Project # 3: Bio-Inspired Flight

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Abstract

Over the past 100 years of flying, we have been using the same basic idea of “steady aerodynamics” when it comes to providing lift and maneuverability. The essential component is a fixed airfoil shape, which is tapered rounded on the leading edge and thin at the trailing edge. Moreover, the fundamental flight stabilization concept based on control surfaces and stabilizers is unchanged over time although it is relatively inefficient in its lift to drag ratio, and ill-designed in its maneuverability (multi-mission flight). The question often asked is whether aeronautical engineers can learn from nature to improve flight efficiency by replacing traditional control surfaces with mission adaptive wings in a manner similar to birds. A true morphing aircraft structure should go far beyond moving one solid wing element to a different angle or location with respect to other wing components on a fixed-wing aircraft. Recently, there has been a growing need for aircraft to perform effectively while flying in aerodynamically different operating regimes within the flight envelope during a single mission. Wing morphing/shape shifting technologies can empower aircraft (manned and unmanned) to adapt its aerodynamic configuration “on demand”, thereby expanding their role and capabilities in the tactical arena. A fine example of effective morphing in a flying creature is the Bat. Bats have very efficient wings, and they have a unique ability to morph wing camber. Morphing (changing camber and aspect ratio) makes bats far more maneuverable than birds especially at very low speeds. Bats’ wings consist of long, thin, lightweight bones, held together by a skin membrane, which enables the rapid change in wing camber. Using the Bat as the biological inspiration behind the proposed research program, we develop an approach for morphed camber control which enables maneuvering without the conventional control surfaces.

The proposed study will investigate the trends in airfoil design as we move towards bio-inspired micro-UAVS (Unmanned Aerial Vehicles). The first phase (two weeks) is obtaining an appreciation for the underlying physics concerning principles of flight, Bernouli’s law, flow around a wing section, significance of airfoil characteristics. Theoretical studies will be complimented with simulated wind tunnel (Figure 1) and experimental work in the Aerospace Engineering undergraduate wind-tunnel laboratory. In the second phase (one week) the RET team will work on the ZAGI hand held glider kit (Figure 2). The gliders will be flight tested. In the third and final phase (3 weeks), the team will use the in-house morphing design software, AEROMORPH (Figure 3), developed by Mr. Cody Lafountain (our graduate student mentor) to develop and predict the performance of new and unique bio-inspired airfoil designs. Teachers will be provided with the necessary documentation for experimental procedures and interpretation of the results and will be trained prior to conducting any experiments.

Possible Ideas for Classroom Implementation

This project is expected to provide a hands-on insight into the exciting world of the aeronautical engineering, and bio-inspired flight to the teachers. It will enable them to possess the necessary tools, which can easily be translated to the classroom, to impress high school students and get them excited about the interdisciplinary field of zoology and physics as integrated naturally in bio-inspired flight. This activity, when integrated into math, physics and biology classes, exposes students to challenges faced by aeronautical engineers as they design and build new bio-inspired aircrafts.

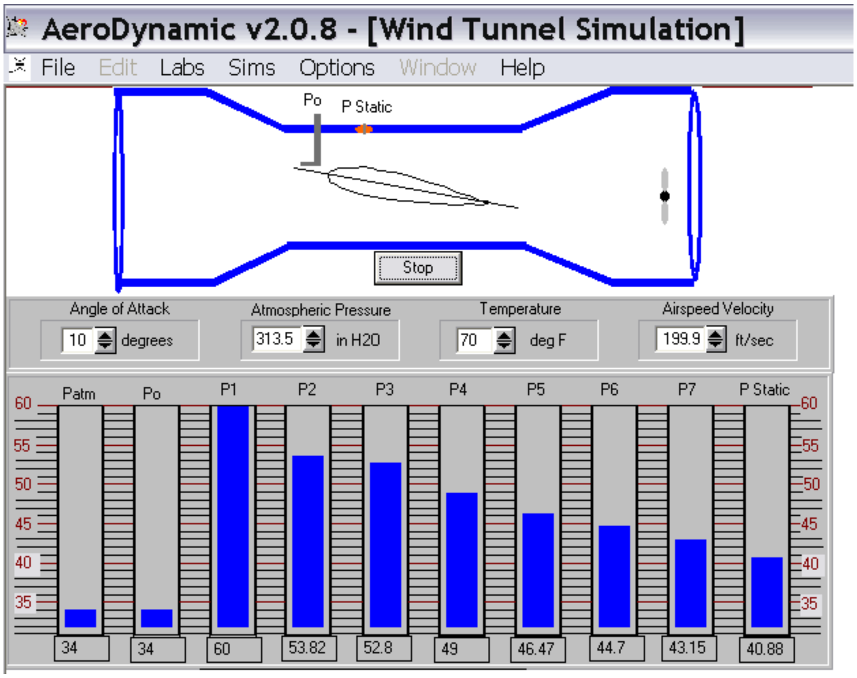

Figure 1. Wind Tunnel Simulation

Figure 2. Zagi Hand Launched Glider

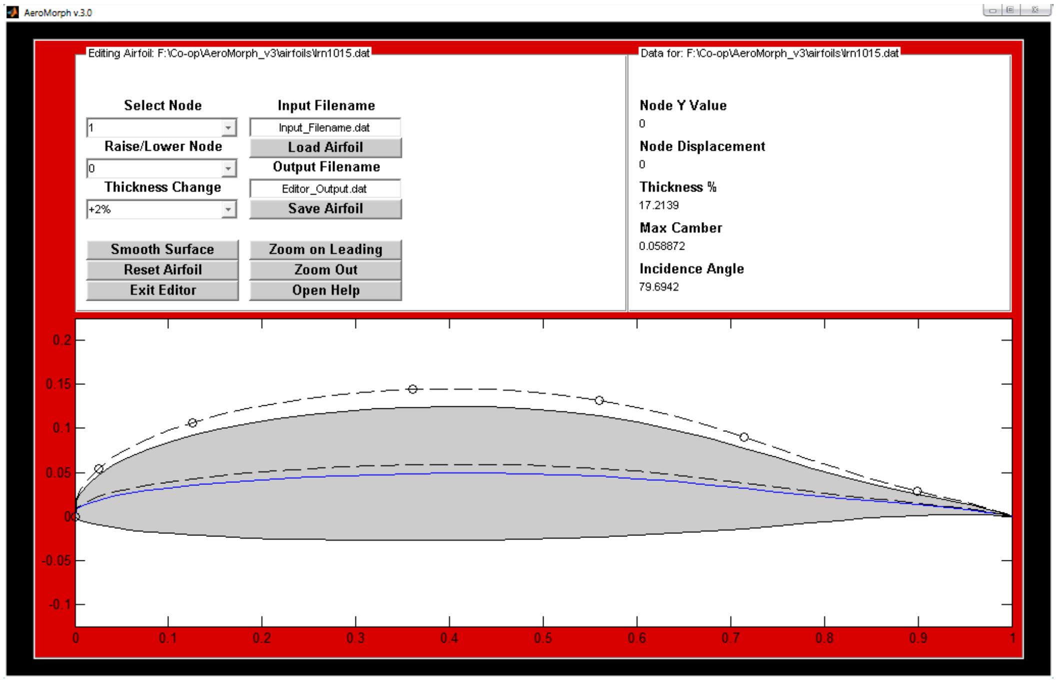

Figure 3. In-House Morphing Airfoil Design Software - AEROMORPH