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Thesis Title: Automated Spike Detection in EEG of Patients with Epilepsy

Abstract:

Automated annotation of EEG from patients with epilepsy is important for the diagnosis and management of epilepsy. Epilepsy is often associated with the presence of epileptiform transients (ET), which is also known as epileptiform discharges or spikes, in the EEG. Interictal EEG data contains mostly background waveforms, since ETs occur occasionally in most patients, and there is a high disagreement among experts in ET interpretation.

In this study, using an annotated dataset provided by Massachusetts General Hospital (MGH), we design a cascade of simple thresholding steps to reject most background waveforms in interictal EEG, while maintaining most ETs. Several simple and quick-to-compute features are chosen. By thresholding these features, background waveforms are rejected sequentially, and the time needed to classify EEG in significantly reduced.

Moreover, we propose another boosting method using a cascade of SVM classifiers to further classify the remaining waveforms. Applying this algorithm helps increase the precision in interictal EEG classification.

In addition, we employed a dataset provided by Medical University of South Carolina (MUSC), which is annotated by 18 neurologists in a 5-point scale. Inter-rater agreement analysis as well as EEG signal analysis methods are applied on the dataset. Using feature selection and correlation analysis, we determine subsets of features, which correlate with expert scoring, and contribute to agreement or disagreement among experts. Regression model using SVR is fitted to predict scores given by experts to each event. In addition, relation of electrode locations on scalp with expert scores is analysed. The results of this study, give us better understanding of features underlying expert interpretation of EEG. It is significantly helpful in developing automated algorithms for epilepsy diagnosis.

Last but not the least, we analysed the performance of an ET detection software claimed to be non-inefrior to humans (Persyst P13). We apply this software to our dataset from MUSC annottaed by 19 academic clinical neurophysiologists. We compute pairwise pefromances of humans and P13, apply accelerated bootstrap analysis to test the non-inferiority, and compare several aspects of P13 versus experts' scoring. In addition to developing methods to compare varioys ET detection software, we demonstrate that P13 is still not as accurate as human experts in ET detection.

Publication List:

1. Elham Bagheri, Jing Jin, Justin Dauwels, Sydney Cash, and M Brandon Westover, “Fast and efficient rejection of background waveforms in interictal eeg,” in 2016 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), IEEE, 2016, pp. 744–748.

2. Elham Bagheri, Justin Dauwels, Brian C Dean, Chad G Waters, M Brandon Westover, and Jonathan J Halford, “Interictal epileptiform discharge characteristics underlying expert interrater agreement,” Clinical Neurophysiology, vol. 128, no. 10, pp. 1994–2005, 2017.

3. Elham Bagheri, Jing Jin, Justin Dauwels, Sydney Cash, and M Brandon Westover, “Classifier cascade to aid in detection of epileptiform transients in Interictal eeg,” in 2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), IEEE, 2018, In Press.

4. Elham Bagheri, Justin Dauwels, Brian C Dean, Chad G Waters, M Brandon Westover, and Jonathan J Halford, “Computers vs human electroencephalographers for annotating epileptiform discharges: Persyst 13 does not yet pass the Turing test,” Under preparation to submit to Clinical Neurophysiology.

5. Elham Bagheri, Justin Dauwels, Brian C Dean, Chad G Waters, M Brandon Westover, and Jonathan J Halford, “A Fast and Automated Method to Facilitate the Detection of Interictal Epileptiform Discharges in the Scalp Electroencephalogram,” Under preparation to submit to Journal of Neural Engineering.