NEURAL ENGINEERING SEMINAR SERIES

Neuron and patient-specific computational modeling for neuromodulation in neurological disorders

Zoom Link: https://psu.zoom.us/j/99043650231?pwd=MWJjdjV3RWJIL0RwLyt6WTducWFNZz09

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ABSTRACT: Neuromodulation is often the last line of therapy for movement disorders, psychiatric disorders, and epilepsy when medication alone cannot manage symptoms. The difference between successful and ineffective therapy often lies in stimulation parameter selection, which can be challenging to optimize. Computational modeling has been used throughout the neuromodulation field to model stimulation influence on tissue, but many aspects of successful neuromodulation, such as its influence on disease networks, are poorly understood.

In her movement disorders-focused work, Dr. Anderson has characterized multiple facets of how stimulation parameter choice affects surrounding tissue. She defined how different neuronal fiber orientations can be selectively targeted by modifying stimulation waveforms, as well as using anodic and bipolar stimulation. She advanced the classic modeling techniques of the volume of tissue activated (VTA) to incorporate anisotropic diffusion imaging. Her Hessian matrix-based VTA method can be computed orders of magnitude faster than classic VTAs, which enabled the creation of a near real-time optimization algorithm to maximize stimulation of a given neural target and avoid stimulation outside the target. This advance is particularly important in determining contact configurations for complex electrode designs, such as novel directional electrodes. She has similarly explored the role of pulse width modulation and small contact size in improving selective targeting of small diameter fibers. In the same vein, Dr. Anderson developed and fabricated a novel, multiresolution DBS electrode with 864 micro-sized, individually controllable contacts to improve targeting of smaller diameter, therapeutic fibers.

Dr. Anderson's latest work is focused on stimulation for drug-resistant epilepsy. Understanding how stimulation affects brain tissue, how brain networks may be modulated through stimulation, and how stimulation can lead to therapeutic benefit are critical, central questions to Dr. Anderson's research in her efforts to improve therapies for epilepsy. Epilepsy is a relatively new application for neuromodulation, and it is unclear how stimulation fundamentally leads to seizure arrest or prevention. Patients undergoing neuromodulation therapy for epilepsy represent some of the most challenging epilepsy cases: they have failed to respond to multiple anti-epileptic medications and are not candidates for resective or lesional therapies. Very few patients, approximately 15%, achieve seizure freedom through stimulation therapy, though outcomes gradually improve over time. In her current work, Dr. Anderson uses structural connectivity analyses derived from patient-specific diffusion imaging to predict patient outcomes in epilepsy. Dr. Anderson has found that non-seizure epoch stimulation (stimulation during low-risk seizure states) and increased time in low-risk states during responsive neurostimulation is predictive of improved clinical outcomes. Given that recent literature has demonstrated that patients with good outcomes undergo network reorganization, Dr. Anderson hypothesizes that stimulation during low-risk periods may be driving neuromodulation-induced plasticity and the long-term improvements that have been observed. Dr. Anderson's future research goals are to understand the long-term, plastic effects of stimulation on epilepsy networks, with the goals of the accelerating the network reorganization effects necessary to generate therapeutic benefit and, ultimately, helping more patients achieve seizure freedom.

BIOGRAPHY: Dr. Daria Anderson completed her undergraduate in biomedical engineering with a minor in neuroscience at Duke University and went on to earn her PhD in the neural interfaces track in biomedical engineering at the University of Utah. Her PhD research under advisors Dr. Chuck Dorval and Dr. Christopher Butson concentrated on computational modeling to estimate neural activation, improve neural selectivity, and develop novel electrode technologies for neuromodulation therapies. Dr. Anderson is currently a postdoc with Dr. John Rolston in Neurosurgery and Dr. Karen Wilcox in Pharmacology and Toxicology at the University of Utah, and she performs translational research focused on neuromodulation therapies for epilepsy in both pre-clinical and patient-specific models. Using pre-surgical electrophysiological data and neuroimaging, her work aims to identify patient-specific neural circuits that may serve as more effective targets for neuromodulation therapy. She is also interested in uncovering functional and structural correlates to therapeutic outcomes through computational modeling approaches to enable future improvements in surgical therapies for refractory epilepsy. Dr. Anderson has been funded consistently throughout her research career. In graduate school, she was awarded a John C. Jackson Fellowship and an NSF GRFP fellowship, while in her postdoc, she earned a TL1 fellowship through the University of Utah Clinical and Translational Science Institute, as well as an F32 NRSA fellowship and an LRP award through the NIH NINDS. In her spare time, Daria enjoys kayaking, hiking, and camping with her partner and pets, collecting tropical plants, and crafting clothing and furniture.

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