Wind-Powered Flight: Exploring the Potential of Dynamic Soaring for Unmanned Aerial Vehicles

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By designing and building an unmanned aerial vehicle (UAV) capable of autonomous dynamic soaring, I demonstrated that UAVs have the ability to harvest wind energy to soar nearly indefinitely without using any fuel. Dynamic soaring works by traversing the wind gradient that naturally occurs near the surface of the earth to gain propulsive energy. While dynamic soaring has been observed in seabirds, this avian-style dynamic soaring has not been practically tested in UAVs. I built the UAV to mimic seabird flight by integrating a novel dynamic soaring flight system into an inexpensive foam glider using a 3D-printed electronics bay. I programmed the flight computer in C++ to utilize proportional-integral-derivative (PID) feedback control to autonomously fly dynamic soaring cycles. Before flight testing, I experimentally validated each of the sensors, and I tuned the PID controller by mounting the UAV on a moving car. In flight, I guided the UAV into position by checking the wind speed using an anemometer, then activated the autonomous test program. I assessed the UAV's dynamic soaring capability by comparing the net forward acceleration of energy-harvesting dynamic soaring flights against non-energy-harvesting control flights. The flight computer logged data to a microSD card onboard the UAV, and I wrote a Python script to analyze the files. A non-pooled, two-sample t-test of the acceleration data showed that the dynamic soaring flights accelerated more than the control flights at the 1% significance level, and orientation data and flight footage verified that the UAV successfully followed the dynamic soaring flight path.

Awards Won:

Second Award of $2,000