Design of Algorithm for the Epileptic Seizure Classification Using Time-frequency Analysis of EEG Signals

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Abstract:
In this paper, we have proposed an algorithm for classification of epileptic seizures of EEG signals. The proposed algorithm is developed in separate modules and later combined to implement epileptic seizure detection and classification of EEG data. In the first stage, analysis of EEG signal is carried out by using discrete wavelet transform. In the second stage, using combination of discrete wavelet transform and fast fourier transform, feature extraction is done. Then extracted features are fed to ANN classifier for classification of epileptic seizures using artificial neural network and analysis of ANN is performed in terms of average selectivity, sensitivity, accuracy.

Keywords : ANN, Cohen class kernel function, EEG, Epileptic seizure, Time-frequency analysis.

I. Introduction
Epilepsy is caused by a synchronized electrical discharge of a group of neurons which is caused by recurrent seizure. In reference to the world population, 0.6-0.8% is affected by Epilepsy, which is the second common neurological disease just after the stroke, of whom 30% have not been able to gain any control over their seizures using current pharmacological treatment measures[1]. The detection of epilepsy which includes visual scanning of EEG recordings for the spikes and seizures is usually time consuming, especially in the case of long recordings, the EEG signal parameters extracted and analyzed using computers are highly useful in diagnostics[2]. EEG, a non-invasive measures of electrical potential originated from neuron activities, offers the most specific test for diagnosing epileptic seizure. Sudden spectral energy redistribution in energy band 0-25Hz is observed at EEG signal during seizure[3]. Signal processing methods introduce a mathematical representation of scattered visual information by different feature set. These feature sets always try to model all visual information in terms of few parameters from where decision making becomes easier and more accurate than the conventional manual methods. These features can be generally categorized as univariate / bivariate and linear / non linear types. Statistical moment, spectral band power, spectral edge frequency, accumulated energy, auto correlation and auto regressive parameters of a single EEG signal are linear univariate measures[4]. In order to find out similarity between two signals, bivariate measures are used. In bivariate system, Maximum line across - correlation and linear coherence are popular linear parameters. Since EEG is a non-stationary signal and distribution of its energy at different frequency bands demonstrate the seizure activities, time-frequency distribution has the potential to perform better than conventional frequency analysis methods[5]. The interictal indications of epilepsy can be identified using a short period EEG recording. However, the long-term video EEG monitoring

II. Methodology
2.1 Time-frequency Analysis and development of kernel functions
Analysis of EEG signal is done by using discrete wavelet transform. Analytical representation facilitates mathematical manipulation during time - frequency analysis, which is performed prior to feature extraction. Among many time frequency energy distribution functions, Cohen class distributions utilize time and frequency covariance properties, where twelve kernel functions are used to reduce interference. Marguer - Hill (MH), Wigner - Ville (WV) and Rihaczek (RIH) are basic kernel functions, which do not
employ any kind of smoothing. Pseudo-Margenau-Hill (PMH) and Pseudo - Wigner-Ville (PWV) are the frequency domain smoothed version of the basic kernels. Born-Jordan (BJ), Butterworth (BUT), Choi-Williams (CW), Generalized rectangular (GRECT), Reduced Interference (RI), Smoothed Pseudo Winge r-Ville (SPWV) and Zhao-Atlas-Marks (ZAM) utilize both time and frequency domain smoothing. The effect of using a time and/or frequency smoothing kernel function on interference can be analyzed using a synthetic signal. The signal consists of two sinusoidal is generated such that one sinusoidal remains for the whole time under consideration and another one appears in the middle for a while with a different frequency. In Fig.1, time –frequency representation by Using WV, PWV and SPWV kernel functions are shown. It is found that time and frequency resolution degrades in an increasing order if we use no smoothing, frequency smoothing and time-frequency smoothing, respectively. But the cross term interference reduces gradually when moving from a no smoothing to a frequency smoothing kernel function and no interferences are observed while using the time and frequency smoothing kernel function.

![Image](image.jpg)

**Figure 1.1:** Time – frequency representation by Using WV, PWV and SPWV kernel functions.

### 2.2 Feature extraction –
In this work, time –frequency domain local variation is extracted instead of considering only either time or frequency domain variation. The proposed feature extraction method is based on extracting minor variations precisely from a number of modules in the time - frequency plane of the EEG signals instead of utilizing the time-frequency plane as a whole. Feature extraction is done by using combination of DWT and FFT.

### 2.3 Artificial neural network -
Extracted features are fed to artificial neural network to determine the efficiency of the feature vector in classifying epileptic seizure originating from different parts of the brain. The architecture of the ANN is N inputs (N is the size of the feature vector), one hidden layer with neurons and k outputs (k is the number of the classes).

### III. Proposed method
In this, pre-processing signal with low pass filter applied. The feature extraction is used for this project are DWT AND FFT then features which are extracted are used to the input of the neural network classification. Figure 3.1 shows the flow of the block diagram of the proposed method.

![Diagram](diagram.png)

**Figure 3.1:** Flow chart of the proposed method.

Data is collected from ten subjects with the electrode locations (as per the International 10 - 20 electrode placement system). The obtained data is of normal as well as patient suffering from epilepsy. Fig shows stepwise procedure for the proposed algorithm. After preprocessing EEG signal, features are extracted by using combination of DWT AND FFT algorithm. Time frequency distribution is used to calculate power spectrum density at each module which represents energy distribution at time - frequency domain.

### IV. Results

#### 4.1 Dataset and details –

For proposed method, EEG dataset is used, where all EEG signals are recorded with 10 – 20 electrode system. Performance is evaluated through iterations by random selection of dataset of EEG signals at each step of iteration. Fig.3.2 shows input signal and its respected dwt coefficients of Margenau –Hill kernel functions.
4.2 Performance parameters

Performance is measured in terms of sensitivity, selectivity, accuracy.

Sensitivity is the ratio of no. of patterns correctly classified in class i to the total no. of patterns in class i.

Selectivity is the ratio of no. of patterns correctly classified in class i to the total no. of patterns classified in class i.

Accuracy is the ratio of total no. of patterns correctly classified to the total no. of patterns.

Fig.4.2.1 shows average selectivity, sensitivity and accuracy obtained from the proposed method using twelve kernel functions.

V. Conclusion

In this paper, time - frequency domain approach for classifying multiclass EEG epileptic seizure data is presented. By using time - frequency distributions involving twelve Cohen class kernel functions and artificial neural network epileptic seizures are classified.

VI. Reference


