Neuroethological Approaches to Biomimetic Robot Autonomy

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Abstract

We have built four classes of biomimetic robots based on the American Lobster. These robots capture the biomechanical advantages of lobsters and employ a sensorimotor system consisting of neuromorphic sensors, a controller based on the command neuron, coordinating neuron, central pattern generator architecture of animals and myomorphic actuators and a behavioral library reversed engineered from studies of the lobsters. We have also created two generations of a biomimetic robot based on the lamprey that swims by lateral axial undulations. We are developing a ultrashort baseline sonar navigation system to allow this robot to home on a sonar beacon. We construct controllers based on three types of electronic nervous systems: (1) Finite state machines that emulate the logic and dynamics of animal central pattern generators. (2). UCSD Electronic Neurons and Synapses and (3). Discrete Time Map-based electronic neurons and Synapses. We actuate our devices with artificial muscle constructed from the shape memory alloy nitinol. These actuators are actuated by current pulse trains generated by the electronic nervous systems and grade force by pulse width duty cycle modulation. We monitor the environment with sensor systems that employ a labeled line code. We have developed neuromorphic sensors for heading, pitch and roll, hydrodynamic flow and surge, collision and impediment. We have developed technologies for reverse engineering the command sequences that underly adaptive behavior and network technologies for embedding these sequences in electronic nervous systems. These behavioral acts are capable of both adaptive modulation and perturbation. We are developing electronic nervous systems for the adaptive augmentation of constraint induced movement therapy for stroke and traumatic brain injury.

Bibliography

Joseph Ayers is a systems neurophysiologist who integrates neuroethological and biomimetic approaches to the control of autonomy in underwater robots. He has extensive experience in cellular neurophysiology of simple neuronal networks, in-vivo recording during behavior, physiological biotelemetry, quantitative video analysis of animal behavior and synthesis of electronic nervous systems for robotic control and neuroreha- bilitation. He was the principal investigator in the development of ambulatory and undulatory robots based on the lobster and sea lamprey. In this capacity, he developed shape memory alloy actuators for underwater operation, MEMS-based sensors, central pattern generator-based controllers and technology for quantifying central command sequences from behaving animals.