Development of a Flapping Wing Test Stand

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Introduction

Background
- Small natural flyers use unsteady aerodynamics mechanisms to produce lift and thrust, which is qualitatively different than large aircraft aerodynamics [1].
- Scaling laws indicate that a reduction in the size of a flyer leads to an increase in environmental influence for smaller flyers – natural flyers overcome this by improving flight performance (force generation, flapping wings and wing tail coordination, etc.) [1].
- Results of a study performed by Sane and Dickinson concluded that subtle alterations in stroke kinematics have large effects on force production [2].
- Understanding the relationship between the wing kinematics and resulting forces on a flapping wing is essential for the development and improvement of flapping wings - e.g., flexible wings can outperform rigid wings in terms of force production and vice versa depending on flight conditions [1,3].

Objective
- Develop a test stand in which a flapping micro-air vehicle or natural flyer can be mounted and the forces around it while in motion measured.

Experimental Overview

- The test stand developed consisted of a custom machined part with a ¼ in thread and circular platform that was mounted to a tripod stand using a tripod mount and a series of styrene and foam plates screwed together. A circular 3D printed piece was placed around the force/torque transducer to provide dampening.
- The test stand was mounted to a tripod stand using a tripod mount and a series of styrene and foam plates screwed together. A circular 3D printed piece was placed around the force/torque transducer to provide dampening.
- A flapper was mounted to the test stand and the forces generated by the flapper as input voltage increased was recorded.
- Flapping frequency was measured using the VICON motion-tracking system by placing a marker on the wing.

Results

- Results from the data generated by measuring force as a function of input voltage indicate that:
  - Flapping frequency increases as input voltage increases.
  - Average force, maximum force, and flapping frequency increase as input voltage and flapping frequency increase.
  - The average force generated in the z-direction (lift) has the greatest magnitude.
  - The maximum force generated in the y-direction has the greatest instantaneous magnitude.
  - An input voltage of 2.5 V generates the maximum amount of force that is produced in z-direction.
  - An input voltage of 2.5 V corresponds to a flapping frequency of approximately 26 Hz.

Conclusions

Future work will not focus on developing a new test stand or improving the current one – it will instead focus on using the observations made as well as a more in depth literature study to develop a flapping MAV inspired by the flapper used for testing.

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References