Electrical & Computer Engineering Seminar Series

Signal Processing and Communications

Neural Circuits and Computations for Attentional Selection

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Attention, the ability to selectively process the most important subset of information in the environment (at the expense of all others) is a fundamental component of adaptive behavior. Much is known about the consequences of attention to behavior and neural representations, about the shaping of attention by neuromodulators, and about genetic factors associated with attentional dysfunction. However, the neural basis of the control of attention has remained largely elusive. Specifically, how do neural circuits select the next target of (spatial) attention, and what canonical neural computations underlie this function? I will share recent findings from our work in barn owls that addresses one such computation underlying stimulus selection for spatial attention, namely, location-invariance. We discovered that specialized inhibitory neurons in the barn owl midbrain, which are conserved across all vertebrates, employ a novel form of population coding, namely, combinatorially-optimized coding, through the use of unusual representations of space. We showed that this results in a combinatorial strategy for solving selection at all possible pairs of stimulus locations, a strategy that also minimizes the net costs of building and operating the neural circuitry. I will then switch gears and share briefly our recent work in developing primate-like behavioral paradigms for visuospatial attention in freely behaving mice. These paradigms are designed to allow the (ongoing) dissection of mammalian neural circuitry underlying spatial attention control. We anticipate that such efforts will help not only to advance our understanding of attention control at a circuit-level, but also to lay a foundation for the 'neurotype' of attentional impairments.

Shreesh Mysore obtained a Bachelor's degree in Mechanical Engineering from IIT Madras (India), and then Masters degrees in Industrial Engineering and Mathematics from Penn State. He spent much of this time thinking about and working on soft computing AI tools such as neural networks and fuzzy logic, and applying advanced methods from dynamical systems and signal processing to data mining. He moved to the Control and Dynamical Systems graduate program at Caltech for his PhD, with an interest in using dynamical systems to "understand the brain". After spending some time building robots and worrying about how to design artificial "brains" to perform complex tasks, he switched to experimental neuroscience and worked on structural neural plasticity for his PhD thesis. This work included experiments imaging the dynamics of dendritic spines in hippocampal neurons, and modeling large scale circuit plasticity in the barn owl midbrain. Following his PhD, he obtained postdoctoral training at Stanford doing experiments (and computational modeling) in barn owls with a focus on how brains handle multiple competing pieces of information. He moved to Hopkins to start his research lab which investigates neural circuits and computations underlying complex behaviors including attention and decision making.