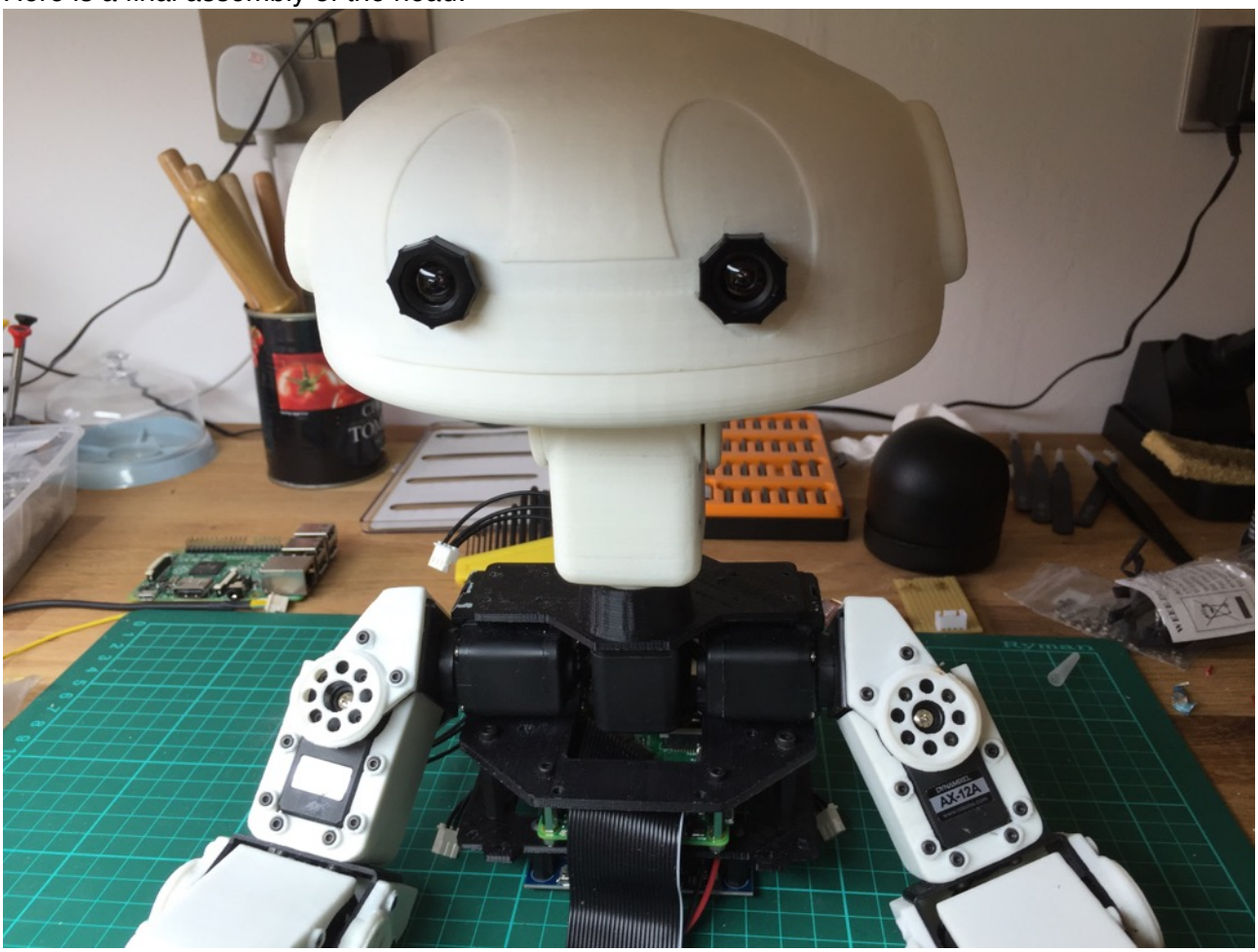
HR-OS1 Customised Head

Based on Jimmy (www.21stcenturyrobot.com)

The head is slightly modified:

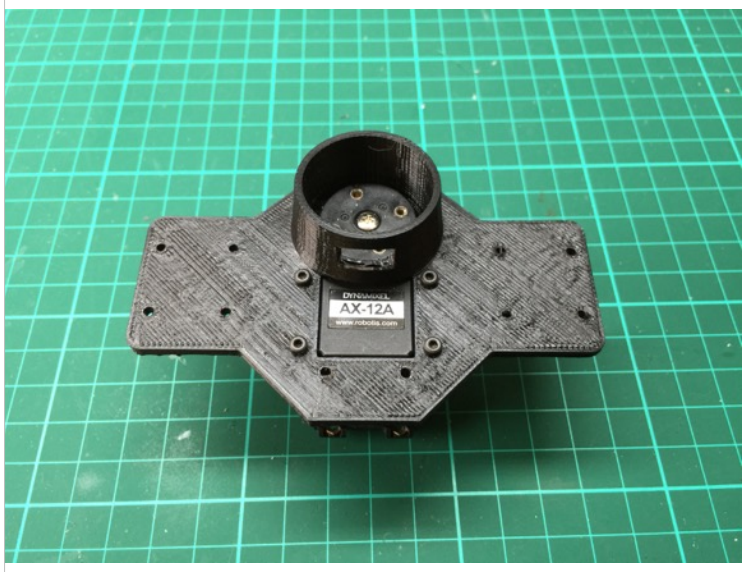
- we have moved the pan servo (#19) bellow the P1 plate, between the two shoulder servos
- the tilt servo (#20) is now in the neck leaving the space in the head free for another Raspberry Pi, cameras, speakers, etc.
- it is slightly ovoid instead of a round shape; this allows a better positioning of the cameras in the head as the curvature towards the centre is less pronounced
- it is made of two parts: the lower part of the head and the top part; this simplifies the assembly

Here is a final assembly of the head:



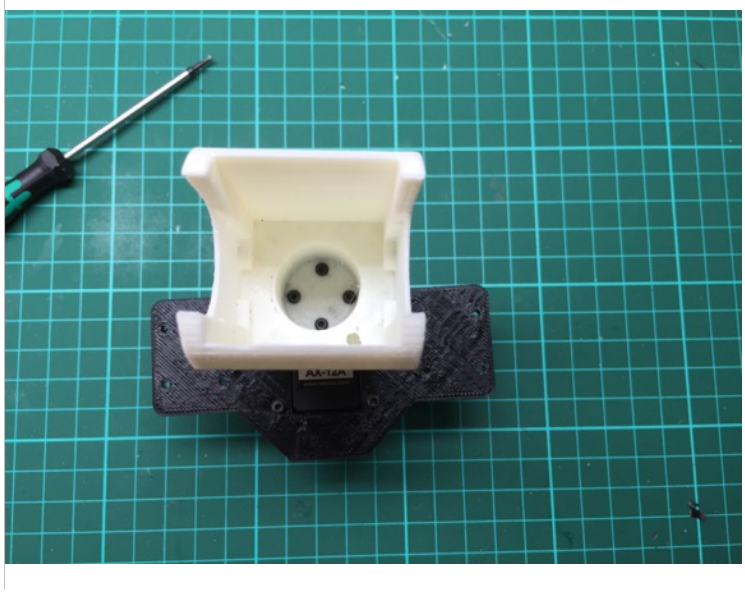
The assembly also features a different cable routing that is less obtrusive and protective.

1. Neck assembly



Place the pan servo (#19) in the cutout of the modified P1 plate as shown in the picture.

Fix the servo using 4 M2x6mm screws. Leave the two lower screws not populated for the time being

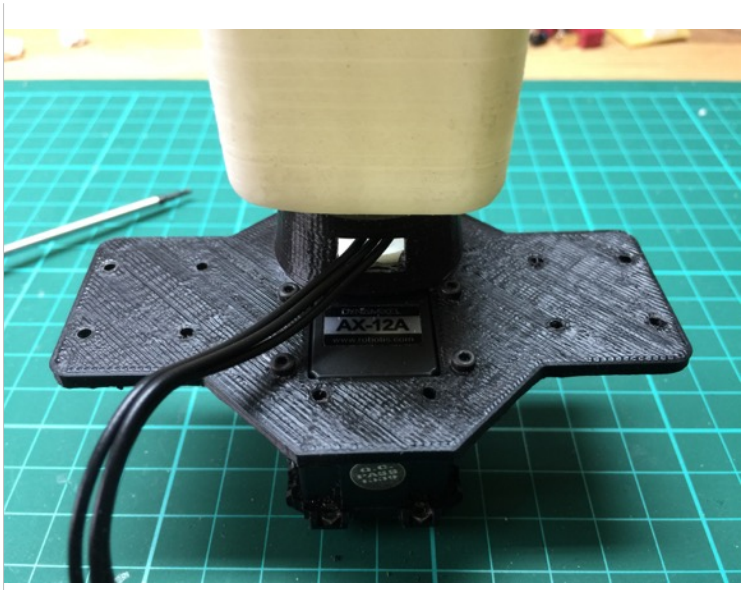


Place the neck part into the cylindrical “collar” from the P1 plate.

Make sure the cutout in the neck part is on the same side as the cutout in the collar in the modified P1 plate.

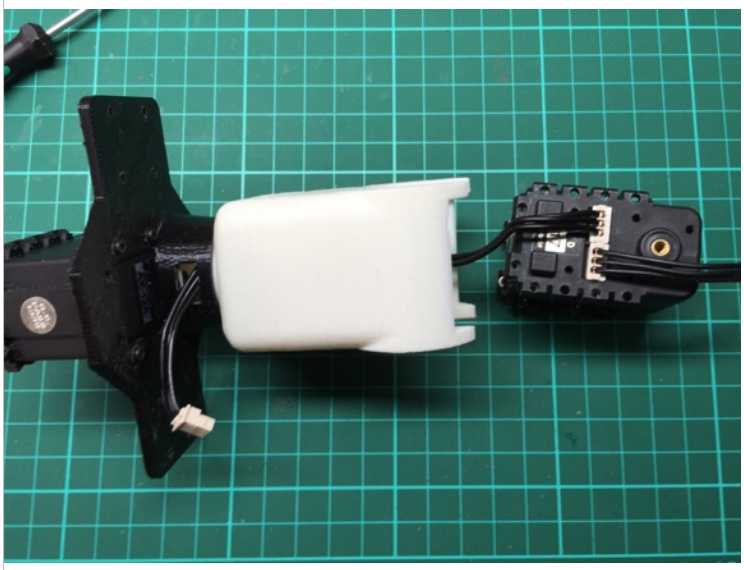
Use 4 M2x6mm screws to fix the neck bracket to the pan servo horn.

Make sure the neck bracket rotates freely and there is no friction between the bottom cylinder in the neck and the interior of the collar.



Place an 18cm Dynamixel cable through the hole and guide it upwards.

Test the neck rotating left and right. It should be allowed to move almost 90º in both directions.



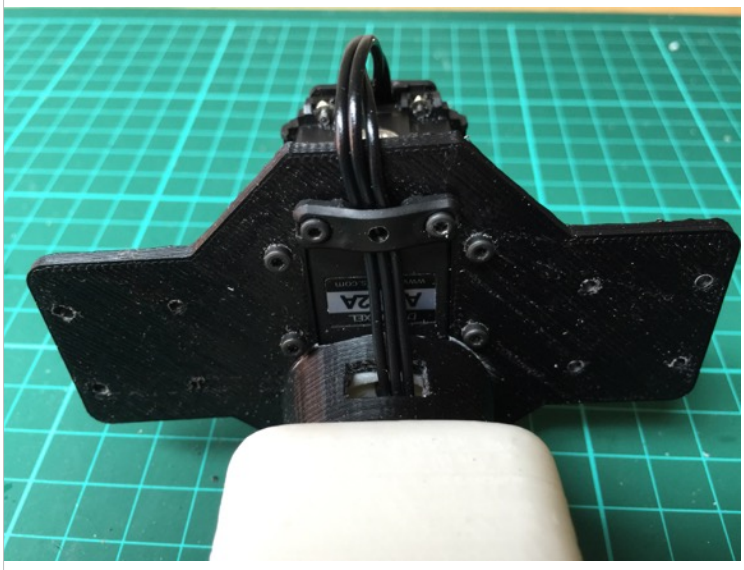
Take the tilt servo (#20) and connect it to the upper end of the Dynamixel cable. Attach a second cable (20cm) and direct it upwards. This second Dynamixel cable will go all to way in the head and will be providing power to the Raspberry Pi and the rest of the electronics there.

Push the tilt servo into the bracket making sure that the horn of the servo is on the left side when looking at the whole assembly from front. This way the movement pages will still move the head correctly and there is no need to alter the poses.

Once the servo is in place, secure it with 6 M2x6mm screws on one side and another 6 on the other side.

Now connect the second end of the first Dynamixel cable to the pan servo.

Ad a cable holder and secure it with 2 screws M2x6mm as seen in the picture.

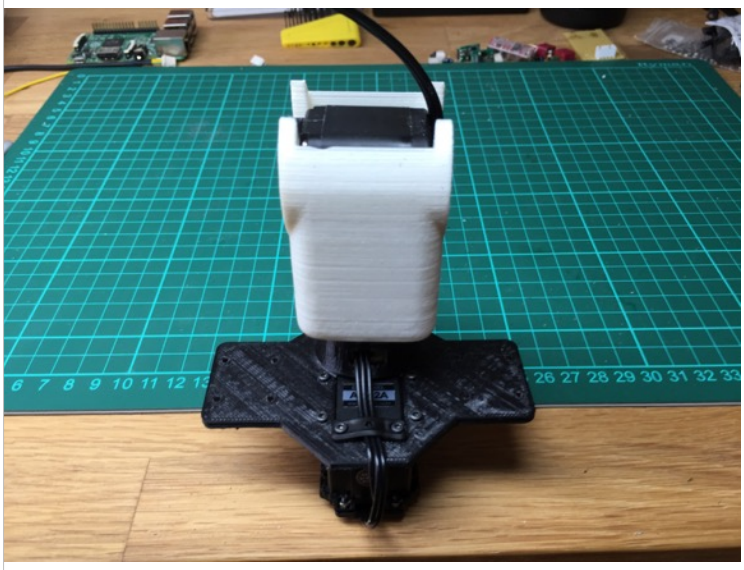


Direct the cable so that the strands as as parallel as possible between the window in the collar an the upper edge of the P1 plate.

Now add a second cable holder and secure using 2 M2x10mm screws.

This should keep the cables neatly and should provide enough flexibility for the pan movement of the neck.

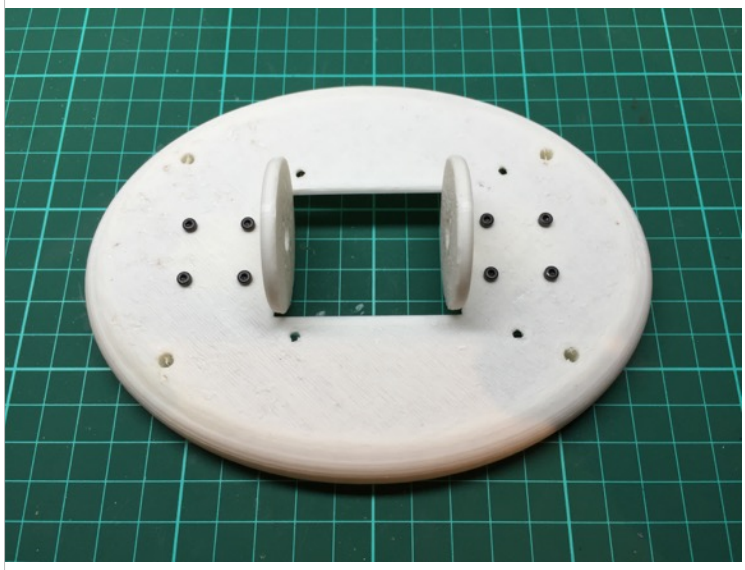
Check again that the neck moves freely and there is no obstruction.



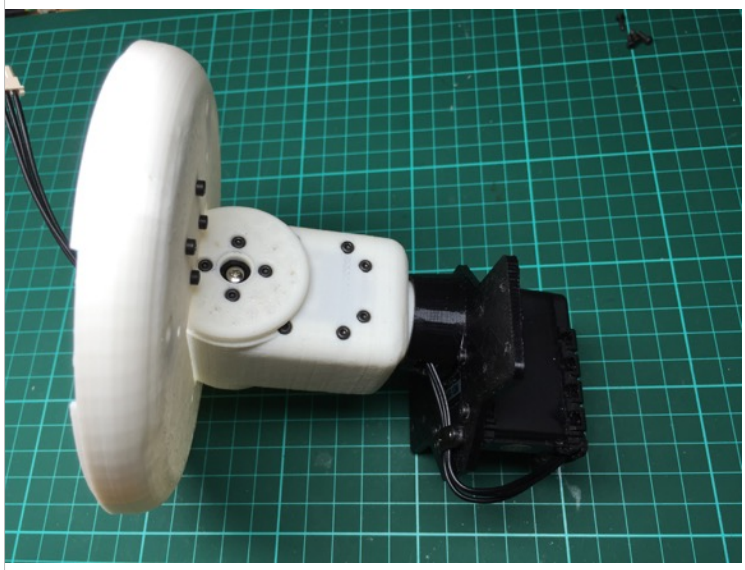
The neck is now ready and prepared for mounting on the shoulders.

It would be better to do this now as after we mount the head bottom part it will be harder to access the 8 screws that fix the P1 plate to the 2 shoulder servos.

2. Head lower part assembly



Use 4 M2x6mm screws and nuts to assemble each of the head joints onto the lower head part.



Mount the lower head on the neck.

Screw the head joints onto the tilt servo using 4 M2x6mm screws on one side and a bearing and an M3x10mm screw on the other side, just as a normal bracket. There is no need for a washer on the bearing side.

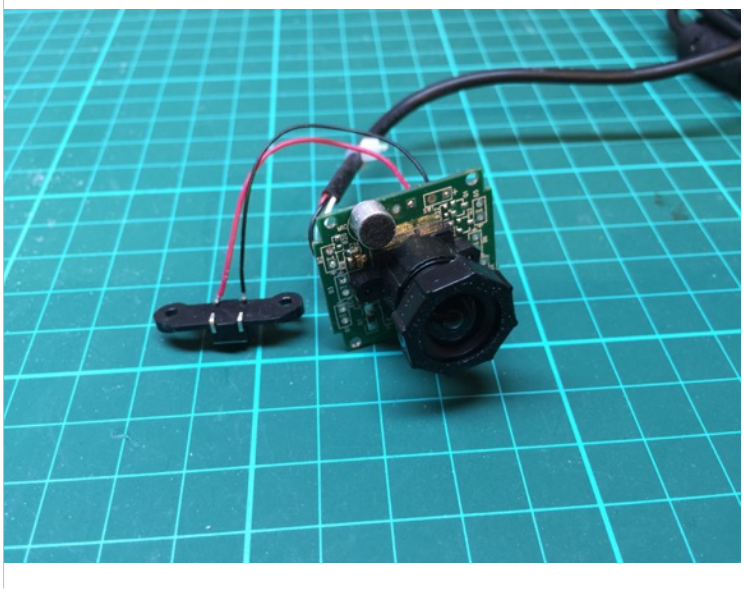
3. Assembling the top part of the head

Install heat searts into the provided holes as follows:

- in the bottom there are supports that match the mounting holes for the Raspberry Pi and the ODROID-XU4; mount 4 M3 heat serts into the appropriate supports
- mount 3 M2 heat serts into the supports for each of the camera; only 3 have holes as the 4th one is too short to accommodate a screw. The next picture shows the cameras I am using and the mounts are designed for those. If you are using different cameras you might need to change the model for the top head. There is a TODO at the end of this document that covers a more generic approach in defining the mounting holes for the cameras.
- mount 2 M2 heat serts in each of the speaker supports

We will now prepare the cameras for mounting.

The picture on the left shows the cameras I am using. They are low cost and low resolution - which is fine considering we'll want to run OpenCV with two cameras on a Raspberry Pi.



Disassemble the camera and keep only the board and the connected cables.

Desolder the switch cables - we do not need them. That switch is provided for the web cam as a way to take a snapshot. For us that is not necessary.

Also desolder the microphone and re-attach it using some cables - about 10-12 cm in length. We will mount the microphones to the side so that they provide better separation and hence better ability to triangulate the sound direction.

We will replace the USB connector that comes with the camera with a much shorter one and we will reduce the length of the cable to about 20cm.

The USB connectors I am using are in the picture on the right. Search eBay on “USB2.0 A Male 4 Pin PCB Mount Solder” or something around that and you should be able to find some sellers.

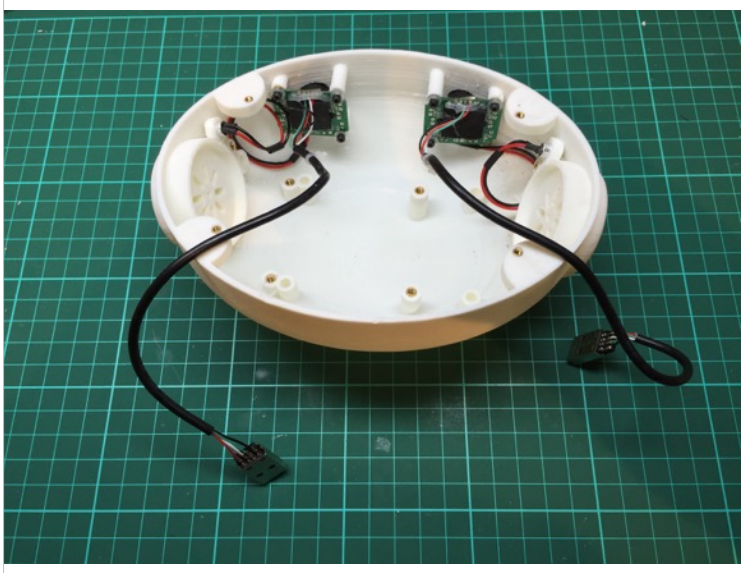
Cut the cable at about 20cm from the camera and then remove isolation from about 2-3cm.

You need to solder the cables in the following order (solder pads facing up and to the back):

- red (most left)
- white
- green
- black (most right)

Once you’re done check and recheck the soldering making sure that you have them in the correct order and that no short-circuits are present.

At this moment it would be good to test your work by connecting the camera to your computer and making sure that it is still visible from the OS, that the image is fine and that you can get sound from the microphone.



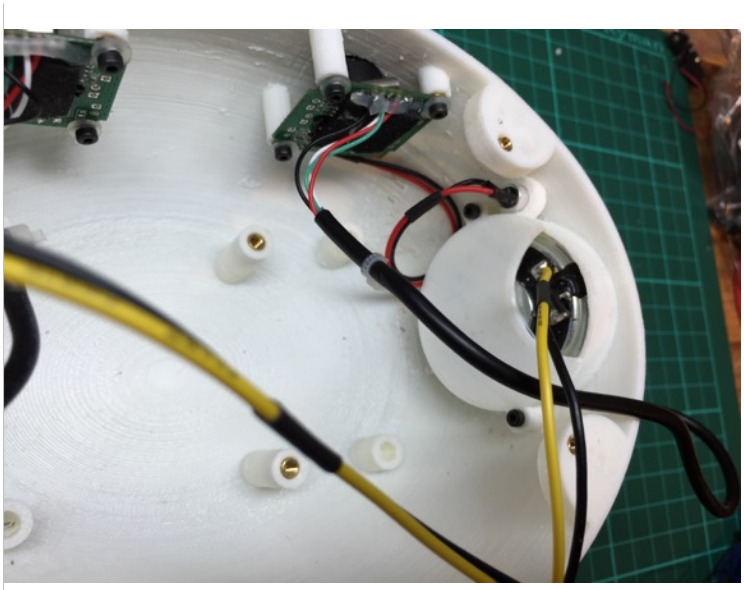
Now mount the camera in the head. You will need to unscrew the lens all the way, then place the camera on the supports. The position of the camera is such that the cables for the microphone are towards the top of the head (bottom in the picture as the head is placed upside down). Use 3 M2x6mm screws to secure the camera in position, then screw back in the lens. Place the microphone in the round holder and guide the cable so that it does not obstruct other parts.

Repeat the procedure for the second camera.

Connect again the cameras one by one to the computer and adjust the focus by rotating the lens until you have focus at about 2 meters in front. You might need to experiments later to see what is the best position that gives you the best depth of field allowing you to have usable images both close and far away.
Once you have a good position place a small drop of thread locker on the side of the camera to reduce the risk of having the cameras loosing focus.

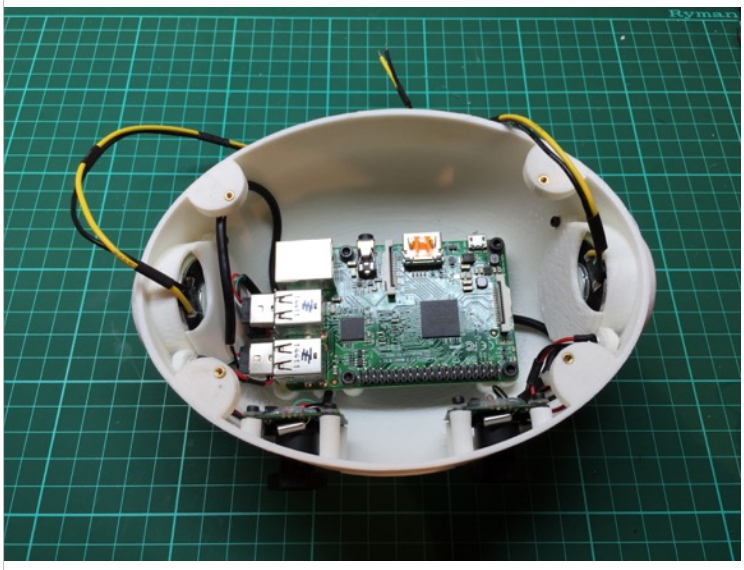
The speakers I have been using are 40mm diameter and 5mm thick. You can find them (or something close) on eBay. They are rated 3W at 4ohm, although don't expect miracles.

Solder about 15cm cables on the connectors.



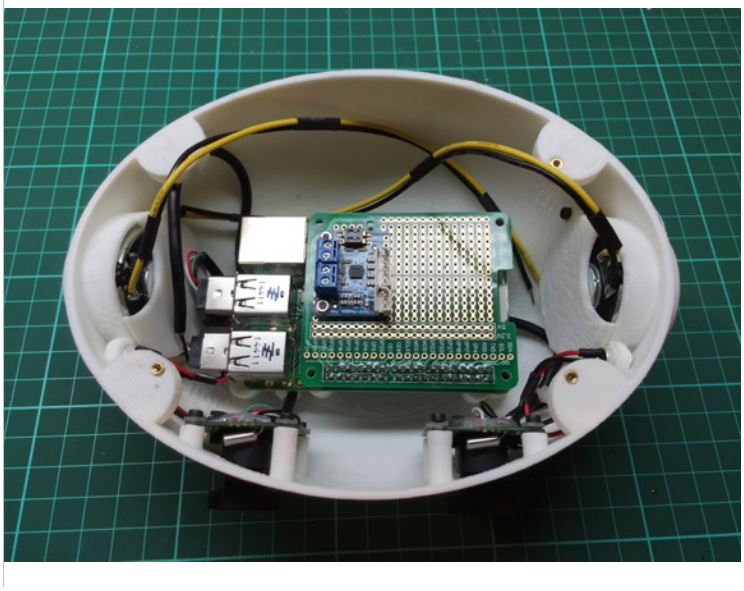
Now place the speaker in the holder and secure it with the 3D printed speaker cap and 2 M2x6mm screws. Make sure the cables are pointed in the direction of the cutout in the speaker cap.

Repeat the procedure for the second speaker.



You will need now to prepare the Raspberry Pi (install OS, ROS, etc.).

Connect on one of the lower USB ports a WiFi adapter and on the upper two USB insert the cameras' newly changed connectors. Guide the USB cables of the 2 cameras on the bottom of the head (under the Raspberry Pi) and then place the Pi on the supports and secure it with 4 M3x6mm screws. It would be helpful to have some plastic washers between the screw head and the board.



You can now attach the custom HAT on the Raspberry. This is a very simple design that includes (the picture on the left shows an unfinished board):

- the Adafruit TS2012 stereo amplified 2x2.8 (http://www.adafruit.com/products/1552)
- A Murata OKR-T/3-W12-C 3A regulator using a 267ohm resistor (so that it produces 5V)
- A MOLEX SPOX 3 pin male connector (will connect to the Dynamixel cable coming from the tilt servo)

Screw the speaker cables into the terminals on the amplifier trying to keep the polarity aligned.

The last thing now is to connect the Dynamixel cable in the HAT, place the top head over the lower part and screw the two together with 4 M2x6mm screws.

TODO

1. A more flexible mounting approach using boards that can be adapted to the part being mounted (camera, speaker or computer board) without needing to adjust the whole head design and re-print it.