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Providing a Feasible Seizure Prediction Algorithm for Implantable Devices

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Introduction: Epilepsy is a sign of a neurological dysfunction manifested by unexpected and recurrent seizures. While epilepsy affects approximately 50 million people worldwide, more than 30% of them suffer from medication-refractory epilepsy that restricts their lives. In recent years, seizure prediction algorithms have received much attention due to their potentials, which can improve life quality of patients who cannot be treated with therapeutic strategies like antiepileptic drugs and surgery. In order to suppress or abate seizures, these algorithms with some methods like stimulation or focal cooling of cortex can be used for developing closed-loop therapy systems in implantable devices. In spite of several claims about the predictability of previous algorithms in seizure predictions, computational requirements, and reliabilities for using in implantable devices have not yet sufficiently been considered and no algorithm has been offered for practical applications. The purpose of this research is to provide the framework for epileptic seizure predictions with lower process time without affecting the quality of distinguishing brain states.

Methods: In this article among several types of features that differentiate between preictal (preceding a seizure) and interictal (between seizures) states, linear features have been selected because of their low computational burden compared to nonlinear features. A 30 minute prediction horizon has been chosen for impeding seizures. Several features such as statistical moments and power spectral density in different frequency bands using moving window techniques with 20 seconds length and half overlap have been applied. However, these features generate high dimensional feature space, which can make problems in computational time and energy consumption. This problem has been solved by Principal Component Analysis (PCA) as a dimensionality reduction technique. PCA selects optimal features, which contain important information from cerebral activity and consequently speeds up seizure prediction algorithms. Also, Support Vector Machine (SVM) has been used for classification of brain states. SVM is a machine learning method with a robust performance in biomedical applications. In this study double cross validation has been used to test our method with untouched sets in order to better assess the performance of proposed algorithms. For this purpose, C and γ parameters of radial basis function has been optimized for each patient. In order to omit noise in SVM outputs, a median filter has been applied as post processing. Results: In order to evaluate realistic performance of the proposed patient specific seizure prediction algorithm, sensitivity and false prediction rate per hour on the 10 patients of Freiburg, dataset has been examined and a high sensitivity of 89% and low false prediction rate of 0.18 have been achieved.

Conclusion: This algorithm, by low computational requirements, can reliably predict impeding seizures and can be beneficially used in implantable devices. This method provides a suitable tradeoff between computational complexity and classification results with faster steps useful for implantable devices.

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