COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN

ME Department Seminar

Towards a Brain-Body-Environment Computational Model of a Living Organism

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Abstract

One of the grand scientific challenges of this century is to understand how the brain works. In order to address this challenge, a detailed map between neural circuitry, neural activity, and behavior must be constructed. With the growing recognition of the central roles that embodiment and situatedness play, the true challenge is even more difficult: to understand how behavior is grounded in the dynamics of an entire brain-body-environment system. In addition to experimental tools to map neural connectivity and to image and manipulate neural activity, such a challenge demands the construction and analysis of computational models of the behaving organisms. In this talk, I will argue that the nematode worm Caenorhabditis elegans is a uniquely qualified target for such an integrated modeling of a complete animal. I will describe my approach: using optimization techniques to explore the space of unknown electrophysiological parameters of the nervous system necessary to generate organism-like behavior. Because biological models are almost always under-constrained, each successful parameter search produces an ensemble of models that are consistent with the known anatomy, physiology, and behavior of the organism. We then analyze the properties of this entire ensemble using techniques ranging from model neuron recordings, neural and behavioral manipulation and lesion studies to parameter clustering, dynamical systems theory and information theory. The focus of the analysis is to identify different possible classes of solutions and to thoroughly understand the operation of the highest-performing exemplars of each. This insight can then be used to suggest specific experiments that could decide between the different possibilities. In addition to accelerating the discovery and understanding of the neural mechanisms underlying specific behaviors of interest, I will show how this methodology allows us to begin to address key theoretical challenges in a situated, embodied, and dynamical understanding of adaptive behavior.

Bio

Eduardo J. Izquierdo is an Assistant Professor at Indiana University in the Cognitive Science Program and the School of Informatics, Computing, and Engineering. He is also affiliated with the Neuroscience Program, the Center for Complex Systems and Networks Research, and the Center for the Integrative Study of Animal Behavior. He received his Doctorate from the University of Sussex, UK. He was a postdoc in the Institute of Neuroscience at the University of Oregon. His current research focuses on understanding the neuromechanical basis of behavior in living organisms through the development and analysis of brain-body-environment computational models