

Preface

About SunFounder

SunFounder is a company focused on STEAM education with products like open source robots, development boards, STEAM kit, modules, tools and other smart devices distributed globally. In SunFounder, we strive to help elementary and middle school students as well as hobbyists, through STEAM education, strengthen their hands-on practices and problem-solving abilities. In this way, we hope to disseminate knowledge and provide skill training in a full-of-joy way, thus fostering your interest in programming and making, and exposing you to a fascinating world of science and engineering. To embrace the future of artificial intelligence, it is urgent and meaningful to learn abundant STEAM knowledge.

About the PiCar-V

As an upgraded version, PiCar-V V3.0 is also suitable for the Raspberry Pi 4 module B, 3 module B and 3 module B+, as the V1.0, V2.0.

The car PiCar-V is equipped with a wide-angle USB webcam, three whole new circuit boards with less but more simple wiring, some acrylic plates with an adjusted structure, and new code suitable for almost all platforms to control the car.

In this book, we will show you how to build the PiCar-V via description, illustrations of physical components, in both hardware and software respects. You will enjoy learning how all this work. You can view the PDF user manual or clone the code by click the link: https://github.com/sunfounder/SunFounder_PiCar-V/tree/V3.0.

You are welcomed to post requests and issues on our page on Github.

Free Support



If you have any **TECHNICAL questions**, add a topic under **Community -> Forum** section on our website and we'll reply as soon as possible.



For **NON-TECH questions** like order and shipment issues, please **send an email to service@sunfounder.com**. You're also welcomed to share your projects on FORUM.

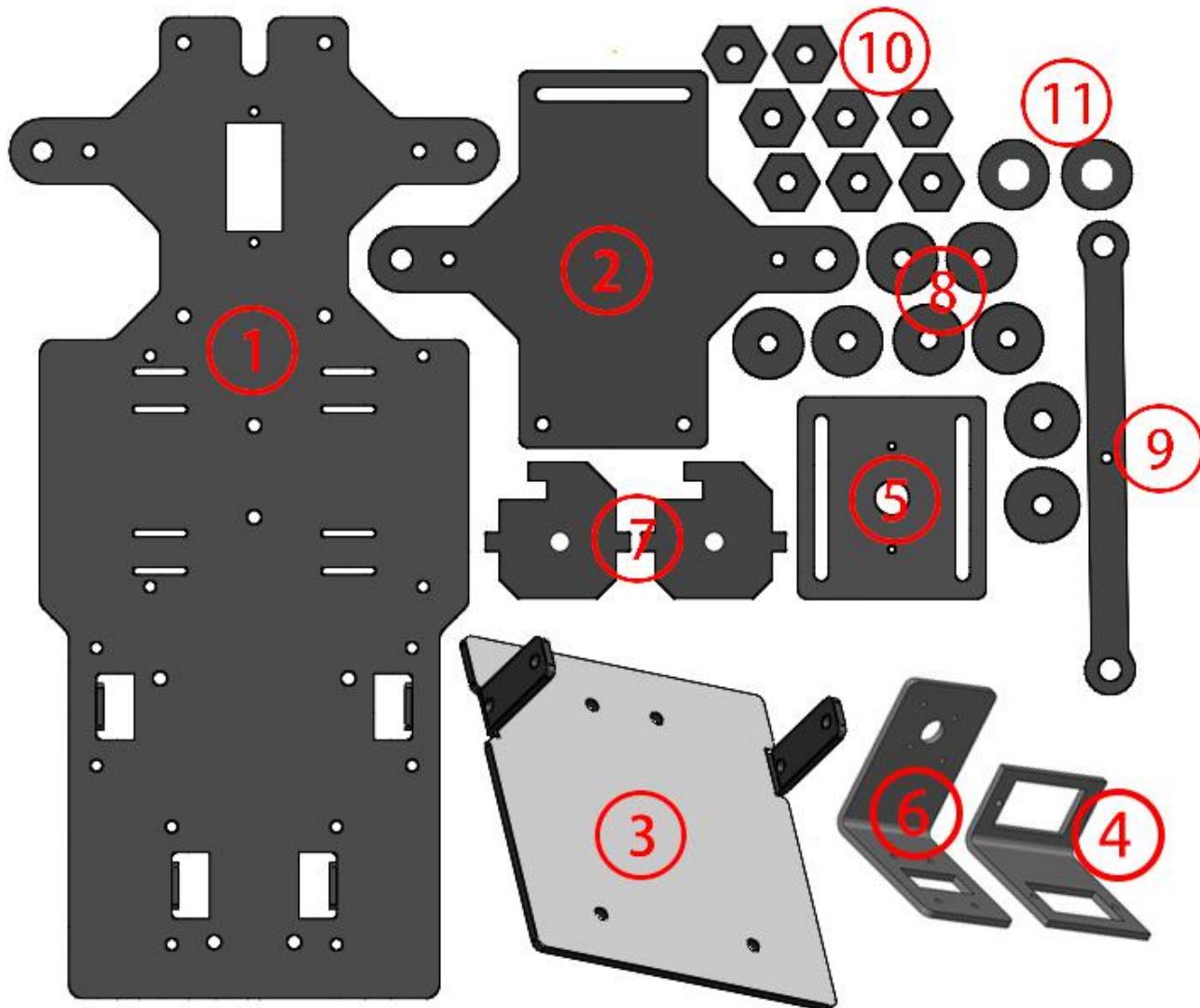
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Components List

Plates



1. Upper Plate x 1
2. Front Half Plate x 1
3. Back Half Plate x 1
4. Pan-and-tilt Plate x 1
5. Pan-and-tilt Base Plate x 1
6. Camera Mount Plate x 1
7. Steering Connector Plate x 2
8. Bearing Shield x 8
9. Steering Linkage Plate x 1
10. Hex Front Wheel Fixing Plate x 8
11. Gasket Plate x 2

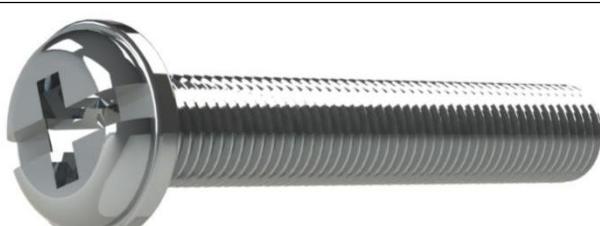
Note: The Bearing Shield is similar to the Gasket Plate, but the aperture of Gasket Plate is large than the Bearing Shield.

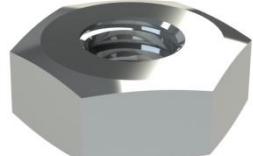
Servo x 3



1. Servo
2. 1-arm Rocker Arm
3. arm Rocker Arm
4. 4-arm Rocker Arm
5. Rocker Arm Fixing Screw
6. Rocker Arm Screw

Mechanical Fasteners

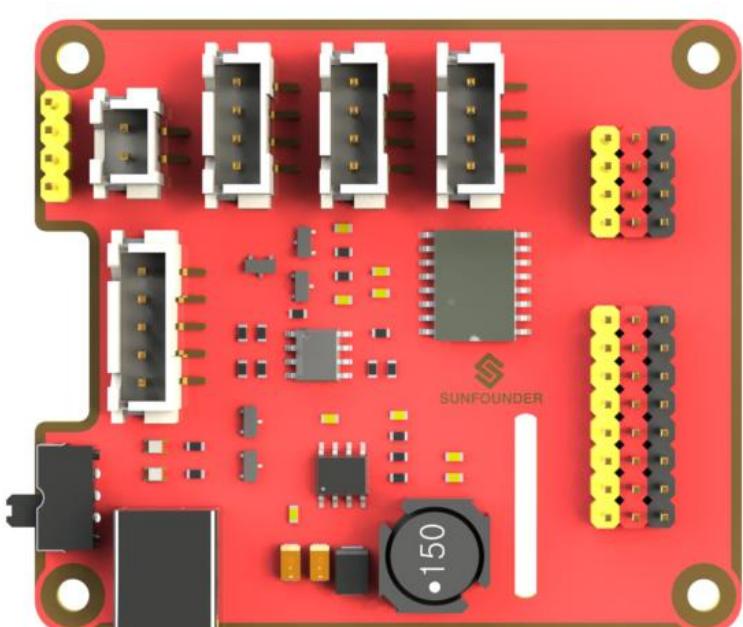
Name	Component	Qty.
M1.5x4 Self-tapping Screw		10
M2x8 Screw		6
M2.5x6 Screw		4
M2.5x12 Screw		8
M3x8 Screw		8
M3x8 Countersunk Screw		2
M3x10 Screw		7
M3x25 Screw		4
M4x25 Screw		2

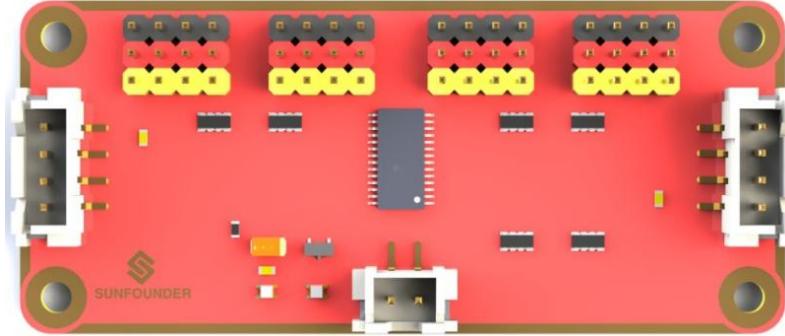
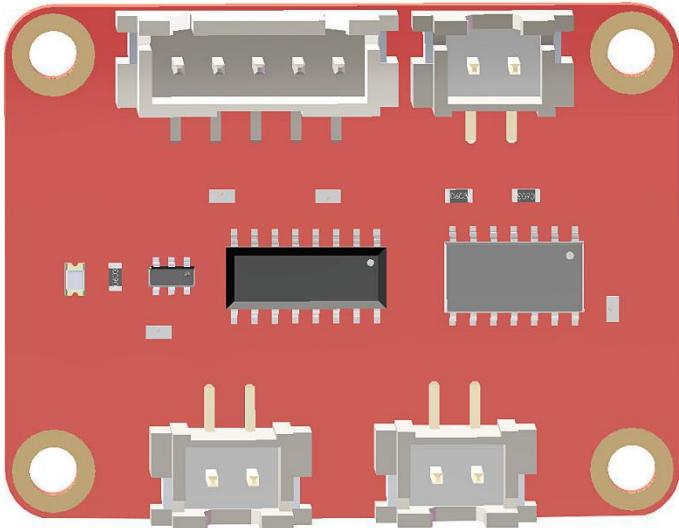
M2 Nut		6
M2.5 Nut		12
M3 Nut		21
M4 Self-locking Nut		2
M2.5x8 Copper Standoff		8
M3x25 Copper Standoff		8

Wires

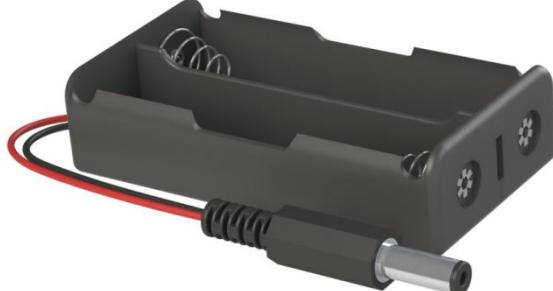
100mm HX2.54 5-Pin Jumper Wire		1
50mm HX-2.54 4-Pin Jumper Wire		1
50mm HX-2.54 2-Pin Jumper Wire		1
100mm HX-2.54 2-Pin Jumper Wire		1

PCB

Robot HATS		1
------------	--	---

PCA9685 PWM Driver	 A red printed circuit board (PCB) featuring a central blue integrated circuit (likely an PCA9685). It has four sets of yellow and black terminal blocks for connecting to four DC motors. There are also several smaller surface-mount components and two circular metal mounting holes.	1
Motor Driver Module	 A red printed circuit board (PCB) with two large grey integrated circuits (likely H-bridge drivers like the L298N). It features two sets of metal terminal blocks at the bottom for connecting to DC motors. Two circular metal mounting holes are located on the left and right sides.	1

Other Components

2x18650 Battery Holder	 A black plastic battery holder designed for two 18650 lithium-ion batteries. It includes a red and black power cable with a 2.1mm DC connector and a metal mounting screw.	1
DC Gear Motor	 A yellow plastic DC gear motor housing. It has a grey metal gear assembly inside, a black cable with a white connector, and a small metal mounting screw.	2

120° Wide-angle USB Camera		1
Rear Wheel		2
Front Wheel		2
Ribbon (30cm)		1

Tools

Cross Screwdriver		1
Cross Socket Wrench		1
M2.5/M4 Small Wrench		1
M2/M3 Small Wrench		1

Self-provided Components

The following components are not included in this kit.

Component	Name	Qty.
	18650 3.7V Rechargeable Li-ion Battery	2

Note:

1. You are recommend to use 18650 batteries **without** a protective board. Otherwise, the car may be cut power and stop running because of the overcurrent protection of the protective board.
2. For unprotected batteries, please purchase those with the anode bulged out (as shown below), so that it can ensure the well connection with the battery holder.



3. In order to keep the car working for a long time, use large-capacity batteries as much as possible

Introduction

The PiCar-V is developed based on the previous Smart Video Car Kit. It's equipped with the new PCA9685 PWM driver, smaller and better-performing DC motor driver module, a Robot Hat with power and interface integrated, a wider-angle camera with clearer vision, some better wheels and tires, and so on. Later we'll check more details.

The basic functions of this new version still stay the same, including controlling the PiCar-V remotely and streaming the video data it captures back. Then what's new? Let's unveil the mysteries!



Building the Car

Are you excited when you open the box and see so many components? Keep your patience and take it easy. Please note that some details in the following steps need careful observation. You should double-check your work based on the figures in the manual after finishing each step. let's start!

Front Wheels

Insert an **M4x25 screw** through a **Steering Connector Plate**, 3 **Bearing Shields**, 3 **Hex Front Wheel Fixing Plates**, and a **front wheel**, into an **M4 Self-locking Nut** as shown below:



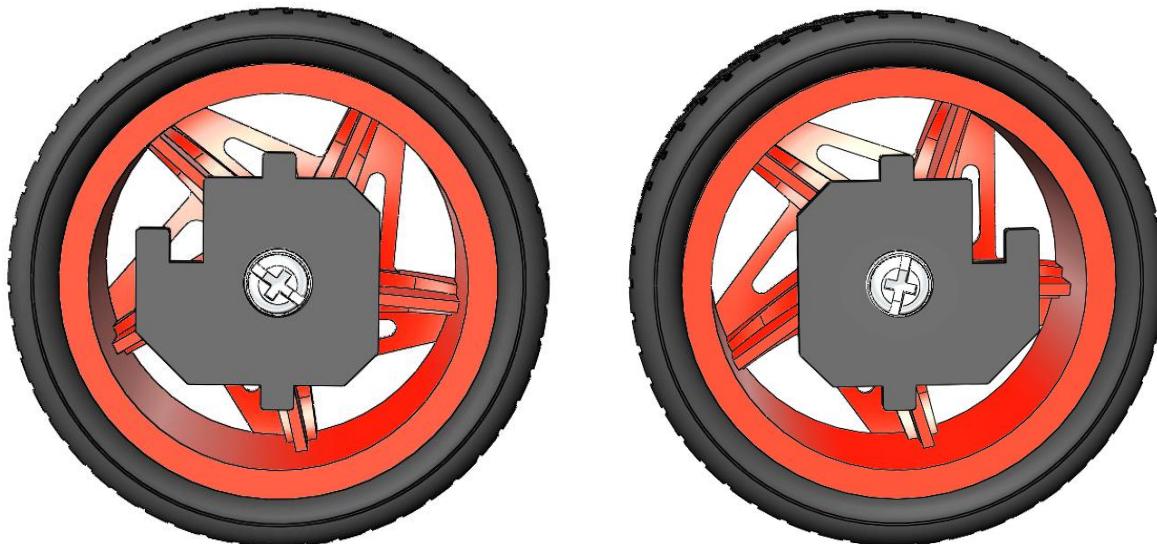
You can use the Cross Socket Wrench to secure the **M4 Self-locking Nut**, then use the screwdriver to tighten the **M4x25 screw**.



Note:

The Self-locking Nut should be screwed tight enough. It would be better to tighten the screw until the wheel and Steering Connector cannot move first, then loosen the screw a little, so that the Steering Plate can just move. Thus, the wheel can turn flexibly when the connection would not be too loose.

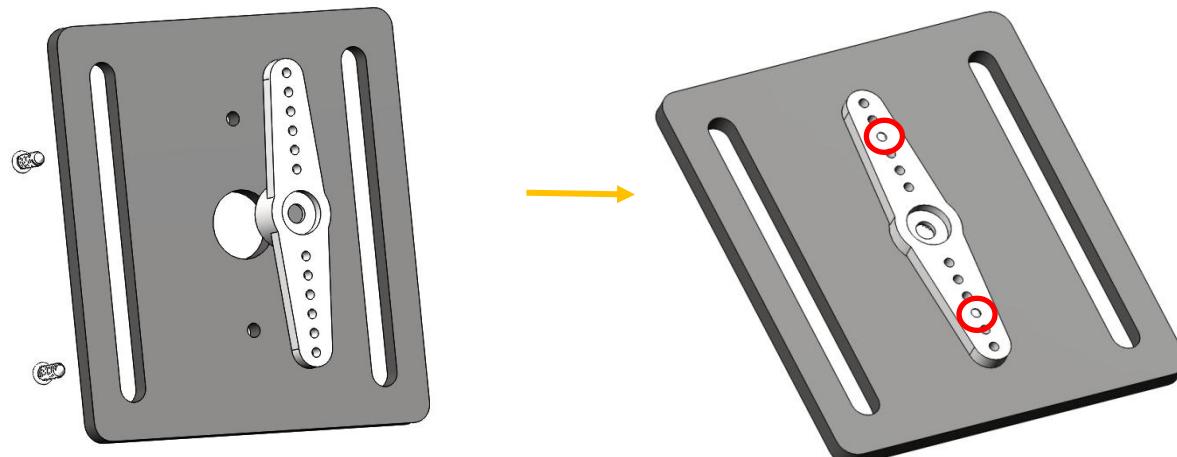
Assemble the other front wheel in the same way, but bear in mind the Steering Connector plate on the wheel should be symmetric with the previous one.



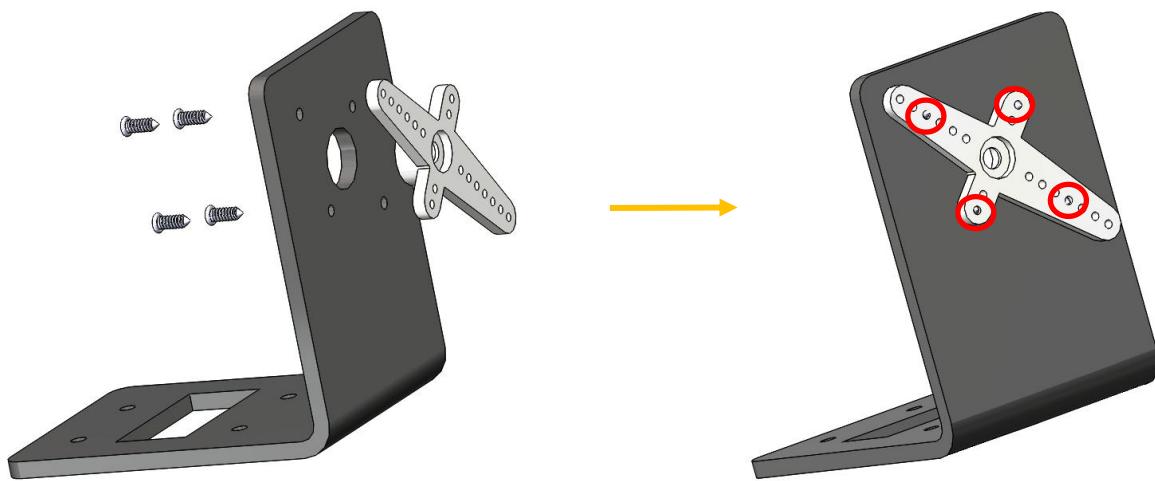
Now two front wheels have finished assembly.

Pan-and-Tilt

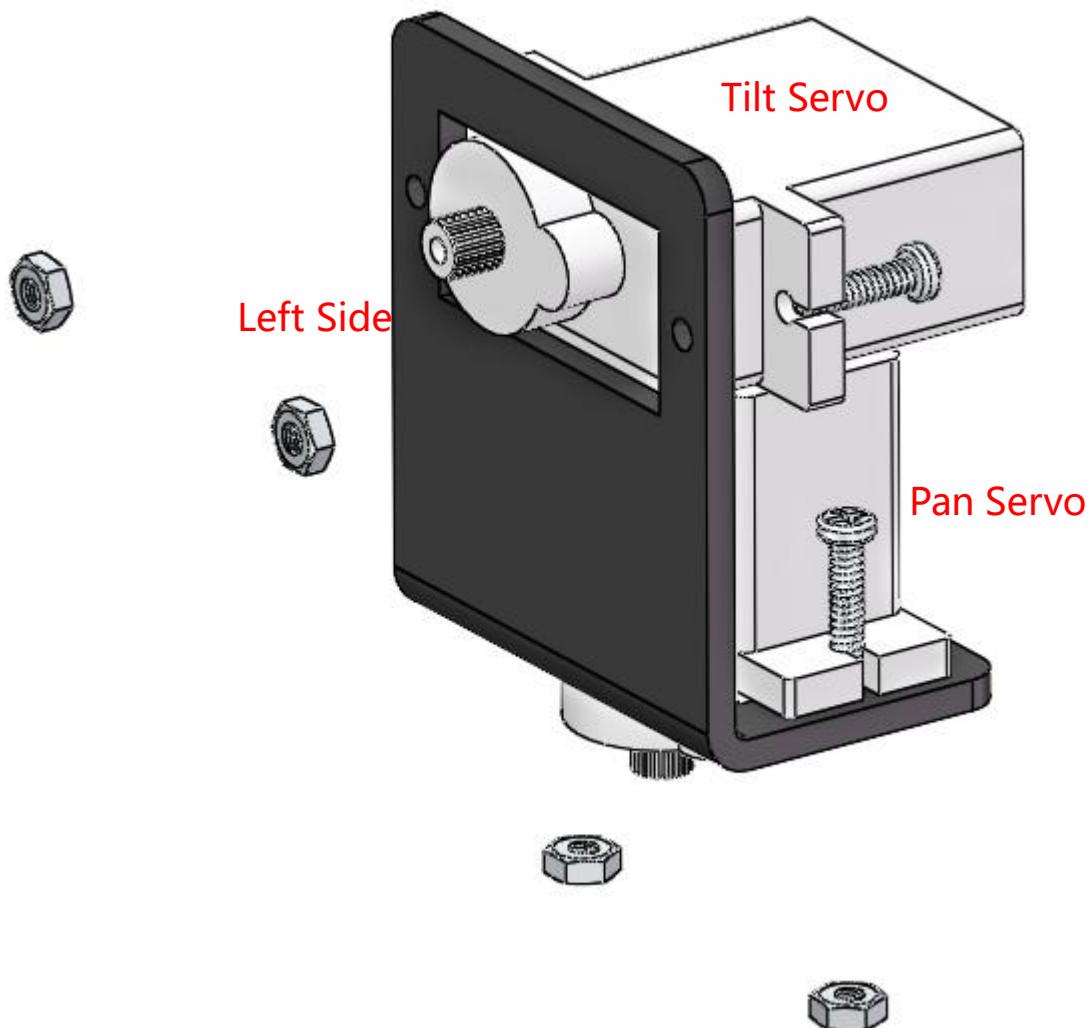
Take out the **Cross rocker arm** and mount it onto the **Pan-and-tilt Base Plate** with 2 **M1.5x4 screws** (into the hole like this). Pay attention to the holes on the round rocker arm to be fastened.



Do the same operation to the **Camera Mount Plate**.



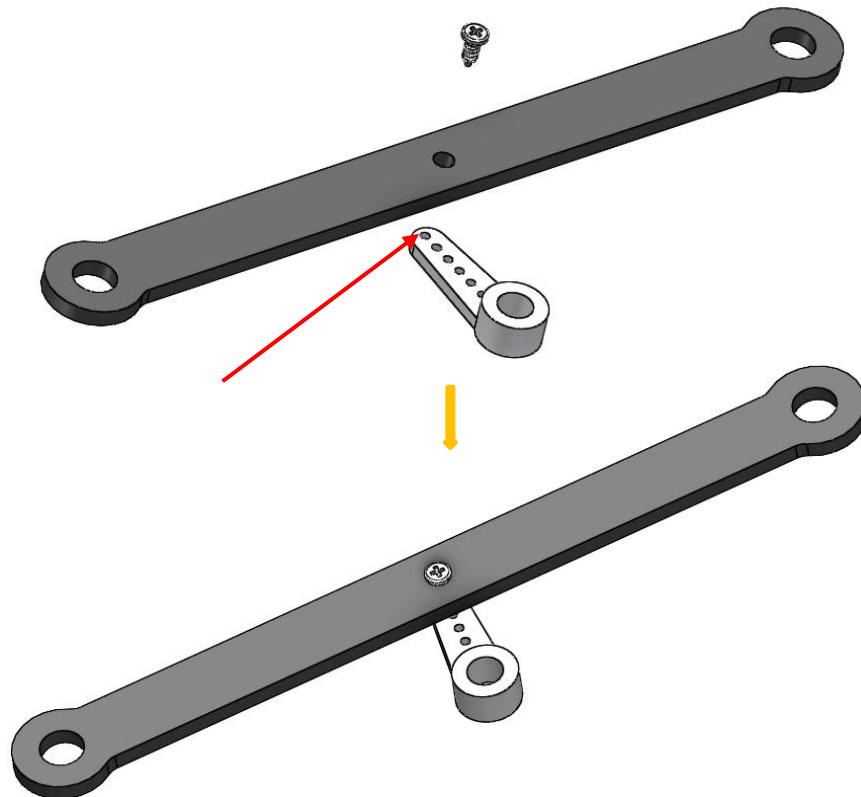
Assemble the two servos to the **Pan-and-tilt Plate** with four **M2x8 screws** and the **M2 nuts** (The 2 servo shaft are close to the left side):



Steering Part

Connect the **Steering Linkage** and the **1-arm Rocker Arm** with the **M1.5x4 Self-tapping Screw**.

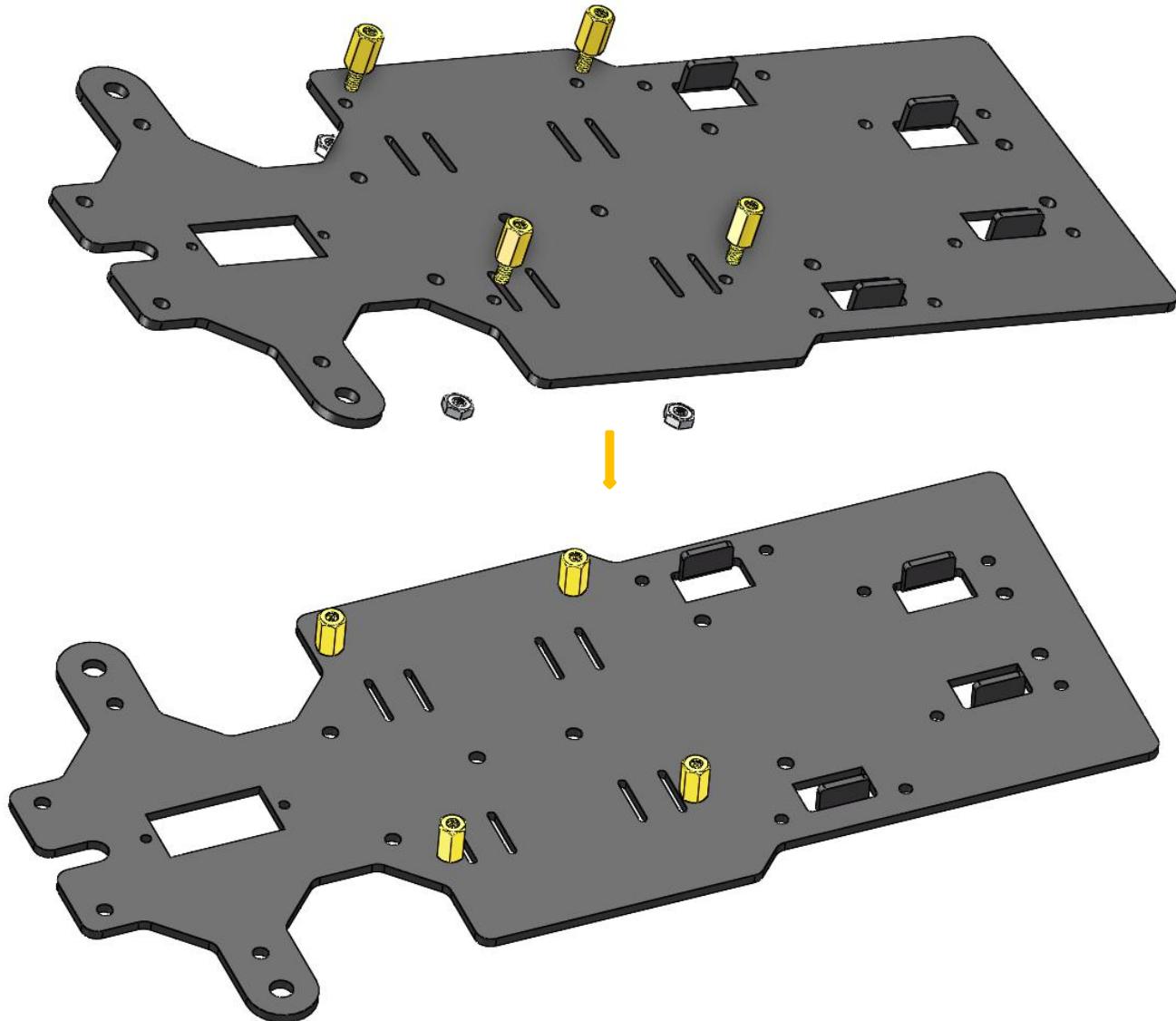
Note: Insert it into the **FIRST** hole of the arm (as indicated by the **arrow** below) which is the farthest from the gears.



And also fasten them as tightly as possible, and **then loosen the screw a little so the Steering Linkage can move flexibly**.

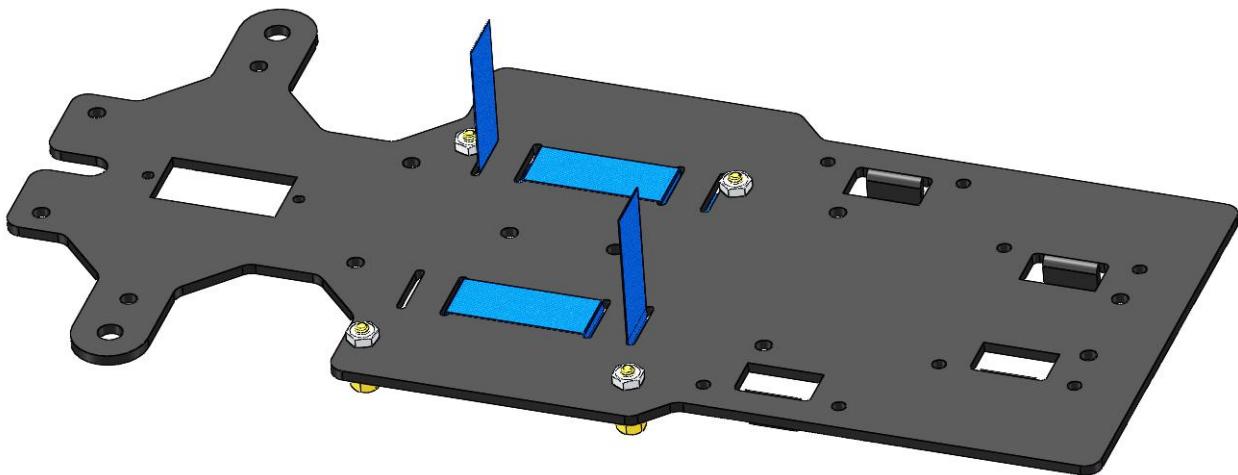
Upper Plate

Mount the **M2.5x8 copper standoffs** and **M2.5 nuts** into the **upper plate** first. Pay attention that the side the protruding prop should face up.

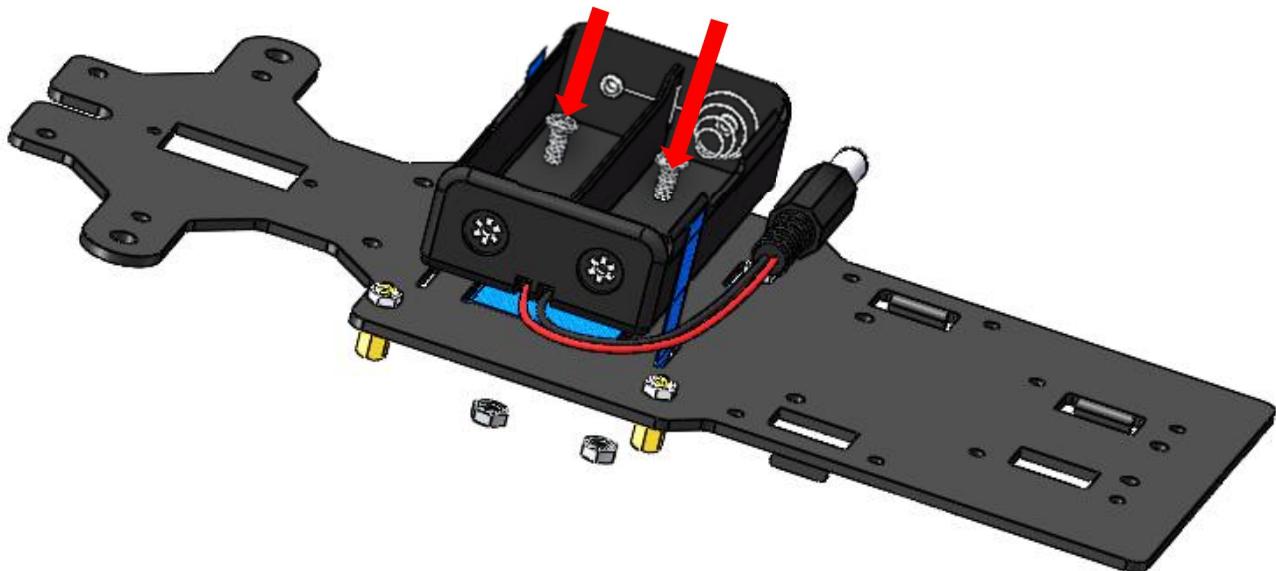


Battery Holder

Turn the Upper Plate upside down. Cut the **ribbon** into two halves. Thread them through the holes on the plate. Pay attention to the direction and leave one end longer out of the plate for each to remove the battery easily later.

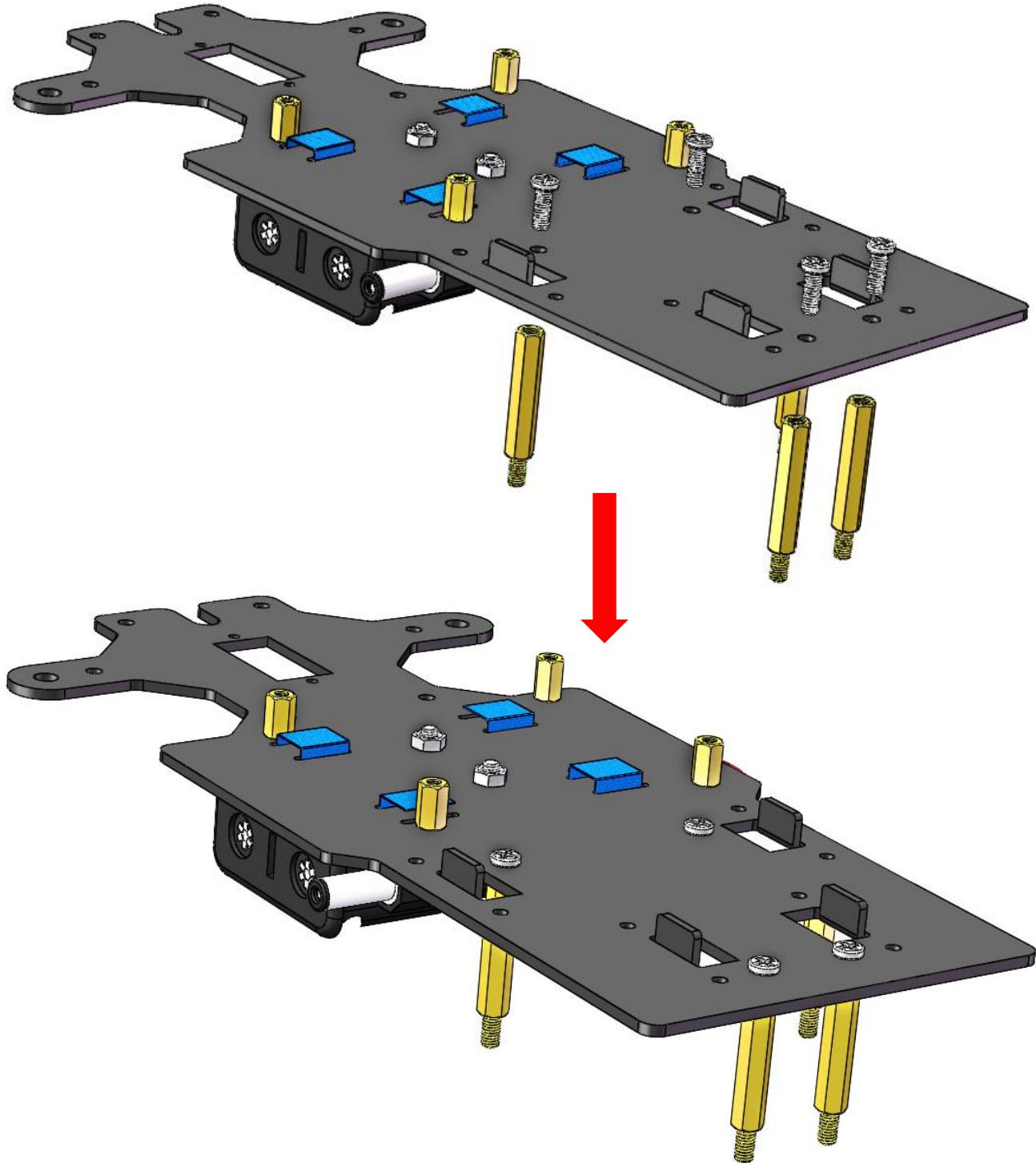


Fasten the battery holder with two **M3x8 countersunk screws** and **M3 nuts**. Pay attention to the direction of battery holder's wire.



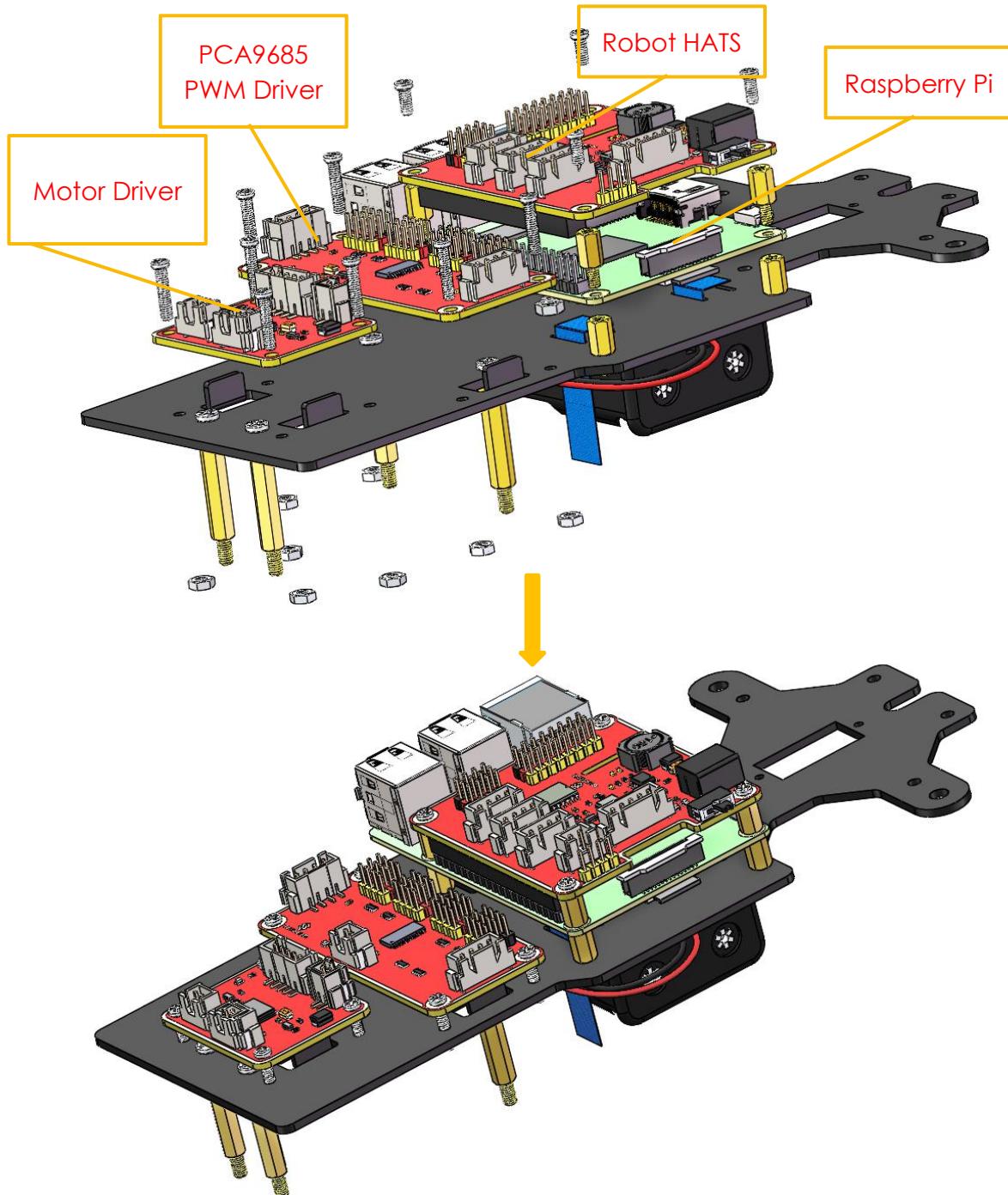
Rear Wheels (Screws)

Insert 4 **M3x8** screws with four **M3x25** copper standoffs:



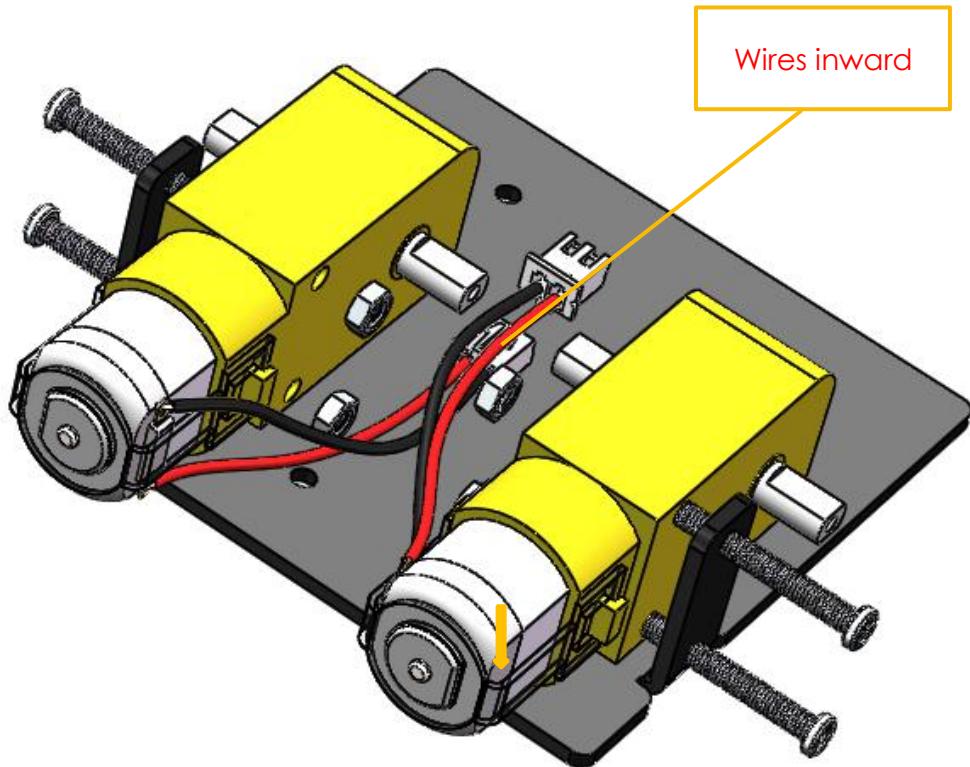
PCB Assembly

- 1) Assemble the **Raspberry Pi** (TF Card inserted) with 8 **M2.5x8 single pass copper standoffs**, then plug the **Robot HATS** onto it.
- 2) Fix the **Robot HATS** with 4 **M2.5x6 screws**.
- 3) Fix The **PCA9685 PWM Driver** and the **Motor Driver** with 8 **M2.5x12 screws and M2.5 nuts** into the down plate:

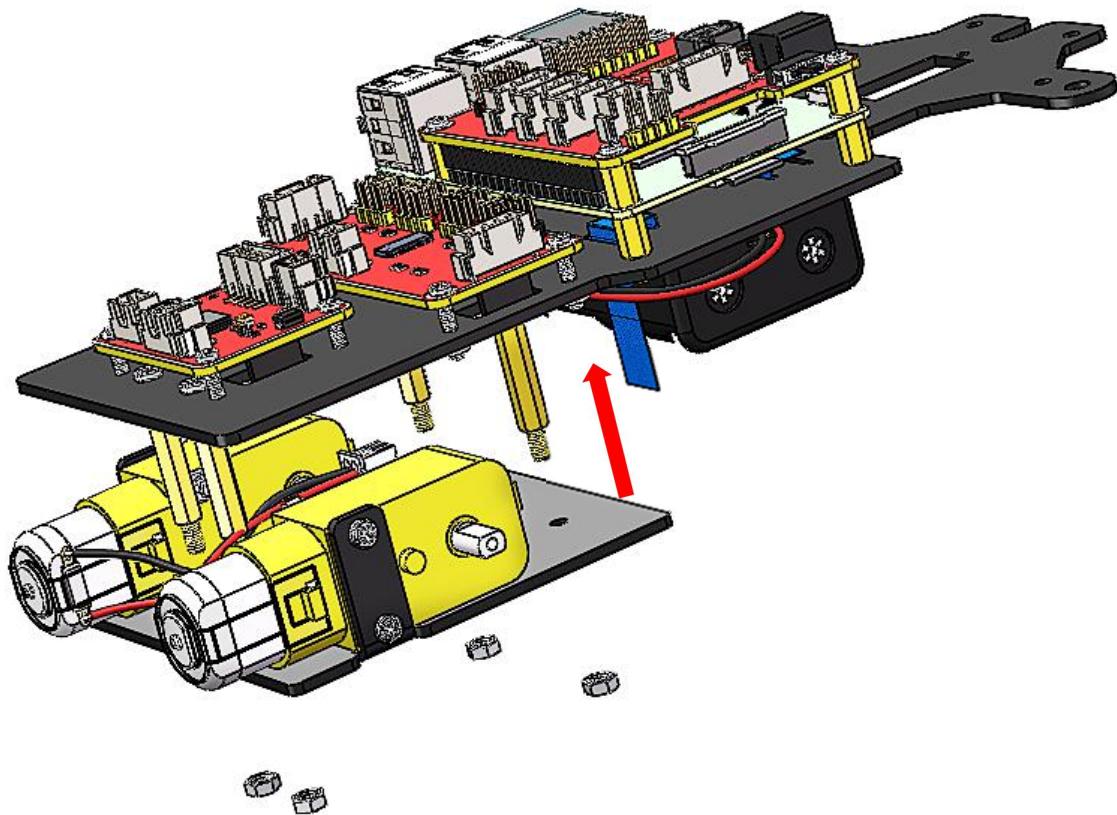


Fixing Rear Wheels

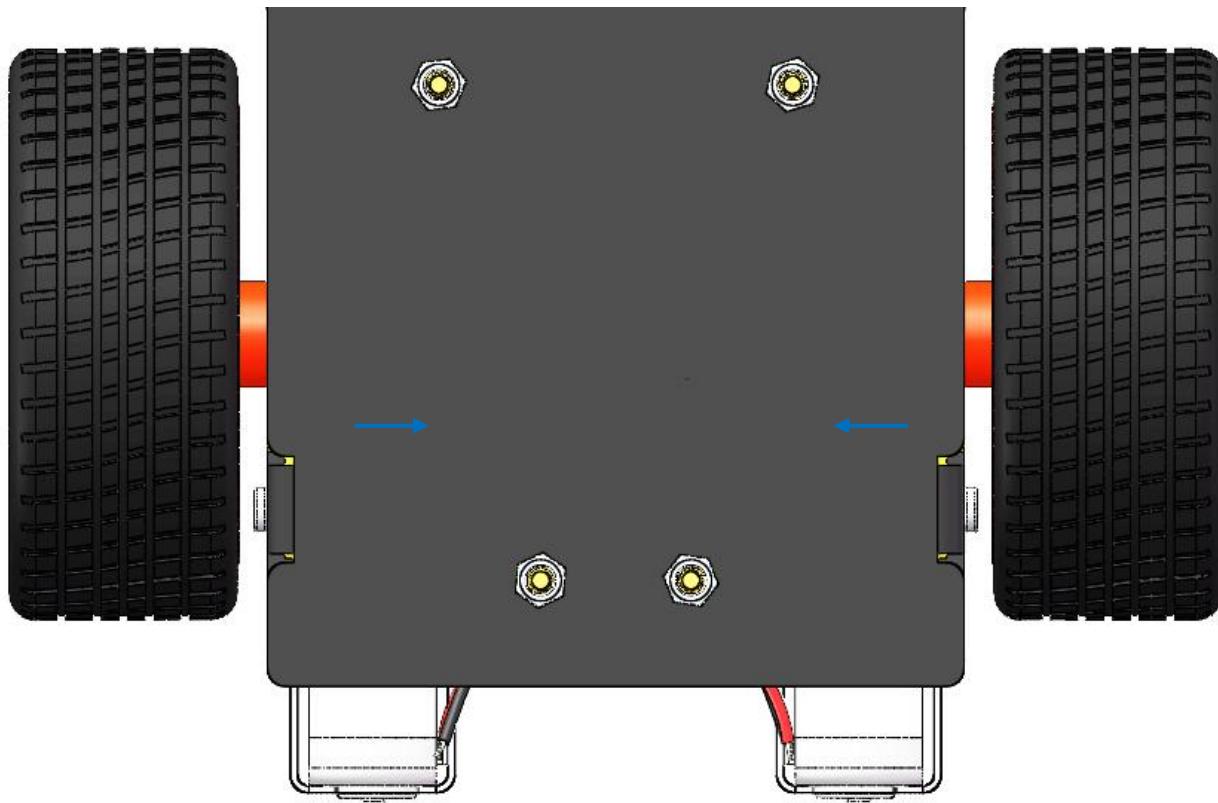
Assemble the two motors with four **M3x25 screws** and **M3 nuts**. Pay attention to place the motors with wires inward, providing convenience for connecting the circuit.



Assemble the rear wheels with 4 M3 nuts.

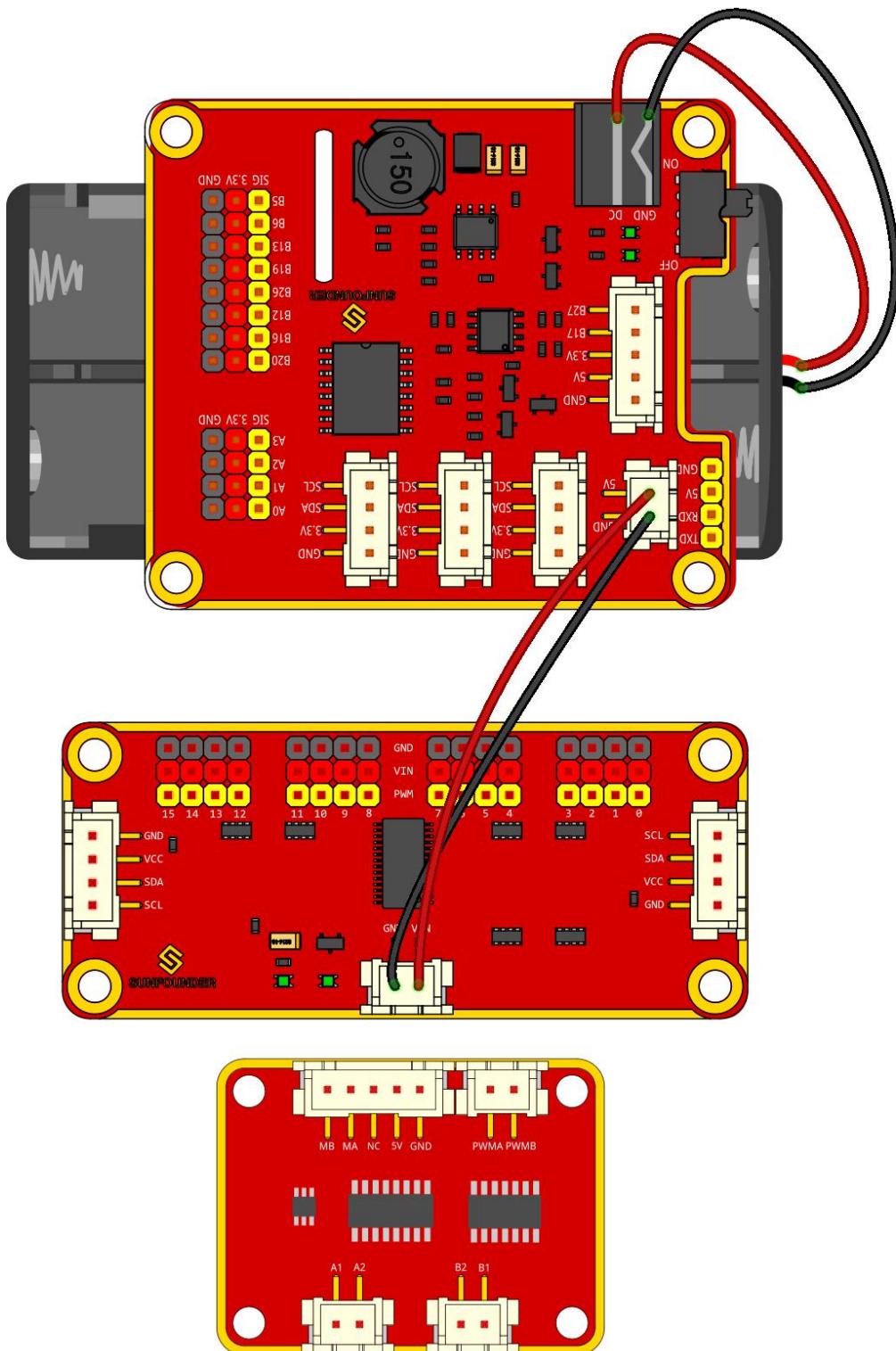


Align the **rear wheels** with the motor shaft, and rotate to insert them gently.

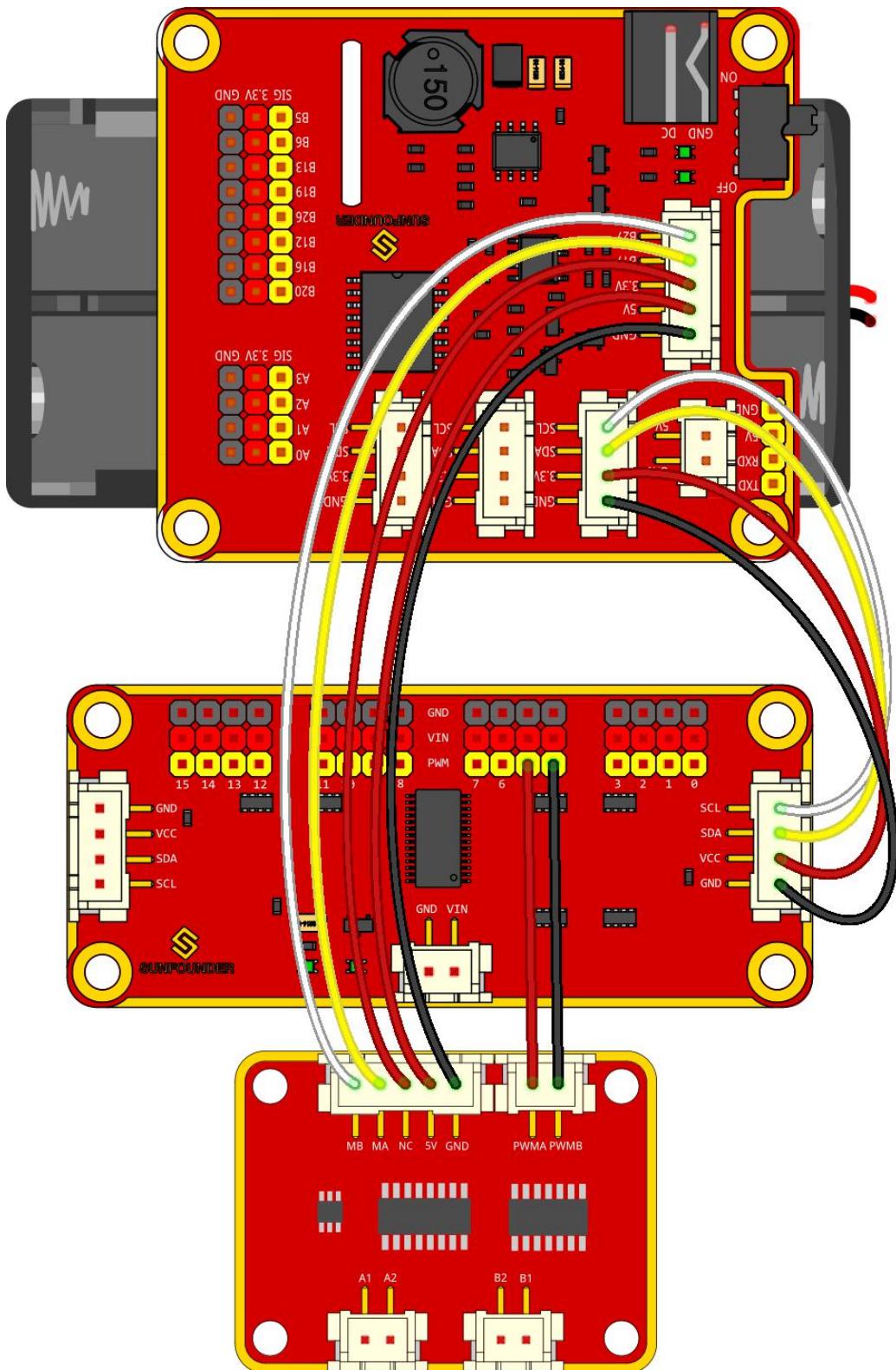


Circuits Building

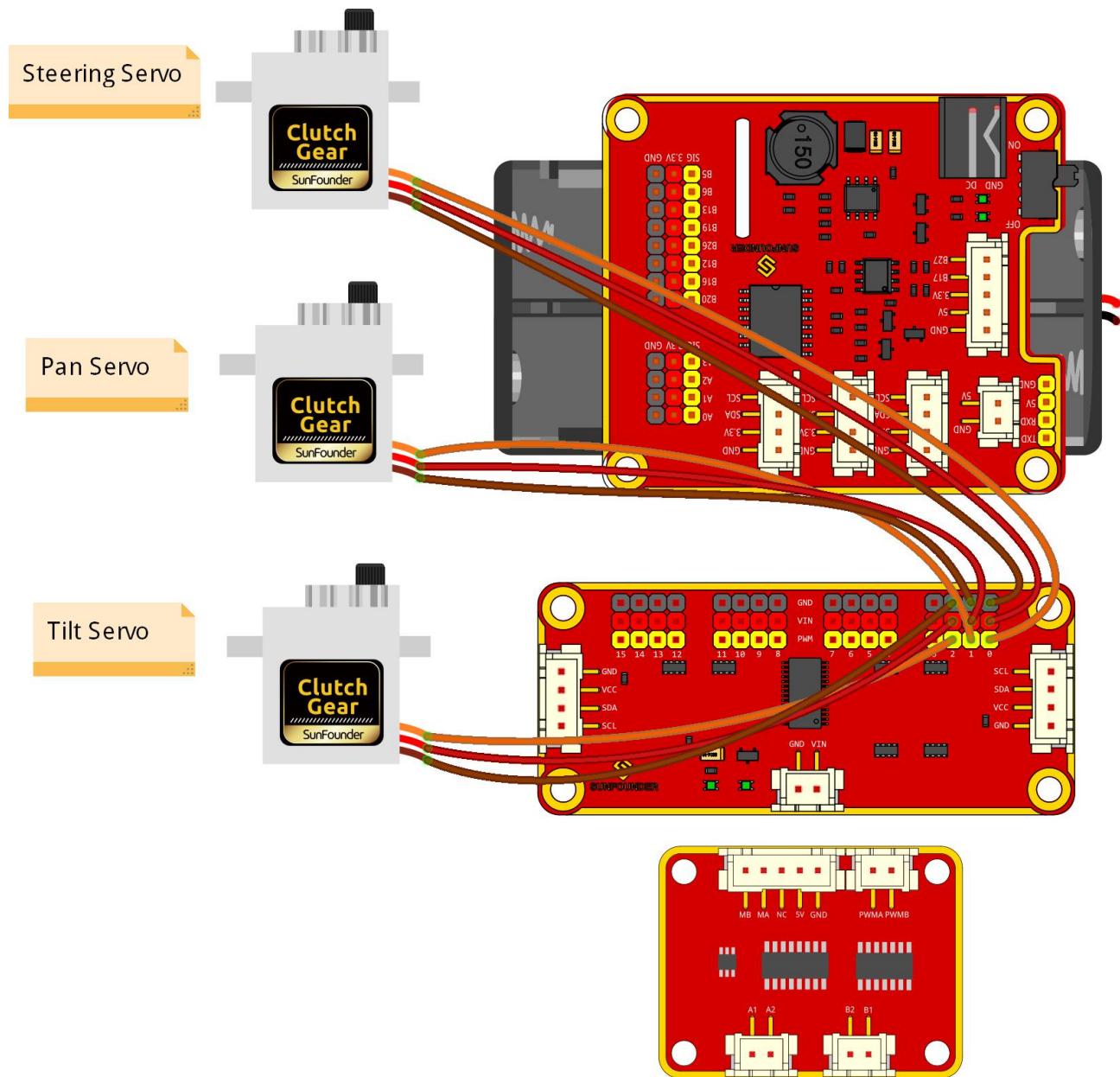
Connect the Power



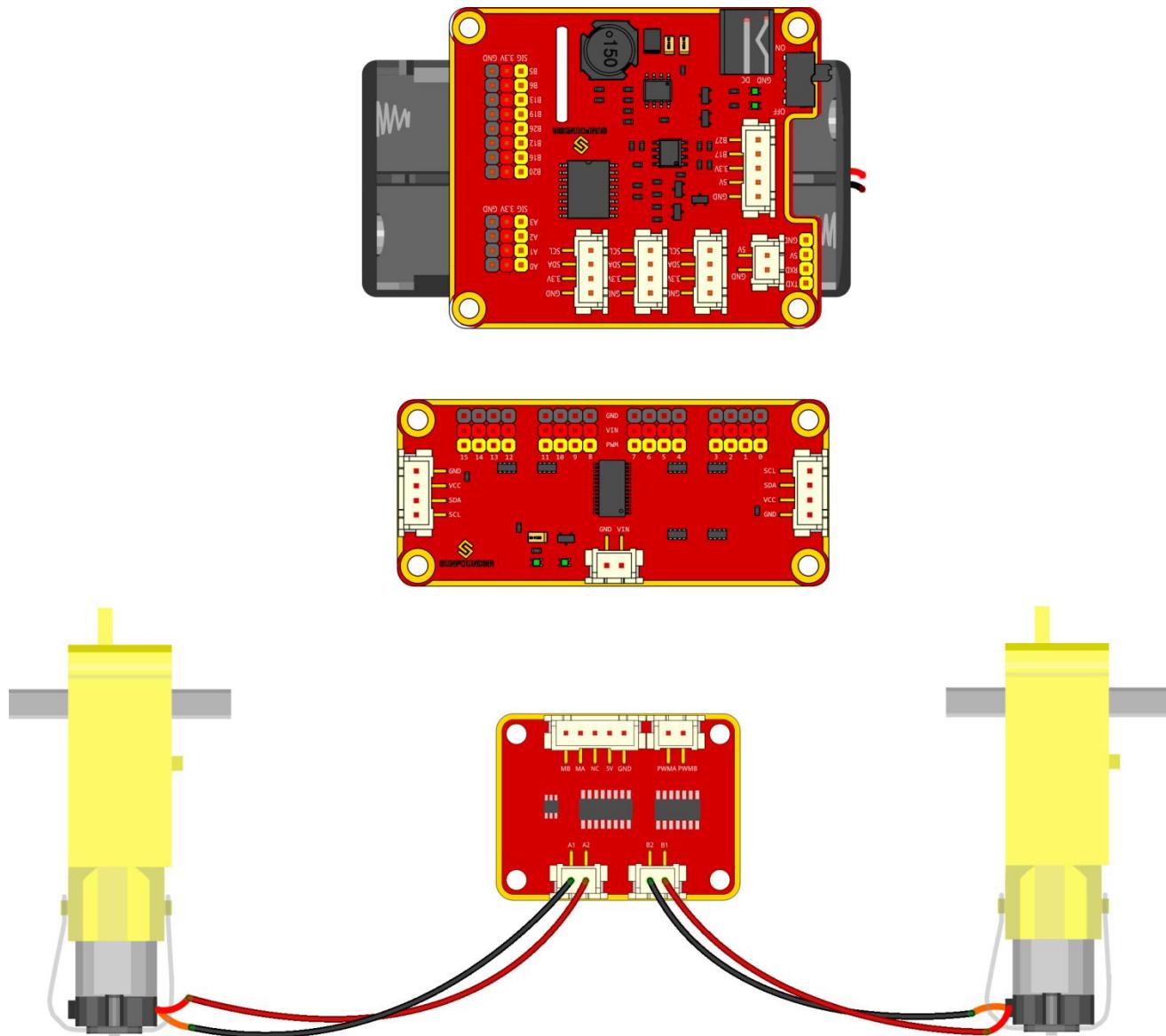
Connect the Modules



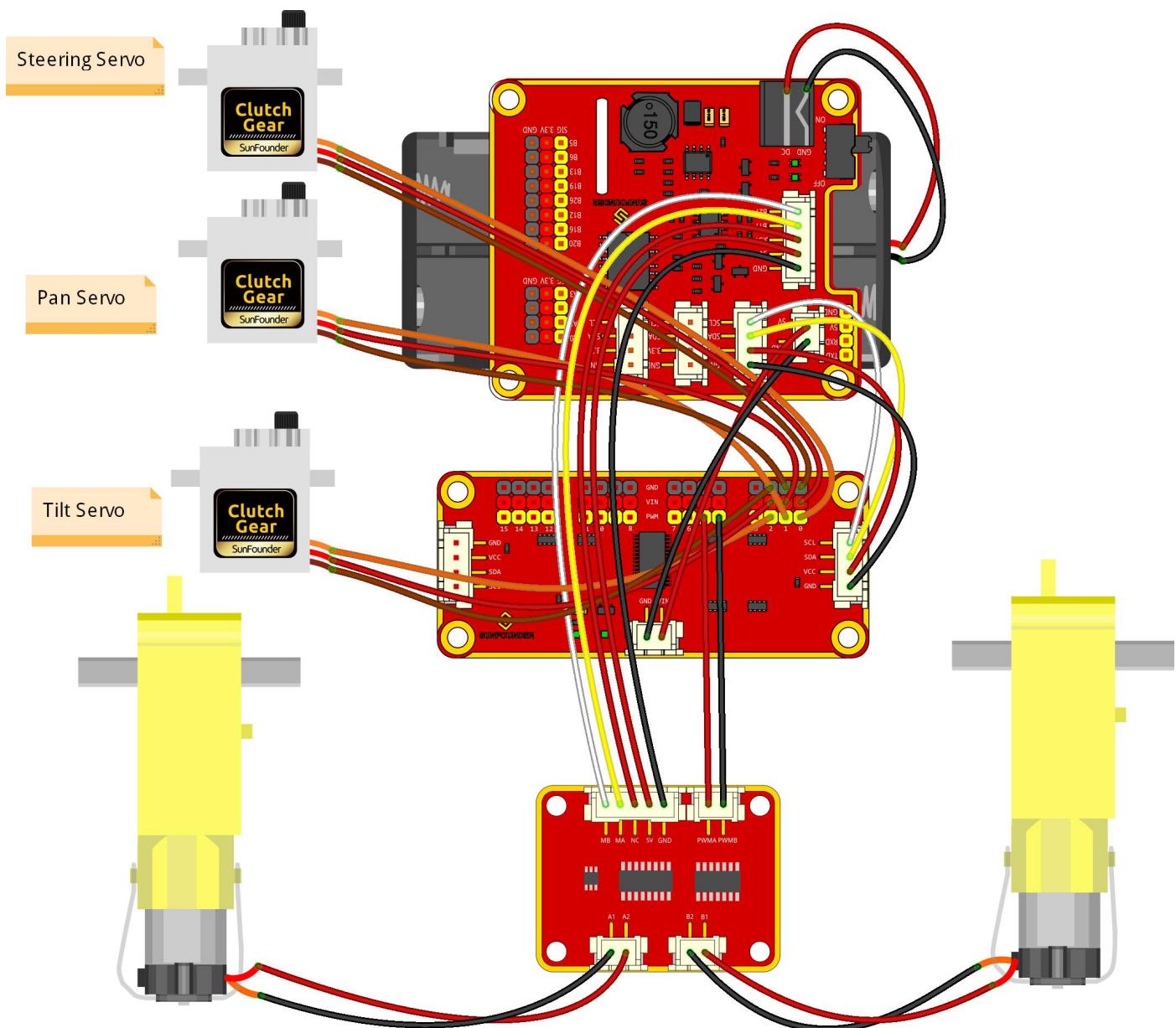
Connect the Servos



Connect the Motor



The complete connection is shown as follows.



Get Started with Raspberry Pi

In this chapter, we firstly learn to start up Raspberry Pi.

Depending on the different devices you use, you can start up the Raspberry Pi in different methods. We have two situations: having a screen or no screen, and you can refer to relevant tutorials respectively. **If your Raspberry Pi is set up, you can skip the part: Get Started with Raspberry Pi and go into the next chapter.**

If You Have A Screen

If you have a screen, you can use the NOOBS (New Out Of Box System) to install the **Raspberry Pi OS**.

- Required Components

Any Raspberry Pi	1 * Power Adapter
1 * Monitor	1 * Monitor Power Adapter
1 * HDMI cable	1 * Micro SD card
1 * Mouse	1 * Keyboard
1 * Personal Computer	

- Procedures

Step 1

To download NOOBS from your PC, you can choose **NOOBS** or **NOOBS LITE** - the only difference is that there is a built-in offline installer in **NOOBS**, while the **NOOBS LITE** can only be operated online. Here, you are suggested to use the former. Here is the download address of NOOBS:

<https://www.raspberrypi.org/downloads/noobs/>



Step 2

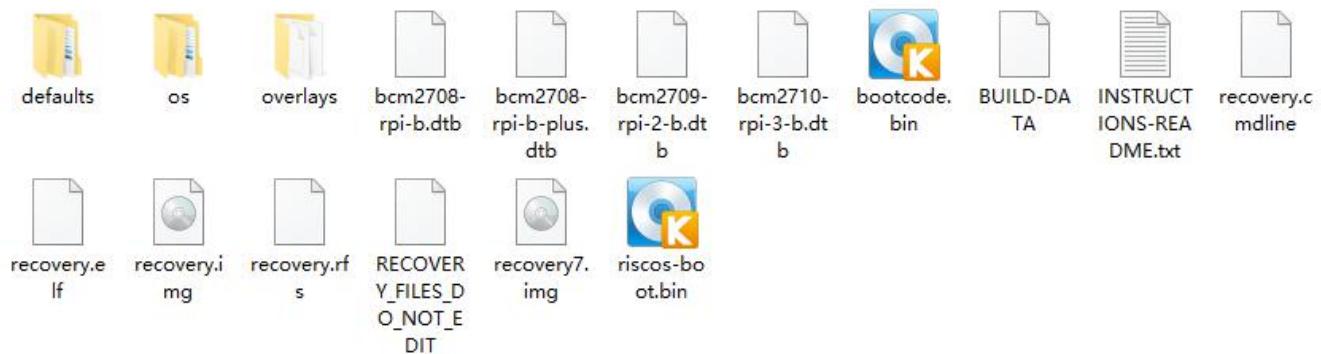
Plug in the Micro SD reader and format the Micro SD card with the **SD Formatter** (<https://www.sdcard.org/downloads/formatter/index.html>). If there are some important files in the Micro SD card, please backup them first.

Step 3

Next, you will need to extract the files from the NOOBS zip archive you downloaded from the Raspberry Pi website.

- Find the downloaded archive — by default, it should be in your Downloads folder.
- Double-click on it to extract the files, and keep the resulting Explorer/Finder window open.

Finally Select all the files in the NOOBS folder and copy them to the Micro SD card.



Step 4

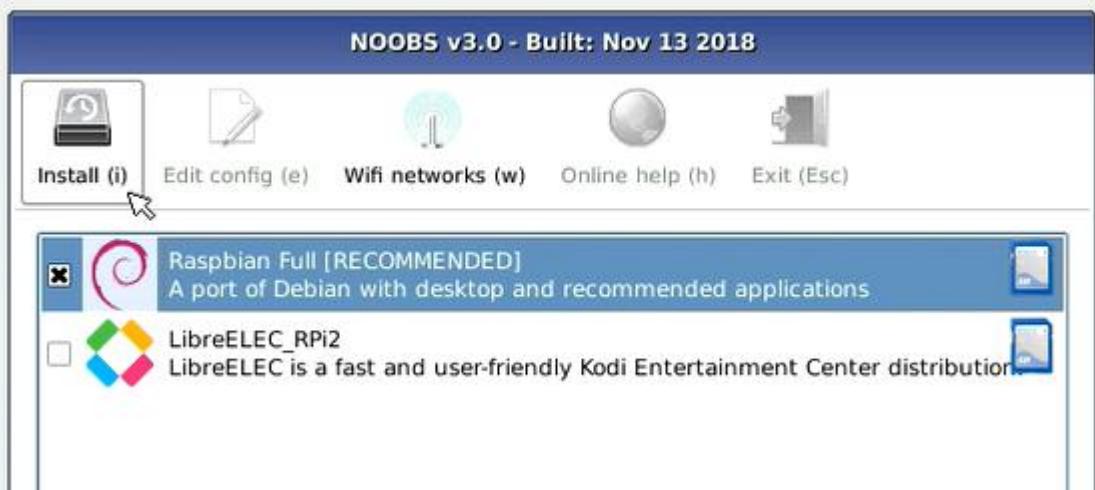
All the files transferred, the Micro SD card pops up.

Step 5

Insert the Micro SD card into the Raspberry Pi. In addition, connect the screen, keyboard and mouse to it. Finally you are also recommended to use the power adapter of Raspberry Pi to power your car for that the first test will take a long time.

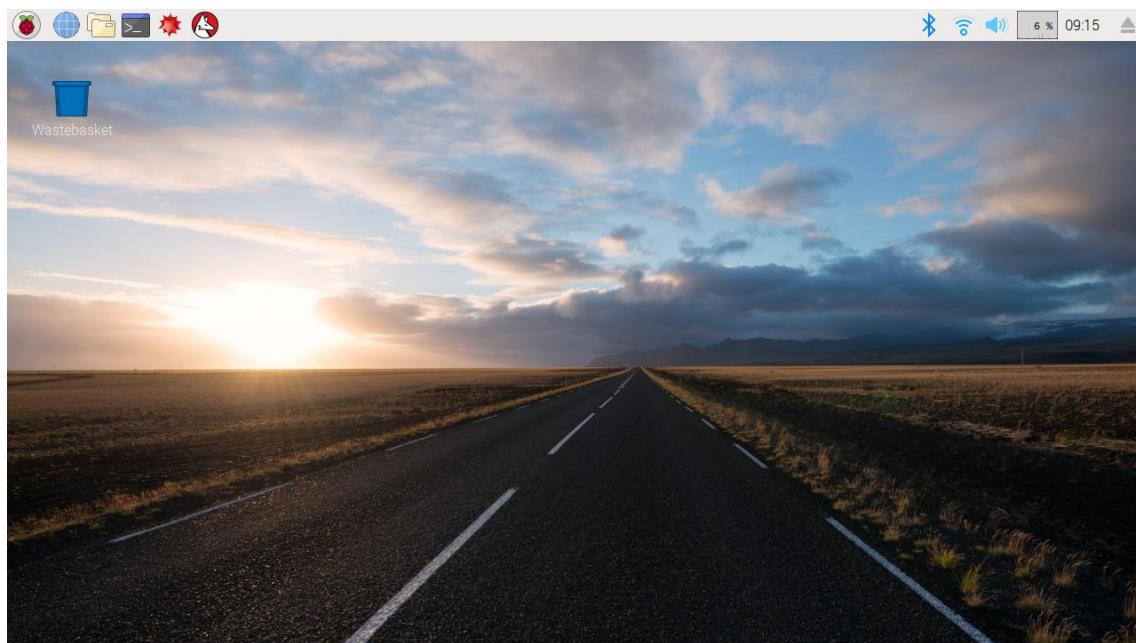
Step 6

It will go to the NOOBS interface after starting up. If you use **NOOBS LITE**, you need to select Wi-Fi networks (w) first. Tick the checkbox of the Raspbian and click Install in the top left corner. The NOOBS will help to conduct the installation automatically. This process will take a few minutes.



Step 7

When the installation is done, the system will restart automatically and the desktop of the system will appear.



Step 8

If you run Raspberry Pi for the first time, the application of “Welcome to Raspberry Pi” pops up and guides you to perform the initial setup.



Step 9

Set country/region, language and time zone, and then click “next” again.



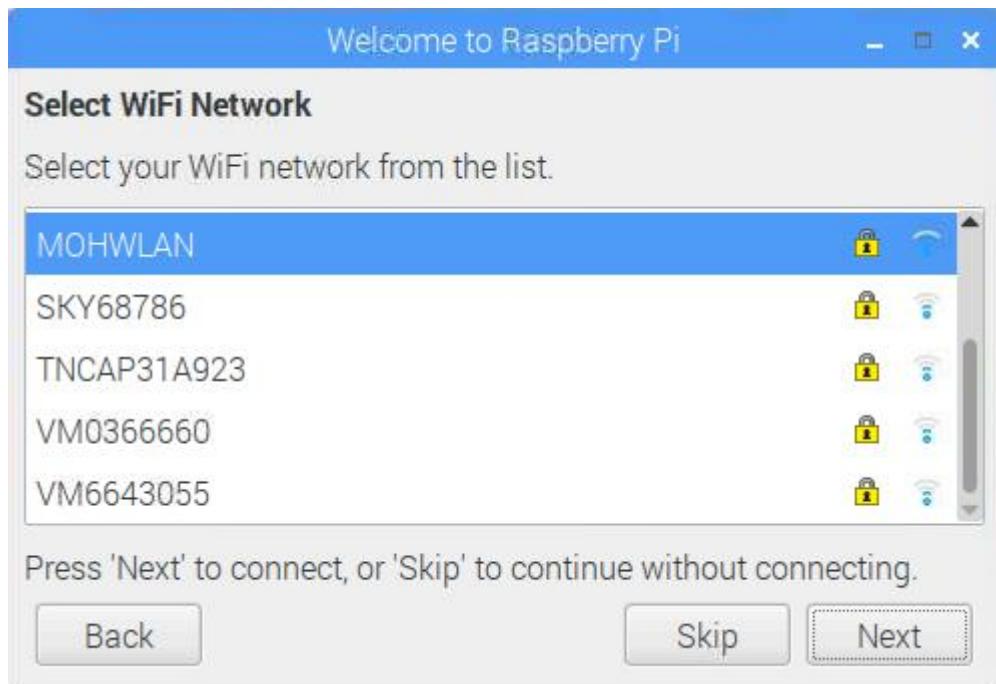
Step 10

Input the new password of Raspberry Pi and click "Next".



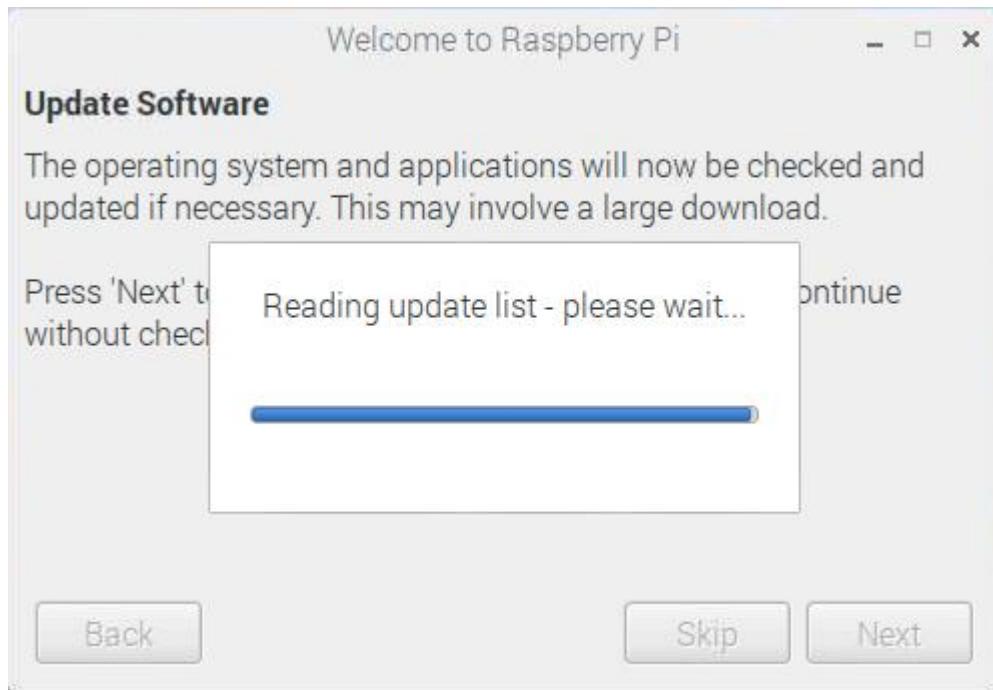
Step 11

Connect the Raspberry Pi to WIFI and click "Next".



Step 12

Retrieve update.



Step 13

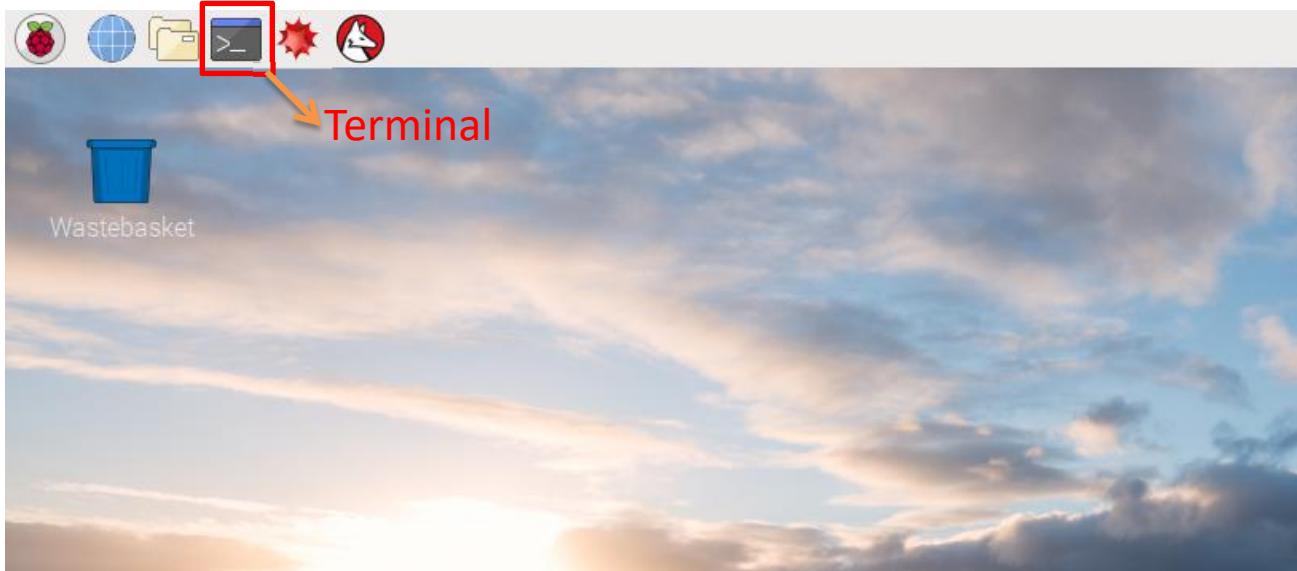
Click "Done" to complete the Settings.



Now we can run the Raspberry Pi.

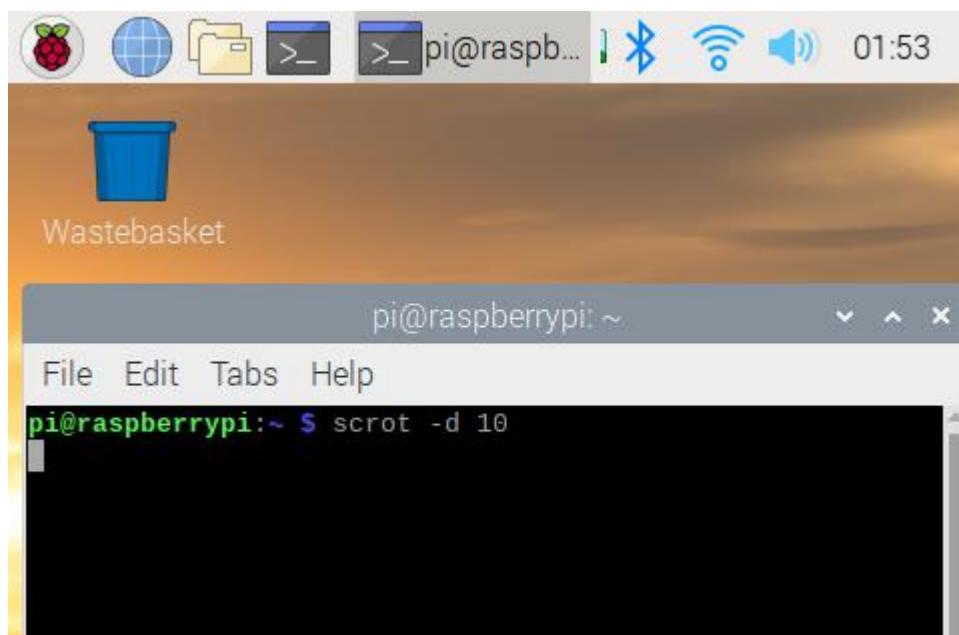
Step 14

Click the Terminal icon on the top left corner.



Step 15

Then you can input the commands on the Terminal.



Note: You can check the complete tutorial of NOOBS on the official website of the Raspberry Pi: <https://projects.raspberrypi.org/en/projects/raspberry-pi-setting-up>

If You Have No Screen

If we don't have a screen, we can directly write the Raspberry Pi OS system to the Micro SD card and we can control the Raspberry Pi on PC remotely by directly modifying the configuration file of the network settings in the Micro SD card.

- Required Components

Any Raspberry Pi	1 * Power Adapter
1 * Micro SD card	1 * Personal computer

- Installing System

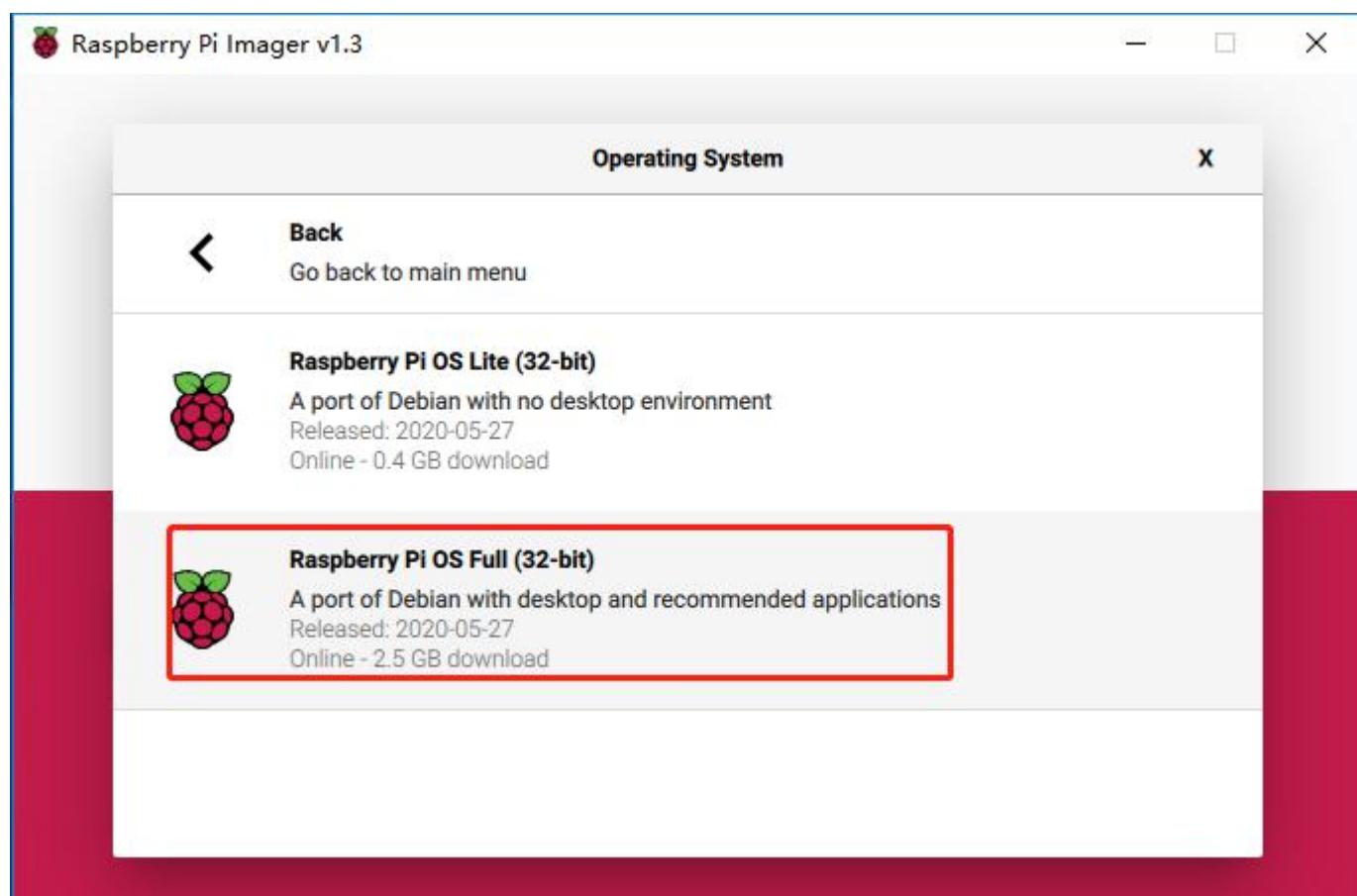
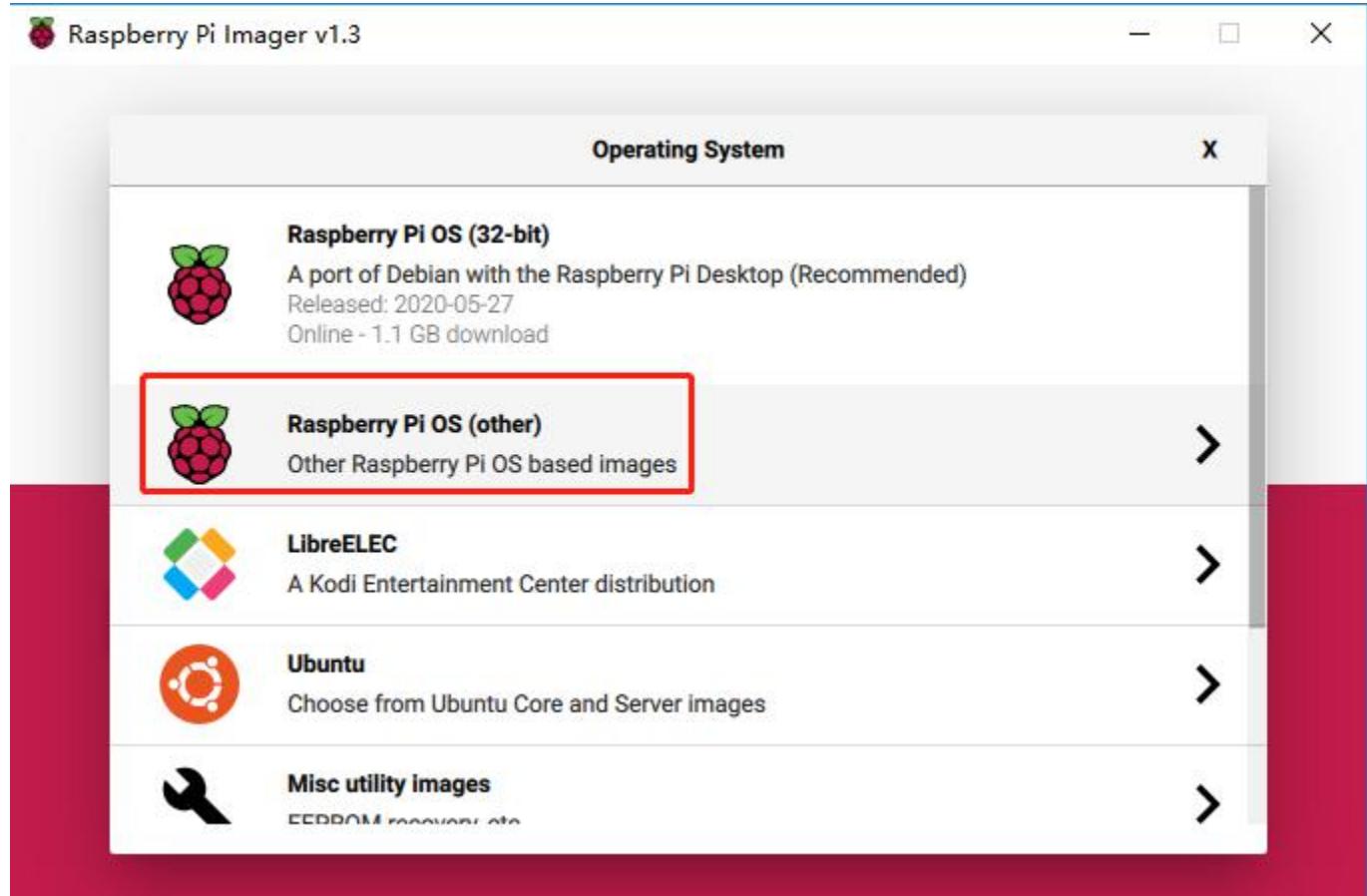
There are 2 ways to install the system, **Using Raspberry Pi Imager** or **Using Raspberry Pi OS**. **Using Raspberry Pi Imager** is a kind of method recommended by Raspberry Pi official website for beginners with which you can directly write the Raspberry Pi OS into SD card after downloading Raspberry Pi Imager. However, each time the system is reinstalled, this method can take several hours.

In the later method, you need to download Raspberry Pi OS image at first, then use the tool to write it to your SD card, which can be confusing. But once you successfully finish the flashing at the first time, it only takes about 10 minutes to flash again.

➤ Using Raspberry Pi Imager

Raspberry Pi have developed a graphical SD card writing tool that works on Mac OS, Ubuntu 18.04 and Windows, and is the easiest option for most users as it will download the image and install it automatically to the SD card.

- 1) Download the latest version of **Raspberry Pi Imager**(<https://www.raspberrypi.org/downloads/>) and install it.
- 2) Connect an SD card reader with the SD card inside.
- 3) Open Raspberry Pi Imager and choose **Raspberry Pi OS (other)** -> **Raspberry Pi OS Full (32-bit)**.



- 4) Choose the SD card you wish to write your image to.
- 5) Review your selections and click 'WRITE' to begin writing data to the SD card.

Note: If using the Raspberry Pi Imager on Windows 10 with Controlled Folder Access enabled, you will need to explicitly allow the Raspberry Pi Imager permission to write the SD card. If this is not done, Raspberry Pi Imager will fail with a "failed to write" error.

➤ Using Raspberry Pi OS

Step 1

Prepare the tool of image burning. Here we use the **balenaEtcher**. You can download the software from the link: <https://www.balena.io/etcher/>

Step 2

Download the complete image on the official website by clicking this link: <https://www.raspberrypi.org/downloads/raspberry-pi-os/>. There are three different kinds of Raspberry Pi OS system available, You are recommend to install the version: **Raspberry Pi OS with desktop and recommended software**.

Step 3

Unzip the package downloaded and you will see the **.img** file inside.

Note: The Raspberry Pi OS with desktop image contained in the ZIP archive is over 4GB in size and uses the ZIP64 format. To uncompress the archive, a unzip tool that supports ZIP64 is required. The following zip tools support ZIP64: 7-Zip (Windows), The Unarchiver (Mac) and Unzip (Linux).

Step 4

Plug the USB card reader into the computer, then you can flash the **.img** file with the Etcher.

At this point, Raspberry Pi OS is installed. **Keep the USB card reader plug in your computer**. If you want to apply it, next you need to complete the settings accordingly.

- Connect the Raspberry Pi to the Internet

There are two methods to help get the Raspberry Pi connected to the network: the first one is using a network cable, the other way is using WIFI. We will talk in detail about how to connect via WIFI as below.

If you want to use the WIFI function, you need to modify a WIFI configuration file `wpa_supplicant.conf` in the Micro SD card by your PC that is located in the directory `/etc/wpa_supplicant/`.

If your personal computer is working on a linux system, you can access the directory directly to modify the configuration file; however, if your PC use Windows system, then you can't access the directory and what you need next is to go to the directory, `/boot/` to create a new file with the same name, **wpa_supplicant.conf**.



Input the following content in the file.

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
country=COUNTRY
network={
ssid="SSID"
psk="PASSWORD"
key_mgmt=WPA-PSK
priority=1
}
```

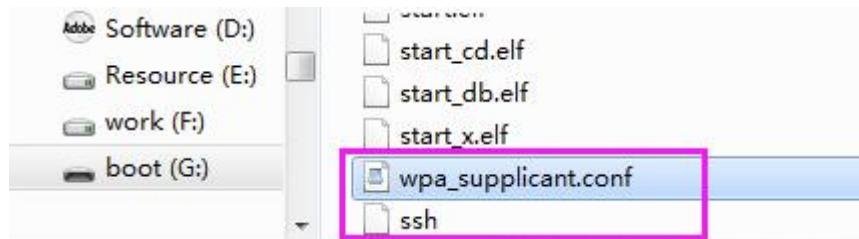
COUNTRY should be set the two-letter ISO/IEC alpha2 code for the country in which you are using your Raspberry Pi, please refer to the following link:

https://en.wikipedia.org/wiki/ISO_3166-1_alpha-2#Officially_assigned_code_elements

You need to replace “**SSID**” with your custom name of WiFi and “**PASSWORD**” with your password. By doing these, the **Raspberry Pi OS** will move this file to the target directory automatically to overwrite the original WIFI configuration file when it runs next time. After doing this step, you also need to **keep the USB card reader plug in your computer**.

- Start SSH

To use the function of remote control of the Raspberry Pi, you need to start SSH firstly that is a more reliable protocol providing security for remote login sessions and other network services. Generally, SSH of Raspberry Pi is in a disabled state. Additionally, if you want to run it, you need to create a file named SSH under directory /boot/.



Now, the Raspberry Pi OS is configured.

- Power on the Raspberry Pi

You can plug out the USB card reader and then plug the Micro SD card into the Raspberry Pi.

Put two 18650 fully charged batteries in the holder, plug the wires from the battery holder into the development board then toggle the switch from off to on. **You are also recommended to use the power adapter of Raspberry Pi to power your car for that the first test will take a long time.**

- Get the IP Address

After the Raspberry Pi is powered on with a power adapter, we need to get the IP address of it. There are many ways to know the IP address, and two of them are listed as follows.

1. Checking via the router

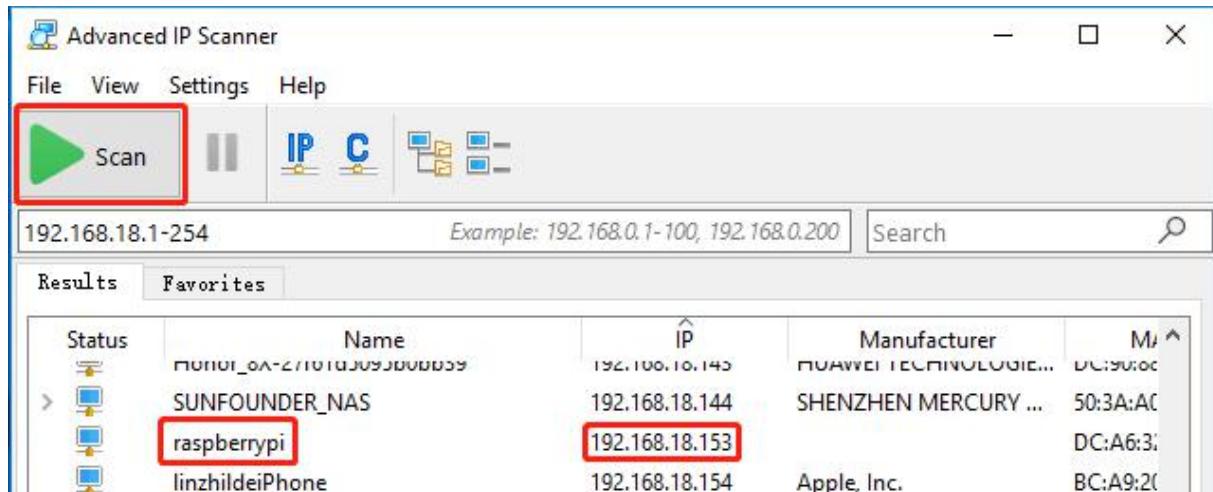
If you have permission to log in the router(such as a home network), you can check the addresses assigned to Raspberry Pi on the admin interface of router.

The default hostname of the system, Raspberry Pi OS is **raspberrypi**, and you need to find it. (If you are using ArchLinuxARM system, please find alarmpi.)

2. Network Segment Scanning

You can also use network scanning to look up the IP address of Raspberry Pi. You can apply the software, **Advanced IP scanner(download from Google)**.

Click **Scan** and the name of all connected devices will be displayed. Similarly, the default hostname of the Raspberry Pi OS is **raspberrypi**, now you need to find the hostname and its IP.



- Use the SSH Remote Control

We can open the Bash Shell of Raspberry Pi by applying SSH. Bash is the standard default shell of Linux. The Shell itself is a program written in C that is the bridge linking the customers and Unix/Linux. Moreover, it can help to complete most of the work needed.

➤ For Linux or/Mac OS X Users

Step 1

Go to **Applications->Utilities**, find the **Terminal**, and open it.

Step 2

Type in **ssh pi@ip_address** . “pi”is your username and “ip_address” is your IP address. For example:

```
ssh pi@192.168.18.197
```

Step 3

Input“yes”.

```
1. ssh pi@192.168.18.197 (ssh)
Last login: Fri Apr 12 16:56:20 on ttys000
# hang_chen @ hang-chendeMacBook-Pro in ~ [17:09:55]
$ ssh pi@192.168.18.197
The authenticity of host '192.168.18.197 (192.168.18.197)' can't be established.
ECDSA key fingerprint is SHA256:60tKKQtCCRvUCohWmvVcbp7tBHTQL0f8/0kusPjVsEU.
Are you sure you want to continue connecting (yes/no)?
```

Step 4

Input the password and the default password is **raspberry**.

```
1. ssh pi@192.168.18.197 (ssh)
Last login: Fri Apr 12 16:56:20 on ttys000
# hang_chen @ hang-chendeMacBook-Pro in ~ [17:09:55]
$ ssh pi@192.168.18.197
The authenticity of host '192.168.18.197 (192.168.18.197)' can't be established.
ECDSA key fingerprint is SHA256:60tKKQtCCRvUCohWmvVcbp7tBHTQL0f8/0kusPjVsEU.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.18.197' (ECDSA) to the list of known hosts.
pi@192.168.18.197's password: *
```

Step 5

We now get the Raspberry Pi connected and are ready to go to the next step.

```
1. pi@raspberrypi: ~ (ssh)
Last login: Fri Apr 12 16:56:20 on ttys000
# hang_chen @ hang-chendeMacBook-Pro in ~ [17:09:55]
$ ssh pi@192.168.18.197
The authenticity of host '192.168.18.197 (192.168.18.197)' can't be established.
ECDSA key fingerprint is SHA256:60tKKQtCCRvUCohWmvVcbp7tBHTQL0f8/0kusPjVsEU.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.18.197' (ECDSA) to the list of known hosts.
pi@192.168.18.197's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Tue May 21 07:29:46 2019 from 192.168.18.126

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set
a new password.

pi@raspberrypi:~ $
```

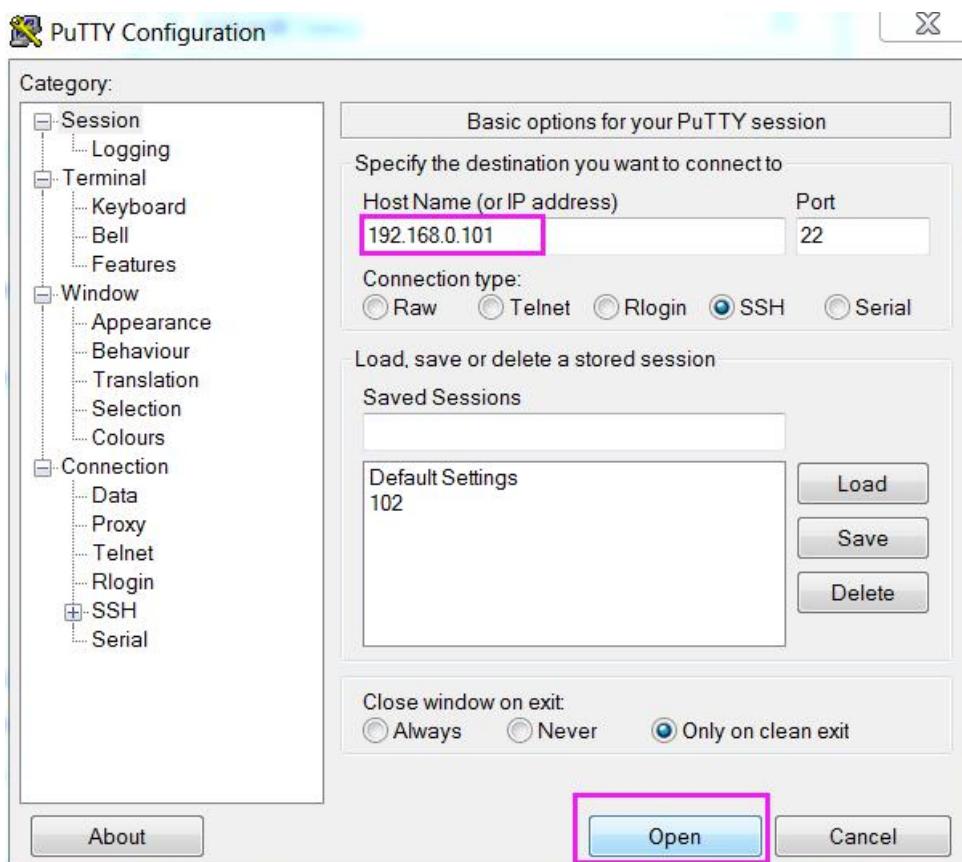
Note: When you input the password, the characters do not display on window accordingly, which is normal. What you need is to input the correct password.

➤ For Windows Users

If you're a Windows user, you can use SSH with the application of some software. Here, we recommend **PuTTY**(You can download from Google).

Step 1

Download PuTTY. Open PuTTY and click **Session** on the left tree-alike structure. Enter the IP address of the RPi in the text box under **Host Name (or IP address)** and **22** under **Port** (by default it is 22).



Step 2

Click **Open**. Note that when you first log in to the Raspberry Pi with the IP address, there prompts a security reminder. Just click **Yes**.

Step 3

When the PuTTY window prompts “**login as:**”, type in “**pi**”(the user name of the RPi), and **password:** “**raspberry**” (the default one, if you haven't changed it).



A screenshot of a terminal window titled "pi@raspberrypi: ~". It shows the user logging in as "pi" with the password "raspberry". The terminal displays standard Debian Linux welcome messages about free software and warranty. The last login information is shown as "Last login: Tue Feb 21 02:54:55 2017". The prompt at the bottom is "pi@raspberrypi:~ \$". A small portion of the password entry is highlighted with a pink box.

```
pi@raspberrypi: ~
login as: pi
pi@192.168.0.234's password: raspberry
The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Tue Feb 21 02:54:55 2017
pi@raspberrypi:~ $
```

Note: When you input the password, the characters do not display on window accordingly, which is normal. What you need is to input the correct password.

Here, we get the Raspberry Pi connected and it is time to conduct the next steps.

Servo Configuration

And since the servos used in this kit are adjusted by software and there's no such physical sticking point as other servos, here we need to configure the servo via software. First you need to finish some software installation before the configuration.

Note: Please do **not** forget to put in the battery and slide the power switch to ON **in this chapter**.

Get Source Code

You can find the source code in our Github repositories. Download the source code by *git clone*:

```
cd ~/  
git clone https://github.com/sunfounder/SunFounder_PiCar-V -b V3.0
```

Note: Please pay attention to your typing – if you get the prompt of entering your user name and password, you may have typed wrong. If unluckily you did so, press Ctrl + C to exit and try again.

Check by the **ls** command, then you can see the code directory *SunFounder_PiCar-V*.

```
pi@raspberrypi: ~  
SSH is enabled and the default password for the 'pi' user has not been changed.  
This is a security risk - please login as the 'pi' user and type 'passwd' to set a new password.  
  
pi@raspberrypi: ~ $ cd ~/  
pi@raspberrypi: ~ $ git clone https://github.com/sunfounder/SunFounder_PiCar-V  
t  
Cloning into 'SunFounder_PiCar-V'...  
remote: Enumerating objects: 3, done.  
remote: Counting objects: 100% (3/3), done.  
remote: Compressing objects: 100% (3/3), done.  
remote: Total 987 (delta 0), reused 1 (delta 0), pack-reused 984  
Receiving objects: 100% (987/987), 9.47 MiB | 25.00 KiB/s, done.  
Resolving deltas: 100% (443/443), done.  
pi@raspberrypi: ~ $ ls  
bcm2835-1.60          Music           RetroPie-Setup_bak  
bcm2835-1.60.tar.gz    nrf             serial-servo-module  
Desktop                NRF             sound-effect-module  
Documents              oled            SunFounder_PiCar-V  
Downloads              picar-4wd        Templates
```

Go to the Code Directory

```
cd ~/SunFounder_PiCar-V
```

Enter the code directory and you can see the installation script:

```
pi@raspberrypi:~ $ cd ~/SunFounder_PiCar-V
pi@raspberrypi:~/SunFounder_PiCar-V $ ls
ball_track    i2cHelper.py          LICENSE      remote_control
client        __init__.py          mjpg-streamer  show
datasheet     install_dependencies README.md
pi@raspberrypi:~/SunFounder_PiCar-V $
```

Install the Environment via the Script

You can get all the required software and configuration done with the `install_dependencies` script. If you want to do step by step instead, please follow the instructions in the **Appendix 1: Function of the Server Installation Scripts**.

```
sudo ./install_dependencies
```

Notes:

1. The installation script will install the required components and configure for the running environment. Make sure your Raspberry is connected to the Internet during the installation, or it would fail.
2. The Raspberry Pi will prompt you to reboot after the installation. You're recommended to type in **yes** to reboot.

Configure the Servo to 90 degrees

After reboot, run the `picar` tool:

```
cd ~/SunFounder_PiCar-V
picar servo-install
pi@raspberrypi:~/SunFounder_PiCar-V $ picar servo-install
```

Notes:

If the "OSError: [Errno 121] Remote I/O error" error message appears, open `raspi-config`:

```
sudo raspi-config
```

Then choose 5 Interfacing Options → P5 I2C → <YES> to enable I2C service.

After the code is running, insert the rocker arm into the servo. You will see the rocker arm is rotate in clockwise and counterclockwise, then stop at a specific location. It means the servo is good. If the any of the conditions below happened to your servo, your servo is bad:

- 1) Noisy, hot.
- 2) If unplug the servo line and rotate the rocker arm, it sounds like "ka" "ka" "ka" or there has no sounds of gear driving.
- 3) Rotate slowly but continuously.

If you find one of the conditions above, please send e-mail to service@sunfounder.com. We will change a new one to you. If it is broken in the process of using or assembling, you should go to the official website www.sunfounder.com to buy.

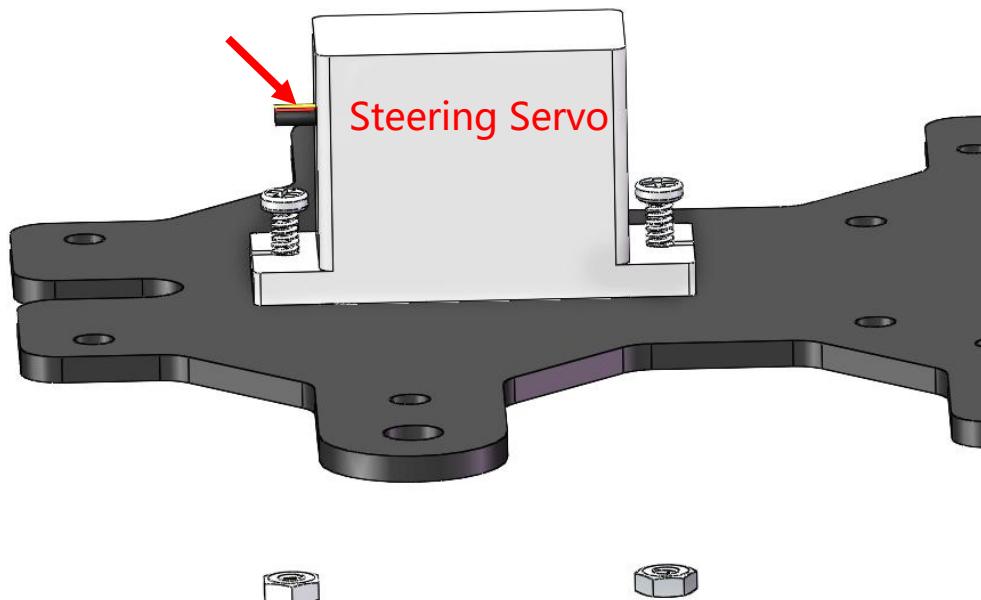
Continue to Assemble



Please do not forget to put in the battery and slide the power switch to ON, then keep servo-install running in the whole process of assembly.

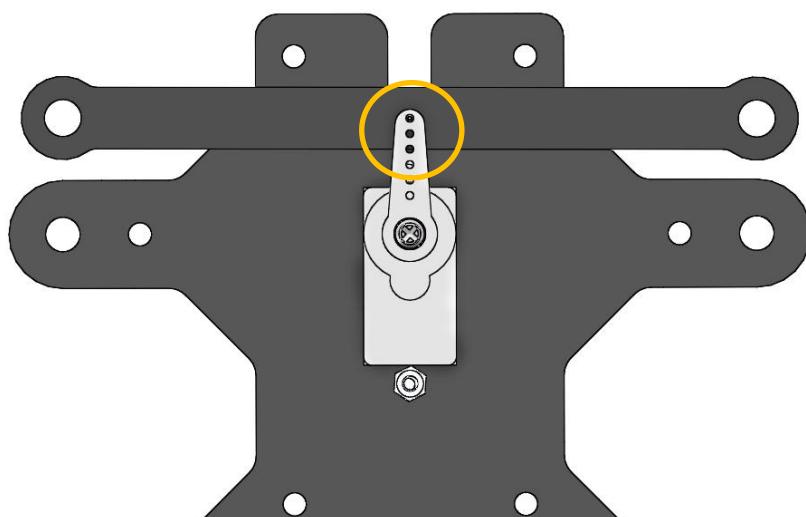
Assemble the Steering Servo

Mount the **Steering Servo** to the Upper Plate with two **M2x8 Screws** and **M2 nuts** (pay attention to the direction of the servo **wires**):

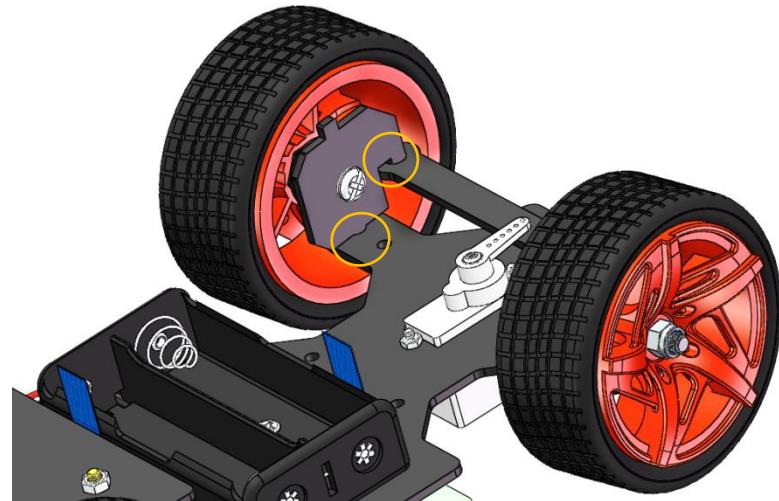


Front Half Chassis

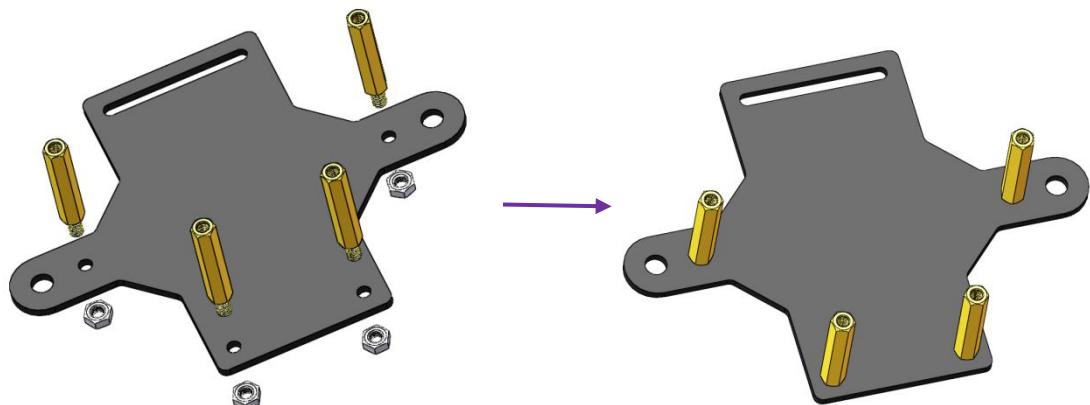
Connect the **Steering Linkage** and the **Rocker Arm** with **Rocker Arm Fixing Screw** (the shortest).



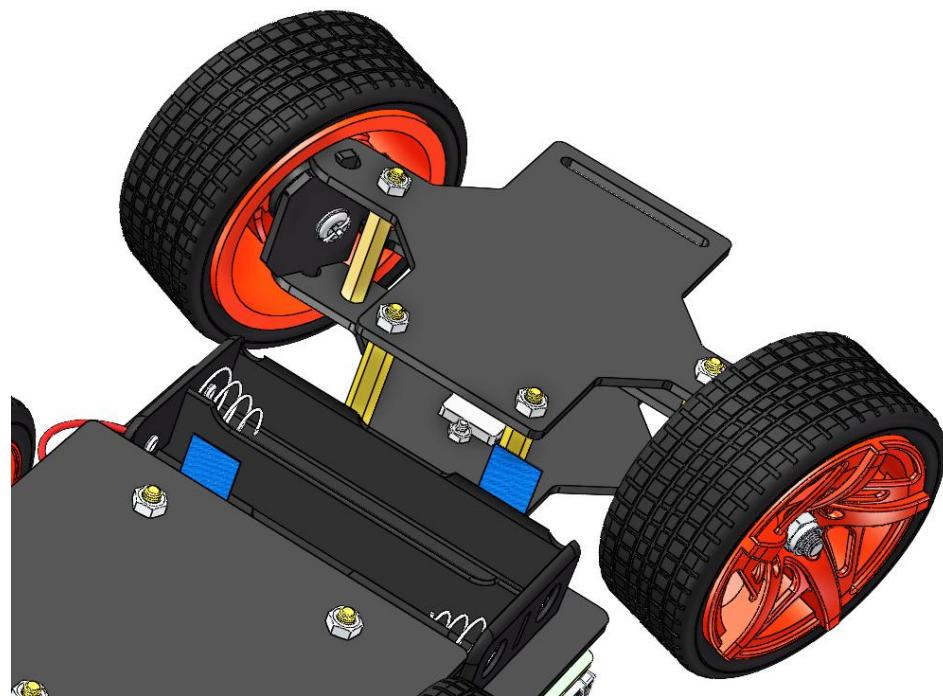
Mount the wheels onto the Upper Plate carefully.



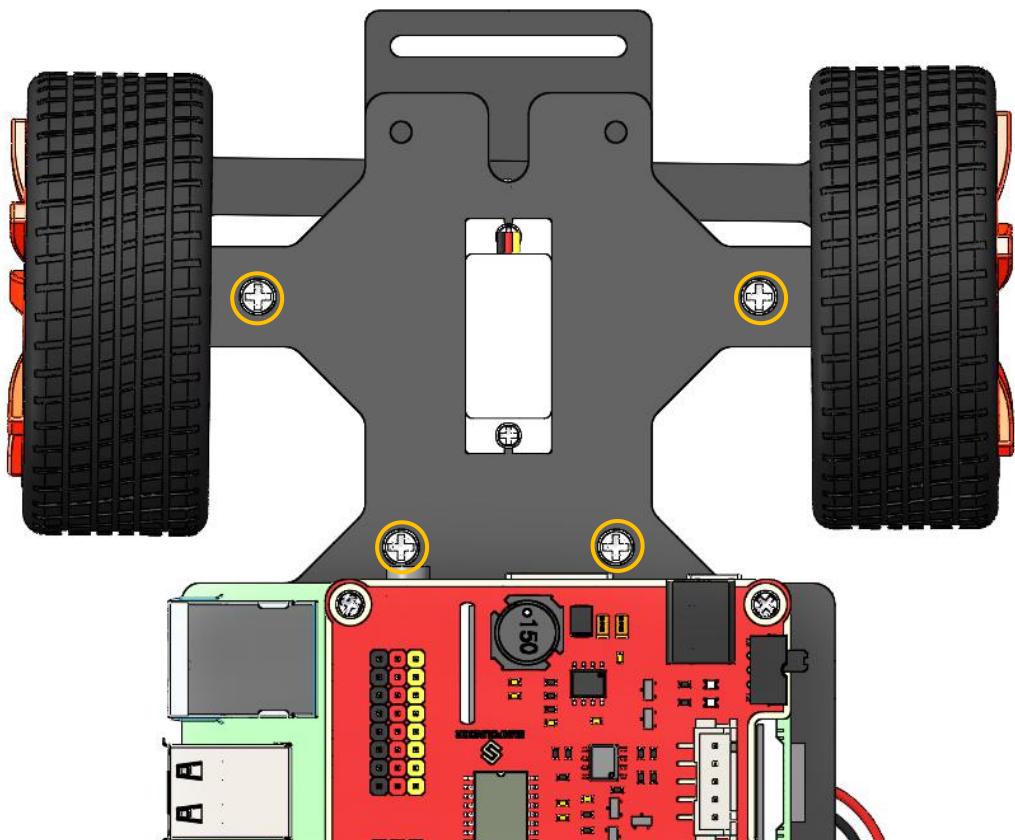
Assemble the **Front Half Chassis** with four **M3x25 copper standoffs** and **M3 nuts**.



Then put the assembled Front Half Chassis onto the Upper Plate with standoffs aligned with the holes.

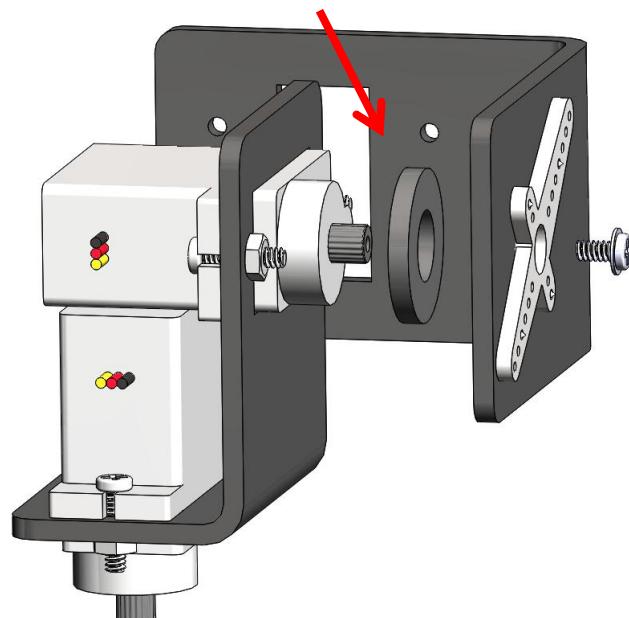


Hold them carefully, turn upside down, and fasten the standoffs and Upper Plate with four **M3x8 screws**.

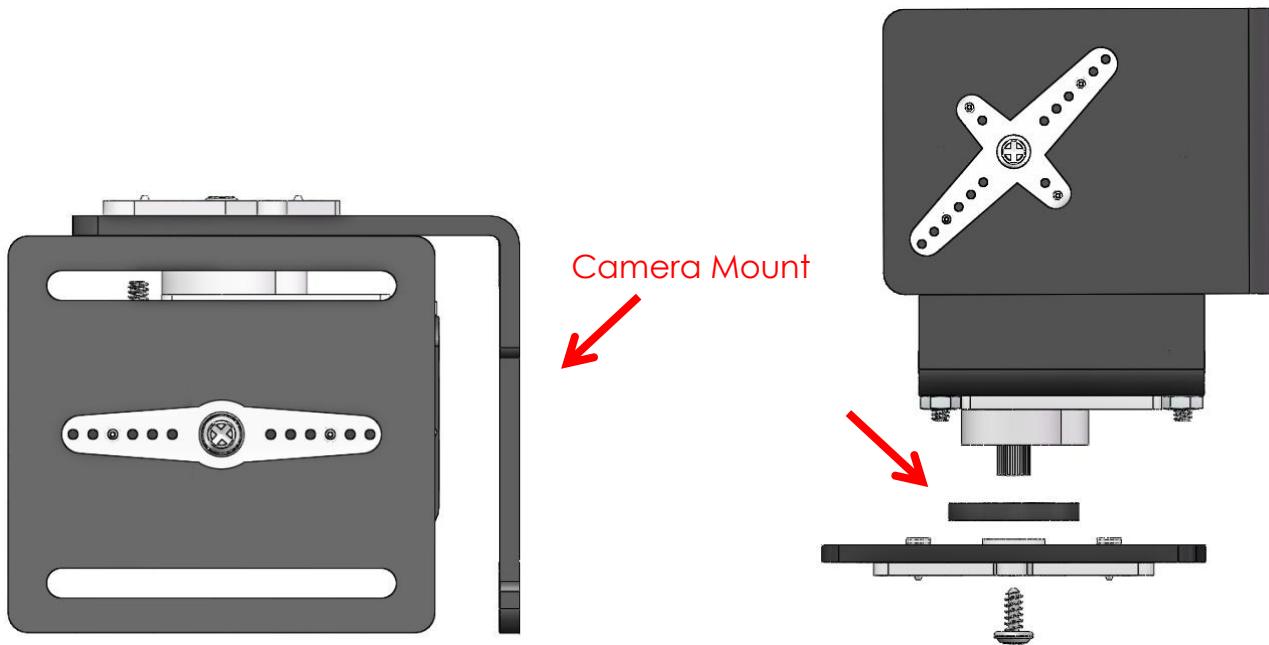


Assemble the assembled **Pan-and-tilt Plate**, **Gasket Plate** and **Camera Mount Plate** with the **Rocker Arm Fixing Screw** in a fixed angle as shown below:

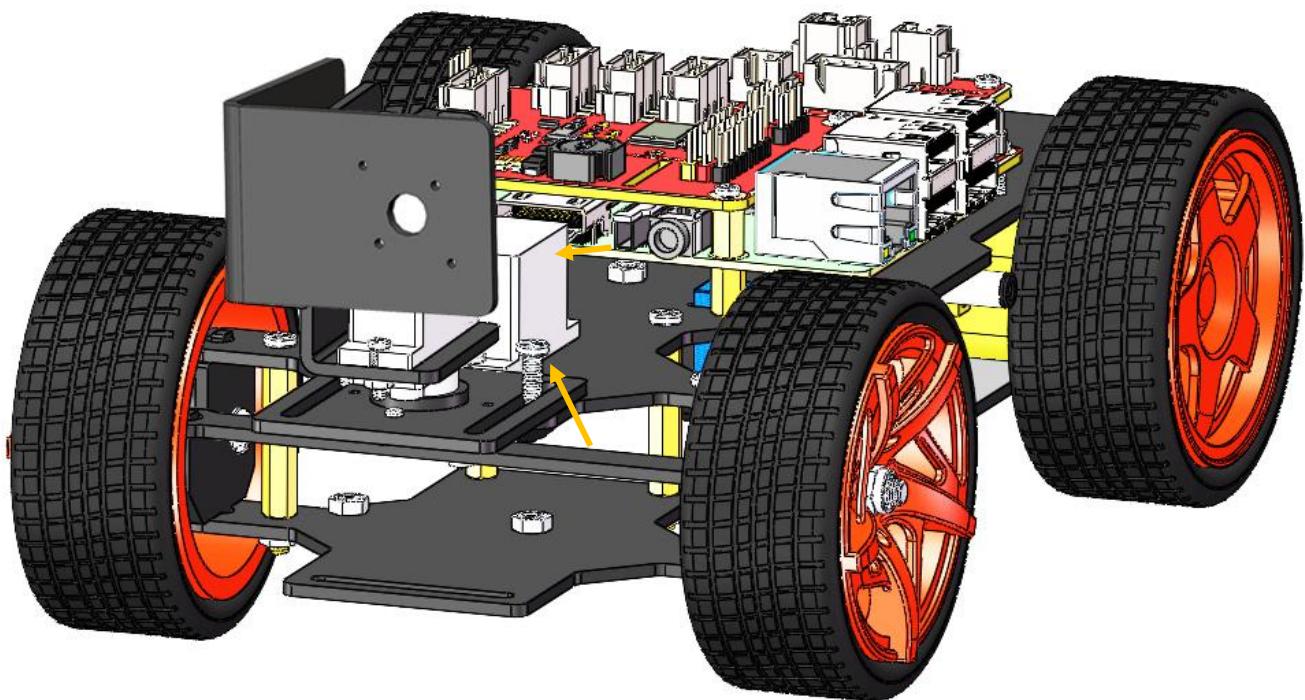
Note: Do not rotate the servo by hands in case of breaking the servo down.



Similarly check that the servo shaft has spun to 90 degrees. Then assemble the **Pan-and-tilt Base Plate** with the **Rocker Arm Fixing Screw** and the **Gasket Plate** in the angle as shown below.



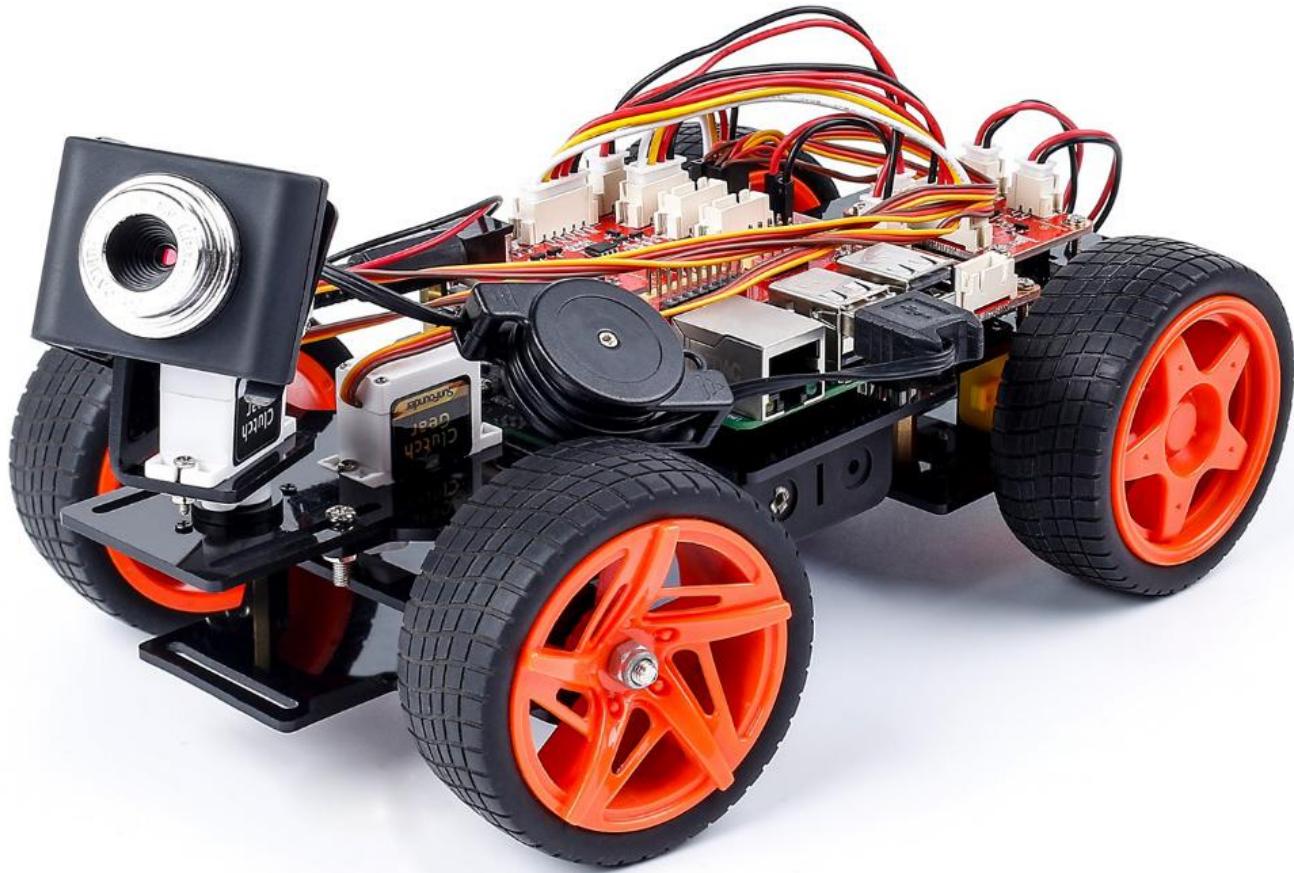
Assemble the **Pan-and-tilt Plate** to the car with two **M3x10 screws** and the **M3 nuts**.



Assemble the Camera

Take out the camera and nip it to the Camera Mount. Connect its USB cable to the USB port on the Raspberry Pi.

So now, the whole assembly is DONE! Congratulations! You can power off the car now! Don't forget to charge your battery.



Getting on the Road!

Make sure all the procedures have been finished, and check there is no problem about the mechanical assembly and software installation.

Here is what we're going to do:

Use the Raspberry Pi as the **server**. Run a web server with an API for controlling the car and transmitting images captured by the camera.

Then take a PC, cell phone, or tablet as the **client**, and acquire the images from the camera and control the car by calling the API of the web server.

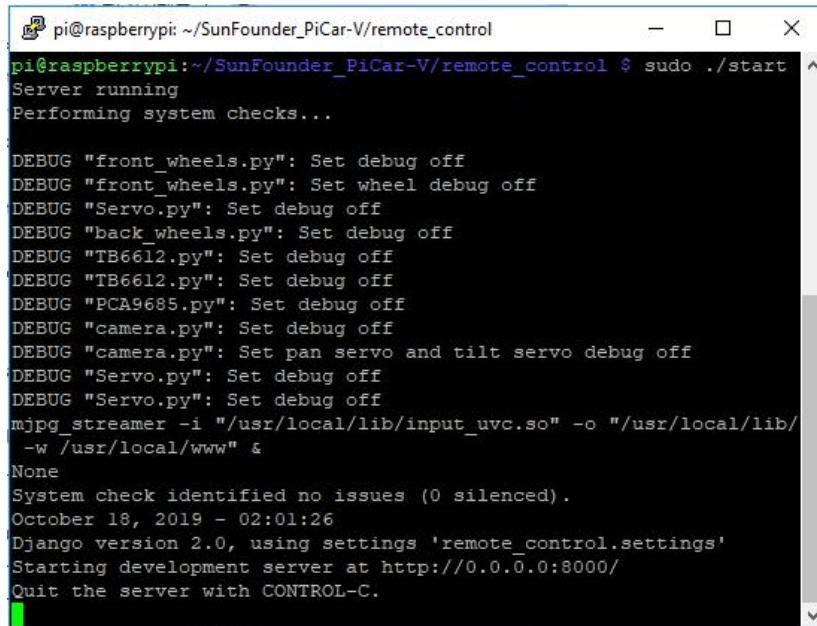
Then you can power on the car again. You are also recommended to use the power adapter of Raspberry Pi to power your car for that the first test will take a long time.

Run the Server(Operation on Raspberry Pi)

Remotely log into the Raspberry Pi. Run the startup script ***start*** under the ***remote_control*** directory to start the web service.

```
cd ~/SunFounder_PiCar-V/remote_control
python3 manage.py migrate
sudo ./start
```

The script will enable the service and the corresponding data will appear. The hardware is initialized at the same time, so the servos connected to the front wheels and the pan-and-tilt will turn, indicating the hardware initialization is done.



```

pi@raspberrypi:~/SunFounder_PiCar-V/remote_control
pi@raspberrypi:~/SunFounder_PiCar-V/remote_control $ sudo ./start
Server running
Performing system checks...

DEBUG "front_wheels.py": Set debug off
DEBUG "front_wheels.py": Set wheel debug off
DEBUG "Servo.py": Set debug off
DEBUG "back_wheels.py": Set debug off
DEBUG "TB6612.py": Set debug off
DEBUG "TB6612.py": Set debug off
DEBUG "PCA9685.py": Set debug off
DEBUG "camera.py": Set debug off
DEBUG "camera.py": Set pan servo and tilt servo debug off
DEBUG "Servo.py": Set debug off
DEBUG "Servo.py": Set debug off
mjpg_streamer -i "/usr/local/lib/input_uvc.so" -o "/usr/local/lib/
-w /usr/local/www" &
None
System check identified no issues (0 silenced).
October 18, 2019 - 02:01:26
Django version 2.0, using settings 'remote_control.settings'
Starting development server at http://0.0.0.0:8000/
Quit the server with CONTROL-C.

```

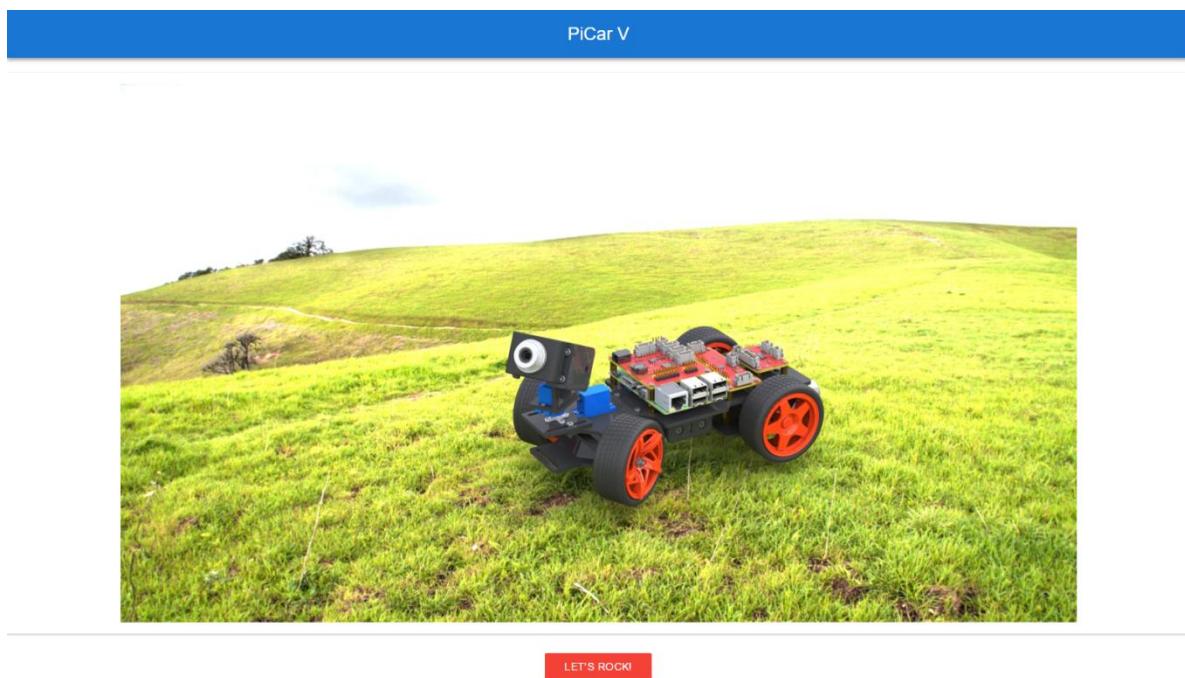
If you get the result similar as shown above, the server is ready. Now move on to start the client.



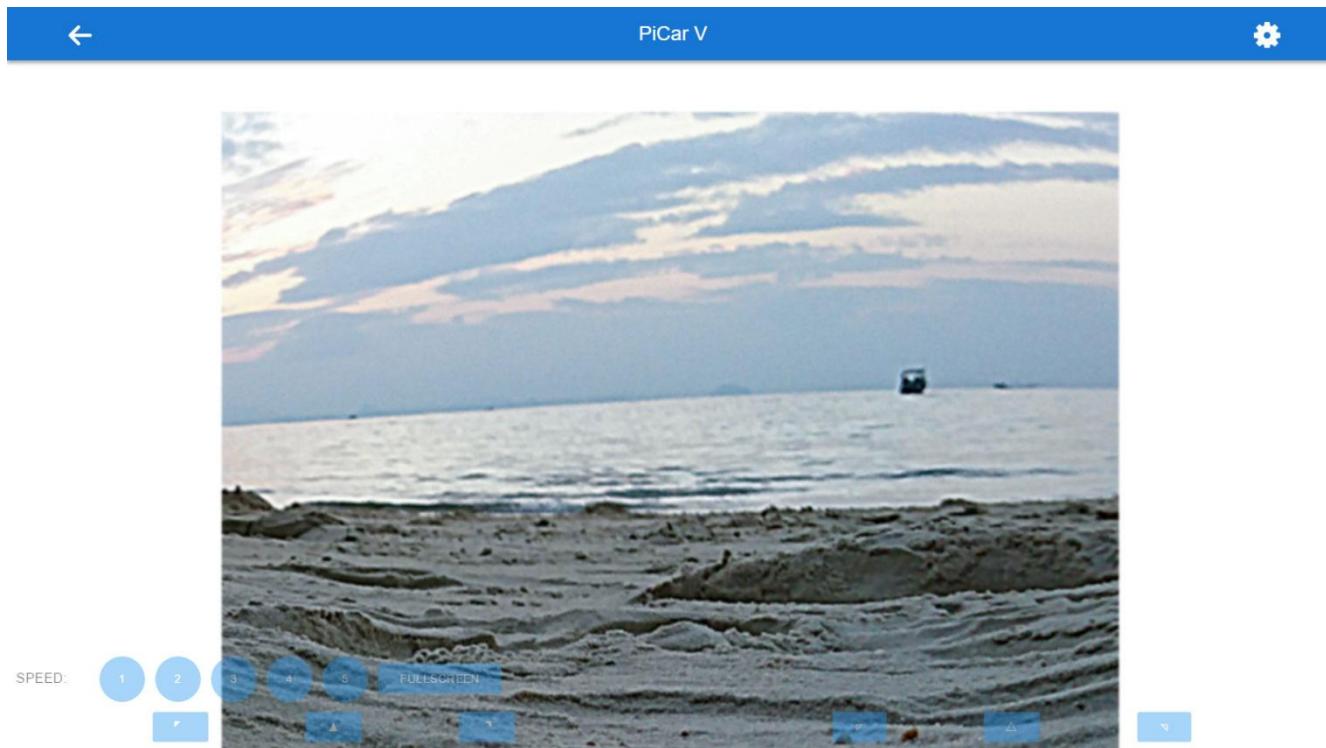
Keep the server being running all the time until you stop to run the Client.

Run the Client(Operation on PC)

Visit the server of the car at http://<RPi_IP_address>:8000/. You will see a welcome page:



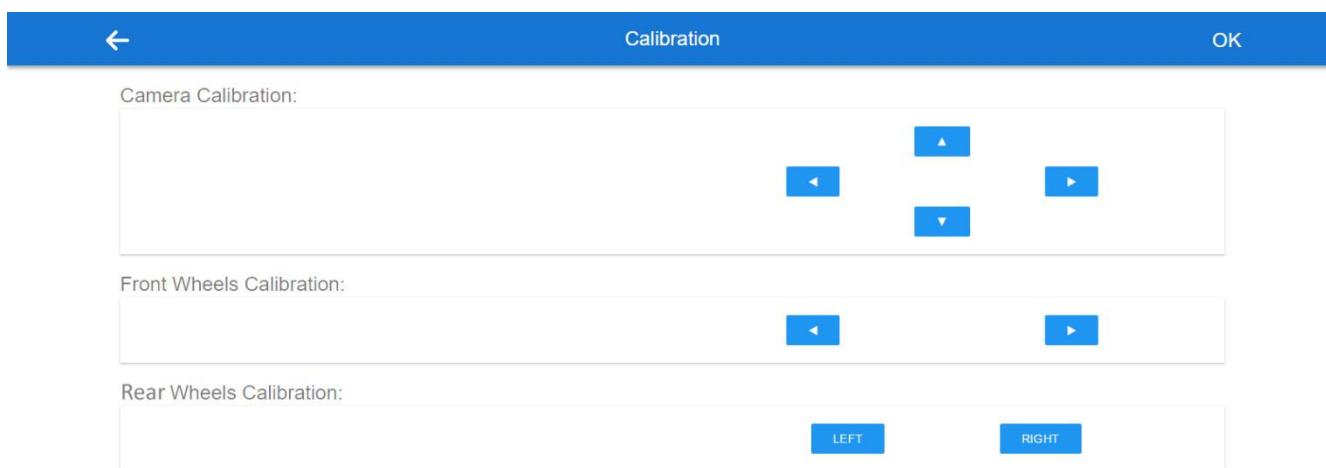
Click LET'S ROCK to go to the operation interface:



On this page, you can press the keys **W**, **A**, **S**, and **D** on the keyboard to control the car to move **forward**, **backward**, **turn left**, and **turn right**, press the arrow keys to control the camera's movement, and number **1~5** to change the speed level.

Calibration

Click **FULLSCREEN** again to bring back the title bar. And then, tap the setting button at the top-right corner of the page to go to the calibration page:



There are three calibration parts: **Camera Calibration**, **Front Wheels Calibration** and **Rear Wheels Calibration**.

When you enter this page, the car will go forward; if not, click **Left** and **Right** in **Rear Wheels Calibration** to adjust the angle of the wheel.

Notes:

Every time you press a button, the angle will be changed slightly. For your larger change per time, you need to long press the button.

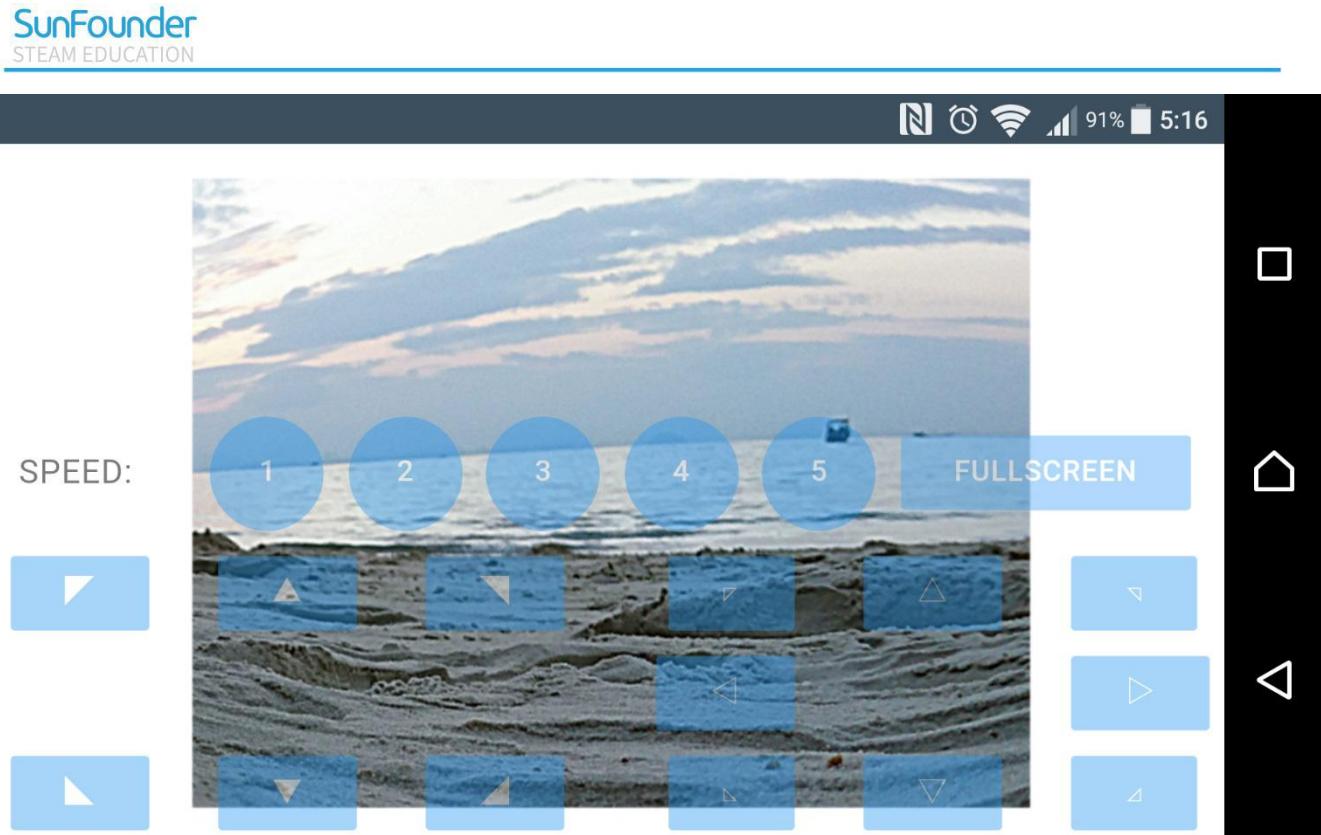
Click **OK** to save the result after all the calibration is done.

For Mobile Phones

Also for mobile phones, tap the **FULLSCREEN** button to have a better view and performance. Then, tap the buttons of 5 speed levels on the page to control the speed, and the arrow buttons to control the direction of the car and the pan-and-tilt. But you can only tab one touch point at **one** time.



Take this screenshot from an Android phone:



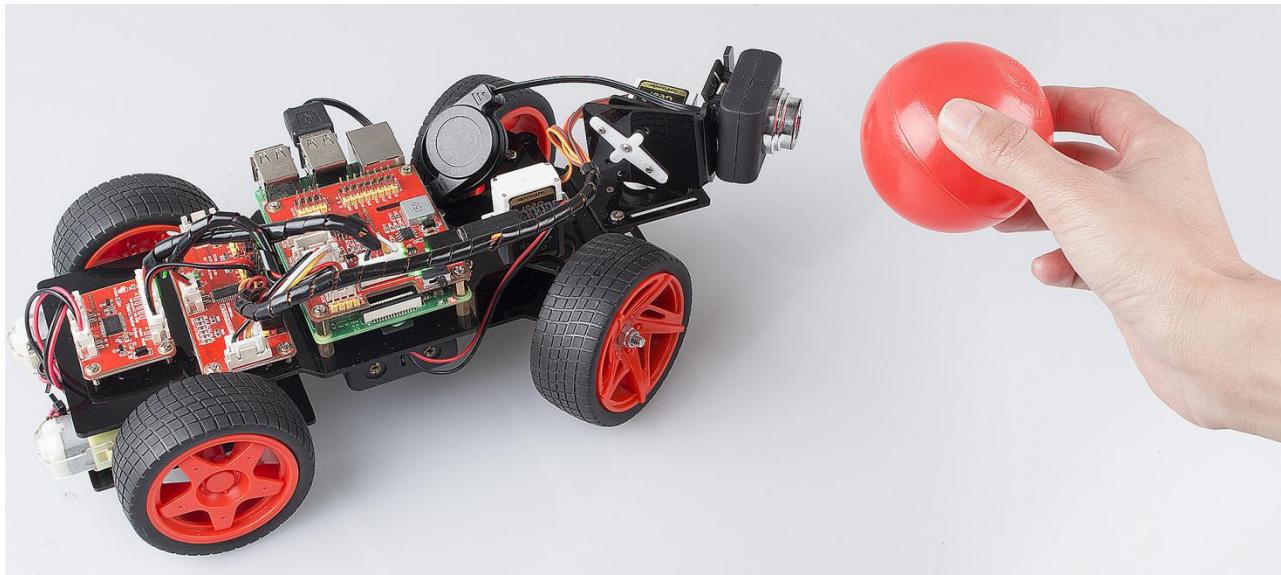
Though the appearance may not be as good as on the PC. Later updates may be released irregularly on **Github**. You are welcome to fork our repository and submit a Pull request with your changes. If there is no problem after testing, we are more than pleased to merge your request.

ball_tracker

In addition to using the keyboard to control the status of the car, we also wrote a ball tracking code.

```
sudo apt-get install libatlas-base-dev libjasper-dev libqt4-test libwebp6 libtiff5  
libopenexr23 libgstreamer1.0-0 libavcodec-dev libavformat-dev libswscale-dev  
libqtgui4 -y  
sudo pip3 install opencv-python==3.4.6.27  
cd ~/SunFounder_PiCar-V/ball_track  
python3 ball_tracker.py
```

After the code runs, find **a red ball (at least larger than the diameter of the camera)** and put it within 10-50cm range in front of the camera to get the car to follow your ball.



If you want to know whether the car has caught your ball, you can do as follows:

Step 1: Enable the VNC on the Raspberry Pi.

```
sudo raspi-config
```

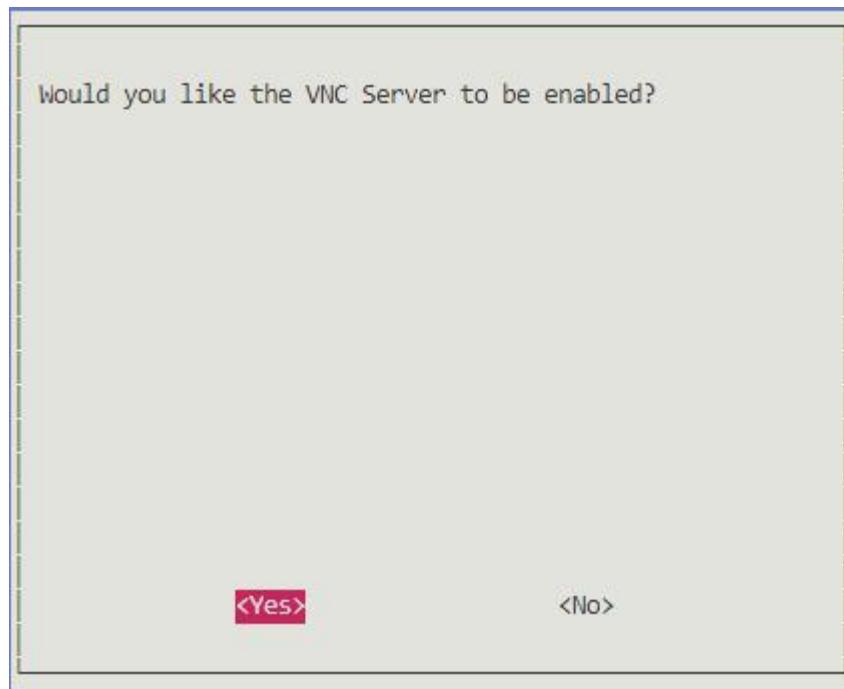
Choose 5 Interfacing Options.

Raspberry Pi Software Configuration Tool (raspi-config)	
1 Change User Password	Change password for the current user
2 Network Options	Configure network settings
3 Boot Options	Configure options for start-up
4 Localisation Options	Set up language and regional settings to match your location
5 Interfacing Options	Configure connections to peripherals
6 Overclock	Configure overclocking for your Pi

P3 VNC

Raspberry Pi Software Configuration Tool (raspi-config)	
P1 Camera	Enable/Disable connection to the Raspberry Pi Camera
P2 SSH	Enable/Disable remote command line access to your Pi using SSH
P3 VNC	Enable/Disable graphical remote access to your Pi using RealVNC
P4 SPI	Enable/Disable automatic loading of SPI kernel module
P5 I2C	Enable/Disable automatic loading of I2C kernel module
P6 Serial	Enable/Disable shell and kernel messages on the serial connection
P7 1-Wire	Enable/Disable one-wire interface
P8 Remote GPIO	Enable/Disable remote access to GPIO pins

Yes



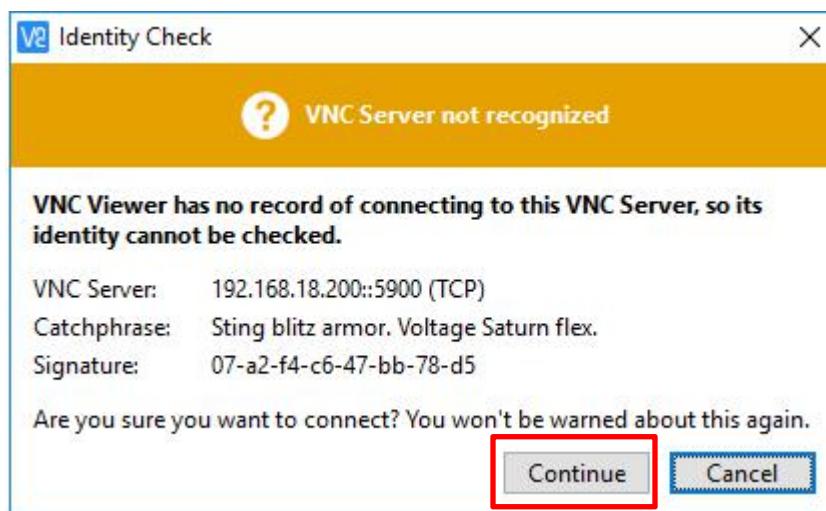
Finally select **OK->Finish** to exit the config.



Step 2: Download the VNC Viewer for your computer and install it.

<https://www.realvnc.com/en/connect/download/viewer/>

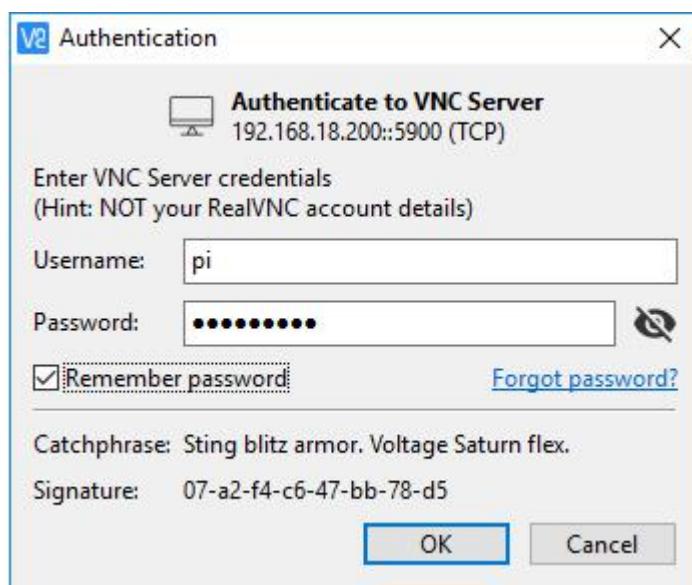
Note: During your installation on your Windows, if you encounter the following prompt, please click **Comtinue** to continue your installation.



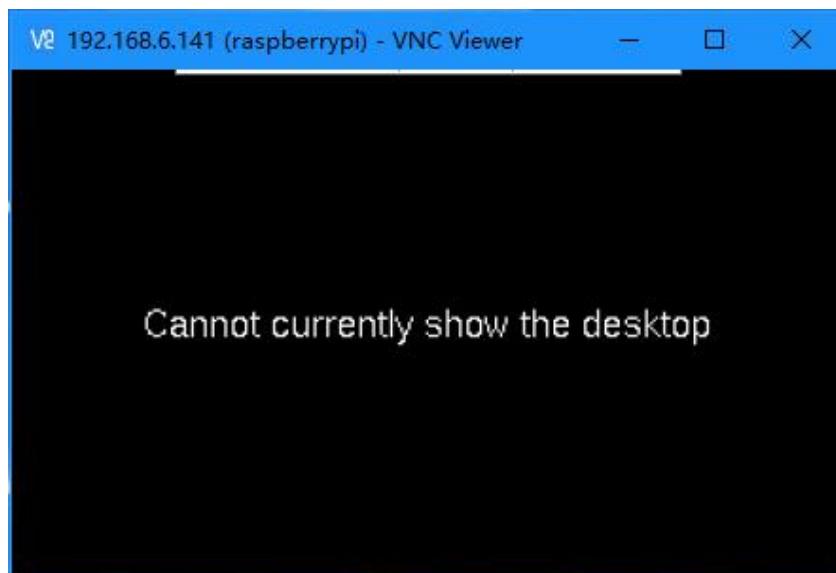
Step 3: Open VNC Viewer you have installed, type in your Raspberry Pi IP address, and press the Enter button.



Step 4: Enter the username and password of your Raspberry Pi on this page, by default, they are pi and raspberry; then click OK.



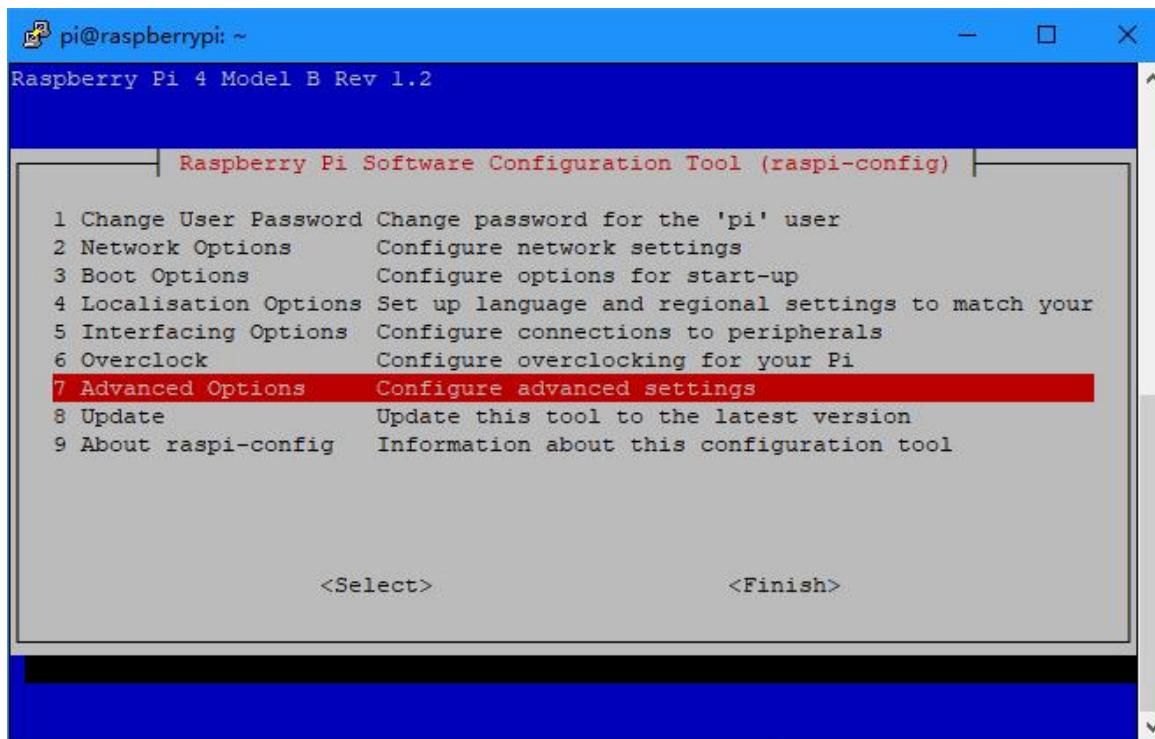
When you log in with VNC Viewer, the screen may be black. If your screen is working, skip to Step 5.



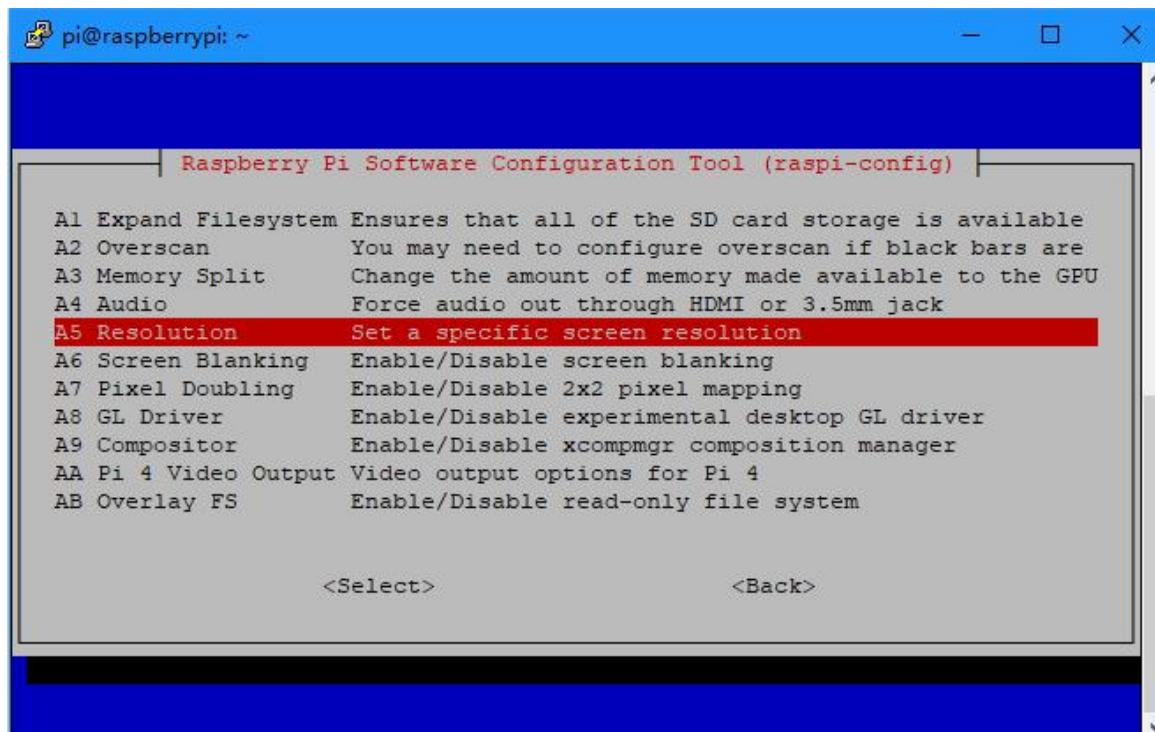
Changing the resolution to the highest on the Raspberry Pi.

`sudo raspi-config`

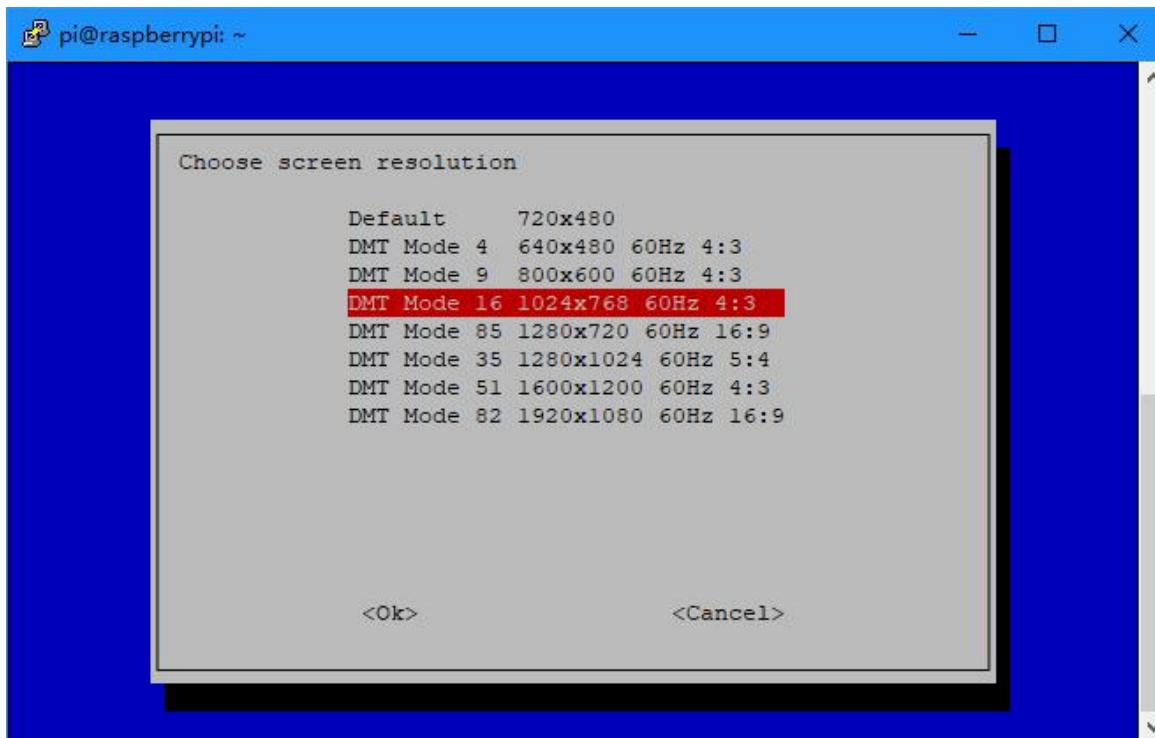
Choose 7 Advanced Options.



Choose A5 Resolution.



Change the default to a higher resolution like Mode 16.



Reboot the Raspberry Pi, log in again, and it will work.

```
sudo reboot
```

Step 5: Now, we enter the Raspberry Pi desktop, click Terminal and type the following commands to open the code ball_tracker.py.

```
cd ~/SunFounder_PiCar-V/ball_track
sudo nano ball_tracker.py
```

Then modify the code as follows:

```
Show_image_enable = True
```

```
Draw_circle_enble = True
```

Press Ctrl+X and Y to save the change.

```

from picar import front_wheels, back_wheels
from picar.SunFounder_PCA9685 import Servo
import picar
from time import sleep
import cv2
import numpy as np
import picar
import os

picar.setup()
# Show image captured by camera, True to turn on, you will need #DISPLAY and it$ 
show_image_enable = True
draw_circle_enable = True
scan_enable = False

```

Note: After you finish doing this step, you must log in the Raspberry Pi via VNC, or you can use a monitor; if not, the warning is as follows:

```

pi@raspberrypi:~/SunFounder_PiCar-V/ball_track $ python3 ball_tracker.py
Warning: Display not found, turn off "show_image_enable" and "draw_circle_enable"
DEBUG "back_wheels.py": Set debug off

```

Step 6: Run the ball_tracker.py.

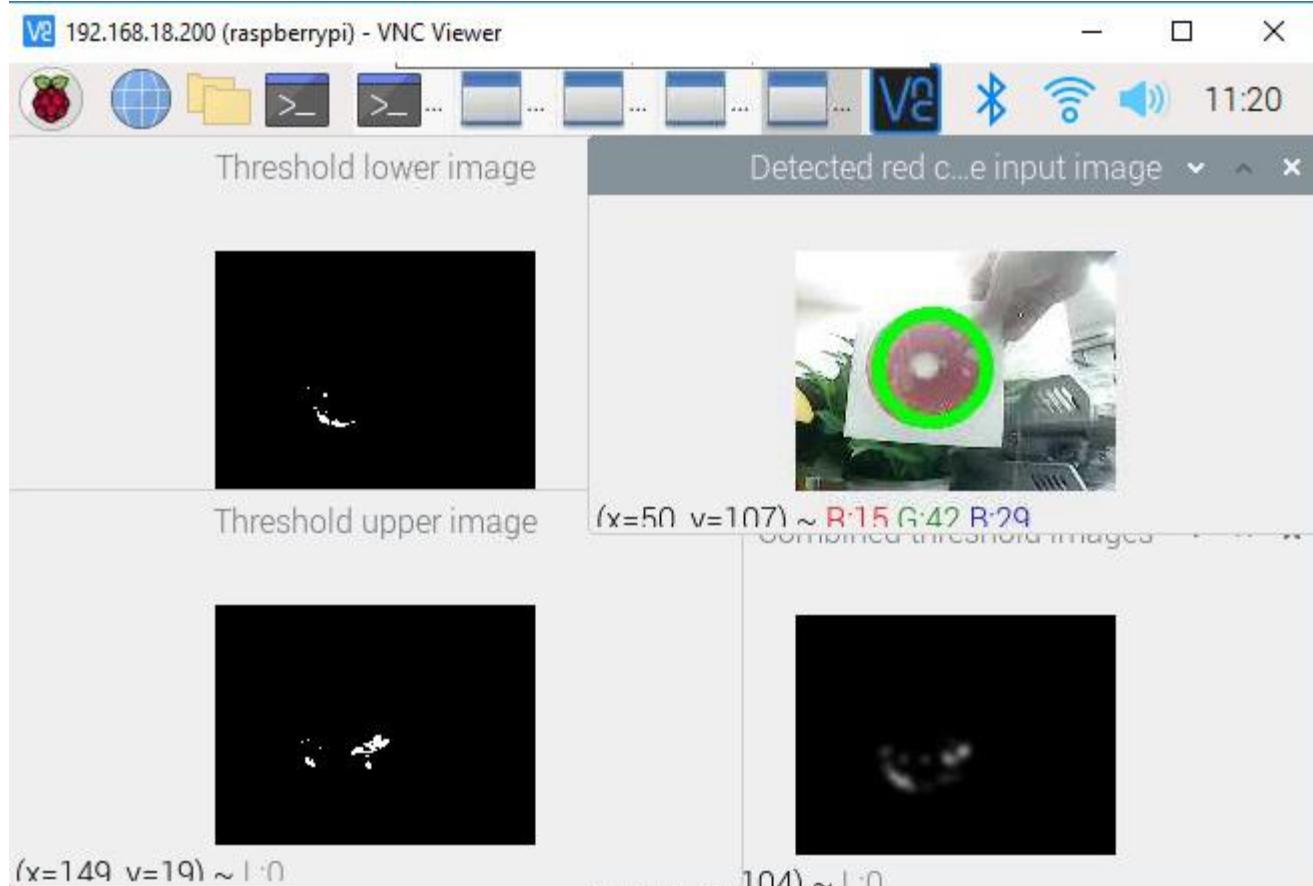
```
python3 ball_tracker.py
```

```

pi@raspberrypi:~ $ cd ~/SunFounder_PiCar-V/ball_track/
pi@raspberrypi:~/SunFounder_PiCar-V/ball_track $ sudo python3 ball_tracker.py
DEBUG "back_wheels.py": Set debug off
DEBUG "TB6612.py": Set debug off
DEBUG "TB6612.py": Set debug off
DEBUG "PCA9685.py": Set debug off
DEBUG "front_wheels.py": Set debug off
DEBUG "front_wheels.py": Set wheel debug off
DEBUG "Servo.py": Set debug off
Begin!
circles: [[100]]

```

Step 7: After running the code ball_tracker.py, these four images will appear. If you place a red ball in front of the camera, you can see a green circle which represents that the car has catched your red ball.

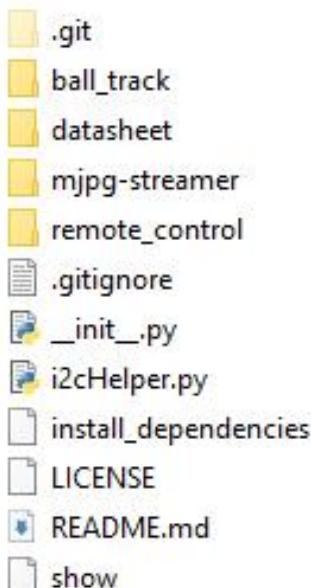


File Analysis

There are two folders under /home/pi: **SunFounder_PiCar** for controlling motors and steering and **SunFounder_PiCar-V** for pan/tilt and wireless control. Here look into the code of PiCar-V.

Since too many contents and instructions are involved in the code, we will not cover every detail. For more knowledge about Python 2, Python 3, Django, HTML, and CSS in the programs, you can visit related websites or buy books to learn by yourself. In the following part, we will go through the overall structure and the process in brief.

First, let's check the files in the code folder:



- `.git` is a hidden directory to store all the information of a Git repository; it's generated automatically after you create the repository.
- `Ball_track` is used to let the car follow the red ball.
- `datasheet` stores the manual of some chips used in the hardware modules.
- `mjpg-streamer` is an open source streaming media library, through which the data of the camera is transferred.
- `Remote_control` is to store the code of the web server; it controls the motor and servo of the car based on the API request.

- `.gitignore` records the requests of file types to be ignored when the Github repository is synchronized.
- `_init_.py` is automatically generated when you create a project which is a standard necessary document of python package, just leave it there.
- `i2cHelper.py` is a Python script written by Python 2 to configure and detect the I2C connection.
- `install_dependencies`, an executable bash script for simple installation and environment configuration.
- `LICENSE`, as the name suggests, is a text file of GNU V2 license.
- `README.md` and `show` record some information normally for statement and prompts.

Server Code

The server code is based on Django 1.10 (adapt to the latest release if needed). If you are interested in this, you can visit the Django website <https://www.djangoproject.com/>. Here we will just learn how the web server works.

Note:

The code may be updated irregularly on Github to fix bugs and release some functions update. So the code here is the initial version. You can view the updates in the Github repository at:

https://github.com/sunfounder/SunFounder_PiCar-V/tree/V3.0

Open the code directory and check the file by `ls`:

```
pi@raspberry:~ $ cd SunFounder_PiCar-V/  
pi@raspberry:~/SunFounder_PiCar-V $ ls  
datasheet      install_dependencies      mjpg-streamer  remote_control  
client         i2cHelper.py    LICENSE        README.md       show
```

`remote_control` is the main code directory of the web server. Open the code directory by `cd remote_control`, and check the file by `ls`:

```
pi@raspberry:~/SunFounder_PiCar-V $ cd remote_control
```

```
pi@raspberry:~/SunFounder_PiCar-V/remote_control $ ls  
db.sqlite3 manage.py remote_control start static
```

- `db.sqlite3` is generated when you create a Django project.
- `manage.py` is the main program of the Django project and is generated when the project is created. It normally does not need to be modified.
- `remote_control` includes the main code files.
- `start` is a small script written to run `sudo python manage.py runserver 0.0.0.0:8000`, and servo installation with attribute `install` just for convenience.
- `static` is to store some static pictures on the web.

The Django web server normally runs `sudo python manage.py runserver` to start. The address `0.0.0.0:8000` means the listening address covers all the addresses on the LAN, and the port number is 8000. Here we will just focus on the code in `remote_control` folder. Go to the directory via `cd remote_control`:

```
pi@raspberry:~/SunFounder_PiCar-V/remote_control $ cd remote_control  
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control $ ls  
driver __init__.py settings.py templates urls.py views.py wsgi.py
```

- `driver` stores the drivers of the car.
- `__init__.py` is automatically generated when you create a Django project which is a standard necessary document of python package, just leave it there.
- `settings.py` is automatically generated and stores the related settings.
- `templates` is a Django app for storing the webs in the html format.
- `urls.py` is generated automatically to configure the URL to associate with the code.
- `views.py` is the code for page control which is associated by the URL. It calls the templates to show the page and the driver to control the car.
- `wsgi.py` is generated automatically and does not need changes. For more, please visit the official website of Django.

So here is how the code works: Run the main program `manage.py` which will be associated with `urls.py` automatically, to respond to the URL. When you run the web browser like the Chrome to visit `http://<rpi_ip_address>:<port>` or visit the configured API via the client, the `manage.py` will turn to `views.py` due to the association of the `urls.py`. Then the `views.py` processes this and returns the templates to the browser. In addition, it will call the `driver` package on the basis of the parameters set in the browser to control the car.

Now open the folder `driver` and check:

```
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control $ cd  
driver/  
  
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control(driver $ ls  
camera.py config __init__.py stream.py
```

The `driver` folder mainly includes the driver modules for controlling the pan and tilt and camera streamer.

`camera.py` for controlling the pan-and-tilt.

`config` stores the calibration data.

`__init__.py` is the essential file of the package and you can just leave it alone.

`stream.py` is a video streaming service based on the MJPG-streamer.

Exit and open the folder `templates` to view:

```
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control(driver  
$ cd ..  
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control $ cd  
templates/  
admin.py __init__.py models.py tests.py  
apps.py migrations templates views.py
```

This folder is created by the `manage.py startapp` just for calling the templates conveniently. Therefore, the files have not been changed except for the `templates`. Open the `templates` again:

```
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control/templates
$ cd templates

pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control/templates/
templates $ ls
base.html  cali.html  run.html
```

There are three HTML files that also consist of layers. The low level `base.html` stores contents contained on each page such as the `<head>` of HTML, the overall layout, and contents of the home page by default. The surface layer: `cali.html` for calibration and `run.html` to control the car.

Advanced

Now the car is running! You may try control it or view the image captured in Windows, Linux, or Mac OS X.

So what to do next?

Yes, sensors! There are 8 digital and 4 analog channels on the Robot HATS, as well as two I2C ports. Plus the 3mm slot on the acrylic plate in the car head, it enables the connection of various sensors, making the car smarter and more intriguing as you want!

And, coding! If you know programming and are capable of compiling code, you may change the code provided for the kit to make the car more fabulous. For instance, you can find the code that controls the front and back wheels in the folder SunFounder_PiCar, downloaded to the directory /home/pi if you've installed the program by install-dependences.

You may check what's in the file:

```
cd ~/SunFounder_PiCar  
ls
```

After you've changed the code, you can go to the page of the Github repository for the car, and fork it to help improve it! Also you're quite welcome to post issues and request a pull on our Github page:

PiCar-V: https://github.com/sunfounder/SunFounder_PiCar-V

PiCar driver:

https://github.com/sunfounder/SunFounder_PiCar

And of course, if you have any questions or ideas, please feel free to email us at service@sunfounder.com.

Appendix 1: Function of the Server Installation Scripts

You may have a question: What do the installation scripts do when we install the server on the Raspberry Pi by them? So here let's check the detailed steps.

1. Install pip.

```
apt-get install python-pip
```

2. Use pip to install django.

```
sudo pip install django
```

3. Install i2c-tools and python-smbus.

```
sudo apt-get install i2c-tools python-smbus -y
```

4. Install PiCar drivers.

```
cd ~/  
git clone --recursive https://github.com/sunfounder/SunFounder\_PiCar.git  
cd SunFounder_PiCar  
sudo python setup.py install
```

5. Download source code.

```
cd ~/  
git clone https://github.com/sunfounder/SunFounder\_PiCar-V.git
```

6. Copy the MJPG-Streamer file to system directory.

```
cd ~/SunFounder_PiCar-V  
sudo cp mjpg-streamer/mjpg_streamer /usr/local/bin  
sudo cp mjpg-streamer/output_http.so /usr/local/lib/  
sudo cp mjpg-streamer/input_file.so /usr/local/lib/  
sudo cp mjpg-streamer/input_uvc.so /usr/local/lib/  
sudo cp -R mjpg-streamer/www /usr/local/www
```

7. Export paths.

```
export LD_LIBRARY_PATH=/usr/local/lib/ >> ~/.bashrc  
export LD_LIBRARY_PATH=/usr/local/lib/ >> ~/.profile  
source ~/.bashrc
```

8. Enable I2C1.

Edit the file /boot/config.txt:

```
sudo nano /boot/config.txt
```

Add the line in the end:

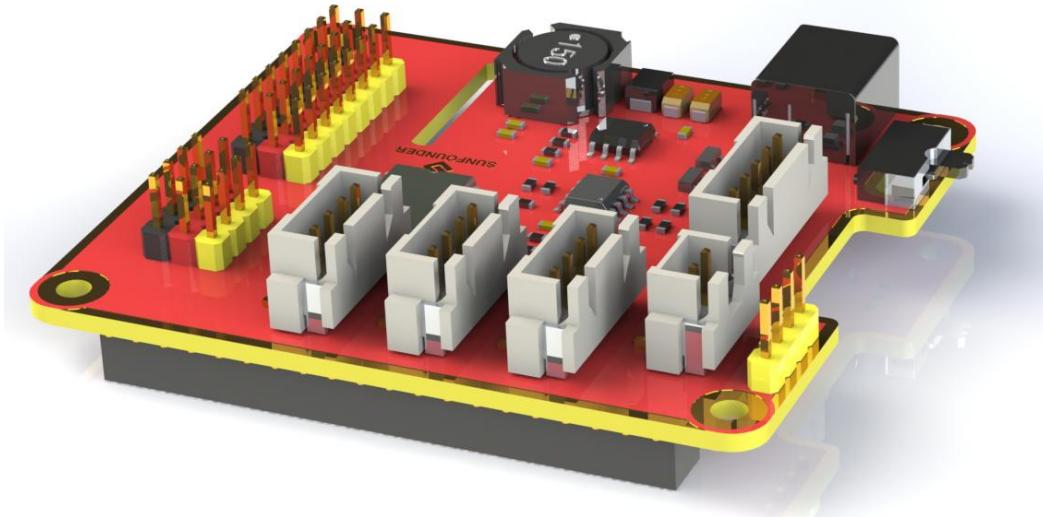
```
dtparam=i2c_arm=ons
```

9. Reboot.

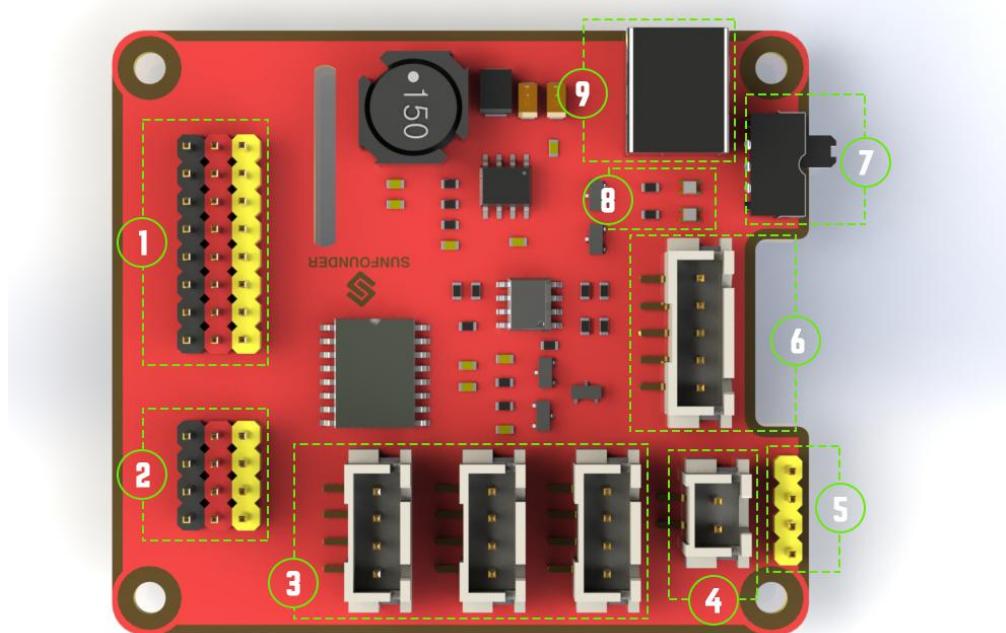
```
sudo reboot
```

Appendix 2: Components

Robot HATS



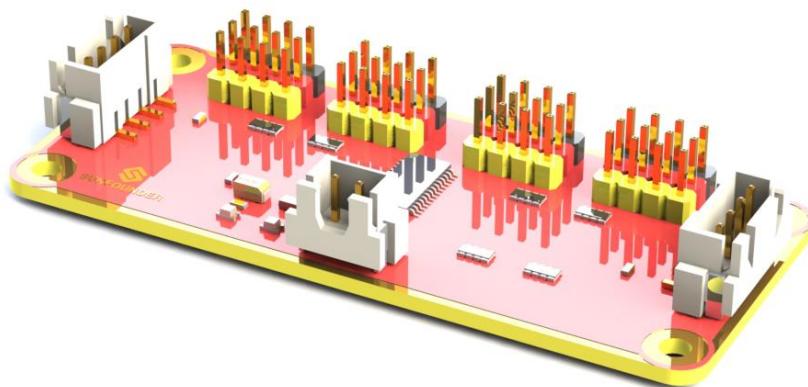
Robot HATS is a specially-designed HAT for a 40-pin Raspberry Pi and can work with Raspberry Pi model B+, 2 model B, 3 model B, 3 model B+, and 4 model B. It supplies power to the Raspberry Pi from the GPIO ports. Thanks to the design of the ideal diode based on the rules of HATS, it can supply the Raspberry Pi via both the USB cable and the DC port thus protecting it from damaging the TF card caused by batteries running out of power. The PCF8591 is used as the ADC chip, with I2C communication, and the address 0x48.



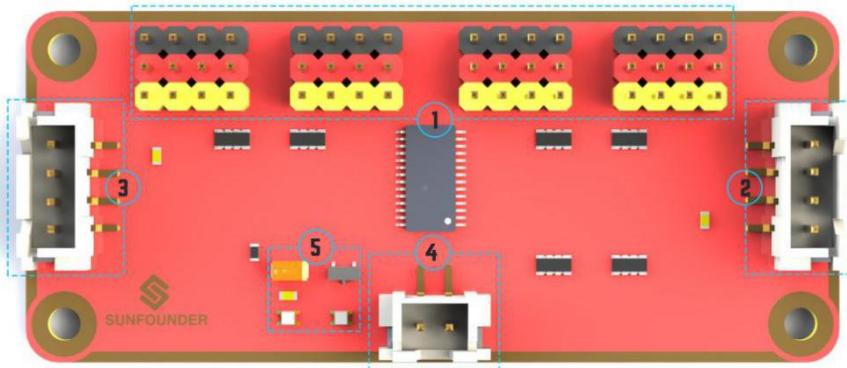
1. **Digital ports:** 3-wire digital sensor ports, signal voltage: 3.3V, VCC voltage: 3.3V.

2. **Analog ports:** 3-wire 4-channel 8-bit ADC sensor port, reference voltage: 3.3V, VCC voltage: 3.3V.
3. **I2C ports:** 3.3V I2C bus ports
4. **5V power output:** 5V power output to PWM driver.
5. **UART port:** 4-wire UART port, 5V VCC, perfectly working with SunFounder FTDI Serial to USB.
6. **Motor control ports:** 5V for motors, direction control of motors MA and MB and a floating pin NC ; working with SunFounder motor driver module.
7. **Switch:** power switch
8. **Power indicators:** indicating the voltage – 2 indicators on: >7.9V; 1 indicator on: 7.9V~7.4V; no indicator on: <7.4V. To protect the batteries, you're recommended to take them out for charge when there is no indicator on. The power indicators depend on the voltage measured by the simple comparator circuit; the detected voltage may be lower than normal depending on loads, so it is just for reference.
9. **Power port:** 5.5/2.1mm standard DC port, input voltage: 8.4~7.4V (limited operating voltage: 12V~6V).

PCA9865



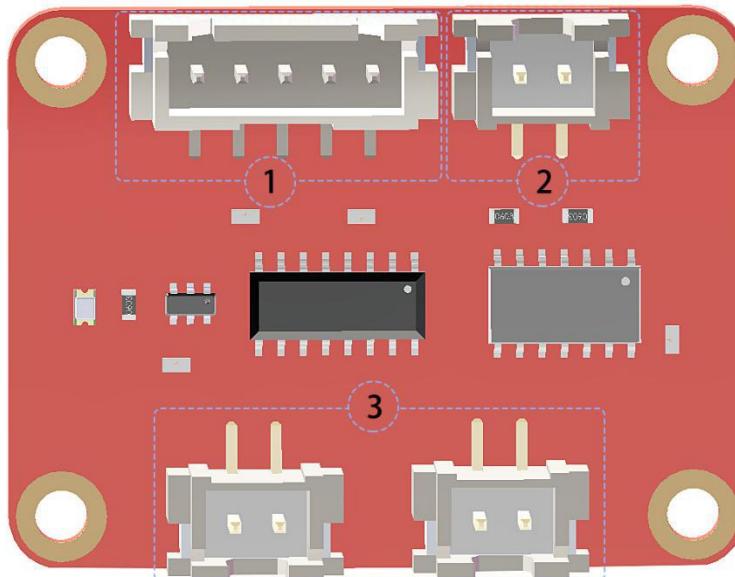
PCA9865 16-channel 12-bit I2C Bus PWM driver. It supports independent PWM output power and is easy to use 4-wire I2C port for connection in parallel, distinguished 3-color ports for PWM output.



1. **PWM output ports:** 3-color ports, independent power PWM output port, connect to the servo directly.
- 2 & 3. **I2C port:** 4-wire I2C port, can be used in parallel. Compatible with 3.3V/5.5V
4. **PWM power input:** 12V max.
5. **LED:** power indicator for the chip and for the PWM power input.

Motor Driver Module

The motor driver module is a low heat generation one and small packaged motor drive.



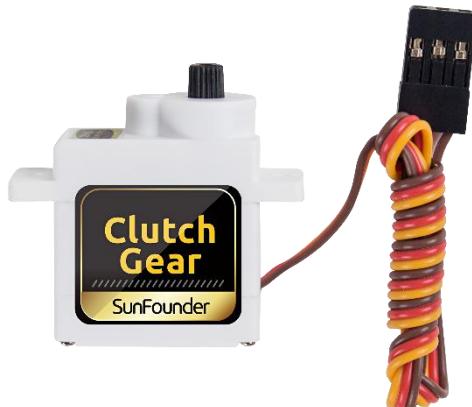
1. **Power and motor control port:** includes pins for supplying the chip and the motors and controlling the motors' direction.
2. **PWM input for the motors:** PWM signal input for adjusting the speed of the two motors.
3. **Motor output port:** output port for two motors.

USB Webcam



This camera supports a wide angle of 120°, which provides a wide and clear vision, thus giving better experience when you're using it on the PiCar-V.

SunFounder SF006C Servo

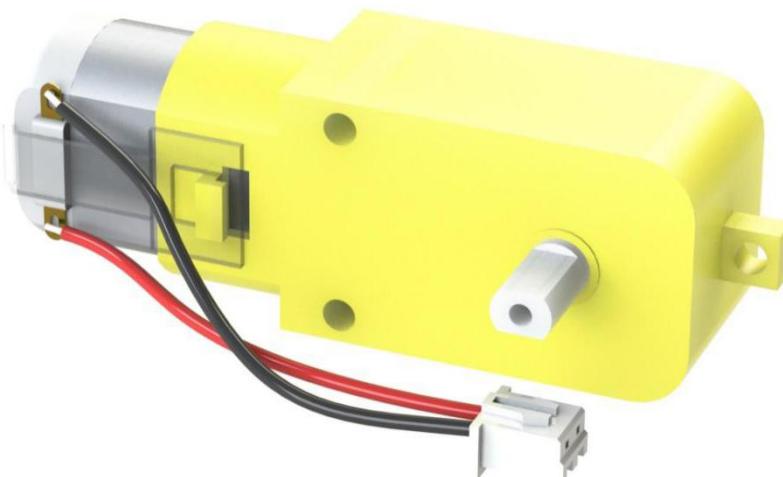


Clutch gear digital servo with a DC core motor inside, After a certain load, the steering gear reducer will automatically clutch and protect the product from damage and normal load.

Function of the Performance:

Item	V = 4.8V	V = 6.0V
Consumption Current* (No Load)	≤50mA	≤60mA
Stall Current	≤550mA	≤650mA
Rated Torque	≥0.6 kgf·cm	≥0.7 kgf·cm
Max. Torque	≥1.4 kgf.cm	≥1.6 kgf.cm
No Load Speed	≤0.14sec/60°	≤0.12sec/60°

DC Gear Motor



It's a DC motor with a speed reducing gear train. See the parameters below:

Motor	Model	F130SA-11200-38V
	Rated Voltage	4.5V-6V
	No-load Current	$\leq 80\text{mA}$
	No-load Speed	$10000 \pm 10\%$
Gear Reducer	Gear Ratio	1:48
	Speed (no-load)	$\approx 200\text{rpm}$ ($\approx 180\text{rmp}$ in test)
	Current	$\leq 120\text{mA}$

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