The Smellicopter: Autonomous Odor Localization on a Micro Air Vehicle using Bioinspired Control and Hybrid Biological/Synthetic Sensors

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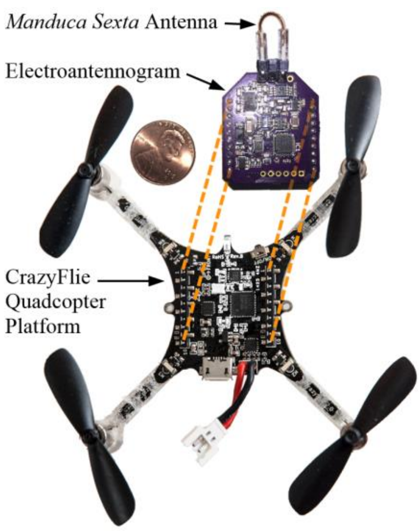
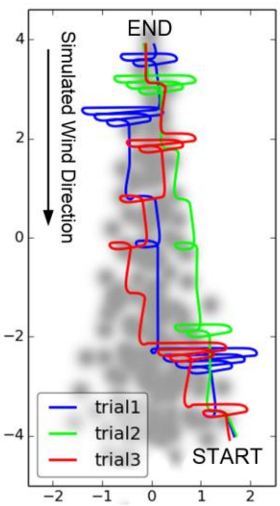
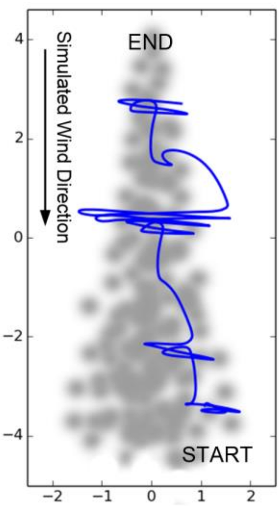
The ability of animals to detect minute chemical concentrations, locate odor sources, and navigate complex flight environments is unparalleled in synthetic systems. Previous work in robotic plume localization has relied primarily on slow-moving ground-based robots responding to time-averaged concentrations, primarily because available engineered chemical sensors respond slowly to chemical changes. Yet experiments on insects, mammals, and birds have revealed that they do not rely on time-averaged properties of chemical plumes, but instead respond dynamically to near-instantaneous (<1s) changes. Biological odor detectors such as moth antennae offer a faster response and more sensitive discrimination than is possible with current engineered chemical sensors. However, due to the challenge of miniaturizing signal conditioning circuitry, plume localization using biological odor detectors has not previously been performed on aerial robots.

We report the development of a semi-autonomous micro air vehicle which uses bioinspired and hybrid biological/synthetic integrated sensors that is intended to detect and locate the source of a volatile chemical plume. We have implemented two key components: 1) a hybrid biological/synthetic integrated chemical sensor (electroantennogram) using excised antenna of the hawkmoth *Manduca Sexta* and associated miniaturized electrophysiology conditioning circuitry, and 2) an insect-inspired cast-and-surge search algorithm based on the odor-tracking behaviour of *Manduca Sexta* operating on a simulated plume on our robotic platform. We've demonstrated cast-and-surge behaviour in flight using a simulated odor plume and a motion capture system to provide velocity feedback for control. Future work will make the system fully autonomous by replacing the motion capture system with an on-board optical flow sensor array that measures unscaled displacement of the vehicle, which is similar to the information provided by insect visual systems. The increased sensing speed and maneuverability of our small aerial platform will allow new experiments to test biological hypotheses about the dynamics of insect flight and odor localization at similar time and spatial scales.





A Kobuki TurtleBot in a Simulated Plume using a Motion Capture Arena



Our Aerial Platform in a Simulated Plume using a Motion Capture Arena