Sharif University of Technology
Department of Electrical Engineering

Assignment 1 for Robot Control 1

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The following problems from your textbook (Spong):

2-11, 2-20, 2-29, 2-33, 2.35, 3-5, 4-9, 4-14, 4-24, 4-25, 4-27

Problem 1: Specify the coordinate frames for the robot shown in Fig. 3.29

Problem 2: For the 3-DOF robot of Fig. 3.27 in your textbook, assume that the third motor is mechanically locked. Therefore, the robot becomes 2-DOF.

a. Determine the coordinate frames for each link, determine forward kinematics and the Jacobian.

b. Derive $M(q)$, $C(q, \dot{q})$ and $g(q)$.

c. Simulate the system with the nominal parameters $m_1 = 1$kg, $m_2 = 2$kg, $l_1 = l_2 = 0.5$m. Links are assumed to be symmetric in geometry such that $l_{c1} = l_{c2} = 0.25$m. Assume $I_1 = I_2 = 0.02$. Coordinate frames are assumed at the links center-of-mass.

d. Using Simulink, simulate the system and plot $q(t) = [\theta_1,\ \theta_2]^T$ and $\dot{q}(t)$ when $\tau = 0$ and $q(0) = [0,\ \pi/2]^T$ and $\dot{q}(0) = 0$. Noting that the joints are frictionless, compare the results with your physical intuition.

e. Repeat part d. if gravity g_0 is assumed to be zero.

f. Plot position of frame 2. Verify numerically that $\dot{M} - 2C$ is skew-symmetric.

g. Convert the system dynamics into $Y\theta$ form with the minimum possible parameters.

Problem 3: Design and implement a PD controller with gravity compensation to derive the manipulator to $q_d = [\pi/2,\ \pi/4]^T$ as fast as possible such that the input torques do not exceed 100Nm.

Problem 4: Let $q_d(t) = [\pi/4 + 0.2\sin(t),\ \pi/2 + 0.1\cos(2t)]^T$. Implement the Slotine controller for tracking $q_d(t)$ and test its performance. Investigate the effect of controller gains K, Λ in convergence rate of s and $\tilde{q}$, and also in the amplitude of the input torque τ. Do not use numerical differentiation for computation of $\dot{q}_d$ and $\ddot{q}_d$.