The transient behavior of a fast-starting robotic fish

Yahya Modarres-Sadeghi*[1]

[1]University of Massachusetts, Amherst – 160 Governors Dr., Amherst MA 01003, United States

Abstract

We discuss the transient behavior observed in a fast-starting robotic fish using different experimental and numerical models. We use (i) a simplified fish model with variable stiffness, (ii) a robotic fish that emulates the fast-starting response of live fishes, and (iii) a nonlinear structural model subject to flow forces to describe the transient behavior during the fast-start maneuver. We show that flexibility during the preparatory stage and increased rigidity during propulsive stage result in velocity profiles and escape angles consistent with those observed in live fish. We also show that the magnitude of swept angle is critical to formation of the propulsive jet, and that the peak power transfer is more sensitive to increasing the angular velocity for larger swept angles, where a complete jet is already formed. The nonlinear structural model that we have derived consists of the beam equation subjected to a non-conservative eccentric compressive force which is constrained to act tangential to the structure at all times and coupled with a fluid dynamic model to approximate the transient behavior of the robot. The model reproduces the response observed in our fast-starting robotic fish and shows that that the magnitude of the external compressive force and the net torque that acts on the tail can increase the contribution of the second mode in the response of the system and signify the snap-through bifurcation-the mechanism responsible for achieving high peak accelerations in the robotic fish.

*Speaker