The Role of Composites in Avian Inspired Morphing Aircraft

The aerodynamics and control that birds using in gliding result in efficiencies in performance not yet realized by fixed wing aircraft. With the advent of smart, multifunctional composites, it is now possible to implement motions inspired by avian gliding in small, unmanned air vehicles (UAV). Initially motivated by the casual observation of flight control motions made by birds, morphing research has proceeded with only limited understanding of how and why birds use their aerodynamic surfaces for flight control. In addition, previous research has not made use of the full spectrum of active materials. A summary of relevant previous results from two fields: avian biology and morphing aircraft, is presented followed by current results on morphing trailing edge research and rudderless yaw control.

It is noted that birds to not have a vertical tail yet have substantial yaw stability and control. By integrating smart materials into the rudderless tail of a small UAV yaw stability and control is investigated in the wind tunnel. The tail consists of Macro Fiber Composites (MFCs) consisting of PZT rods oriented at θ degrees were simulated to induce bending twisting coupling in the control surface. When actuated, the resulting deformation has a novel curvature, which is used to produce a restoring moment over a large range of sideslip angles. This work shows that the complex 3D curvature induced by the MFCs substantially aids in increasing the yaw moment, maintains directional stability and increases stability in diving maneuvers.

Birds also use a shape changing trialing edge in gliding maneuvers. Here we present a combination of shape memory alloys and MFCs to experimentally investigate the aerodynamic advantages of shape changing, spanwise trailing edges for small UAVs. This work investigates the capabilities of the a smart composite trailing edge to adapt to nonlinear aerodynamics which is then applied to stall recovery, by tailoring the trailing edge deflection of the six actuators. In order to predict the actuator configurations for stall recovery, a model which accurately captures the nonlinear behavior of finite wing aerodynamics.

Short Biography

Daniel J. Inman received his Ph.D. from Michigan State University in Mechanical Engineering in 1980 and is Chair of the Department of Aerospace Engineering at the University of Michigan, as well as the C. L. “Kelly” Johnson Collegiate Professor. Since 1980, he has published eight books (on vibration, energy harvesting, control, statics, and dynamics), eight software manuals, 20 book chapters, over 350 journal papers and 600 proceedings papers, given 62 keynote or plenary lectures, graduated 62 Ph.D. students and supervised more than 75 MS degrees. He works in the area of applying smart structures to solve aerospace engineering problems including energy harvesting, structural health monitoring, vibration suppression and morphing aircraft. He is a Fellow of AIAA, ASME, IIAV, SEM and AAM.