CNeuro2025 Lecture Abstracts

Yuxiu Shao

Abstract 1 – Basic Lecture:

The Theory and Method in Random Recurrent Neural Network Models

In this introductory lecture, I will focus on random recurrent neural networks (RNNs), a prominent trend in contemporary neuroscience research, including continuous-time RNNs, low-rank RNNs, and multi-regional RNNs. I will review theoretical frameworks and analytical methods related to the role of recurrent connections, the impact of linear and nonlinear transfer functions, and the various forms of neural dynamics that RNNs can generate. Both autonomous and task-driven dynamics will be discussed. The goal of this lecture is to demonstrate how a mathematical perspective can be used to uncover the computational capabilities of RNN models, thereby laying the groundwork for understanding their broad applications in neuroscience.

Abstract 2 – Advanced Lecture:

Bridging Network and Circuit Models: A Low-Rank Approach

In this more advanced lecture, by integrating two traditionally distinct perspectives in neuroscience: the network and circuit models, I will introduce how biological network connectivity gives rise to the rich dynamics in the brain. The network approach, commonly applied to primate data, emphasizes the role of distributed neural activity recorded during behavioral tasks, often without cell-type information. It focuses on explaining heterogeneous single-neuron responses through low-dimensional dynamics and mixed selectivity. In contrast, the circuit approach, largely informed by rodent studies with genetic access to cell types, explains computation through stereotyped activity patterns and connectivity profiles of specific cell types. While both frameworks aim to link neural structure to function, they differ fundamentally in granularity and assumptions. This lecture presents a unifying low-rank modeling framework that captures the population-level dynamics of network models while remaining interpretable in terms of circuit-level

components, offering a path toward reconciling these two views of cognitive computation.

This session provides a concrete and accessible example of how Bayesian principles and neural coding theories converge to explain complex cognitive phenomena. The lecture will give students a deeper understanding of how probabilistic computations are grounded in neural activity, while also illustrating how to construct and analyze models that bridge theory and experiment.