Wavelet Based Seizure/Epileptic Activity Characterization on EEG

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Abstract: Electroencephalography (EEG) is an important tool for the diagnosis of various brain disorders especially for seizure/epilepsy, which reflects the electrical activity of the brain. At present, long-term EEG recordings are usually inspected by experts visually to identify seizure activities, which is a time-consuming and tedious task. As a result, automatic seizure detection technology is very necessary to assist medical staff in analysing EEG recordings. So to design an efficient detection algorithm efficient features should be used. In order to satisfy these needs in are paper various features like entropy, variance, energy are used based on the wavelet coefficients extracted with the stationary wavelet transform and the visual characterisation of seizure activity is achieved. The features extracted gave promising results for distinguishing the epileptic EEG signal from the normal signal.

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I. INTRODUCTION

The EEG is generated mainly by inhibitory and excitatory postsynaptic potentials of cortical nerve cells. The discharge of a single neuron or single nerve fiber in the brain generates a very small potential field, and does not contribute significantly to scalp potential recordings. Instead, the recorded scalp EEG represents the summation of the far field potentials generated by many thousands or even millions of neurons or fibers when they fire synchronously. The entire frequency range is usually divided into several basic rhythms: δ-rhythm (0.5–4 Hz), θ-rhythm (4–7.5 Hz), α-rhythm (7.5–14 Hz), β-rhythm (14–30 Hz) and γ -rhythm (30–80 Hz).

Epilepsy is a common neurological disorder defined by recurring and unprovoked seizures that produce strange sensations and emotions or behavior in people. Seizures or paroxysms are temporary amendments in brain functions due to atypical electrical activity of a collection of brain cells that present with perceptible clinical symptoms and findings [1]. Epilepsy can be characterized by an unexpected and abrupt malfunction of the brain that is termed as "seizure". But seizures may also occur in those people who have not been subjected to epilepsy. The superficial effect of epileptic seizure may be a wild thrashing movement or a mild loss of awareness. The occurrence of this brain malfunction is unpredictable, and may cause altered perception or behaviour as sensory disturbances, or loss of consciousness. Seizures are a paroxysmal alteration of one or more neurological functions such as motor, behaviour, and/or autonomic functions. Seizures are subdivided into two sets, i.e., partial and generalized. In partial seizures, a limited brain area is implicated in the epileptic discharge. In contrast, generalized seizures originate from multiple brain regions and are characterized by general neurological symptoms.

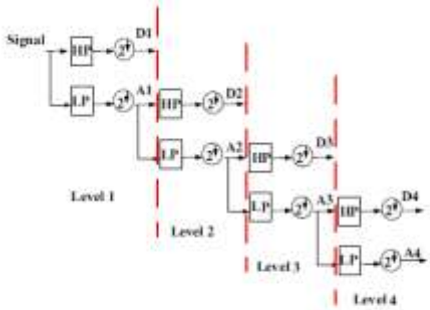
In the detection of epilepsy number of people have worked for designing the algorithms for the efficient characterization of epilepsy out of which [] has worked on the statistical features in the time domain signal i.e on the time series data. Bt we have worked on the wavelet coefficient using the stationary wavelet transform where a level 4 decomposition was achieved. Here the approximate and detailed coefficient is achieved and then the features are applied where the visual detection of seizure activity is achieved. In the section 2 we describe the data acquisition mechanism for the EEG. Section 3and 4 describes the wavelet transform and the features extraction. And lastly the section 5 and 6 describes the result and the conclusion.

II. DATA ACQUISITION

In our work we analysed EEG seizure recordings from ten epileptic patients prone to surgical treatment. Seizure recordings include normal, ictal and inter - ictal periods. We have acquired the EEG signals extra cranially from patients whose ages range between 2 and 60 years. The patients were diagnosed with temporal lobe epilepsy having partial and complex seizures. The 17 channel recordings were used, during 84 h, from the scalp. During the long recording of patients' EEG data, the patients had 4 h of break after each 20 h of recording. During the break time, the physicians made inspection of the patient's EEG and looked for patterns related to seizure. The data used are a subset of the EEG data for both healthy and epileptic subjects. EEG signals from two different groups are analysed: non patient and patient. The EEG segments were selected and cut out from continuous multi-channel EEG recordings after visual inspection for artifacts, e.g., due to muscle activity or eye movements [5]. EEGs from 20 patients were selected. Here segments were selected from all recording sites. By loading this data to the MATLAB software and by developing appropriate program we have extracted some features. We are working on the EEG signal data of 10 epileptic patients and 10 non patients. We have extracted the EEG signal of 17 different lobes of each patient. We have taken 911 samples of each lobe for better accuracy [6]. The machine used for recording the electrical activities of brain was from the Neuro physician with neuro plus software was used to record and process on the EEG signal.

I. WAVELET TRANSFORM

The wavelet transform is a transform which provides the time-frequency representation. (There are other transforms which give this information too, such as short time Fourier transform, Wigner distributions, etc.) Often times a particular spectral component occurring at any instant can be of particular interest. In these cases it may be very beneficial to know the time intervals these particular spectral components occur. For example, in EEGs, the latency of an event-related potential is of particular interest (Event-related potential is the response of the brain to a specific stimulus like flash-light, the latency of this response is the amount of time elapsed between the onset of the stimulus and the response. To make a real long story short, we pass the time-domain signal from various high pass and low pass filters, which filters out either high frequency or low frequency portions of the signal. This procedure is repeated, every time some portion of the signal corresponding to some frequencies being removed from the signal flash-light, the latency of this response is the amount of time elapsed between the onset of the stimulus and the response.



Wavelet transform is capable of providing the time and frequency information simultaneously, hence giving a time-frequency representation of the signal.
Here we are using the stationary wavelet transform where a level 4 decomposition is achieved. Where 1aproximate and four detailed are selected

II. FEATURE EXTRACTION

- Wavelet variance:
  It defines how far the signal behaviour is or how the signal is spread from the reference i.e. the average value.
- Wavelet STD:
  It defines the deviation of the signal sample points from the mean of the signal
- Wavelet entropy:
  It defines the measure of the disorder in the signal.

III. RESULTS

Following are the results for the Wavelet features for patient and non-patient. The results in tabular form shows only the C3.C4,Cz lobe. And the graphical representation shows that the value for patient is more as compared to that of non-patient.

Features for non-patient

	STD	VAR	ENTROPY
D1	0.494447759	0.244478586	4.507923907
D2	2.411972643	5.817612033	2.475090634
D3	9.210259093	84.82887255	1.378950097
D4	18.07153665	326.580437	1.246425182
A4	23.60782793	557.3295396	1.166573929
D1	0.802338445	0.64374698	4.676923699
D2	3.272201282	10.70730123	2.222605685
D3	11.78855628	138.9700592	1.378960618
D4	19.09043744	364.4448015	1.190325682
A4	24.0053124	576.2550233	1.132292471
D1	0.609643698	0.371665438	4.603419479
D2	2.659371898	7.072258894	2.469183964
D3	10.78073928	116.2243394	1.311896904
D4	20.67752766	427.56015	1.191244994
A4	23.56727998	555.4166858	1.157060986

Above are the features of the C3,C4,Cz lobe

Features for Patient

	STD	VAR	ENTROPY
D1	0.4073058	0.165898088	4.615650943
D2	2.6317257	6.925980325	2.416449163
D3	10.902091	118.8556995	1.321103951
D4	26.257073	689.4339146	1.134485453
A4	23.716605	562.4773787	1.220549589
D1	0.5469322	0.299134878	4.638260758
D2	3.3019653	10.9029754	2.044180094
D3	12.940418	167.4544192	1.330023292
D4	30.900160	954.8199162	1.143666431
A4	25.052117	627.6085682	1.112569813
D1	0.7392499	0.546490414	4.375954799
D2	4.4542972	19.840764	1.837624908
D3	15.163322	229.926362	1.392625701
D4	34.525482	1192.008943	1.111180365
A4	37.842071	1432.022357	1.042512856

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Above are the features of the C3,C4,Cz lobe for Patient

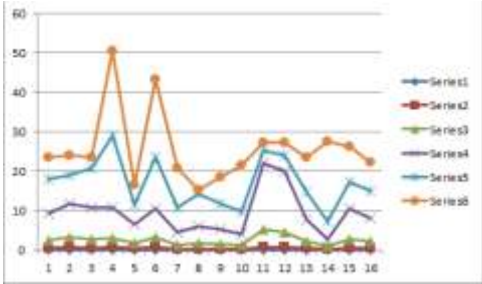

Figure 1: Wavelet Standard Deviation Non-patient

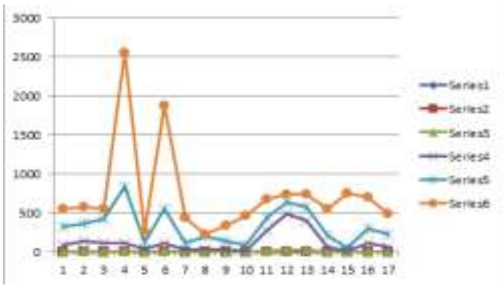

Figure 2: Wavelet Variance Non-patient

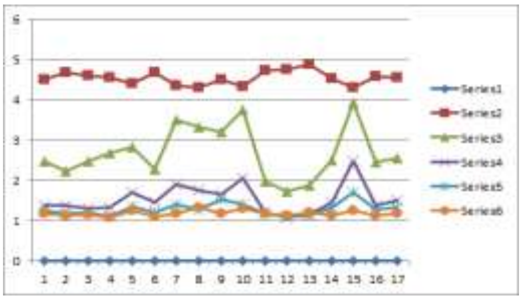

Figure 3: Wavelet entropy Non-patient

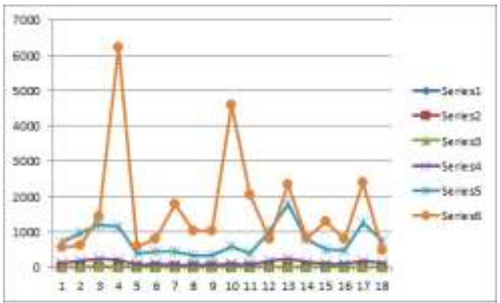

Figure 4: Wavelet Standard Deviation patient

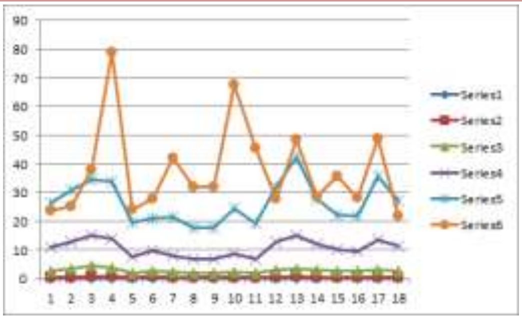

Figure 5: Wavelet Variance patient

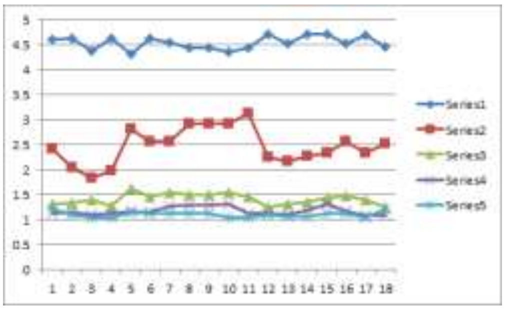

Figure 6: Wavelet Entropy Patient

IV. CONCLUSION

In this work, wavelet entropy is used to analyze the Epileptic EEG signals. Wavelet entropy (WEN), wavelet variance and the wavelet standard deviation can be used as a feature for the characterization. This features are Calculated from the wavelet coefficients of high and low frequency sub-bands. These sub-bands are obtained using the stationary wavelet decomposition of EEG data sets. These results show that the wavelet entropy differs drastically for the patient and the non patient, also it is obtained that the wavelet variance is more fotr the patient as compared to the non-patient and the same is observed for the standard deviation and can be used as a quantitative measure of EEG signals. The P-value for the wavelet variance is less than 0.005. This results obtained from the different features can be used as a features vectors for designing an automatic highly efficient seizure activity detection mechanism.

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