMicroseconds(2 * SONIC_TIMEOUT);
16             sumDisntance += tempDistance[i][j];
17         }
18         if (leftToRight == 0) {
19             distance[i] = sumDisntance / COUNT_GET SONAR;
```

```

20 } else {
21     distance[2 - i] = sumDisntance / COUNT_GET SONAR;
22 }
23 sumDisntance = 0;
24 }
25 leftToRight = (leftToRight + 1) % 2;
26 Serial.println("Sonar : " + String(distance[0]) + " " + String(distance[1]) + " " +
String(distance[2]));
27 if (distance[1] < OBSTACLE_DISTANCE) { //Too little distance ahead
28     if (distance[0] > distance[2] && distance[0] > OBSTACLE_DISTANCE) { //Left distance is
greater than right distance
29         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
30         delay(100);
31         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), (SONAR_MODE_CRUISE_SPEED +
speedOffset));
32     } else if (distance[0] < distance[2] && distance[2] > OBSTACLE_DISTANCE) { //Right distance
is greater than left distance
33         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
34         delay(100);
35         Motor_Move((SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset));
36     } else { //Get into the dead corner, move back, then turn.
37         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset));
38         delay(100);
39         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), (SONAR_MODE_CRUISE_SPEED +
speedOffset));
40     }
41 } else {
42     if (distance[0] < OBSTACLE_DISTANCE_LOW) { //Obstacles on the left front.
43         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
44         delay(100);
45         Motor_Move((70 + speedOffset), (20 + speedOffset));
46     } else if (distance[2] < OBSTACLE_DISTANCE_LOW) { //Obstacles on the right front.
47         Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
48         delay(100);
49         Motor_Move((20 + speedOffset), (70 + speedOffset));
50     } else { //Cruising
51         Motor_Move((30 + speedOffset), (30 + speedOffset));
52     }

```

53	}
54	}

Code Explanation:

The PWM value represents different speeds when the voltage of battery changes, so we set a speedOffset to compensate the difference.

```
void oa_CalculateVoltageCompensation() {
    Get_Battery_Voltage();
    float voltageOffset = BAT_VOL_STANDARD - batteryVoltage;
    oa_VoltageCompensationToSpeed = voltageOffset * OA_SPEED_OFFSET_PER_V;
}
```

OA SPEED OFFSET PER V: The default value is three, which is a tested value. You can try to test what is the most proper value.

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

Get one ultrasonic module value (distance) at one angle.

```
int distance[3], tempDistance[3][5], sumDisntance;
static u8 leftToRight = 0, servoAngle = 0, lastServoAngle = 0;
const u8 scanAngle[2][3] = { { 150, 90, 30 }, { 30, 90, 150 } };
int speedOffset = oa_VoltageCompensationToSpeed;
for (int i = 0; i < 3; i++) {
    servoAngle = scanAngle[leftToRight][i];
    Servo_1_Angle(servoAngle);
    if (lastServoAngle != servoAngle) {
        delay(100);
    }
    lastServoAngle = servoAngle;
    for (int j = 0; j < COUNT_GET SONAR; j++) {
        tempDistance[i][j] = Get_Sonar();
        delayMicroseconds(2 * SONIC_TIMEOUT);
        sumDisntance += tempDistance[i][j];
    }
    if (leftToRight == 0) {
        distance[i] = sumDisntance / COUNT_GET SONAR;
    } else {
        distance[2 - i] = sumDisntance / COUNT_GET SONAR;
    }
    sumDisntance = 0;
}
leftToRight = (leftToRight + 1) % 2;
```

Then make the car react according to the distances above. Please refer to the flow chart for its logic.

```
if (distance[1] < OBSTACLE_DISTANCE) { //Too little distance ahead
    if (distance[0] > distance[2] && distance[0] > OBSTACLE_DISTANCE) { //Left distance is greater than right distance
        Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
```

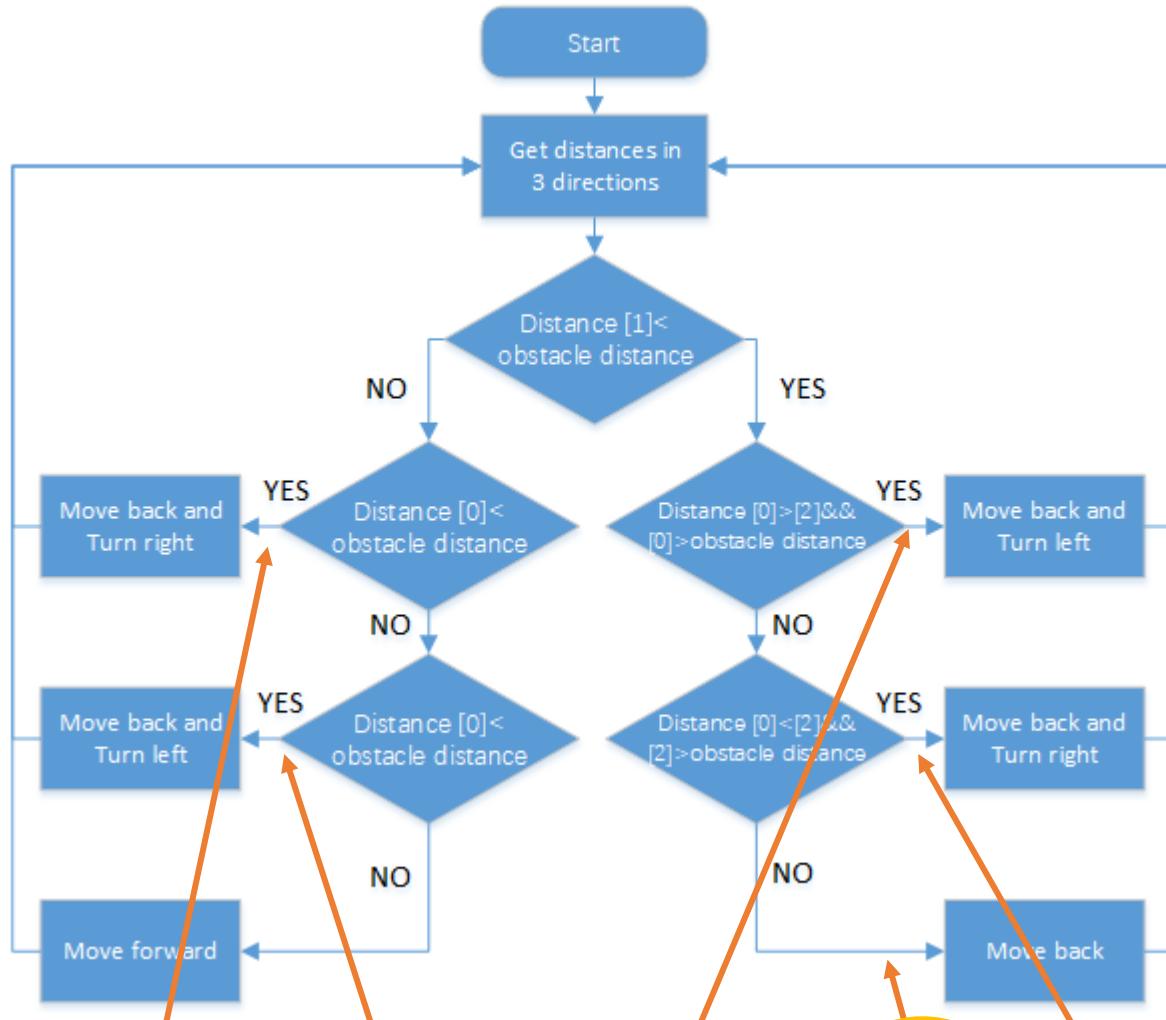
```
speedOffset)); //Move back
delay(100);
Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), (SONAR_MODE_CRUISE_SPEED +
speedOffset));
} else if (distance[0] < distance[2] && distance[2] > OBSTACLE_DISTANCE) { //Right distance
is greater than left distance
    Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
    delay(100);
    Motor_Move((SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset));
} else { //Get into the dead corner, move back, then turn.
    Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset));
    delay(100);
    Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), (SONAR_MODE_CRUISE_SPEED +
speedOffset));
}
} else {
    if (distance[0] < OBSTACLE_DISTANCE_LOW) { //Obstacles on the left front.
        Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
        delay(100);
        Motor_Move((70 + speedOffset), (20 + speedOffset));
    } else if (distance[2] < OBSTACLE_DISTANCE_LOW) { //Obstacles on the right front.
        Motor_Move(-(SONAR_MODE_CRUISE_SPEED + speedOffset), -(SONAR_MODE_CRUISE_SPEED +
speedOffset)); //Move back
        delay(100);
        Motor_Move((20 + speedOffset), (70 + speedOffset));
    } else { //Cruising
        Motor_Move((30 + speedOffset), (30 + speedOffset));
    }
}
}
```

Code logic is as shown in the flow chart below:

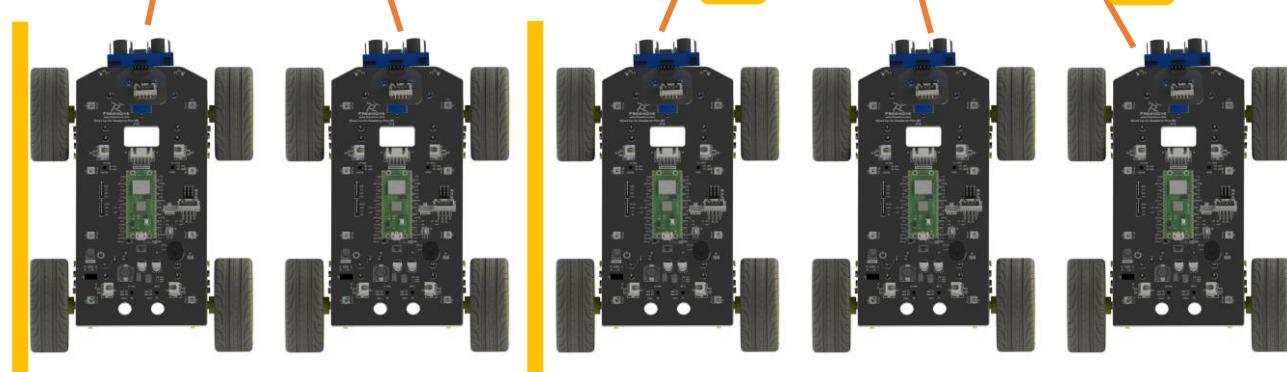
Distance[0] is the distance to obstacle at the left.

Distance[1] is the distance to obstacle at the center.

Distance[2] is the distance to obstacle at the right.



This project can be referred to as follows:



Chapter 4 Light Tracing Car

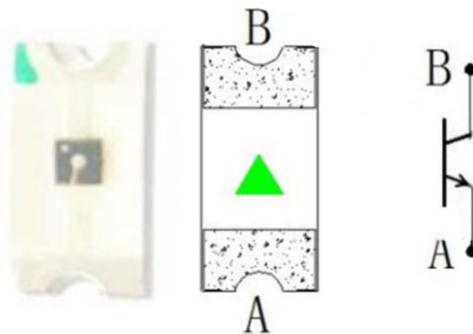
4.1 Photoresistor ADC

The photoresistor is very sensitive to the amount of light present. We can use this feature to make a light-tracing car. The car is controlled to turn toward the light source by reading the ADC values of the two photoresistors at the head of the car. Before we start, let us learn how to read the photoresistor value.

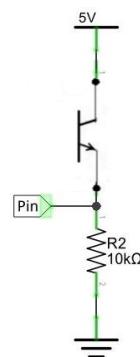
Photoresistor

A photoresistor is a NPN photosensitive triode. The output

A Photoresistor is simply a light sensitive resistor. A Photoresistor's output current will change in proportion to the ambient light detected, thus changing the voltage value. With this characteristic, we can use a Photoresistor to detect light intensity. The Photoresistor and its electronic symbol are as follows.



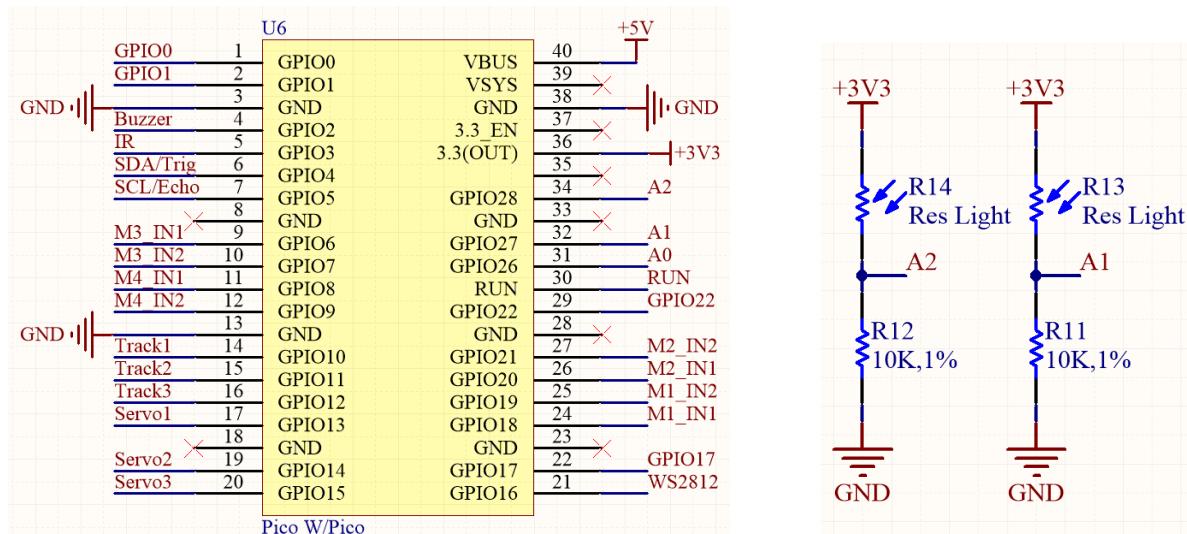
The circuit below is used to detect the change of a photoresistor's resistance value:



In the above circuit, when a photoresistor's resistance value changes due to a change in light intensity, the voltage between the photoresistor and resistor R1 will also change. Therefore, the intensity of the light can be obtained by measuring this voltage.

Schematic

Photosensitive sensors are distributed on both sides of the front of the car, and the ADC value collection range of A1 and A2 is 0-1023. It can be seen from the circuit that photoresistors R13 and R14 are two independent light collection channels. When the photoresistor is in an absolutely dark environment, its corresponding ADC value is close to 0; and when it receives absolutely bright light, the value is close to 1023. When the photosensitive sensor receives light of a certain brightness, its corresponding ADC value is between 0-1023. Therefore, if the brightness of the light received by the two photoresistors is different, the values read by the ADC will have a large difference. Utilizing this difference, the car can realize the function of finding light.



Sketch

Next, we download the code to Raspberry Pi Pico W to test the photoresistors. Open the folder "03.1_Photosensitive" in "Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches" and double click "03.1_Photosensitive.ino"

Code

```

1 #define Left_PHOTOSENSITIVE_PIN 28 //Define the pins that Raspberry Pi Pico reads
2   photosensitive
3
4 #define Right_PHOTOSENSITIVE_PIN 27 //Define the pins that Raspberry Pi Pico reads
5   photosensitive
6
7 int getLeftPhotosensitiveADCValue; //Define a variable to store the left photosensitive adc
8   value
9
10 int getRightPhotosensitiveADCValue; //Define a variable to store the right photosensitive adc
11   value
12
13 void setup()
14 {
15   pinMode(Left_PHOTOSENSITIVE_PIN, INPUT); //Configure the pins for input mode
16   pinMode(Right_PHOTOSENSITIVE_PIN, INPUT); //Configure the pins for input mode
17 }
```

```

10   Serial.begin(115200);      //Initialize the serial port and set the baud rate to 115200
11 }
12
13 void loop()
14 {
15   getLeftPhotosensitiveADCValue = analogRead(Left_PHOTOSENSITIVE_PIN);
16   getRightPhotosensitiveADCValue = analogRead(Right_PHOTOSENSITIVE_PIN);
17   Serial.print("The photosensitive ADC on the left: ");
18   Serial.println(getLeftPhotosensitiveADCValue);      //Print the photosensitive ADC value on
the left
19   Serial.print("The photosensitive ADC on the right: ");
20   Serial.println(getRightPhotosensitiveADCValue);      //Print the photosensitive ADC value on
the right
21   delay(500);
22 }
```

Code Explanation:

Define the pin to read photoresistors.

```

1 #define Left_PHOTOSENSITIVE_PIN 28 //Define the pins that Raspberry Pi Pico reads
photosensitive
2 #define Right_PHOTOSENSITIVE_PIN 27 //Define the pins that Raspberry Pi Pico reads
photosensitive
```

Call analogRead to read the differential value of the photoresistors and store it in the photosensitiveADC.

```

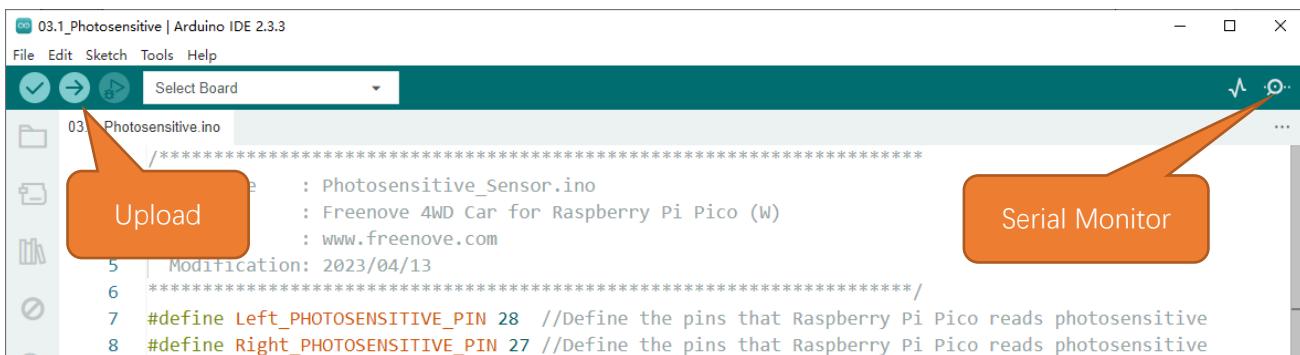
15   getLeftPhotosensitiveADCValue = analogRead(Left_PHOTOSENSITIVE_PIN);
16   getRightPhotosensitiveADCValue = analogRead(Right_PHOTOSENSITIVE_PIN);
```

Print the photoresistor value through the serial port.

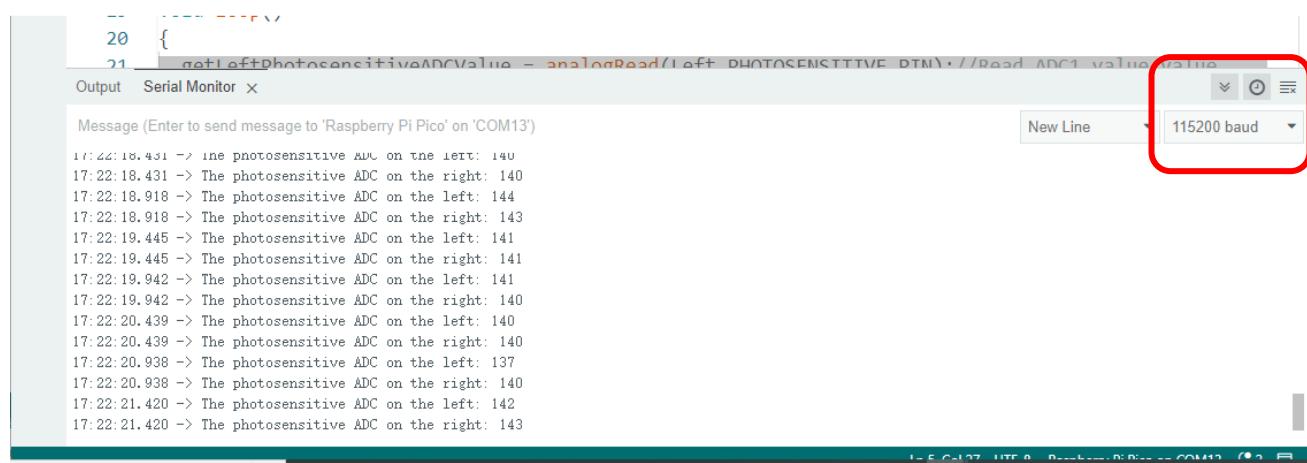
```

17   Serial.print("The photosensitive ADC on the left: ");
18   Serial.println(getLeftPhotosensitiveADCValue);      //Print the photosensitive ADC value on
the left
19   Serial.print("The photosensitive ADC on the right: ");
20   Serial.println(getRightPhotosensitiveADCValue);      //Print the photosensitive ADC value on
the right
```

Click “Upload” to upload the code to Raspberry Pi Pico W. When finishes uploading, click Serial Monitor.



Set baud rate as 115200.

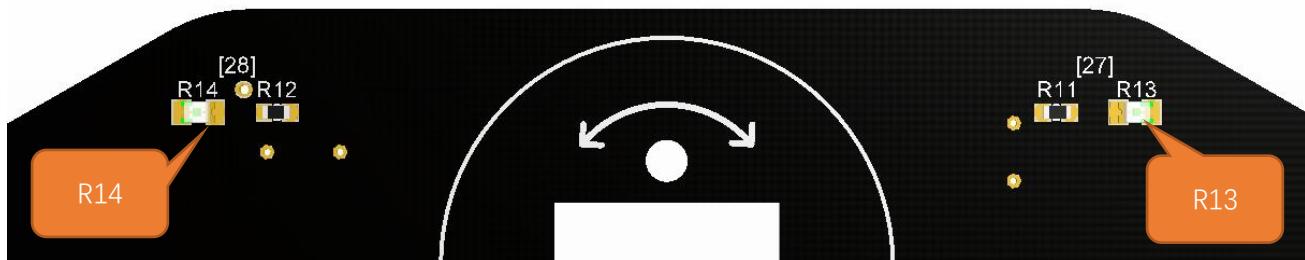


The screenshot shows the Arduino IDE's Serial Monitor window. The baud rate dropdown menu at the top right is circled in red and set to "115200 baud". The main text area displays a series of messages indicating ADC values for two photosensitive ADCs:

```
Message (Enter to send message to 'Raspberry Pi Pico' on 'COM13')
17:22:18.431 -> The photosensitive ADC on the left: 140
17:22:18.431 -> The photosensitive ADC on the right: 140
17:22:18.918 -> The photosensitive ADC on the left: 144
17:22:18.918 -> The photosensitive ADC on the right: 143
17:22:19.445 -> The photosensitive ADC on the left: 141
17:22:19.445 -> The photosensitive ADC on the right: 141
17:22:19.942 -> The photosensitive ADC on the left: 141
17:22:19.942 -> The photosensitive ADC on the right: 140
17:22:20.439 -> The photosensitive ADC on the left: 140
17:22:20.439 -> The photosensitive ADC on the right: 140
17:22:20.938 -> The photosensitive ADC on the left: 137
17:22:20.938 -> The photosensitive ADC on the right: 140
17:22:21.420 -> The photosensitive ADC on the left: 142
17:22:21.420 -> The photosensitive ADC on the right: 143
```

4.2 Light Tracing Car

It can be seen from the circuit board that R13 and R14 are photosensitive sensors on the right and left respectively. Set the ADC value read by photosensitive R13 to ADC1, and the ADC value read by photosensitive R14 to ADC2. When the light shines on R13, the resistance value of R13 gets smaller, and the ADC1 value increases, and the same is true for R14. Therefore, when ADC1 and ADC2 are greater than the set value at the same time, it means that there is a light source, and the car moves forward, otherwise, the car stops moving. When the car moves forward, detect the values of ADC1 on the right and ADC2 on the left. When ADC1 is greater than ADC2, it indicates that the light source is on the right side of the car, so the car turns right. When ADC1 is to be smaller than ADC2, the car turns left. When the difference between the light intensity on the left and the the right changes, the speed of the car changes accordingly.



Sketch

When car is powered ON, the ADC value of the current environment will be obtained. After initialization, the buzzer will sound once to remind users to test the light-tracing function. When users approach the car with light source, the car will turn following the light source.

Open the folder “03.2_Photosensitive_Car” in
“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches” and double click
“03.2_Photosensitive_Car.ino”

Code

```

1 #include <Arduino.h>
2 #include "Freenove_4WD_Car_For_Pico_W.h"
3
4 void setup() {
5     Buzzer_Setup();
6     Photosensitive_Setup(); //Photosensitive initialization
7     Motor_Setup(); //Motor initialization
8     Buzzer_Alert(1, 1); //The buzzer beeps to prompt the user to start playing
9     Serial.begin(115200); //Initialize the serial port and set the baud rate to 115200
10 }
11
12 void loop() {

```

```

13     Light_Car();
14 }
```

The code of light tracing car is as follows:

```

1 void Light_Car() {
2     if (isLightModeFirstStarting) {
3         isLightModeFirstStarting = false;
4         Motor_Move(40, 40);
5         delay(200);
6     }
7     int leftLightValue = getLeftPhotosensitiveADCValue();
8     int rightLightValue = getRightPhotosensitiveADCValue();
9     int diffLightValue = (leftLightValue - rightLightValue) / 8;
10    if (leftLightValue > LIGHT_MIN_MOVED && rightLightValue > LIGHT_MIN_MOVED) {
11        int lsp = constrain(LIGHT_MODE_CRUISE_SPEED + diffLightValue, -100, 100);
12        int rsp = constrain(LIGHT_MODE_CRUISE_SPEED - diffLightValue, -100, 100);
13        Serial.println("sp: " + String(lsp) + " " + String(rsp) + " " + String(diffLightValue));
14        Motor_Move(lsp, rsp);
15    } else {
16        Motor_Move(0, 0);
17    }
18 }
```

Code Explanation:

Set the sensitivity of the photoresistor. You can adjust the value according to the change of the environment. The value is recommended to be between 50-150.

```
#define LIGHT_MIN_MOVED 50
```

Initialize buzzer, photoresistor and motor.

```

5     Buzzer_Setup();
6     Photosensitive_Setup(); //Photosensitive initialization
7     Motor_Setup(); //Motor initialization
```

Get the ADC value of ambient light during initialization.

```

7     int leftLightValue = getLeftPhotosensitiveADCValue();
8     int rightLightValue = getRightPhotosensitiveADCValue();
```

Adjust the steering of the car according to the location of the light source.

```

10    if (leftLightValue > LIGHT_MIN_MOVED && rightLightValue > LIGHT_MIN_MOVED) {
11        int lsp = constrain(LIGHT_MODE_CRUISE_SPEED + diffLightValue, -100, 100);
12        int rsp = constrain(LIGHT_MODE_CRUISE_SPEED - diffLightValue, -100, 100);
13        Serial.println("sp: " + String(lsp) + " " + String(rsp) + " " + String(diffLightValue));
14        Motor_Move(lsp, rsp);
15    } else {
16        Motor_Move(0, 0);
17    }
```

Chapter 5 Line Tracking Car

5.1 Line tracking sensor

Track 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.

When conducting experiments in this chapter, please replace the locomotive with LED Matrix as per the instructions.

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

Sketch

The line tracking module is connected to the Raspberry Pi Pico (W). The Raspberry PI Pico (W) tracks whether the three channels of the module are triggered by acquiring the existence of the line, and prints it out through the serial port.

Open the folder “04.1_Tracking_Sensor” in “Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches” and double click “04.1_Tracking_Sensor.ino”.

Code

```
1 #include <Arduino.h>
```

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```
2 #include "Freenove_4WD_Car_For_Pico_W.h"
3
4 void setup() {
5     Serial.begin(115200); //set baud rate
6     Track_Setup();
7 }
8
9 void loop() {
10    Track_Read();
11    Serial.print("Sensor Value (L / M / R / ALL) : ");
12    for (int i = 0; i < 4; i++) {
13        Serial.print(sensorValue[i]);
14        Serial.print(' \t');
15    }
16    Serial.print(' \n');
17    delay(500);
18 }
```

Code Explanation:

Trace module initialization

6	Track_Setup();
---	----------------

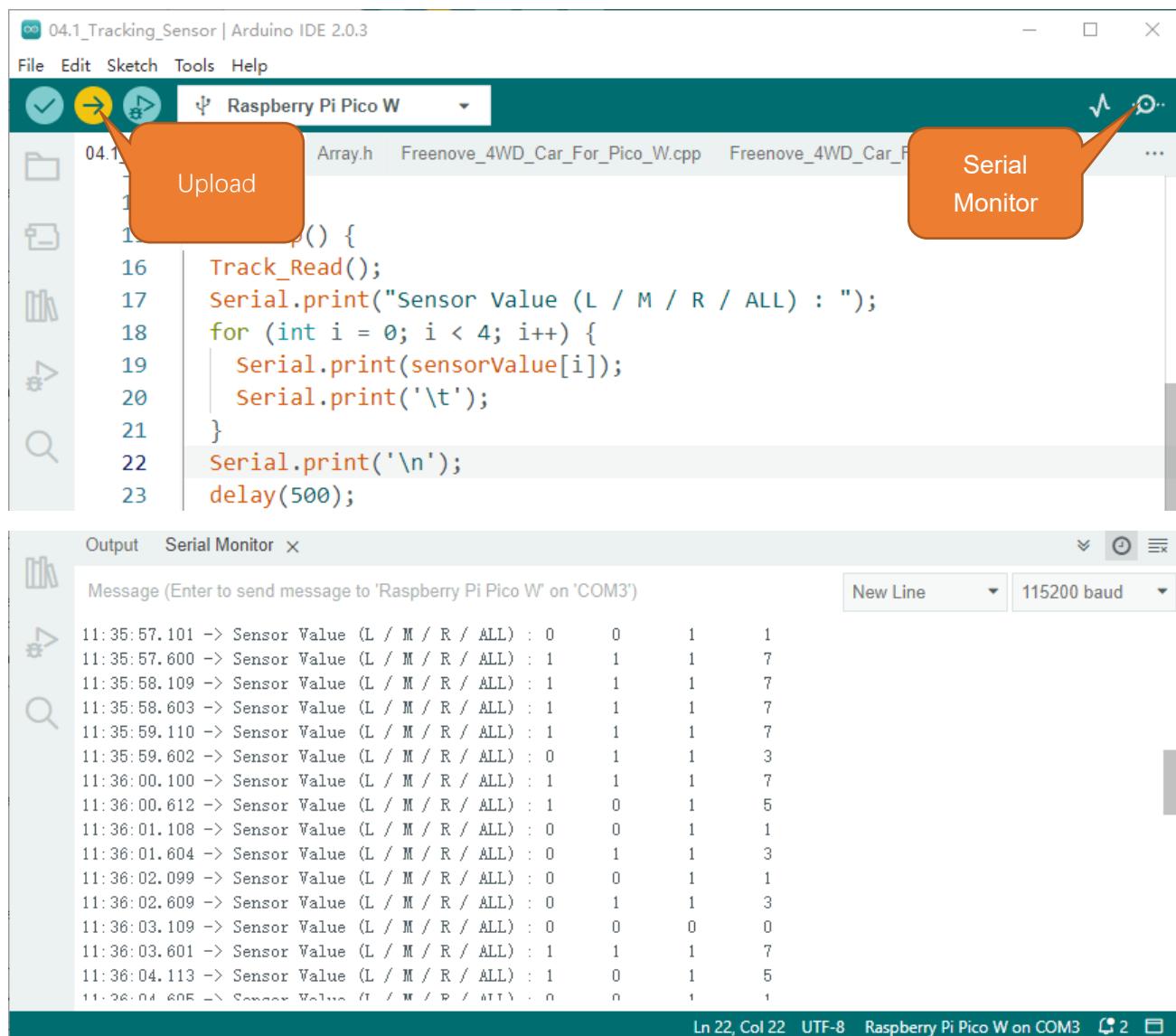
The function that obtains the tracking module feedback value. After calling this function, Raspberry Pi Pico W will store the data in the array `sensorValue[]`.

10	Track_Read();
----	---------------

Print the obtained feedback value through serial port.

11	Serial.print("Sensor Value (L / M / R / ALL) : ");
12	for (int i = 0; i < 4; i++) {
13	Serial.print(sensorValue[i]);
14	Serial.print('\t');
15	}
16	Serial.print('\n');

Click "Upload" to upload to code to Raspberry Pi Pico (W) development board. After uploading successfully, click "Serial Monitor".

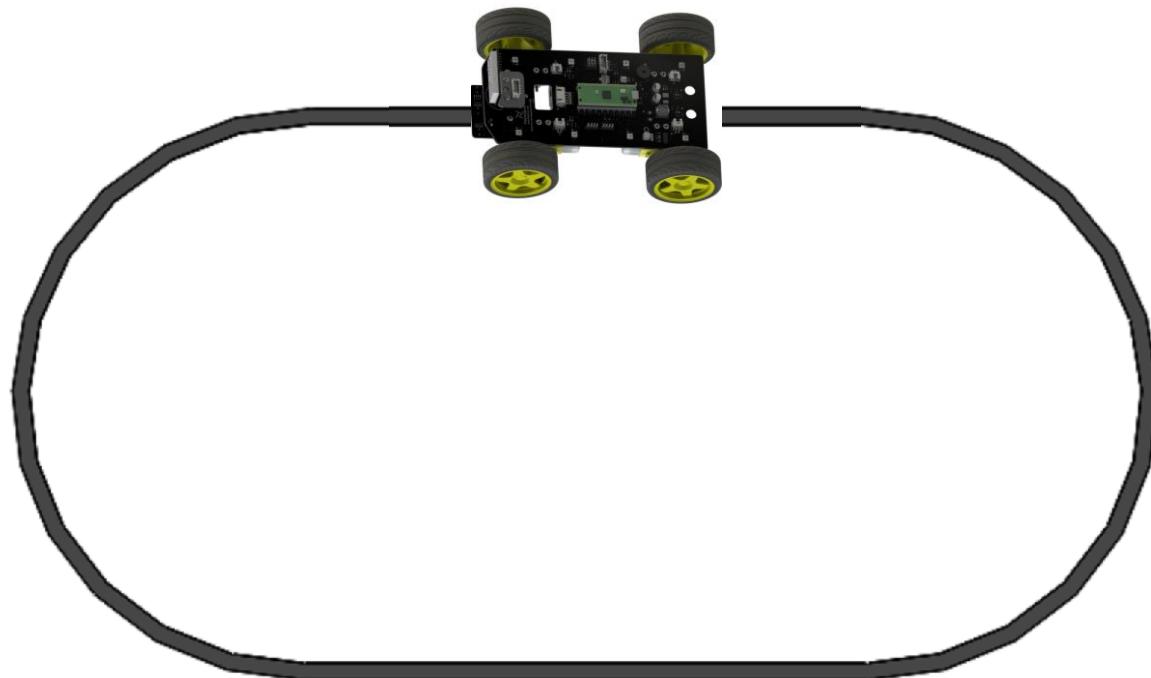


5.2 Line Tracking Car

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

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

Turn on the power. Use a black tape to build a line and then put your car on it as below.



Sketch

Open the folder “04.2_Track_Car” in “**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico_W\Sketches**” and double click “04.2_Track_Car.ino”.

Code

```

1 #include <Arduino.h>
2 #include "Freenove_4WD_Car_For_Pico_W.h"
3
4 #define SPEED_LV4 ( 90 )
5 #define SPEED_LV3 ( 75 )

```

```

6 #define SPEED_LV2 ( 60 )
7 #define SPEED_LV1 ( 45 )
8
9 void setup() {
10   Track_Setup(); //Trace module initialization
11   Motor_Setup(); //Motor drive initialization
12   Emotion_Setup(); //Emotion initialization
13 }
14
15 void loop() {
16   Track_Read();
17   switch (sensorValue[3])
18   {
19     case 2: //010
20     case 5: //101
21       showArrow(1, 100);
22       Motor_Move(SPEED_LV1 , SPEED_LV1); //Move Forward
23       break;
24     case 0: //000
25       Motor_Move(SPEED_LV1 , SPEED_LV1); //Move Forward
26       break;
27     case 7: //111
28       eyesBlink1(100);
29       Motor_Move(0 , 0); //Stop
30       break;
31     case 4: //100
32     case 6: //110
33       wheel(2, 100);
34       Motor_Move(-SPEED_LV4 , SPEED_LV3); //Turn Left
35       break;
36     case 1: //001
37     case 3: //011
38       wheel(1, 100);
39       Motor_Move(SPEED_LV3 , -SPEED_LV4); //Turn Right
40       break;
41     default:
42       break;
43   }
44 }
```

Code Explanation:

Initialize PCF8574 chip, Motor, Emotion module.

```

10 Track_Setup(); //Trace module initialization
11 Motor_Setup(); //Motor drive initialization
12 Emotion_Setup(); //Emotion initialization
```

The function that obtains the feedback value from the tracking module. After calling this function, Raspberry Pi Pico W will store the data in the array `sensorValue[]`.

```
16 Track_Read();
```

Control the car to move forward, turn left, turn right, stop, etc. based on the value of line tracking module.

```
17 switch (sensorValue[3])
18 {
19     case 2:    //010
20     case 5:    //101
21         showArrow(1, 100);
22         Motor_Move(SPEED_LV1 , SPEED_LV1);      //Move Forward
23         break;
24     case 0:    //000
25         Motor_Move(SPEED_LV1 , SPEED_LV1); //Move Forward
26         break;
27     case 7:    //111
28         eyesBlink1(100);
29         Motor_Move(0 , 0);      //Stop
30         break;
31     case 4:    //100
32     case 6:    //110
33         wheel(2, 100);
34         Motor_Move(-SPEED_LV4 , SPEED_LV3); //Turn Left
35         break;
36     case 1:    //001
37     case 3:    //011
38         wheel(1, 100);
39         Motor_Move(SPEED_LV3 , -SPEED_LV4); //Turn Right
40         break;
41     default:
42         break;
43 }
```

Note: The tracks made of black tape vary among individuals. If your car cannot move along the black tape, you can modify the parameters in `Motor_Move()`.

Chapter 6 Infrared Car

6.1 Introduction of infrared reception function

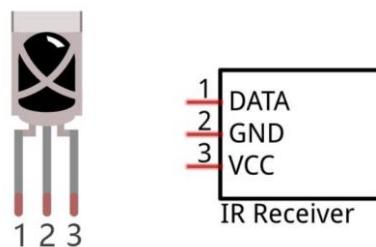
Infrared Remote

An 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 ray with different command. Infrared remote control technology is widely used in electronic products such as TV, air conditioning, etc. Thus making it possible for you to switch TV programs and adjust the temperature of the air conditioning when away from them. The remote control we use is shown below:



Infrared receiver

An 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.



When you use the infrared remote control, the infrared remote control sends a key value to the receiving circuit according to the pressed keys. We can program the Raspberry Pi Pico W to do things like lighting, when a key value is received.

The following is the key value that the receiving circuit will receive when each key of the infrared remote control is pressed.

ICON	KEY Value	ICON	KEY Value
	BA45FF00		F20DFF00
	B847FF00		F30CFF00
	BB44FF00		E718FF00
	BF40FF00		A15EFF00
	BC43FF00		F708FF00
	F807FF00		E31CFF00
	EA15FF00		A55AFF00
	F609FF00		BD42FF00
	E916FF00		AD52FF00
	E619FF00		B54AFF00

This sketch uses the infrared receiving tube to receive the value sent from the infrared remote control, and print it out via the serial port.

Sketch

Each time when you press the infrared remote control, the car will print the received infrared coding value through serial port.

Open the folder “05.1_IR_Receiver” in

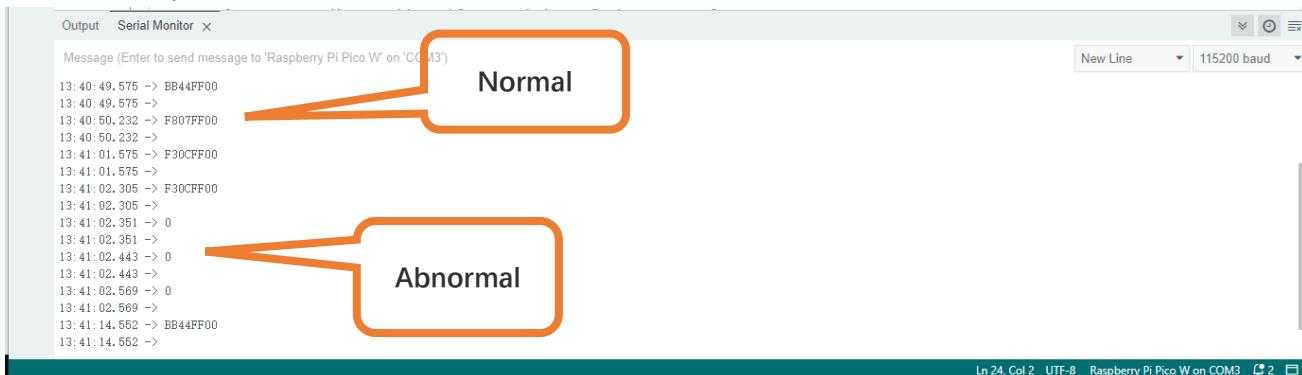
“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches” and double click “05.1_IR_Receiver.ino”.

Code

```

1 #include <IRremote.hpp>
2 #define IR_Pin 3 // Infrared receiving pin
3 #define ENABLE_LED_FEEDBACK true
4 #define DISABLE_LED_FEEDBACK false
5
6 void setup() {
7   Serial.begin(115200); // Initialize the serial port and set the baud rate to 115200
8   IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
9   Serial.print("IRrecvDemo is now running and waiting for IR message on Pin ");
10  Serial.println(IR_Pin); //print the infrared receiving pin
11 }
12
13 void loop() {
14   if (IrReceiver.decode()) {
15     unsigned long value = IrReceiver.decodedIRData.decodedRawData;
16     Serial.println(value, HEX); // Print "old" raw data
17     IrReceiver.resume(); // Enable receiving of the next value
18   }
19 }
```

Download the code to Raspberry Pi Pico (W), open the serial port monitor, set the baud rate to 115200, press the IR remote control, the pressed keys value will be printed out through the serial port. As shown in the following figure: (Note that if the remote control button is long pressed, the infrared receiving circuit receives a "0".)



First, include header file. Each time you use the infrared sensor, you need to include the header file at the beginning of the program.

```
1 #include <IRremote.hpp>
```

Second, define an infrared receive pin and the infrared sensor is initialized.

```

2 #define IR_Pin 3 // Infrared receiving pin
...
8 IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
```

Finally, **IrReceiver.decode()** is used to determine whether an infrared signal has been received, returning true/1 if an infrared signal has been received, or false/0 if no infrared signal has been received; If an infrared signal is received, the received infrared coded value is printed through the serial port.

Please note that **IrReceiver.resume()** must be applied to release the infrared receiver function each time data are received. Otherwise, the infrared receiver function can only be used once and data cannot be received

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next time.

```
14  if (IrReceiver.decode()) {  
15      unsigned long value = IrReceiver.decodedIRData.decodedRawData;  
16      Serial.println(value, HEX); // Print "old" raw data  
17      IrReceiver.resume(); // Enable receiving of the next value  
18 }
```

6.2 Infrared Car

Based on the previous section, we use the infrared remote control to control the car. Press the black button on the infrared remote control to control the car to move forward, backward, turn left, and turn right. Press other buttons and the cart stops moving.

Sketch

Open the folder “05.2_IR_Receiver_Car” in the **“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches”** and double click “05.2_IR_Receiver_Car.ino”.

Code

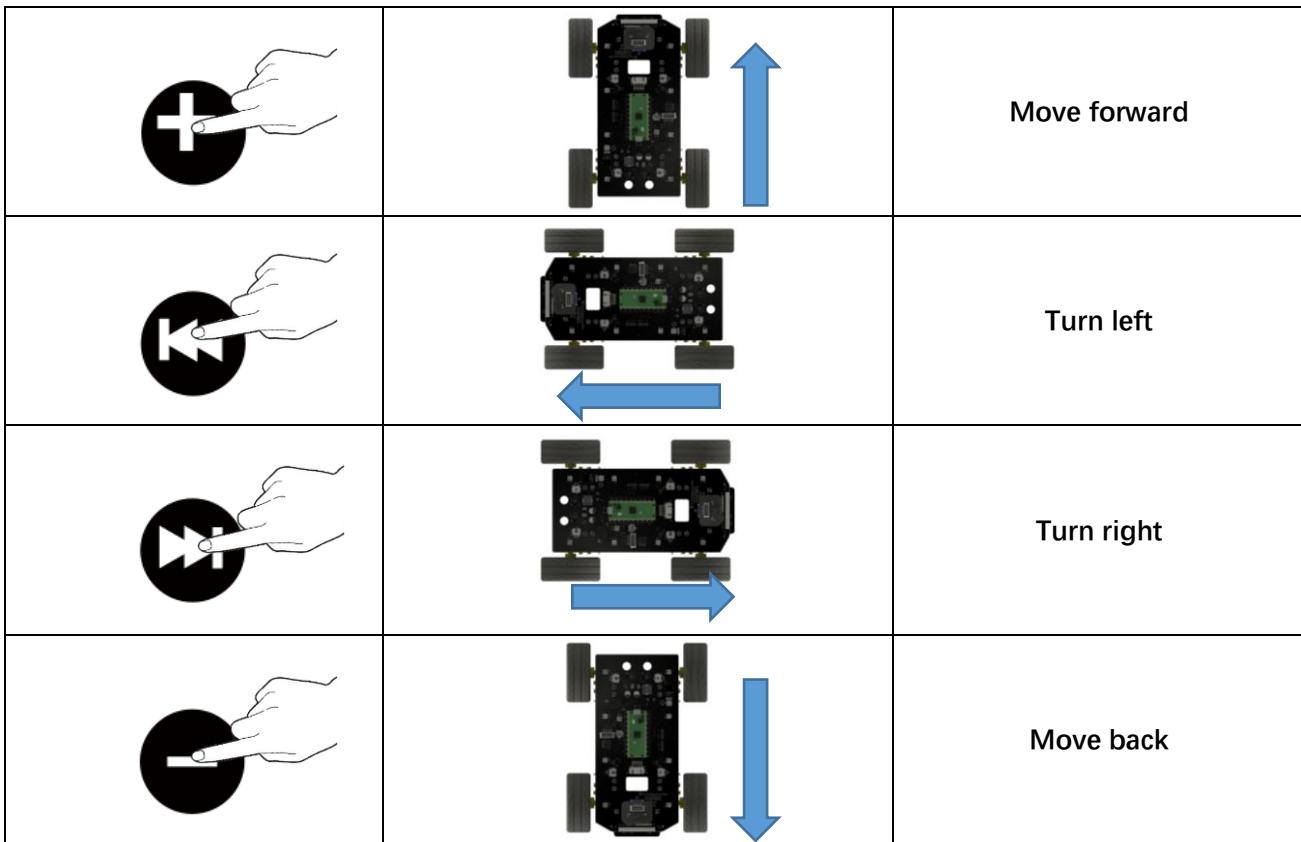
```

1 #include <Arduino.h>
2 #include <IRremote.hpp>
3 #include "Freenove_4WD_Car_For_Pico_W.h"
4 #define IR_Pin 3
5 #define ENABLE_LED_FEEDBACK true
6 #define DISABLE_LED_FEEDBACK false
7 int motor_speed = 50;
8 int emotionMode = 4;
9 int motor_flag = 0;
10
11 void setup() {
12     Serial.begin(115200);
13     Motor_Setup(); //Motor initialization
14     Emotion_Setup(); //Initializes Emotion module
15     IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
16 }
17
18 void loop() {
19     if (IrReceiver.decode()) {
20         unsigned long value = IrReceiver.decodedIRData.decodedRawData;
21         handleControl(value); // Handle the commands from remote control
22         Serial.println(value, HEX); // Print "old" raw data
23         Serial.println();
24         IrReceiver.resume(); // Enable receiving of the next value
25     }
26     showEmotion(emotionMode);
27 }
28
29 void handleControl(unsigned long value) {
30     // Handle the commands

```

```
31 switch (value) {  
32     case 0xBF40FF00: // Receive the number '+'  
33         motor_flag = 1;  
34         Motor_Move(motor_speed, motor_speed); // Go forward  
35         delay(200);  
36         Motor_Move(0, 0);  
37         break;  
38  
39     case 0xE619FF00: // Receive the number '-'  
40         motor_flag = 2;  
41         Motor_Move(-motor_speed, -motor_speed); // Back up  
42         delay(200);  
43         Motor_Move(0, 0);  
44         break;  
45  
46     case 0xF807FF00: // Receive the number '|<<'  
47         motor_flag = 3;  
48         Motor_Move(-motor_speed, motor_speed); // Turn left  
49         delay(200);  
50         Motor_Move(0, 0);  
51         break;  
52  
53     case 0xF609FF00: // Receive the number '|>>'  
54         motor_flag = 4;  
55         Motor_Move(motor_speed, -motor_speed); // Turn right  
56         delay(200);  
57         Motor_Move(0, 0);  
58         break;  
59  
60     case 0xE916FF00: // Receive the number '0'  
61         emotionMode = millis() % 10;  
62         break;  
63  
64     default:  
65         motor_flag = 0;  
66         Motor_Move(0, 0); //stop  
67         break;  
68     }  
69 }
```

Compile and upload the code to Raspberry Pi Pico (W). When pressing "0" of the infrared remote control, the expression module will randomly display the content dynamically.



Code Explanation:

Variable **IrReceiver.DecodedIRData.DecodedRawData** holds the infrared remote control encoding information, call handlecontrol function performs different code value corresponding action. After each execution of the program, call the **IrReceiver.resume()** function to release the infrared pin. If you do not call this function, you cannot use the infrared receiving and decoding functions again.

```

18 void loop() {
19   if (IrReceiver.decode()) {
20     unsigned long value = IrReceiver.decodedIRData.decodedRawData;
21     handleControl(value);      // Handle the commands from remote control
22     Serial.println(value, HEX); // Print "old" raw data
23     Serial.println();
24     IrReceiver.resume(); // Enable receiving of the next value
25   }
26   showEmotion(emotionMode);
27 }
```

Infrared key code value processing function, receives instructions sent by the infrared remote control, and execute the corresponding program.

```

29 void handleControl(unsigned long value) {
30   // Handle the commands
31   switch (value) {
32     case 0xBF40FF00: // Receive the number '+'
33     ...
39     case 0xE619FF00: // Receive the number '-'
38     ...
40 }
```

```
46      case 0xF807FF00: // Receive the number '|<<'  
...  
53      ...  
53      case 0xF609FF00: // Receive the number '|>>|'  
...  
60      ...  
60      case 0xE916FF00: // Receive the number '|0'|  
...  
64      ...  
64      default: // Control the car to stop moving  
...  
68      ...  
69  }
```

6.3 Multi-Functional Infrared Car

Following the previous section, we now integrate other functions into the infrared car, and most of the car's functions can be controlled by the infrared remote.

Sketch

Open the folder "05.3_Multi_Functional_Car" in the "**Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches**" and double click "05.3_Multi_Functional_Car.ino".

Code

```

1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include <IRremote.hpp>
4 #include "Freenove_4WD_Car_For_Pico_W.h"
5 #include "Freenove_4WD_Car_Emotion.h"
6 #include "Freenove_VK16K33_Lib.h"
7 #include "Freenove_4WD_Car_WS2812.h"
8
9 #define IR_Pin 3 // Infrared receiving pin
10 #define ENABLE_LED_FEEDBACK true
11 #define DISABLE_LED_FEEDBACK false
12
13 static int servo_1_angle = 90;
14 int emotion_flag = 0;
15 int ws2812_flag = 0;
16
17 int CAR_MODE_VOL = 0;
18 int LAST_CAR_MODE_VOL = 0;
19
20 void setup() {
21     Serial.begin(115200); //Turn on the serial port monitor and set the baud rate to 115200
22     Motor_Setup(); //Initialize motor
23     Servo_Setup(); //Initialize servo
24     Buzzer_Setup(); //Initialize the buzzer
25     WS2812_Setup(); //WS2812 initialization
26     Emotion_and_Ultrasonic_Setup();
27     IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
28     Servo_1_Angle(servo_1_angle);
29     delay(100);
30 }
31

```

```
32 void loop() {
33     if (IrReceiver.decode()) {
34         unsigned long value=IrReceiver.decodedIRData.decodedRawData;
35         handleControl(value); // Handle the commands from remote control
36         Serial.println(value, HEX); // Print "old" raw data
37         Serial.println();
38         IrReceiver.resume(); // Enable receiving of the next value
39     }
40     Emotion_and_Ultrasonic_Setup();
41     oa_CalculateVoltageCompensation();
42     if (Check_Module_value == MATRIX_IS_EXIST) {
43         Emotion_Show(emotion_task_mode); //Led matrix display function
44     } else if (Check_Module_value == SONAR_IS_ESIST) {
45     }
46     Car_Select(carFlag);
47     WS2812_Show(ws2812_task_mode); //Car color lights display function
48 }
49
50 void handleControl(unsigned long value) {
51     // Handle the commands
52     switch (value) {
53         case 0xBF40FF00: // Receive the number '+'
54             Motor_Move(50, 50);
55             delay(300);
56             Motor_Move(0, 0);
57             break;
58         case 0xE619FF00: // Receive the number '-'
59             Motor_Move(-50, -50);
60             delay(300);
61             Motor_Move(0, 0);
62             break;
63         case 0xF807FF00: // Receive the number '|<<|'
64             Motor_Move(-50, 50);
65             delay(300);
66             Motor_Move(0, 0);
67             break;
68         case 0xF609FF00: // Receive the number '|>>|'
69             Motor_Move(50, -50);
70             delay(300);
71             Motor_Move(0, 0);
72             break;
73         case 0xEA15FF00: // Receive the number '▶'
74             Motor_Move(0, 0);
75             break;
```

```
76     case 0xE916FF00: // Receive the number '0'  
77         servo_1_angle = servo_1_angle + 10;  
78         Servo_1_Angle(servo_1_angle);  
79         break;  
80     case 0xF30CFF00: // Receive the number '1'  
81         servo_1_angle = servo_1_angle - 10;  
82         Servo_1_Angle(servo_1_angle);  
83         break;  
84     case 0xF708FF00: // Receive the number '4'  
85         servo_1_angle = 90;  
86         Servo_1_Angle(servo_1_angle);  
87         break;  
88     case 0xF20DFF00: // Receive the number 'C'  
89         isLightModeFirstStarting = true;  
90         Servo_1_Angle(90);  
91         Car_SetMode(1);  
92         break;  
93     case 0xA15EFF00: // Receive the number '3'  
94         Servo_1_Angle(90);  
95         Car_SetMode(2);  
96         break;  
97     case 0xA55AFF00: // Receive the number '6'  
98         Servo_1_Angle(90);  
99         if (Check_Module_value == SONAR_IS_ESIST) {  
100             LASt_CAR_MODE_VOL = 1;  
101             Car_SetMode(3);  
102         }  
103         if (Check_Module_value != SONAR_IS_ESIST) {  
104             Buzzer_Variable(2000, 50, 2);  
105             Car_SetMode(0);  
106             Motor_Move(0, 0);  
107         }  
108         break;  
109     case 0xB54AFF00: // Receive the number '9'  
110         emotion_flag = 0;  
111         Emotion_SetMode(emotion_flag);  
112         Servo_1_Angle(90);  
113         Car_SetMode(0);  
114         Motor_Move(0, 0);  
115         break;  
116     case 0xBB44FF00: // Receive the number 'TEST'  
117         Buzzer_Variable(2000, 100, 1);  
118         break;  
119     case 0xE718FF00: // Receive the number '2'
```

```
120     if (Check_Module_value == MATRIX_IS_EXIST) {
121         emotion_flag = emotion_flag + 1;
122         if (emotion_flag > 7) {
123             emotion_flag = 0;
124         }
125         Emotion_SetMode(emotion_flag); //Display
126         Serial.print("\n matrix is exist !!! \n");
127     }
128     if (Check_Module_value != MATRIX_IS_EXIST) {
129         Buzzer_Variable(2000, 50, 2);
130         Serial.print("\n sonar is exist !!! \n");
131     }
132     break;
133 case 0xE31CFF00: // Receive the number '5'
134     emotion_flag = 0;
135     Emotion_SetMode(emotion_flag);
136     break;
137 case 0xBD42FF00: // Receive the number '7'
138     ws2812_flag = ws2812_flag + 1;
139     if (ws2812_flag >= 6) {
140         ws2812_flag = 0;
141     }
142     WS2812_SetMode(ws2812_flag);
143     break;
144 case 0xAD52FF00: // Receive the number '8'
145     ws2812_flag = 0;
146     WS2812_SetMode(ws2812_flag);
147     break;
148 case 0xFFFFFFFF: // Remain unchanged
149     break;
150 default:
151     break;
152 }
153 }
```

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



ICON	KEY Value	Function	ICON	KEY Value	Function
+	BF40FF00	Move forward	2	E718FF00	Change the expression display mode
◀	F807FF00	Turn left	5	E31CFF00	Turn off emoticons
▶	F609FF00	Turn light	7	BD42FF00	Change the display mode of the WS2812
-	E619FF00	Move back	8	AD52FF00	Turn off WS2812 display
▶▶	EA15FF00	Stop the car	C	F20DFF00	Light tracing car mode
0	E916FF00	Control servo turn left	3	A15EFF00	Line tracking car mode
1	F30CFF00	Control servo turn right	6	A55AFF00	Ultrasonic obstacle avoidance car mode
4	F708FF00	Control servo turn to 90°	9	B54AFF00	Manual control mode
TEST	BB44FF00	Control the buzzer			

Since the ultrasonic module shares the interface with the LED Matrix, only one of them can be used at the same time. When the function of the sent button conflicts with the current head module, the buzzer will sound twice continuously. The situations can be as follows:

When "6" is pressed, if the LED Matrix is connected to the head, the buzzer will sound twice.

When "2" is pressed, if the head is connected to an ultrasonic module, the buzzer will sound twice.

When you hear the buzzer beep twice, please replace the module on the head to continue the experiment.

Code Explanation:

Add the header file for the car.

```

1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include <IRremote.hpp>
4 #include "Freenove_4WD_Car_For_Pico_W.h"
5 #include "Freenove_4WD_Car_Emotion.h"
6 #include "Freenove_VK16K33_Lib.h"
7 #include "Freenove_4WD_Car_WS2812.h"

```

Initialize each function of the car.

```

21 Serial.begin(115200); //Turn on the serial port monitor and set the baud rate to 115200
22 Motor_Setup(); //Initialize motor
23 Servo_Setup(); //Initialize servo
24 Buzzer_Setup(); //Initialize the buzzer
25 WS2812_Setup(); //WS2812 initialization
26 Emotion_and_Ultrasonic_Setup();
27 IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
28 Servo_1_Angle(servo_1_angle);
29 delay(100);

```

Infrared key code value processing function receives instructions sent by the infrared remote control and execute the corresponding program.

```

50 void handleControl(unsigned long value) {
51 // Handle the commands
52 switch (value) {
53 case 0xBF40FF00: // Receive the number '+'
...
58     ...
59     case 0xE619FF00: // Receive the number '-'
60     ...
61     case 0xF807FF00: // Receive the number '|<<|'
62     ...
63     case 0xF609FF00: // Receive the number '|>>|'
64     ...
65     case 0xEA15FF00: // Receive the number '▶'
66     ...
67     case 0xE916FF00: // Receive the number '0'
68     ...
69     case 0xF30cff00: // Receive the number '1'
70     ...
71     case 0xF708FF00: // Receive the number '4'
72     ...
73     case 0xF20dff00: // Receive the number 'C'
74     ...
75     case 0xA15EFF00: // Receive the number '3'
76     ...

```

```
97      case 0xA55AFF00: // Receive the number '6'  
...  
109     ...  
110     case 0xB54AFF00: // Receive the number '9'  
...  
116     ...  
117     case 0xBB44FF00: // Receive the number 'TEST'  
...  
119     ...  
120     case 0xE718FF00: // Receive the number '2'  
...  
133     ...  
134     case 0xE31CFF00: // Receive the number '5'  
...  
137     ...  
138     case 0xBD42FF00: // Receive the number '7'  
...  
144     ...  
145     case 0xAD52FF00: // Receive the number '8'  
...  
148     ...  
149     case 0xFFFFFFFF: // Remain unchanged  
150         break;  
151     default:  
152         break;  
153     }
```

Chapter 7 WiFi Car(Only for Pico W)

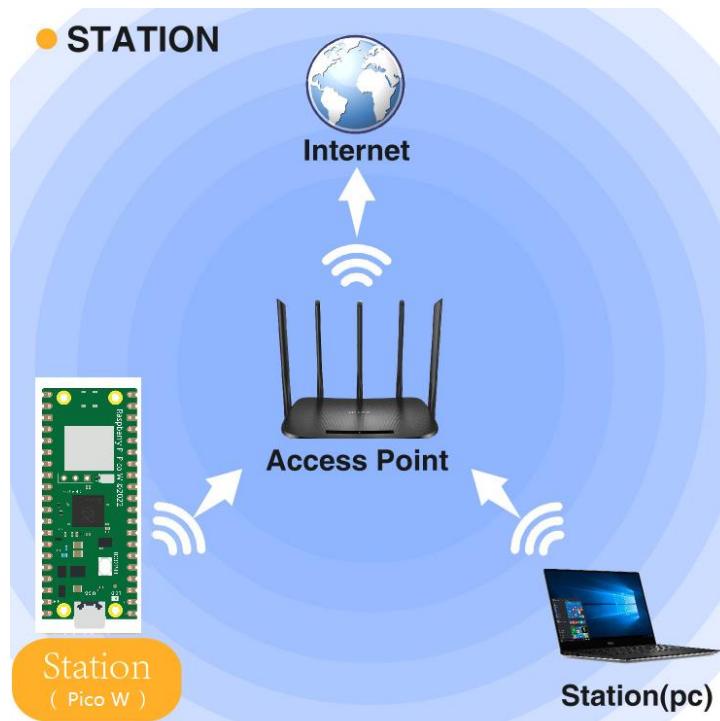
7.1 WiFi Sending and Receiving Data

This chapter requires the use of a Raspberry Pi Pico W. If you use a Pico, you will not be able to finish projects in this chapter.

Before programming, we need to have a basic understanding of WiFi.

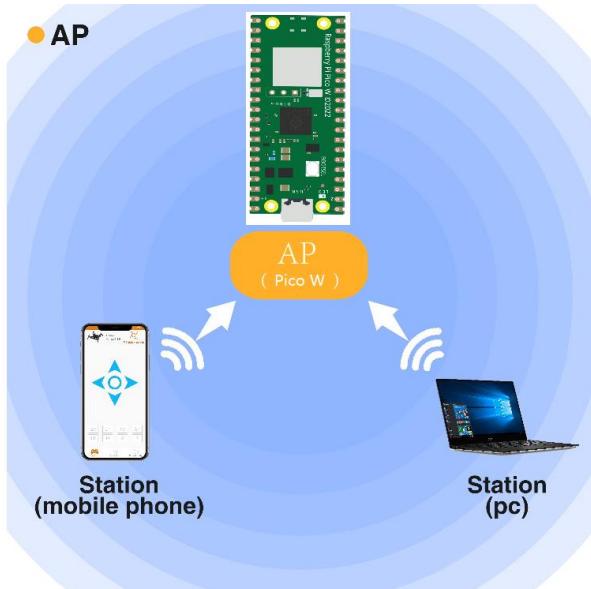
Station mode

When Raspberry Pi Pico W is in Station mode, it acts as a WiFi client. It can connect to the router network and communicate with other devices on the same LAN. As shown below, the PC is connected to a wireless router, and if Raspberry Pi Pico W wants to communicate with the PC, it needs to be connected to the same router.



AP mode

When Raspberry Pi Pico W selects AP mode, it creates a hotspot network that is separate from the Internet and waits for other WiFi devices to connect. As shown in the figure below, Raspberry Pi Pico W is used as a hotspot. If a mobile phone or PC wants to communicate with Raspberry Pi Pico W, it must be connected to the hotspot of Raspberry Pi Pico W. Only after a connection is established with Raspberry Pi Pico W can they communicate.



AP+Station mode

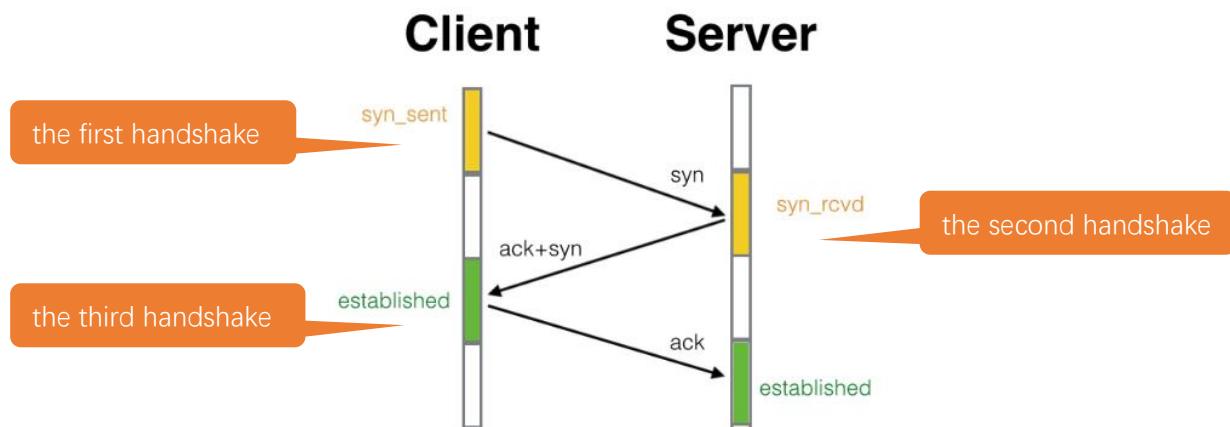
In addition to AP mode and station mode, Raspberry Pi Pico W can also use AP mode and station mode at the same time. This mode includes the functions of the previous two modes. Turn on Raspberry Pi Pico W's station mode, connect it to the router network, and it can communicate with the Internet via the router. At the same time, turn on its AP mode to create a hotspot network and other WiFi devices can choose to connect to the router network or the hotspot network to communicate with Raspberry Pi Pico W.

TCP connection

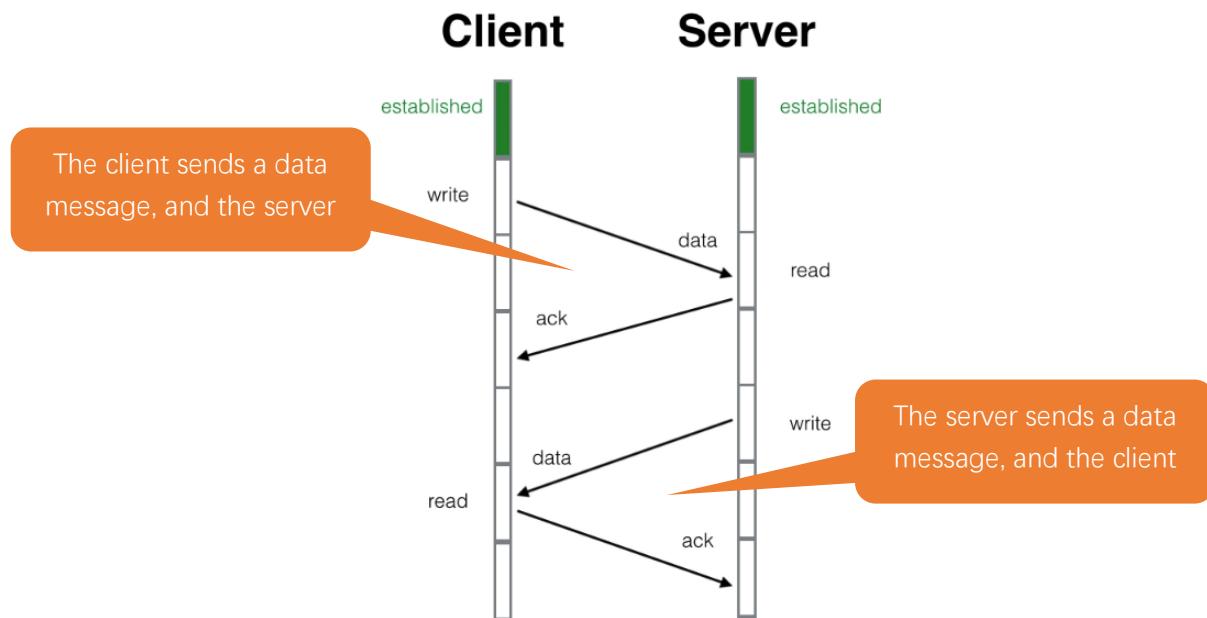
Before transmitting data, TCP needs to establish a logical connection between the sending end and the receiving end. It provides reliable and error-free data transmission between the two computers. In the TCP connection, the client and the server must be clarified. The client sends a connection request to the server, and each time such a request is proposed, a "three-times handshake" is required.

Three-times handshake: In the TCP protocol, during the preparation phase of sending data, the client and the server interact three times to ensure the reliability of the connection, which is called "three-times handshake". The first handshake, the client sends a connection request to the server and waits for the server to confirm. The second handshake, the server sends a response back to the client informing that it has received the connection request.

The third handshake, the client sends a confirmation message to the server again to confirm the connection.



TCP is a connection-oriented, low-level transmission control protocol. After TCP establishes a connection, the client and server can send and receive messages to each other, and the connection will always exist as long as the client or server does not initiate disconnection. Each time one party sends a message, the other party will reply with an ack signal.

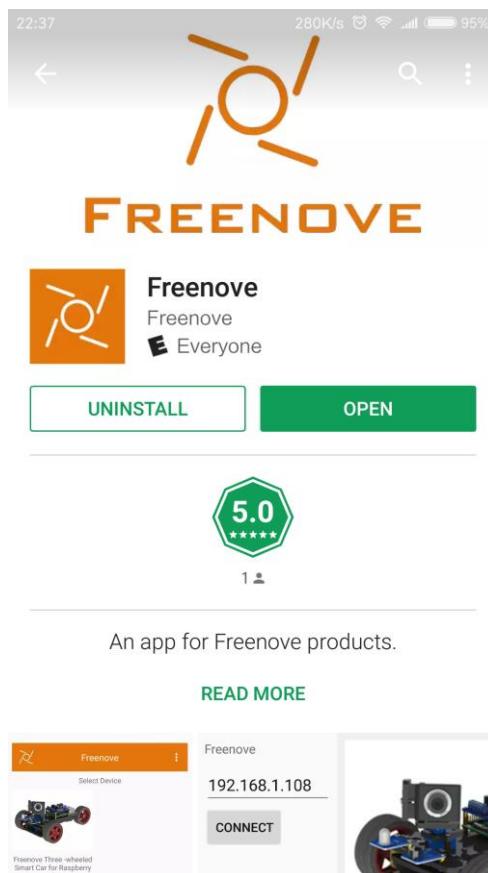


Install Freenove app

There are three ways to install our app.

Method 1

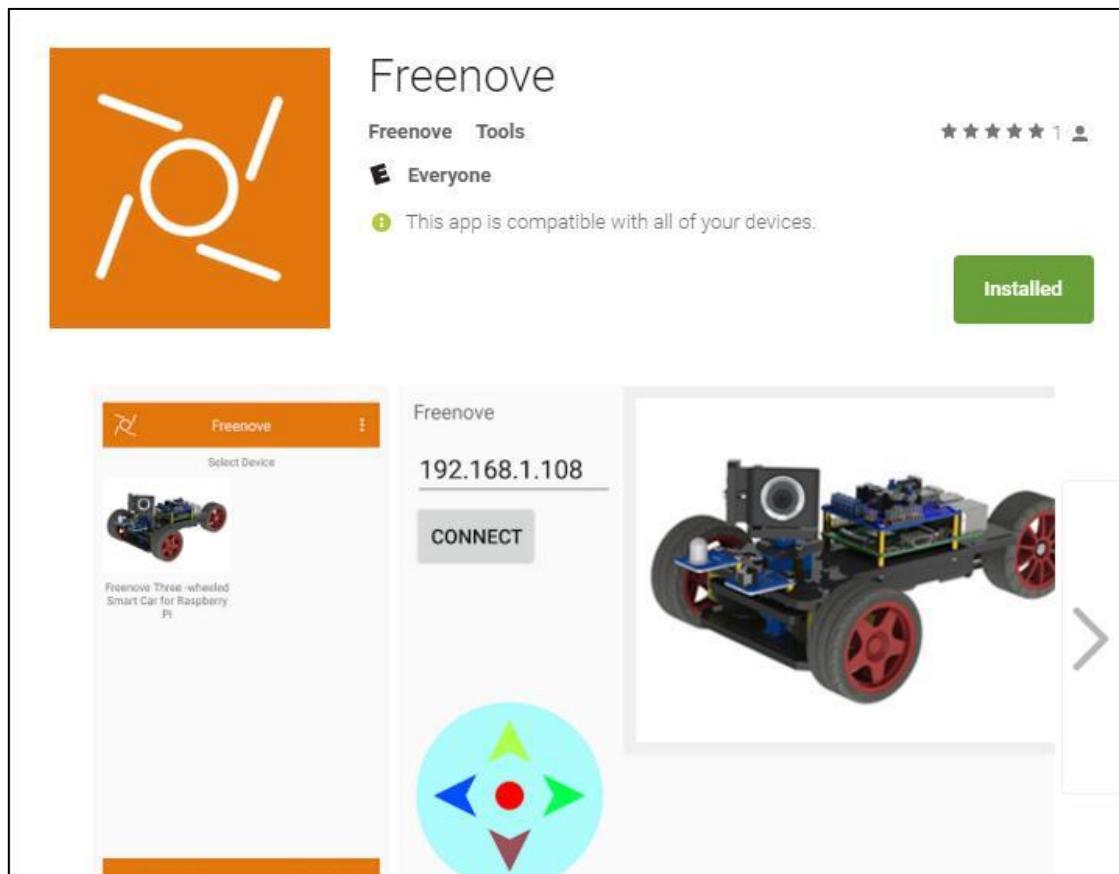
Use Google play to search “Freenove”, download and install.



Need support? ✉ support.freenove.com

Method 2

Visit <https://play.google.com/store/apps/details?id=com.freenove.suhayl.Freenove>, and click install.



Method 3

Visit https://github.com/Freenove/Freenove_app_for_Android, download the files in this library, and install freenove.apk to your Android phone manually.

A screenshot of a GitHub repository page for 'Freenove / Freenove_app_for_Android'. The repository has 1 commit, 1 branch, 0 releases, and 1 contributor. It has 2 pull requests, 0 issues, 0 projects, 0 wiki, 0 pulse, 0 graphs, and 0 settings. The 'Code' tab is selected. A red arrow points from the 'Clone or download' button in the top right to a callout bubble at the bottom right containing the text 'Click here to download.' The repository was first published 3 minutes ago. The 'Clone or download' button is highlighted with a green box.

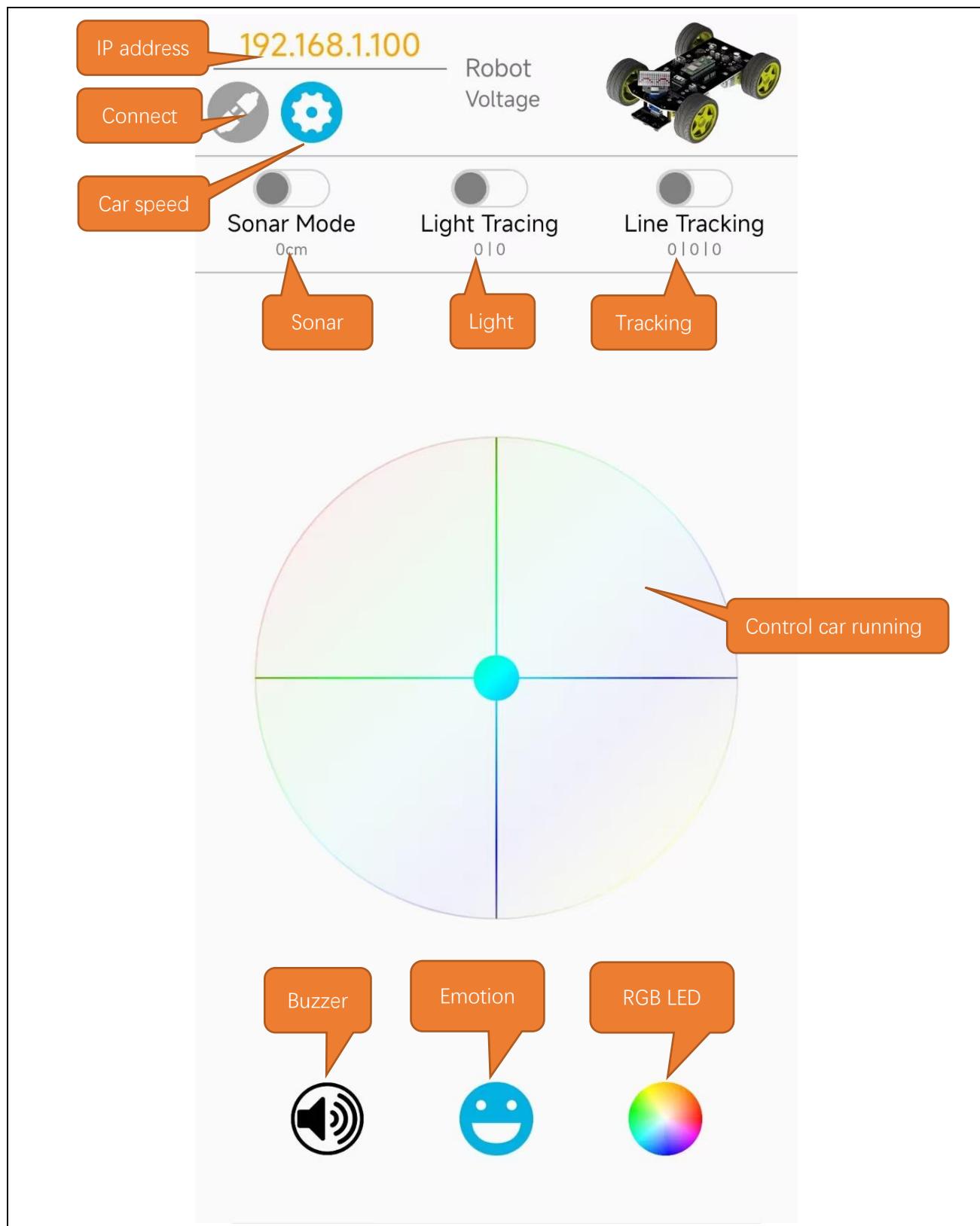
Menu

Open application “Freenove”, as shown below:



Introduction to the APP

In this chapter, we use Freenove 4WD Car for Raspberry Pi Pico W, so it is necessary to understand the interface of this mode.



Sketch

Open “06.1_WiFi_APP_TcpServer” in

“Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches” and double click “06.1_WiFi_APP_TcpServer.ino”.

Before uploading the code, you need to modify it according to the name and password of your router.

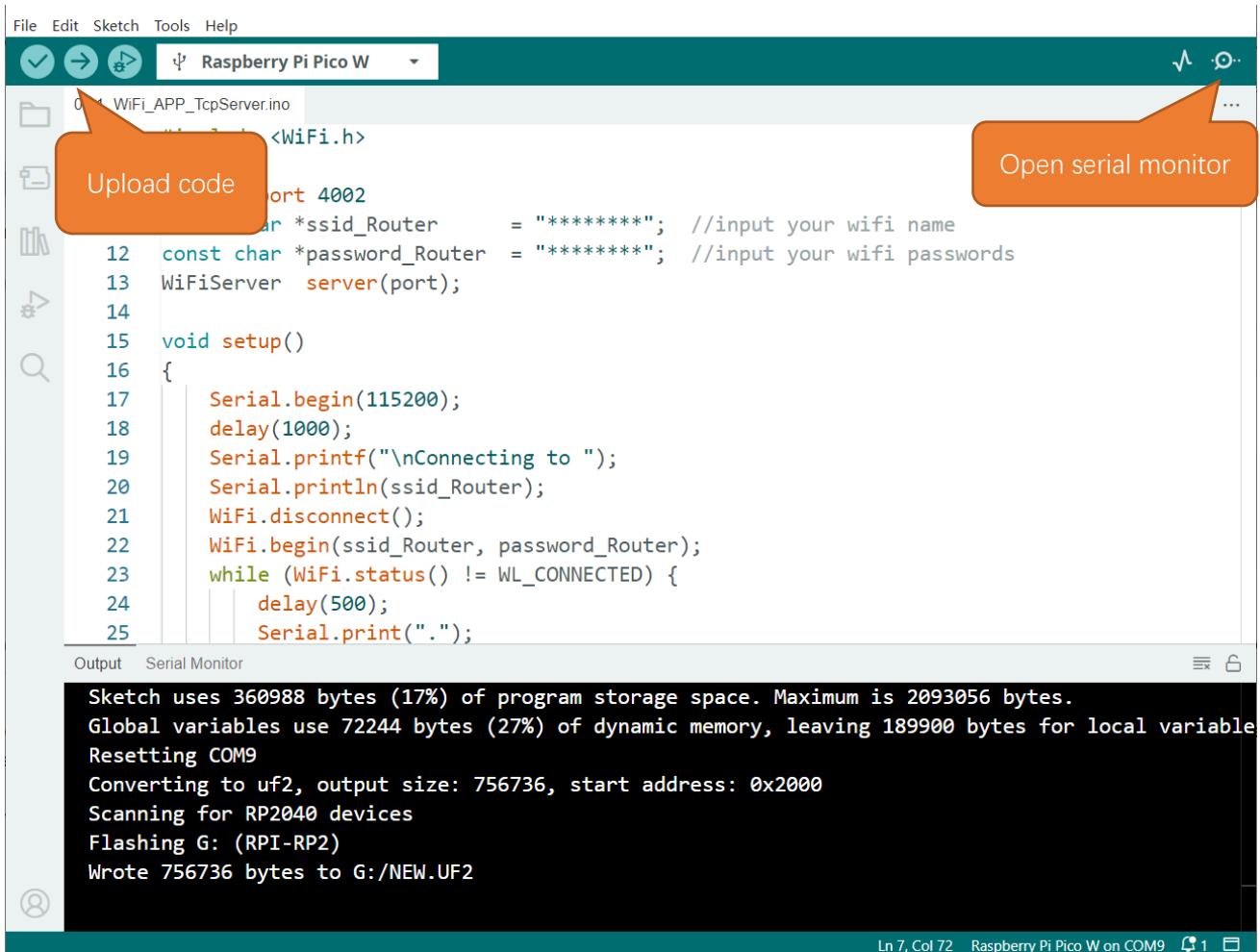
Code

```

1 #include <WiFi.h>
2
3 #define port 4002
4 const char *ssid_Router      = "*****"; //input your wifi name
5 const char *password_Router  = "*****"; //input your wifi passwords
6 WiFiServer server(port);
7
8 void setup()
9 {
10    Serial.begin(115200);
11    delay(1000);
12    Serial.printf("\nConnecting to ");
13    Serial.println(ssid_Router);
14    WiFi.disconnect();
15    WiFi.begin(ssid_Router, password_Router);
16    while (WiFi.status() != WL_CONNECTED) {
17        delay(500);
18        Serial.print(".");
19    }
20    Serial.println("");
21    Serial.println("WiFi connected.");
22    Serial.print("IP address: ");
23    Serial.println(WiFi.localIP());
24    Serial.printf("IP port: %d\n", port);
25    server.begin(port);
26 }
27
28 void loop() {
29    WiFiClient client = server.accept();           // listen for incoming clients
30    if (client) {                                  // if you get a client,
31        Serial.println("Client connected.");
32        while (client.connected()) {                // loop while the client's connected
33            if (client.available()) {                // if there's bytes to read from the
34                client,                                // client,
35                Serial.println(client.readStringUntil('\n')); // print it out the serial monitor
36                while(client.read()>0);               // clear the wifi receive area cache
37            }
38        }
39    }
40 }
```

```
37     }
38     if(Serial.available()){           // if there's bytes to read from the
39     serial monitor,
40     client.print(Serial.readStringUntil('\n')); // print it out the client.
41     while(Serial.read()>0);                  // clear the wifi receive area cache
42     }
43   }
44   client.stop();                   // stop the client connecting.
45   Serial.println("Client Disconnected.");
46 }
47 }
```

Upload the code to Raspberry Pi Pico W car and open serial monitor.



```

File Edit Sketch Tools Help
Raspberry Pi Pico W
WiFi_APP_TcpServer.ino
<WiFi.h>
Upload code
port 4002
const char *ssid_Router      = "*****"; //input your wifi name
const char *password_Router  = "*****"; //input your wifi passwords
WiFiServer server(port);
void setup()
{
    Serial.begin(115200);
    delay(1000);
    Serial.printf("\nConnecting to ");
    Serial.println(ssid_Router);
    WiFi.disconnect();
    WiFi.begin(ssid_Router, password_Router);
    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }
}

```

Output Serial Monitor

Sketch uses 360988 bytes (17%) of program storage space. Maximum is 2093056 bytes.
Global variables use 72244 bytes (27%) of dynamic memory, leaving 189900 bytes for local variable
Resetting COM9
Converting to uf2, output size: 756736, start address: 0x2000
Scanning for RP2040 devices
Flashing G: (RPI-RP2)
Wrote 756736 bytes to G:/NEW.UF2

Ln 7, Col 72 Raspberry Pi Pico W on COM9 1



Output Serial Monitor

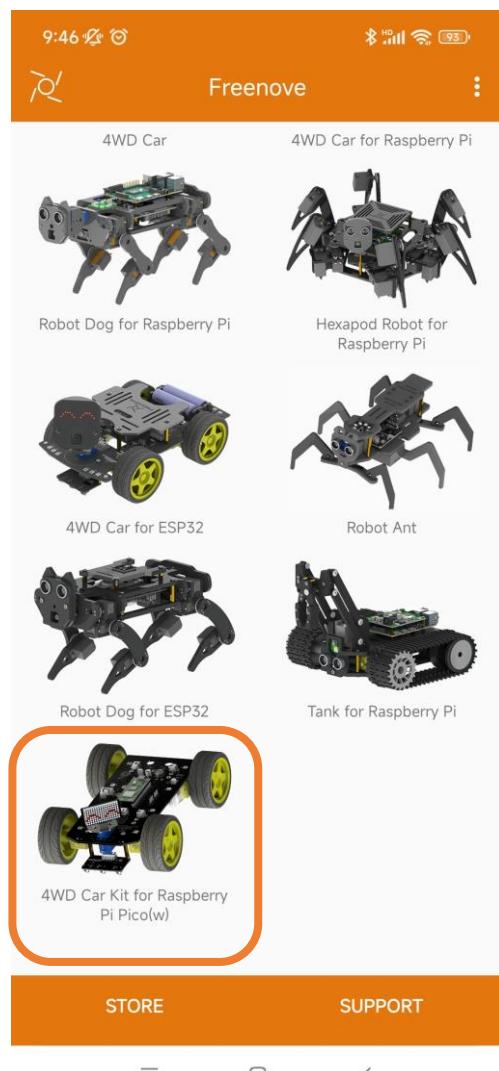
Message (Enter to send message to 'Raspberry Pi Pico W' on 'COM9') New Line 115200 baud

09:17:14.234 ->
09:17:14.234 -> Connecting to FYI_2.4G
09:17:21.265 ->
09:17:21.265 -> WiFi connected.
09:17:21.265 -> IP address: 192.168.1.92
09:17:21.265 -> IP port: 4002

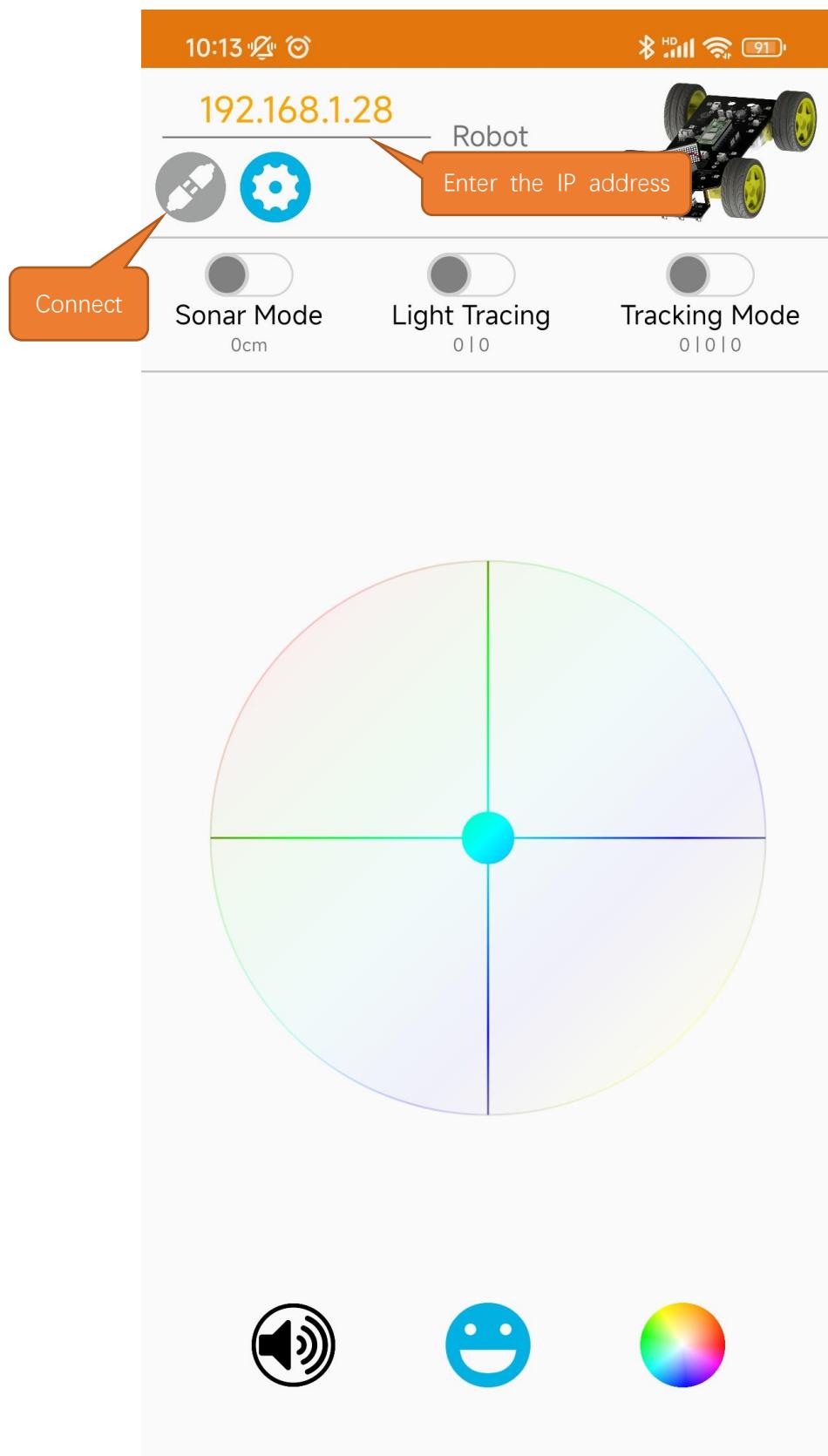
Make sure your phone and Raspberry Pi Pico W are connected to the same router. This IP address is the device IP address.

COM9 1

Open mobile phone app and select Freenove 4WD Car for Raspberry Pi Pico (W).



Make sure your mobile phone and Raspberry Pi Pico W car are connected to the same router. According to the aforementioned IP address, enter the corresponding IP address, and then click Connect. Tap the button on the screen and you can see the data on the serial monitor.



Output Serial Monitor x

Message (Enter to send message to 'Raspberry Pi Pico W' on 'COM3')

11:00:16.645 -> Command Server connected to a client.
 11:00:25.287 -> M#-22#-16
 11:00:25.381 -> M#-22#-6
 11:00:25.381 -> M#-22#0
 11:00:25.728 -> M#-23#7
 11:00:25.728 -> M#-24#16
 11:00:25.728 -> M#-25#23
 11:00:25.728 -> M#28#-26
 11:00:25.728 -> M#0#0
 11:00:31.782 -> B#2000
 11:00:31.875 -> D#0
 11:00:32.580 -> T#4
 11:00:33.760 -> T#4
 11:00:34.407 -> T#5
 11:00:34.780 -> T#6
 11:00:35.663 -> D#0
 11:00:36.528 -> D#1
 11:00:36.873 -> D#2

Ln 46, Col 4 UTF-8 Raspberry Pi Pico W on COM3 2

Code Explanation:

Add the library functions of WiFi. Each time before using WiFi, please add these library functions.

```
1 #include <WiFi.h>
```

Define two pointer variables to store information.

```
4 const char *ssid_Router = "*****"; //input your wifi name  

5 const char *password_Router = "*****"; //input your wifi passwords
```

Connect Raspberry Pi Pico W to the router. After the router is successfully connected, Raspberry Pi Pico W will print the IP address information to the serial monitor.

```
22 Serial.print("IP address: ");  

23 Serial.println(WiFi.localIP());
```

Mobile applications use a server for transmitting commands. Set Raspberry Pi Pico W to start a server. The server with port 4002 is used to send commands.

```
24 Serial.printf("IP port: %d\n", port);  

25 server.begin(port);
```

Define a WiFi client object to monitor whether the server has a client requesting access signal.

```
29 WiFiClient client = server.accept(); // listen for incoming clients
```

Determine whether there is a client connected to the server.

```
32 while (client.connected()) { // loop while the client's connected
```

Call available function to query whether the client has sent data to the server.

```
33 if (client.available()) { // if there's bytes to read from the  

34 client,
```

Call readStringUntil function to read a line of data from the client and print it to the serial monitor.

```
35 Serial.println(client.readStringUntil('\n')); // print it out the serial monitor  

36 while(client.read()>0); // clear the wifi receive area cache
```

Call stop() function to close the client connection.

```
44 client.stop(); // stop the client connecting.
```

Reference

Class Station

Every time when using WiFi, you need to include header file "WiFi.h".

begin(ssid, password,channel, bssid, connect): Raspberry Pi Pico W is used as Station to connect hotspot.

ssid: WiFi hotspot name

password: WiFi hotspot password

channel: WiFi hotspot channel number; communicating through specified channel; optional parameter

bssid: mac address of WiFi hotspot, optional parameter

connect: boolean optional parameter, defaulting to true. If set as false, then Pico W won't connect WiFi.

config(local_ip, gateway, subnet, dns1, dns2): set static local IP address.

local_ip: station fixed IP address.

subnet: subnet mask

dns1,dns2: optional parameter, defines IP address of domain name server

status: obtain the connection status of WiFi

local IP(): obtian IP address in Station mode

disconnect(): disconnect wifi

setAutoConnect(boolean): set automatic connection Every time Raspberry Pi Pico W is powered on, it will connect WiFi automatically.

setAutoReconnect(boolean): set automatic reconnection Every time Raspberry Pi Pico W disconnects from WiFi, it will reconnect to WiFi automatically.

Class AP

Every time when using WiFi, you need to include header file "WiFi.h".

softAP(ssid, password, channel, ssid_hidden, max_connection):

ssid: WiFi hotspot name

password: WiFi hotspot password

channel: Number of WiFi connection channels, range 1-13. The default is 1.

ssid_hidden: Whether to hide WiFi name from other devices. The default is not hide.

max_connection: Maximum number of WiFi connected devices. The range is 1-4. The default is 4.

softAPConfig(local_ip, gateway, subnet): set static local IP address.

local_ip: station fixed IP address.

Gateway: gateway IP address

Subnet: subnet mask

softAP(): obtian IP address in AP mode

softAPDisconnect (): disconnect AP mode.

Class Client

Every time when using Client, you need to include header file "WiFi.h".

connect(ip, port, timeout)/connect(*host, port, timeout): establish a TCP connection.

ip, *host: ip address of target server

port: port number of target server

timeout: connection timeout

connected(): judge whether client is connecting. If return value is 1, then connect successfully; If return value is 0, then fail to connect.

stop(): stop tcp connection

print(): send data to server connecting to client

available(): return to the number of bytes readable in receive buffer, if no, return to 0 or -1.

read(): read one byte of data in receive buffer

readString(): read string in receive buffer

Class Server

Every time use Server functionality, we need to include header file "WiFi.h".

WiFiServer(uint16_t port=80, uint8_t max_clients=4): create a TCP Server.

port: ports of Server; range from 0 to 65535 with the default number as 80.

max_clients: maximum number of clients with default number as 4.

begin(port): start the TCP Server.

port: ports of Server; range from 0 to 65535 with the default number as 0.

setNoDelay(bool nodelay): whether to turn off the delay sending functionality.

nodelay: true stands for forbidden Nagle algorithm.

close(): close tcp connection.

stop(): stop tcp connection.

7.2 WiFi Car by APP

Based on the previous sector, we now integrate other functions with WiFi, so that most of the car's functions can be controlled with phone APP.

Sketch

Open the folder “06.2_Multi_Functional_Car” in Freenove_4WD_Car_Kit_for_Raspberry Pi

Pico\Ordinary_wheels\Sketches and double click “06.2_Multi_Functional_Car.ino”.

Before compiling the code, please modify the code according to the name and password of your WiFi.

To enable Raspberry Pi Pico W's own router functionality, set line 37 to WiFi_Setup(1); to connect Raspberry Pi Pico W to the router, set line 37 to WiFi_Setup(0).

In the code we provide, the default is: WiFi_Setup(0).

At this point, you need to make sure your phone and the Raspberry PI Pico W car are connected to the same router.

Code

```

1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include <WiFi.h>
4 #include <WiFiClient.h>
5 #include <Wire.h>
6 #include "Freenove_4WD_Car_WiFi.h"
7 #include "Freenove_4WD_Car_Emotion.h"
8 #include "Freenove_4WD_Car_WS2812.h"
9 #include "Freenove_4WD_Car_For_Pico_W.h"
10
11 #define UPLOAD_VOL_TIME 3000
12 long int lastUploadVoltageTime;
13 #define UPLOAD_LIGHTVOL_TIME 500
14 long int lastUploadLIGHTADCTime;
15 #define UPLOAD_LINEVOL_TIME 200
16 long int lastUploadLINEVOLTime;
17 long int lastUploadSONARVOLTime;
18 int buzzer_frequency = 0;
19 int CAR_MODE_VOL = 0;
20 int LAST_CAR_MODE_VOL = 0;
21
22 char CmdArray[8];
23 int paramters[8];
24 int sendOnceModuleCheck = 1;
25 int cmdFlag;
26

```

```
27 //WiFi parameter setting
28 char ssid_Router[] =      "*****";           //Modify according to your router name
29 char password_Router[] =  "*****";           //Modify according to your router password
30 char ssid_AP[] =          "Sunshine";         //Pico W turns on an AP and calls it Sunshine
31 char password_AP[] =      "Sunshine";         //Set your AP password for Pico W to Sunshine
32 WiFiServer server_Cmd(4002);
33
34 void setup() {
35     Buzzer_Setup();                      //Buzzer initialization
36     Serial.begin(115200);
37     WiFi_Setup(0);                      // Set mode. When the parameter is 1, AP mode is enabled.
38     If the parameter is 0, the STA mode is enabled.
39     server_Cmd.begin(4002);              //Start the command server
40     server_Cmd.setNoDelay(true);        //Set no delay in sending and receiving data
41     Wire.begin();
42     Motor_Setup();                     //Motor initialization
43     Servo_Setup();                     //Servo initialization
44     WS2812_Setup();                   //WS2812 initialization
45     Emotion_and_Ultrasonic_Setup();   //Emotion initialization or Ultrasonic initialization
46     Photosensitive_Setup();           //Light initialization
47     Track_Setup();                    //Track initialization
48     Servo_1_Angle(90);
49     delay(500);
50 }
51
52 void loop() {
53     WiFiClient client = server_Cmd.available(); //listen for incoming clients
54     if (client) {                         //if you get a client
55         Serial.println("Cmd_Server connected to a client.");
56         while (client.connected()) {
57             if (sendOnceModuleCheck == 1) {
58                 if (Check_Module_value == SONAR_IS_ESIST)
59                     cmdFlag = SONAR_IS_ESIST;
60                 else
61                     cmdFlag = MATRIX_IS_EXIST;
62                 sendOnceModuleCheck = 0;
63                 client.print("A#" + String(cmdFlag) + "\n");
64             }                               //loop while the client's connected
65             if (client.available()) {       //if there's bytes to read from the client
66                 String inputStringTemp = client.readStringUntil('\n'); //Read the command by WiFi
67                 Serial.println(inputStringTemp);                  //Print out the command received by WiFi
68                 int string_length = inputStringTemp.length() + 1;
69                 char str[string_length];
70                 inputStringTemp.toCharArray(str, string_length);
```

```

70     Get_Command(str);
71     if (CmdArray[0] == CMD_LED_MOD) //Set the display mode of car colored lights
72     {
73         WS2812_SetMode(paramters[1]);
74     }
75     if (CmdArray[0] == CMD_LED) //Set the color and brightness of the car lights
76     {
77         WS2812_Set_Color_1(paramters[1], paramters[2], paramters[3], paramters[4]);
78     }
79     if (CmdArray[0] == CMD_MATRIX_MOD) //Set the display mode of the LED matrix
80     {
81         if (Check_Module_value == MATRIX_IS_EXIST) {
82             Emotion_SetMode(paramters[1]); //Display
83             Serial.print("\n matrix is exist !!! \n");
84         }
85         if (Check_Module_value != MATRIX_IS_EXIST) {
86             client.print("A#" + String(SONAR_IS_ESIST) + "\n");
87             Serial.print("\n sonar is exist !!! \n");
88         }
89     }
90     if (CmdArray[0] == CMD_BUZZER) //Buzzer control command
91     {
92         tone(2, paramters[1]);
93     }
94     if (CmdArray[0] == CMD_POWER) { //Power query command
95         float battery_voltage = Get_Battery_Voltage();
96         client.print(CMD_POWER);
97         client.print(INTERVAL_CHAR);
98         client.print(battery_voltage);
99         client.print(ENTER);
100    }
101    if (CmdArray[0] == CMD_MOTOR) { //Network control car movement command
102        Car_SetMode(0);
103        if (paramters[1] == 0 && paramters[2] == 0) {
104            Motor_Move(0, 0); //Stop the car
105        } else //If the parameters are not equal to 0
106        {
107            Motor_Move(paramters[1], paramters[2]);
108        }
109    }
110    if (CmdArray[0] == CMD_SERVO) { //Network control servo motor movement command
111        Servo_1_Angle(paramters[1]);
112    }
113    if (CmdArray[0] == CMD_CAR_MODE) { //Car command Mode

```

```
114     oa_CalculateVoltageCompensation();
115     if (paramters[1] == CAR_MODE_LIGHT_TRACING) //Light seeking car command
116     {
117         LAST_CAR_MODE_VOL = 1;
118         Car_SetMode(1);
119     } else if (paramters[1] == CAR_MODE_LINE_TRACKING) //Tracking car command
120     {
121         LAST_CAR_MODE_VOL = 1;
122         Car_SetMode(2);
123     } else if (paramters[1] == CAR_MODE SONAR) //Ultrasonic car command
124     {
125         if (Check_Module_value == SONAR_IS_ESIST) {
126             LAST_CAR_MODE_VOL = 1;
127             Car_SetMode(CAR_MODE SONAR);
128         }
129         if (Check_Module_value != SONAR_IS_ESIST) {
130             Car_SetMode(CAR_MODE MANUAL);
131             client.print("A#" + String(MATRIX_IS_EXIST) + "\n");
132         }
133     } else if (paramters[1] == 0) {
134         LAST_CAR_MODE_VOL = 2;
135         Car_SetMode(0);
136     }
137     if (CAR_MODE_VOL != LAST_CAR_MODE_VOL) {
138         if (CAR_MODE_VOL == 1) {
139             emotion_task_mode = 0; //Display
140             Motor_Move(0, 0); //Stop the car
141             Servo_1_Angle(90);
142             delay(100);
143             isLightModeFirstStarting = true;
144         }
145         CAR_MODE_VOL = LAST_CAR_MODE_VOL;
146     }
147 }
148 //Clears the command array and parameter array
149 memset(CmdArray, 0, sizeof(CmdArray));
150 memset(paramters, 0, sizeof(paramters));
151 }
152 if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {
153     float battery_voltage = Get_Battery_Voltage();
154     client.print("P#" + String(battery_voltage) + "\n");
155     lastUploadVoltageTime = millis();
156 }
Emotion_and_Ultrasonic_Setup();
```

```

158     if (Check_Module_value == MATRIX_IS_EXIST) {
159         Emotion_Show(emotion_task_mode); //Led matrix display function
160     } else if (Check_Module_value == SONAR_IS_ESIST) {
161     }
162     WS2812_Show(ws2812_task_mode); //Car color lights display function
163     Car_Select(carFlag); //Pico W Car mode selection function
164     if (carFlag == CAR_MODE_LIGHT_TRACING) {
165         if (millis() - lastUploadLIGHTADCTime > UPLOAD_LIGHTVOL_TIME) {
166             float leftADCVoltage = getLeftPhotosensitiveADCValue();
167             float rightADCVoltage = getRightPhotosensitiveADCValue();
168             client.print("C#1#" + String(leftADCVoltage) + "#" + String(rightADCVoltage) +
169             "\n");
170             lastUploadLIGHTADCTime = millis();
171         }
172         if (carFlag == CAR_MODE_LINE_TRACKING) {
173             if (millis() - lastUploadLINEVOLTime > UPLOAD_LINEVOL_TIME) {
174                 Track_Read();
175                 client.print("C#2#" + String(sensorValue[0]) + String(sensorValue[1]) +
176                 String(sensorValue[2]) + "\n");
177                 lastUploadLINEVOLTime = millis();
178             }
179             if (carFlag == CAR_MODE SONAR && Check_Module_value == SONAR_IS_ESIST) {
180                 float distance = Get_Sonar();
181                 client.print("C#3#" + String(distance) + "\n");
182                 lastUploadSONARVOLTime = millis();
183             }
184         }
185         client.stop(); //close the connection:
186         Serial.println("Command Client Disconnected.");
187         sendOnceModuleCheck = 1;
188         // rp2040.restart();
189     }
190 }
191
192 void Get_Command(char *string) {
193     char *token = strtok(string, INTERVAL_CHAR);
194     CmdArray[0] = token[0]; //Put the command into an array
195     for (int i = 0; i < 5; i++) {
196         if (token != NULL) {
197             token = strtok(NULL, INTERVAL_CHAR);
198         }
199     }

```

```

200     paramters[I + 1] = atoi(token); //Put the paramters into an array and convert them to
201     integers
202 }
203 }
```

Code Explanation:

Add the driver header files of the car.

The three header files starting with "WiFi" contain the WiFi driver configuration function of Raspberry Pi Pico W.

Freenove_4WD_Car_WiFi.h Freenove_4WD_Car_WiFi.h contains command information for WiFi signal transmission and camera pin configuration for Raspberry Pi Pico W.

Freenove_4WD_Car_Emotion.h contains the driver configuration function of the LED matrix module.

Freenove_4WD_Car_WS2812.h contains the driver configuration function of the RGB LEDs.

Freenove_4WD_Car_For_Pico_W.h contains the driver configuration function of the car.

```

1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include <WiFi.h>
4 #include <WiFiClient.h>
5 #include <Wire.h>
6 #include "Freenove_4WD_Car_WiFi.h"
7 #include "Freenove_4WD_Car_Emotion.h"
8 #include "Freenove_4WD_Car_WS2812.h"
9 #include "Freenove_4WD_Car_For_Pico_W.h"
```

Before each code upload, you can change the following ssid_Router and password_Router based on your WiFi name and password. The program uses STA mode by default. You need to make sure your phone is connected to the same router as your Raspberry PI Pico W car.

When you use AP mode, change the code to WiFi_Setup(1), and the Raspberry PI Pico W will create a WiFi named "Sunshine" corresponding to the WiFi configuration. Note: Sunshine is not connected to the Internet. So if you choose to connect it, your phone will disconnect from the Internet.

```

28     char ssid_Router[] =      "*****";    //Modify according to your router name
29     char password_Router[] =  "*****";    //Modify according to your router password
30     char ssid_AP[] =         "Sunshine";   //Pico W turns on an AP and calls it Sunshine
31     char password_AP[] =    "Sunshine";   //Set your AP password for Pico W to Sunshine
```

Open a TCP server port. Port 4002 is used to receive commands from the car.

```
33 WiFiServer server_Cmd(4002);
```

Call the WiFi_Init() to initialize the WiFi parameters. Call the WiFi_Setup() to initialize the Raspberry Pi Pico W's WiFi.

AP mode starts when the WiFi_Setup parameter is 1, and STA mode when the parameter is 0. After Raspberry Pi Pico W starts WIFI, it prints the IP information on the serial monitor.

```

37 WiFi_Setup(0);           // Set mode. When the parameter is 1, AP mode is enabled. If
                           // the parameter is 0, the STA mode is enabled.
```

Initialize the car's buzzer, LED matrix module, RGB LEDs, WiFi, motor, servo, photoresistor and line tracking modules.

```

34 void setup() {
35     Buzzer_Setup();          //Buzzer initialization
```

```

36 Serial.begin(115200);
37 WiFi_Setup(0); // Set mode. When the parameter is 1, AP mode is enabled.
38 If the parameter is 0, the STA mode is enabled.
39 server_Cmd.begin(4002); //Start the command server
40 server_Cmd.setNoDelay(true); //Set no delay in sending and receiving data
41 Wire.begin();
42 Motor_Setup(); //Motor initialization
43 Servo_Setup(); //Servo initialization
44 WS2812_Setup(); //WS2812 initialization
45 Emotion_and_Ultrasonic_Setup(); //Emotion initialization or Ultrasonic initialization
46 Photosensitive_Setup(); //Light initialization
47 Track_Setup(); //Track initialization
48 Servo_1_Angle(90);
49 delay(500);
}

```

Monitor TCP server port 4002. If a client connects to this port, Raspberry PI Pico W will print messages of WiFi connection on the serial port. When a client connects to this port, it receives information from the client until the client disconnects. When Raspberry PI Pico W detects that the client is disconnected, it closes the TCP connection and prints a WiFi disconnect prompt message.

```

52 WiFiClient client = server_Cmd.available(); //listen for incoming clients
53 if (client) { //if you get a client
54   Serial.println("Cmd_Server connected to a client.");
55   while (client.connected()) {
...
181 }
182   client.stop(); //close the connection:
183   Serial.println("Command Client Disconnected.");
184   sendOnceModuleCheck = 1;
185   // rp2040.restart();
186 }

```

Get_Command(), the command parsing function. Every time this function is used, the command received by TCP will be sent to this function through inputStringTemp, and the command and parameters will be parsed and stored in the global variable array CmdArray and paramters.

```

193 void Get_Command(char *string) {
194   char *token = strtok(string, INTERVAL_CHAR);
195   CmdArray[0] = token[0]; //Put the command into an array
196   for (int i = 0; i < 5; i++) {
197     if (token != NULL) {
198       token = strtok(NULL, INTERVAL_CHAR);
199     }
200     paramters[i + 1] = atoi(token); //Put the paramters into an array and convert them to
201   integers
202 }

```

203 }

Judge the client's data and use different functions of the car according to different commands.

```

71      if (CmdArray[0] == CMD_LED_MOD) //Set the display mode of car colored lights
...
...
75      if (CmdArray[0] == CMD_LED)   //Set the color and brightness of the car lights
...
...
79      if (CmdArray[0] == CMD_MATRIX_MOD) //Set the display mode of the LED matrix
...
...
90      if (CmdArray[0] == CMD_BUZZER) //Buzzer control command
...
...
94      if (CmdArray[0] == CMD_POWER) //Power query command
...
...
101     if (CmdArray[0] == CMD_MOTOR) //Network control car movement command
...
...
110     if (CmdArray[0] == CMD_SERVO) { //Network control servo motor movement command
...
...
113     if (CmdArray[0] == CMD_CAR_MODE) { //Car command Mode
...
...

```

The following three functions run in a non-blocking manner. Call the Emotion_Show() function to control the LED matrix, call the WS2812_Show() function to control the RGB LEDs of the car, and call the Car_Select() function to control the mode of the car.

```

159     Emotion_Show(emotion_task_mode); //Led matrix display function
...
...
162     WS2812_Show(ws2812_task_mode); //Car color lights display function
163     Car_Select(carFlag);           //Pico W Car mode selection function

```

7.3 WiFi Car by PC

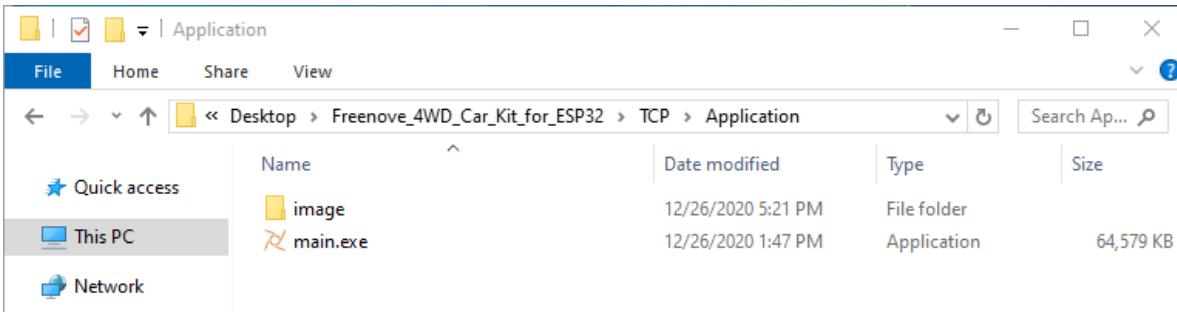
In addition to using a mobile phone to control the WiFi car, we also provide users with a host computer to control the car. In this chapter, the car still uses the [code](#) in section 7.2

Run client on windows system

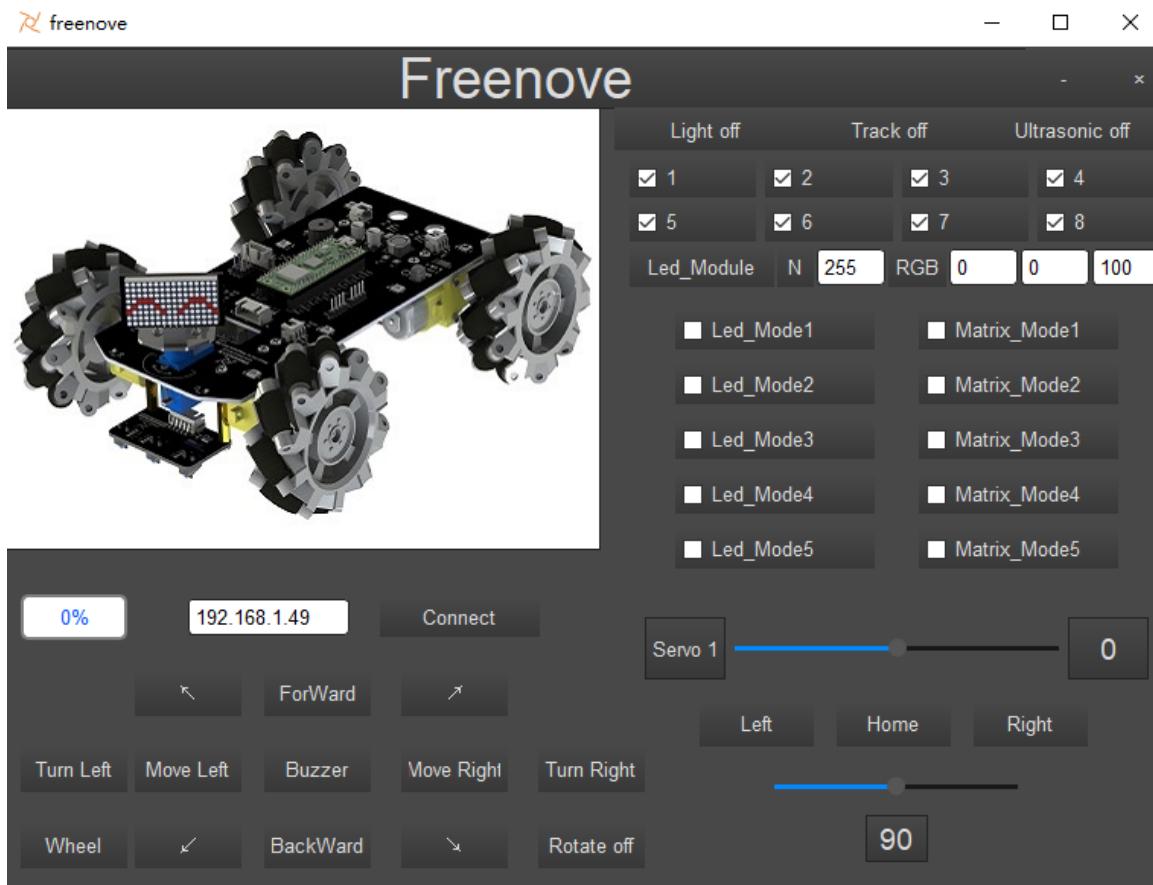
There are two ways to run client on Windows.

Option 1 Run the executable file directly.

Open main.exe in Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Application.

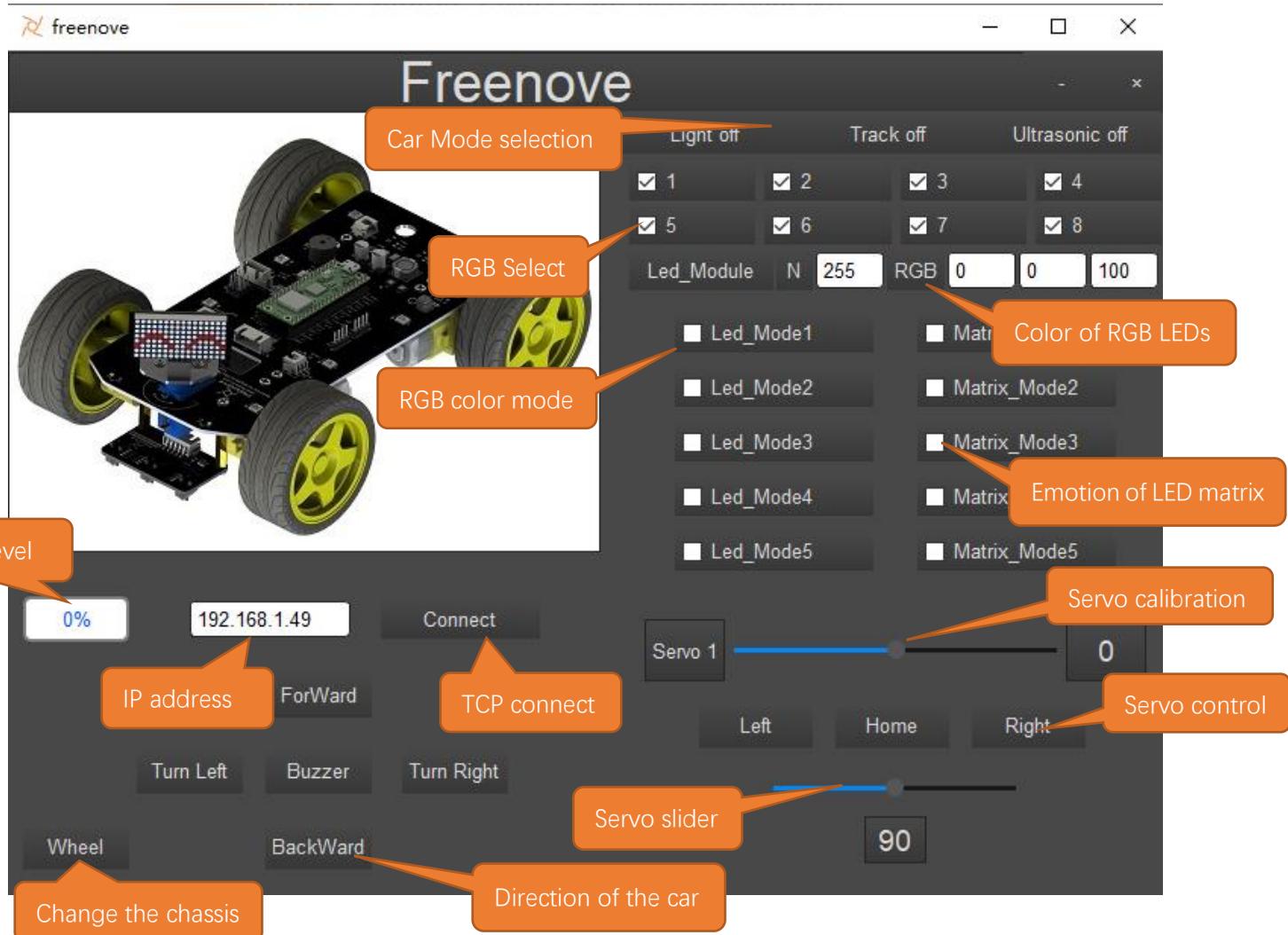


The interface of client is as follows:



Need support? ✉ support.freenove.com

Note: You Can See the control end of the car, but this time need to click on the lower right corner of the button "Wheel" to enter our car control interfaceThe function of the client is as follows :



According to the prompt message printed on the Raspberry Pi Pico W serial monitor, enter the IP address into "IP Address" and click "Connect", and you can control the Raspberry Pi Pico W car through this client

Option 2 Install python3 and some related python libraries to run client.

If you want to modify the client, please follow this section.

Install python3

Download and install Python3 package.

<https://www.python.org/downloads/windows/>

The screenshot shows the Python Releases for Windows page. At the top, there is a navigation bar with three tabs: 'About', 'Downloads', and 'Documentation'. Below the navigation bar, the text 'Python »» Downloads »» Windows' is displayed. The main title 'Python Releases for Windows' is centered above two bullet points:

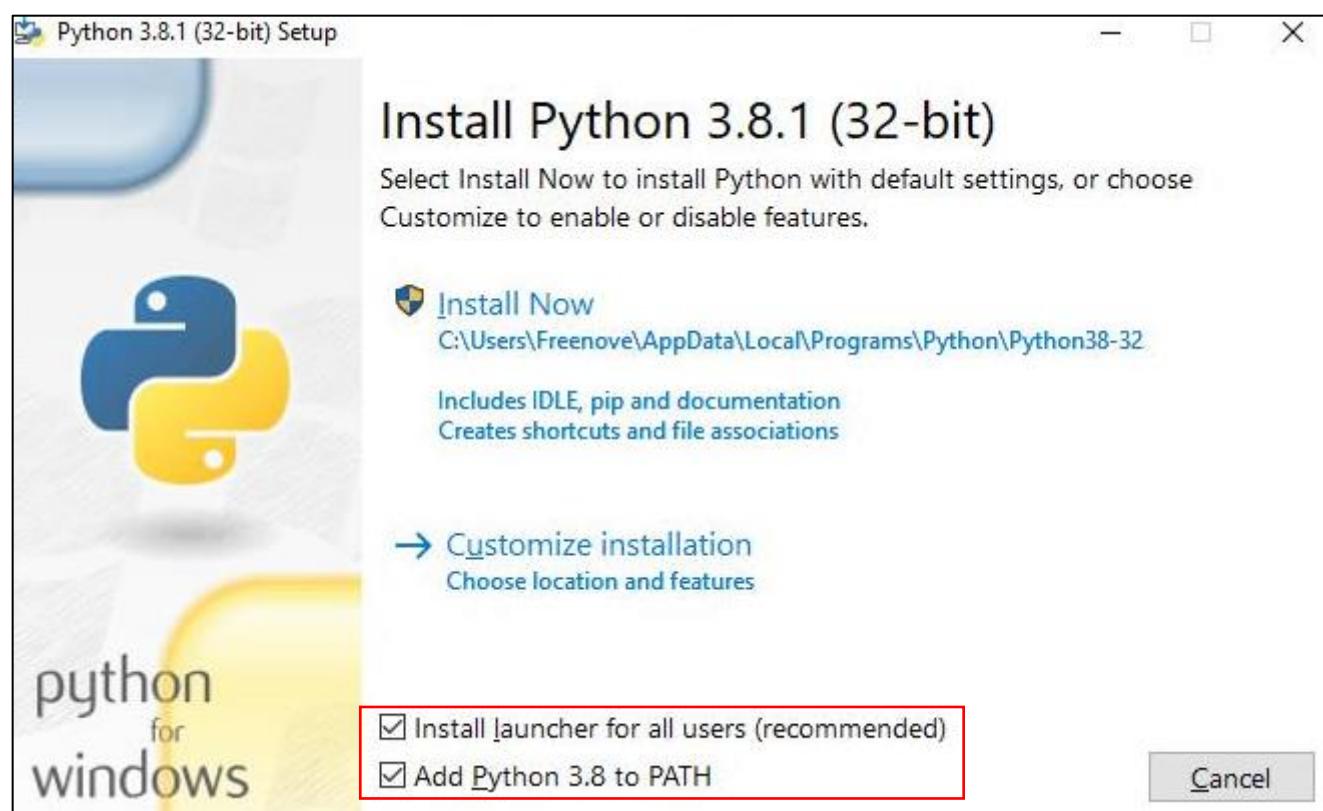
- [Latest Python 3 Release - Python 3.8.1](#)
- [Latest Python 2 Release - Python 2.7.17](#)

Select Python3.8.1.

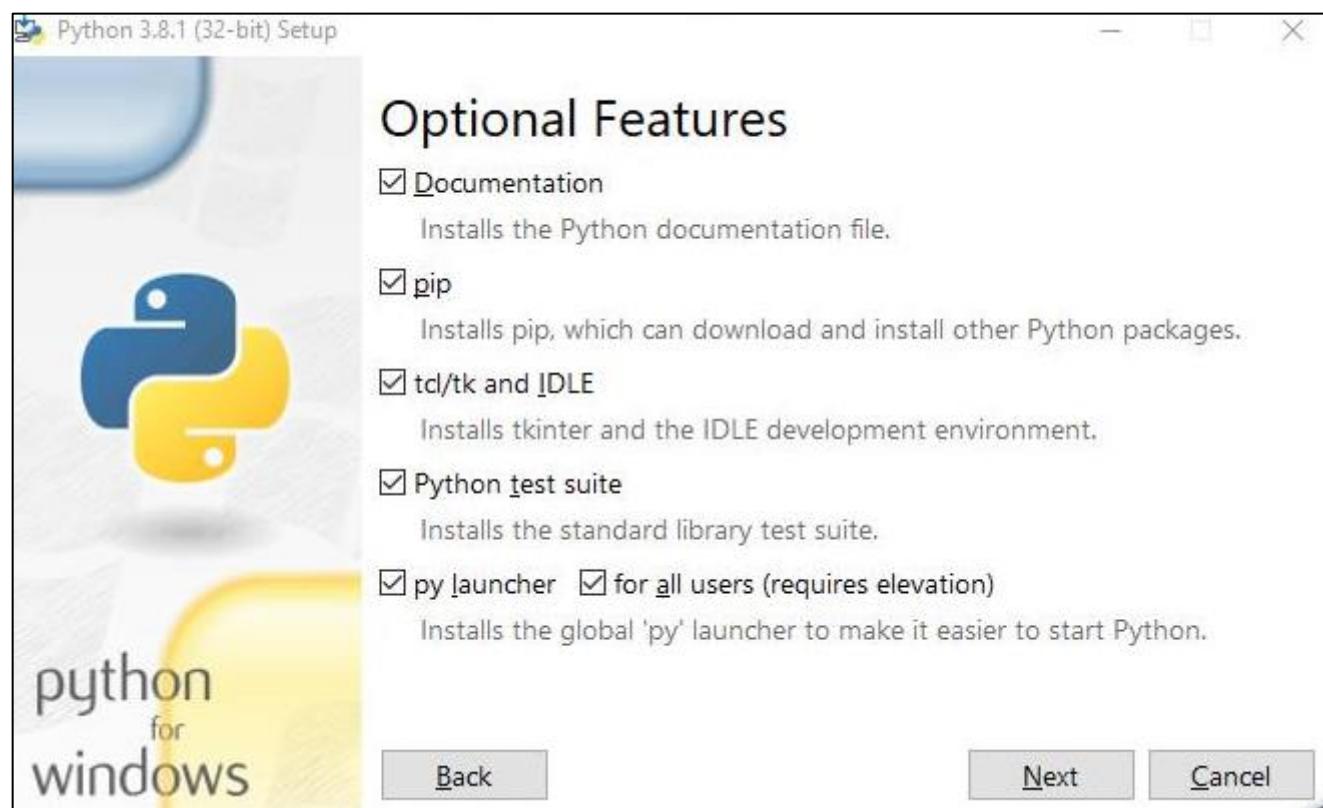
Version	Operating System	Description
Gzipped source tarball	Source release	
XZ compressed source tarball	Source release	
macOS 64-bit installer	Mac OS X	for OS X 10.9 and later
Windows help file	Windows	
Windows x86-64 embeddable zip file	Windows	for AMD64/EM64T/x64
Windows x86-64 executable installer	Windows	for AMD64/EM64T/x64
Windows x86-64 web-based installer	Windows	for AMD64/EM64T/x64
Windows x86 embeddable zip file	Windows	
Windows x86 executable installer	Windows	
Windows x86 web-based installer	Windows	

Click Windows x86 executable installer to download. After downloading, click to install.

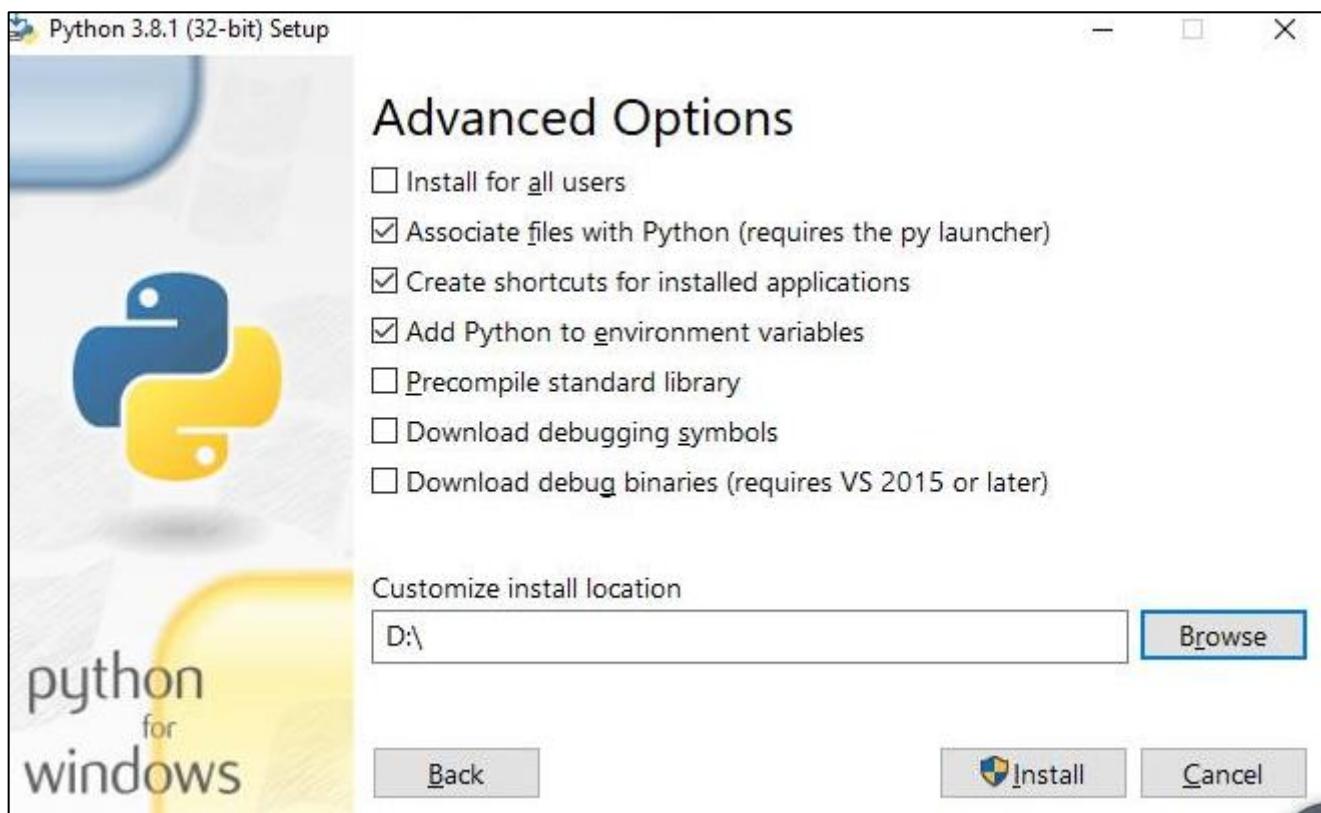
Please note that “Add Python 3.8 to PATH” MUST be checked.



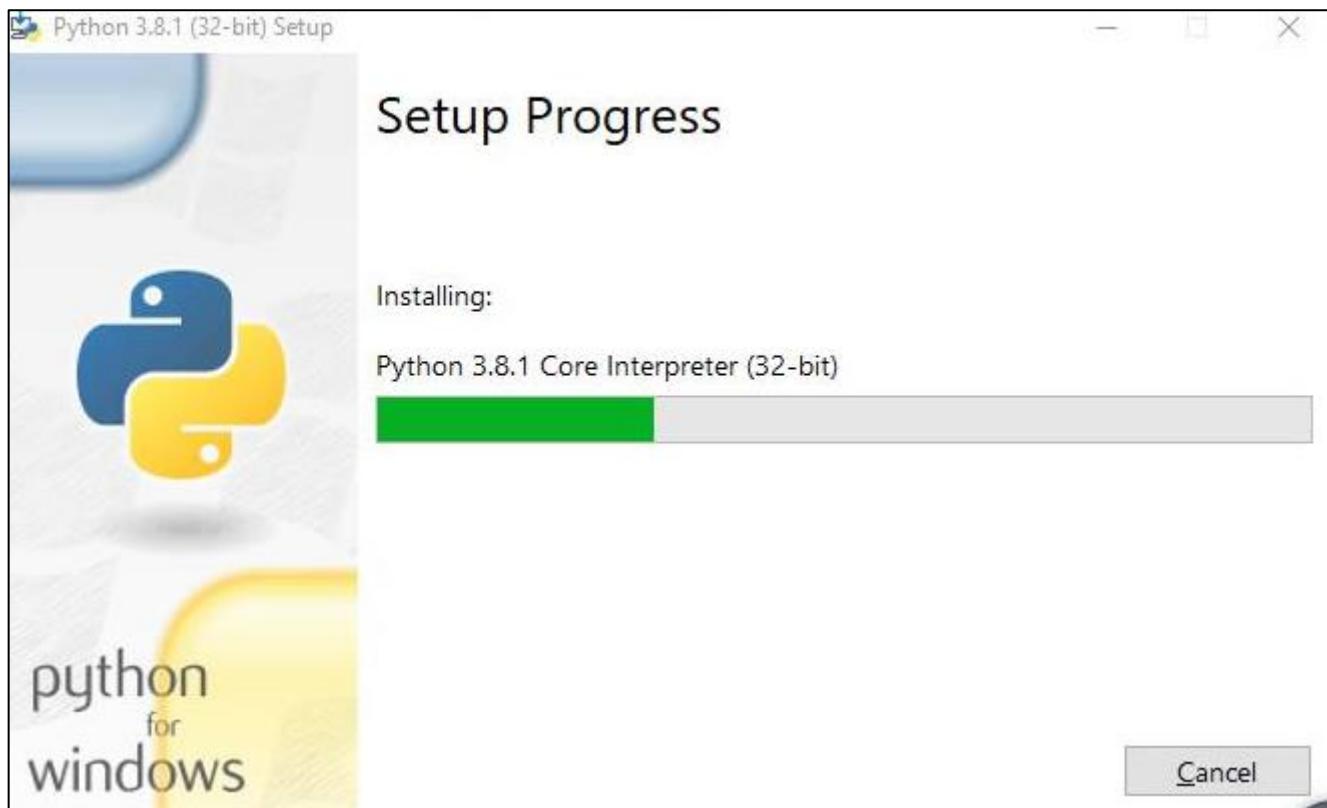
Check all the options and then click “Next”.



Here you can select the installation path of Python. We install it at D drive. If you are a novice, you can select the default path.



Wait for it to finish installing.

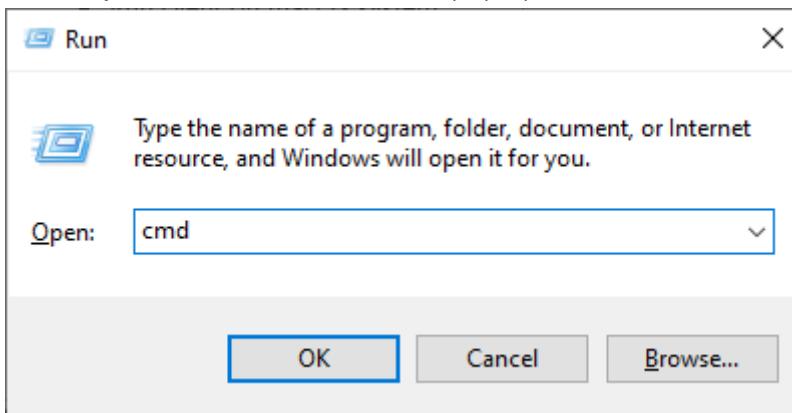


Now the installation is finished.



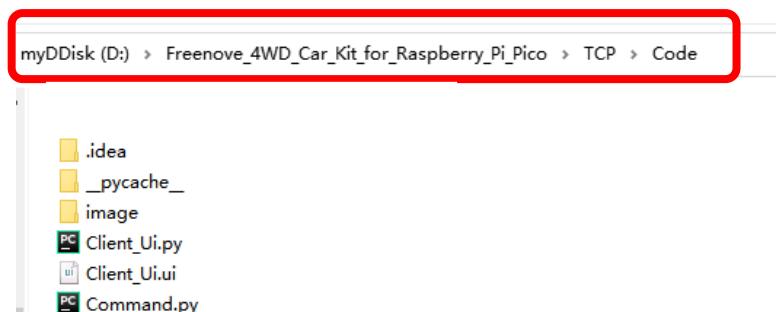
Install PyQt5、opencv、numpy and other libraries.

Press "Ctrl" and "R" on the keyboard at the same time will pop up a window.



Enter **cmd** in the pop-up window and click "OK".

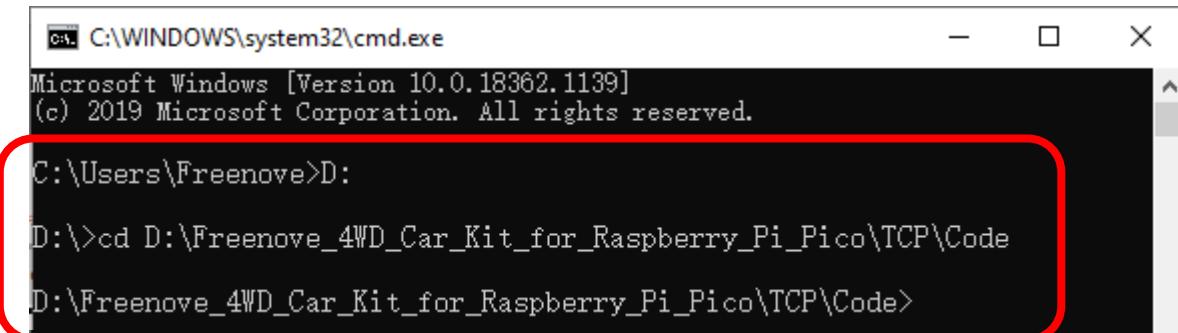
Use the command to enter the storage location of Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico Here we assume it is saved in D drive.



The address depends on where you saved Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico. You need to modify it based on your own storage location.

1. Input "D:", press enter to enter D drive, and then input "cd

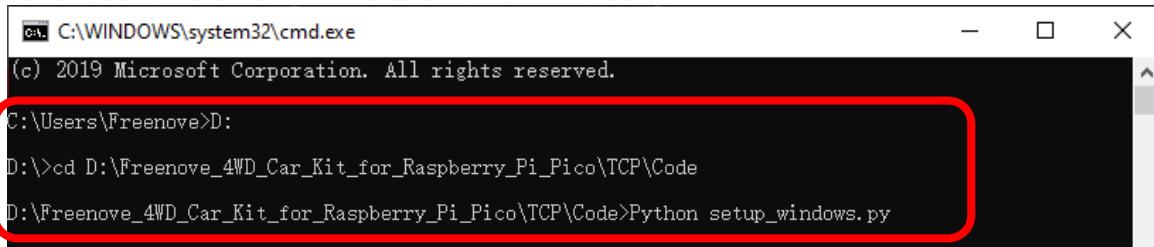
D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code", press enter to enter the folder.



```
C:\WINDOWS\system32\cmd.exe
Microsoft Windows [Version 10.0.18362.1139]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\Freenove>D:
D:>cd D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code
D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code>
```

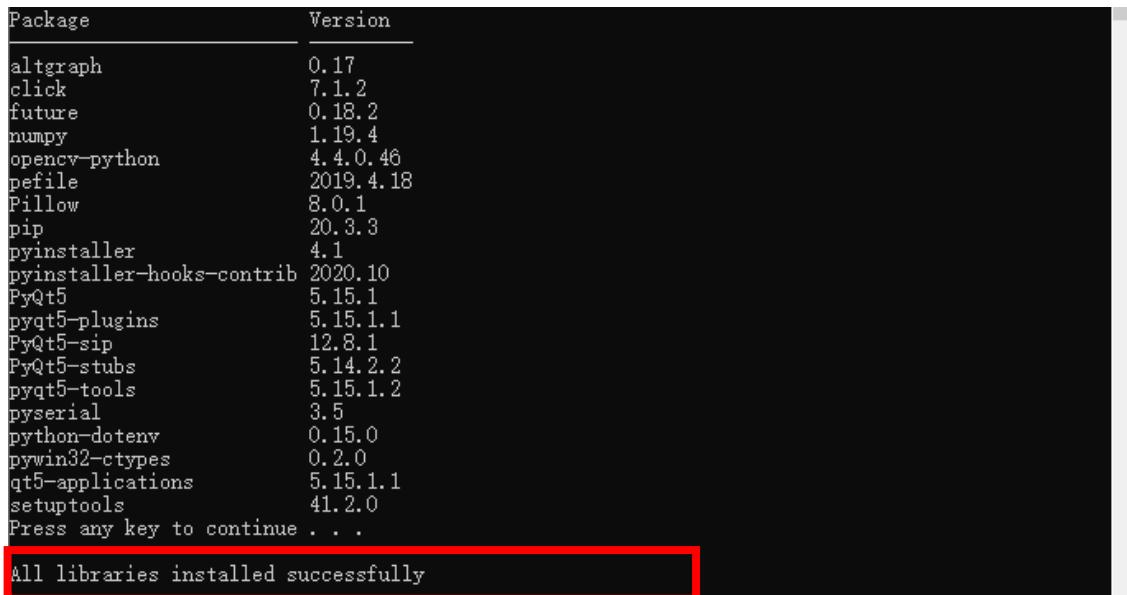
2. Input "Python setup_windows.py" and press enter. If it fails, you can input "Python3 setup_windows.py" to try again.



```
C:\WINDOWS\system32\cmd.exe
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\Freenove>D:
D:>cd D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code
D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code>Python setup_windows.py
```

3. Wait for it to finish installing and press any key according to the prompt. When it displays "All libraries installed successfully", it indicates the environment is installed successfully.



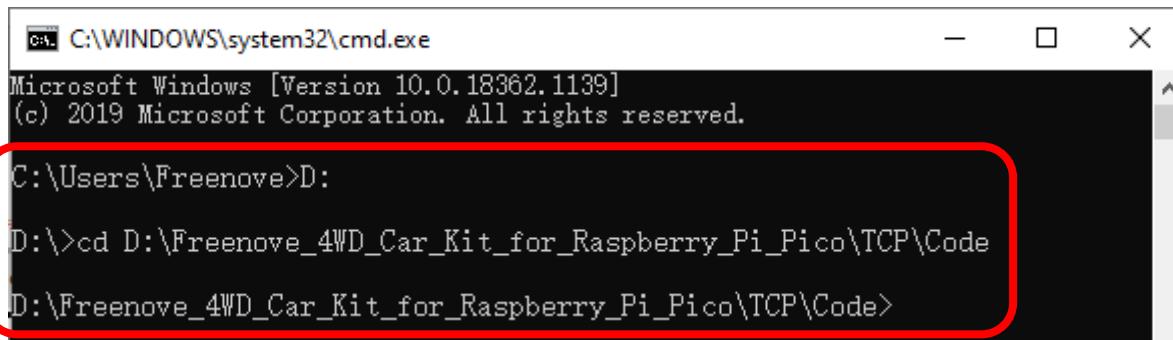
Package	Version
altgraph	0.17
click	7.1.2
future	0.18.2
numpy	1.19.4
opencv-python	4.4.0.46
pefile	2019.4.18
Pillow	8.0.1
pip	20.3.3
pyinstaller	4.1
pyinstaller-hooks-contrib	2020.10
PyQt5	5.15.1
pyqt5-plugins	5.15.1.1
PyQt5-sip	12.8.1
PyQt5-stubs	5.14.2.2
pyqt5-tools	5.15.1.2
pyserial	3.5
python-dotenv	0.15.0
pywin32-ctypes	0.2.0
qt5-applications	5.15.1.1
setuptools	41.2.0

```
Press any key to continue . . .
All libraries installed successfully
```

If not all libraries are installed successfully, it will prompt "Some libraries have not been installed. Please run Python3 setup_windows.py again", and then you need to enter and execute the command again. Most installation failures are caused by poor networks. You can Check your network before installation.

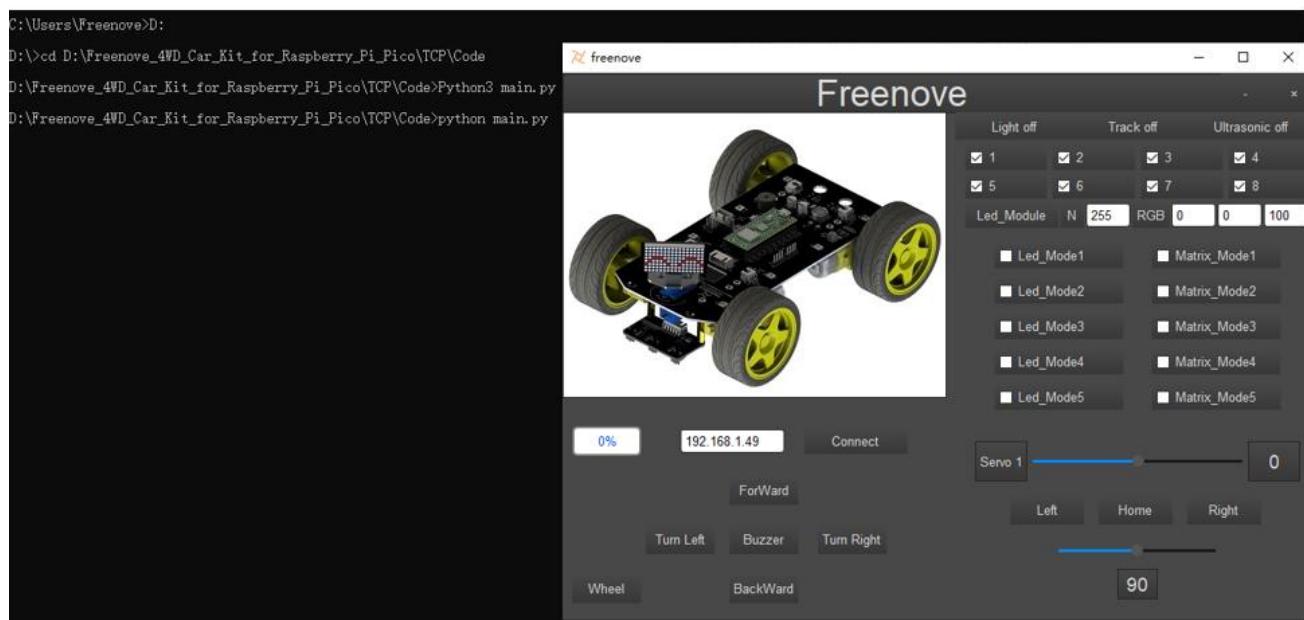
Run main.py

1. Input "D:", press enter to enter D drive and then input "cd D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code", press enter to enter the folder.



```
C:\Users\Freenove>D:  
D:\>cd D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code  
D:\Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico\TCP\Code>
```

2. Input "Python main.py" and press enter. If it fails, you can input "Python3 main.py" to try again.

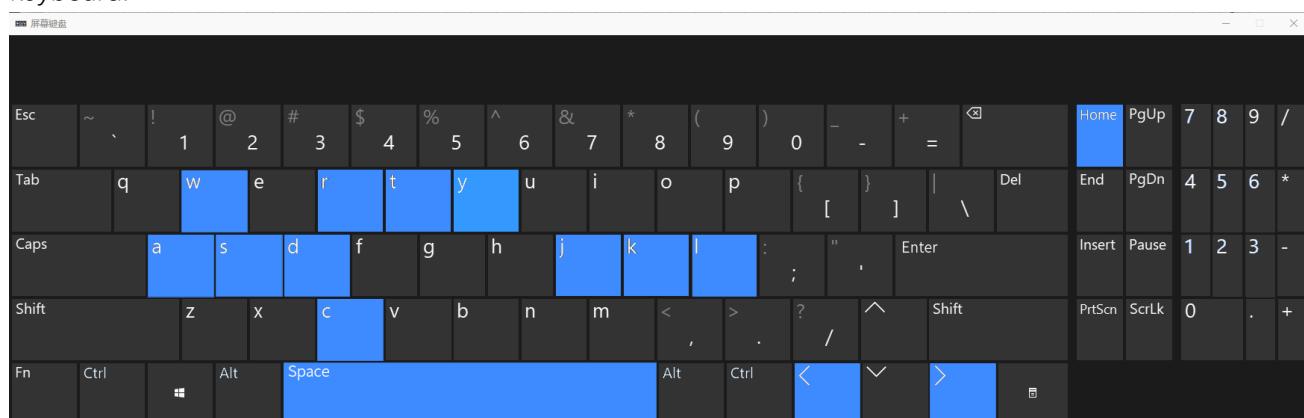


After the program runs, you can control the car through this window.

If you want to modify the code, you can modify the files in TCP folder.

Control the car with keyboard

The car can be controlled by clicking the client. And it can also be controlled by pressing keys on your keyboard.



The following is the corresponding operation of the buttons and keys.

Button on Client	Key	Action
ForWard	W	Move
BackWard	S	Back off
Turn Left	A	Turn left
Turn Right	D	Turn right
Left	left arrow	Turn servo left
Right	right arrow	Turn servo right
Home	Home	Turn servo back Home
Connect/ Disconnect	C	On/off Connection
Buzzer	Space	On/off Buzzer
Led_Mode 1,2,3,4,5	L	Switch RGB Led Mode
Matrix_Mode 1,2,3,4,5	K	Switch Matrix Mode
Matrix_Static Mode	J	Switch Matrix Static Mode
Light Car Mode	R	On/off Light Car Mode
Track Car Mode	T	On/off Track Car Mode
Ultrasonic Car Mode	Y	On/Off Ultrasonic Car Mode

The function of SliderBar is below:

SliderBar	Function
Servo 1	SliderBar Servo 1 is used to slightly adjust the angle. If the servo is not fully centered during installation, you can slightly tune it via the SliderBar.

Other control information:

Control	Function
IP address Edit box	Enter IP address of Raspberry Pi Pico W.
Power box	Show power level.
N,R,G,B Edit box	Control the color of LED selected.
Button "Light On/Off"	Turn on the light seeking function of the car.
Button "Track On/Off"	Turn on the tracking function of the car.
Button "Ultrasonic On/Off"	Turn on the car's obstacle avoidance function.

Run client on macOS system

Here we take MacOS 10.13 as an example. To run client on MacOS, you need to install some software and libraries. MacOS 10.13 comes with python2 but not python3. However, the projects in this program need to be run with python3, so you need to install it first.

Install python3

Download installation package, link: <https://www.python.org/downloads/>

Click Python 3.8.2.

Release version	Release date	
Python 3.8.2	Feb. 24, 2020	 Download
Python 3.8.1	Dec. 18, 2019	 Download
Python 3.7.6	Dec. 18, 2019	 Download
Python 3.6.10	Dec. 18, 2019	 Download
Python 3.5.9	Nov. 2, 2019	 Download
Python 3.5.8	Oct. 29, 2019	 Download

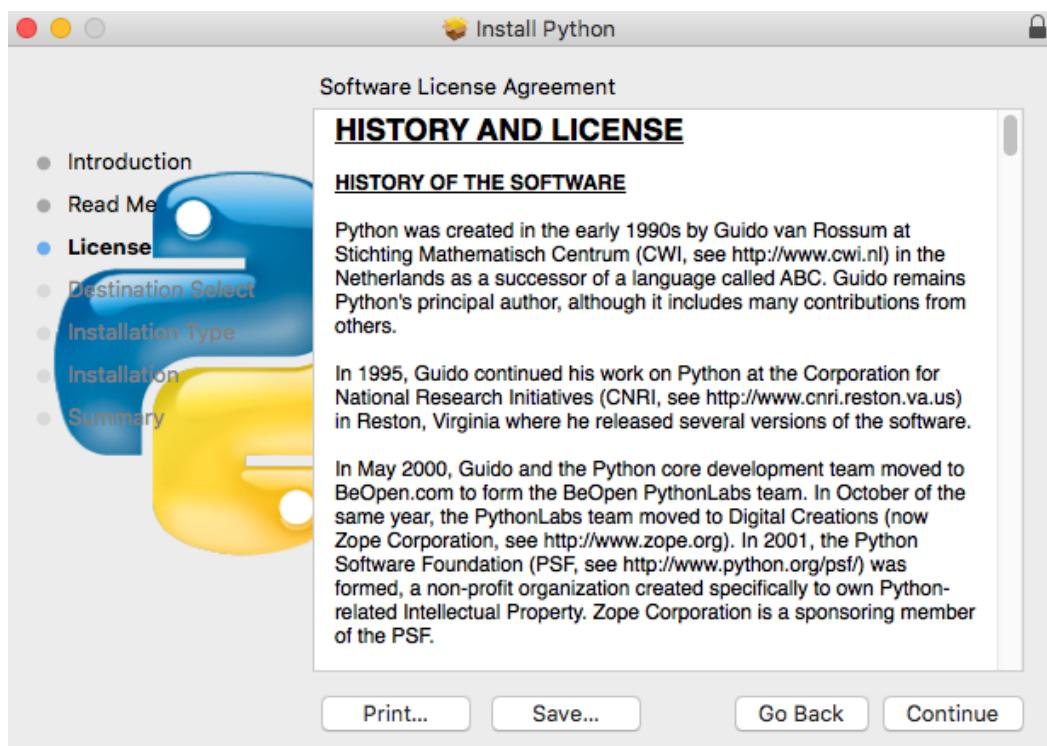
At the bottom of the page, click macOS 64-bit installer and download installation package.

Version	Operating System	Description
Gzipped source tarball	Source release	
XZ compressed source tarball	Source release	
macOS 64-bit installer	Mac OS X	for OS X 10.9 and later
Windows help file	Windows	
Windows x86-64 embeddable zip file	Windows	for AMD64/EM64T/x64
Windows x86-64 executable installer	Windows	for AMD64/EM64T/x64
Windows x86-64 web-based installer	Windows	for AMD64/EM64T/x64
Windows x86 embeddable zip file	Windows	
Windows x86 executable installer	Windows	
Windows x86 web-based installer	Windows	

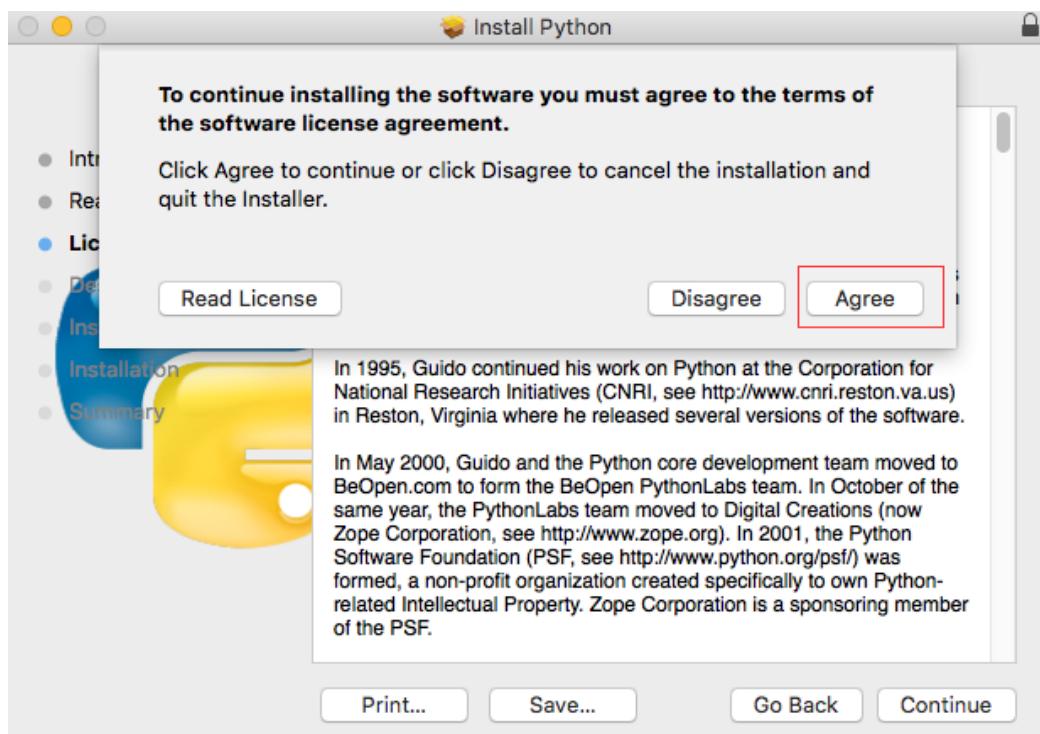
Click Continue.



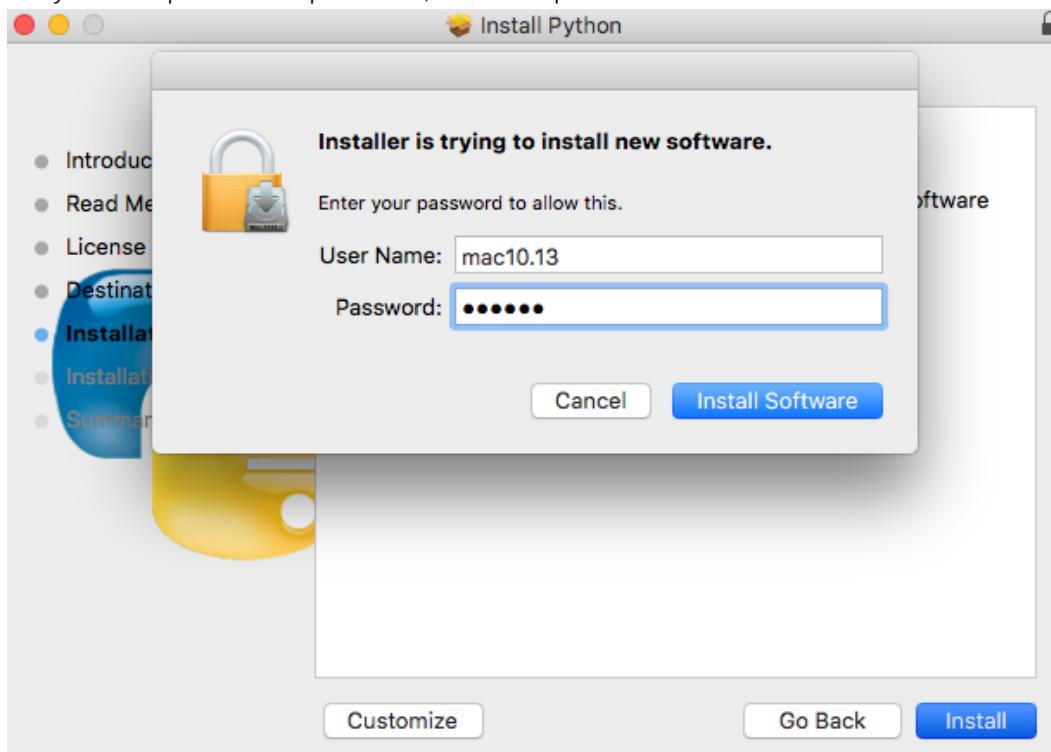
Click Continue



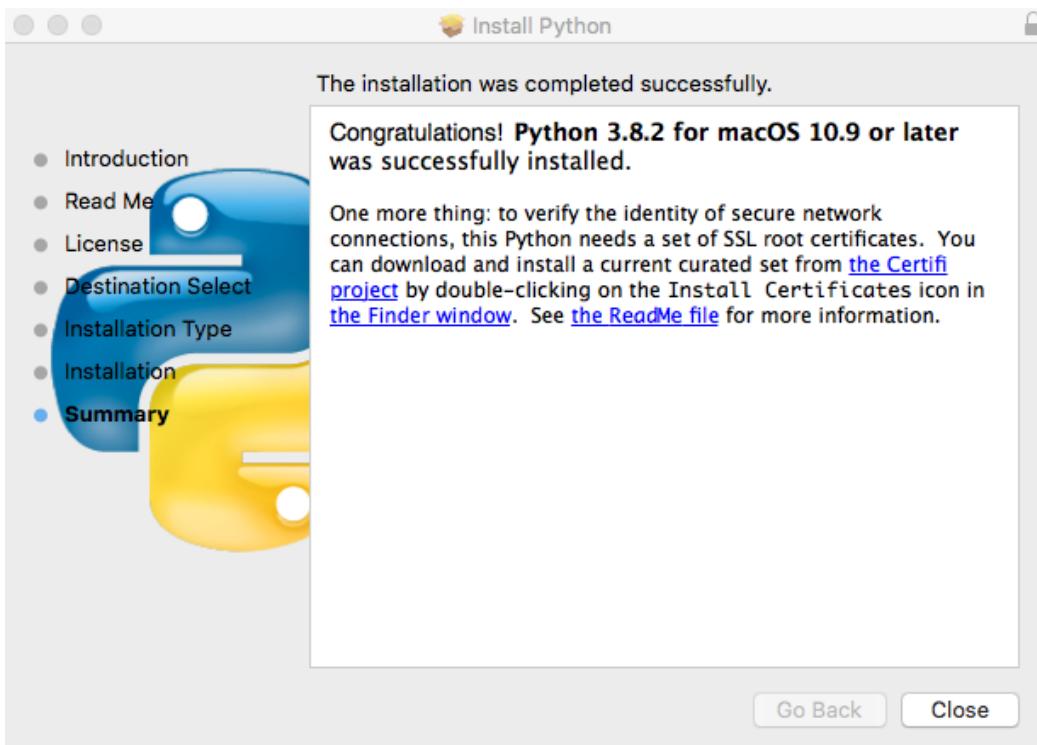
Click Agree.



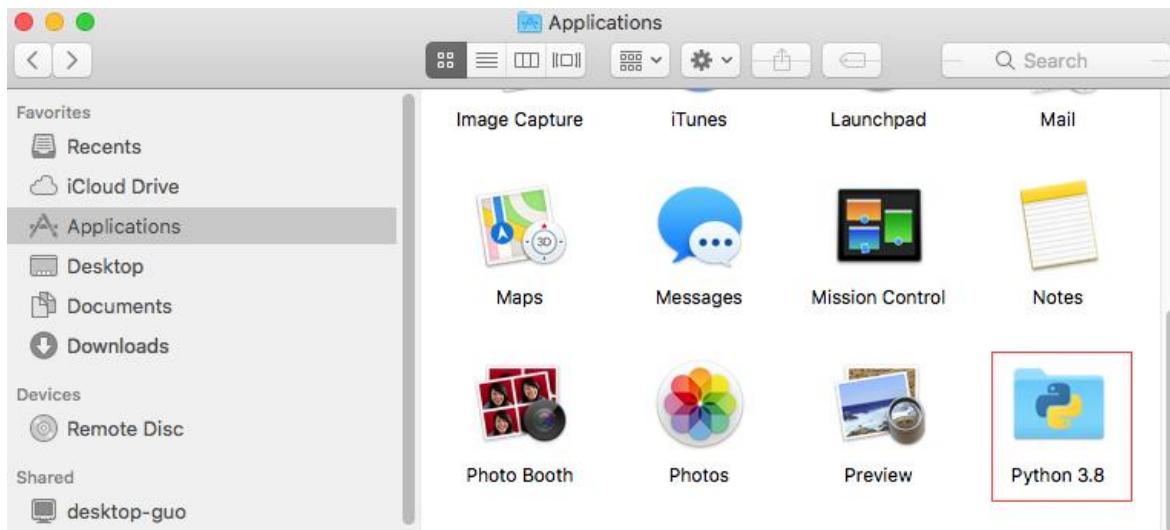
Click Install. If your computer has a password, enter the password and Install Software.



Now the installation succeeds.



You can find it in Applications.



Install PyQt5、opencv、numpy and other libraries

If you have not yet downloaded the code of Raspberry Pi Pico W car to your macOS, you can download it from the following link: https://github.com/Freenove/Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico.git

After downloading, you can find it in **Downloads** of Macintosh HD.

Open **Terminal**.



Enter the following commands in Terminal

1. Enter “**Downloads**” (where the code locates). If your code locates in a different path, you need to enter the location of your code.

```
cd Downloads
```

2. Enter the directory where setup_mac.py locates

```
cd Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico/TCP/Code
```

```
Last login: Thu Apr 27 10:10:53 on ttys000
[freenove@03c22fb61fad ~ % cd Downloads
[freenove@03c22fb61fad Downloads % cd Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico/TCP/Code
freenove@03c22fb61fad Code %
```

3. Run setup_macos.py:

```
python3 setup_macos.py
```

The installation takes some time. Please wait with patience. When installs successfully, it will print "All libraries installed successfully":

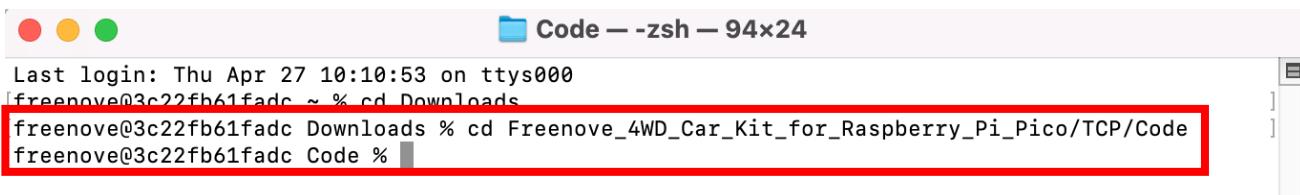
Package	Version
altgraph	0.17
certifi	2020.12.5
macholib	1.14
modulegraph	0.18
numpy	1.19.0
opencv-contrib-python-headless	4.3.0.36
opencv-python-headless	4.3.0.36
Pillow	7.2.0
pip	20.3.3
py2app	0.22
pyinstaller	4.0
pyinstaller-hooks-contrib	2020.8
PyQt5	5.12
PyQt5-sip	4.19.19
pyserial	3.5
setuptools	47.1.0
wheel	0.34.2

All libraries installed successfully

Note: If not all libraries are installed successfully, it will prompt “Some libraries have not been installed”. Please input and run Python3 setup_macos.py again. Most installation failures are caused by poor networks. You can Check your network before installation

Run main.py

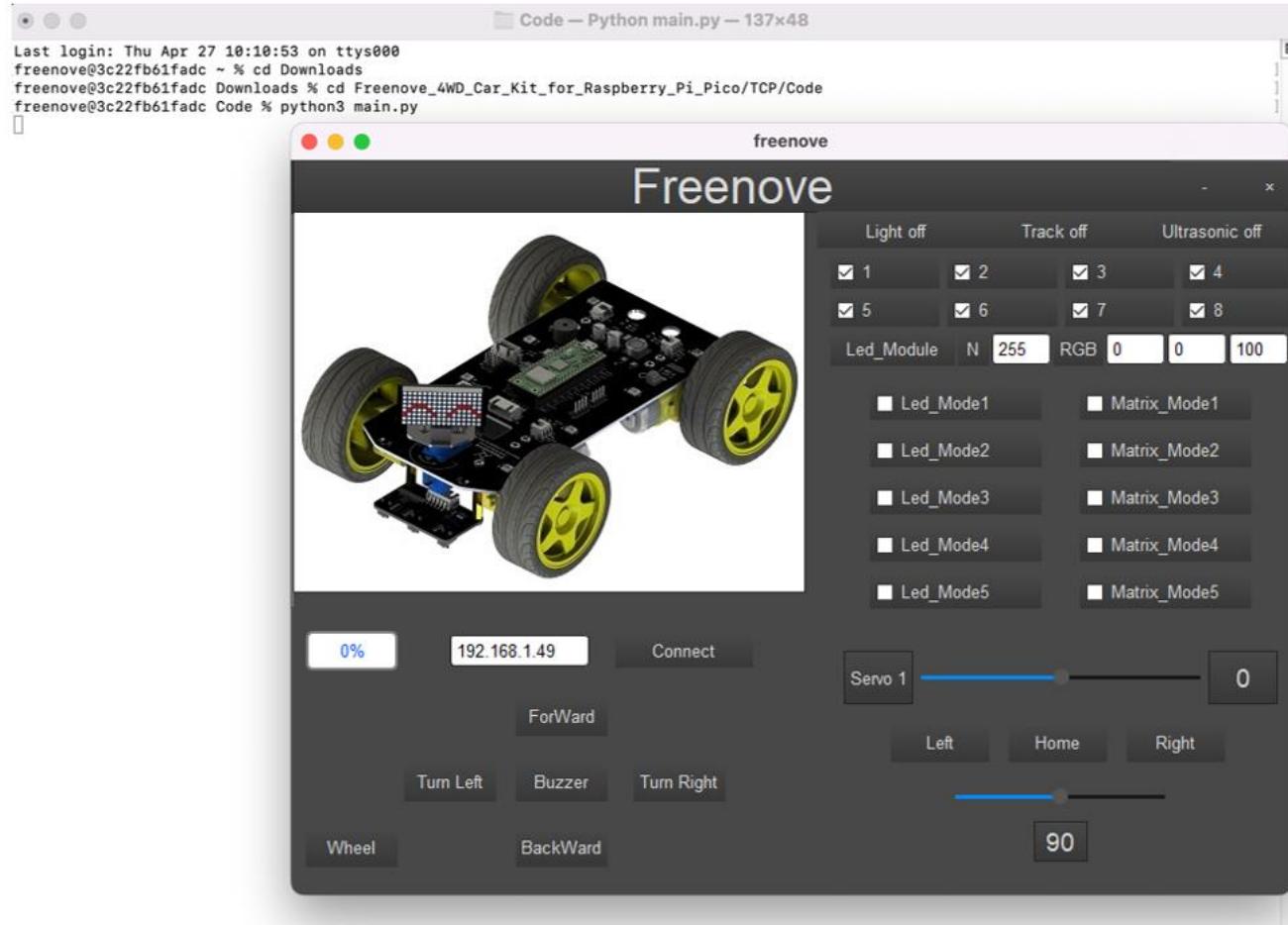
Following the previous steps, after the installation completes, you are now in the directory where setup_macos.py is located. (Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico/TCP/Code)



```
Last login: Thu Apr 27 10:10:53 on ttys000
freenove@03c22fb61fad ~ % cd Downloads
freenove@03c22fb61fad Downloads % cd Freenove_4WD_Car_Kit_for_Raspberry_Pi_Pico/TCP/Code
freenove@03c22fb61fad Code %
```

Enter the following command to run main.py.

```
python3 main.py
```



The way to control macOS System client is the same as Windows ([Control](#)).

What's next?

Thank you again for choosing Freenove products.

THANK YOU for participating in this learning experience!

We have reached the end of this Tutorial. If you find errors, omissions, or you have suggestions and/or questions about the Tutorial or component contents of this Kit, please feel free to contact us:
support@freenove.com

We will make every effort to make changes and correct errors as soon as feasibly possible and publish a revised version.

If you want to learn more about Arduino, ESP32, Raspberry Pi Pico W, Raspberry Pi, Smart Cars, Robotics and other interesting products in science and technology, please continue to visit our website. We will continue to launch fun, cost effective, innovative and exciting products.

<http://www.freenove.com/>

Thank you again for choosing Freenove products.