FLAPPING WING MICRO AIR VEHICLE (FWMAV)

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Future Areas of Research

With the first iterations of the quadflappers being finalized, the distinct nature of flapping wing mechanisms will be scrutinized further. This includes using wind tunnels to gather efficiency data to investigate the steady state flying conditions of the quadflappers. Particle Image Velocimetry can be utilized to track and quantify the flow field surrounding the quadflappers during flight, revealing the aerodynamic mysteries that exist. A 3D motion tracking system can be used to investigate the freeflying abilities of the quadflappers, namely its responsiveness to in-flight disturbances. Propeller drones can contribute to this research as well, for they provide meaningful baseline data regarding drone performance. FWMAVs can have many future applications, including mimicking tiny insects for covert surveillance, as well as providing aid to first responders.

Wind Tunnel

The Alpha and Beta drones can be tested in one of UCI's Low Speed Wind Tunnels, in different orientations and at various angles of attack. The purpose of these tests is to measure the power input required for certain airspeeds. The Wind Tunnel can also be used for flow visualization experiments, to see how the air interacts with the full drone prototype. These interactions will inform future designers on ways to minimize the drag of the wing subassemblies and center frames of the drone.

Figure. 1: Low Speed Wind Tunnel (Credit: Aerolab)

Particle Image Velocimetry (PIV)

PIV combines an air particle seeder, synchronizer, high-power laser, and high-speed camera alongside capture software to trace individual air particle flow and eventually quantify the velocity vectors of the flow field around the aircraft. This paints the picture for the unsteady aerodynamic flow field of the flapping mechanism and shows how the flow generated by each wing interacts with one another.

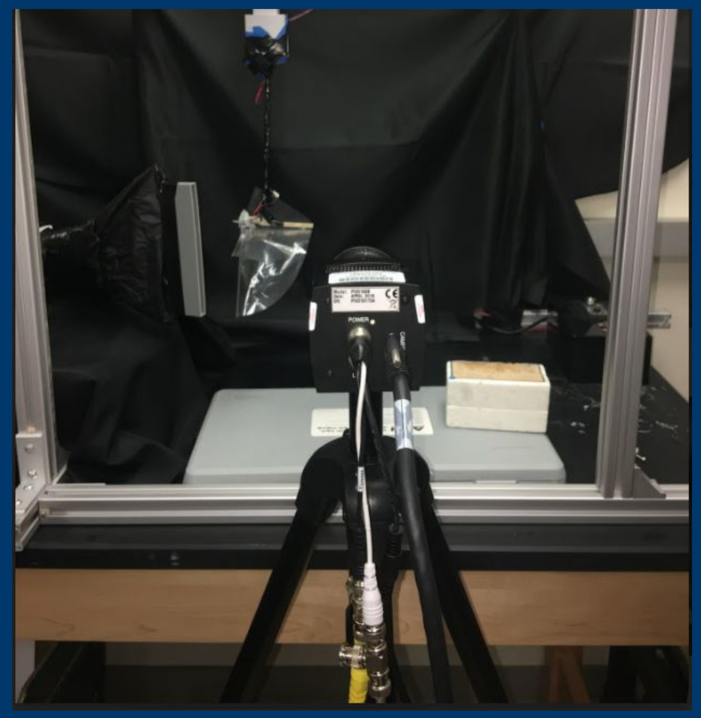

Figure. 2: PIV capture setup

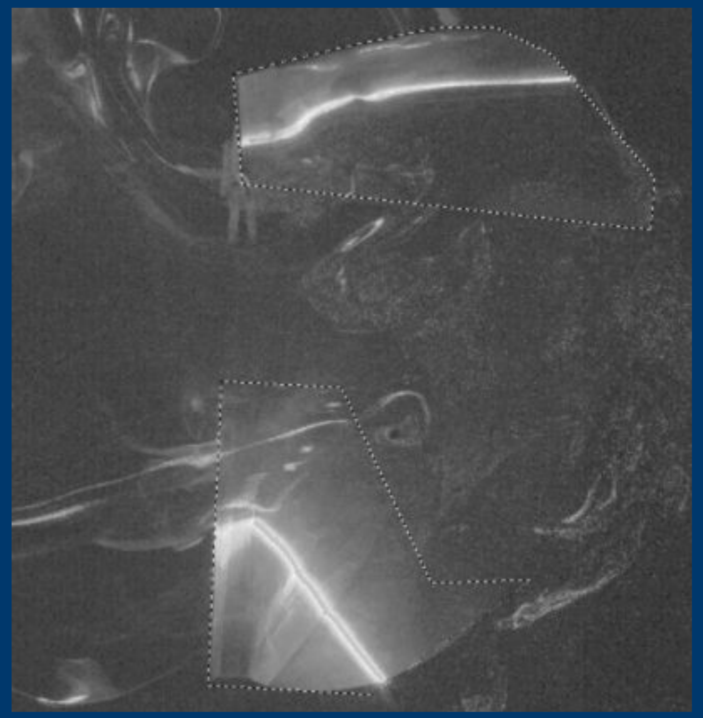

Figure. 3: PIV capture of flow field around FWMAV

3D Motion Capture

The cornerstone idea of FWMAV technology is vibrational stability, which is the ability of the quadflapper to return to its steady state flight conditions when its flight path is disrupted, and to maintain a near perfect hover, when unperturbed. To capture the freeflying performance of the drones, a 3D motion capture system can be used to investigate some worthwhile topics, including the capability of the quadflapper to pitch, roll, and yaw, along with its ability to recover from certain disruptions.

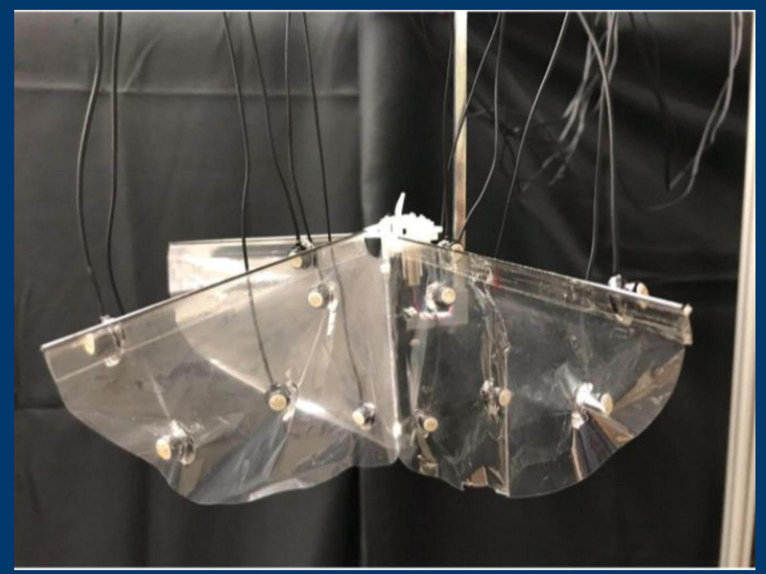

Figure. 4: 3D Motion Capture LED trackers on the wings

Figure. 5: 3D Motion Capture Camera by PTI Phoenix Technologies

Quadflapper vs Quadcopter

In order to more precisely compare the performance of a flapping wing design, traditional propeller drones of similar specifications (weight, motor size, thrust ability) are built and tested in tandem with the FWMAVs. The abilities of the quadcopter provide data for how a control group would behave during experimentation, allowing the quadflapper data to be measured directly against it.

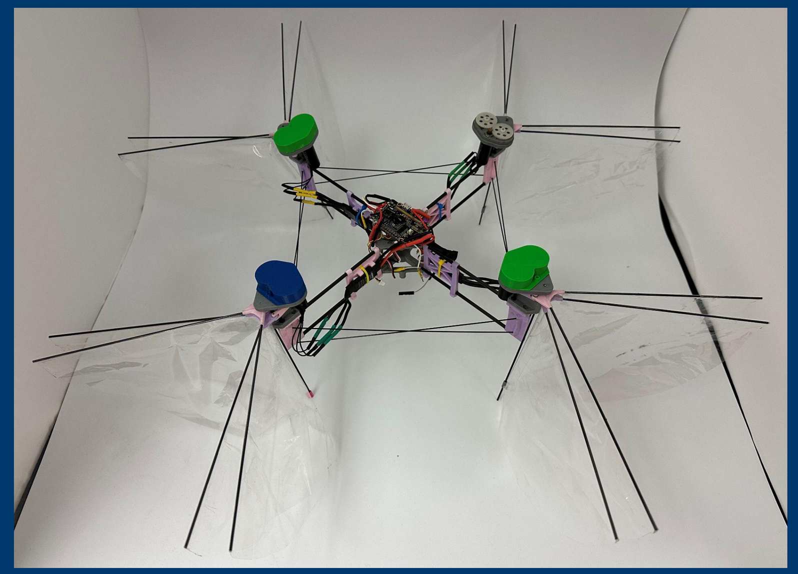

Figure. 6: Old Beta Prototype Quadflapper

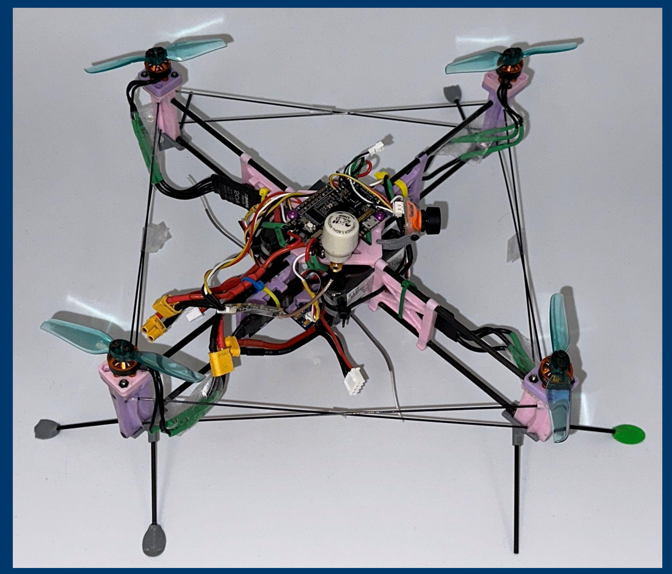

Figure. 7: Corresponding Beta Quadcopter

Applications

Due to high maneuverability and relative inconspicuousness first responders can utilize FWMAVs to perform search and rescue. The smaller drones may be used intelligence gathering, as they are able to conduct surveillance in areas that traditional drones cannot. However, current prototypes are limited in size because of the lack of available driving technologies.

Figure. 8: "Hummingbird" MAV by DARPA

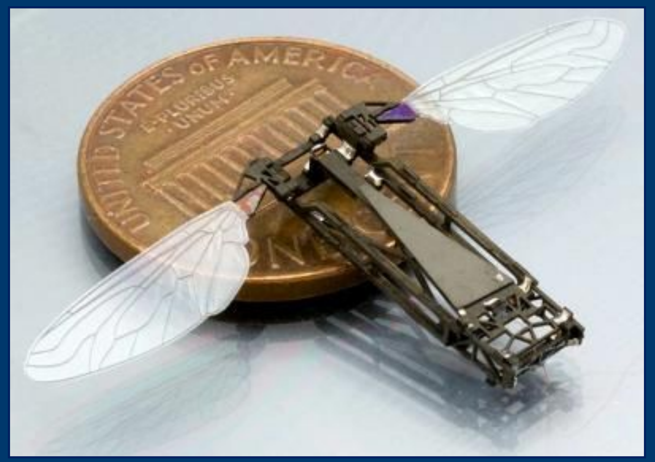

Figure. 9: "Microrobotic fly" MAV by Harvard

Acknowledgements:

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[2] Taha, H. E., Kiani, M., and Navarro, J., Experimental Demonstration of the Vibrational Stabilization Phenomenon in Bio-inspired Flying Robots, IEEE Robotics and Automation Letters. Vol 3, No. 2, 2018, pp. 643-647.

[3] Taha, H., Hajj, M. and Beran, P., 2014. State-space representation of the unsteady aerodynamics of flapping flight. *Aerospace Science and Technology*, 34, pp.1-11.

[4] D. Deb, K. Huang, and M. Fouda, "Effect of self-induced body vibrations on thrust generation in bio-inspired Flying Robots," *AIAA SCITECH 2022 Forum*, 2022.