SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

Systems-Theoretic Synthesis of Neuronal Dynamics for Memory and Control Objectives

PhD Preliminary Research Examination

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Abstract:

In the brain, networks of neurons produce activity that is decoded to achieve complex functional goals, such as retaining memory of a visual image, or directing the movement of a limb. How the architecture and dynamics of brain networks support these decoding processes is a major scientific question. That is, while we understand the basic biophysical mechanisms by which neurons produce activity, whether these dynamics reflect an overlying functional objective is not understood. In the proposed thesis, we will examine neuronal dynamics from a systems-theoretic viewpoint. In the first part of the thesis, we will focus on circuit mechanisms of motor control. Here, we postulate that neuronal activity is decoded into a control signal that drives a limb model. Using a recently proposed principle from theoretical neuroscience, we optimize the production of neuronal spikes so that the limb model produces efficient end-to-end trajectories. It turns out that such optimization leads to a recurrent network architecture wherein each neuron possess integrative dynamics comparable to actual first-order neuronal biophysics. The network amounts to an efficient and robust event-based controller where each neuron (node) produces a spike if doing so improves performance. In the second part of the thesis, we shift attention to the domain of working memory. We specifically examine how a distributed network of neurons efficiently retains memories of input stimuli. We approach this question by framing it as an optimal resource allocation problem, wherein memories are encoded using as few neurons as possible. Similar to the motor control case, it turns out that this problem can also be solved in an online manner using biophysically plausible dynamics. We will discuss the technical steps involved in deriving these solutions and their interpretations, as well as several remaining open questions and extensions.

DATE: Thursday, January 17, 2019
TIME: 1:00 p.m.
PLACE: Green Hall, Room 0120

Dissertation advisor:
Dr. ShiNung Ching

This seminar is in partial fulfillment
of the Doctor of Philosophy degree

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