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Self-Propulsion of a Flapping Airfoil Using Cyber-Physical Fluid Dynamics[1] JAY YOUNG, DANIEL ASSELIN, C.H.K. WILLIAMSON, Cornell University — The fluid dynamics of biologically-inspired flapping propulsion provides a fertile testing ground for the field of unsteady aerodynamics, serving as important groundwork for the design and development of underwater vehicles and micro air vehicles (MAVs). These technologies can provide low cost, compact, and maneuverable means for terrain mapping, search and rescue operations, and reconnaissance. However, most laboratory experiments and simulations have been conducted using tethered airfoils with an imposed freestream velocity, which does not necessarily reflect the conditions under which an airfoil employed as a propulsor would operate. Using a closed-loop force-feedback control system, defined as Cyber-Physical Fluid Dynamics, or CPFD (Mackowski & Williamson 2011, 2015, & 2016), we allow a flapping airfoil to fly forward freely, achieving an equilibrium velocity at which thrust and drag are balanced. We study a combination of actively and passively controlled pitching and heaving dynamics in order to find motions that minimize the energy expended per distance traveled by the propulsion system.

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