COLLEGE OF ENGINEERING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

Research Horizons Day & Research Week April 6-13, 2018

Research Horizons Day

Measurement of Forces on a Flapping Wing Micro Aerial Vehicle

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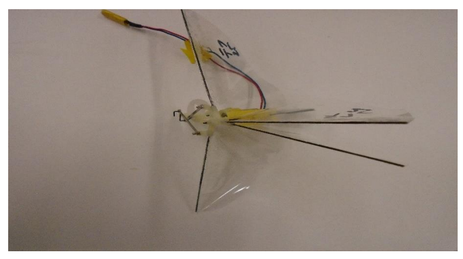
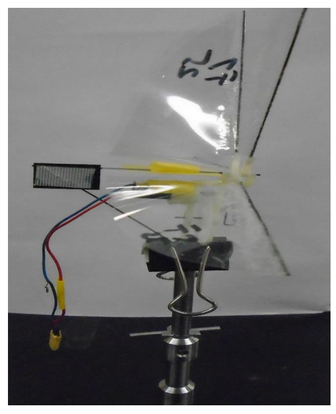
Introduction





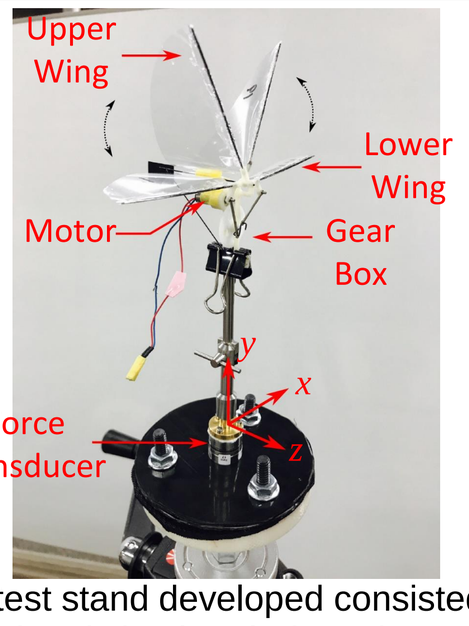
Background

- 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

- The objective of this research project is to measure and analyze the forces generated by a flapping wing MAV.

Experimental Overview



Force Transducer

- The test stand developed consisted of a custom machined part with a ¼ in thread and circular platform that was mounted to a ATI Nano17 Titanium Force/Torque Transducer and screwed into a metal rod with a binder clip screwed to the top.
- 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, donated by Dr. Aono (Tokyo University of Science) 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.

References

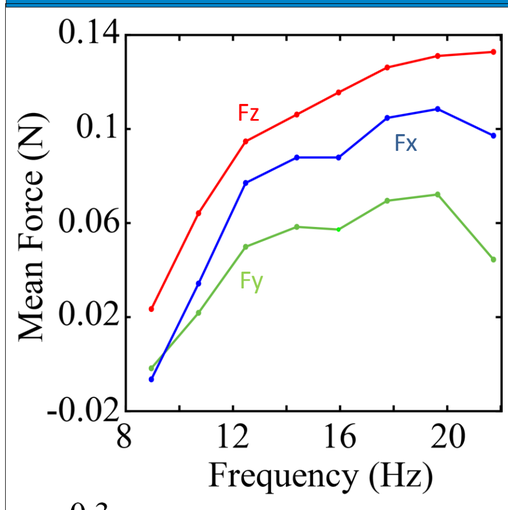
[1] W. Shyy, H. Aono, C.-K. Kang and H. Liu, An Introduction to Flapping Wing Aerodynamics, New York: Cambridge University Press, 2013.

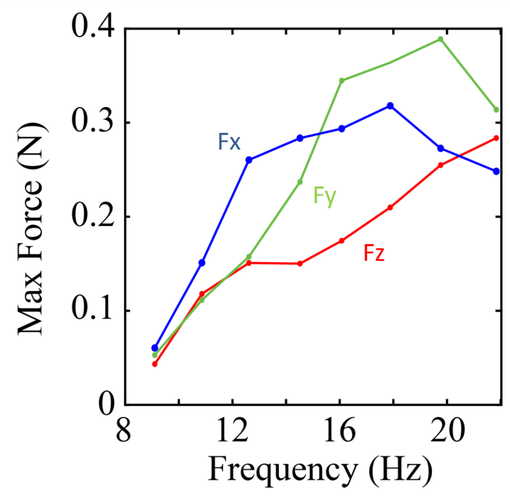
[2] M. H. Dickinson and S. P. Sane, "The Control of Flight Force by a Flapping Wing: Lift and Drag Production," *Journal of Experimental Biology ,* vol. 204, no. 16, pp. 2607-2626, 2001.

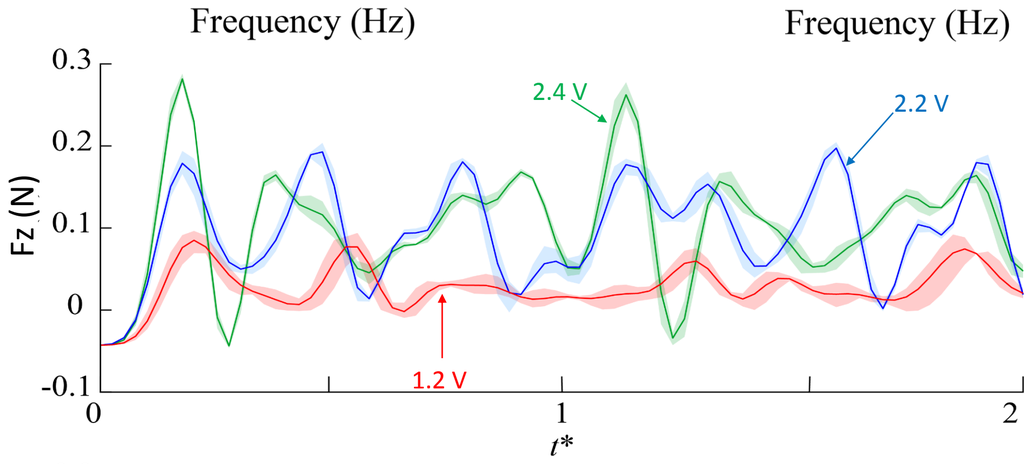
[3] L. Zhao, Q. Huang, X. Deng and S. P. Sane, "Aerodynamic effects of flexibility in flapping wings," *Journal of the Royal Society Interface,* vol. 7, no. 44, pp. 485-497, 2010.

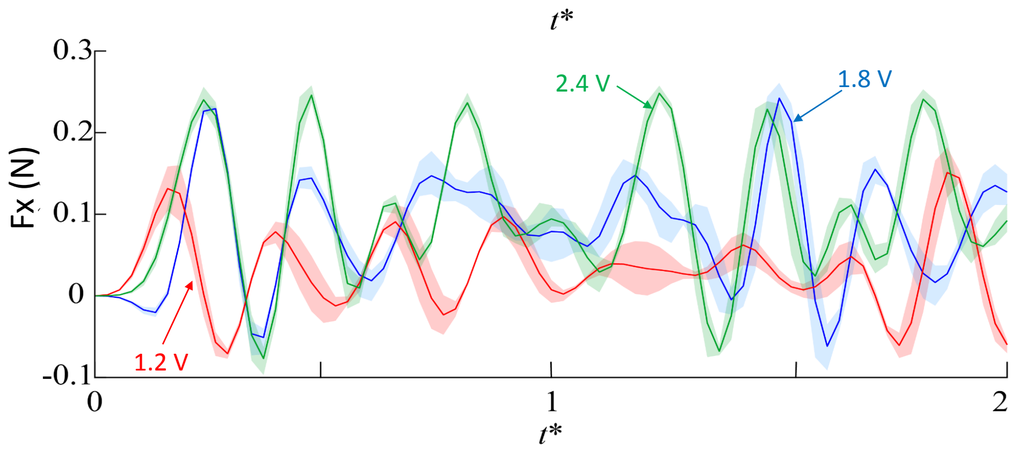
[4] Nature's Invitation (2016). Hummingbirds Ultra Slow Motion - Amazing Facts, Full HD. [image] Available at: https://www.youtube.com/watch?v=FPRswRWZ23Q [Accessed 8 Feb. 2018].

Results









Conclusions

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.
- The oscillation of the forces around 0 in the x-direction and y-direction result in high maximum values and low mean values.
- Based on the forces measured in the z-direction, the flapper can lift a total weight of approximately 14 grams.

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.

Acknowledgements

Acknowledgements go out to:

- Dr. Brian Landrum, Madhu Sridhar, Kabilan Nedunchezian and Daniel Aiken of the MAE Department.
- Dr. Hikaru Aono of Tokyo University of Science.
- UAH College of Engineering
- UAH Office of the Provost
- UAH Office of the President and Vice President for Research and Economic Development

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