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Title
Tilt Angle Control Planning for eVTOL using Trim Analysis

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Abstract
Recent endeavors have been made toward the development of electric vertical take-off and landing (eVTOL) vehicles for utilization in unmanned aerial vehicles (UAVs) and urban air mobility (UAMs). The eVTOL, which possesses the capability of vertical ascent and descent akin to a helicopter and utilizes an electric propulsion system, encompasses three configurations - the Multicopter Type, Lift and Cruise Type, and Tiltrotor Type. Among these configurations, the Tiltrotor configuration is particularly noteworthy due to its unique ability to perform vertical take-off and landing while also achieving high-speed cruising in a fixed-wing mode.

A defining characteristic of the Tiltrotor configuration is its transition flight phase, during which the aircraft switches between helicopter and fixed-wing flight modes. This transition is achieved by altering the thrust direction of the propulsion system, thereby modifying the aircraft's configuration. However, the transition flight phase is also associated with numerous challenges, including fluctuations in lift and forward thrust, and the potential for altitude loss or suboptimal target flight speeds. These issues arise from the relationship between the tilt angle of the propulsion system, the aircraft's flight speed, and its aerodynamic and propulsion characteristics.

To mitigate these challenges and ensure a stable transition flight, proper tilt angle control is essential. This can be quantified through the concept of the tilt corridor, which is a representation of the limited range of minimum and maximum airspeed values associated with specific tilt angles of the propulsion system. The tilt corridor can be obtained either through flight tests or through trim analysis utilizing high-fidelity performance data from the aircraft. However, simply determining the tilt corridor is insufficient. To attain a stable and efficient transition flight, it is necessary to derive a tilt angle control plan that operates within the bounds of the tilt corridor.

In this paper, we present a method for deriving a tilt angle control plan that ensures stable and efficient transition flight in Tiltrotor aircraft. Rather than relying on time-consuming and costly flight tests, our approach leverages trim analysis on steady-level flight utilizing high-fidelity performance data from the aircraft. By utilizing the results from this trim analysis, we derive a tilt angle control plan that operates within the bounds of the tilt corridor, thereby enabling stable and efficient transition flight for the Tiltrotor aircraft.

References

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