Unitree A1 Robot Motor Replacement Instruction Manual

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• Introduction

There are no comprehensive official tutorials and documents available online for your Unitree dog robot maintenance. This document provides step-by-step instructions for safely replacing a damaged motor of Unitree Quadruped Robot A1 with the necessary tools. It aims to be helpful, particularly for those unfamiliar with the A1 robot. While I'll demonstrate the replacement of the calf motor in this guide, the process remains similar or even easier for other types of motors such as hip or thigh.

• Motor Testing (optional)

Buy an A1 motor online and request the after-sales service to adjust the motor ID (0, 1, 2 corresponding to hip, thigh, calf) before delivery. If you get a motor that isn't correctly configured or if you want to conduct a test, prepare necessary materials, and refer to the tutorial videos for guidance.

➢ **Material List:**

1). XT30 Power Supply Cable: Amazon Link;

2). A 24V Adjustable DC Power Supply: Amazon Link1 and Link2;

3). A USB-to-RS485 Interface Converter: Amazon Link;

➢ **Official Motor Test Tutorial:**

1). Documentation: Link;

2). Video (Chinese Version): Link1, Link2;

• Mechanical Assembly

I). Preparations:

Cautions: When assembling or disassembling parts of the robot, it's important to exercise caution if you choose to do it manually. This is in that these tasks are typically carried out with electric tools in the factory, making manual handling inconvenient. For example, attempting to turn hex screws by hand might be difficult due to the existing lubrication, leading to resistance and potentially causing the ***screws strip***. Things like this would just make the task even more challenging.

Therefore, a useful toolbox together with a pair of anti-slip gloves are strongly recommended for this work. Demo pictures and links are provided:

➢ **<u>Material List:</u>**

1). Toolbox (Screwdriver + Electric Drill): [Amazon Link];

2). Safety Work Gloves (Must be anti-slip): [Amazon Link];

<u>II). Disassembly/Assembly:</u>

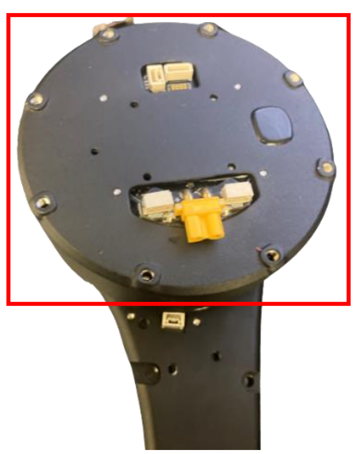
Note that for each leg it contains three motors (**body motor** – yellow, **thigh motor** – red, and **calf motor --** blue). See the picture below. Here we showcase the replacement of the calf motor.

Step 1: First remove the shell on the leg which hides the connected wires of the motor. Then unplug all the cables (Power Cable and RS-485).

Step 2: A motor contains eight screw holes. Use the electric drill to disassemble all of them. (Be careful about screw strip!)

Step 3: After getting the detached leg, take a photo to record its current orientation info (see below picture).



Step 4: Begin disassembling the screws on the leg's knee joint (red) and hip joint (blue) respectively.

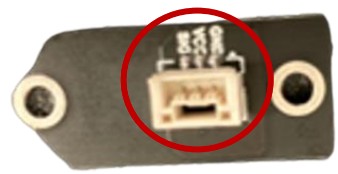
Step 5: Then you can remove the shell. Also remember to take a photo for the orientation as below, and disassemble all the screws (red regions):

Step 6: Now you should be able to detach the motor and replace it with a new one. Finally do the assembling to restore it following the reverse steps. Note that when you do the motor assembling, please refer to previously taken photos for the right motor orientation (you can also refer to the motors placed on other legs but it's inconvenient).

III). Sensor Replacement (optional):

This section provides instructions for individuals who have accidentally damaged the foot sensor during assembly (just like I did…) or for those who want to replace the air pressure sensor in the leg. Below is a picture of the damaged sensor:

The air pressure sensor consists of an air pump head and a RS-485 female connector, which appears to be manufactured in-house by Unitree. Contact their support to purchase one (around 10$ each).

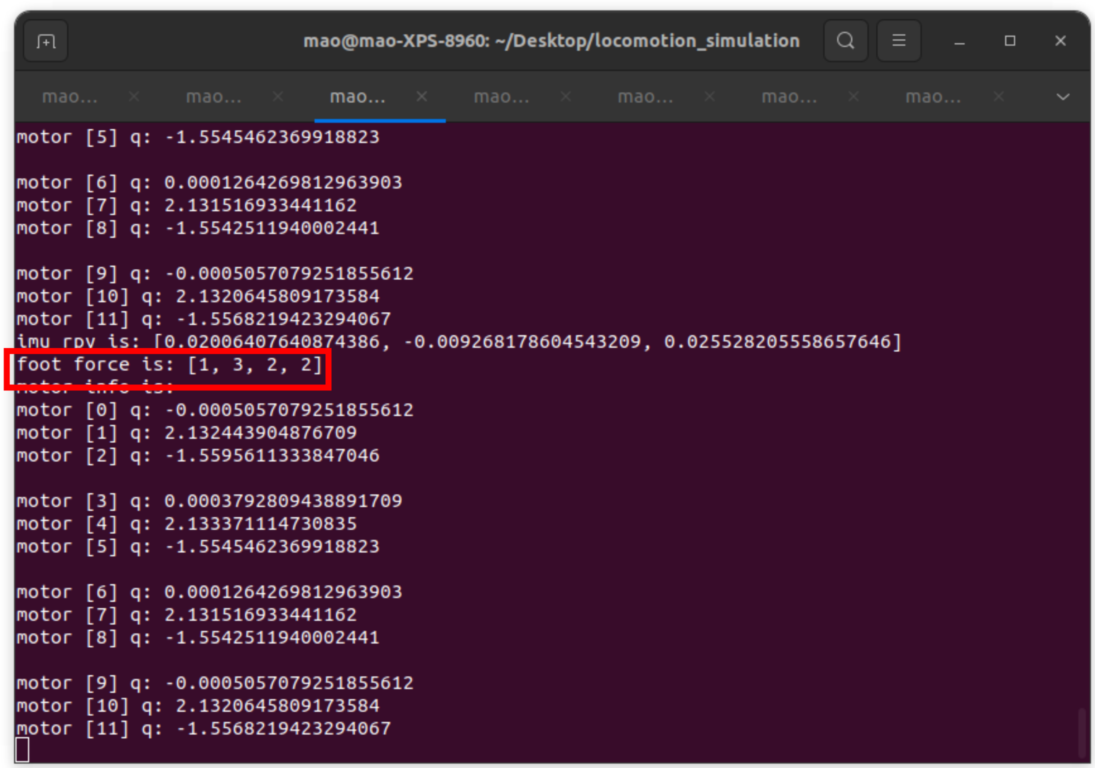
To replace the sensor, I assume you have already removed the leg shell. Please follow the steps to complete the remaining process.

Step 1: Disassemble and detach the screws marked as red:

Step 2: Unplug the black trachea from the pump head and connect it with the new sensor (You'd better do this part wearing a pair of work gloves to increase the friction force). After that, use a super glue to seal the black rubber trachea.

Step 3: Additionally, ensure that the foot side (indicated by the red area) is completely sealed with the super glue. Conduct a preliminary check by pressing the foot to listen for any sounds indicating air leakage.

Step 4: Lastly, confirm the sensor's proper functionality by writing a program that calls the API to display real-time foot forces. Verify that the values change accordingly when you apply pressure to the foot.



● Calibration

Following the motor replacement in a quadruped robot, it's essential to perform a calibration process to revert the robot back to its usual status. Without calibration, the robot may not pass the self-examination program necessary for standing up after booting (although you can still use the remote controller to help it stand up). Typically, the calibration process includes **Motor Calibration** and **IMU Calibration**:

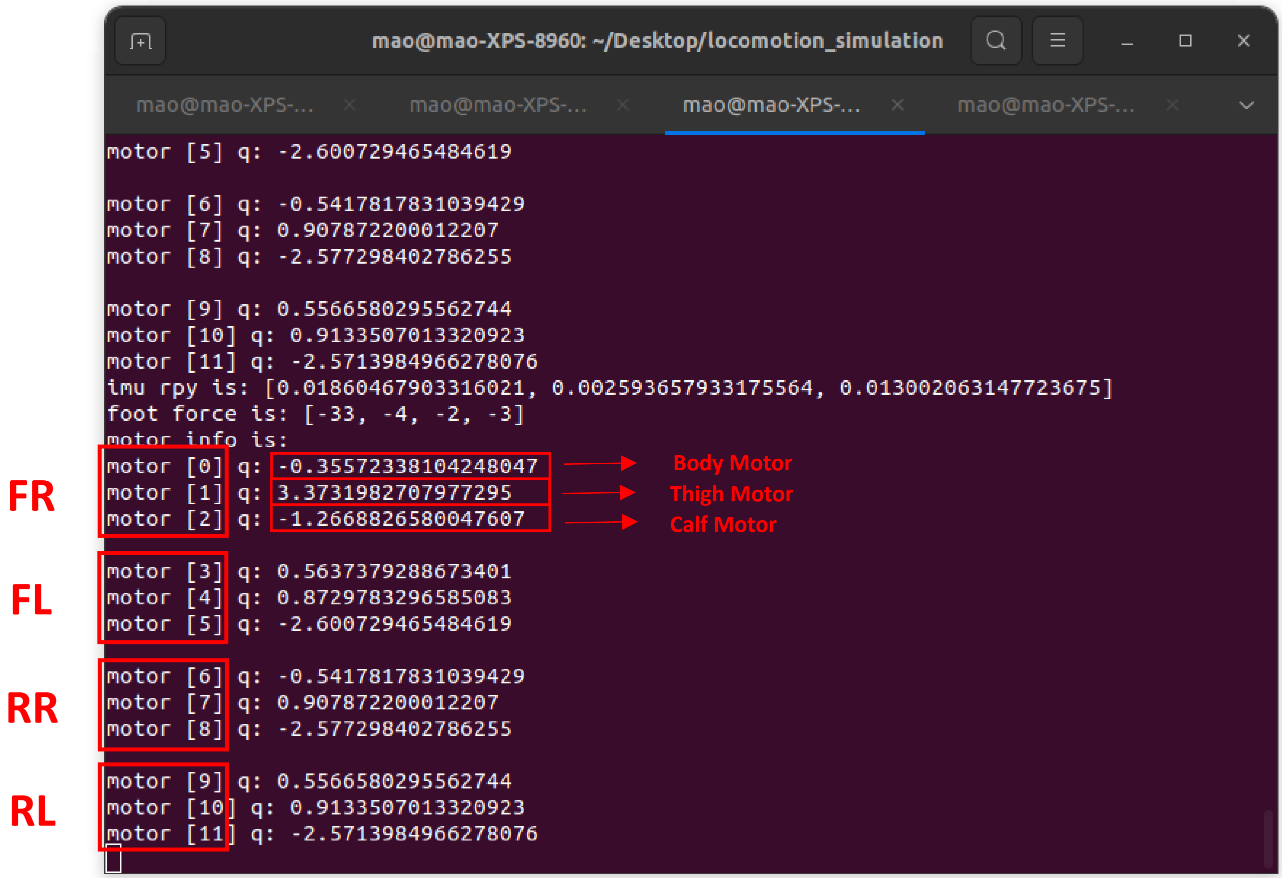
I). Motor Calibration:

Whenever you replace a motor in the robot, it requires motor calibration to ensure the quadruped dog operates normally. The essential materials for this procedure include a **Calibration Rod** and a **Remote Controller**, ensuring a smooth calibration process. Typically, these two materials are provided when you purchase a robot dog.

Here is a video online for guidance on motor calibration. It covers all the steps, and you will get a rough calibration result which should be fine. However, if you think it unclear or wish to increase the calibration precision, you may follow the subsequent steps below, which involve using a program to assist with calibration. It's also recommended to familiarize yourself with the controller operations in advance. The basic steps correspond to those in the video:

(**Tips:** The state of the replaced calf motor differs from the other three calf motors. However, the states of the body and thigh motors are accurate, and we don't want to alter their status during calibration)

Step 1: Write a [code]() to get the motor states (position) of the robot. It could be either cpp or python (with pybind11) form. Compile the code if written in cpp and make sure to get the motor's position information after you run it. You can do it either locally on the robot or remotely if you're able to connect to the robot through its hotspot (useful [link]() for wireless control configuration). Here is an example:

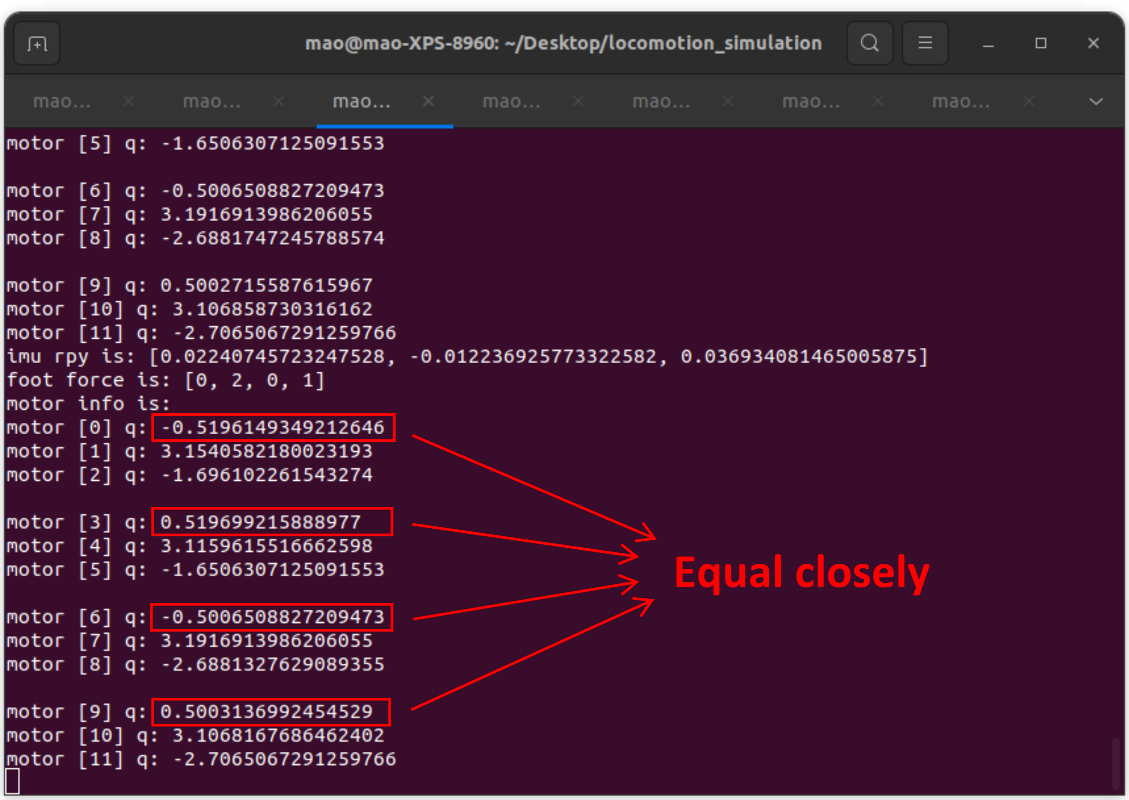


Step 2: Place the robot on the ground and power it on by pressing the button (It will attempt to stand up but eventually fail because it cannot pass the self-examination program after the motor replacement).

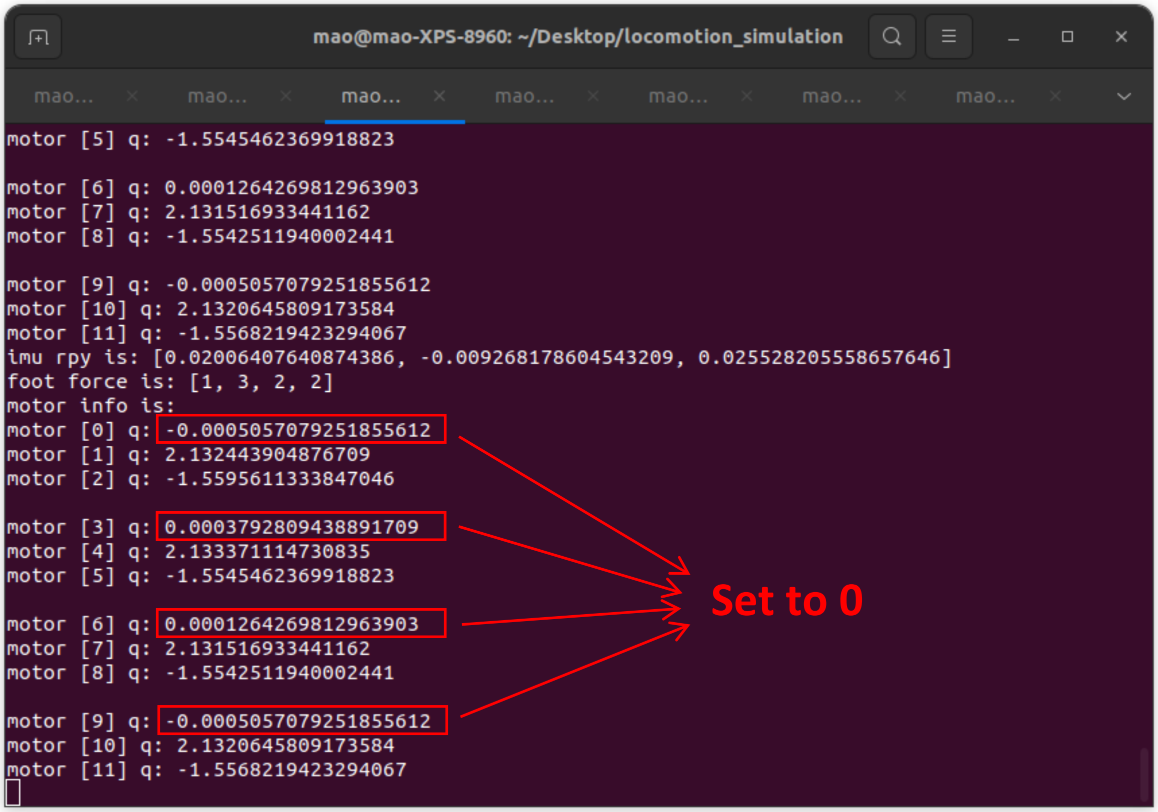
Step 3: Be aware that pressing **L2 + B** allows the robot to toggle between three distinct modes: *No Noise Damping*, *Noise Damping*, and *Zero Torque*. (Note that you might need to press the B button slightly longer each time to activate the switching) Make sure to switch to the *Zero Torque* mode just as demonstrated in the video.

Step 4 (Hip Calibration): This is the step to calibrate the robot body motors. Lay down the robot and get its base facing up. Lay the robot down with its base facing upward. Position the robot legs as shown in the picture. Ensure that the leg joints and feet are touched individually.

Obtain real-time motor positions by running the code. Slightly adjust the legs to ensure that the position values of each leg correspond to each other as closely as possible:

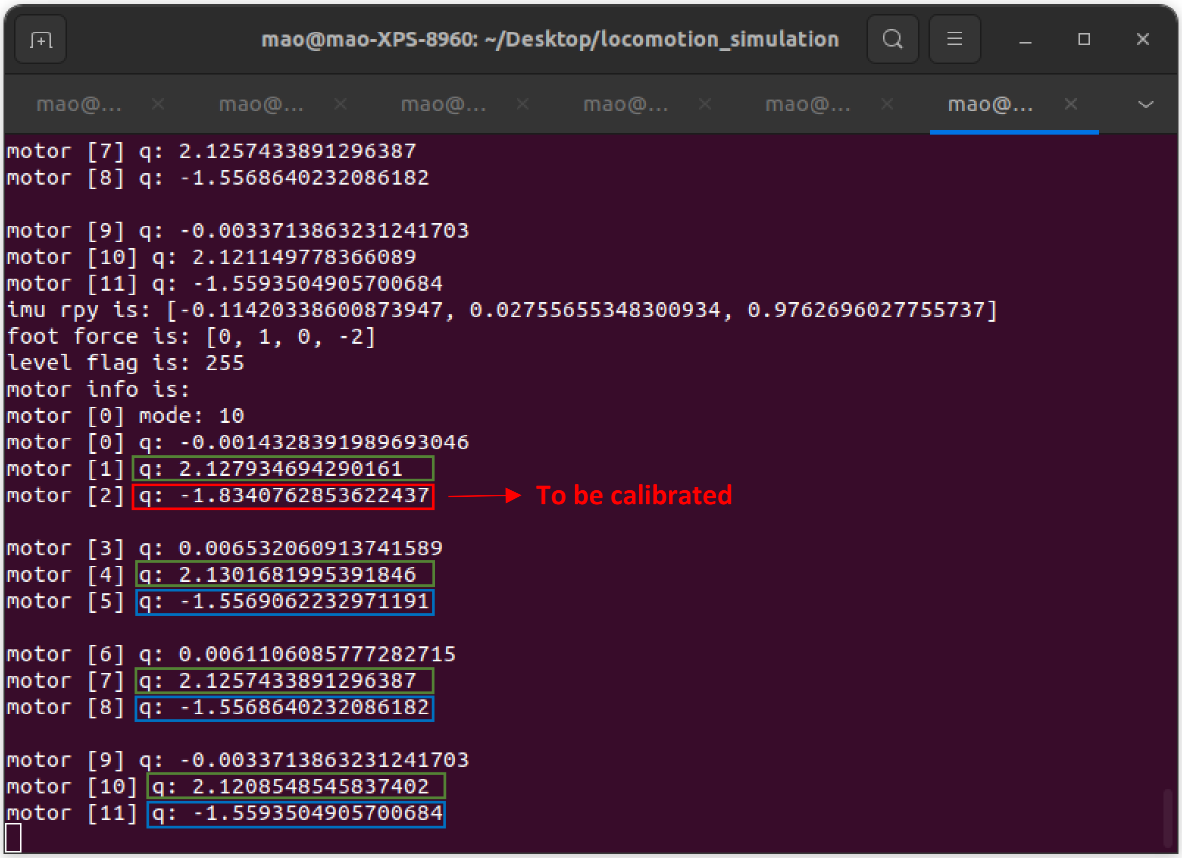


Once the positions are adjusted correctly, press **L2 + R2** on the controller. You will observe that all the robot hips are fixed to their initial positions after a movement (just as shown in the video). From the terminal, you'll also find that all hip position values have been set to 0.



Step 5 (Calf/Thigh Calibration): Upon completing the hip calibration, proceed to the remaining calf/thigh calibration. Use the rod to connect the hip joint and the calf as below. Repeat it for all four legs:

Similarly, make slight adjustments to the thigh and calf of each leg to ensure their positions closely match each other (indicated by the green and blue marks). The red mark identifies the calf motor with a position error (around 0.3 rad), and this is the one we aim to calibrate:



After adjusting the positions accurately, follow the instructions below to press the button on the controller to confirm:

*1). Press **L2 + L1** twice.*

*2). Press **L2 + R1** twice.*

*3). Press **L1 + R1 + R2** once.*

By now, you may have noticed a significant reduction in the robot's noise compared to before, and the robot hip can now be easily moved by hand. Up to this stage, the motor calibration process is completed.

Tips: If the Calibration Rod is missing, download the STL file to use 3D printing. Alternatively, any other standard rods can be a simple solution.

II). IMU Calibration:

Following a successful motor calibration, your robot dog should now be able to pass the self-test program and stand up on the ground. However, it's still likely that when you attempt to use the controller to get it walk, it may fall down or drift (either left or right). In this case, you may need to perform the IMU Calibration, which includes both the ***body skew calibration*** and ***remote controller calibration***.

1). Body Skew IMU Calibration

Step 1: After the robot boots up and stands on the ground, press **L2 + A** twice to make it lie down.

Step 2: Press **L2 + B** twice to get the robot into *Zero-Torque* mode.

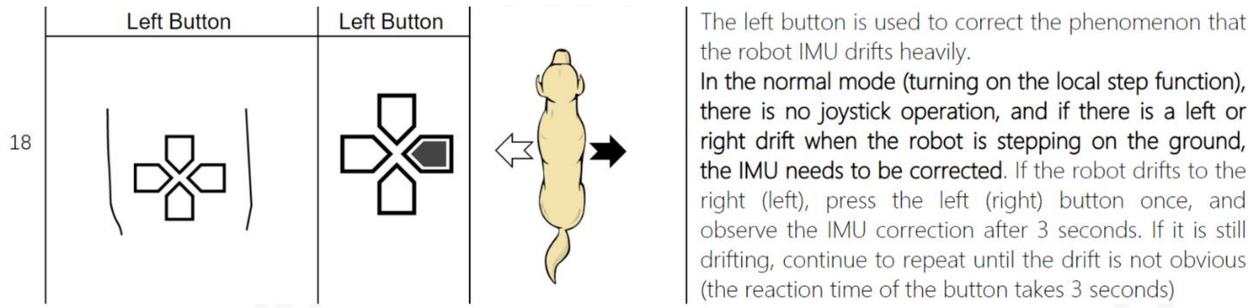
Step 3: Position the four robot legs as shown in below picture and make sure that every thigh is parallel to the fuselage:

Step 4: Press **L1 + B** and keep the state for more than 3 minutes. After that reboot it to finish this calibration part.

Tips: You can also consider using a programming approach, as explained earlier, to achieve a precise IMU calibration result for the body skew.

2). Remote Controller IMU Calibration

This section is crucial for accurate control of the robot dog with the remote controller. As in previous steps, start by booting the robot to make it stand up on the ground. Then, follow the official instructions provided:



	Left Button	Left Button		
18				The left button is used to correct the phenomenon that the robot IMU drifts heavily. In the normal mode (turning on the local step function), there is no joystick operation, and if there is a left or right drift when the robot is stepping on the ground, the IMU needs to be corrected. If the robot drifts to the right (left), press the left (right) button once, and observe the IMU correction after 3 seconds. If it is still drifting, continue to repeat until the drift is not obvious (the reaction time of the button takes 3 seconds)

Upon completing all these calibration procedures, your robot dog should operate normally, just as it did before.

● Some Useful Links

Below are some of the useful links from the shared official documents or online videos by Unitree:

OneDrive Shared Files:
https://onedrive.live.com/?authkey=%21AKVasQNzFkMYjdA&id=CDE1BA91EFBCF992%21134&cid=CDE1BA91EFBCF992

Unitree A1 Motor:
https://onedrive.live.com/?authkey=%21AKVasQNzFkMYjdA&id=CDE1BA91EFBCF992%21770&cid=CDE1BA91EFBCF992

Unitree Docs:
https://unitreedocs.readthedocs.io/en/latest/A1/A1.html#whichstatement-returns-version-information-that-is-the-version