A Novel Approach to Biomimicking the Avian Tail on Fixed Wing Micro Air Vehicles

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Nature has already perfected flight in the form of birds. One especially critical yet often overlooked aspect of avian flight is the highly nimble and drag-reducing aerodynamics of the avian tail. The conventional tail design for fixed-wing airplanes includes a long fuselage and horizontal and vertical stabilizers. It is aerodynamically stable but trades off efficiency, whereas the avian tail does not waste energy on passive stability. Birds are able to fly even with an unstable aerodynamic configuration by using active control and the complex motions of their tail, another aspect this project focused on. To demonstrate the feasibility of this concept, I designed a flight-capable prototype Micro Air Vehicle (MAV) alongside a novel avian tail control algorithm. I utilized small, powerful microcontrollers to control and stabilize the MAV in flight. To test the effectiveness of the flight computer, I programmed a custom data logging solution which was then paired with flight footage. In order to rapidly iterate prototypes, I implemented a modular wing and tail, allowing for local changes in the design. Furthermore, I conducted ground testing with a custom-built wind tunnel and gimbal setup to tune the PID controllers. Flight data analysis revealed the success of the aerodynamics and control of this avian tail design. Using transient CFD analysis I found a significant increase in the lift-to-drag ratio over a conventional tail with the same design constraints, verifying the higher theoretical efficiency. This avian tail approach is promising in improving aircraft performance and minimizing the carbon footprint of aviation.

Awards Won:
Fourth Award of $500
American Institute of Aeronautics &amp
Astronautics: 1st Prize of $2,000
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category