Kalman Filter Design for Cessna 172

Design Method

The first step was to discretize the state-space model I had previously developed for the Cessna 172. The result is shown below.

$$A_d = \begin{bmatrix} 0.9911 & -0.0034 & 0 \\ -0.0011 & 0.9988 & 0 \\ -0.0004 & 0.8381 & 1.0000 \end{bmatrix}$$

$$B_d = \begin{bmatrix} -0.0156 \\ -0.0000 \\ -0.0000 \end{bmatrix}$$

$$C_d = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}$$

$$D_d = \begin{bmatrix} 0 \end{bmatrix}$$

Afterwards, I added noise to the system and processed that random noise to create measurement noise variance for realism. Next, I stored estimated for the Kalman Filter and ran the discrete Kalman Filter. After applying LQR I plotted the results shown below. These show that the estimate and the actual values line up very well.

The LQR is a feedback controller that determines the best input to achieve a desired state with minimal costs. This is then used in conjunction with the Kalman Filter, which estimates a system's state given noisy measurements. So the Kalman Filter first estimates the state and then the LQR computes the gain matrix K to minimize the performance and effort to effectively stabilize the system.

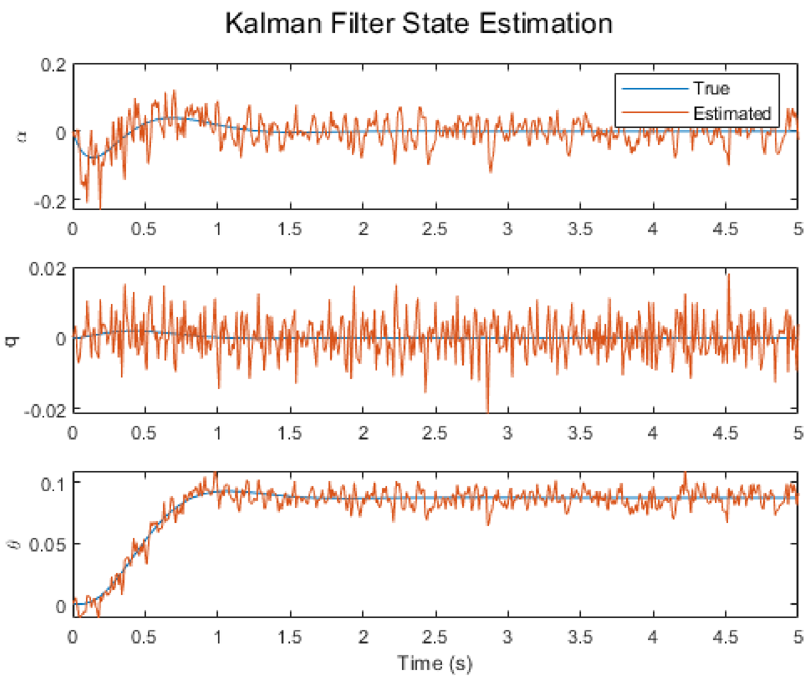

Figure 1: Kalman Filter Estimation plots showing α (Angle of Attack), q (Pitch Rate), and θ (Pitch Angle).

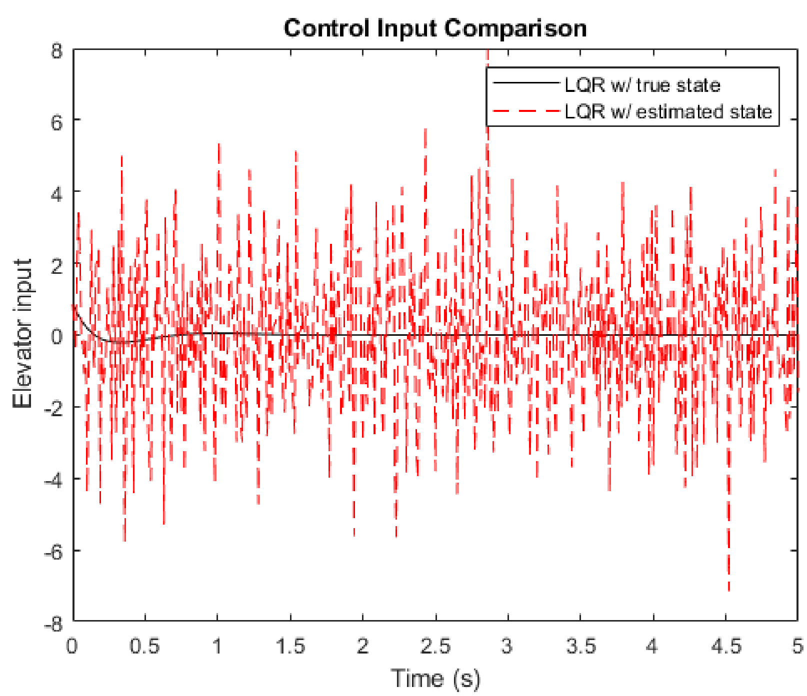

Figure 2: Control Input Comparison.