Non-Linear Time Domain System Identification of F-16 Aircraft

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ABSTRACT

The objective of this study is to retrieve the aerodynamic coefficients of an aircraft from given flight data. The time-domain methods are employed to retrieve non-linear aerodynamic models from flight carried out with a closed loop control system. Currently, system identification methods in the frequency domain are widely used. However, these methods are used to retrieve linear models that imitate the aircraft only around a specified trim condition. Moreover, special manoeuvres that contain frequency rich data are required. On the other hand, given the rise of high-quality sensors, measurement noise has reduced substantially paving the way for time domain methods to be applicable. Additionally, flight data retrieved from most new aircraft involves a high-level autopilot system. Frequency domain methods generally give poor results since the controller supresses low frequency excitation. As seen in this study, time domain methods can be applied to solve for non-linear models with flight data retrieved when the autopilot is on.

A complete 6-DOF simulation of the F-16 fighter aircraft is prepared in Simulink. Manoeuvres are carried out with the help of an autopilot system and the flight data is recorded. To imitate a real-life scenario, measurement noise, calibration errors and delays are included. Next, time domain methods such as equation error and output error methods are implemented using the appropriate non-linear state and response equations. Finally, the maximum likelihood cost function is minimized using the Gauss-Newton optimization method.

Major findings of the study include:

- When the measurement noise is low, time domain methods (especially output error method) perform quite well.
- It is possible to solve for a non-linear aerodynamic model using the time domain methods.
- Output error method results may be affected if the plant is unstable and works in a closed loop. It is shown that this can be fixed using artificial stabilization.

***Keywords*:** System identification, Equation error method, Output error method, Simulation, Aircraft dynamics