ASE 479W: Simulator Refinements and Quadcopter Control

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1. Introduction

This laboratory assignment was focused on refining the simulator created for the previous lab, by taking into consideration the effects due to aerodynamic forces on the body of the drone and the motor dynamics. Additionally, a controller was developed to vary the voltages received by the drone's rotor in order to change their speeds.

An error was corrected in the submission for lab 1, where in the function for the ODE, instead of taking the inverse of the J matrix, the transpose was taken.

All the relevant information that was used for this assignment was taken from Dr. Humpherys' class notes as well as from MATLAB's documentation page.

2. Theoretical Analysis

Aerodynamic Forces on the Body

The drag coefficient of the drone is sensitive to its pitch and roll, as well as to the properties of the medium it is flying through (the density and viscosity of the air). A simple experiment which can be used to derive this is moving a thin disk through the air at different inclinations. This will result in a varying drag force being felt on the disk.

A simple expression for f_d is:

$$f_d = norm(v_I) * v_I \cdot z_I \tag{1}$$

3. Results

Motor Dynamics

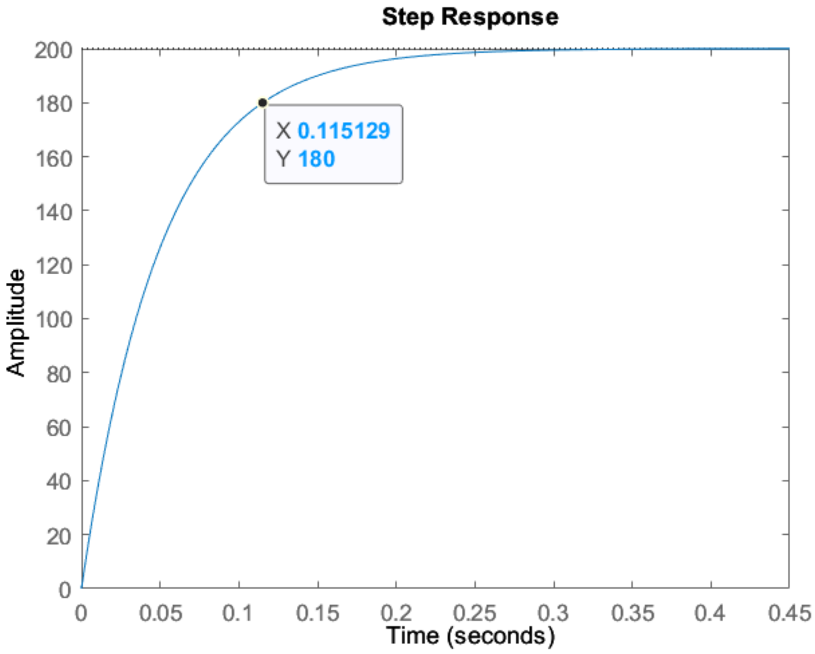

Figure 1 Step response

As can be seen from the point plotted on figure 1, the 90% rise time is around 0.115 seconds. According to the transfer function, the rise time does not depend on the magnitude, however, in practice it would be expected to have an increase in rise time with increasing amplitude, as more power is required to generate a bigger change in voltage.

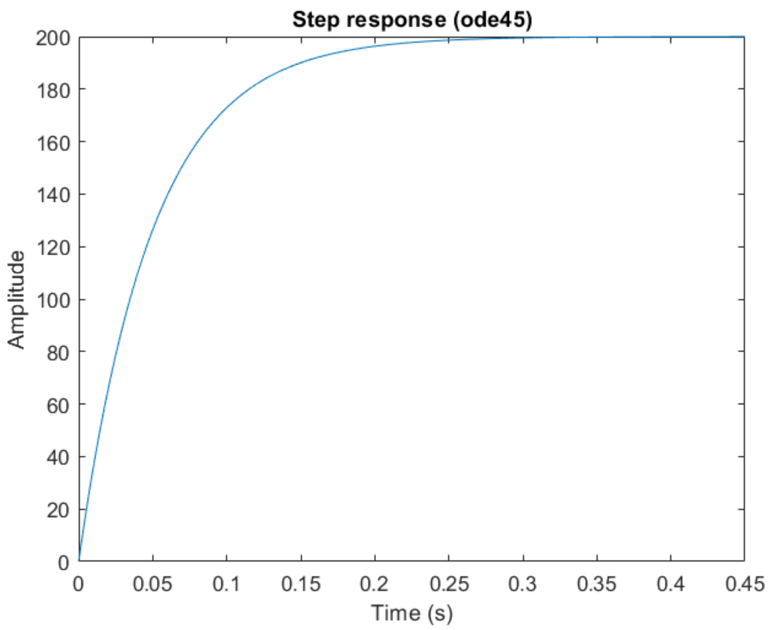

Figure 2 Step response with ode45

Figure 2 shows that the step response plotted using ode45 is identical to the plot made by the step() function.

Simulator Refinements

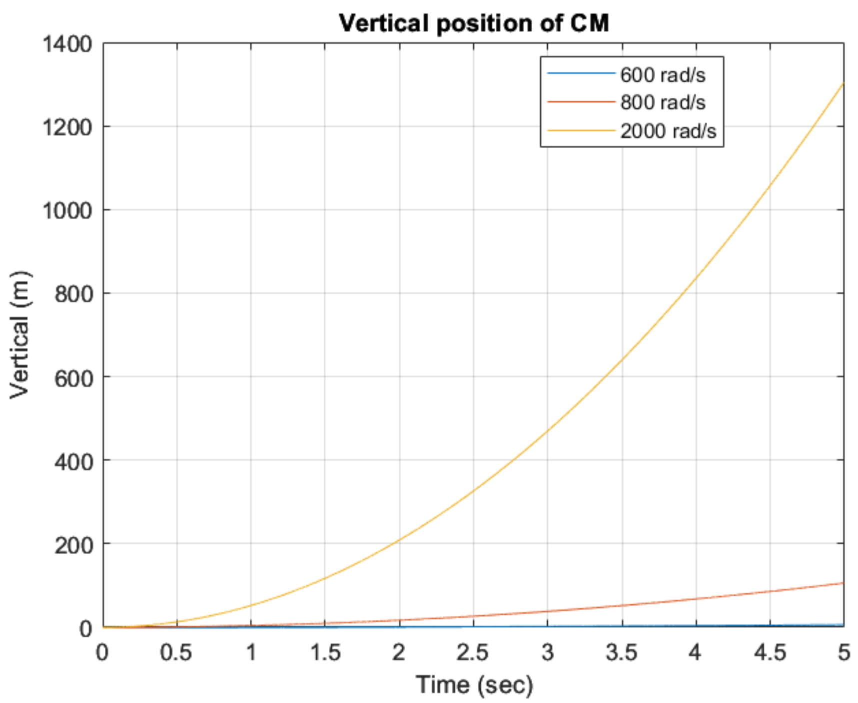

Figure 3 Vertical position at 3 different values for omega

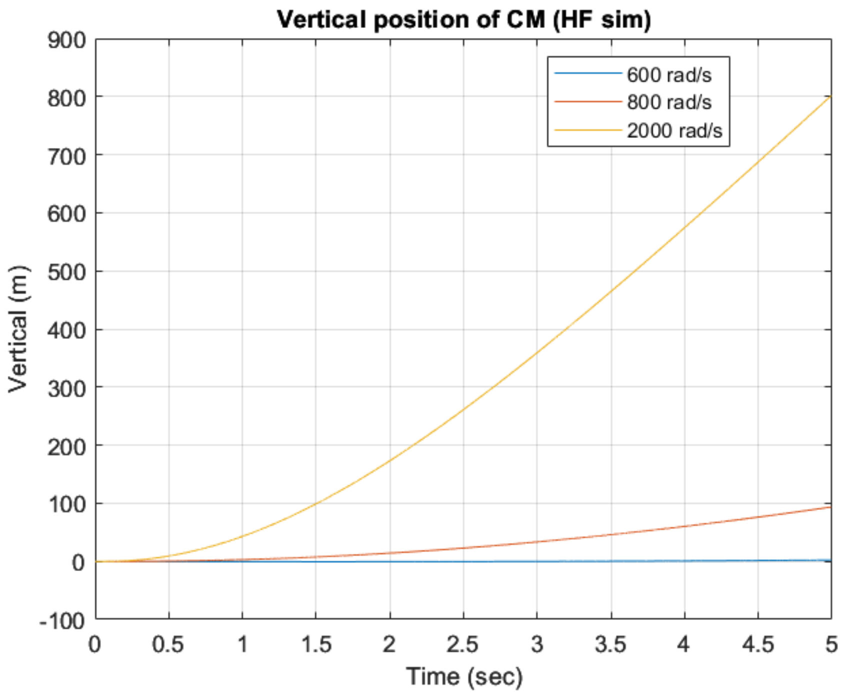

Figure 4 Vertical position at 3 different values for omega using the high fidelity simulation

By comparing figures 3 and 4, it can be seen that the high fidelity simulator reaches a lower maximum height. This is due to the fact that the high fidelity simulator accounts for the time it takes to reach the desired rotor speed, therefore, less distance is covered.

Tuning a Basic PD Controller

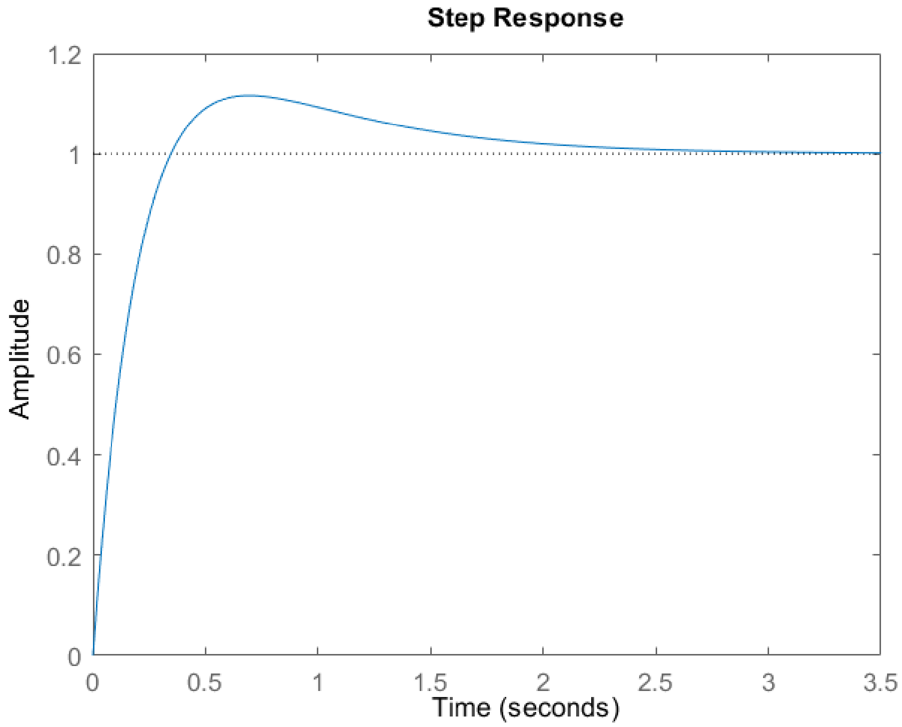

Figure 5 Step response of a tuned PD controller

Rise time (seconds)	0.2483
Settling time (seconds)	1.9942
Overshoot (%)	11.6362

The controller was tuned through trail and error to reflect the above values, the gains that reached this answer being: $k = 7.7$, $k_d = 6.2$, and $k_y = 1$.

4. Conclusion

The quad simulator was refined and a controller was added to account for motor dynamics.