University of Houston - Biomedical Engineering Seminar

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Uncovering projections to motor cortex using single-pulse electrical stimulation

Kai J. Miller, M.D., Ph.D.

Abstract

Brain networks can be explored by delivering brief pulses of electrical current in one area while measuring responses in other areas. If we focus on a single brain site and observe the average effect of stimulating each of many other brain sites, visually apparent motifs in the temporal response shape emerge from adjacent stimulation sites. We describe and illustrate a data-driven approach to determine characteristic spatiotemporal structure in these response shapes, summarized by a set of unique "basis profile curves" (BPCs). Each BPC may be mapped back to underlying anatomy in a natural way, quantifying projection strength from each stimulation site using simple metrics. This framework enables straightforward interpretation of single-pulse brain stimulation data and can be applied generically to explore the diverse milieu of interactions that comprise the connectome. We then apply this framework to measurements from the motor cortex, to disentangle connections with the primary motor (pre-central) area. Using BPCs, movement-related changes over a wide distribution on the brain surface are shown to be comprised of several sub-domains of different interaction types.

Biosketch

Kai Miller is a neurosurgeon at Mayo Clinic, with adjunct appointments in physiology & biomedical engineering, and pediatrics. His clinical sub-specialty focuses are epilepsy, deep-brain stimulation, and tumor resection in children and adults. Kai attended UC San Diego, where he played on the intercollegiate tennis team. At the University of Washington he obtained a PhD in Physics, an MD, and a second PhD in Neuroscience. Kai was a neurosurgical resident at Stanford, and he completed separate fellowships in stereotactic neurosurgery (Stanford), awake/eloquent tumor resections (Utrecht), and pediatrics with an emphasis in epilepsy (Utrecht). Kai's research lab's emphases are basic human neurophysiology and clinical translation for cybernetics, epilepsy and functional neurosurgery. The goal is to develop more precise closed-loop stereotactic procedures, taking advantage of emerging hardware for recording and stimulation. Research into large-scale brain dynamics will be applied to human neurosurgery for creation of new devices to 1) control cybernetic prostheses, 2) induce brain plasticity after injury, and 3) intervene with distributed circuits in neuropsychiatric disease and movement disorders.