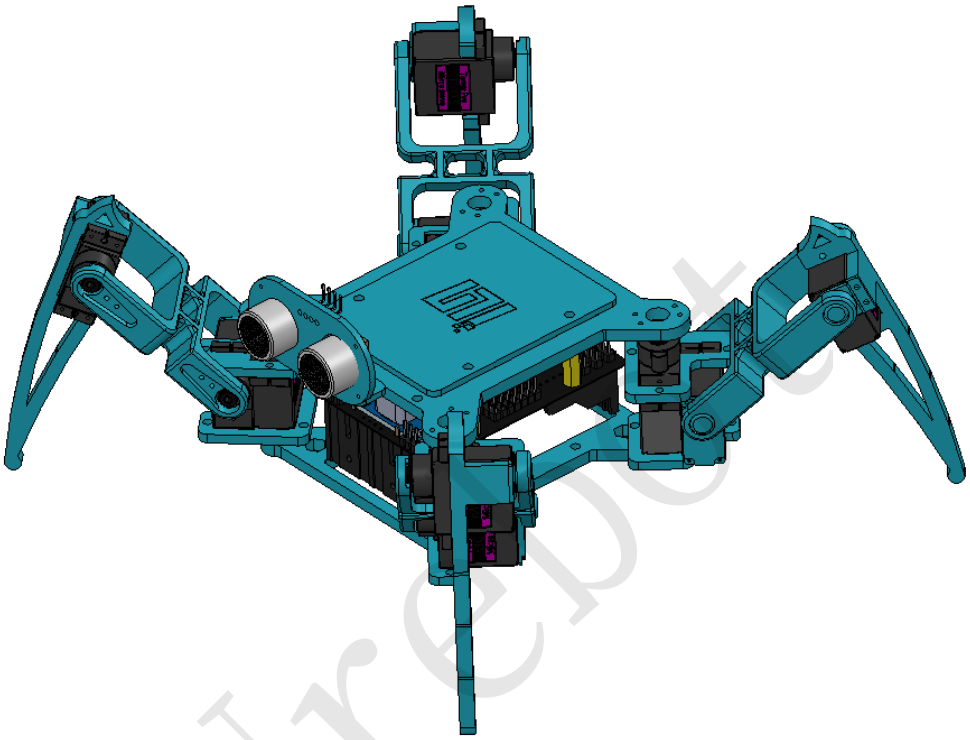
Twelve degrees of freedom quadruped robot

catalogue



0 statement

0.1 Statement of Use:

0.1.1 Please read this manual carefully before use;
0.1.2 Product design appearance is for reference only, please refer to the actual situation;
0.1.3 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.

0.2 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.

0.3 Information statement

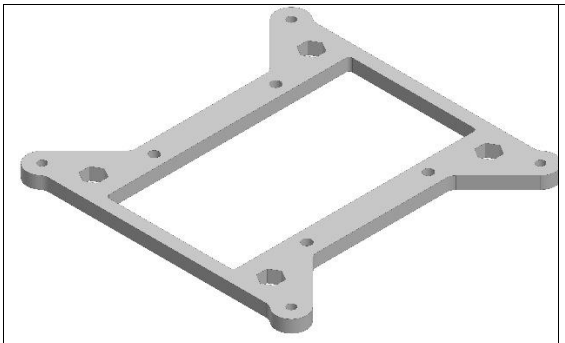
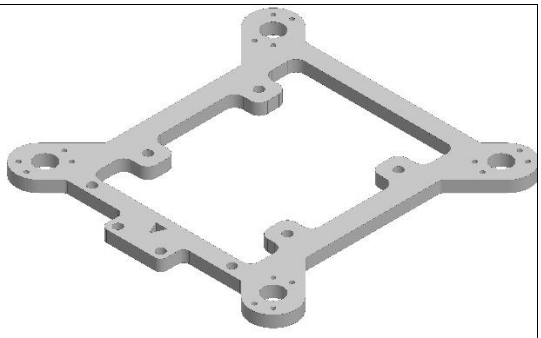
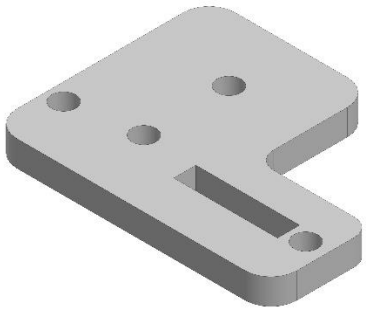
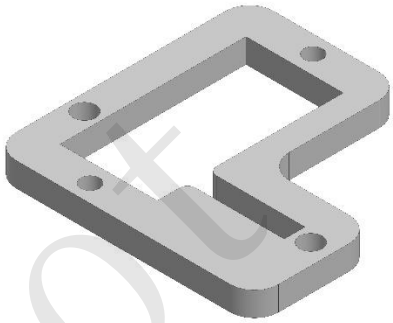
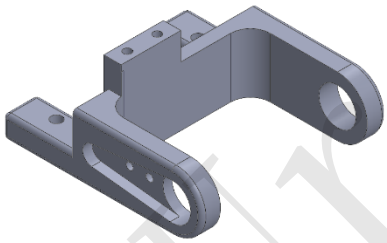
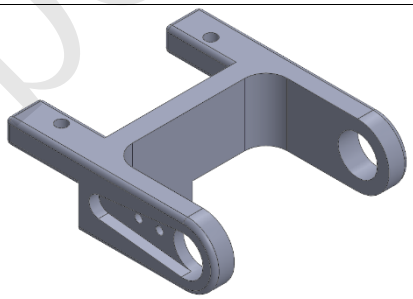
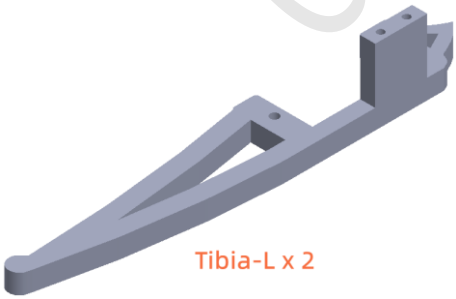
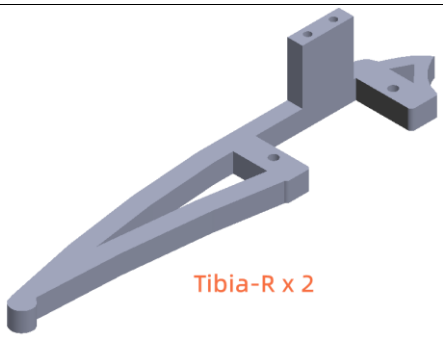
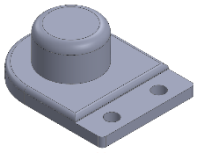
.3.1 0 The copyright of this product information belongs to the company all XINZHILI is the registered trademark of the company, unauthorized plagiarism or dissemination, will be investigated for legal responsibility;

1. Kite list

.1.1 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 icro USB, Data line	1
6	Acrylic structural parts	1
7	The 3D-printed structural pieces	1
8	Beam line tube	4
9	bottle opener	1
10	M 2.5 * 6 screw	16
11	M 2.5 * 23 double-pass copper column	8
12	M 2.5 * 20 single-pass copper column	4
13	M 2.5 * 20 double-pass copper column	4
14	M 2.5 * 10 screws	10
15	M2 * 10 screw	8
16	M 2 nut	8
17	M 2.5 loose nut	4
18	M 1.5 * 6 self-tapping screw	12
19	M 1.4 * 6 self-tapping screw	8
20	M 1.4 * 4 self-tapping screw	8
21	M 2.5 * 14 screws	4
22	Ultrasound module	1
23	Ultrasound fixed frame	1

.2.1 List of structural parts

 Body-Down	 Body-Up
 Coxa-Down	 Coxa-Up
 Coxa-L x 2	 Coxa-R x 2
 Tibia-L x 2	 Tibia-R x 2
	 5-Hold x 8

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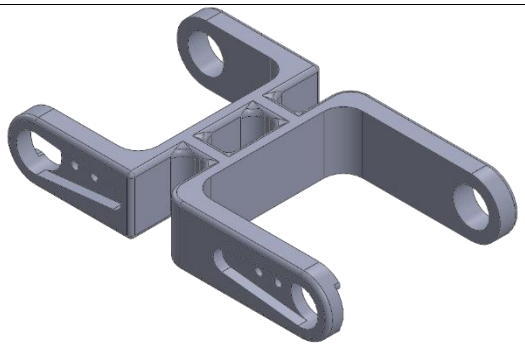
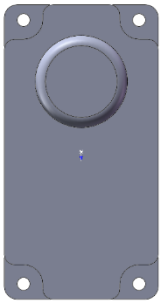
<tr><td> 
Femur x 4</td><td> 
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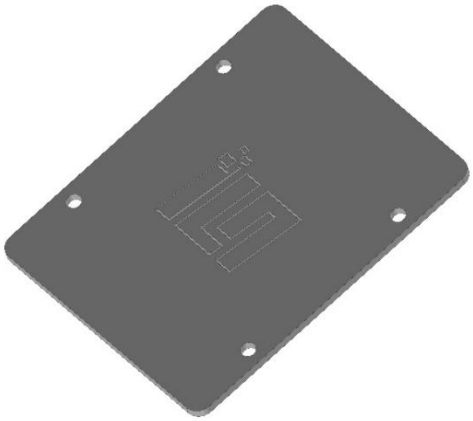
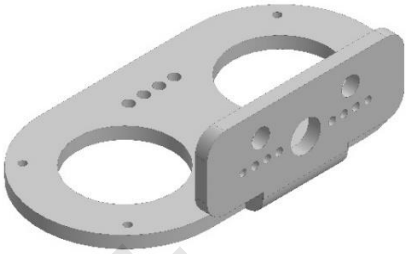
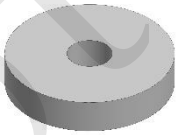
<tr><td rowspan="2"> 
Cover</td><td> 
Sonar-Holder</td></tr>
<tr><td> 
Washer</td></tr>
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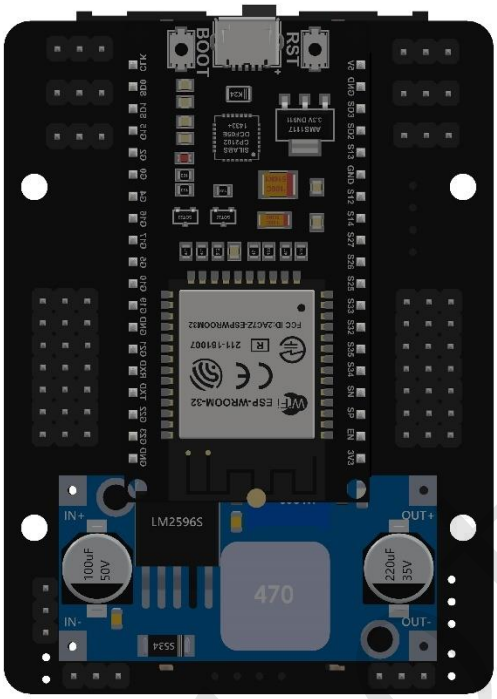
.3.1 The rudder machine

.4.1 Circuit description



The battery is in series mode, the positive battery is connected to the "+" character end next to the circuit board switch, and the other battery is connected to the circuit board switch next to the "-" character end.

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 successfully building 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.

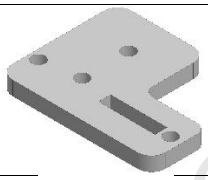
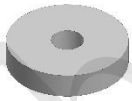
After testing the gear, open the data pack and navigate to calibration under 03 Tutorial and Code → Course 2 Installation and Calibration → calibration.ino ", burn it into the single microcontroller.

Step 2. Prepare for the assembly

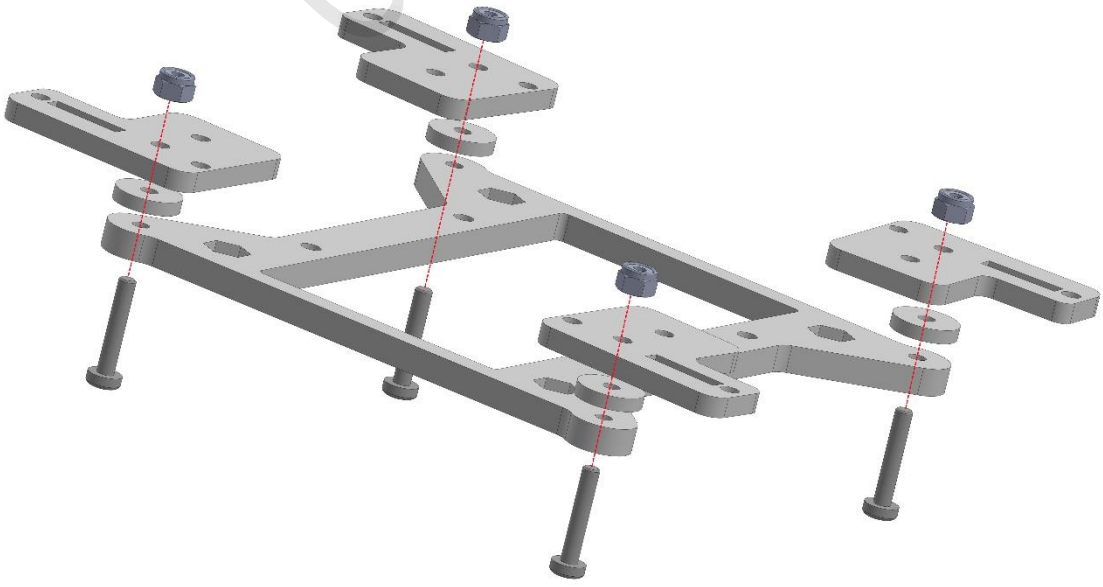
Toff the protective film on the surface of the acrylic structure.

Step 3. Install the Coxa-D own section

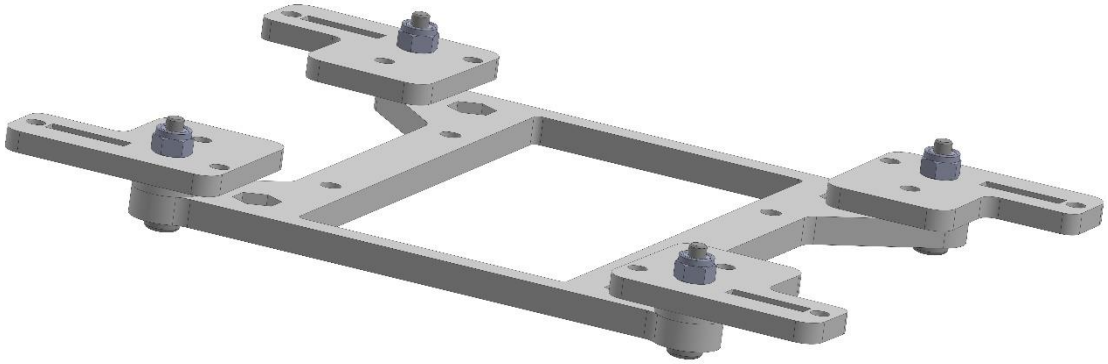
Materials used:

name	picture	quantity
Body-Down		1
Coxa		4
Pad		4
M2.5 * 14 screws		4
M2.5 for relaxing the nut		4

Use M2.5 * 14 screws through Body-Down, gasket and Coxa-Down, together with M2.5 loose nut (Note that the nut does not lock the Coxa-Down, gasket and Body-Down, so that Coxa-Down can be easily turned!!!)

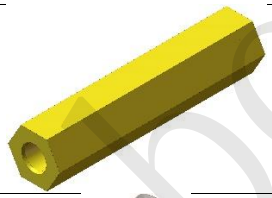


The effect after the installation is shown in the figure below

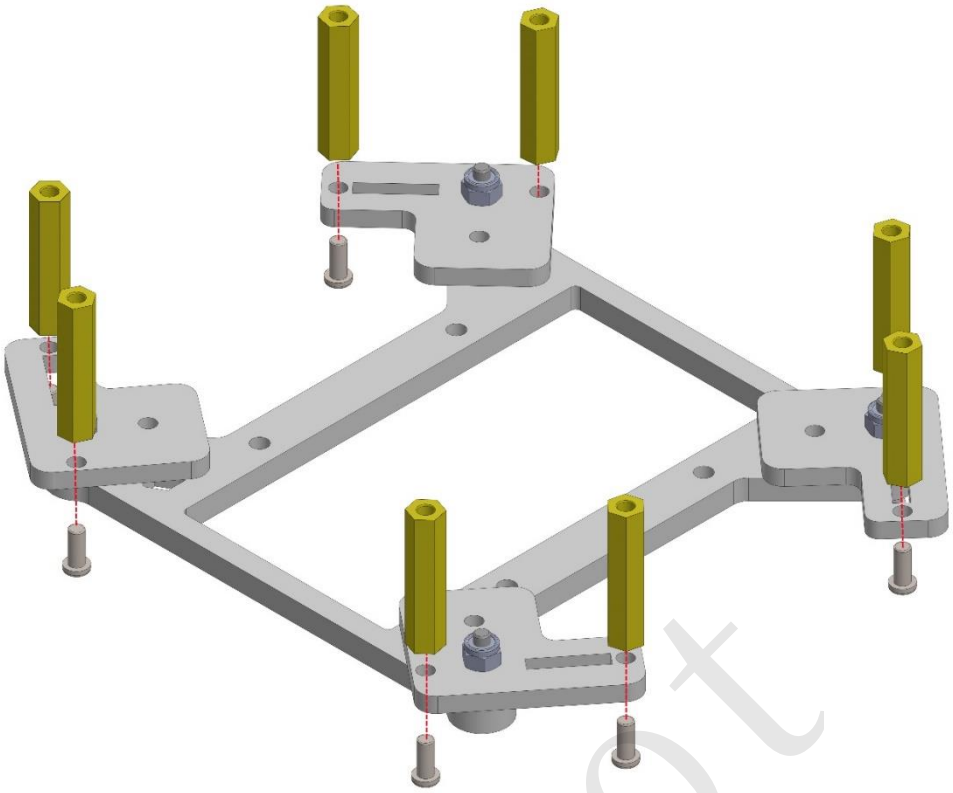


Step 4. Install the copper column

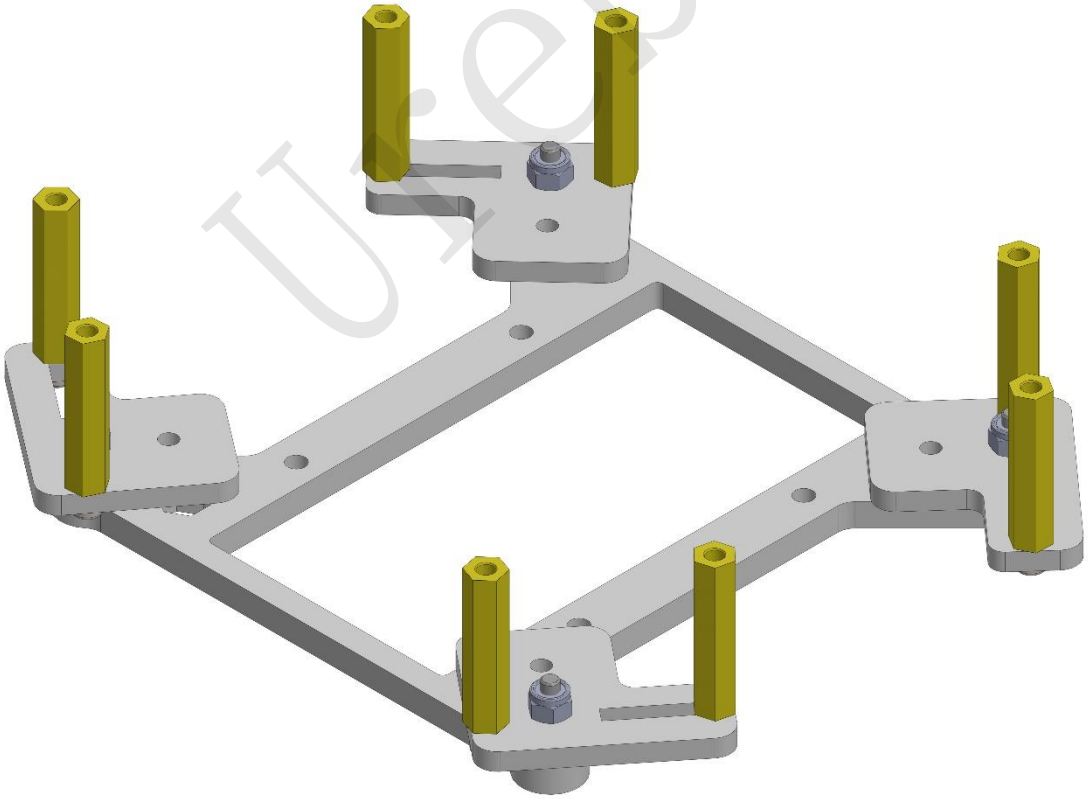
New materials:

name	picture	quantity
M 2.5 * 23 copper column		8
M 2.5 * 6 screw		8

Attach the eight M2.5 * 23 copper posts to the Coxa-Down with the M2.5 * 6 screws

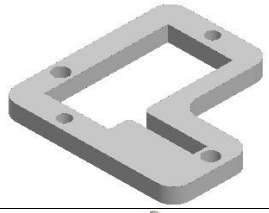


The effect after assembly is shown in Fig



Step 5. Coxa-Up. Install the steering gear

New materials:

name	picture	quantity
The MG90S steering gear		4
Coxa-Up		4
M2 * 10 screw		8
M2 nut		8

With the screw of M2 * 10 and the nut of M2 (note the direction of the rudder machine), as shown in the following figure

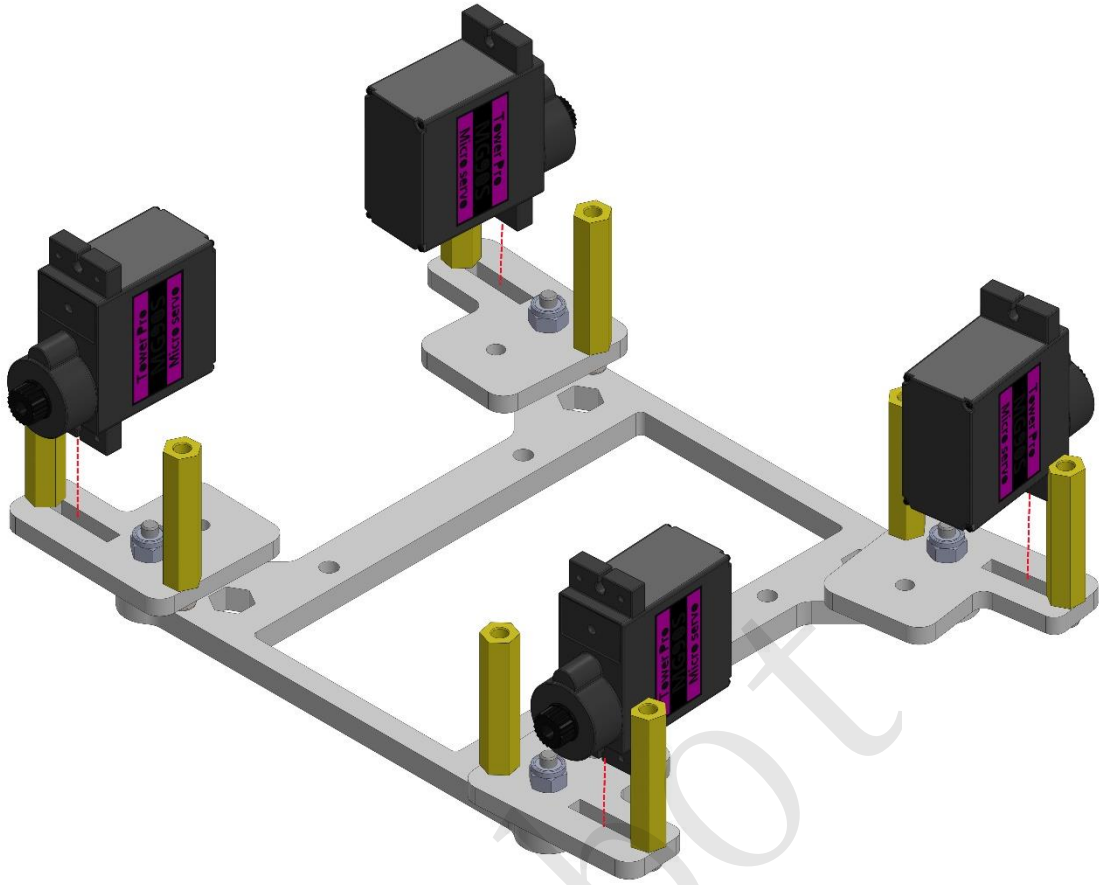
The effect after assembly is shown in Fig

Step 6. Coxa-Down. Install the steering gear

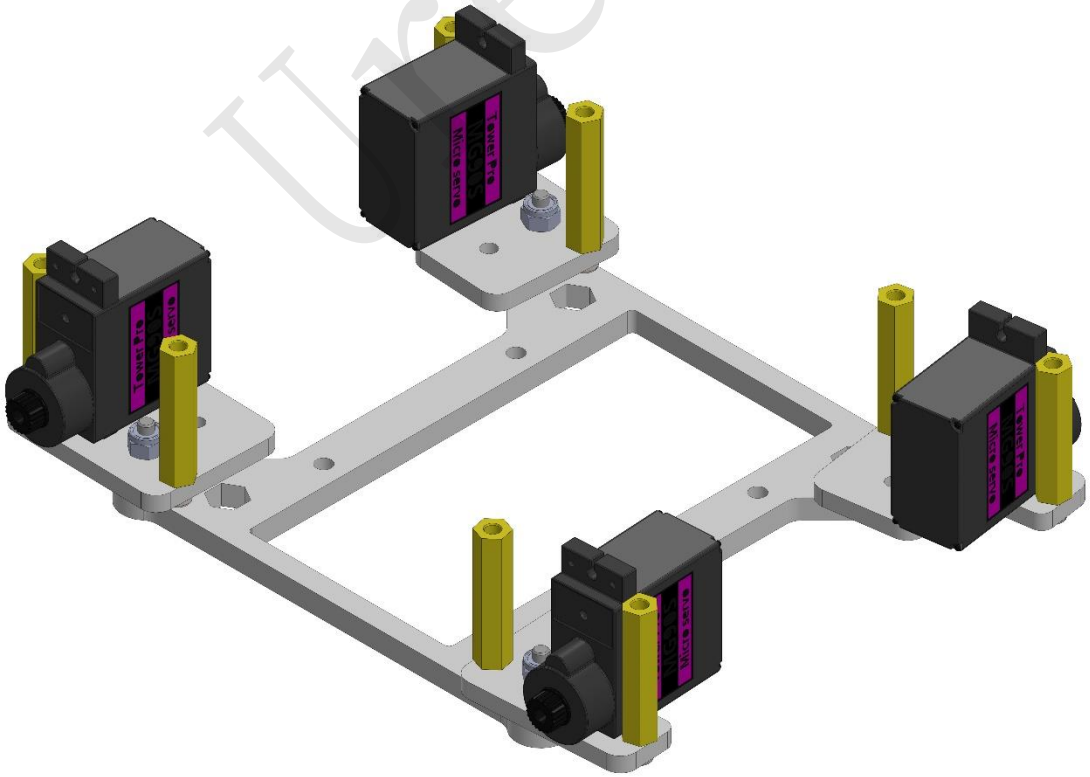
New materials:

name	picture	quantity
The MG90S steering gear		4

Insert 4 rudder into the slot on Coxa-Down (**note below the rotation axis of the rudder!!!!!!**)



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

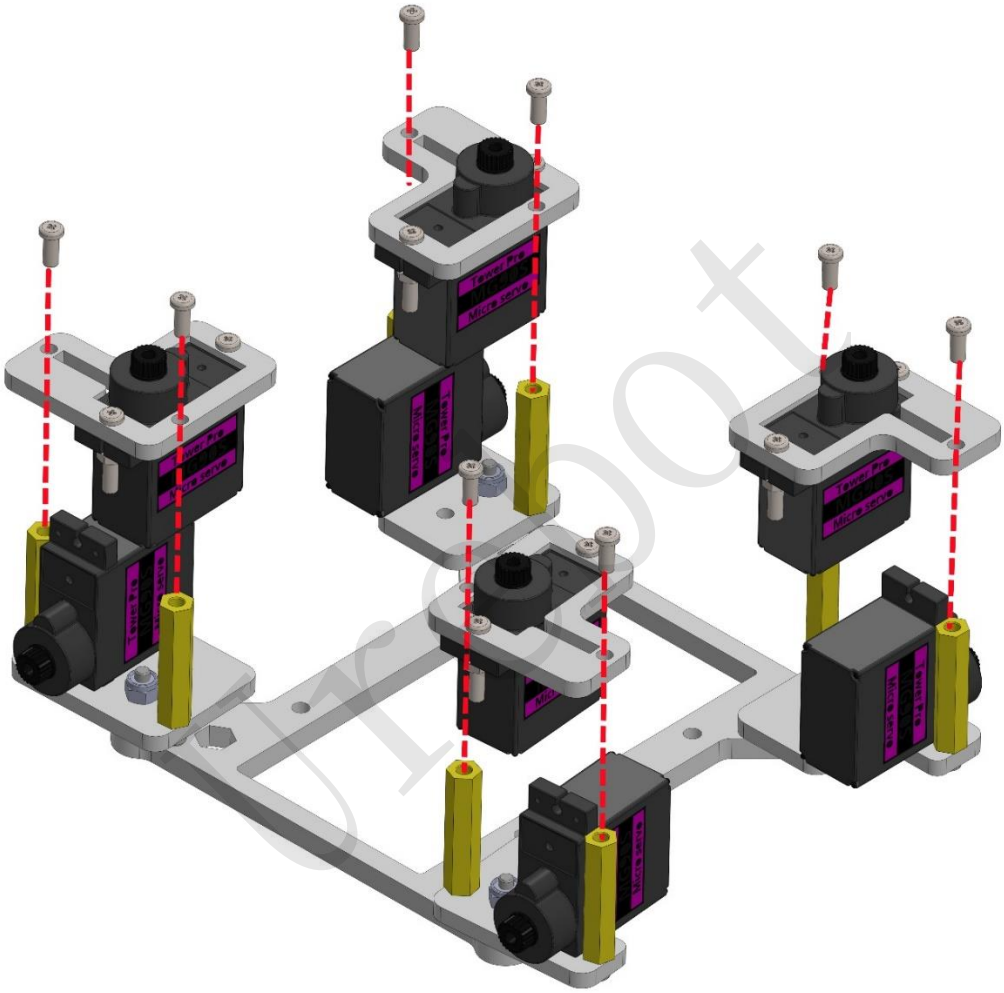


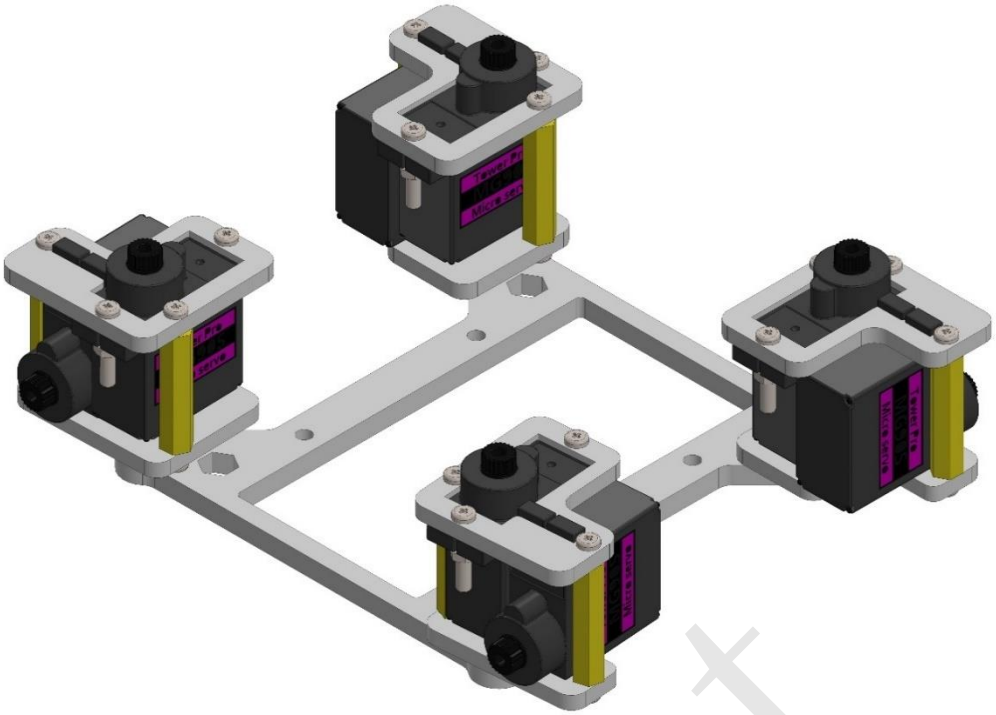
Step 7. Connect Coxa-Up and Coxa-Down

New materials:

name	picture	quantity
M2.5 * 6 screw		8

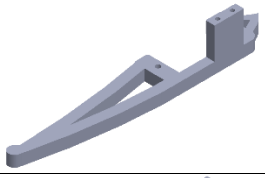
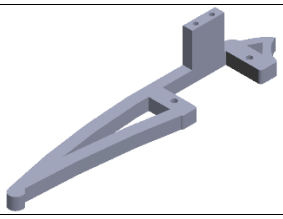
The front assembled Coxa-Up and rudder combination are joined with Coxa-Down with eight M2.5 * 6 screws. As shown in the figure below.



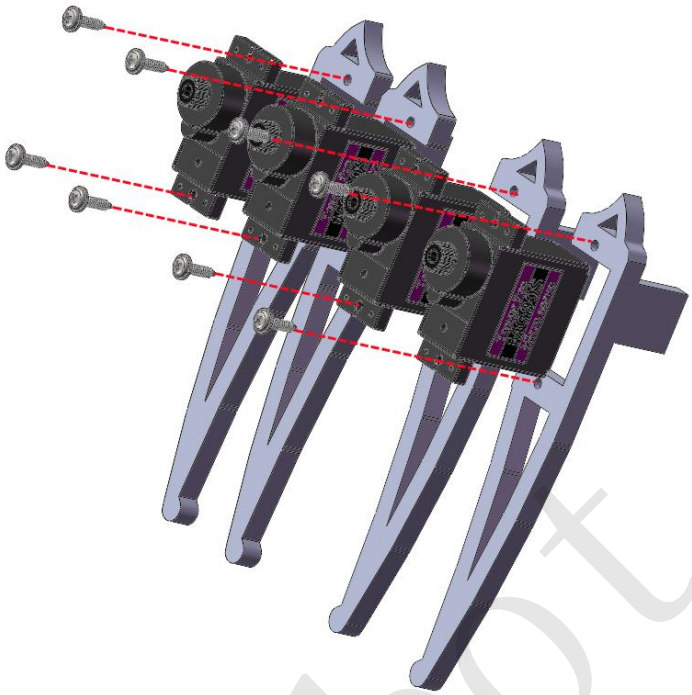


Step 9 Tibia gear the steering gear

New accessories:

name	picture	quantity
steering engine		4
Tibia-L		2
Tibia-R		2
M1.9 * 7 Self-tapping screw (in the steering gear bag)		8

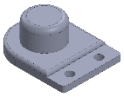
Install the steering gear on the Tibia structure with the M1.9 * 7 screw removed from the rudder bag as shown in the following below.



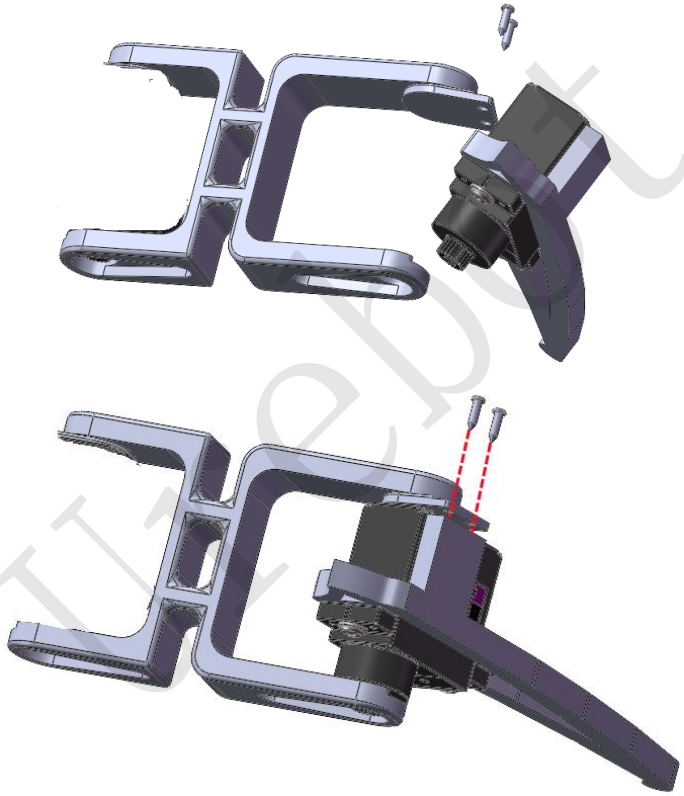
The installed effect is shown in the figure below,

Step 8 to connect Tibia and Femur

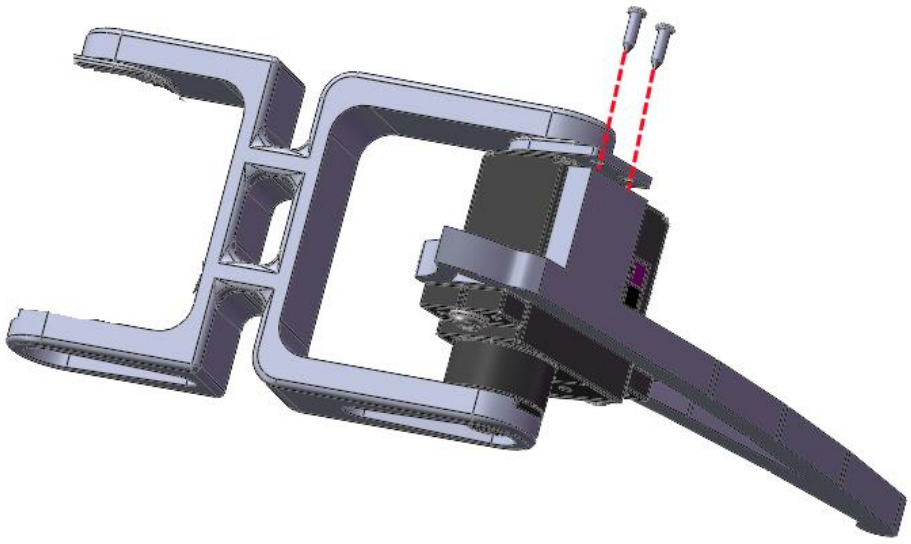
New accessories:

name	picture	quantity
S-Hold		4
M1.4 * 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



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

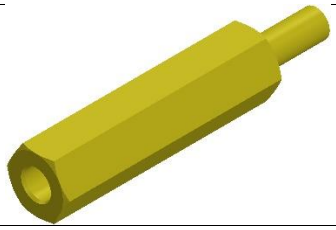


The well-installed effect is as shown in the figure below

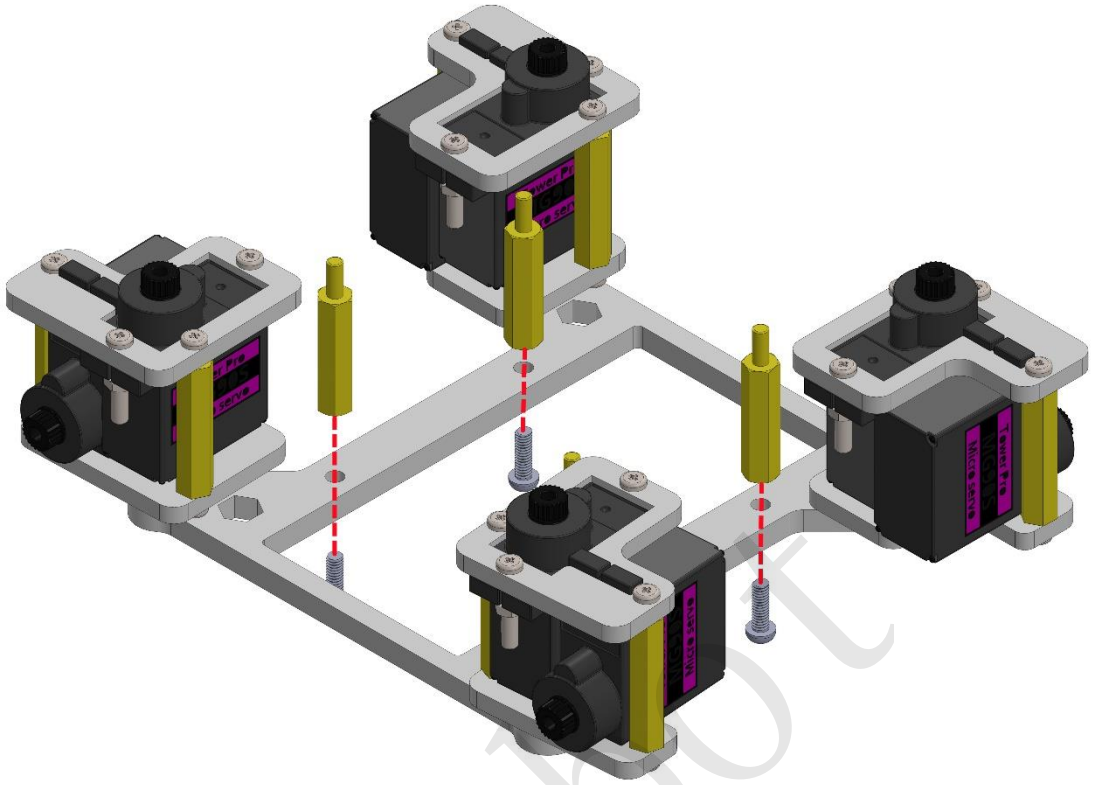
Same method for installing several other legs

Step 9.Body-Down, install the copper column above

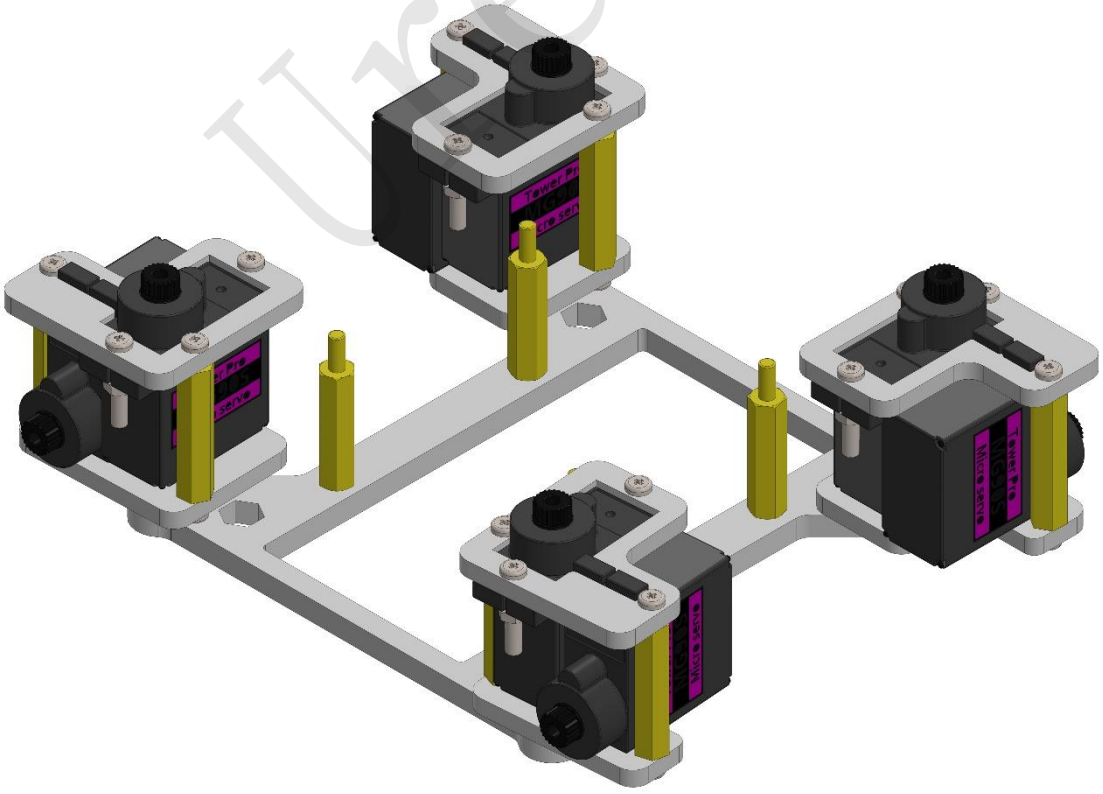
New materials:

name	picture	quantity
M 2.5 * 20 single-pass copper column		4
M2.5 * 10 screws		4

Install 4 copper columns onto Body-Down with M 2.5 * 10 screws, as shown below.

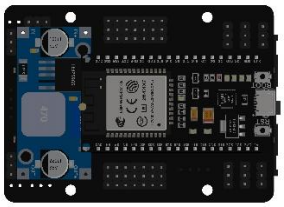
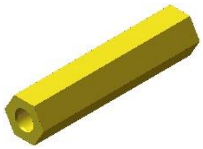


The installed effect is as shown in the figure below.

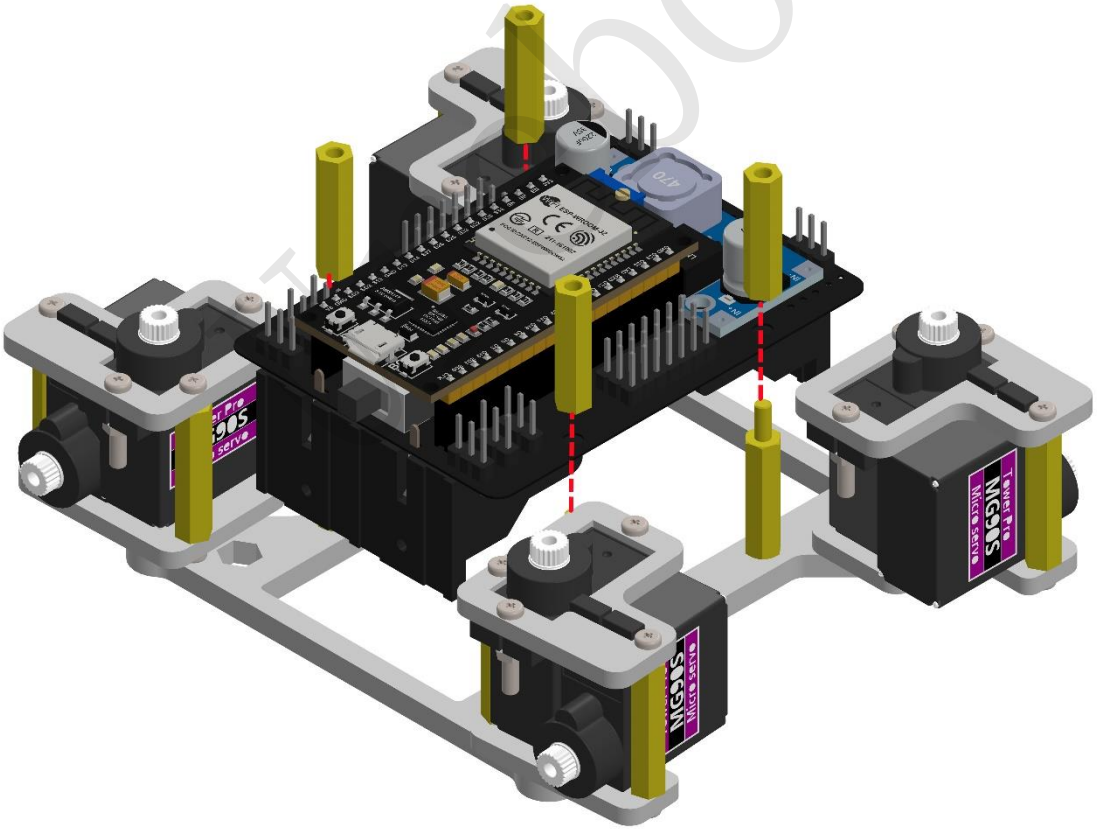


Step 10. Install the circuit board

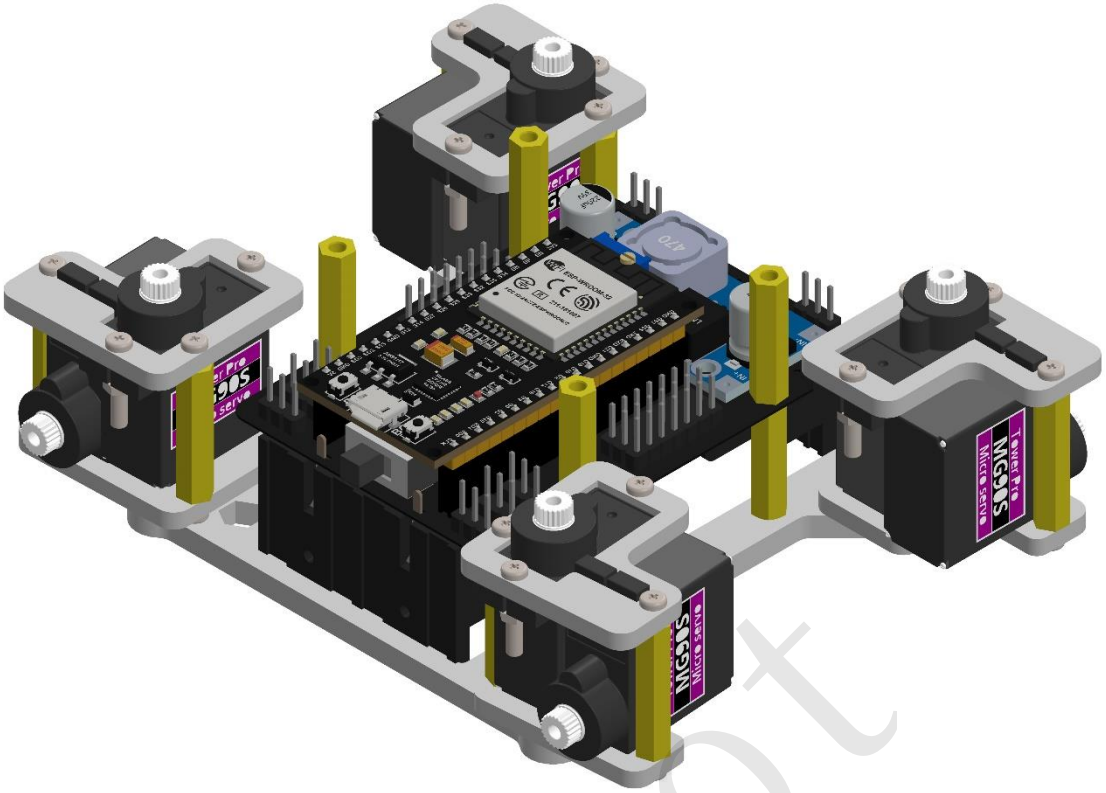
New materials:

name	picture	quantity
circuit board		1
M2.5 * 20 double-pass copper column		4

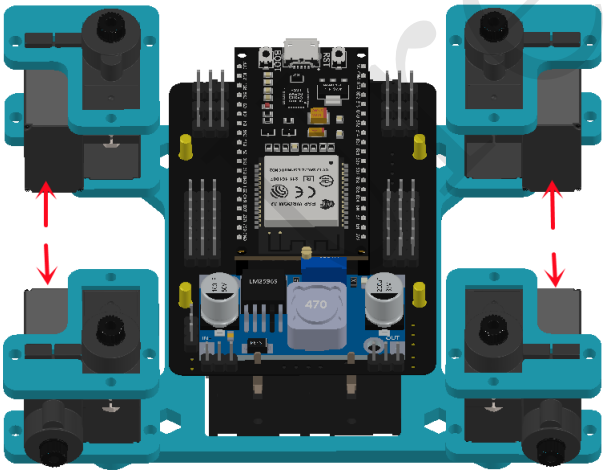
Install the circuit board on the four M 2.5 * 21 double-pass copper columns below.



The installed effect is as shown in the figure below.



Step 11. Install the Servo-Bottom on the steering gear



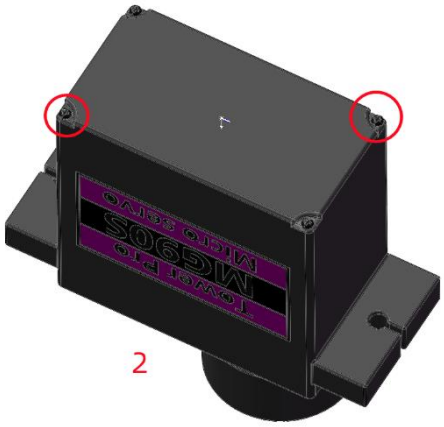
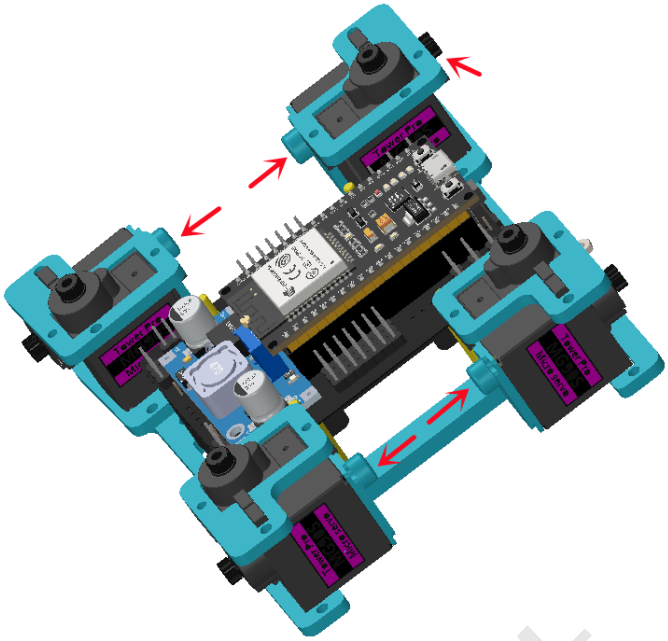
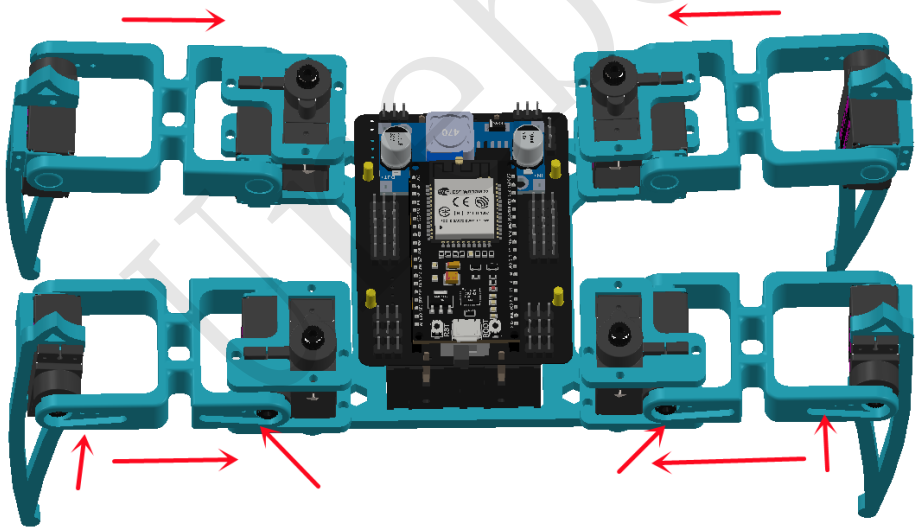


Figure 1, Figure 2



graph 3

Turn out the screws of the four steering gear shown in Figure 1 (at the circle position of Figure 2), and secure the four S ervo-B ottom with the screws shown in Figure 1 (note the bulge of the Serv o-Bottom above and the steering shaft). The final effect is shown in FIG. 3.

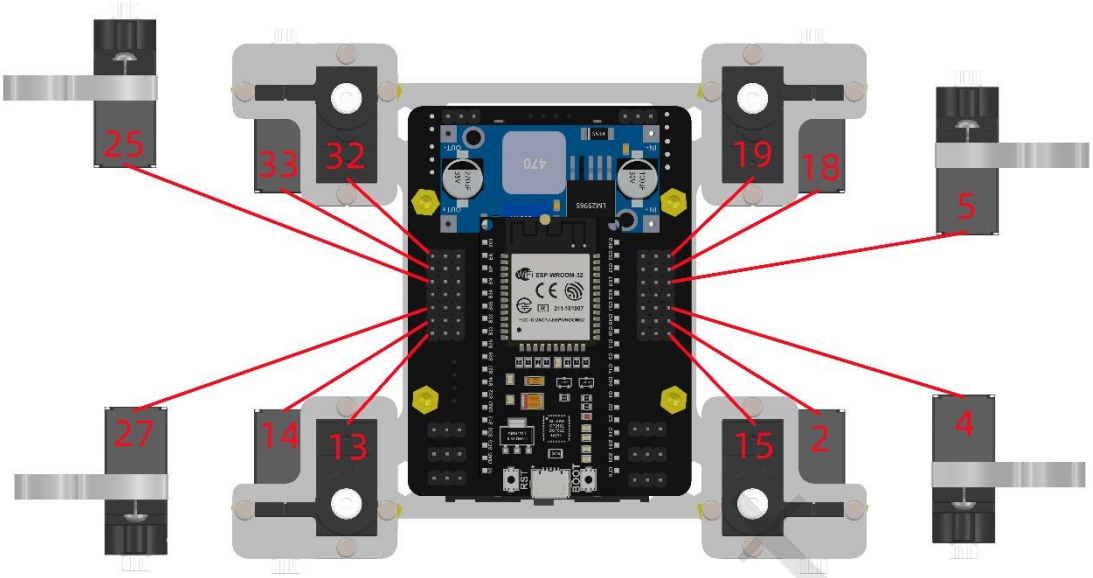


Install the four thighs on the trunk, pay special attention to the steering plate at this time, the groove to be out.

Step 12. Connect the steering gear to the circuit board

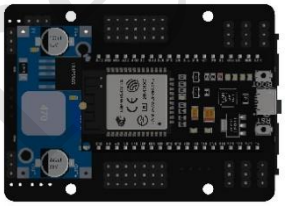
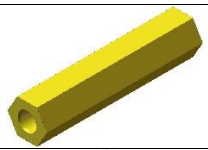
Connect the rudder engine and the rudder engine expansion board as shown in the figure below. (Note: the brown line of the steering gear cable is the ground line, the red line is the power line, the orange line is the signal line, the

signal line is connected to the S terminal of the steering gear expansion board, the power line is connected to V, the ground line is connected to G!!!)

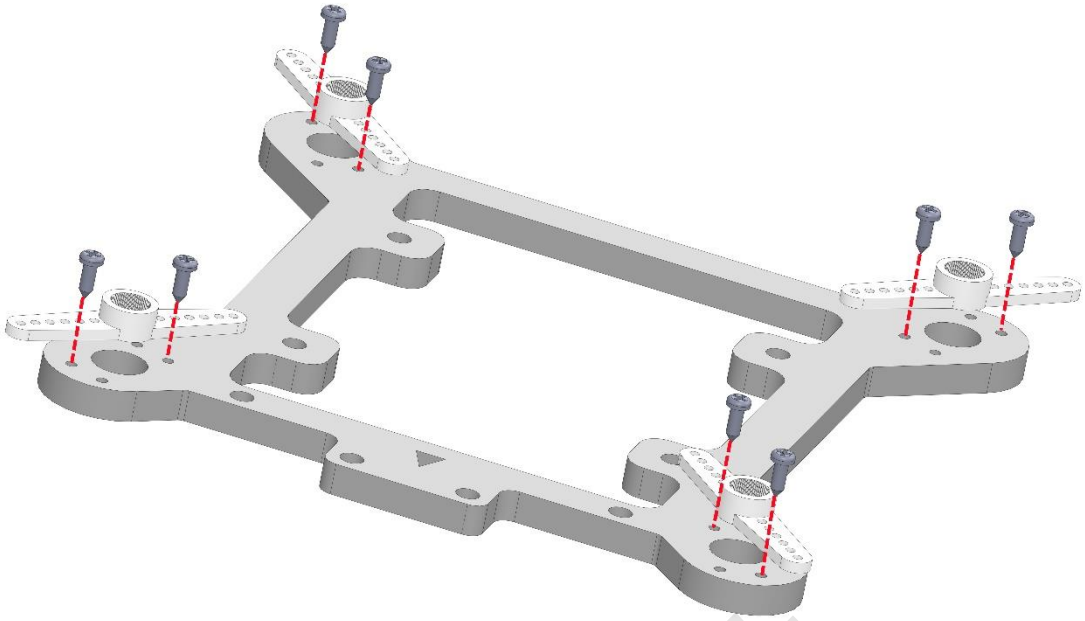


Step 13.Body-Up: Install the steering arm

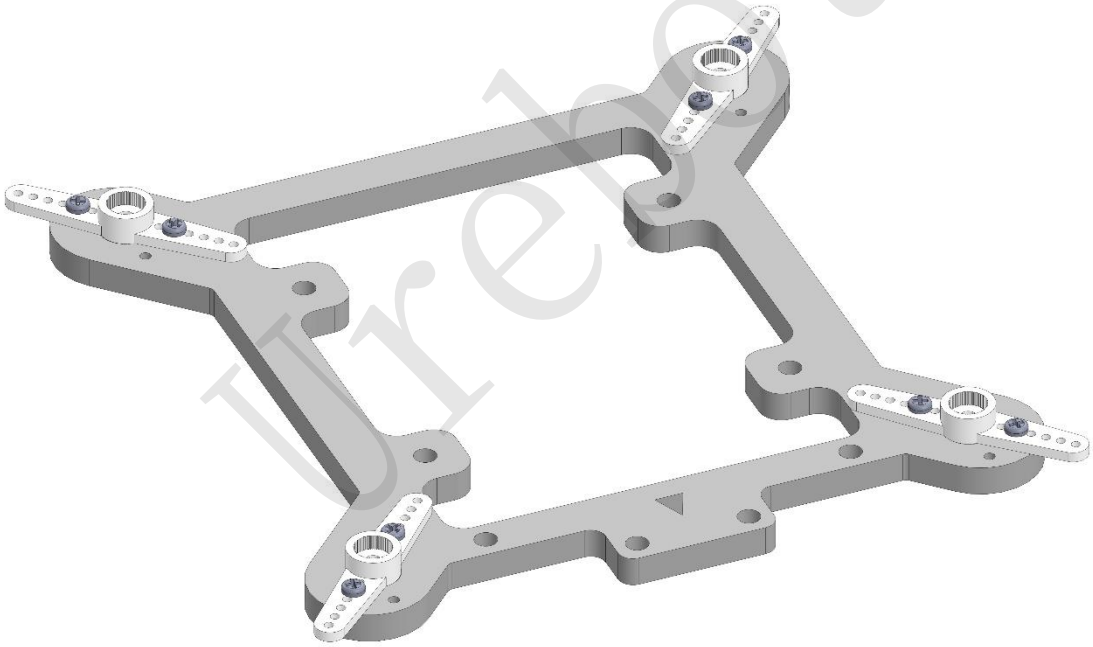
New materials:

name	picture	quantity
Body -U p		1
One word rudder arm		4
M 1.5 * 6 self-tapping screw		8

Attach the four one-word rudder arms to the B ody-Up with eight M 1.5 * 6 tapping screws.



The installed effect is as shown in the figure below.

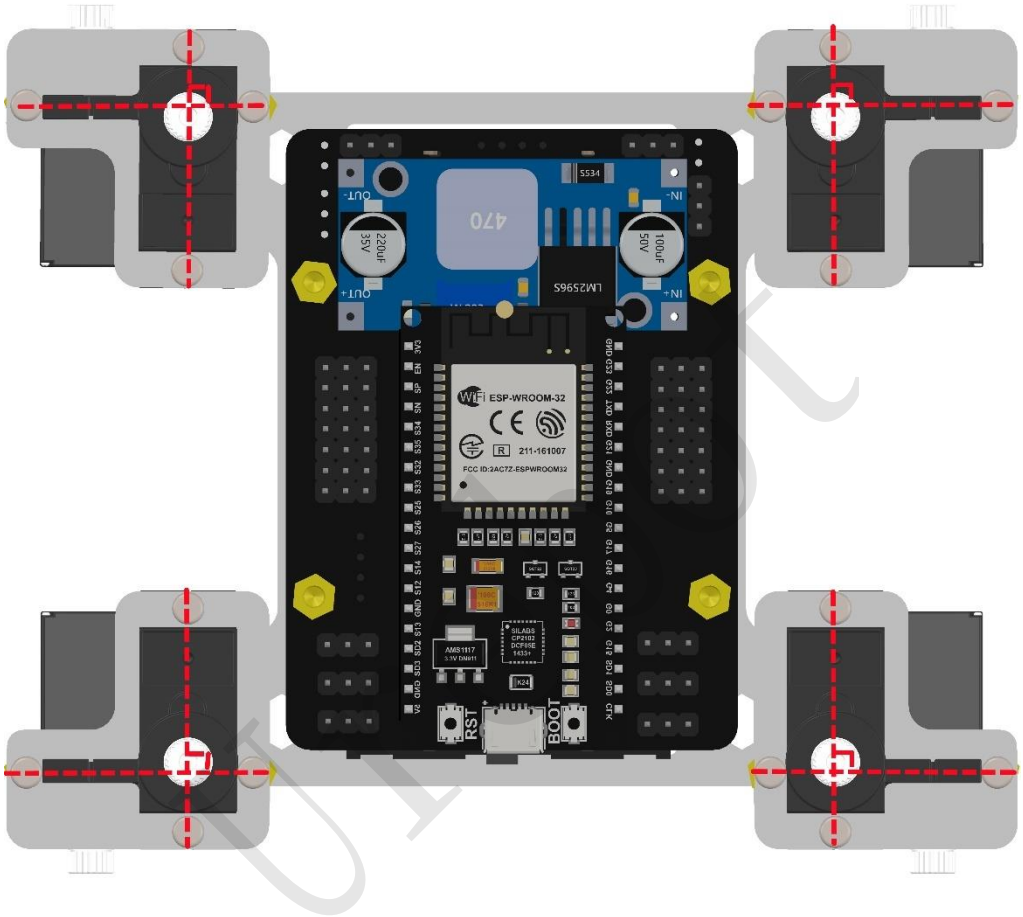


Step 14. Fithe Coxa and steering gear

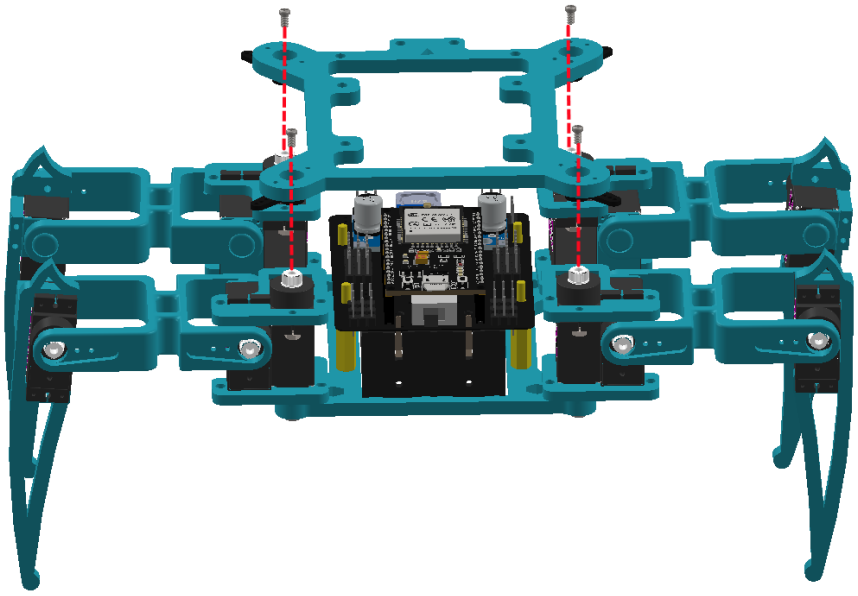
New materials:

name	picture	quantity
M 2.5 * 4 screws (in the steering gear bag)		4

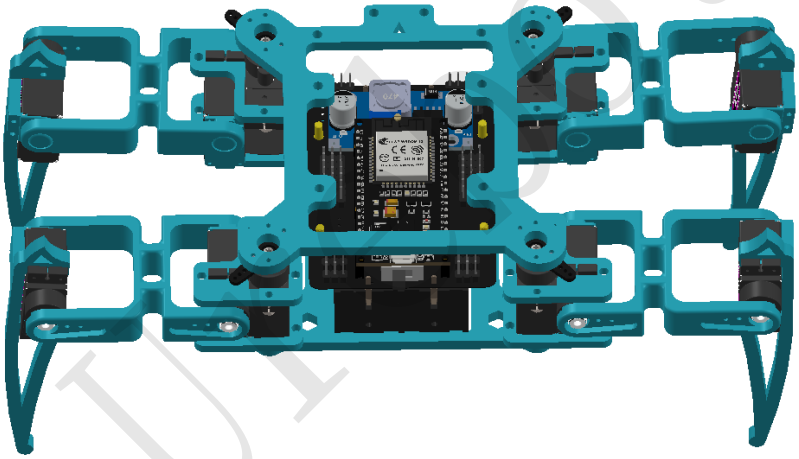
First to dial the switch on the circuit board to OFF, and then put two 18650 batteries into the battery box. (note, the positive electrode of the battery has the "+" character next to the circuit board switch, and the negative electrode of the battery has the end of the "-" character next to the switch!!!!!!), Turn on the switch and turn off the switch after hearing the steering gear turn. Install Body-Up on the steering gear at Coxa. Note that the vertical relationship should be installed as far as possible in the following figure (Note: the rotation shaft of the steering gear is not at the round hole of the steering arm)



Take four M 2.5 * 4 screws from the bag of the steering gear and connect the four one-word rudder arms on the Body-Up to the steering gear at Coxa, as shown in the figure below.



The installed effect is as shown in the figure below.

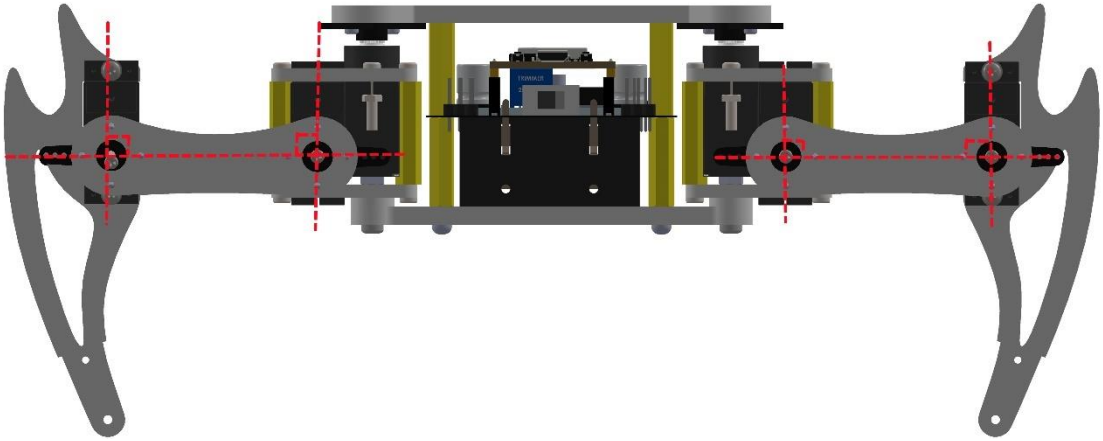


Step 15. Fixed the steering gear at F emur and Tibia

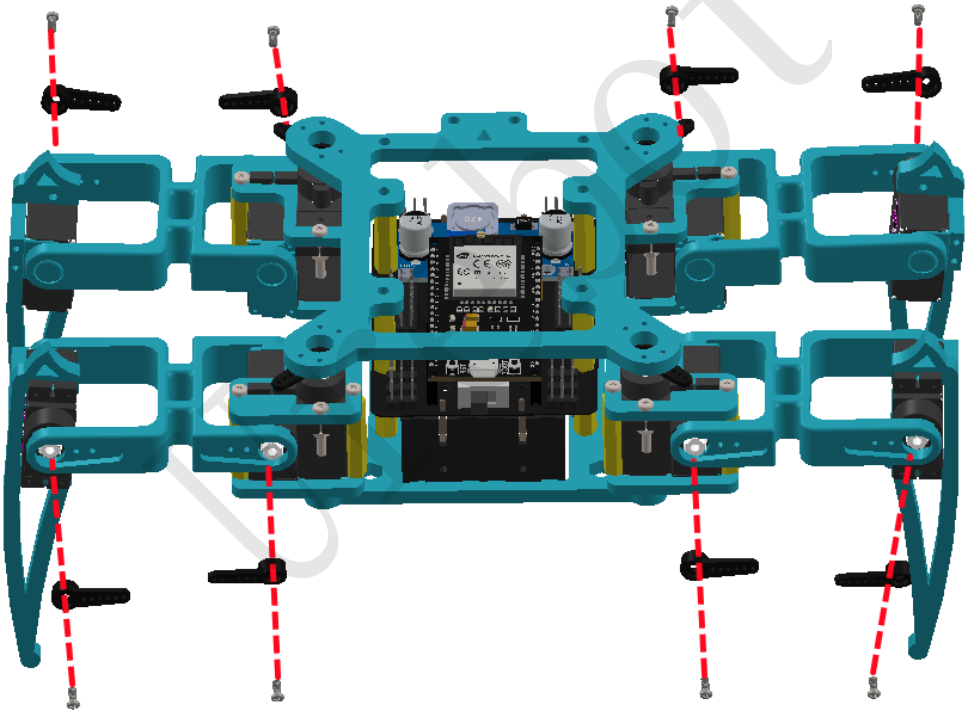
New materials:

name	picture	quantity
M 2.5 * 4 screws (in the steering gear bag)		8

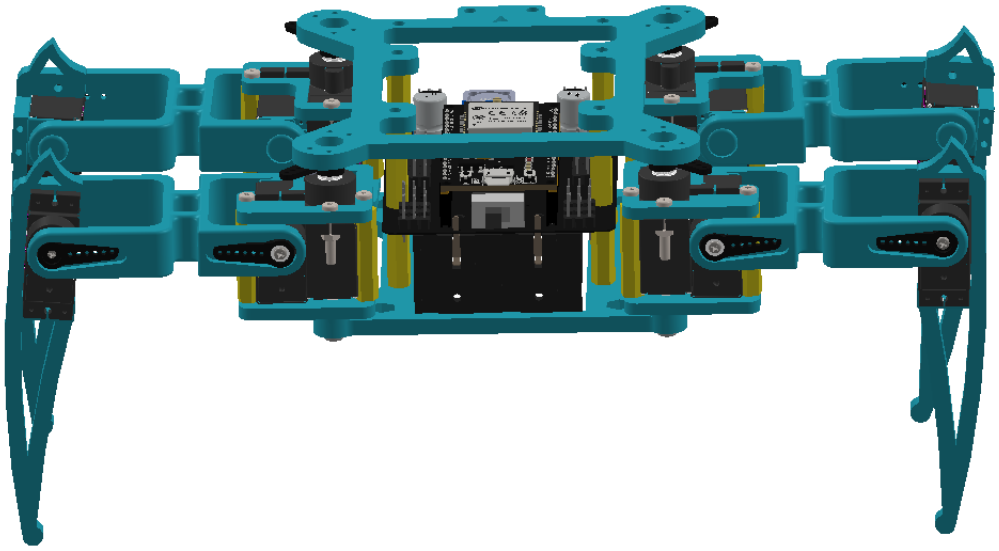
The Femur structure connects Tibia and Coxa according to the vertical relation shown in the figure below.



Use eight M 2.5 * 4 screws from the steering bag to connect the steering gear on the Femur, on the outside of the Coxa.(Note: Do not turn the rotation shaft of the steering gear when installing!!!!!!)

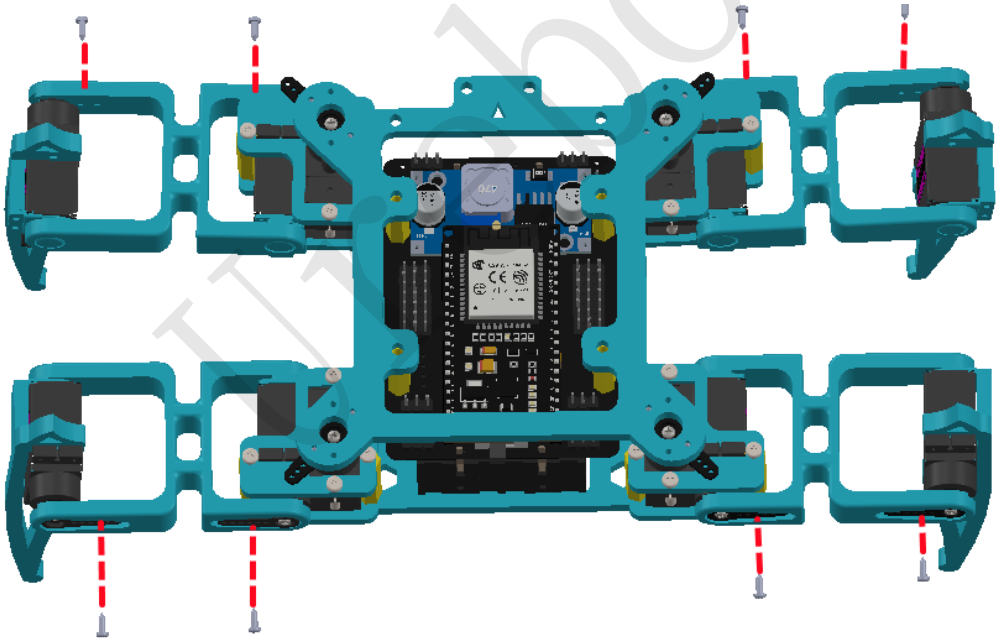


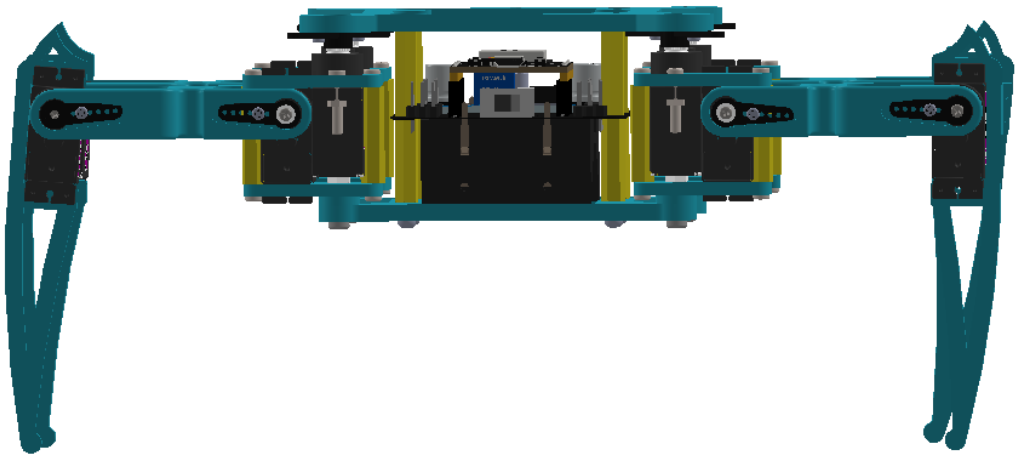
The well-installed effect is as shown in the figure below.



Step 16. Fixed the steering plate

Attach the steering wheel to the structure with 8 M 1.5 * 6 tip screws



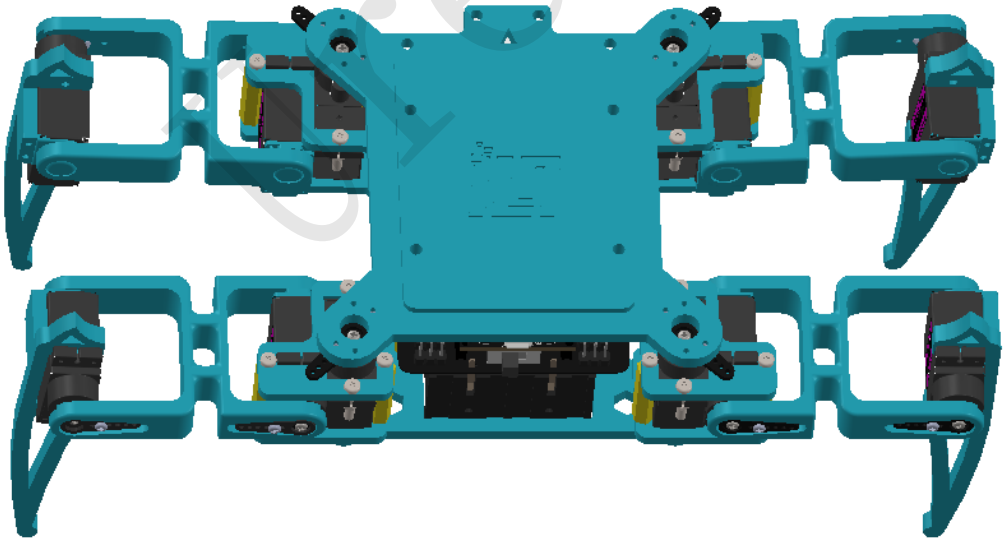


Step 16. Install the Cover over

New materials:

name	picture	quantity
M 2.5 * 10 screws		4

First tie the cable of the steering gear (note to ensure the length of the cable to ensure that the four legs can rotate normally!!!!!!), The Cover was then secured to the Body-Up with four M 2.5 * 10 screws.



Step 17. Calibration

Please read the calibration instructions under the manual catalogue.pdf

Step 18. Download the program

After the calibration, locate to the data package and double-click "Quad Bot _ TAD _ APP in" 03 tutorial and code course 6 mobile phone APP control Robot QuadBot _ TAD _ APP ".ino ", download to the microcontroller.→→ Then open the " class 6 mobile APP control robot. The pdf ", according to the tutorial.

3. Core code interpretation

.1.3 Kinematic inverse solution

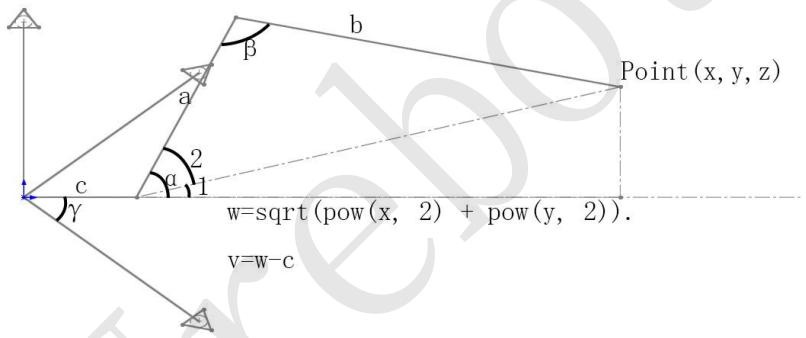
This paper focuses on how to convert the coordinates at the end of each leg to the rotation angle of each steering gear. First check the function void cartesian_to_polar (volatile float & alpha, volatile float & beta, volatile float & gamma, volatile float x, volatile float y, and volatile float z).

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.

.2.3 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.