Neural Fragility of Epileptic Networks Pinpoint the Epileptogenic Zone in Medically Refractory Epilepsy

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LECTURE ABSTRACT

Over 20 million epilepsy patients do not respond to medication and suffer from medically refractory epilepsy (MRE), costing $16+ billion dollars a year in the US to treat patients. There are 2 treatments for MRE: surgical removal of the epileptogenic zone (EZ - region where seizures start); and electrical stimulation of the EZ. Successful outcomes critically depend on the clinician's ability to accurately identify the EZ, which is a complex costly process involving specialized epileptologists inspecting days of EEG signals. Despite much data gathered from a patient, surgical outcomes are disappointing and vary between 30%-70% seizure control post-treatment. We developed a solution that computes a new EEG marker, neural fragility of brain regions, and presents results in the form of an easy-to-read heatmap. To create our fragility marker, we first build a personalized dynamic model of the brain network from iEEG data. Using this model, we then calculate which network nodes are imbalanced, meaning they have more excitatory or less inhibitory influence on the network and thus can trigger seizures. Neural fragility measures the degree to which a node is imbalanced. We hypothesized that the most fragile "red hot" nodes in the iEEG network constitute the EZ. We tested our hypothesis via a retrospective analysis of 91 patients treated across 5 epilepsy centers. Neural fragility of the treated EZ was used as a metric to predict surgical outcomes, where low/high fragility values suggested failed/successful outcomes. Neural fragility was able to predict 43/47 surgical failures with an overall prediction accuracy of 76%, compared to the accuracy of clinicians being 48% (successful outcomes). In failed surgical outcomes, we identified fragile regions that were left untreated and patients who may have been poor surgical candidates due to too many regions being highly fragile.

SPEAKER BIOSKETCH

Sridevi Sarma received the B.S. degree in electrical engineering from Cornell University, Ithaca NY, in 1994; and an M.S. and Ph.D. degrees in Electrical Engineering and Computer Science from Massachusetts Institute of Technology in, Cambridge MA, in 1997 and 2006, respectively. From 2000-2003 she took a leave of absence to start a data analytics company. From 2006--2009, she was a Postdoctoral Fellow in the Brain and Cognitive Sciences Department at the Massachusetts Institute of Technology, Cambridge. She is now an associate professor in the Institute for Computational Medicine, Department of Biomedical Engineering, at Johns Hopkins University, Baltimore MD. Her research interests include modeling, estimation and control of neural systems using electrical stimulation. She is a recipient of the GE faculty for the future scholarship, a National Science Foundation graduate research fellow, a L'Oreal For Women in Science fellow, the Burroughs Wellcome Fund Careers at the Scientific Interface Award, the Krishna Kumar New Investigator Award from the North American Neuromodulation Society, and a recipient of the Presidential Early Career Award for Scientists and Engineers (PECASE) and the Whiting School of Engineering Robert B. Pond Excellence in Teaching Award.

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