ASEN 5519 Small UAS Guidance and Control

Homework 5 Assignment

Assigned: Thursday, February 23, 2023

Due: 11:59 PM, Thursday, March 2, 2023

Submit a single pdf answering the questions below. Only submit code for running one of the parts of Problem 2. Unlike past assignments, this assignment does not specify the exact form or decomposition of the functions you must create.

Problem 1

Write a function whose input is a trim definition for straight, wings-level flight and an aircraft parameter structure, and returns $\mathbf{A}_{lon}$, $\mathbf{B}_{lon}$, $\mathbf{A}_{lat}$, and $\mathbf{B}_{lat}$ where

$$\mathbf{x}_{lon} = \begin{bmatrix} \overline{u} & \overline{\alpha} & \overline{q} & \overline{\theta} & \overline{h} \end{bmatrix}^T, \tag{1}$$

$$\mathbf{u}_{lon} = \begin{bmatrix} \overline{\delta}_e & \overline{\delta}_t \end{bmatrix}^T, \tag{2}$$

$$\mathbf{x}_{lat} = \begin{bmatrix} \overline{\beta} & \overline{p} & \overline{r} & \overline{\phi} & \overline{\psi} \end{bmatrix}^T, \tag{3}$$

$$\mathbf{u}_{lat} = \begin{bmatrix} \overline{\delta}_a & \overline{\delta}_r \end{bmatrix}^T. \tag{4}$$

1. Using your function, determine the linear state space models for the Ttwistor aircraft flying at trim condition $V_a = 18$ m/s, $\gamma = 0$, and $h_{trim} = 1800$ m.

2. What are the damping ratio and natural frequency of the short period mode, the phugoid mode, and the dutch roll mode?

3. What are the time constants of the roll mode and the spiral mode? Are the modes stable or unstable?

Problem 2

The aircraft modes can be excited using two different methods. Mathematically, setting the initial conditions to the trim state plus disturbances determined from the eigenvectors of the **A** matrices will yield the modal response. However, it is not possible in practice to arbitrarily set the initial condition of an aircraft. Instead, modes can be excited by giving the aircraft certain input sequences from the trim condition.

Simulate the aircraft at trim condition $V_a = 18$ m/s, $\gamma = 0$, and $h_{trim} = 1800$ m and then apply the stated control inputs. Plot and describe the results.

1. The phugoid and short period modes can be excited by applying an impulse on the elevator when in trim. Apply an impulse (or approximate it with a very short pulse) and compare to the predicted behavior from Problem 1. Be sure to run the simulation long enough, but also zoom into the initial short period behavior.

2. Excite the lateral modes by applying a doublet to the aileron. A doublet is a sequence of two short pulses, one positive and then one negative, and then back to zero control input. Comment on what modes are excited and if they match the predictions from Problem 1.

3. Excite the lateral modes by applying a doublet to the rudder. Comment on what modes are excited and if they match the predictions from Problem 1.