EN.580.694: Statistical Connectomics
Final Project Proposal

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Identifying changes in electrode communities during seizure in medically refractory epilepsy patients using pre-seizure and seizure sEEG recordings

Opportunity Medically refractory epilepsy (MRE) is defined as epilepsy that cannot be treated by standard therapies or drugs. The only effective treatment for MRE is to resect the region of the brain that is generating seizures. Community detection is of particular interest in this field. It has been shown that the centrality of a electrode in the epileptogenic zone, the region of the brain generating the seizures, evolves over the course of the seizure similarly to other electrodes in the EZ and distinctly from those not in the EZ [1]. It would be useful to localize the EZ without the necessity for seizure recordings, using only inter-ictal data.

Challenge Community detection is often a difficult task to perform precisely. A organizing electrodes in the network according to time-series data is critical in community detection. Once communities are detected in ictal and inter-ictal periods, changes in communities should be identified.

Action Modularity is a scalar value representing the strength of clustering performed. Modularity is maximized when there are strong connections within communities and weak connections between communities. A modularity optimization algorithm will be applied to the same community of electrodes before and during seizure in order to form inter-ictal and ictal communities [2]. Modularity will be optimized according to the centrality of each electrode during the course of ictal and inter-ictal time-series data.

Resolution We will gain insight into the existence, or lack thereof, of communities during inter-ictal periods as compared to those that have been demonstrated to exist during seizure. If these communities are well-defined with high modularity values, we will gain insight into similarities in communities before and during seizure.

Future Work One likely difficulty with this project is small variation in the lobes from which data is recording. Most patients are temporal lobe patients, and thus we cannot demonstrate that these findings are consistent across multiple lobes.

Statistical Decision Theoretic

Each subject will have an implanted set of sEEG electrodes and recording of at least two seizures, with at least one hour of inter-ictal space before and after each seizure. Raw voltage recordings will be converted into centrality time-series data that will be used in the modularity optimization algorithm.
Modularity optimization separates each electrode into it's own community. The algorithm then joins each community with every other community and shows which provides with greatest increase in optimization, ΔQ. This algorithm is performed in several iterations. The gain in modularity ΔQ for moving an isolated node i into a community C is estimated as:

$$\Delta Q = [\frac{\sum_{in}+k_{i,in}}{2m} - (\frac{\sum_{tot}+k_i}{2m})^2] - [\frac{\sum_{in}}{2m} - (\frac{\sum_{tot}}{2m})^2 - (\frac{k_i}{2m})^2], \text{ [2]}$$

where $\sum_{in}$ is the sum of the weights of the links inside C, k_i is the sume of the weights of the links incident to node i, $k_{i,in}$ is the sum of the weights of the links from i to nodes in C and m is the sum of the weights of all the links in the network [2].

References

[1] Yaffe, R.; Burns, S.; Gale, J.; Park, H.; Bulacio, J.; Gonzalez-Martinez, J.; Sarma, S.V., "Brain state evolution during seizure and under anesthesia: A network-based analysis of stereotaxic eeg activity in drug-resistant epilepsy patients," Engineering in Medicine and Biology Society (EMBC), 2012 Annual International Conference of the IEEE , vol., no., pp.5158,5161, Aug. 28 2012-Sept. 1 2012.

[2] Blondel, Vincent D., et al. "Fast unfolding of communities in large networks." Journal of Statistical Mechanics: Theory and Experiment 2008.10 (2008): P10008.