Control and Robotics in Medicine 2017-2018

Deliverable D2 $\,$

September 14, 2017

Deadline: October 17th, 2017 - 9:00 **Total mark contribution**: 40 % **Modality**: Workgroup

This deliverable is based on the robot of Figure 1.



Figure 1: Laboratory robot.

The degrees of freedom, rotations and reference axes of the robot will be represented as shown in Figure 2. Dimensions of the robot are shown in Table 1 and the mechanical constraints of the rotational angles in Table 2

segment	length (mm)	notation	minimum (nod)	maximum (nad)
10	86.8	Fotation	IIIIIIIIIIIII (Fau)	maximum (rau)
10	21.0	q1	-2.62	2.62
11	51.0	q2	-0.33	2.97
12	150.2		2.80	0.26
13	146.3	qə	-2.89	0.20
14	70.0	q4	-1.83	1.86
14	70.0	d2	-2.62	2.62
15	66.3	-1-		

Table 1: Dimensions of the robot.

Table 2: Mechanical constraints of every joint.



Figure 2: Representation of the degrees of freedom and local coordinate axes of the robot.

Problem definition:

- 1. Trajectory planning (45%).
 - (a) Cubic trajectory planning of joints with zero velocity in the initial and final points, where the initial point is defined by the generalized coordinates $q(t_0) = \{0, 2.89, -2.89, 0, 0\}$ in radians and the final point is defined by the Cartesian coordinates $Q(t_g) = (240, 0, l0 + l1), a(t_g) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}^T$ and $s(t_g) = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}^T$ in millimeters. (40%).
 - (b) Cubic trajectory planning of joints with zero velocity in the initial and final point passing by an intermediate point, where the initial point is defined by $Q(t_g) = (240, 0, l0 + l1)$, $a(t_g) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}^T$ and $s(t_g) = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}^T$ and the final point by $Q(t_r) = (150, 150, 150)$, $a(t_r) = \begin{bmatrix} 0 & 0 & -1 \end{bmatrix}^T$ and $s(t_r) = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}^T$. Intermediate point $Q(t_v) = (x_v, y_v, z_v)$, with orientation $a(t_v)$, $s(t_v)$ and $n(t_v)$ must be defined by taking into account that there exists an obstacle located at $Q_O = (190, 90, 0)$ with base of $15 \times 15 \text{ mm}^2$ and height of 225 mm. The definition of the intermediate point is part of the evaluation of this part (60%).

Graphical material of the trajectories of every joint of the robot should be presented.

- 2. Implementation on the real robot (50%). Information about the robot usage is provided in http://wiki.robolabo.etsit.upm.es/index.php/PhantomX_Reactor_Robot
 - (a) Implementation on the real robot of the trajectory defined in Part 1a together with the grasping of a cylindric piece located at $Q(t_q)$ (40%).
 - (b) Implementation on the real robot of the trajectory defined in Part 1b together with the release of the cylindric piece in a box centered on $Q(t_r)$ over the XY plane (60%).
- 3. Conclusions (5%).
- 4. References

Submission. A compressed file (preferably a .tar.gz file) will be submitted before the deadline through the Moodle platform.

Files should have the following nomenclature:

- The **compressed file** which includes the manuscript and the code should have the following name: "GRXX-D2.tar.gz", where XX represents the group number.
- The **manuscript file** should have the following name: "**GRXX-D2.pdf**", where XX represents the group number.
- The code file or files for the laboratory should have the following name: "GRXX-D2Y.ino", where XX represents the number of the group and Y a letter from "a" to "z" depending on the number of files provided.