

Bio-Inspired Deployable Morphing Wing Architecture for Space-Efficient Surveillance UAV Systems

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Abstract:

Space-efficient unmanned aerial vehicle (UAV) systems are increasingly important for aerospace surveillance, autonomous deployment, and defense applications. This paper presents a bio-inspired deployable morphing wing architecture derived from the folding mechanism of the Ensign wasp, which exhibits both longitudinal and transverse wing folding. The proposed concept enables compact storage and rapid deployment of UAV systems while maintaining aerodynamic continuity in the deployed configuration. Two wing deployment mechanisms are investigated: an initially developed string-based mechanism employing servo-pulley coupling, and an improved umbrella-based mechanism designed to enhance structural robustness and deployment reliability. Geometric modeling and kinematic analysis of the folding topology were carried out using Autodesk Fusion 360. Preliminary aerodynamic evaluation across fully folded, partially deployed, and fully deployed configurations was conducted using ANSYS Fluent to investigate pressure distribution trends during deployment. Structural feasibility under aerodynamic loading was further examined through static structural analysis. In addition, state-space modeling concepts and Simulink-based control-system integration are introduced to assess deployment controllability and actuator coordination. Results indicate that the umbrella-based mechanism reduces coupling complexity while improving deployment stability and structural adaptability. The proposed architecture demonstrates strong potential for integration into compact surveillance UAV platforms, deployable aerospace robotics systems, and parent-child autonomous aerial networks.

Keywords:

Aerospace robotics, autonomous systems, biomimetic design, deployable UAV, morphing wings, surveillance systems.