ECE-521

Lab 6:Full Order Observers and Type One State Variable Feedback Systems

Note: Be sure all initial estimates in your observers are set to zero before you try and control the ECP systems.

One degree of freedom system.

a) Set up the one degree of freedom system you used in lab 1.

b) Try and control the system with a controller you used in lab 1 and be sure you get similar results. (This is just a starting point to be sure the system is behaving in the same manner as before)

c) Simulate the system with a state feedback controller and a full order observer. Place the closed loop poles near -15 and -20. Keep the state variable feedback poles and the observer poles identical (with pole locations **p**).

d) Run the ECP system with your controller/full order observer.

e) Compare the actual states (from the ECP system), the predicted states (from the model), and the estimated states (from the observer implemented in the ECP system). You will have to modify compare1.m to do this. Be sure to change the legend command and use different line types so the results will be acceptable with black and white printers. Only plot until the system reaches steady state. Your system may have a position error, but we'll fix that later.

f) Make a plot of the estimated state versus time.

g) Repeat steps (c-f) keeping the state variable poles at **p** but changing the observer poles to **2p**, **4p**, and **6p**. You should notice two things: (1) as the observer poles become more negative, the observer estimated states converge more quickly to the true states, and (2) as the observer poles become more negative the estimated states are not very smooth. This is because we are now letting more noise into the system (by increasing the observer's bandwidth). Be aware that our ``true'' derivative is really just an estimate itself.

h) Simulate the system with a state feedback controller and a full order observer, with a configuration that forces a type 1 system. Try to place the closed loop poles near -10, -15 and -20. Do not try for a particularly fast response, it will overwhelm the system! Put the observer poles at **p** = eig(A-B*K).

i) Run the ECP system with your controller/full order observer type 1 system configuration.

j) Compare the actual states (from the ECP system), the predicted states (from the model), and the estimated states (from the observer implemented in the ECP system). Only plot until the system reaches steady state. Your system should have near zero position error.

k) Repeat steps (g,h,i) keeping the state variable poles where they are but changing the observer poles to **p**, **2p**, and **3p**. This system is really driven by its desire to produce zero position error. Most likely you will notice that the observer estimated velocity is much worse than with the system with just an observer.

Two degree of freedom system.

a) Set up the two degree of freedom system you used in lab 2.

b) Try and control the system with a controller you used in lab 2 and be sure you get similar results. (This is just a starting point to be sure the system is behaving in the same manner as before)

c) Simulate the system with a state feedback controller and a full order observer. Assume the only output available for the observer is the position from cart 2, and we are trying to control the position of cart 2. Place the closed loop poles near -10, -15, -20, and -25. Do not try for a particularly fast response, it will overwhelm the system! Keep the state variable feedback poles and the observer poles identical (with pole locations **p**).

d) Run the ECP system with your controller/full order observer.

e) Compare the actual states (from the ECP system), the predicted states (from the model), and the estimated states (from the observer implemented in the ECP system). You will have to modify compare2.m to do this. Be sure to change the legend command and use different line types so the results will be acceptable with black and white printers. Only plot until the system reaches steady state. Your system may have a position error, but we'll fix that later.

f) Make a plot of the estimated state versus time.

g) Repeat steps (c-f) keeping the state variable poles at **p** but changing the observer poles to **2p** and 3**p**. You should notice two things: (1) as the observer poles become more negative, the observer estimated states converge more quickly to the true states, and (2) as the observer poles become more negative the estimated states are not very smooth. This is because we are now letting more noise into the system (by increasing the observer's bandwidth). Be aware that our ``true'' derivative is really just an estimate itself.

h) Now assume the positions of ***both*** carts are available for the observer. Rerun steps (c-g). Compare your results.

i) Now implement a full order observer with a state variable configuration that forces the system to be a type one system.

j) Simulate the system with a state feedback controller and a full order observer, with a configuration that forces a type 1 system. Assume the positions of both carts are available and we want to control the position of the second cart. Place the closed loop poles near -15, -17, -19 -21 and -23. Do not try for a particularly fast response, it will overwhelm the system! Place the observer poles at **p** = eig(A-B*K).

k) Run the ECP system with your controller/full order observer type 1 system configuration.

l) Compare the actual states (from the ECP system), the predicted states (from the model), and the estimated states (from the observer implemented in the ECP system). Only plot until the system reaches steady state. Your system should have near zero position error.

m) Repeat steps (j,k,l) keeping the state variable poles where they are but changing the observer poles to **p**, **2p**, and **3p**. This system is really driven by its desire to produce zero position error. Most likely you will notice that the observer estimated velocity is much worse than with the system with just an observer.

n) Repeat steps (j-m) and try to control the position of the first cart.

Your memo should contain all of your plots as attachments, with figure numbers and captions so I can follow your results. The short body of the memo should contain any discussion.