*International Journal of Information Technology and Knowledge Management*
*December 2012, Volume 6, No. 1, pp. 3-5*

# EPILEPSY DETECTION USING EEG AN OVERVIEW

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***Abstract***: Brain is one of the vital organs of human body. Epilepsy can be defined as a disorder of the central nervous system that results in recurrent seizures due to chronic abnormal bursts of electrical discharge in the brain. This paper reviews the different methods proposed by the researchers for detection of Epileptic activity using EEG.

***Keywords***: EEG, STFT, EFD, DWT, Bayesian Information Criterion, Entropy.

## 1. ELECTROENCEPHALOGRAM

Brain is the most complex of all the other organs of human body. It generates electrical signals to directly or indirectly control the entire body. The electrical activity of the brain generated by millions of neurons is recorded by medical technique known as electroencephalogram (EEG). An EEG channel is formed by taking the difference between potentials measured by placing two electrodes, and records the summed potential of neurons. EEG is measured using 10-20 electrode system as shown in Figure 1.

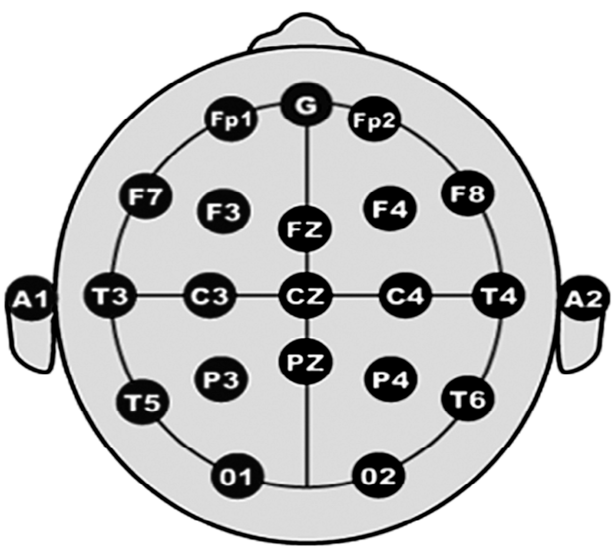


**Figure 1: 10-20 Electrode Placement System**

EEG is used for diagnosis of brain disorders like coma, to verify brain death, to monitor anaesthetic depth etc. One of the main applications of EEG lies in diagnosing epilepsy. A patient suffering from epileptic attack has a distinctly different EEG as compared to excessive neural activity in the brain.

## 2. EPILEPSY

The word 'epilepsy' is derived from the Greek word *epilambanein*, which means 'to seize or attack'. Epilepsy is the second most common neurological disorder (after stroke), affecting more than 50 million patients around the world [1, 2]. This is a serious disorder of central nervous system which results in recurrent, unprovoked epileptic seizures due to chronic abnormal bursts of electrical discharge in the brain. The epileptic seizure activity is classified mainly on basis of its generation and area of brain in which it is localized. In a partial seizure epileptic activity begins and remains localized in one part of the brain on the other hand a generalized seizure involves the epileptic activity in entire brain. The classification of epileptic seizures is summarized in figure 2.

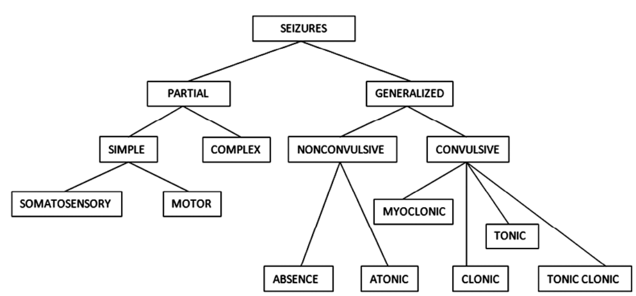


**Figure 2: Classification of Epileptic Seizure Activity**

## 3. METHODS OF EPILEPSY DETECTION

The early methods were based on the representation of a signal using Fourier transform for processing EEG automatically. EEG spectrum contains characteristic waveforms that fall basically within four frequency bands. Such methods have been proved beneficial for various EEG characterizations, but fast Fourier transform (FFT) suffer from large noise sensitivity. Power spectrum estimation as

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a parametric method such as autoregressive (AR), reduces the spectral loss problems and gives better frequency resolution. Since the EEG signals are non-stationary, the parametric methods are not suitable for frequency decomposition of these signals. Hence, for such transient signals, analysis and representation in time-frequency domain is highly desirable approach.

### 3.1 Time-Frequency Analysis

Most of EEG based analysis models requires the time, the frequency or the time-frequency analysis followed by a linear or non-linear classifier [3]. Generally it is seen that the methods using the features in the time-frequency domain usually provide higher successes than the others in the classification studies on EEG signals. However, it is dependent on both the classifier and the features to be applied into that classifier that the classification results in a success.

Most of the classifiers used the statistical features obtained by the time-frequency analysis of EEG signals Short Term Fourier Transform (STFT) and various Time-Frequency Distributions are used for the *t–f* analysis. For STFT, the signal $x(u)$ at an instant of time $t$, the Fourier transform is calculated for each instant of time $t$

$$STFT(t, f) = \int_{+\infty}^{-\infty} x(\tau)h(\tau - t)\, e^{-if\tau} d\tau \qquad (1)$$

where $h(t)$ is a short time window. Short time Fourier Transform undergoes trade-off between its window length and its frequency resolution. Using t-f analysis, the Power Spectral Density is calculated of the signal, which represents the distribution of the energy of the signal over the *t–f* plane [4].

### 3.2 Association Rules

This is a methodology for the epilepsy detection is based on association rule mining and classification of transient events in electroencephalographic (EEG) recordings which distinguishes between the electrical activity of a healthy subject and an epileptic one. Transient events are classified into four categories: epileptic spikes, muscle activity, eye blinking activity, and sharp alpha activity. The methodology involves four stages: 1. transient event detection, 2. clustering of transient events and feature extraction, 3. feature discretization and feature subset selection, 4. association rule mining and classification of transient events [5].

### 3.3 Probability Density Function

The Equal Frequency Discretization (EFD) based probability density approach can be used for detecting epilepsy from EEG signals. These signals are decomposed by using the Discrete Wavelet Transform (DWT) into its various subbands, the coefficients in each subband are then discretized to several intervals by EFD method, and the probability density of each subband of each EEG segment is computed according to the number of coefficients in discrete intervals. Then, two probability density functions can be defined by means of the curve fitting over the probability densities of the sets of both healthy and epileptic patients. EEG signals are then classified by calculating the mean square error (MSE) of these probability density functions. The result of the classification of epileptic subjects is evaluated by Orhan et al [6].

### 3.4 Autoregressive Method

This method for epilepsy detection is based on autoregressive (AR) estimation of EEG signals. The optimum order for AR model is determined by Bayesian Information Criterion (BIC) and then AR parameters of EEG signals and their sub-bands are extracted by discrete wavelet transform. These parameters are used as a feature to classify the EEG signals into normal and epileptic by multilayer perceptron (MLP) classifier [7].

### 3.5 Wavelet-Spectral Entropy Based Detection

Entropy is a thermodynamic quantity which is the amount of disorder in the system. The spectral entropies basically use the amplitude of the power spectrum of the signal as the probabilities in entropy calculations. This is a method for detection by analysing EEG subbands based on determining discrete wavelet-spectral entropy. The EEG signal is decomposed by discrete wavelet transform into its sub-bands by high pass and low pass filtering to different levels as shown in Figure 3 and is then characterized by spectral entropy.

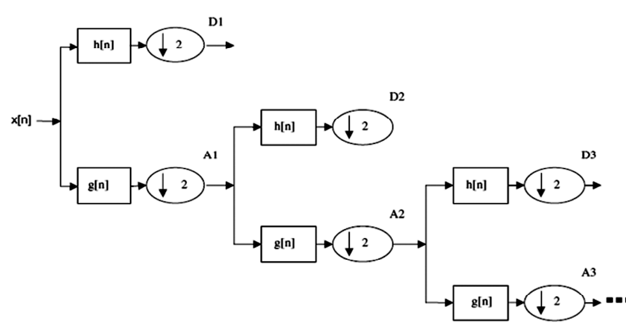


**Figure 3: Discrete Wavelet Decomposition of Signal**

$$\text{ENTROPY } (e_i) = \sum_{-j=1}^{n} Dij^2 \log(Dij^2) \qquad (2)$$

This method is applied to three different groups of EEG signals: 1) healthy, 2) epileptic during a seizure-free interval,

3) epileptic during a seizure [8]. Spectral entropy is used which differentiated between these three states and their sub-bands. Then statistical approach is applied to determine the measure of distinguishing between different subjects. Also there is an approach using wavelet transform where ?rst the pre-processed signal is decomposed into a wavelet packet tree. Then features are extracted from standard frequency pattern. These features are then fed to neural network classifier for detection of seizure activity or normal result [9]. The whole technique is explained through this Figure 4 shown below.

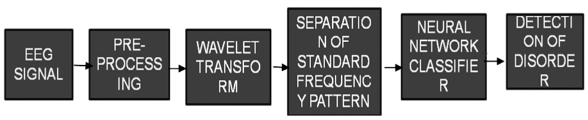


**Figure 4: Detection Using Wavelet Transforms Method**

## 4. CONCLUSION

Epilepsy is a serious neural disorder that needs to be detected accurately. Electroencephalogram is a good non-invasive diagnostic tool that can be digitally analyzed to detect the epileptic disorder. Various methods proposed by the researchers are reviewed in this paper. This is an aid of scope for further improvements in these methods or their combinations.

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