Bio-Inspired Wing Design, Aerodynamic Simulations, and Autonomous Flight Tests for Airborne Wind Energy

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Airborne Wind Energy (AWE) poses uncertainty in its contribution to renewable energy due to the lack of a comprehensive design . The technology is in its early stages, requiring significant development for large-scale deployment. Experimental AWE designs and challenges in autonomous flight necessitate focused research for integration into renewable energy. This project designs, tests, and builds a nature-inspired wing for an AWE aircraft, using Computational Fluid Dynamics (CFD) simulations and autonomous flight testing. The gull wing is a promising platform for AWE. Notably, its high aspect ratio plays a pivotal role in minimizing induced drag. Moreover, the gull wing's elbow angles, ranging between 110-130 degrees, are crucial for efficient cruising range. Building upon the gull wing's features, the analysis employs both Reynolds-Averaged Navier-Stokes and Reformulated Vortex Particle Method numerical methods in search of the most efficient wing concept. The new wing's aerodynamic performance is validated by autonomous flight tests, flying in circular flight paths in real-world conditions. Finally, on-board energy generation is attempted using propellers that harvest wind energy. Numerical results from CFD simulations demonstrate 15%-16% improvement in aerodynamic efficiency with the bio-inspired wing, as evidenced by improved lift-to-drag ratios compared to the baseline wing. Concurrently, autonomous flight tests demonstrate a 22% improvement based on power usage. The velocity sweep map illustrates that the on-board turbines generate power closely in line with theoretical predictions, with a deviation of within 7%. This achievement emphasizes the role that the state-of-the-art design framework developed in this project can play for innovation in AWE design.

Awards Won:

Second Award of $2,000