

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

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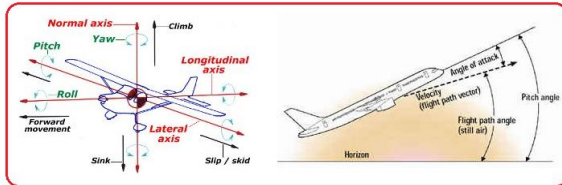
## Abstract:

- 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, 2<sup>nd</sup> 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.

## 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.

## Aircraft Vehicle Movements:



## 1-SISO Feedback Linearization FBL:

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

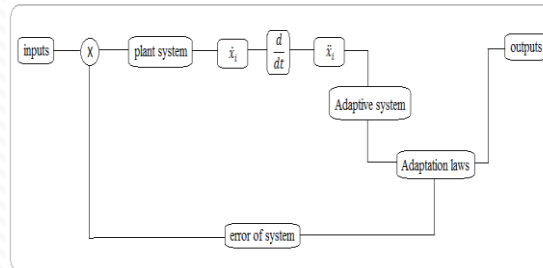
$$\dot{v}_p = \frac{1}{m} (T * \cos(\alpha) - D) - g * \sin(\gamma)$$

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

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

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

## 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 1<sup>st</sup> approximation of Drag, Lift, and Pitch moment.
- MIMO adaptive control also has good performance for both controller Vp and FPA with 2<sup>nd</sup> approximation of Drag, Lift, and Pitch moment.

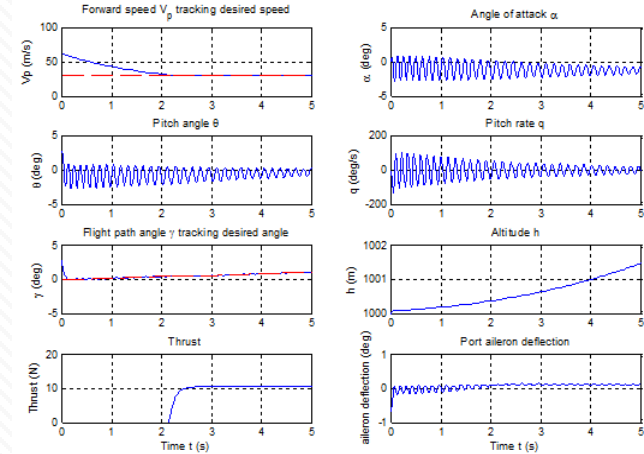


Figure (1): FBL states behaviors

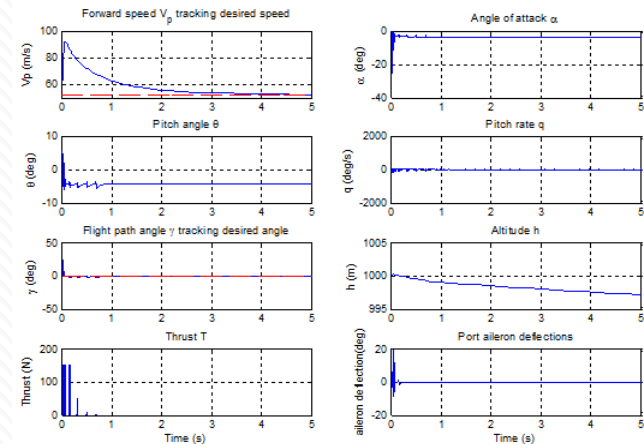


Figure (2): MIMO adaptive states behaviors

## 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.