Neuroscience Letters 765 (2021) 136269

Contents lists available at ScienceDirect

Neuroscience Letters

journal homepage: www.elsevier.com/locate/neulet

Research article

Effect of combining features generated through non-linear analysis and wavelet transform of EEG signals for the diagnosis of encephalopathy

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ARTICLE INFO

Keywords:
Electroencephalogram
Encephalopathy
Discrete wavelet transform
Gini impurity score
Support vector machine
Random forest

ABSTRACT

Electroencephalogram (EEG) signals portray hidden neuronal interactions in the brain and indicate brain dynamics. These signals are dynamic, complex, chaotic and nonlinear, the nature of which is represented with features - fractal dimensions, entropies and chaotic features. This study aims at examining the discriminative power of individual features and their combination in the diagnosis of a neuro-pathological condition called encephalopathy. Feature combination is accomplished with the help of feature selection using Gini impurity score that improves discriminative power and keeps redundancy minimal. Further, three widely used non-parametric classifiers which are known to be effective with wavelet features on EEG signals — Support Vector Machine, Random Forest, Multilayer Perceptron — are employed for disease classification. The models created by the combination of aforementioned stages are analysed and evaluated with performance scores, leading to an optimal model for automated diagnostic applications.

1. Introduction

Electroencephalogram (EEG) is a signal acquired by connecting electrodes on the scalp of a person, which can be used to study the electrical activity of millions of neurons in the brain. EEG signals have been utilised for the diagnosis of major neurological diseases. It clearly portrays the dynamics of brain and gives evidence on various neuro-pathologies [1]. It can be used more effectively by employing powerful signal processing techniques, reducing expert interventions.

Encephalopathy is a disease state in which higher brain activities are affected by metabolic disturbances. It is characterized by global cerebral dysfunction without structural abnormalities in brain. Metabolic homeostasis influences neuron activities and any metabolic system variations can lead to brain disorders. Types of encephalopathy include hepatic encephalopathy due to liver failure, hypoglycemic encephalopathy due to low sugar level in the blood, hypocalcemia and hypercalcemia due to variation in calcium levels and renal or uremic encephalopathy due to acute or chronic renal failure. Thus, metabolic encephalopathy is a secondary neurological disease as brain is not primarily affected with this disease. Fig. 1 shows an EEG recording of an encephalopathic patient, with slowing of background activity to 5.5 Hz. Paper speed (acquiring speed) was kept at 30 mm/sec and sensitivity was kept at 10 μV/mm.

This study aims to identify the performance of various classifiers namely, support vector machine, random forest and multilayer perceptron for diagnosing encephalopathy cases based on various chaotic and other nonlinear features. EEG signals, being nonlinear, can be assessed using these features more efficiently than linear time-domain features.

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https://doi.org/10.1016/j.neulet.2021.136269
Received 20 June 2021; Received in revised form 19 September 2021; Accepted 23 September 2021
Available online 25 September 2021