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 build your own project. If you have interest in open source or making something cool, welcome to join us! Visit www.sunfounder.com for more!

About Crawling Quadruped Robot Kit for Arduino

This learning kit is based on the popular open source electronics platform Arduino. It is different from most popular kits on the market. With this kit, you cannot only learn how to use Arduino, servo and wireless module but also DIY a cool crawling quadruped robot with wireless remote control. We provide a very detailed manual and technical support for free. And we are ready to answer your questions at any time. If you want to DIY your own robot, this kit is a good start.

The detailed explanation of the code is provided in this manual for high-level learning. Apart from the current functions the robot supports, you may also explore much more possibilities on it! Just think big and try to bring it into reality. If you find it hard to implement, welcome to share your thoughts with our engineers!

Notes

- There are some 3D models showed in this manual, whose color and shape may be different from real objects.
- Please follow instructions in the manual in case of damage to the components.
- These components may be fragile, so please do not attempt any operations that may hurt them.
- We provide free technical support, but man-made damages to components are excluded.

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.

Reprint 3.0

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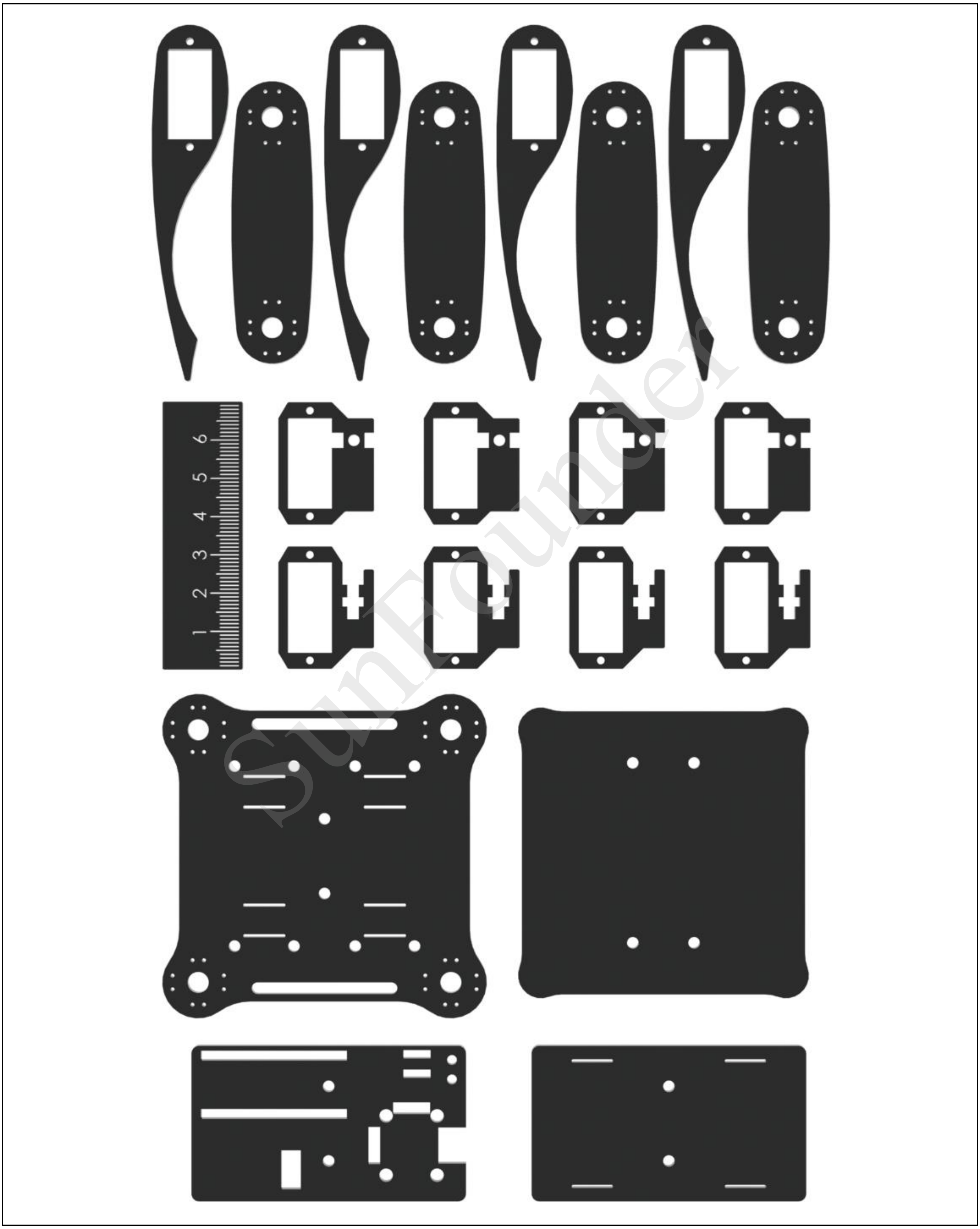
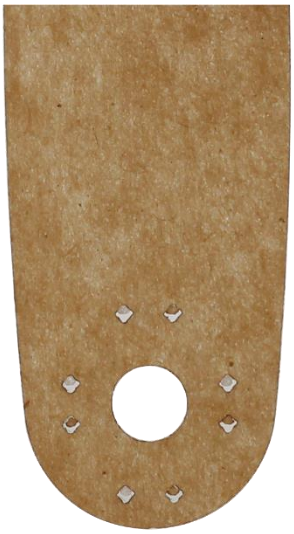
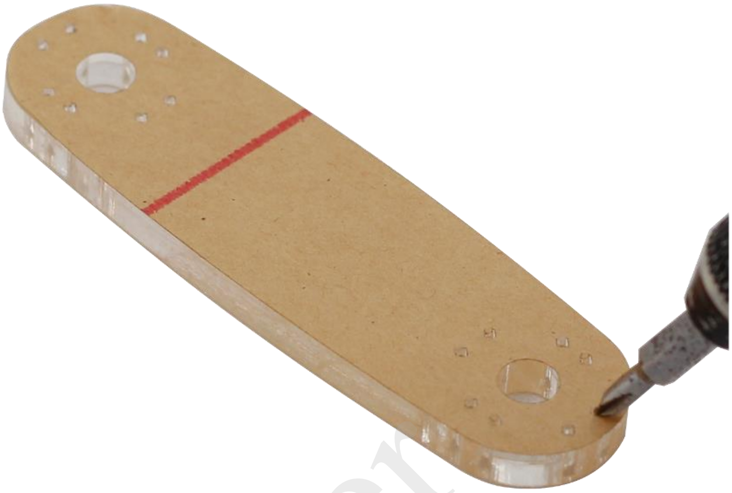
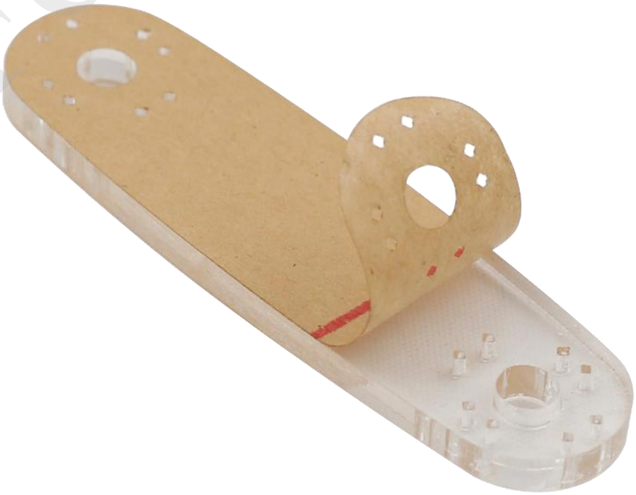
Components List

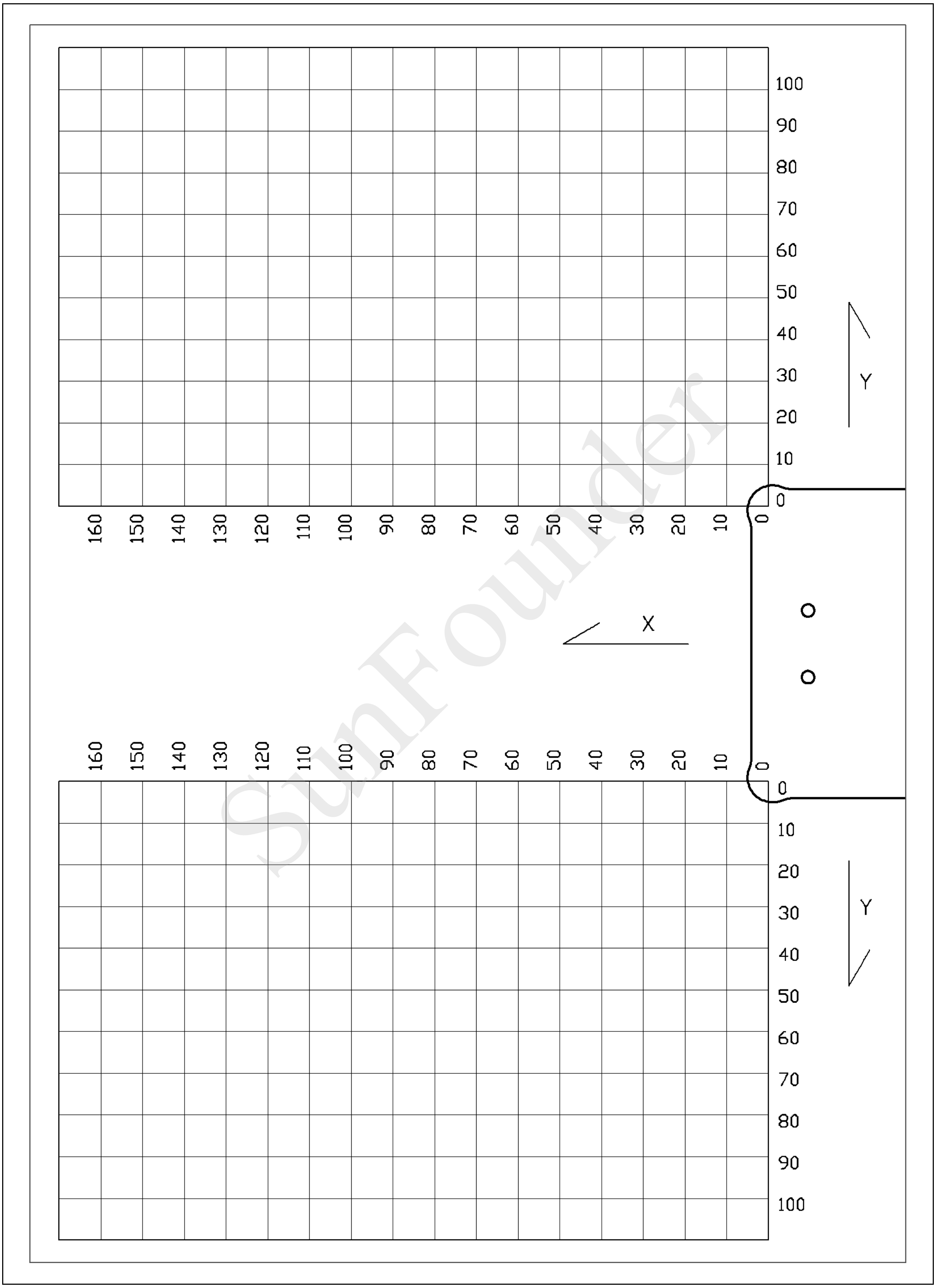
Acrylic Plates



You need to clean the acrylic plates before using them. We take one plate for example.

1. There are some residues in the holes of the plate. 	2. Clean the residues – use a tool with sharp point. 
3. Make sure all residues are cleared out. 	4. Finally remove the sticker on two faces of the plate (you may need a sharp tool to help scrape the edge of the sticker). 

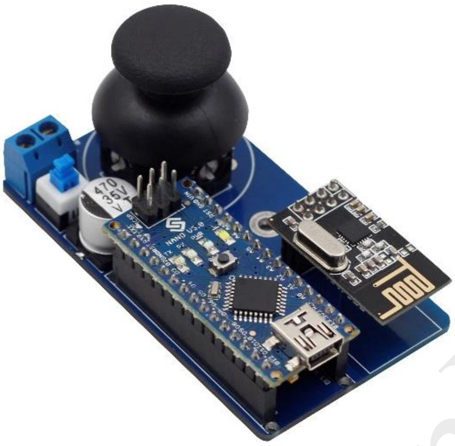
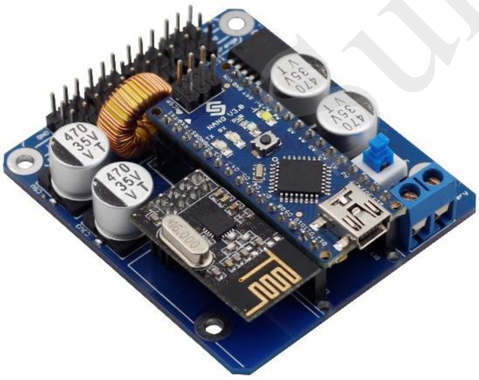
Calibration Chart

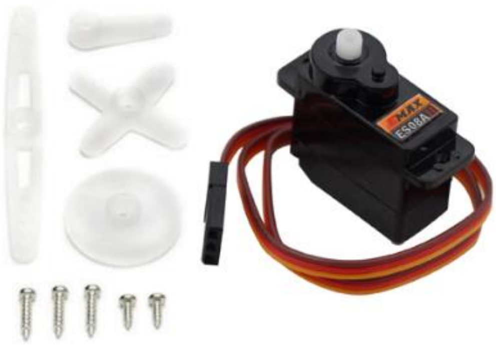


Threaded Fasteners

Accessory	Name	Quantity
	M1.2*4 Self-tapping Screw	100
	M2*8 Screw	26
	M2 Nut	26
	M3*10 Screw	6
	M3*8 Screw	6
	M3*6 Screw	6
	M3*14 Countersunk Screw	4
	M3*10 Countersunk Screw	4
	M3*30 Copper Standoff	6
	M3*8 Copper Standoff	6
	M3 Nut	20

Electronic Accessories

Accessory	Name	Quantity
	nRF24l01 Module	2
	SunFounder Nano Board	2
	SunFounder Mobile Robot Remote Controller	1
	SunFounder Servo Control Board	1
	2x18650 Battery Holder	2

	EMAX ES08AⅡ Analog Servo	12
	USB Data Cable	1
	Wire Harness Tube (80cm)	1
	Ribbon (50cm) (Divided into four equal parts)	1

Tools

Accessory	Name	Quantity
	Screwdriver	1

Self-provided Components

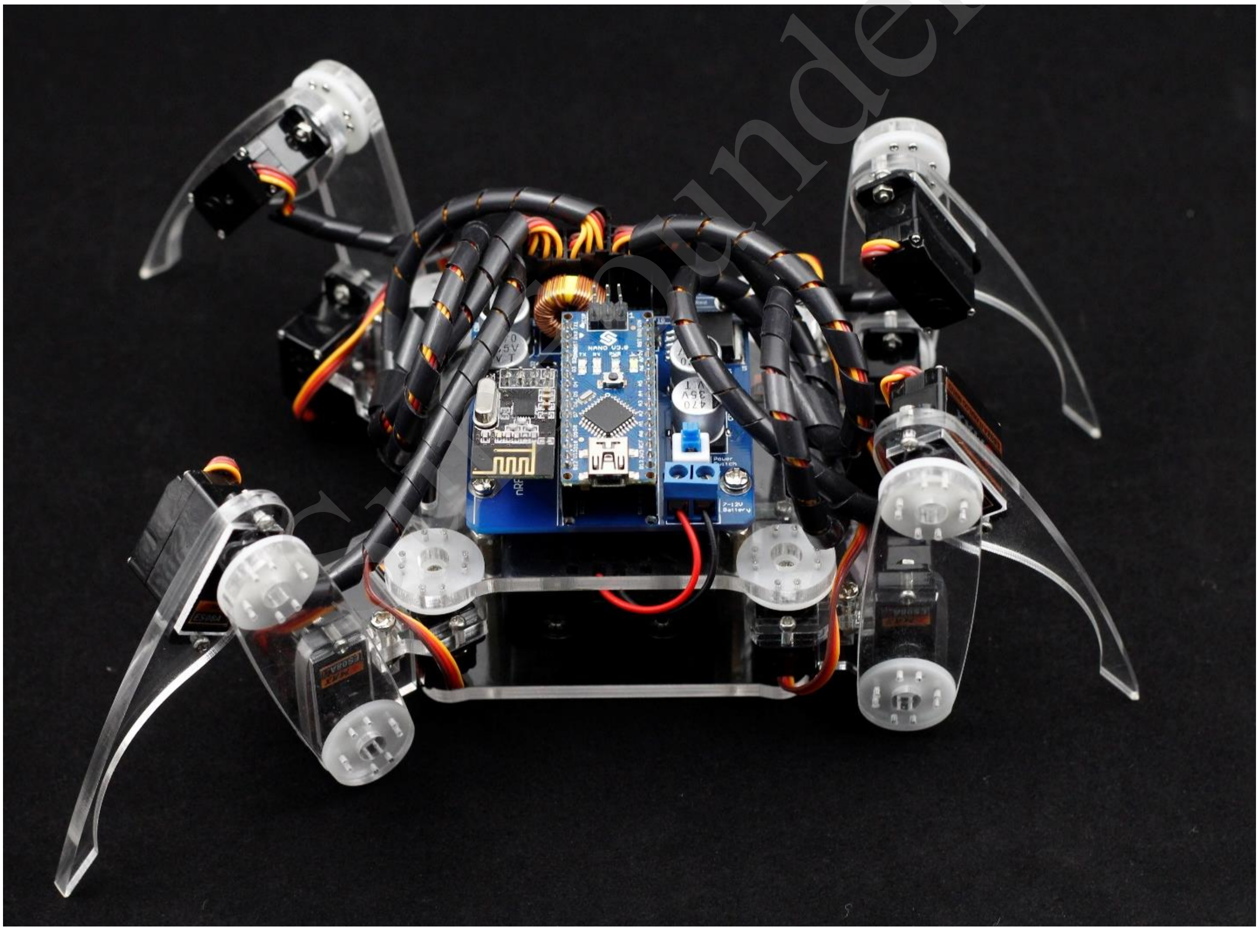
The following components are not included in this kit.

Accessory	Name	Quantity
	18650 Rechargeable Li-ion Battery (3.7V)	4

1. Introduction

The SunFounder Crawling Quadruped Robot kit is a great learning tool for Arduino and robotics enthusiasts. With the knowledge in mechanic structure and electronic design, you can take it as a functional stepping stone into the amazing coding world!

This interesting "creature" is a four-leg mobile robot, and each leg has three joints driven by a servo. It is powered by two 18650 rechargeable Li-ion batteries, compatible with Arduino Nano V4.0 board and uses the SunFounder Nano board as control. In addition, a SunFounder Servo Control Board integrates battery, servo, SunFounder Nano board, and nRF24l01 wireless module together. This kit is equipped with a SunFounder Mobile Robot Remote Controller so that you can observe and control the robot remotely. Or you may control it by your computer (mouse or keyboard) after installing a sketch provided on your PC.



2. Getting Started with Software

Note:

Before starting your own project, you must download the file ***CD****.zip* on our official website on **LEARN** -> **Get Tutorials** -> **Crawling Quadruped Robot Kit for Arduino** and unzip it.

Arduino

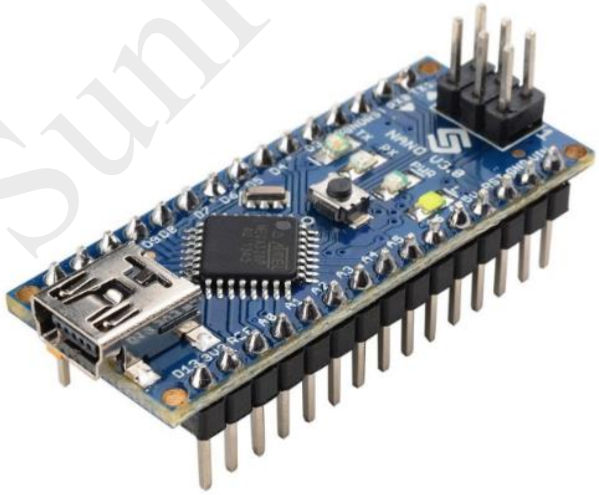
Description

Arduino is an open source platform that applies simple software and hardware. You can get it in a short even when you know little of it. It provides an integrated development environment (IDE) for code editing and compiling, compatible with multiple control boards. So you can just download the Arduino IDE, upload the sketches (i.e. the code files) to the board, and then you can see experimental phenomena. For more information, refer to http://www.arduino.cc.

Arduino Board – SunFounder Compatible

Arduino senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators.

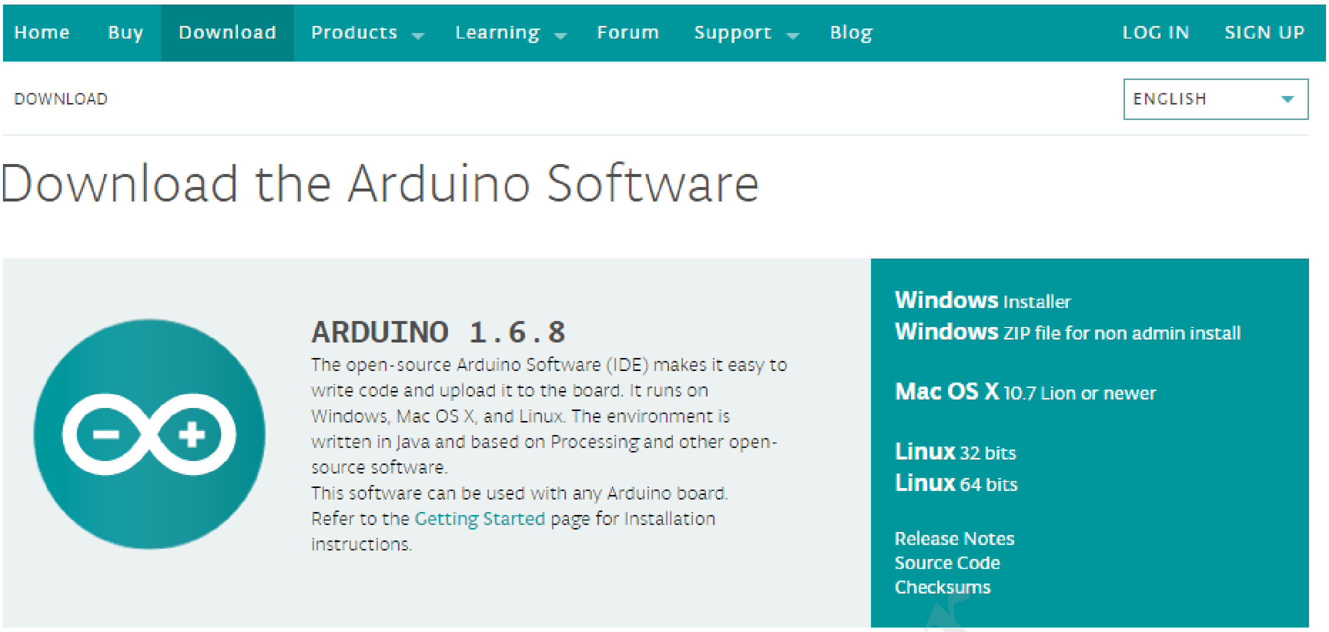
In this kit, SunFounder Nano board is used.



Install Arduino IDE

The code in this kit is written based on Arduino, so you need to install the IDE first. Skip it if you have done this.

Now go to the arduino.cc website and click **DOWNLOAD**. On the page, check the software list on the right side under **Download the Arduino Software**.



Download the Arduino Software

ARDUINO 1.6.8

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.
This software can be used with any Arduino board.
Refer to the Getting Started page for Installation instructions.

Windows Installer
Windows ZIP file for non admin install

Mac OS X 10.7 Lion or newer

Linux 32 bits
Linux 64 bits

Release Notes
Source Code
Checksums

Find the one that suits your operation system and click to download. There are two versions of Arduino for Windows: Installer or ZIP file. You're recommended to download the former. Just download the package, and run the executable file to start installation. It will download the driver needed to run Arduino IDE. After downloading, follow the prompts to install. For the details of installing steps, you can refer to the guide on **Learning**->**Getting Started with Arduino**, scroll down and see **Install the Arduino Software**.

After installing, you will see Arduino icon on your desk and double click to open it.

Install the Driver

If the driver is not installed, the Nano board will not be able to be recognized by your computer. Therefore, before using it, please install appropriate driver.

For Windows users, run ***PL2303_Prolific_DriverInstaller_v1.10.0.exe*** in the folder CD.

For Mac users, refer to the folder ***PL2303_MacOSX_1_6_1_20160309*** in the folder CD.

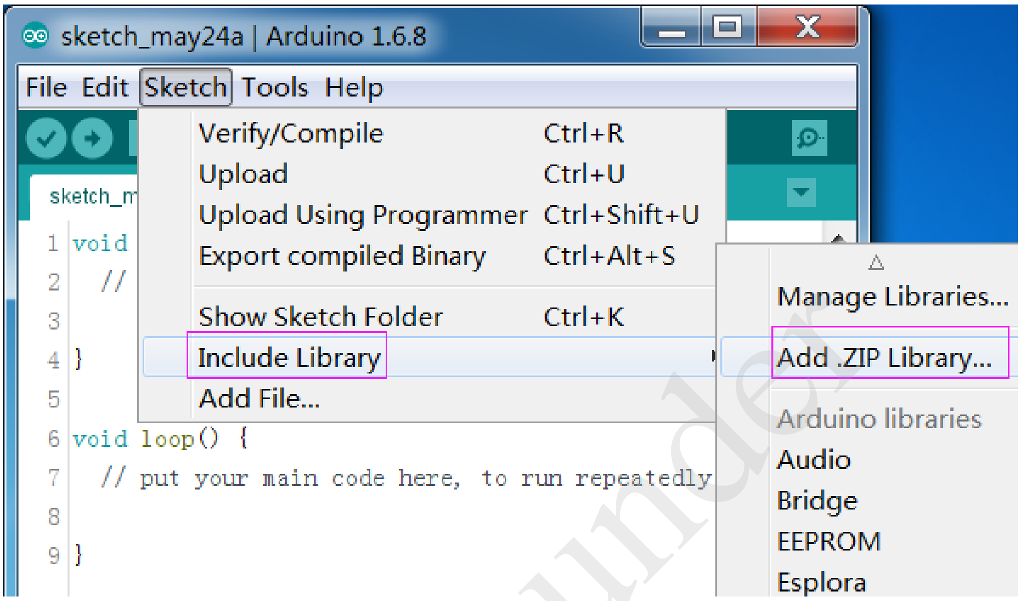
Add Libraries

Libraries are a collection of code that makes it easy for you to connect to a sensor, display, module, etc. There are hundreds of additional libraries available on the Internet for download.

The Arduino IDE can be extended through the use of libraries, just like most programming platforms. Libraries provide extra functionality for use in sketches, like working with hardware or manipulating data. A number of libraries come installed with the IDE, but you can also download some or create your own.

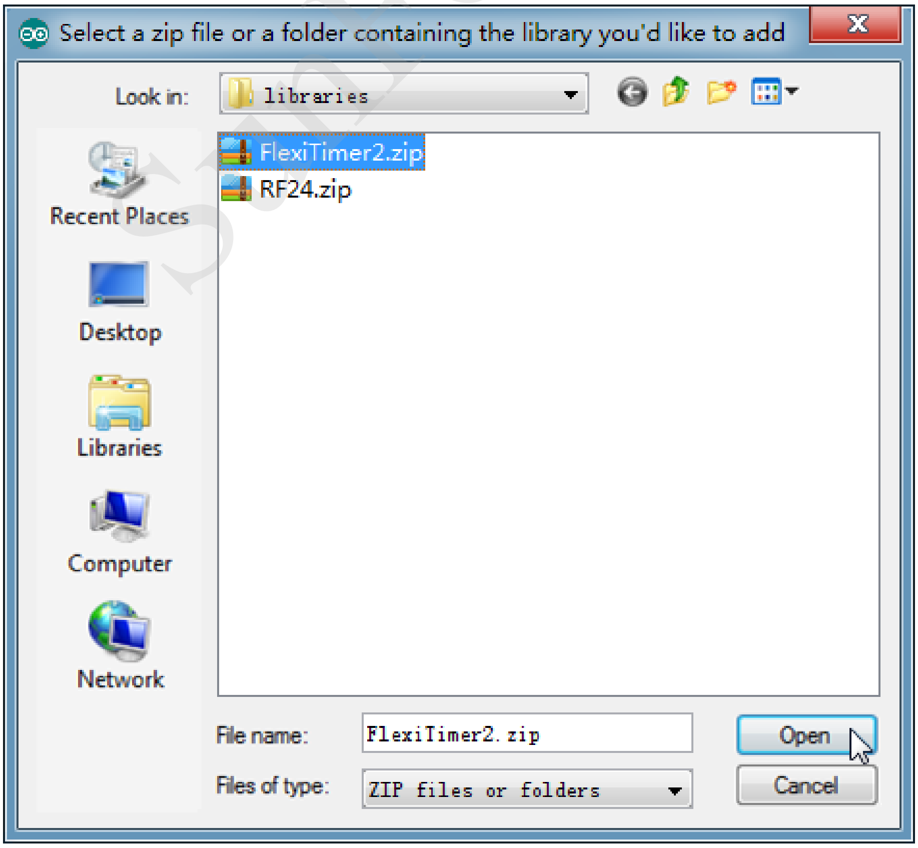
In this kit, you will need to add two libraries to the Arduino *libraries* folder: *FlexiTimer2* and *RF24*.

1) Select **Sketch** -> **Import Library** -> **Add Library**.

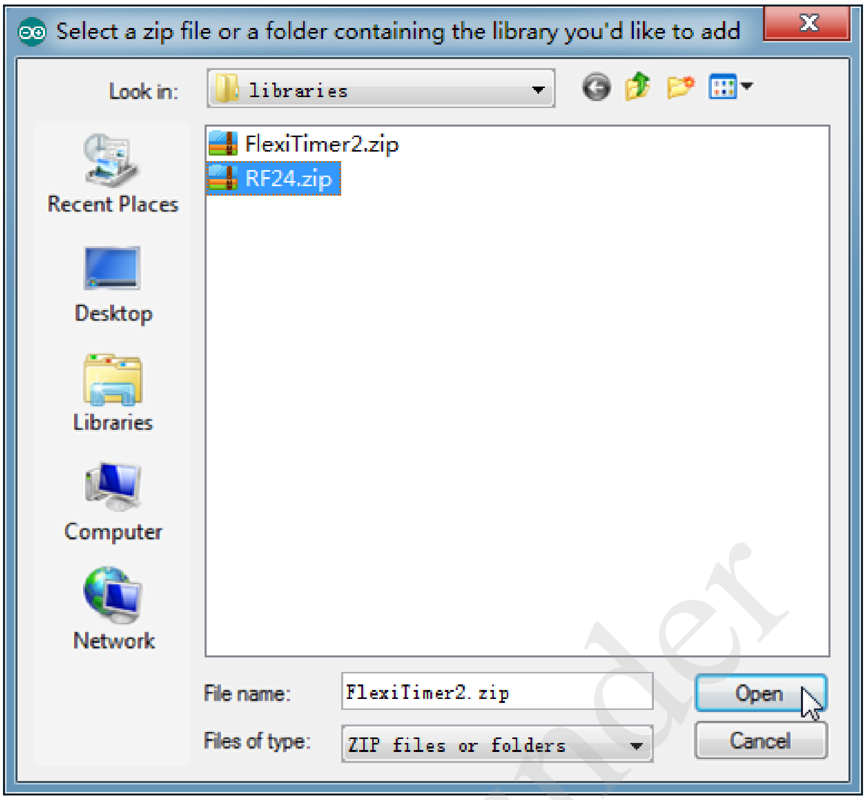

sketch_may24a | Arduino 1.6.8
File Edit Sketch Tools Help
Verify/Compile Ctrl+R
Upload Ctrl+U
Upload Using Programmer Ctrl+Shift+U
Export compiled Binary Ctrl+Alt+S
Show Sketch Folder Ctrl+K
Include Library
Add File...
Manage Libraries...
Add .ZIP Library...
Arduino libraries
Audio
Bridge
EEPROM
Esplora
sketch_m

```
void
  //

}

void loop() {
  // put your main code here, to run repeatedly

}
```

2) Find the *FlexiTimer2.zip* library under the *libraries* folder in the CD. Click **Open**.



3) Import the *RF24.zip* library from the *libraries* folder in the same way.

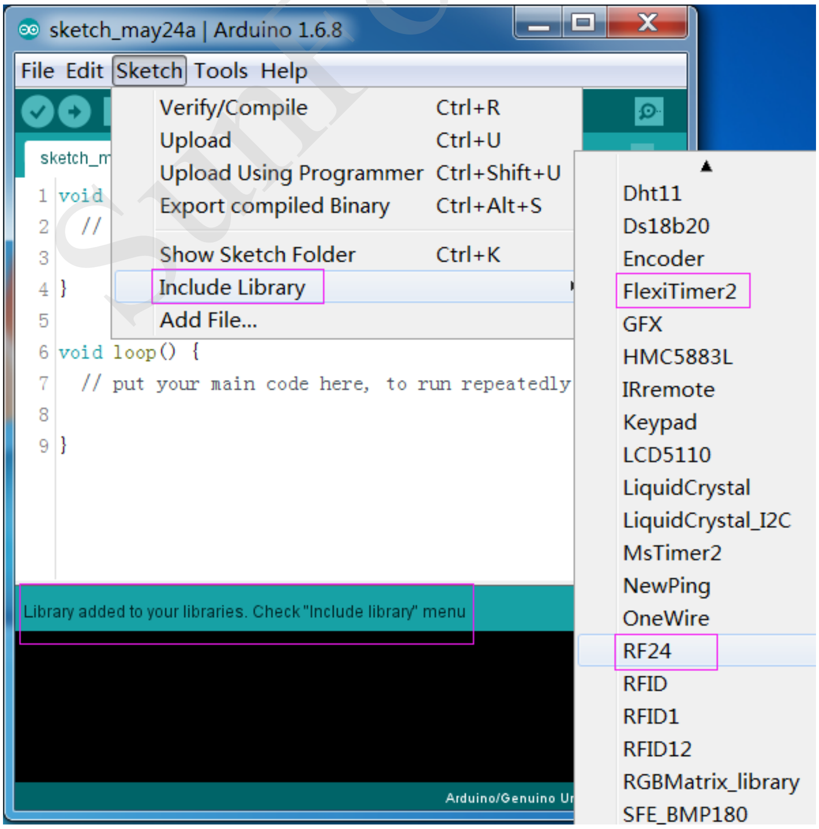


Look in: libraries

File name: FlexiTimer2.zip

Files of type: ZIP files or folders

4) Here you should see the library added to your *libraries*. Click **Sketch**-> **Include Library** and the libraries just imported now appears on the list.



```
void
  //
}

void loop() {
  // put your main code here, to run repeatedly

}
```

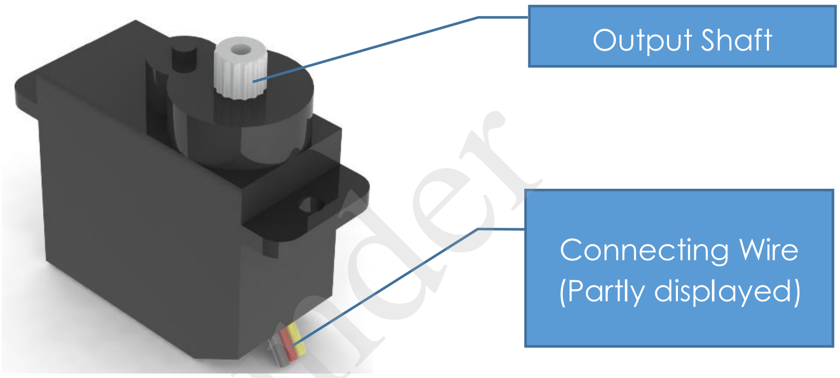
Library added to your libraries. Check "Include library" menu

Servo

Description

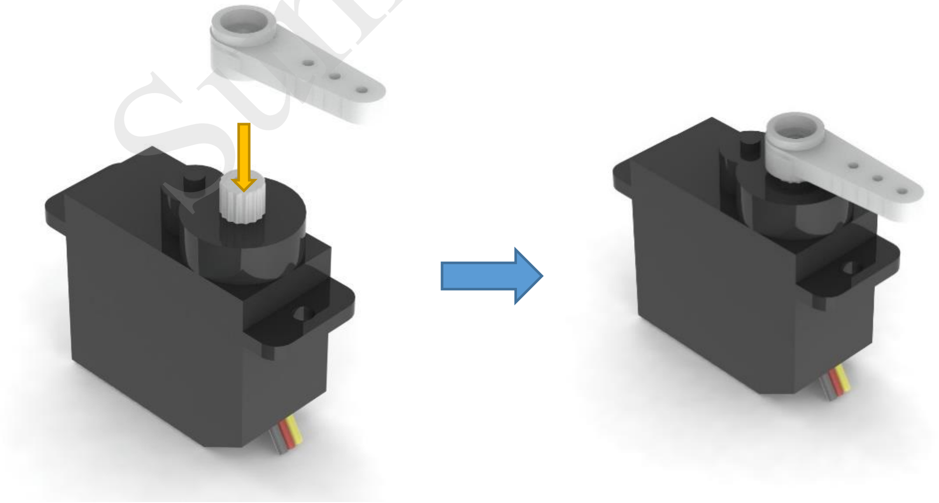
Servo is a set of automatic control system composed of DC motors, reduction gear set, sensors and control circuits. The output shaft can be rotated to a certain angle by sending signals. The servo can only rotate in a certain range, for example, 180°. It cannot rotate any circles like the DC motor. The servo enables you to easily rotate an object in a certain angle, so it is widely used in model planes and robot joints.

In this kit, twelve EMAX ES08A II servos are used to drive the joints of the robot.



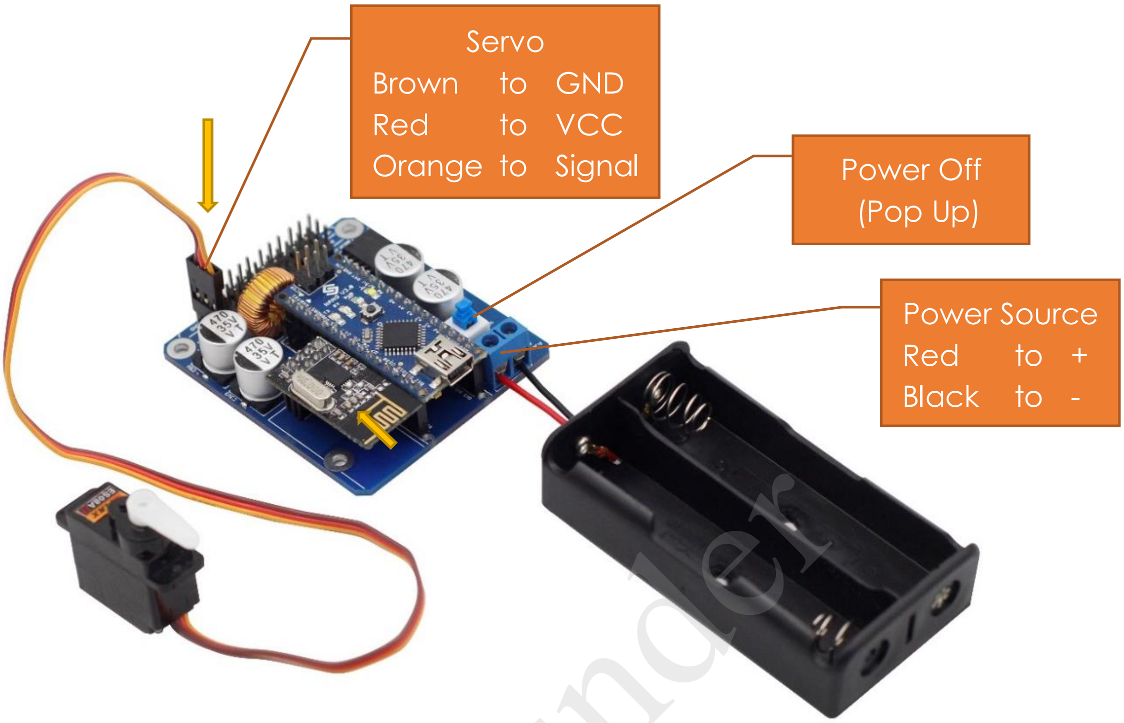
Servo Test

1) Find the rocker arm packaged with the servo, and plug it into the servo shaft.



2) Connect the battery holder and the servo. Make sure the power source is connected in the right way and that the power is kept off.

   Plug the servo to the group of three pins marked with **1** beside on the SunFounder Servo Control Board. The name of the pins and the color of the wires are marked on two sides of all the pins. Pay attention not to get them wrong.



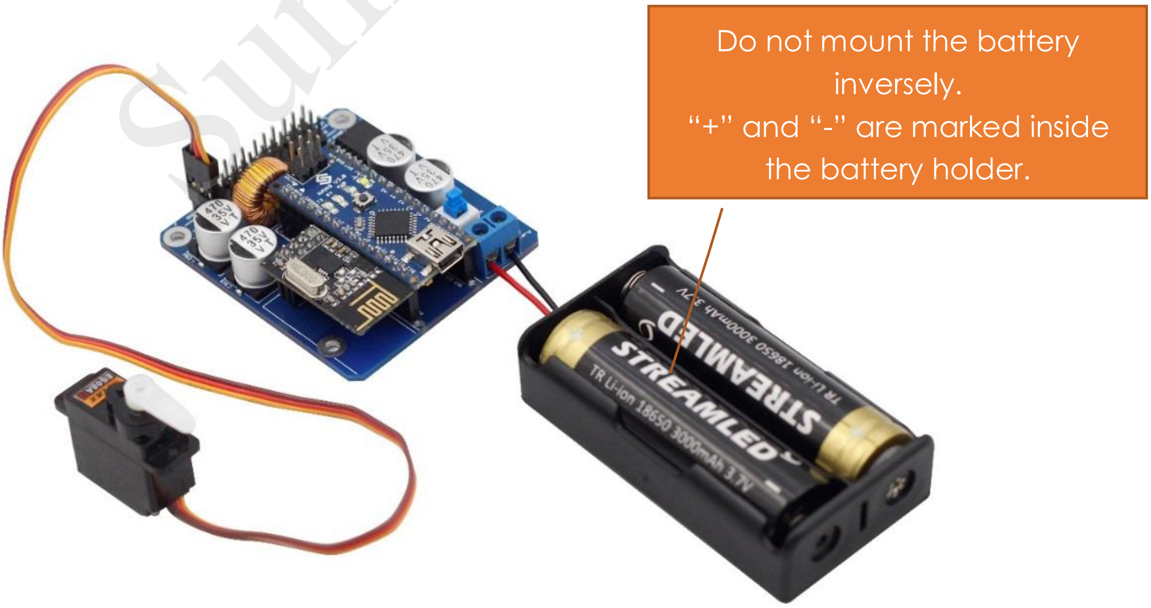
Servo
Brown to GND
Red to VCC
Orange to Signal

Power Off
(Pop Up)

Power Source
Red to +
Black to -

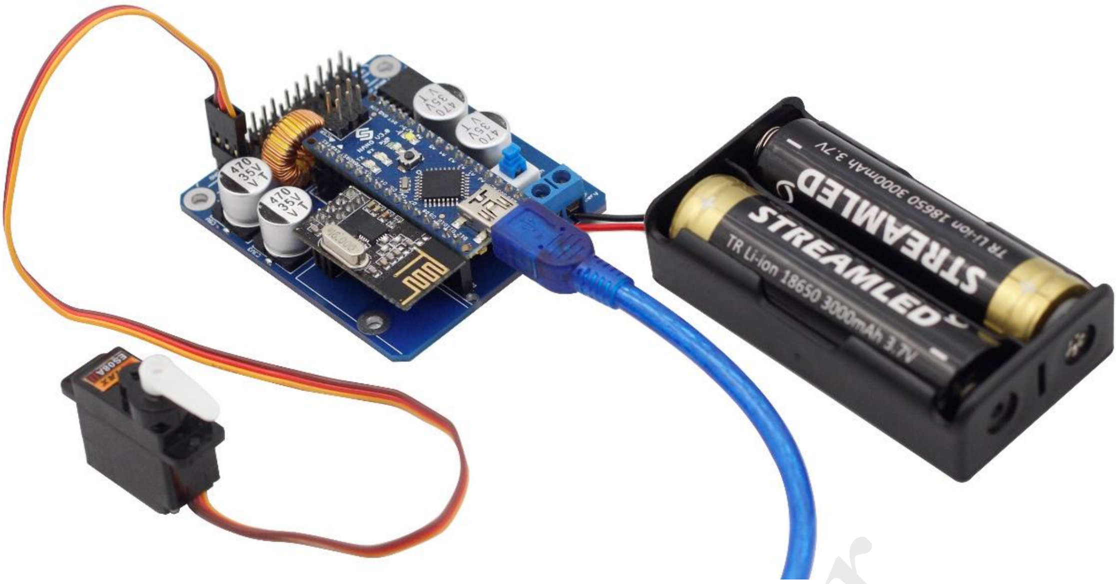
3) Mount two 18650 batteries (please pay attention not to mount it inversely).

Check again whether the battery holder and the battery are wired correctly. If everything looks good, switch it on. Then the blue LED on SunFounder Nano will light up. Keep the power on.

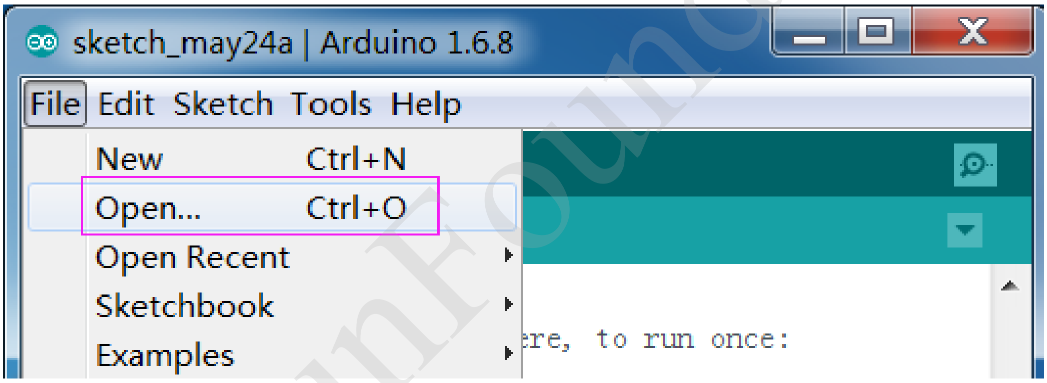


Do not mount the battery inversely.
"+" and "-" are marked inside the battery holder.

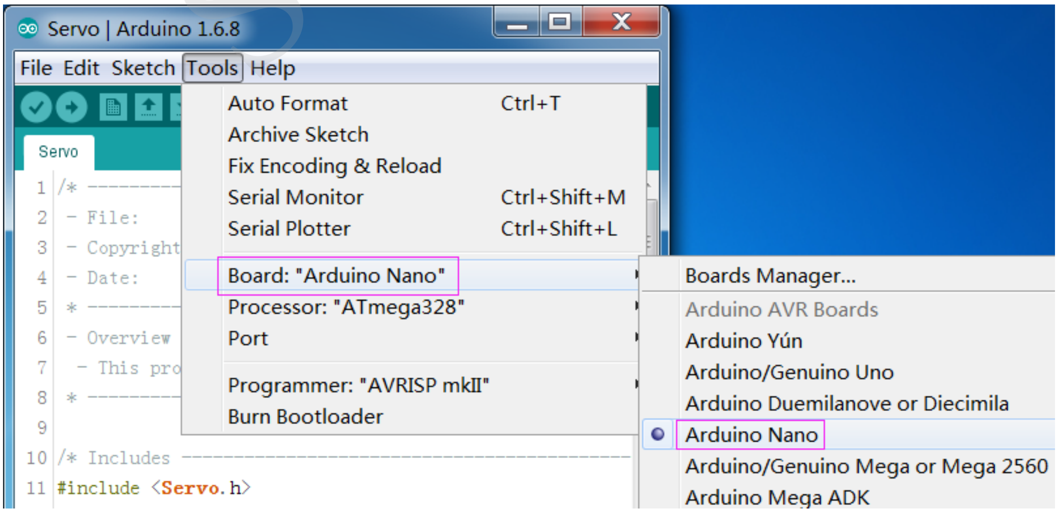
4) Connect the SunFounder Servo Control Board to your PC with a USB cable.



5) Open the Arduino Software (IDE), Select **File**->**Open**. On the pop-up window, go to the *CD\code\1.Servo\Servo* directory and find *Servo.ino*. Click it to open.

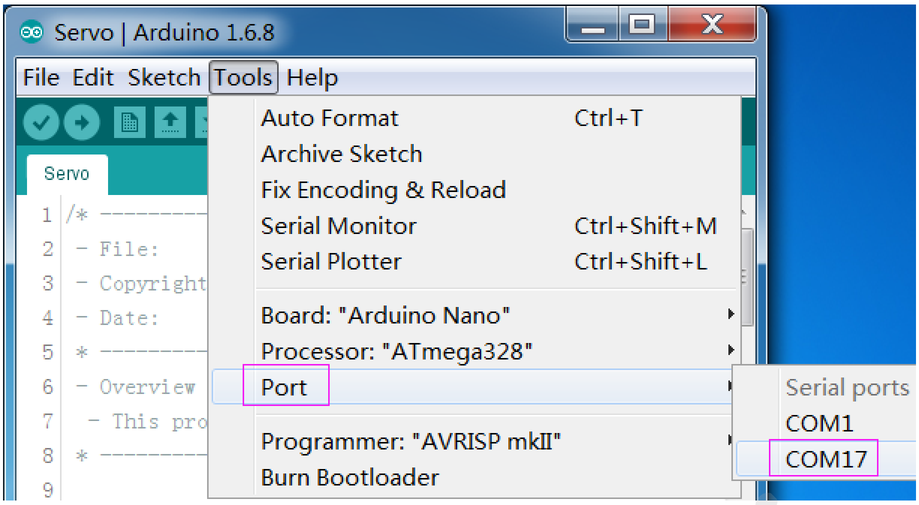


6) Select a board. Here we select **Arduino Nano**.

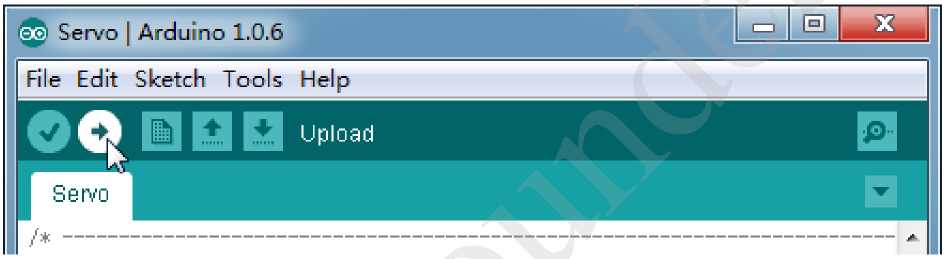


```
/* ---------
 - File:
 - Copyright
 - Date:
 * ---------
 - Overview
   - This pro
 * ---------

/* Includes ------------------------------------------------
#include <Servo.h>
```

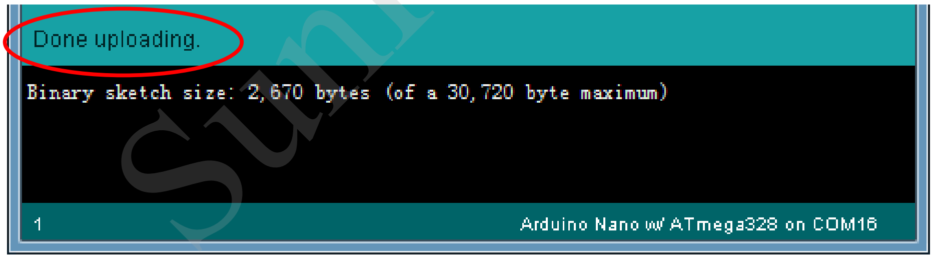
7) Go to **Tools** -> **Serial Port** to select the port. Your serial port may be different from what's shown here (right-click **My Computer** on desktop, click **Properties**>**Device Manager**>**Ports**).



8) Click the following button to upload.



9) Wait for a moment until the following information appears at the bottom of the window, which indicates it is uploaded successfully.



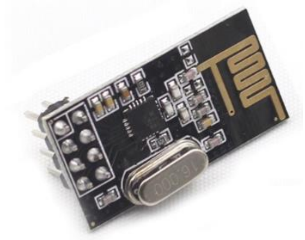
```
Done uploading.
Binary sketch size: 2,670 bytes (of a 30,720 byte maximum)
```

10) Remove the USB cable, switch on the power. Now, the rocker arm will sway continuously. . So the servo test is done. Test all the 12 servos in the same way if necessary. If you find some jitters at 0 degree of a few servos, it's fine. The point here is to check whether the servo can work.

nRF24l01

Description

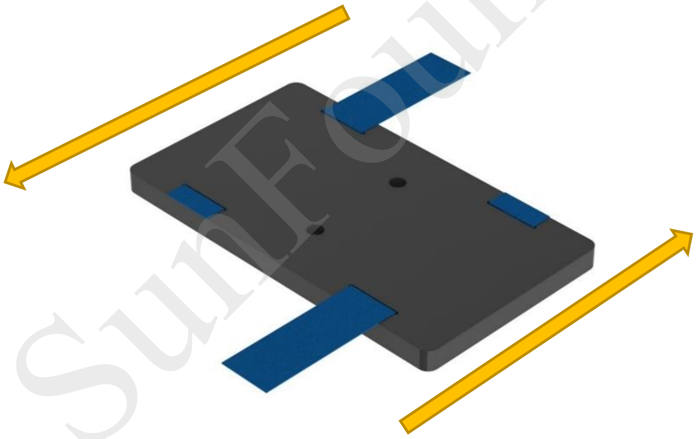
The nRF24L01 is a single-chip wireless transceiver chip, which is manufactured by NORDIC and works in the 2.4 GHz ~ 2.5 GHz ISM frequency band. The wireless transceiver includes frequency generator, enhanced ShockBurst mode controller, power amplifier, crystal oscillator, modulator and demodulator.



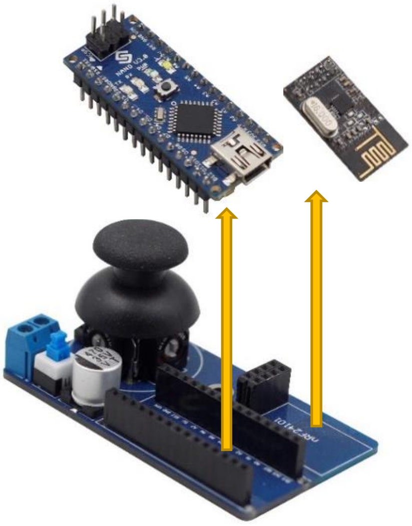
nRF24l01 Test & Remote Control Assembly

1. Cross the ribbon through the acrylic plate.

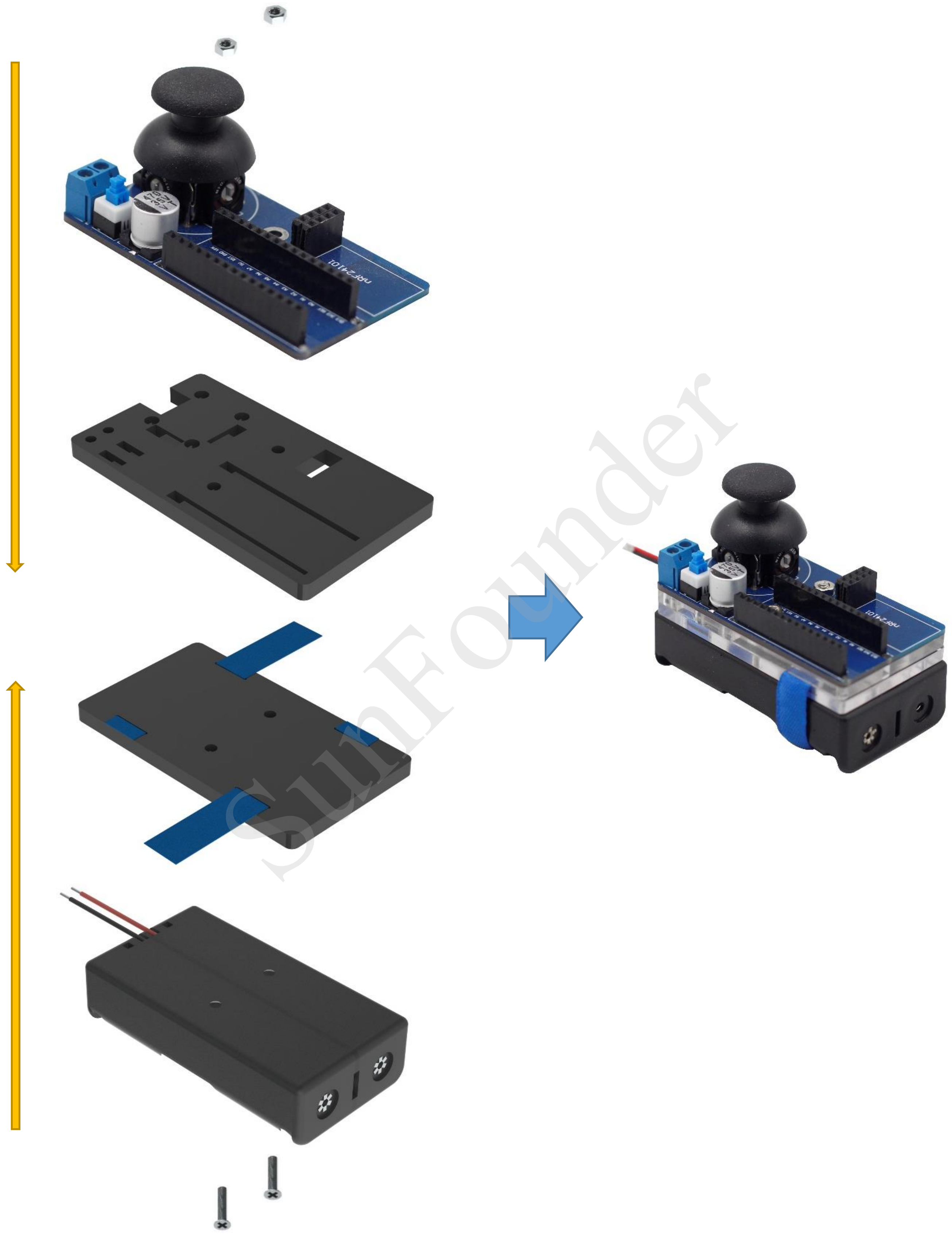
   The ribbon enables you to easily remove the battery (you can skip this step and plate if you feel unnecessary). Please note that one side of the ribbon should be longer and the other shorter, in the opposite direction (as shown below).



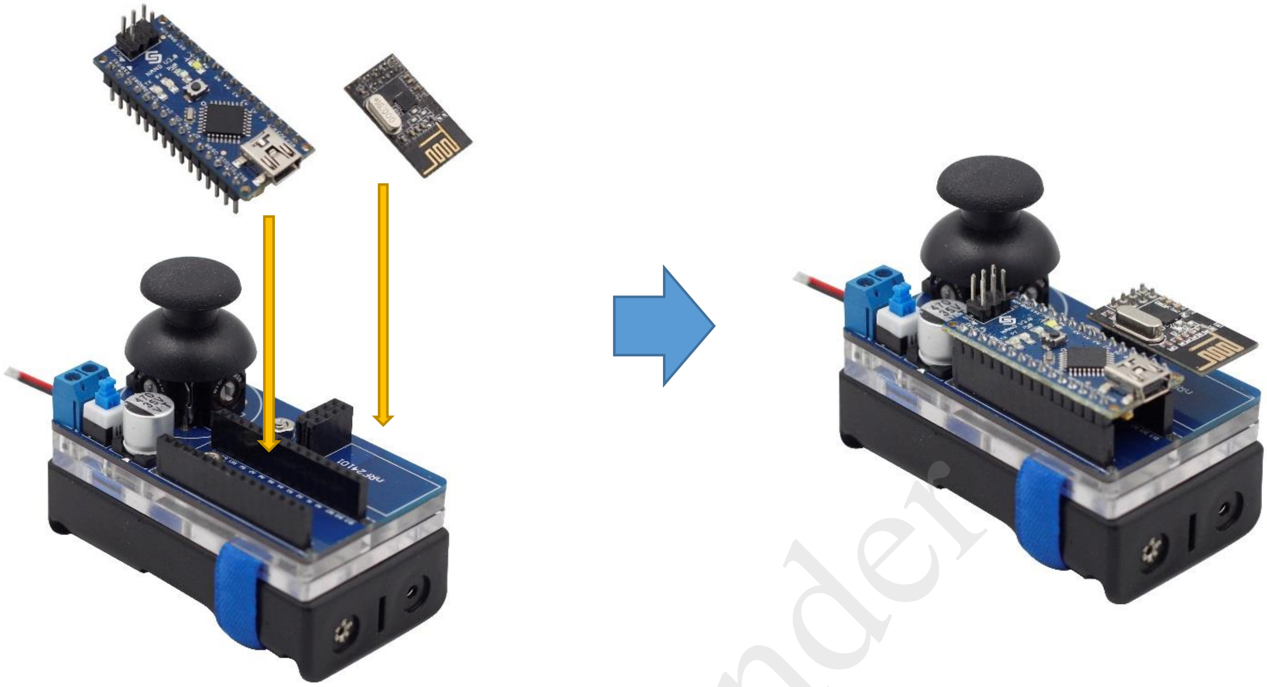
2. Remove the nRF24L01 and SunFounder Nano board for installing the battery holder later.



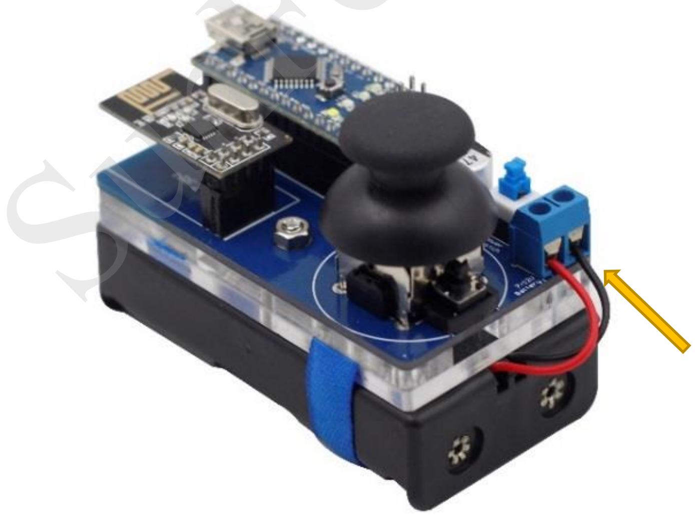
3. Connect the following components with two M3*14 countersunk screws and two M3 nuts.



4. Plug SunFounder Nano board and nRF24l01 module into the SunFounder Mobile Robot Remote Controller board.



5. Wire the battery holder to the board. Make sure the power source is wired correctly and the power is kept off.



6. Mount two 18650 batteries (pay attention not to mount them inversely).

   Check whether the battery holder and the battery are wired correctly. If everything looks good, switch it on. Then the blue LED on SunFounder Nano board will light up. Keep the power on.

7. Connect the SunFounder Mobile Robot Remote Controller to PC with a USB cable.

8. Upload the following code for the SunFounder Mobile Robot Remote Controller as mentioned previously:

   Transmit.ino under *CD\code\2.nrf24l01\Transmit* directory.

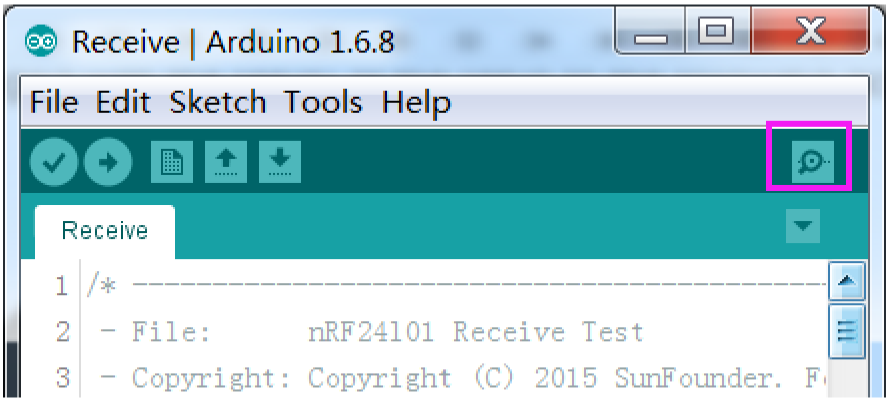
   Remove the USB cable after upload, and keep the power on.

9. Connect the SunFounder Servo Control Board to your PC with a USB cable.

10. Upload the following code to the SunFounder Servo Control Board:

    Receive.ino under the *CD\code\2.nrf24l01\Receive* directory.

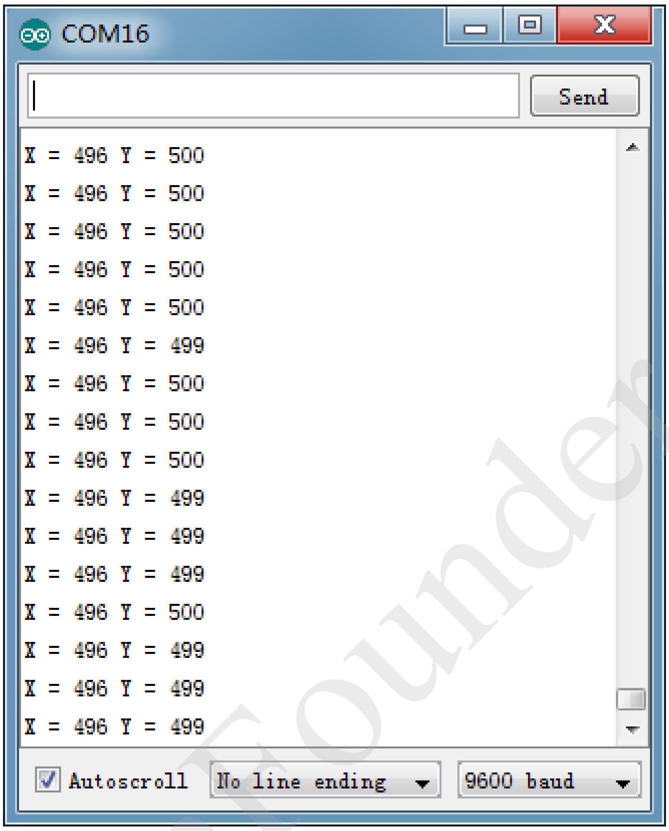
    DO NOT remove the USB cable after upload. Open **Serial Monitor**.



```
/* ------------------------------------------------
 - File:       nRF24l01 Receive Test
 - Copyright: Copyright (C) 2015 SunFounder. F
```

Now, you should see the information received by the nFR24l01 module (on the servo control board) displayed on **Serial Monitor**.

Turn the sticker. The value displayed on **Serial Monitor** will change accordingly, which indicates the wireless communication is working.



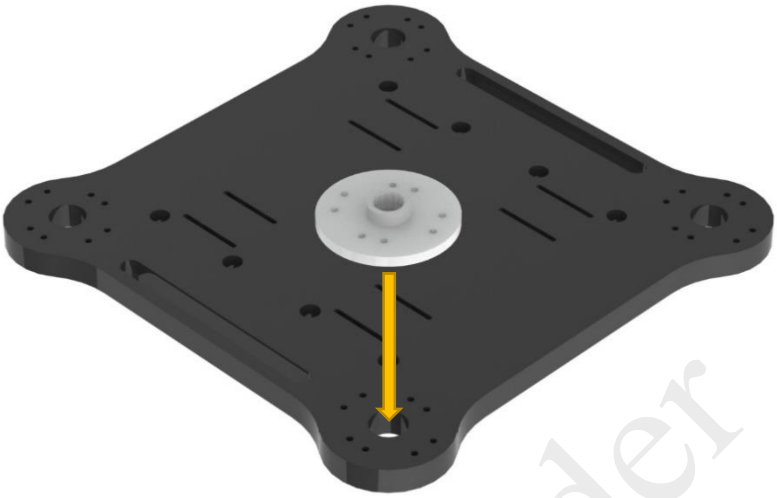
```
X = 496 Y = 500
X = 496 Y = 500
X = 496 Y = 500
X = 496 Y = 500
X = 496 Y = 500
X = 496 Y = 499
X = 496 Y = 500
X = 496 Y = 500
X = 496 Y = 500
X = 496 Y = 499
X = 496 Y = 499
X = 496 Y = 499
X = 496 Y = 500
X = 496 Y = 499
X = 496 Y = 499
X = 496 Y = 499
```

Now you can remove the USB cable and turn off the power switch.

3. Mechanical Assembly & Circuits

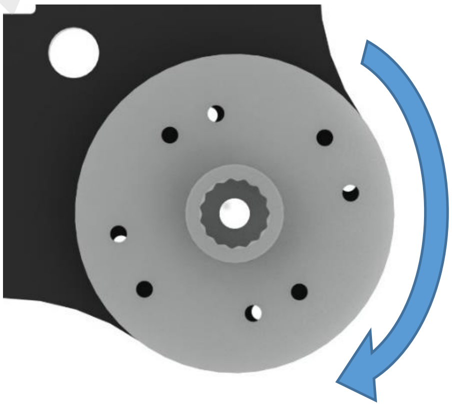
Upper Plate + Rocker Arm

1. Assemble the round rocker arm (packaged with the servo) to the following acrylic plate.

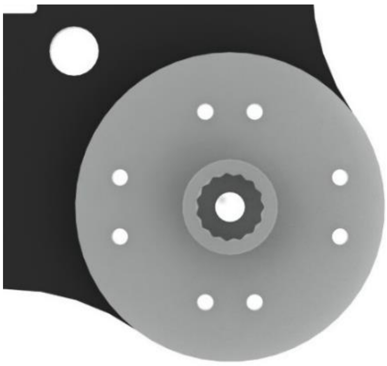


2. Fasten the rocker arm to the acrylic plate.

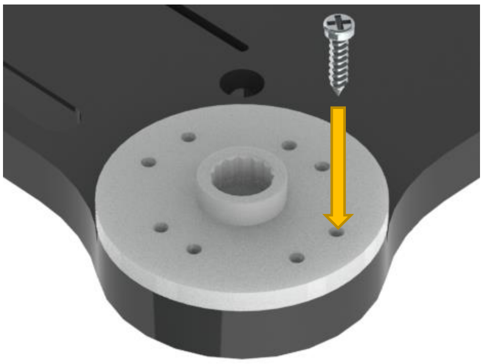
3. Spin the rocker arm.



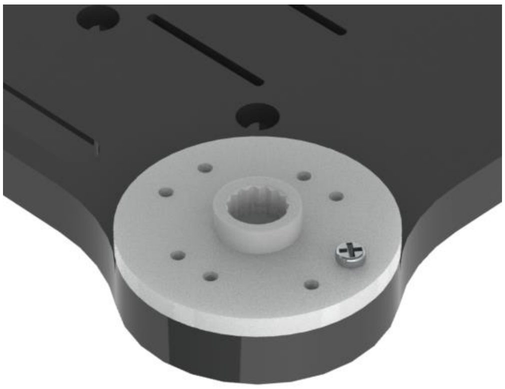
4. Align all holes of the rocker arm and the plate.



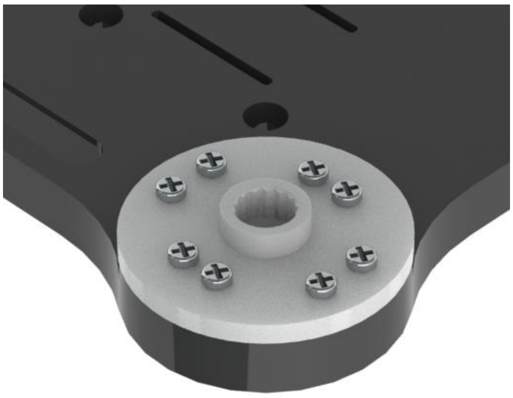
5. Insert an **M1.2*4 self-tapping screw** into a hole.



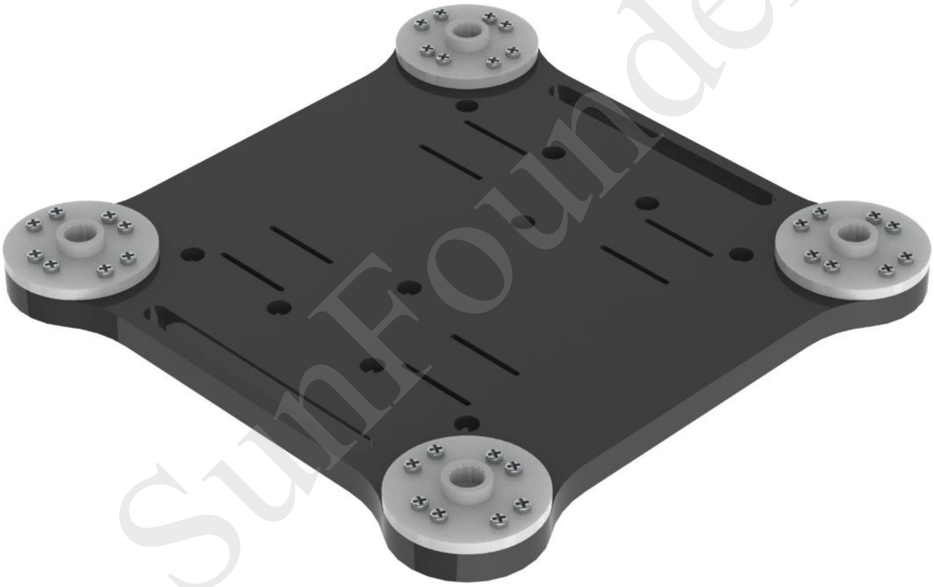
6. Tighten the screw.
   Do not over tighten it! Or the screw may be broken!



7. Assemble the rest 7 screws.

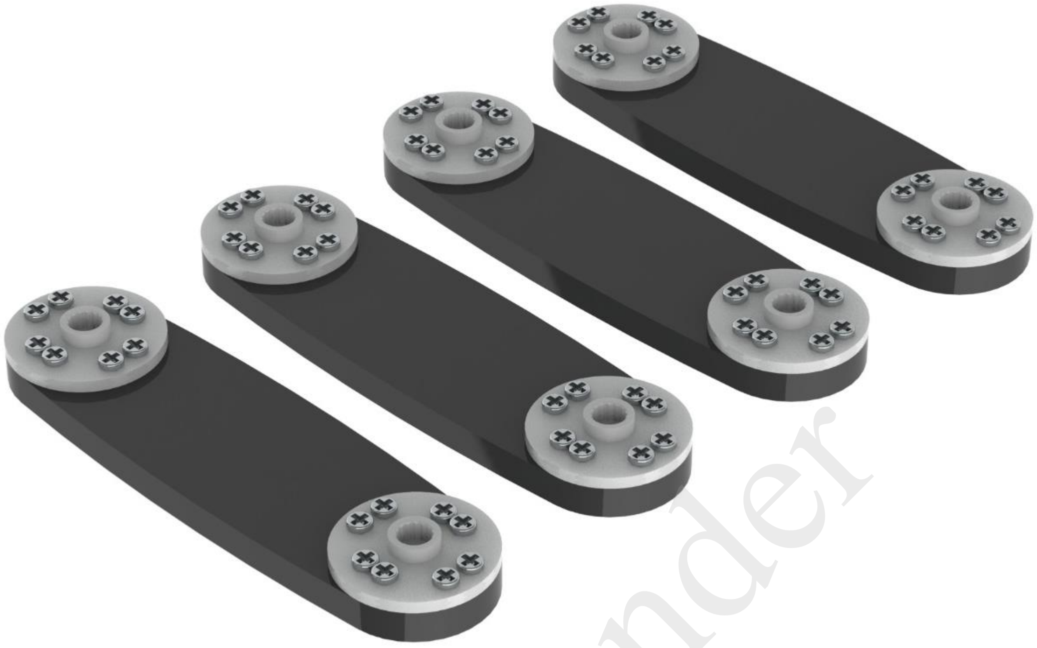


8. Assemble the rest 3 rocker arms similarly.



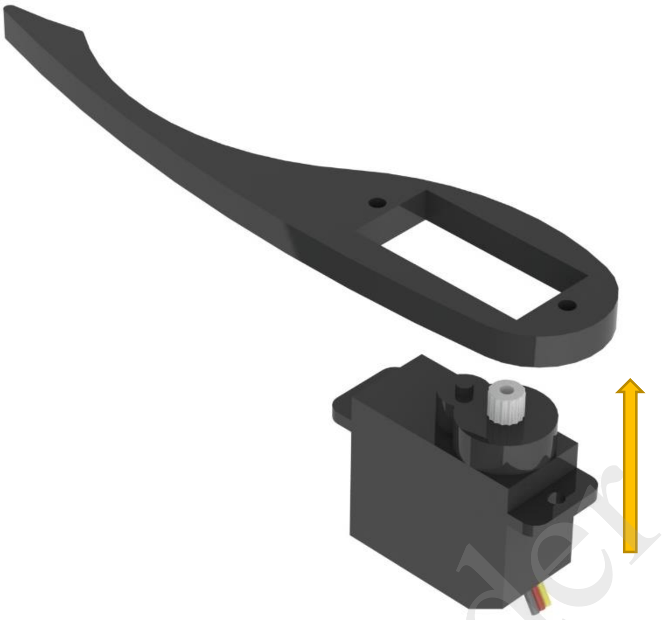
Thigh + Rocker Arm

In the same way, connect the rocker arms and the thighs with **M1.2*4 self-tapping screws**.

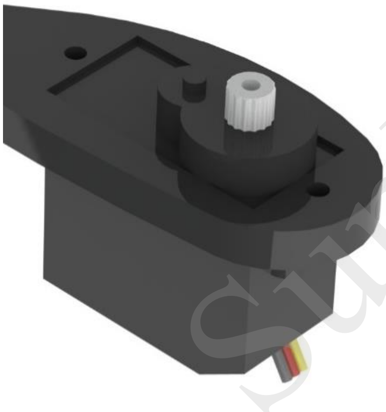


Crus + Servo

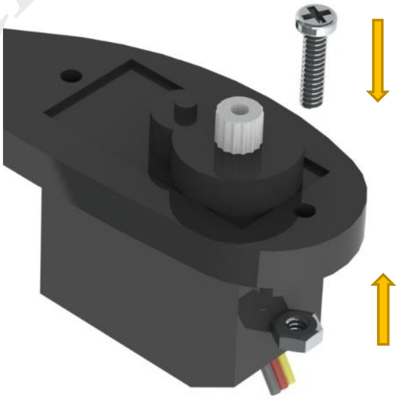
1. Assemble the servo to the crus .



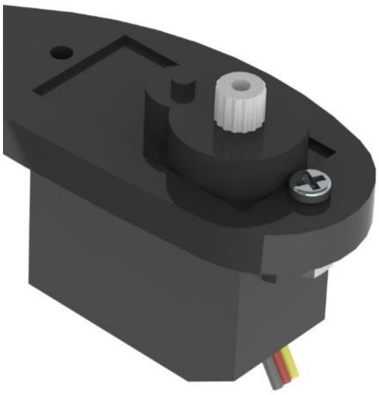
2. Fasten the servo to the crus.



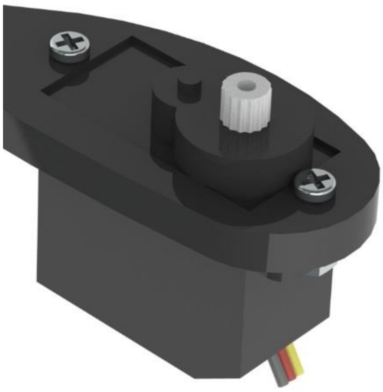
3. Connect these two components with an **M2*8 screw** and an **M2 nut**.



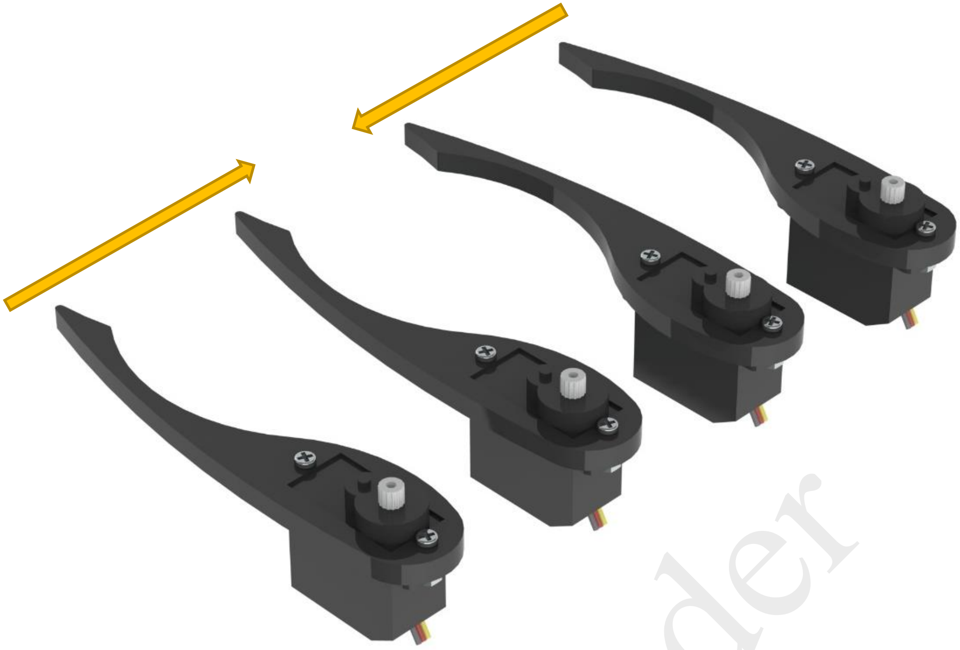
4. Tighten the screw.



5. Tighten the other screw and nut.

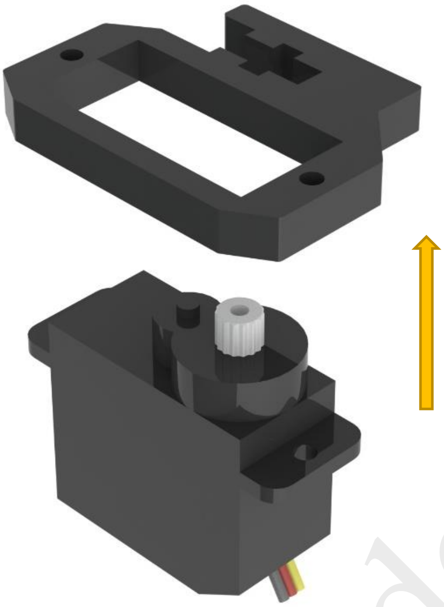


6. Assemble the rest 3 servos to thighs.
   Please pay attention to the direction of the thighs. They should be two opposite pairs, with servos on the same side, as shown below:

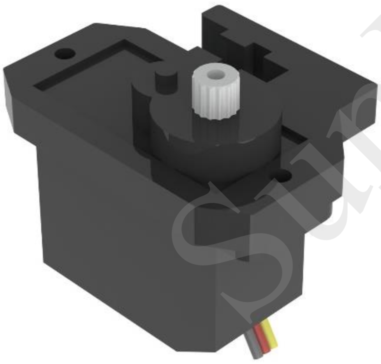


Thigh Joint 1 + Servo

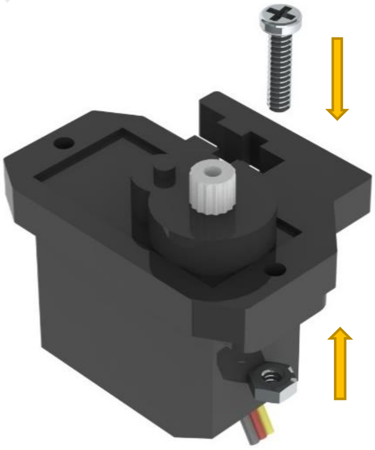
1. Assemble the servo to the following thigh joint 1 (the one next to the thigh).



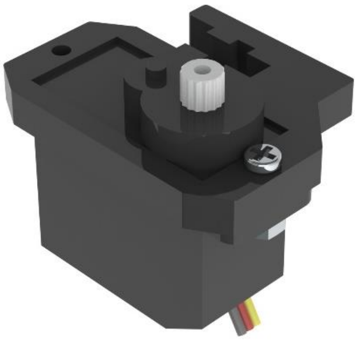
2. Fasten the servo to the thigh joint 1.



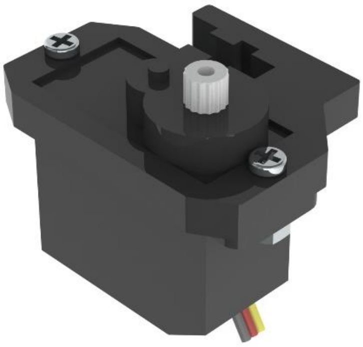
3. Connect the two components with an **M2*8 screw** and an **M2 nut**.



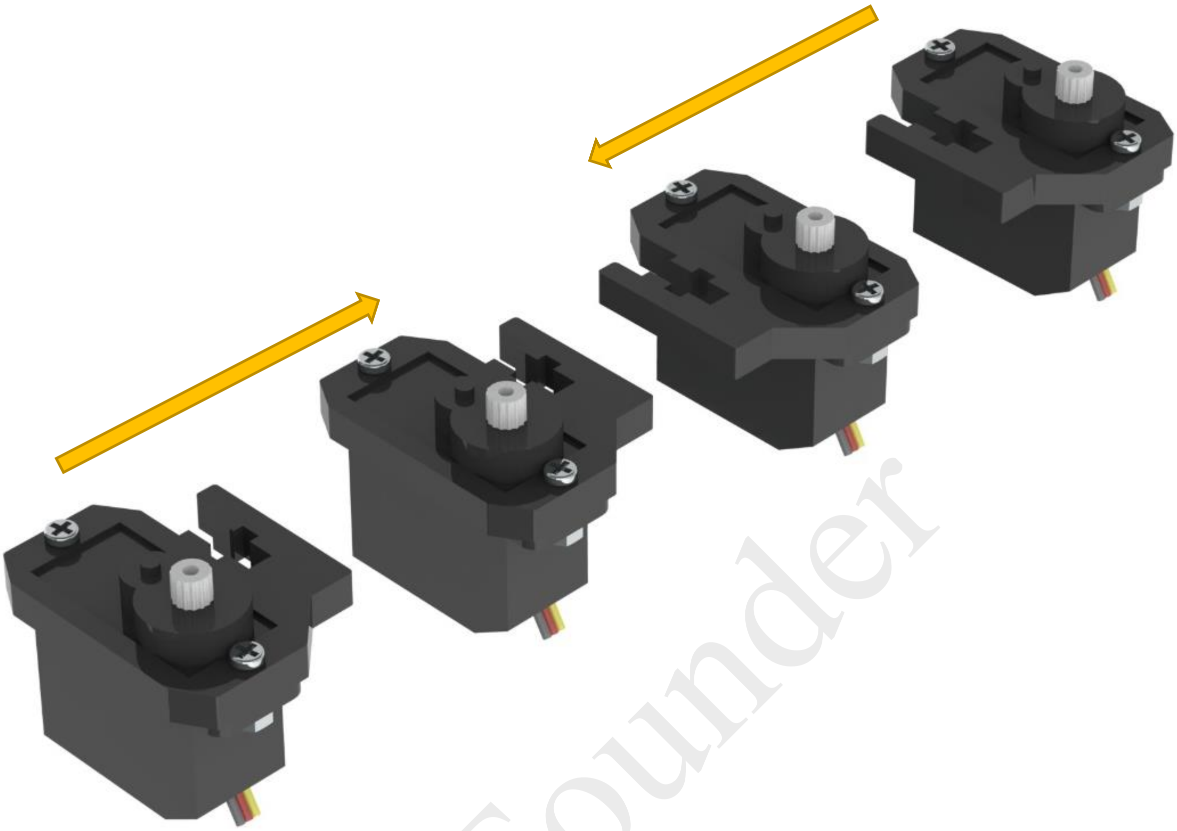
4. Tighten the screw.



5. Tighten the other screw and nut.

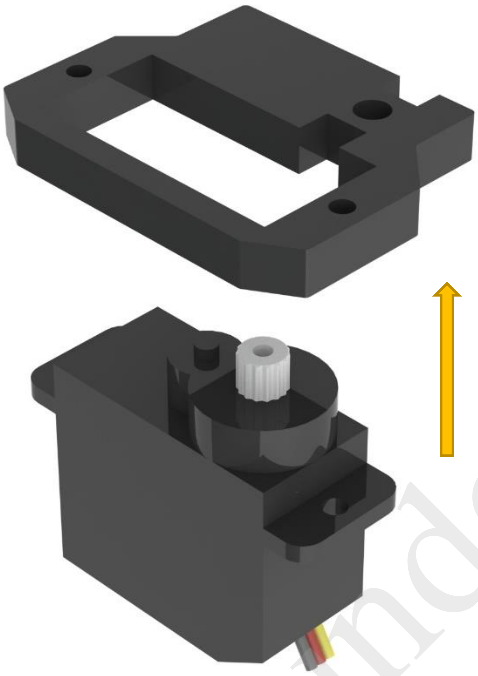


6. Assemble the other 3 joints.
   Please pay attention to the direction. They should be two opposite pairs, with servos on the same side, as shown below:

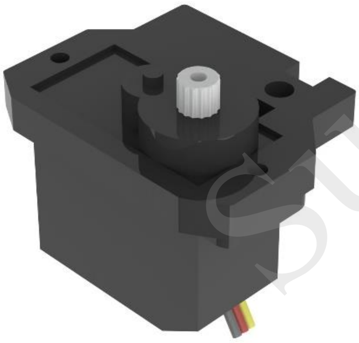


Thigh Joint 2 + Servo

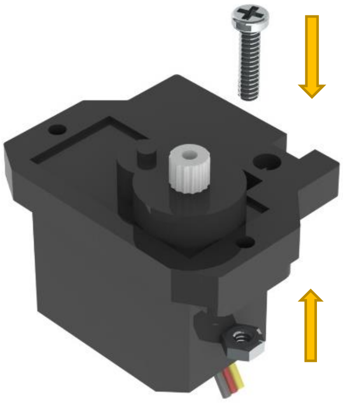
1. Assemble the servo to the following thigh joint 2 (the one close to the upper body plate).



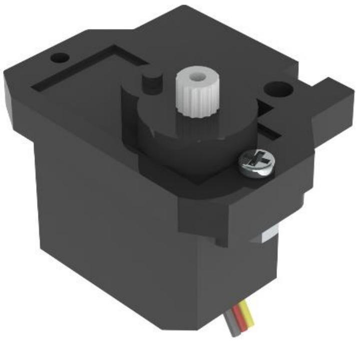
2. Fasten the servo to the thigh joint.



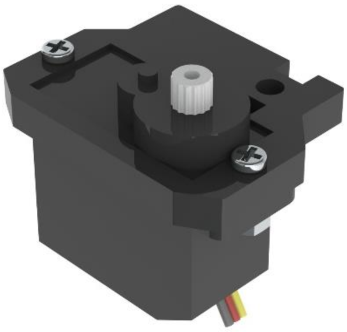
3. Connect the two components with an **M2*8 screw** and an **M2 nut**.



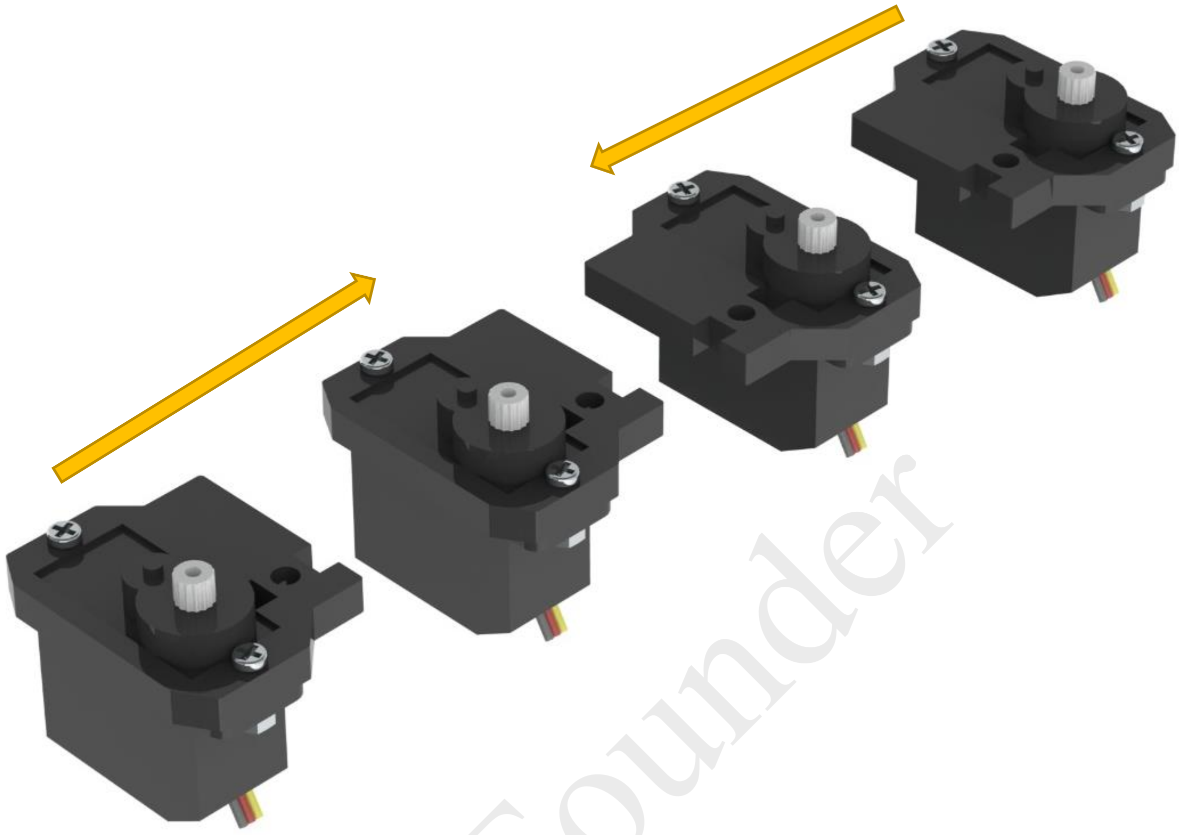
4. Tighten the screw.



5. Tighten the other screw and nut.

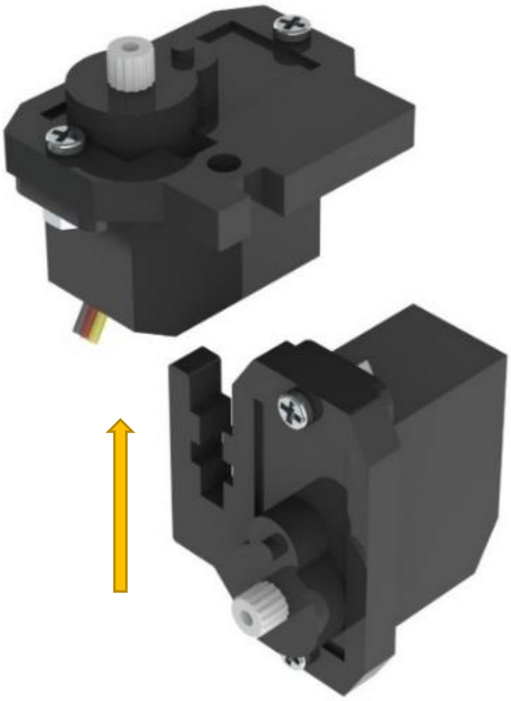


6. Assemble the other 3 servos.
   Please pay attention to the direction. They should be two opposite pairs, with the servos on the same side, as shown below:

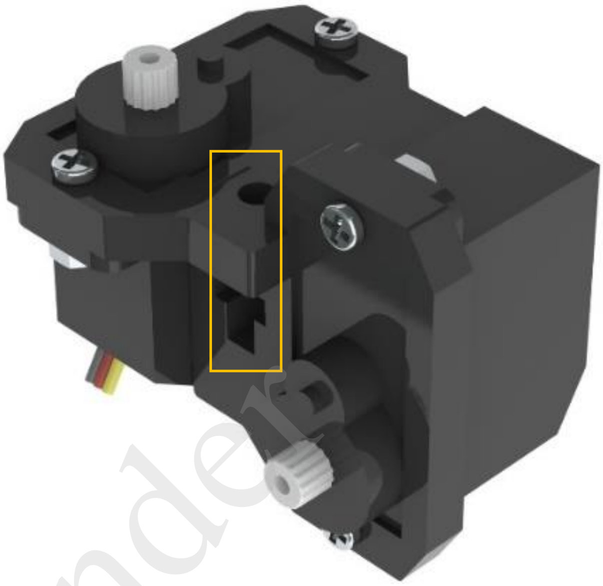


Thigh Joint 1 + Thigh Joint 2

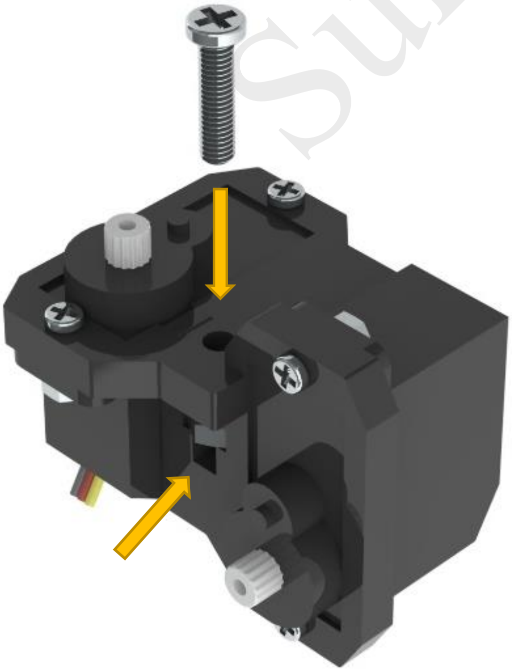
1. Assemble the following two joints.



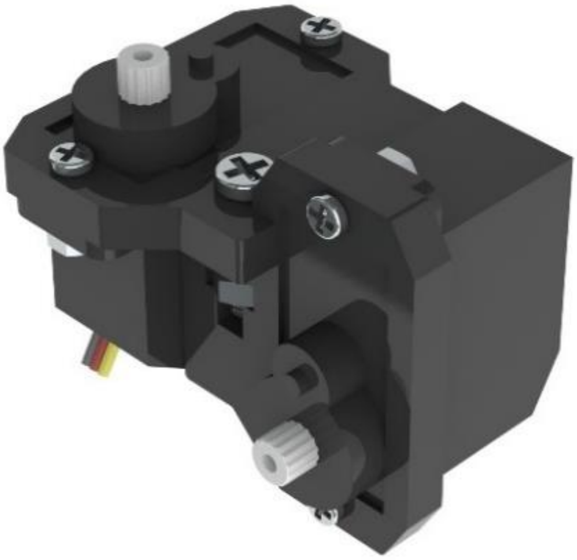
2. Stick one into the other (you may hear a sound like "da").



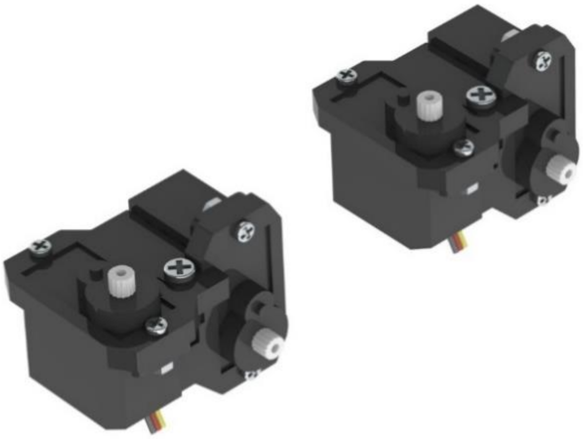
3. Fasten with an **M3*10 screw** and **M3 nut** (for ease, put the nut into the hole first, then the screw into the other from top).

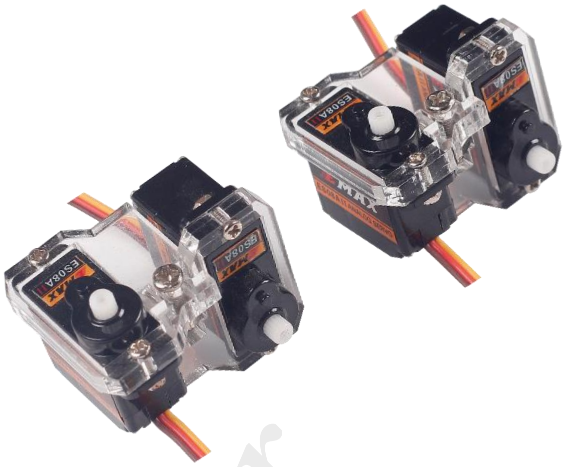


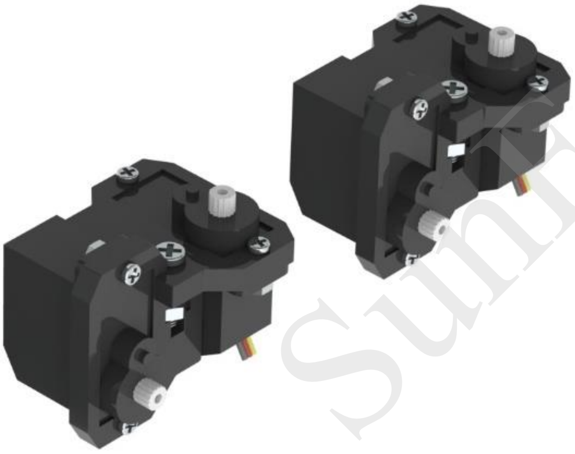
3. Tighten the screw.

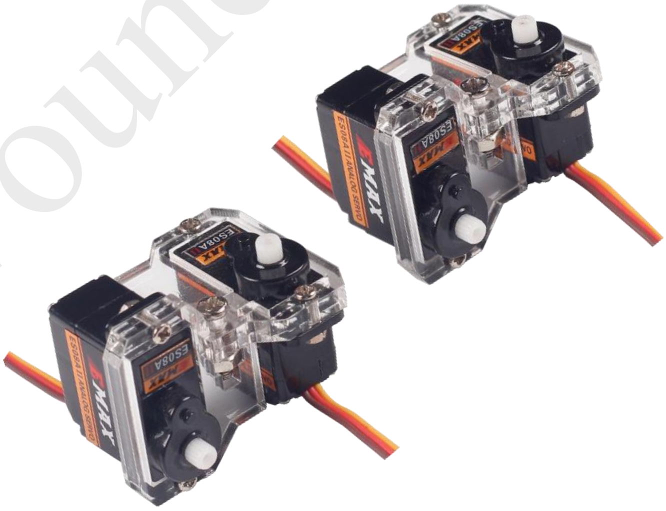


4. Assemble the other 3 pairs similarly. Pay attention to the direction. The two combined pairs should be of opposite directions, as shown below:



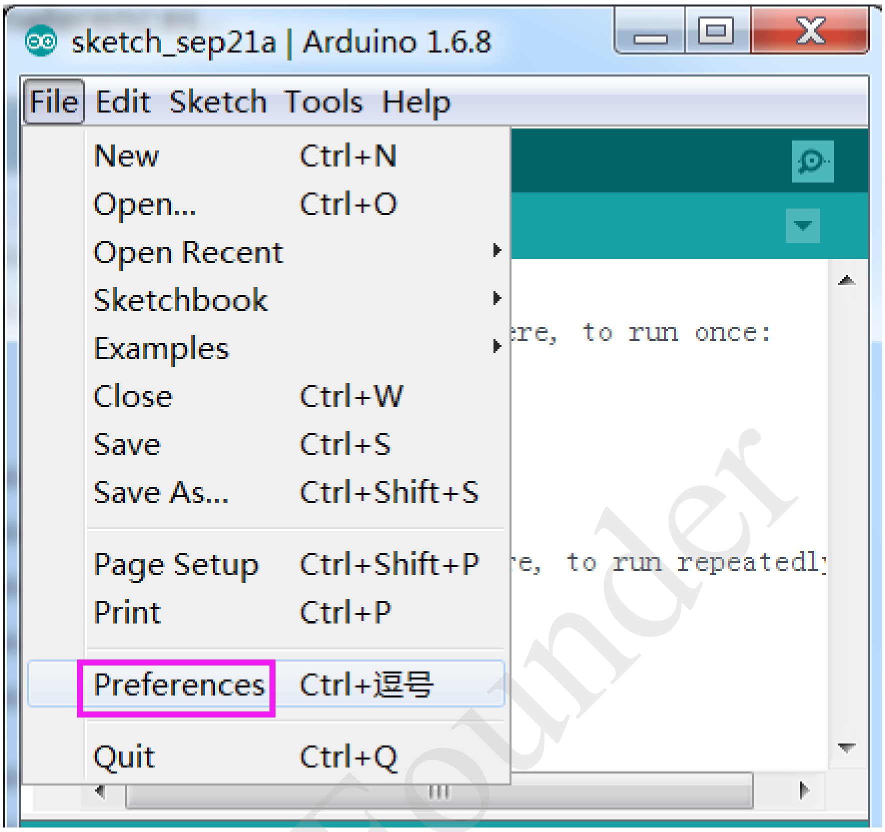




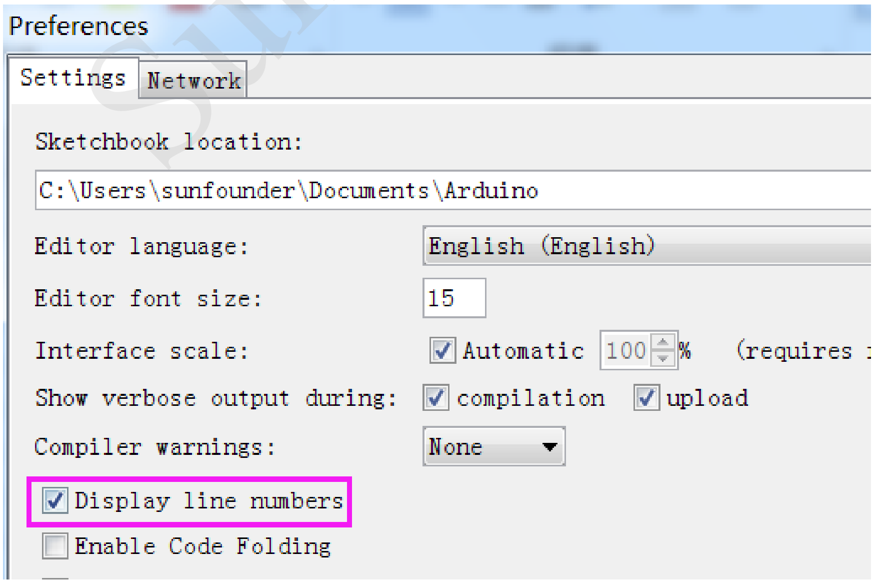


Uploading Assembly Program

Open Arduino IDE, and then select **File** -> **Preferences**.



On the pop-up window, tick the checkbox **Display line numbers**.


Preferences

Settings Network

Sketchbook location:

C:\Users\sunfounder\Documents\Arduino

Editor language: English (English)

Editor font size: 15

Interface scale: ☑ Automatic 100 % (requires

Show verbose output during: ☑ compilation ☑ upload

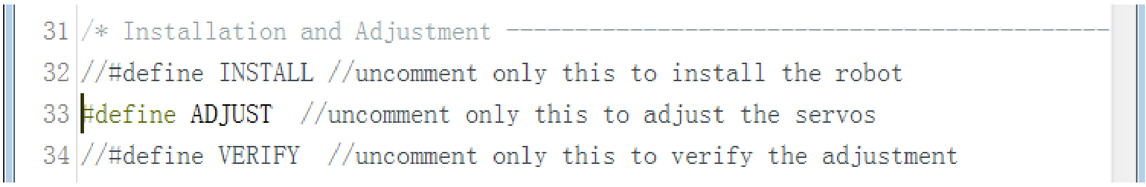
Compiler warnings: None

☑ Display line numbers

□ Enable Code Folding

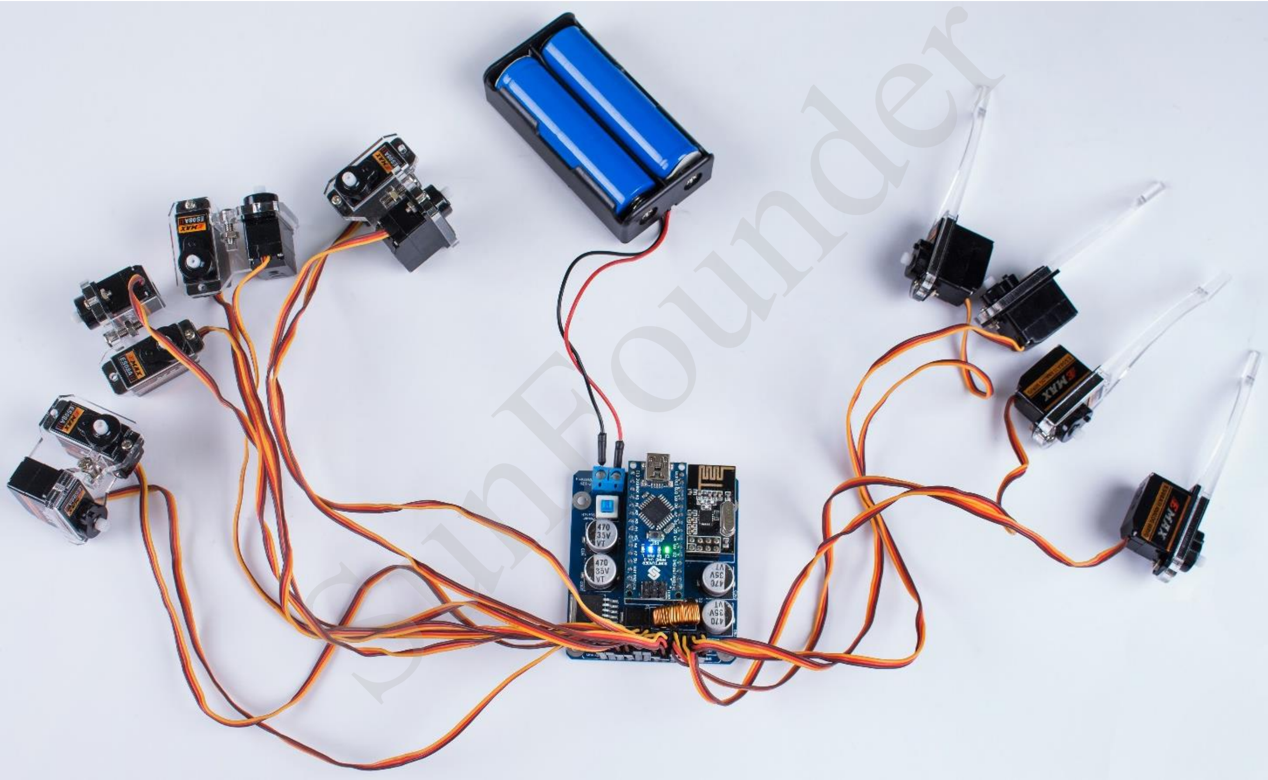
Go to *Crawler.ino* under *CD\code\3.Crawl\Crawler* directory.

Modify code Line 32-34 as follows (uncomment the Line 32 #define INSTALL), compile and upload the sketch to the SunFounder Servo Control Board, and then remove the USB cable.



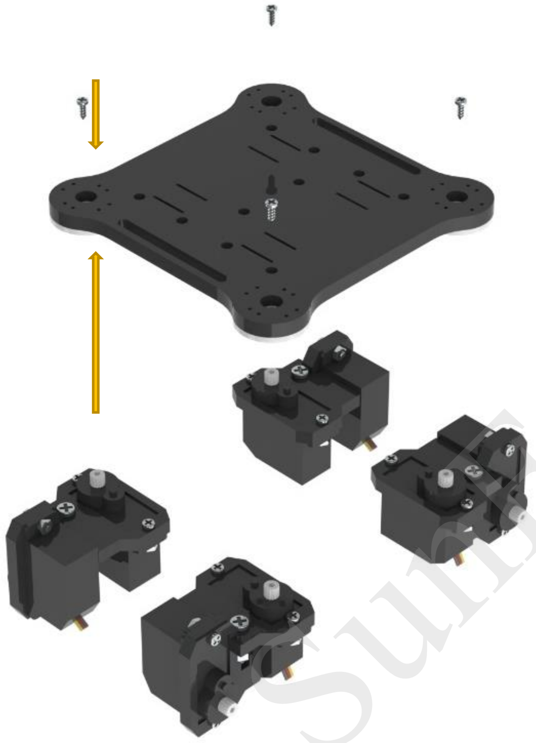
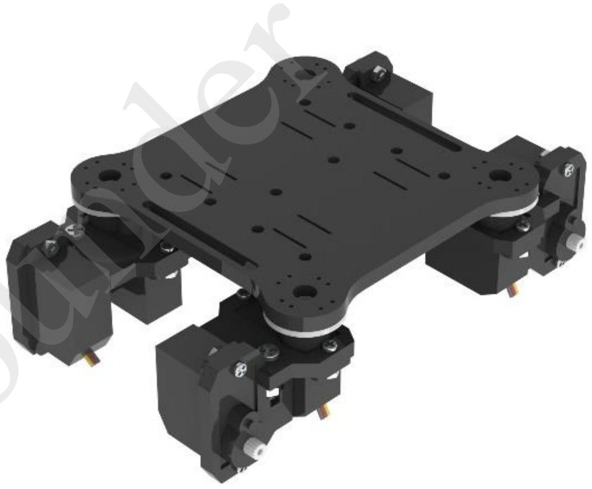
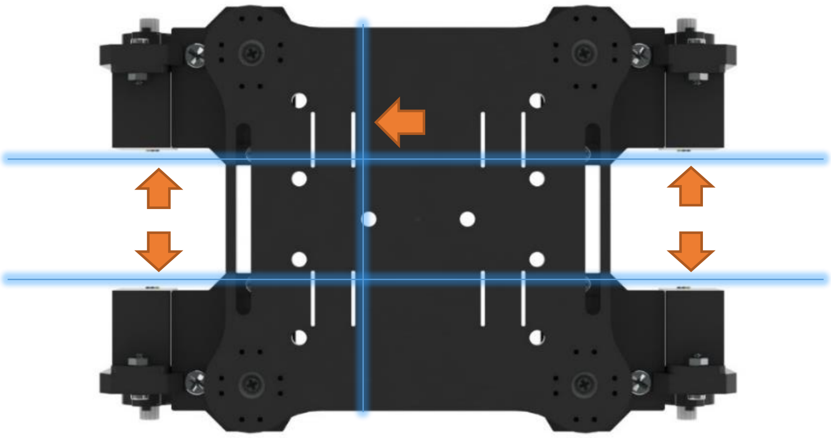
```
31 /* Installation and Adjustment ---------------------------------------------
32 //#define INSTALL //uncomment only this to install the robot
33 #define ADJUST  //uncomment only this to adjust the servos
34 //#define VERIFY  //uncomment only this to verify the adjustment
```

! ! ! Connect all the 12 servos to the SunFounder Servo Control Board, and then turn on the power switch. Now all the servos will rotate and then stay at the center position. Keep the power on and the servos connected.



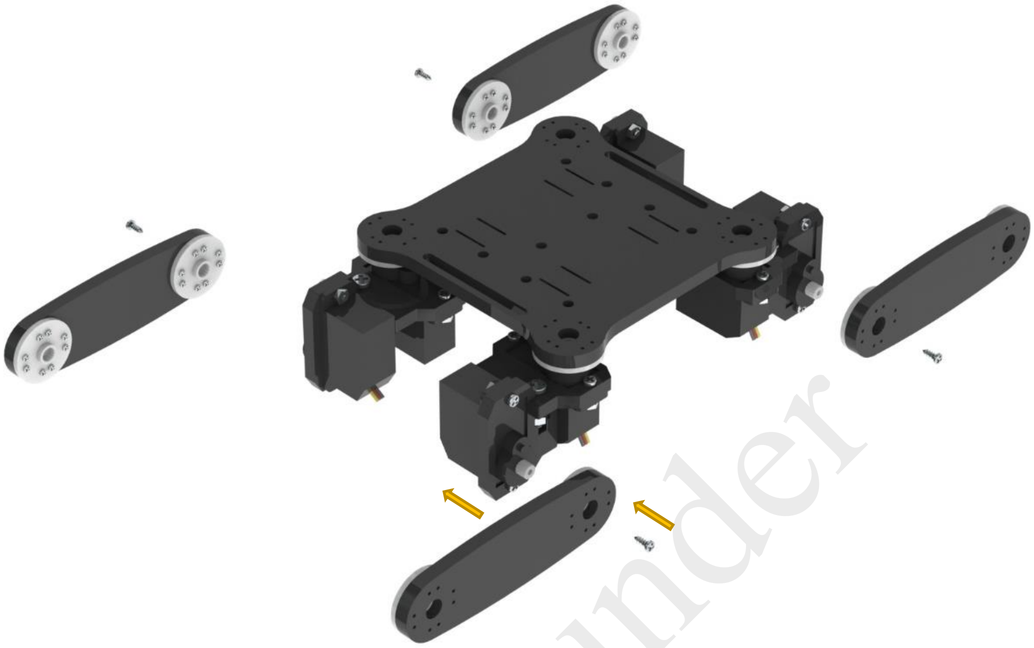
Upper Plate + Thigh Joint

Note: Through the assembly below, please keep the power ON and the servos CONNECTED. Pay attention to do the assembly **GENTLY**, and DO NOT rotate the rocker arm forcefully, or the servo may be damaged. You should remove the arm and plug it in again if necessary.

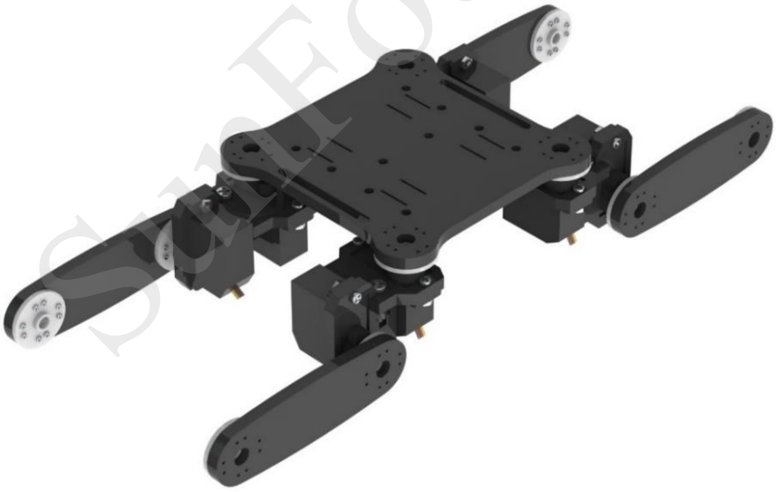
<table>
<tr>
<td>1. Connect the servo rocker arm and the servo with servo screws.
(Packaged with the servo, the screws are the smaller two of five screws.)
The directions of all components must be exactly the same with the following picture:
</td>
<td>2. Tighten the screw.
</td>
</tr>
<tr>
<td colspan="2">After connection, the top view is as follows. Please pay attention to the direction of these components. Try your best to make it close to the following picture. But if there is some deviation, that's OK.
</td>
</tr>
</table>

Thigh Joint + Thigh

1. Connect the servo rocker arm of thighs and the servo of the joints with servo screws. (Packaged with the servo, the screws are within the smaller two of five screws.) The directions of all components must be exactly the same as what's shown below:

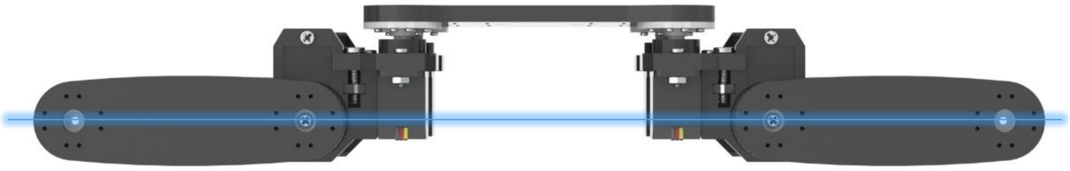


2. Tighten the screw.



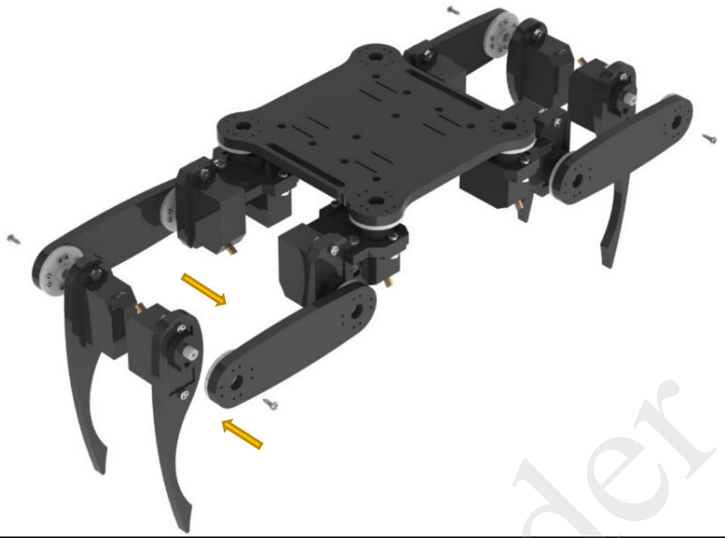
After connection, the front view is as follows. Please pay attention to the direction of these components, it should be horizontal. (DO NOT rotate the rocker arm forcefully.)

Try your best to make it close to the following picture, but if there is some deviation, that's OK.

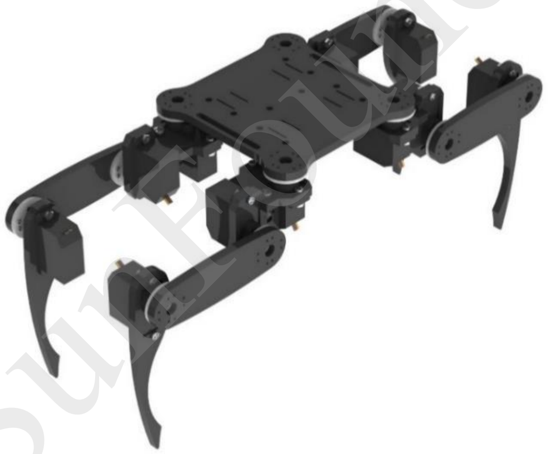


Thigh + Crus

1. Connect the servo rocker arm of thighs and the servo of crura with servo screws. (Packaged with the servo, the servo screws are within the smaller two of five screws.) The directions of all components must be exactly the same as what's shown below:

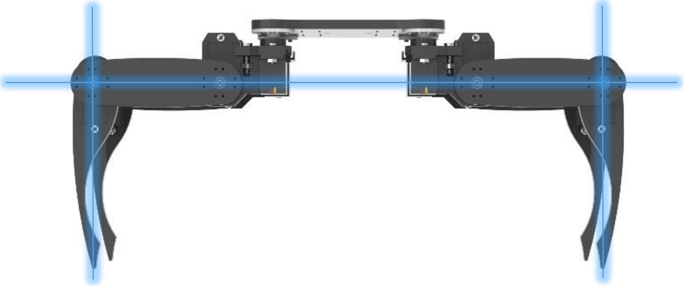


2. Tighten the screw.



After connection, the front view is as follows. Please pay attention to the direction of these components, it should be vertical. (DO NOT rotate the rocker arm forcefully. You should remove it and plug it in again if necessary.)

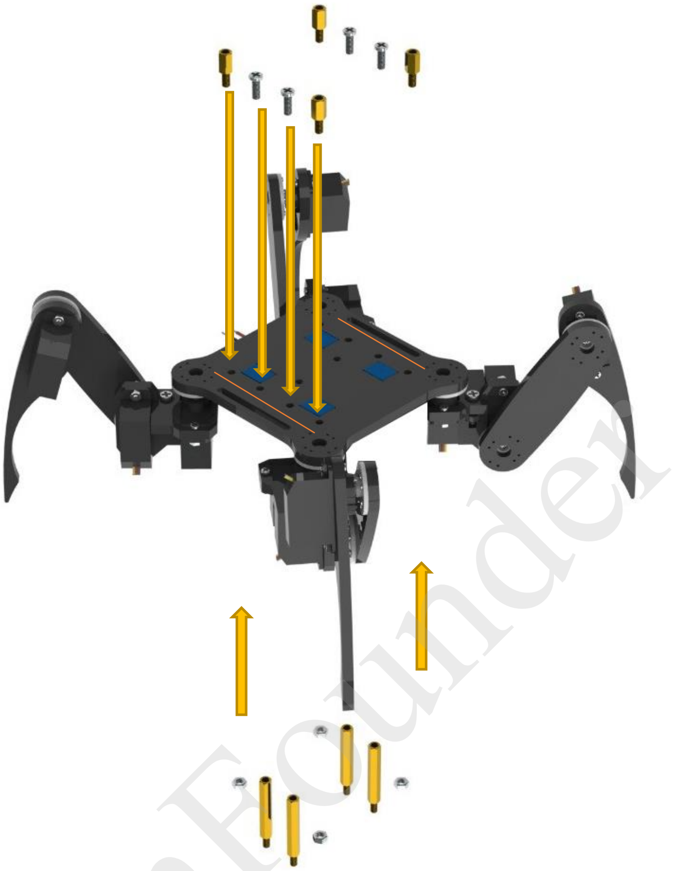
Try to make it close to the following picture, but if there is some deviation, that's OK.



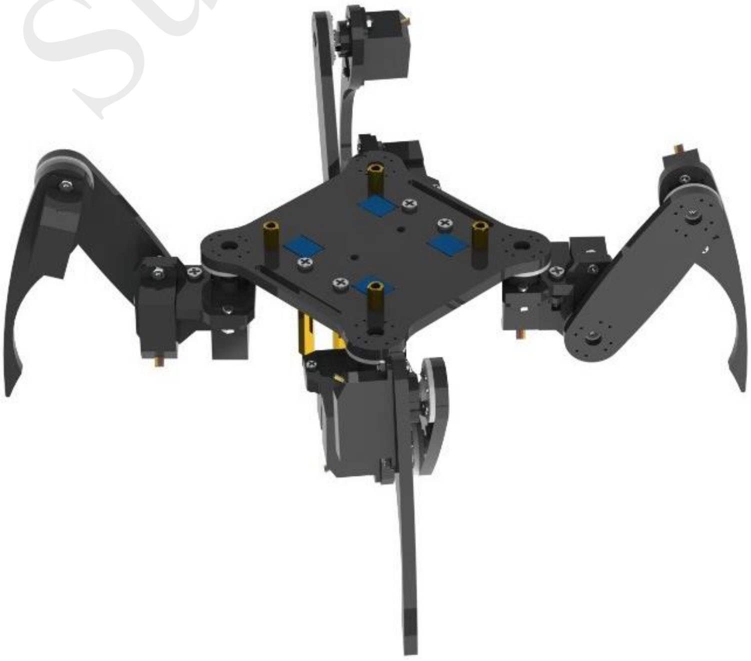
Switch off the SunFounder Servo Control Board. Remove the batteries first, then the battery holder, and finally all the servo wires. Now the joints of the robot can be rotated freely.

Upper Plate + Copper Standoffs

Fasten the **M3*30 copper standoffs**, **M3*8 copper standoffs**, **M3*8 screws**, and **M3 nuts** into the following plate.

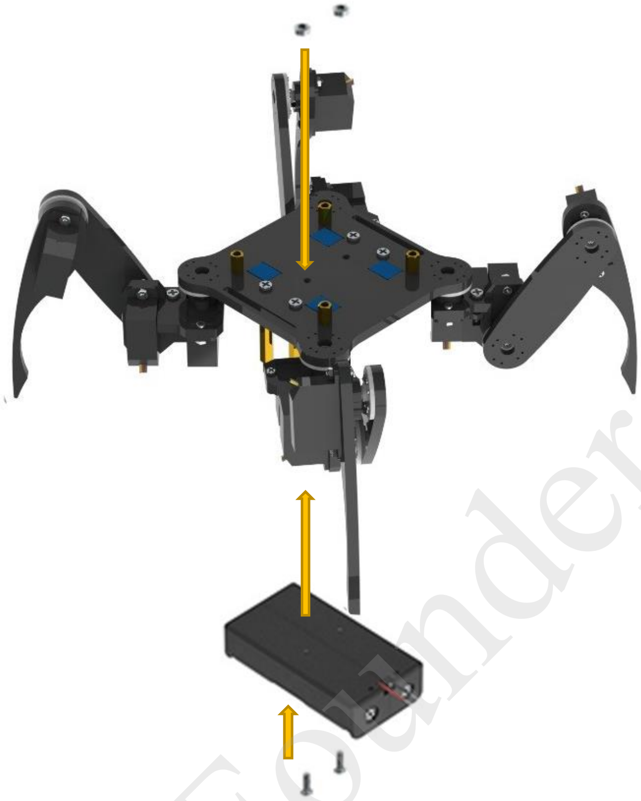


It is shown as follows after connection.

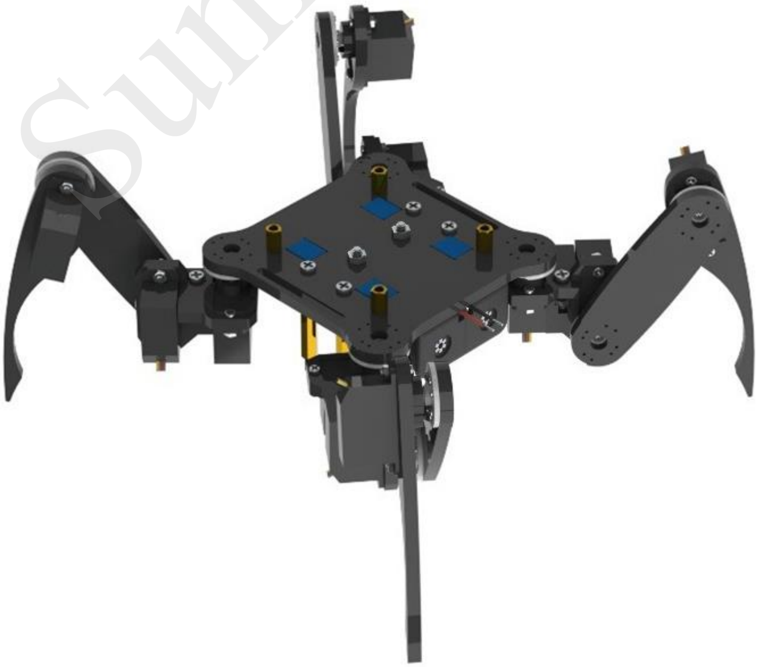


Battery Holder

Cross the ribbon through the plate (similar to previous purpose; may be skipped), and install the other battery holder to the plate with **M3*10 countersunk screws** and **M3 nuts**.

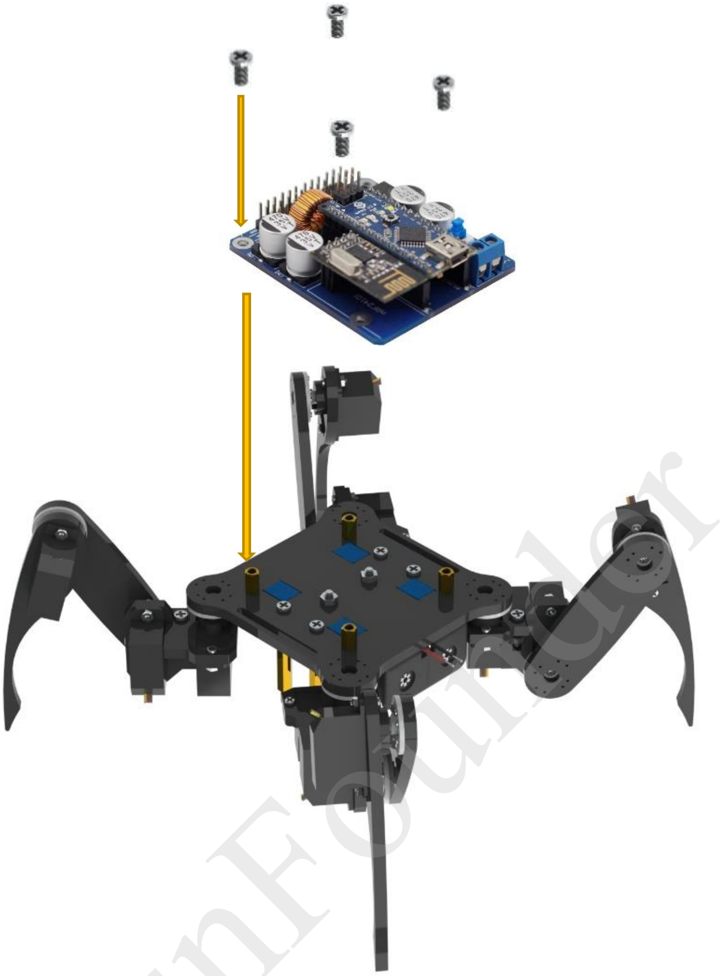


It is shown as follows after connection.

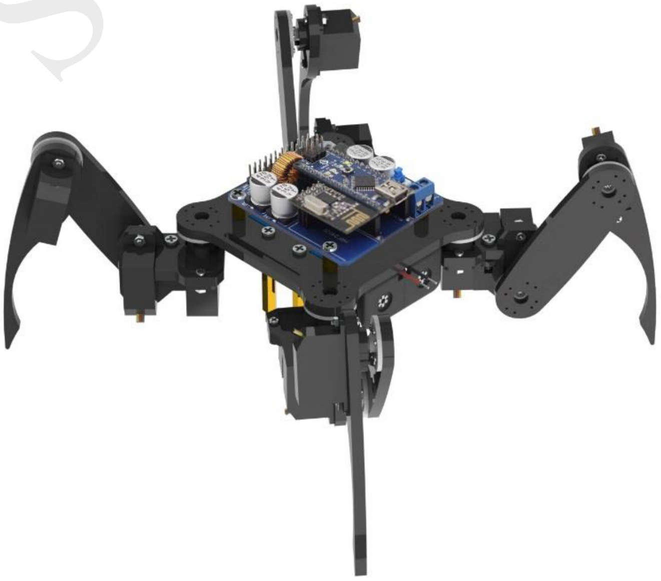


Servo Control Board

Connect the SunFounder Servo Control Board to the upper plate with **M3*6 screws**.

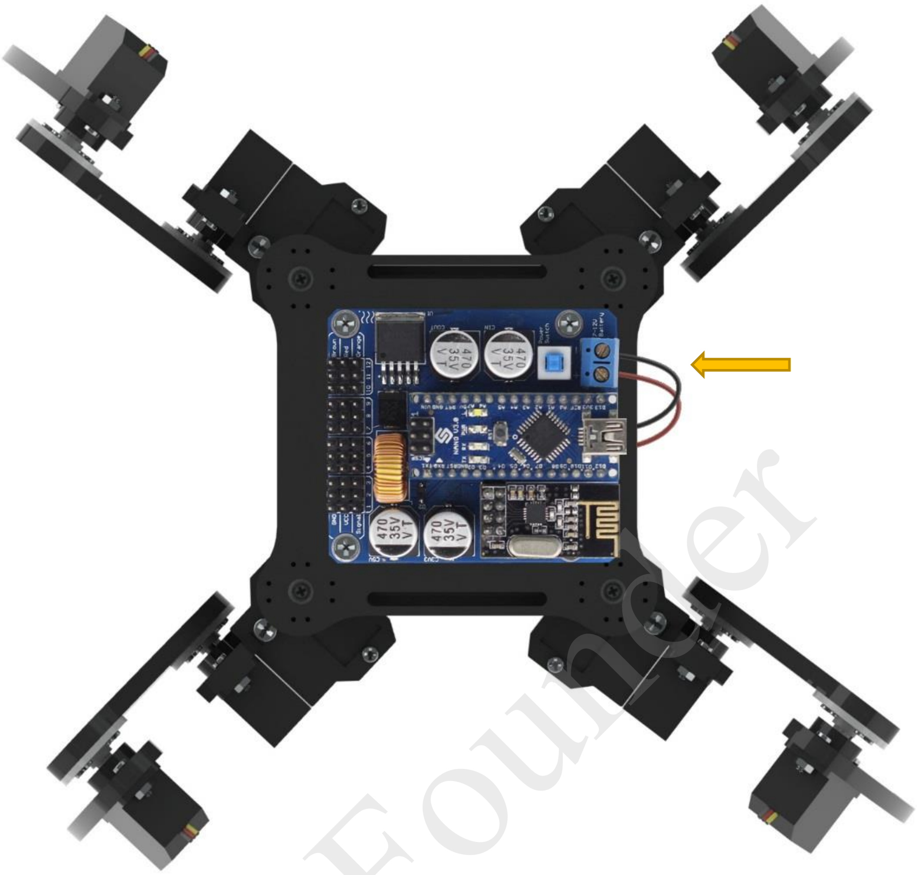


It is shown as follows after connection.

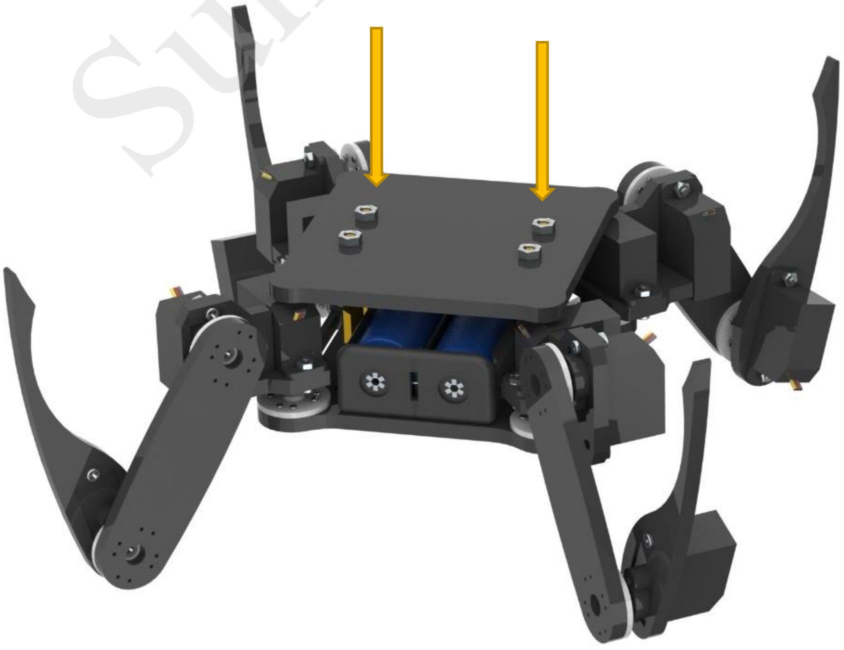


Lower Plate

1. Keep the power off and connect the battery holder. Pay attention not to wire inversely.

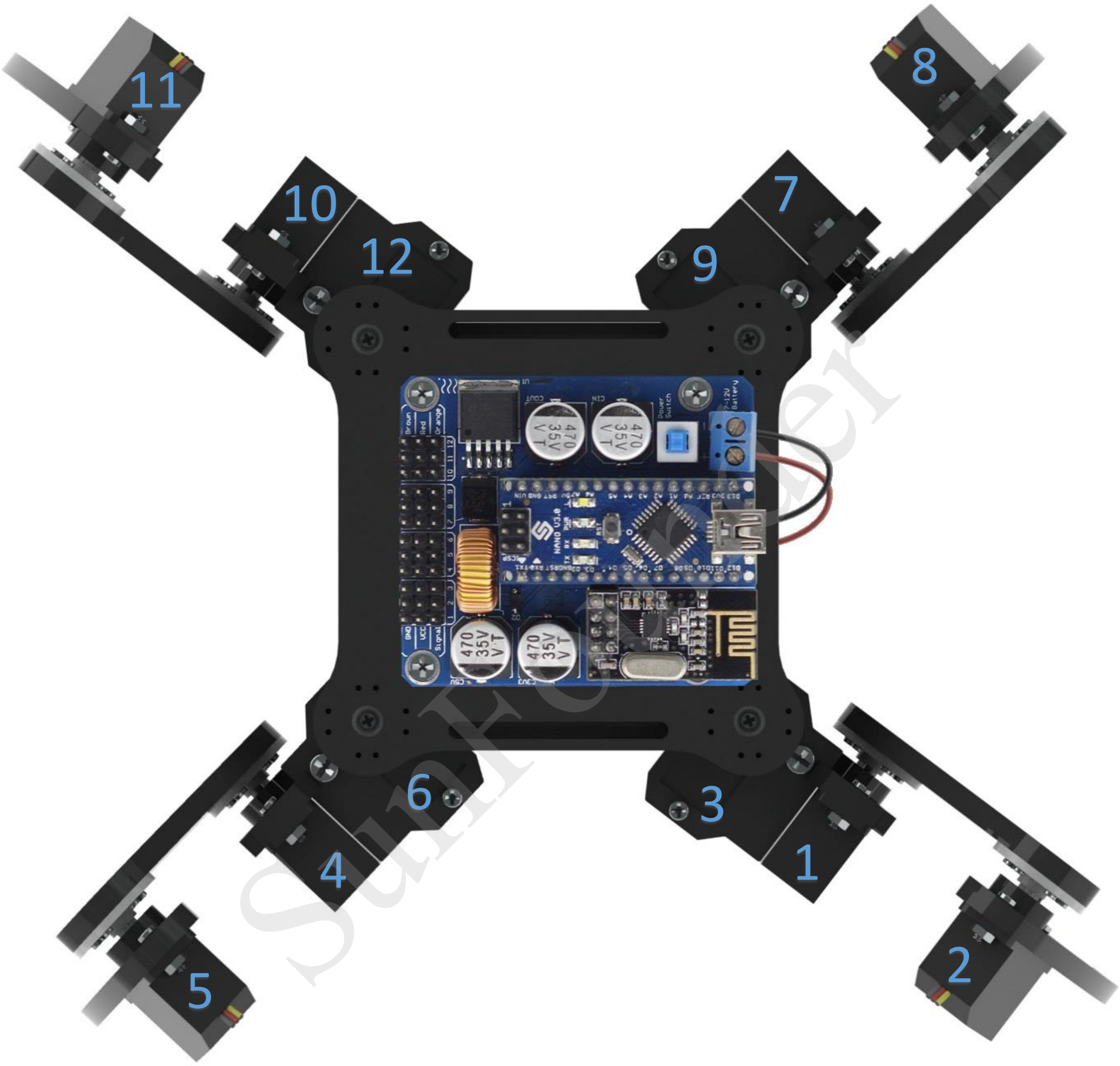


2. Install two 18650 batteries and mount the lower plate. Fix the plate with **M3 nuts**.

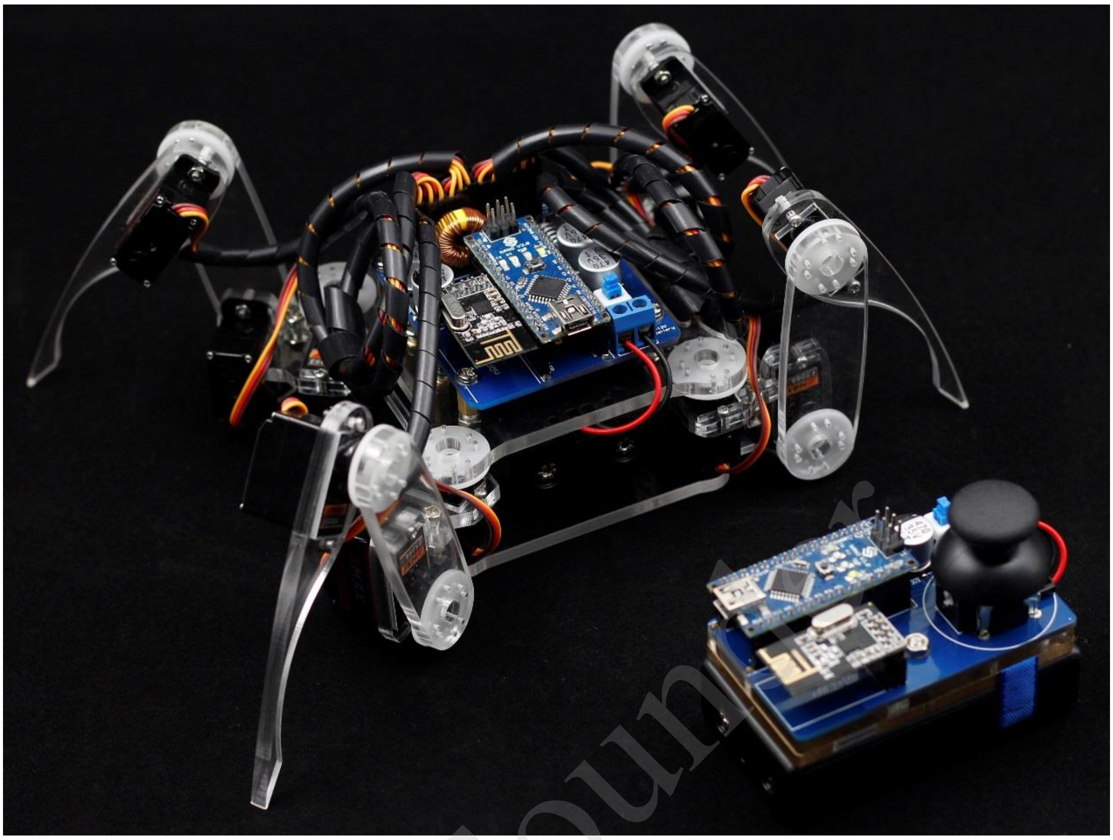


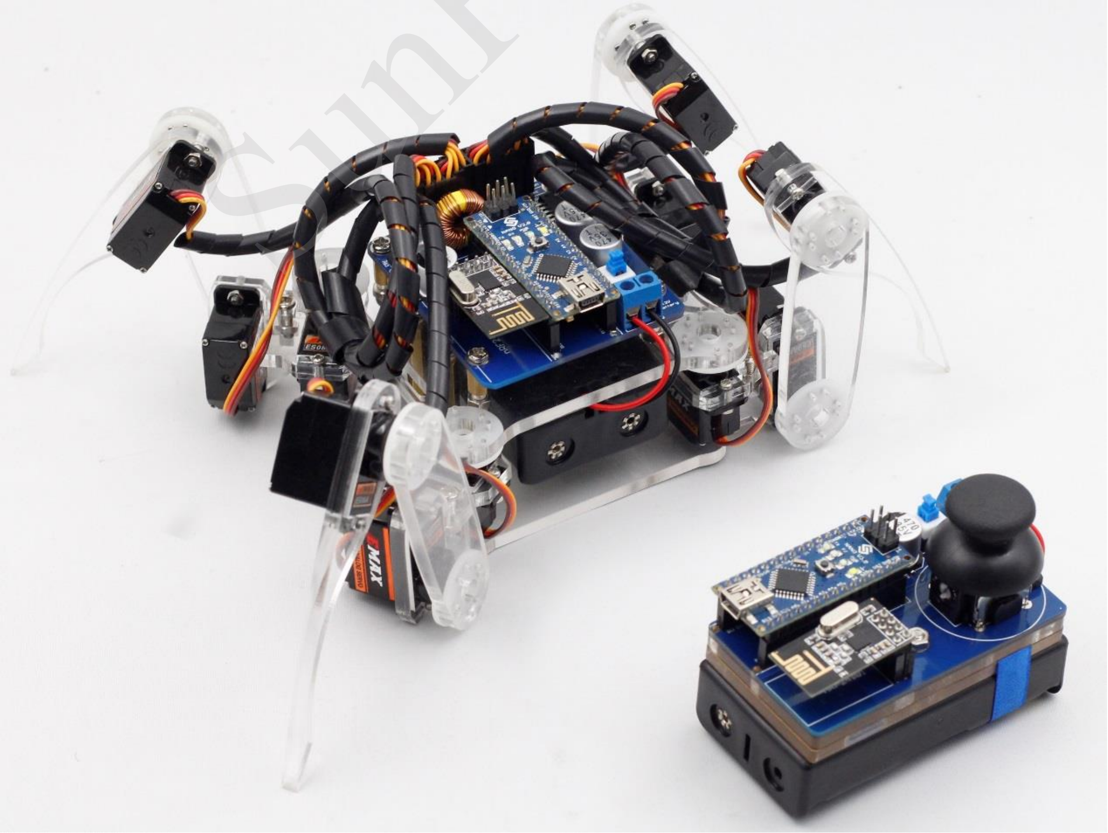
Servo Wiring

Wire the servos to the SunFounder Servo Control Board according to the number marked on the servo below. The numbers correspond to those beside the pins on the control board.



Organize the wires of the servo with wire harness tube. Now the crawling quadruped robot with the remote control has been completely assembled.





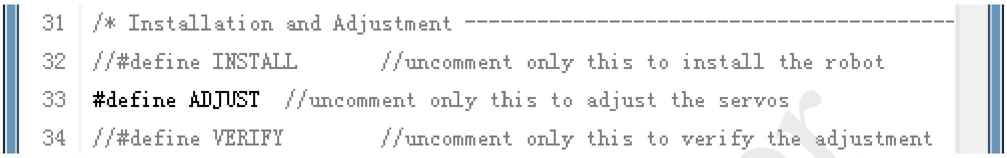
4. Calibrating

During the installation, errors may happen to mechanical connection. So you need to calibrate the robot to make sure the accuracy.

Uploading Code for Calibration

Open *Crawler.ino* under *CD\code\3.Crawl\Crawler*.

Modify Line 32-34 as follows (uncomment the Line 33 #define ADJUST), compile the code, upload it to the SunFounder Servo Control Board, and then remove the USB cable.

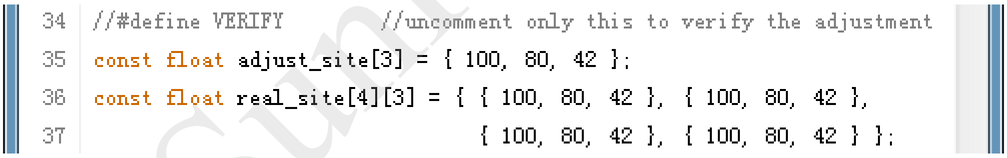


```
31  /* Installation and Adjustment -----------------------------------------
32  //#define INSTALL       //uncomment only this to install the robot
33  #define ADJUST  //uncomment only this to adjust the servos
34  //#define VERIFY        //uncomment only this to verify the adjustment
```

Switch on SunFounder Servo Control Board. At this point, the crawling robot will keep the calibration poses.

Calibrating

Measure the 3D (x, y, z) coordinates of toe tip the four legs, put them in the array *real_site[4][3]* at Line 36 to calibrate the error during the installation.

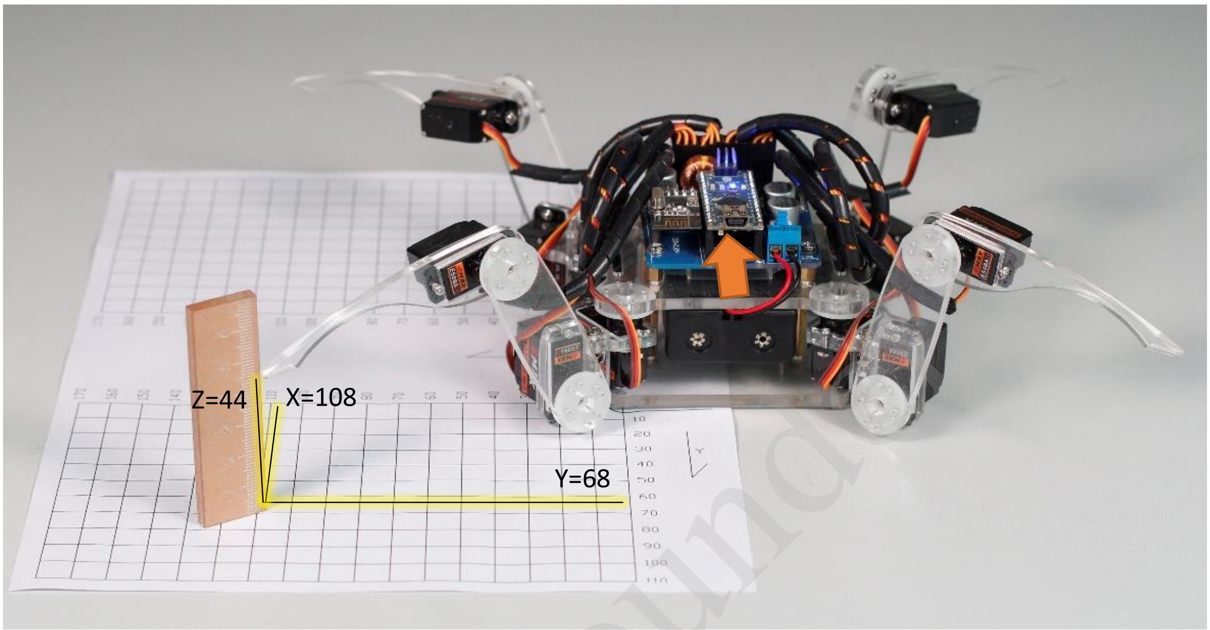


```
34  //#define VERIFY        //uncomment only this to verify the adjustment
35  const float adjust_site[3] = { 100, 80, 42 };
36  const float real_site[4][3] = { { 100, 80, 42 }, { 100, 80, 42 },
37                                  { 100, 80, 42 }, { 100, 80, 42 } };
```

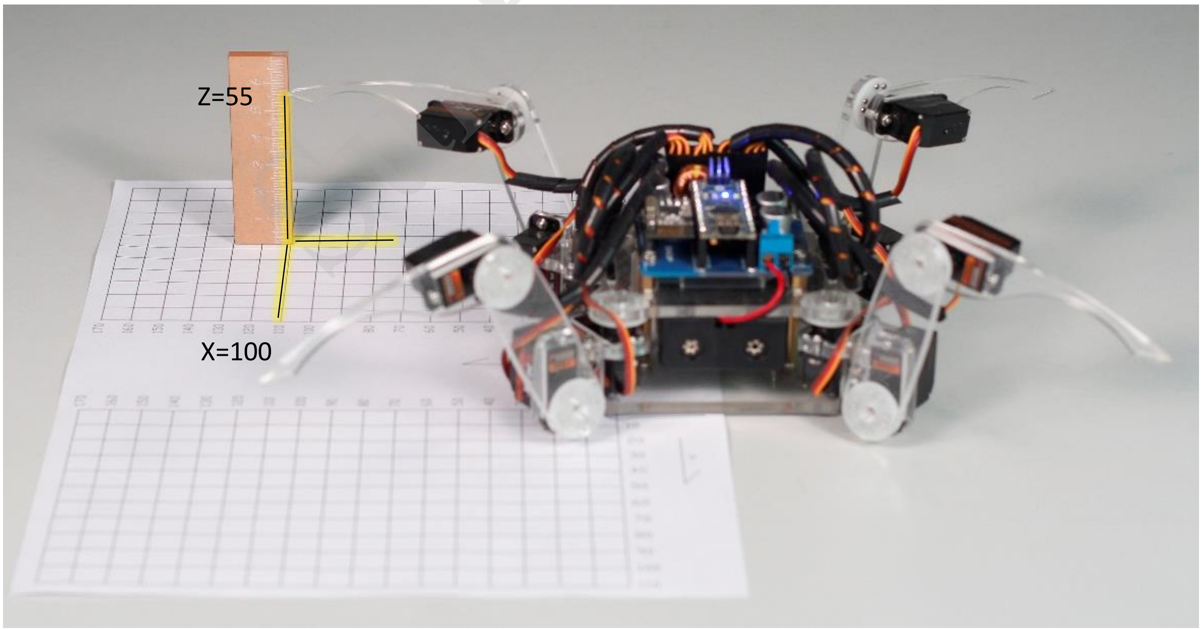
a. Place the robot on the Calibration Chart (a piece of paper included in the package) as shown in the following picture. Measure the coordinates (x, y, z) of leg 1 with a ruler. Here it is (108, 68, 44).

Please pay attention to the direction of the robot and refer to the orange arrow below.

The yellow lines below are not the exact X, Y, and Z axes of the robot; they are marked just for your better understanding of the values at three axes.

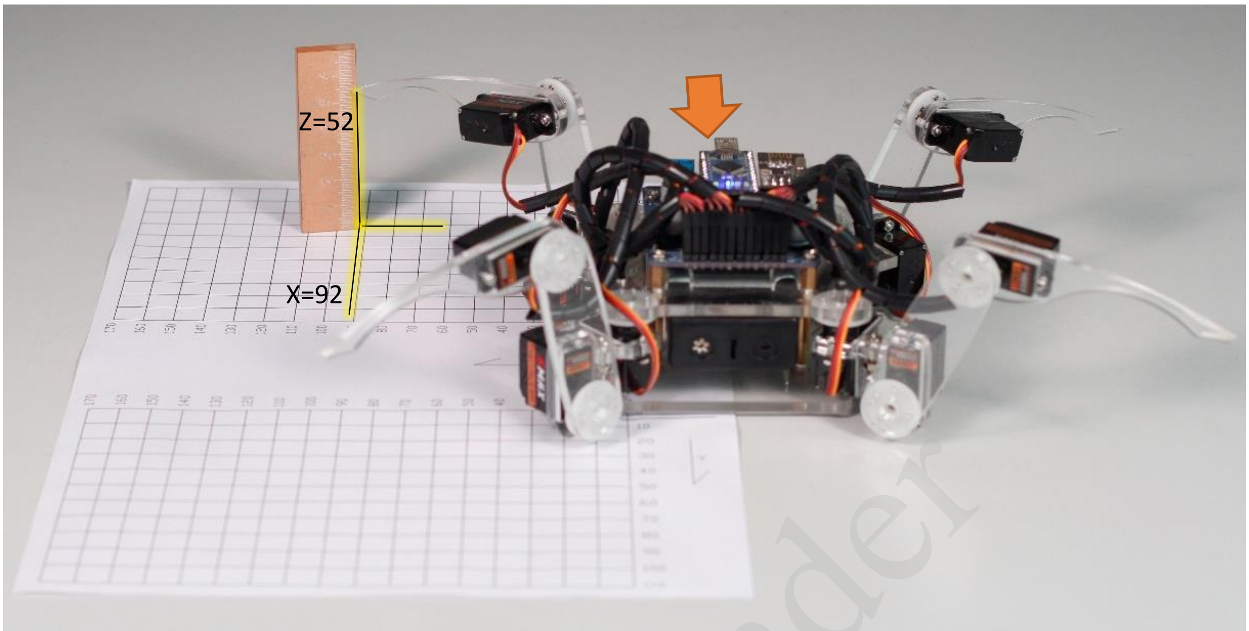


b. Measure the coordinate (x, y, z) of leg 2. Here it is (100, 65, 55).

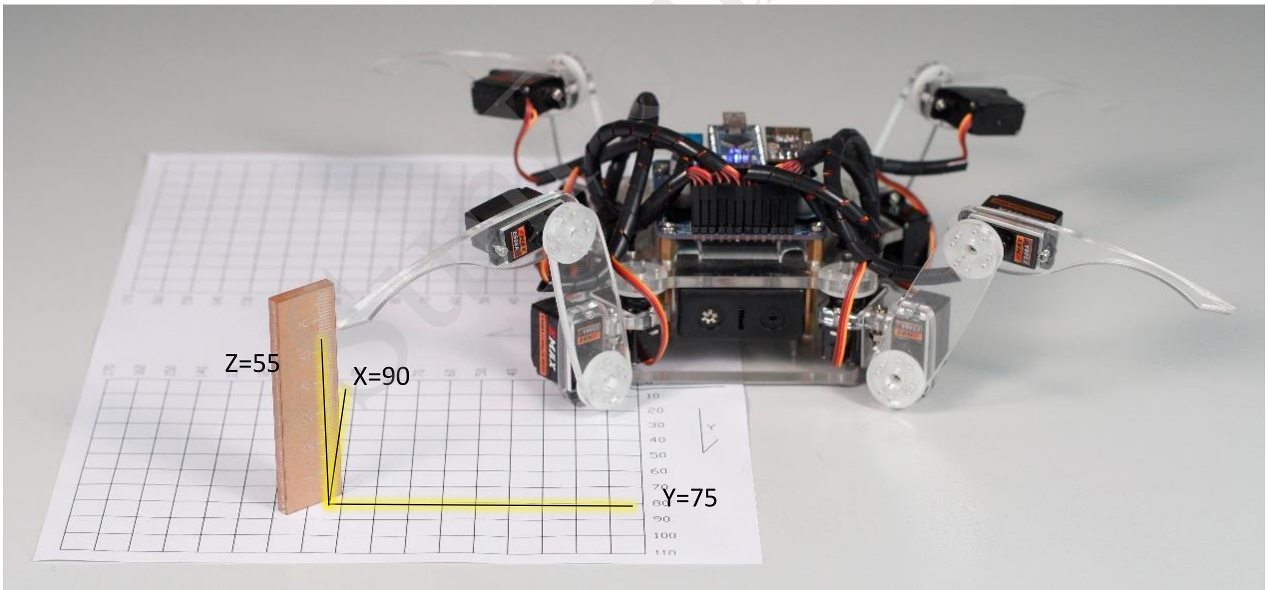


c. Rotate the robot as shown in the following figure, and measure the coordinates (x, y, z) of leg 3. Here it is (92, 72, 52).

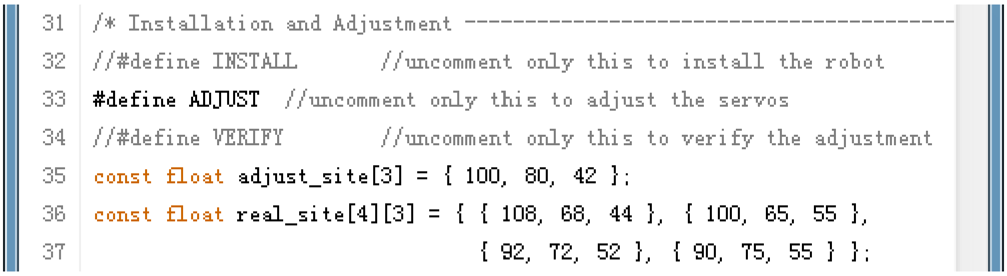
Please pay attention to the direction of the robot and refer to the orange arrow below.



d. Measure the coordinate (x, y, z) of leg 4. Here it is (90, 75, 55).



So, the coordinates filled in the array are (108,68,44), (100,65,55), (92,72,52), and (90,75,55), as shown below:

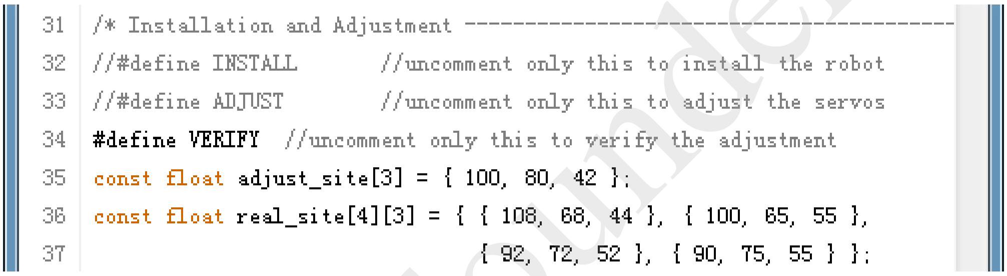


```
31  /* Installation and Adjustment -----------------------------------------
32  //#define INSTALL       //uncomment only this to install the robot
33  #define ADJUST  //uncomment only this to adjust the servos
34  //#define VERIFY        //uncomment only this to verify the adjustment
35  const float adjust_site[3] = { 100, 80, 42 };
36  const float real_site[4][3] = { { 108, 68, 44 }, { 100, 65, 55 },
37                                  { 92, 72, 52 }, { 90, 75, 55 } };
```

Fill in the values according to your actual measurements to calibrate the robot correctly.

Uploading Code for Verification

Modify Line 32-34 as follows (uncomment the Line 34 #define VERIFY), compile and upload the sketch to the SunFounder Servo Control Board, and then remove the USB cable.



```
31  /* Installation and Adjustment -----------------------------------------
32  //#define INSTALL       //uncomment only this to install the robot
33  //#define ADJUST        //uncomment only this to adjust the servos
34  #define VERIFY  //uncomment only this to verify the adjustment
35  const float adjust_site[3] = { 100, 80, 42 };
36  const float real_site[4][3] = { { 108, 68, 44 }, { 100, 65, 55 },
37                                  { 92, 72, 52 }, { 90, 75, 55 } };
```

Switch on SunFounder Servo Control Board. At this point, the crawling robot will keep the verification poses.

Verifying

Place the crawling robot on the calibration chart, and then measure the 3D coordinates (x, y, z) with a ruler. If it is close to the calibration coordinates (100, 80, 42) set in *adjust_site[3]* and the error of each axis is less than 10mm, it means calibration is successful. Otherwise, recalibrate it until it succeeds.

5. Movement

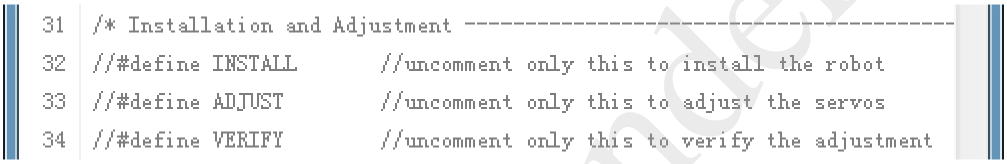
Crawling

Uploading Code for SunFounder Mobile Robot Remote Controller
Open *Remoter.ino* under the *CD\code\3.Crawl\Remoter* directory.

Compile the code, upload it to SunFounder Mobile Robot Remote Controller, and then remove the USB cable. Switch on the remote controller.

Uploading Code for SunFounder Servo Control Board
Open *Crawler.ino* under the *CD\code\3.Crawl\Crawler* directory.

Modify Line 32-34 as follows (uncomment Lines 32-34), compile and upload the sketch to the SunFounder Servo Control Board, and then remove the USB cable.



```
31  /* Installation and Adjustment -----------------------------------------
32  //#define INSTALL       //uncomment only this to install the robot
33  //#define ADJUST        //uncomment only this to adjust the servos
34  //#define VERIFY        //uncomment only this to verify the adjustment
```

Switch on SunFounder Servo Control Board. Now you can control the robot crawling with the remote controller.

Dancing

Uploading Code for SunFounder Mobile Robot Remote Controller
The SunFounder Mobile Robot Remote Controller uses the above code, and you don't need to upload it again.

Uploading Code for SunFounder Servo Control Board
Open *Dance.ino* under the *CD\code\4.Dance\Dance* directory.

Compile and upload the code to SunFounder Servo Control Board, and then remove the USB cable.

Switch on SunFounder Servo Control Board. The robot will dance for a while.

When the robot stops, switch on SunFounder Mobile Robot Remote Controller. Now, you can use it to make the robot dance.

6. Code Explanation

Overview

For the quadruped, you can not only learn things about robotics and electrics, but also the code that animates the robot. In this section, the core code of the sketch, manipulator model of each leg, and proof of the model as well as the corresponding code for the proof will be presented in detail. When you've thoroughly understood these, you can write your own code for the robot! For example, you may write a sketch to make the robot swing the legs when walking, or sway a bit, walk in a bigger pace, dance more steps, etc. Sound amazing? Let's get started!

Core Code

This chapter focuses on how to transform the coordinates of the end of each leg into the rotational angle of each servo. First check the functions void cartesian_to_polar (volatile float &alpha, volatile float &beta, volatile float &gamma, volatile float x, volatile float y, and volatile float z). These are the core of the code for the quadruped robot, which is to transform the coordinates of the legs into the servo rotational angles.

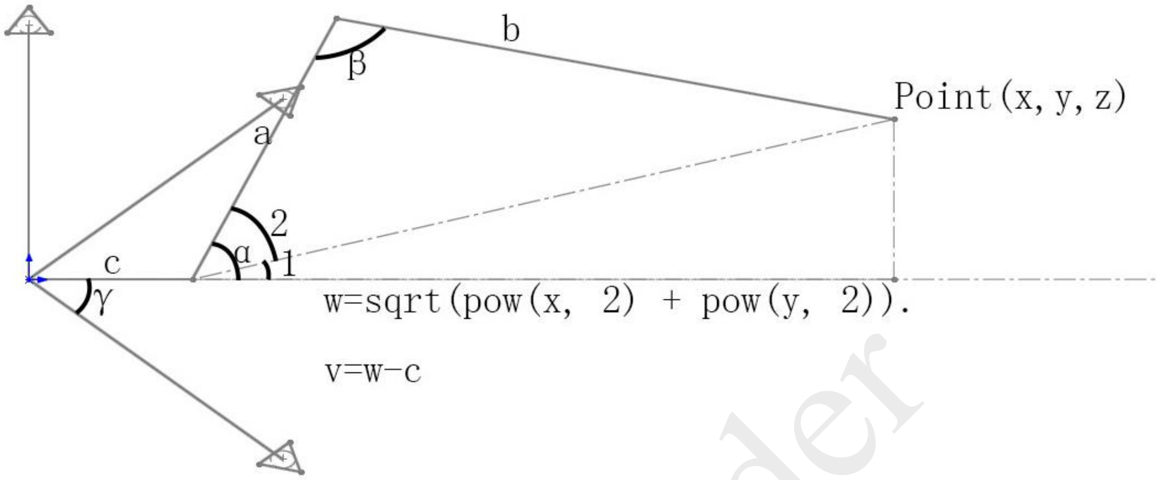
Parameters: alpha, beta, gamma, the address that stores the output angle.

Parameters: x, y, z, the coordinates of the position of the leg end.

The source code of cartesian_to_polar:

```
/*
 - trans site from cartesian to polar
 - mathematical model 2/2
 * ---------------------------------------------------------------------------*/
void cartesian_to_polar(volatile float &alpha, volatile float &beta, volatile
float &gamma, volatile float x, volatile float y, volatile float z)
{
    //calculate w-z degree
    float v, w;
    w = (x >= 0 ? 1 : -1)*(sqrt(pow(x, 2) + pow(y, 2)));
    v = w - length_c;
    alpha = atan2(z, v) + acos((pow(length_a, 2) - pow(length_b, 2) + pow(v, 2)
+ pow(z, 2)) / 2 / length_a / sqrt(pow(v, 2) + pow(z, 2)));
    beta = acos((pow(length_a, 2) + pow(length_b, 2) - pow(v, 2) - pow(z, 2)) /
2 / length_a / length_b);
    //calculate x-y-z degree
    gamma = (w >= 0) ? atan2(y, x) : atan2(-y, -x);
    //trans degree pi->180
    alpha = alpha / pi * 180;
    beta = beta / pi * 180;
    gamma = gamma / pi * 180;
}
```

First build a 3D model for a certain leg. The coordinate direction should be consistent with that on the calibration chart, as shown below:



Here we'll only analyze the first quadrant of the leg end: given the end position Point (x,y,z) and segment a, b, c (the length of each segment of the leg), to calculate the rotational angle of the servo α, β, γ. Within, $\pi/2 \leq \alpha \leq \pi/2$, $0 \leq \beta \leq \pi$, $-\pi/2 \leq \gamma \leq \pi/2$. In this way, transform these into a basic mathematic model. The proof of the model:

w= $\sqrt{x^2+y^2}$

V=w-c

With the law of cosines, cos a = $\frac{b^2+c^2-a^2}{2*b*c}$, the result of ∠2 can be calculated.

∠2=arc cos $\frac{a^2+(z^2+v^2)-b^2}{2*a*\sqrt{z+v^2}.}$

∴ ∠α=∠1+∠2=arc tan(z/v)+ arc cos $\frac{a^2+(z^2+v^2)-b^2}{2*a*\sqrt{z+v^2}.}$

The program should be:

```
alpha = atan2(z, v) + acos((pow(length_a, 2) - pow(length_b, 2) + pow(v, 2) +
pow(z, 2)) / 2 / length_a / sqrt(pow(v, 2) + pow(z, 2)));
```

Similarly, ∠β = arc cos $\frac{a^2+b^2-(z^2+v^2)}{2*a*b}$.

The program should be:

```
beta = acos((pow(length_a, 2) + pow(length_b, 2) - pow(v, 2) - pow(z, 2)) / 2 /
length_a / length_b);
```

Similarly, ∠γ=arc tan (y/x).

The program should be (here only analyze the case for the leg end in the first quadrant):

```
gamma = (w >= 0) ? atan2(y, x) : atan2(-y, -x);
```

Hereto all the transformation from coordinates of the leg end into the servo rotational angle is done.
Each leg has its own coordinate system, which is calculated independently.

Servo_Service Function

After the function cartesian_to_polar is done in the sketch, immediately call the function void polar_to_servo(int leg, float alpha, float beta, float gamma) to adjust the servo rotational angle to the set angle. These two functions will be called one by one in the 50HZ service function void servo_service(void). It is a critical function and you need to pay much attention here.

Streamline Programming

After you've understood the core code and the working sequence, review the code:

```
/* Installation and Adjustment ----------------------------------------------
*/
#define INSTALL //uncomment only this to install the robot
//#define ADJUST    //uncomment only this to adjust the servos
//#define VERIFY    //uncomment only this to verify the adjustment
```

Activate the INSTALL command line and then add a *for()* loop in setup.

```
void setup()
{
#ifdef INSTALL
    //initialize all servos
    for (int i = 0; i < 4; i++)
    {
        for (int j = 0; j < 3; j++)
        {
            servo[i][j].attach(servo_pin[i][j]);
            delay(100);
        }
    }
    while (1);
```

Here set the shaft of the each servo in the center position so as to minimize the error during the installation. After servos are installed, run the calibration program to check whether all the servo are in the center position. Activate ADJUST line and start the calibration:

```
/* Installation and Adjustment ----------------------------------------------
*/
//#define INSTALL   //uncomment only this to install the robot
#define ADJUST  //uncomment only this to adjust the servos
//#define VERIFY    //uncomment only this to verify the adjustment
```

The program still waits in the loop in setup. Set a set of calibration coordinates manually. Then obtain the real coordinates via the calibration chart provided in the kit and a ruler (also an acrylic one included), and then modify the default real coordinates in the sketch.

```
const float real_site[4][3] = { { 115, 68, 42 }, { 105, 66, 60 },
{ 92, 70, 56 }, { 92, 70, 56 } };
```

Activate VERIFY and store the coordinates just obtained. Calculate the error and add it every time the servo rotates, so the accuracy of each segment moving can be ensured.

When all the calibration above mentioned is done, comment the three lines under Installation and Adjustment. After initialization, enter the loop. Here the servo service program runs in the frequency of 50Hz.

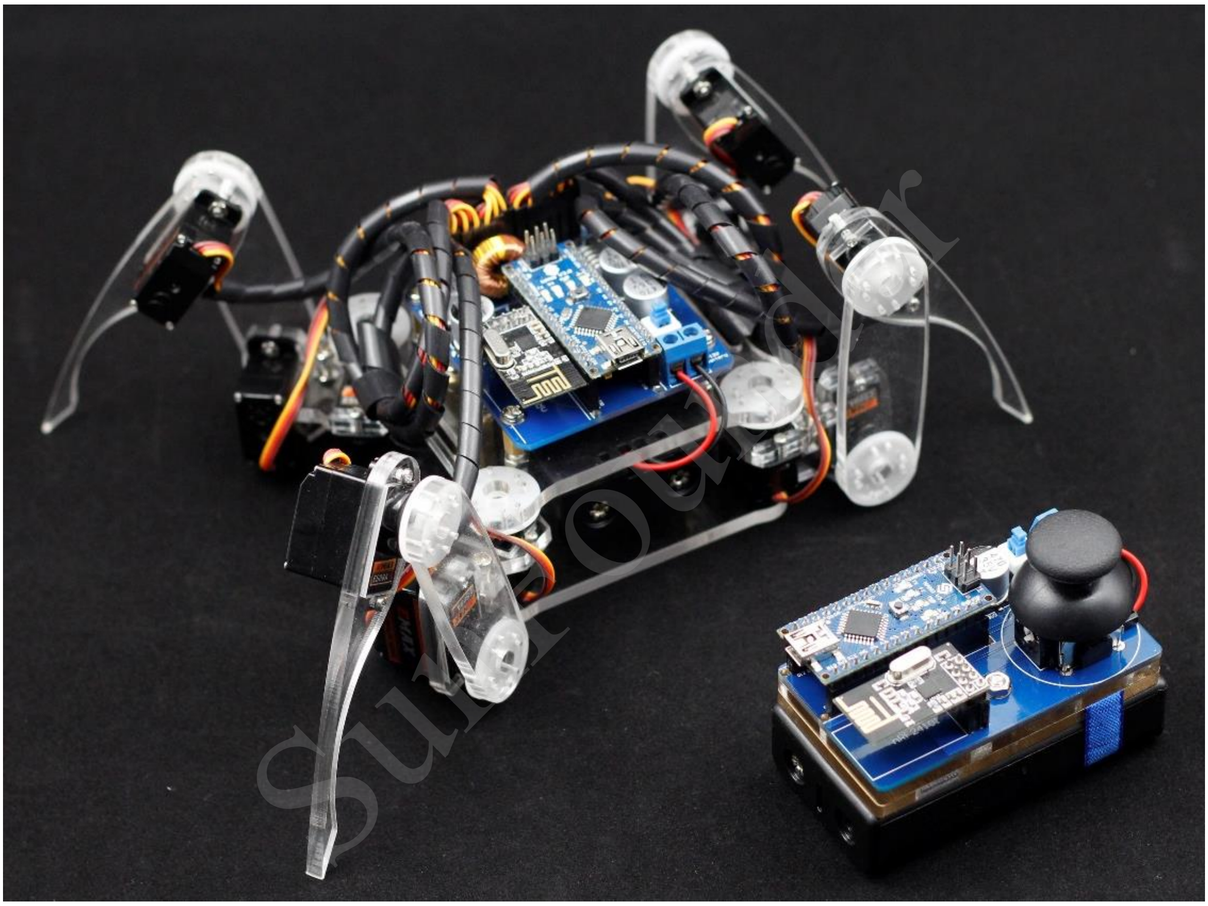
During this period, the main function waits for the remote control commands, so the robot moves accordingly under different command, while the service function is executed all the time, constantly determines whether there is a new target position, and drives the servo to rotate to the position by the functions cartesian_to_polar and polar_to_servo. Thus, when you push the joystick of the remote control, the corresponding command sent can be executed.

After all the explanation, you may hopefully be able to solve the problem encountered in coding and gain a lot from the kit now. Then try to make your own projects by modifying the code!

Afterword

That's all for the SunFounder crawling quadruped robot. You can start your journey now and have lots of fun with the bot!

If you have any suggestions or ideas, please send emails to service@sunfounder.com or post forums on our website www.sunfounder.com. We will reply ASAP. Enjoy the fun!



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