EC4.401 Robotics: Dynamics and Control

Assignment 3

Robotics Research Center

International Institute of Information Technology Hyderabad

Total Marks : (15)
Due Date : 15-11-2021
Late Submission : Each day after the due date will receive a penalty of 1 mark - deducted from the total marks obtained.

Instructions:

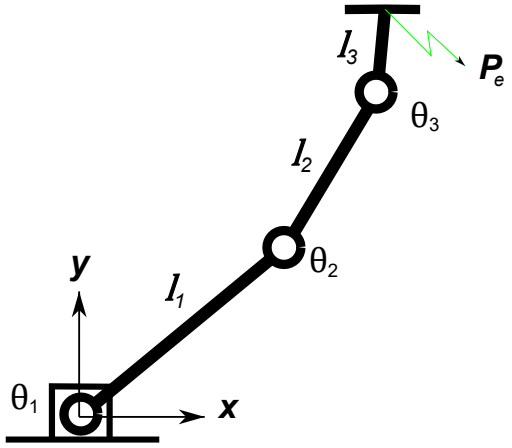
Matlab is preferred for writing the programs.

Students should 1) write the code individually

2) submit the script as well as the document with the program outputs.

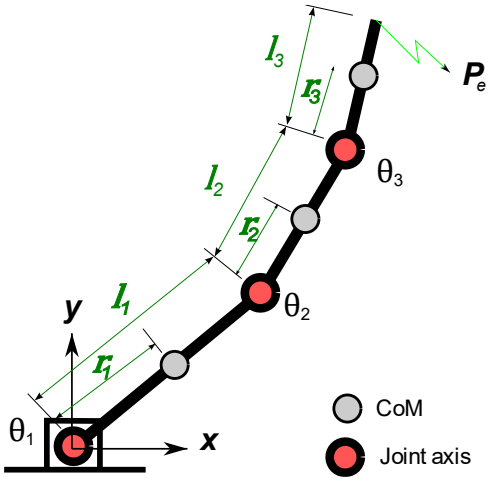
Answer all the questions:

1. Refer to the 3R planar manipulator shown below. (5 marks)
   - 1.1 Derive the inverse kinematics solutions (1)
   - 1.2 Generate a path in an XY plane and simulate the manipulator to trace this path in the XY plane for a fixed orientation (3)
   - 1.3 Discuss the singularity - assume the pose of the end-effector is given (1)



2. Velocity Kinematics for a 3 DoF spatial manipulator (Ortho-parallel configuration) (3 marks)
   - 2.1 Determine J_v. (1.5)
   - 2.2 Determine J_ω. (1.5)

3. Dynamics (you can use Matlab for solving/simplification) (7 marks)
   - 3.1 Derive the equation of motion for the 3R planar manipulator shown below and write it in the form of $\boldsymbol{\tau} = \boldsymbol{M}(\boldsymbol{q})\ddot{\boldsymbol{q}} + \boldsymbol{C}(\boldsymbol{q}, \dot{\boldsymbol{q}})\dot{\boldsymbol{q}} + \boldsymbol{G}(\boldsymbol{q})$ (5)
   - 3.2 Check whether the mass matrix $\boldsymbol{M}$ is symmetric $\boldsymbol{M} - \boldsymbol{M}^{\mathrm{T}} = 0$ (0.5)
   - 3.3 Check the matrix $\dot{\boldsymbol{M}} - 2\boldsymbol{C} \in \boldsymbol{R}^{\mathrm{nxn}}$ is skew-symmetric, where $\dot{\boldsymbol{M}}$ is the time derivative of the mass matrix, and $\boldsymbol{C}$ is the Coriolis matrix. (1.5)



θ_{i} is the joint angle of i^{th} axis, where $i = 1,2,3.$

l_{i} is the link length of i^{th} link

r_i is the center of mass (CoM) position relative to i^{th} axis.

Assume the Moment of Inertia of i^{th} link as $\boldsymbol{I}_{\mathrm{c_i}} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \boldsymbol{I}_{\mathrm{zz_i}} \end{bmatrix}$ and

τ_{i} be the i^{th} joint torque.

All the best for your end semester