ELEC442
Assgt #4
Due Dec 1, 2017 (11:59pm)

- You may submit your work in groups of up to 3 individuals.

Two-Link Manipulator Open-Loop Simulation

Consider the two-link planar manipulator described in the dynamics section Ch.6, p.87. Let $l_1=l_2=1$ m, $m_1= m_2=1$ kg. Implement a Simulink "Robot" block having as output the robot state $\boldsymbol{x} = [\theta_1 \quad \theta_2 \quad \dot{\theta}_1 \quad \dot{\theta}_2]$ and as inputs the motor torques and the initial state. Assume that the base frame is oriented so that the gravity vector is aligned with $-\mathbf{j}_0$ as shown in the figure of page 87.

Simulate and plot the angles for a time period of 30 seconds for the following conditions:

(i) $\boldsymbol{x}(0) = [0\ 0\ 0\ 0]^T$, both motor torques set to zero.

(ii) $\boldsymbol{x}(0) = [0\ \pi/2\ 0\ 0]^T$, $\tau_1 = 0$, $\tau_2 = 5$ N·m.

(iii) Same as item (i) but with added friction, modeled as $\tau_1 = -0.5\dot{\theta}_1$, $\tau_2 = -0.5\dot{\theta}_2$ (assume coefficients have appropriate units of N·m·s/rad).

Controller Implementation

Closed loop joint-space control:

Implement the PD + gravity controller as a Simulink "Control" block. With the state initialized to $\boldsymbol{x}(0) = [-\pi/2\ 0\ 0\ 0]^T$, plot the resulting joint angles for $t \in [0,15s]$ using set point $\boldsymbol{q_d} = [0\ \pi/2]^T$, and gain matrices K_p=diag[1,1], K_v=diag[2, 2].

Closed loop Cartesian-space control:

Implement the stiffness controller as a Simulink "Control" block. Demonstrate the response of the controller, for gains K_{p1}=diag[1,1], K_{p2}=diag[0.2,1] and K_{p3}=diag[1,0.2], with K_v=diag[2, 2], simulating the various spring directions in cartesian space. With the state initialized to $\boldsymbol{x}(0) = [-\pi/2\ 0\ 0\ 0]^T$, plot the resulting end-effector trajectories for $t \in [0,15s]$ if the set point in the task space is $\boldsymbol{\varrho_d} = \boldsymbol{\varrho_0} + \underline{C_0} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$.