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Computational modeling of highly flexible membrane wings in micro air vehicles

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Abstract

Highly flexible nonlinear membrane wing models are required in the design of aerospace structures for predicting aerodynamic characteristics and failure mechanics. In this work, we develop a new structural model for studying the dynamics of the wing of a micro-air vehicle. The proposed model involves the development of a new membrane structural solver that can be coupled to beam structures, to model the flexible aircraft wing. The governing equations are discretized by the finite element method and tested on various benchmark applications.

Nomenclature

$\vec{X}$	Position vector in the undeformed configuration
$\vec{x}$	Position vector in the deformed configuration
ξ^i	Element-wise convecting coordinates
$\vec{G_\alpha}$	Curvilinear basis in the undeformed configuration
$\vec{g_\alpha}$	Curvilinear basis in the deformed configuration
$\vec{I_\alpha}$	Orthonormal basis with associated coordinates s_α
$\tilde{F}$	Deformation Gradient
$\tilde{C}$	Right Cauchy Green Strain
$\tilde{S}$	Second Piola-Kirchoff stress tensor
w	Two-dimensional strain energy function
W	Three-dimensional strain energy function
I_i	Two-dimensional Strain Invariants
$\bar{I}_i$	Three-dimensional Strain Invariants
H	Undeformed thickness of the membrane
$\mathbf{N}$	Shape Function Matrix
p	pressure
$\hat{n}$	Outward unit normal
$\mathbf{K}$	Tangent stiffness matrix

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