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A reduced-order vortex model of three-dimensional unsteady non-linear aerodynamics[1] JEFF D. ELDREDGE, University of California, Los Angeles — Rapid, large-amplitude maneuvers of low aspect ratio wings are inherent to biologically-inspired flight. These give rise to unsteady phenomena associated with the interactions among the coherent structures shed from wing edges. The objective of this work is to distill these phenomena into a low-order physics-based dynamical model. The model is based on interconnected vortex loops, composed of linear segments between a small number of vertices. Thus, the dynamics of the fluid are reduced to tracking the evolution of the vertices, whose motions are determined from the velocity field induced by the loops and wing motion. The feature that distinguishes this method from previous treatments is that the vortex loops, analogous to point vortices in our two-dimensional model, have time-varying strength. That is, the flux of vorticity from the wing is concentrated in the constituent segments. Chains of interconnected loops can be shed from any edge of the wing. The evolution equation for the loop vertices is based on the impulse matching principle developed in previous work. We demonstrate the model in various maneuvers, including impulse starts of low aspect ratio wings, oscillatory pitching, etc., and compare with experimental results and high-fidelity simulations where applicable.

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