Control and Robotics in Medicine
2022-2023

Deliverable D1

August 30, 2022

Deadline: September 20th, 2022 - 08:59
Total mark contribution: 20 %
Modality: Individual

This deliverable is based on the robot of Figure 1.

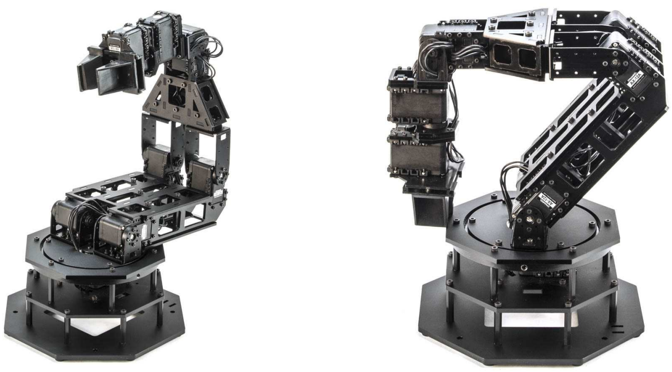

Figure 1: Laboratory robot.

The degrees of freedom, rotations and reference axes of the robot must 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.

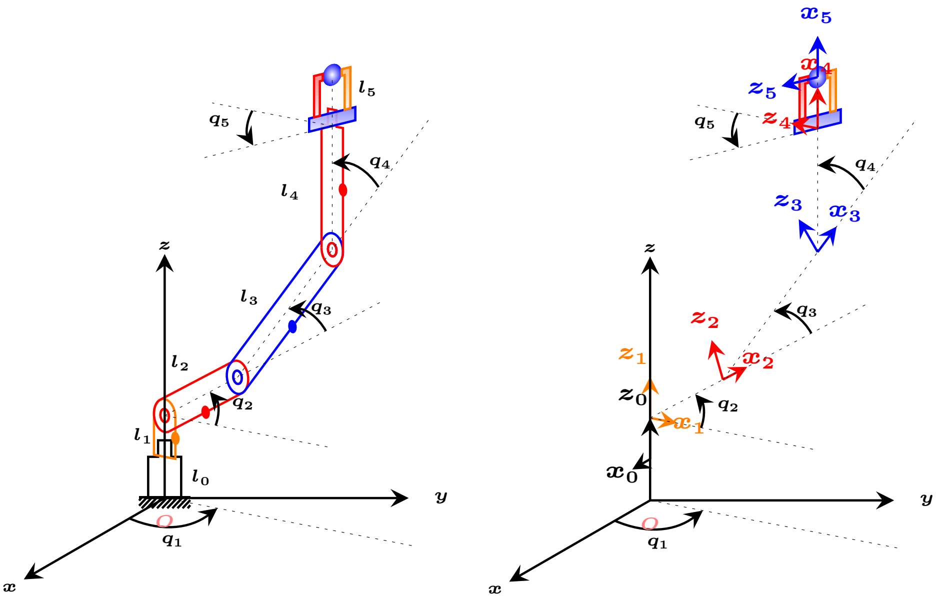

Figure 2: Representation of the degrees of freedom and local coordinate axes of the robot.

Problem definition:

1. **Formulate the forward kinematics problem in position and orientation (25 %)**.
2. **Inverse kinematics problem (75 %)**.
   (a) **Formulate the inverse kinematics problem by using the kinematic decoupling technique** (60 %).
   (b) **Solve the inverse kinematics problem when** $Q(t_g) = (220, 40, 150)$**,** $a(t_g) = \begin{bmatrix} 0.9839 & 0.1789 & 0 \end{bmatrix}^T$ **and** $s(t_g) = \begin{bmatrix} -0.1789 & 0.9839 & 0 \end{bmatrix}^T$. Units are in millimeters (20 %).
   (c) **Solve the inverse kinematics problem when** $Q(t_r) = (40, 170, 150)$**,** $a(t_r) = \begin{bmatrix} 0 & 0 & -1 \end{bmatrix}^T$ **and** $s(t_r) = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix}^T$. Units are in millimeters (20 %).

Submission. A pdf file will be submitted before the deadline through the Moodle platform. The file should be typeset as: <SURNAME1><SURNAME2><NAME>-D1.pdf, without accent marks or tildes.