Localization of the Seizure Focus from Interictal Intracranial EEG

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Abstract—Localization of seizure focus is crucial for epilepsy patients undergoing surgical resection. In this work, we develop methods to extract multiple seizure signatures from interictal intracranial EEG, and further apply them in a fuzzy classification scheme, so as to localize the seizure focus in a reliable and automated fashion.

For approximately 30% of epilepsy patients, seizures are poorly controlled with medications alone [1]. Those patients may be successfully cured by surgically removing the brain area(s) where the seizures originate. It is therefore crucial to accurately localize the seizure foci. Neurologists rely heavily on seizures to determine the foci. Seizures are unpredictable and infrequent. The invasive recordings usually continue for days or weeks until enough seizures are captured. The procedure is costly, uncomfortable, and risky of side effects.

Figure 1. Semi-chronic EEG recording containing epileptic seizures.

Our long-term objective is to drastically shorten the hospitalization of epilepsy patients, from weeks to a few days: We hope to localize the seizure foci from short invasive recordings made in the operating room, before the resection surgery. The goal of the proposed project is to explore the feasibility of this idea, building upon our promising preliminary results.

Figure 2. (a) Signatures of epileptic EEG activity: spikes (top) and HFO (bottom); (b) physical locations of surface electrodes, where the actual focus is red-color labeled by doctors from ictal EEG; (c) the distribution of a single measure (e.g. spike rate) over all electrodes, where the corresponding ground truth is marked using back-color squares.

Our hypothesis is that, even at rest, the seizure focus is characterized by seizure measures such as interictal spikes [2], high frequency oscillations (HFOs) [3], slowing and local synchrony [4]. Our novelty is to exploit combinations of all measures in a machine-learning framework to localize the seizure foci. We have proposed methods for detecting spikes and HFOs respectively. We have applied signal processing techniques to invasive semi-chronic recordings between seizures, in order to extract signatures of the seizure foci. We have applied statistical decision algorithms [5] that leverage those signatures to determine the seizure foci in an automated fashion.

In future work, we will apply those algorithms to short invasive recordings made in the operating room. The proposed procedure may have enormous impact on clinical practice of epilepsy, and would substantially reduce treatment costs. Moreover, our novel automated approach to medical decision making is not only relevant for neurosurgery but many other medical disciplines.

REFERENCES