ASSIGNMENT #7: FLIGHT

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(1) **In-Class Demonstration of Flight Simulation:** 03/19 6:00 pm
(2) **In-Class Demonstration of Flight Control:** 03/24 6:00 pm
(3) **Short Report Documenting your work:** 03/26 6:00 pm

1. Academic Integrity

This is an individual or group assignment. You have the option to work with a partner on this assignment, if you would like.

Please don't be a mooch. No one likes a dead-beat partner, and I will require that you submit your own written report of your findings.

You may share code with your partner on this assignment, and you must state clearly on your assignment who your partner was.

2. Flight Control Simulation

Reuse your simulation of the nonlinear and linear dynamics of your UAV to create a linear and nonlinear simulation of your UAV in a hover. The hover control law is for you to design, using the techniques we've discussed in class.

We will need to add some additional fidelity to the UAV simulation. The actuator model takes a motor command n_{ic} and determines how the actual motor speed n_i, where i corresponds to 1,2,3,4 for motors 1,2,3,4 respectively.

The transfer function of the actuator is parameterized by a D.C. gain determined by the ratio of the measured battery voltage V to the nominal battery voltage of the UAV V_0. Assume that both V and V_0 are constants. The simulation should connect your UAV to 4 identical actuator motor models with a delay time τ_1 of 30 ms and 10 Hz bandwidth. Recall that the bandwidth specifies its first-order transfer function time constant τ_2. The actuator output is restricted to 10 and 500 hz. Equation (2.1) models the zero-state response of the actuator.

$$\frac{n_i}{n_{ic}} = \frac{V}{V_0}\left(\frac{e^{-\tau_1 s}}{\tau_2 s + 1}\right). \tag{2.1}$$

A diagram that shows the necessary components of your simulation is shown below in Figure 1

3. Flight Control Demonstration

(1) Make your drone take-off.
(2) Put your drone into a stable hover 1.5m above the ground.
(3) Land your drone.

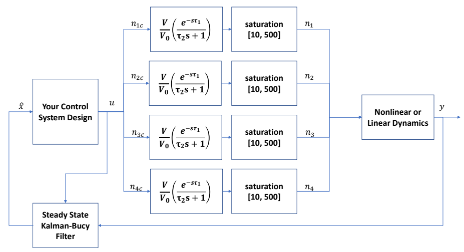

FIGURE 1. Simulation Architecture

4. Flight Control Documentation

Please report the following in a concise manner for your TEAR linear models assuming 90% of the nominal voltage:

(1) Provide the A, B, C, D matrices for a linear state-space description of your controller. Please tell me what the states, inputs, and outputs are.
(2) Provide the A, B, C, D matrices for a linear state-space description of your linear aircraft dynamics. Please tell me what the states, inputs, and outputs are.
(3) Provide the A, B, C, D matrices for a linear state-space description of your state-estimator. Please tell me what the states, inputs, and outputs are.
(4) Provide the A, B, C, D matrices for a linear state-space description of one of your actuator models. Please tell me what the states, inputs, and outputs are.
(5) Break your loops at the input to the linear UAV dynamics (before the actuator). Report the input open-loop transfer functions and loop gain margin and phase margins with and without the actuator model connected in-series with the controller and plant.

5. Helpful Advice

When doing any engineering, build things up incrementally and methodically. Here are my hot-takes on how to do this efficiently:

(1) Start by connecting linear dynamics, for example for the vertical speed and height, to your observer. Then connect your observer to your state-estimator. Then devise a controller that stabilizes the two. When all the linear control systems work, add the actuator models. Then, when you have everything stable, add the nonlinear dynamics.
(2) Get each piece of your simulation and flight control system working in an organized, legible, and clear fashion. Label signals and annotate your diagrams so that you know what's going on.
(3) Please use me. I'm here to help you.

6. What to turn in

Please submit files individually into Canvas (no-more Zips please).

(1) Turn in your reports, models, and code before the deadline in Canvas.

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