Optimality in movement and sensing in weakly electric fish

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The way an animal senses its world is conditioned by the ways in which it can move its sensory surfaces, which in turn is determined by the mechanical constraints of the body and its mechanical coupling to the volume of space in which the behavior is occuring. An intuitive view is that evolution is an optimizer of this coupled process of moving and sensing. Though this may not be the case, the notion of optimality under some cost functional can provide a useful endpoint on the spectrum of solutions that the evolved solution will inhabit. We are combining prior work on modeling the full afferent input to the active electrosensory system of a weakly electric fish ($\approx$14,000 primary afferent spiketrains) occurring as a result of prey capture behavior with an optimal control approach to trajectory generation to assess the relative contributions of the mechanical and sensing constraints to the animal's behavior. Currently, we are generating optimal trajectories for a highly simplified model of the fish moving in an ideal fluid to determine whether basic movement patterns quantified in the natural case are achieved. Using an accurate model of the fish surface, and empirical measurements of the electric field around the fish and sensory receptor distribution, we have recently estimated that the fish's active sensing system is filling the space around the body in a near-optimal manner, despite orders of magnitude variation in the field strength and receptor density along its length.