Preface

About SunFounder

SunFounder is a technology company focused on Raspberry Pi and Arduino open source community development. Committed to the promotion of open source culture, we strive to bring the fun of electronics making to people all around the world and enable everyone to be a maker. Our products include learning kits, development boards, robots, sensor modules and development tools. In addition to high quality products, SunFounder also offers video tutorials to help you make your own project. If you have interest in open source or making something cool, welcome to join us!

About the PiCar-V

As an upgraded version, PiCar-V (Smart Video Car V2.0 for Raspberry Pi) is also suitable for the Raspberry Pi model B+, 2 model B and 3 module B, as the V1.0.

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 may visit our website www.sunfounder.com to download the related code and view the user manual on **LEARN -> Get Tutorials** and watch related videos under **VIDEO**, or clone the code on our page of github.com at

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

You are welcome to pull requests and issue posts on our page on Github.

Free Support

If you have any **TECHNICAL questions**, add a topic under **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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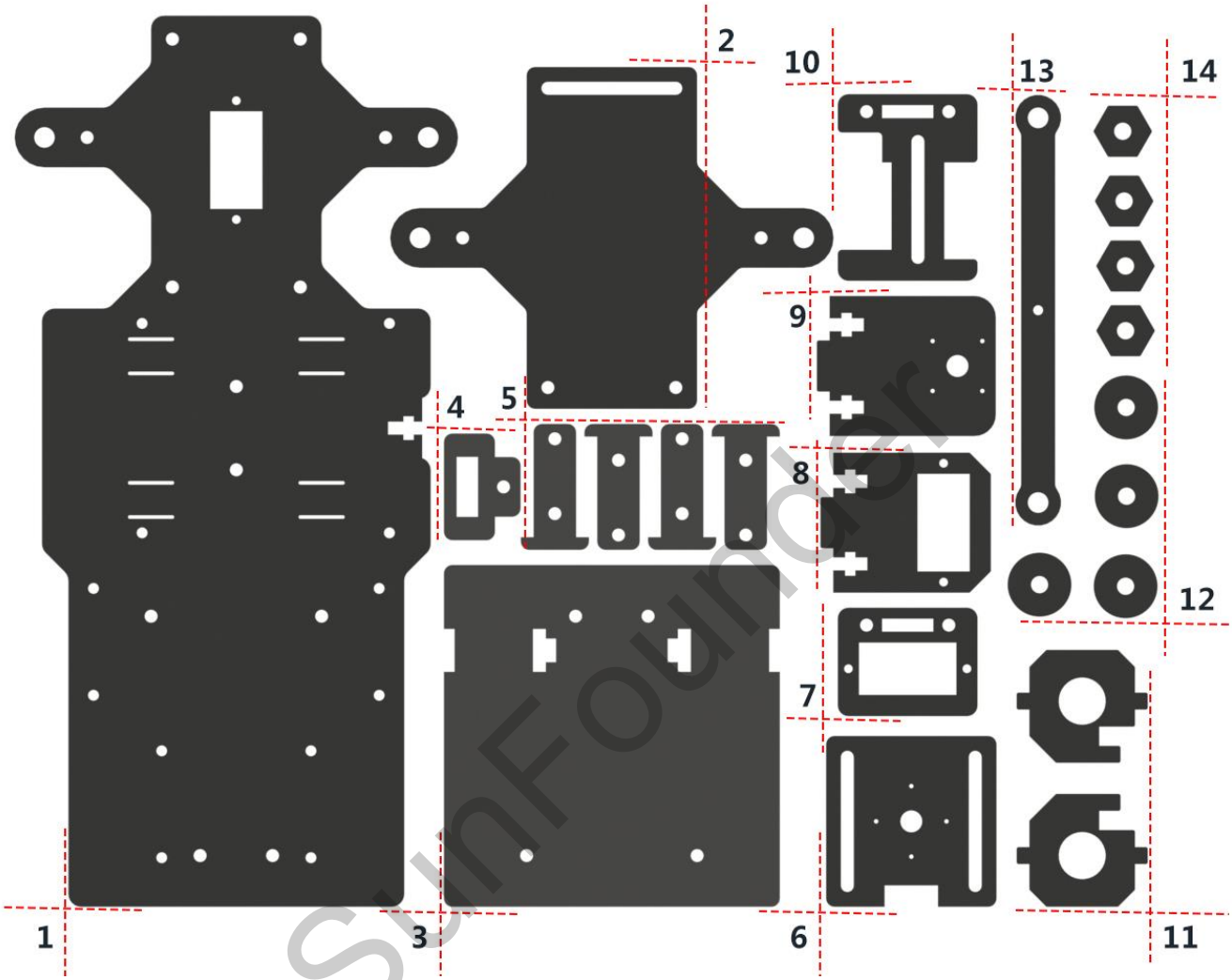
Components List

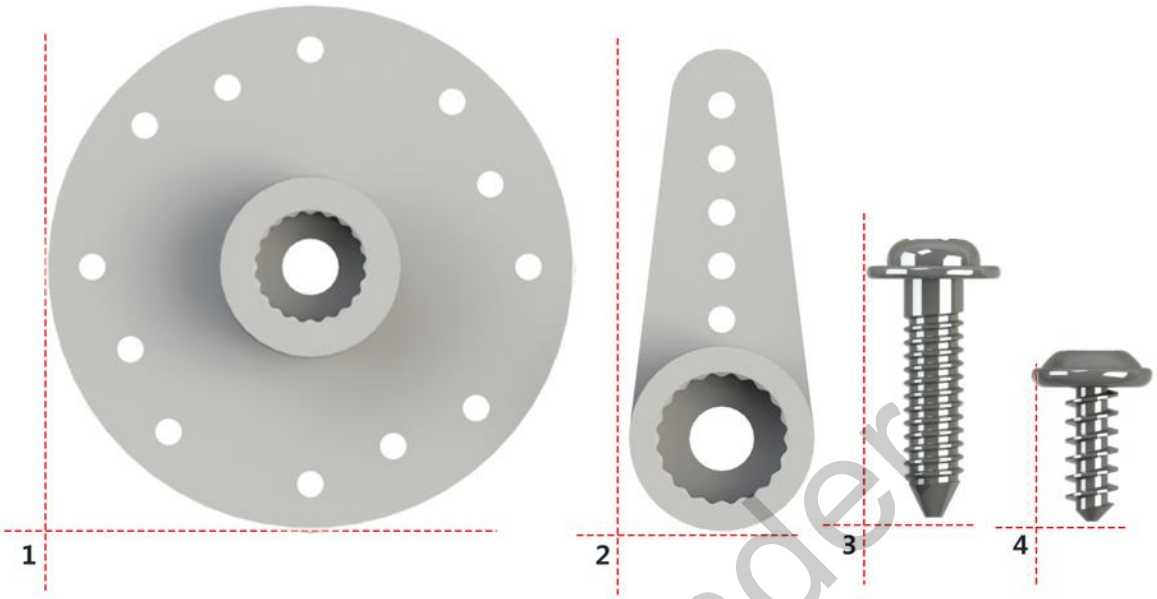
Acrylic Plates



1. Upper Plate x 1
2. Front Half Chassis x 1
3. Back Half Chassis x 1
4. TF Card Guard x 1
5. Motor Support x 4
6. Pan-and-tilt Base x 1
7. Pan Servo Mount x 1
8. Tilt Servo Mount x 1
9. Tilt Arm x 1
10. Camera Mount x 1
11. Steering Connector x 2
12. Bearing Shield x 4
13. Steering Linkage x 1
14. Hex Front Wheel Fixing Plate x 4

Servo Accessories

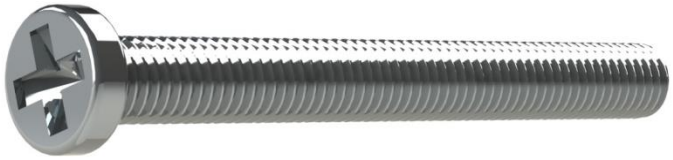
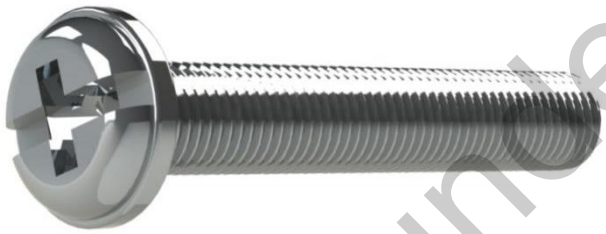
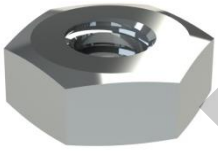
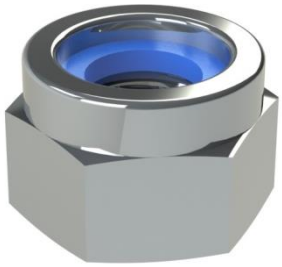
We will use the following four parts:

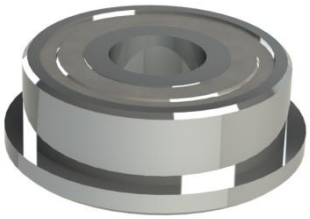


1. Round Rocker Arm
2. 1-arm Rocker Arm
3. Rocker Arm Screw
4. Rocker Arm Fixing Screw

Mechanical Fasteners

Name	Component	Qty.
M1.2x4 Cross Self-tapping Screw		8
M2x8 Cross Screw		6
M2.5x6 Cross Screw		12
M3x8 Cross Screw		8

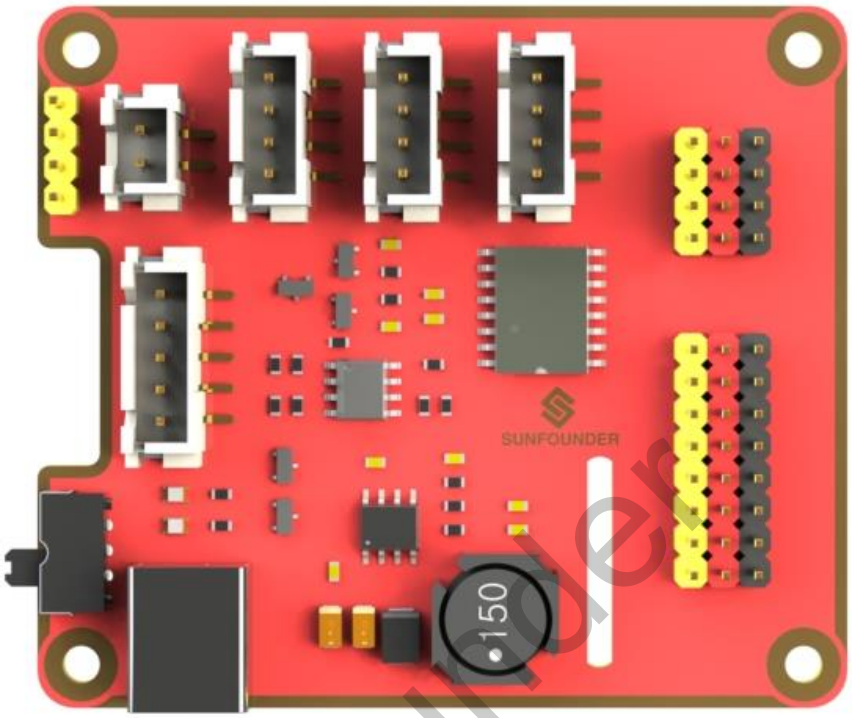
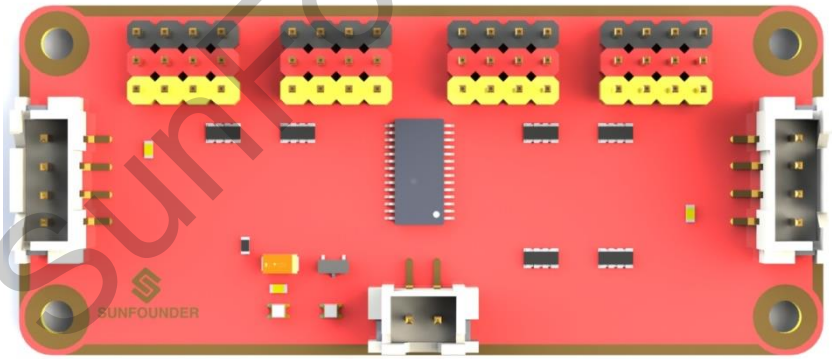
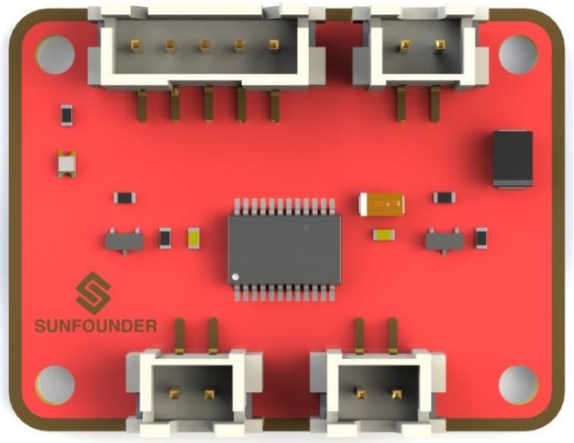
M3x8 Countersunk Cross Screw		2
M3x10 Cross Screw		7
M3x30 Cross Screw		4
M4x25 Cross Screw		2
M2 Nut		6
M2.5 Nut		12
M3 Nut		21
M4 Self-locking Nut		2

M2.5x8 Copper Standoff		16
M3x25 Copper Standoff		8
4x11x4 F694ZZ Flange Bearing		2

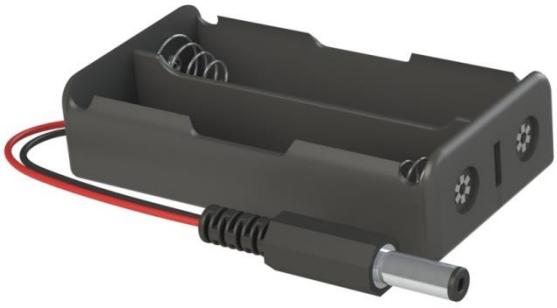
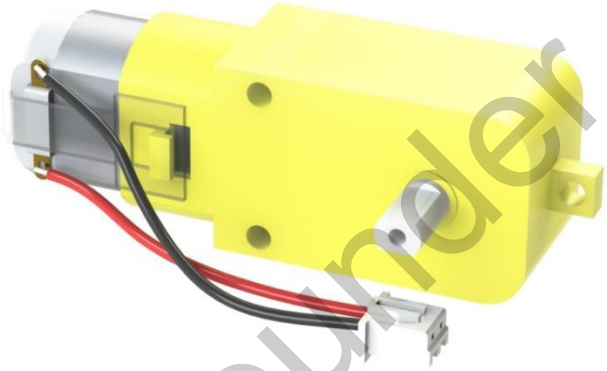
Wires

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		1
TB6612 Motor Driver		1

Other Components

2x18650 Battery Holder		1
DC Gear Motor		2
SunFounder SF0180 Servo		3
120° Wide-angle USB Camera		1

Rear Wheel		2
Front Wheel		2
USB Wi-Fi Adapter		1
Ribbon (30cm)		1

Tools

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

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 TB6612, 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.

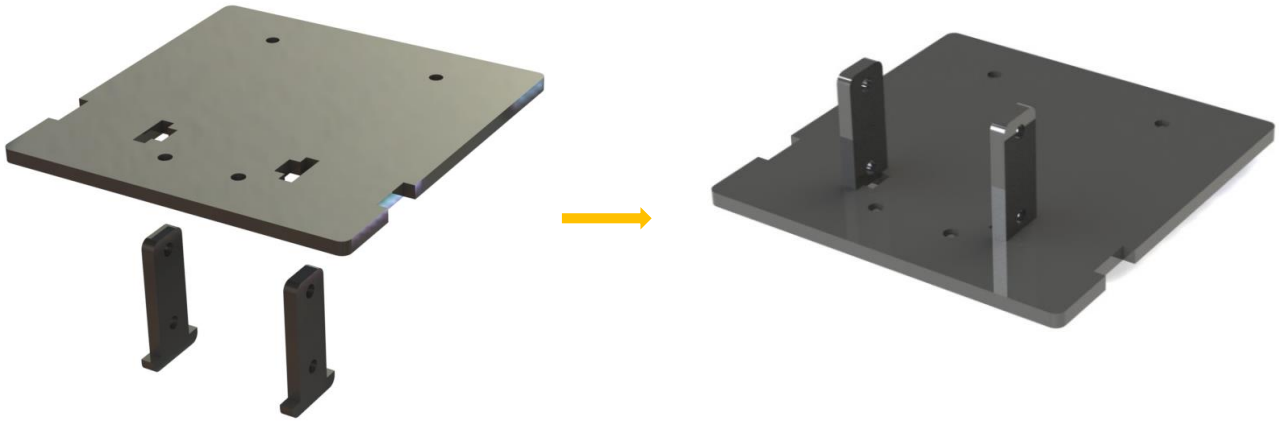
The basic functions of this new version still stay the same, including controlling the PiCar-V remotely and streaming the video data it captures back. Then what's new? Let's unveil the mysteries!

Building the Car

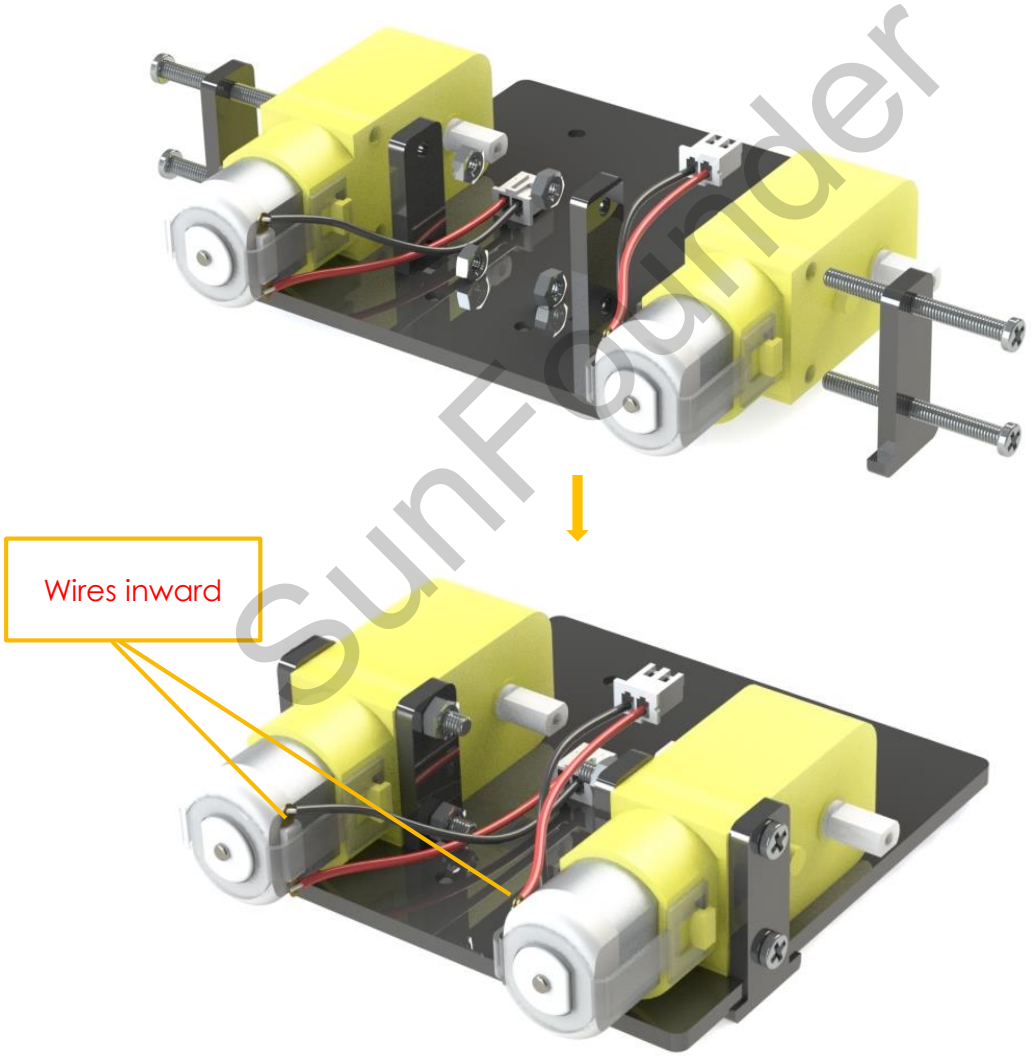
Are you excited when you open the box and see so many components? Keep your patience and take it easy. Please note that some details in the following steps need careful observation. You should double-check your work based on the figures in the manual after finishing each step. Don't worry! Kindly reminders will be given in some particular steps. Just follow the tutorials step by step. Okay, guys, let's start!

Fixing Rear Wheels

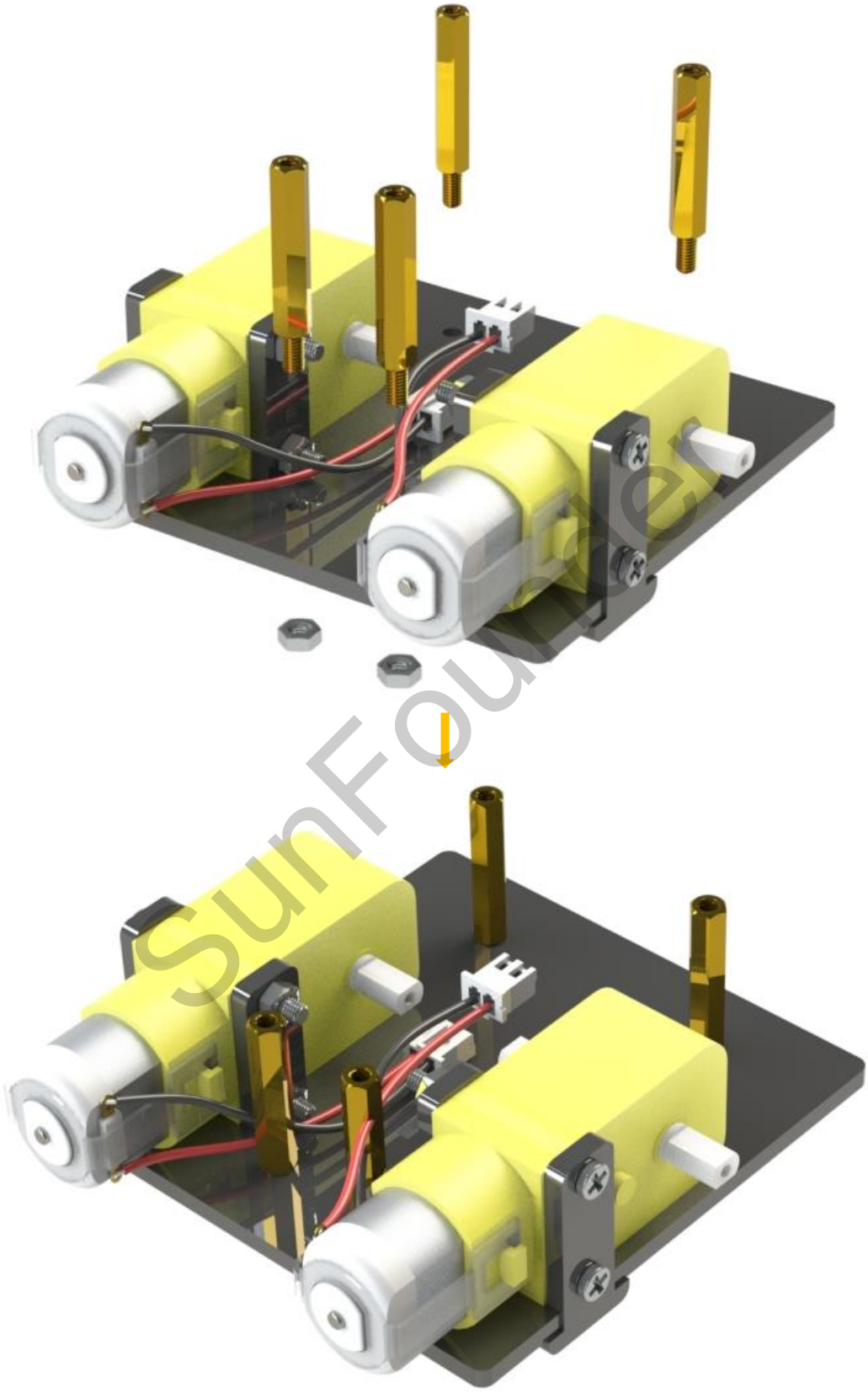
· Assemble the **Motor Support plate** into the **Back Half Chassis** as shown below.



· Assemble the two motors with four **M3x30 screws** and **M3 nuts**. Pay attention to place the motors with wires inward, providing convenience for connecting the circuit.



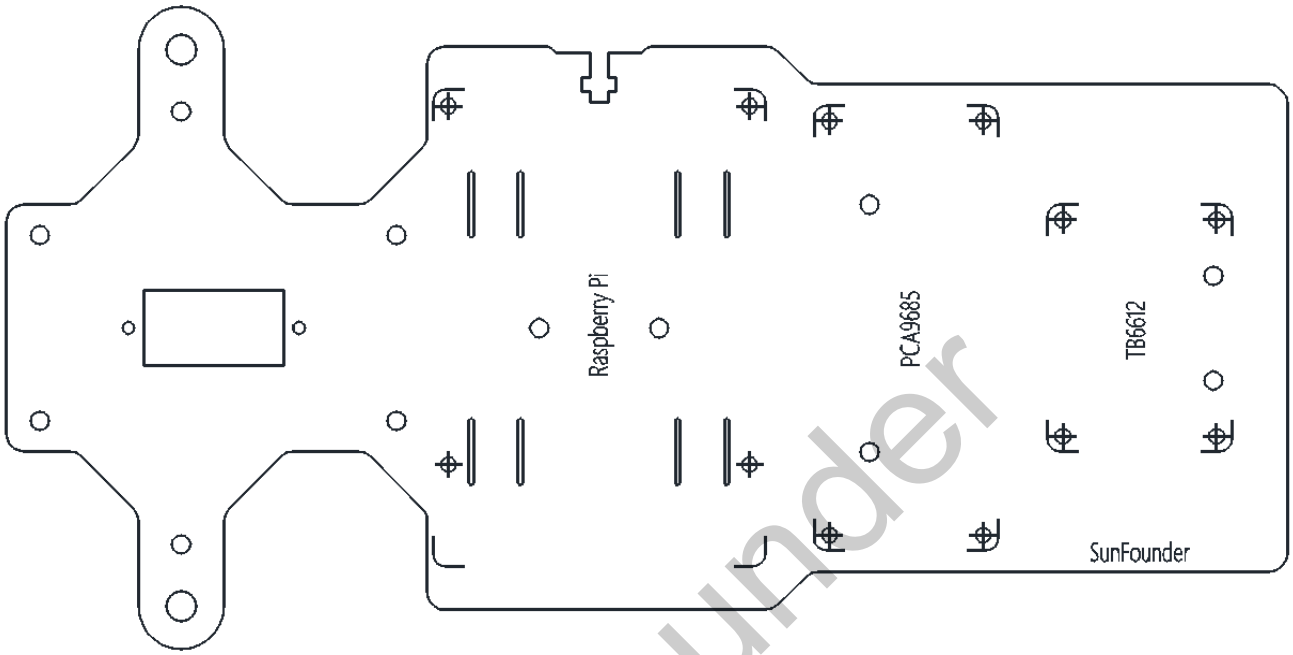
· Insert four **M3x25 copper standoffs** through the acrylic plate into **M3 nuts** as shown below:



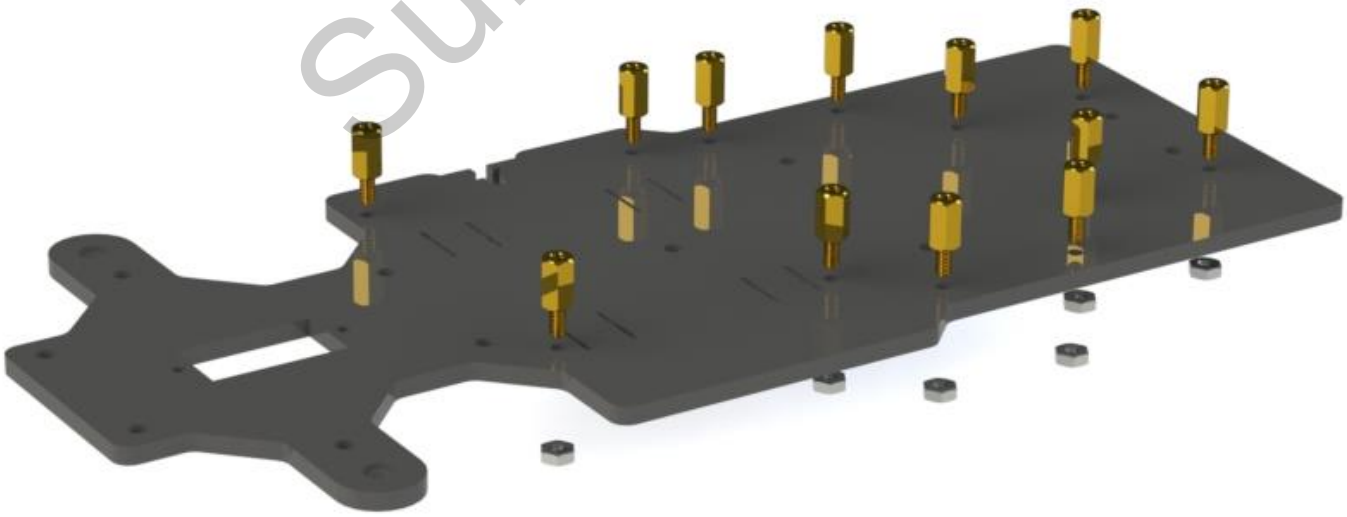
So now this part is completed. You can put it aside for now.

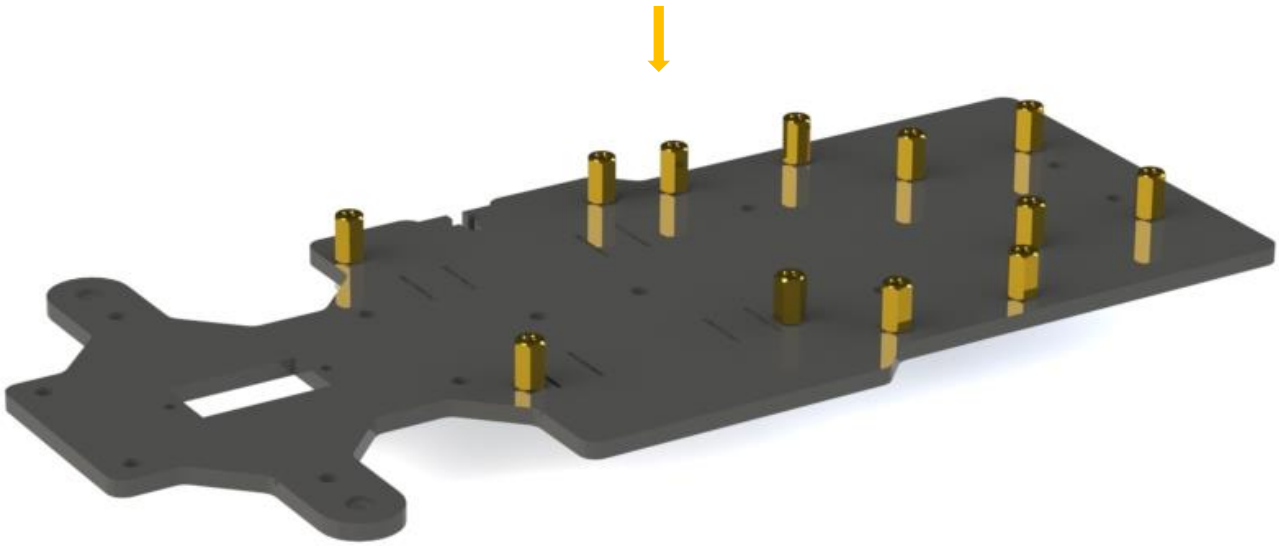
Upper Plate

· Mount the **M2.5x8 copper standoffs** and **M2.5 nuts** into the **upper plate** first. There are three PCBs to be installed onto the plate and four copper standoffs are needed for each. So here 12 holes should be used, marked with cross as shown below:



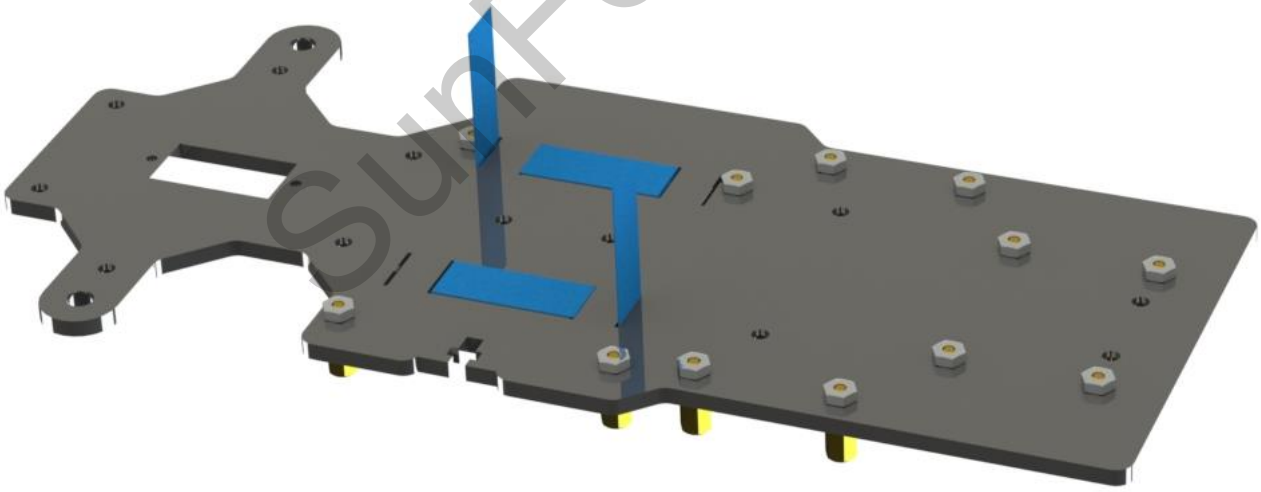
· Assemble the **M2.5x8 copper standoffs** and **M2.5 nuts** as shown below. Pay attention that the side the logo carved should face up.



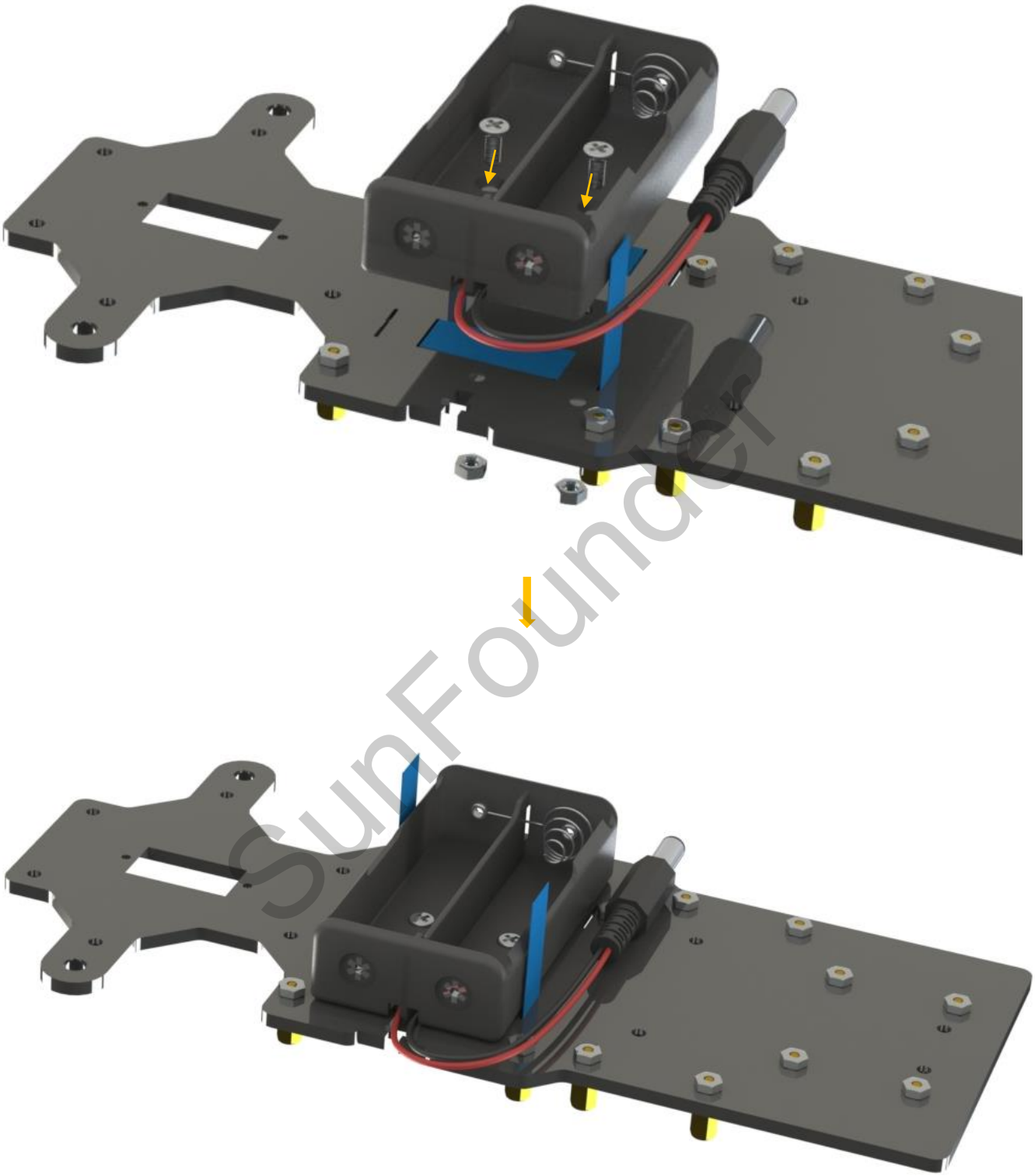


Battery Holder

· 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.

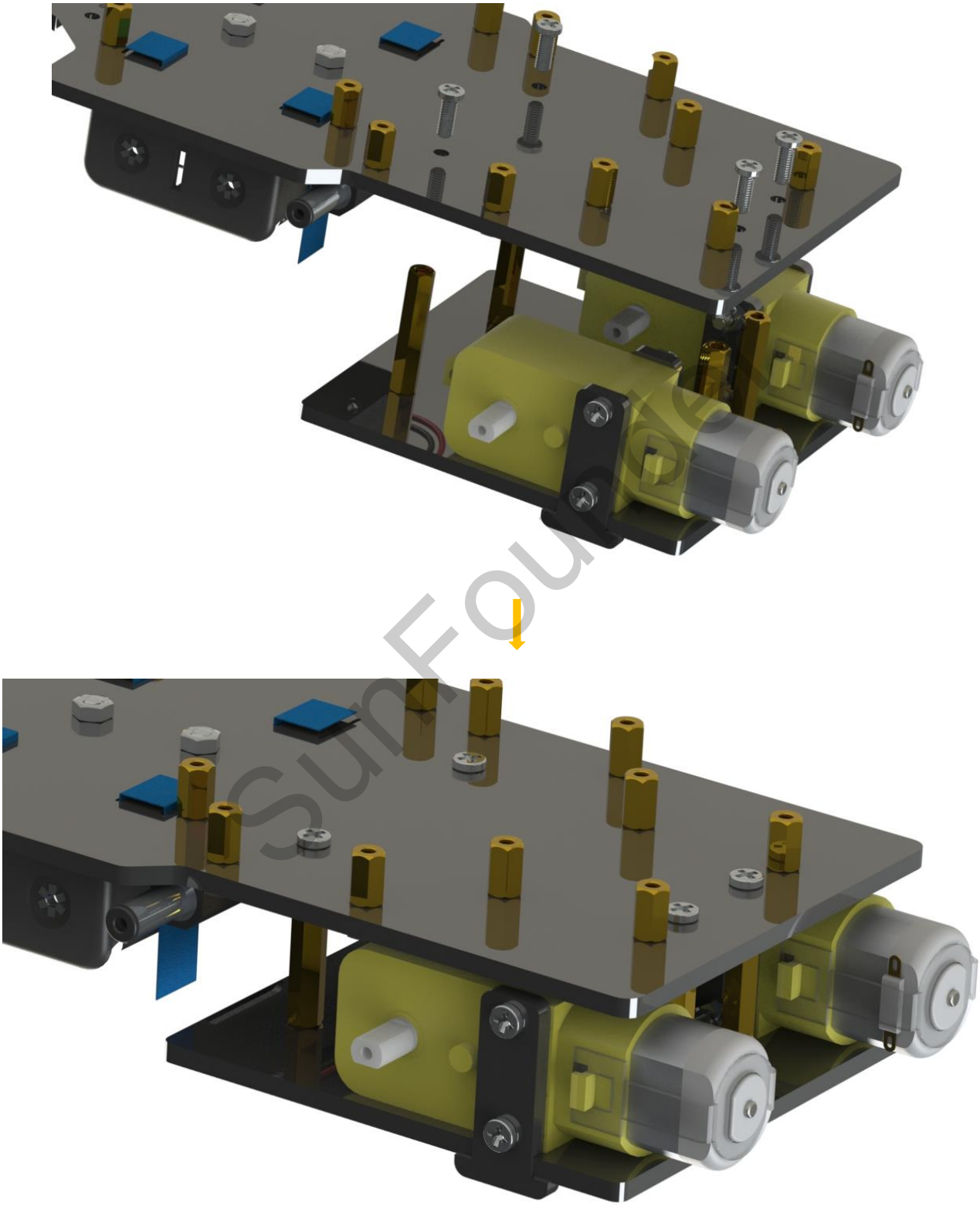


Fasten the battery holder with two **M3x8 countersunk screw**s and **M3 nuts**: pay attention to the direction of battery holder's wire.



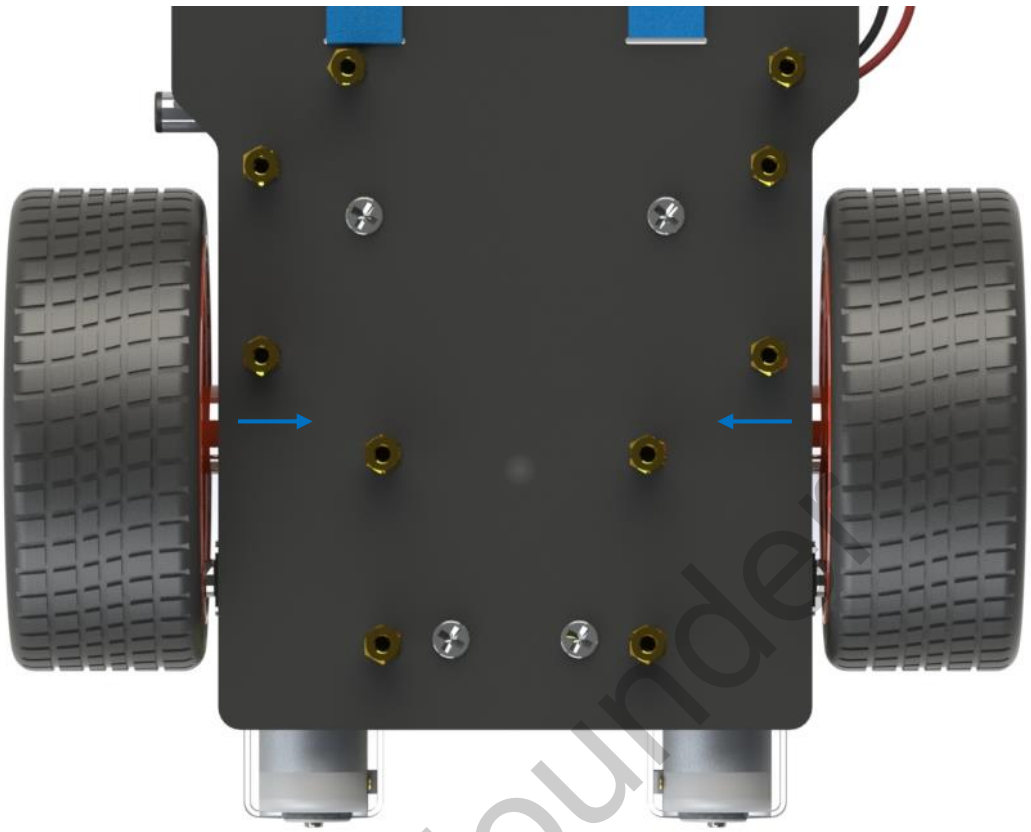
Rear Wheels (Driving)

· Mount the assembled rear wheel driving part onto the Upper Plate with four **M3x8 screws**:



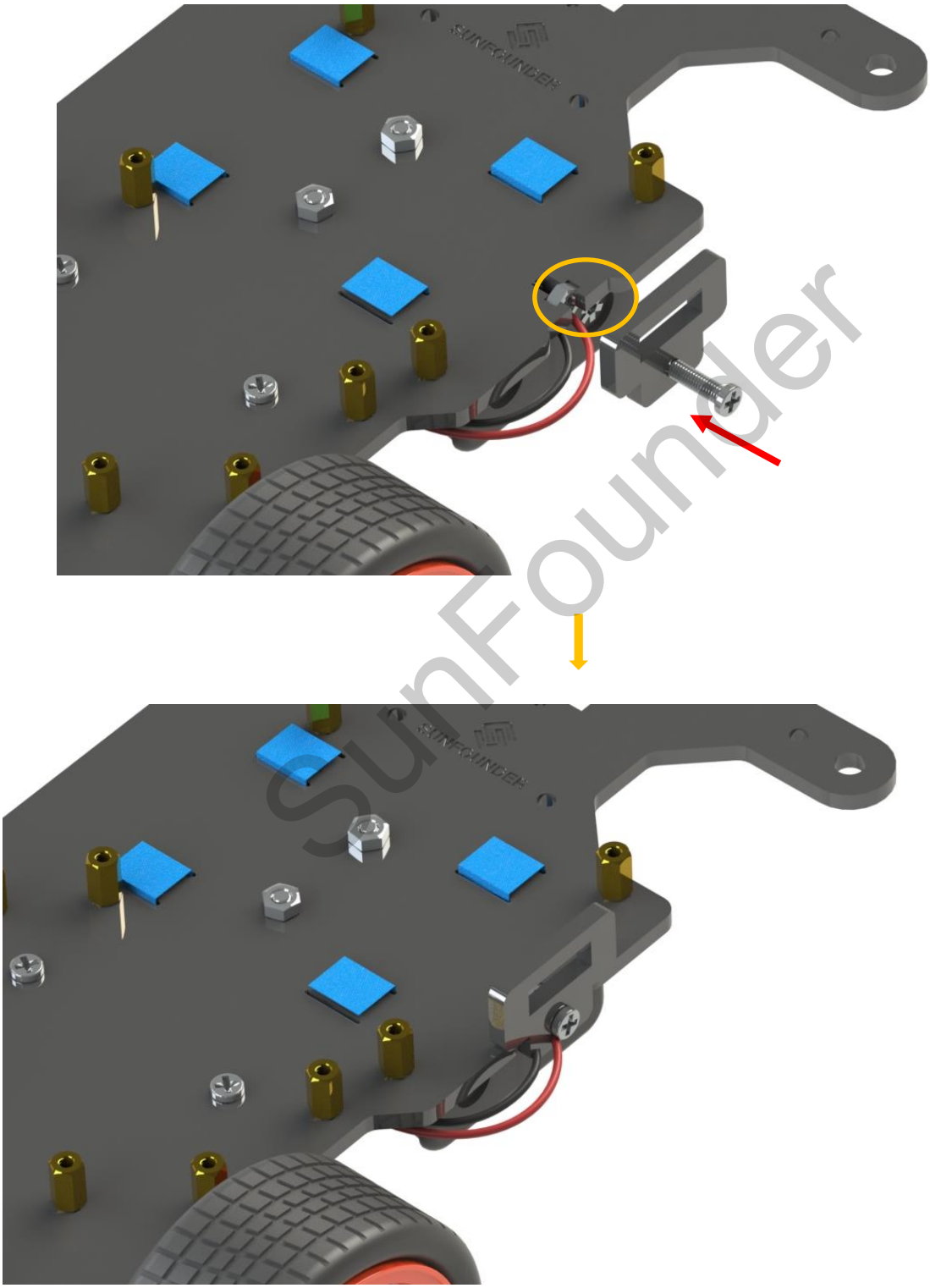
Assemble the **rear wheels**:

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



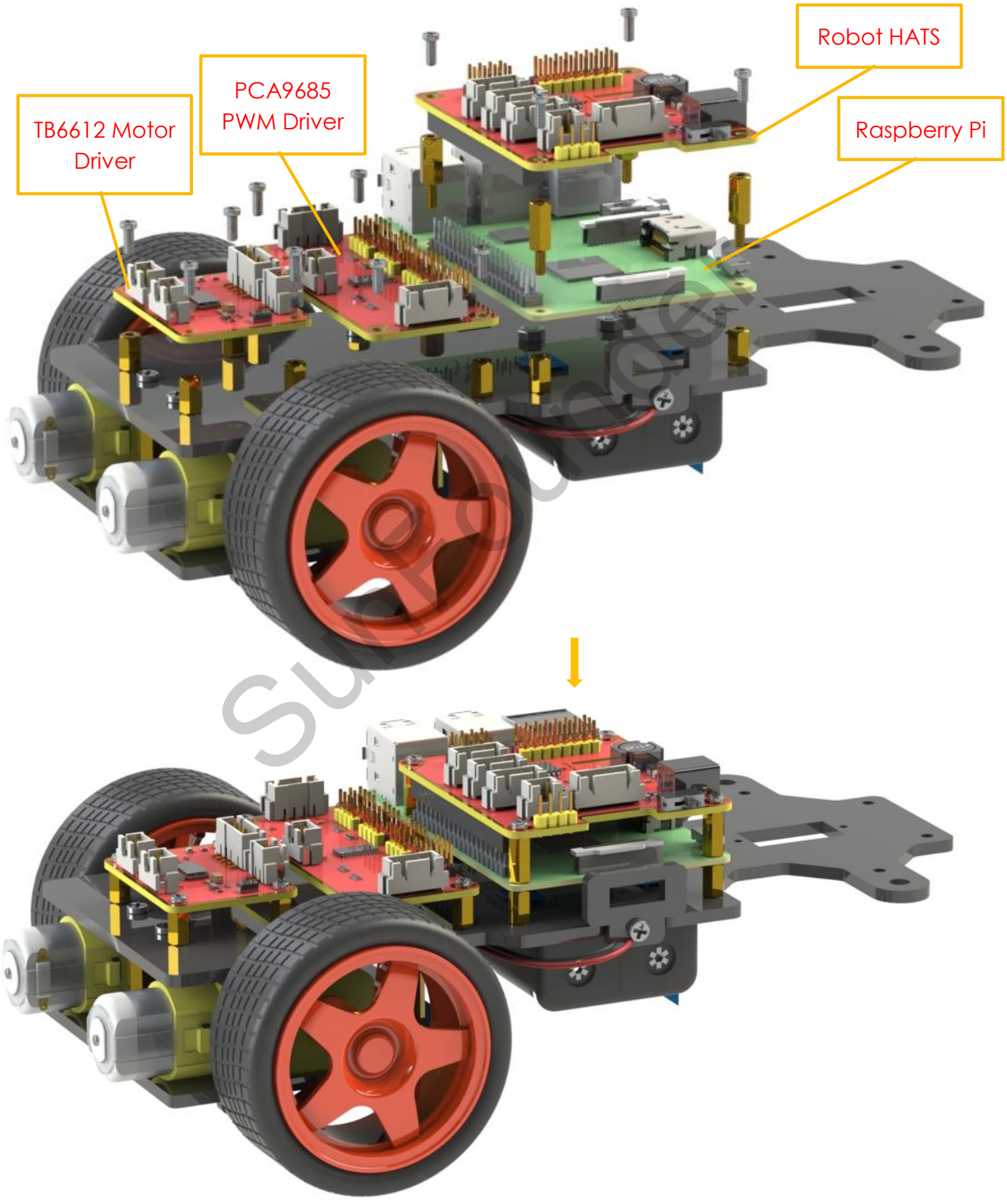
TF Card Guard

Mount the **TF Card Guard** plate onto the side near the front wheel with an **M3x10 screw** and **M3 nut**. First place the nut into the slot from the underneath, and then insert the screw into the nut through the plate.

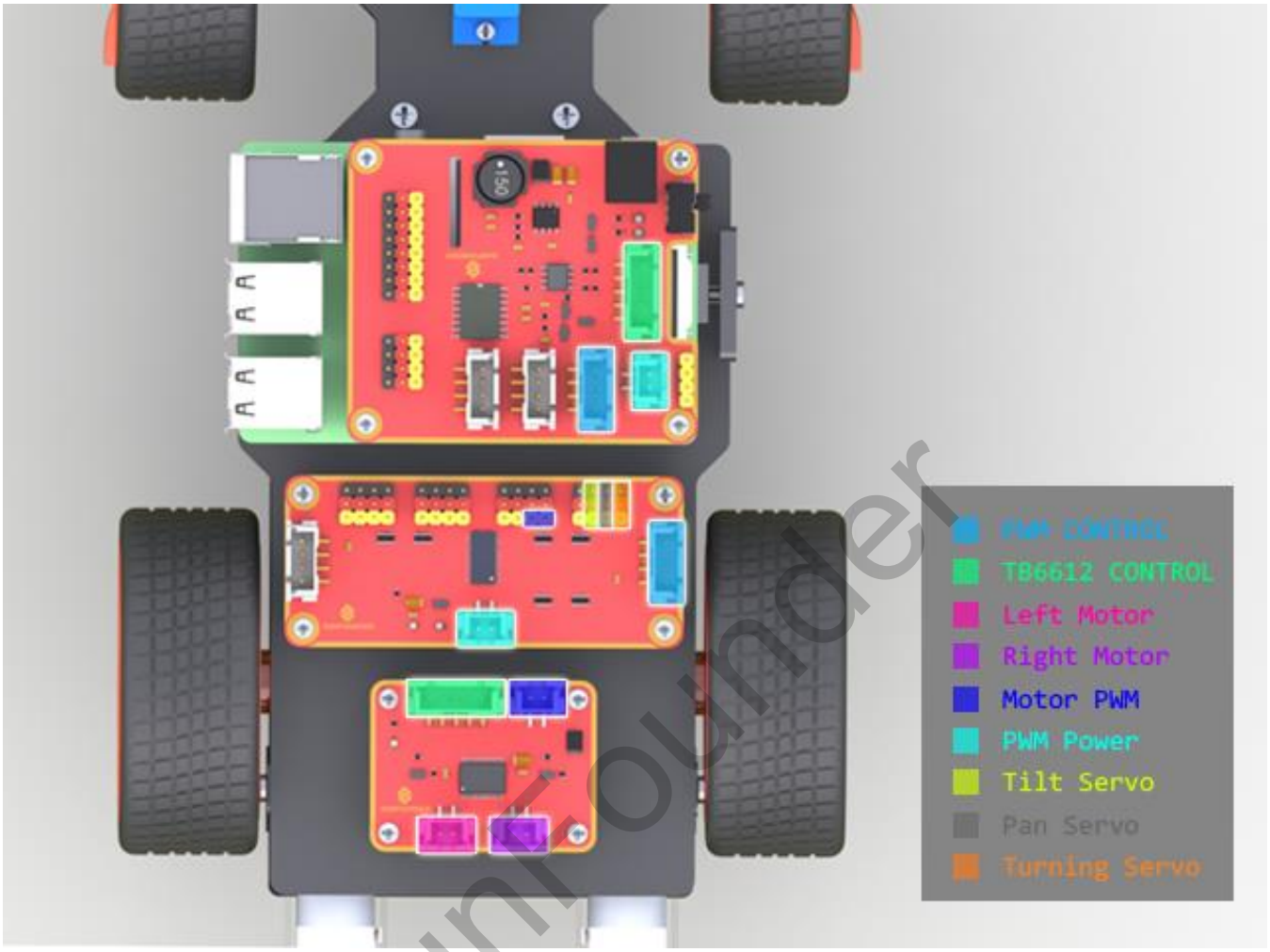


PCB Assembly

· Assemble the **Raspberry Pi** (TF Card inserted, with Raspbian already installed) with four **M2.5x8 copper standoffs**, then plug the **Robot HATS** onto it, and fix the **PCA9685 PWM Driver**, the **TB6612 Motor Driver** and the **Robot HATS** with twelve **M2.5x6 screws**.



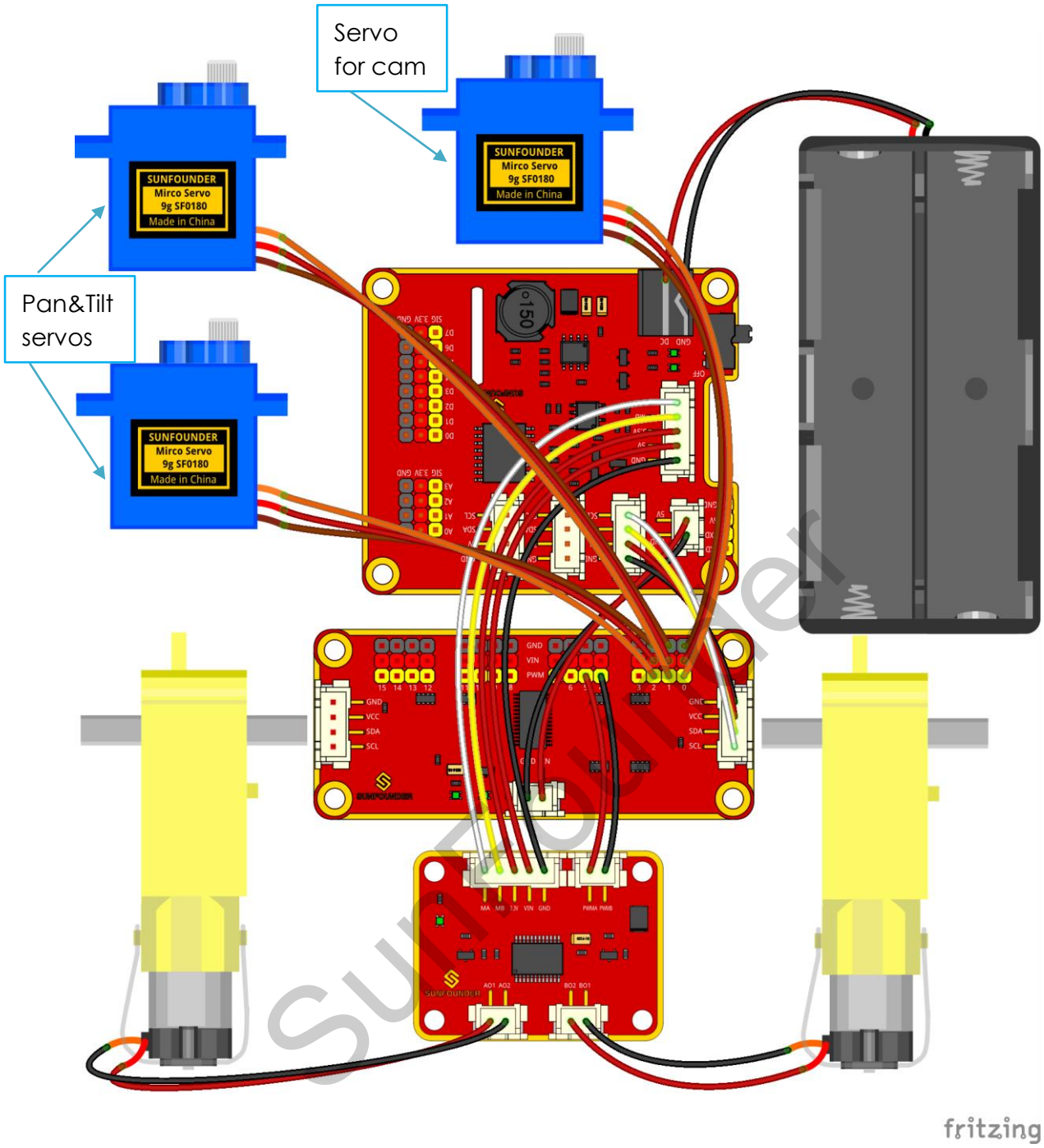
Circuits Building



Connect the **PWM CONTROL** of the Robot HATS with the PCA9685 PWM Driver, and the **TB6612 CONTROL** with the TB6612 Motor Driver.

Then the **Left Motor** and the **Right Motor** of the TB6612 to two motors, and the **Motor PWM** with the No. 4 and 5 PWM channel of the PCA9685.

Connect the **PWM Power** of the PCA9685 with the Robot HATS, and its channel 0, 1, and 2 of with the **Turning Servo**, the **Pan Servo** and the **Tilt Servo** respectively.



Servo Configuration

So the back part of the car is completed. Next we'll move on to the front part. But before assembly, since servos are used in this part, they need some configuration for protection. We need to make the servo rotate to the 90 degrees when it's mounted, so the rotating range can match with the application in the car. Otherwise, damages may be caused to servos. PLEASE DO FOLLOW THIS STEP BEFORE MOVING ON!

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.

1. Log into Raspberry Pi

The TF card onto which the Raspbian has been burnt is inserted into the Raspberry Pi before. Now power the Raspberry Pi.

The installation may take a long time, so you're recommended to **supply Robot HATS by battery and the Raspberry Pi via a USB cable** in case of power cut-off thus causing a sudden shutdown and file damage of the Raspberry Pi. You can directly power it via the Micro USB port because the Robot HATS won't get damaged by it due to the built-in protective circuit.

Plug in the USB Wi-Fi dongle (skip this if you use a Raspberry Pi 3 with the WiFi) and complete the setting in the way you're comfortable with.

Log into the Raspberry Pi via ssh or ssh tools like PuTTY.

2. 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.git
```

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:~ $ cd ~/
pi@raspberrypi:~ $ git clone https://github.com/sunfounder/SunFounder_PiCar-V.git
Cloning into 'SunFounder_PiCar-V'...
remote: Counting objects: 747, done.
remote: Total 747 (delta 0), reused 0 (delta 0), pack-reused 747
Receiving objects: 100% (747/747), 9.08 MiB | 9.00 KiB/s, done.
Resolving deltas: 100% (293/293), done.
Checking connectivity... done.
pi@raspberrypi:~ $ ls
Desktop          Public
Documents        python_games
Downloads        SunFounder_PiCar-V
Music            Templates
Pictures         Videos
```

3. Go to the Code Directory

```
cd ~/SunFounder_Smart_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
client     i2cHelper.py          LICENSE         README.md       show
datasheet  install_dependencies  mjpg-streamer   remote_control
```

4. 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**.

```
sudo ./install_dependencies
```

```
pi@raspberrypi:~/SunFounder_PiCar-V $ 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.

5. Configure the Servo to 90 degrees

After reboot, run the `picar` tool:

```
picar servo-install
```

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

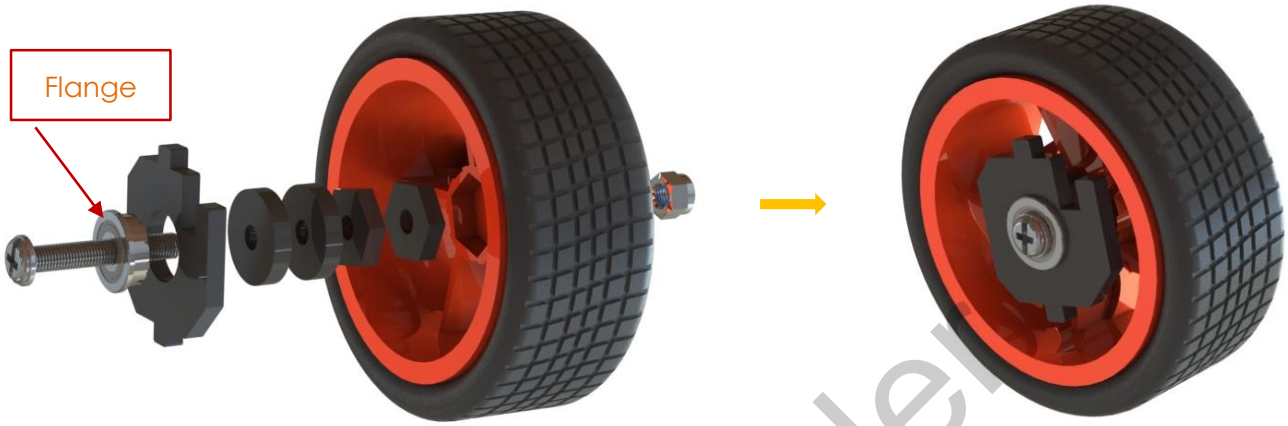
Now the servo rotates to 90 degrees. You can continue the assembly. You may notice that the motors make some noise and are turning slowly. Well, the reason is, all the 16 channels of the PCA9685 have been set to a value that makes the servo rotate to 90 degrees, which is a signal for a fairly slow rotation of the motor. Therefore, just leave it alone.

Warning: After power on, a shortcut circuit may happen because the exposed contacts of the PCB may be touched by conductive objects like screw or screwdriver. If it occurs, please remove the conductor immediately or unplug the power as quickly as you can.

After running, the program will exit immediately. So the servo has been adjusted well and keep at the 90 degrees. DO NOT power down the circuit (especially the PCA9685). If it's off, you need to run the command above again.

Front Wheels

Insert an **M4x25 screw** through a **Flange Bearing** (pay attention to the direction – the flange near the cap of the screw), a **Steering Connector**, 2 **Bearing Shields**, 2 **Hex Front Wheel Fixing Plates**, and a **front wheel**, into an **M4 Self-locking Nut** (note the direction) as shown below:



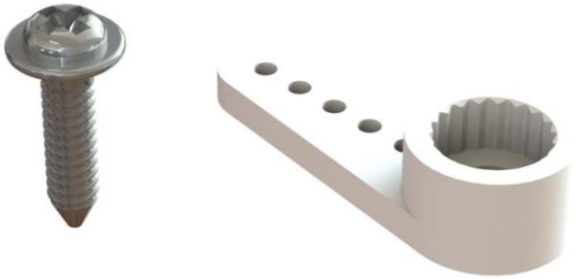
The Self-locking Nut should be screwed tight enough. It would be better to tighten the screw until the wheel and Steering Connector cannot move first, then loosen the screw a little, so that the Steering Plate can just move. Thus, the wheel can turn flexibly when the connection would not be too loose.

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:

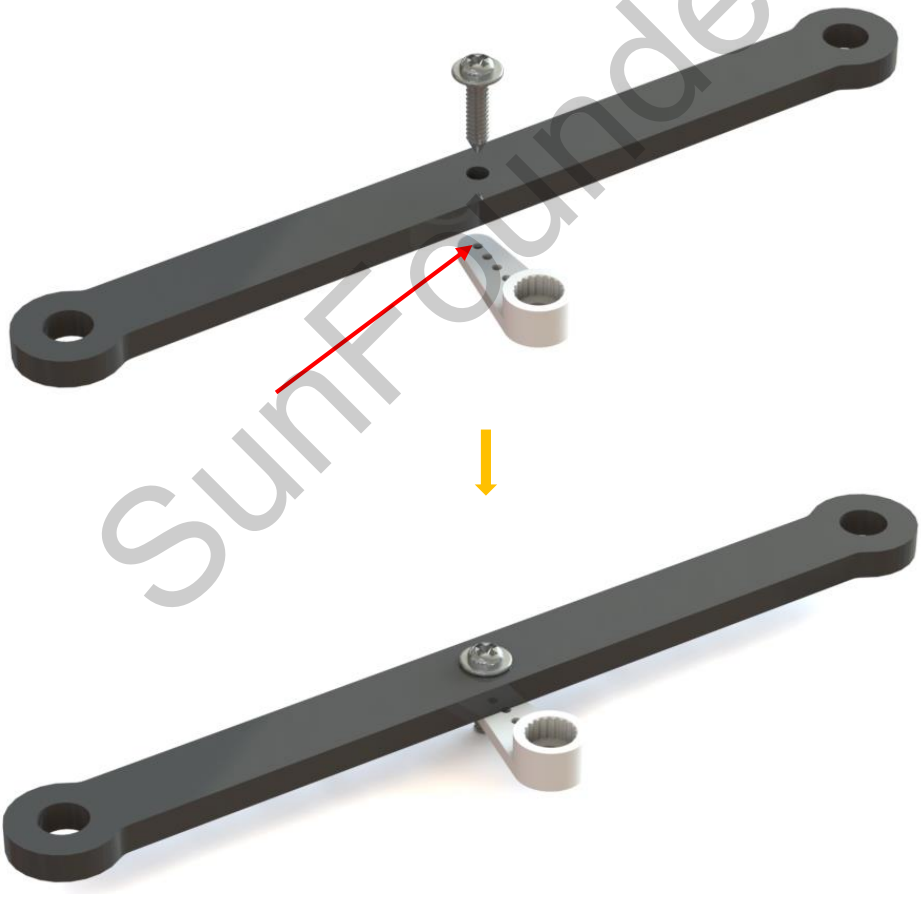
Now two front wheels have finished assembly.

Steering Part

Take out the **1-arm Rocker Arm** and the **Rocker Arm Screw** (a longer one in the servo pack):

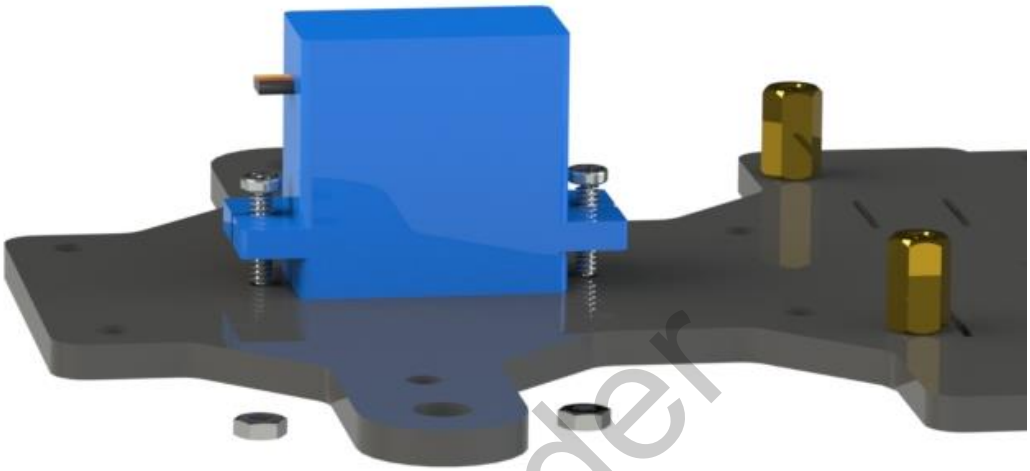


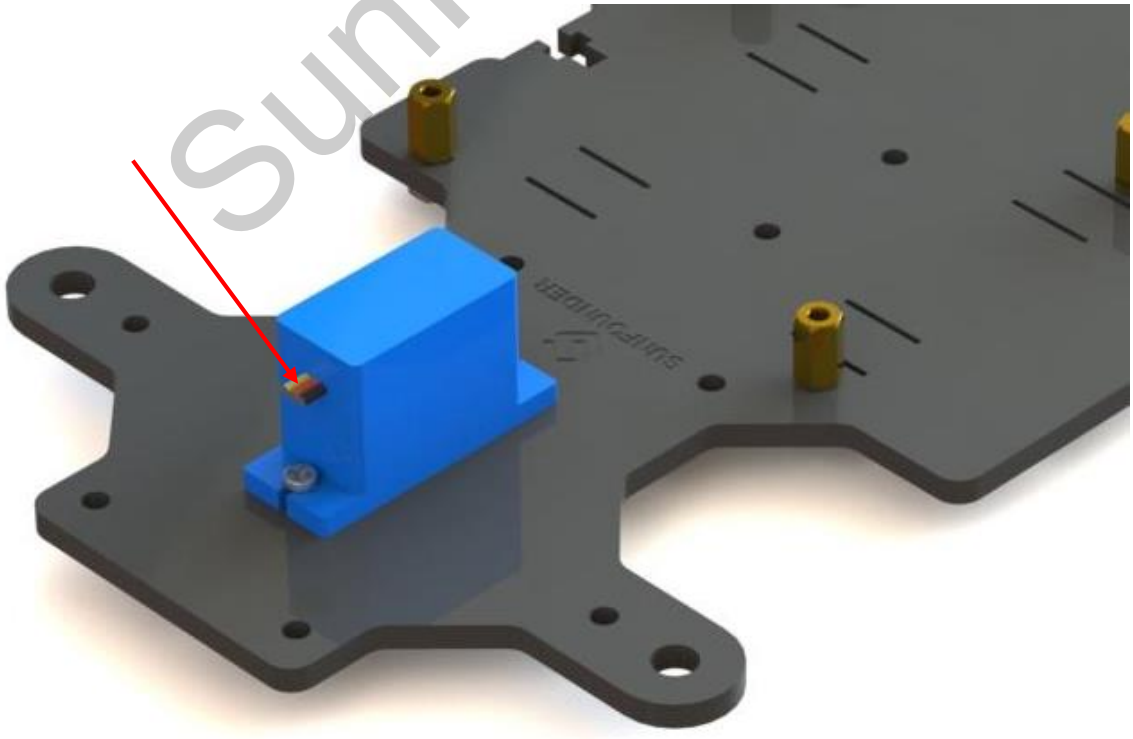
- Connect the **Steering Linkage** and the **rocker arm** with the screw. **Note:** Insert it into the FIRST hole of the arm (as indicated by the arrow below) which is the farthest from the gears. Since the screw is larger than the hole, you should try to screw it hardly so as tight to the arm. Don't worry of the arm which is soft.



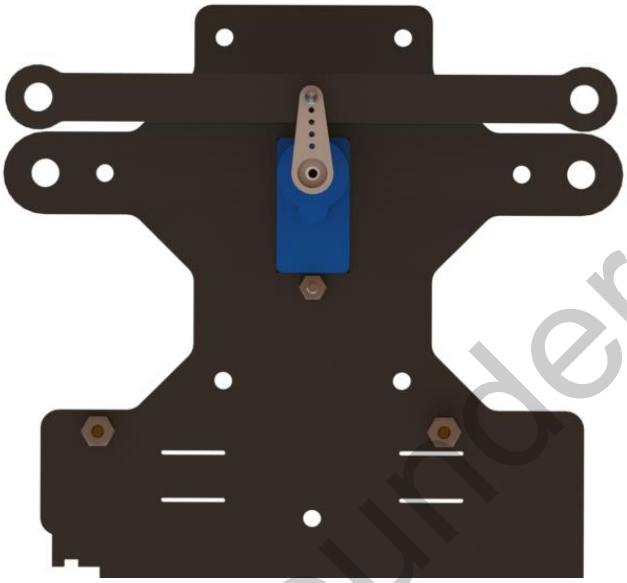
- And also fasten them as tightly as possible, and then loosen the screw a little so the Steering Linkage can move flexibly.

· Mount the servo that connects to PWM Channel 0, the steering servo, to the Upper Plate with two **M2x8 Screws** and **M2 nuts** (pay attention to the direction of the servo wires):

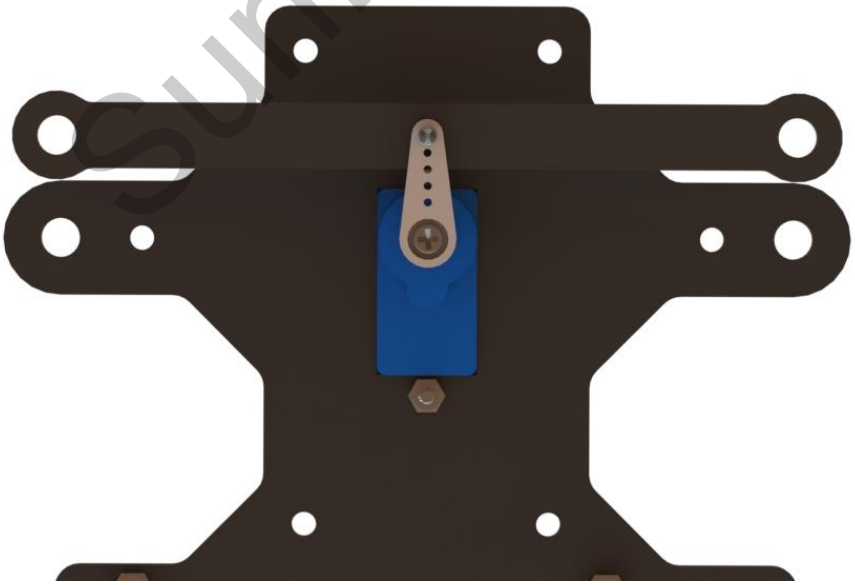




- Connect the Steering Linkage and the rocker arm. **Make sure the rocker arm is in an angle as shown below**. Try to spin the arm on the shaft, **NOT** on the linkage). If it's unmovable, it means the servo is adjusted to 90 degrees. But if it spins, it indicates that the servo is not adjusted successfully; check whether the wiring is correct and run the program at **Step 5** before. Besides, **the screw is quite sharp at the end, so be careful to assemble in case of getting hurt**.

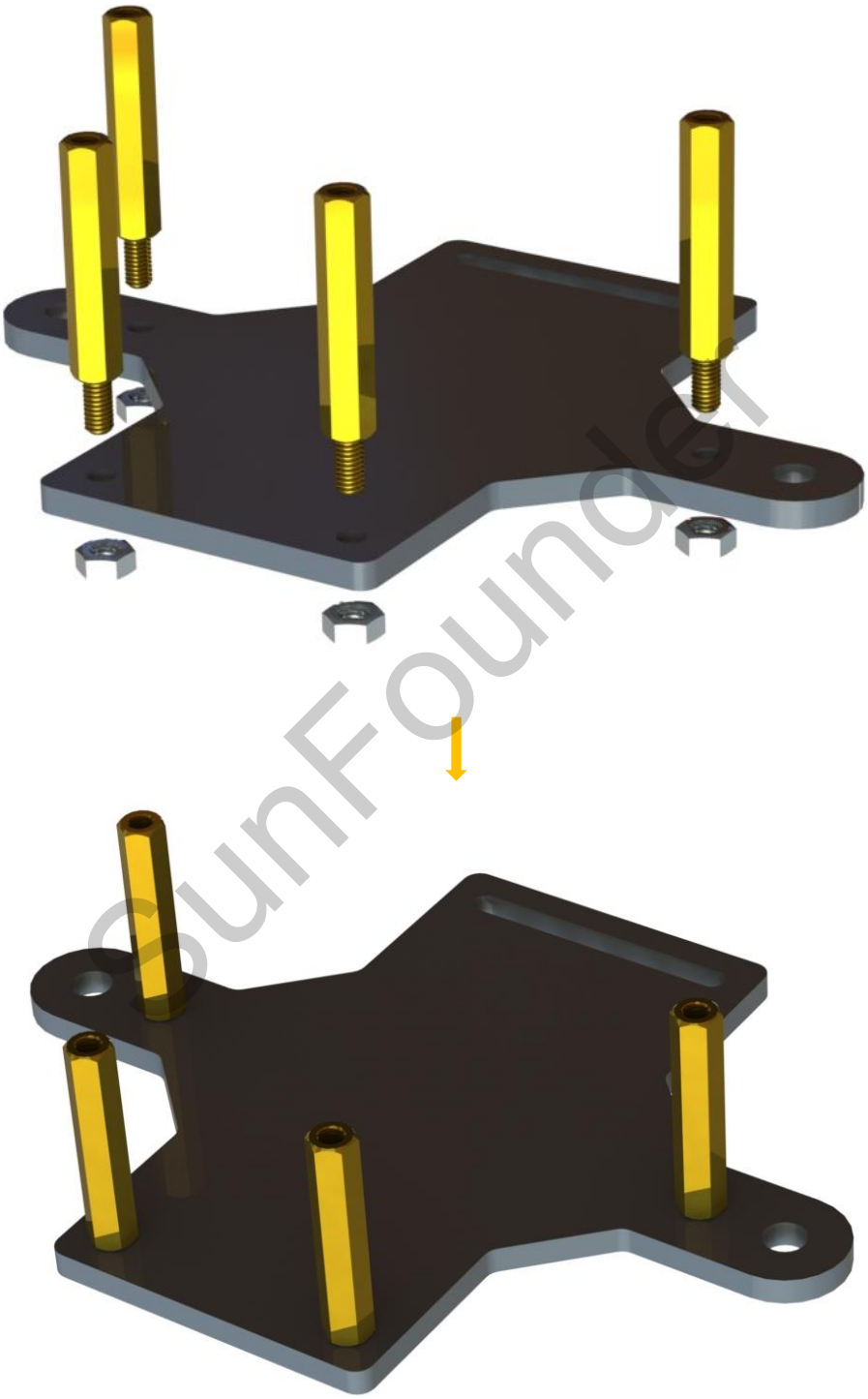


- If everything is OK, take out the **Rocker Arm Fixing Screw** (the shortest) to connect them as shown below.

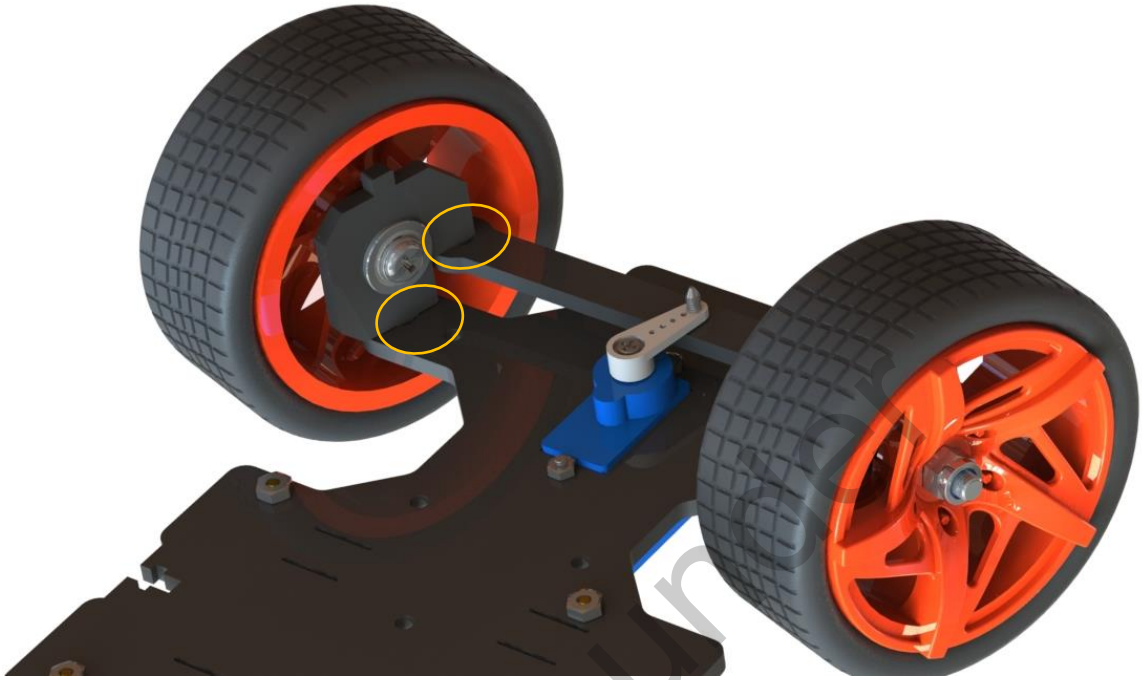


Front Half Chassis

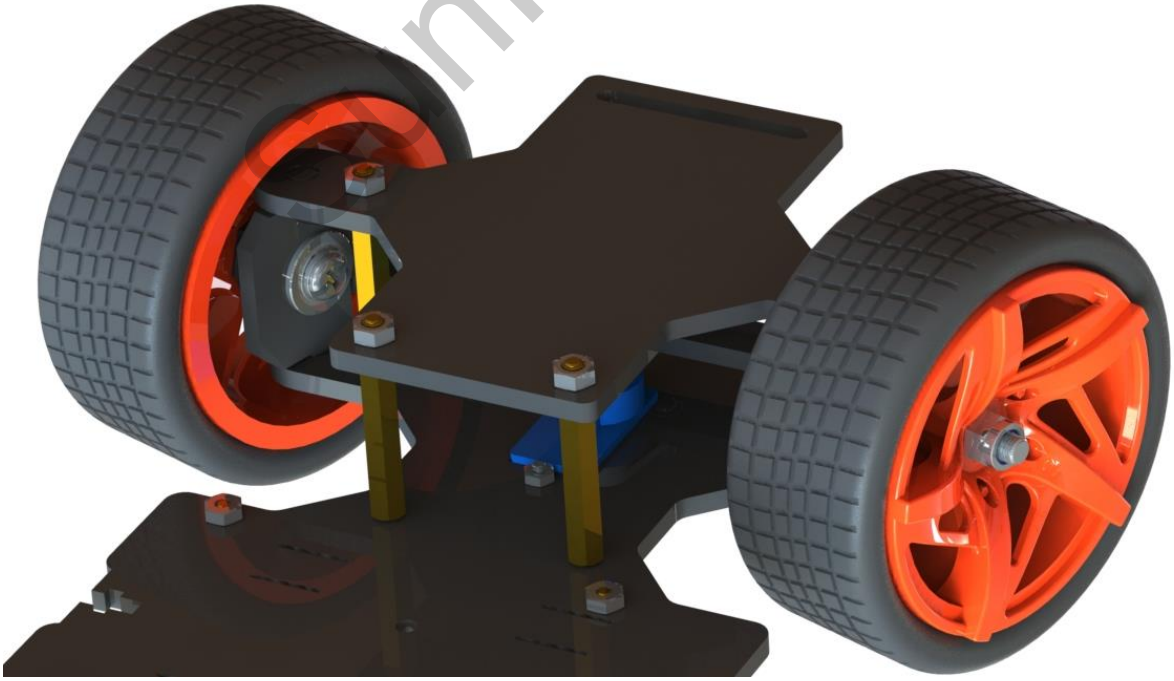
- Assemble the **Front Half Chassis** with four **M3x25 copper standoffs** and **M3 nuts** as shown below:



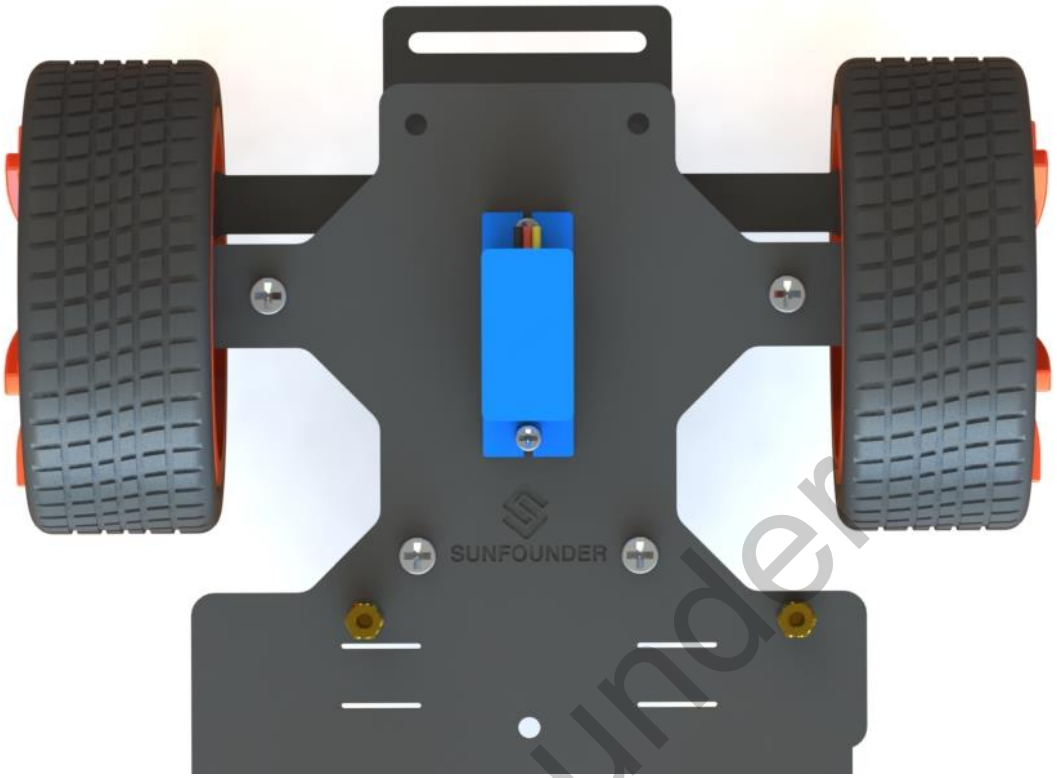
- Take out the assembled front wheels and the Upper Plate, and mount the wheels onto the Upper Plate carefully: insert one bulge of the Steering Connector at one wheel into the hole on the Steering Linkage plate at the corresponding end, and the other bulge into the Upper Plate (pay attention to the height level of two bulges), and similar with the other wheel.



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

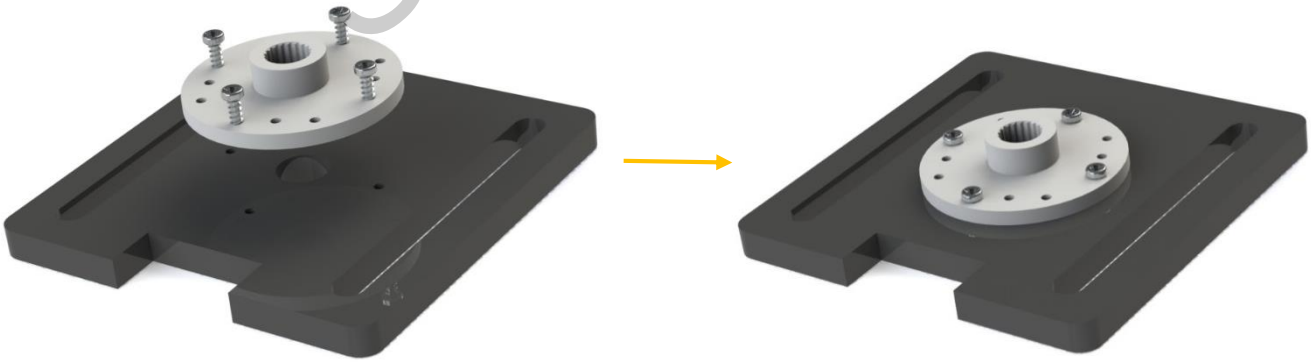


· Hold them carefully, turn upside down, and fasten the standoffs and Upper Plate with four **M3x8 screws**:

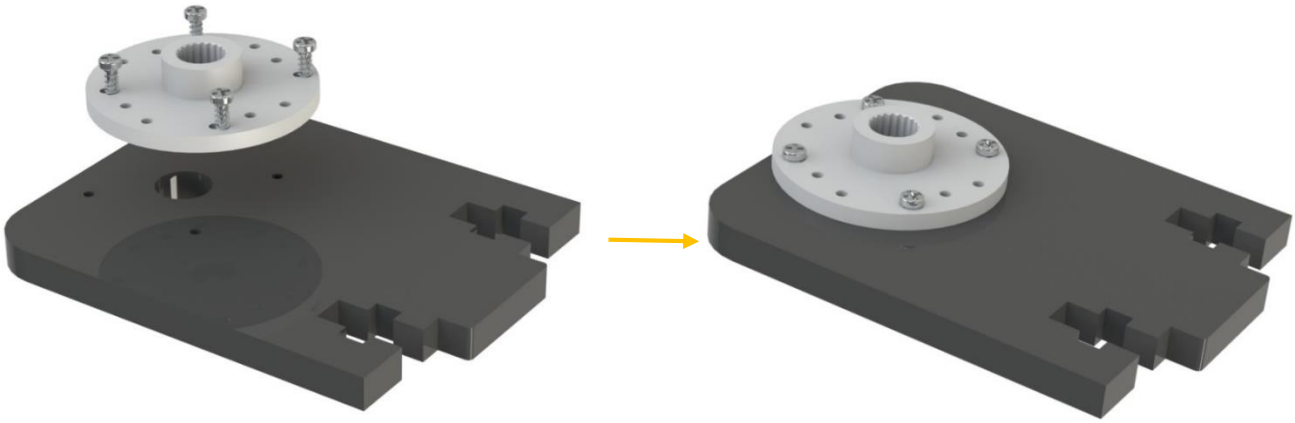


Pan-and-Tilt

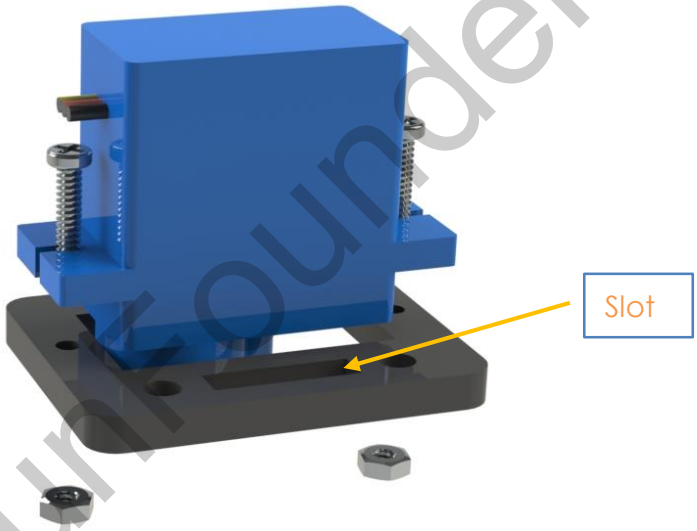
· Take out the **round rocker arm** and mount it onto the **Pan-and-tilt Base** with four **M1.2x4 screws** (into the hole like this). Pay attention to the holes on the round rocker arm to be fastened; though the pointed end of the screwdriver is a little bigger than the screws, you can still tighten them – just insert them and screw slowly:



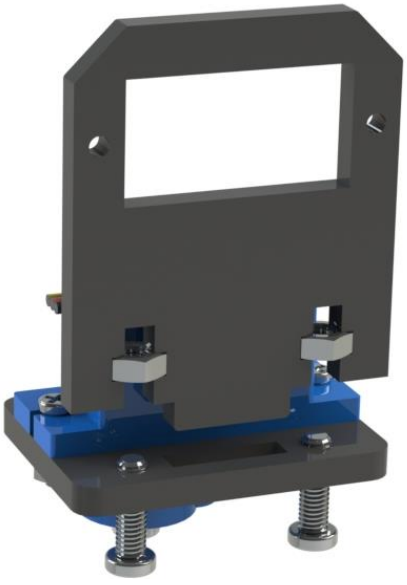
- Do the same operation to the Tilt Arm.



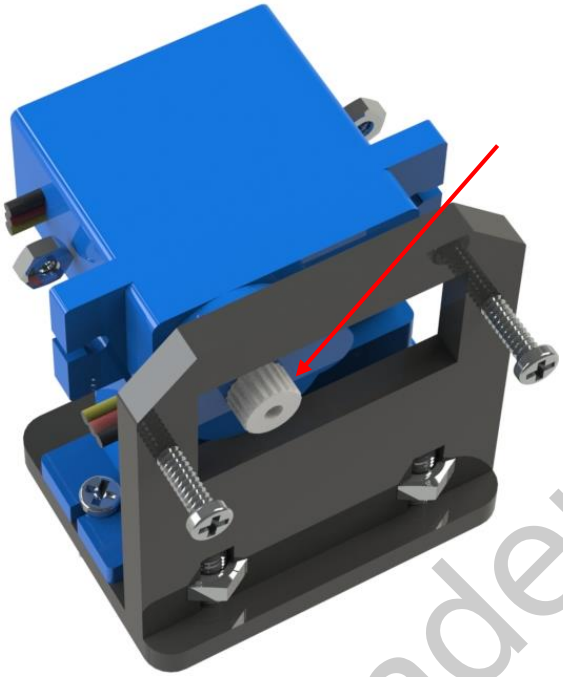
- Assemble the servo connected to PWM Channel 1, i.e. the **Pan Servo**, to the **Pan Servo Mount** with two **M2x8 screws** and the **M2 nuts** (pay attention to the relative position of the servo shaft to the slot on the plate):



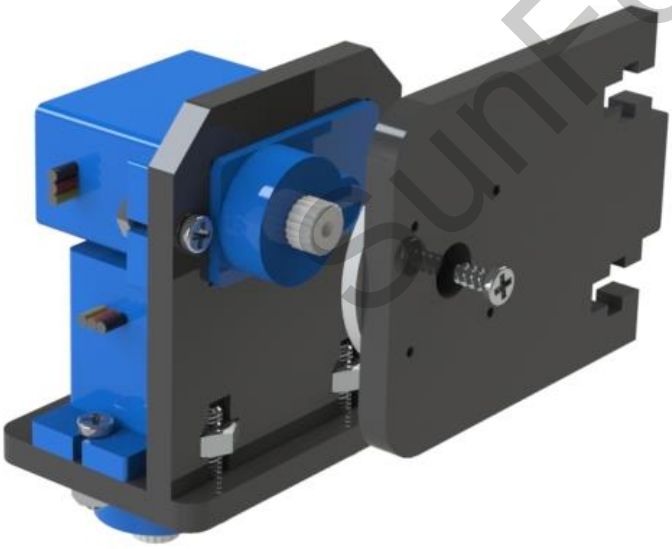
- Fasten the **Tilt Servo Mount** to the **Pan Servo Mount** plate with two **M3x10 screws** and the **M3 nuts** (the bulge into the slot above):

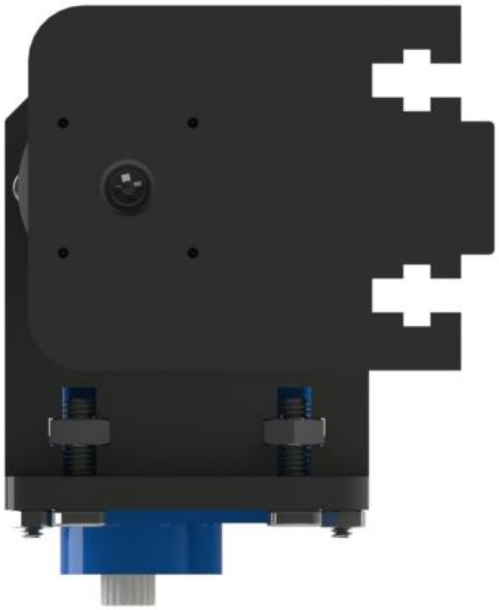


- Insert the servo connected to PWM Channel 2, the Tilt Servo, into the slot (pay attention to the shaft position) and fix it with two **M2x8 screws** and the **M2 nuts**:

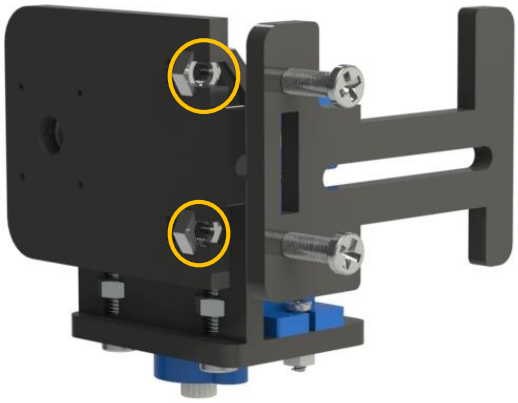


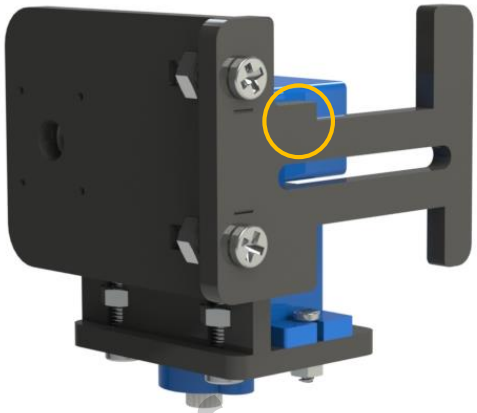
- Make sure the servo shaft has spun to 90 degrees. Then assemble the **Tilt Arm** with the **Rocker Arm Fixing Screw** in a fixed angle as shown below:



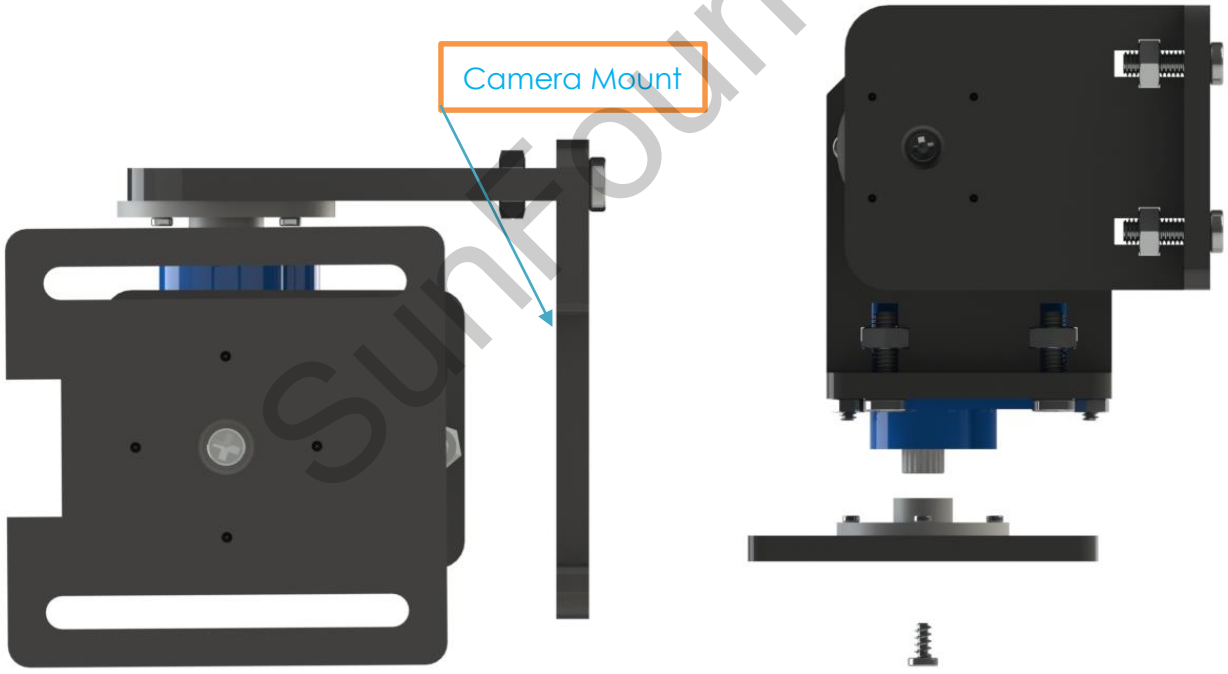


- Then assemble the **Camera Mount** with two **M3x10 screws a**nd the **M3 nuts** (the bulge of the Tilt Arm plate into the slot of the Mount which should be at the same side of the servos). Make sure the cut-off with a little bulge should be on top, which is to mount the webcam:



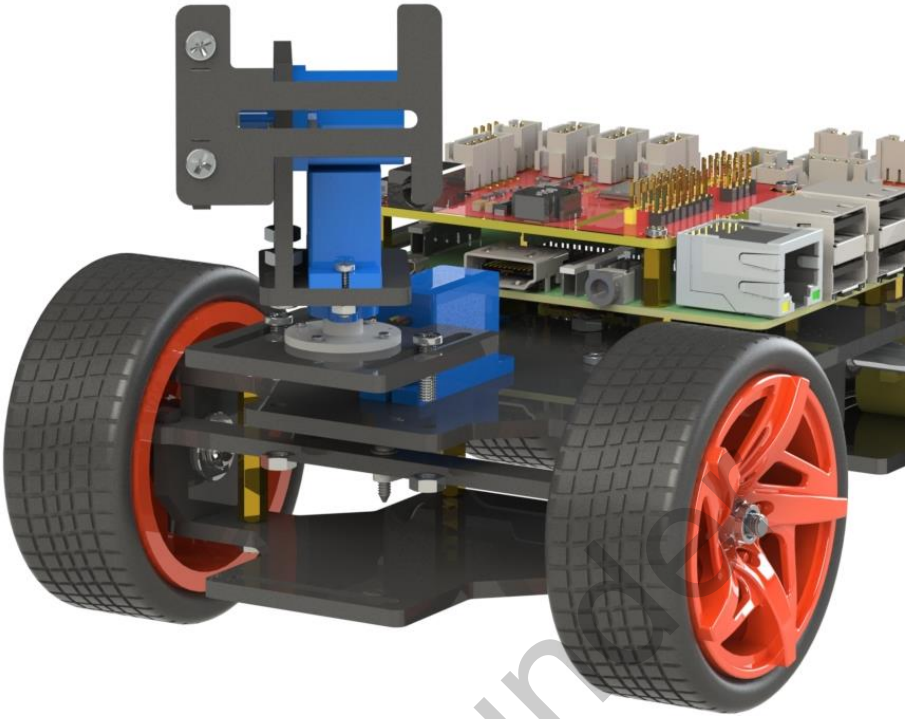


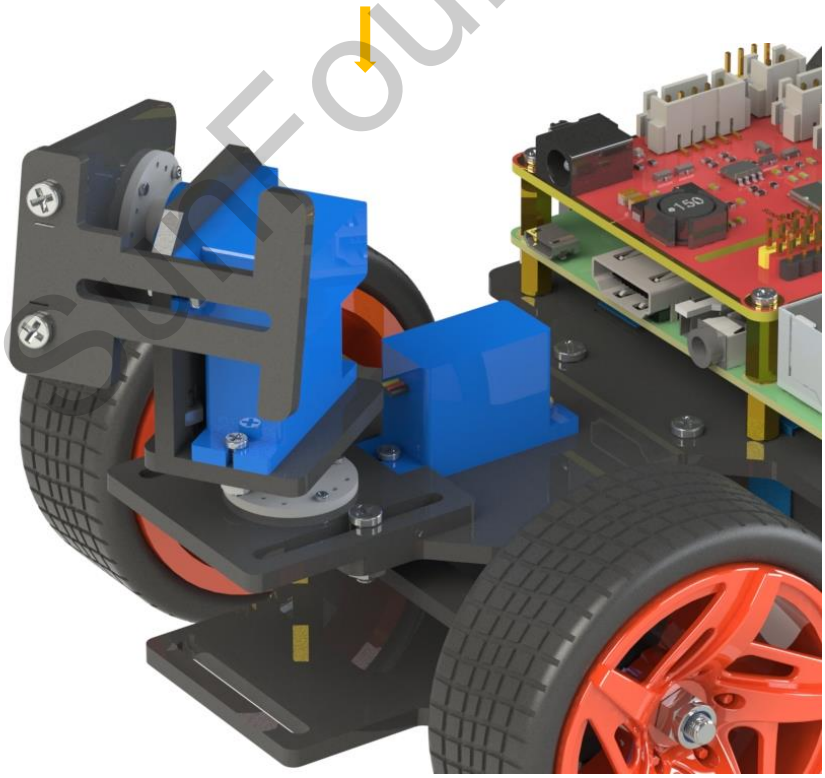
- Similarly check that the servo shaft has spun to 90 degrees. Then assemble the **Pan-and-tilt Base** with the **Rocker Arm Fixing Screw** in the angle as shown below (the shaft of the pan servo should be closer to the concavity of the base plate):



Try to turn the pan and tilt servos and make sure they are unmovable at 90 degrees.

Assemble the Pan-and-tilt to the car if everything is OK. Insert the shaft of the pan servo into the rocker arm on the Upper Plate (PCBs not shown in the figure):

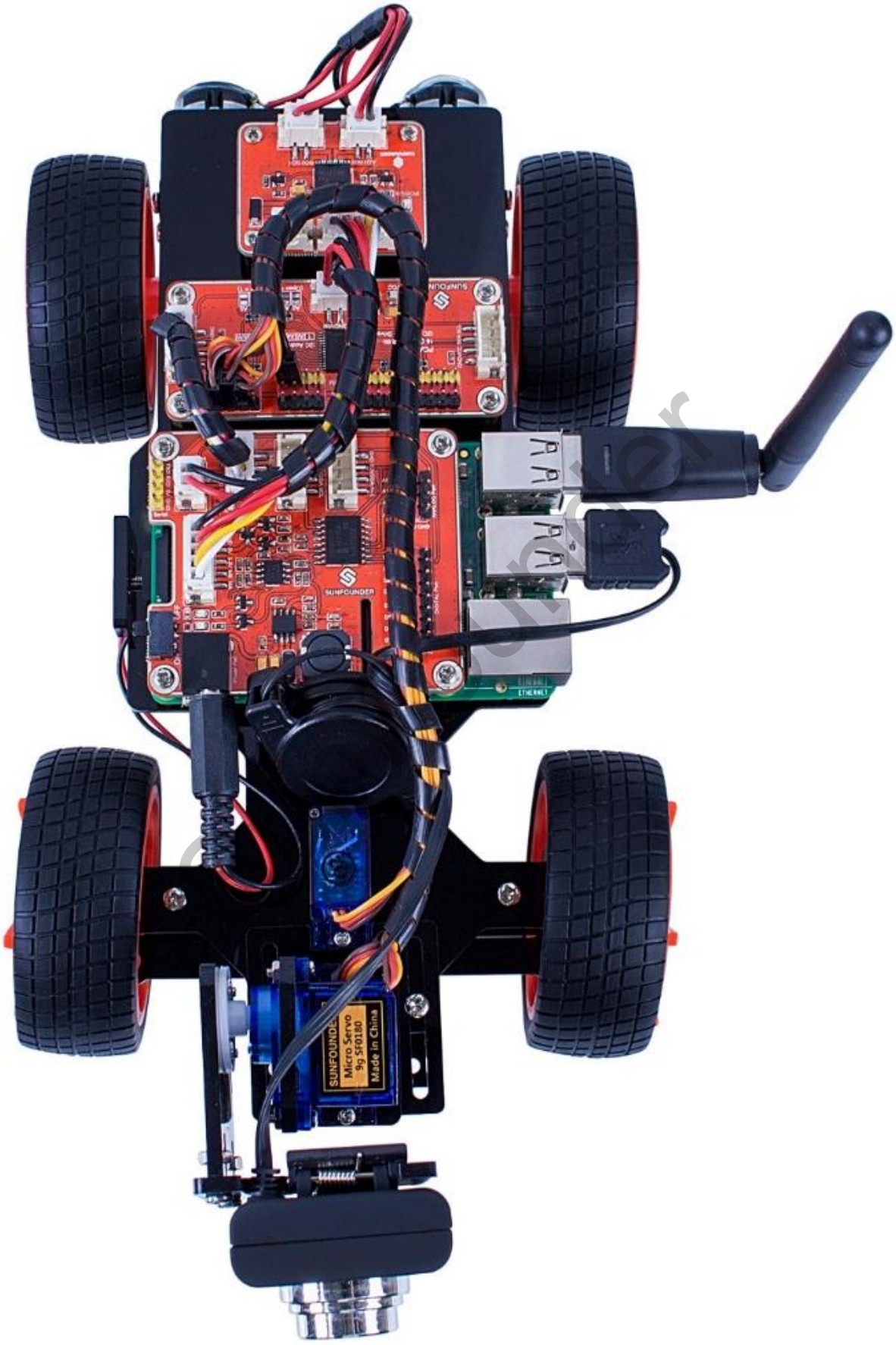


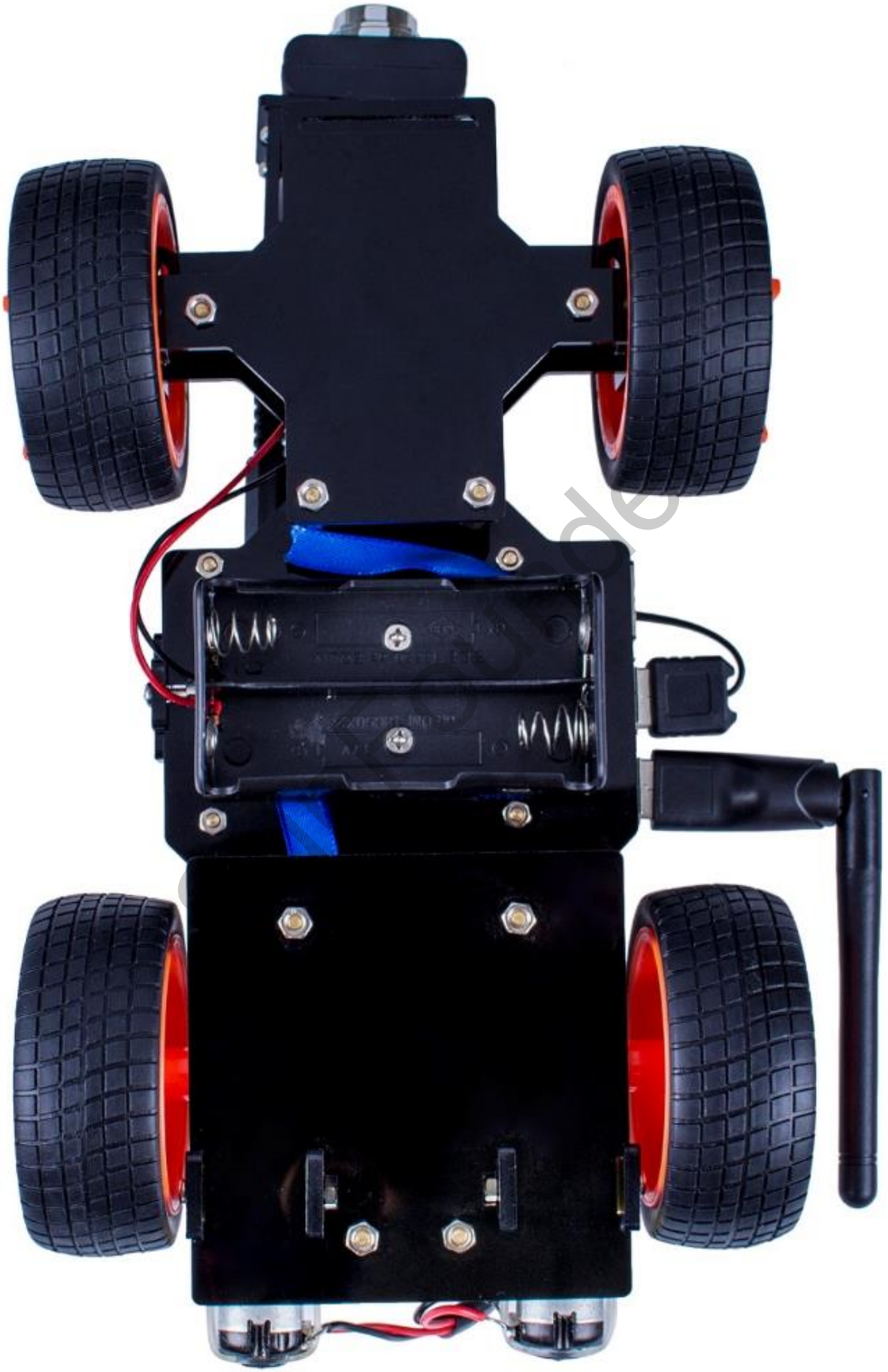


Other Components

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!





Installing the Client

Since you've finished the car building, now it's time to configure the environment for the client. Or you may skip this part and go to the subsequent Web Client for controlling on the webpage.

Environment Configuration

The client is written by Python 3 + PyQt5, so it's necessary to install the two in your PC.

Python 3 website: https://www.python.org/downloads/

Select the proper version of Python 3 for your PC, and follow the instructions to install.

PyQt5 website: https://www.riverbankcomputing.com/software/pyqt/download5/

The installation method is provided: http://pyqt.sourceforge.net/Docs/PyQt5/installation.html, and the preferred way is installing by pip:

```
pip3 install pyqt5
```

For Windows users who are inclined to click **Next** all the way during the installation, you can try to search out the .exe file: https://sourceforge.net/projects/pyqt/. Then you can complete the installation in the same way as other software in Windows.

Notes:

1. You may need to install python3-pip. If you get the prompt of "pip3 not found", first

   ```
   apt-get install python3-pip
   ```

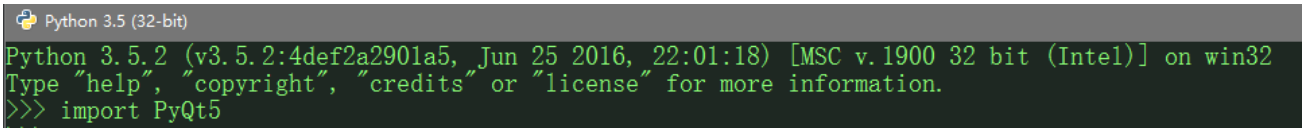
   Then,

   ```
   pip3 install pyqt5
   ```

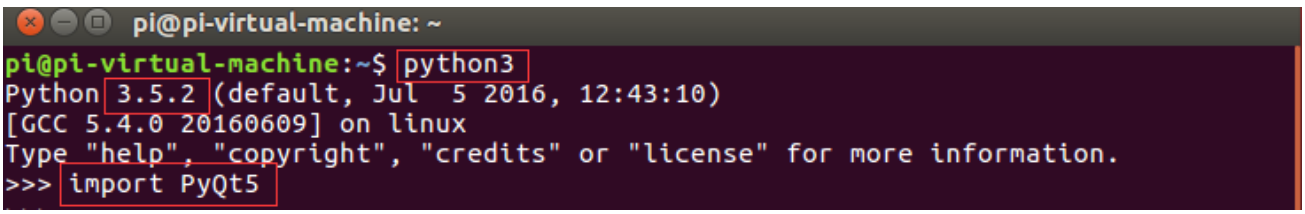
2. The method of pip3 install pyqt5 only supports the 32-bit and 64-bit Windows, 64-bit OS X and 64-bit Linux. If your PC is running on the 32-bit Linux or other systems, you will be prompted that the corresponding version file cannot be found. In this case, please take the second method **Building and Installing from Source** provided on the PyQt5 download page.

Check whether the installation is successful. Open the Python 3 command line/Python 3 shell after installation, and type in import PyQt5. If there is no error message, then everything is OK:

On **Windows**, double click on the Python 3.5  , type in *import PyQt5*, and run:



On **Linux** and **Mac OS X**, type in command *python3* in the terminal, and *import PyQt5* and run

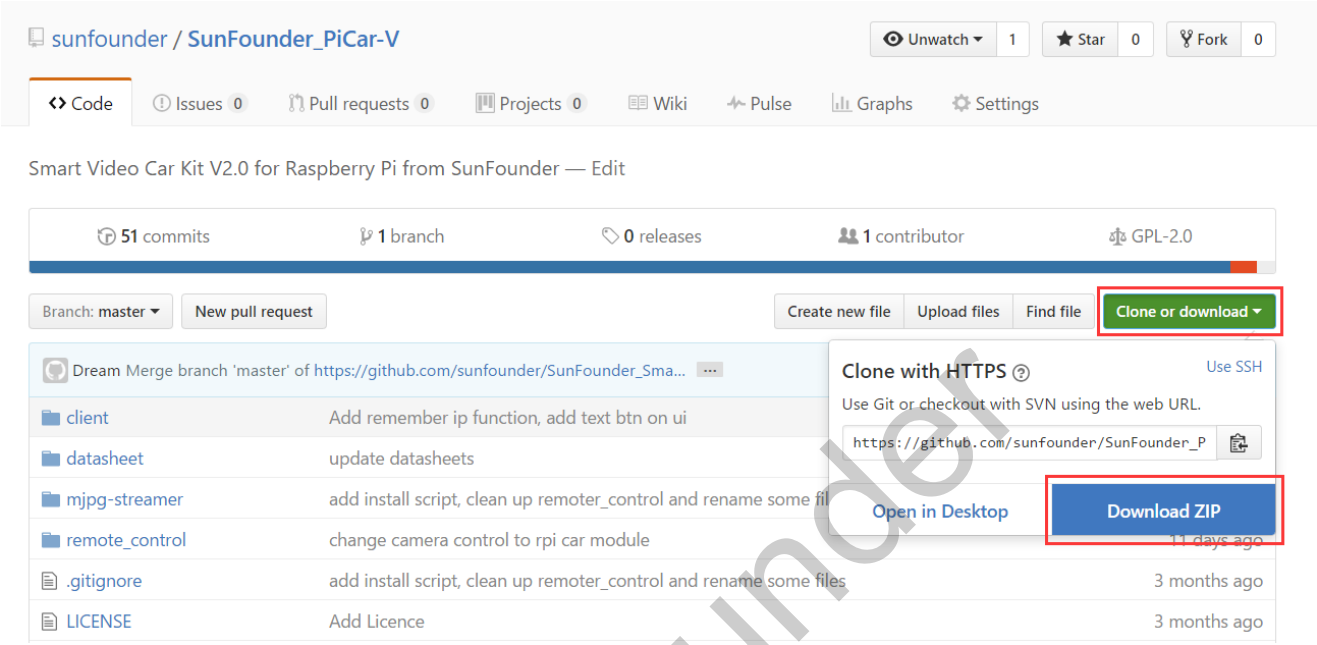


Code Package Download

Open a web browser and go to the Github page of the PiCar-V:

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

Click **Clone or download** on the page, and click **Download ZIP** as shown below.



After download, unzip the file.

Or in **Linux**, you can download the code package by git clone (recommended):

Install git with software manager:

Ubuntu/Debian:

```
sudo apt-get install git
```

Fedora/Red Hat:

```
sudo yum install git
```

Then clone the code:

```
git clone https://github.com/sunfounder/SunFounder_PiCar-V.git
```

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.

The code downloaded is the same with that under the server, but the client will only use the file in the client folder.

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. Then you can start the car now. Install two batteries, and turn on the power switch.

Tips: If you keep the Raspberry Pi power on from the beginning, now you do not need to turn it off. DO NOT unplug the Micro USB cable until you've installed the batteries and switched it on. So you do not need to turn it on or off again. If later the batteries run out, or half does, and you want to do the debugging, you can also just plug in the USB cable for power without shutting down. The Robot HATS integrates a backflow prevention diode to protect it from being damaged by the USB power, so does the Raspberry Pi. So take it easy for using the two power sources at the same time!

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.

1. Run the Server

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

```
cd ~/SunFounder_PiCar-V/remote_control
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:~ $ cd ~/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
None
System check identified no issues (0 silenced).
November 09, 2016 - 06:28:41
Django version 1.10.2, 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.

2. Run the Client

There are **TWO** methods to run the client. On one hand, you can open *Client* in the directory of the SunFounder_PiCar-V in PC, run *client.py* by Python 3. Or, if you happen to fail to install PyQt 5 or Python 3, or just want to control it on your phone or tablet, we have also prepared a web client via web browser.

- **Method A**

Open *Client* in the directory of the SunFounder_PiCar-V in PC, run *client.py* by Python 3.

If yours PC runs on **Linux**, you can run python 3 client.py in the terminal.

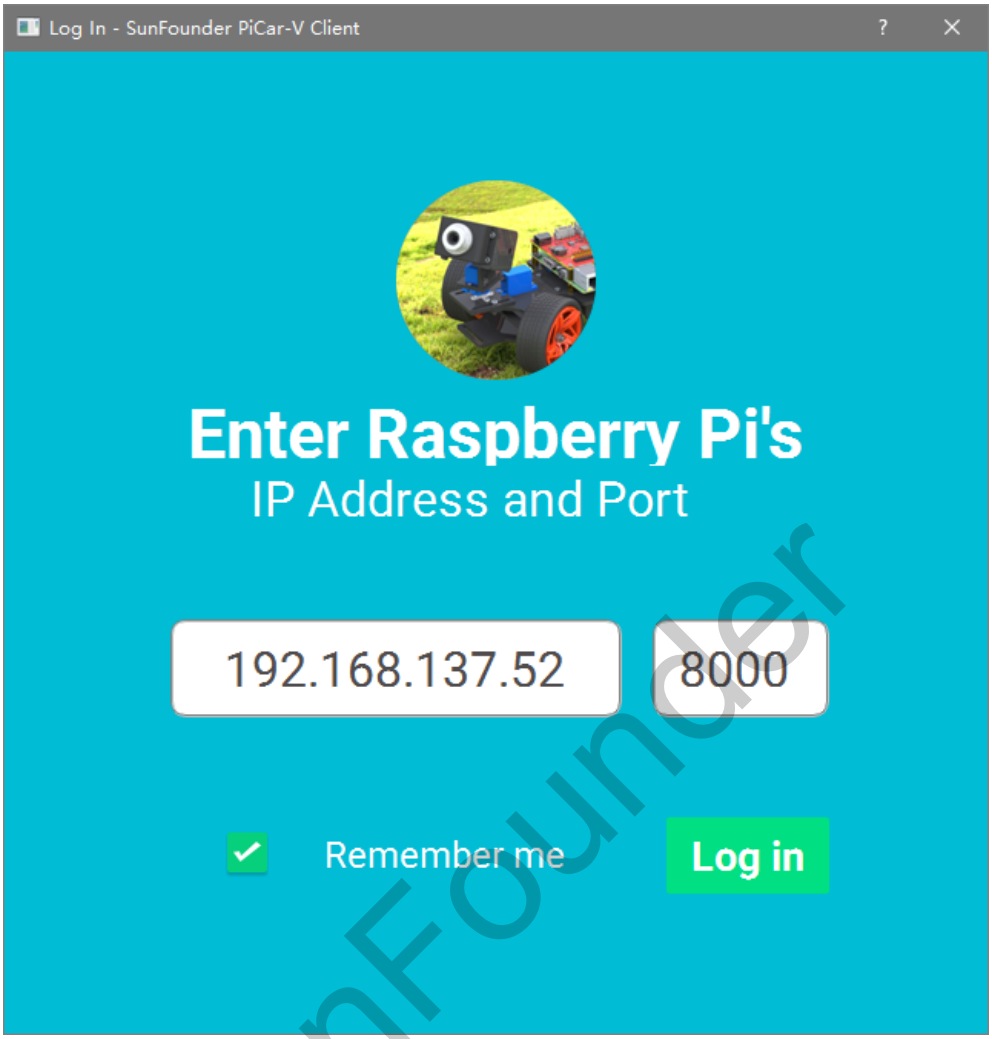
```
python client.py   # If Python 3 is the default or only python
python3 client.py  # Or you have both Python 2 and Python 3, and the default is Python 2
```

If it runs on **Windows**, since Python 3 has been installed previously, you can just double-click to run *client.py*. Make sure it runs under Python 3 not Python 2, if both are installed in your PC.

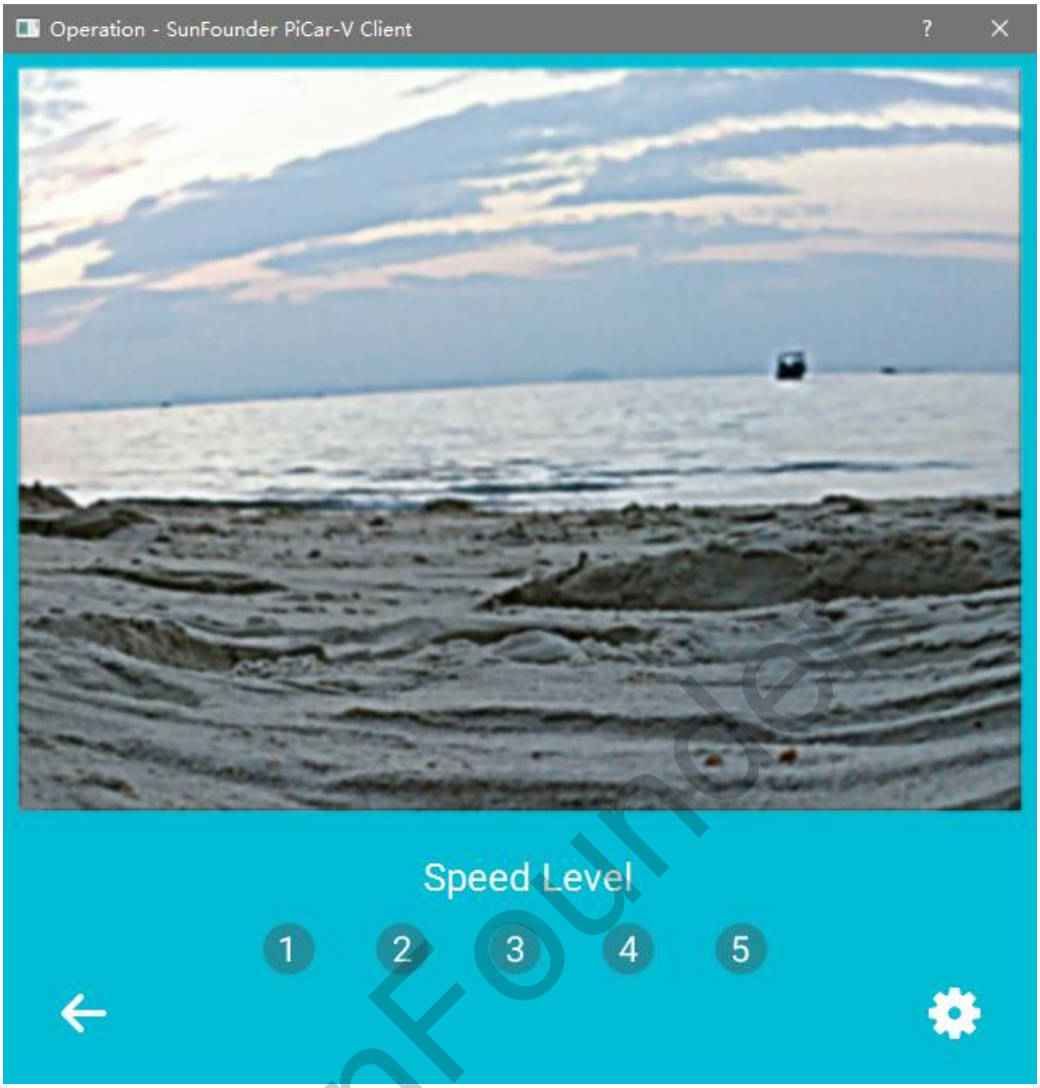
Notes:

In Linux, if only Python 3 is installed, python = python 3 in the terminal; if there're both Python 2 and Python 3 (quite a lot of systems have those two pre-installed), the python command will start Python 2 by default. To use Python 3, you need to use python 3 commands. Or you can configure the Python environment, to set the Python 3 as default.

Run the client and you will see:



This is the login interface of the client. Enter your Raspberry Pi's IP address and the port, 8000 by default, and then click **Log in** to connect to the Raspberry Pi. It may take a while to establish connection, sometimes may not respond at all, so just wait several seconds. If it's successful, you'll be on the operation interface. If not, double check your Raspberry Pi's IP address and make sure the server script is run without error prompts.



The interface will show the view captured by the camera in a real-time manner.

There are some number buttons at the bottom to adjust the car's speed, ascending from level 1 to 5. You can also press the key 1-5 on the keyboard. The rest control movements of the car are implemented by keyboard.

On keyboard:

W, **S**: to control the rear wheels to move forward/backward;

A, **D**: to control the front wheels to turn left/right;

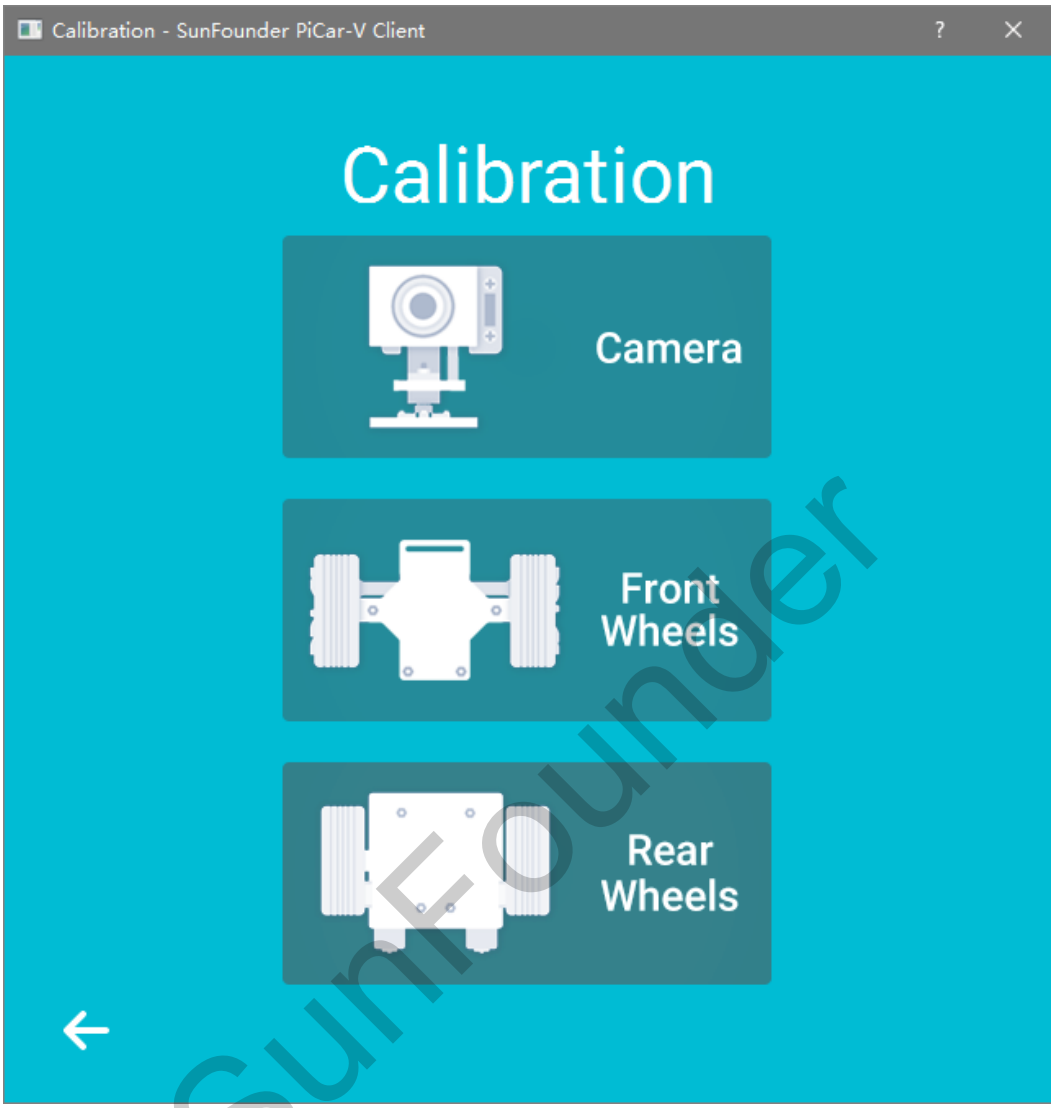
↑, ↓: to control the camera's rotating up/down;

←, →: to control the camera's rotating left/right.

Click the left arrow button at the bottom left or press **Alt** + ← to return to the previous page, that is, the login.

For better application, you're recommended to calibrate the assembled car first.

Click the setting button at the bottom right or press **Alt** + **S**, and you will see the **Calibration** page as below (click the three larger icons for the corresponding calibration):



Camera – to calibrate the camera movement. Short cut: **Alt** + **C**.

Front Wheels – to calibrate the front wheels. Short cut: **Alt** + **F**.

Rear Wheels – to calibrate the rear wheels. Short cut: **Alt** + **R**.

Click the arrow return button or **Alt** + ← and you will go back to the operation interface.

Calibration: Camera

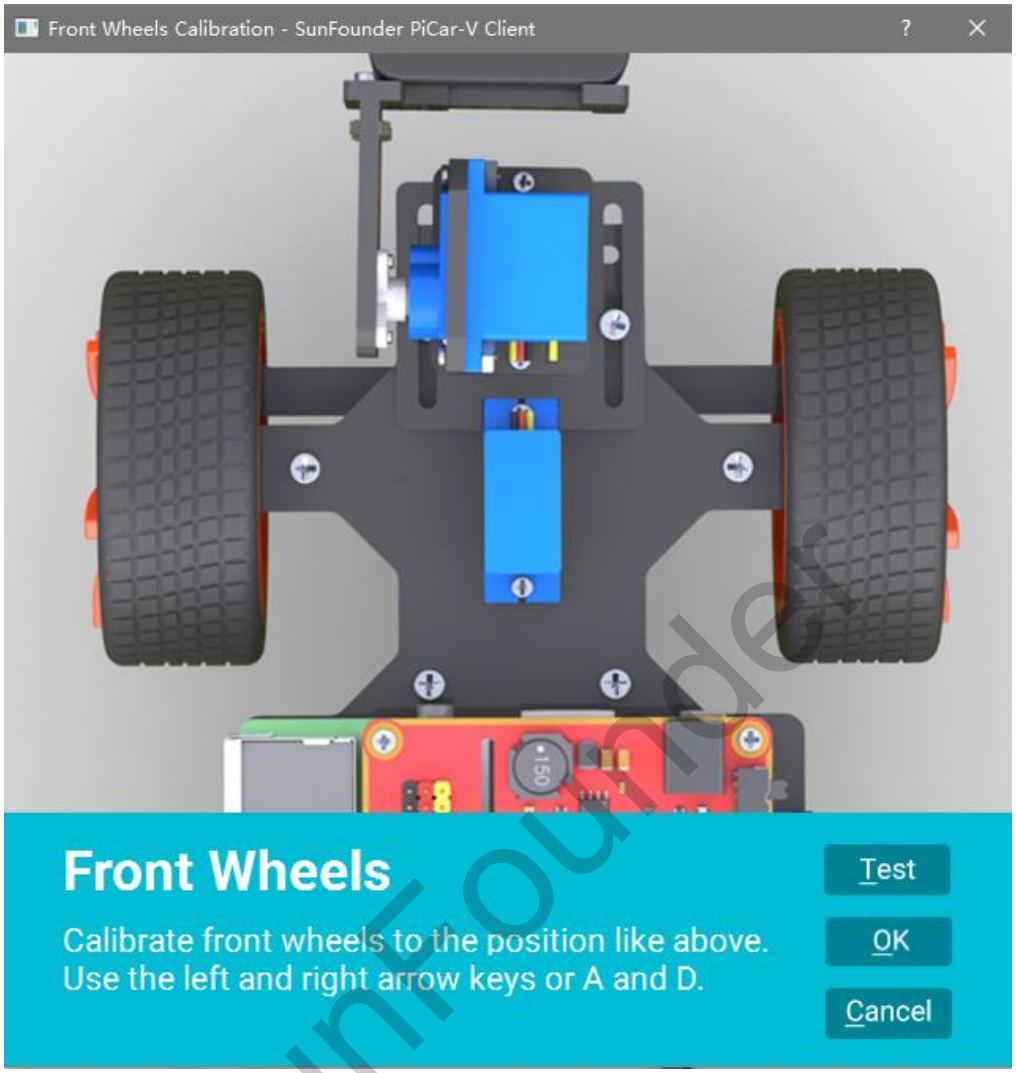
When completed, the camera should look like the figure above. The camera should be in the center line of the car and face exactly front. You can use the keyboard to adjust, by the arrow keys ↑, ←, ↓, and →, or **W**, **A**, **S**, and **D**. The servo turning angle is very small, so it's quite suitable for fine tuning; press and hold it to coarsely adjust quickly. Click **OK** or press **Alt** + **O** to save the calibration result; click **Cancel** or press **Alt** + **C** to cancel the calibration and exit.

Notes:

During the calibration, the servo may get stuck with an abnormal sound, and heated abnormally after a while if the servo shaft is not adjusted to 90° in the previous mechanical assembly. You should at once disconnect the wires of the servo and remove the rocker arm to readjust the shaft to 90° (refer to the previous **Servo Configuration** part).

After all the adjustments are done, click **OK**, and the server will write the data into the database files. Then the servo will respond to the database initialization with a little movement. Only after the initialization is done can you start the next step, or the server will reject the calibration request.

Calibration: Front Wheels



Adjust the front wheels to the appropriate position according to the above figure. You can use the keyboard to adjust, that is, ←, →, **A**, and **D**.

Click **OK** or press **Alt** + **O** to save the calibration result; click **Cancel** or press **Alt** + **C** to cancel the calibration and exit.

If the servo gets stuck, remove the rocker arm and readjust again (refer to the **Servo Configuration**).

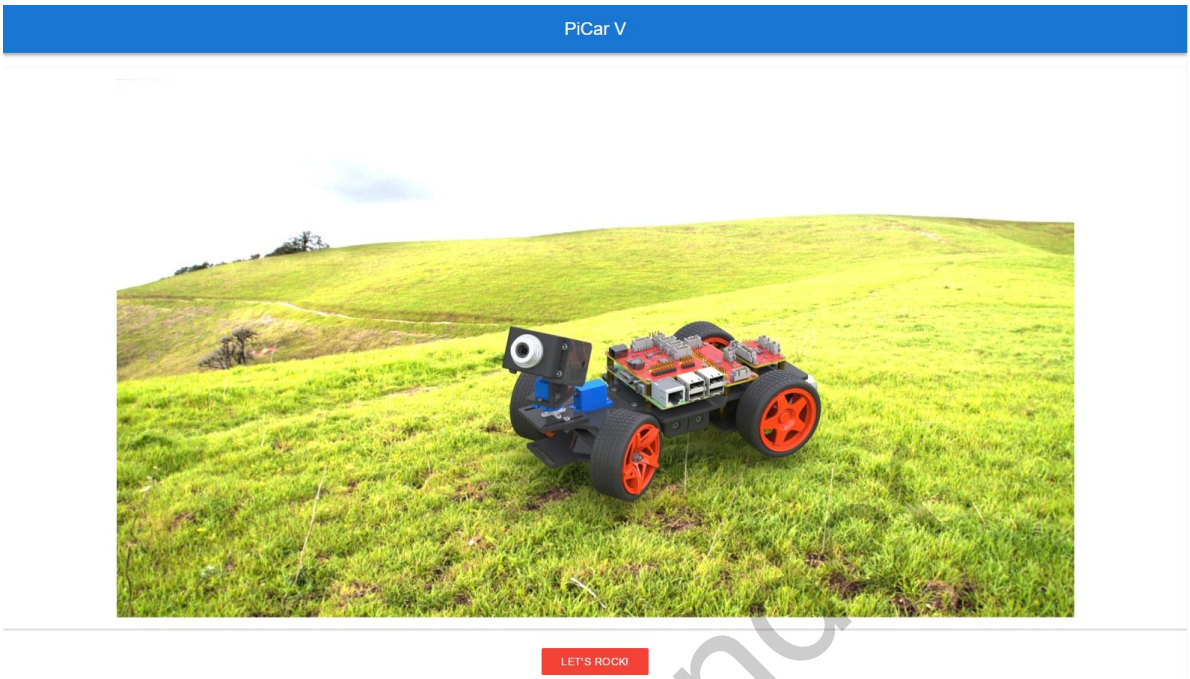
Calibration: Rear Wheels

Adjust the rotating direction of the rear wheels, to make the car go forward. Adjust the wheels by the keys ← and → or **A** and **D**. The left and right is to control the left and right wheels respectively and each clicking will reverse the rotation of the wheel.

After all the calibration is done, you can return to the operation interface. Make sure both LED indicators on the Robot HATS board light up. Now you can unplug the Micro USB cable and put the car on the ground. Let's start the journey!

- **Method B**

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

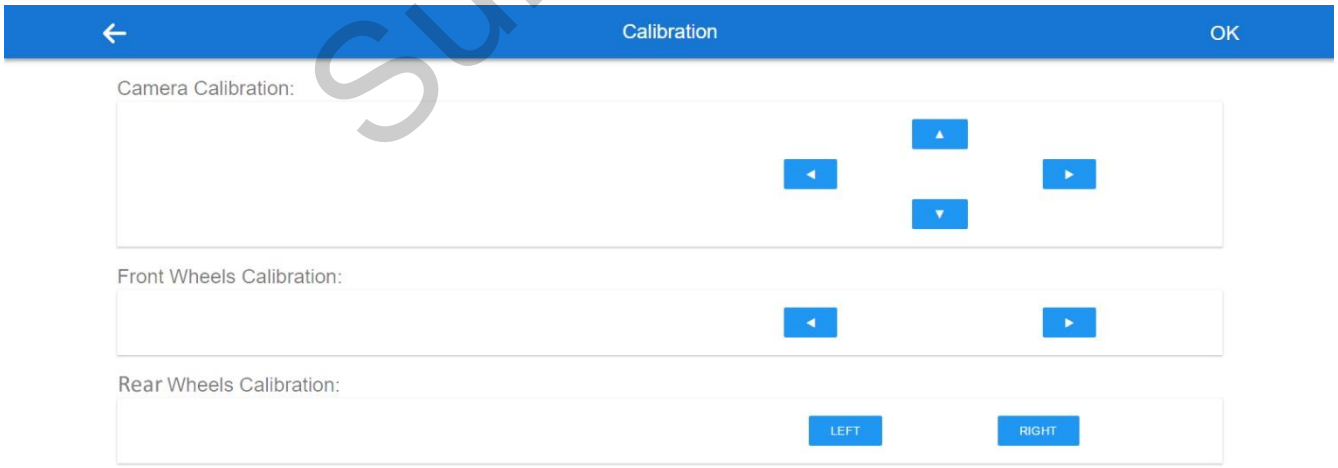


Click **LET'S ROCK** to go to the operation interface:

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.

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 touchpoint at one time.

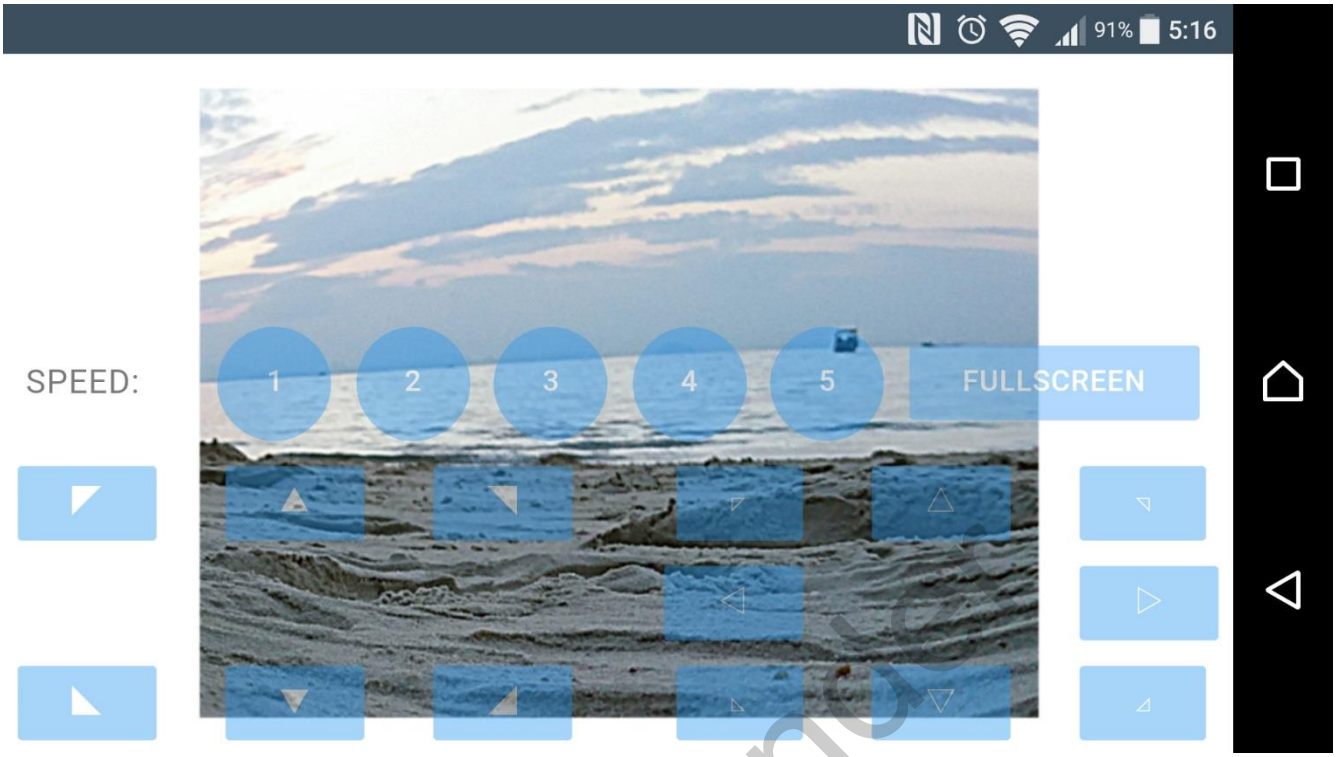
Click **FULLSCREEN** again to bring back the title bar. And then, tap the setting button at the top-right corner of the page to go to the calibration page:



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

Do the calibration for the servos and motors just as done in the PyQt client. Click **OK** to save the result after all the calibration is done.

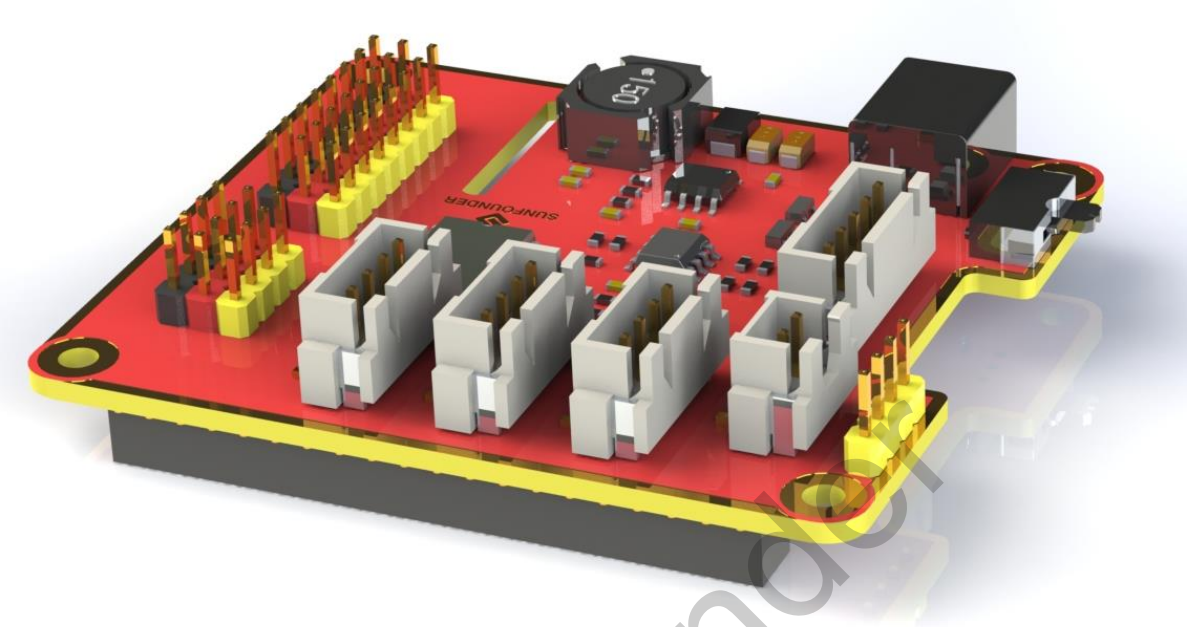
Take this screenshot from an Android phone:



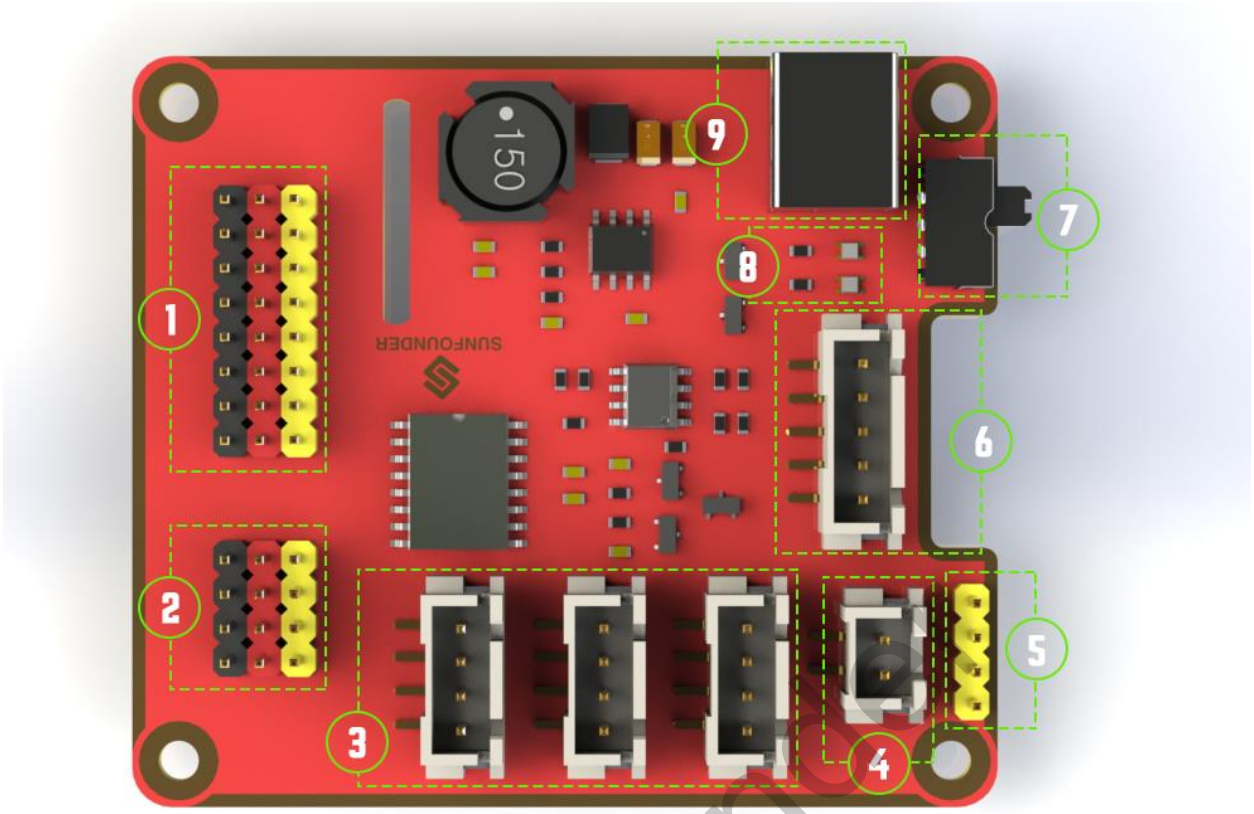
Though the appearance may not be as good as on the PC. Later updates may be released irregularly on **Github**. You are welcome to fork our repository and submit a Pull request with your changes. If there is no problem after testing, we are more than pleased to merge your request.

Components

Robot HATS

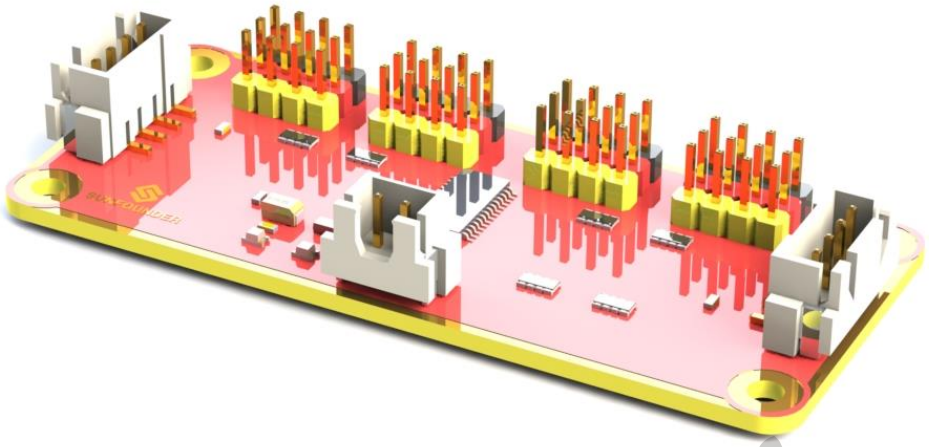


Robot HATS is a specially-designed HAT for a 40-pin Raspberry Pi and can work with Raspberry Pi model B+, 2 model B, and 3 model B. It supplies power to the Raspberry Pi from the GPIO ports. Thanks to the design of the ideal diode based on the rules of HATS, it can supply the Raspberry Pi via both the 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.

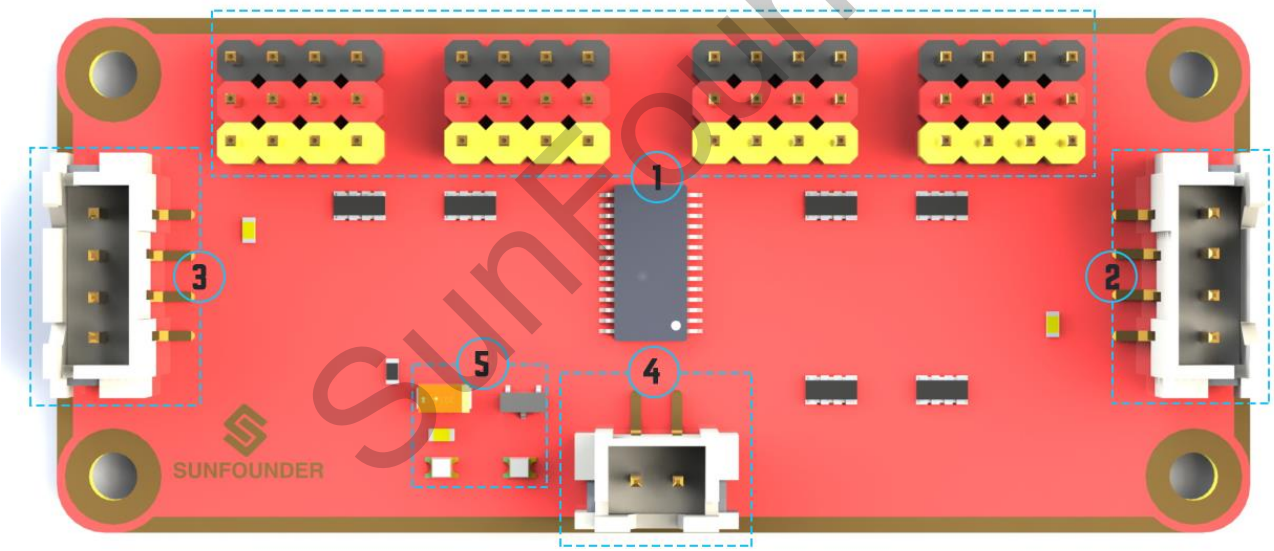


1. **Digital ports**: 3-wire digital sensor ports, signal voltage: 3.3V, VCC voltage: 3.3V.
2. **Analog ports**: 3-wire 4-channel 8-bit ADC sensor port, reference voltage: 3.3V, VCC voltage: 3.3V.
3. **I2C ports**: 3.3V I2C bus ports
4. **5V power output**: 5V power output to PWM driver.
5. **UART port**: 4-wire UART port, 5V VCC, perfectly working with SunFounder FTDI Serial to USB.
6. **TB6612 motor control ports**: includes 3.3V for the TB6612 chip, 5V for motors, and direction control of motors MA and MB; working with SunFounder TB6612 Motor driver.
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



PCA9685 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.



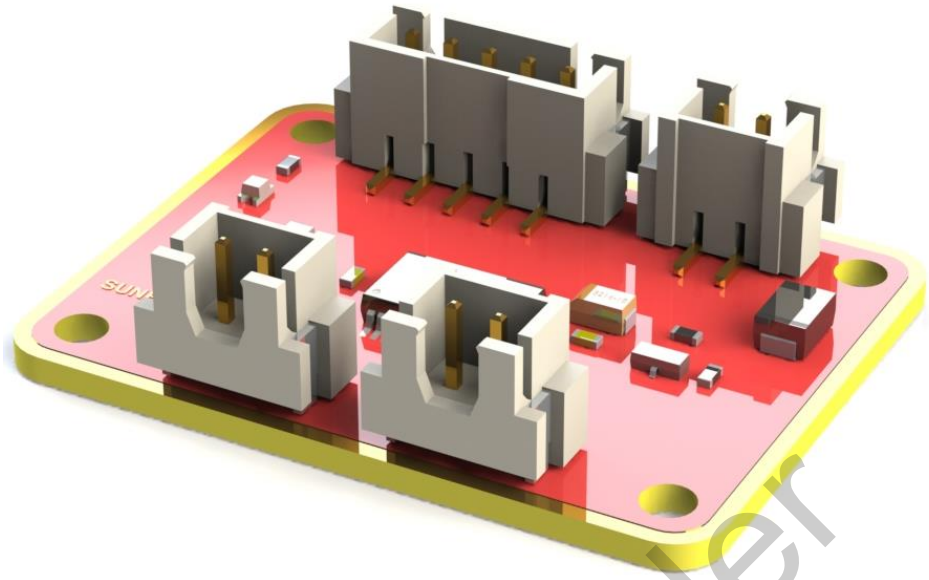
1. **PWM output ports**: 3-color ports, independent power PWM output port, connect to the servo directly.

2 & 3. **I2C port**: 4-wire I2C port, can be used in parallel. Compatible with 3.3V/5.5V

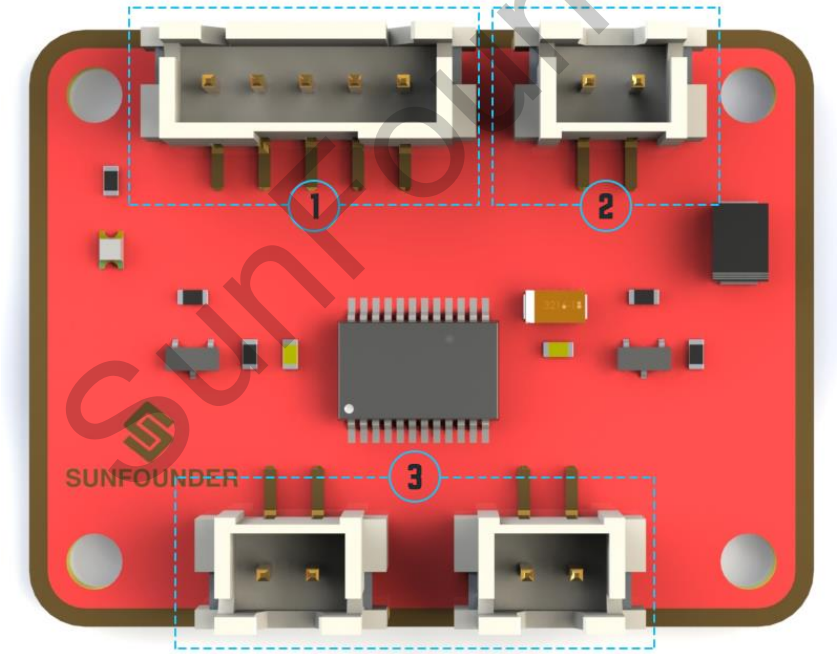
4. **PWM power input**: 12V max.

5. **LED**: power indicator for the chip and for the PWM power input.

TB6612



The TB6612 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 SF0180 Servo

The SunFounder SF0180 Servo is a 180-degree three-wire digital servo. It utilizes PWM signal of 60Hz and has no physical limit – only control by internal software to 180 degrees at most.

Electrical Specifications:

Item	V = 4.8V	V = 6.0V
Operating speed (no load)	0.12 Sec/60°	0.09 Sec/60°
Running current (no load)	140 mA	200 mA
Stall torque (locked)	2.0 kg-cm	2.5 kg-cm
Stall current (locked)	520 mA	700 mA
Idle current (stop)	5 mA	5 mA

For more information, refer to SunFounder_PiCar-V/datasheet/SunFounder_SF0180.pdf in the code package on our Github page. .

WiFi Adapter

The Ralink RT5370 Wireless Adapter is used in the car. Below are the features:

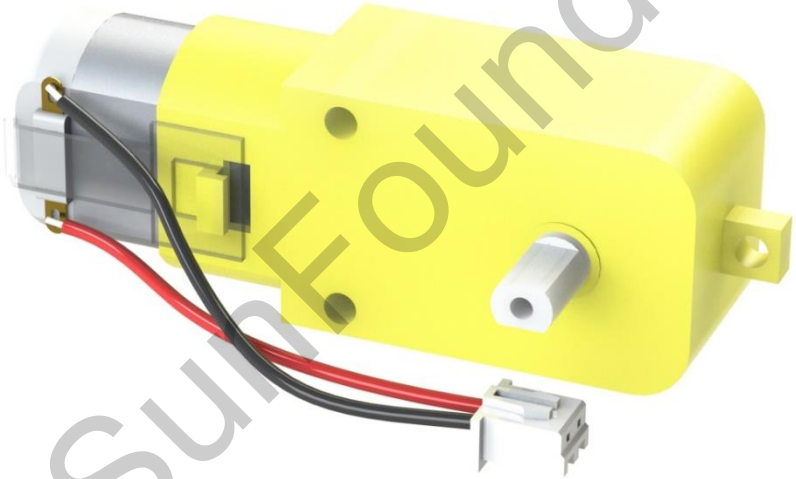
USB: XC1291

Network Connectivity: Wireless-Wi-Fi 802.11b, Wireless-Wi-Fi 802.11g, Wireless-Wi-Fi 802.11n

Applicable Network Type: Ethernet

Transmission Rate: 150Mbps

DC Gear Motor



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

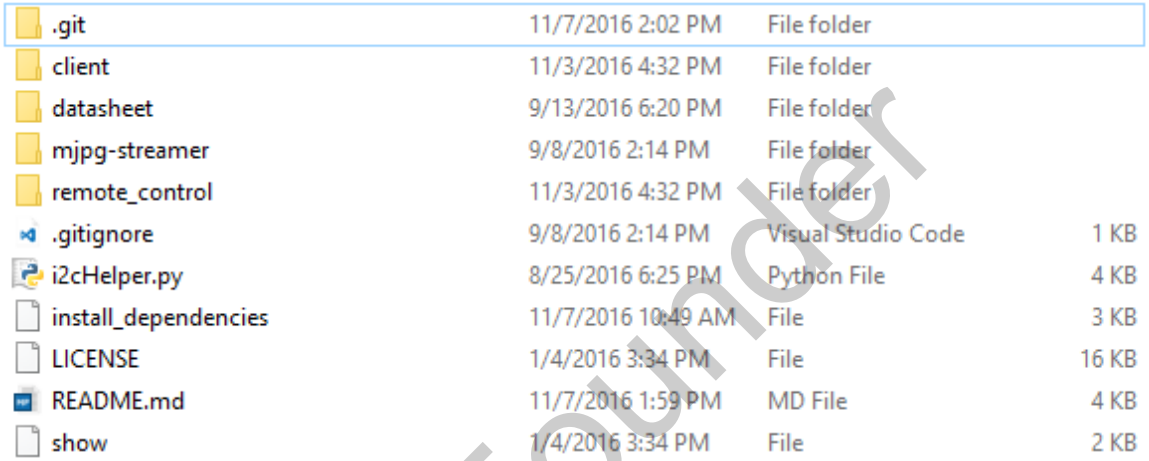
Motor	Model	F130SA-11200-38V
	Rated Voltage	4.5V-6V
	No-load Current	≤80mA
	No-load Speed	10000±10%
Gear Reducer	Gear Ratio	1:48
	Speed (no-load)	≈200rpm (≈180rmp in test)
	Current	≤120mA

Code Explanation

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, PyQt, 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.
- `client` is to store the code of the PC client.
- `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.
- `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/, or read *The Django Book* to learn more at http://gsl.mit.edu/media/programs/south-africa-summer-2015/materials/djangobook.pdf. 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.

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:

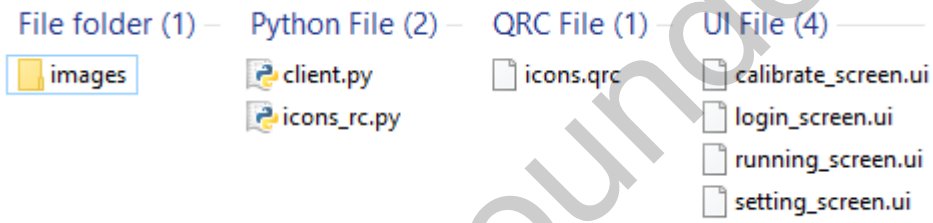
```
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control/templates $ cd
templates
pi@raspberry:~/SunFounder_PiCar-V/remote_control/remote_control/templates/templates
$ ls
base.html  cali.html  run.html
```

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.

So that's the code of the server. Next we will come to the code of the client written by PyQt.

Client Code

In **Windows**, you can check the contents of client directory by grouping files by file type:



- `client.py`, is the main part of the code of the client.
- `icons_rc.py` is the python code converted from the UI resource file of Qt, which is the `icons.qrc` file beside, by `pyrcc5 -o icons_rc.py icons.qrc`.
- `icons.qrc` is the Qt resource file and restores the location of the resource pictures.
- `.ui` is the ui file, or the graphical user interface (GUI) file designed by the Qt tool. Open it by a text editor and you will see the code is written similar to an xml file.
- `images` stores the picture resources used in designing the UI (user interface). Do not rename or move the folder and the files in it, or else the corresponding content on the UI will be missing because it fails to find the graphic resource.
- `_pycache_` not shown in the figure above, is a cache folder automatically generated when you run a `.py` file of the client. If you've just downloaded it and not run yet, it's not generated.

The code of the client is written in Python 3, and the GUI is designed by the Qt tool. The open source library PyQt is used in the client.py to load the .ui file written by Qt into the python code.

For more information about PyQt, please visit the website:

https://riverbankcomputing.com/software/pyqt/intro

The interfaces go one by one like this:

1. The **login** page: enter the Raspberry Pi's IP address and click **Log in** go to the operation interface.

2. The **operation** interface will show the view captured by the camera. You can control the movement of the car on this page. You can click the return button, to go back to login, and the settings button to go to calibration interface.

3. The **calibration** interface: you can control and adjust the car by keyboard. Click **OK** to save the calibration data, and **Cancel** to return to the upper level interface.

Now after going through the code, you may wonder actually how to design the graphical interface and use PyQt. So let's take a closer look!

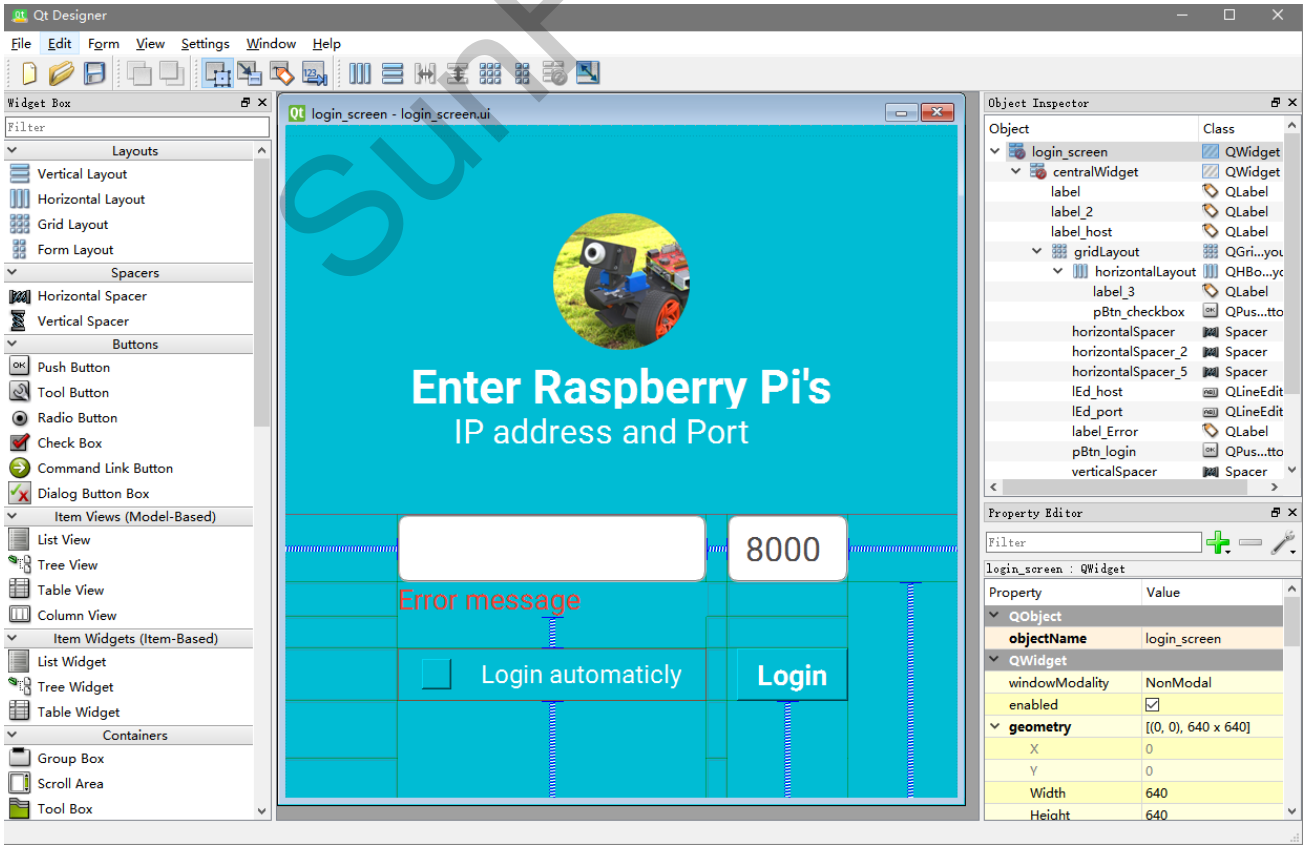
1. Designing the Interface

Let's start with the design interface.

In **Windows**, if you install the PyQt by the .exe package, select the option to install all, so the GUI design tools like the Qt Designer will be installed automatically. Or you can install the entire kit of Qt by yourself. Download the package (may need some setting and registration):

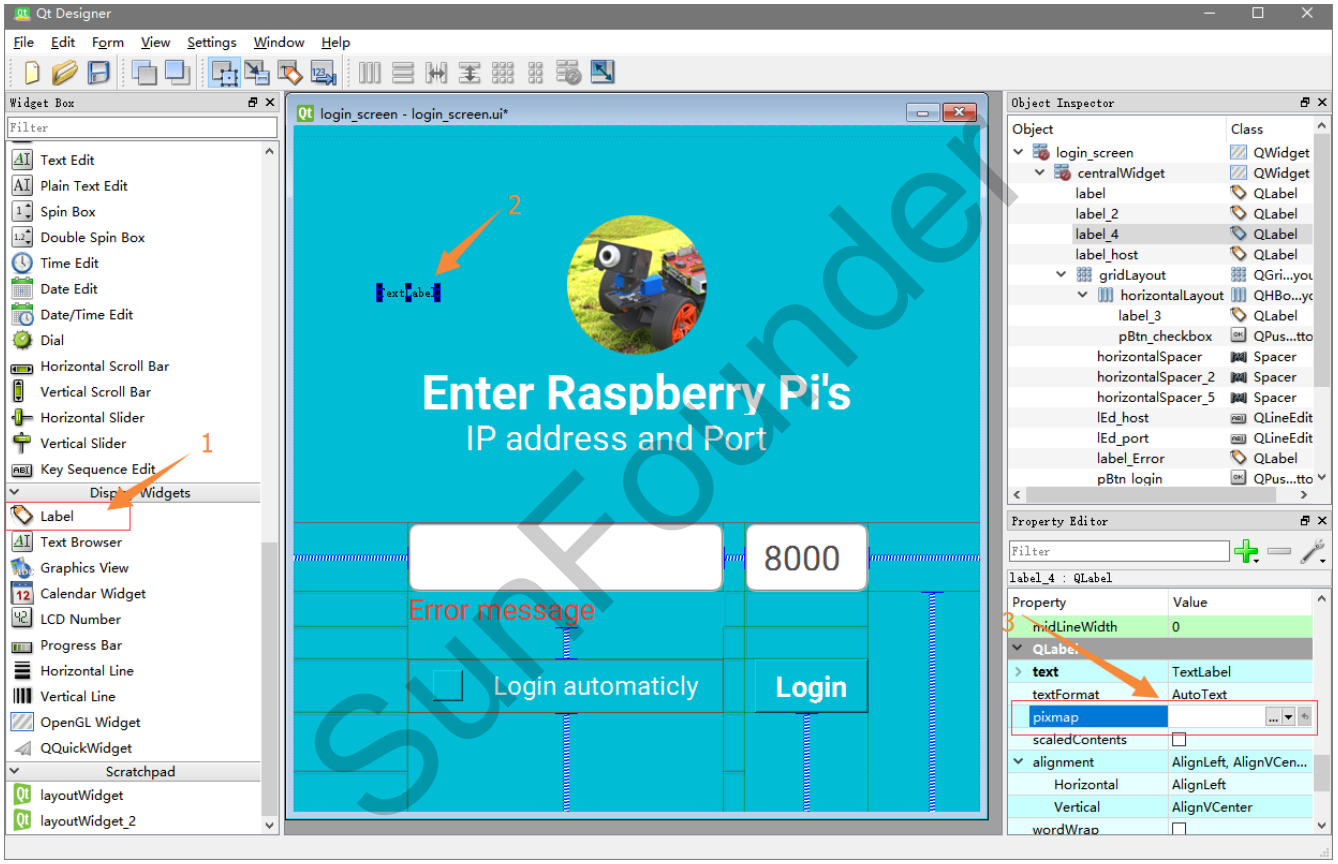
https://www.qt.io/developers/

Open the .ui file with a Qt tool after the installation is completed. The Qt designer in Qt tools is a GUI design tool.

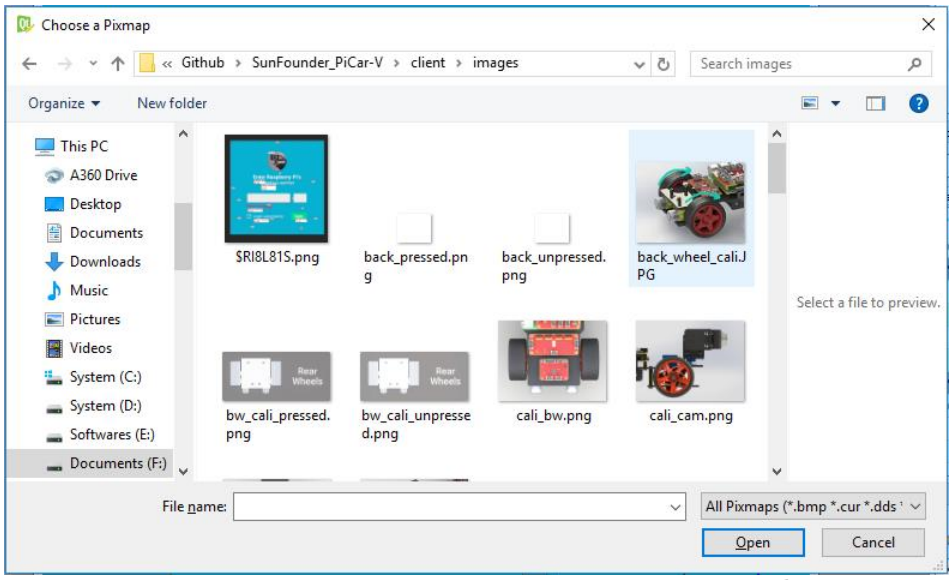


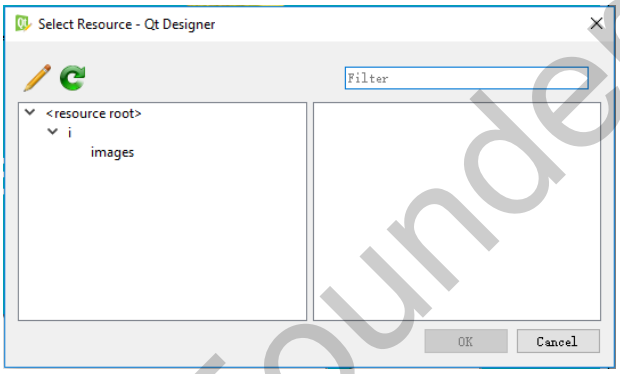
Design the first interface (login), with the GUI design tool. In the left column is the **Widget Box** section. You can just drag the components available here to the edit window in the center to see the effect directly. In the right column, on top is **Object Inspector**, where you can check the association and category of the added objects. Under this section, the property of the object is shown. You can set the attributes in this part, to differentiate all the widget objects.

Let's take the picture of the login interface as an example. Drag a **Label** from **Widget Box** to the picture, then click on the label and there is a square around, by which you can change its size and position. Then in the property part, select **pixmap** under **text** and click the box next to it, and on the pop-up drop-down list, select to read the picture from resource or from file.



If you choose to read from file, find the picture to be used, select it and click **OK**; to read from resource, create the resource file first. It is very simple – by the pencil icon (edit button) in the window of creating from resource. Click the icon, and select to create a resource and load it.





The setting of other components such as button, line edit and on, is just similar, though the properties are different. The name of the objects whose property has been changed will be marked bold automatically for convenience in next check. You can open those .ui files to see the property details that can be changed, or the widget type by objects in **Object Inspector**. After editing, you can select **Window** -> **Preview** in the Qt Designer to see the effect, or by the shortcut **Ctrl** + **R**.

Don't need to worry if you are not familiar with Qt because great details are given in the Qt document. If you don't know which property is for what use, you can check **Help** or the Qt assistant. And those sample sketches of Qt will help a lot for you to learn about Qt.

2. Programing the Functions

Now the interface design is finished. However, the interface files are just some static images and cannot be put into use. So the next step, write the client.py to implement all the interfaces with the corresponding functions as well as redirections. The PyQt is like this:

```
1
2  import sys
3  from PyQt5 import QtCore, QtWidgets, uic
4
5  qtCreatorFile = "" # Enter file here.
6
7  Ui_MainWindow, QtBaseClass = uic.loadUiType(qtCreatorFile)
8
9  class MyApp(QtGui.QMainWindow, Ui_MainWindow):
10     def __init__(self):
11         QtGui.QMainWindow.__init__(self)
12         Ui_MainWindow.__init__(self)
13         self.setupUi(self)
14
15 if __name__ == "__main__":
16     app = QtGui.QApplication(sys.argv)
17     window = MyApp()
18     window.show()
19     sys.exit(app.exec_())
20
```

In Line 5, enter the name of the ui file you designed in the quotation marks.

In Lin 7e, "uic" is the contents in the previously imported PyQt; the built-in function loads the ui files.

In Line 9-13, the class defined is just your GUI window. Define (*def*) the corresponding functions in the class and write the functions in them. The first *def* __init __ (self) is the initialization function which is a constructor in C++. It means when the instance is created, the program will run the code and initialize the instance.

Line 15-19 is the entry of the __main__ function, where it starts to execute the whole program.

So here's how the program goes:

1. Run the __main__ function and create an instance *app* of QApplication, which is the GUI application.
2. Create an instance *window* of the MyApp class type. After the creation is done, run the __init__ initialization function of the class.
3. The window instance is displayed.
4. Wait for a while. If the instance *app* of the GUI application sends an exit signal *app.exec_()*, then enter sys.exit() to exit Python.

So that's all for the code. Here we've only looked at the entry-level usage. For more detailed code explanation, go to the *client.py* file. There you can see very detailed comments.

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/SunFouner_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: 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=on
```

9. Reboot

```
sudo reboot
```

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