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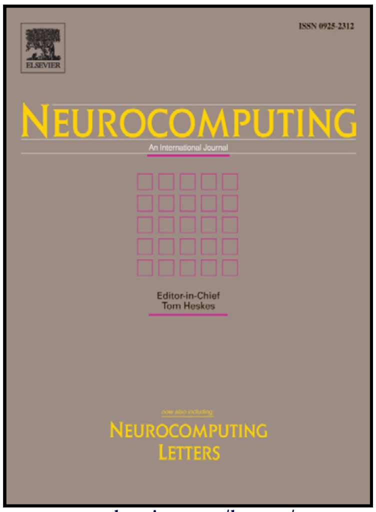

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Epileptic Seizure Detection by Analyzing EEG Signals using Different Transformation Techniques

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ABSTRACT

Feature extraction and classification are still challenging tasks to detect ictal (i.e., seizure period) and interictal (i.e., period between seizures) EEG signals for the treatment and precaution of the epileptic seizure patient due to different stimuli and brain locations. Existing seizure and non-seizure feature extraction and classification techniques are not good enough for the classification of ictal and interictal EEG signals considering for their non-abruptness phenomena, inconsistency in different brain locations, type (general/partial) of seizures, and hospital settings. In this paper we present generic seizure detection approaches for feature extraction of ictal and interictal signals using various established transformations and decompositions. We extract a number of statistical features using novel ways from high frequency coefficients of the transformed/decomposed signals. The least square support vector machine is applied on the features for classifications. Results demonstrate that the proposed methods outperform the existing state-of-the-art methods in terms of classification accuracy, sensitivity, and specificity with greater consistence for the large size benchmark dataset in different brain locations.

Keywords:
EEG
Epilepsy and Seizure
Ictal and Interictal
EMD
LS-SVM

1. Introduction

The human brain processes sensory information received by external/internal stimuli. Human brain is an organic electrochemical computer as neurons exploit chemical reaction to generate electricity [1]. *Electroencephalogram* (EEG) is a graphical record of ongoing electrical activity, which measures the changes of the electrical activity in term of voltage fluctuations of the brain through multiple electrodes place on the brain [2]. In the clinical contexts, the main diagnosis of EEG is to discover abnormalities of brain activities referred to the epileptic seizure. A seizure occurs when the neurons generate uncoordinated electrical discharges that spread throughout the brain and epilepsy is a recurrent seizure disorder caused by abnormal electrical discharges from brain cells, often in the cerebral cortex [3]. Another clinical use of EEG is in diagnosis of coma, brain death, encephalopathies, and sleep disorder, etc. Moreover, EEG can be used in many applications such as emotion recognition [4], video quality assessment [5], alcoholic consumption measurement [6], sleep stage detection [7], change the brainwaves by smoking [8], and mobile phone usages [9], etc.

People may experience abnormal activities in sensation, movement, awareness, and behavior during seizure as a result they cannot perform normal task. Ictal and interictal both are medical condition of seizure where ictal represents the period of seizure and interictal represents the intermediate period between two seizures. Note that interictal is significantly different from normal non-seizure (mainly for healthy people) signal in terms of signal characteristics. A prediction of seizures (i.e., ictal) from interictal could aware a patient to put away from the next seizure and also can make sure better treatment and precaution. A number of existing EEG features extraction and classification techniques [11]-[17] are able to classify seizure and non-seizure EEG signals for a small size dataset almost perfectly. However, those methods are struggling to provide acceptable classification accuracy for ictal (i.e., seizure period) and interictal (i.e., period between seizures) EEG signals due to the non-abruptness and inconsistence phenomena [10] of the signals in different brain locations. Moreover, it is more challenging to get acceptable label of accuracy by a particular method if we do not have any domain knowledge of the available EEG signals due to different types of seizures (i.e., generalized or partial), patients, hospital setting, brain location, and artifact. Note that Ictal signals are considered the EEG signals during the seizure period when a patient shows abnormal activities, whereas interictal signals are considered as non-ictal signals between two seizure periods of an epileptic patient. Thus, we can consider the characteristics of interictal signal as a middle stage of non-seizure and ictal signals (although a patient may show normal brain activities similar to the non-seizure signals during the interictal period).

Existing methods [11]-[18] used small epilepsy dataset [19] (for detailed information of the dataset, see Section 3.1). The small dataset with duration 23.6 second has seizure (i.e., ictal) and non-seizure signals which can be distinguished by their visual phenomena such as magnitude of amplitude and changing rate of frequency (see in Figure 1 (a)). For the non-seizure signal the amplitude is low and the frequency is high while the nature of seizure signal is totally opposite (see Figure 1(a)). Figure 1(b) and (c) show the ictal and interictal EEG signals from a large dataset [22]. The figure demonstrates the non-abrupt phenomena (i.e., not easily distinguishable between ictal and interictal based on amplitude and frequency) of the ictal and interictal signal for both cases of Frontal and Temporal lobes compared to the dataset in [19]. Moreover, EEG signals from different locations exhibit different phenomenal activities for an