Control and Robotics in Medicine
2018-2019

Deliverable D2

September 16, 2018

Deadline: October 16th, 2018 - 08:59
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)**
l0	86.8
l1	31.0
l2	150.2
l3	146.3
l4	70.0
l5	66.3

Table 1: Dimensions of the robot.

rotation	**minimum (rad)**	**maximum (rad)**
q1	-2.62	2.62
q2	-0.33	2.97
q3	-2.89	0.26
q4	-1.83	1.86
q5	-1.05	4.19

Table 2: Mechanical constraints of every joint.

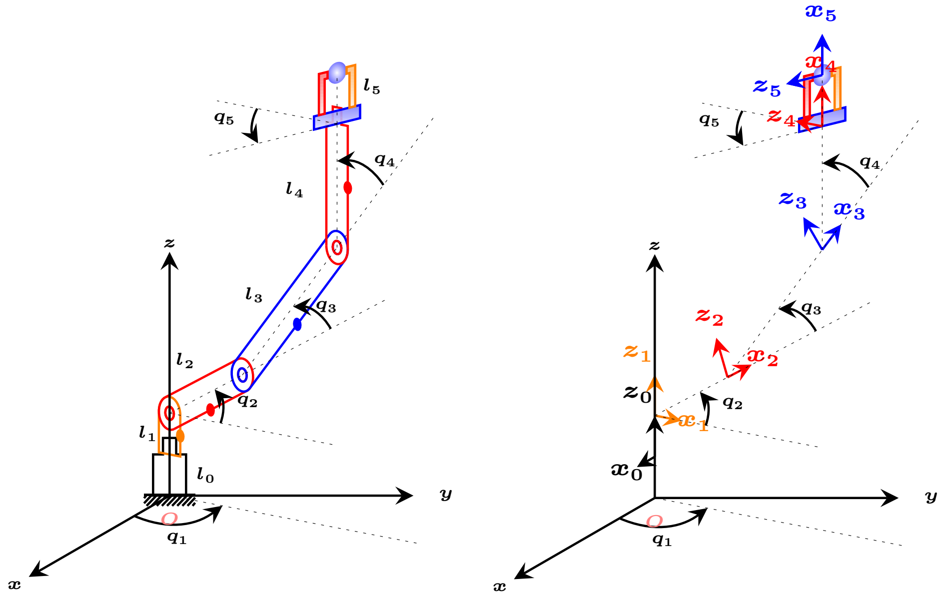

Figure 2: Representation of the degrees of freedom and local coordinate axes of the robot.

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 $Q(t_g) = (250, 150, 150)$, $a(t_g) = \begin{bmatrix} 0.8575 & 0.5145 & 0 \end{bmatrix}^T$ and $s(t_g) = \begin{bmatrix} -0.5145 & 0.8575 & 0 \end{bmatrix}^T$ 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 $Q(t_g) = (250, 150, 150)$, $a(t_g) = \begin{bmatrix} 0.8575 & 0.5145 & 0 \end{bmatrix}^T$ and $s(t_g) = \begin{bmatrix} -0.5145 & 0.8575 & 0 \end{bmatrix}^T$ and the final point by $Q(t_r) = (0, 220, 150)$, $a(t_r) = \begin{bmatrix} 0 & 0 & -1 \end{bmatrix}^T$ 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 $Q_O = (150, 150, 0)$ with base of 15x15 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 $Q(t_g)$ (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.