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Addition of Passive Dynamics to a Flapping Airfoil to Improve Performance[1] DANIEL ASSELIN, JAY YOUNG, C.H.K. WILLIAMSON, Cornell University — Animals which fly or swim typically employ flapping motions of their wings and fins in order to produce thrust and to maneuver. Small, unmanned vehicles might also exploit such motions and are of considerable interest for the purposes of surveillance, environmental monitoring, and search and rescue. Flapping refers to a combination of pitch and heave and has been shown to provide good thrust and efficiency (Read, et al. 2003) when both axes are independently controlled (an Active-Active system). In this study, we examine the performance of an airfoil actuated only in the heave direction but allowed to pitch passively under the control of a torsion spring (an Active-Passive system). The presence of the spring is simulated in software using a force-feedback control system called Cyber-Physical Fluid Dynamics, or CPFD (Mackowski & Williamson 2011, 2015, 2016). Adding passive pitch to active heave provides significantly improved thrust and efficiency compared with heaving alone, especially when the torsion spring stiffness is selected so that the system operates near resonance (in an Active-Passive system). In many cases, values of thrust and efficiency are comparable to or better than those obtained with two actively controlled degrees of freedom. By using carefully-designed passive dynamics in the pitch direction, we can eliminate one of the two actuators, saving cost, complexity, and weight, while maintaining performance.

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