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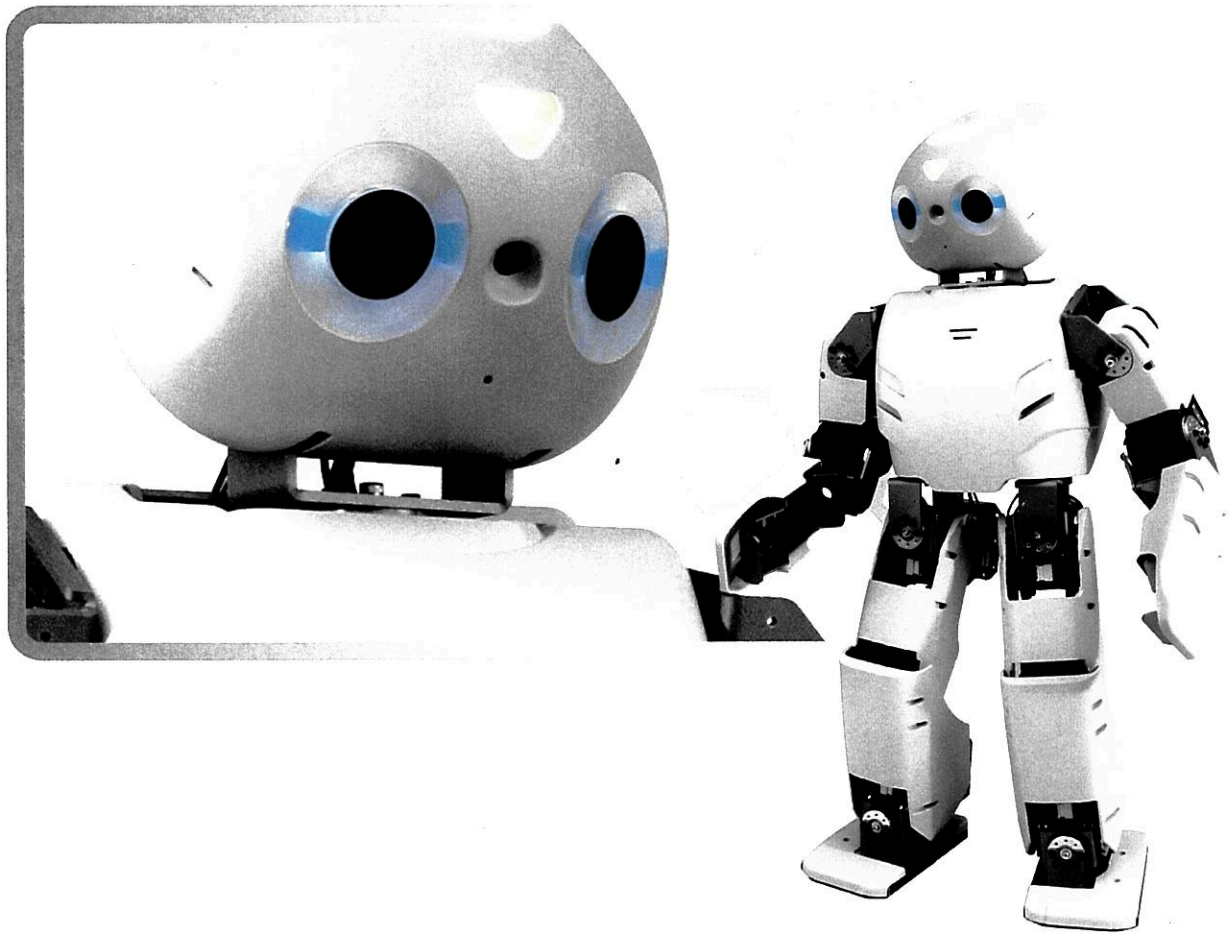
1. What is ROBOTIS OP2?

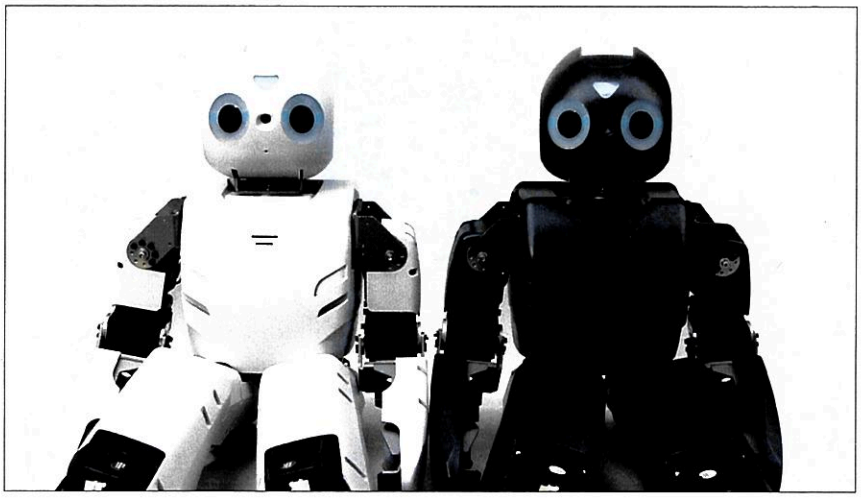
Open Platform Humanoid Project



ROBOTIS OP2 (formely known as "DARWIN 2" or DARWIN-OP2") remains mostly unchanged with respect to ROBOTIS OP (formerly known as "DARwIn-OP"). Despite the change in name the robot may be colloquially still be called "Darwin." The only major change comes from the upgrade in computing. When ROBOTIS OP was first released it was stated that it supported Windows OS. This claim is, and remains, technically true. However, in practice installing Windows is impossible due to the 4GB cap of the embedded SSD from ROBOTIS OP's PC. The scant 4GB made difficult installing the later releases of Ubuntu and significant workaround was required to be able to install the later Linux releases. ROBOTIS OP2 upgrade is aimed at eliminating the difficulties relating to computing from the previous generation. You can now focus your efforts more into developing the robot and less on devoting resources for computing.

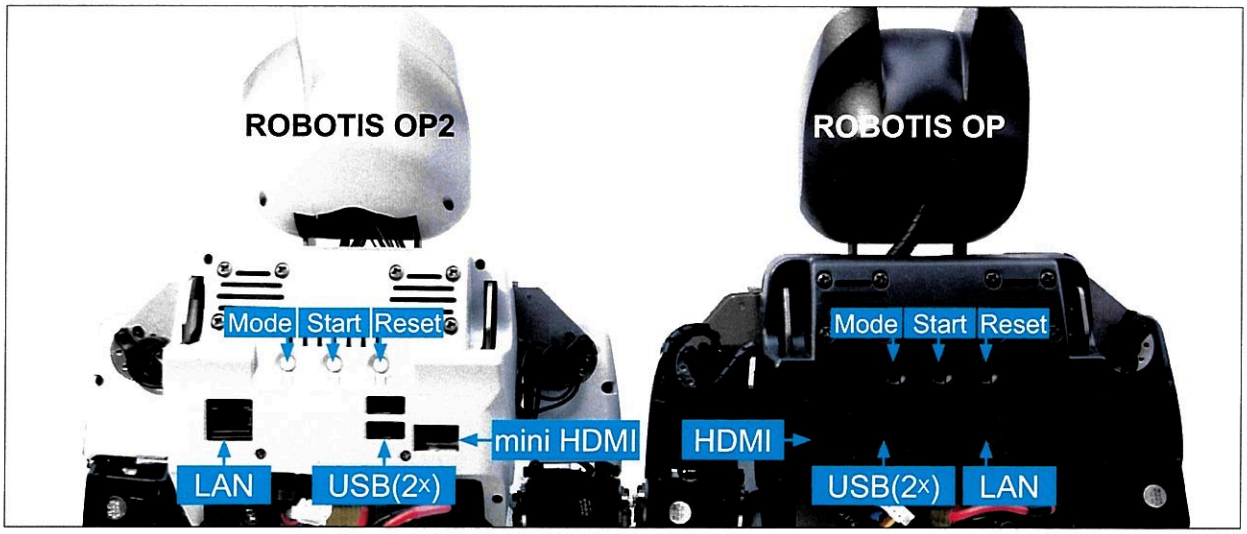
Visual differences with ROBOTIS OP

The overall appearance on ROBOTIS OP2 remains largely unchanged with respect to ROBOTIS OP.



▲Besides color is it almost impossible to differentiate between both robot types

The only difference is the mini HDMI port connector from ROBOTIS OP2. Also, the location of the ports differ from ROBOTIS OP2 with respect to ROBOTIS OP. The Mode, Start, and Reset buttons remain unchanged. ROBOTIS OP2 lacks the 3.5cm microphone and audio jacks. In practice these were not implemented with ROBOTIS OP so the loss of these ports from ROBOTIS OP2 will not affect robot operations.



▲Without careful close inspection it is difficult to tell the difference between both robots

Advantages of ROBOTIS OP2 compared to ROBOTIS OP

As stated above the changes come in the form of an updated PC. The advantages of the new PC are listed as follows:

- user-replaceable SSD
- user-replaceable RAM
- increased compute power (obviously)
- reduced size of the PC
- reduced size of the management controller (CM-730 ⇨ CM-740)

Comparative specs

	ROBOTIS OP	ROBOTIS OP2
CPU	Intel Atom Z530 @1.6GHz single core	Intel Atom N2600 @1.6GHz dual core
RAM	1GB DDR2 (fixed capacity)	up to 4GB DDR3 204-pin SO-DIMM module (user-replaceable)
storage	4GB NAND flash IDE100 (fixed capacity)	half-size mSATA module (up to SATA3 speeds) (user-replaceable)
LAN speed	100 Mbps	1 Gbps
Installable OS	Linux only (32-bit)	any Linux release (32-bit) any Windows release (32-bit)
wi-fi	802.11g	802.11n (2.4GHz-only)

ROBOTIS OP2 is an affordable, miniature-humanoid-robot platform with advanced computational power, sophisticated sensors, high payload capacity, and dynamic motion ability to enable many exciting research and education activities.

2. Safety information

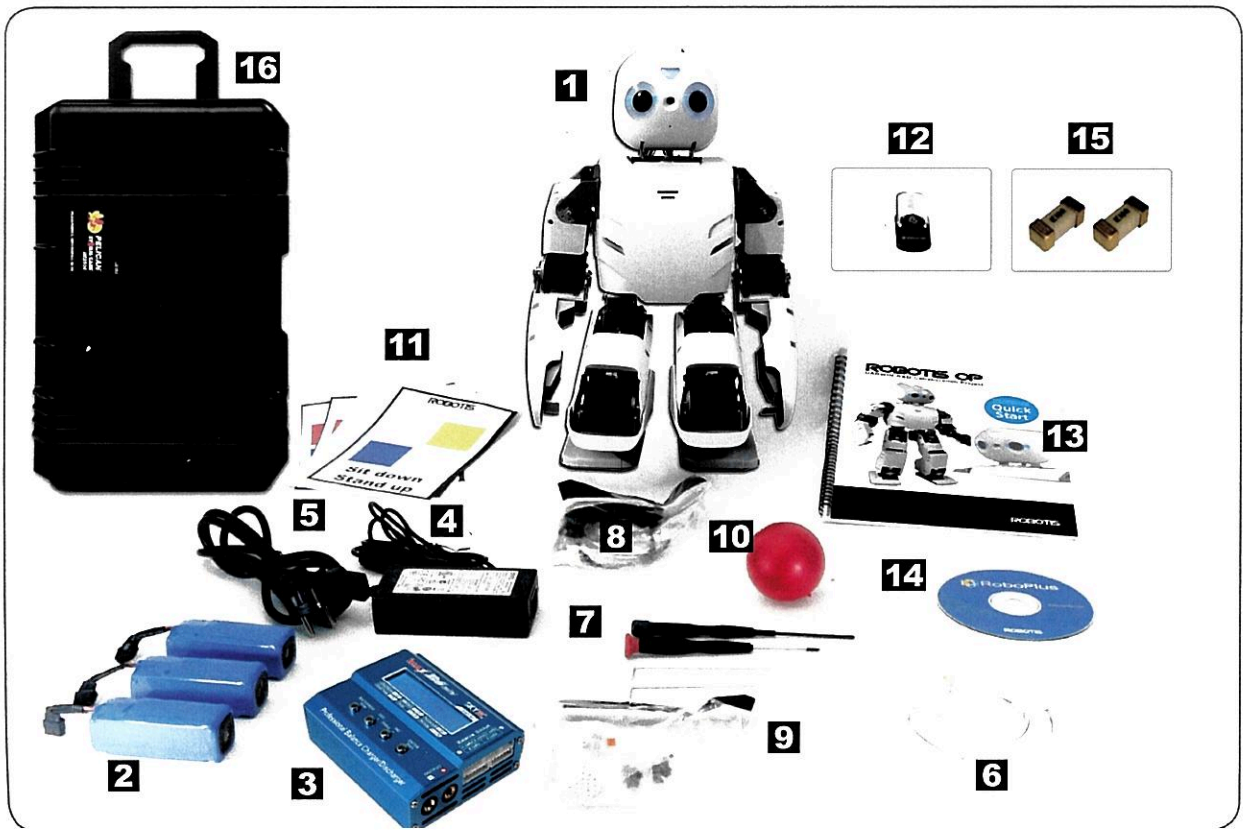
We will not be held responsible for the result of any accidents caused by the user's negligence.

- Read the instructions carefully before getting started.
- Not suitable for children under 15 years of age.
- Do not use any other tools other than those provided in the kit.
- Keep robot away from your face and body when the robot is moving.
- Prevent from getting your fingers stuck between the servos.
- Do not place near water, heat, or fire.
- Only use the battery and charger included in the kit.
- Gears must be replaced after long excessive use.

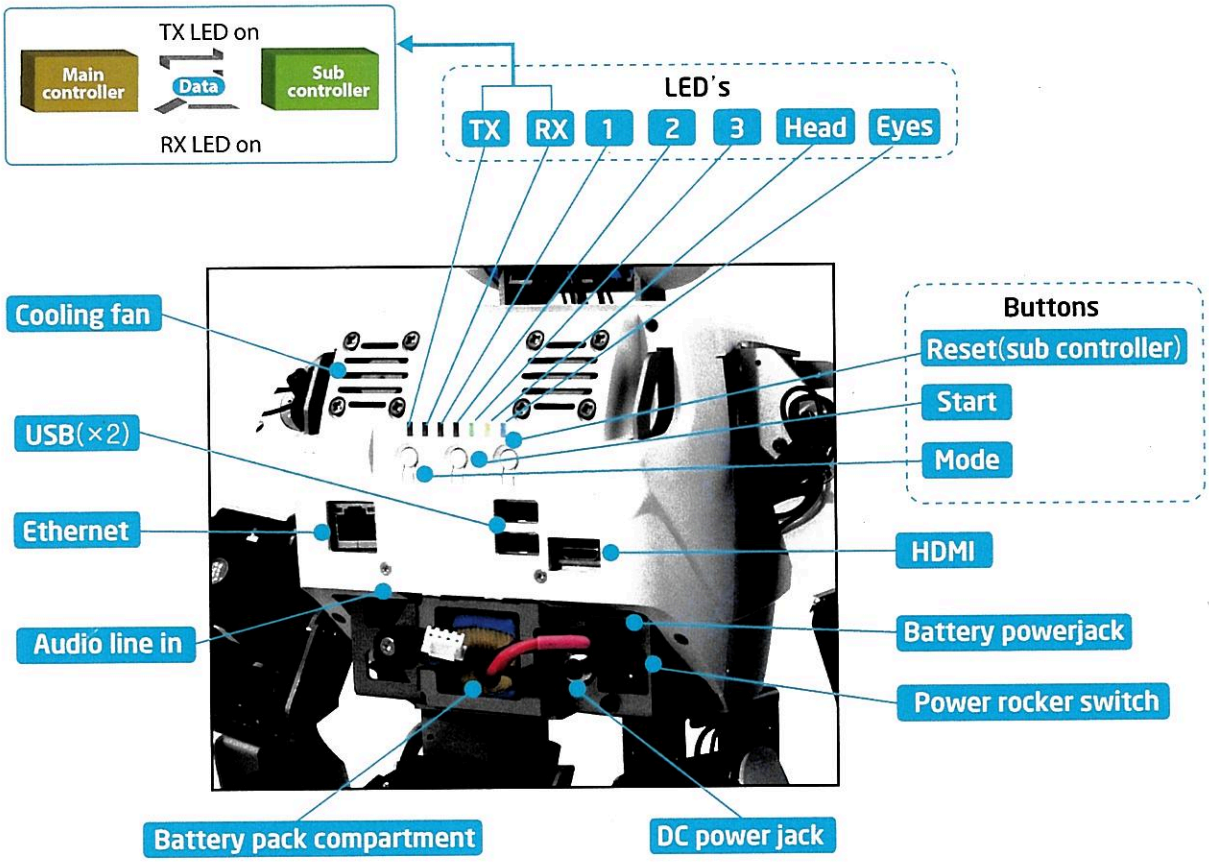
3. Package Contents

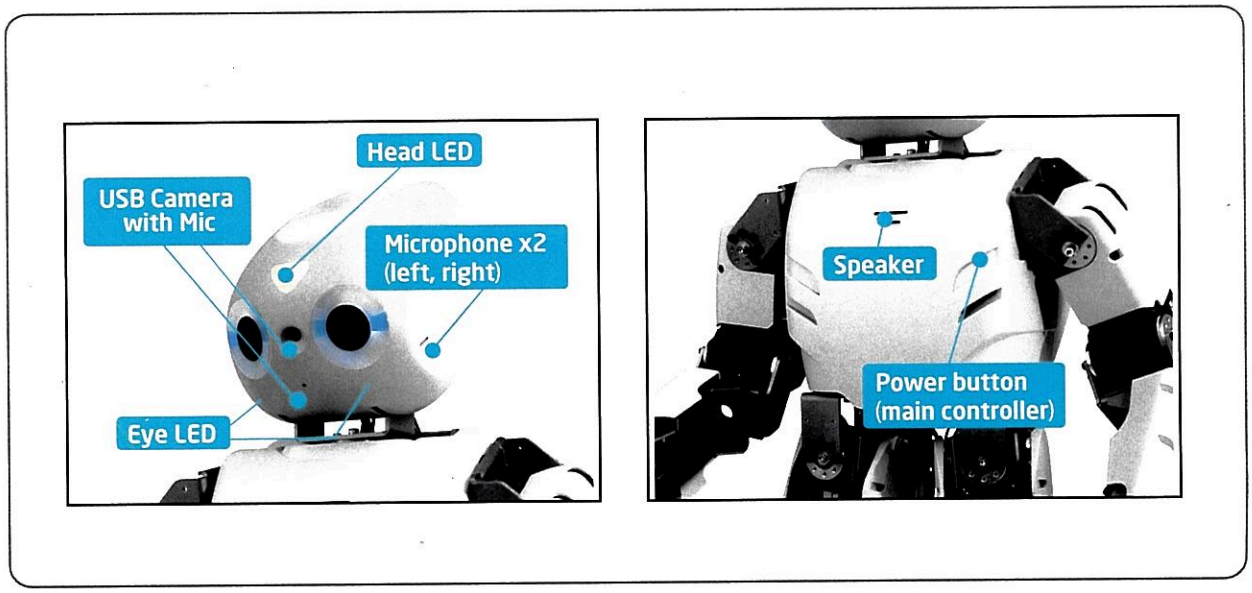
Check your ROBOTIS OP2 package for the following items.

1. Fully-assembled ROBOTIS OP2 robot x1
2. Battery packs x3
3. Battery charger x1
4. DC power supply x1
5. Power cable x1
6. Ethernet cable x1
7. Wrenches x2, screwdrivers x2
8. Spare cables
9. Spare bolts and nuts
10. Red ball x1
11. Color cards x7
12. USB thumb drive (with installed recovery software) x1
13. QuickStart x1
14. RoboPlus CD
15. Fuse x2
16. Hard Case



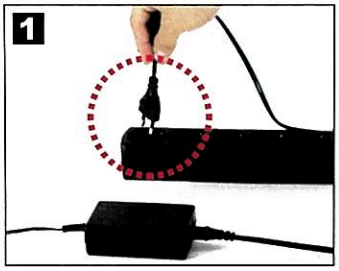
4. Layout


TX LED on
Main controller
Data
Sub controller
RX LED on
LED's
TX
RX
1
2
3
Head
Eyes
Cooling fan
USB(×2)
Ethernet
Audio line in
Battery pack compartment
Buttons
Reset(sub controller)
Start
Mode
HDMI
Battery powerjack
Power rocker switch
DC power jack

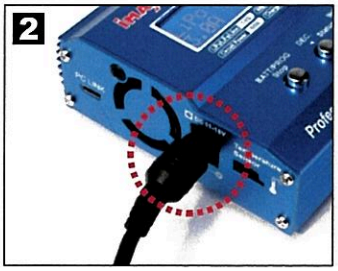

Head LED
USB Camera with Mic
Microphone x2 (left, right)
Eye LED
Speaker
Power button (main controller)

5. Charging the Battery

Please charge the battery pack according to the following procedure.

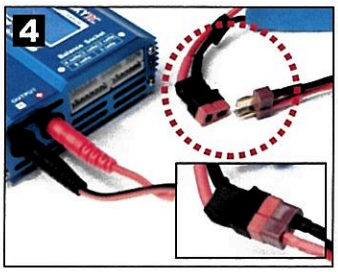


Insert the AC plug of the DC power supply into the power socket

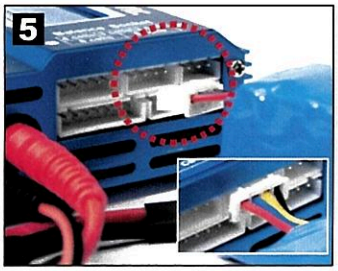


Connect the DC power supply to the battery charger

Connect the banana plug end of red and black charging cable into the OUTPUT sockets of the battery charger



Connect the other end of the charging cable male "T" connector to the female "T" connector of the battery



Connect the battery's balance connector into the 3 cells balance socket (4 pins)

Press BATT/PROG button; then press either the left or right buttons until the lower portion of the display shows LiPo BATT; press the ENTER button

Press either left or right button until the upper portion of the display shows LiPo BALANCE CHG

Press the ENTER button once and see the amperage value blink. Use the left or right key to set the amperage at 1.8A.

Press the ENTER button one more time to select the battery cell type. Use the left or right key until the display shows 11.1V(3S)

Press the ENTER button once to set settings. Hold the ENTER button to enter battery check mode; the charger will sound off a small melody while the display shows BATTERY CHECK

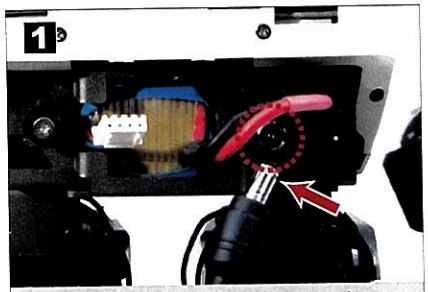
The lower portion of the display will toggle between CANCEL(STOP) and CONFIRM(ENTER) While toggling press the ENTER button to begin charging.

✓ If the connection is unstable, please unplug the battery completely and plug the battery in again.

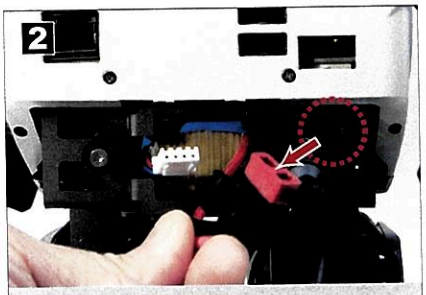
⚠ Only use the supplied battery charger. Charging the battery pack with any other charger may cause damages.

6. Changing Battery without Shutting Down

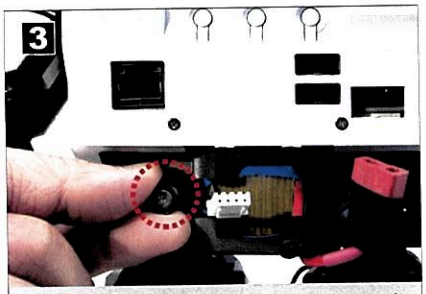
One distinguishing feature of ROBOTIS OP2 is its ability to change the battery without the need of shutting down. To replace the battery during operation, please follow the procedures below.



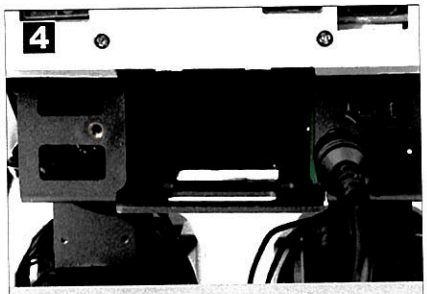
Connect the DC power to the DC jack



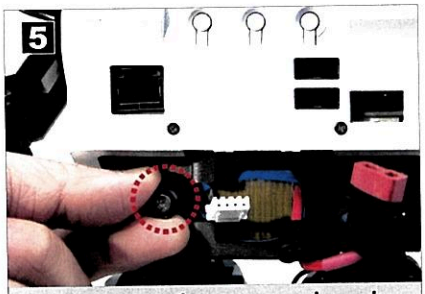
Disconnect the battery cable



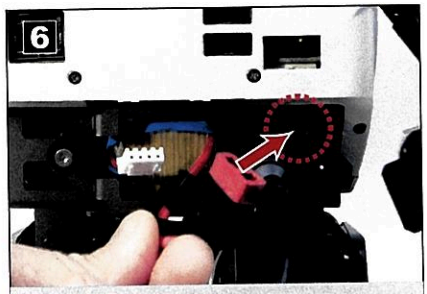
Open the battery compartment door



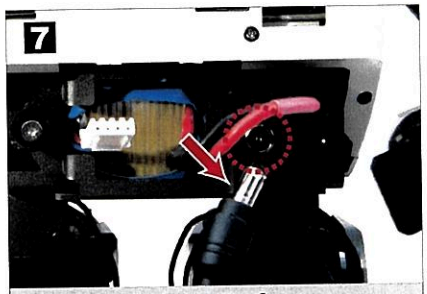
Remove the battery pack



Insert a new battery pack and close the door



Connect the battery cable again

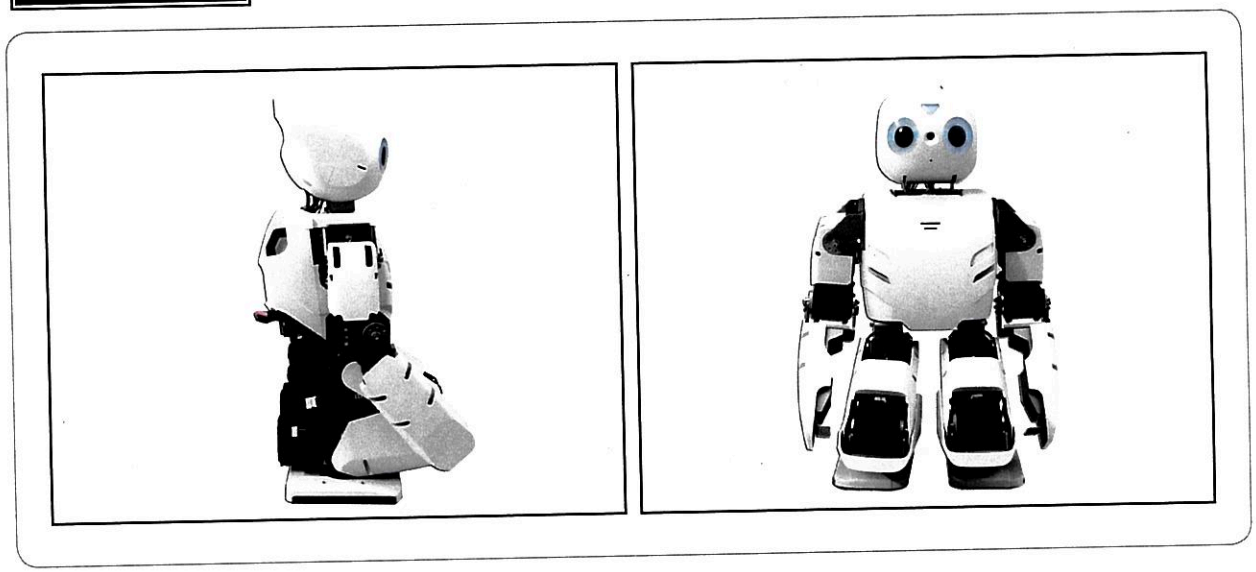


Remove DC power from the DC jack

1. Ready Position and Powering On

The following procedure takes you through the set up process.

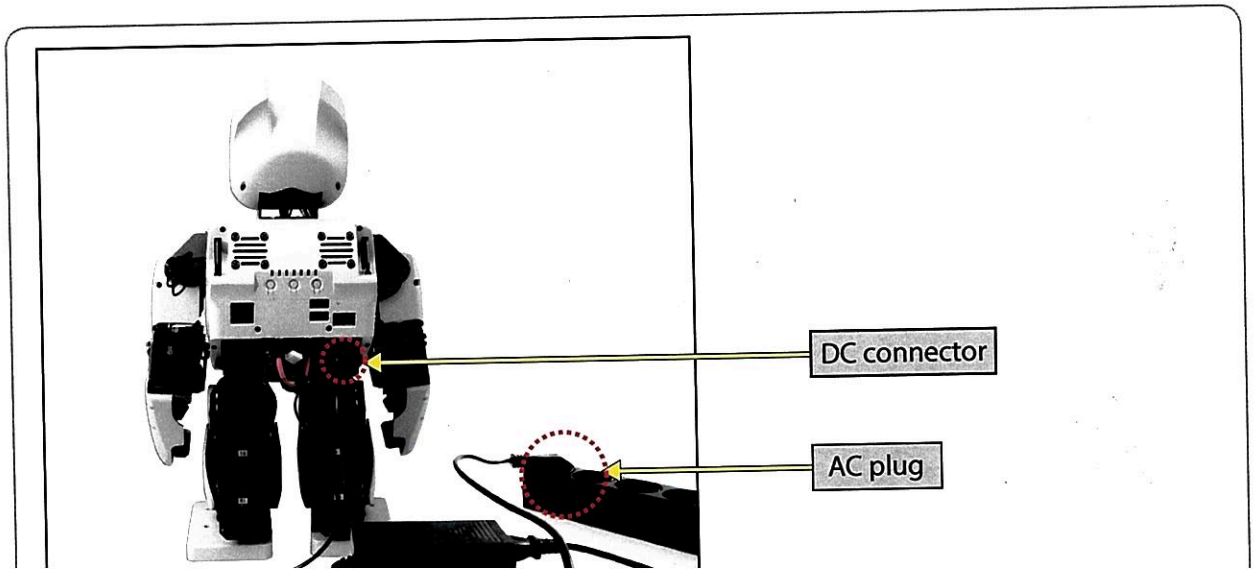
STEP 1 Set ROBOTIS OP2 in ready position as illustrated below.



Setting ROBOTIS OP2 other than this ready position may cause physical damages.

STEP 2-A Plug in the DC power (12V) supply to provide power to ROBOTIS OP2

Connect the AC plug of your power adapter into a power outlet and the DC connector into ROBOTIS OP2's DC jack. The DC jack is located at the back and lower right side of ROBOTIS OP2

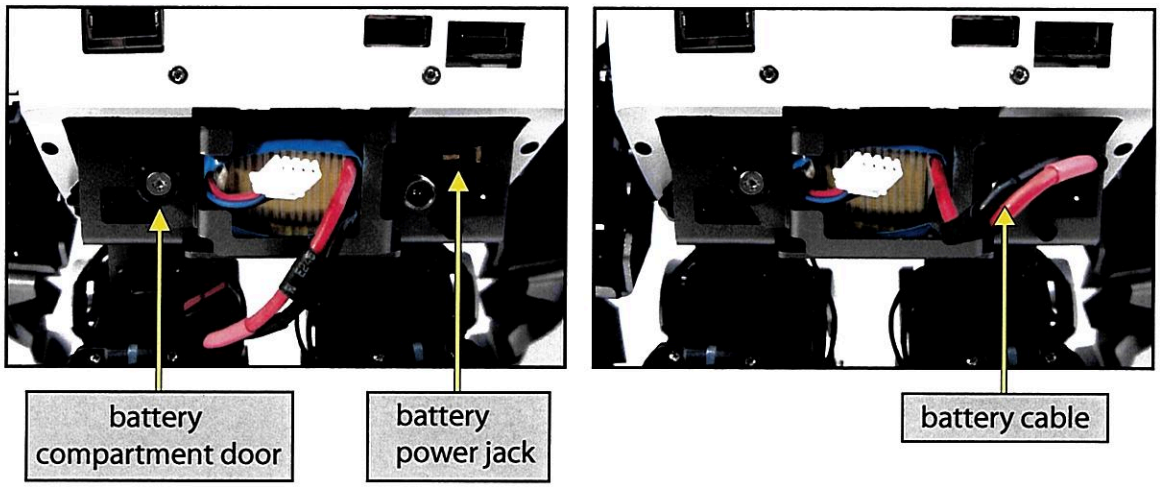


STEP 2-B Using Battery Pack (11.1V) instead of the DC power supply

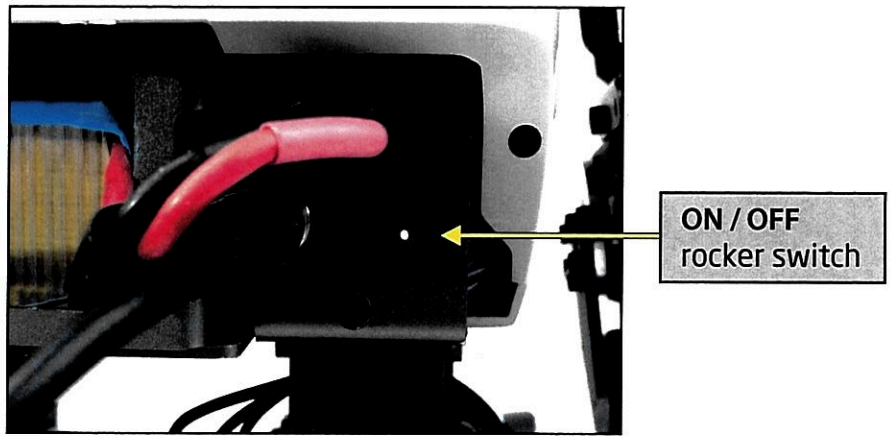
You can select either the DC power supply or battery pack to power on ROBOTIS OP2. If you want to use the battery pack please follow the steps below.

1) Ensure the battery pack is fully charged.
2) Open the battery compartment door (unscrew the thumbscrew) and insert the battery pack. Close and secure the compartment (screw the thumbscrew) afterwards.
3) Connect the battery cable to the battery power jack
4) Disconnect DC power supply.

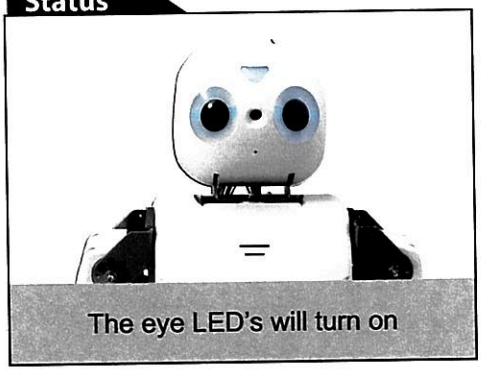
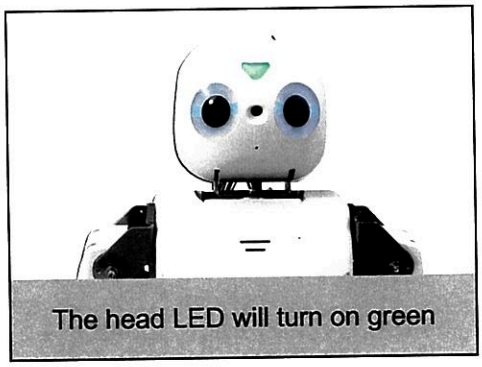
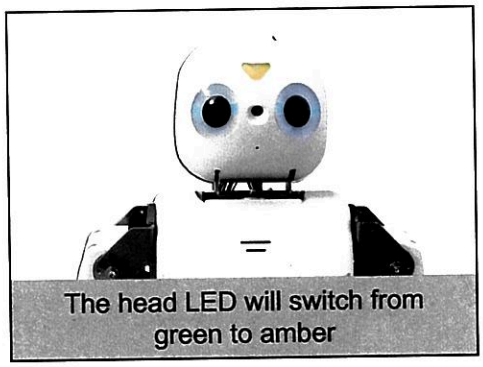
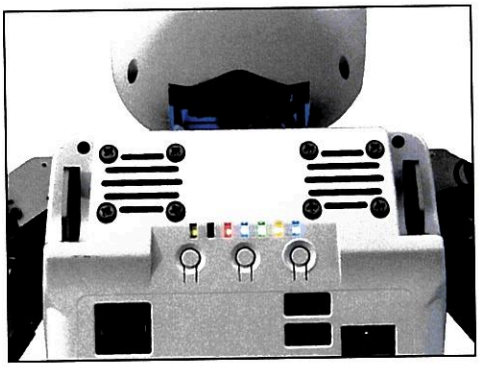
⚠ To prevent unexpected shutdown, ensure that ROBOTIS OP2 is connected to at least 1 active power source.



STEP 3 Switching On



Once power is on, the following will take place sequentially.

Status		Robot Action
 The eye LED's will turn on	1.	Power is on
 The head LED will turn on green	2.	The PC inside ROBOTIS OP2 operating system is booting
 The head LED will switch from green to amber	3.	Demo program is loaded, and ROBOTIS OP2 is ready to operate
	4.	

2. Running the Demonstration Programs

ROBOTIS OP2 comes pre-configured with the follwing 4 modes of operations :

1) Demonstration-Ready Mode

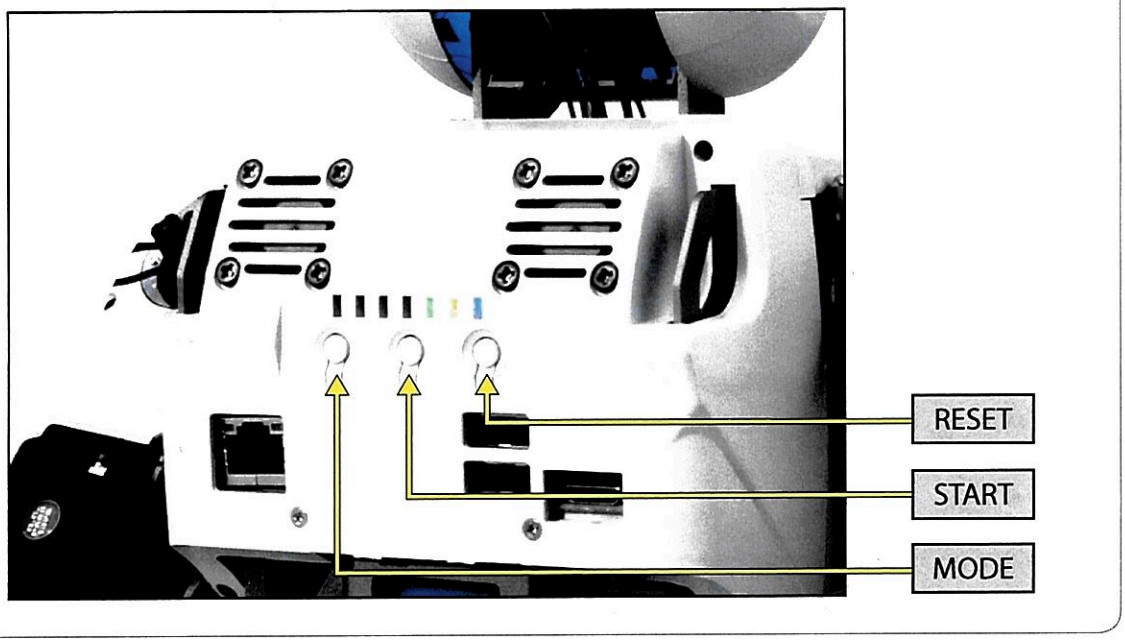
2) Autonomous Soccer Mode

3) Interactive Motion Mode

4) Vision Processing Mode

ROBOTIS OP2 defaults to Demonstration-ready mode when turned on.

To switch between modes, press the MODE button. ROBOTIS OP2 announces each mode with each pressing. Each mode has its own indicating LED.
To run each mode press START button. After pressing START ROBOTIS OP2 will stand up and begin operations.



RESET button

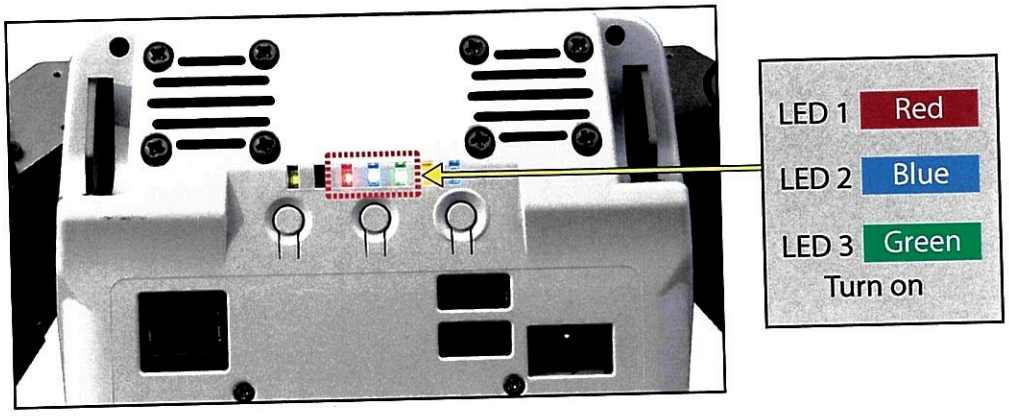
The RESET button resets the actuators and sub-controller, not the entire robot. Please keep in mind that the demo program is still running in the main controller.

Pressing the RESET button will release torque on ALL actuators. It is highly recommended that ROBOTIS OP2 is set at kneeling position before pressing RESET or hold ROBOTIS OP2 by its carrying handle.

2-1. Demonstration-Ready Mode

The Demonstration-Ready Mode is the default mode when you turn ROBOTIS OP2 on. LED 1 (red), LED 2 (blue), and LED 3 (green) are on; the head LED changes from green to amber, and ROBOTIS OP2 announces "Demonstration-ready mode." ROBOTIS OP2 is ready for action!

ROBOTIS OP2 remains in kneeling position and does not move under this mode. This is the best-suited mode to change the power source.

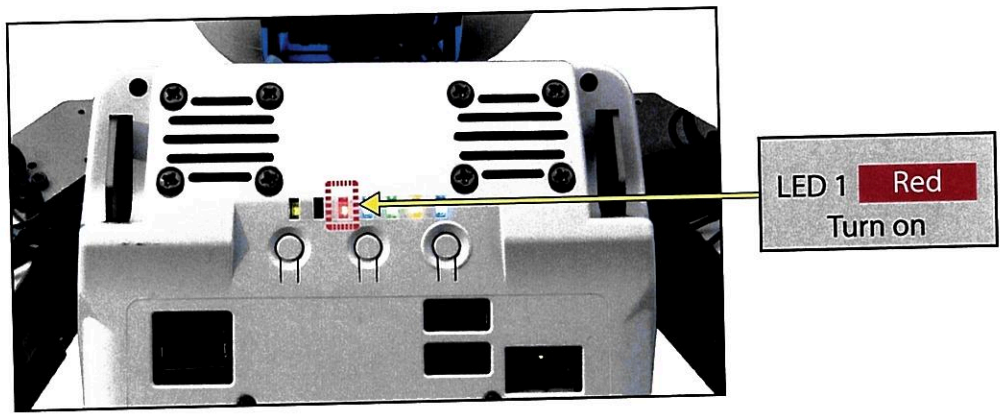


2-2. Autonomous Soccer Mode

ROBOTIS OP2 Follows and kicks a red ball (you can change the ball color) and plays a soccer by itself. When ROBOTIS OP2 falls down (either on its back or belly) it gets up, resumes ball search, and pursuit.

1) Start Autonomous Soccer Mode

① Press the MODE button until the LED 1 (red) is on.
ROBOTIS OP2 announces "Autonomous soccer mode."



② Press the START button to begin. ROBOTIS OP2 will stand up and announce Either "sensor calibration failed" or "sensor calibration complete."

ROBOTIS OP2 announces "sensor calibration failed" if the robot cannot calibrate its IMU's prior to walking. ROBOTIS OP2 will keep announcing "sensor calibration failed" until it achieves sensor calibration.

To minimize or prevent ROBOTIS OP2 announcing "sensor calibration failed" place ROBOTIS OP2 on a stable surface. Do not shake ROBOTIS OP2 during standing up as it may result in a failure to calibrate its sensors.

ROBOTIS OP2 announces "sensor calibration complete" calibration is complete and begins soccer mode. ROBOTIS OP2 make the announcement only once.

③ When ROBOTIS OP2 sees the ball it walks towards the ball.
Once the ball is close ROBOTIS OP2 kicks the ball with either its left or right foot. If ROBOTIS OP2 falls during pursuit or kick, it gets back up.

2) Stop Autonomous Soccer Mode

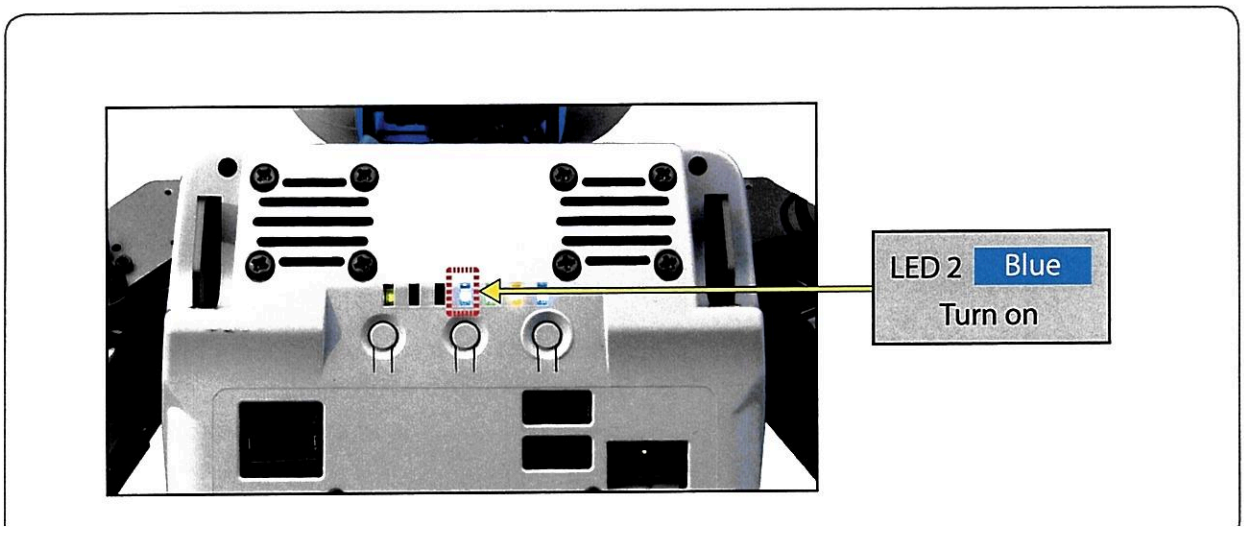
If you press the MODE button, ROBOTIS OP2 returns to Demonstration-Ready Mode.

2-3. Interactive Motion Mode

ROBOTIS OP2 performs pre-programmed motions sequentially while talking.

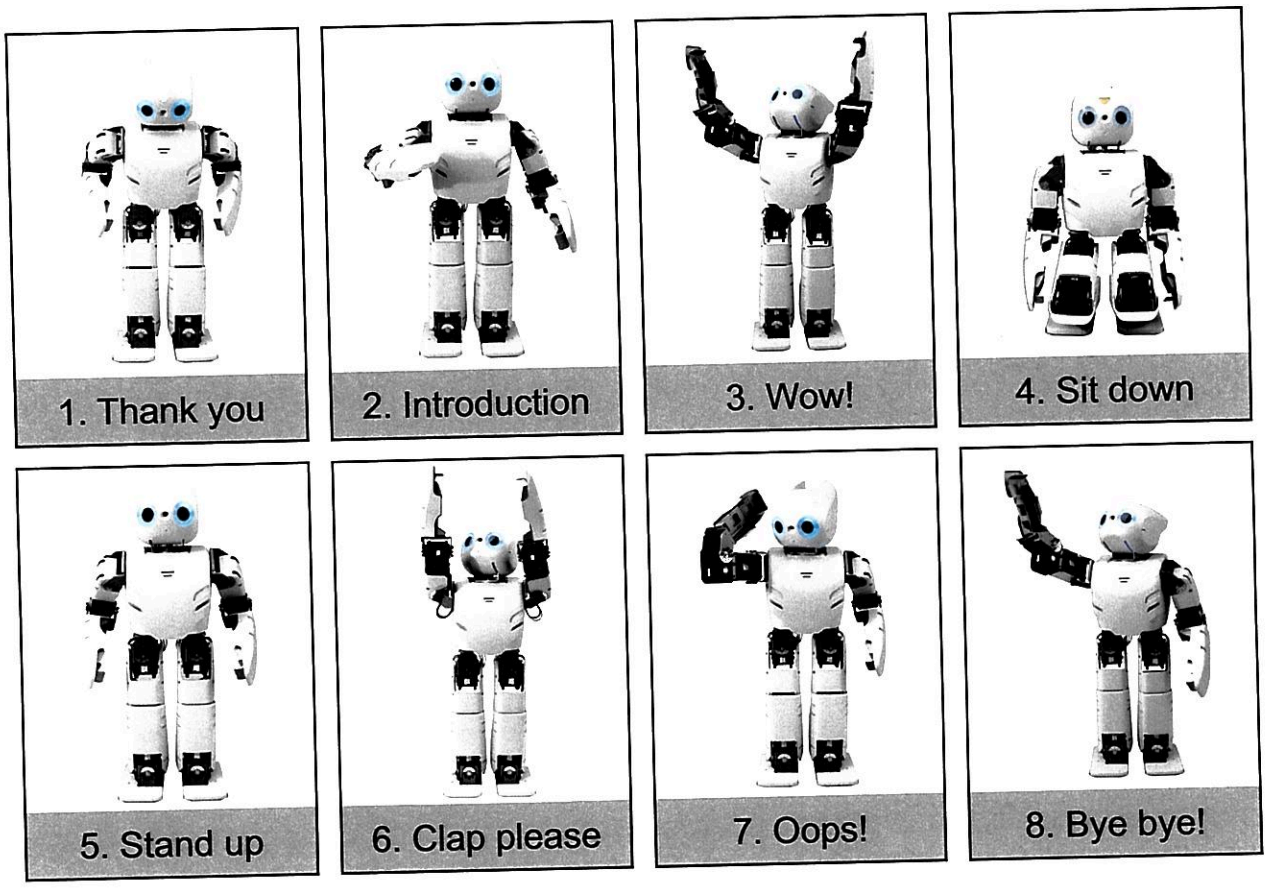
1) Start Interactive Motion Mode

① Press the MODE button until the LED 2 (blue) is on. ROBOTIS OP2 announces "Interactive motion mode."



② Press the START button to begin. ROBOTIS OP2 will stand up and announce "Start motion demonstration."

③ ROBOTIS OP2 performs the following actions sequentially.



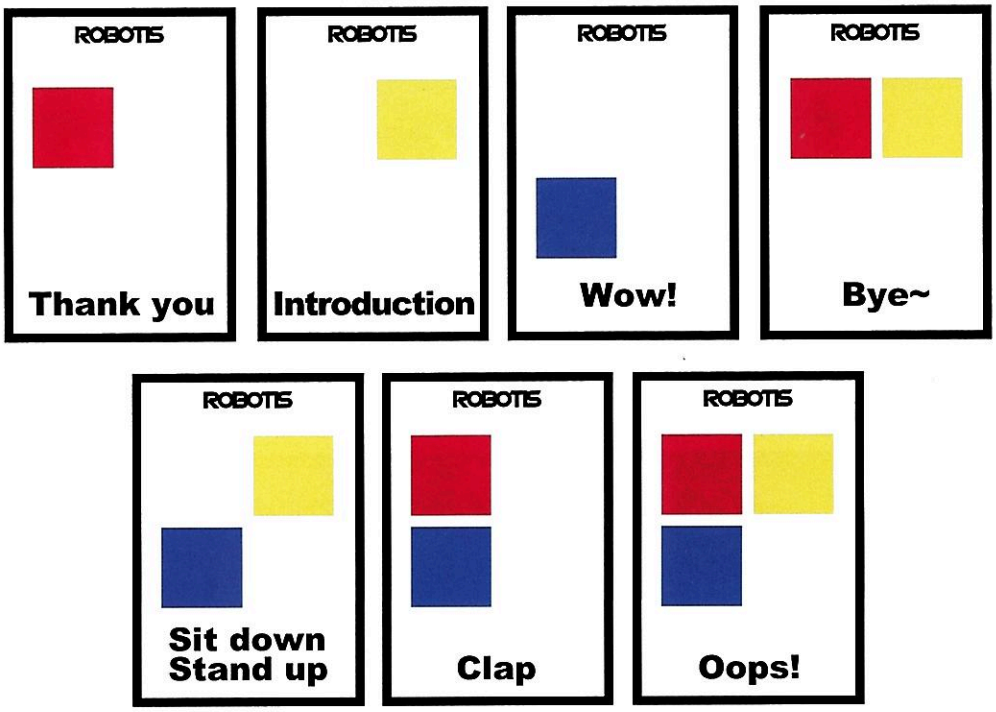
2) Stop Interactive Motion Mode

If you press the MODE button, ROBOTIS OP2 returns to demonstration-ready mode.

2-4. Vision Processing Mode

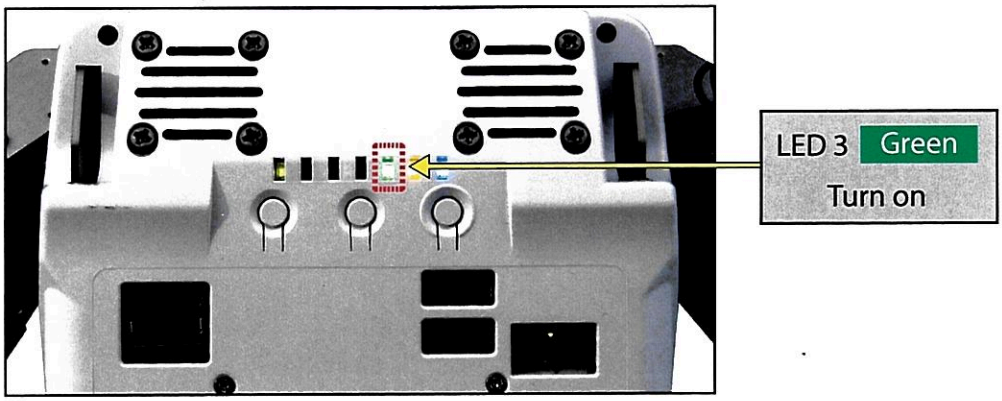
ROBOTIS OP2 will perform the same motions as when in interactive motion mode, but individually, depending on the color(s) card. Use the supplied color cards

Color Cards



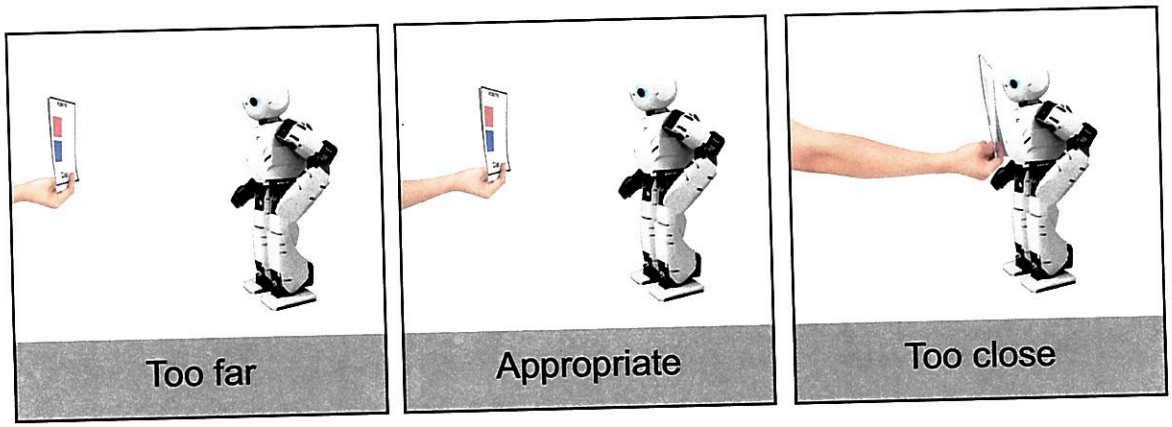
1) Start Vision Processing Mode

① Press the MODE button until LED 3(green) is on. ROBOTIS OP2 announces "Vision processing mode."



② Press the START button to begin. ROBOTIS OP2 announces "Start vision processing demonstration" and gets up.

③ Select a color(s) card and place it in front of ROBOTIS OP2. The color card should be approximately 15cm (about 6in) in front of ROBOTIS OP2.



2) Stop Vision Processing Mode

If you press the MODE button, ROBOTIS OP2 returns to demonstration-ready mode.

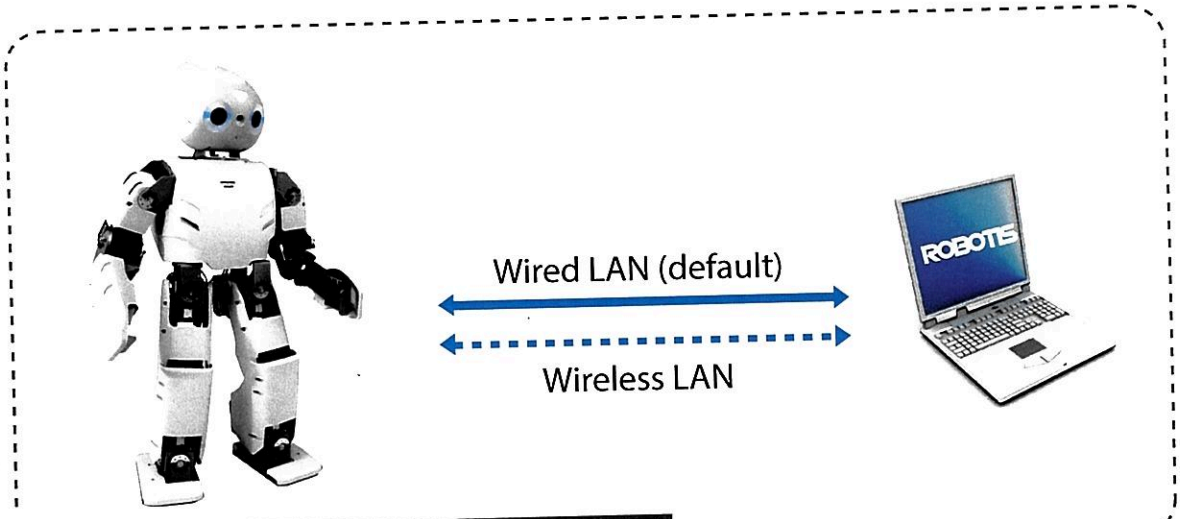
If ROBOTIS OP2 experiences difficulties with reading the card, you may need to adjust color and white balance. For more information, refer to the "Color and White Balance Calibration" section below or the e-manual by visiting http://support.robotis.com

3. Color and White Balance Calibration

If it the lighting around ROBOTIS OP2 is too bright or too dark, it may be difficult to operate ROBOTIS OP2.

You may change settings for color and white balance, and modify color settings to change ball color for soccer mode.

Connect ROBOTIS OP2 via ethernet cable for calibration



To be able to manipulate color settings you must

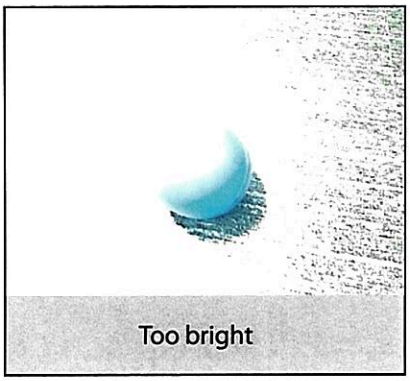
1) Connect to ROBOTIS OP2 via ether wired or wireless LAN.

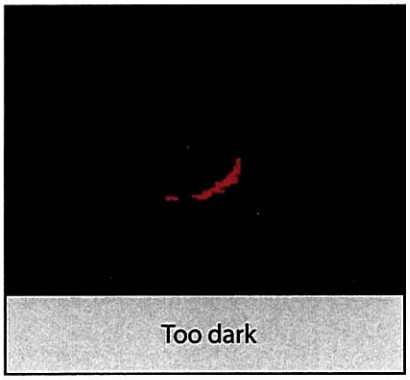
2) Check on the 'Obtain an IP address automatically' menu from the Internet Protocol (TCP/IP) properties of 'Local area connection properties'

from using Chrome as it will eventually cause a memory leak possibly causing your computer to crash.

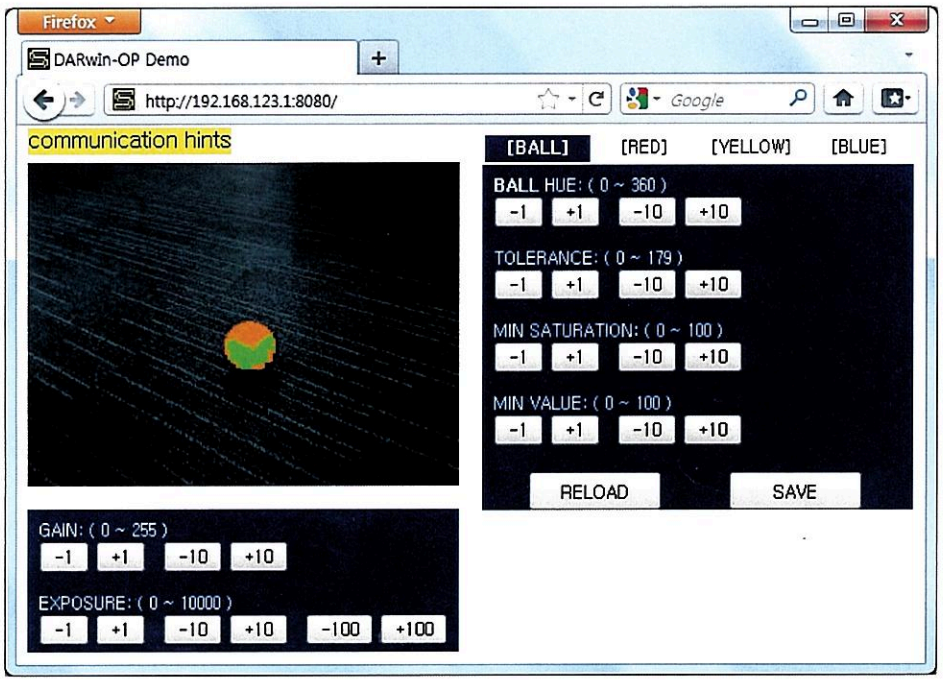
The following procedure to access color settings assumes a connection via wired LAN

1) Ensure you have a proper connection with ROBOTIS OP2.
2) Open up your computer's web browser.
3) On the address line type: http://192.168.123.1:8080
4) Click on the increment/decrement buttons until you have desired settings.
   You can see the changes visually.
5) Save any changes made if necessary.





Calibration

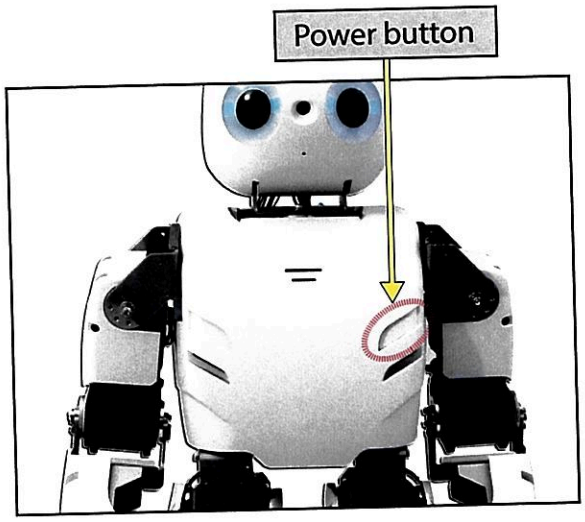


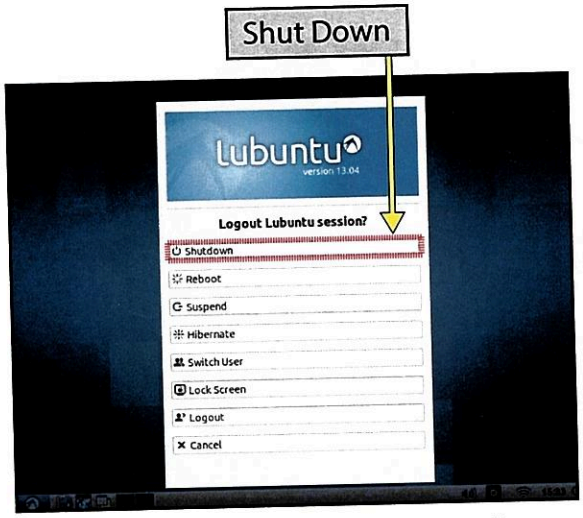
4. Turning ROBOTIS OP2 Off

To shut down the computer inside ROBOTIS OP2 perform one of the following:

1) Press the power button (1st depression), located on the front left side of the chest, once.

ROBOTIS OP2 will announce 'bye-bye" and begin the shut-down procedure.

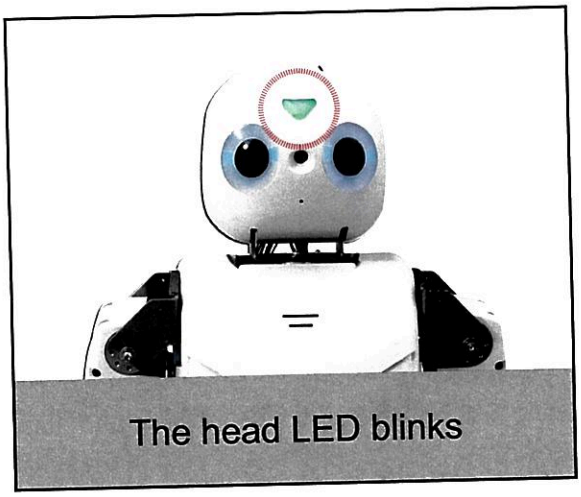


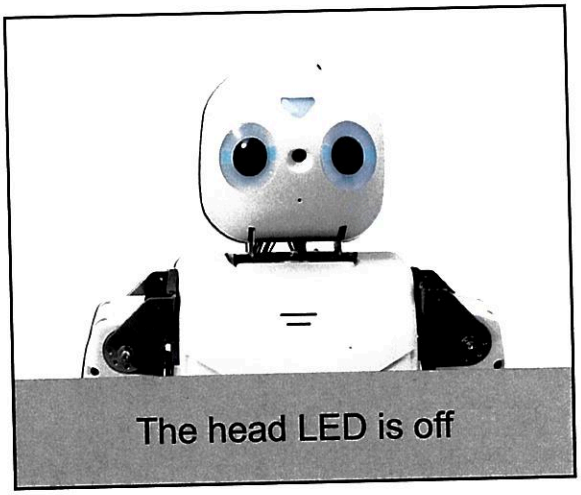


▲ The screen above may differ depending on the settings on X Window Manager.

ROBOTIS OP2's head LED will blink on and off (OS shutdown). Once the head LED stops blinking and remains off, you may cut the power off.

2) If ROBOTIS OP2 does not announce "bye bye" then you may need to force shut down by holding the power button until the head LED starts blinking.





If you cut the power off while the head LED blinks, ROBOTIS OP2 may have problems powering the next time.

1. Connect your PC to Main Controller

From your computer go to your LAN settings and set DHCP to automatic (Obtain an IP address automatically). Then connect an ethernet cable from PC to ROBOTIS OP2.

Example with SSH Client

1) Execute SSH client program (ex: PuTTY)

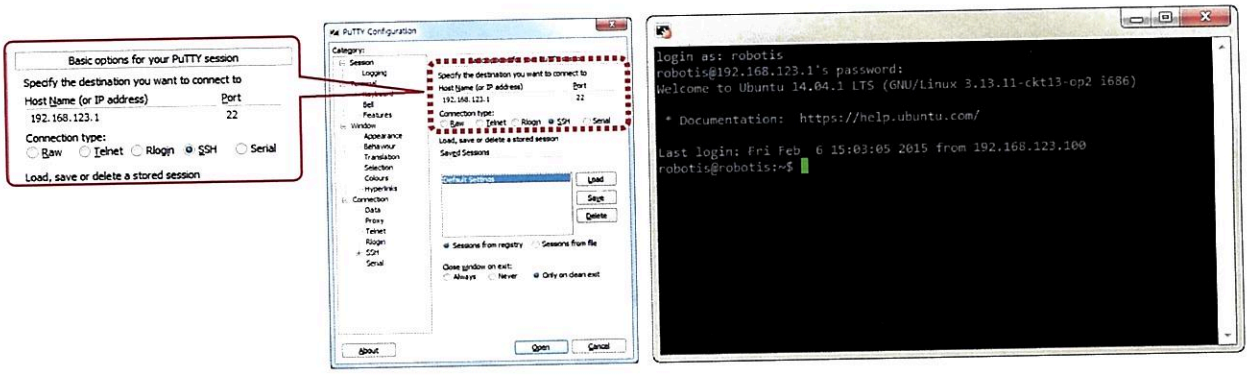
2) Input ROBOTIS OP2's IP address: **192.168.123.1**

3) Select **SSH** as a correction type and then open it.

4) Input ROBOTIS OP2's user name: **robotis**

5) Input ROBOTIS OP2's password: **111111**

ROBOTIS recommends that users connect via SSH client.



Example with Remote Desktop

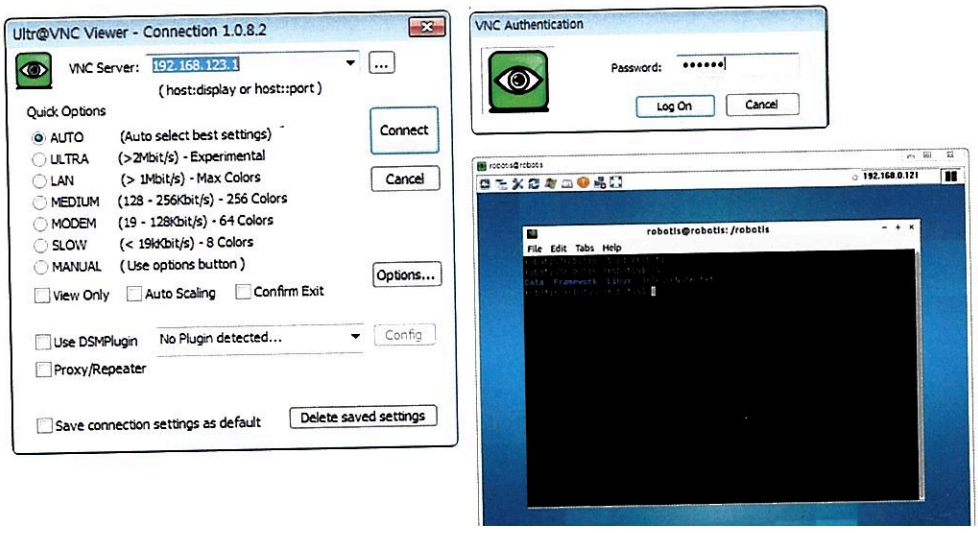
Users may connect via remote desktop if graphical interface is better accommodating.

1) Execute VNC client program (ex: Ultra VNC Viewer)

2) Input ROBOTIS OP2's IP address: **192.168.123.1**

3) Input ROBOTIS OP2's password: **111111**

Accessing ROBOTIS OP2 via remote desktop may result in slower performance.



◀ The screen on the left may differ depending on the settings on X

2. Development Environment

The following list is information on tools for source code development

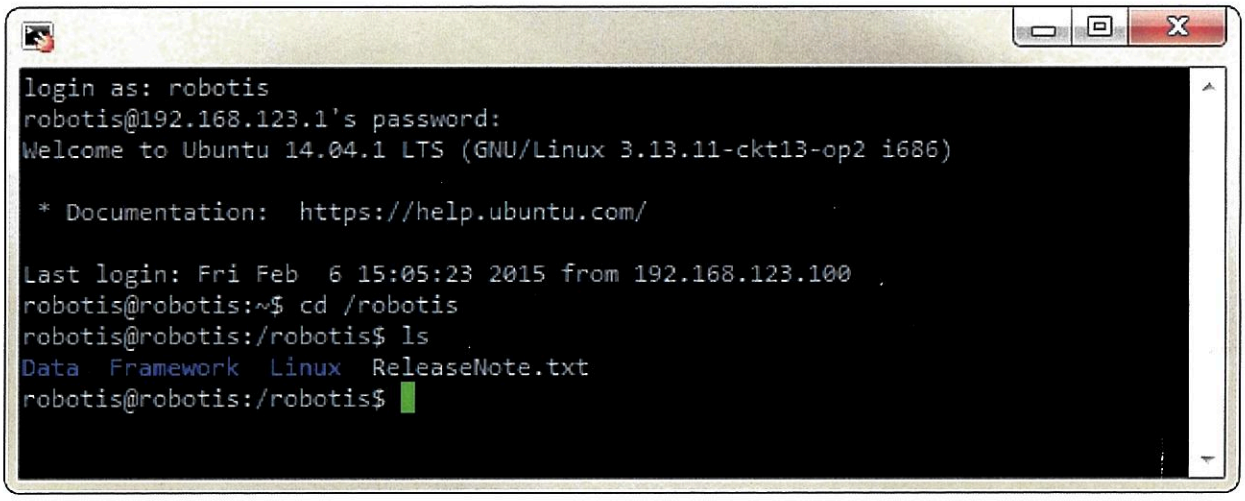
- OS : Linux (Lubuntu 13.04 32bit - recommended)
- Compiler : GNU project C and C++ Compiler
- Programming Language : C++

If you wish to learn more about ROBOTIS OP2 operations you may perform the tutorials provided with the source code. Tutorial files can be found at
/robotis/Linux/project/tutorial

For more detailed information please refer to the e-Manual.

3. Source Code

You may find the source code directory at '/robotis' from ROBOTIS OP2's PC.



The pre-installed source code may be updated without prior notice. Please check for updates periodically. You may obtain updated source code via the following :
Download from http://sourceforge.net/projects/darwinop

or

We strongly suggest you practice the included tutorial programs located in the directory '**/robotis/Linux/project/tutorial**'

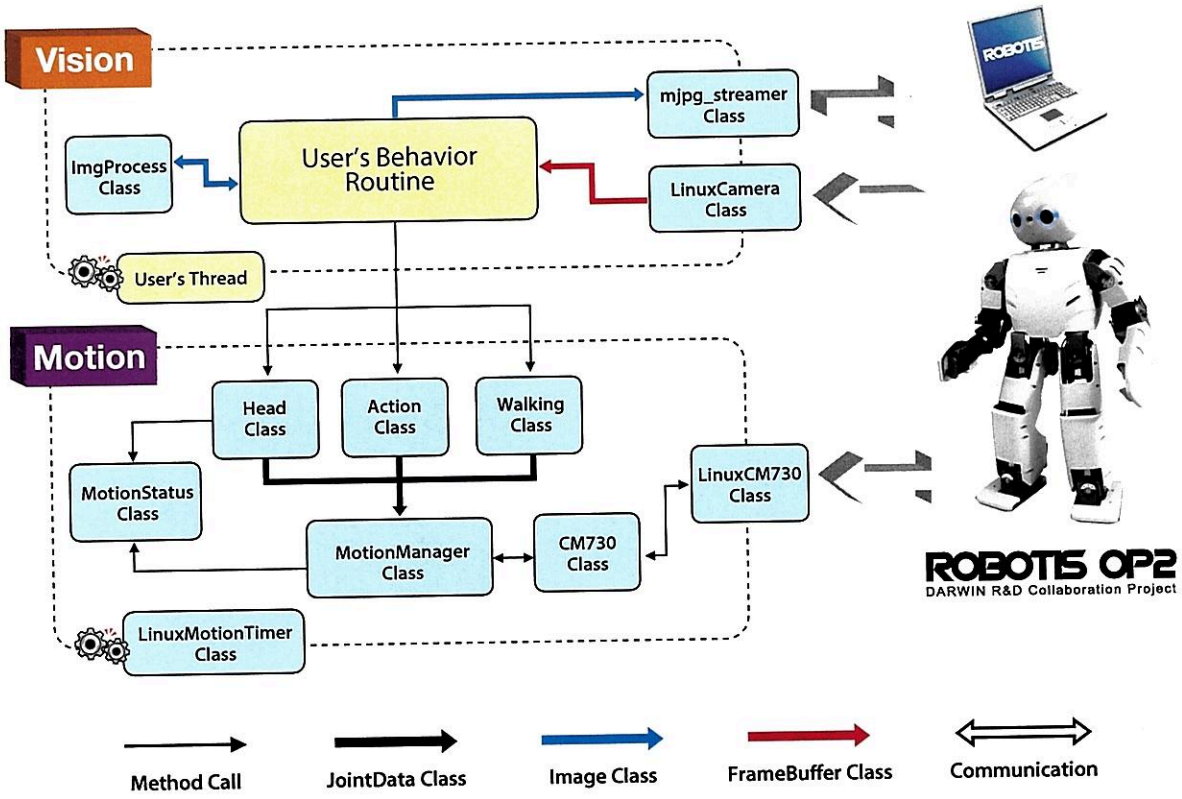
4. ROBOTIS OP2 Framework

The following flowchart diagrams represent class breakdown and data pipelines. You may modify the framework at

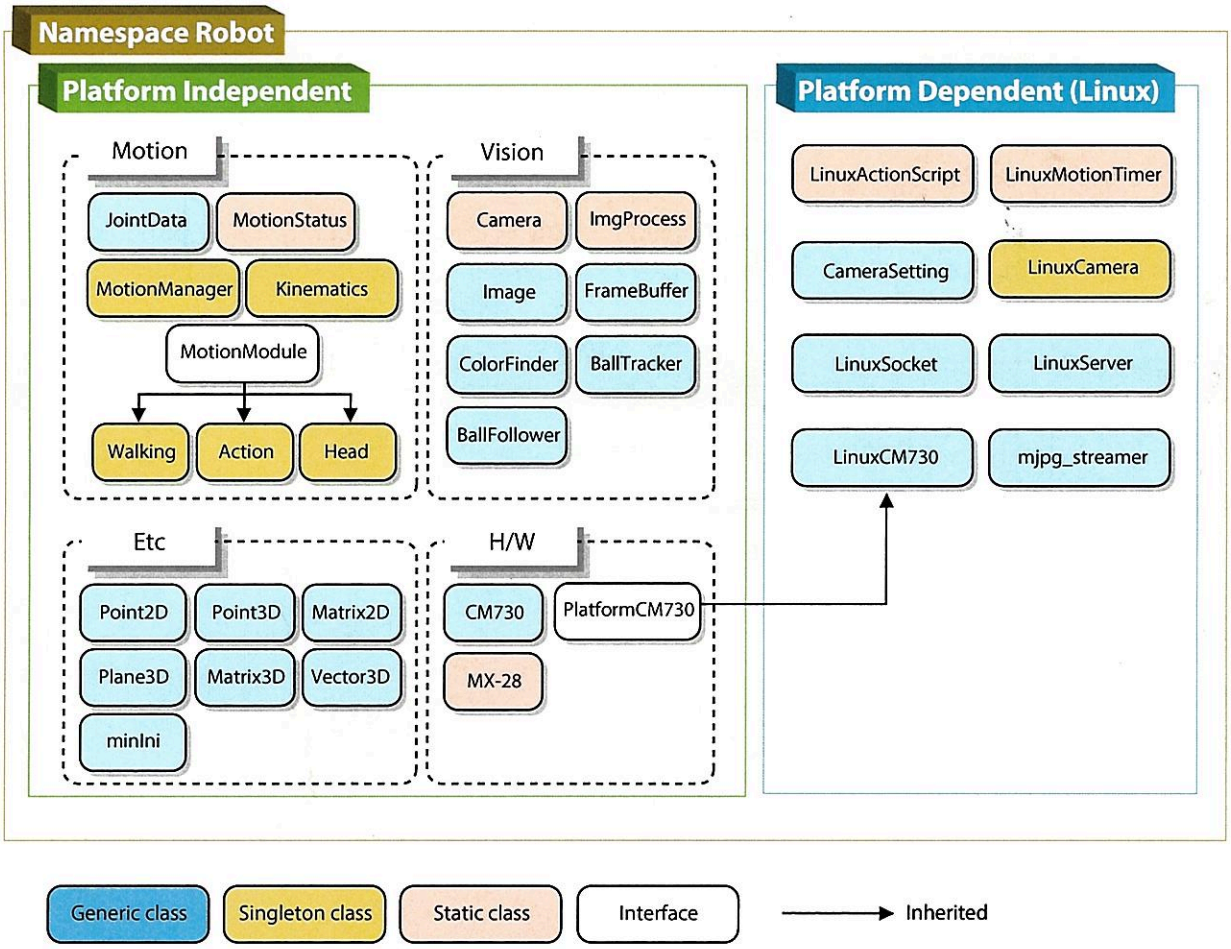
/robotis/Framework

For more information please refer to the e-Manual.

[ROBOTIS OP2 data flow diagram]



[ROBOTIS OP2 Framework Class Library Diagram]



5. S/W Utilities for Customizing and Diagnosis

Users who wish to either customize or diagnose ROBOTIS OP2 should establish a connection via SSH. The tools are located at the directory:
/robotis/Linux/project

From there you can find code for :

Customizing	**Motion creation/manipulation** (via RoboPlus or Action Editor) **Tuning** (walk parameters with Walk Tuner, robot pose offset with Offset Tuner)
Diagnosis	**dxl_monitor** (actuator and sub controller monitoring) **firmware_installer** (sub controller and actuator firmware installer)

For further information refer to the e-manual :
http://support.robotis.com

6. Recovery Software

The supplied USB thumb drive contains the same software that comes preinstalled with ROBOTIS OP2. You may obtain updates softwares at the link below.

http://support.robotis.com

Software updates may be performed without prior notice. Please check the site periodically for update information. For more information please refer to the e-Manual.

7. Useful Information

You may download other ROBOTIS OP2-related items at:

http://sourceforge.net/projects/darwinop

For more detailed information on ROBOTIS OP2 please refer to the e-Manual.
The e-Manual can be found at :

http://support.robotis.com

for any other inquiries send us an email at :

International : contactus2@robotis.com

Korea : korea@robotis.com

Third party terminal client

PuTTY : ***http://www.chiark.greenend.org.uk/~sgtatham/putty/***

VNC : ***http://www.realvnc.com/***

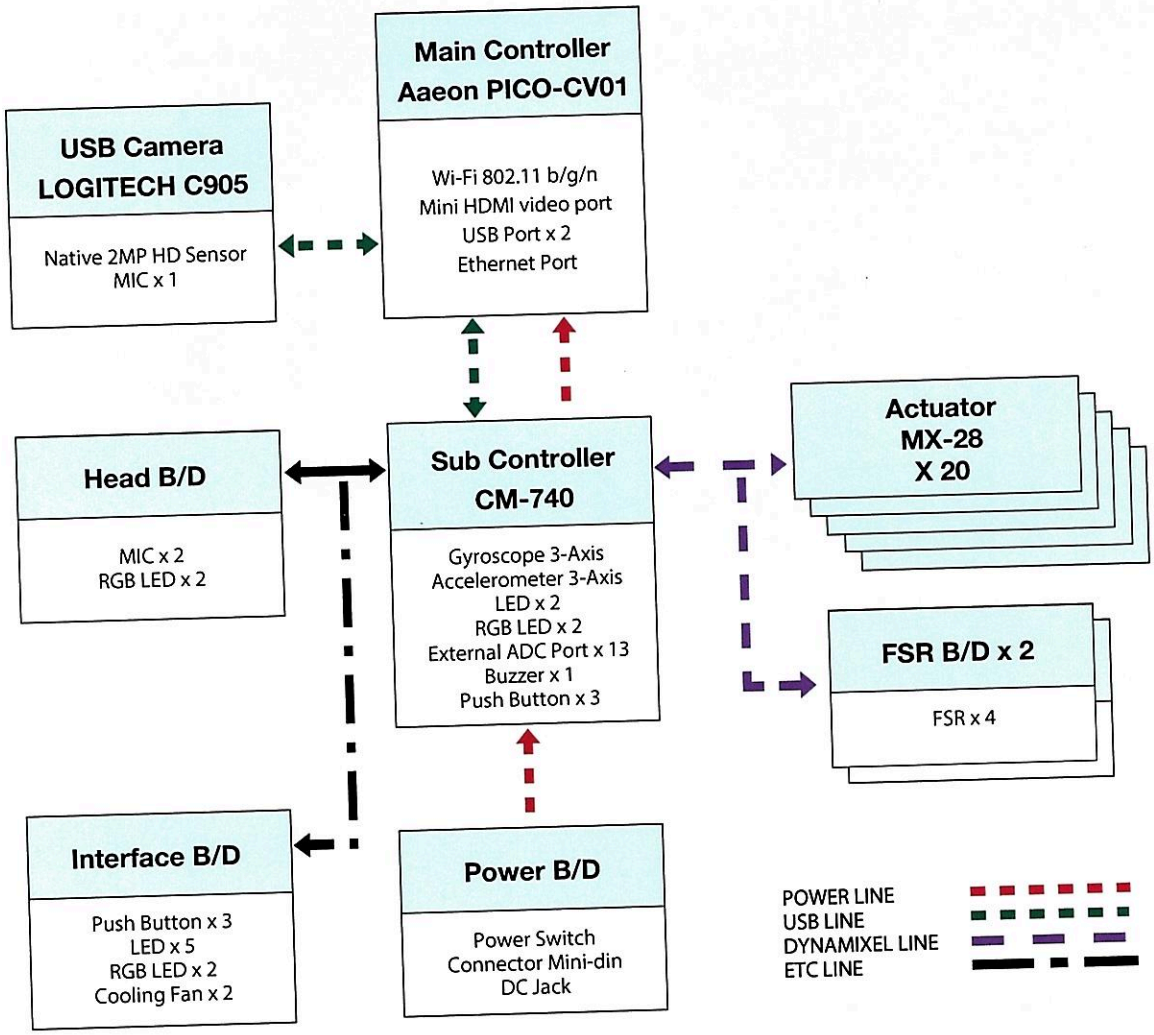
ZOC : ***http://www.emtec.com/zoc/***

RBrowser (for Mac users) : ***http://www.rbrowser.com/***

Chicken of the VNC (for Mac users) : ***http://sourceforge.net/projects/cotvnc/***

1. System Block diagram

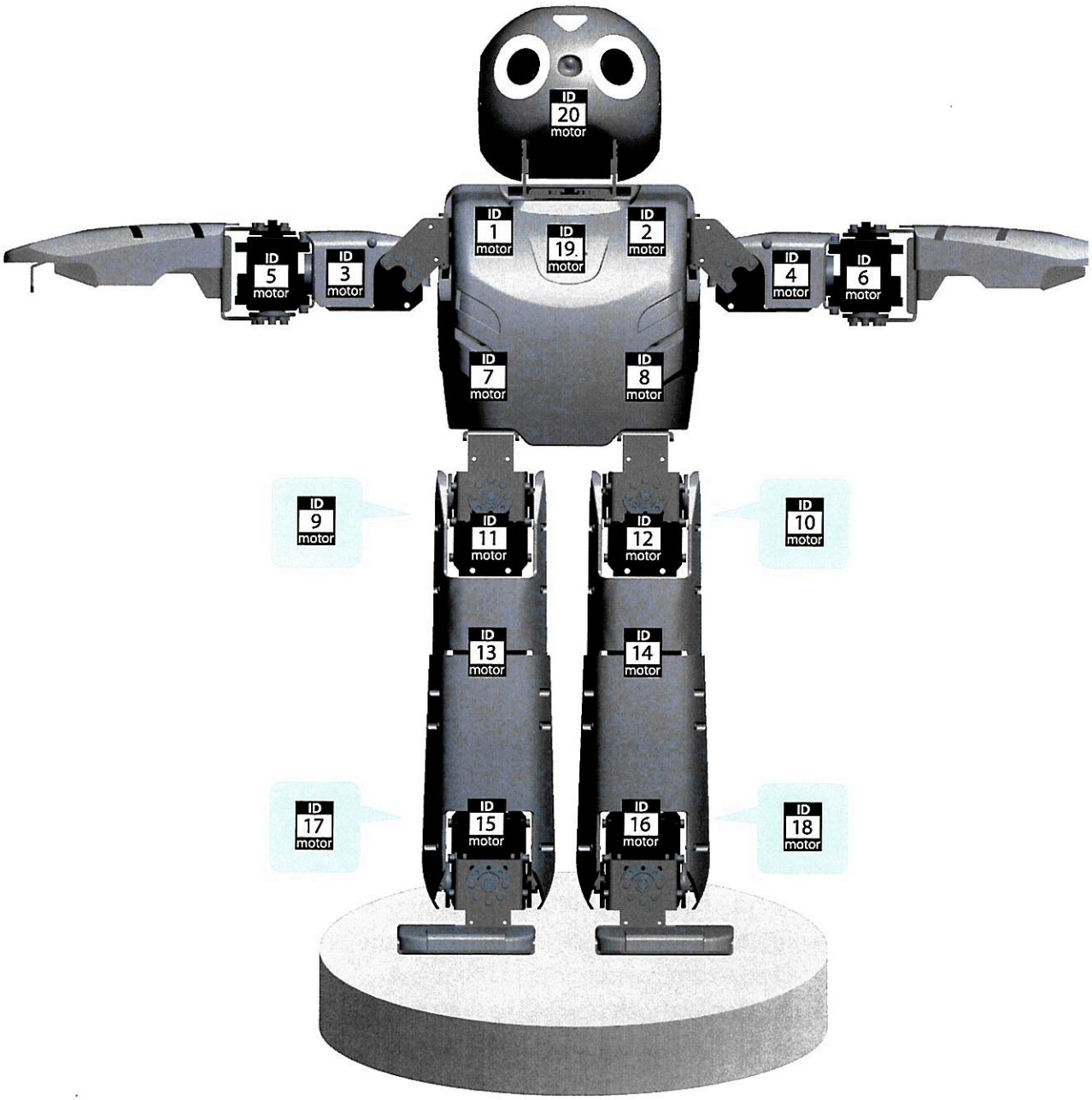
The diagram below illustrates the overall structure of ROBOTIS OP2's system.



1) **Main controller** powered by Intel Atom N2600 dual-core, dual-threaded.
2) **Sub controller** powered by STMicroelectronics Cortex-M3 STM32F103RE (clocked at 72 MHz).
3) **Camera**
   ① 2MP HD webcam with up to 1600x1200 resolution (720p-capable)
   ② 1600×1200@10fps, 1280×720@30fps
   ③ Output : YUYV, MJPG
   ④ Carl Zeiss® optics with autofocus

2. ID Map

The following diagram illustrates the actuators ID numbers in ROBOTIS OP2's default configuration.



3. Warranty

ROBOTIS OP2 includes the following warranty :

A. 90 days warranty against manufacture defects (RMA required) *

B. Local Maintenance Service (by local partner) : 1 years **
- Re-installation of S/W and firmware
- Replacement for cable/gear/screw (RMA required – exempt from faulty return)
- Replacement for faulty frame/cover/actuator (RMA required)

C. Core System Maintenance Service (by ROBOTIS) : 1 years
- Replacement for faulty PC/sub-boards (RMA required)
- Maintenance for actuator/sub-boards (RMA required)
- Maintenance for PC (RMA required, additional fee applies)

D. Parts replacement for malfunctions during normal operation for 1 years.

* Please download RMA (Return Material Authorization)
Form at ***http://en.robotis.com/index/service_04.php?tab=4***
No return shipping will be accepted without a RMA number issued by ROBOTIS.

** Customers who require extended warranty period may purchase another "1 year warranty" from ROBOTIS before their standard warranty period is over.

Important Notice:

1. Product registration is required for all customers. ***http://support.robotis.com***
2. Parts replacement can only be done through RMA(Return Material Authorization) application.
3. After the initial 90 days, shipping fee is not covered under warranty.
4. Warranty does NOT cover ordinary wear/tear, any accident or damage caused by followings.
   - Physical damage equivalent to dropping the robot from 20cm or higher
   - Disabling system safety function (DYNAMIXEL Overload Shutdown)
   - Dangerous movement (jump, roll, fight) or excessive operation without rest
   - Any liquid or unauthorized chemical material to the robot
   - Unauthorized power or electric shock applied to the robot
   - Improvising core system programming area.
5. Direct check-up service
   Evaluation, maintenance and quality assurance of assembled robot can be provided by ROBOTIS only.
   RMA is required and additional fee may apply. Service will not be rendered for seriously [illegible] hardware