SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

Constructing and Analyzing Network Dynamics for Information Objectives and Working Memory

PhD Preliminary Exam

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Abstract: Creation of quantitative models of neural functions and discovery of underlying principles of how neural circuits learn and compute are long-standing challenges in the field of neuroscience. In this work, we blend ideas from computational neuroscience, information and control theories with machine learning to shed light on how certain key functions are encoded through the dynamics of neural circuits. In the first part of this research, our primary motivation is to reveal optimal dynamical substrate of information processing in neuronal networks. Specifically, we devise a strategy to optimize the dynamics of the system at hand using information maximization as an objective function. In this vein, our principle contributions are in terms of (i) mathematical formulation of the optimization problem (ii) use of system impulse response and variational inference techniques to reduce the computational burden associated with mutual information optimization and (iii) illustration of novelty of our ideas for well-understood systems. Our methodology results in dynamics that generically perform as encoder of afferent inputs distribution and facilitate information propagation. In the second part of this research, we aim to study the neural dynamical mechanism underlying working memory which is essential for performing cognitive tasks such as problem-solving and reasoning. We approach this problem by developing a new framework for constructing recurrent dynamical neural networks as a proxy of biological neural circuits and train such networks to perform a sequential working memory task. We then study the emergent network dynamics and structure to shed light on the mechanistic basis of how this network achieves working memory. We particularly examine how the training imparts a low-dimensional structure upon the states of network activity and how, in turn, memories are represented through these dynamics. We will discuss the theoretical and technical steps involved in our interpretations, as well as remaining open questions and future directions.

Date: Monday, March 30, 2020
Time: 2:00 p.m.
Location: https://wustl.zoom.us/j/3958230406
Meeting ID: 395 823 0406

Dissertation advisor:
Dr. ShiNung Ching