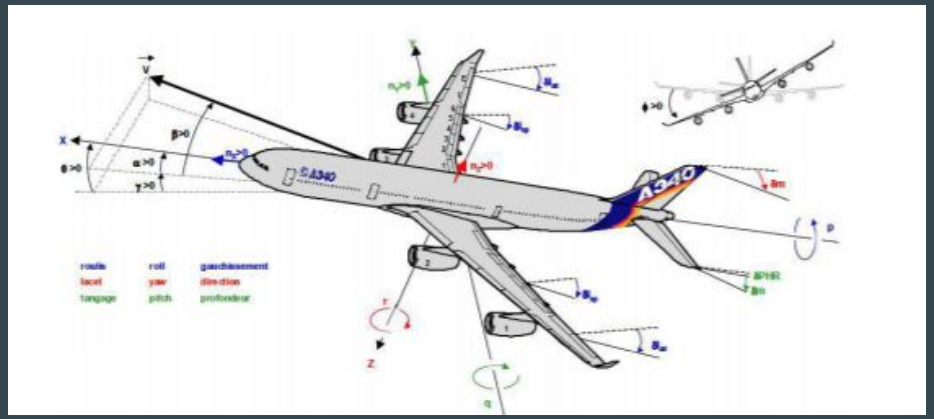
Autopilot Design for Longitudinal Airplane Model



Zhiyu Zhang, Ramona Devi, Ryan Perry

Introduction and Objective

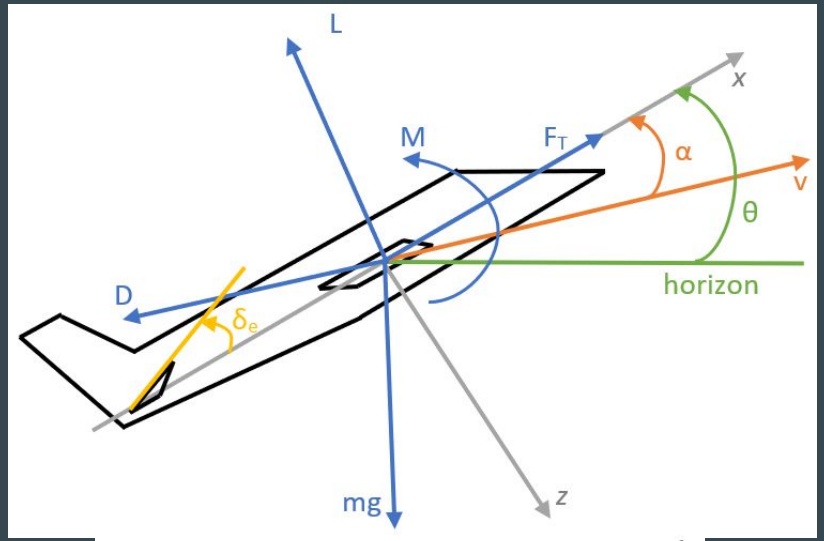
- Design an autopilot for airplane using Linear Quadratic Gaussian (LQG) controller on the longitudinal flight dynamics of aircraft control system.

- Objective is to drive four longitudinal outputs (Airspeed, Angle of Attack, Pitch, Pitch Rate) to follow a reference input with zero steady state errors.

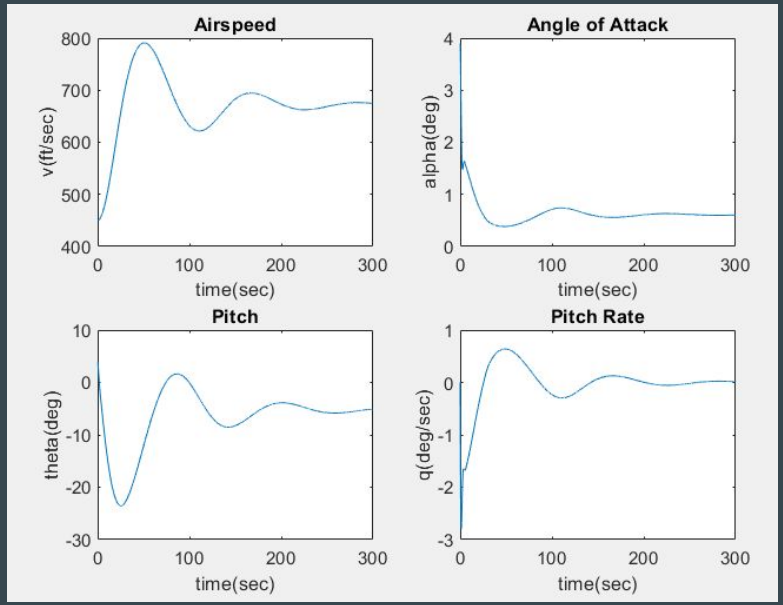
- Since it might be impossible to measure all the states in an aircraft for feedback, so we designed an estimator for all four outputs and used in full-state feedback.

- Synthesis and analysis of stability are done in MATLAB

Model and Open-Loop Simulation Results



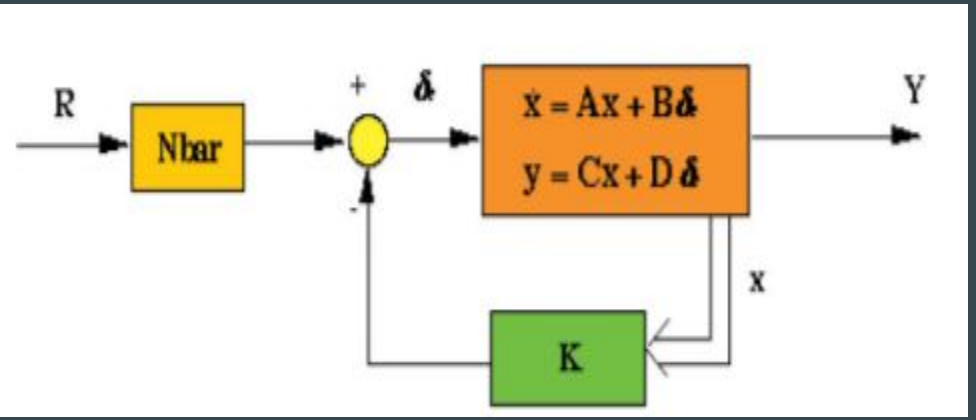
States are v, α, θ, and q, where $q = \dot{\theta}$
Input is δ_e

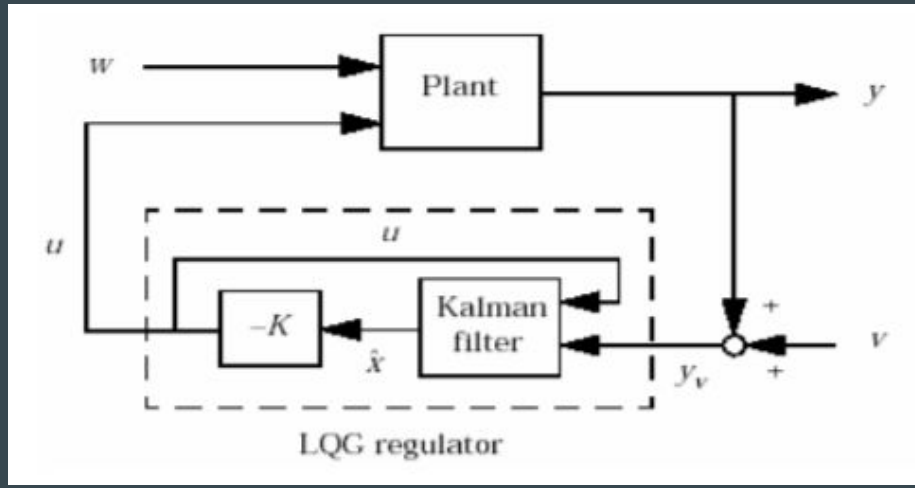


OL response to elevator step input in Nonlinear Simulation

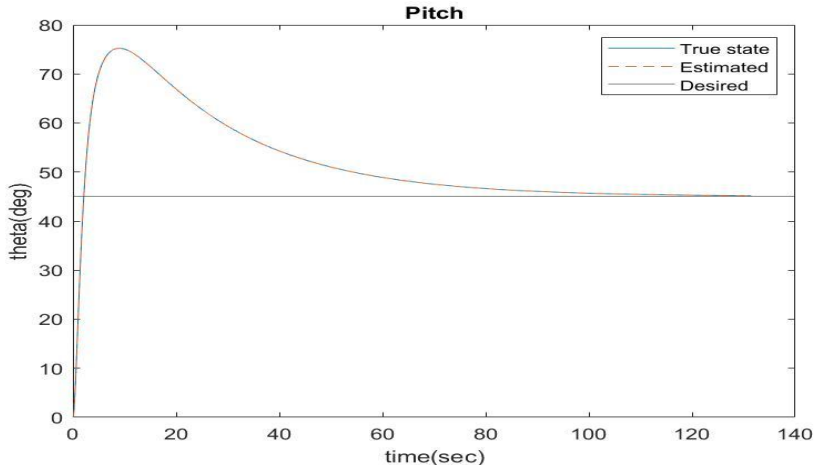
Analysis and Design

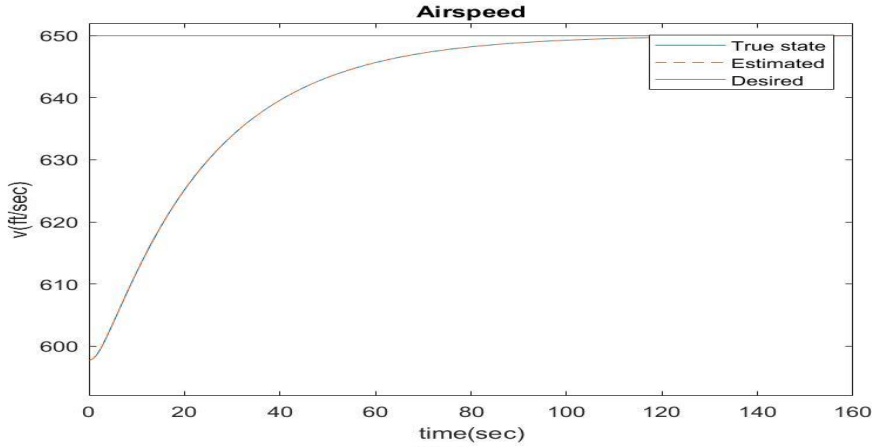
- **Controller:** Linear quadratic gaussian controller is used to design optimal dynamic regulator. It enables the trade off regulation performance and control effort and to take into account process and measurement noise. It simply connects Kalman filter and LQ optimal gain K as shown:
- To drive steady state error to zero, constant gain **Nbar** was used after the reference input.
- Q = diag([0 1/(pi/6)^2 1/(pi/4)^2 1/(pi/4)^2])
- R =0.005
- x0=[597.7454,-0.5093,-0.4062, 0.0001]

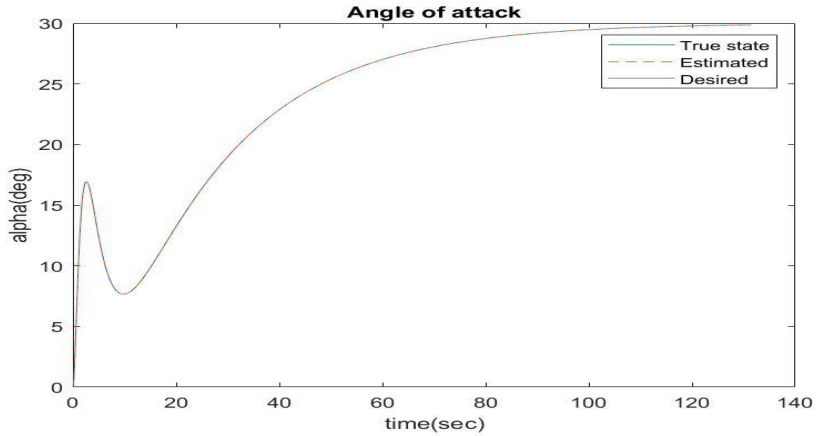


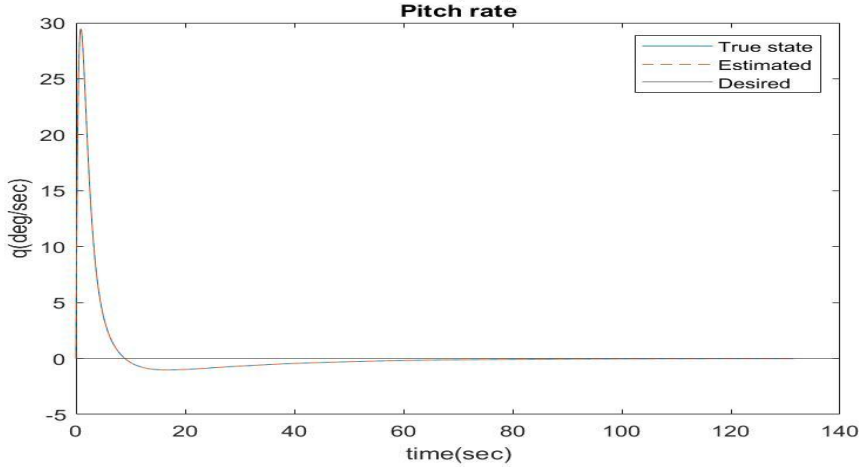


Closed-Loop Simulation Results: Response to a Reference Input









Conclusions

- Our Autopilot design was successful in driving and holding our states to constant reference values.
- The pitch attitude, our main state of interest, was capable of reaching 45 degrees within 100 seconds, albeit with some large overshoot.
- The designed Kalman filter estimated states correctly when initialized at 0. This verifies that I will work when tested against noise.
- **Future work:** Might include testing reference inputs other than steps, testing against noise, and developing a lateral autopilot.