The Detection of Anomalies in EEG Data Using Diffusion Geometry

Dominique Duncan,
Department of Mathematics,
Ronald Coifman,
Departments of Mathematics and Computer Science,
Hitten Zaveri,
Department of Neurology,
Yale University, New Haven, CT,

Intracranial EEG (icEEG) data are recorded from patients for evaluation for epilepsy surgery. Our focus has been on using diffusion geometry to define patient state from these data. We compare icEEG data from resting state, sleep, and seizure periods.

A possibly powerful way of analyzing EEG data is by using diffusion mapping. With this method, eigenfunctions of Markov matrices are used to construct coordinates that generate efficient representations of complex geometric structures. Initially, a matrix describing local affinities is constructed and then normalized to become a Markov matrix. Selected eigenfunctions of this matrix are chosen to make the diffusion map embedding in a lower dimensional Euclidean space. Not only does diffusion mapping allow for dimensionality reduction of the data, but this method also provides pattern recognition so that specific parts of the data may be analyzed more closely. Diffusion maps extend principal components analysis and provide a nonlinear approach. The geometry of the data in the diffusion mapping is used to define state. Analysis was performed on five channel icEEG data (three of which were from the seizure onset area).

Our analysis suggests that diffusion maps of intracranial EEG data show promise as an indicator of state. Diffusion maps were used to distinguish resting state or baseline data that are recorded at some time prior to the occurrence of a seizure to data recorded immediately prior to the occurrence of a seizure. Furthermore, spectrograms were used to identify the parts of the brain that were most active during resting state, sleep, and seizure states.

Future work will include modifying the algorithm to improve the accuracy of this method to detect state as well as investigating the feasibility of this method to provide insight into the occurrence of individual seizures.