Nonlinear Control Design Project

October 7, 2021

Due date: Last Day of the Class

Tracking Control of a Robot Manipulator with Uncertainties

Design, simulate, and compare 3 different nonlinear controllers: 1) Exact model knowledge (EMK), 2) Adaptive control, and 3) Robust control for a tracking task (i.e., track a desired trajectory, $q_d(t)$). Except for EMK controller, the controllers should be designed to account for uncertain system parameters.

Robot Dynamics

$$\begin{bmatrix} \tau_1 \\ \tau_2 \end{bmatrix} = \begin{bmatrix} p_1 + 2p_3 cos(q_2) & p_2 + p_3 cos(q_2) \\ p_2 + p_3 cos(q_2) & p_2 \end{bmatrix} \begin{bmatrix} \ddot{q}_1 \\ \ddot{q}_2 \end{bmatrix}$$

$$+ \begin{bmatrix} -p_3 sin(q_2)\dot{q}_2 & -p_3 sin(q_2)(\dot{q}_1 + \dot{q}_2) \\ p_3 sin(q_2)\dot{q}_1 & 0 \end{bmatrix} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \end{bmatrix} + \begin{bmatrix} f_{d_1} & 0 \\ 0 & f_{d_2} \end{bmatrix} \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \end{bmatrix} + \begin{bmatrix} \tau_{d_1} \\ \tau_{d_2} \end{bmatrix}$$

where $p_1 = 3.473 kg.m^2$; $p_2 = 0.196 kg.m^2$; $p_3 = 0.242 kg.m^2$; $f_{d_1} = 5.3 Nm.sec$; $f_{d_2} = 1.1 Nm.sec$.

The project will be evaluated based on both written report, correctness of design and analysis, and effort made in simulating the controllers. The report should be professionally written and some weightage will be given to the writing style and presentation of the results in the report. For each controller, show 1) nonlinear control design, 2) stability analysis, and 3) simulation results. Also, show what assumptions were made for the design of each controller.

Your project should be typed, not hand written. It should have sections on 1) Introduction (stating what is the purpose of this report), 2) Dynamic Model, 3), 4), 5) Three controllers with control development, stability analysis, and simulation results, and 6) discussion on how a bounded disturbance affects EMK, adaptive control, and robust control. Please provide justification using both theoretical or stability analysis and simulation results.

The simulation results should have plots of actual vs desired angle, error plots, estimates of parameters (if applicable), and torque plots, and 6) conclusion.

The rubric for report grading follows the above guidelines. So make sure that your report has the above mentioned section/subsections.