UNRAVELING THE COMPLEXITY OF THE BRAIN

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Abstract

The brain is a complex system consisting of microscopic and macroscopic networks that give rise to its function. To understand the brain, we need simultaneous measurements at multiple spatiotemporal scales. Over the years, technology has been established to record high-dimensional electrical activity from a network of brain cells at small (single neurons) and large (local field potentials and ECoG) scales. Recent advance in optogenetic techniques has further enabled the possibility of imaging and controlling a large number of neurons. The ability to collect high-dimensional neural activity introduces the great challenge of analyzing and modeling this activity to understand the brain's function and dysfunction, to devise novel treatments for various neurological disorders, and to enhance brain function. Advanced mathematical techniques are being developed spanning the fields of machine learning, signal processing, control, and information theory. Novel photonic and genetic techniques are being explored for increasingly precise optogenetic imaging and control. Finally, developing the next generation of neurotechnologies requires the design of low-power biocompatible electronic implants that can simultaneously record and stimulate the brain, and wirelessly transmit the recorded data to the outside world. In this session, we explore these various challenges and the advances that engineers have made to tackle them. Together these efforts will help pave the way to understand the brain, treat its disorders, and enhance its functions.

The session will begin with a talk by Ellis Meng (University of Southern California) on technologies to interface with the brain for recording and modulation. She will be followed by Jose Carmena (University of California, Berkeley), who will discuss understanding the neural basis of skill learning using brain-machine interfaces. The third speaker is Konrad Kording (University of Pennsylvania), who will focus on new models for neuroscience. The session will conclude with a talk by Azita Emami (California Institute of Technology) on efficient feature extraction and classification methods in neural interfaces.