Chapter 5. Design Project

5.1. Read **Appendix F** in the textbook carefully and familiarize yourself with the Simulink `trim` and `linmod` commands.

5.2. Complete compute_trim.m that computes the trim values for the Simulink simulation developed in chapters 2 through 4. The input to this function should be the desired airspeed V_a, the desired path angle $\pm\gamma$, and the desired turn radius $\pm R$, where $+R$ indicates a right-hand turn and $-R$ indicates a lefthand turn. Once completed, you could run the below script in the command window to obtain trim conditions:

```
[x_trim, u_trim]=compute_trim('mavsim_trim',P.Va0,gamma,R);
```

5.3. Use the above Matlab script to compute the trimmed state and controls for wings-level straight flight with V_a = 35m/s and γ = 0 rad. In param_chap5.m, set the initial states in your Simulink simulation (mavsim_chap5.slx) to the trim state and the inputs to the trim controls for simulation. If the trim algorithm is correct, the MAV states will remain constant during the simulation. Run the trim algorithm for various values of γ. The only variable that should change is the altitude h. Convince yourself that the climb rate is correct.

5.4. Use the Matlab script to compute the trimmed state and controls for constant turns with V_a= 35 m/s, R = 250 m and level flight. Set the initial states in your original Simulink simulation to the trim state, and the inputs to the trim controls. If the trim algorithm is correct, the UAV states will remain constant during the simulation except for the heading ψ.

5.5. Create a Matlab script that uses the trim values computed in the previous problem to create the transfer functions listed in section 5.4 (i.e. complete compute_tf_model.m).

5.6. Create a Matlab script that uses the trim values and the `linmod` command to linearize the Simulink model about the trim condition to produce the state-space models given in equations (5.50) and (5.43) (i.e. complete compute_ss_model.m).

5.7. Compute eigenvalues of `A_lon` obtained from previous problem and notice that one of the eigenvalues will be zero and that there are two complex conjugate pairs. Using the formula

$$(s+\lambda)(s+\lambda^*) = s^2 + 2\hbar\lambda s + |\lambda|^2 = s^2 + 2\zeta w_n s + w_n^2,$$

extract w_n and ζ from the two complex conjugate pairs of poles. The longitudinal modes can be excited by starting the simulation in a wings-level, constant-altitude trim condition, and placing an impulse on the elevator. (The file `mavsim_chap5.mdl` shows how to implement an impulse and doublet.) Using Figure 5.8 convince yourself that the eigenvalues of A_lon adequately predict the short period and phugoid modes.

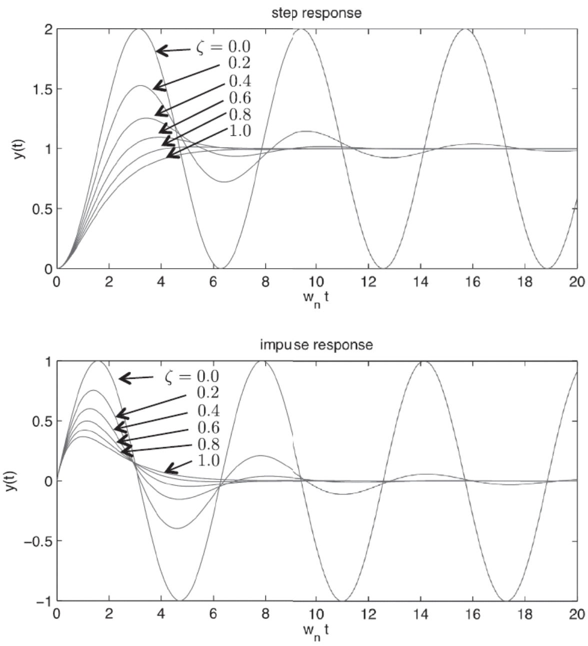

Figure 5.8 Step and Impulse response for a second order system with transfer function equal to $T(s) = w_n^2/(s^2 + 2\zeta w_n s + w_n^2)$.

5.8. Compute eigenvalues of A_lat and notice that there is an eigenvalue at zero, a real eigenvalue in the right half plane, a real eigenvalue in the left half plane, and a complex conjugate pair. The lateral modes can be excited by starting the simulation in a wings-level, constant-altitude trim condition, and placing a unit doublet on the aileron or on the rudder. Using figure 5.8 convince yourself that the eigenvalues of A_lat adequately predict the roll, spiral-divergence, and dutch-roll modes.

5.9. (Optional) You will find that the longitudinal and lateral modes for a small-sized MAV are hard to observe in the simulation due to its small scale. So, if interested, use other conventional aircraft model parameters (e.g. given in the Lecture note) to visualise each mode more clearly (you could submit movie clips for this if needed).