ENN 581 – Semester 2 – 2023
Week 6 – Trajectories

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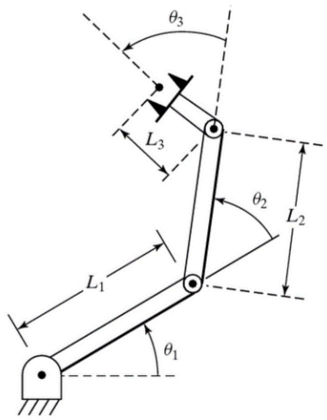
Theory

1. A robot with 6 joints is required to move from the start to the goal through 3 via points. If a cubic polynomial is used to describe joint positions, how many coefficients are required to generate the trajectory from start to end?
2. Consider a trajectory with a single via point between the start and the goal. Determine expressions for cubic curves representing the trajectory if the acceleration is constant at the via point. Assume that the time duration for each segment is the same. You are given: q_0, q_{via}, q_F, and $\dot{q}_0 = \dot{q}_F = 0$ and an acceleration a_{via}.
3. In the lecture, we discussed linear paths with parabolic blends. When a blend is applied at a via point, the joint moves close to the via but never reaches it. Discuss ways in which you can make the joint pass through a via. Consider two cases (1) when the joint is allowed to stop at that point and (2) when the joint must have a non-zero velocity at that point.

Numerical problem

4. The following trajectory is specified for a particular joint in a robot. The positions of the joint in degrees are given as 10, 35, 25 and 10. The duration for the three segments between these positions must be 2, 1 and 3 seconds respectively. At all blend points, it is suggested that the motor have an acceleration of 50 degrees/s^2. Calculate all segment velocities, blend times and times for which a linear path is followed.
5. Consider the 3-link planar manipulator shown below.



The geometry of the robot is given as L1 = 3m, L2 = 2m, L3 = 1m. The robot starts from rest where the end effector pose is given as (5,1,90°). We would like to move it to (-3,3, 90°) and come to a rest there. Use a cubic interpolation of joint angles to plan a path. Plot the positions, velocities, and accelerations of the joints. Also plot the robot at 5 intermediate positions. You can either use an analytical approach for FK and IK or rely on the robotics toolbox.

Simulation – CoppeliaSim

6. Revisit the 6DoF robot from earlier exercises on IK and FK that we simulated in CoppeliaSim. Use the same scene file and set the robot into kinematic mode.

Our aim is to make the robot follow a circular path of radius 50 mm, centred at (-200,200,60) mm. The plane of the circle is aligned with the floor at a height of 60 mm. There is no constraint on orientation. Implement an algorithm that moves the robot along the desired path at a constant velocity of 20π mm/s.