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Design and Analysis of Hybrid Morphing Smart Wing for Unmanned Aerial Vehicles

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Abstract : Unmanned aerial vehicles, of all sizes, are prime targets of the wing morphing concept as their lightweight structures demand high aerodynamic stability while traversing unsteady atmospheric conditions. In this research study, a hybrid morphing technology is developed to aid the trailing edge of the aircraft wing to alter its camber as a monolithic element rather than functioning as conventional appendages like flaps. Kinematic tailoring, actuation techniques involving shape memory alloys (SMA), piezoelectrics – individually fall short of providing a simplistic solution to the conundrum of morphing aircraft wings. On the other hand, the feature of negligible hysteresis while actuating using compliant mechanisms has shown higher levels of applicability and deliverability in morphing wings of even large aircrafts. This research paper delves into designing a wing section model with a periodic, multi-stable compliant structure requiring lower orders of topological optimization. The design is sub-divided into three smaller domains with external hyperelastic connections to achieve deflections ranging from -15° to +15° at the trailing edge of the wing. To facilitate this functioning, a hybrid actuation system by combining the larger bandwidth feature of piezoelectric macro-fibre composites and relatively higher work densities of shape memory alloy wires are used. Finite element analysis is applied to optimize piezoelectric actuation of the internal compliant structure. A coupled fluid-surface interaction analysis is conducted on the wing section during morphing to study the development of the velocity boundary layer at low Reynold's numbers of airflow.

Keywords : compliant mechanism, hybrid morphing, piezoelectrics, shape memory alloys
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