EML 6351 Spring 2020

Simulation Project 2 - Due Tuesday Feb 11 by Midnight.

Instructions:

For this simulation project collaboration with colleagues and any available resource is encouraged. However, any sharing of electronic files with any other individual is considered a violation of the honor code. You may use any simulation software you desire, but Matlab is highly recommended. A text file (*.m) is provided in the files section of the class Canvas page that contains the dynamic model. This assignment is due based on the dates given in the assignment section. You are expected to turn in (on-line only) a zipped file containing a written report, which includes all plots and mathematical derivations. You are also required to provide an executable code (meaning a *.m file, Simulink file or other file that can be examined to validate that the results from your report match your simulation code).

Model:

For this simulation project, use the model of a two-link rigid revolute robot manipulator given by (see Canvas for the *.m file)

$$\begin{bmatrix}\tau_1\\ \tau_2\end{bmatrix} = \begin{bmatrix} p_1 + 2p_3c_2 & p_2 + p_3c_2 \\ p_2 + p_3c_2 & p_2 \end{bmatrix}\begin{bmatrix}\ddot{q}_1\\ \ddot{q}_2\end{bmatrix} + \begin{bmatrix} -p_3s_2\dot{q}_2 & -p_3s_2\left(\dot{q}_1+\dot{q}_2\right) \\ p_3s_2\dot{q}_1 & 0 \end{bmatrix}\begin{bmatrix}\dot{q}_1\\ \dot{q}_2\end{bmatrix}$$

$$+ \begin{bmatrix} f_{d1} & 0 \\ 0 & f_{d2}\end{bmatrix}\begin{bmatrix}\dot{q}_1\\ \dot{q}_2\end{bmatrix} + \begin{bmatrix} 0.5cos(0.5t) \\ sin(t)\end{bmatrix} \tag{1}$$

where $p_1, p_2, p_3, f_{d1}, f_{d2}$ are unknown positive scalar constants (obviously the simulation file has known values for these parameters, but they can not be used in the controller/adaptation law), $s_2 = sin(q_2)$, $c_2 = cos(q_2)$, $\tau_1(t)$ and $\tau_2(t)$ denote the control torque inputs on the first and second joint respectively, and $q(t)$, $\dot{q}(t)$, $\ddot{q}(t)$ represent the angular position, velocity and acceleration of the about the joints of the robot, respectively, where the subscripts denote which joint. For this simulation, only $q(t)$ and $\dot{q}(t)$ are assumed to be measurable. For this simulation, use the following desired trajectory

$$\begin{aligned} q_{d1} &= cos(0.5t) \\ q_{d2} &= 2cos(t). \end{aligned}$$

Assignment:

1. (25 points) Implement a RISE controller (no adaptive feedforward component). Turn in the code in such a manner that it can be implemented/verified that your simulation produces these results.

2. (25 points) Implement a composite adaptive controller with a gradient update law that includes an additional RISE term as we have derived in class. Turn in the code in such a manner that it can be implemented/verified that your simulation produces these results.

3. (50 points) Write a discussion that compares the performance of the RISE controller, standard composite (gradient) adaptive controller from simulation project 1, and the composite adaptive controller with the additional RISE component. The typed report should include the following sections:

   (a) Dynamic model

   (b) Simulation section including (FOR EACH CONTROLLER):

      1. List control gains used and their values
      2. Tracking error plot for each link
      3. Control input plot for each link (link 1 max torque is 250Nm, link 2 is 30Nm)
      4. Plot of the adaptive estimates
      5. Plot of the parameter estimate errors (i.e., $\widetilde{\theta}(t)$)

   (c) Discussion section that describes the following points:

      1. Differences in tuning the control gains/adaptation gains
      2. Performance of the tracking error for each controller
      3. Performance of the adaptation for each case
      4. For the above three discussion topics, be sure to compare and contrast the different results.