EE 451 Intro. to Robot Control
Bogazici University, Electric Electronic Eng.

20.11.2023
Due date: 30.11.2023

Project 3

The focus of this project is on robot velocity kinematics and differential movements. Consider the serial RRR robot given in Project 2.

(a) Derive the velocity kinematic map $J(\theta_1, \theta_2, \theta_3)$ for tip of the robot. Show your calculations.

(b) Now consider the following tasks. Pls refer to the code as given in Project 2 and also given on the Moodle page.

- In your code, consider first the robot holds the configuration: $\theta_1 = \theta_2 = \theta_3 = 0$

  Consider moving your robot differentially between $0 < t \leq 6$ seconds with $\delta t = 0.01$ with revolute joint speed $\dot{\theta}_i$ (rad/sec), $i = 1, 2, 3$ having the following forms - namely acceleration, constant speed and deceleration:

$$\dot{\theta}_1 = \dot{\theta}_3 = \begin{cases} 0.1t & 0 \leq t \leq 1 \\ 0.3 & 1 < t < 5 \\ 0.3 - 0.1(t-5) & 5 < t < 6 \end{cases} \quad \text{and } \dot{\theta}_2 = \begin{cases} 0.01t & 0 \leq t \leq 1 \\ 0.1 & 1 < t < 5 \\ 0.1 - 0.01(t-5) & 5 < t < 6 \end{cases} \tag{1}$$

  Now simulate this robot for $t = k\delta t$ for each $k = 1, \ldots, 600$ as follows:

  1. First compute the Jacobian matrix $J(q(t))$, $v(t)$ and $\omega(t)$ and print them on the screen. Save these values for later use in part **(c)**.
  2. Use the linear and angular velocities to determine the resulting change in position $\delta o(t) \in R^3$ and orientation $\delta\phi(t) \in SO(3)$. Again print them on the screen.
  3. Move your robot accordingly.
  4. Use $\delta o(t)$ and $\delta\phi(t)$ to incrementally update the kinematic map $A(q(t))$.

(c) Now consider applying inverse velocity kinematics. Using $v(t)$ and $\omega(t)$ values found with $J(q(t))$ for $t = k\delta t$ for each $k = 1, \ldots, 600$, try to find $\dot{\theta}_1, \dot{\theta}_2, \dot{\theta}_3$. Compare the results with those of Eq. 1 through generating a plot for each joint speed.

Pls submit 1) the written part of the project as a PDF file and 2) your workspace C++ code along with a readme file that explains how to run your code.