UNIVERSITY OF CALIFORNIA, SANTA CRUZ
BOARD OF STUDIES IN COMPUTER ENGINEERING

CMPE-242:
APPLIED FEEDBACK CONTROL

HOMEWORK #10
DUE 15-MAR-2016 (M-FILE TO BE EMAILED)

Note: these problems are very similar to the MATLAB section of the final exam. This problem set is extra credit, and will overwrite your lowest HW grade, however, I would expect you to go through this carefully in order to study for the exam. You will not be turning in a paper copy. Instead, you will turn in an m-file that completes the homework assignment.

1. *Attitude Stabilization revisited*: You are going to redesign the controller for the non-collocated plant of the satellite model, this time in state space form. We've converted the model for you, and here is the state space version of $\boldsymbol{G_{FORE}(s)}$, which maps the input of the aft thrusters to the fore-body angle:

```
 A =[0          0          0          0          0          0
     0    -0.7555    41.9632          0          0          0
     0   -41.9632    -0.7555          0          0          0
     0          0          0    -0.2990    14.9470          0
     0          0          0   -14.9470    -0.2990          0
     0          0          0          0          0    -0.5000]

B = [0.3329   22.9467  110.6833  -85.2094    9.2657    1.9153]^T
C = [87.6846    0.0004   -0.0001   -0.0016   -0.0130  -15.2495]
D = [0]
```

   a. Use LQR techniques to pick controller that yields a response similar to what you got on HW#7/8. What is $\boldsymbol{K}$? Where are your closed loop poles?

   b. Add in the state command structure so that you can control to a reference signal. What are your two matrices, $\mathbf{N_u}$ and $\mathbf{N_x}$? Draw the block diagram of the entire control structure.

   c. Simulate the closed loop system, plot the step and impulse responses (make sure to include both output and control). Comment on how this compares to your system in HW#7/8.

   d. Pick estimator poles that are "faster" than the poles you got in (a) above, but also much slower than your Nyquist frequency, $\omega_s/2$. You will again be using a sample rate of 25Hz. What is your $\boldsymbol{L}$, where are your closed loop estimator poles? Again, draw the block diagram of the whole structure (including $\mathbf{N_u}$ and $\mathbf{N_x}$).

   e. Convert your controller/estimator to a transfer function form, $\boldsymbol{K(s)}$, and compare it to what you did on HW#8. Does is look the same? Check the compensator on both bode and root locus techniques (extra poles/zeros, etc).

f. Simulate the whole system, for a step and impulse response, and make sure to plot both ***y*** and ***u***.

g. Descretize the controller/estimator to create ***K(z)***, using a sample rate of 25Hz, and simulate it using the simulink files from HW#7/8. ***Note***: if you do this as a transfer function, make sure to carry a whole lot of significant digits, or it won't work.

2. The state space representation we gave you in Problem 1 (above) is a transfer function directly from ***u*** (thrusters) to Θ_{FORE}. In truth, we actually have measurements of both Θ_{AFT} and Θ_{FORE}. This only changes the [C] and [D] matrices, but they are changed to:

```
 A =[0          0          0          0          0          0
     0    -0.7555    41.9632          0          0          0
     0   -41.9632    -0.7555          0          0          0
     0          0          0    -0.2990    14.9470          0
     0          0          0   -14.9470    -0.2990          0
     0          0          0          0          0    -0.5000]

B = [0.3329   22.9467  110.6833  -85.2094    9.2657    1.9153]^T
C = [21.9063   -0.0015    0.0001   -0.0053   -0.0790  -15.4214
     87.6846    0.0004   -0.0001   -0.0016   -0.0130  -15.2495]
D = [0; 0]
```

Repeat problem (1)a-1(f) with the new system, see how things change.