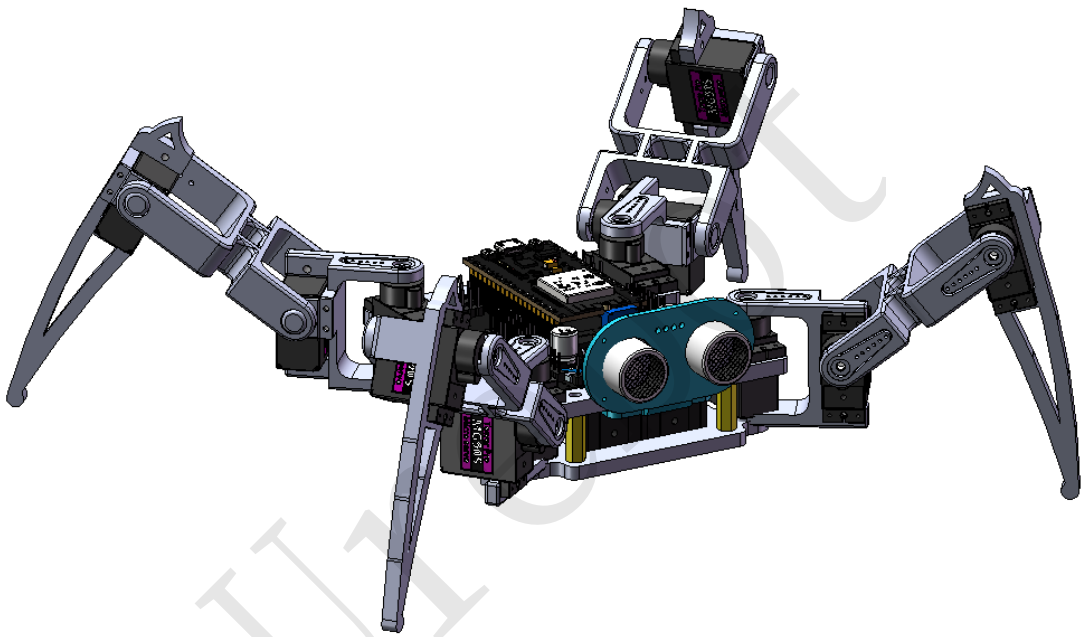
12 DOF quadruped bionic spider robot

catalogue



0 statement

0.1 Statement of Use:

.1.1 0 Please read this manual carefully before use;
.1.2 0 Product design appearance is for reference only, please refer to the actual situation;
.1.3 0 The Company reserves the right to interpret this specification. In case of product update or upgrade, please refer to the actual purchased product function without prior notice.

.2 0 Warranty Statement:

.2.1 0 Normal use of products will provide free one-year warranty service, if the damage caused by human damage, improper use and force majeure factors, the company does not provide free warranty service, will be paid maintenance in accordance with the company's standards;
.2.2 0 The warranty scope of this product is only used for the product subject, and does not include the warranty responsibility of accessories and consumables.

.3 0 Information statement

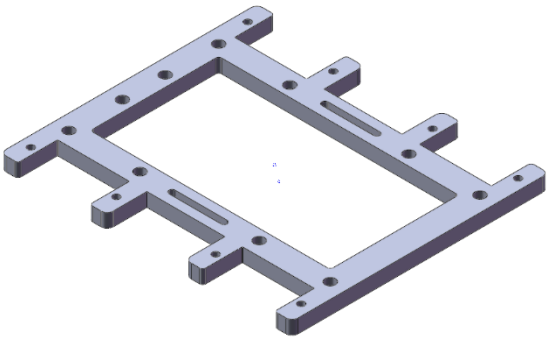
.3.1 0 The copyright of this product information belongs to the company all XINZHILI is the registered trademark of the company, unauthorized plagiarism or dissemination, will be investigated for legal responsibility;

1 A list of the kits

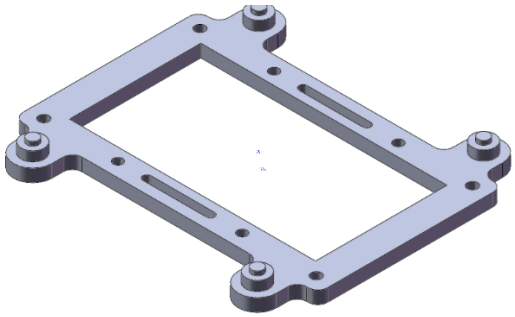
.11 Accessories collection

order number	name	quantity
1	ESP32	1
2	Coaster extension board	1
3	MG90S Steering gear	12
4	18650 Battery (provided, flat head)	2
5	M ini USB, Data line	1
6	The 3D-printed structural pieces	1
7	Beam line tube	a surname
8	bottle opener	1
9	M 2.5 * 14 screws	4
10	M 2.5 nut	4
11	M 3 * 10 screws	10
12	M 3 * 18 double-pass plastic column	4
13	M 3 nut	2
14	M 1.5 * 6 self-tapping screw	16
15	M 1.4 * 4 self-tapping screw	12
16	Ultrasound module	1
17	Ultrasound fixed frame	1
18	M 1.7 * 5 self-tapping screw	4

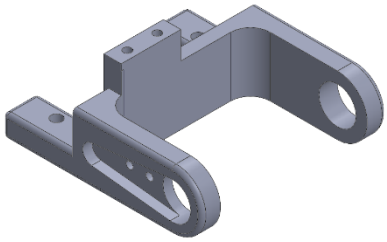
.21 List of structural parts



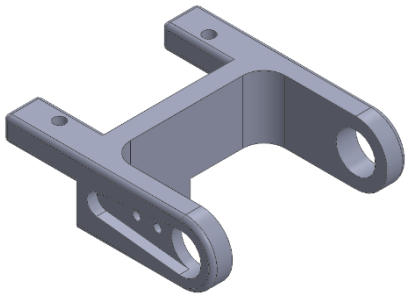
Body-Up x 1



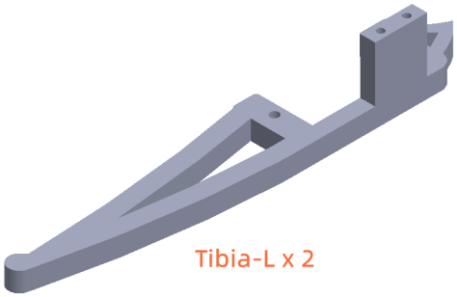
Body-Down x 1



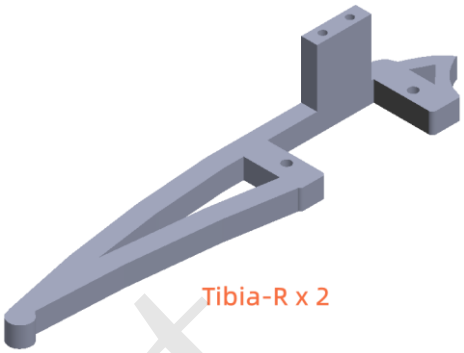
Coxa-L x 2



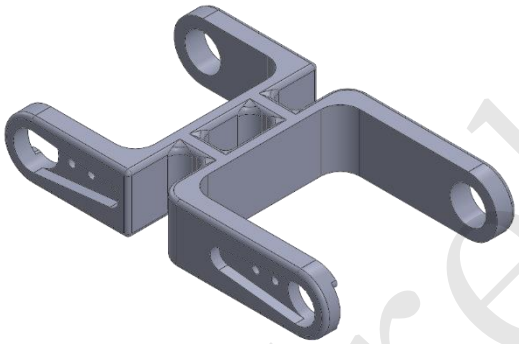
Coxa-R x 2



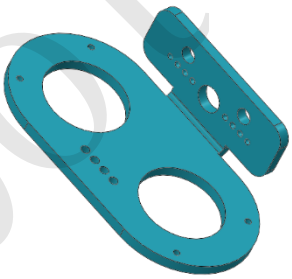
Tibia-L x 2



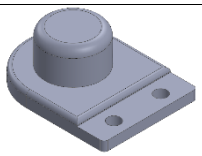
Tibia-R x 2



Femur x 4



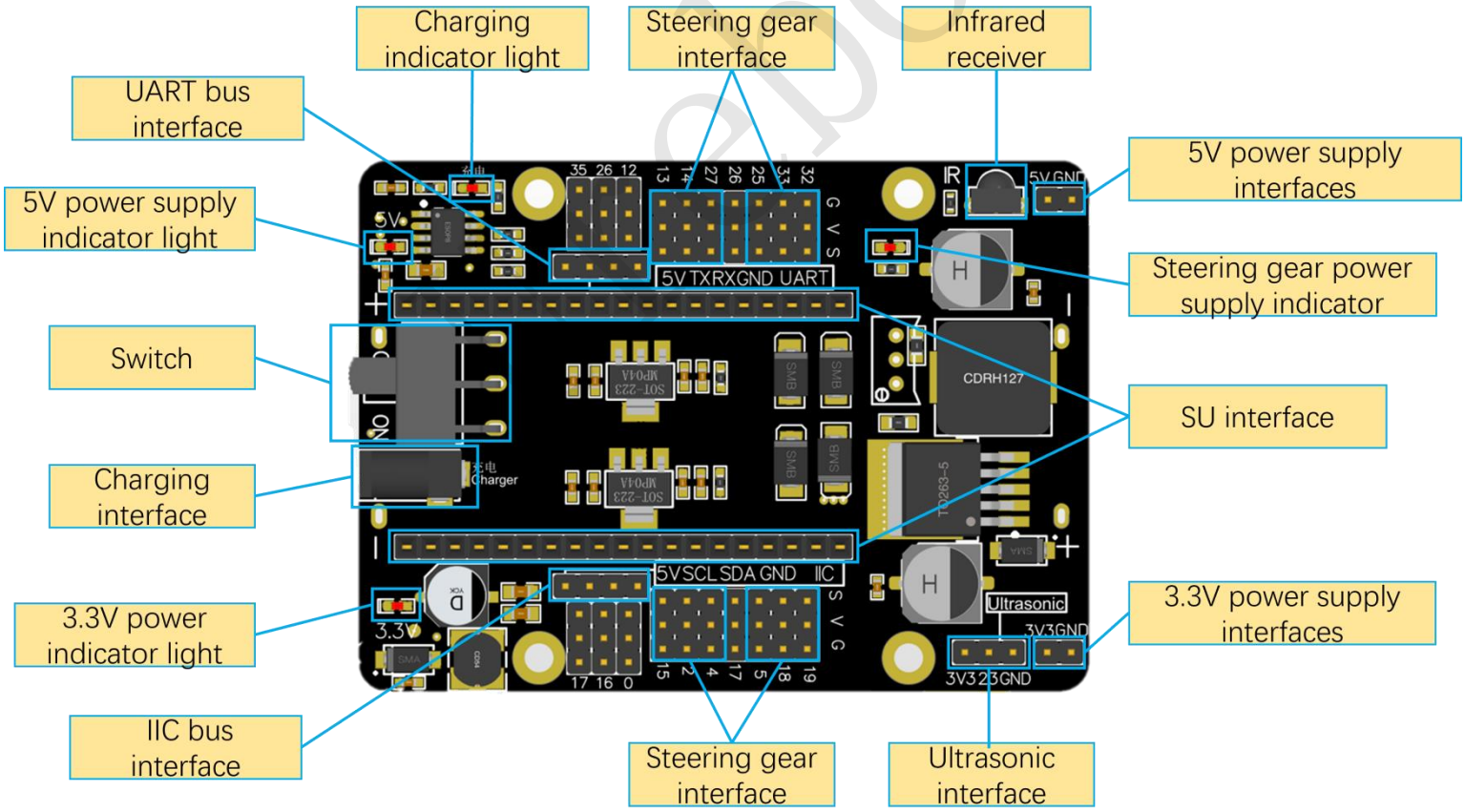
Sonar-Bracket x 1



S-Hold x 8

.31 The rudder machine

.41 Circuit description



Switch: rudder gear expansion board power supply switch, dial the ON gear for the MCU, and other expansion resources power supply, stop the OFF gear, and OFF

gear when charging.

Charging interface: When the switch is switched to the OFF gear, insert the charging cable to charge the lithium battery.

Charging indicator light: the light will light up when charging, please check for detailsCharging instructions.

Steering gear interface: the steering gear connection interface to send signals and supply power to the steering gear.

5V power supply indicator light: the light is lit to indicate that the MCU and 5V power supply interface are working normally.

3.3V power indicator light: the light is on to indicate that 3.3V is working normally.

5V and 3V power supply interfaces: provide the external 5V and 3.3V voltages which can be used for the power supply of the DIY expansion module.

UART bus interface: connect to the single-chip microcontroller hardware UART interface.

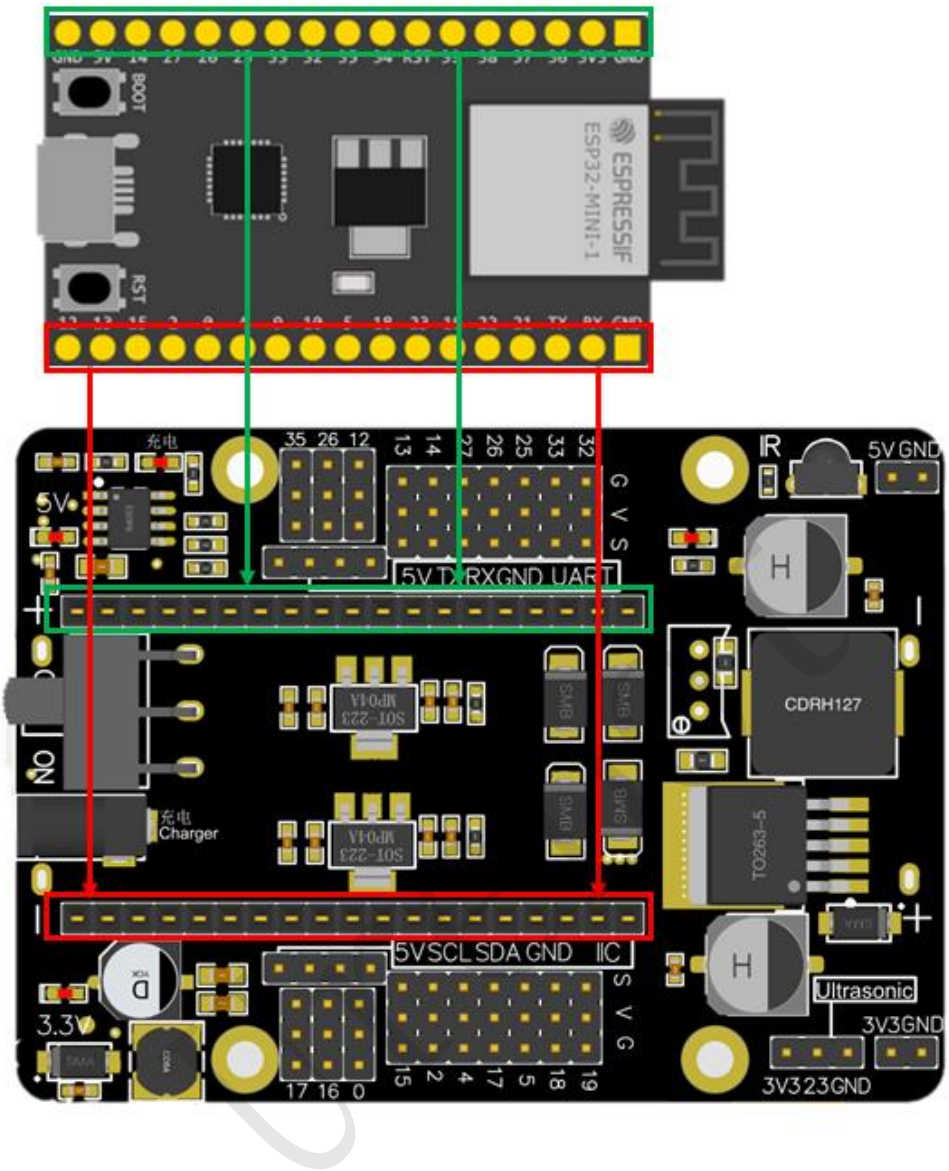
IIC bus interface: connect the single-chip microcontroller hardware IIC interface.

Steering gear power supply indicator: the power supply of steering engine is normal.

Infrared receiver: receiving the infrared signal.

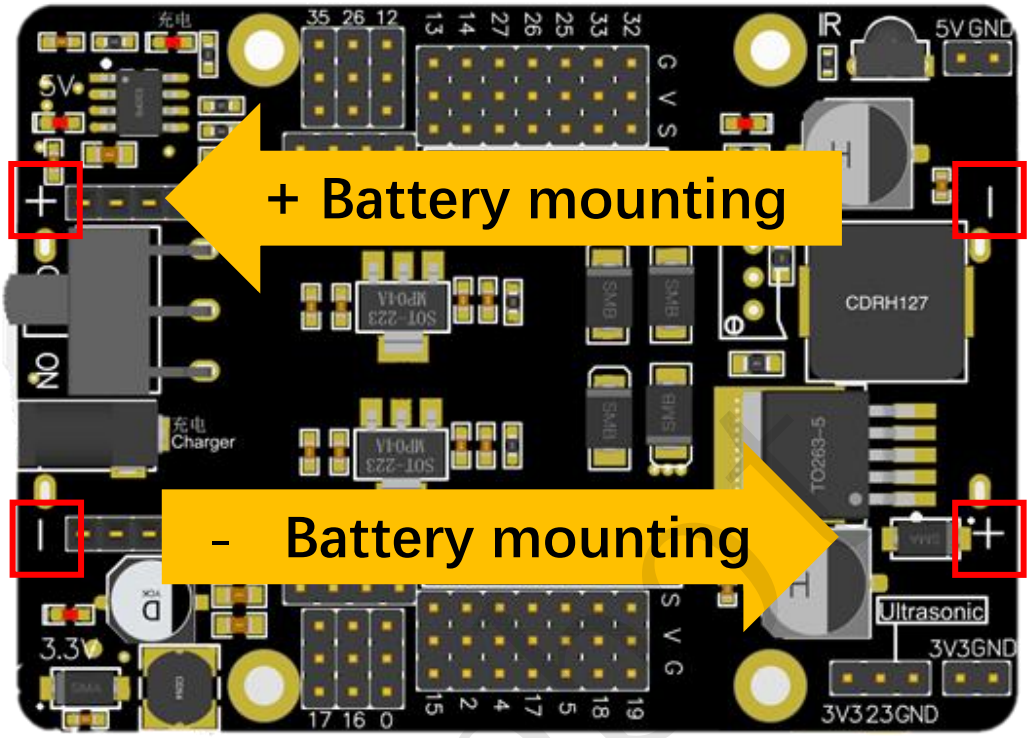
Ultrasonic interface: receiving the ultrasonic signal.

SU interface: install the MCU, please install the MCU in the direction shown in the following figure


BOOT
RST
ESPRESSIF
ESP32-MINI-1
充电
5V
35 26 12
13 14 27 26 25 33 32
G V S
5V TX RX GND UART
IR
5V GND
CDRH127
TO263-5
ON
充电
Charger
5V SCL SDA GND IIC
S V G
3.3V
17 16 0
15 2 4 17 5 18 19
Ultrasonic
3V3 GND
3V3 23 GND

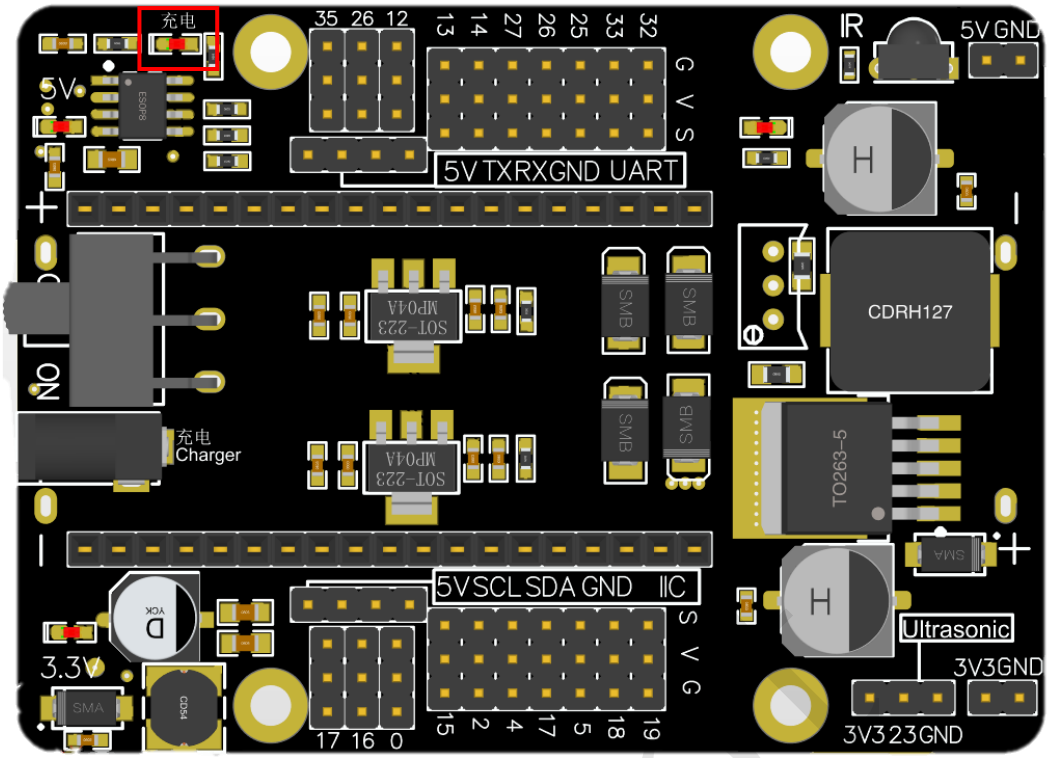
Charging instructions

Install the battery in the direction shown in the figure below. Note that the battery direction connection will burn the circuit.



Insert the charging cable into the charging interface and dial the switch to OFF before inserting the charging cable.

After the charging cable is inserted into the charging interface, the charging light will light up when the power supply is normally connected to enter the charging program normally.



Generally, after three hours, the charging light flashes at high frequency. The closer it is to the filling, the lower the flashing frequency will be, and it will be extinguished after filling.

When the high frequency flicker, the power is generally close to full charge, about 90% -95% of the battery power. It can stop charging and then use normally, and then enter the small current charging mode until it is fully charged.

If the high frequency flashes for more than three hours, stop charging and check if the battery is normal.

The normal voltage of a single battery is 3.2V-4.2V, which is abnormal in this range.

2 Assembly

Step 1: Test the steering gear

Before the pilot test, it is necessary to set up the development environment on the computer. Please open the data package and locate the "class 0 setting development environment under the" 03 tutorial and code course 0 setting development environment ".pdf "。Complete the development environment according to the tutorial instructions.→

After the successful construction of the development environment, please open the data package and locate the "Course 1 Drive Single Pilot-ESP32.pdf" under "03 Course and Code Course 1 Drive Single Pilot". Follow the test following the test.→

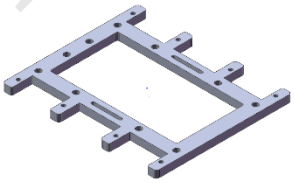
After testing the gear, open the data pack and navigate to cali bration under 03 Tutorial and Code Course 2 Installation and Calibration c alibration.ino ", burn it into the single microcontroller.→→

Step 2: Prepare the assembly

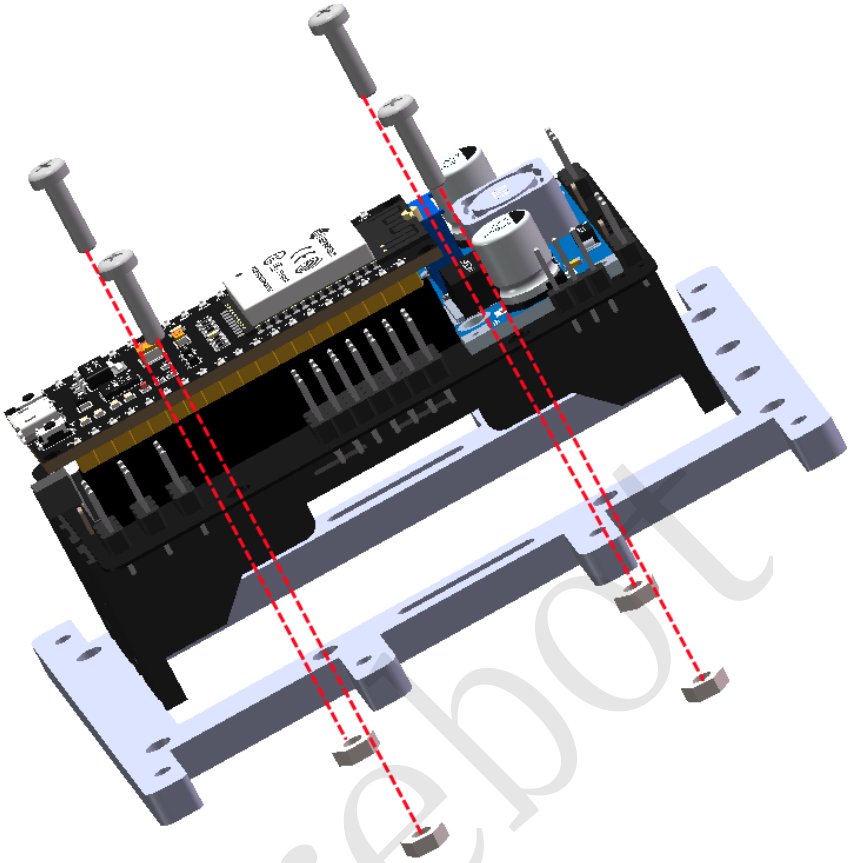
Clean up the protective burr on the surface of the 3D printed structure.

Step 3. Install the circuit board

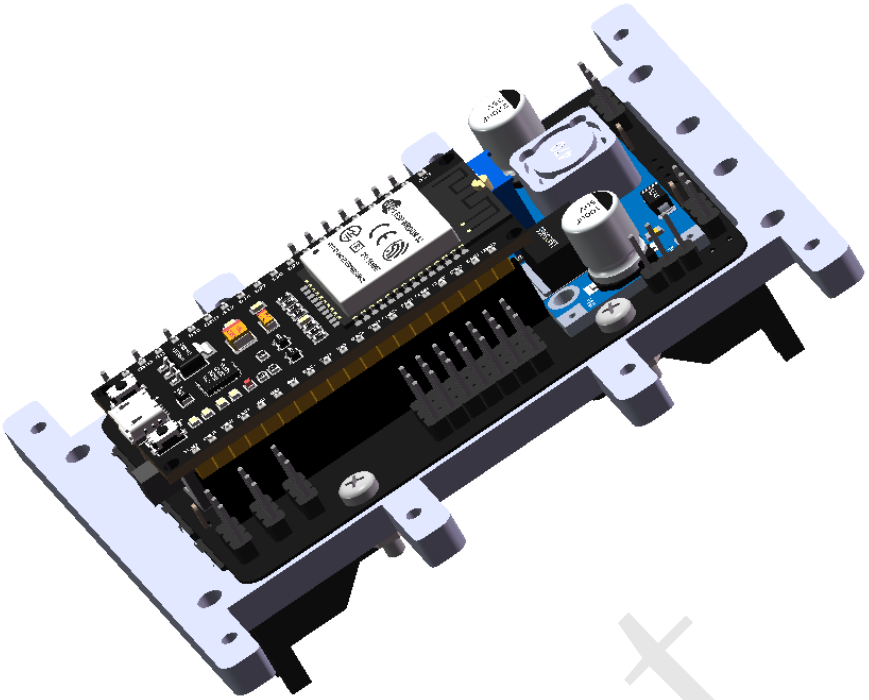
Materials used:

name	picture	quantity
Body -U p		1
E SP32+Servo shield		1
M 2.5 * 14 screws		4
M 2.5 nut		4

Attach the steering plate to the Body-Up plate with 4 M 2.5 * 14 screws and M 2.5 nuts as shown in the figure below



After assembly, as shown in the figure below

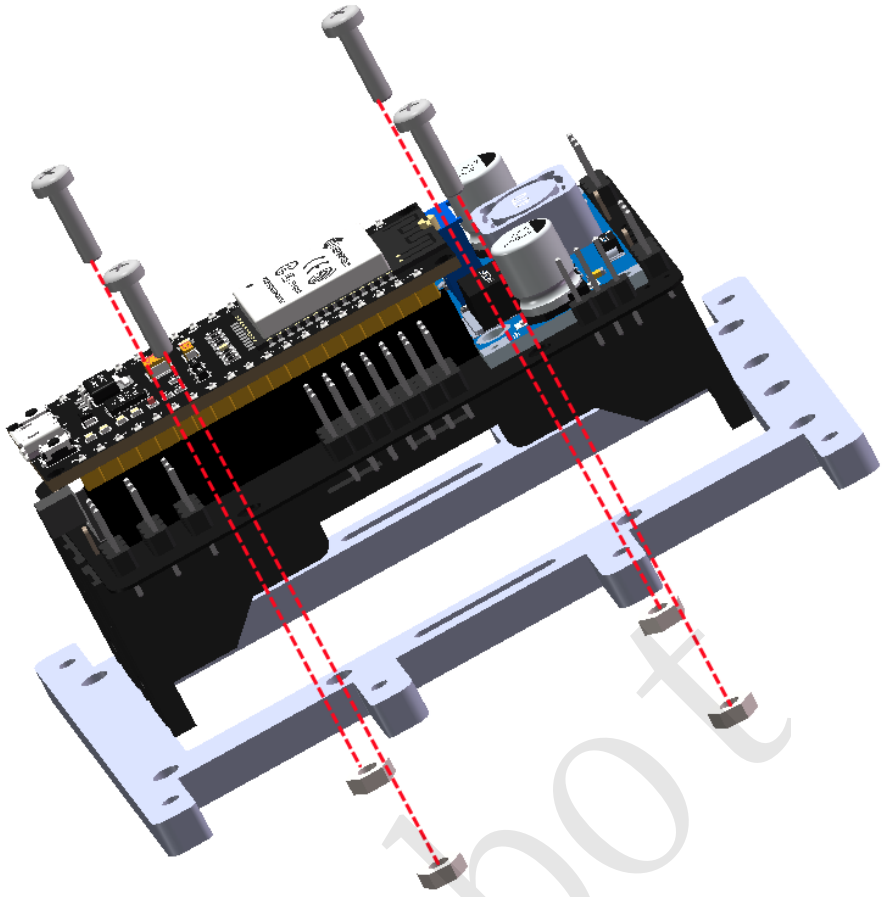


Step 4. Install the steering gear

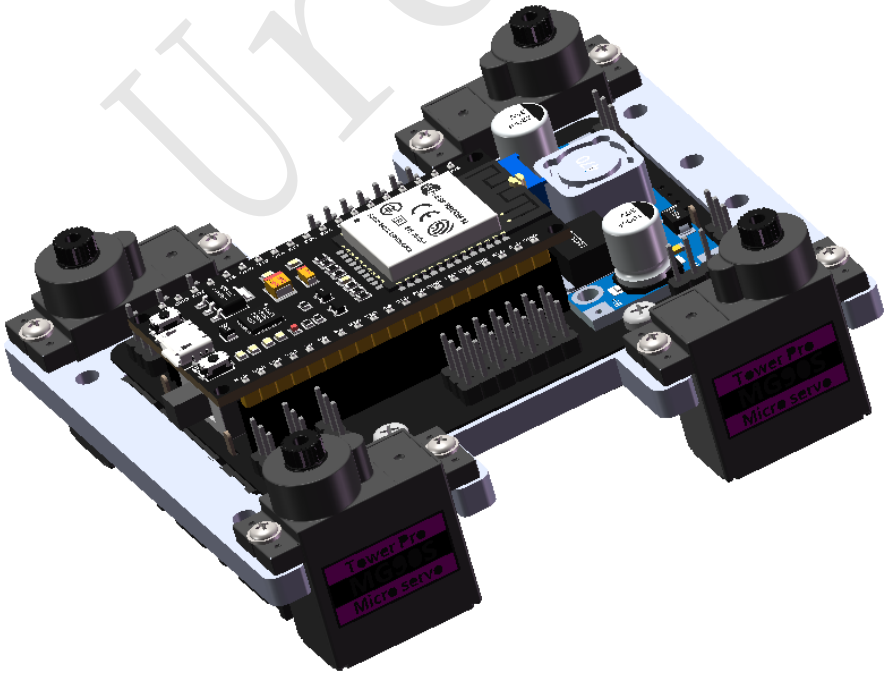
New accessories:

name	picture	quantity
steering engine		4
M 1.9 * 7 Self-tapping screw (in the steering gear bag)		8

Remove 8 M 1.9 * 7 screws from the rudder bag and mount the rudder machine on the Body-Up.

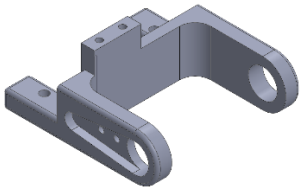
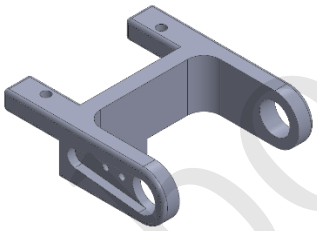


The effect after assembly is shown in Fig



Step 5 Coxa to install the steering gear

New accessories:

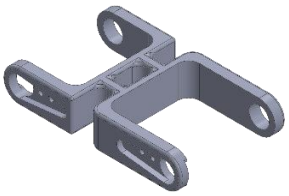
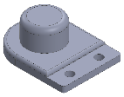
name	picture	quantity
steering engine		4
Coxa -L		2
C oxa-R		2
M 1.9 * 7 Self-tapping screw (in the steering gear bag)		8

Remove 8 M 1.9 * 7 screws from the steering gear bag and mount the steering gear on the Coxa, as shown in the figure below

The installed effect is as shown in the figure below

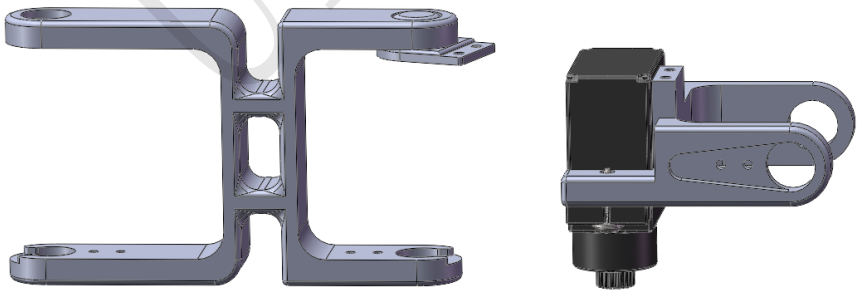
Step 6. Install the Femur

New accessories:

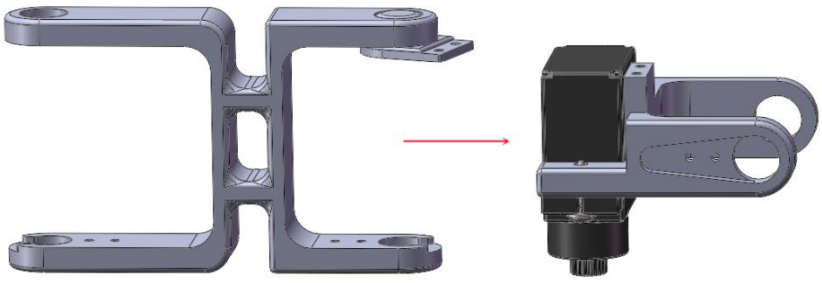
name	picture	quantity
Femur		4
S-Hold		4
M 1.4 * 6 self-tapping screw		8

Taking one of the legs as an example, the S-Hold was placed on the Femur first, as shown in Fig

The effect after being well placed is shown in the figure below

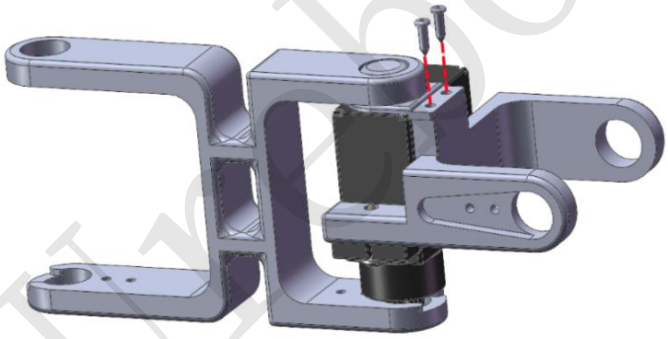


After placing the S-Hold, connect Femur and Coxa and secure with M 1.4 * 6 screws as shown in the figure below

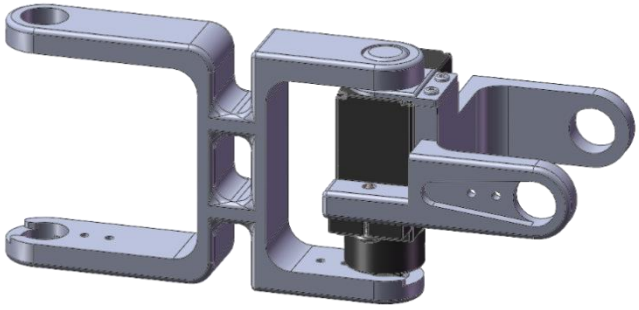


The results are shown in Fig

Secure it with the M 1.4 * 6 screws



The well-installed effect is as shown in the figure below

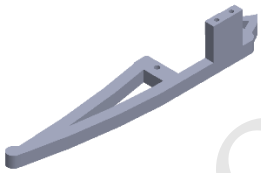
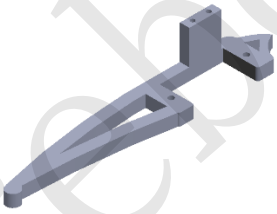


Similarly, install the other four legs, as shown in the figure below

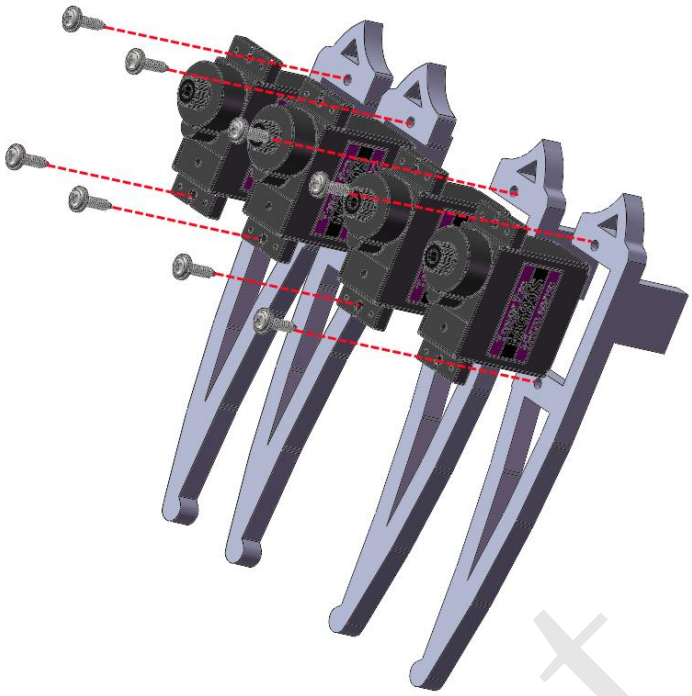
Be careful not to install the steering arm on the rudder engine at this step.

Step 7 Tibia gear the steering gear

New accessories:

name	picture	quantity
steering engine		4
Tibia -L		2
T ibia-R		2
M 1.9 * 7 Self-tapping screw (in the steering gear bag)		8

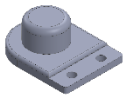
Install the steering gear on the Tibia structure with the M 1.9 * 7 screw removed from the rudder bag as shown in the following below.



The installed effect is shown in the figure below,

Step 8 Connect with Tibia and Femur

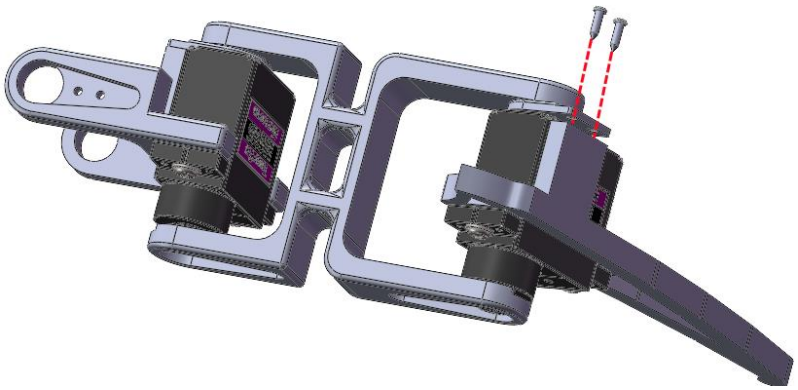
New accessories:

name	picture	quantity
S-Hold		4
M 1.4 * 6 self-tapping screw		8

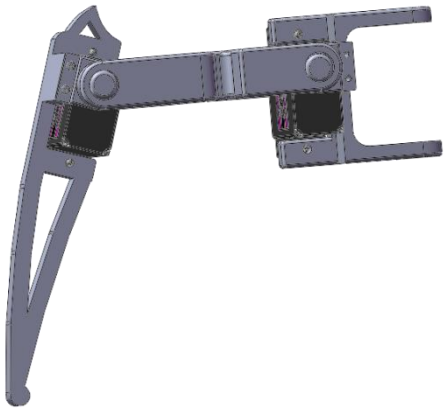
Take one leg as an example, the Ti bia-R is tilted into the shaft hole of Femur, as shown in the figure below

The good effect is shown in the figure below

Finally, the S-H older was fixed with the Tibia-R with M 1.4x 6 screws, as shown in the figure below



The well-installed effect is as shown in the figure below



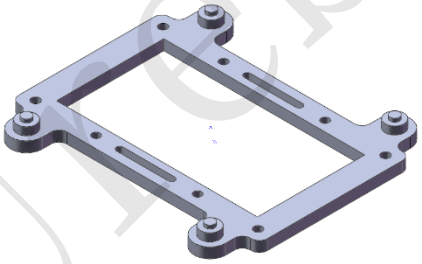
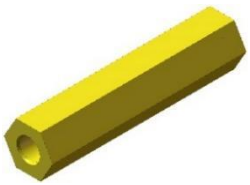
Install the other legs in the same way as good (be careful not to install the steering arm on the steering gear)

Step 9 connects Body-Up to the leg as shown in the following below

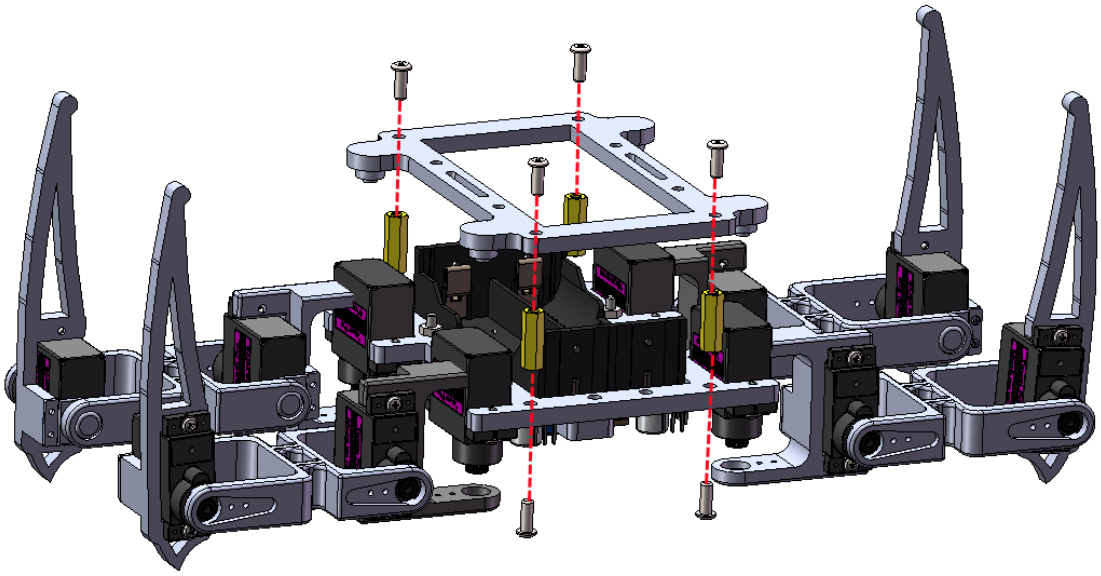
Note: The surface of the rudder arm needs to be installed on the outside!!!!!!

Step 10 Install the lower bottom plate Body-Down

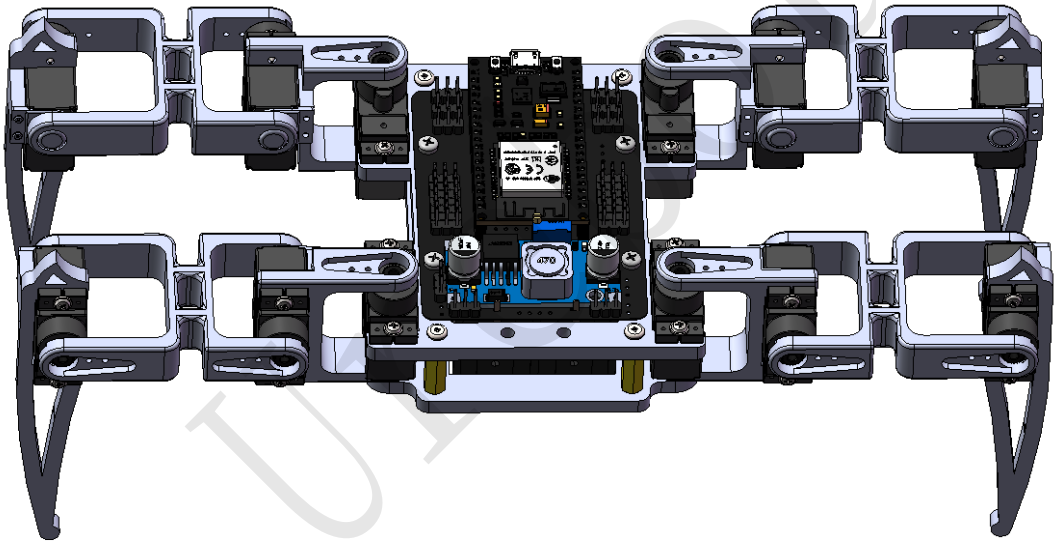
New accessories:

name	picture	quantity
Body -Down		1
The M 3 * 18 copper column		4
M 3 * 10 screws		8

Body-Down and Body-Up were fixed with 8 M 3 * 10 screws and 4 M 3 * 18 copper columns, as shown in the following below

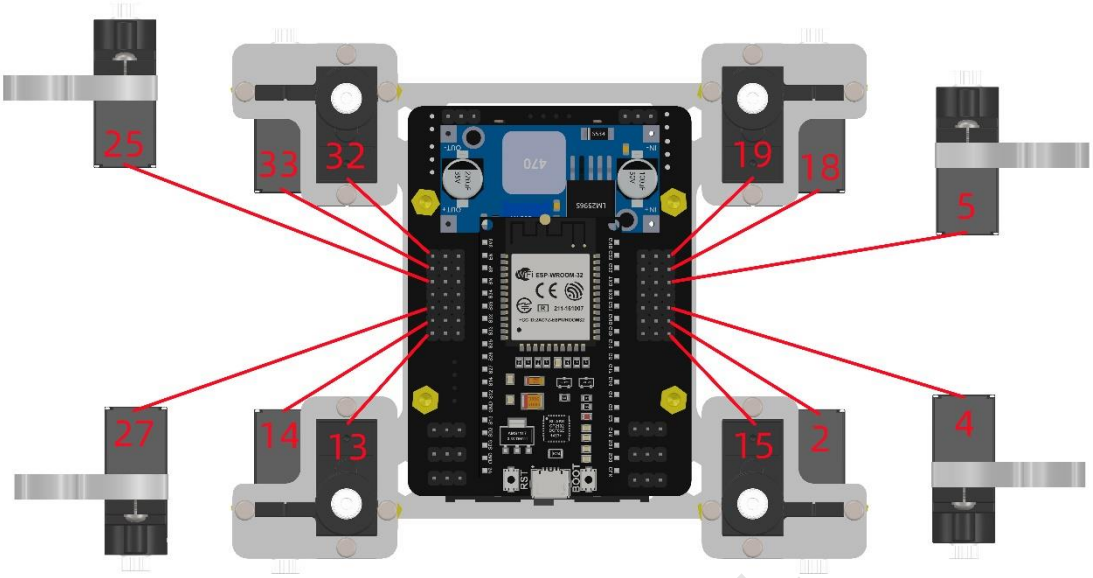


The well-installed effect is as shown in the figure below



Step 11 Connect the steering gear to the expansion board

The steering gear has 3 control lines: power cord, ground wire and signal line. Definition of rudder engine pin: brown line —— GND, red line —— 5V, orange line —— signal. The brown line of the rudder is connected to the G row of needles on the expansion board, the red line of the rudder is connected to the V row on the expansion board, and the orange line of the rudder is connected to the S row of needles on the expansion board. The connection relationship between the steering gear and the expansion board is shown in the figure below.

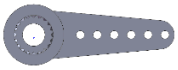


Take Leg 1 as an example, the signal line of the steering gear on Tibia is connected to the 5th pin on the expansion board, the signal line of the steering gear on Femur is connected to the 18th pin on the expansion board, and the signal line of the steering gear on Coxa is connected to the 19th pin on the expansion board. And so on, 12 steering ders are connected to the expansion board.

After connecting the steering gear, put two 18650 batteries into the battery case.

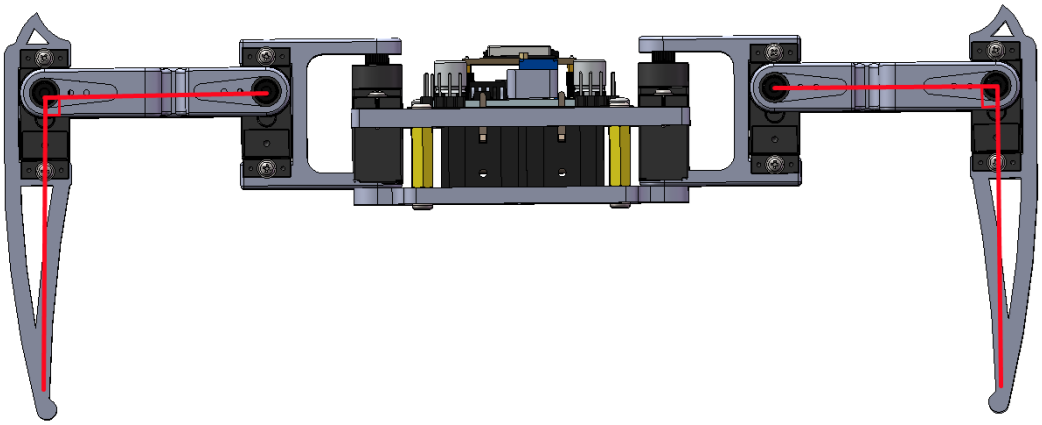
Step 12 Position the initial position of the leg

New accessories:

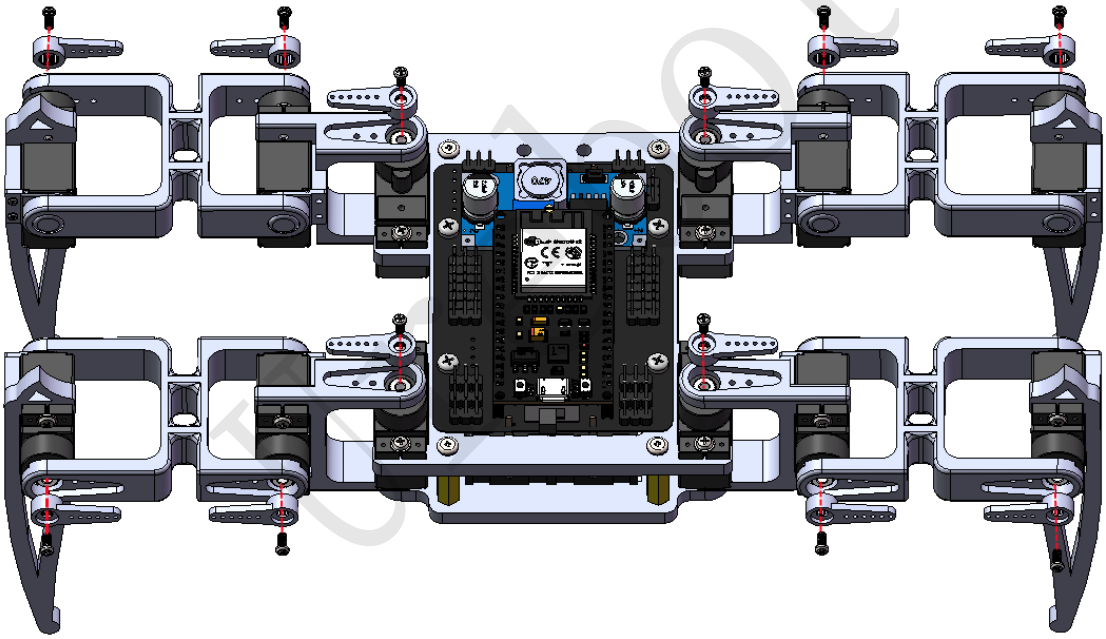
name	picture	quantity
M2.5 * 4 screws (short screw in steering gear bag)		12
Steering arm (in the steering gear bag)		12
M 1.4 * 4 screw		12

Make sure to switch the switch to OFF. Enter the tutorial information that we provide, and double-click to open the "calibration" under "03 Tutorial and Code Course 2 Installation and Calibration cali bration".ino "。→→Connect the USB 32 to the computer with a USB cable. As with the previous operation of burning the code, the c ali bration. The ino program is burned to the microcontroller. Pull out the USB cable, dial the switch to ON for 10 seconds (hear the steering rotation stop) to OFF. Fixed the steering gear and the structural parts, and maintain the following position. Remember, do

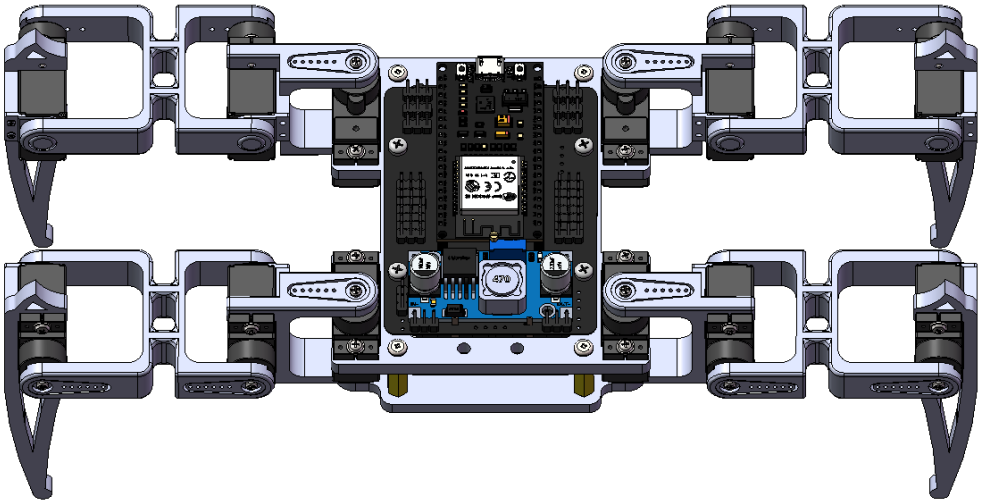
not rotate the rotating shaft of the steering gear when installing the steering gear. For details, please read "Calibration Instructions" under "02 Instructions".pdf "



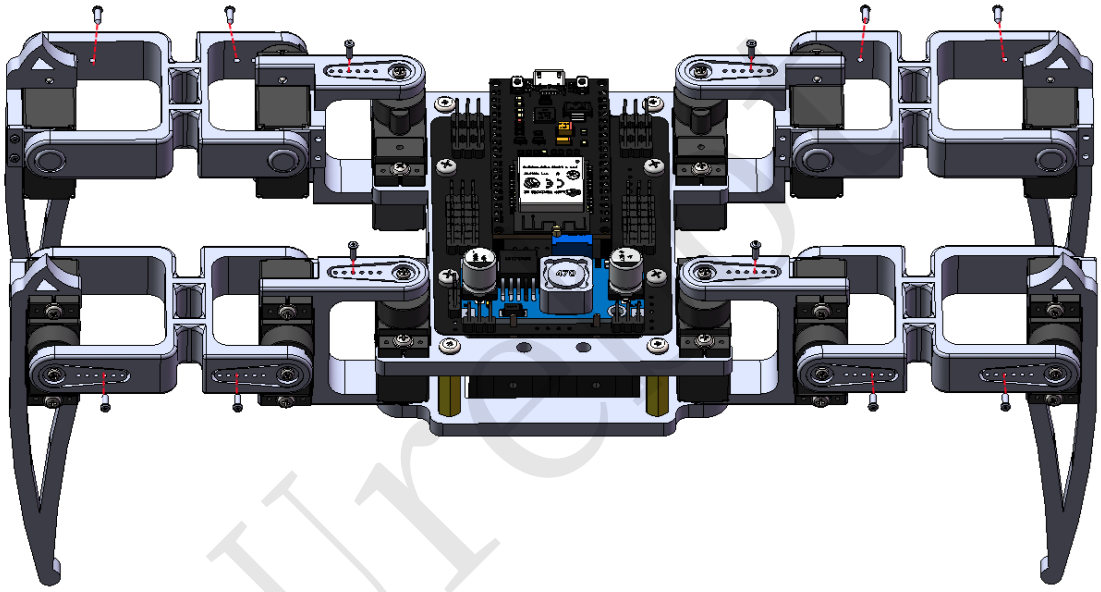
Secure the rudder arm to the rudder with the M 2.5 * 4 screw removed from the rudder bag as shown in the following below



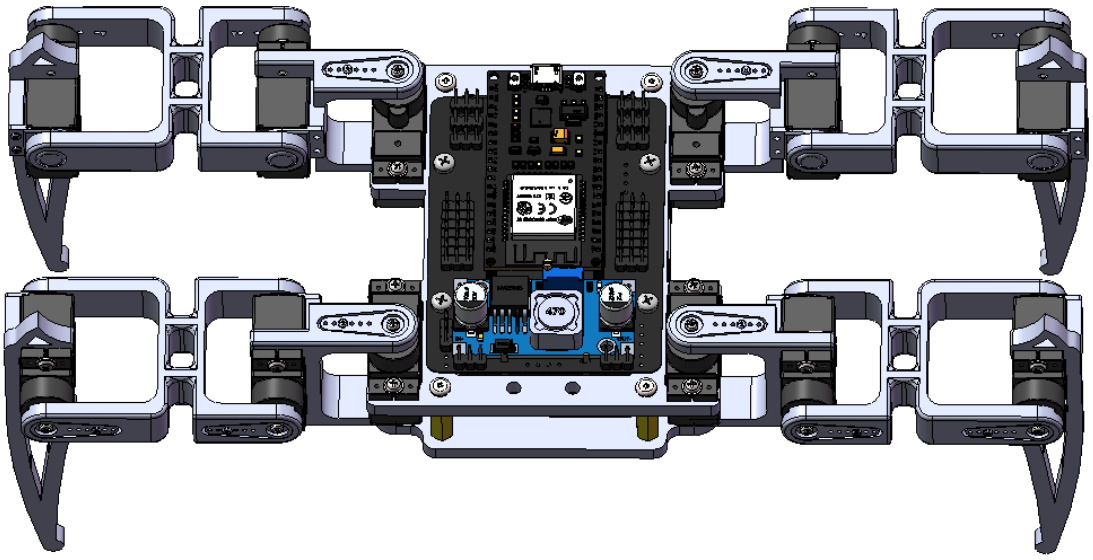
The well-installed effect is as shown in the figure below



Attach the steering arm to the structure with M 1.4 * 4 screws as shown in the figure below.



The effect after the installation is shown in the figure below



This step needs to ensure that the position is as close as possible after the battery is replugged in, otherwise it needs to be repeated until it is close. At this point, the structure installation is complete. You can continue to learn the "03 tutorial and code" folder, the rest of the course content, learning can be developed twice.

3 Core code interpretation

.13 for the inverse kinematic solution

This paper focuses on how to convert the coordinates at the end of each leg to the rotation angle of each steering gear. First check the function 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 quadruped robot code, converting the coordinates of the legs into servo rotation angles.
Parameters: alpha, beta, gamma, the address of the storage output angle.
Parameters: x, y, z, leg end position coordinates.
The cartesian_to_polar source code is as follows:

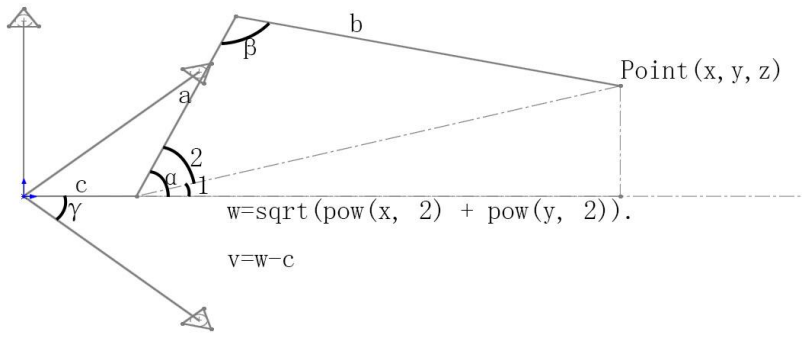
```
/*- trans site from cartesian to polar

- 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 shall be consistent with the calibration drawing, as shown in the figure below:



Here we only analyze the first quadrant of the leg: given the end position Point (x, y, z) and segment a, b, c (length of each leg) to calculate the

rotation angle servo α, β, γ. Inside, π / 2 α π / 2,0 β π, - π / 2 γ π / 2. In this way, these are transformed into basic mathematical models.
Model proof:

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

$$v = w - c$$

$\cos\alpha = \frac{b^2 + c^2 - a^2}{2*b*c}$ From the cosine rule,, the result of 2 can be calculated.

$$\angle 2 = \arccos\frac{a^2 + (z^2 + v^2) - b^2}{2*a*\sqrt{z + v^2}}$$

$$\therefore \angle\alpha = \angle 1 + \angle 2 = \arctan(z/v) + \arccos\frac{a^2 + (z^2 + v^2) - b^2}{2*a*\sqrt{z + v^2}}$$

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)));
```

allied, $\angle\beta = \arccos\frac{a^2 + b^2 - (z^2 + v^2)}{2*a*b}$

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);
```

allied, $\angle\gamma = \arctan(y/x)$

The procedure should be (only the leg end of the first quadrant here):

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

At this point, all transformations from the leg end coordinates to the servo rotation angle are completed.
Each leg has its own coordinate system, which is calculated independently.

.23 for the Servo _ Service function

After completing the cartesian_to_polar function in the code, immediately call the function void polar _ to _ serve (int leg, float alpha, float beta, float gamma) to adjust the steering gear rotation angle to the set angle. These two functions are called in the 50 HZ service function void server_service (void). This is a key feature that you need to pay special attention to here.

.3.3 Program process

After understanding the core code and the work sequence, view 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
```

Uncomment INSTALL, command line and then add a for () loop in the 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);
```

The shaft of each steering gear is set in the center position to minimize errors during installation.