Poppy Humanoid Robot Assembly Guide

Manon Cortial, Gnration Robots

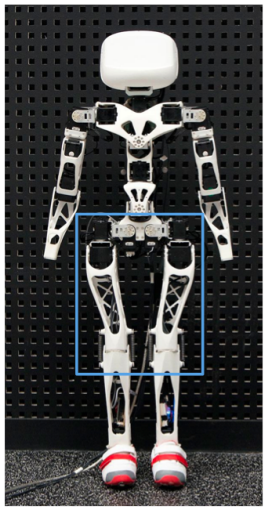
May 7, 2015

1 Introduction

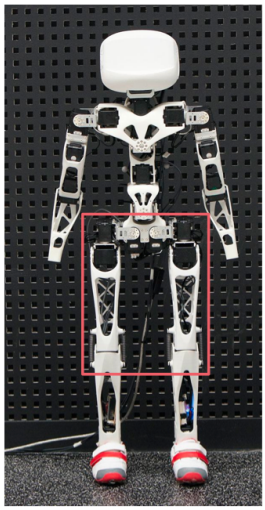
1.1 The Poppy project

Poppy is an open hardware and open-source robotics project. It has been designed to allow researchers and students to easily remove and replace some parts of the body.

For example, different leg shapes have been tested on the Poppy Humanoid robot to make the robot walk.



(a) bended thighs



(b) straight thighs

1.2 Safety warning

The Poppy humanoid robot is built using mainly MX-28 Dynamixel servomotors, which are pretty powerful and may be harmful to your fingers or materials.

So be very careful and put the robot in a free space while testing your programs.

1.2.1 About this documentation

This documentation contains some help and tips to build a Poppy Humanoid robot. It does not replace the videos made by Inria, but complete and sometimes corrects or updates them.

It contains a bit of context about Dynamixel servomotors and how to assemble them (section 2) and also how to set the right parameters for them (section 3).

You will also find pictures of all the parts to help you name them (section 4), then assembly tips and links to the assembly videos (section 5). As there is no video for the head assembly, this doc contains a pretty complete guide for head assembly (section 5.4).

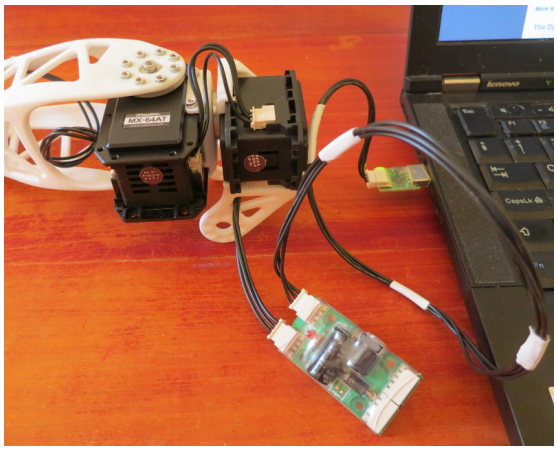
At the end, you will find a list of useful links (section 6) to help you find more information and help.

Please don't hesitate to comment and correct this documentation on the Poppy forum !

2 Dynamixel hardware

The Poppy Humanoid robot is mainly built with MX-28AT Dynamixel servomotors (MX-28T are the previous version and can be used without any problem). The other servomotors are MX-64T (bigger and stronger) and AX-12A (smaller, used for the head).

Each Dynamixel servomotor embeds an electronic board allowing it to receive different kind of orders (about goal, torque...) and communicate with other Dynamixel servos. Therefore, you can chain up several Dynamixel servomotors (each with a different ID) and command them all from one end of the chain: each servomotor will pass the orders to the next one.

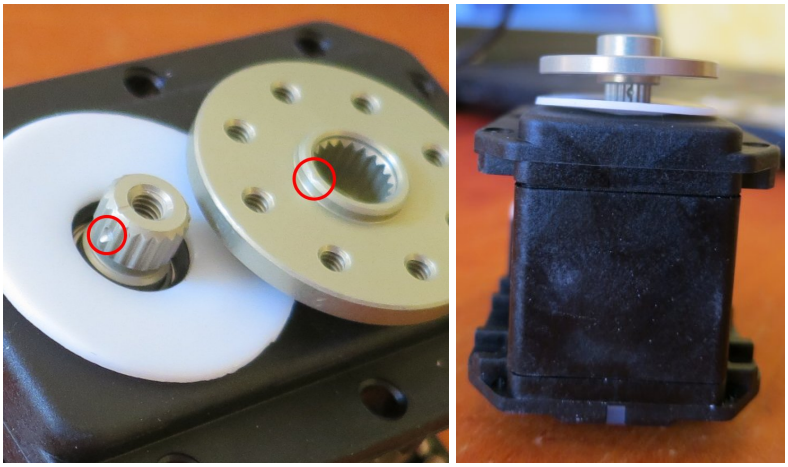


2.1 Putting the Dynamixel horns to zero

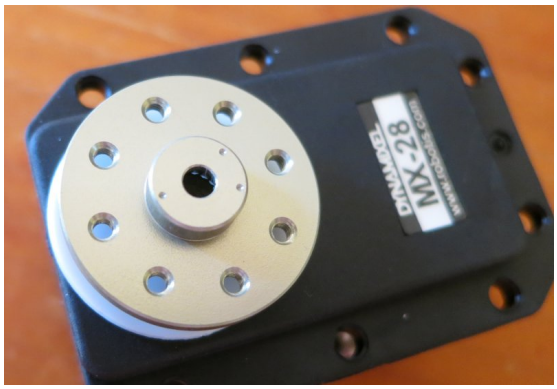
This step is critical to avoid damaging your Dynamixel servomotors !

When you receive your Dynamixel servomotors, the horns are not mounted. They are included in the packaging if the servo is packaged alone or packaged separately for 6-pieces bulks (see next section to know what horn goes to what servo).

When putting the controlled horn, be very careful to **put the dot on the horn at the same point than the dot on the servo axis**. Once the horn is put, it is most of the time **impossible to remove** ! This will ensure that the zero position of the servo matches with the zero position of the structure around.



On the outside of the horn, you also have three dots indicating the orientation. You should find the same three dots on structural parts, so be sure to match them.



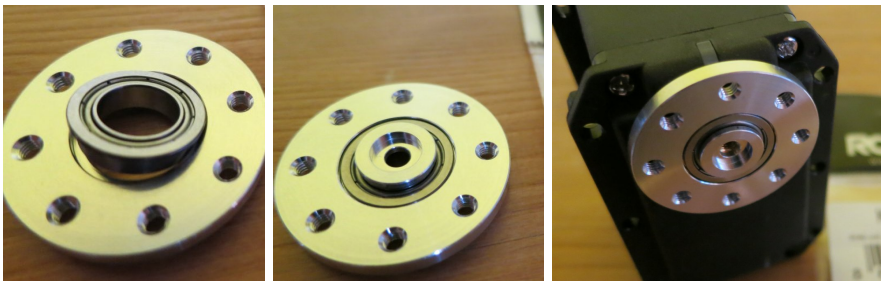
2.2 Horns of MX-28 and MX-64

On each Dynamixel servomotor apart from the AX-12A, you will have to mount a horn to the motor axis. Most of the time, you will also have to mount a free horn on the opposite side to provide better fixation points for the structure parts.

To mount the main horn, put the plastic ring (white or black) and drive the horn on the axis. **Be careful of the zero when putting the main horn!** Then put thread locker on the big screw and screw it in the middle.

Main horn mounted on a MX-28

For the free horn, first clip the ball bearing and the cap on the side without shaft shoulder. Then put the horn on servomotor (with shaft shoulder on servo side). Put thread locker on the big screw and screw it. The horn should turn freely.



Free horn mounted on a MX-64

Quick reminder of horn names and screw sizes:

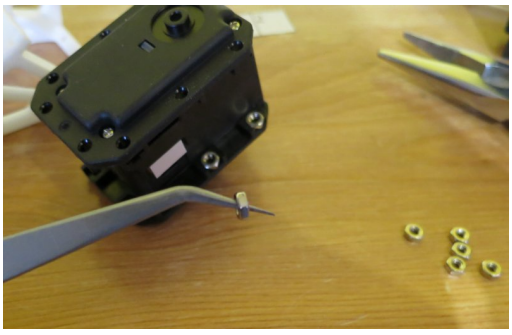
Servomotor	main horn	free horn	big horn screw	horn screws	case screws
AX12-A	none	none	⌀3x10mm	⌀2	⌀2
MX28	HN07-N101	HN07-I101	⌀2.5x8mm	⌀2x3mm	⌀2.5x6mm
MX64	HN05-N102	HN05-I101	⌀3x8mm	⌀2.5x4mm	⌀2.5x6mm

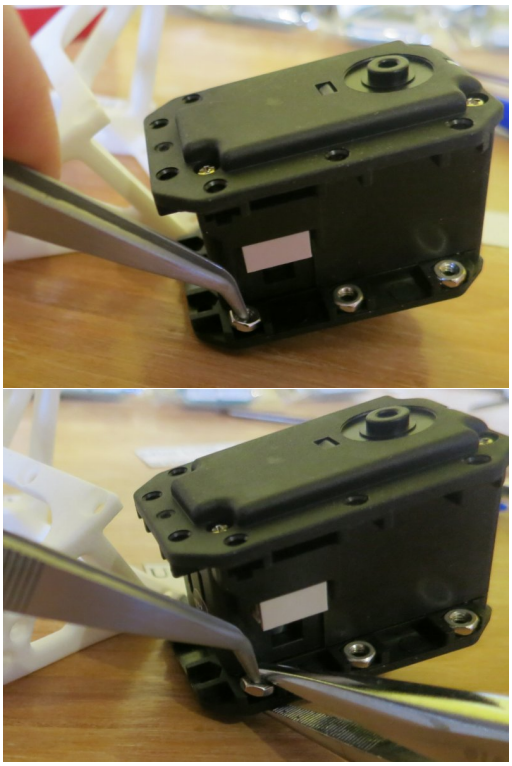
You need 1.5mm for ⌀2 screws, an allen wrench of size 2mm for ⌀2.5 screws and 2.5mm for ⌀3 screws.

2.3 Putting the nuts

To attach structural parts on the body of the servomotors, you have to first insert the nuts in their sites. This step may be quite painful if you don't have elfic fingers.

Here's my tip: take the nut using thin tweezers and bring it in the site with the right orientation. Put the end of the tweezers in the hole to ensure good alignment. Then use flat pincers to ajust the nut.





These nuts correspond to diameter 2.5mm screws, Allen wrench 2mm.

To build a full Poppy Humanoid robot, an electrical screwdriver is strongly advised!

3 Addressing Dynamixel motors

By default, every Dynamixel servomotor has its ID set to 1. To use several servomotors in a serial way, each of them must have a unique ID.

3.1 Installing the driver for USB2AX

USB2AX is the device that will connect the Poppy Humanoid robot's head to the Dynamixel servomotors. It can also be used to control the servomotors directly from your computer and that's what we will do to address the motors.

On Linux, no installation is needed, but you must add yourself in the dialout group to have access to the USB port:

```
sudo addgroup "username" dialout
```

Otherwise, the driver is available here.

Don't forget to power up your motors (using a SMPS2Dynamixel) otherwise they won't be detected !

3.2 Installing the scanning software

Use one of the two following software to access the Dynamixel servomotors registers:

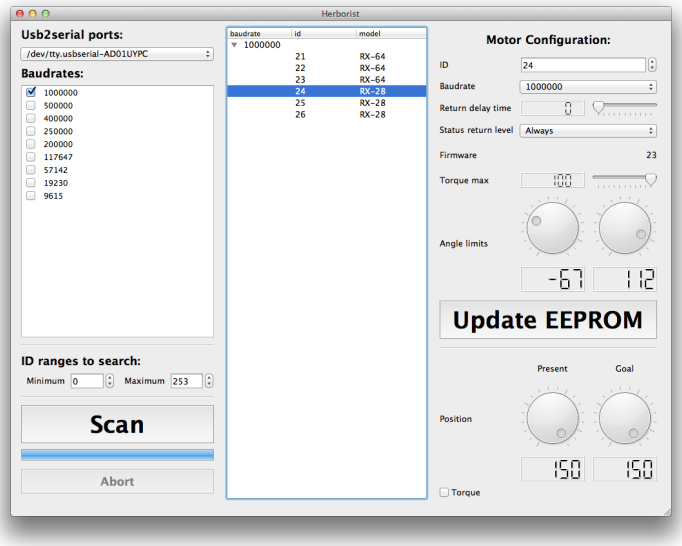
- Herborist: tool created by the Poppy Project team.
- Dynamixel Wizard: windows-only tool provided by Robotis.

Herborist comes with the Pypot library, but needs the additional library PyQt4 for graphical interface.

```
sudo pip install pypot
sudo apt-get install python-qt4
```

It should then be directly accessible for a terminal:

```
sudo herborist
```



Connect each motor **one by one** to the USB2AX and use the 'scan' button in Herborist or Dynamixel Wizard to detect it. If it's a new motor, it should have ID 1 and baudrate 57600bps, apart from AX-12A servos who already have a 1000000 baudrate.

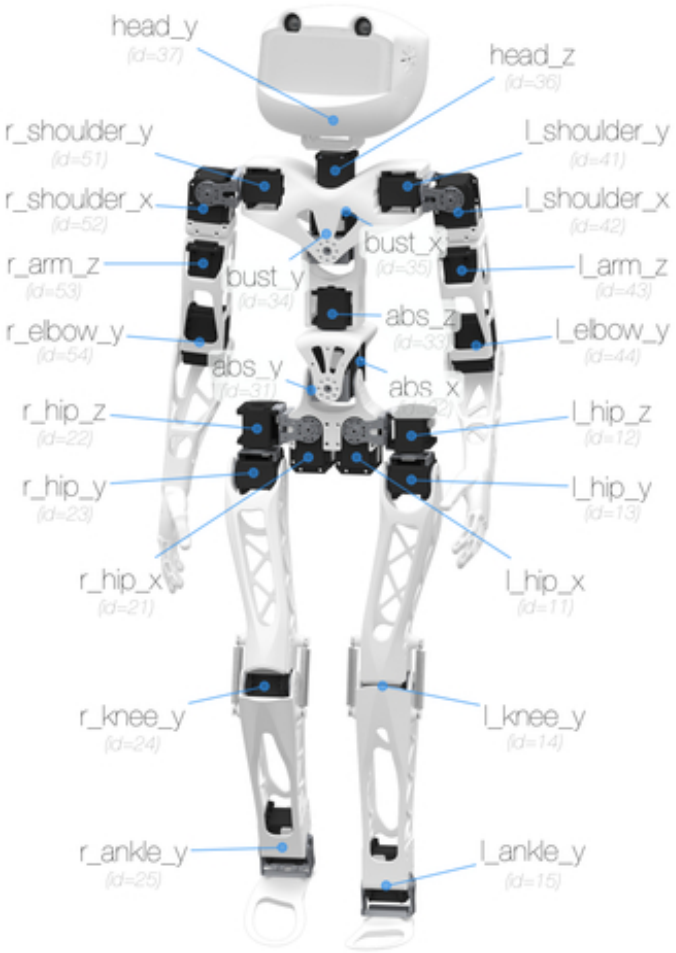
You have to set:

- ID corresponding to the naming convention
- Baudrate to 1 000 000 bps
- Return delay time to 0 ms instead of 0.5 ms

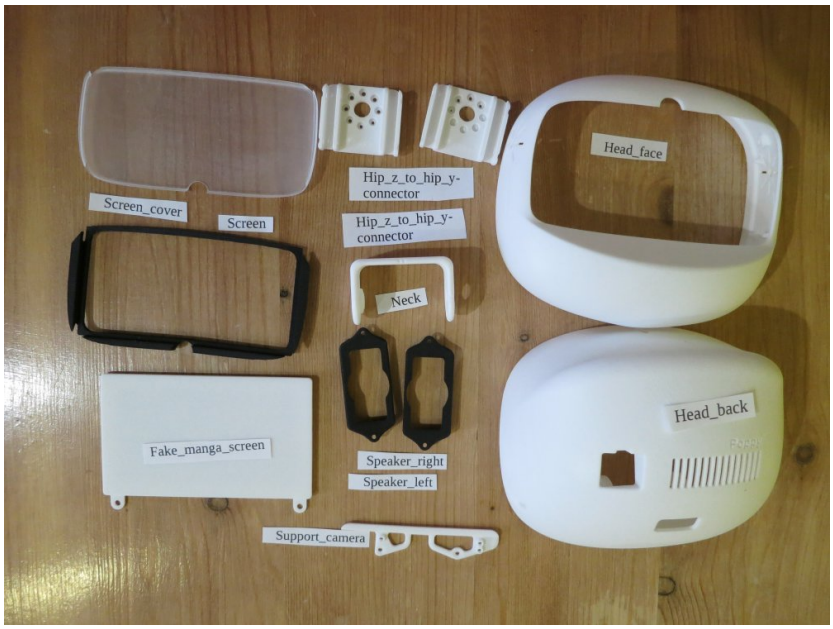
In Herborist, don't forget to click on the 'Update EEPROM' button so the changes are taken in account.

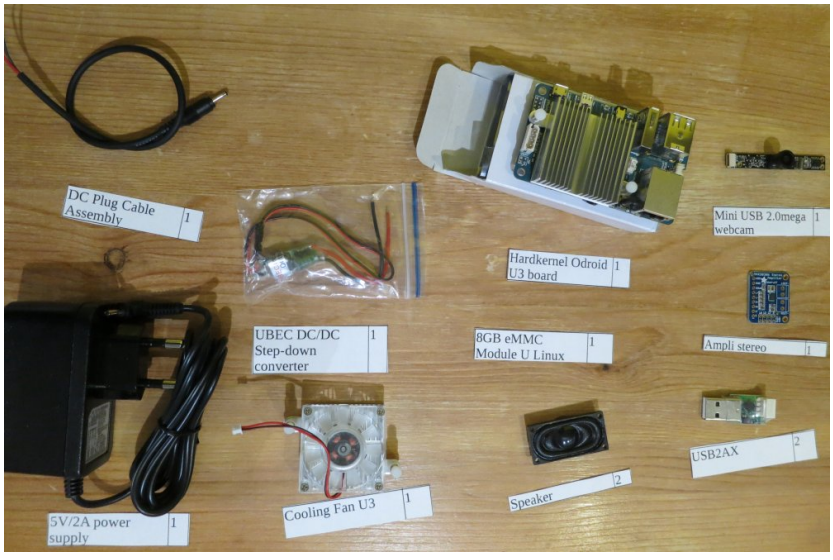
3.3 Naming conventions

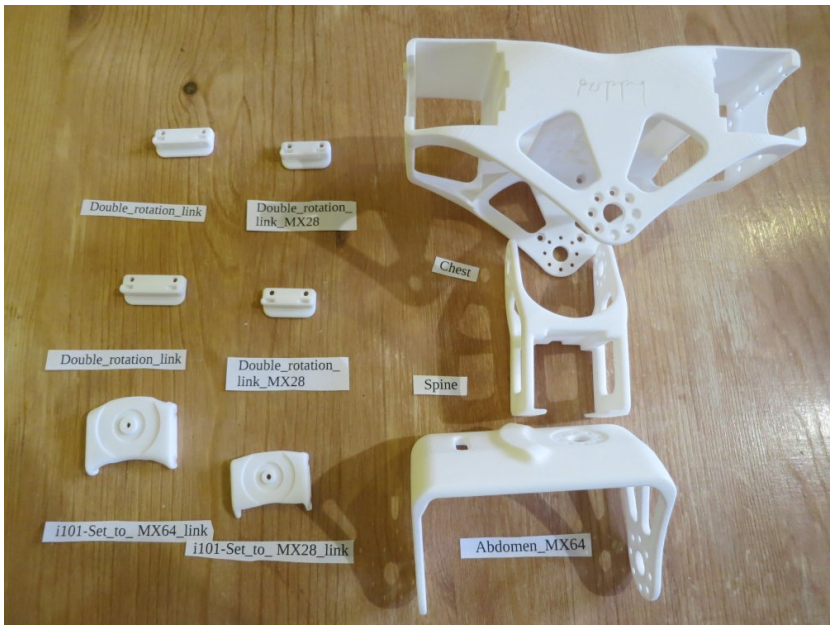
If you want your PoppyHumanoid object to correspond to your robot without having to modify the configuration file, you should stick to the Poppy Humanoid robot naming and addressing convention. This will ensure that, in your code, when you use a motor's name, you will really send orders to the corresponding physical motor.

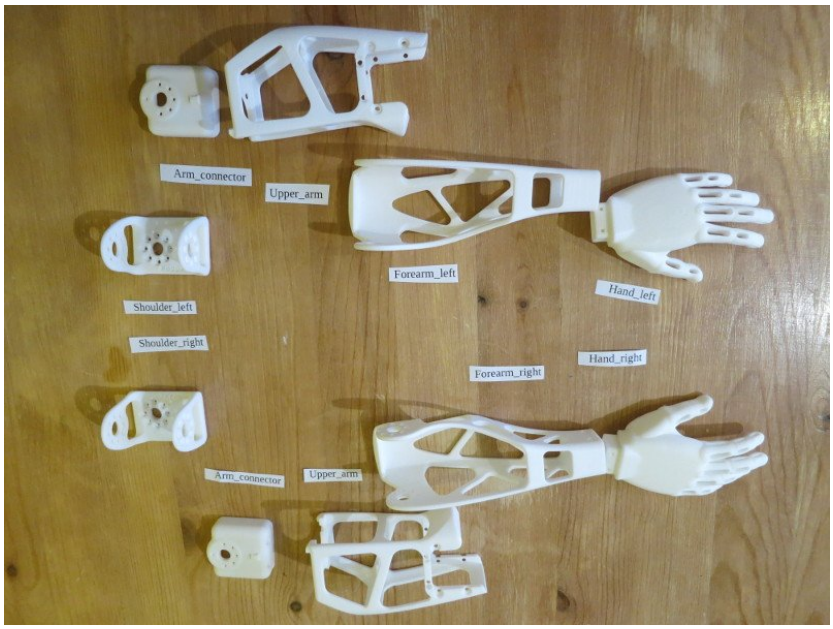


4 Structural parts





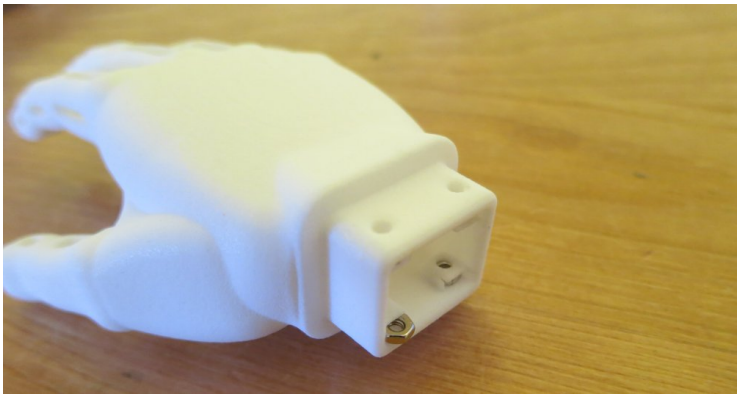

Double_rotation_link
Double_rotation_
link_MX28
Chest
Double_rotation_link
Double_rotation_
link_MX28
Spine
i101-Set_to_ MX64_link
i101-Set_to_ MX28_link
Abdomen_MX64


Arm_connector
Upper_arm
Forearm_left
Hand_left
Shoulder_left
Shoulder_right
Forearm_right
Hand_right
Arm_connector
Upper_arm

5 Assembly tips

5.1 Arms

- **Right/Left forearm** The hand design slightly changed from the videos, but the nuts and screws remain the same.



- **Right/Left upper arm** Plug a 200mm cable in the unused plug before screwing the arm_z motors (ids 43 and 53), because it will be really hard to plug once the motor is inside the structure part.
- **Right/Left upper arm/shoulder**

- **Right/Left arm assembly**
- **Trunk and arms assembly** To distinguish between left and right shoulder parts, look at the three dots: the single dot should be down when the shoulder is in "zero" position (along the shoulder_y motor).

Motors lists:

Sub-assembly name	Motor name	Type	ID
Left upper arm/shoulder	l_shoulder_x	MX-28AT	42
Left upper arm	l_arm_z	MX-28AT	43
Left upper arm	l_elbow_y	MX-28AT	44

Sub-assembly name	Motor name	Type	ID
Right upper arm/shoulder	r_shoulder_x	MX-28AT	52
Right upper arm	r_arm_z	MX-28AT	53
Right upper arm	r_elbow_y	MX-28AT	54

5.2 Trunk

- **Double MX64**
- **Double MX28** Don't screw the i101-Set_to_ MX28_link (the plastic part with a free horn on it) too tightly, or don't screw it at all since you will need to unscrew it during the trunk assembly.
- **Spine**
- **Chest** The video shows a HN07_I101 in the prepared parts, but you don't need it.
- **Trunk assembly** You have to insert the nuts in the chest before mounting the double MX-28 part. You also have to put nuts in the abdomen before mounting the double MX-64 part.

  The abdomen part you have has a "Poppy" mark on the back, while the one on the video don't. You also have holes to screw the SMPS2Dynamiel, instead of sticking it (use 2.5*8mm screws).

Motors list:

Sub-assembly name	Motor name	Type	ID
Double MX64	abs_y	MX-64AT	31
Double MX64	abs_x	MX-64AT	32
Spine	abs_z	MX-28AT	33
Double MX28	bust_y	MX-28AT	34
Double MX28	bust_x	MX-28AT	35
Chest	head_z	AX-12A	36
Chest	l_shoulder_y	MX-28AT	41
Chest	r_shoulder_y	MX-28AT	51

5.3 Legs

There is only a video for left leg assembly. While assembling the right leg, be sure to put your motors symmetrical compared to the left leg. Also don't forget to change the motors IDs from 12-15 to 22-25.

- **Hip**
- **Tight**
- **Shin** If you received your Poppy kit from Generation Robots, you can use the custom 220mm cables instead of really short 200mm cables.
- **Right/Left leg assembly**
- **Pelvis** The videos shows ⌀2x5mm screws. Use the ⌀2x6mm screws that you can find in the Bolt-nut set BNS-10.

- **Torso and legs assembly**

Motors lists:

Sub-assembly name	Motor name	Type	ID
Pelvis	l_hip_x	MX-28AT	11
Left hip	l_hip_z	MX-28AT	12
Left hip	l_hip_y	MX-64AT	13
Left thigh	l_knee_y	MX-28AT	14
Left shin	l_ankle_y	MX-28AT	15

Sub-assembly name	Motor name	Type	ID
Pelvis	r_hip_x	MX-28AT	21
Right hip	r_hip_z	MX-28AT	22
Right hip	r_hip_y	MX-64AT	23
Right thigh	r_knee_y	MX-28AT	24
Right shin	r_ankle_y	MX-28AT	25

5.4 Head

Sub-assembly name	Motor name	Type	ID
Head	head_y	AX-12A	37

5.4.1 Setup of the Odroid board

The Odroid is normally shipped with a eMMC module with Ubuntu 1.14 already flashed (it should have a red sticker on it). Simply plug it on the Odroid board and power it. After boot time, it should have the red light steady and the blue light flashing.

If you don't have a pre-flashed eMMC module, follow these instructions: `https://github.com/poppy-project/poppy_install`

Connect the Odroid board to your network using an ethernet cable. You have to access a wired network for initial setup (I tried link-local without success).

Windows users may wish to install the Bonjour software (the link is for the printer version, which does very well what we want it to do). Bonjour is installed by default on Linux and Mac. It is used to communicate with another device using its name instead of its IP.

You should get an answer if you type:

```
ping odroid.local
```

Windows users now probably wish to install Putty or any SSH client. Linux and Mac users have one installed by default. Then:

```
ssh odroid@odroid.local
```

Password is odroid. Congratulations, you are now inside the Odroid!

Make sure the Odroid board has access to the internet and enter:

```
curl -L https://raw.githubusercontent.com/poppy-project/
poppy_install/master/poppy_setup.sh | sudo bash
```

Enter the odroid password. This command will download and run a script which will download and prepare installation. The board asks for a reboot:

```
sudo reboot
```

You loose the SSH connection. The board has changed hostname and password, so wait for the blue light to flash regularly and connect with:

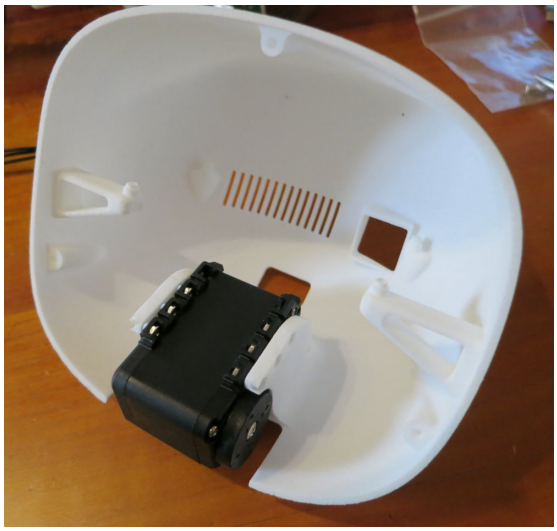
```
ssh poppy@poppy.local
```

As you guessed, password is poppy. Installation process takes place automatically (and takes a while). When you see 'System install complete', do a Ctrl+C to finish. After a new reboot, your Odroid board is ready.

5.4.2 Neck assembly

The last servomotor is head_y, a AX-12A. Set its ID to 37 and response time to 0 (baudrate is already at 1000000).

Screw the neck to head_z servo (⌀2x8mm screws). There are marks on the neck and on the servo to help you determine the orientation.



Put ⌀2 nuts in the servo case and attach it in the head_back part.

Assemble the servo on the neck (⌀2 screws on the controlled side, the big screw on the other side). You again have marks on the neck and on the servo for orientation.

Connect head_y to the dispatcher by passing the cable through the hole in the head.

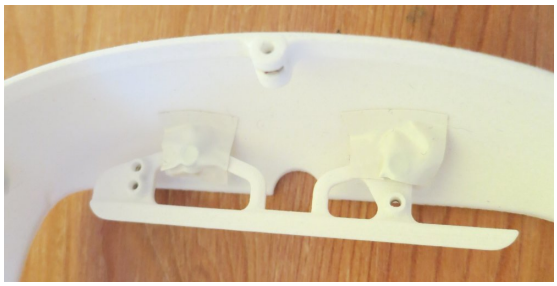
Plug a 500mm cable from the pelvis SMPS2Dynamixel board to the back of the head. Attach a USB2AX at the end of this cable in the head.

Use a 140mm cable to connect the head_y motor to another USB2AX.

5.4.3 Camera and screen

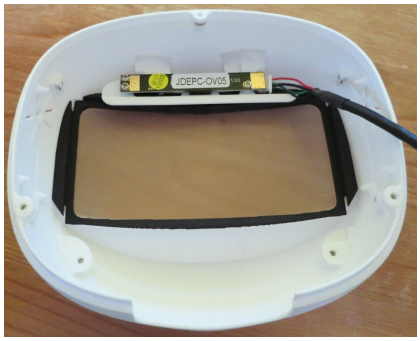
Put 3 ⌀2 nuts in the camera support and attach the camera using ⌀2 x6mm screws.

Attach the camera support to head_front using ⌀2.5x4mm screws. Put tape on the screws to avoid electrical interferences with the camera board.



Attach the camera to its support using ⌀2x6mm screws.

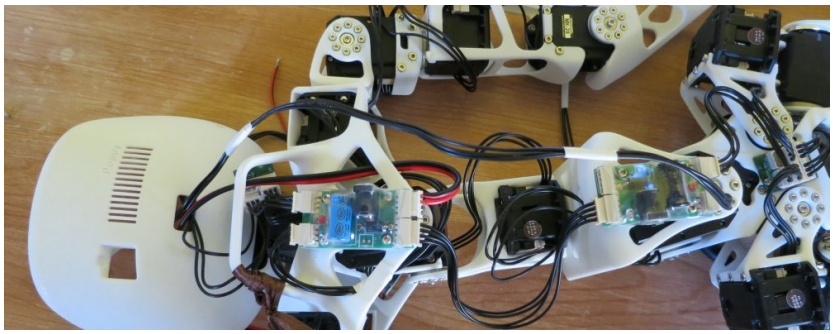
Put the screen and screen cover in the head. Attach the manga screen (or the fake one) with 2 ⌀2.5x6mm screws.



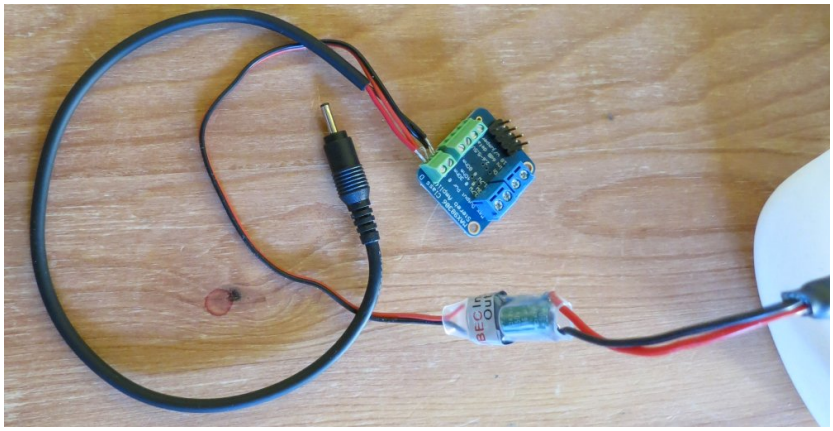
5.4.4 Electronics

If you don't have pre-soldered components, see: `https://github.com/poppy-project/Poppy-minimal-head-design/blob/master/doc/poppy_soldering.md`

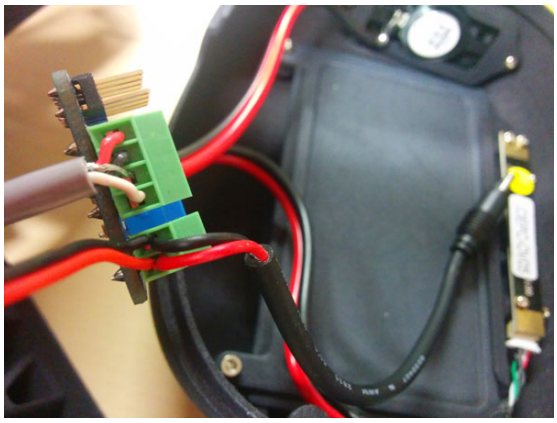
Pass the Dynamixel connector of the Ubec through the hole in the head and connect it to the torso SMPS2Dynamixel.



Attach both the other side of Ubec and the Odroid power cable to the audio amplifier. Be sure no to allow any short-circuit.

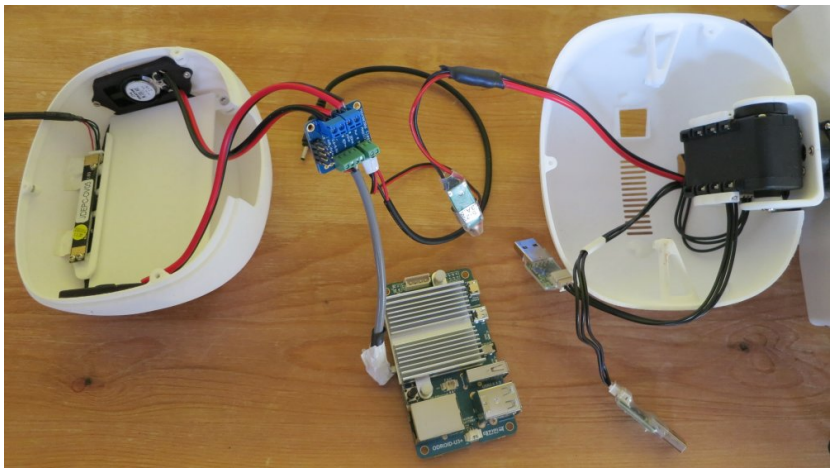


Plug the audio jack. Wires order from left to right (when power terminal is farthest right): red-black-uncolored-white

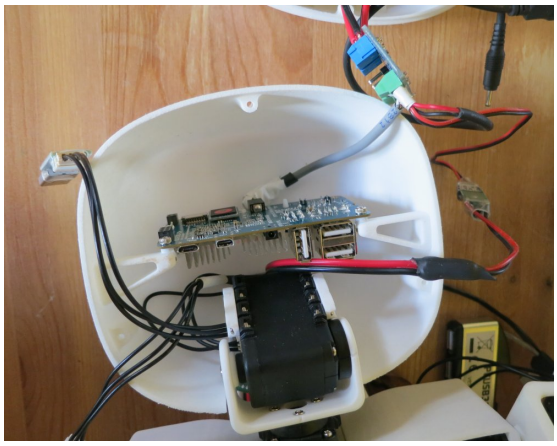


Put ⌀2 nuts around the flowers openings then attach the speakers using ⌀2 x3mm screws.

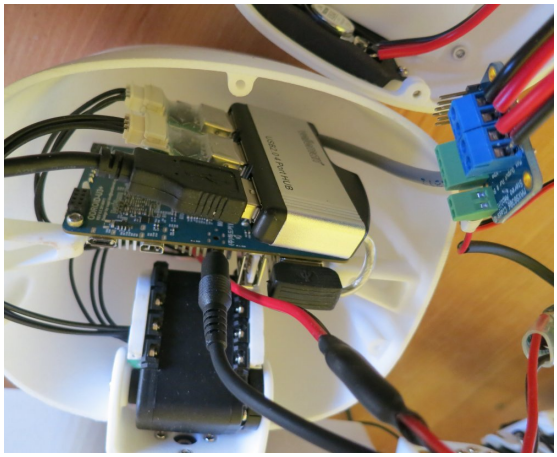
Connect the speakers to audio ampli, left speaker black wire on Lout, Right ampli black wire on Rout.



Plug audio jack in Odroid, then use 2 ⌀2.5x8mm screws to attach the Odroid board. Make sure the Ethernet connector is correctly placed in front of the corresponding hole.



Plug the power jack. On the hub, plug the camera and the two USB2AXs. Plug the wifi dongle if you have one. Push the hub above the Odroid.



Then close the head using 3 ⌀2x8mm screws.

6 Useful links

Assembly instructions:

https://github.com/poppy-project/poppy-humanoid/blob/master/hardware/doc/Poppy_Humanoid_assembly_instructions.md

Bill of Material:

https://github.com/poppy-project/Poppy-lightweight-biped-legs/blob/master/doc/BOM.md

Poppy project website: `https://www.poppy-project.org/`
Poppy project forum: `https://forum.poppy-project.org/`
herborist doc.: http://poppy-project.github.io/pypot/herborist.html
Dynamixel wizard doc.:

http://support.robotis.com/en/software/roboplus/dynamixel_monitor/quickstart/dynamixel_monitor_connection.htm

Bonjour software:

https://support.apple.com/kb/DL999?locale=fr_FR&viewlocale=fr_FR

STL files:

https://github.com/poppy-project/poppy-humanoid/releases/download/Official_1.0_Hardware_release/STL_3D_printed_parts.zip