

Quadruped Robot Secondary Development Version Development Manual V1.0

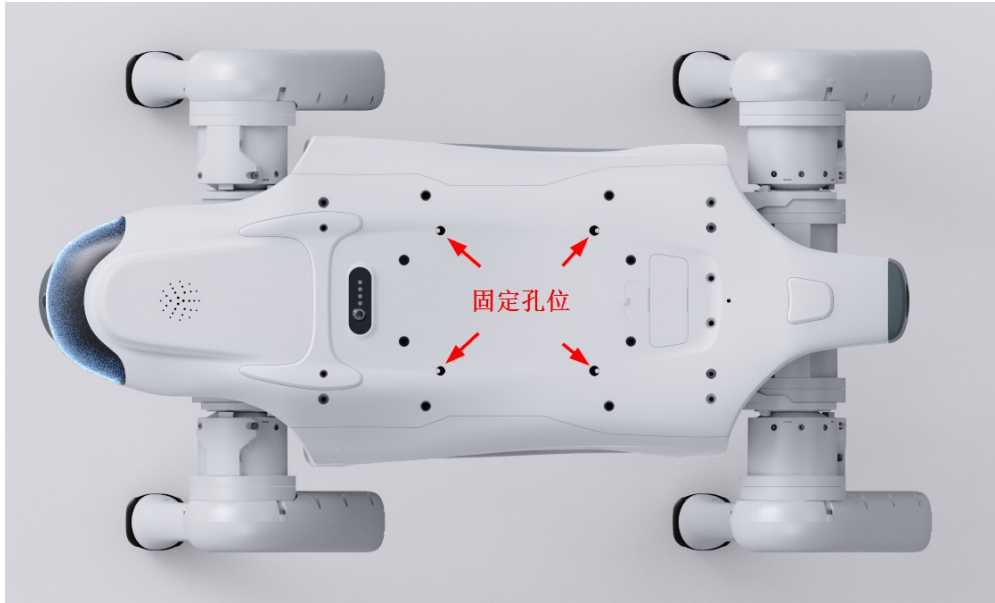
1. Description of Secondary Development Version

(1) Device Fixation

The back of the quadruped robot is equipped with fixing holes, expansion interfaces and power interfaces.

The fixing holes are used to fix the developer's devices. The threaded holes can be seen after removing the silicone plugs, at the positions shown in the figure below.

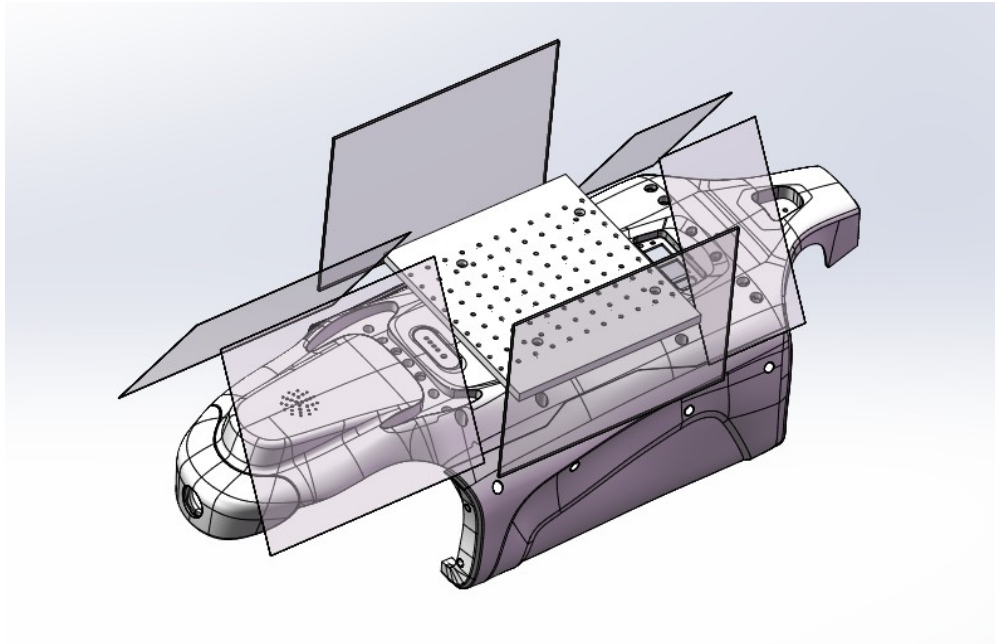
The thread specification here is M4



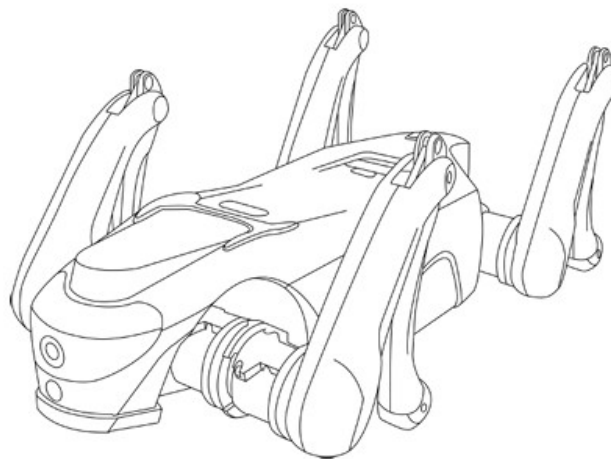
Please contact the sales staff to obtain the 3D drawing when designing the upper-mounted equipment.

The drawing includes the reference design shown in the figure below, and the developer's device can be fixed on the flat plate shown in the figure. The threaded holes on the flat plate are M4.

Since the robot dog's legs swing in a fixed trajectory during homing, standing up and lying down, we recommend installing the device within the area shown in the figure.



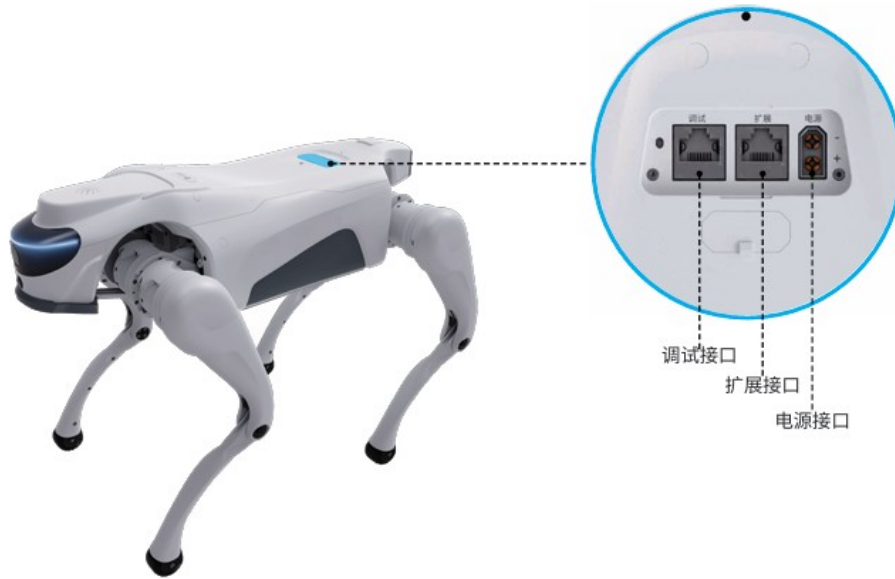
Note: Place the four legs in the posture shown in the figure below before powering on.



Note: Do not block the power button and charging port when designing the upper-mounted equipment. The robot dog can carry a weight of no more than 8kg, and the load should be placed as centrally on the body as possible.

(2) Power and Communication Interfaces

Unscrew the back cover with an Allen wrench to see the **Expansion Interface** and **Power Interface**, as shown in the figure below.



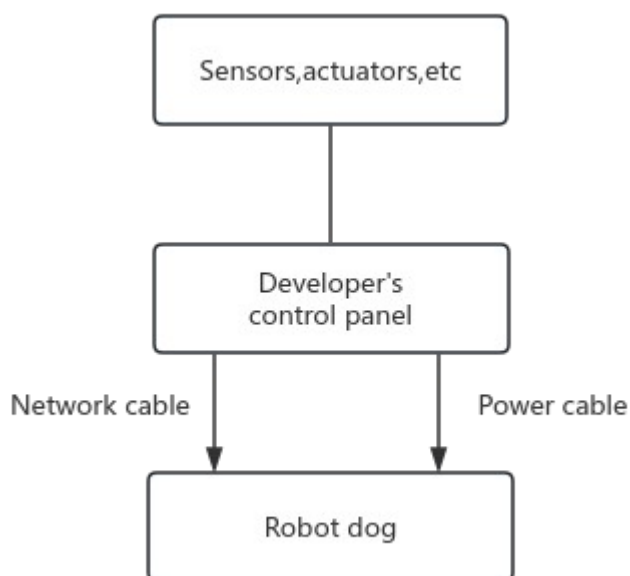
Expansion Interface: Gigabit Ethernet port is adopted.

Power Interface: XT60 terminal is adopted. The power supply comes from the battery module, with a voltage range of 22.4V ~ 33.6V.

Note: Do not reverse the positive and negative poles ("+" for positive, "-" for negative). Ensure that the power terminal is plugged and unplugged when the device is powered off. The battery can supply a continuous current of 40A and a peak current of 60A, part of which is used for the operation of the robot dog. Please contact the sales staff for technical support during design.

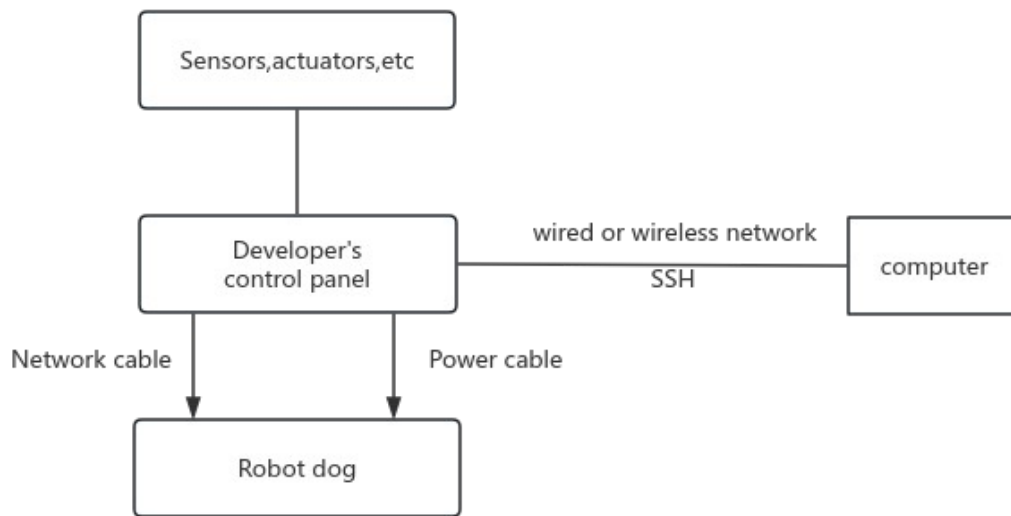
2. Hardware Connection

The hardware connection relationship is shown in the figure below.



3. Development Environment Framework

The recommended development environment framework is shown in the figure below.



(1) Laboratory Test Environment

Control Board: Orange Pi 5 Pro development board

Operating System: Ubuntu 20.04



(2) SDK

We provide an SDK based on C++. Please contact the sales staff to obtain it. The SDK runs in the control board.

Developers can log in to the control board via SSH and test the functions of the SDK through the keyboard.

4. Test the SDK

(1) Control Board Configuration

Install the Ubuntu system

The SDK has no strong dependence on the Ubuntu version, and developers can adapt it by themselves.

The system we tested is Ubuntu 20.04.

```
orangeipi@orangeipi5pro:~$ lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 20.04 LTS
Release:        20.04
Codename:       focal
```

Connect the control board to WIFI

Connect the display to the HDMI interface of the control board, connect the keyboard and mouse to the USB interface of the control board, and power on the control board.

After logging in to the Ubuntu system, use the graphical interface to enter the user name and password to connect to WIFI first.

Install the jsoncpp dependency package:

Open the terminal and enter the command:

```
sudo apt install libjsoncpp-dev
orangeipi@orangeipi5pro:~$ sudo apt install libjsoncpp-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  libjsoncpp-dev
0 upgraded, 1 newly installed, 0 to remove and 294 not upgraded.
Need to get 85.5 kB of archives.
After this operation, 496 kB of additional disk space will be used.
Get:1 http://mirrors.tuna.tsinghua.edu.cn/ubuntu-ports focal/main arm64 libjsoncpp-dev arm64 1.7.4-3.1ubuntu2 [85.5 kB]
Fetched 85.5 kB in 0s (184 kB/s)
Selecting previously unselected package libjsoncpp-dev:arm64.
(Reading database ... 221692 files and directories currently installed.)
Preparing to unpack .../libjsoncpp-dev_1.7.4-3.1ubuntu2_arm64.deb ...
Unpacking libjsoncpp-dev:arm64 (1.7.4-3.1ubuntu2) ...
Setting up libjsoncpp-dev:arm64 (1.7.4-3.1ubuntu2) ...
```

Obtain the IP addresses of the wired and wireless network ports:

Open the terminal and enter the command:

```
ifconfig
```

The wired network address is set to 192.168.96.3 on the control board.

Record the address of wlan0 (e.g., 192.168.110.82, the address may vary as assigned by the router) for subsequent SSH connection.

```

orangeipi@orangeipi5pro:~/cyber1_dev_sdk$ ifconfig
docker0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    inet 172.17.0.1 netmask 255.255.0.0 broadcast 172.17.255.255
    ether 02:42:48:05:03:7d txqueuelen 0 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

enP4p65s0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.96.3 netmask 255.255.255.0 broadcast 192.168.96.255
    inet6 fe80::c274:2bff:efc:e25e prefixlen 64 scopeid 0x20<link>
    ether c0:74:2b:fc:e2:5e txqueuelen 1000 (Ethernet)
    RX packets 47 bytes 3027 (3.0 KB)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 16 bytes 1290 (1.2 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
    device interrupt 136 base 0x8000

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.110.82 netmask 255.255.255.0 broadcast 192.168.110.255
    inet6 fe80::9938:4280:63fc:ef67 prefixlen 64 scopeid 0x20<link>
    ether 9c:b8:b4:8c:34:bc txqueuelen 1000 (Ethernet)

```

If the IP address of the wired network interface cannot be viewed, configure a static IP as 192.168.96.3 first. For specific configuration steps, refer to the static IP configuration method in Point 6.

```

orangeipi@orangeipi5pro: ~
TX packets 0 bytes 0 (0.0 B)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

enP4p65s0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
    ether c0:74:2b:fc:e2:5e txqueuelen 1000 (Ethernet)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
    device interrupt 136 base 0x8000

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
    inet 127.0.0.1 netmask 255.0.0.0
    inet6 ::1 prefixlen 128 scopeid 0x10<host>
    loop txqueuelen 1000 (Local Loopback)
    RX packets 0 bytes 0 (0.0 B)
    RX errors 0 dropped 0 overruns 0 frame 0
    TX packets 0 bytes 0 (0.0 B)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
    inet 192.168.110.82 netmask 255.255.255.0 broadcast 192.168.110.255
    inet6 fe80::9938:4280:63fc:ef67 prefixlen 64 scopeid 0x20<link>
    ether 9c:b8:b4:8c:34:bc txqueuelen 1000 (Ethernet)
    RX packets 1242 bytes 350428 (350.4 KB)
    RX errors 0 dropped 156 overruns 0 frame 0
    TX packets 208 bytes 26702 (26.7 KB)
    TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

orangeipi@orangeipi5pro:~$

```

Compile the SDK

Copy the SDK compressed package into the development board (it is recommended to place it in the user directory).

```

orangeipi@orangeipi5pro:~$ ls
cyber1_dev_sdk.zip Desktop Documents Downloads Music Pictures Public Templates Videos

```

Enter the command in the terminal to decompress the cyber1_dev_sdk.zip file:

```
unzip cyber1_dev_sdk.zip
```

```

orangepi@orangepi5pro:~$ unzip cyber1_dev_sdk.zip
Archive:  cyber1_dev_sdk.zip
  creating: cyber1_dev_sdk/
  creating: cyber1_dev_sdk/lib/
  inflating: cyber1_dev_sdk/lib/udp_client.o
  inflating: cyber1_dev_sdk/lib/imu_data.o
  inflating: cyber1_dev_sdk/lib/json_parser.o
  inflating: cyber1_dev_sdk/lib/libquadruped_sdk.a
  inflating: cyber1_dev_sdk/Makefile
  creating: cyber1_dev_sdk/src/
  inflating: cyber1_dev_sdk/src/udp_client.cpp
  inflating: cyber1_dev_sdk/src/json_parser.cpp
  inflating: cyber1_dev_sdk/src/imu_data.cpp
  creating: cyber1_dev_sdk/include/
  creating: cyber1_dev_sdk/include/cyber1_dev_sdk/
  inflating: cyber1_dev_sdk/include/cyber1_dev_sdk/udp_client.h
  inflating: cyber1_dev_sdk/include/cyber1_dev_sdk/json_parser.h
  inflating: cyber1_dev_sdk/include/cyber1_dev_sdk/imu_data.h
  creating: cyber1_dev_sdk/examples/
  inflating: cyber1_dev_sdk/examples/imu_client_example.cpp
  inflating: cyber1_dev_sdk/examples/example.cpp
  inflating: cyber1_dev_sdk/examples/keyboard_test.cpp
  creating: cyber1_dev_sdk/bin/
  inflating: cyber1_dev_sdk/bin/example
  inflating: cyber1_dev_sdk/bin/keyboard_test
  inflating: cyber1_dev_sdk/bin/imu_client_example

```

Enter the cyber1_dev_sdk directory and execute the command first:

`make clean`

```

orangepi@orangepi5pro:~$ cd cyber1_dev_sdk/
orangepi@orangepi5pro:~/cyber1_dev_sdk$ make clean
清理构建文件...
✓ 清理完成

```

Compile the SDK: execute the command

`make`

```

orangepi@orangepi5pro:~/cyber1_dev_sdk$ make -j8
编译 src/udp_client.cpp...
编译 src/imu_data.cpp...
编译 src/json_parser.cpp...
g++ -std=c++11 -Wall -Wextra -pedantic -pthread -Iinclude -fPIC -c src/udp_client.cpp -o lib/udp_client.o
g++ -std=c++11 -Wall -Wextra -pedantic -pthread -Iinclude -fPIC -c src/imu_data.cpp -o lib/imu_data.o
g++ -std=c++11 -Wall -Wextra -pedantic -pthread -Iinclude -fPIC -c src/json_parser.cpp -o lib/json_parser.o
创建静态库 lib/libquadruped_sdk.a
ar rcs lib/libquadruped_sdk.a lib/udp_client.o lib/json_parser.o lib/imu_data.o
✓ 静态库创建完成
编译测试 bin/example...
编译测试 bin/keyboard_test...
编译测试 bin/imu_client_example...
g++ -std=c++11 -Wall -Wextra -pedantic -pthread -Iinclude examples/example.cpp lib/libquadruped_sdk.a -o bin/example -ljsoncpp -lm
g++ -std=c++11 -Wall -Wextra -pedantic -pthread -Iinclude examples/keyboard_test.cpp lib/libquadruped_sdk.a -o bin/keyboard_test -ljsoncpp -lm
g++ -std=c++11 -Wall -Wextra -pedantic -pthread -Iinclude examples/imu_client_example.cpp lib/libquadruped_sdk.a -o bin/imu_client_example -ljsoncpp -lm
examples/keyboard_test.cpp: In function 'int main(int, char**)':
examples/keyboard_test.cpp:212:17: warning: comparison is always true due to limited range of data type [-Wtype-limits]
212 |         if (key != EOF) { // 有按键输入
    |
examples/imu_client_example.cpp: In function 'void signalHandler(int)':
examples/imu_client_example.cpp:20:24: warning: unused parameter 'signal' [-Wunused-parameter]
20 | void signalHandler(int signal) {
    |
✓ 测试编译完成
✓ 测试编译完成
✓ 测试编译完成

```

Under normal circumstances, the compilation will prompt the above information

(2) Build the Hardware Environment

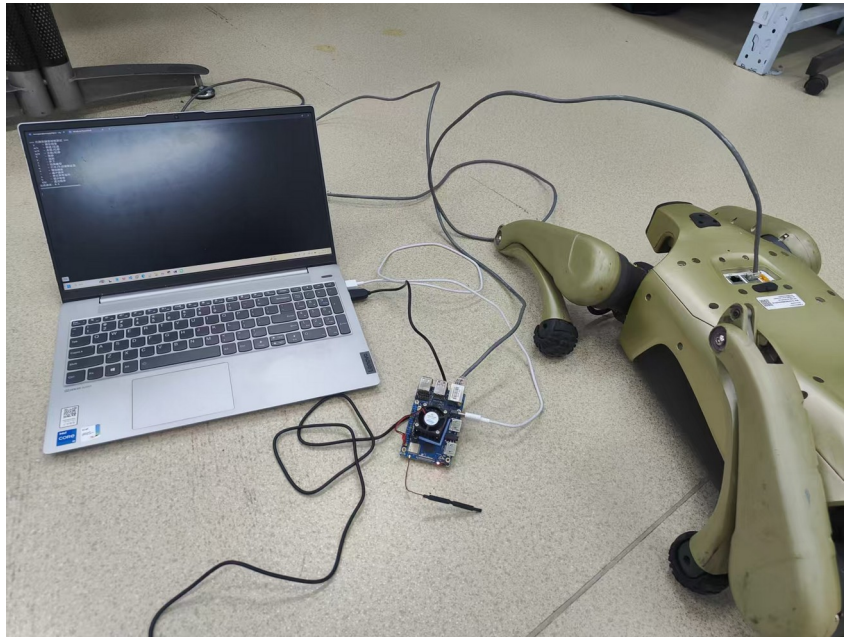
Ensure that there are no obstacles within 3 meters of the robot dog.

Connect the development board to the expansion Ethernet port of the robot dog with a network cable.

Connect the computer to the control board for power supply with a USB cable.

Ensure that the computer and the control board are connected to the same WIFI.

Note: Do not power on the remote control.



Open the cmd on the computer.

Enter the command:

```
ssh orangepi@192.168.110.82
```

Enter **yes** when prompted with yes/no.

Enter the password (built-in to the control board).

```
orangepi@orangepi5pro: ~ X + v
Microsoft Windows [版本 10.0.22631.6060]
(c) Microsoft Corporation. 保留所有权利。

C:\Users\admin>ssh orangepi@192.168.110.82
The authenticity of host '192.168.110.82 (192.168.110.82)' can't be established.
ED25519 key fingerprint is SHA256:kwzqTbFiwUkyH+LV3LIX7uvZzDixQEvgbT407DqaBVY.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.110.82' (ED25519) to the list of known hosts.
orangepi@192.168.110.82's password:

  O P I S P R O
Welcome to Orange Pi 1.0.6 Focal with Linux 5.10.160-rockchip-rk3588

System load: 13%      Up time: 1 min      Local users: 3
Memory usage: 7% of 7.75G  IP: 172.17.0.1 192.168.110.82
CPU temp: 25°C      Usage of /: 70% of 29G

[ 78 security updates available, 233 updates total: apt upgrade ]
Last check: 2025-12-26 11:22

Last login: Fri Dec 26 11:22:18 2025
orangepi@orangepi5pro:~$ |
```

(3) Run the SDK Sample Programs

Long press the power button on the back of the robot dog for more than 3 seconds to power it on. The robot dog is successfully started after hearing the voice prompt '**Robot dog startup completed**'.

Run the program *example*

Note: The robot dog will perform a series of continuous actions including homing reset, moving forward, moving backward, translating left, translating right, turning left, turning right and lying down. Ensure that there are no obstacles within 3 meters.

Enter the command in the computer's cmd:

```
./bin/example
```

```
orangepi@orangepi5pro:~/cyber1_dev_sdk$ ./bin/example
=== UDP客户端已启动 ===
目标服务器: 192.168.96.2:8080
Trying to connect udp server...
=== 成功连接到UDP服务器 ===:
后台接收线程已启动
后台发送线程已启动
UDP send loop started at 1.0 Hz
=== change mode to Reset ===
=== change mode to forward ===
=== change mode to backward ===
=== change mode to move_left ===
=== change mode to move_right ===
=== change mode to turn_left ===
=== change mode to turn_right ===
=== change mode to Lie Down ===
=== change mode to 10 ===
UDP send loop stopped后台发送线程已停止
后台接收线程已停止
客户端连接已关闭
```

Run the program *keyboard_test*:

Enter the command in the computer's cmd:

```
./bin/keyboard_test
```

The robot dog's operations corresponding to the keyboard keys will be displayed. Execute the commands according to the corresponding keys, and press the **h** key to clear the screen and redisplay the keyboard prompt (the robot dog's reset action is invalid if the above `./bin/example` command has been executed):

```
=== 机器狗键盘控制测试 ===
r      - 复位回零
w/s    - 前进/后退
a/d    - 左移/右移
q/e    - 左转/右转
t      - 急停
y      - 站起
u      - 趴下
i      - 切换模型
o      - 打开/关闭障碍设置
+      - 增加速度
-      - 减少速度
x      - 停止所有运动
h      - 显示帮助
ESC    - 退出程序
当前速度: 0.5
=====
```

Start the IMU data display example:

Enter the command in the computer's cmd:

```
./bin/imu_client_example
```

The current IMU data will be displayed.

```

Angular Velocity:
X: -0.0016 rad/s
Y: 0.0021 rad/s
Z: -0.0004 rad/s

Orientation (Quaternion):
W: 0.9756
X: -0.0044
Y: 0.0106
Z: -0.2193

Euler Angles:
Roll: -0.75 °
Pitch: 1.07 °
Yaw: -25.35 °

Magnitudes:
Acceleration: 9.759 m/s²
Angular Vel: 0.003 rad/s
=====
IMU Data - Time: 1766653703.860 | Accel: (-0.21, -0.15, 9.80) m/s² | Gyro: (-0.00, 0.00, 0.00) rad/s | RPY: (-0.8,
IMU Data - Time: 1766653703.912 | Accel: (-0.17, -0.15, 9.80) m/s² | Gyro: (-0.00, -0.00, -0.00) rad/s | RPY: (-0.8,
1.1, -25.3) degIMU Data - Accel: (-0.2, -0.1, 9.8) m/s², RPY: (-0.8, 1.1, -25.3) deg
IMU Data - Time: 1766653703.960 | Accel: (-0.18, -0.14, 9.81) m/s² | Gyro: (-0.00, 0.00, -0.00) rad/s | RPY: (-0.8,
IMU Data - Time: 1766653704.012 | Accel: (-0.16, -0.13, 9.81) m/s² | Gyro: (-0.00, 0.00, 0.00) rad/s | RPY: (-0.7,
IMU Data - Time: 1766653704.060 | Accel: (-0.18, -0.14, 9.78) m/s² | Gyro: (0.00, -0.00, -0.00) rad/s | RPY: (-0.7,
IMU Data - Time: 1766653704.112 | Accel: (-0.21, -0.10, 9.79) m/s² | Gyro: (0.00, 0.00, -0.00) rad/s | RPY: (-0.7,
IMU Data - Time: 1766653704.162 | Accel: (-0.18, -0.14, 9.78) m/s² | Gyro: (-0.00, -0.00, 0.00) rad/s | RPY: (-0.7,
IMU Data - Time: 1766653704.342 | Accel: (-0.18, -0.13, 9.79) m/s² | Gyro: (-0.00, 0.00, 0.00) rad/s | RPY: (-0.7,
IMU Data - Time: 1766653704.392 | Accel: (-0.17, -0.15, 9.78) m/s² | Gyro: (-0.00, -0.00, -0.00) rad/s | RPY: (-0.7,
IMU Data - Time: 1766653704.442 | Accel: (-0.19, -0.12, 9.77) m/s² | Gyro: (0.00, 0.00, 0.00) rad/s | RPY: (-0.7,
1.1, -25.4) deg

```

5. SDK API Description

(1) Network Connection

Create a UDP client

```

std::string server_ip = "192.168.96.2";
int server_port = 8080;
UDPClient client(server_ip, server_port);

```

Create a JsonParser parser

```

JsonParser parser(std::move(client));
parser.run();

```

Establish a connection

Due to the time difference in system loading between the robot dog and the control board after power-on, the control board needs to check whether the robot dog is loaded completely. Adopt the following operation method and

use the **testConnection** method to determine whether the robot dog server is connected:

```
bool isConnect = client.testConnection();
```

isConnect is **true** means the robot dog server has been connected.

(2) Obtain Robot Dog Status

Function Name: getDogStatus

Parameters: None

Return Value Type: DogStatus

Usage:

```
DogStatus status = parser.getDogStatus();
```

Details of status information:

- battery: Battery level
- motion_mode: Current motion mode of the robot dog (0 - Lying down without homing, 1 - Lying down, 2 - Standing, 3 - Low posture, 4 - Tipped over)
- velocity_level: Speed gear (not used currently)
- model: 1 - High-speed mode, 0 - Obstacle avoidance mode
- hw_failure: List of faulty hardware
- software_version: Software version
- latest_version: The latest software version on the server
- robot_number: Robot dog serial number
- robot_type: Robot dog model
- hardware_error: Whether there is a fault (overall fault) (0 - No fault, 1 - Fault exists)

(3) Homing Reset

Function Name: handleResetCommand

Parameters: None

Return Value: None

Usage:

```
parser.handleResetCommand();
```

(4) Stand Up

Function Name: handleStandUpCommand

Parameters: None

Return Value: None

Usage:

```
parser.handleStandUpCommand()
```

(5) Lie Down

Function Name: handleLieDownCommand

Parameters: None

Return Value: None

Usage:

```
parser.handleLieDownCommand();
```

(6) Emergency Stop

Function Name: handleEmergencyCommand

Parameters: None

Return Value: None

Usage:

```
parser.handleEmergencyCommand();
```

(7) Switch Model

Function Name: handleSwitchMnnCommand

Parameter Type: int

Parameter Meaning: 0 - Switch to obstacle avoidance mode, 1 - Switch to high-speed mode

Return Value: None

Usage:

```
parser.handleSwitchMnnCommand(1);
```

(8) Set Ultrasonic Radar Obstacle Avoidance

Function Name: handleSwitchObstacleCommand

Parameter Type: int

Parameter Meaning: 0 - Disable obstacle avoidance, 1 - Enable obstacle avoidance

Return Value: None

Usage:

```
parser.handleSwitchMnnCommand(1);
```

(9) Motion Control

Method 1

Function Name: sendDirectionVel

Parameter Type: int direction, double velocity

Parameter Meaning:

- The first parameter corresponds to the direction: 1 - Translate forward/backward, 2 - Translate left/right, 3 - Turn left/right
- The second parameter corresponds to the speed: Positive values correspond to forward, left translation and left turn respectively; Negative values correspond to backward, right translation and right turn respectively
- The range of the second parameter: -1 to 1

Return Value: None

usage:

```
parser.sendDirectionVel(0.5 0 0); // 0.5
```

(10) Register IMU Client

Function Name: enableIMUStream

Parameters: None

Return Value Type: bool

Usage:

```
// IMU
parser.setIMUDataCallback(imuDataCallback)
//
parser.run();
bool result = parser.enableIMUStream();
```

(11) Obtain IMU Data Information

Function Name: getLatestIMUData

Parameters: None

Return Value Type: IMUData

Usage:

```
// IMU
parser.setIMUDataCallback(imuDataCallback)
//
parser.run();
// IMU
bool result = parser.enableIMUStream();
// IMU
IMUData imu_data = parser.getLatestIMUData(); //IMUData
```

(12) Unregister IMU Client (No IMU information will be read after unregistration)

Function Name: disableIMUStream

Parameters: None

Return Value Type: bool

Usage:

```
bool result = parser.disableIMUStream
```

6. Static IP Configuration Method

(1) Create a file named 01-network-manager-all.yaml in /etc/netplan and enter the following content:

```
# Let NetworkManager manage all devices on this system
network:
  version: 2
  renderer: NetworkManager
  ethernets:
    enP4p65s0:
      dhcp4: no
      dhcp6: no
      addresses: [192.168.96.3/24]
      routes:
        - to: default
          via: 192.168.96.1
      nameservers:
        addresses: [114.114.114.114, 8.8.8.8]
```

(2) Execute `sudo reboot` or restart the power supply