ME 4811

Lab #3: Observer Design

Consider the "Phoenix" equations of motion as developed in Lab #2.

Do the following:

1. First we would like to investigate the observability of the system. First assume that states $[r, \psi, y]$ are measurable. Write the *C* matrix, find the observability matrix and its rank. Can you estimate *v*? Next assume that $[r, y]$ are measurable, can you estimate ψ and *v*? Assume that only [*y*] is measurable, can you estimate ψ , *v*, and *r*? Finally assume that $[v, r, \psi]$ are measurable, can you estimate *y*? Summarize your conclusions, what sensors are necessary to have in this problem?

2. Assume that you do not have any measurements for your variables except for *y*. Design a full order observer to estimate the rest. Find the observer gain matrix such that the observer has an approximate time constant equal to:
   a) Half the time constant that you selected for your control law in Lab #2. This should make the observer dynamics about twice as fast as the controller.
   b) Ten times larger than the controller time constant, this will be a very slow observer compared to the controller.
   c) Ten times smaller that the controller time constant, a very fast observer. How do the gains change as the time constant (or the observer poles) are varied?

3. Simulate the system using the observer gains from (a) and controller gains from Lab #2, (6). Initial conditions are as for Lab #2, the observer initial conditions should all be at zero. Implement your control law based on the estimated values and, if needed, change the controller/observer poles to get a satisfactory response. Plot and compare both the true and the estimated values for your states. Is the observer working? Compare the simulated response with that of Lab #2.

4. Usually all state variables are measurable with the exception of the lateral velocity *v*; this requires a Doppler sonar which may not be always available. Design a reduced order observer to estimate *v* using measurements of the rest three state variables. Select three time constants as for the previous question and calculate the observer gain(s).

5. Simulate the system using the reduced order observer and appropriate poles. Use the estimated value of *v* in your control law. Use the same initial conditions as before and compare the response to Lab #2 and question (3). Summarize your conclusions, observations, or recommendations.