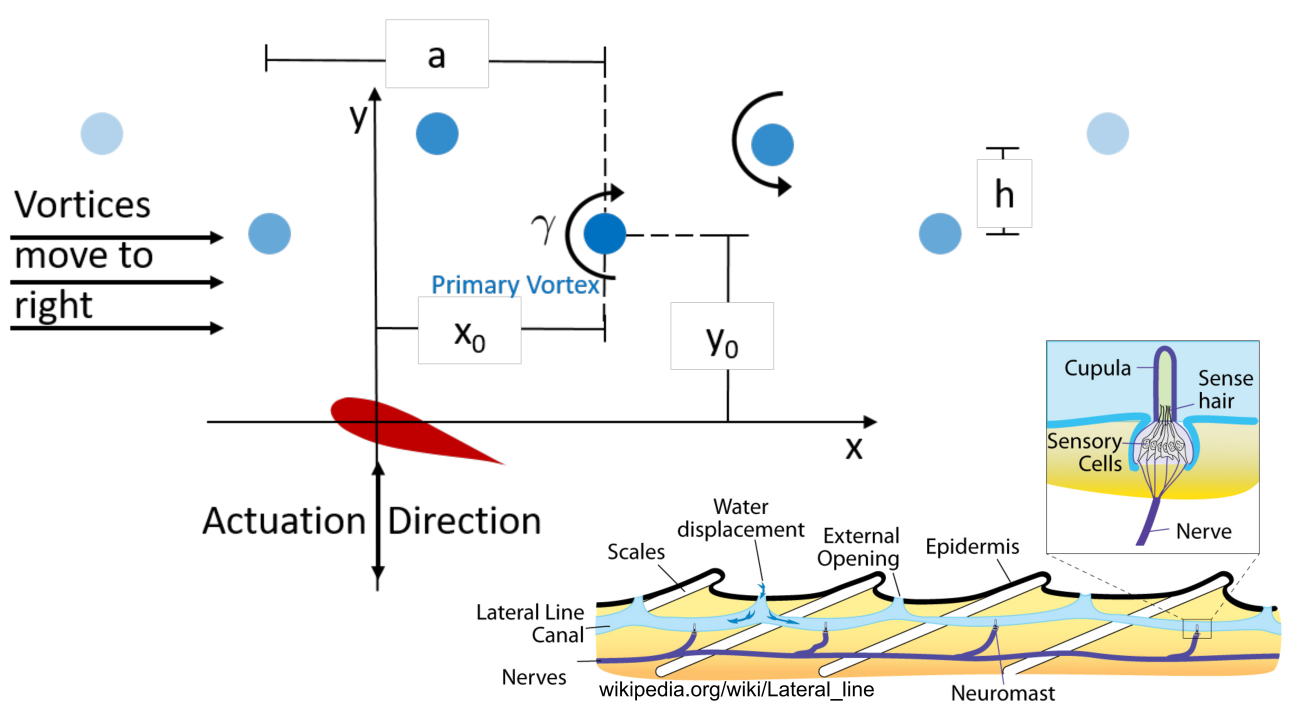
Bioinspired Sensing and Locomotion for Underwater Vehicles

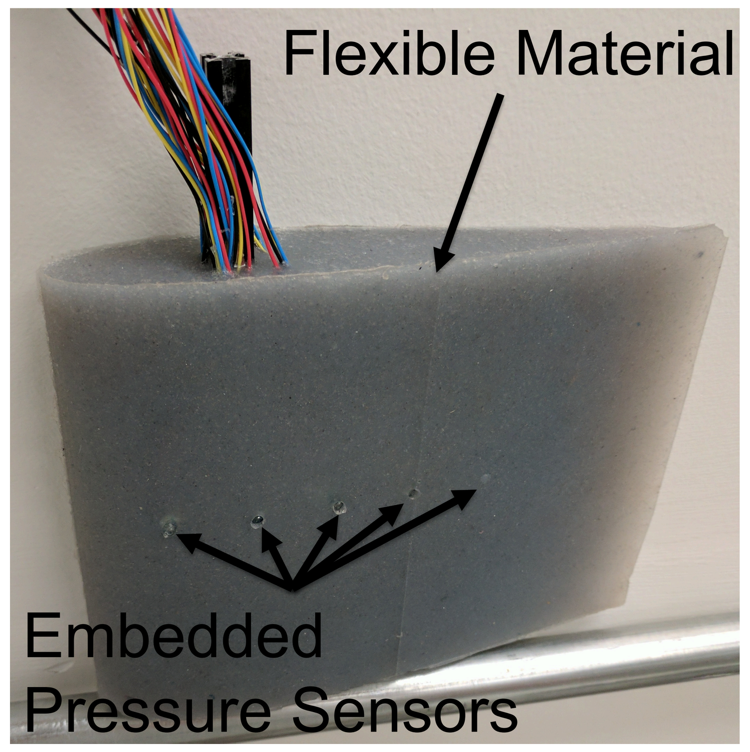
Brian Free, Jinseong Lee, and Derek A. Paley

University of Maryland 1856 — Institute for Systems Research, A. James Clark School of Engineering

Introduction

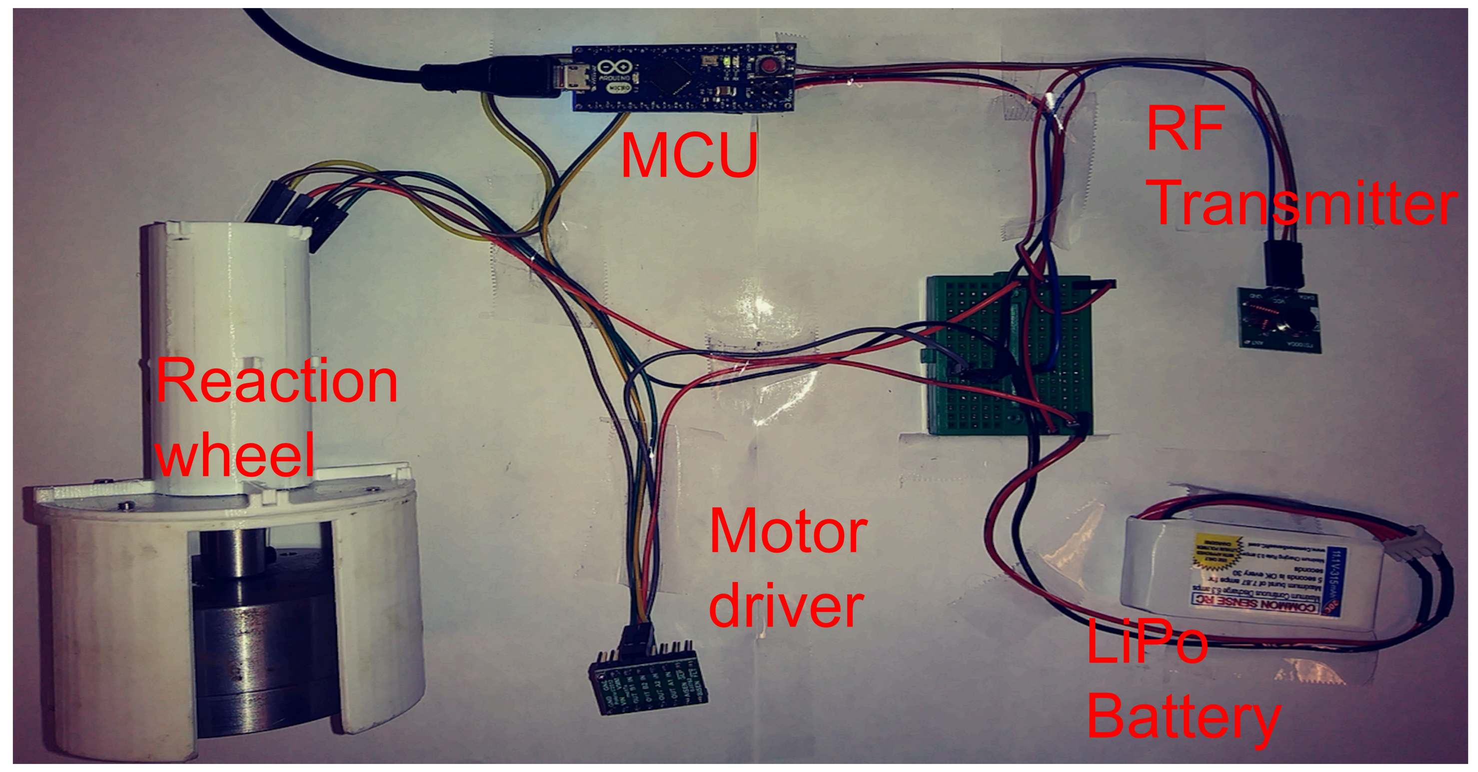
The lateral line in fish allows navigation in murky environments and prey detection and tracking. Creating an autonomous fish robot capable of this behavior requires parallel development of vortex estimation and reaction wheel driven propulsion.

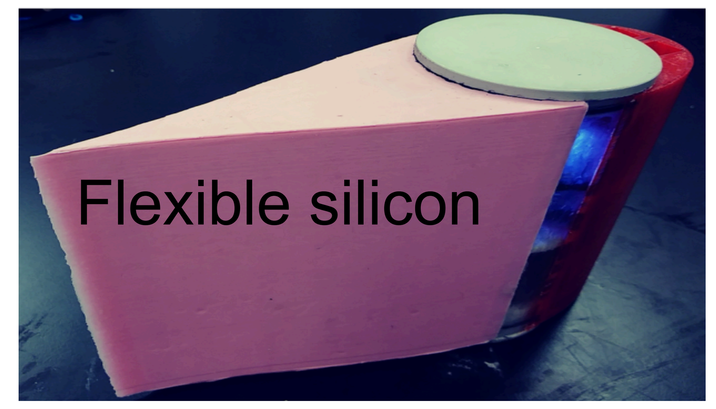




Internal Actuator Driven Propulsion

Flexibility of a swimming robot provides higher maneuverability underwater. For a novel design, a reaction wheel as an internal actuator is driven in a self-contained system. The reaction wheel rotates a flexible body by conservation of angular momentum, thus generating underwater propulsion.



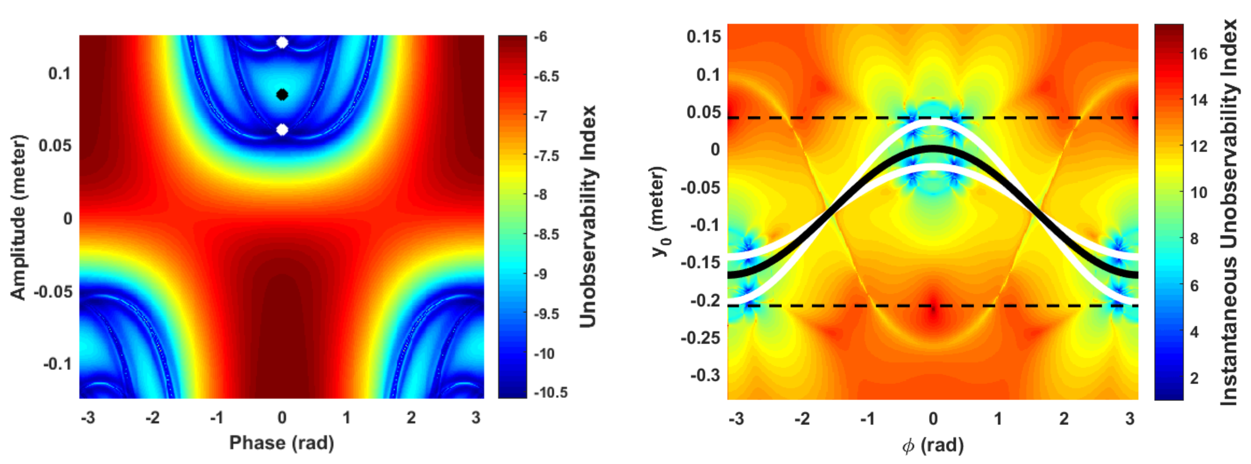


Item	Specification
Size (mm)	200 (L) x 76(W) x 150 (H)
Mass (Kg)	1.8
Power (W)	12

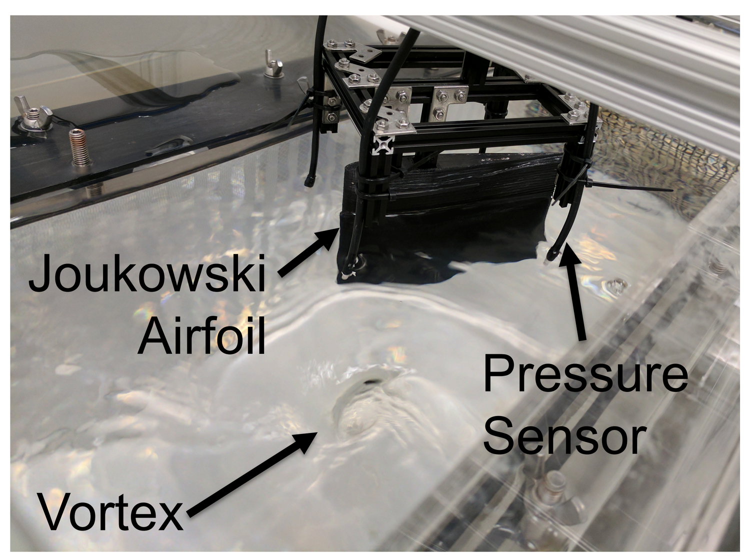
Vortex Estimation with an Artificial Lateral Line

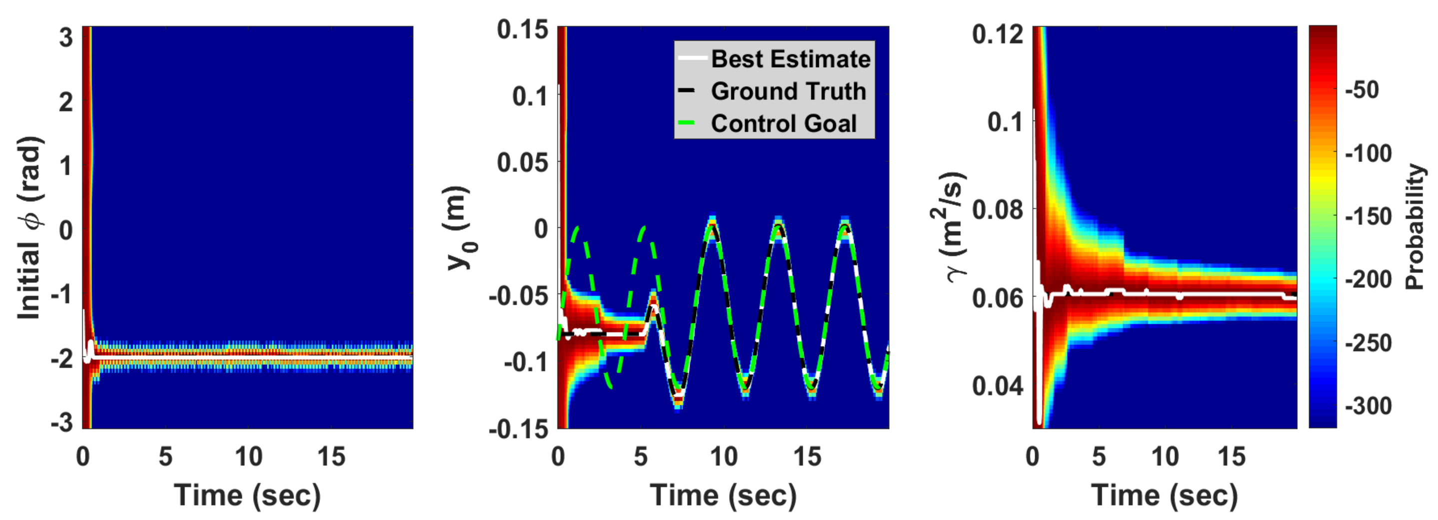
A recursive Bayesian filter used with a potential flow model and the Joukowski transformation estimates the location and strength of a vortex street. Karman vortex streets are shed from obstacles or other fish in the flow.

$$f(\zeta) = \mathbf{j}\frac{\gamma}{2\pi}\left[\log\sin\left(\frac{\pi}{a}(\zeta-\zeta_v)e^{-\mathbf{j}\alpha}\right) - \log\sin\left(\frac{\pi}{a}\left((\zeta-\zeta_v)e^{-\mathbf{j}\alpha} - \left(\tfrac{1}{2}a+\mathbf{j}h\right)\right)\right)\right]$$



An unobservability metric showed the optimal path to be a slaloming trajectory through the vortex street. Experiments in a 25 cm flow tank validate the model.



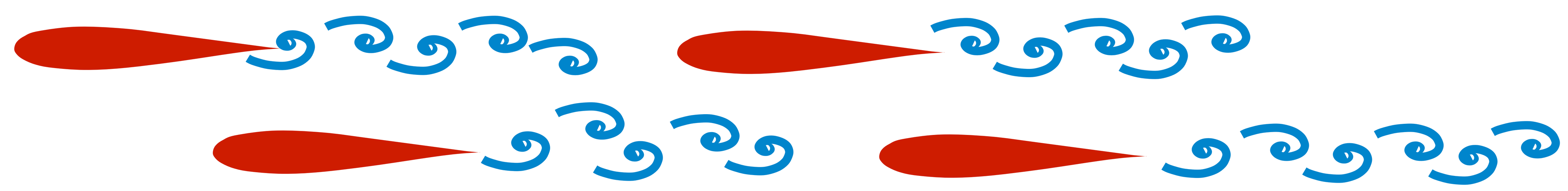


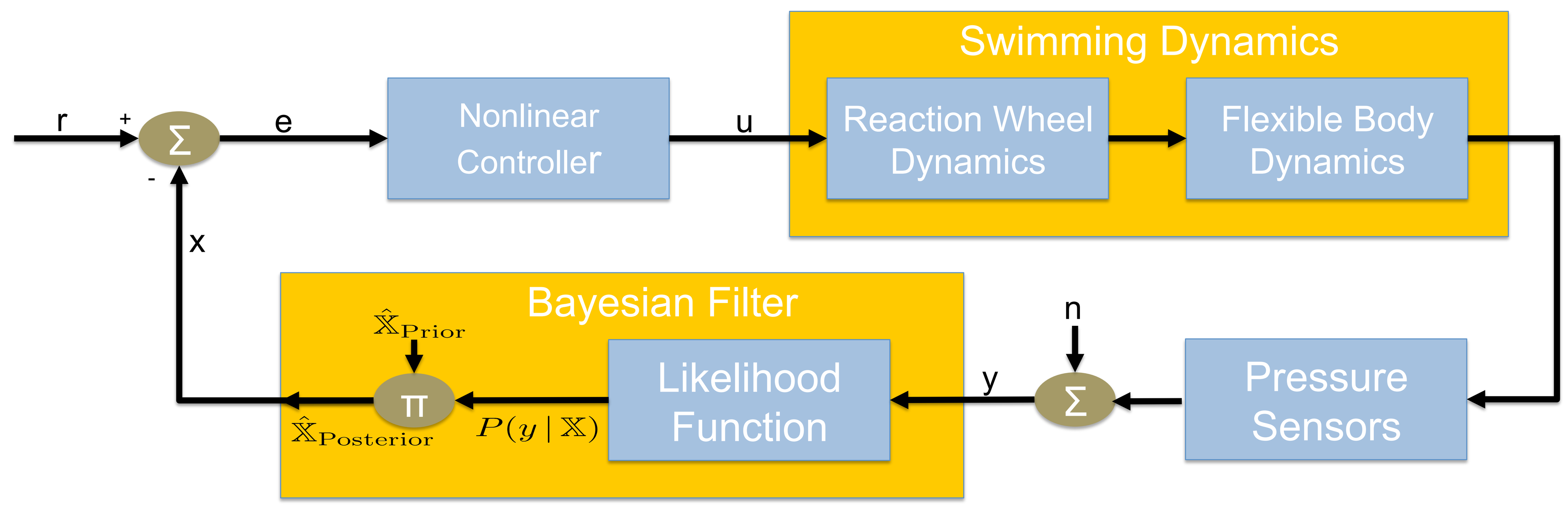
Future Work on Autonomous Fish Robots

The lateral line sensing scheme and the reaction wheel propulsion system will be combined into a fleet of autonomous underwater vehicles.

Characteristics:

- Highly agile and stable maneuver for coordinated motion
- Formation with sensing systems only, no direct communication
- Predation using bioinspired pursuit and energy efficient path planning





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Collective Dynamics and Control Laboratory
Department of Aerospace Engineering, University of Maryland