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Automated Seizure Onset Detection and Prediction Using EEG: A Comprehensive Model with Multiscale Analysis and Machine Learning

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Abstract

Accurate and timely detection of seizure onset is crucial for effectively managing epilepsy. This paper presents a novel and fully specified model for automated seizure onset detection and prediction based on electroencephalography (EEG) measurements. The model is evaluated using two widely recognized EEG databases, namely Freiburg (intracranial EEG) and CHB-MIT (scalp EEG), to assess its performance against state-of-the-art models. The proposed model incorporates four key components to enhance its effectiveness: (1) multiscale principal component analysis for EEG de-noising to improve signal quality, (2) EEG signal decomposition using empirical mode decomposition, discrete wavelet transform, or wavelet packet decomposition to capture relevant signal characteristics, (3) statistical measures for extracting informative features, and (4) machine learning algorithms for accurate classification. Experimental results demonstrate the superior performance of our model in comparison to existing approaches. It achieves an impressive overall accuracy of 100% in distinguishing between ictal and inter-ictal EEG for both the Freiburg and CHB-MIT databases. Furthermore, the model exhibits high accuracy in seizure onset prediction, successfully discriminating between inter-ictal, pre-ictal, and ictal EEG states with an accuracy of 99.78% and distinguishing between inter-ictal and pre-ictal EEG states with an accuracy of 99.72%. Importantly, the proposed model's versatility extends beyond seizure detection and prediction. It can be applied to other classification tasks involving bio-signals, such as electromyography (EMG) and electrocardiography (ECG). Thus, our model holds promise as a comprehensive tool for various biomedical signal analysis applications.

Keywords: Electroencephalography, Seizure onset detection, Seizure onset prediction, EEG de-noising, Feature extraction, Machine learning.

I. Introduction

Epilepsy is a neurological disorder characterized by recurrent seizures, and timely detection of seizure onset plays a vital role in its management. Electroencephalography (EEG) is a widely used technique for monitoring and analyzing brain activity, offering valuable insights into seizure patterns. This study aims to develop a comprehensive model for automated seizure onset detection and prediction using EEG data [1]. The proposed model combines several key components to enhance its performance and accuracy. Firstly, multiscale principal component analysis is employed for EEG de-noising, enabling the removal of noise and artifacts to improve signal quality. Secondly, the model incorporates various signal decomposition techniques, such as empirical mode decomposition, discrete wavelet transform, or wavelet packet decomposition, to extract meaningful features from the EEG data. These decomposition methods enable identifying and extracting relevant signal characteristics at different scales [2]. Statistical measures are then applied to the decomposed signals to extract informative features that capture important patterns associated with seizure onset. Finally, machine learning algorithms are utilized for accurate classification and prediction based on the extracted features [3-4].

To evaluate the effectiveness of the proposed model, two benchmark EEG databases, Freiburg (intracranial EEG) and CHB-MIT (scalp EEG), are employed. The model's performance is compared against state-of-the-art approaches to

model's exceptional performance, as demonstrated by its high accuracy in both seizure detection and prediction, signifies its potential as a valuable tool in epilepsy management. Moreover, its versatility makes it suitable for diverse biomedical signal analysis tasks.

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