F-16 Model

Linear vs. Non-linear models

- Linear model has form

$$\dot{x} = Ax + Bu$$

$$y = Cx + Du$$

- Contains all dynamics around an operating (trim) point
- Is defined by matrices A, B, C, and D

- Non-linear model has form $\dot{x} = f(x, u)$

- In this case function f is called *nlplant*
  - In Simulink it is contained in a Matlab function block
  - Source is a C-function (`nlplant.c`)
  - Compiled into Mex-function (`mex nlplant.c`)

F-16 Model

States

- Model has 12 “core” states (x) which need to be integrated
  - North position
  - East position
  - Altitude
  - Bank angle φ
  - Pitch angle θ
  - Heading angle ψ
  - Total airspeed V
  - Angle of attack α
  - Sideslip angle β
  - Roll rate p
  - Pitch rate q
  - Yaw rate r

F-16 Model

States

- Model has 6 “auxilliary” states
  - Mostly 1st order dynamics
    - Gain usually 1

$$\frac{K}{\tau s + 1}$$

  - Engine thrust dynamics
  - Elevator actuator
  - Aileron actuator
  - Rudder actuator
  - Leading edge flap
    - 2 internal states
    - Not used in low fidelity model

- Total of **18** states in linear & non-linear model

18

F-16 Model

Inputs

- Model has 4 pilot inputs
  - Thrust [lbf]
    - Range from 1000 to 19000
  - Elevator angle [deg]
    - Range from -25° to +25°
  - Aileron angle [deg]
    - Range from -21.5° to +21.5°
  - Rudder angle [deg]
    - Range from -30° to +30°
- Linear model only has these inputs (B matrix size = 18 x 4)
  - Are passed through the first order actuator dynamics before going to the aerodynamic part of the model
  - Non-linear model is different

F-16 Model

Inputs non-linear model

$$\dot{x} = f(x, u)$$

- Non-linear model (nlplant function) has **18** inputs
  - 12 “core” states
  - Thrust (after dynamics!)
  - Elevator angle (after dynamics!)
  - Aileron angle (after dynamics!)
  - Rudder angle (after dynamics!)
  - Leading edge flap angle (keep at zero)
  - Fidelity switch (keep at zero for lofi)

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F-16 Model

Outputs

- Linear and non-linear model have 18 outputs
  - 12 “core” states
  - Longitudinal load factor nx
  - Lateral load factor ny
  - Vertical load factor nz
  - Mach number
  - Dynamic pressure qbar
  - Static pressure ps
- Linear model’s C matrix has size **18** x **18**
  - Outputs are deviations from trim point
- Output from *nlplant* function has size **18**
  - 12 “core” state derivatives to be integrated
  - 6 “quasi” derivatives that are really outputs

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