Energy Efficient Drone Landing from Space

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Model

If you drop a quadcopter from space in a vertical line, will the quadcopter have enough energy to land and, if so, what is the ideal height to turn on the drone to use the least amount of energy?

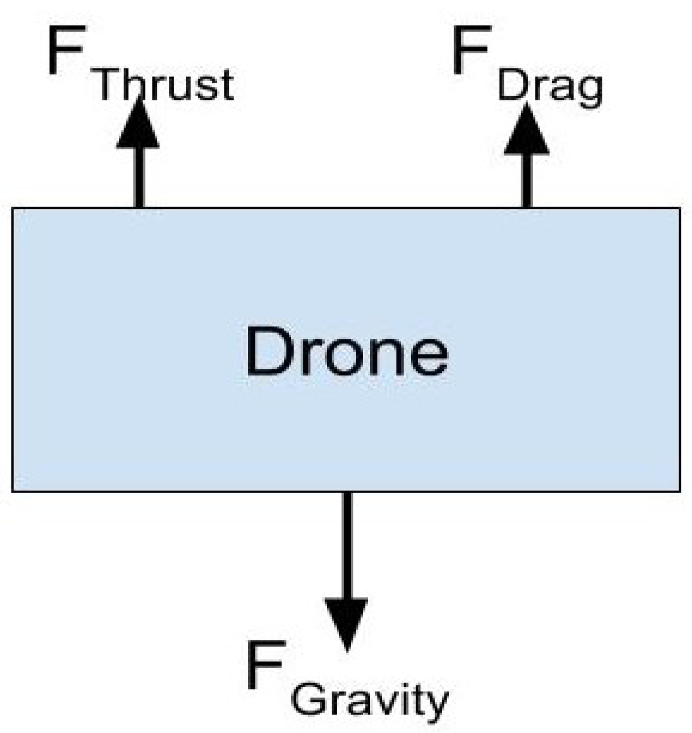


Figure 1: Force Diagram

Assumptions

- The drone can survive extremely high speeds
- The trajectory is a vertical line
- The drone can generate any amount of thrust necessary to land from a given height
- The propellers have no drag
- The drone does not change orientation while dropping

Outcomes

It is possible to land this model quadcopter from space by turning on the thrusters at the most energy efficient altitude.

Results:
Peak Thrust = 14.8 N
Charge Used = 465 mAh
Altitude = 24 m

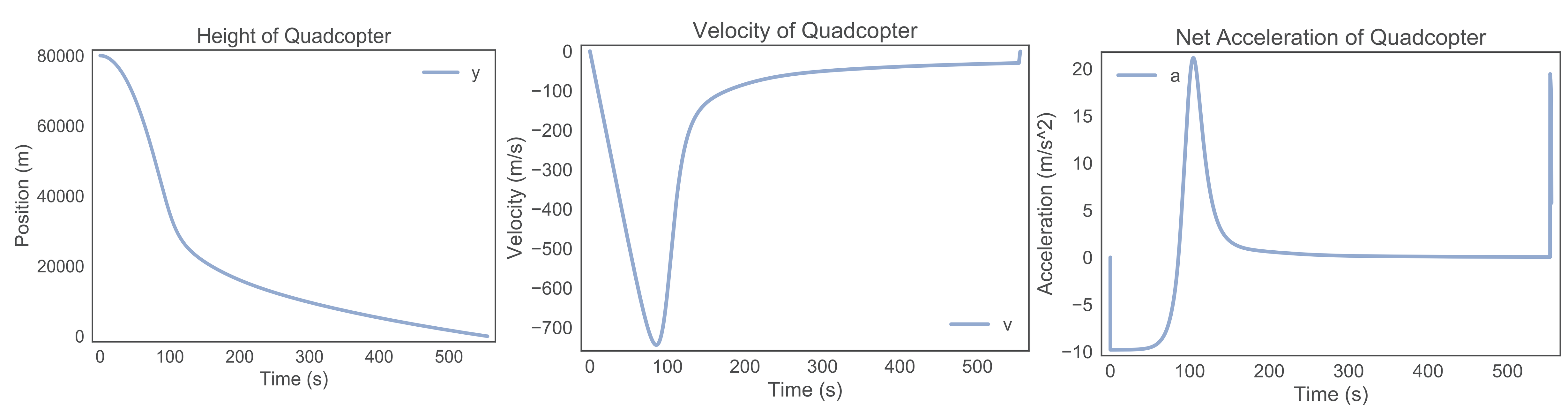
ABSTRACT

Our project began with dropping a drone from a high altitude, and seeing how late you could possibly turn it on to still prevent it from hitting the ground. We then moved to calculating the energy needed to land on the ground, and what the most energy-efficient way to land the drone is, between dropping slowly with low power, or going full power for a shorter amount of time.

III. Mathematical Model of Falling Drone

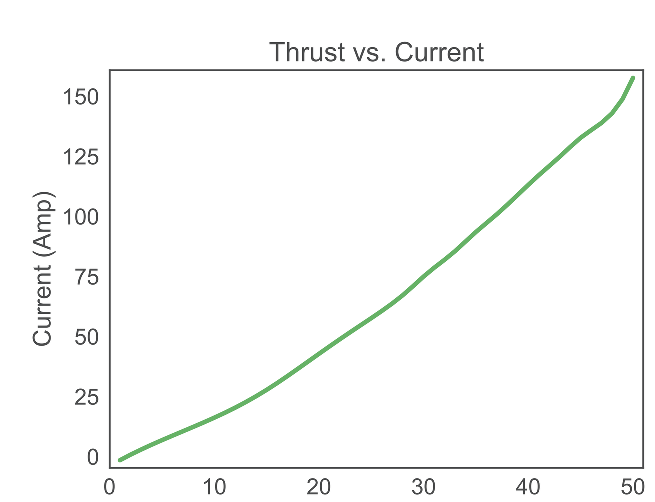
$$F_{drag} = \frac{\rho * C_d * A * V^2}{2} \qquad F_{thrust} = \frac{m * v^2}{2 * h} + m * g - F_{drag}$$

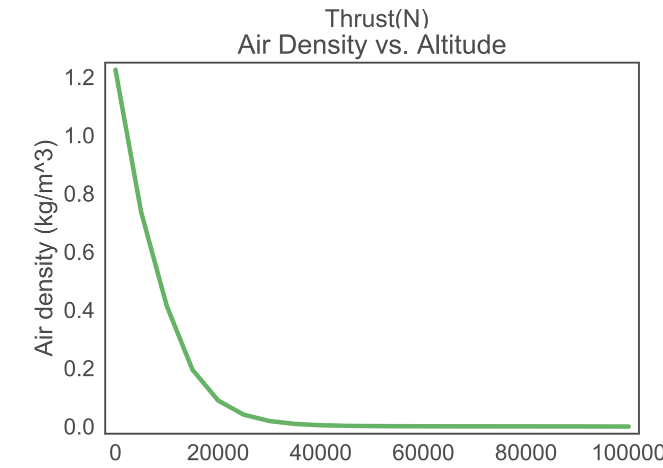
Conditions: $C_d = .3$, Mass = .525 kg, $A_C = .017$ m², $H_i = 80{,}000$ m

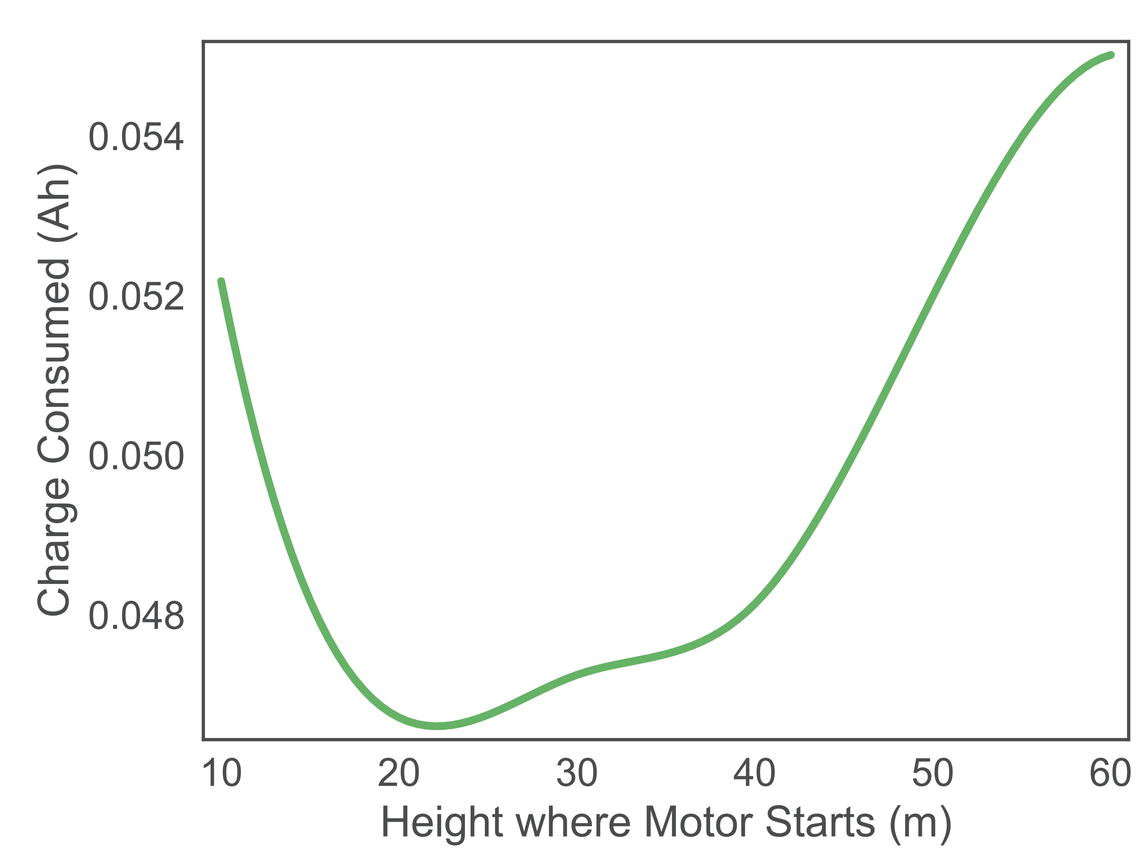


These figures show the height, velocity, and acceleration of the quadcopter when it is dropped from 80,000 m and it is turned on at 24 m.

IV. Final Output







Validation

We found the real drag coefficient for the frame of the drone we are modeling to be 0.3 and we measured the weight of the drone to be 0.525 kg. In addition, we tested that the drone reaches a maximum thrust of 15 N. However, the theoretical limit of thrust the drone can produce is 40 N (using a higher voltage battery and better propellers). The equation for air density was an interpolation of real data points from NASA. The relationship between current and thrust was based on data from the manufacturer of the motors.

Conclusion

While our data shows that it is "possible" to land, there are a lot of issues with entering the atmosphere that would prevent this from being a reality with today's drone technology.

Next steps

- Add horizontal motion
- Different landing techniques
- Different angles of attack
- Add drag to the propellers
- Add a heat shield

References

- Drag Coefficient https://drive.google.com/file/d/0B4aBRX-5zlezbNHM3NjhISzVLUWs/view
- Drag Equation https://www.grc.nasa.gov/www/k-12/airplane/drageq.html
- Atmospheric Data https://www.engineeringtoolbox.com/standard-atmosphere-d_604.html
- Thrust vs Current Data https://www.emaxmodel.com/emax-rs2205s-racespec-motor.html