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Boundary Element Methods for the Preliminary Design, Analysis and Optimization of Compliant Flapping Wings

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ABSTRACT

The flapping flight design space is complex, and contains a large number of possible kinematics and structural design parameters. In our research efforts we are pursuing a multi-fidelity approach [1] for designing and analyzing flapping flight. This presentation will focus on the potential flow methods used in the multi-fidelity framework. The potential flow methods include (1) a wake only boundary element formulation for optimal wake circulation determination [2] as well as (2) a pFFT-Fast Multipole Tree accelerated, linear strength potential flow boundary element method [3]. In the presentation we will describe the development of both of these methods while focusing on the importance of recent developments in BEM's including iterative solutions, matrix vector product acceleration methods as well as the use of a vortex particle method for unsteady wake convection.

Examples which are presented will examine large amplitude flapping including fluid-structure interactions. A finite element method beam-membrane model will be coupled to the potential flow boundary element method for representing the wing structures. The two examples which will be examined are: (1) a bottom-up design problem in which the design of efficient, aeroelastic flapping wings will be investigated and (2) a top-down design problem in which the analysis of computational models derived from experimentally recorded bat flight will be shown.

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