JING TIAN

ROBOTIS OP3

Speaker：刘裕诗

2020.06.22

目录 Agenda

1、硬件Hardware

2、软件Software

3、示例Demonstration

4、Q&A

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硬件
Hardware

ROBOTIS OP3 Specs

ROBOTIS OP3	Specifications
身高	510mm
体重	3.5kg without skin
自由度	20
主控制器	Intel NUC i3, OpenCR
传感器	FHD Webcam, 9-Axis IMU
IO Devices	LEDs(x4), Buttons(x4), Speaker(x1)
电池	LiPo 11.1V, 1800mA
开发环境	Linux Mint 18.1(64-bit) C++, ROS, Dynamixel SDK

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OP3 Hardware Specs

	ROBOTIS OP2	ROBOTIS OP3
舵机	MX-28	**XM430-W350**
CPU	Intel Atom N2600 @1.6GHz dual core	**Intel Core i3 processor dual core**
RAM	2GB DDR3 SODIMM 1066MHz (user-replaceable)	**8GB DDR4 SODIMMs 2133MHz (32GB maximum) (user-replaceable)**
Storage	half-size mSATA module (32GB) (user-replaceable)	**M.2 SSD module (128GB) (user-replaceable)**
操作系统	any Linux release (32-bit) any Windows release (32-bit)	**any Linux release (32-bit/64-bit) any Windows release (32-bit/64-bit)**
网络	Realtek 10/100/1000 Mbps Ethernet 802.11n (2.4GHz-only)	**Intel 10/100/1000 Mbps Ethernet 802.11ac (2.4GHz, 5GHz) Bluetooth 4.1**
摄像头	Logitech C905 (1600x1200)	**Logitech C920 (1920x1080)**

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OP3 Hardware (Dynamixel)

	MX-28	XM430-W350
Operation Mode	Wheel Joint Multi-turn	**Current Velocity Position Extended Position Current based Position PWM**
Gear Ratio	193 : 1	**353.5 : 1**
Stall Torque	2.5 Nm @ 12.0V	**4.1 Nm @ 12.0V**
No Load Speed	55 RPM @ 12.0V	**46 RPM @ 12.0V**
Protocol	Protocol 1.0 / Protocol 2.0	**Protocol 1.0 / Protocol 2.0**
Dimension	35.6 x 50.6 x 35.5	**28.5 x 46.5 x 34**
Material	Full Metal Gear Engineering Plastic	**Full Metal Gear Metal Body**
Weight	77g	**82g**

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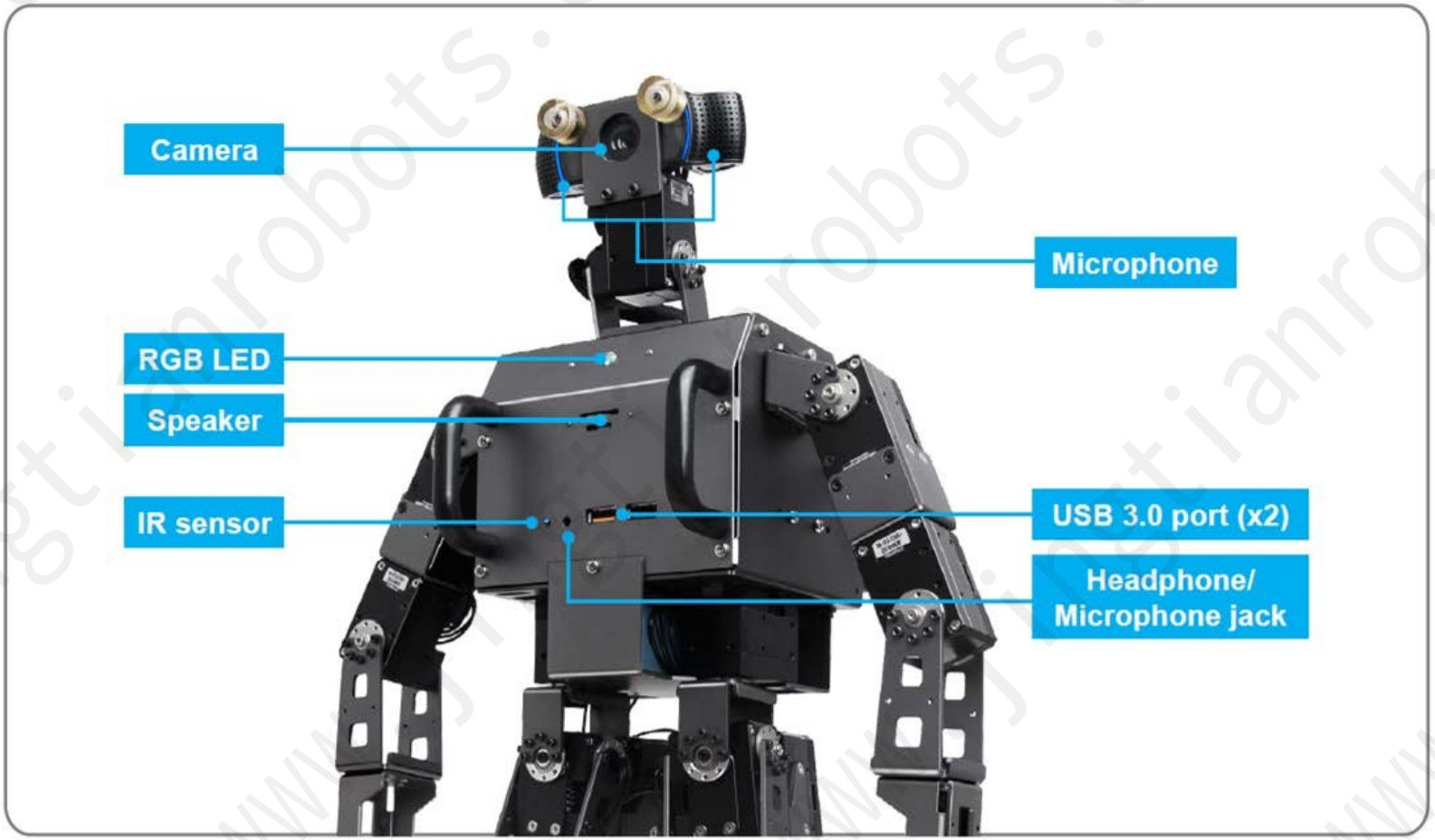
OP3 装箱包清单


14
1
13
11
10
15
ROBOTIS OP3
Quick Start
12
LOCTITE 248
8
7
5
4
9
6
2
3
Professional Balance Charger/Discharger

Layout - 正面



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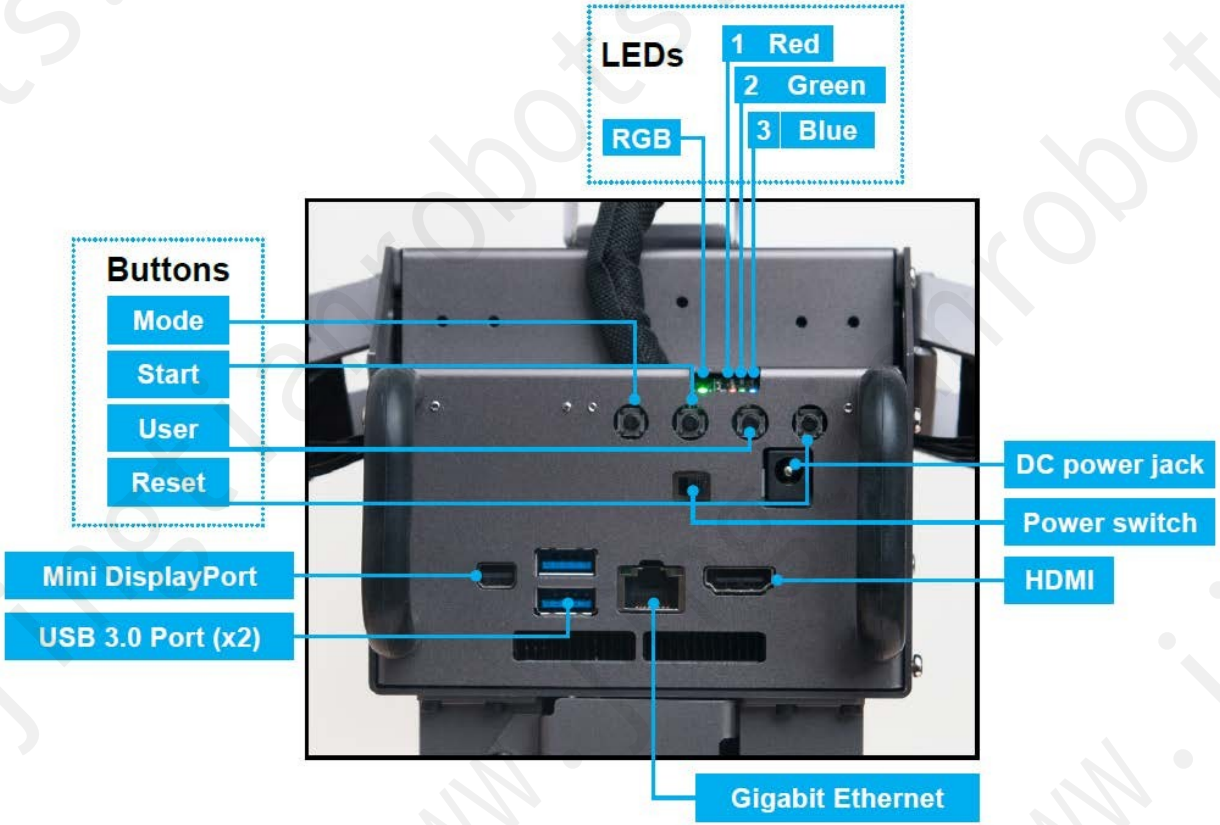
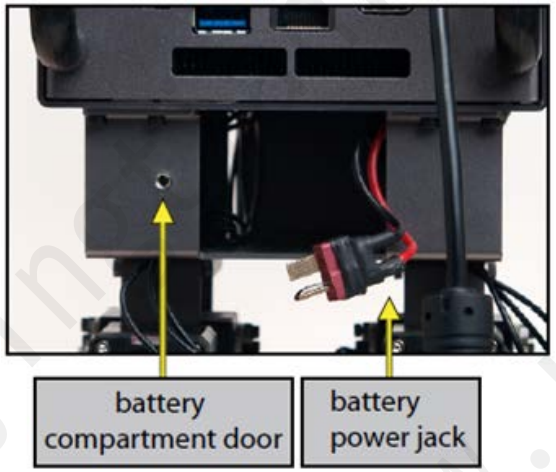
Layout - 背面





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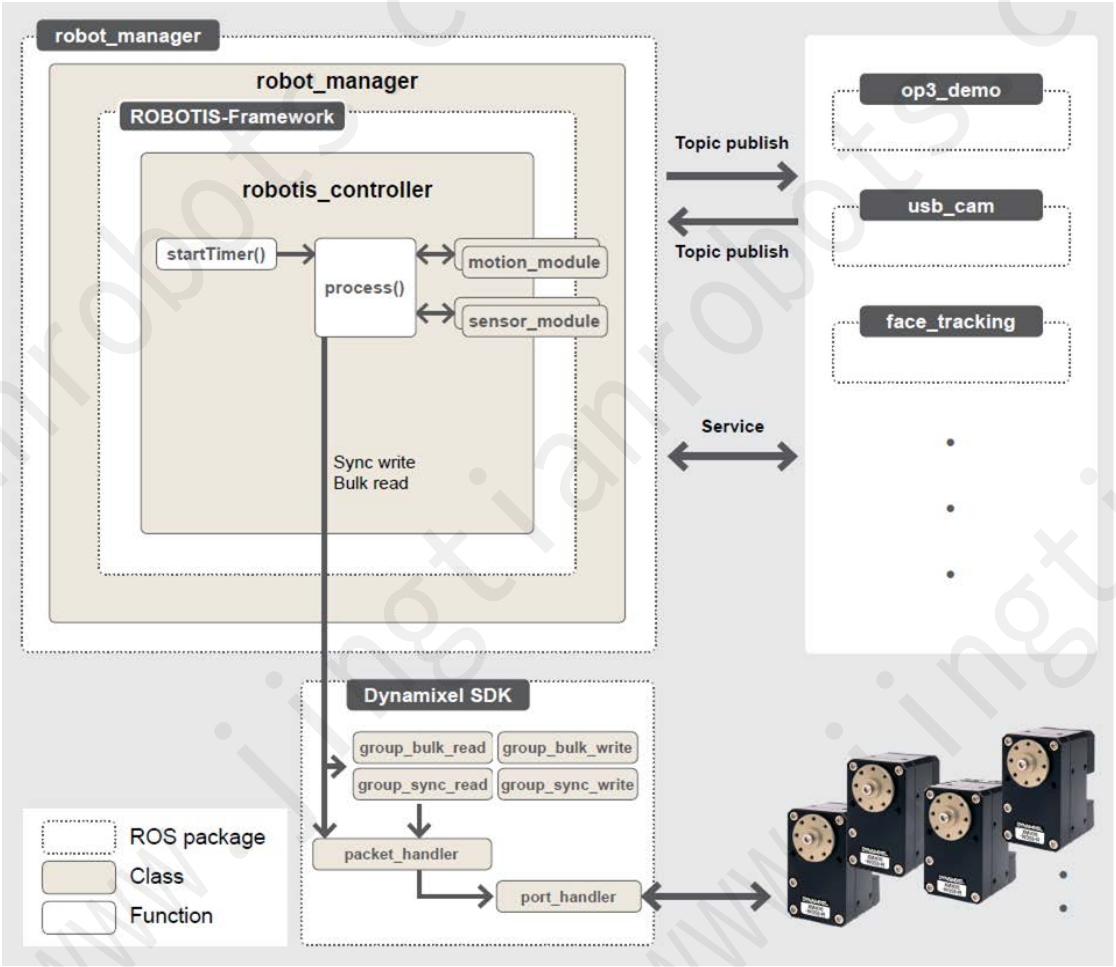
软件
Software

OP3 框架图


robot_manager
robot_manager
ROBOTIS-Framework
robotis_controller
startTimer()
process()
motion_module
sensor_module
Sync write
Bulk read
Topic publish
Topic publish
Service
op3_demo
usb_cam
face_tracking
Dynamixel SDK
group_bulk_read
group_bulk_write
group_sync_read
group_sync_write
packet_handler
port_handler
ROS package
Class
Function

OP3 ROS Packages

ROBOTIS-OP3

Motion Module

- op3_action_module : This module manages every joint actions.
- op3_base_module : This module manages initial pose and basic functions.
- op3_head_control_module : This module controls the head.
- op3_walking_module : This module controls walking.

Sensor Module

- open_cr_module : This module is required to use OpenCR as a sensor.

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OP3 ROS Packages

ROBOTIS-OP3-msgs

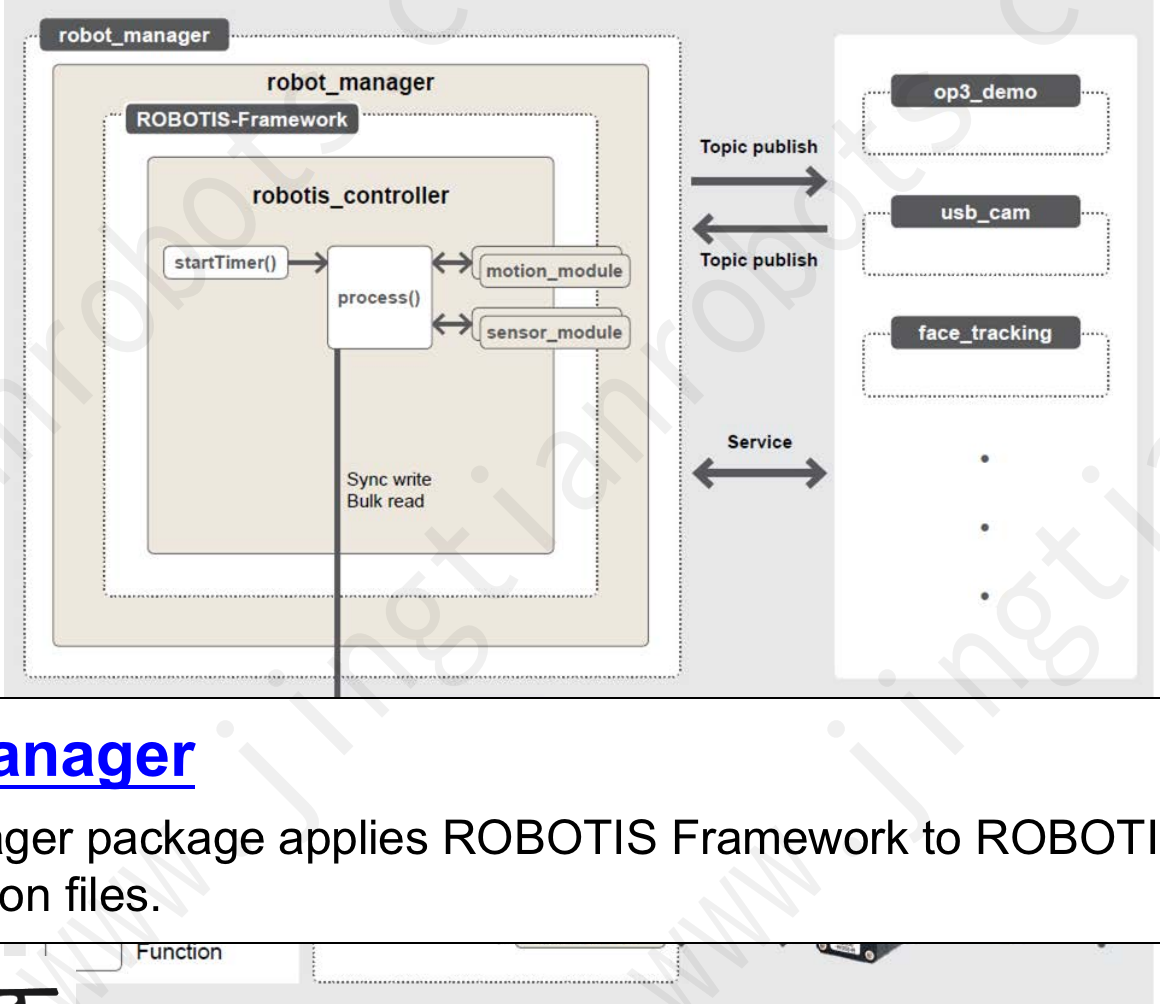
Module msgs

- op3_action_module_msgs : This message/service is used for op3_action_module.
- op3_walking_module_msgs : This message/service is used for op3_walking_module.

Tool msgs

- op3_offset_tuner_msgs : This message/service is used for OP3 offset tunning.

OP3 ROS Packages



op3_manager

op3_manager package applies ROBOTIS Framework to ROBOTIS OP3 using configuration files.

OP3 ROS Packages

ROBOTIS-OP3/op3_manager

Robot File(op3_manager/config/OP3.robot)

```
[ control info ]
 control_cycle = 8 # milliseconds

 [ port info ]
 # PORT NAME | BAUDRATE | DEFAULT JOINT
 /dev/U2D2         | 2000000       | r_sho_pitch

 [ device info ]
 # TYPE     | PORT NAME    | ID  | MODEL        | PROTOCOL | DEV NAME      | BULK READ ITEMS
 dynamixel | /dev/U2D2      | 1   | XM-430       | 2.0      | r_sho_pitch   | present_position
 dynamixel | /dev/U2D2      | 2   | XM-430       | 2.0      | l_sho_pitch   | present_position
 dynamixel | /dev/U2D2      | 3   | XM-430       | 2.0      | r_sho_roll    | present_position
...
...
 dynamixel | /dev/U2D2      | 19  | XM-430       | 2.0      | head_pan      | present_position
 dynamixel | /dev/U2D2      | 20  | XM-430       | 2.0      | head_tilt     | present_position
 sensor    | /dev/U2D2      | 200 | OPEN-CR      | 2.0      | open-cr       | button, present_voltage, gyro_x, gyro_y, gyro_z,
                                                                             acc_x, acc_y, acc_z, roll, pitch, yaw
```

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OP3 ROS Packages

ROBOTIS-OP3/op3_manager

Joint Initialize File(op3_manager/config/dxl_init_OP3.yaml)

```
r_sho_pitch :   # XM-430
   return_delay_time        : 1    # item name : value
   min_position_limit       : 0
   max_position_limit       : 4095

r_sho_pitch :   # XM-430
   return_delay_time        : 1    # item name : value
   min_position_limit       : 0
   max_position_limit       : 4095
...
```

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OP3 ROS Packages

ROBOTIS-OP3/op3_manager

Offset File(op3_manager/config/offset.yaml)

```
offset:
  head_pan: 0
  head_tilt: 0
  l_ank_pitch: 0.0174532925199433
  l_ank_roll: 0
  l_el: 0
  l_hip_pitch: 0.01221730476396031
  l_hip_roll: -0.01570796326794897
  l_hip_yaw: 0.004363323129985824
  l_knee: 0.006981317007977318
  l_sho_pitch: 0
  l_sho_roll: 0
  r_ank_pitch: 0.008726646259971646
  r_ank_roll: 0
  r_el: 0
  r_hip_pitch: 0.01658062789394613
  r_hip_roll: 0.0148352986419518
  r_hip_yaw: 0.008726646259971646
  r_knee: 0.008726646259971646
  r_sho_pitch: 0
  r_sho_roll: 0
```

```
init_pose_for_offset_tuner:  head_pan: 0
  head_tilt: 0
  l_ank_pitch: 0
  l_ank_roll: 0
  l_el: 0
  l_hip_pitch: 0
  l_hip_roll: 0
  l_hip_yaw: 0
  l_knee: 0
  l_sho_pitch: 0
  l_sho_roll: 0
  r_ank_pitch: 0
  r_ank_roll: 0
  r_el: 0
  r_hip_pitch: 0
  r_hip_roll: 0
  r_hip_yaw: 0
  r_knee: 0
  r_sho_pitch: 0
  r_sho_roll: 0
```

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OP3 ROS Packages

ROBOTIS-OP3-Demo

- ball_detector : This package detects a specific colored ball from the image acquired from USB camera.

- op3_demo : Basic Demo for OP3(Soccer, Vision, Action)

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OP3 ROS Packages

ROBOTIS-OP3-Common

robotis_op3_description

- doc : document for ROBOTIS OP3 joint & link information
- launch : launch file to execute Rviz
- stl : STL files of ROBOTIS OP3's each parts
- src : ROS node for Rviz to publish imaginary gripper joint
- urdf : urdf & xacro files for Thormang3 model

robotis_op3_gazebo

- config : ROS controller for gazebo
- launch : launch files to execute gazebo simulation
- worlds : simulation environments

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OP3 ROS Packages

ROBOTIS-OP3-Tools

- op3_action_editor : The software that can create and edit actions for ROBOTIS-OP3
- op3_gui_demo : GUI software for ROBOTIS-OP3
- op3_offset_tuner_server : op3_offset_tuner_server communicates with op3_offset_tuner_client to control OP3 for offset tuning, and manages tuned offset file.
- op3_offset_tuner_client : op3_offset_tuner_client is a GUI program to communicate with op3_offset_tuner_server for offset tuning.
- op3_walking_tuner : This package is used to tune OP3 walking motion

Install OP3 Packages

OP3 Dependent Packages from ROBOTIS

```
$ cd ~/catkin_ws/src/
$ git clone https://github.com/ROBOTIS-GIT/DynamixelSDK.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-Framework.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-Framework-msgs.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-Math.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-OP3.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-OP3-Common.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-OP3-Demo.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-OP3-msgs.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-OP3-Tools.git
$ git clone https://github.com/ROBOTIS-GIT/ROBOTIS-Utility.git
```

Install OP3 Packages

OP3 Additional Dependent Packages

```
$ git clone https://github.com/ROBOTIS-GIT/face_detection.git
$ git clone https://github.com/clearpathrobotics/robot_upstart.git
$ sudo apt install v4l-utils
# apt-get install ros-kinetic-ros-control
# apt-get install ros-kinetic-ros-controllers
# apt-get install ros-kinetic-gazebo-ros-control
```

Build Dependent Packages

```
$ cd ~/catkin_ws && catkin_make
```


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Network Configuration

OP3

Remote PC

```
ROS_MASTER_URI = http://10.41.0.1:11311
ROS_HOSTNAME   = 10.41.0.1(IP of OP3)
```

```
ROS_MASTER_URI = http://10.41.0.1:11311
ROS_HOSTNAME   = 10.41.0.XXX(IP of Remote PC)
```

* ROS Master is running on OP3

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Gazebo Simulator

Gazebo Simulator

1. Run “roscore”

```
$ roscore
```

2. Run OP3 gui demo

```
$ roslaunch op3_gui_demo op3_demo.launch
```

3. Run OP3 manager

```
$ roslaunch op3_manager op3_gazebo.launch
```

4. Run Gazebo

```
$ roslaunch robotis_op3_gazebo robotis_world.launch
```

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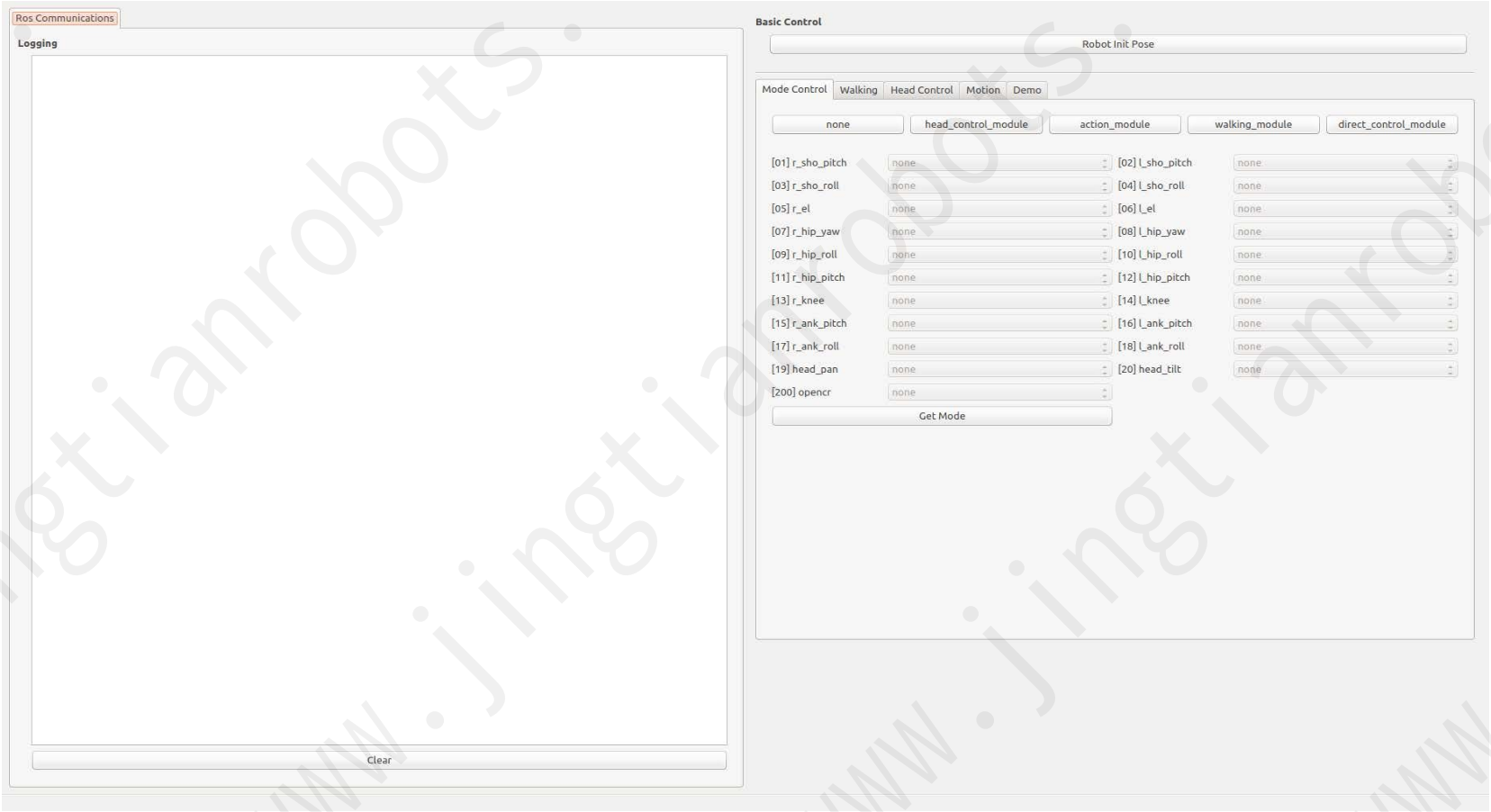
OP3 GUI



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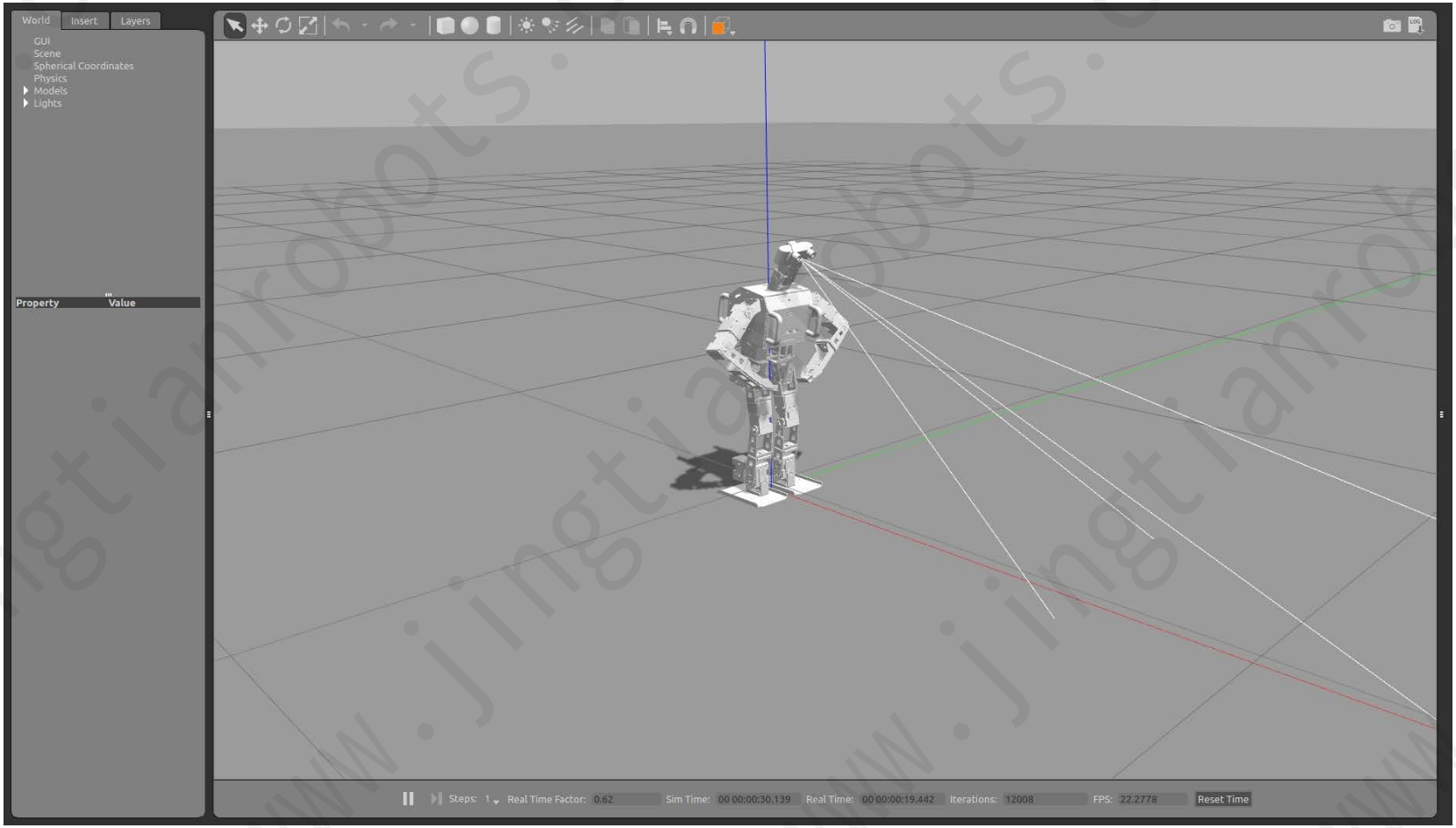
OP3 Gazebo



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OpenPose

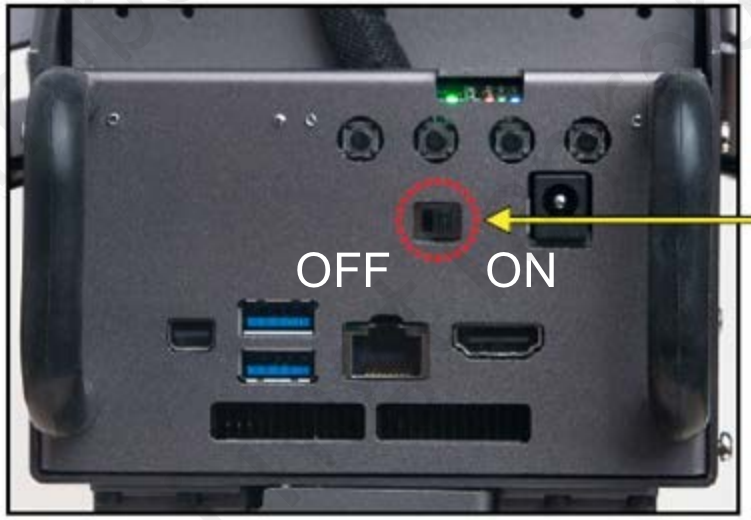
https://youtu.be/gfljsGqKERk

https://github.com/Seri-Lee/robotis_op3_following_motion

示例
Demonstration

Basic Operation

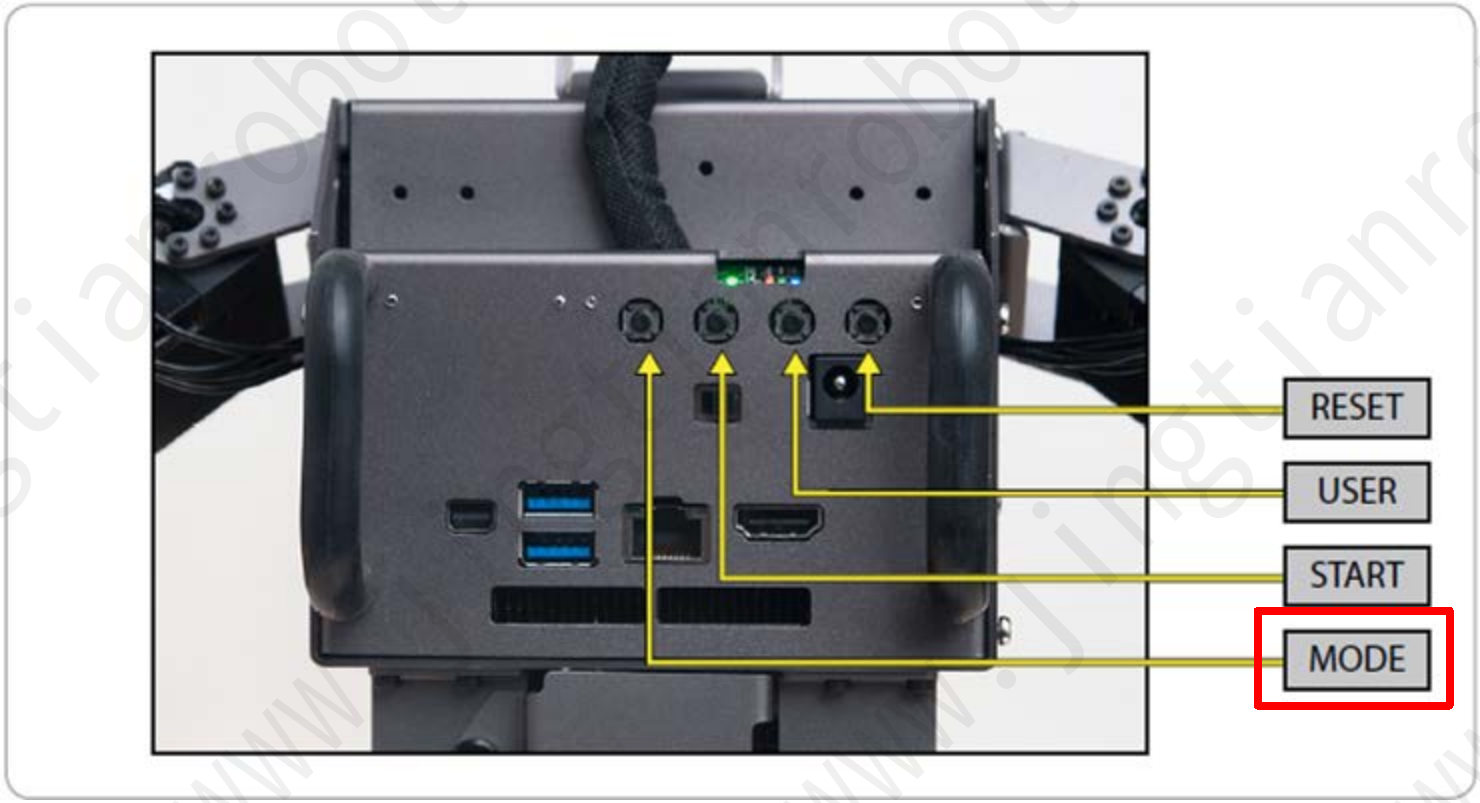
1. Power On



On/Off
Switch

Basic Operation

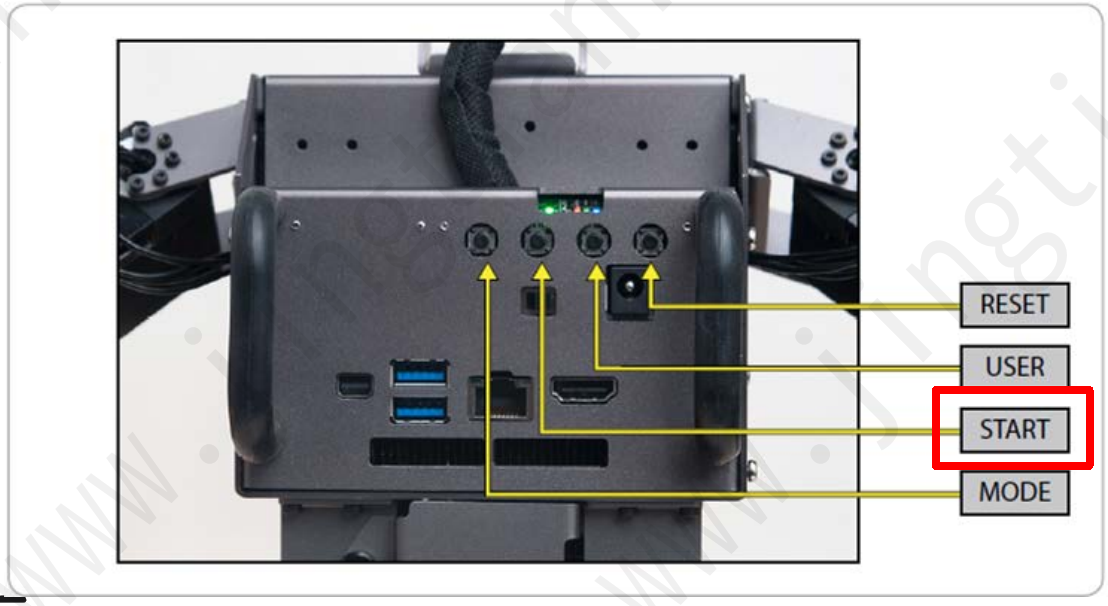
2. Select Demonstration Program



Basic Operation

3. Run Demonstration Programs

1. Autonomous Soccer Mode
2. Vision Processing Mode
3. Interactive Motion Mode



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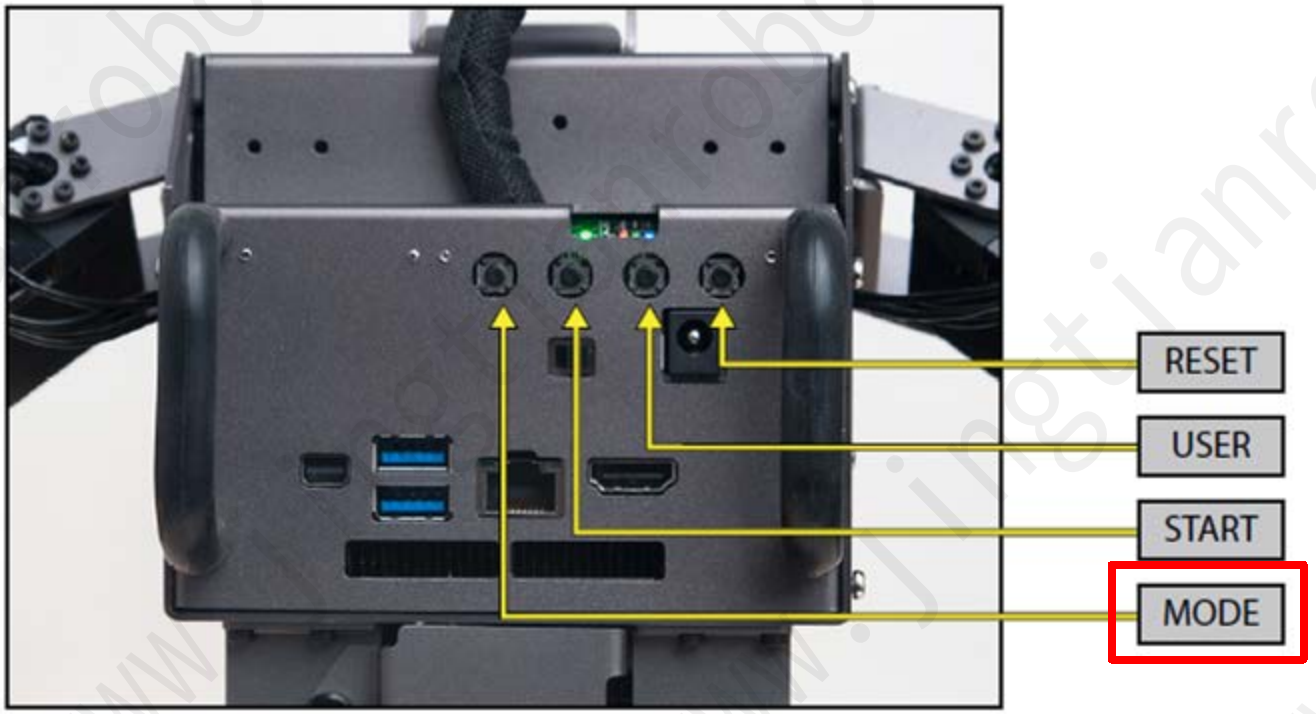
Basic Operation

4. Quit Demonstration Program



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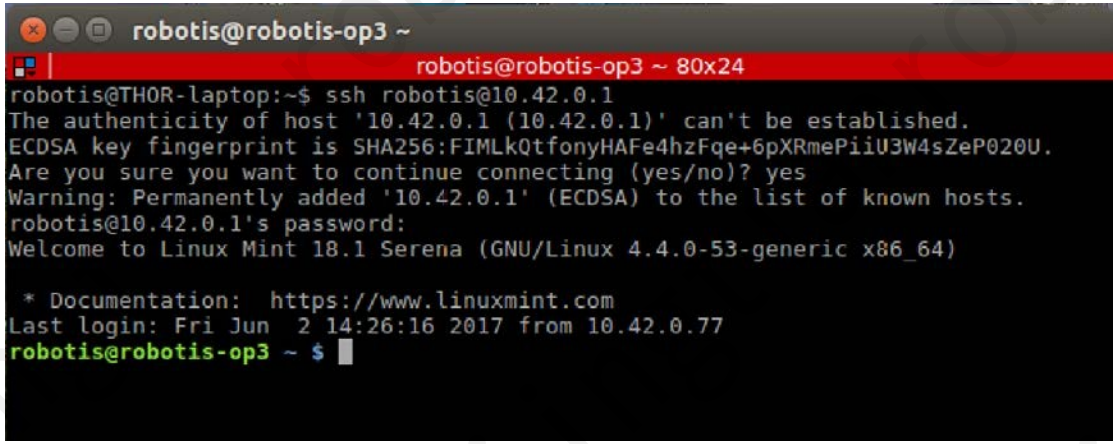
Connecting to OP3

SSID : ROBOTIS-OP3-share
AP Password : 11111111




```
$ ssh robotis@10.42.0.1
```

Password : 111111

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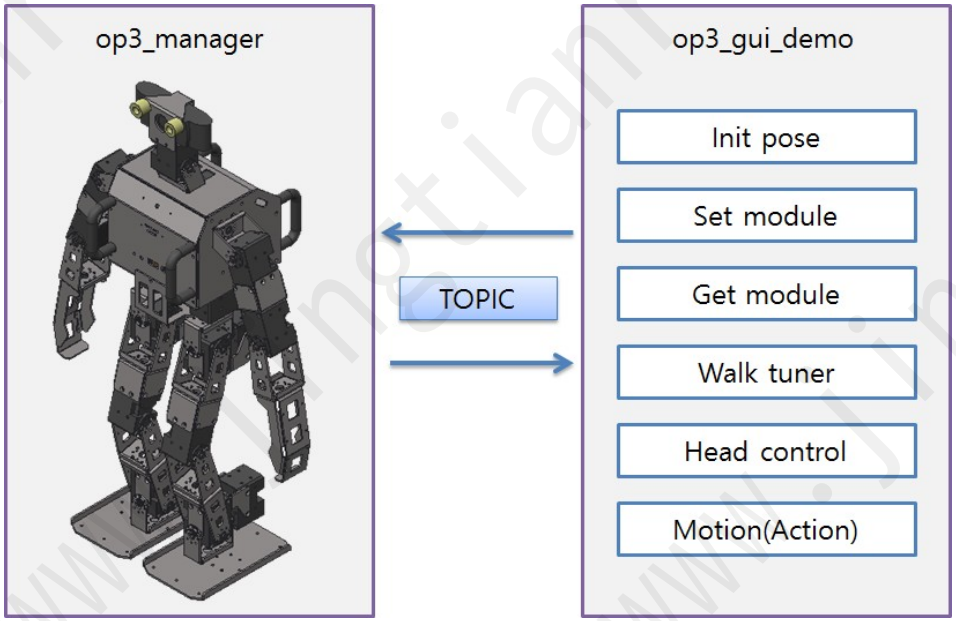
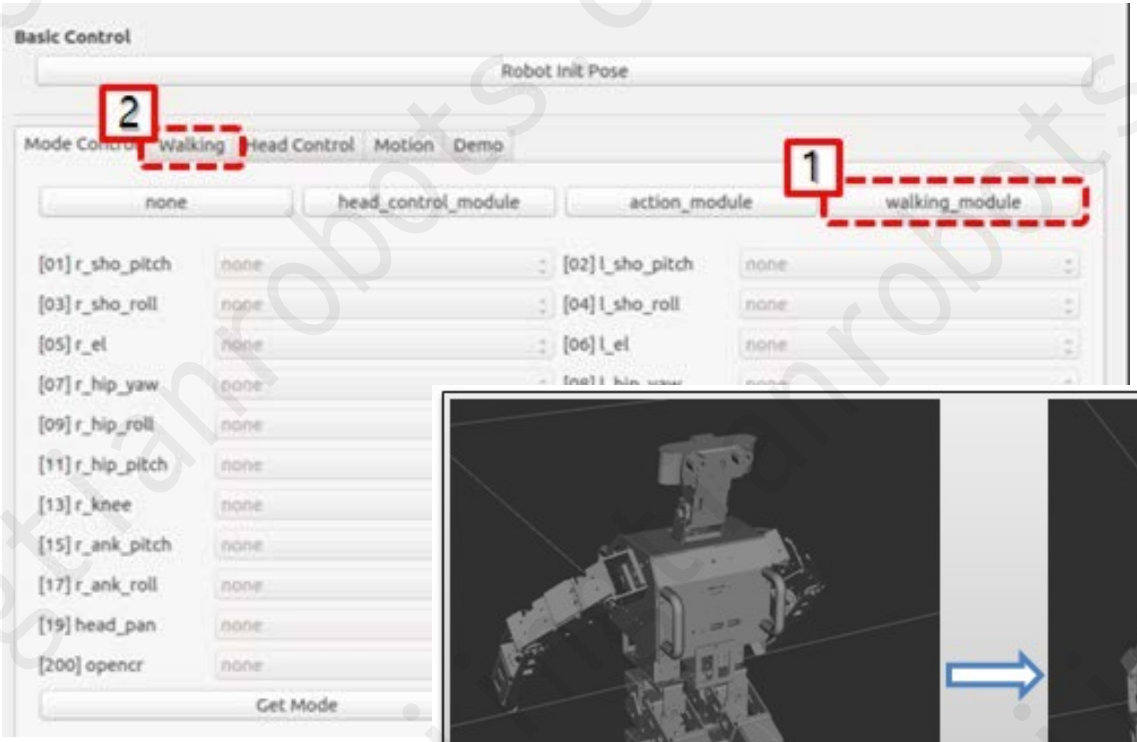
GUI Tool

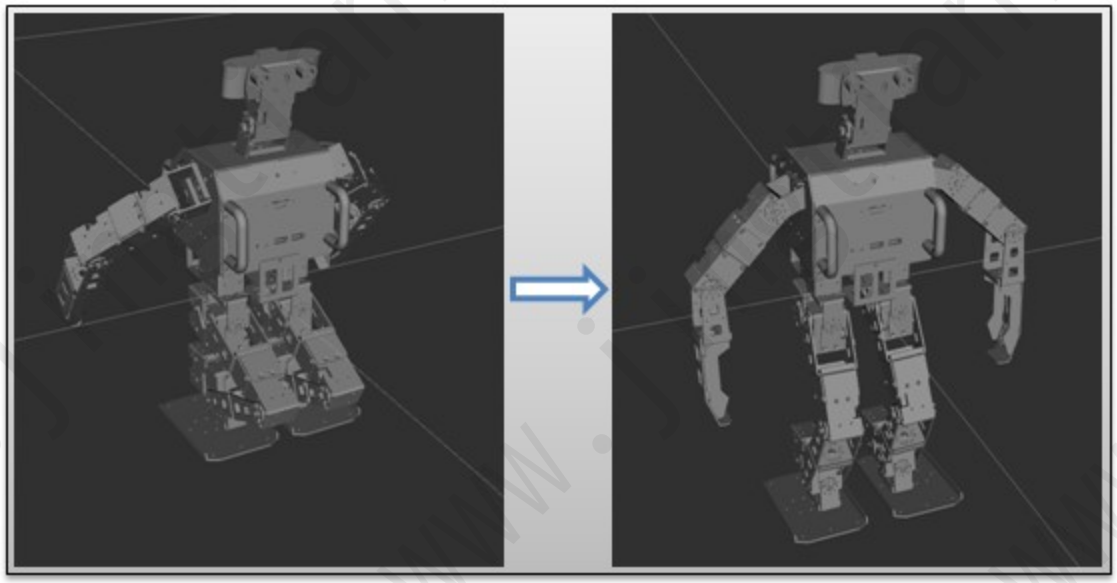
```
$ sudo bash
# roslaunch op3_manager op3_manager.launch
```

```
$ roslaunch op3_gui_demo op3_demo.launch
```



GUI Tool(Walking Tuner)





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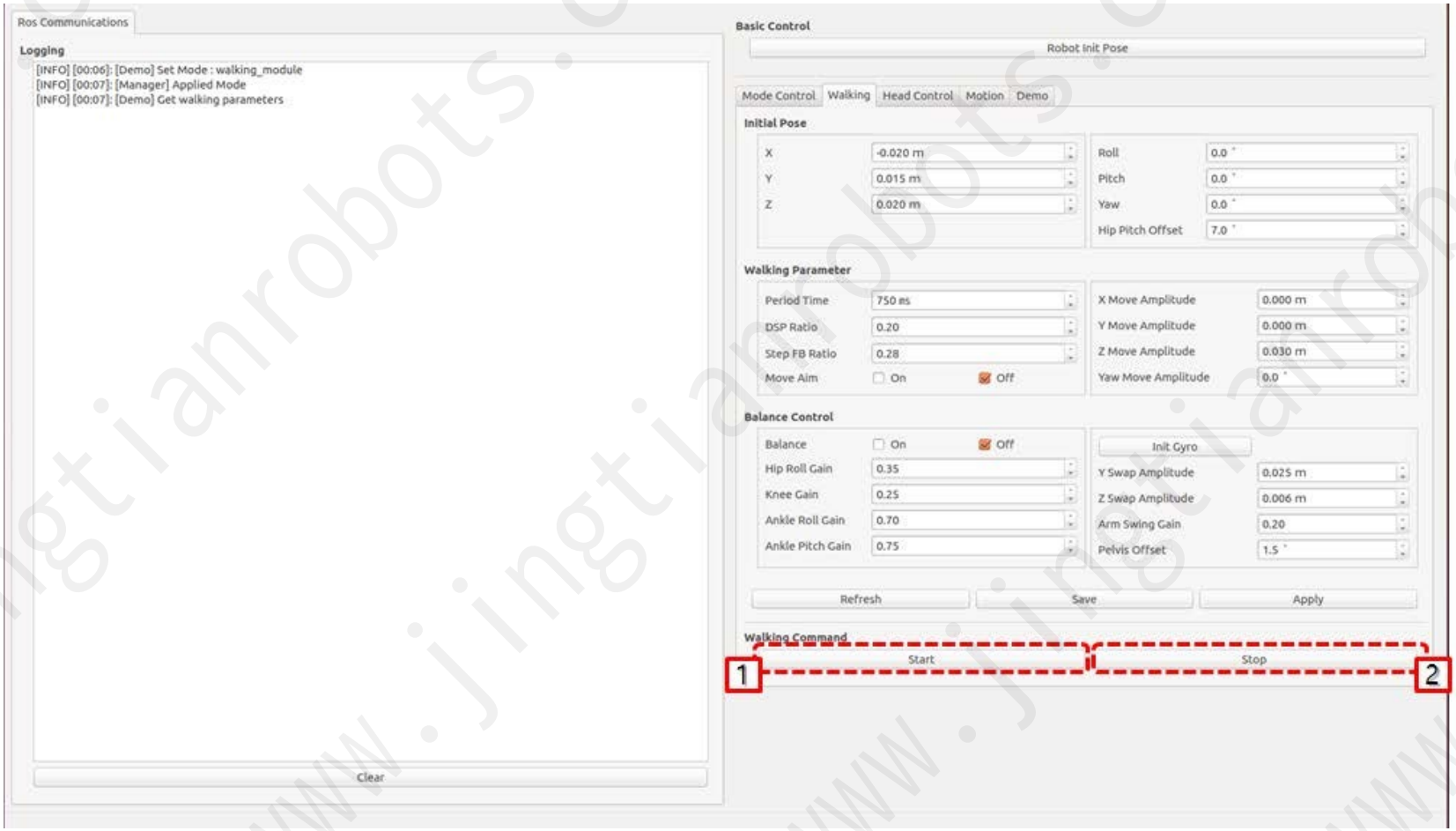
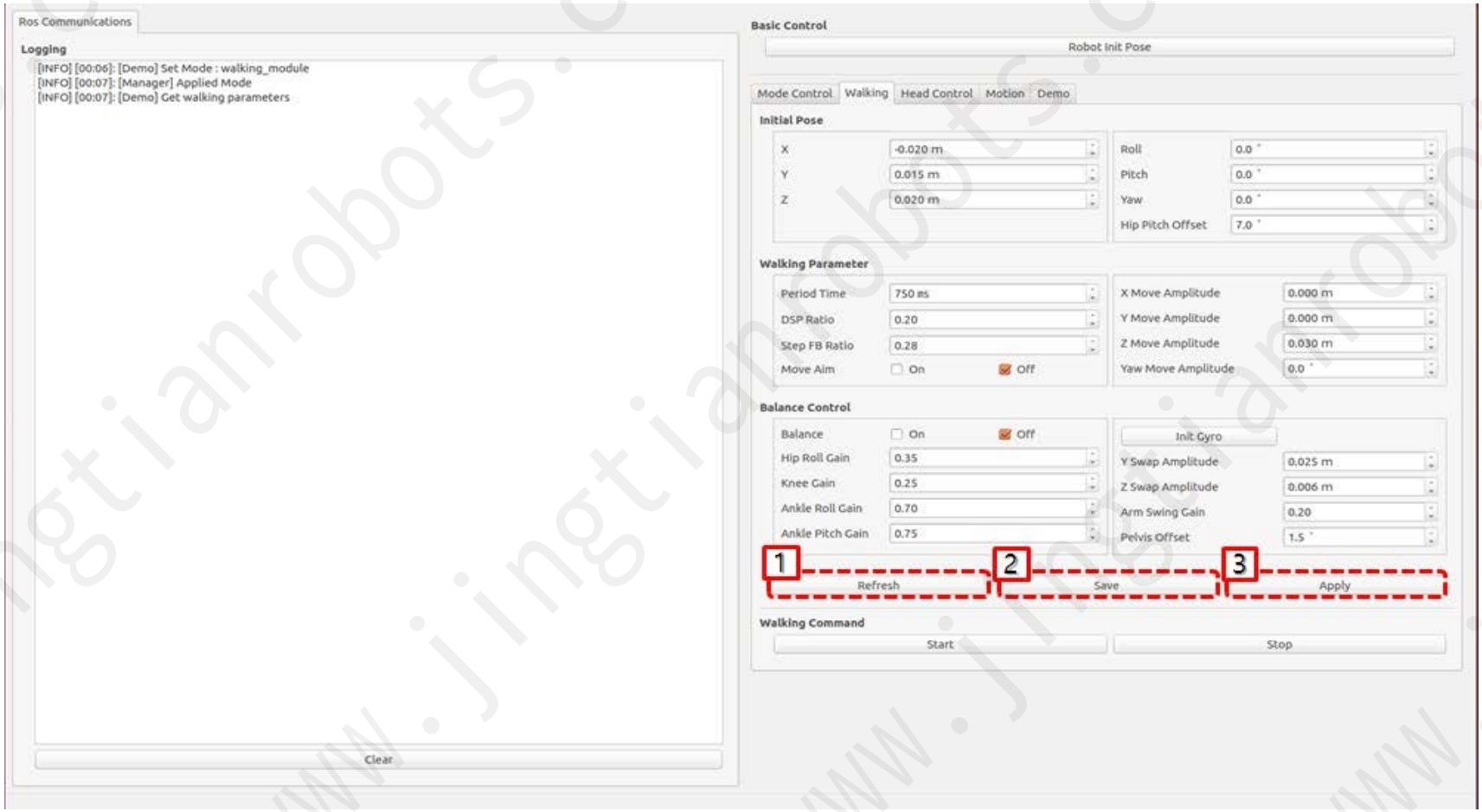
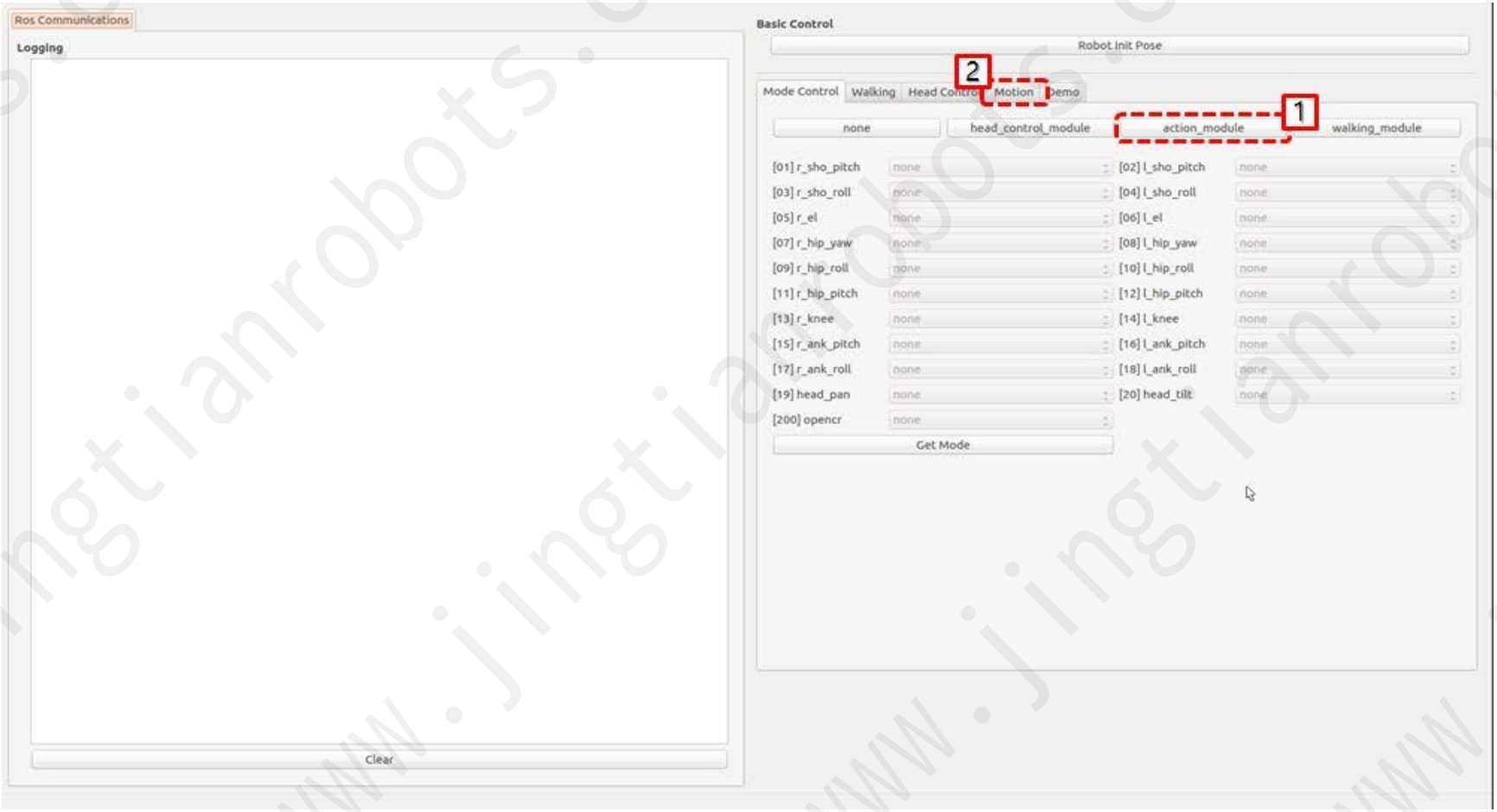
GUI Tool(Walking Tuner)



GUI Tool(Walking Tuner)



GUI Tool (Motion Play)



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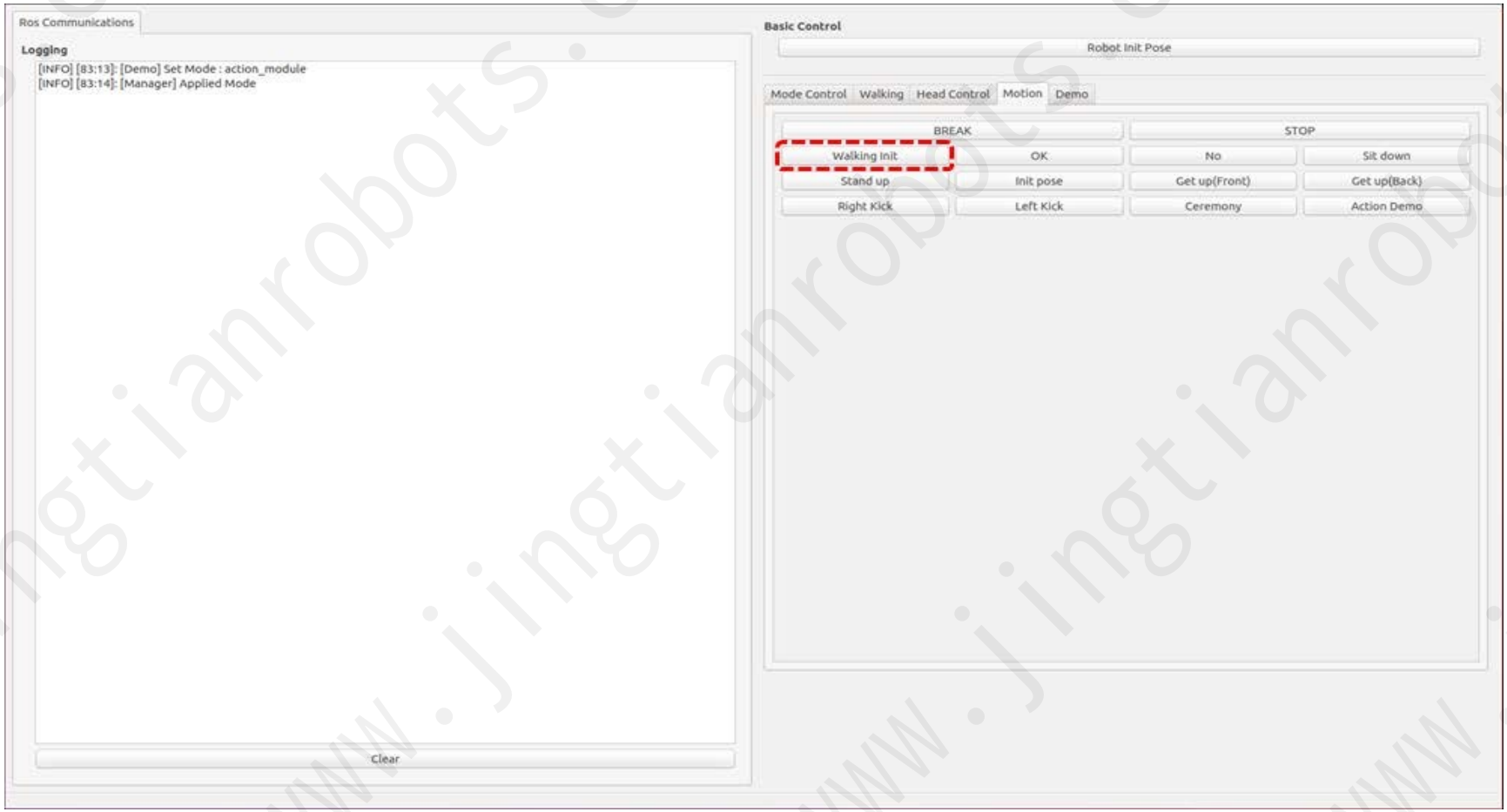
GUI Tool (Motion Play)



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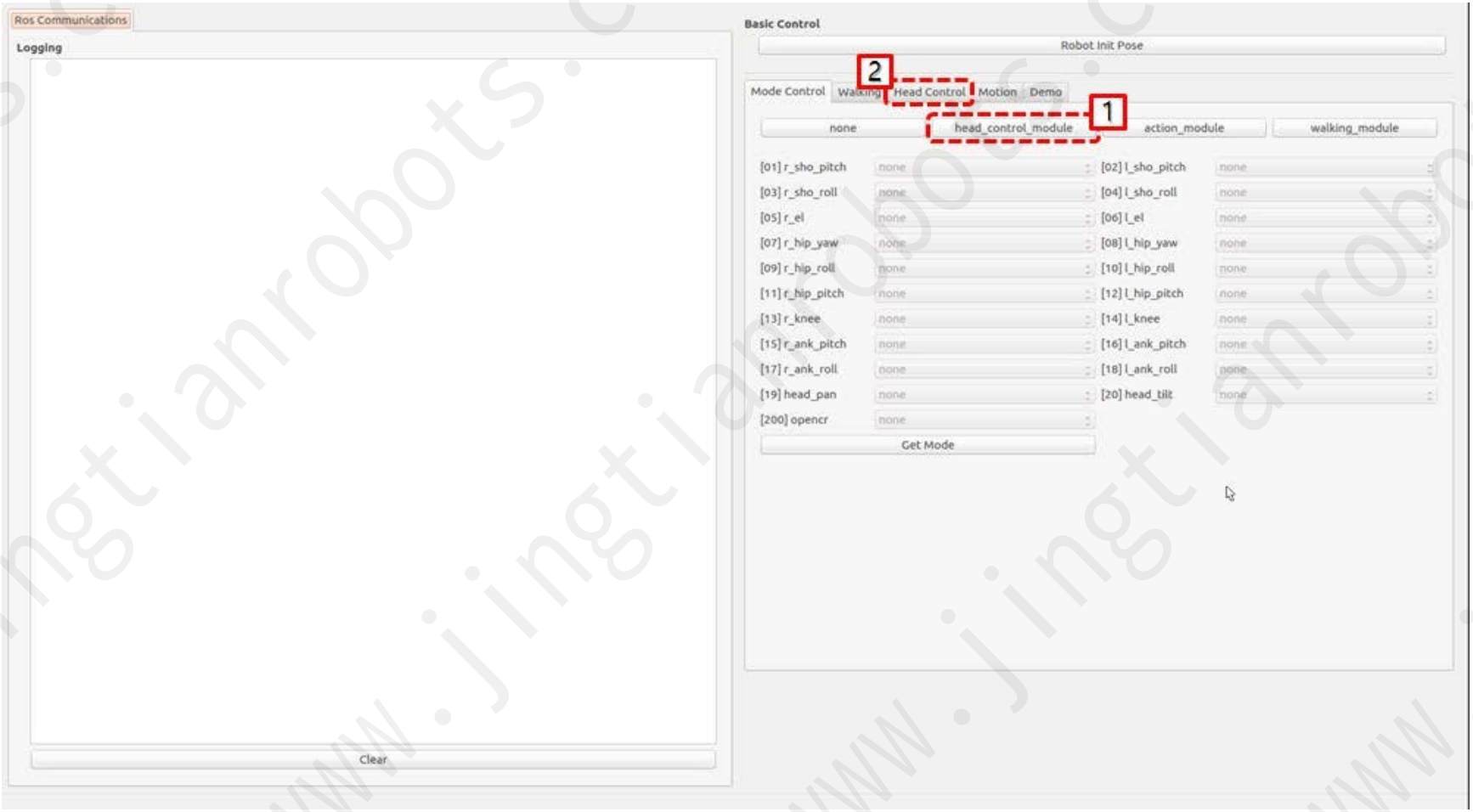
GUI Tool (Control Head)



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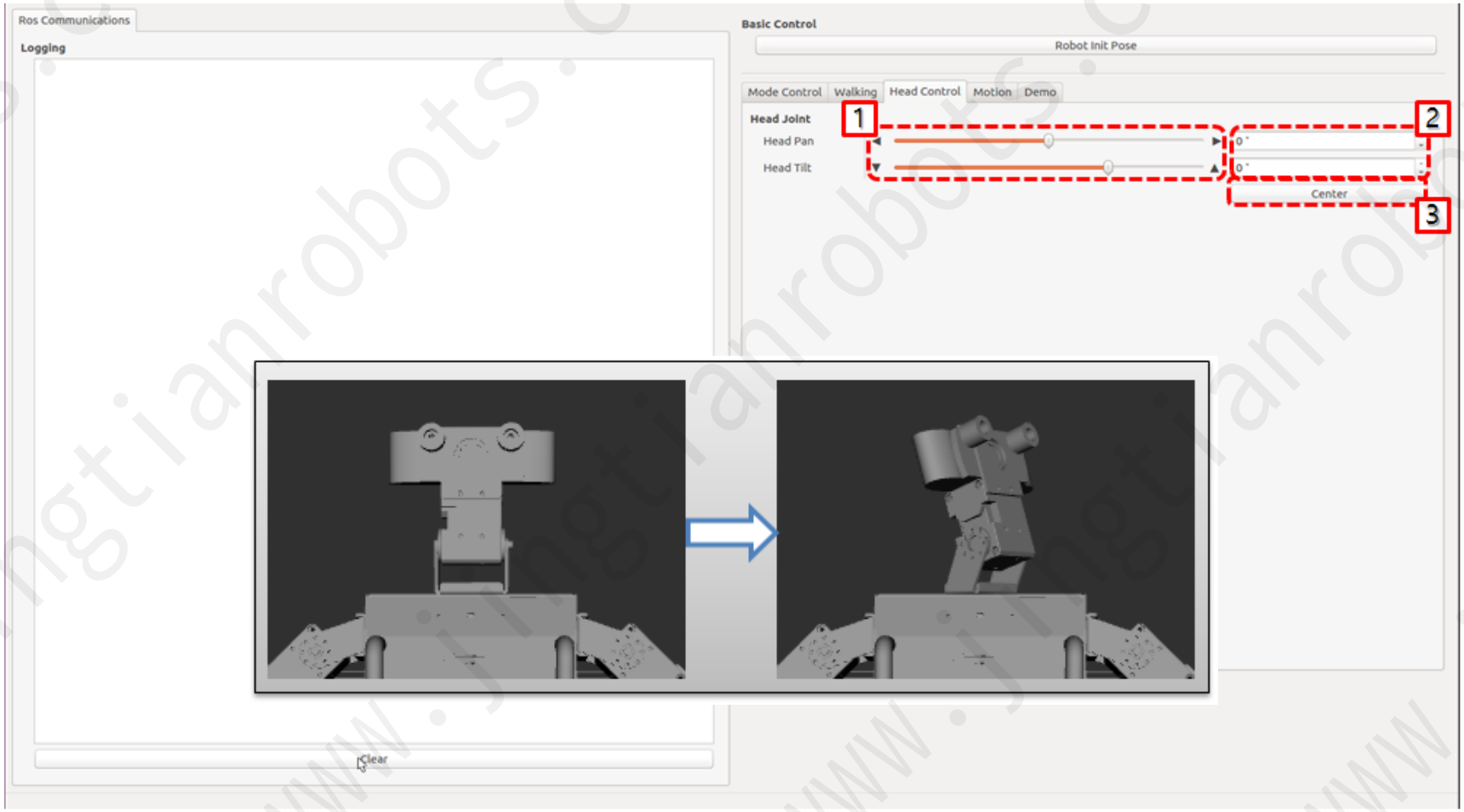
GUI Tool (Control Head)



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Offset Tuner

```
$ roslaunch op3_offset_tuner_server op3_offset_tuner_server.launch
```

```
$ rosrun op3_offset_tuner_client op3_offset_tuner_client
```

1. op3_offset_tuner_server configuration files

offset.yaml : Offset data and offset adjusting posture information are saved

OP3.robot : Description of ROBOTIS-OP3 is saved

dxl_init_OP3.yaml : Dynamixel configurations are saved and used for joint initialization

2. op3_offset_tuner_client configuration file

joint_data.yaml : GUI menu configuration file

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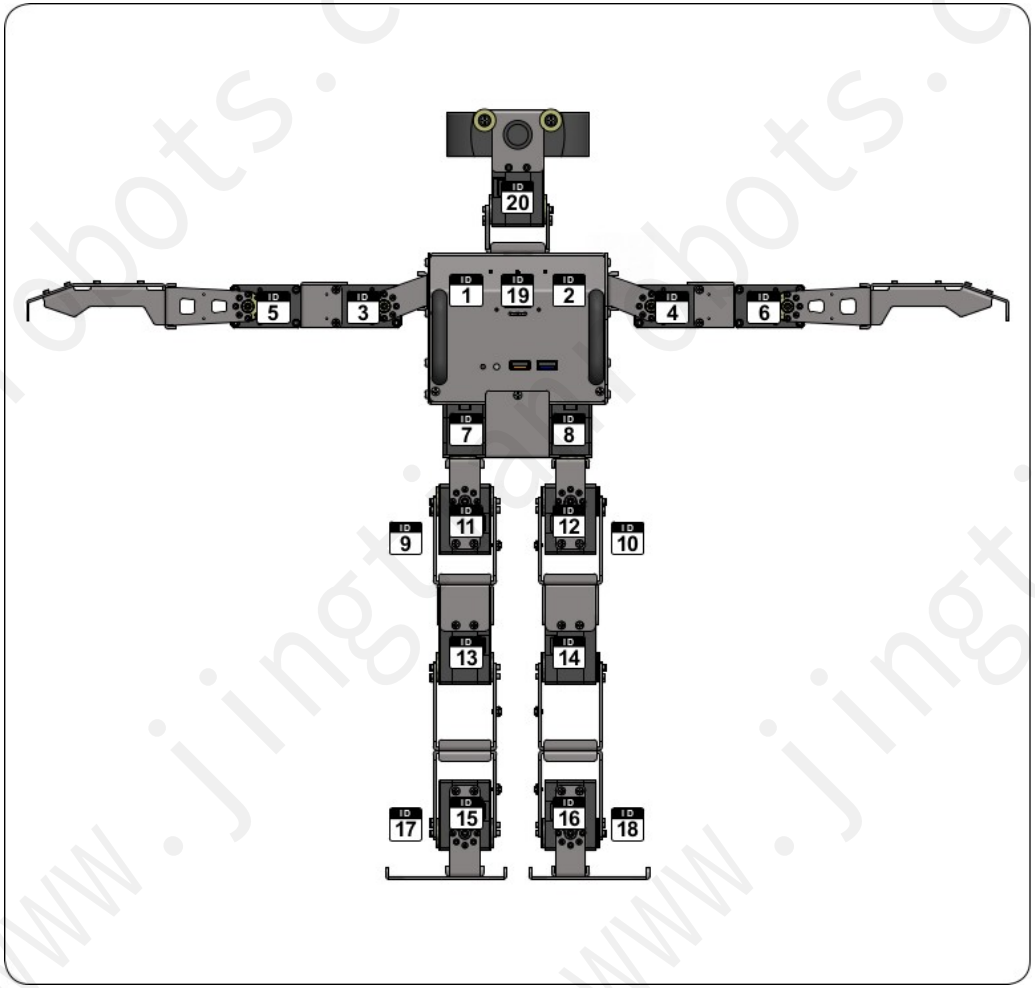
Offset Tuner



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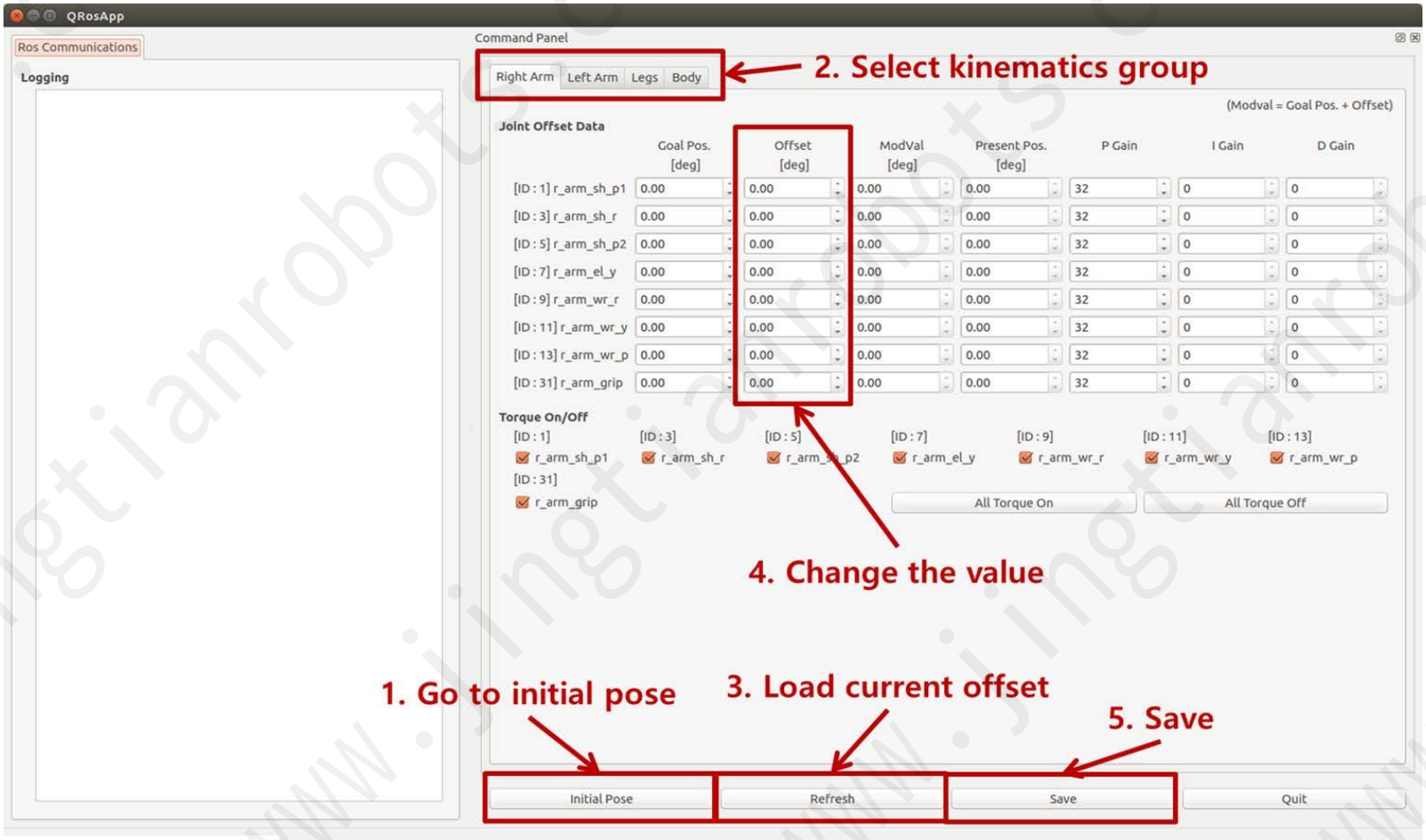
Offset Tuner



Action Editor

```
$ roslaunch op3_action_editor op3_action_editor.launch
```

Acton file is located at “op3_action_module/data” folder.

The action file contains 256 pages and each page can store up to 7 steps of motion.

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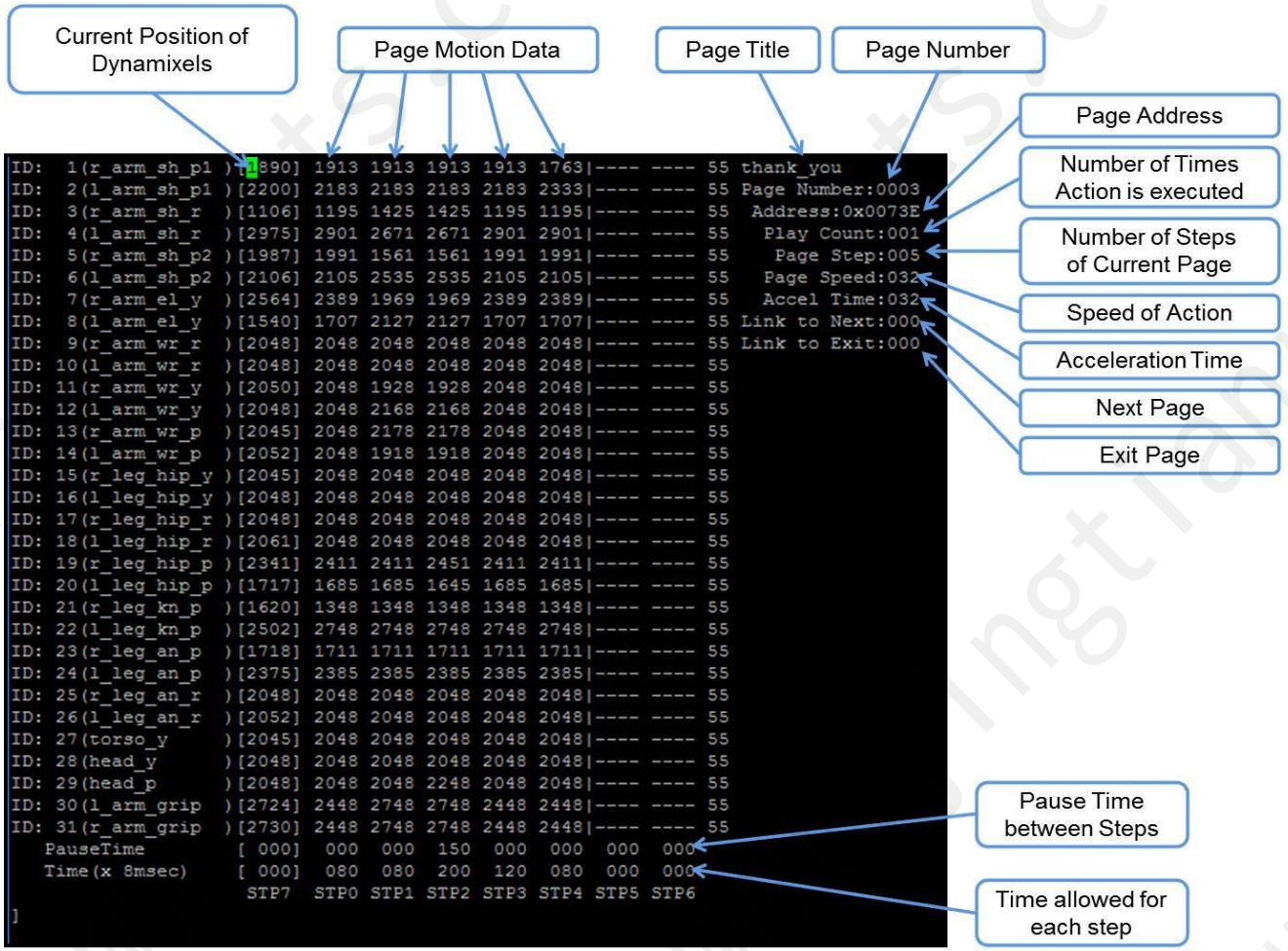
Action Editor



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Ball Detector

```
$ roslaunch ball_detector ball_detector_from_usb_cam.launch
```

```
$ rqt
```


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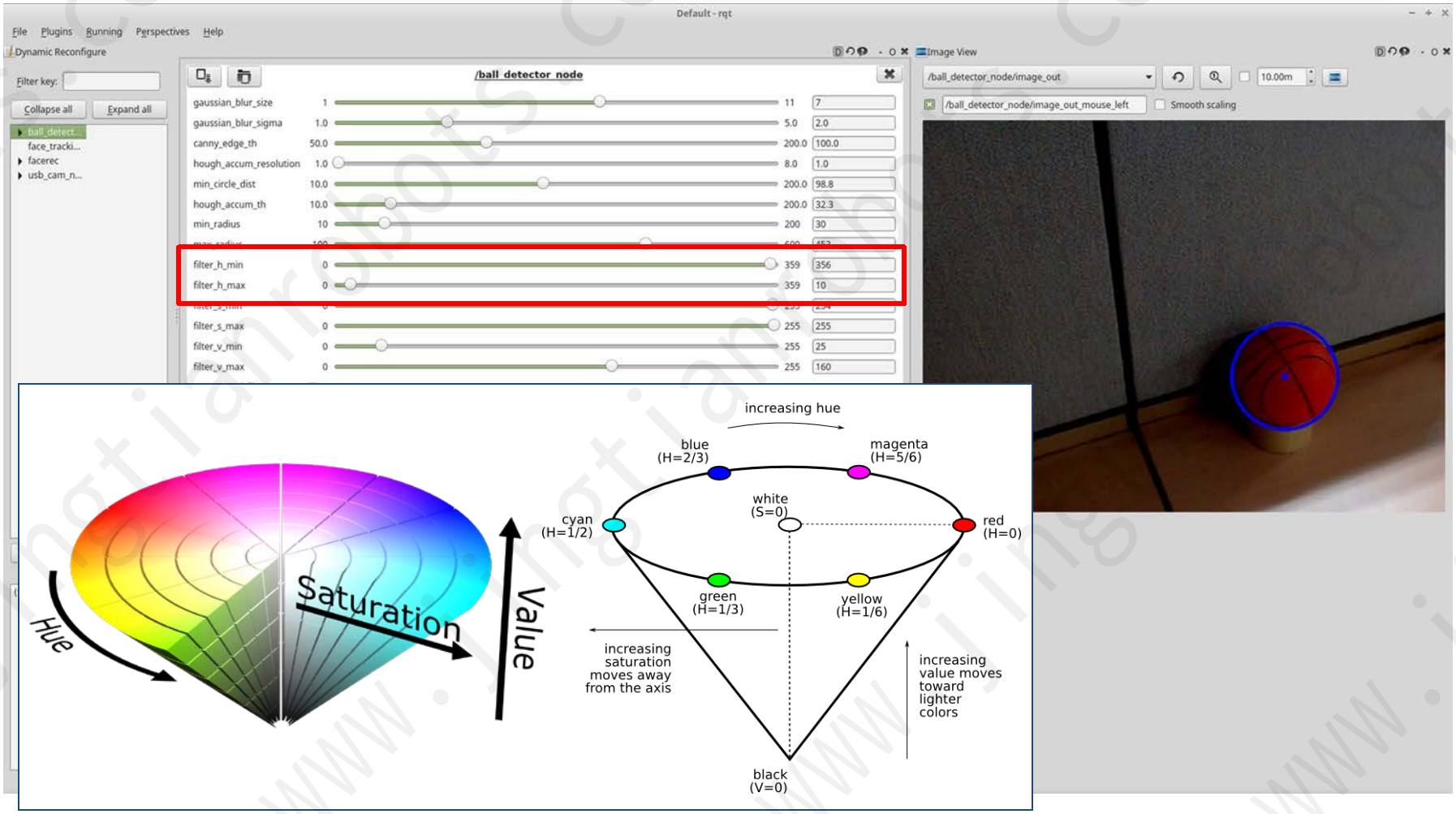
Ball Detector



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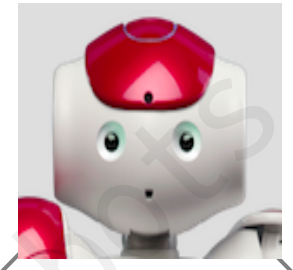
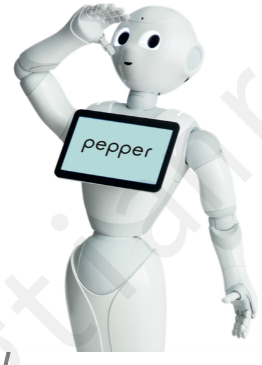
Q&A

谢谢观赏





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