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Nonlinear MIMO Adaptive Control for Longitudinal Aerodynamics Forces and Moments of Hypersonic Aircraft Vehicle Model

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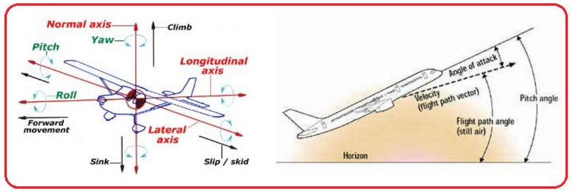
Turki Alsuwian
Prof. Raul Ordonez, Advisor

University of Dayton
Dept. of Electrical and Computer Engineering

Abstract:

- Aircraft vehicle has complex nonlinear system which effected in design the control issues.
- Introduce and design accurate control of longitudinal dynamic and pitch moment in low speed aircraft.
- Solve Longitudinal dynamics equations by maintains control methods of SISO Feedback linearization method by separating system into two subsystem, (1st subsystem for aircraft speed, 2nd subsystem for flight path angel) with second approximations of Drag, lift, and Pitch moment parameters " which means the derivative of them"
- MIMO adaptive control approach is used instead of feedback linearization with first approximations of drag, lift and moments functions to achieve reasonable results of aircraft dynamics control.

Aircraft Vehicle Movements:



1-SISO Feedback Linearization FBL:

$$input\ ; u = [T\ ,\delta_E\ ]^T \quad ; \ output;\ y = [v_p\ \ ,\gamma]^T$$

$$\dot{V}_p = \frac{1}{m}(T * cos(\alpha) - D) - g * sin(\gamma)$$

$$\dot{\alpha} = \frac{-1}{mV_p}(T * sin(\alpha) + L_i) + \frac{g}{V_p} * cos(\gamma) + q$$

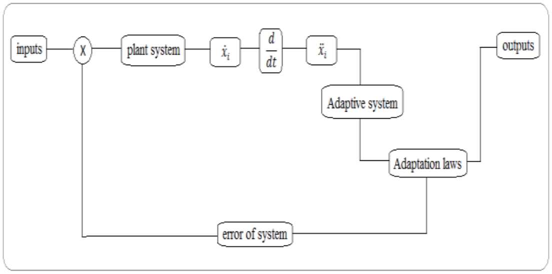
$$\dot{\gamma} = \frac{1}{mV_p}(T * sin(\alpha) + L_i) - \frac{g}{V_p} * cos(\gamma)$$

$$\dot{q} = \frac{1}{I_y} * M$$

2-MIMO Adaptive control:

- For this method , we used two inputs and two outputs for the dynamics system.
- Then we calculated the second derivative of aircraft speed and flight path angle.
- In MIMO adaptive control we used one system where included both two outputs and two inputs.
- Design the control system by using the first approximation of drag, lift and pitch moment.
- Used MIMO adaptive control instead of FBL of first approximation because FBL with first approximation was unstable system.
- Simulations and results of MIMO adaptive control is illustrated and determined the tracking of aircraft speed and flight path angles to desired aircraft speed and desired flight path angle.

States Diagram:



Simulation Results and Conclusion:

- FBL method has good performance for the aircraft speed and flight path angle controller.
- FBL is working very well with 1st approximation of Drag, Lift, and Pitch moment.
- MIMO adaptive control also has good performance for both controller Vp and FPA with 2nd approximation of Drag, Lift, and Pitch moment.

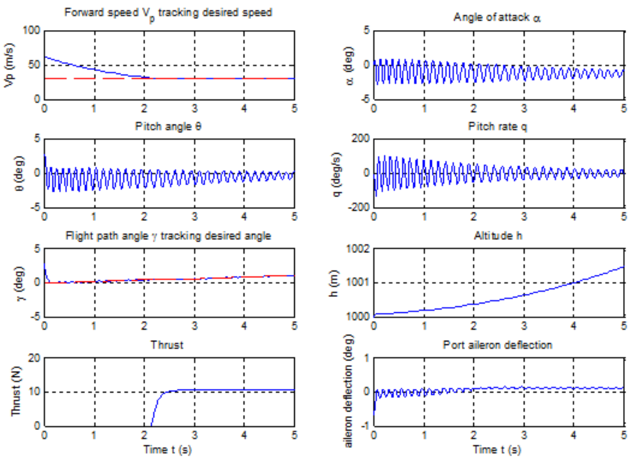


Figure (1): FBL states behaviors

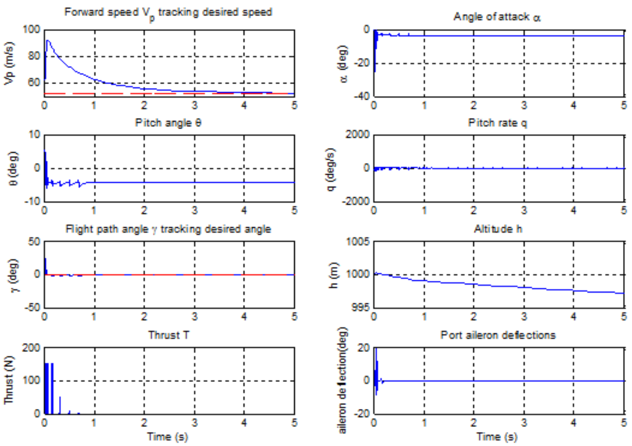


Figure (2): MIMO adaptive states behaviors

Future Work:

- Design the second part of aircraft dynamics control which is Lateral aerodynamic forces and moments.
- Lateral design will be able to control the hypersonic vehicle in low speed and find the admissible range for states of system.