

# **BALL TRACKING NAO**

## **FUNCTIONALITY:**

This library allows the robot to be able to follow a colored ball with the head and move towards it until they are at a certain distance from it.

Prior to the monitoring of the ball has a stage of recognition and / or calibration of the color of the same, so that the desired detection range is performed automatically without having to vary any parameter in the library.

Therefore, the general functioning of the library can be divided into these two stages:

- HSV color range detection.
- Follow the ball with the head or with the whole body.

### **1. HSV COLOR RANGE DETECTION:**

This step is done with the help of the tactile buttons included in the upper part of the head of the robot, which are shown in figure 1.

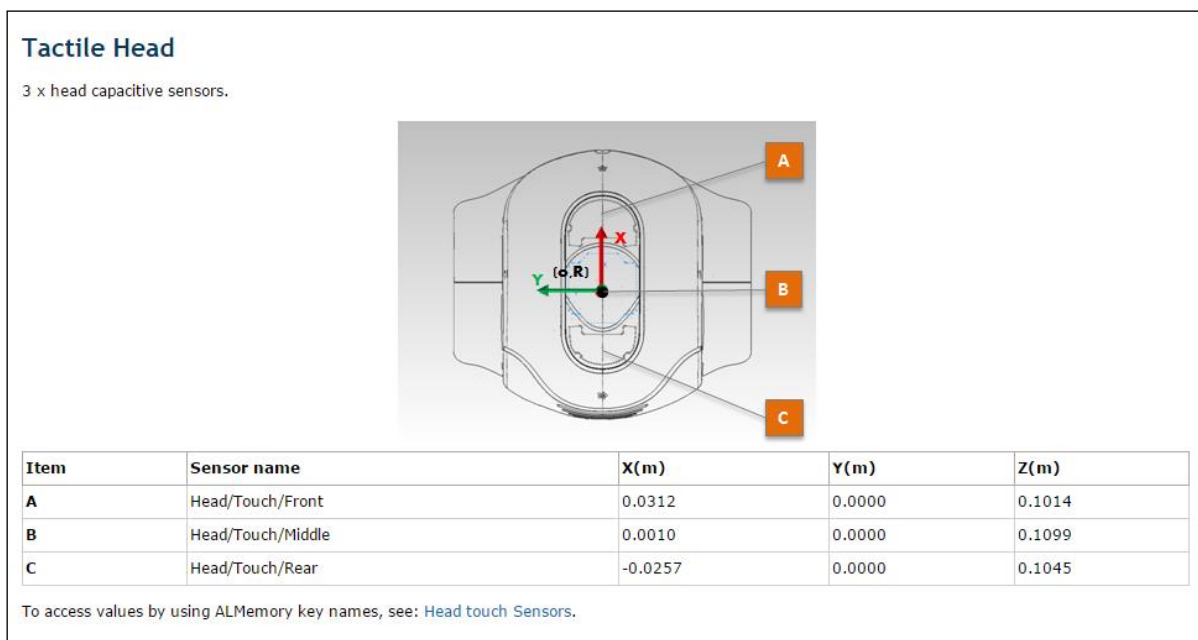


Figure 1 - Tactile buttons located on the head.

The operating mode of the tactile buttons of the head is shown in diagram form in figure 4 and is as follows:

- **Button A: Front.**

By pressing this button deactivates the tracking mode, so the robot stops following the ball. In turn, their arms are placed in “recognition position”, that is, stretched forward, so that the ball is placed between their hands and ensure in this way that the circular shape of the ball is perfectly seen to make more accurate the detection of its color, as can be seen in figure 2.

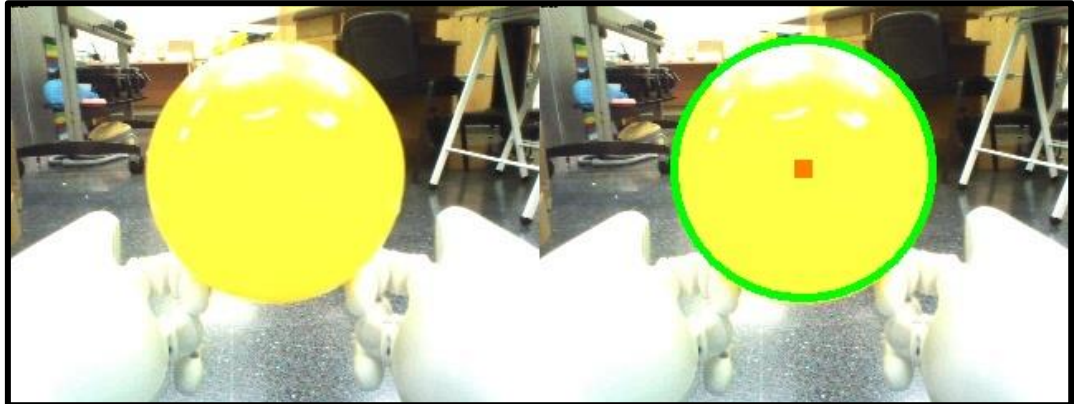


Figure 2 - Ball between Nao's hands to ensure its recognition.

- **Button B: Medium.**

By pressing this button, and once the ball is placed between the hands of Nao, a capture of the image seen through the robot's camera is done, so that in this image the ball can be recognized and an estimation of the HSV color of the pixels of the same can be made, as shown in figure 3.



Figure 3 – Representative rectangle of the pixels used for the estimation.

The orange rectangle of the figure 3 would correspond to the pixels taken to calculate the average of the color range, since they occupy the greater percentage of the seen area of the ball. The approximation is done in this way because in the upper part of the ball there may be reflections due to

light in the room that distort the measurement and produce a range of false color detection.

The actions to be taken by pressing this button can be summarized as follows:

- Image acquisition from the NAO camera.
- Delimitation of the contour and center of the ball to delimit in which area to take the pixels.
- Calculate the HSV mean of the chosen pixels.
- Determination of the detection range from the calculated HSV value.

- **C button: Rear.**

By pressing this third button concludes the stage of color recognition and detection range and it begins the tracking of the identified colored ball. In turn, the robot puts his arms back into the initial position (stretched out next to his body) to start with the tracking stage.

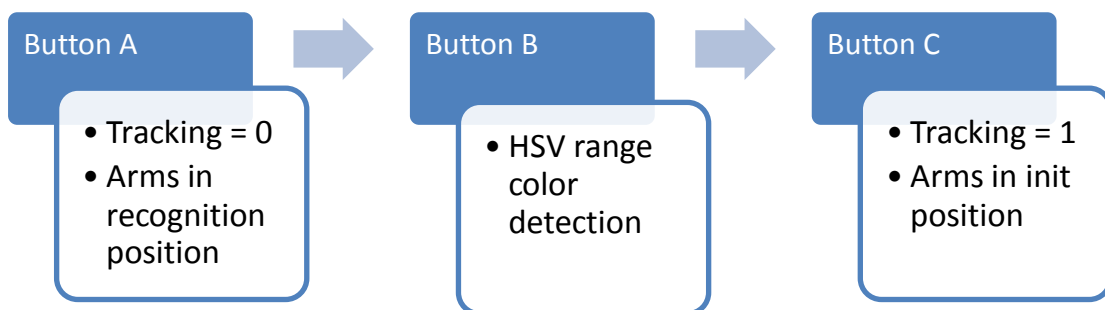


Figure 4 - Operating mode of the tactile buttons.

## 2. BALL TRACKING:

- **Head movements.**

The head movement necessary to track the ball is calculated so that the ball is always kept in the center of the image being obtained in real time through the camera of the Nao robot.

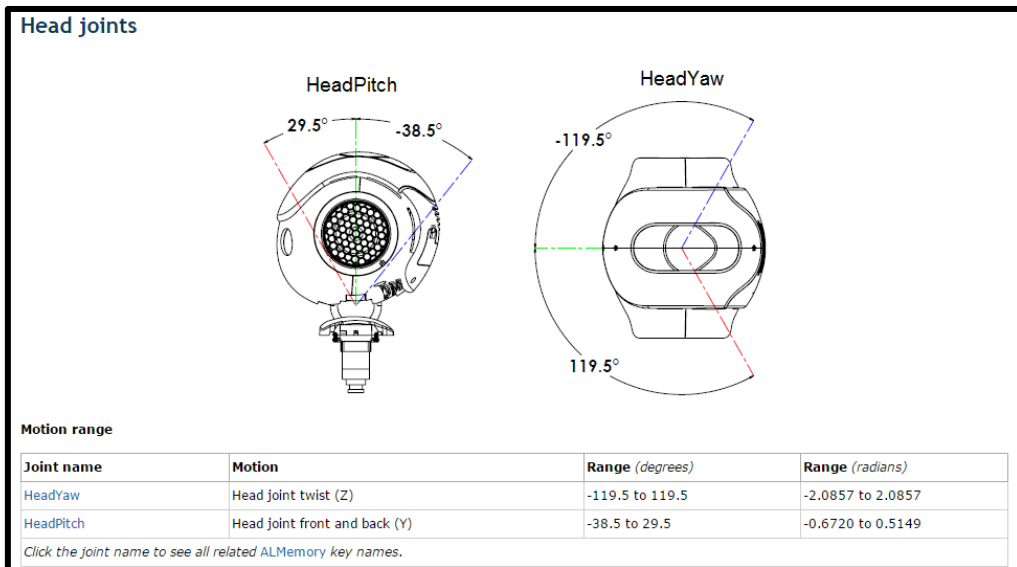


Figure 5 - Head movement ranges.

Some movements of the head are restricted, figure 6, to prevent this one from colliding with the shoulders of the robot and to avoid its wear. For this, in each iteration is made a prediction of which will be the new position of the head and, if this is conflicting, its movement is restricted to avoid the shock.

**Anti collision limitation**

Due to potential shell collision at the head level, the **Pitch** motion range is limited according to the **Yaw** value.

HeadYaw	HeadPitch Min	HeadPitch Max	HeadYaw	HeadPitch Min	HeadPitch Max
(degrees)			(radians)		
-119.52	-25.73	18.91	-2.086017	-0.449073	0.330041
-87.49	-18.91	11.46	-1.526988	-0.330041	0.200015
-62.45	-24.64	17.19	-1.089958	-0.430049	0.300022
-51.74	-27.50	18.91	-0.903033	-0.479965	0.330041
-43.32	-31.40	21.20	-0.756077	-0.548033	0.370010
-27.85	-38.50	24.18	-0.486074	-0.671951	0.422021
0.0	-38.50	29.51	0.000000	-0.671951	0.515047
27.85	-38.50	24.18	0.486074	-0.671951	0.422021
43.32	-31.40	21.20	0.756077	-0.548033	0.370010
51.74	-27.50	18.91	0.903033	-0.479965	0.330041
62.45	-24.64	17.19	1.089958	-0.430049	0.300022
87.49	-18.91	11.46	1.526988	-0.330041	0.200015
119.52	-25.73	18.91	2.086017	-0.449073	0.330041

Figura 6 – Head movement restriction.

- **Movement of the body towards the ball.**

As for the movement towards the ball, this is done as a function of the distance to which it is located, so its radius is used as a characteristic parameter to determine this, and depending on the position of the robot head, the robot will move forward or sideways according to the position in which the ball is.

It is taken as a reference a radius of 50 pixels to start walking. This radius corresponds to the one that has the ball seen through the robot's camera when it is at a distance equivalent to the length of the robot arm stretched forward. From there, if the ball moves away, the radius becomes smaller and the robot walks towards it until it is approximately 25cm apart, which is where it is able to catch it by stretching its arms, and if the ball approaches, Nao will move backwards until it is at the corresponding distance to take the ball.

As for the position of the head, such as this on the X axis (HeadYaw) can move from -2.0857 to 2.0857 radians, as shown in figure 5, it is considered that the ball is centered when the head is in the range of -0.3 to 0.3 radians, in which case the robot will only walk forward. If the head is rotated more than 0.3 radians or less than -0.3 radians, the ball is considered to be on one side and, therefore, the robot will walk forward and turn its body towards the corresponding side.