Homework 13-14

(Due time: 24:00, May. 15, 2020)

1. Calculate $\dot{\theta}_{12}, \dot{\theta}_{23}, t_1, t_2,$ and t_3 for a two-segment linear function with parabolic blends (LFPB). For this joint, $\theta_1 = 5.0^\circ, \theta_2 = 15.0^\circ, \theta_3 = 40.0^\circ$. Assume that $t_{d12} = t_{d23} = 1.0$ seconds and that the default acceleration to use during blends is 80 degrees/second^2. Use Matlab to sketch plots of position, velocity, and acceleration of θ. The derivation, Matlab code, and result graphs are required.

2. Use Matlab to sketch graphs of position, velocity, and acceleration for a two-segment spline where each segment is a cubic. Sketch them for a joint where $\theta_0 = 5.0^\circ$ for the initial point, $\theta_v = 15.0^\circ$ is a via point, and $\theta_g = -10.0^\circ$ is the goal point. Assume that each segment has a duration of 2.0 seconds and that the velocity at the via point is to be 0.0 degrees/second. The derivation, Matlab code, and result graphs are required.

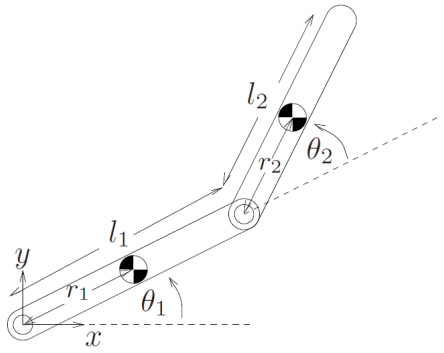
3. A single cubic trajectory is given by

$$\theta(t) = 10 + 90t^2 - 60t^3$$

and is used over the time interval from $t = 0$ to $t = 1$. What are the starting and final positions, velocities, and accelerations?

4. It is desired for the tool point to follow a linear trajectory with parabolic blends that starts at $P_1 = [0.0\ 0.0]^T$ and ends at $P_3 = [3.0\ 3.0]^T$, with $P_2 = [2.0\ 1.0]^T$ as a via point. The desired segment durations are $t_{d12} = t_{d23} = 1$ and the acceleration magnitudes are $\ddot{x} = \ddot{y} = 6$. Plot the x-y coordinates of this trajectory. The derivation, Matlab code, and result graphs are required.

5. For the two-link planar manipulator shown below.



Model each link as a homogenous rectangular bar with mass $m_1 = m_2 = 12\ Kg$, length $l_1 = l_2 = 1.0\ m$, $r_1 = r_2 = 0.5\ m$ and moment of inertia tensor

$$I_1 = I_2 = \begin{bmatrix} 0.0125 & 0 & 0 \\ 0 & 1.0025 & 0 \\ 0 & 0 & 1.01 \end{bmatrix}$$

relative to a frame attached at the center of mass of the link and aligned with the principle axes of the bar.

(a) Derive the dynamic equations of the manipulator.

(b) Write a Matlab program to compute the time history of torques needed to move the arm along the trajectory of Problem 1&2 and make the plots.

(c) Do the position control simulation in joint space of the manipulator with Matlab&Simulink to move the arm along the trajectory of Problem 1&2, while the maximum joint torque $\tau_{1max} = \tau_{2max} = 20\ N/m$, with the controllers the following three controller. Try to obtain the best performance of the tracking problem, provide the chosen control parameters, K_p and K_v. The torque, position, velocity history graphs are required. Try to compute position error history for both joint angles. Discuss the relationship between the joint position error and the control parameters.

i) Computed torque control.

ii) PD control

iii) Augmented PD control