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Ph.D. DISSERTATION DEFENSE

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Degree: Doctor of Philosophy

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Title: Piezoelectric Energy Harvesting from Flapping Elements

Chairperson: Muhammad R. Hajj, Civil, Environmental, and Ocean Engineering

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ABSTRACT

The revolution in sensing and monitoring technology has attracted interest in energy harvesting to reduce the dependence on depletable batteries. Piezoelectric transduction is an effective approach to harvest energy from ambient vibrations, which are available through different environmental sources, for the purpose of developing self-powered and micro sensors. The design of a harvester is defined by an objective function under specific constraints, which are mostly geometrical depending on the available space to place such a harvester. Yet, attaching a piezoelectric energy harvester to an oscillating body element like a fish tail for the purpose of fish migration monitoring can impact its performance which needs to be assessed. In this dissertation, we address fundamental questions through a series of investigations and provide approaches for performance analysis and design of piezoelectric energy harvesters. We conduct parameter discovery for optimal performance of a cantilever piezoelectric energy harvester under regular and irregular ambient vibrations. Because attaching a piezoelectric harvester to a flapping element changes its stiffness, we determine the performance limits in terms of hydrodynamic forces and efficiency of the element under a broad range of leading-edge stiffness and its distribution. Finally, we investigate the effects of attaching a piezoelectric element to a flapping element such as a fish tail on its hydrodynamic performance in terms of generated thrust and efficiency.