Physics Colloquium

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IPM
Institute for Research in Fundamental Sciences
School of Physics

Uncovering hidden neuronal microcircuits using Boltzmann like correlations, a unified framework

Speaker
Dr. Seyyed Nader Rasuli

Affiliation
School of Physics, IPM

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Abstract

The information transfer and processing in our brain relies on cells called neurons. They are connected to each other through connections called synapse, and form an interconnected complex network, known as gray matter. Each neuron receives signals from its upstream neurons, generates a spike, and passes it to many downstream neurons. To understand this complex structure, one should have learnt the connectivity map of neurons, in a living brain. However, it is practically impossible to record from one neuron and all its hidden inputs to determine the influential synapses which dominate the activity of that neuron. Although there are methods to find the connectivity among recorded (observed) neurons, the majority of downstream neurons remain unobserved. Here, we find the analytical input-output relation which describes how a specific input to a neuron controls statistics of its spiking pattern. Then, using this analytics, we connect the hidden microcircuits which are shared by two or more neurons with the observed correlation between their spiking patterns. We present a guide map in the space of neural interactions (i.e pairwise and triple-wise correlations) to infer the influential hidden circuits from data. We verify the validity of the guide map by extensive simulations, using multicompartmental neuron models of Blue Brain Project. Applying the guide map to monkey and mouse, we observed the hidden circuitry of excitatory inputs shared between each pair of three neurons is the motif behind most of the data. We hope experimentalists use our guide-map, to reveal the hidden microcircuits behind their data.

Link
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