ME EN 5230/6230, CS 6330, ECE 6651

Intro to Robot Control – Spring 2023

Problem Set #7: Operational Space Control

For this assignment you will simulate coordinated motion control in operational space. Your task is to design and simulate a series of operational space controllers to track the same circular trajectory as in PS#5 and 6. Use the Simulink template from PS#5, but now you can delete the inverse kinematics, move the forward kinematics into your feedback path, and use a summing junction to create error in operational space.

1. Begin with **Jacobian Inverse Control**, in which case you can use the same the same PD gains that you used when doing decentralized control in joint space (PS#5, problem 1). Simulate at low speed (f=0.2 circles/s) and high speed (f=1 circles/s), and compare the **trajectory** and **joint errors** from with Problem 1.1 of PS#5.
2. Next, you will implement a series of operational space controllers based on the **Jacobian Transpose**. For each of the following control schemes, simulate at low speed (f=0.2 circles/s) and high speed (f=1 circles/s) and compare the tracking performance with the other control schemes. For these controllers, you will not be computing the joint errors at all, so just compare the errors in operational space. Since the PD gains for these controllers will now be penalizing errors in operational space, you will have to find a different set of PD gains than you used in problem 1. For problem 2.1, find a set of PD gains that results in comparable RMS errors to problem 1. Use the same PD gains in problems 2.1-2.3 for a fair comparison.
   - **2.1** Jacobian Transpose Control
   - **2.2** Inverse Dynamics Control in Operational Space
   - **2.3** Robust Control in Operational Space

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**Note:** For problem 1, make a plot of the x-y trajectory (for reference, plot the actual trajectory overtop of the desired trajectory) and plots for both joint errors vs. time and operational space errors vs. time. For problem 2, make plots of the x-y trajectory and only the operational space errors vs. time. Compare the peak and RMS values of the operational space errors for the various controllers. For each control scheme, provide an image of your Simulink model and printouts of your Embedded MATLAB Functions. Be sure to properly title your plots and label your axes. If you wish you can use the *RobotApp* that is posted on Canvas to control the simulations.