Introduction to robotic systems: Project #2

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Medical Image Analysis and Applications, academic year 2020-2021

Assuming the Kinova Jaco^2 robot, the candidate is required to implement four MATLAB main scripts, visualizing the motion of the robot in CoppeliaSim. At the end of each one of the simulations, the candidate should plot all the time-varying variables ($\boldsymbol{q}$, $\dot{\boldsymbol{q}}$, position/orientation errors, etc..).

1 Exercise 1

Starting from the home configuration $\boldsymbol{q} = [1.3439 \;\; -0.2967 \;\; 0 \;\; 0.7505 \;\; -1.6406 \;\; 1.3439 \;\; 1.2392]^T$ rad, and assuming the base frame denoted as $\boldsymbol{\Sigma} - \boldsymbol{x}, \boldsymbol{y}, \boldsymbol{z}$, the candidate is required to design an inverse kinematics controller such that:

- the desired end-effector position $\boldsymbol{x}_d = [0.0 \;\; -0.3 \;\; 0.3]^T$ m
- the final orientation matches the one shown in Fig. 1

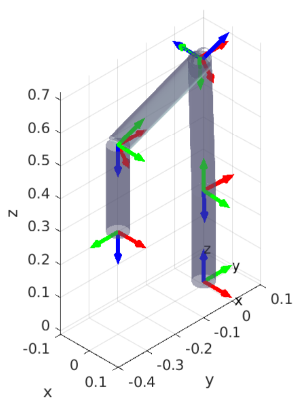

Figure 1: Desired final end-effector position/orientation for the first exercise

Info: The orientation feedback has to be given using quaternions. The candidate is asked to compute the desired rotation matrix $\boldsymbol{R}_d$ and to express it in a desired quaternion $\mathcal{Q}_d$

2 Exercise 2

Starting from the final joint configuration of the previous exercise, the candidate is required to design an inverse kinematics controller such that the end-effector follows a segment of 20cm along the negative direction of the y-axis of the base frame, assigning a trapezoidal velocity profile with:

- $t_f = 3s$
- $\dot{q}_c = 0.1$m/s

The orientation of the end-effector has to be equal to the initial one during the movement. The 3D representation of the desired segment is shown in Fig. 2.

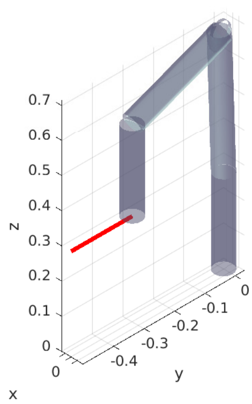

Figure 2: Desired end-effector path for the second exercise (in red)

3 Exercise 3

Starting from the final joint configuration of the previous exercise, the candidate is required to design an inverse kinematics controller such that the end-effector follows an arc of circumference of 90^o anti-clockwise with:

- center: $\boldsymbol{c} = [0.0 \quad -0.3 \;\; 0.3]^T$m
- radius: 20cm
- rotated by $\boldsymbol{R} = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ with respect to the base frame

and a trapezoidal velocity profile characterized by the following parameters:

- $t_f = 3$s
- $\dot{q}_c = 0.17$m/s

The orientation of the end-effector has to be equal to the initial one during the movement. The 3D representation of the desired arc of circumference is shown in Fig. 3.

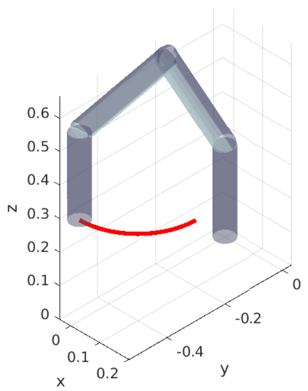

Figure 3: Desired end-effector path for the third exercise (in red)

4 Exercise 4

Starting from the final joint configuration of Ex.2, the candidate is required to design an inverse kinematics controller such that the end-effector follows the same arc of circumference described in Ex. 3. The candidate is required to assign a trapezoidal velocity profile to the orientation from the initial one to

$$\boldsymbol{R}_f = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -1 \\ 0 & 1 & 0 \end{bmatrix}$$

with

- $t_f = 3$s
- $\dot{q}_c = 0.8$rad/s

Info: The candidate should implement two matlab functions to transform a rotation matrix into the corresponding axis-angle representation and vice-versa.

A video of the execution on the four simulations can be found here.