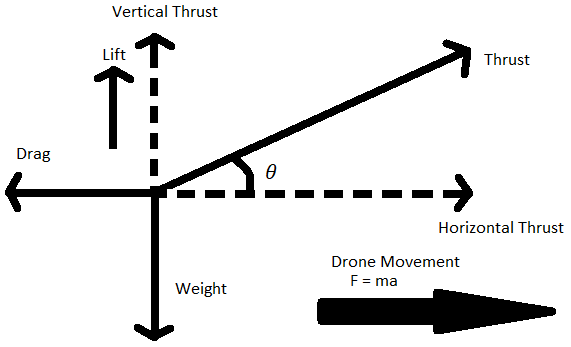
**Conventions:**

* Tilt angle in horizontal flight is set as 0o and in vertical flight as 90o.

**Mathematical Model:**

For simplicity, we assume that thrust magnitude during the transition phase remain constant and only the tilt angle changes. Thrust provided by rotors is divided into vertical and horizontal components depending on the instantaneous tilt angle.

Acceleration of UAV is represented as function of tilt angle & drag force. Tilt angle is a function of lift in (i). Fluent simulations show that drag & lift can be written as function of horizontal velocity as:

Hence, using (i) and (iv), θ can be written as function of velocity.

Using (ii), (iii) & (v), acceleration is written as function of velocity. Hence, equation becomes:

Velocity & Speed are given as:

Since the flight controller doesn’t control tilting in a continuous way but in a discrete way, i.e., changing every clock cycle. Which changes the tilt angle every micro-second according to the equations above.

The easiest and most accurate way to calculate the complete spectrum of tilt angle, horizontal & vertical speed, lift, and drag is to distribute time domain into discrete parts of microseconds (Δt) and then, from t = 0s & v = 0ms-1, start calculating lift, drag and acceleration. Use & to calculate distance and next interval velocity.

Treating the thrust force as an impulse during transition a relationship between the tilt angle and force was obtained. Knowing that the vertical and horizontal forces vary with a cos and sin functions respectively the following conclusions were made:

Maple® was used to plot these functions and hit-and-trail method was employed to reach a physically feasible solution. By deploying 2.5kg thrust from each motor and a tilting rate of 0.794 rad/s the final horizontal velocity achieved is 16.25 m/s which is the ideal cruise velocity for this UAV during the initial transition state.

Chart, histogram

Description automatically generatedChart, line chart

Description automatically generated

To calculate the distance covered during this state:

**Conclusion:**

It was seen that the model was valid up till 110N force which was well within our operation range. Also, a decrease in thrust resulted in an increased angular velocity. The thrust was limited by the motor power and efficiency whereas the angular velocity was limited by servo power and stability. As such, an efficient solution had to be reached for transition state dynamics. Similar method was employed to calculate all transition states activities.