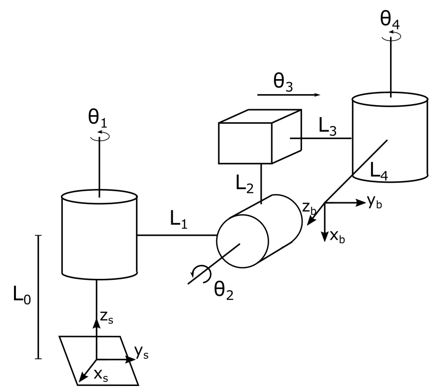
Problem Set 4

19fmiROBEG - AI Robotics

1 Problems

Problem 1. (1 point) Given the RRPR robot shown below, the configuration shown is the home position of this robot. Determine using analytic or geometric methods the joint angles which correspond to the following target end-effector transformation matrix

$$T = \begin{bmatrix} 1 & 0 & 0 & -(L_1 + L_2) \\ 0 & 0 & 1 & L_4 \\ 0 & -1 & 0 & L_0 - (L_3 + 2) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



Problem 2. (1 point) The end-effector of a robot is traversing a fixed screw trajectory from X_{start} to X_{end} this robot is operating with a cubic time-scaling function, for a duration $T = 2$

$$X_{start} = \begin{bmatrix} 1 & 0 & 0 & 0.5 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}, X_{end} = \begin{bmatrix} -1 & 0 & 0 & 3 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Find the configuration at the time instant $t = 1$. Show all neccesary working to obtain the answer.

Problem 3. (2 point) For a fifth-order time scaling function find the maximum and minimum joint accelerations and joint velocities along the trajectory $\theta(t)$. Suppose you are operating a robot for which each joint has a velocity limit $|\dot{\theta}| = 1$ rad/s and a acceleration limit $|\ddot{\theta}| = 0.25$ rad/s^2 For a joint trajectory with $\theta_{start} = [0 \quad 0 \quad 0]$ and $\theta_{end} = [\frac{\pi}{3} \quad \frac{\pi}{2} \quad \pi]$ find the minimum time duration T which does not violate the velocity and acceleration limits.

Problem 4. (1 point) Consider a robot link, with a weighted spherical object at the end-effector. Both the link arm and spherical object are made of the same material with a density $2710kg/m^3$. The dimensions of the arm are that of a cylinder of length $0.45m$ and diameter $0.05m$. The spherical object has a radius of $0.1m$. Find the following

1. The inertial matrix $\mathcal{I}_b$ in the frame $\{b\}$ located at the center of mass and aligned with the principal axes of inertia
2. The spatial inertia matrix $\mathcal{G}_b$

Problem 5. (2 points) Given a planar 2R robot as shown below, we have seen how the joint torques could be derived using the Lagrangian formulation. Use the Newton-Euler formulation and rederive the resultant joint torques. Show all working for the both the forward and backward iterations and show that the Lagrangian and Newton-Euler methods produce equivalent results.