DETECTION OF EPILEPTIC SEIZURE USING DISCRETE WAVELET TRANSFORM OF EEG SIGNAL

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Abstract- In this study, detection of epileptic seizure has been done using EEG. EEG signal has been decomposed using wavelet transform. After that, features of signal like entropy, variance, maximum value and minimum value of the signal have been calculated. These feature are given to kNN classifier for classification. The accuracy between ICTAL and normal EEG signal (open eye) has been calculated as 100 percent.

Keywords- EEG, Epilepsy, Signal Classification, Wavelet Transforms

I. INTRODUCTION

The human brain is very complex. The electrochemical process going in human brain generates the electric potential in the brain. Electroencephalogram (EEG) record the change in the electric activity of the brain by placing the electrode at different positions on the scalp. EEG is used for diagnosis of many diseases such as sleep disorder, epileptic seizure detection, alcoholic consumption measurement etc [1]. In epileptic seizure attack, there is abrupt flow of the charge in the brain. Due to this, a person start doing abnormal activity. One percent of the total population in the world is having seizure attack [2].

They are divided into two main groups, viz. partial epileptic seizure and primary generalized epileptic seizure. In the partial seizure, one part of brain is affected. The primary generalized epileptic seizure involves whole brain. A patient suffering from epileptic seizure attack has two type of abnormality in the recording of EEG signal (i) Interictal (recording between two epileptic seizure attack). (ii) Ictal (recording during the epileptic seizure) [3]. The abnormal EEG waveform have sharp, spikes waves, which also change in amplitude and frequency. The techniques used for seizure detection are divided into many groups like frequency domain analysis, time domain analysis, time-frequency domain analysis, non-linear method analysis, and artificial neural network analysis [4].

EEG signal is non-stationary signal so time-frequency based method is better [5].In this study, Daubechies Discrete wavelet decomposition (DWT-db4) and kNN classifier have been used to distinguish normal and epileptic signal. Signal is decomposed to third level by using DWT.

The features like entropy, variance, maximum value of signal and minimum value of signal have been evaluated. These features have been used for training and testing.

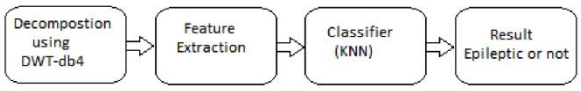

Fig.1 Block diagram of analysis of EEG signal

II. DATA SET

The data sets of EEG signals have been taken from University of Bonn, Germany [6]. Signal has five data sets (A-E), each containing 100 single channels of EEG segment of 23.6 sec. Table 1 shows the different type of data set along with their specification. All EEG signals have been recorded with 128 channel amplifier system, using an average common reference. A 12-bit A to D converter has been used for continuously storing the data on the disk of a data acquisition system at a sampling rate of 173.11 Hz [7]. In this study, A, D and E data set have been used.

Table 1 Type of data set

Type	Specification
A	Healthy person; recorded with open eye.
B	Healthy person; recorded with close eye.
C	Interictal; epileptogenic zone during seizure free interval.
D	Interictal; hippocampal formation of opposite hemisphere of brain.
E	Ictal; during epilepsy.

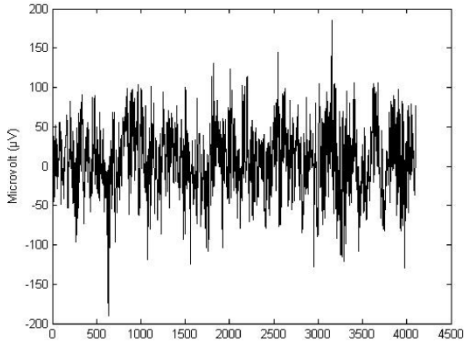

Fig.2 Non epileptic signal (Type (A))

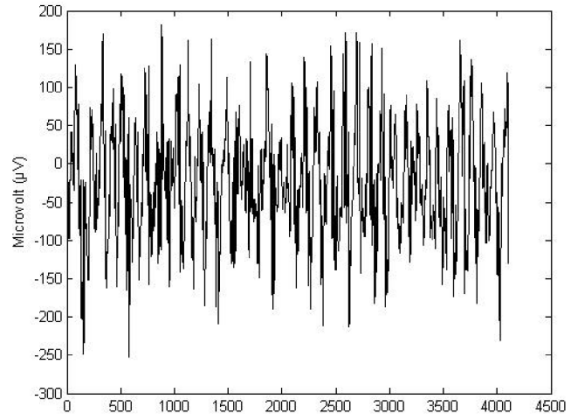

Fig.3 Interictal signal (Type (D))

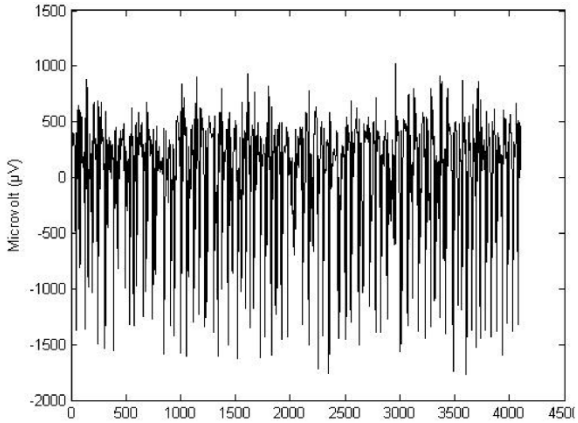

Fig.4 Epileptic signal (Type (E))

III. METHODOLOGY

Wavelet transform have been used for non-stationary signals. The fourier transform lack to analyse the signal in time domain as well as in the frequency domain. The short time fourier transform (STFT) solve the problem; but, there is resolution problem. During lower frequency analysis, the window size is large, and for high frequency signals (time domain) the window size is small. In the STFT, the window size is not variable. This problem is solved by the wavelet transform: larger window for low frequency resolution and smaller window for high frequency resolution. The wavelet transform is of two types: continuous wavelet transform (CWT) and discrete wavelet transform (DWT). If x(t) is the signal then its CWT is:

$$\text{CWT (a, b)} = \int_{-\infty}^{\infty} x(t) \frac{1}{\sqrt{|a|}} \psi \left(\frac{t-b}{a}\right) dt \qquad (1)$$

where a and b are scaling and shifting parameter respectively. At each scale, calculation of wavelet coefficient is a computationally expensive task. Scaling and shifting parameter have been changed with power of two for making them more efficient.

This is called dyadic scale and position.

$$\text{DWT (j, k)} = \frac{1}{\sqrt{2^j}} \int_{-\infty}^{\infty} x(t)\, \psi \left(\frac{t-k*2^j}{2^j}\right) dt \qquad (2)$$

where a and b are replaced by 2j and k*2j

respectively. To use DWT in efficient way, Mallet et al.[8] designed a algorithm in which pair of low pass and high pass filter have been used. This has been named as quadrature mirror filter. In first step of decomposition in DWT, the cutoff frequency of low pass and high pass is one fourth of sampling frequency. The output of low pass filter is approximation (A) coefficient and the output of the high pass filter is detail (D) coefficient. According to Nyquist rule, the original signal can be down sampled by two and the bandwidth of the original signal is half the input signal. In every step of decomposition, time resolution is halved and frequency resolution is doubled.

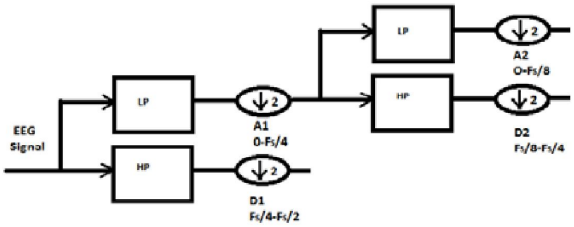

Fig.5 Wavelet decomposition

A. Feature extraction

In this study, the statistical parameters like entropy, variance, maximum value and minimum value of the signal have been calculated using Matlab. These parameters are calculated at third level of decomposed signal.

If 'x' is the signal, the parameters have been calculated as follows: Entropy of a signal is defined as the uncertainty in the signal. Mathematical expression of the entropy is,

$$\text{Entropy} = \log (x(i)\text{^}2); \; i=1,2,3\ldots.n \qquad (3)$$

Variance of the signal tells about the data lies near the mean i.e spread out. Mathematical expression of variance is,

$$\text{Variance} = \frac{1}{n} \sum_{i=1}^{n} (x(i) - mean) \qquad (4)$$

$$\text{Maximum value of signal} = \text{maximum (x(i))} \qquad (5)$$

$$\text{Minimum value of signal} = \text{minimum (x(i))} \qquad (6)$$

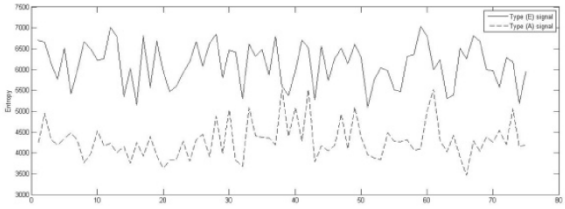

Fig.6 Entropy comparison between A and E type signal

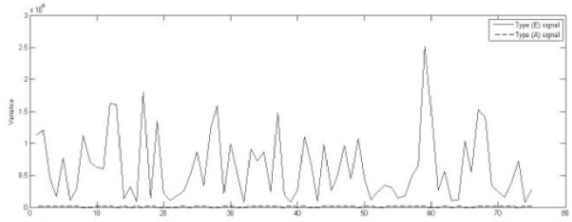

Fig.7 Variance comparison between A and E type signal

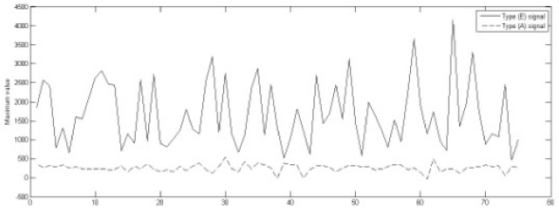

Fig.8 Maximum value comparison between A and E type signal

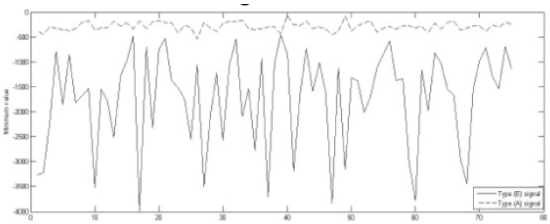

Fig.9 Minimum value comparison between A and E type signal

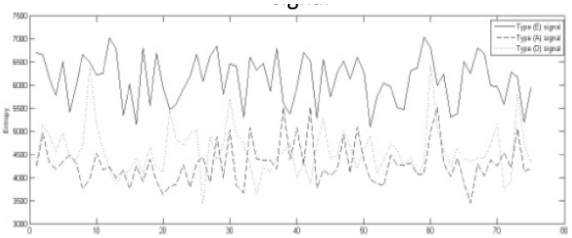

Fig.10 Entropy comparison between A, D and E type signal

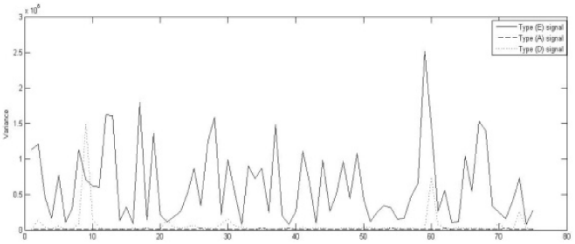

Fig.11 Variance comparison between A, D and E type signal

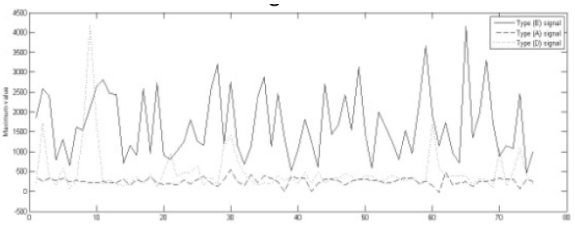

Fig.12 Maximum value comparison between A, D and E type signal

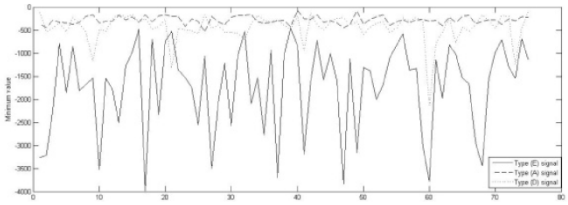

Fig.13 Minimum value comparison between A, D and E type signal

Table 2 Classification accuracy

Type	Data Set	Classification accuracy (%)
A-E	Training (75% of A and 75 % of E)	100
	Testing (25% of A and 25 % of E)	
A,D-E	Training (75% of A, 75% of D and 75 % of E) A and D considered in one class.	96
	Testing (25% of A, 25% of D and 25 % of E) A and D considered in one class.	

B. kNN Classifier

kNN stands for 'k-nearest neighbor algorithm'. In this algorithm, the object is classified according to their distance from its neighbor [9]. One matrix is for training data set and other set has been used for classification of data set. But there has been a problem in selection of K which affects the efficiency of system. In this study, K=1 has been used for classification. In this study, 75% data of each set has been used for the training and 25% data of each set have been used for testing. In this study, if any two feature of classified signal have been detected as epileptic signal then the result will be epileptic.

Table 3 Comparison of classification accuracy of proposed method and others existing method

S.No	Reference	Method (Feature extraction and classification)	Year	Database Reference	Cases	Classification accuracy (%)
1	[10]	Non-linear preprocessing filter + neural network	2004	--	A-E	97.20
2	[11]	Entropy measure + adaptive neuro-fuzzy interface system	2005	[7]	A-E	92.22
3	[12]	Time and frequency domain features + Recurrent neural network	2005	[7]	A-E	99.60
4	[13]	Discrete wavelet transform + mixture	2007	[14]	A-E	95.00
5	[14]	Fast fourier transform + decision tree	2007	[7]	A-E	98.72

6	[15]	Discrete wavelet transform + Relative wavelet energy-MPLNN	2009	[7]	A-E	95.20
7	[4]	Discrete wavelet transform + approximate entropy	2009	--	A-E	99.6
					A,C,D-E	96.65
8	[16]	Multi-wavelet transform-approximate entropy feature-MLPNN	2010	[7]	A-E	99.85
					A,B,C, D-E	98.27
9	[17]	DWT-PCA, ICA, LDA and SVM	2010	[7]	A-E	98.75 (PCA)
						99.50 (ICA)
						100.00 (LDA)
10	[18]	Line length features + ANN	2010	[7]	A-E	99.60
					A,C,D-E	97.75
					A,B,C, D-E	97.77
11	[19]	LS-SVM model based method coefficient	2010	[7]	A-E	99.56
12	[20]	Wavelet packet entropy + hierarchical EEG classification	2011	[7]	A-E	99.44
13	[21]	GP-based feature extraction + KNN classifier	2011	--	A-E	99.20
14	[22]	Permutation entropy + SVM	2012	[7]	A-E	93.55
					B-E	82.88
					C-E	88.00
					D-E	79.94
15	This study	Discrete wavelet transform +Statistical parameters + kNN	2015	[7]	A-E	100
					A,D-E	96

CONCLUSION

In this study, 300 samples of three different type (A, D and E) of EEG signal has been used. These EEG signals have been decomposed using DWT. The features like entropy, variance, maximum value and minimum value of the signal have been calculated. kNN classifier has been used for classification of the epileptic signal and the non-epileptic signal. 75 % of these samples have been used for training and 25 % of the samples have been used for testing. If any two feature of classified signal have been detected as epileptic, then the signal will be classified as epileptic. The classification accuracy between signal A and E is 100% and classification accuracy between A, D and E is 96% as shown in table 2. The accuracy of the proposed method has been compared with reported studies. It has been shown in table 3 that the proposed method gives best output in comparison to reported studies. Thus the proposed method can be used in medical field for diagnosis purpose.

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