CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

S0308

Project Title

Aeroelastic Flight Dynamic Modeling and Fabrication of an Adaptive Camber-Morphing Aircraft Using Nickel Titanium Alloys

Abstract

Objectives/Goals

The concept of an adaptive unmanned aerial vehicle with variable camber morphing wings has been proposed to evaluate its flight characteristics and to investigate the feasibility of using the shape-memory alloy wires, Flexinol, to change the shape of the wing and to address the global challenge of improving aircraft fuel efficiency.

Methods/Materials

The adaptive aircraft was constructed by modifying the fuselage and wings of a D.53 Hummingbird remote controlled aircraft and installing flexible control surfaces which use Flexinol Smart Material Actuators to accomplish the proposed variable camber mechanism. Surface continuity was provided by a flexible skin using the thermoplastic polyurethane-coated film Dureflex, which provided sufficient strength and elasticity for the wing in both baseline and morphing configuration. An unaltered remote controlled aircraft using standard micro servos and ailerons was then constructed as a control for comparison.

The aerodynamic consequences of the wing deformation in the camber-varying morphing wing were then quantified with the experimental data attained from a Scantek AeroStream Wind Tunnel, Computational Fluid Dynamic flight simulation softwares XFOIL and Athena Vortex Lattice, and actual test flights.

Results

The wind tunnel results showed significant advantages of the variable camber over the conventional profiles with a discrete trailing edge, such as higher stall angle and higher lift-to-drag ratio. Shown through titanium-tetrachloride smoke visualization, the variable-camber trailing edge reduces the possibility of a laminar separation bubble, which would lead to lower profile drag. Flight tests demonstrated that the morphing surfaces and the Flexinol wires were sufficient to control aircraft in roll, taking off and landing at a 30% steeper angle than the unmodified rc aircraft. The total flight time of the adaptive aircraft was 15 minutes.

Conclusions/Discussion

Ultimately, it was demonstrated that a non-planar wing optimization concept such as a variable camber morphing wing can reduce the drag on traditional wing configurations during cruise and enhance lift performance during take-off and landing compared to conventional actuation systems, bringing future aircraft concepts to the next level in terms of performance, efficiency, and maneuverability.

Summary Statement

In this research, an adaptive radio-controlled aircraft with aeroelastically tailored variable camber morphing wings using nickel-titanium control surfaces was fabricated and flown in order to assess its aerodynamic benefits and penalties.

Help Received

Aerosente Co. and StevensAero Co. generously supplied balsa wood laser-cut parts, radio transceiver and receiver, motor-gear and servos; NASA engineer referred me to various Computational Fluid Dynamic and CAD software; AP Physics teacher supervised me with wind tunnel.