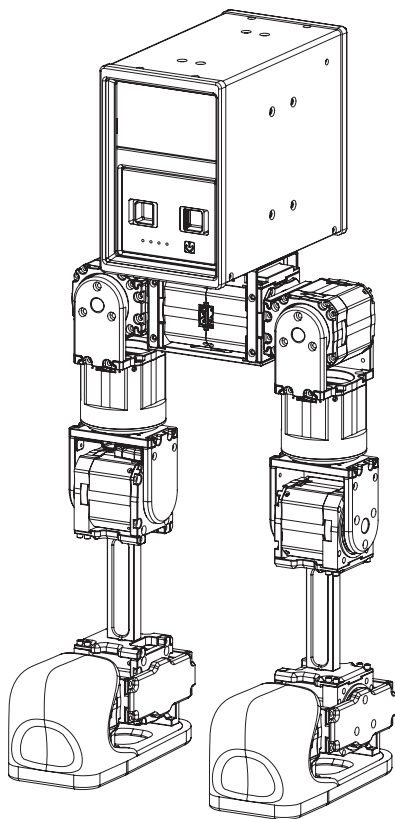


Mini Pi ROBOT

User Manual



HIGH TORQUE
高擎机电

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I. Disclaimer

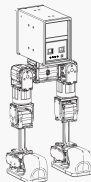
- ◎ This manual is compiled by Guangzhou High Torque Robotics Technology Co., Ltd. (hereinafter referred to as High Torque Robotics). With the aim of helping users use this product correctly and safely, please read this manual carefully before using the product for the first time and operate it strictly in accordance with the instructions.
- ◎ Once this product is used, the user shall be deemed to have read, understood, and accepted all the terms and conditions set forth in this manual, including but not limited to the safety instructions for use, usage restrictions, and disclaimers.
- ◎ If the user violates the operating specifications in this manual, or modifies the system configuration, intended use, or other aspects of the product without authorization, High Torque Robotics shall not bear any legal liability for personal injury, property damage, or other adverse consequences arising therefrom.
- ◎ The user undertakes to be responsible for their own actions and independently bear all legal consequences arising from the use of this product.
- ◎ The user shall use this product solely for legal and compliant purposes, and shall not use it for any acts that violate laws and regulations, infringe upon the legitimate rights and interests of third parties, or endanger public safety. Otherwise, High Torque Robotics shall have the right to terminate its after-sales support and services, and pursue legal liability in accordance with the law.
- ◎ To the maximum extent permitted by law, High Torque Robotics makes no express or implied warranties regarding this product, including but not limited to warranties of merchantability, fitness for a particular purpose, or non-infringement of third-party rights.
- ◎ To the maximum extent permitted by law, High Torque Robotics shall not be liable for any direct, indirect, incidental, or consequential damages arising from the use, inability to use, or improper use of the product. It shall also not be liable for any claims arising from product performance issues, service delays, interruptions, or errors, including but not limited to loss of profits, business interruption, or loss of information, even if High Torque Robotics has been notified of the possibility of such damages.
- ◎ The total amount of any compensation liability that High Torque Robotics may bear to the user in respect of this product (whether based on contract, tort, or other legal grounds) shall be capped at the actual purchase price paid by the user for the product.
- ◎ Given that the product may undergo continuous optimization and upgrades, there may be discrepancies between the functions, appearance, parameters, etc., listed in this manual and the actual product. The physical product shall prevail. This manual does not constitute a legally binding commitment regarding product performance.
- ◎ When using this product, the user shall strictly comply with the laws and regulations of the place where the product is used, including but not limited to provisions on safe use, transportation, import, and export restrictions. The user shall not use this product for any dangerous purposes, including but not limited to harming humans or animals, or modifying it into a weapon.
- ◎ If the user violates applicable laws and regulations or these terms, the warranty rights for the purchased product shall automatically become invalid, and High Torque Robotics shall have the right to refuse to provide any subsequent technical support, maintenance, or replacement services.
- ◎ High Torque Robotics reserves the right to update, modify, or terminate these terms as needed, without prior notice. The updated terms shall take effect from the date of publication.
- ◎ The right to interpret the content involved in this manual shall belong to High Torque Robotics, and the manual shall be implemented in accordance with the relevant laws and regulations of the People's Republic of China.

II. Safety Instructions

- ⊗ Please place the robot on a flat and stable surface to avoid falling and damage.
- ⊗ Do not insert fingers or other objects into the robot's joints to prevent pinching injuries.
- ⊗ Avoid placing robots in damp or dusty environments to prevent damage to electronic components.
- ⊗ To extend the product's service life, do not use this product in high-temperature or high-pressure environments for a long time.
- ⊗ When using the robot (especially when it is not protected by a protective frame or safety rope), ensure the robot remains within your line of sight. The robot must maintain a safe distance from crowds (especially the elderly, weak, disabled, pregnant women, and children), obstacles, complex ground surfaces, water bodies, and other objects!
- ⊗ The robot is not waterproof. Do not use it on wet ground or in rainy, snowy weather.
- ⊗ The robot is not dustproof. Do not use it in gravel or dusty environments.
- ⊗ Do not use the robot in severe weather conditions, such as fog, snow, rain, lightning, sandstorms, storms, tornadoes, etc.
- ⊗ Do not use the robot in environments with electromagnetic interference, including but not limited to high-voltage transmission lines, high-voltage substations, mobile phone base stations, and TV broadcasting towers.
- ⊗ Do not use the robot in scenarios where multiple wireless communication devices are in operation.
- ⊗ Controllers vary in their operating proficiency. To ensure stability, use the robot in a flat and open environment.
- ⊗ Do not suddenly push or kick the robot with force, as this may cause it to fall and be damaged; such damage will not be covered by the warranty.
- ⊗ If the robot needs to be on standby for a long time, hoist it on a protective frame.
- ⊗ When the battery level is too low or the battery overheats, stop and turn off the robot in a timely manner.
- ⊗ The robot is only for use by persons aged 14 and above.
- ⊗ The robot must not be used by persons with physical, sensory, or intellectual disabilities, nor by persons without relevant experience, skills, or knowledge.
- ⊗ All parts and accessories of the robot must be correctly installed and used in accordance with the User Manual. Improper installation or use may pose risks during operation.
- ⊗ Before use, check whether the lithium battery and power adapter are damaged. Do not use the product if the lithium battery or power adapter is damaged.
- ⊗ The interior of the product and the power adapter contain live components. Do not immerse them in water or other liquids for cleaning. Wipe the robot body, cameras, and other sensors with a dry cloth, and wait until they are completely dry before use.
- ⊗ Charge the product in accordance with the instructions in the manual. Incorrect charging may damage the battery.
- ⊗ During charging, if there is an unusual odor, smoke, overheating, discoloration, or deformation, immediately unplug the charger from the robot and stop using the robot.
- ⊗ If the battery leaks and the electrolyte gets into the eyes, do not rub the eyes; rinse the eyes with clean water and seek medical treatment immediately.

III. Package List

Essentials



1 Robot



1 Battery



1 Charging Chamber



1 Zero-Position
Bracket



2 Knee Joint
Zero-Position
Blocks



1 Control Handle



1 USB-to-CANFD
Debugging Board



2 XT 30 (2+2) Wires



1 Charging Head



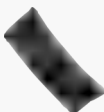
1 Type-C Charging
Cable



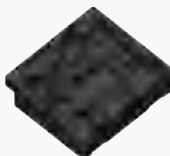
1 Screwdriver



4 Hexagon Allen
Wrenches



1 Handle
Protective Cover



1 Set of EVA
Packaging Inner
Liner



1 Rolling Luggage

PART 01

Product Introduction

IV. Product Overview

1. Product Information

◎ **Product Name:** Bipedal Robot Mini Pi

◎ **Product Introduction:** Mini Pi is a bipedal robot development platform independently researched, developed and manufactured by High Torque Robotics. It has a total of 12 degrees of freedom (DoF), a self-weight of 7kg and a height of approximately 52cm. As a secondary development platform integrating high cost-effectiveness, high performance and high expandability, it is widely applicable to application scenarios such as scientific research and development, educational practice and individual makers. It helps users conduct algorithm verification and system integration development in fields including motion control, reinforcement learning, perceptual cognition and behavior planning.

◎ **ROS Version:** ros-noetic-desktop

◎ **Operating System:** Ubuntu_20.04_desktop_arm

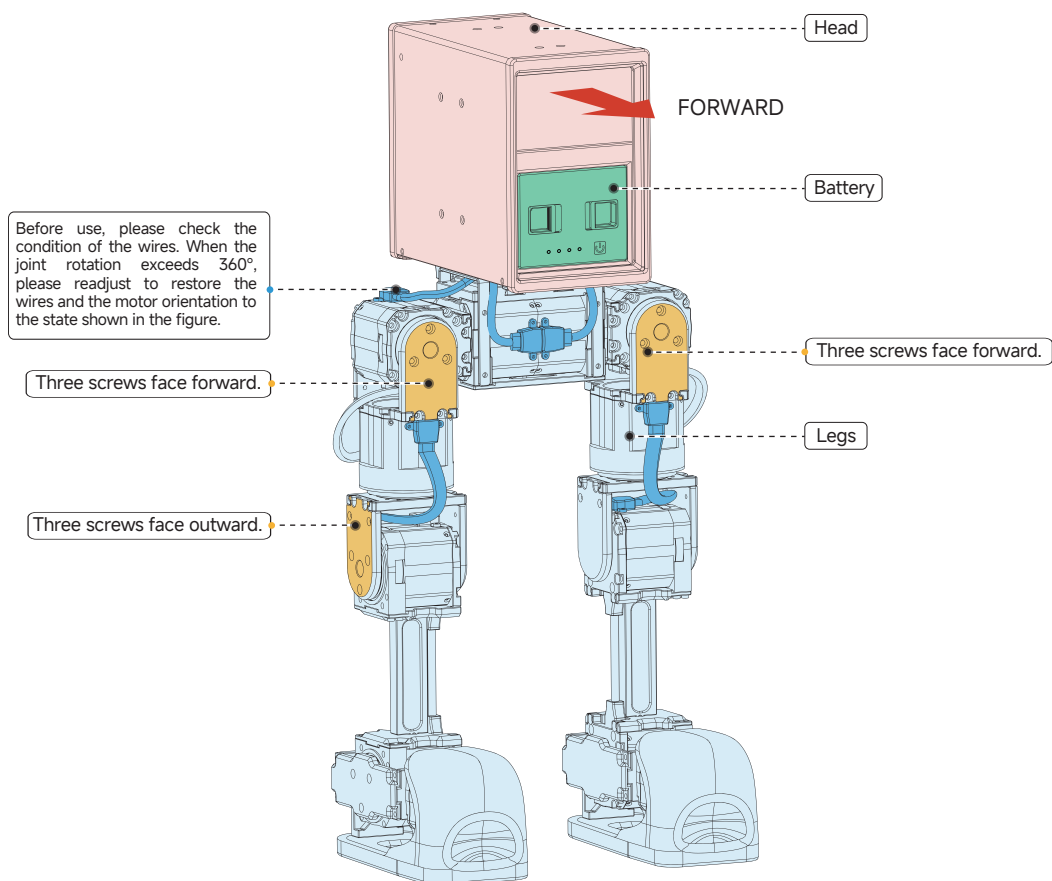
◎ **Factory-installed Algorithm Version Number:** HT-RL2.0.1

◎ **User Name and Password**

Version	Pi
user name	hightorque
operating password	ht

2. Product Composition

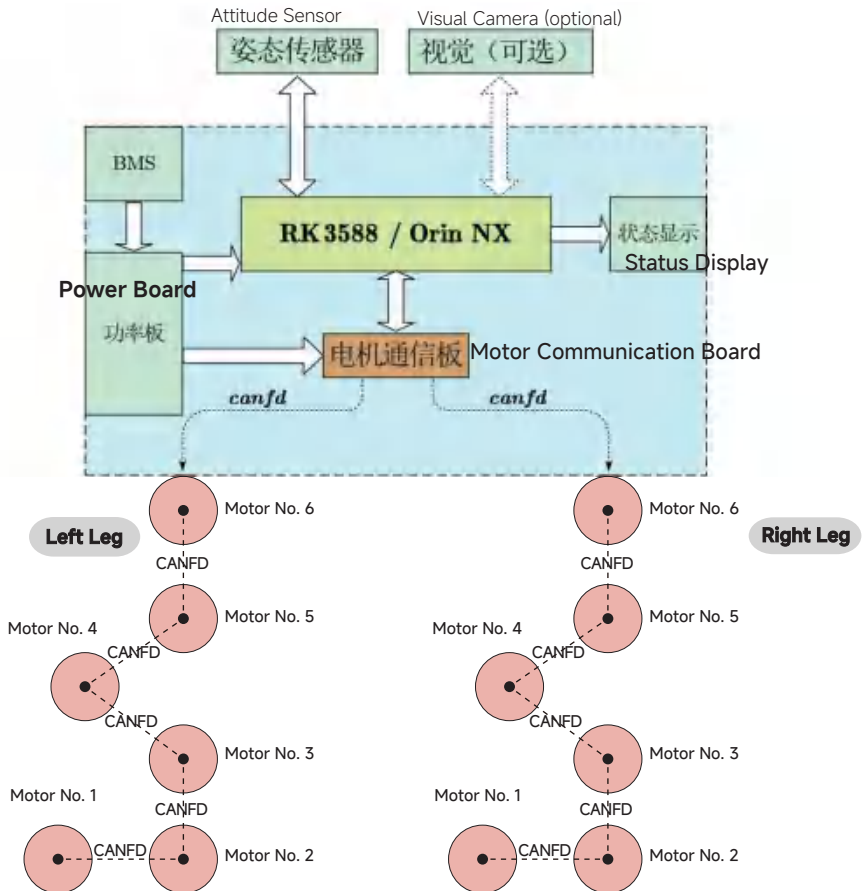
2.1 External Structure



Note: All wires shall be connected to the motor from the outside.

2.2 Main Control Hardware System

The core of the system is RK3588, which communicates with multiple motors via the motor communication board and transmits data using the CAN FD protocol.



2.2.1 Main Control

The main controller of Mini Pi consists of three parts: the RK3588 core board, the RK3588 base board, the power board, and the IMU. It provides a variety of interfaces and supports the expansion of interfaces such as microphones, fans, WiFi network cards, displays, and speakers.

Main Controller Parameters:

- CPU:	8-core 64-bit (4x Cortex-A76 + 4x Cortex-A55), up to 2.4GHz
- GPU:	ARM Mali-G610
- MEMORY:	16+128G
- NPU:	6T

IMU Attitude Angle Indicator:

Parameters		Typical Value	Remark
Roll angle	Precision	0.15°	1σ RMS,25°C
	Range	±180°	
Pitch angle	Precision	0.15°	1σ RMS,25°C
	Range	±90°	
No reference heading angle	Precision	0.2°	1σ RMS,25°C
	Range	±180°	
Angular resolution		0.001°	

IMU Gyroscope Indicators:

Parameters	Typical Value	Remark
Range	$\pm 2000^{\circ}/s$	
Nonlinearity	$\pm 0.05\%FS$	
Noise density	$0.005^{\circ}/s/\sqrt{Hz}$	
Zero bias instability	$6^{\circ}/h$	Allan variance @ 25°C (1 σ)
Bandwidth (-3dB)	50Hz	
Zero offset	$\pm 1^{\circ}/s$	1 σ RMS, 25°C
Zero temperature drift	$\pm 1^{\circ}/s$	1 σ RMS, -40~85°C

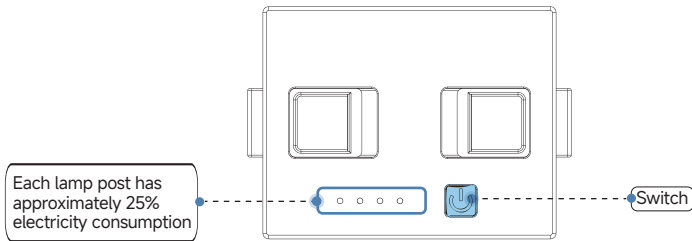
2.2.2 Joint Module

The bipedal robot Mini Pi is equipped with self-developed Planetary Series servo motors by High Torque Robotics throughout its body, boasting strong torque and load capacity. It features a total of 12 HTDW-5047-36-NE motors, among which the No. 4 motor of each leg is the crossed roller version.

The detailed parameters of HTDW-5047-36-NE are introduced as follows:

- Reduction ratio: 36	- Rated current: 2A
- Voltage range: 24-48V	- Peak current: 10A
- Peak torque: 16Nm	- Rated torque: 4Nm
- Rated speed: 40RPM	- No-load speed: 60RPM
- Baud rate: 5Mbps	- Control frequency: 3KHz
- Speed control accuracy: $\pm 15\%$	- Response time: $\leq 200\mu s$

2.2.3 Battery



The battery equipped on the bipedal robot Mini Pi is the self-developed HTB-24 lithium battery by High Torque Robotics.

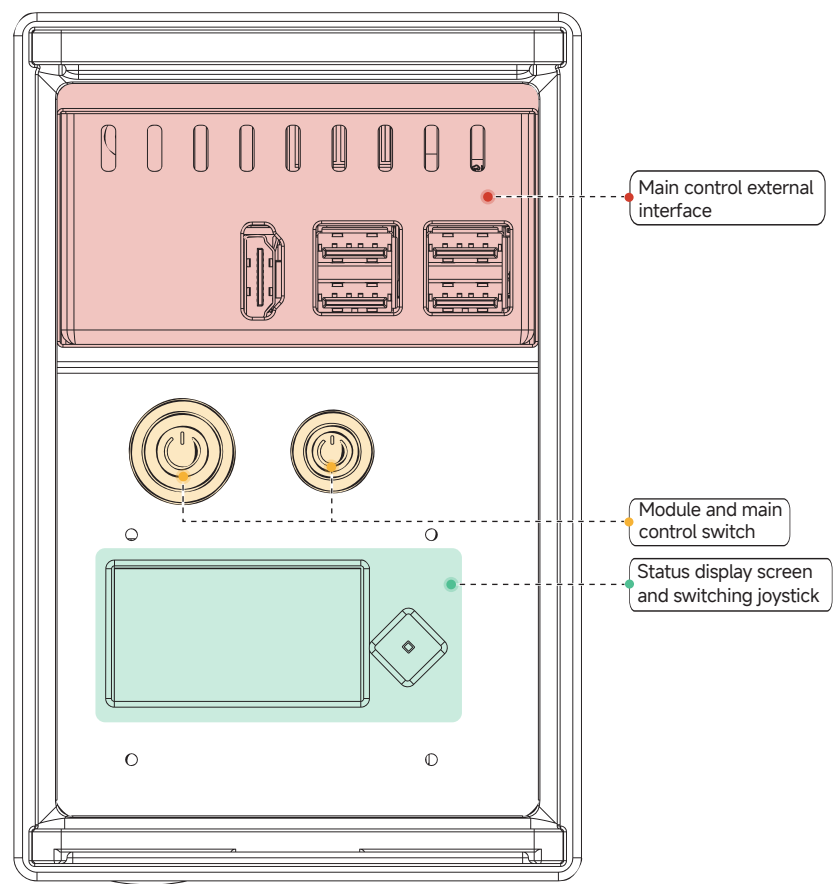
Parameter Information:

- Battery capacity:	5000mAh
- Output voltage:	24V
- Output current:	Sustainable output of 20A current, with a maximum instantaneous output of 60A or more current

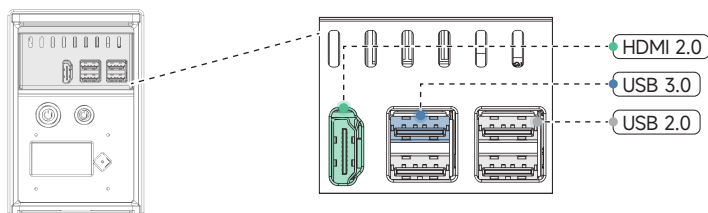
- ⦿ Charge and discharge protection: equipped with overvoltage, overcurrent, and reverse connection protection mechanisms to ensure safe and stable charging. Supports over discharge, over-current, and short circuit protection to prevent battery damage.
- ⦿ Automatic discharge: When the battery is fully charged for more than 1 day, it will automatically discharge to around 97%; exceed after 7 days, it will automatically discharge to around 60% for storage.
- ⦿ Thermal balance: It can balance and adjust the heat generated during operation, effectively preventing performance degradation of the battery cell due to rapid temperature rise.

3. Backplane Description

3.1 Overview of Mini Pi Backplane



3.2 External Interfaces of Mini Pi Main Control



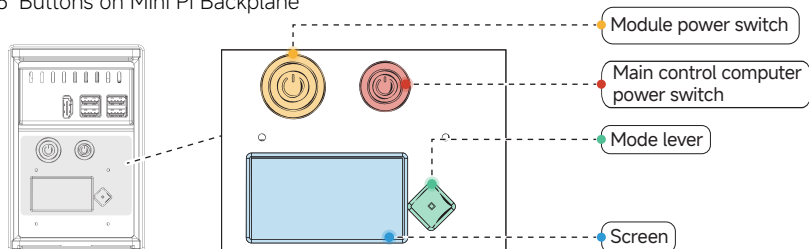
Parameter Information:

- CAN Baud Rate: **1Mbps**
- CANFD Baud Rate: **5Mbps**
- Serial communication speed: **4Mbps**

◎ Feature Introduction:

- Output up to 4 channels of CANFD information through SDK, with each channel capable of controlling up to 20 motor modules.
- Use software algorithms to control the overall hardware system and achieve robot attitude control.

3.3 Buttons on Mini Pi Backplane



◎ Module power switch:

- Power on: Short press the switch button to turn on the power of the joint module, and then turn on the lights
- Power off: Short press the switch button to turn off the power of the joint module, and the switch light will turn off after turning off

◎ Main control computer power switch:

- Power on: Press the power button for more than 2 seconds and then release it. When turned on, the switch light will turn on
- Power off: Press and hold the power button for more than 2 seconds, then release it. After turning it off, the switch light will turn off

◎ Mode lever:

- By continuously moving the lever, the robot's IP address, battery level, and other different statuses can be viewed on the screen (see 3.4 for details)

3.4 Backplane Display Screen

Status Display

Joint Status Display

After connecting the status display screen, the joint status can be detected in real time. When a joint module signal is lost, the light at the corresponding position on the status display screen will turn off; Generally, if individual joint status signal lights go out, it indicates that the corresponding module may have a power abnormality. If there are joint status signal lights, they will turn off sequentially until the end. It indicates that the CAN signal of the joint module in this channel is lost.

Motor State

IMU Data Printing

The status display screen can achieve IMU data printing, making it easier for developers to operate without an external display.

IMU State

R:0.0.0
P:0.0.0
Y:0.0.0

IP Address Display

Print the return address (lo), wired network address (eth0), and wireless network address (wan0)

Robot IP

Lo: 127.0.0.1
eth0: 127.0.0.1
wan0: 127.0.0.1

Battery Level Display

This page allows real-time viewing of battery level information.

Battery

Robot Mode Management

This page allows you to select the corresponding robot control mode.

Robot State

INITIAL

Joystick Switch

The left and right joystick switches can be used to switch between IMU information, joint status display, IP address, robot mode management, battery display, and other functions in sequence.

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PART 02

Preparation

V. Unboxing and Startup Preparation

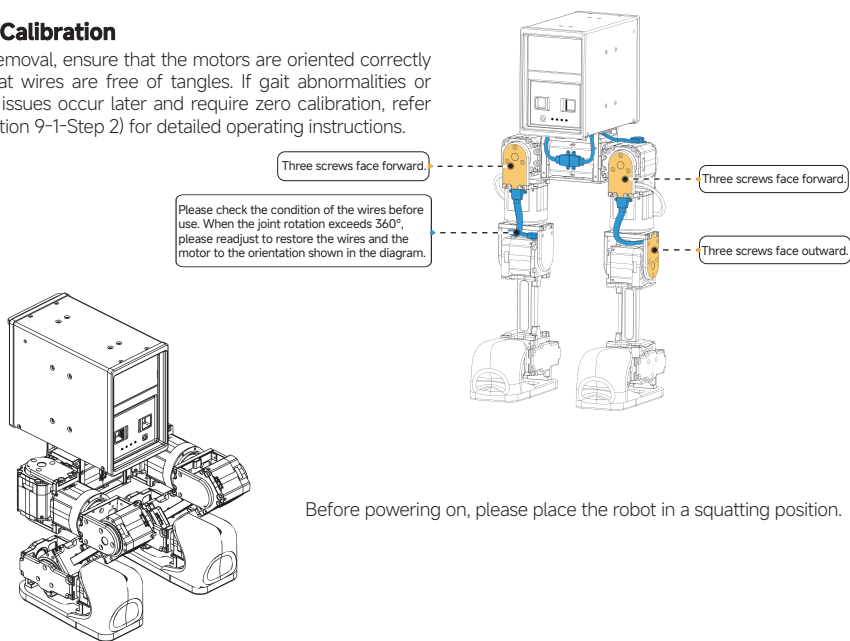
① Unboxing

After receiving the robot package, please carefully remove the outer packaging materials. Open the attached customized luggage case and confirm that all internal accessories are complete, including: the robot body, battery, control handle, power adapter, spare screws and tool kit, user manual, etc. (see Chapter 3. Packaging List for details).

Grasp the handle on the robot's head, lift it out of the case with a slight force, and then take out the other accessories one by one.

② Pose Calibration

After removal, ensure that the motors are oriented correctly and that wires are free of tangles. If gait abnormalities or similar issues occur later and require zero calibration, refer to (Section 9-1-Step 2) for detailed operating instructions.

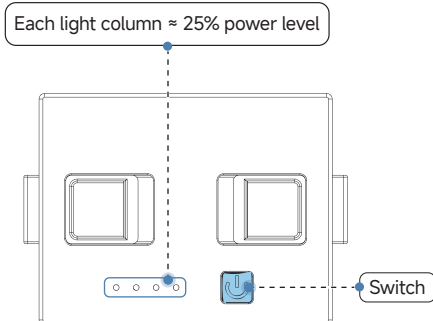


Before powering on, please place the robot in a squatting position.

③ Battery Level Check

Press the power button on the battery briefly to check the power level. The number of illuminated light columns indicates the current battery power status (see Chapter 4 Section 2.2.3 for details). Please charge the battery in a timely manner if the power level is below 25%.

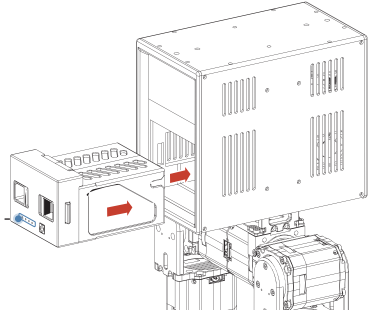
(Note: The battery needs to be fully charged before first use.)



④ Battery Installation

There are two buckle structures on the front end of the battery. Firmly squeeze the two buckles, insert the battery into the battery compartment at the front of the robot in the direction shown in the diagram, and push it to the deepest position to release the two buckles so that they lock in place. Press the battery power button briefly, then press and hold it for another 2-3 seconds. The battery's light columns will display a flowing marquee effect, indicating that the battery has been turned on successfully.

The battery displays a flowing marquee effect when it is successfully turned on.



⊙ Battery charging:

There are two buckle structures at the front end of the battery. Clamp the two buckles firmly and insert them into the charging compartment in the direction shown in the diagram. Push them to the deepest point to release the two buckles and lock them in the charging compartment, then the battery can be installed in the charging compartment. Remove in the same way, but in the direction of extraction. Use a Type-C charging cable and a 45W or higher power adapter to charge, and the battery needs to be turned on during charging.

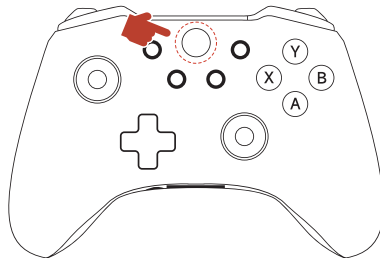
⊙ Battery level display:

The battery has four light bars, each corresponding to a different percentage of charge. During the charging process, the light bars will illuminate in sequence. When fully charged, the battery will automatically shut off, and all light bars will turn off.

⑤ Handle Power-On and Battery Level Check

Observe the BeiTong button light ring on the controller. If the light ring is off, the controller is in a shutdown state (Note: The controller is usually in a shutdown state when first used, and it needs to be fully charged before first use). Press the BeiTong button, and the RGB light ring starts flashing, indicating that the controller is turned on.

When the device is turned on, the RGB light ring on the controller will flash slowly. When the RGB light ring on the controller flashes rapidly, it indicates that the controller is in a low battery state and needs to be charged in time to ensure subsequent use.



Insert the receiver of the wireless controller into any external USB port of the robot. If the handle vibrates and the RGB light ring displays a constant white light, it indicates that the handle has been successfully paired.

Comparison table of handle RGB light ring status:

Handle RGB light ring status	Representative meaning
Slowly flashing in alternating colors	Waiting for pairing in normal state
Rapid alternating flashing of multiple colors	Battery level is below 30%, please charge
Slowly flashing white	Charging in shutdown state
The white light stays on for 10 seconds and then goes off	Fully charged when turned off
White steady on	The receiver has been successfully paired

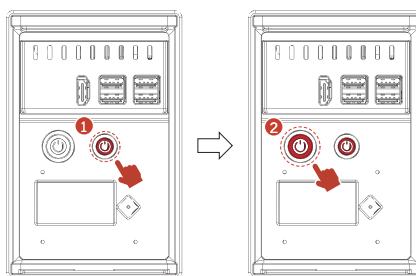
⑥ Robot Power-On and Power-Off

Attention:

Please check the initial positions of the robot's motors and the condition of the wire harnesses before powering on (see details in this chapter ②) ;

Please pay attention to the on/off sequence of the buttons on the back panel and monitor the product status during this process.

Power on



- 1 After the battery is installed, turn on the battery by pressing it briefly and then pressing and holding it (see details in this chapter 4).
- 2 First, turn on the main control system. Face the robot's back panel, press and hold the small button on the right for 2-3 seconds until the red indicator light illuminates and the screen displays "loading" — this indicates the main control system has been successfully activated.
- 3 Activate the joint modules. Face the robot's back panel, press the large left button briefly, and the red indicator light will illuminate — indicating the joint modules have been successfully activated.
- 4 Remove the sliding cover on the back of the handle, take out the USB receiver, and insert it into the USB interface area on the back panel. If the handle vibrates and the RGB light ring stays steadily white, the handle has been successfully connected.

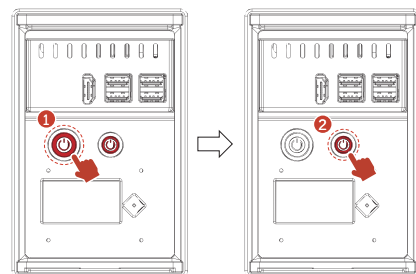
Power off

① Ending robot control:

1) Ensure the robot is in a flat and open area. Meanwhile, make sure all control operations on the robot have been terminated. Press the LB button, and the robot will disconnect from the remote control handle and slowly squat down under its own gravity.

2) Check the OLED status display to confirm that the node management shows "INITIAL" (initial state).

- 2 Face the robot's back panel. First, press the large left button briefly to turn off the joint modules, then press and hold the small right button to shut down the main control system.
- 3 Press the battery's power button briefly first, then press and hold it to turn off the power.
- 4 Remove the USB receiver and plug it back into the back of the handle.

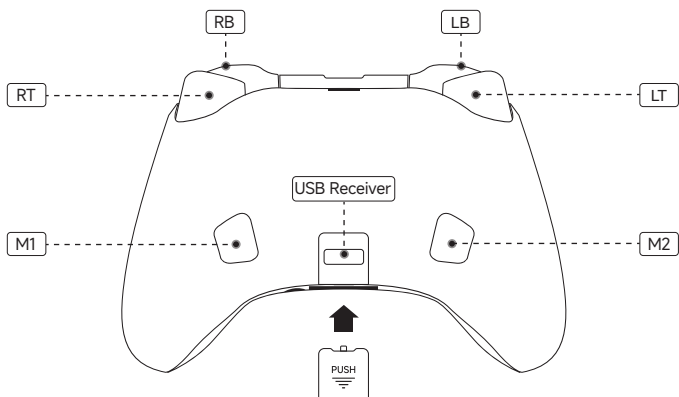
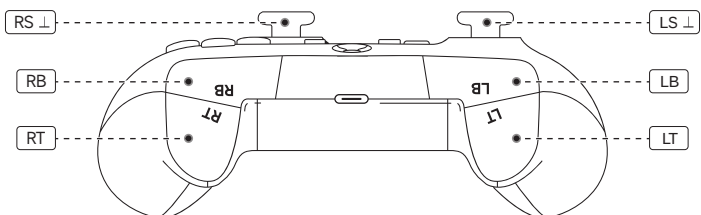
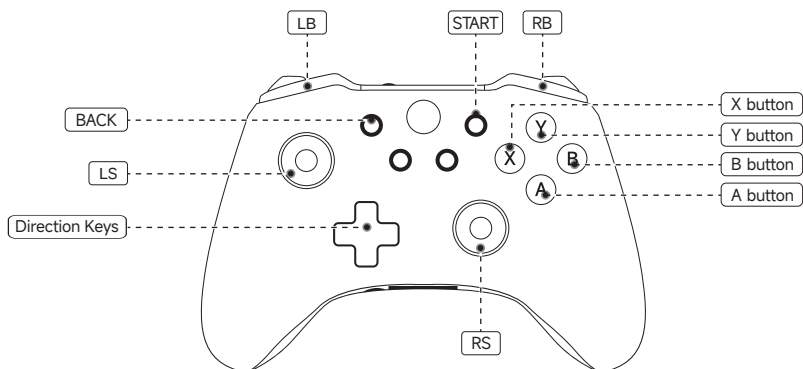


PART 03

Operation Guide

VI. Operation Guide

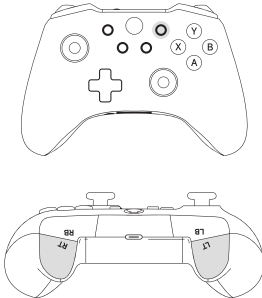
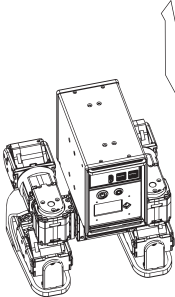
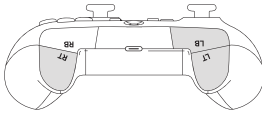
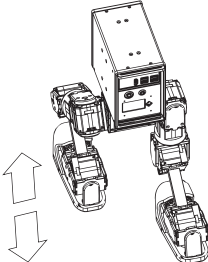
1. Wireless Controller Buttons and Operation Instructions

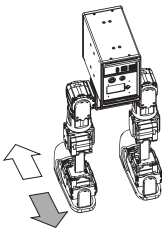
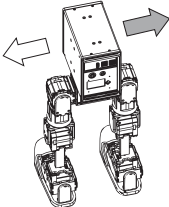
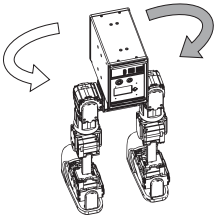
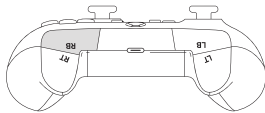
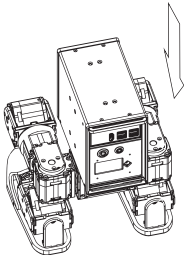


2. Running Basic Movements of the Robot

Observe the display screen on the robot's back panel. After a brief loading screen, the robot enters default mode.

Command	Operation and Status
Start the robot	Press LT+RT+START simultaneously, and the robot will stand up
Walk and Stopping	When LT+RT+LB are pressed simultaneously, the robot will activate; pressing them again will lock it (Note: Only after pressing LT + RT + LB in advance to unlock the robot can subsequent commands such as forward movement, translation, and backward movement take effect.)
Moving forward and backward	Left joystick (LS ⬇️): When the joystick is pushed up, the robot moves forward; when it is pushed down, the robot moves backward
Moving left and right	Left joystick (LS ⬇️): When the joystick is pushed left, the robot moves left; when it is pushed right, the robot moves right
Steering and Yaw	Right joystick (RS ⬇️): When the joystick is pushed to the left, the robot yaw to the left; when it is pushed to the right, the robot yaw to the right
Terminate Control	When RT+LT+RB are pressed simultaneously, the robot will stop accepting remote control and squat (When the control is turned off, please keep your fingers and other body parts away from the robot to ensure safety and be careful not to get your fingers pinched)

Remote Control Handle	Status Display	Control Methods
		RT+LT+START, press to make the robot slowly stand up
		Activation and Locking: When LT+RT+LB are pressed simultaneously, the robot can execute subsequent commands. Pressing them again will lock the commands

Remote Control Handle	Status Display	Control Methods
		Left joystick (LS): When pushing up the joystick, the robot moves forward Left joystick (LS): When pushing down the joystick, the robot moves backward
		Left joystick (LS): When pushing the left joystick, the robot translates to the left Left joystick (LS): When pushing the right joystick, the robot translates to the right
		Right Joystick (RS): Push the joystick to the left to make the robot yaw left. Right Joystick (RS): Push the joystick to the right to make the robot yaw right.
		Terminate Control: When LT + RT + RB are pressed simultaneously, the robot will stop accepting commands from the remote control and enter a damped state, slowly squatting down under its own gravity. (When terminating control, do not place fingers or other objects near the robot. Please exercise caution to avoid pinching hazards.)

Adjust the walking state of the robot:

Command	Operation and Status
Cadence (plus)	Press (A) to increase the robot's step frequency
Cadence (decrease)	Press (Y) to decrease the robot's step frequency
Stride (plus)	Press (X) to increase the robot's stride frequency
Stride (decrease)	Press (B) to decrease the robot's stride frequency

Note: Try to avoid excessively adjusting parameters during the robot's walking process

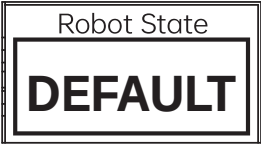
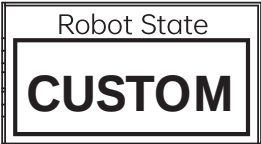
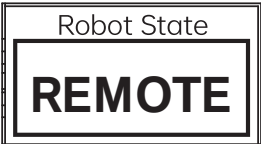
Strengthening algorithm switching:

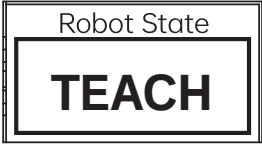
1)	When the robot is in the startup state, please press RT+LT+LB simultaneously to lock the robot
2)	When the robot is in a locked state, pressing RT+LT+the cross arrow key (either left or right) simultaneously will cause the robot to shake
3)	After the robot shakes, press RT+LT+LB. The robot will take steps in place, indicating that the mode has been successfully switched
4)	When it is necessary to switch back to the default algorithm, repeat steps 1) to 2) above. The robot will switch back to the default algorithm. Press RT+LT+LB again, and the robot can be started

Teaching Mode Control:

Command	Operation and Status
Start Recording	Press (LT + View button) to start recording actions.
Add Waypoint	Press (Y) to add a waypoint.
Delete a waypoint	Press (X) to delete a waypoint.
Delete All Waypoints	Press (RT + X) to delete all waypoints.
Complete Recording	Press (A) to complete the recording, and a path file will be automatically generated with the completion time as the file name.
Lock/Unlock Joints	Press (B) to lock/unlock the joints.
Select the locked joint(s)	Press (RT + Directional Key DOWN) to lock/unlock the left leg. Press (RT + Directional Key RIGHT) to lock/unlock the right leg.
Load Trajectory	Press (LT + Menu button) to start loading the trajectory file.
Execute Trajectory	Press (LS) to start executing the trajectory.

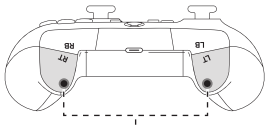
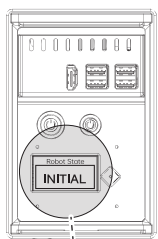
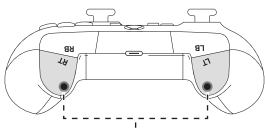
3. Instructions for Different Modes of the Robot (For detailed application scenarios, please refer to the Advanced Development Tutorials on the official website.)

Control Mode Node Management Display	Backplane Screen Status	Node Description
Initial State	 The screen displays 'Robot State' at the top and 'INITIAL' in large, bold, black letters in the center.	The robot management node starts up, but no triggering action will occur.
Default State	 The screen displays 'Robot State' at the top and 'DEFAULT' in large, bold, black letters in the center.	The original sim2real operation logic is as follows: if the sim2real internal button is pressed to shut down or the shutdown is triggered by a limit switch, it is regarded as a normal shutdown, and the system will jump to the init state. If an issue with the IMU or motor is detected, the system will enter protection mode. Alternatively, if the external shutdown mode is actively activated, the system will also enter damping mode.
Custom State	 The screen displays 'Robot State' at the top and 'CUSTOM' in large, bold, black letters in the center.	It is completely consistent with the default mode, but provides a config file interface that allows you to modify the policy and other parameters. However, the replaced policy should preferably be trained using our open-source training algorithm. (If our algorithm is not used, it is at least necessary to ensure that the input and output dimensions of your policy are consistent with those of ours.)
Remote State	 The screen displays 'Robot State' at the top and 'REMOTE' in large, bold, black letters in the center.	On the robot side, it continuously subscribes to the jointstate topic published by the host and executes it in real time. On the host side, it obtains the visualization of the robot's joint states and IMU state, and continuously publishes jointstate to the robot.

Control Mode Node Management Display	Backplane Screen Status	Node Description
Calibration State	 The image shows a rectangular screen with a double border. Inside, the text "Robot State" is at the top, and "RSTZERO" is in large, bold, black letters below it.	Place the robot on the calibration bracket as described in (Section 9-1-Step 2). After entering this mode, the robot will automatically perform calibration and display the calibration result on the OLED screen.
Teach State	 The image shows a rectangular screen with a double border. Inside, the text "Robot State" is at the top, and "TEACH" is in large, bold, black letters below it.	Manually control the robot to multiple fixed poses and record them using the controller. Pico will automatically generate and execute the motion path, and the path file will be saved locally for later repeated calls.
Protection State	 The image shows a rectangular screen with a double border. Inside, the text "Robot State" is at the top, and "PROTECT" is in large, bold, black letters below it.	This mode is entered when there is an issue with the IMU or joints, or when the mode is actively interrupted during other motion mode phases. If the active interruption is triggered again, the motors will not respond to any control commands.
Error State	 The image shows a rectangular screen with a double border. Inside, the text "Robot State" is at the top, and "ERROR" is in large, bold, black letters below it.	When the robot detects that a motor is not connected, the error status will be displayed. It is necessary to check the joint communication, and it will automatically recover after a while.

4. Methods for Switching Control Modes

If you need to switch between different modes, please follow the steps below:
First, check whether the robot is in a certain mode. If you need to switch modes, press and hold LT+RT first, and press B briefly to exit the current mode.

Remote Control Handle	Status Display	Control Method
 Press and hold (LT & RT) simultaneously. 	 Robot State INITIAL ↓ Robot State DEFAULT	Mode switching: Keep (LT +RT) pressed, and then press [Cross Direction Key (Left or Right)] to switch between different control modes
 Press and hold (LT & RT) simultaneously. 	Robot State DEFAULT ↓ Robot State DEFAULT	Selecting State: Hold (LT+RT) and then press (A) to select the current control mode Hold (LT+RT) and then press (A) to select the current control mode

For the detailed real-machine deployment tutorial, please visit the High Torque Robotics official website - Technology & Support - Document Center - MiNi Pi Real-Machine Deployment section, and refer to the link:
<https://www.hightorque.cn/chapter/mini-pi-sim2real-docu>



For the detailed tutorial on TEACH Mode, please visit High Torque Robotics official website - Technology & Support - Document Center - TEACH Mode Tutorial, and refer to the link:
<https://www.hightorque.cn/chapter/mini-pi-teach-mode>



For more detailed tutorials on action configuration, please visit High Torque Robotics official website - Technology & Support - Document Center - Stylized Action Teaching, and refer to the link:
<https://www.hightorque.cn/chapter/mini-pi-stylized-action-teaching>



PART 04

Maintenance

VII. Transportation, Handling and Storage

1. Public Transportation Such as Aviation and High-Speed Rail

- ⦿ The outer packaging suitcase of the Mini Pi meets the size requirements for carry-on luggage, allowing you to take it on public transportation such as airplanes and high-speed trains.
- ⦿ If the product contains batteries (such as lithium batteries like HTB24/HTB48), relevant national laws, regulations and security inspection requirements on lithium battery transportation shall be complied with during shipment. If you need to carry the product with you on high-speed trains or flights, please check the security inspection policies of the destination in advance. We can provide battery compliance certification materials, but we shall not be liable for transportation delays, return shipments or safety incidents caused by regional policy differences or refusal of acceptance by the carrier.

2. International Transportation

- ⦿ For exported products, please provide battery compliance certification documents (such as CE, UN38.3, RoHS, etc.) in accordance with the relevant requirements of the destination country. It is recommended to use international logistics services with dangerous goods transportation qualifications to ensure smooth customs clearance.
- ⦿ Clear warning labels shall be pasted in the package.

3. Notes for Express Transportation

- ⦿ Our delivery or repair logistics companies are compliant and regular logistics companies with dangerous goods transportation qualifications, and the packaging, identification and transportation processes comply with national and relevant industry standards to ensure the safety and specification of robot and battery products during transportation.
- ⦿ If the user sends the product for maintenance spontaneously, please confirm the transportation mode and packaging requirements with us in advance to ensure that the product and battery will not be damaged or detained due to improper packaging, logistics non-compliance and other reasons.
- ⦿ If third-party express delivery is used to deliver products, it is recommended to select a logistics company with lithium battery carrier qualification.
- ⦿ When packing, be sure to use the original protective foam and pressure resistant box to prevent violent vibration, extrusion, fall, etc. during transportation, and avoid damage or fire risk to the product and battery.

4. Handling Instructions

- ⦿ Do not shake or dump the product violently to avoid falling or hitting the robot structure.
- ⦿ When moving robot equipment, it is recommended that two people cooperate to avoid structural deviation or joint damage caused by single person handling.

5. Storage Requirements

- ⦿ The product should be stored in a dry, ventilated environment without strong magnetism and corrosive gas, avoiding direct sunlight, high temperature and humidity.
- ⦿ When not in use for a long time, please disconnect the main power supply. The battery should be kept at 30%~60% power. The storage temperature is recommended to be between 10~35 to prevent over discharge or cell performance degradation.

VIII. Maintenance and Servicing

1. Mainframe maintenance

- ⊙ Please regularly check whether the appearance of each part is in good condition and whether it has been damaged by external impact.
- ⊙ Before maintenance and cleaning, please ensure that the product has been turned off.
- ⊙ Use a mild detergent to clean the outside of the robot. Do not use strong solvents.
- ⊙ When using, make sure that the head surface is clean. Avoid scratching the camera lens.
- ⊙ During handling, please handle with care to avoid falling. Mechanical impact will cause damage to parts.
- ⊙ When placing the robot, ensure that the legs are in a natural state to avoid joint force.

2. Battery maintenance

- ⊙ Please check the battery power and health condition regularly. When the battery is recycled for more than 1000 times or the battery life is significantly shortened, please contact the customer service to replace the battery.
- ⊙ Do not use the charger to charge in the environment with too high or too low temperature. The charging temperature is 15 °C~35 °C.
- ⊙ The charging time should not exceed 24 hours. Overcharging will shorten the battery life.
- ⊙ If the battery is not used for a long time, check the remaining battery power regularly. If the battery power is lower than 30%, please charge the battery to 70% and save it to avoid excessive discharge and damage to the battery.
- ⊙ When in use, the robot may not have enough power to move and perform actions when the battery shows 10% power. Please stop using and charge as soon as possible.
- ⊙ Do not charge immediately after use, and wait for cooling to room temperature before charging. Forced charging may seriously damage battery life.
- ⊙ Never clean the charger with alcohol or other flammable agents.

IX. Troubleshooting

This chapter is intended to help users quickly locate and resolve problems that may arise during the robot's operation. If you encounter any of the following situations, please first refer to the content of this section. If the problem still cannot be resolved, please contact the after-sales support team in a timely manner.

1. Common Problems and Solutions

It is recommended that you confirm the correct orientation of the robot's joints and the proper routing of the wiring harness before each use. Failure to check the wiring harness routing and motor orientation may result in issues such as wire tangling of the robot, motor disconnection, command failure, and leg curling.

1.1 Zero Calibration

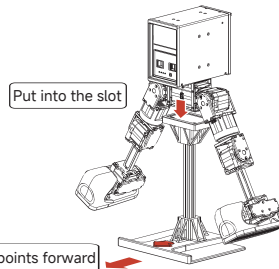
When the robot exhibits symptoms such as abnormal gait or partial joint curling, it may indicate that the zero position requires recalibration. Please follow the steps below to proceed.

Method 1: Calibration in Built-in Mod

Step 1: Perform pose calibration using the zero-position bracket

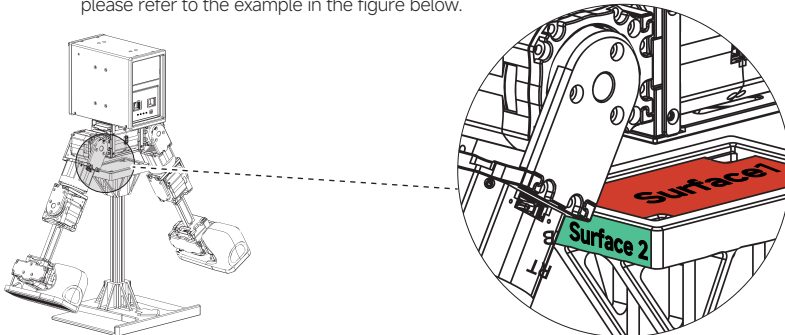
Step 1

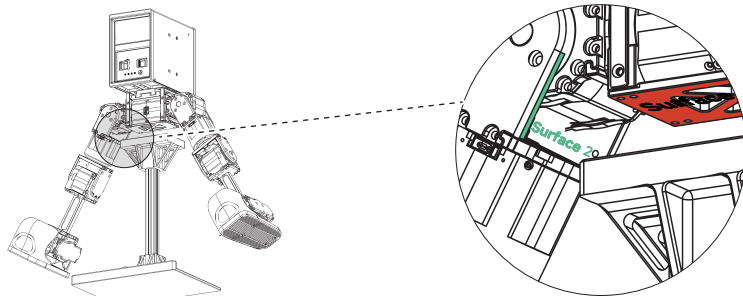
- 1 Prepare the zero-position bracket and knee joint zero blocks: Take out the zero-position bracket (marked with an identification arrow) and two knee joint zero blocks from the packaging.
- 2 Position the robot: Spread the robot's legs at an appropriate angle and place it firmly on the zero-position bracket.



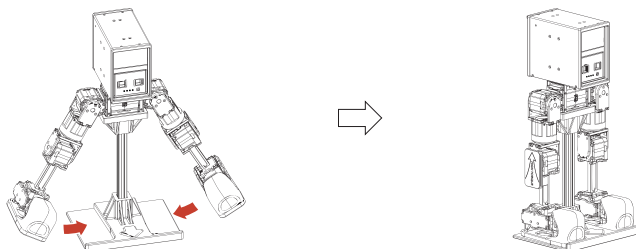
Step 2

Position the hip joints: Place the two hip motors of the robot on the upper end of the zero-position bracket, align them, and then fit them into the slot. Ensure Surface 1 corresponds to Surface 1 and Surface 2 corresponds to Surface 2; please refer to the example in the figure below.

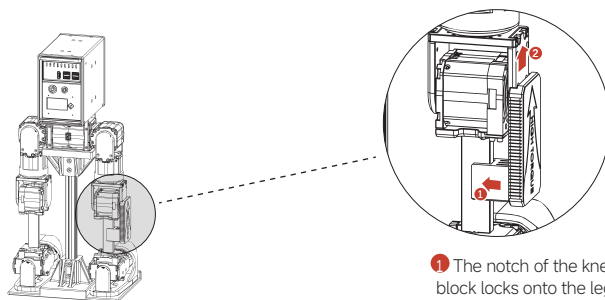




Step 3 Gather the robot's legs toward the center, ensuring the front, rear, and inner sides of the feet fit tightly against the corresponding edges in the lower slot of the "zero-position bracket".



Step 4 Fit the lower notch of the knee joint zero block into the leg part as shown in the figure, then push upward to lock the knee joint in place.

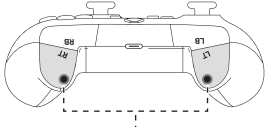
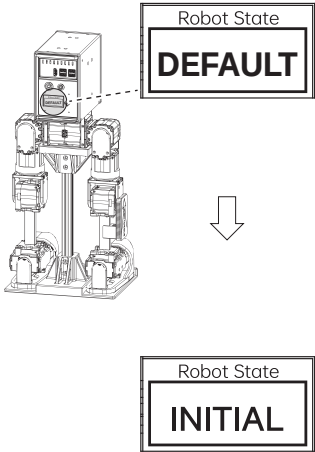
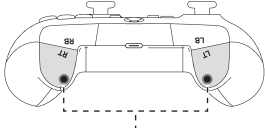
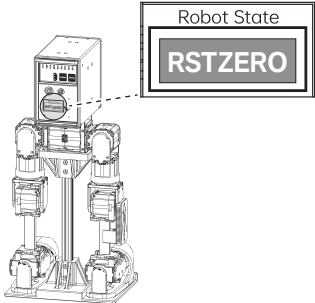


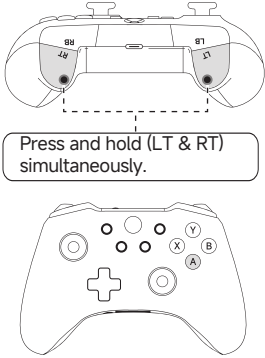
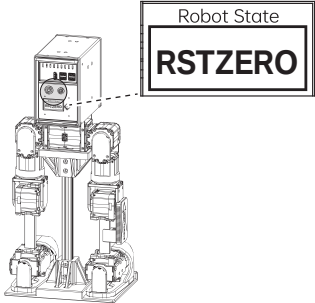
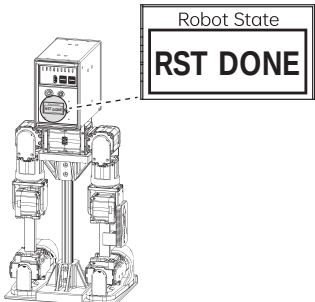
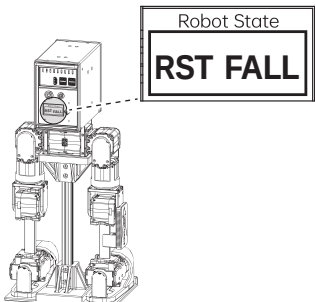
❶ The notch of the knee joint zero block locks onto the leg part.

❷ Push the knee joint zero block upward to restrict the degree of freedom of the knee joint.

After completing the above steps, the robot will be in its initial pose and ready for calibration.

Step 2: Zero Calibration in RSTZERO Mode

Remote Control Handle	Status Display	Control Method
 Press and hold (LT & RT) simultaneously. 		In Default mode, press RT + LT + B on the controller to exit the current mode. At this point, the screen will display "INITIAL" mode.
 Press and hold (LT & RT) simultaneously. 		Press and hold LT + RT + the right direction button simultaneously to switch modes, and switch to RSTZERO mode.

Remote Control Handle	Status Display	Control Method
 Press and hold (LT & RT) simultaneously.		Press RT + LT + A to select RSTZERO mode. The robot will then automatically start zero calibration —please do not perform any other operations while waiting for the calibration to complete.
		The screen will display zero calibration feedback after a period of time. Please pay attention to the screen status when the screen shows "RST DONE", it indicates that the zero calibration has been successfully completed.
		When "RST FAIL" appears on the screen, it indicates that the zero calibration has failed this time. At this point, you need to check the robot's pose, repeat the above steps, and perform zero calibration again until "RST DONE" is displayed on the screen.

Method 2: Instruction Calibration

Step 1 Please repeat Step 1 from Method 1 to ensure the robot is placed with an accurate pose.

Step 2 1. When the robot is powered on, connect the robot host to an external display via the HTDM cable. Open the terminal, navigate to the robot workspace directory where the SDK is located, and execute the `test_reset_zero.sh` command.

```
1 cd sdk所在的机器人工作空间
2 source devel/setup.bash
3 roslaunch livelybot_bringup motor_set_zero.launch
```

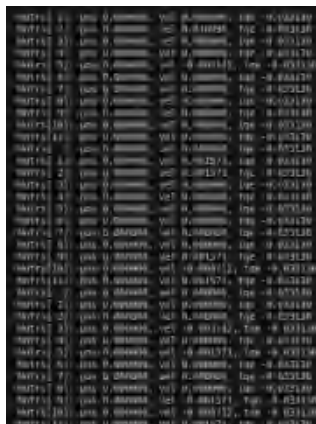
2. Confirm the successful zero setting after executing the zero calibration command, two possible scenarios may occur as follows:

If the illustrated pos data value has two zeros after the decimal point, it indicates that the command execution is successful.

If individual joints have non-zero values, please follow the steps below:

- 1 Press "Ctrl+C" in the terminal to execute the exit command and terminate the node.
- 2 Restart the power supply of the joint modules.
- 3 Execute the `test_reset_zero.sh` command (Step 2)

After successfully executing the zero calibration command, press "Ctrl+C" in the terminal to exit the command, then restart the power supply of the joint modules.



Step 3 3. Check if the robot's zero position status is normal:

Fix the robot on a bracket of a certain height or lift it with your arms (when executing the command, ensure to maintain a safe distance from the robot); when the robot is powered on, open the terminal, navigate to the robot workspace directory where the SDK is located, and execute the `test_motor_run.sh` command.

```
1 cd sdk所在的机器人工作空间
2 ./test_motor_run.sh
```

After executing the command, check if the robot's zero position is normal. Press Ctrl +C in the terminal to exit the command state.

1.2 Handle Connection

? Problem 1: Failed to connect?

Under normal circumstances, an obvious vibration will occur upon successful connection of the controller. When you find that the controller fails to pair successfully with the robot, please consider the following scenarios:

- ⦿ The handle indicator flashes rapidly, which may be due to the insufficient power of the handle. It is recommended to charge it in time.
- ⦿ The handle indicator light is off, which may be that the handle is not powered on. Press the logo key to power on.
- ⦿ The wireless receiver is not plugged in correctly. Please take out the receiver from the card slot on the back of the handle and plug it into any HDMI interface on the robot backplane.
- ⦿ The handle is powered but cannot be connected. You can plug the receiver into another host (such as a laptop) and wait for the handle to vibrate again for pairing. Or use a USB to type C data cable to connect the handle with the robot host to realize wired operation.
- ⦿ Restart pairing. At the same time, press and hold the LT key, the back key and the right rocker (RS V) to start up and reset, and then press the B key and the back key to shut down. At this time, the logo key flashes for a few seconds and then goes out. After the receiver is plugged into the host backplane, long press the logo key on the handle to pair again. At this time, the logo key is in a white light state.

? Problem 2: Key mapping error

According to the official instructions and use experience of Beitong, the handle can switch modes by pressing the LOGO key for about 5 seconds. When you find that the key positions of the handle keys in the manual are disordered, please consider the following situations:

- ⦿ If there is an incorrect mode switching of the controller, you can press and hold the logo button + A button to switch the mode.
- ⦿ Restart and re-pair. Same as above.

? Problem 3: Indicator flashes

- ⦿ The handle is looking for pairing. After the receiver is removed and the operation is over, the handle indicator still flashes, indicating that the handle has not entered the standby mode or is still looking for a pair. You can wait a moment until it automatically turns off. If it flashes for a long time, you can press the logo key for 5-10s.
- ⦿ The handle is charging. It is normal for the indicator light to flash when the handle is charged.
- ⦿ Restart and re-pair. Same as above.

1.3 Battery Charging

? Problem: The battery cannot be charged or the charging speed is very slow?

If you find that the battery cannot be charged or the charging speed is very slow, please consider the following situations:

- ⊙ Power adapter above 45W or fast charging data cable is not used;
- ⊙ The device was not powered on before charging;
- ⊙ The charging interface has poor contact;
- ⊙ Hot-swapping the battery causes internal damage.

1.4 Motor Disconnection

? Common problems of motor error reporting

There are 12 motors on Mini Pi. You can toggle the black lever on one side of the display screen on the back panel to check the motor status. When an error code appears while you are connecting an external display for development, please consider the following scenarios:

- ⊙ Loose or falling off wiring
 - *The power cable or communication cable is not properly connected, inserted in reverse, or has poor contact.*
 - *The connector is aging or the terminal is oxidized.*
- ⊙ Interface damage
 - *The CAN interface, CANFD module, or driver board is damaged.*
 - *The cable is broken or has internal breakage.*
- ⊙ Wrong interface
 - *Motors are connected to an incorrect communication port, or there is an address conflict among multiple motors.*
- ⊙ CAN ID conflict or configuration error
 - *Multiple motors using the same ID cause recognition failure.*
- ⊙ The terminal resistor is not connected or connected incorrectly
 - *120Ω terminating resistors are not connected to both ends of the CAN bus, or connected in the wrong position.*
- ⊙ Motor not initialized or calibrated
 - *Failure to complete the self-check or initialization process causes the motors to fail to respond to control commands.*

X. After-Sales Warranty

- ⑥ After you purchase the complete machine and other related products, the warranty period starts from the day you receive the goods.
- ⑥ The warranty period for the entire robot is 1 year, and for other accessories (joint modules, batteries, charging cases, zero-position brackets, knee joint zero-position blocks, Type-C charging cables, controllers, USB-to-CANFD debugging boards, wires, sensors) is 3 months. The warranty period commences from the date the user picks up the product in person or the date of receipt as indicated in the courier logistics information.
- ⑥ During the warranty period, any unauthorized modification, disassembly, opening of the case, or similar actions by the user will result in the immediate termination of the warranty.
- ⑥ During the warranty period, if the product experiences non-human-induced performance failures under normal use, we will provide corresponding free repairs or component replacements for the product you purchased. You are required to provide valid proof of purchase (invoice/order/contract record).
- ⑥ If the product you purchased has exceeded the warranty period, you can also obtain our assistance by purchasing additional services.
- ⑥ You can submit your after-sales request and check the after-sales progress through the official after-sales platform at <https://www.hightorque.cn/support>.



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