Chapter 8
Approximation-Aided Epilepsy Detection Using Linear and Non-Linear Classifiers

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ABSTRACT

Patients with brain-related symptoms and diseases are diagnosed using electrocardiogram (EEG) signals. Epilepsy in humans can be diagnosed from EEG signals. This chapter focuses on identification of seizure-free, seizure, epileptic, and normal EEG signals with minimum-length EEG signal. The algorithm could classify the seizure and normal EEG signals even for a length of 1000 samples per segment. The algorithm was tested on various EEG signals. The traits are extracted from the EEG signal and preprocessed and fed to five different classifiers to check the accuracy of the scheme. The algorithm provided a better accuracy of 99.8945%. The sample signals were taken from an EEG signal database available at University of Bonn. The proposed scheme was tested with performance measures such as specificity (SPE), NPV (negative predictive value), PPV (positive predictive value), ACC (accuracy), MCC (Matthews's correlation coefficient), and sensitivity (SEN). The test results proved that the proposed methodology could perform real-time epileptic seizure detection.

DOI: 10.4018/978-1-6684-4671-3.ch008

INTRODUCTION

Out of the several disorders of the human brain, Epilepsy seems to be prominent and most occurring, Identification of Epilepsy patients is critical for the quick treatment and recovery. Epilepsy could be identified by analyzing the EEG signals of the human. In (Güzel, 2019), the algorithm hybridized the linear and nonlinear classifiers with the discrete wavelet transforms (DWT) and principal component analysis (PCA), separately. The model estimation process with multivariate logistic regression (MLR) and artificial neural networks (ANNs) was used to control the complexity of model and reduce the dimension of feature matrix, and implementation was done using PCA. In addition, to quantify the complexity and select the best models, the information criteria were considered for both MLR and ANNs. To improve the classification performance, ANNs were trained by various gradient algorithms and early stopping and cross-validation techniques were used. In (Martinez-del-Rincon et al., 2017), a novel approach was proposed for automatic epilepsy seizure detection based on EEG analysis that exploited the underlying non-linear nature of EEG data. The research involved two main contributions namely the use of non-linear classifiers through the so-called kernel trick and the proposal of a Bag-of-Words model for extracting a non-linear feature representation of the input data in an unsupervised manner. The obtained results proved the robustness of the proposed solution to more realistic for variable conditions.

In (Siddiqui et al., 2020), detailed review of various approaches to seizure detection using machine learning classifiers and statistical features, was done. The main challenges were selection of appropriate classifiers and features. An overview of the wide varieties of these techniques over the last few years based on the taxonomy of statistical features and machine learning classifiers 'black-box' and 'non-black-box', was done. Globally, epilepsy affects approximately 50 million people, with 100 million being affected at least once in their lifetime (WHO, 2022). Applications of machine learning are significantly seen on health and biological data sets for better outcomes (Mahmud et al., 2020). Researchers/scientists on different areas, specifically, data mining and machine learning, are actively involved in proposing solutions for better seizure detection. Machine learning plays a significant and potential role in solving the problems of various disciplines like healthcare (Singh & Gupta, 2019). Seizure detection has been done by various machine learning classifiers such as ANN, SVM, decision tree, decision forest, and random forest (Abbasi & Goldenholz, 2019).

Javad Birjandtalab et al. (Andrzejak et al., 2001) used ANN with a weighted cost function to imbalanced EEG dataset, by achieving 86% F-measure. In 2018, Lahmiri et al. (Birjandtalab et al., 2018) used generalized Hurst exponent (GHE) and KNN, to propose a system for identifying the 'seizure' and 'non-seizure' classes from