Math Awareness Month Talk

Monday, April 21, 2014
4:00 PM
306 Snow Hall

Dominique Duncan

Department of Mathematics,
University of California at Davis

Mathematics and Mystery of the Brain

A novel approach to describe the variability of the statistics of EEG data is proposed that is an adaptation of the recently developed diffusion map framework. Diffusion maps, which extend principal components analysis and provide a nonlinear approach, provide dimensionality reduction of the data as well as pattern recognition that can be used to distinguish different states of a patient, for example, interictal and preseizure. A new algorithm, which is an extension of diffusion maps, is developed to construct coordinates that generate efficient geometric representations of the complex structures in the icEEG data. This method is adapted to the icEEG data and enables the extraction of the underlying brain activity to identify preseizure states. The algorithm is tested on icEEG data recorded from several electrode contacts from a patient being evaluated for possible epilepsy surgery at the Yale-New Haven Hospital. Numerical results show that the proposed approach provides a distinction between interictal and preseizure states.

In addition, the icEEG is used to test the existence of a relationship between distant parts of the default mode network (DMN), a resting state network defined by fMRI studies. Magnitude squared coherence, mutual information, cross-approximate entropy, and the coherence of the gamma power time-series are estimated, for one hour intracranial EEG recordings of background activity from 9 patients, to evaluate the relationship between two test areas. These two test areas are within the DMN (anterior cingulate and orbital frontal, denoted as T1 and posterior cingulate and mesial parietal, denoted as T2), and one control area (denoted as C) is outside the DMN. The goal is to test if the relationship between T1 and T2 is stronger than the relationship between each of these areas and C. A low level of relationship is observed among the 3 areas tested. The relationships among T1, T2, and C do not demonstrate support for the DMN. The results obtained underscore the considerable difference between electrophysiological and hemodynamic measurements of brain activity and possibly suggest a lack of neuronal involvement in the DMN

Dominique Duncan is currently a Postdoctoral Research Fellow at the Department of Mathematics at the University of California at Davis. She is a 2003 graduate of Lawrence Free State High School, 2007 graduate of University of Chicago with a B.S. in Mathematics, B.A. in Polish Literature and Minor in Computational Neuroscience. She received M.S., M.Phil. and Ph.D degrees from Electrical Engineering at Yale University. Her Ph.D focused on Nonlinear Factor Analysis of the EEG for Detection of Seizure Onset and Geometric Sensor Modeling and was supervised by Ronal R. Coifman, Professor of Mathematics. Dominique Duncan was a Postdoctoral Fellow at the Department of Neurology and Neurological Sciences at the Stanford University School of Medicine before moving to UC Davis. Her research is multidisciplinary and focuses on mathematics computational neuroscience, and the brain.

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Cakes will be served at 3:30 in 406 Snow Hall.