Focal Epileptic Seizure Forecasting in EEG Signals Using Wavelet Transform and Artificial Neural Networks

K. A. Helini Kulasuriya and M.U.S. Perera

Department of Computing
Informatics Institute of Technology
University of Westminster
57, Ramakrishna Road,
Colombo, Sri Lanka.
e-mail: h.kulasuriya@yahoo.com
e-mail: udayangi@iit.ac.lk

Abstract – Seizure prediction has become a major field of neurological research, because of the suggestion of recent research that electrophysiological changes develop minutes to hours, before the actual clinical onset in focal epileptic seizures. This paper describes a novel approach for forecasting focal epileptic seizures, by applying statistical analysis methods and classifying, the features derived from intracranial Electroencephalographic (EEG) recordings, of brain activity. The decision making consists of two stages; initially the signal features are extracted by applying wavelet transform (WT) and then an artificial neural network (ANN) model, which is a supervised learning-based algorithm classifier, used for signal classification. Wavelet transform is an effective tool for analysis of transient events in non-stationary signals, such as EEGs. The performance of the ANN classifier is evaluated in terms of sensitivity, specificity and classification accuracy. The obtained classification accuracy confirms that the proposed scheme has potential in classifying EEG signals.

Keywords – Electroencephalogram (EEG), Discrete Wavelet Transform (DWT), Artificial Neural Networks (ANNs), Epilepsy, Seizure forecasting, Seizure Prediction.

I. INTRODUCTION

The human brain being a complex system, exhibits rich spatiotemporal dynamics and bio medical signals are the observations of neurological activities forming inside the brain. Among numerous techniques used for probing human brain dynamics, electroencephalography (EEG) is an important bio medical signal, which provides a direct measure of cortical activity with millisecond temporal resolution. Especially, it is useful in diagnosing neurological disorders, such as epilepsy [3].

Epilepsy is a chronic illness that affects approximately 1 to 2% of the world's population [11] and epileptic seizures are the results of the transient and unexpected electrical agitations of the brain, which involves uncontrolled neuron firings including brief transient discharges (spikes) or combinations such as spike-wave discharges. But, the occurrence of an epileptic seizure is unpredictable, and also its process has not yet been understood completely. Sometimes seizures may remain unnoticed, depending on their presentation, and it can also get confused with other events, such as a stroke [8].

Analysis of the electroencephalogram (EEG) records provides valuable means for detecting widespread brain disorders. Therefore, EEGs have become the most utilized bio medical signal, to clinically assess brain activities. According to the current context, the detection of epilepti-form discharges in the EEG record is an important component in the diagnosis of epilepsy. EEG systems usually generate large amount of data. Although, early on, EEG analysis was restricted to visual inspection of the EEG signal, it became impossible to analyse large amount of data efficiently and effectively, since there is no definite criterion evaluated by the experts. Along with that, visual inspection is insufficient when alpha activity is dominant. The EEG spectrum contains some characteristic waveforms that fall primarily within four frequency bands—delta (1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), and beta (13–30 Hz) [9]. Therefore, when alpha activity is dominant, delta and theta activities get unnoticed.

Hence, consideration of these issues has emerged the need of some automated system for forecasting epileptic seizure activity prior to their onset. Therefore, this proposed system has been developed for forecasting epileptic seizures, using digital EEG signals, Wavelet Transform, which is a digital signal processing technique, for time frequency analysis of the signal and Artificial Neural Network models for the classification using Wavelet coefficients.

II. RELATED WORK

Signal processing has also been made use of, to deal with miscellaneous issues in EEG analysis such as data compression, detection and classification, noise reduction, signal separation, and feature extraction [14]. During the process of forecasting epileptic seizures, these raw EEG signals are processed in the purpose of extracting certain features, for classification in the second step. The results of the studies in the literature have demonstrated many techniques for feature extraction of discrete EEG time signals. Fast Fourier Transform (FFT) [13], Wavelet Transform (WT) or Discrete Wavelet transform (DWT) [9], Independent Component Analysis (ICA) [14] and AutoRegression (AR) are some of the reported technologies, by other researchers.

According to Jahankhani, Kodogiannis and Revett (2006) [9], representations based on a Fourier transform have been applied, since the early days of automatic EEG processing. Although, such methods have proved to be beneficial for various EEG characterizations, Fast Fourier transform (FFT) suffers from having large noise sensitivity [13]. FFT also requires longer duration data records, for efficient extraction of EEG features (coefficients) and it has