SC602: Nonlinear Dynamical Systems Problem 1: Two-Link Manipulator Dynamics

Sayan Ray

December 18, 2024

Problem Statement

Consider the two-link manipulator robot dynamics in joint space:

$$M(q)\ddot{q} + C(q,\dot{q})\dot{q} + D\dot{q} + g(q) = u$$

where:

- $q \in \mathbb{R}^2$ is the generalized coordinates,
- $\dot{q}$ represents the generalized velocities,
- $M(q) \in \mathbb{R}^{2\times 2}$ is a positive definite matrix,
- $C(q,\dot{q})$ are the Coriolis and centrifugal forces,
- D is a positive semi-definite viscous damping matrix,
- $g(q)$ represents the gravity.

The objective is to track constant reference q_r using the control input u. The dynamics are modified as:

$$M(q)\ddot{e} + C(q,\dot{q})\dot{e} + D\dot{e} + g(q) = u,$$

where $e = q - q_r$.

The task involves:

1. Simulating the designed control input u to ensure the generalized coordinates $q(t)$ track q_r. Provide plots of:
   - Joint angles $q(t)$ and their desired values,
   - Control torques,
   - Chosen constants.
2. Simplifying the dynamics into scalar form and designing a backstepping-based control law. Simulate and plot the control torques and joint angles.