RESEARCH ARTICLE OPEN ACCESS

Study & Analysis of EEG Signal

Rashmi Awanti[1], Prof.Kalpana Vanjerkhede,[2] Prof.ChannappaBhyri[3]
[1]PG Student, PDACE, Kalaburgi
[2] Professor, Dept of Instrumentation Technology, PDACE, Kalaburgi
[3]Prof.Dept of Instrumentation Technology, PDACE, Kalaburgi

Abstract:

Brain is the most complex organ among all the systems in human body.Brain disorders include Alzheimer's disease, learning disability, stroke, traumas, epilepsy, emotional disorders etc.Epilepsy is one of the major neurological brain disorder which results in uncontrolled electrical seizures. Seizures occasionally known as a 'fit' are most commonly occurring brain disorder among humans.The middle of a seizure is often called the ictal phase.This correlates with the electrical seizure activity in the brain.Electroencephalograph(EEG) is a technique which is used to identify the neurological disorder of brain. It is a noninvasive testing method. This paper analyses about human normal & ictal epileptic electroencephalographic (EEG) signals with popular & efficient signal processing technique fast fourier transform(FFT) .The delta , theta, alpha & beta sub bands of EEG are obtained using FFT. Then corresponding to each segment higher order statistical features like power spectral density (PSD), Mean, Standard deviation(STD), Variance, Skewness & Kurtosis have been calculated for each band. After feature extraction analysis is done for normal & ictal epileptic subjects based on the results obtained. The database used here is from Bonn database which consists of two sets of data healthy i.e, 'Z' set & ictal subjects i.e, 'S' here we have used five healthy subject's data & five abnormal subject's data.

Keywords - **EEG, Epilepsy, FFT ,Bands of EEG Signals, feature extraction.**

I. INTRODUCTION

EEG electrical activity recorded through electrodes on the scalp.In medical science ,human brain is also called an encephalon & the medical technique that reads scalp electrical activity of the encephalon is called electroencephalograph (EEG).EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. EEG is measured using international 10-20 electrode placement placed on the scalp as shown in the fig 1.

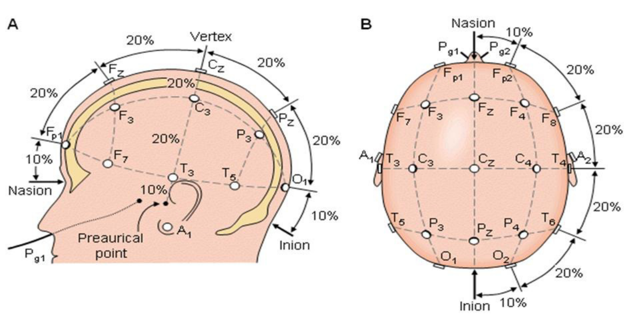

Fig.1 EEG Electrode placement system

EEG Signals contain a great deal of information about the functioning of the brain. Since fourier transform has been most commonly used for the EEG processing. This approach is based on some characteristic waveforms with various frequency bands : Delta(1-4hz), Theta(4-8hz),Alpha(8-13hz),Beta(13-30hz) & Gamma(30-60hz).

The main diagnostic applications of EEG is detection of epilepsy. Epileptic activities can create clear abnormalities on a standard EEG study.The patient suffer from epilepsy has different EEG as compared to the normal human brain. EEG is the most common & most useful test performed in evaluating patients suspected of epilepsy. Apart from this EEG is also used for diagnosis of coma, encephalopathy, & brain death .

Epilepsy is a neurological condition in which chronic abnormal bursts of electrical discharge in the brain are observed. A seizure is usually defined as a sudden alteration of behavior due to temporary change in the electrical functioning of the brain ,in particular the outside rim of the brain called the cortex. It is usually diagnosed after a person has had atleast two seizures that were not caused by some known medical condition like alcohol withdrawal or extremely low blood sugar.An epileptic attack may result in a series of involuntary contractions of the voluntary muscles, abnormal sensations , abnormal behaviours, or some combination of these events. Abnormal data used here is 'ictal' i.e, refers to a physiologic state event such as stroke or headache.

Bonn database from the department of epileptology is used. It consists of five different types of data sets .The dataset used here is 'Z' those have EEG recordings that were obtained from healthy subjects with their eyes opened & another dataset used here is 'S' which has ictal EEG recordings from the epileptogenic zone.

II. METHODOLOGY

We have considered normal & abnormal EEG recorded data from the Bonn database. We load the recorded data into MATLAB software .This section has 3 parts:

a. Load the signal into MATLAB software
b. Decomposition of signal into four different sub-bands
c. Feature Extraction

Brain disorders can usually be diagnosed by recording of electrical activity of EEG . EEG recording is a useful tool for studying the functional state of the brain & for diagnosing certain disorders.It examines the brain patterns & assists in epilepsy diagnosis,if any unusual activity takes place in the brain . For a normal brain activity , the firing of neuron occurs about 80 times per second & neurons fires about 500 times per second for an epileptic brain activity.

We have considered 5 normal subjects data & 5 ictal epileptic EEG data. All the subbands of EEG are extracted. Then the various parameters like Power spectral density,(PSD) Mean, Standard deviation,(STD) Variance, Skewness & Kurtosis have been calculated for each band.

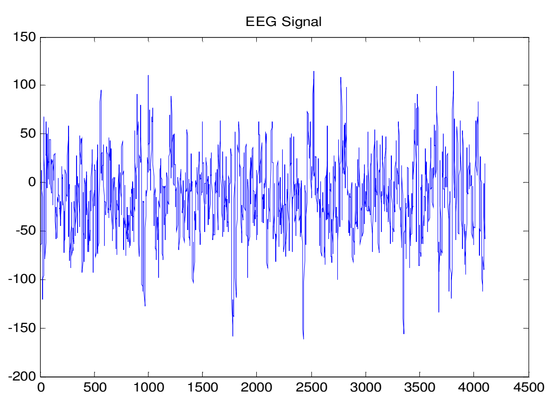

Fig 2 Original EEG input Sig

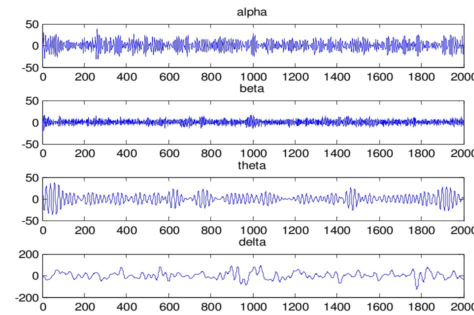

Fig 3 Decomposition of EEG signal into four sub-bands

Feature Extraction : Higher order statistical features such as PSD, Mean etc are noted for each band for both normal & abnormal sets then their values are compared.

1.PSD : It describes how the power of a signal or time series is distributed with frequency. It is calculated by : PSD = $lt_{T\to\infty}$ (1/2T) $_{-T}\int^{T} x(t)^2dt$

2.Mean : It is the average value of two or more data sets.
It is calculated by : $\mu=\sum X/N$

3.Standard deviation(STD) : It is a measure of the dispersion of a set of data from its mean.

It is calculated by: $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N} (x_i - \mu)^2}$

4.Variance: It is a measure of statistical dispersion.
It is calculated by : $Var(X)=E[(X-\mu)]^2$

5 .Skewness : It is the measure of asymmetry of a probability distribution function. It is the standardized moment .

It is calculated by : $\Upsilon_1 = \mu_3/(\partial)^3$ where μ_3 is the third moment, ∂ is the STD.

6.Kurtosis : It is the degree of peakedness of a real valued random variable

It is calculated by : $\Upsilon_2 = \mu_4/(\partial)^4$ where μ_4 is the fourth moment & ∂ is the STD.

III. RESULTS

Statistical features values of normal subject's data:

Table 1: Statistical features values of normal subject's data

Z001

Statistical features	Alpha	Beta	Delta	Theta
PSD	223.44	188.73	442.83	136.17

STD	11.54	6.30	29.38	13.40
Mean	9.153	4.93	23.176	10.51
Variance	49.32	15.433	326.199	69.176
Skewness	1.008	1.4477	1.2148	1.1425
Kurtosis	3.73	8.5494	4.6332	4.2389

Table 2:Statistical features values of normal subject's data Z002

Statistical features	Alpha	Beta	Delta	Theta
PSD	358.57	262.34	457.91	169.86
STD	18.69	8.34	31.20	16.43
Mean	14.911	6.5641	24.78	12.4915
Variance	126.82	26.48	359.413	113.745
Skewness	0.93	1.257	0.959	1.344
Kurtosis	3.477	5.687	3.686	4.8518

Table 3:Statistical features values of normal subject's data Z003

Statistical features	Alpha	Beta	Delta	Theta
PSD	248.33	221.04	476.35	123.8
STD	12.82	6.46	32.07	12.22
Mean	9.327	5.106	25.598	9.327
Variance	62.315	15.667	373.33	62.315
Skewness	1.523	1.8131	0.946	1.523
Kurtosis	6.046	15.9235	3.45	6.04

Table 4 : Statistical features values of normal subject's data Z004

Statistical features	Alpha	Beta	Delta	Theta
PSD	400.32	461.04	412.21	159.04
STD	20.37	12.15	26.98	16.09
Mean	16.05	9.576	21.213	12.518
Variance	157.21	55.984	277.737	102.19
Skewness	1.234	1.223	1.198	1.30

Kurtosis	4.864	4.858	5.143	5.1183

Table 5:Statistical features values of normal subject's data Z005

Statistical features	Alpha	Beta	Delta	Theta
PSD	262.72	269.92	406.9	114.32
STD	13.53	7.24	28.72	11.32
Mean	10.58	5.762	23.23	8.74
Variance	72.82	19.23	284.58	51.77
Skewness	1.33	0.99	0.858	1.312
Kurtosis	5.256	3.823	3.426	4.9

Statistical features values of abnormal subject's data

Table 6:Statistical features values of abnormal subject's data S001

Statistical features	Alpha	Beta	Delta	Theta
PSD	4158.75	1531.15	4775.56	1274.57
STD	228.7439	49.6377	331.96	129.94
Mean	175.9826	35.1060	282.155	106.4
Variance	2.1346.	1231.2	30568.	5560.3
Skewness	1.2513	2.1675	0.5	0.887
Kurtosis	4.4917	9.2012	2.899	4.1194

Table 7:Statistical features values of abnormal subject's data S002

Statistical features	Alpha	Beta	Delta	Theta
PSD	5019.2	1893.62	5428.46	1203.02
STD	291.21	56.56	353.99	120.29
Mean	226.65	43.958	290.22	94.25
Variance	33419.	1266.1	41056.	5585.2
Skewness	0.9	1.33	0.6796	1.61
Kurtosis	3.186	5.3	2.938	7.314

Table 8:Statistical features values of abnormal subject's data S003

Statistical features	Alpha	Beta	Delta	Theta
PSD	4449.34	1796.75	2997.24	777.23
STD	243.442	50.94	207.3	79.78
Mean	180.88	35.44	172.41	64.06
Variance	26536.	1338.7	13239.	2259.3
Skewness	1.386	6.16	0.66	0.97

Kurtosis	4.826	125.41	3.08	3.835

Table 9:Statistical features values0 of abnormal subject's data S004

Statistical features	Alpha	Beta	Delta	Theta
PSD	756.74	359.1	1671.95	337.69
STD	41.31	11.0	134.36	34.17
Mean	33.91	8.578	115.417	27.438
Variance	555.66	49.34	4727.4	414.31
Skewness	0.6753	2.58	0.228	0.745
Kurtosis	2.867	31.82	2.153	2.93

Table 10:Statistical features values of abnormal subject's data S005

Statistical features	Alpha	Beta	Delta	Theta
PSD	262.72	269.92	406.9	114.32
STD	13.53	7.24	28.72	11.32
Mean	10.58	5.762	23.23	8.74
Variance	72.82	19.23	284.58	51.77
Skewness	1.33	0.99	0.858	1.312
Kurtosis	5.256	3.823	3.426	4.9

Above fig 2 shows input EEG signal & fig 3 shows sub bands of an EEG signal. Tabulated statistical values are represented in the above tables.

CONCLUSION

Epilepsy seizures are the result of the transient and unexpected electrical disturbance of the brain.

About 50 million people worldwide have epilepsy, and nearly two out of every three new cases are discovered in developing countries. Epilepsy is more likely to occur in young children or people over the age of 65 yrs; however it can occur at any age. The detection of epilepsy is possible by analyzing EEG signals.

In this work, the proposed method provides an objective means of analyzing the signal for normal & abnormal we have analyzed EEG normal & ictal epileptic signals based on the results obtained. Ictal phase is the period of time from the first symptoms to the end of seizure activity.This correlates with the electrical seizure activity in the brain.Sometimes the visible symptoms last longer than the seizure activity on an EEG.This is because some of the visible symptoms may be after effects of a seizure or not related to seizure activity at all. As here analysis of EEG signal involves extraction of higher order statistical features like PSD, Variance,Skewness, Kurtosis, Mean, & STD from the sub-bands of EEG to study the comparison.As it is seen that the features are very much higher for a seizure signal i.e, ictal one than a normal one. Results shows that PSD determines more power distribution in the abnormal signal than normal.STD shows that amount of variation of data values is higher in seizure signal compared to healthy signal.

Mean represents that average of healthy signal is less in normal compared to abnormal.Variance shows that values are statistically dispersed more in abnormal signal when compared with healthy one Likewise Skewness represents asymmetry or imbalance is less in healthy signal than in abnormal one.Meanwhile Kurtosis shows that flatness or peakedness is evenly distributed in healthy signal whereas in seizure signal it is varied more according to the theory.

REFERENCES

[1] Varun bajaj & Ram Bilas Pachori,"Classification of seizure & Nonseizure EEG signals using empirical mode decomposition",IEEE Transactions on Information Technology in Biomedicine,vol.16,No.6,pp.1135-1142, Nov.2012.

[2] V.P. Nigam & D.Graupe, "A neural network based detection of epilepsy,"Neurological Research,Vol.26,No.1,pp.55-60,2004

[3] Mandeep Singh, Sunpreet Kaur,"A novel scoring system for epilepsy detection using EEG",International Journal of Information Technology & Knowledge Management Vol.6,No.1,Dec 2012

[4] A.Subasi,"EEG signal classification using wavelet feature extraction & a mixture of expert model",Expert Systems with Applications,32(4):1084-1093,2007

[5] L.Nicolas –Alonso & L.GomezGil,"Brain computer interfaces a review",Sensors,vol 12 no.2 pp 1211-79, jan 2012.

[6] S.M.Shafiul Alam,M.I.H.Bhuiyan,Aurangozeb,&Syed TarekShahriar "EEG Signal discrimination using nonlinear dynamics in the EMD domain",International Journal of Computer & Electrical engg,Vol.4, No.3,pp.326-330,2012.

[7] Ganesan.M, Sumesh.E.P, Vidhyalavanya.R "Multi-Stage, Multi-Resolution Method for Automatic", *International Journal of Signal Processing, Image Processing and Pattern Recognition*. Vol 3, No 2, June, 2010.

[8] https://en.wikipedia.org/wiki/Electroencephalography .

[9] http://inside-the-brain.com/tag/neural-activity/ P. L. Nunez. 1995. Neocortical Dynamics and Human EEG Rhythms, Oxford University Press, New York.