Visual flight control for the very smallest aerial vehicles

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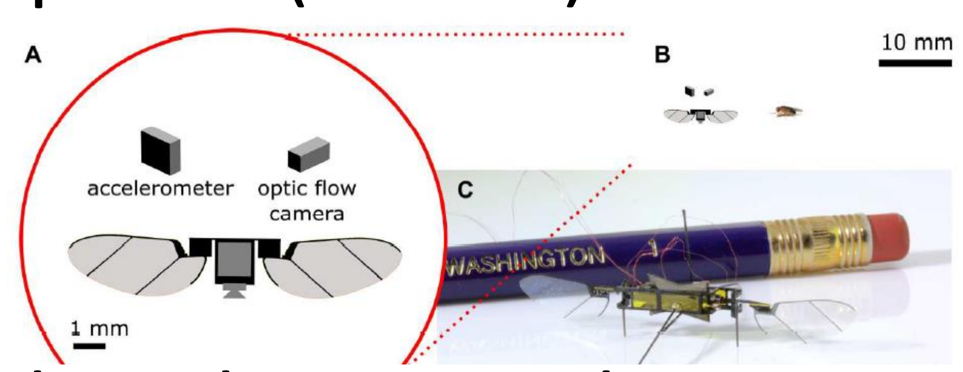
https://depts.washington.edu/airlab/

The goal of the proposal is to create a control architecture and design guidelines and for vision-based estimation and control of robots as small as flies and even gnats. Applications range from detecting and mapping gasses to low-cost space exploration.

Challenges:

- Extreme speed size, weight, and power (SSWaP) constraints
  - Size: a grain of rice
  - Weight: 10 mg
  - Power: 10 mW

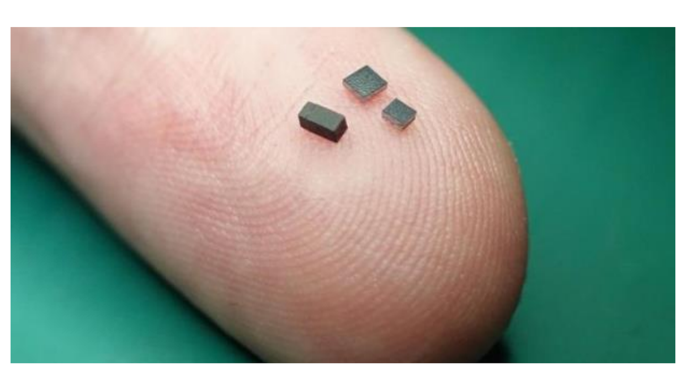


- New technology needed across the robotics stack:
  - New sensor suite architecture
  - Origami-based microfabricated actuators
  - Extremely power efficient software and logic.

Scientific impact:

- Model and analyze the effects of physical scale on robot sensing, control, and power
- Design and analyze a hovering controller compatible with the constraints of the very smallest, millimeter-sized flying robots
- Design and analyze a system for navigation tasks such as maneuvering through a cluttered space, obstacle avoidance, and source-seeking

On-board Sensor suites:



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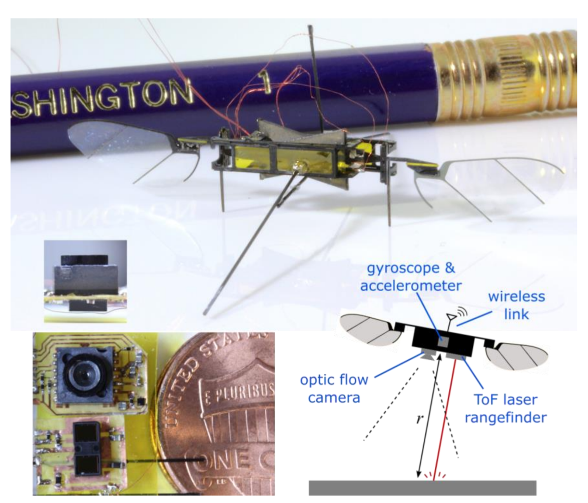

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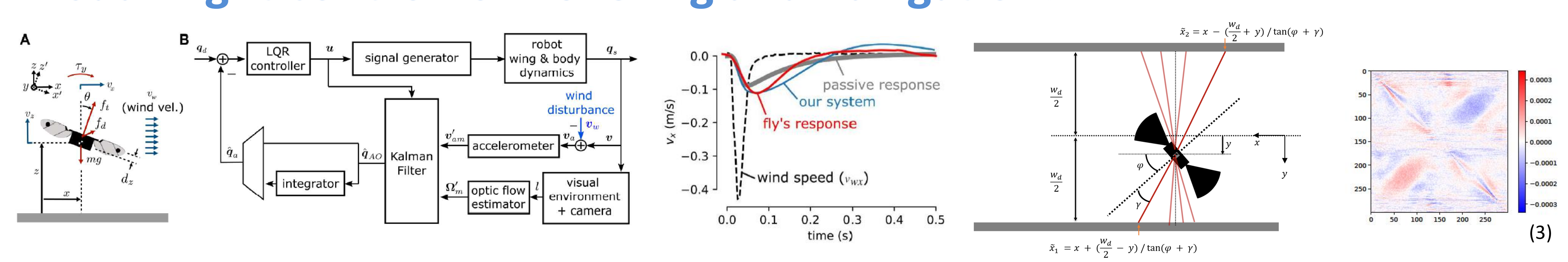
Visual flight control for hovering and navigation:



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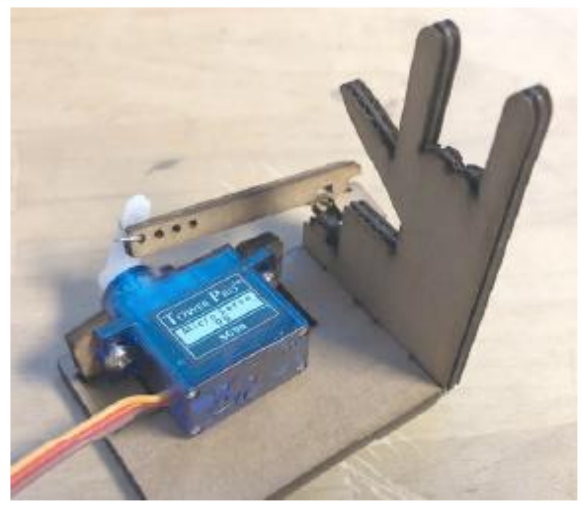
Greater Impact:

- Gas leak detection
- Indoor air quality maps
- Pest detection in agriculture
- Space exploration



Education:

- University teaching: Biology-inspired robotics
- K-12 STEM education: public online lesson plans for foldable robotics at Sciencebuddies.org

Future work:

- Sensor autonomous hover on a bumblebee-sized platform, the U Washington Robofly.
- Application of avionics to wearable human and insect motion tracking.
- Low-power 3D visual navigation.

References:

1. Fuller, Sawyer, Zhitao Yu, and Yash P. Talwekar. "A gyroscope-free visual-inertial flight control and wind sensing system for 10-mg robots." Science Robotics 7.72 (2022): eabq8184.
2. Z. Yu, G. Zardini, A. Censi, and S. Fuller. "Visual confined-space navigation using an efficient learned bilinear optic flow approximation for insect-scale robots." 2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).
3. Y. Talwekar, A. Adie, V. Iyer, and S. Fuller. "Towards Sensor Autonomy in Sub-Gram Flying Insect Robots: A Lightweight and Power-Efficient Avionics System." 2022 International Conference on Robotics and Automation (ICRA).

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