UNDERSTANDING AERODYNAMIC PROPERTIES OF QUADROTORS NEAR SURFACES FOR OPTIMIZATION IN PERFORMANCE AND DESIGN

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Research Question and Significance

Broad Overview:

Have you ever seen a bat going full speed and with two flaps change directions completely? Have you been annoyed that wasps can squeeze through any tight space and find their way into your room? These wonders are the inspiration for our research project.

We hoped to gain insight on how aerodynamic effects enables flying birds and insects to maneuver in constrained spaces (see below). With an emerging interest in drones and quad-rotor technology, understanding different aerodynamic scenarios could lead to task specific drop designs, optimizing flying capabilities, performance, and energy efficiency.

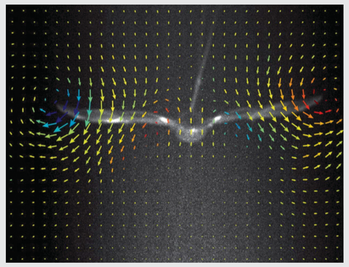


Fig.1 - (Front View) Flow fild visualization for bird flght

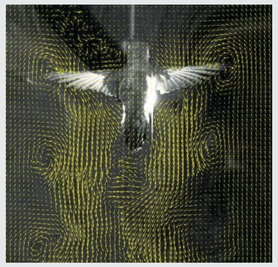


Fig.2 - (Top View) Flow fild visualization for bird flght

Prior Work:

Extensive research on the field of feedback control for the stabilization of these quad-rotors has previously done before. The study of how birds are able to stall in mid air before approaching a branch or an obstacle have also been studied. Our findings aimed to discover new relevant information regarding the design and control of quad- rotors in order to perform highly dynamic maneuvers in order to recreate those motions found in nature.

Proposed Research

This project addresses a specific question, what are the consequences of flying very close to a surface (floor / wall / ceiling). Most solutions to stabilizing a quad-rotors counteract the aerodynamic forces destabilizing it without much thought in what those forces and effects are.

Experimental Set Up

Quadrotor Anchor:

Using a custom CNC-machined attachment, the quad-rotor was anchored to the grand using a weighted bass so that the quad-rotor would remain isolated from outside effects.



Fig.3 - Quad-rotor with custom attachment connected to stand.

Laser:



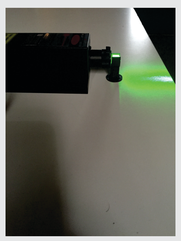


Fig.4 - 500mW Green Laser (532nm) with power source (left) and close up on Powell lens (right)

By diffusing a green laser with a 30° Powell lens we managed to isolate a two dimensional plane in space. Isolating planes allowed us to select different planes of interest to analyze.

Fog Machine and Camera:

The fog machine creates the smoke necessary to analyze the streamlines. Using a high speed camera to capture small segment of time we can find interesting phenomena.

Preliminary Results

The fog machine created turbulence in our recordings, a new approach was then adopted to compare flow fields: A static configuration was made - the room is filled with the fog until a uniform distribution was attained, only then was the survey taken. The second method is the turbulence model where the quadrotor can be further developed to combat high windspeed, in this case, the fog being release by the fog machines nozzle at a given velocity.

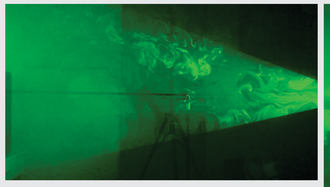


Fig.4 - Flow development in static confiuration

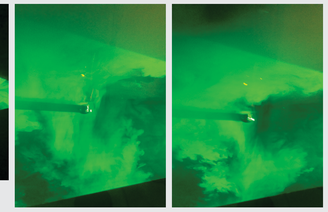


Fig.5 - Flow development in quadrotor section (no near surfaces)

Conclusion

Given more time, our ultimate goal of collecting data in order to mesh together a three dimensional flow visualization would have lead to further understanding of design optimization.

The results of our research will improve the understanding of the aerodynamics forces that destabilize quad-rotors as they move in tight spaces close to surfaces and hopefully will extend the range quad-rotors will be operable in. We could have flying robots moving around in small ventilation ducts and other tunnels very soon, for the purpose of inspection and maintenance.

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