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Epilepsy Seizure Prediction by Effective Connectivity Estimation Using Granger Causality and Directed Transfer Function Analysis of Multi-Channel Electroencephalogram

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Abstract : Epilepsy is a persistent neurological disorder that affects more than 50 million people worldwide. Hence, there is a necessity to introduce an efficient prediction model for making a correct diagnosis of the epileptic seizure and accurate prediction of its type. In this study we consider how the Effective Connectivity (EC) patterns obtained from intracranial Electroencephalographic (EEG) recordings reveal information about the dynamics of the epileptic brain and can be used to predict imminent seizures, as this will enable the patients (and caregivers) to take appropriate precautions. We use this definition because we believe that effective connectivity near seizures begin to change, so we can predict seizures according to this feature. Results are reported on the standard Freiburg EEG dataset which contains data from 21 patients suffering from medically intractable focal epilepsy. Six channels of EEG from each patients are considered and effective connectivity using Directed Transfer Function (DTF) and Granger Causality (GC) methods is estimated. We concentrate on effective connectivity standard deviation over time and feature changes in five brain frequency sub-bands (Alpha, Beta, Theta, Delta, and Gamma) are compared. The performance obtained for the proposed scheme in predicting seizures is: average prediction time is 50 minutes before seizure onset, the maximum sensitivity is approximate ~80% and the false positive rate is 0.33 FP/h. DTF method is more acceptable to predict epileptic seizures and generally we can observe that the greater results are in gamma and beta sub-bands. The research of this paper is significantly helpful for clinical applications, especially for the exploitation of online portable devices.

Keywords : effective connectivity, Granger causality, directed transfer function, epilepsy seizure prediction, EEG
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