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DECOMPOSITION OF SEIZURES IN EEG SIGNALS USING DISCRETE WAVELET TRANSFORMS (DWT)

Neurology

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ABSTRACT

An electroencephalogram (EEG) is a test that records electrical activity in the brain. Epileptic seizures affect approximately 50 million people worldwide, making it one of the most serious neurological disorders. Seizures cause a loss of consciousness, but there are no specific signs associated with epileptic seizures. analysing the brain's activity during seizures and locating the seizure duration in EEG recordings is difficult and time consuming. A discrete wavelet transform (DWT), which is an effective tool for decomposing EEG signals into delta, theta, alpha, beta, and gamma ($\delta,\theta,\alpha,\beta$ and γ) frequency bands. For research, the db4 is used, which has a morphological structure that is different to that of EEG.

KEYWORDS

DWT, Decomposition, EEG, frequency bands, Morphology

INTRODUCTION

Neurological issues are therapeutically characterized as problems that influence the human cerebrum just as the sensory system found all through the body and the spinal rope. Neurological disorder causes brain irregularity. Epilepsy is one of the cerebrum abnormalities which make significant issues to individuals because of neurological disorder. According to World Wellbeing Association (WHO) report 2003, around 450 million individuals are influenced with mental and neurological problems and 50 million have Epilepsy.

Electroencephalogram (EEG) is the significant device to distinguish any sort of cerebrum anomaly like Epilepsy. EEG is the account of electrical exercises of the cerebrum. By inspecting the EEG of the Patients, Epilepsy suspected seizures, dynamic cerebral capacity, surprising spells and any sort of neurological problems can be assessed.

1.1 TYPICAL EEG SYSTEM

The EEG can be recorded with the help of a device known as Electrodes. Electrodes are connected with amplifiers to enlarge the microvolt signal into a required range where they can be analyzed easily. There are two types of EEG measurements based on the electrodes placement. The non-invasive measurement in which the electrodes are placed on the scalp with the help of a jel or paste. Normally, a scalp electrode is 1mm to 3mm diameter disk which is made up of silver-silver chloride (Ag-Ag-Cl).

The other type of EEG measurement is invasive method in which the needle electrode is inserted under the scalp by a surgery. This invasive method is applicable for long recording of EEG[1].

To ensure sufficient coverage of all regions of the brain, the head is divided into proportional distances from prominent skull landmarks (nasion, preauricular points, inion). Proportional is denoted by the label 10-20. the percentage distance between the ears and the nose, where the electrode points are selected. The locations of the electrodes are numbered according to the brain regions that are nearby. such as , Central (C), Frontal (F), Temporal (T), Posterior (P), and Occipital(O). Dataset have collected from basveshwer hospital Kalburgi, Karnataka 18 electrodes are used for recording purpose. Odd number is represented by electrode position on the left hemisphere and even number represented by electrode position on the right hemisphere. Seizures activity it appears on Central part (CZ, PZ). The cerebral activity (FPZ, CZ, PZ, OZ) recorded and the second group channels show the activities over the left parasagittal (FP1, C3, P3, O1) head region. The third group of channels show the right parasagittal (FP2, F4, C4, P4, O2) head region and the fourth group of channels show the left temporal (FP1,F7,T7,P7,O1) region activity. The last group of channels show the right temporal (FP2,F8,T8,P8,O2) regional activity. As shown

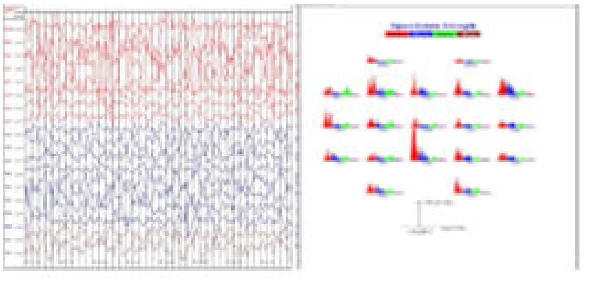

Figure1: Seizures activity and spectrum of 9 year boy

Epilepsy is a form of epilepsy caused by a neurological condition. The only apparent symptom of epilepsy is seizures. The unexpected surge of electrical activities in the brain is known as a seizure. Epilepsy does not affect anyone who has seizures. Epilepsy develops when a seizure happens repeatedly following an accident or illness. The seizures had attack 2-3 time per day i.e. called epileptic seizures. There are no fixed symptoms in epileptic seizures.

Different types of seizures like generalized seizures produced by entire brain, in that absence, tonic, myoclonic seizures and partial seizures produced by only one hemisphere of the brain, in that simple seizures and complex seizures.

METHODOLOGY

The data acquisition from the input of signals that measure the electrical activity in the brain as recorded by electrodes placed on the scalp surface in the cerebral cortex is shown in figure. EEG is a test that is used to identify abnormalities that occur in brain activities as shown in figure. The 10-20 placement system is the most widely known; this signal converts digital numeric values into digital numeric values that can be manipulated by a computer. The majority of epilepsy diagnosis is based on the occurrence of seizures, which are difficult to diagnose reliably using EEG signals from traditional methods. Feature extraction, among other things, is one of the components of the epilepsy detection system. It is essential to enhance feature selection and classification.

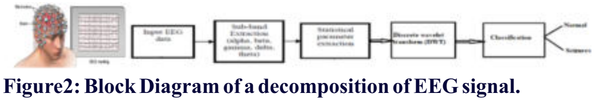

Figure2: Block Diagram of a decomposition of EEG signal.

EEG is test used to diagnose the abnormalities that occur in brain activities as shown in figure the input of sampling signals that live the electrical activity within the brain as recorded by the electrodes placed on the scalp surface in cortex. The 10-20 placement system is most generally adopted, these A sampling signal transforms digital numeric values into digital numeric values that a machine can control. the computer help facilitate in recognition of abnormalities in brain from encephalogram signal occur in frequency ranges of delta (0.5-4Hz), alphabetic character (4-8Hz), alpha(8-13Hz), beta(13-30Hz) and gamma(>30Hz). brain wave (8-13 Hz) totally on lobe 20-200 µV. Normal, relaxed awake rhythm with eyes closed, brainwave brain wave. (14-30 Hz.) largely below 30µV because of tension, brain wave swinging, 4-7 Hz Drowsy, cortical potential slow, < 3.5 Hz in adults traditional sleep rhythm.

For the preprocessed data the features in time domain and frequency domain are extracted by using discrete wavelet transform (DWT). DWT is that the most effective tool for analysis of encephalogram signal supported info in each time and frequency. Time-frequency analysis is employed to examine totally different completely different events occurred at different frequencies. To decompose the encephalogram signals into totally different band. Most waves of 8Hz and better frequencies square measure traditional findings within the encephalogram of Associate in Nursing awake adult. With frequency of 7Hz or less usually classified as abnormal. These coefficients are measure used as feature that describes the signal once extracting the applied mathematics options of the encephalogram signal square measure

EEG Recording and Preprocessing

EEG was recorded on the BIOPAC MP150 method with 20 Ag/AgCl scalp electrodes at 500 Hz sampling frequency and amplified from DC to 100 Hz. Offline, eye blinks, body movements, and other artefacts were corrected. EEG analysis was performed using self-written Matlab software that used a DWT to derive different EEG frequency bands. The data were rearranged to prevent data artefacts at the epoch's margins.

Decomposition of EEG signal

The decomposition of the signal yields wavelet coefficients, which can be used to reconstruct the signal. The wavelet can be chosen based on one of two criteria: simplicity or accuracy. Lower order wavelets, such as Haar, are used when simplicity is needed, while higher order wavelets (4,6,8,...) are used for accuracy. The wavelet analysis is used to identify patterns in data. When using DWT to analyses signals, identifying the appropriate wavelet and the number of decomposition stages to perform is crucial. The number of decomposition levels is determined by the signal's dominant frequency component.

The DWT algorithm can be implemented. Any time domain signal can be decomposed into two components: approximation coefficients (provided by the scaling function) and detail coefficients (provided by the wavelets) (mother wavelet). The wavelet function is linked to the low pass filter (LPF), and the scaling function is linked to high pa.

The wavelet function is connected to the low pass filter (LPF), while the scaling function is connected to the high pass filter (HPF) (HPF). The decomposition process begins with the desired signal passing through these filters. After the outputs from both filters are decimated by 2, the LPF generates approximation coefficients and the HPF generates detail coefficients, same procedure is repeated to get the analysis and synthesis of next level as shown in figure.

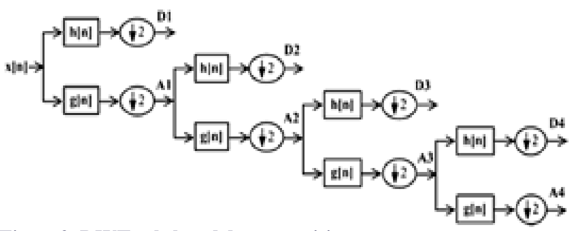

Figure3: DWT sub-band decomposition

The frequency band $[f_{m/2} : f_m]$ of each detail scale of the DWT is directly related to the sampling frequency of the WT can detect the important hidden features from the original signal.

Table 2: EEG frequency sub bands after decomposition using DWT (db4, order=4, level=9)

$$F = 2^K\left(\frac{F_S}{N}\right)$$

Where N=2^k k=number of decomposition levels
F_s sampling frequency

F is the limit of higher frequency band, According to the Nyquist theorem the maximum frequency present in the signal

$$fs \geq 2fm$$

The original EEG have been decomposed as four Approximation and detailed coefficients (d1, d2, d3, d4) and (a1, a2, a3, a4), level are denoted as

$$A_i = \frac{1}{\sqrt{M}}\sum_n x(n) \times \varphi_{j,k}(n)$$

$$D_i = \frac{1}{\sqrt{M}}\sum_n x(n) \times \psi_{j,k}(n)$$

Where I = 0,1,2,…..j-1, Ai is approximate coefficient and di is detail coefficient

$$\varphi_{j,k}(n) = 2^{j/2}h(2^jn - k)$$

$$\psi_{j,k}(n) = 2^{j/2}g(2^jn - k)$$

Sampling frequency (fs) 256,8 level of decomposition and two levels are noisy signal. Remaining level is frequency band of EEG signal like Delta, theta, alpha, beta, Gamma, each level is decimated by factor or the output of the frequency is half of the original signal. The tree diagram of approximate coefficient and detail coefficient as shown in figure 2.

After the seven level of decomposition the frequency components obtained are D1(256-512), A1(0-256), D2(128-256),A2(0-128),D3(64-128),A3(0-64),D4(32-64),A4(0-32),D5(16-32),A5(0-16),D6(8-16),A6(0-16),D7(4-8) and A7(0-4) respectively.

Frequency band (Hz)	Decomposition levels	EEG Rhythms
256- 512	A1	Noise
128 -256	A2	Noise
64- 128	A3	Noise
32-64	A4	Γ
16-32	A5	Β
8-16	A6	Α
4-8	A7-A8	Θ
0-4	A9	Δ

The Db4 wavelet are better choice for precisely detecting the EEG and short duration of information signal. Daubichies filter: n=4, level=9 used to separate EEG frequency bands.

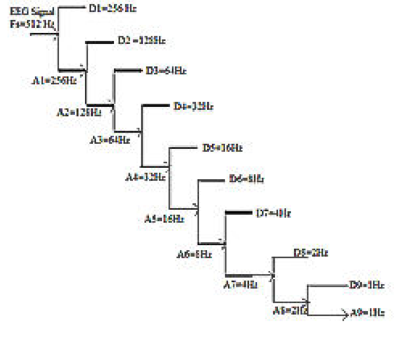

Figure 4: Tree diagram of wavelet decomposition of EEG signal

The EEG signal was acquired with sampling frequency of 256 Hz. The useful information of this signal lies in the range of 0.5-70Hz. As a result, the EEG signal was decomposed into approximate (A1-A8) and information (D1-D8) coefficients with a level of 8 using db4. Noise components were assigned to the decomposition levels A1-A2. The EEG frequency sub bands and, respectively, are represented by the final approximate coefficients level from A3 to A8. It decomposes the signal and analyses it at various frequencies.

RESULTS AND DISCUSSION

Seizures and healthy patients are two separate lists that are studied. The first step is to collect an EEG signal database.

Step 1: Wavelet decomposition and pre-processing.

Step 2: Convert time to frequency domain parameters such as mean, standard deviation, approximate entropy, and so on.

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DWT uses the db4 wavelet at level 8 to decompose the EEG signals into a variety of waveforms.

- The EEG signal was acquired with sampling frequency of 256 Hz. The useful information of this signal lies in the range of 0.5-70Hz. Hence a level of 8 using db4 was applied to decompose the EEG signal into its approximate (A1-A8) and detail(D1-D8) coefficients.
- Daubechies filter: n=4, level=8 used to separate EEG frequency bands. The decomposition levels from A1-A2 were considered as noise components. final approximate coefficients level from A3-A8 are represents the EEG frequency sub bands of γ , β ,α, θ, and δ respectively. It analyses the signal at different frequency band by decomposing the signal into a set of high and low pass filters called as Approximation and Detailed coefficients.

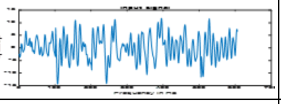
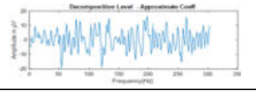
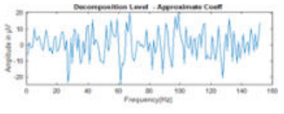
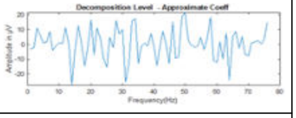
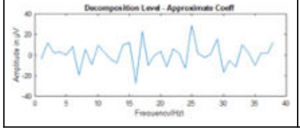
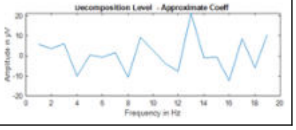
Input Signal	**1. Gamma frequency band (32-64Hz) after decomposition (A3)**
	
2. Beta frequency band (16-32Hz) after decomposition (A4)	**3. Alpha frequency band (8-16Hz) after decomposition (A5)**
	
4. Theta frequency band (4-8Hz) after decomposition (A6)	**5. Delta frequency band (4-8Hz) after decomposition (A7-A8)**
	

Figure5: Decomposition of EEG signal using Seizure's patient

CONCLUSION

Electroencephalogram is a test used to check abnormalities of seizures. which helps to recognize the different problems because it is related to the electrical activity of the brain. With the help of the electrodes, the brain activities are captured via the signal. The recorded EEG signal is mostly helpful to diagnose the seizure. The recorded EEG signal contains various noises which reduce the entire recognition system performance using discrete wavelet transform.

DWT is a most efficient method for analysis of seizures EEG signal easily used debauchies wavelet for decomposition, in future will have classify the normal and seizures patient using Neural network.

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