ECSE/CSDS/EMAE 489
Problem Set 10: Feedback Control
Assigned: 4/15/21
Due: 4/22/21

This problem set explores linear control applied to a 2DOF, planar robot arm. Code is provided for you. Your objective is to explore the influences of control gains, and variations including velocity feedforward and "computed torque" feedforward and interpret and comment on your results.

The robot has torque limits, but no joint velocity limits. You may not change the torque limits. For all cases examined, do apply torque saturation: tau_vec = sat_vec(tau_vec_max,tau_vec).

A hand path planner is provided for you. You can vary the trajectory parameters amax and vmax.

You will experiment with gains in Kp and Kv.

1) open-loop control with computed torque:
Start with trajectory parameters of:
amax=0.5
vmax=0.4

Try simulating the open-loop motion of the robot. i.e., set:
tau_vec=tau_ffwd;

How far along the path does the hand get before it exceeds 1mm of error in the y direction?

2) Servo control, no feedforward:
Apply feedback with the control policy:
tau_servo = Kp*q_err-Kv*qdot_vec;
(and saturation: tau_vec = sat_vec(tau_vec_max,tau_vec);)

Choose gains in matrices Kp and Kv. Choose trajectory parameters amax and vmax. What values do you recommend to achieve hand tracking for which the y-error is less than 1mm for the entire path. What is the fastest you can complete this motion (within 1mm of the hand goal) without exceeding 1mm of y-error along the path?

3) Servo control with velocity feedforward:
Repeat (2), but include velocity feedforward, i.e.:
tau_servo = Kp*q_err+Kv*qdot_err;
(and saturation: tau_vec = sat_vec(tau_vec_max,tau_vec);)

How does this affect the fastest trajectory subject to 1mm error bound?

4) Servo control with computed torque feedforward:
Repeat the same analysis, but with computed torque feedforward included, i.e.:
tau_servo = Kp*q_err+Kv*qdot_err;
tau_vec=tau_servo+ tau_ffwd;
(and saturation: tau_vec = sat_vec(tau_vec_max,tau_vec);)
How does this affect your fastest trajectory subject to 1mm error bound?

Deliverables:

Include your plots for each case, documenting the success (1mm tolerance) of your robot motion. State your chosen parameters and minimum time for each case. What are your values of omega and zeta for your choices of Kp's and Kv's?

At what values of Kp and Kv did you find instability? Can you explain these values in terms of the time step, DT?

All members of a group will submit the same solution (redundantly). Don't forget to enter your group/ self rankings with your submission.