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Epileptic Seizure Detection Using an Algorithm Based on Fractal Dimension

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Abstract : Epilepsy is one common neurological disorder pertaining to approximately 1% of the population. It is a complex disorder that is not well-explained at the biochemical and physiological levels and hence there is a need for investigating novel methods that can be extracted and used for differentiating epileptic EEG signals from the normal one. Efficient detection is still a challenging task for many neurological disorders and there is need for investigating more novel features. The present study is on design of system that detects the epileptic activity with efficiency. Parameters of EEG are calculated in Time Frequency Domain and the analysis of signals was performed by nonlinear quantifier Higuchis Fractal Dimension (HFD) analysis which reflects the complexity of underlying brain dynamics. It is found that the fractal dimension feature with brain complexity gives an overall accuracy of 95% in determining seizures and showed parietal (P4) region of brain reflecting the sensation of seizure. This system for analysing epileptic activity detection is designed using MATLAB state of art Signal Processing algorithms. Fractal dimension was calculated reflecting brain complexity. Genes responsible for epilepsy and prediction of protein structures involved were identified that were not available earlier in any database.

Keywords: EEG, epilepsy, fractal dimension, signal processing, protein structures.

I. INTRODUCTION

Epilepsy is a neurological condition that causes an individual to have two or more seizures, which is due to abnormal bursts of electrical discharge in the brain .The word epilepsy was derived from the Greek word *epilambanein* which means 'to seize or attack'.[1,2] A seizure is a paroxysmal event due to abnormal excessive or synchronous neuronal activity in the brain that causes alteration in sensation, behaviour or consciousness. The word Seizure was derived from Latin word *sacire* which means "to take possession of".[1,2] Epilepsy is the second most common neurological disorder after stroke, affecting more than 50 million patients around the world. It's a serious disorder of central nervous system (CNS), which results in recurrent, unprovoked epileptic seizures due to chronic abnormal bursts of electrical discharge in the brain.[3] Although the biochemical mechanisms are not clearly explained yet, certain typical electrical phenomena were observed in epilepsy. Intercellular measurements at epileptic foci show an extraordinary long lasting, high amplitude membrane depolarization accompanied with spike trains. This phenomenon can be defined as paroxysmal depolarization shift (PDS). [3] There may be various mechanisms or combinations of them promoting this phenomenon: decreased inhibition (insufficient gamma-amino butyric acid –GABA), increased excitation (derangement in N-methyl-D-aspartate (NMDA) receptor and glutamate), alterations in Na^+, Ca^+, K^+ ion concentrations or alterations in membrane ion channels[2,3]. A seizure is an involuntary alteration in behaviour, movement, sensation, or consciousness resulting from abnormal neuronal activity in the brain. In case of epilepsy, a malfunctioning region of brain or the dysfunction of a biochemical mechanism causes the abnormal neuronal activity. The fundamental principle is that, seizures may be either focal or generalized [4]. Focal seizures arise from neuronal network either discretely localized within one cerebral hemisphere or more broadly distributed, but still within the hemisphere. Generalized seizures are thought to arise at some point in the brain but immediately and rapidly engage neuronal networks in both cerebral hemispheres.[5] The brain works by transmitting electrical signals between neurons. One way to investigate the electrical activity is to record scalp potential resulting from brain activity. This method is non-invasive and all measurements are made outside the head without wounds or scars. The recorded signal is the potential difference between two positions which is known as electroencephalogram (EEG).[5,6]

II.MATERIAL AND METHODOLOGY

The methodology of the present work is represented in the block diagram and flow chart of EEG signal processing - as shown in figure 2.1 and figure 2.2

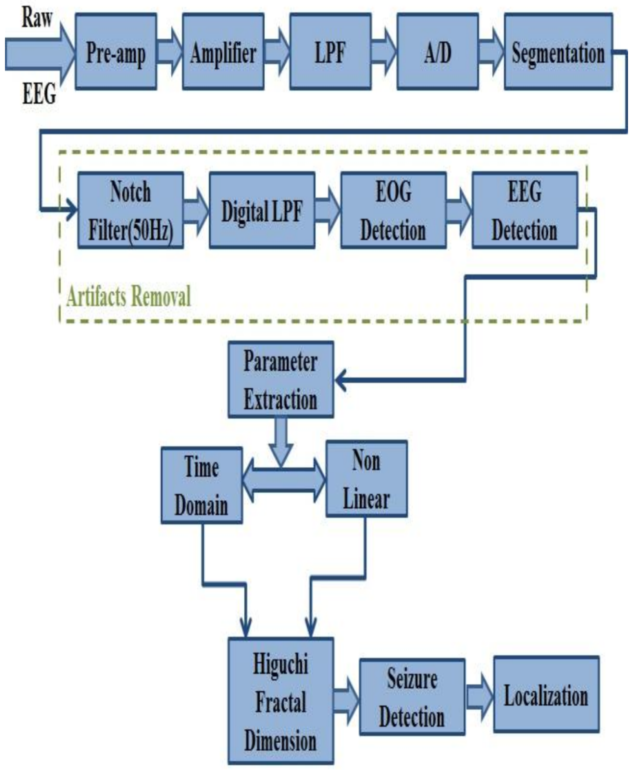

Fig2.1: Block diagram of EEG signal processing

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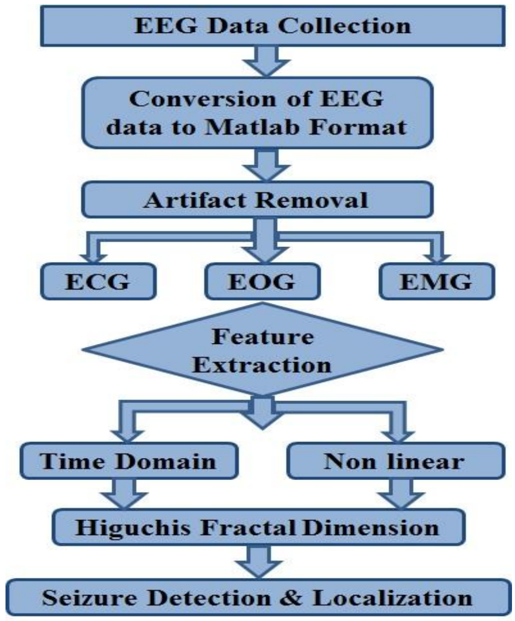


Fig2.2: Flow diagram of the seizure detection and localization.

2.1 EEG Signal Processing

Raw EEG signal from the scalp of patient is amplified by standard EEG amplifier. The LPF after amplifiers is the Butterworth filter of 24 db/octave with f_c=70Hz to prevent the effect of muscle activity. The A/D conversion is done at a sampling rate of Fs = 256 Hz. The segmentation of data is done to extract epochs of desired duration. Normal segmentation is 120 seconds.

2.2 EEG Artifacts and their removal

There are usually three physiological signals - ECG, EMG and EOG (because of scalp muscle activity and interference due to the eye blinks) that interfere with EEG.

2.3 EEG Analysis

EEG data were recorded in normal and under seizure conditions from three locations of the brain.

a) Frontal Region (FP1 (active) - Nasion (reference) - A1 (ground))

b) Parietal Region (P3 (active) - Cz (reference) - Nasion (ground))

c) Central Region (C3 (active) - Cz (reference) - Nasion (ground))

2.4 MATLAB and application development

In the present study the MATLAB version R2008b software was used as it allows matrix manipulation, plotting of functions, data implementation of algorithms and creation of user interface. We can construct a long sequence of statements, which is done by writing the commands in a file and calling it from within MATLAB.

The Epileptic Seizure Detection in EEG Recordings using an Algorithm Based on Fractal Dimension is used to detect the seizure presence by EEG analysis, Fractal Dimension evaluated by Higuchi Algorithm, which will evaluate underlying brain complexity. This algorithm can be used to detect the origin of dominant seizures generated in the brain. GUI and algorithm development work using MATLAB and loading the EEG data in the directory.

2.5 Higuchi's Fractal Dimension

Fractal dimension of EEG is calculated by using Higuchis algorithm. This was based on the measure of the mean length of the curve¸ L(k) by using a segment of k samples as a unit of measure. From a given time series X(1), X(2), . . . , X(N), the algorithm constructs k new time series; each of them, X_m^k, defined as X_m^k= X (m), X (m+k), X (m+2 * k),….. , X (m+int((N-m)/k) * k) [8]

where m=1, 2, . . . , k
m and k are integers indicating the initial
time and interval time respectively. For example if
k=4 and N=1000 then four time series are produced.
X^4_1= X (1), X (5), X (9), . . ., X(997)
X^4_2 =X (2), X (6), . . . ……, X(998)
X^4_3= X (3), X (7), . . . …… , X(999)
X^4_4 =X(4), X(8), . . ……… , X(1000)

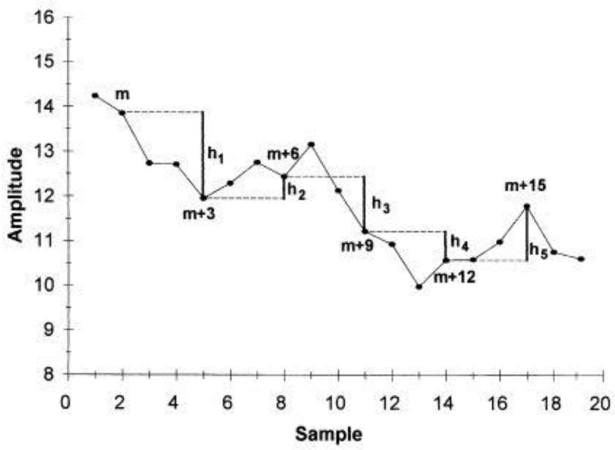


Fig 2.3: Sequence h_i determination on a curve for length calculation

Then, the length Lm (k) of each curve X_m^k is calculated as

$$L_m(k) = \sum_{i=1}^{[\frac{N-m}{k}]} |x(m+ik) - x(m+(i-1)k)| (n-1) / [\frac{N-m}{k}] k$$

where N is the total number of samples and the term (N-1) /(int((N-m)/k)) * k is a normalization factor. Thus Lm (k) represents the normalized sum of the segment length h_i.

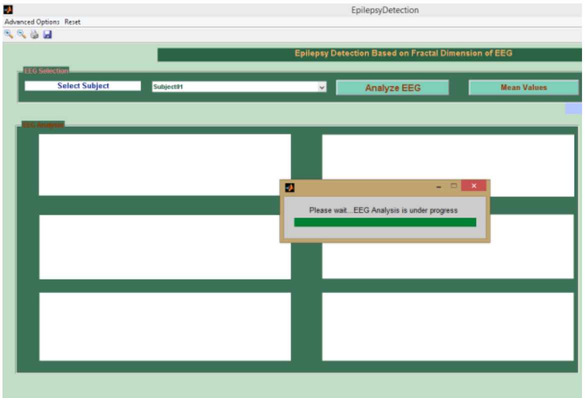
2.6 Identification of Genes Involved in Epilepsy

Several lines of investigation open up, by identifying the genes involved in the disease. The knowledge of knowing which gene causes epilepsy will help and make it easy in analyzing the disease and its functions. Once the genes responsible for epilepsy are identified, a search for the protein sequence in NCBI (National Center for Biotechnology Information) and PDB (protein data bank) is conducted. If not available then by protein structure prediction (PSP).

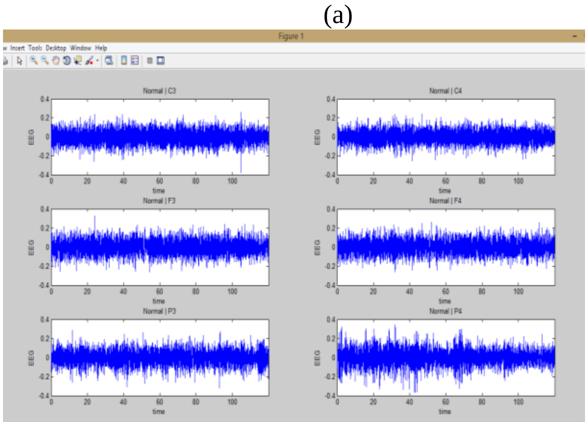
II. RESULTS AND DISCUSSION
III.

3.1 Seizure Detection System based on Fractal Dimension

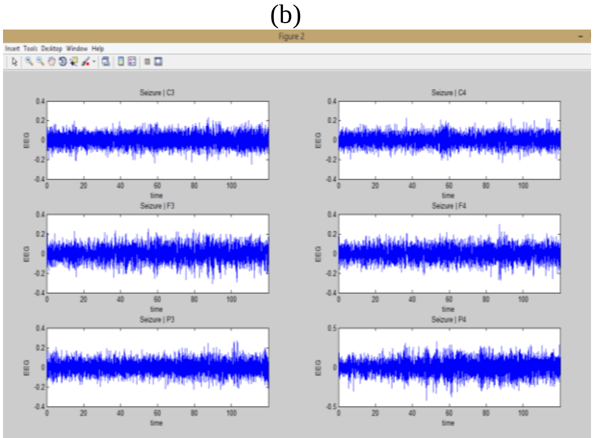
GUI design for the epileptic seizure detection includes 6 axes for 6 channels and 4 push buttons for its selection and analysis. Programmed GUI obtained after giving the tags, strings and properties are programmed. The MATLAB document is saved in the directory as ***Epilepsy Detection.m*** file in the current directory.



(a)

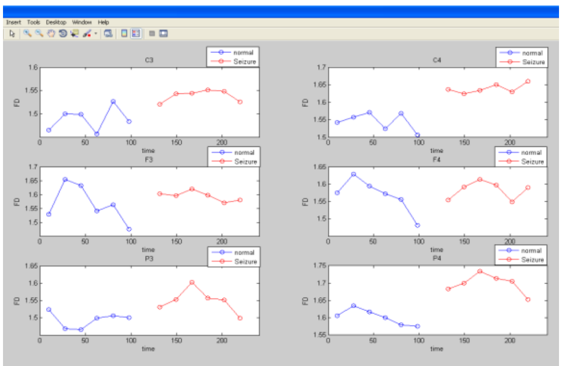


(b)

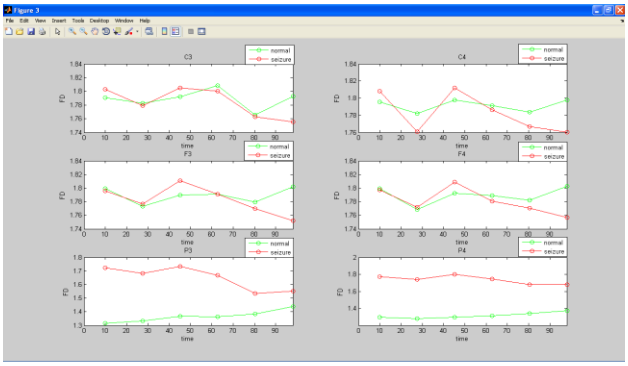


(c)

Fig 3.1 :(a)Working Environment of Seizure detection by EEG analysis Programmed GUI, (b) Normal EEG pattern from all six channels.(c) Seizure EEG pattern from all six channels



(a)

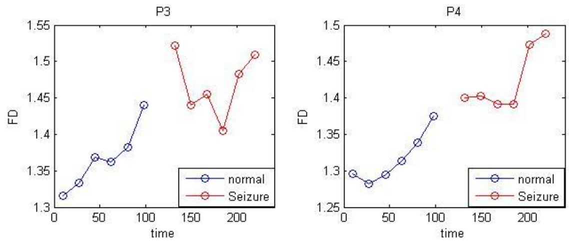


(b)

Fig 3.2: (a) Result of fractal dimension algorithm on all six channels. (b) Analysis of Higuchi Fractal dimension

3.3 Results of Fractal Dimension for Seizure Detection

The fractal dimension for seizure detection of two channels P3 and P4, of all the 12 subjects showed increase in FD values that measures the brain complexity from normal state to seizure state



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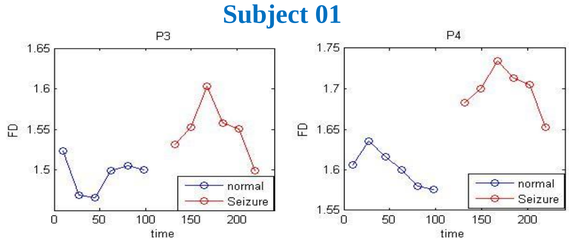

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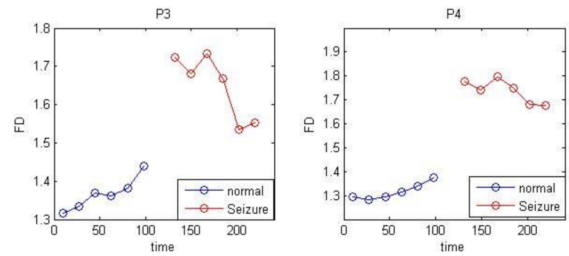

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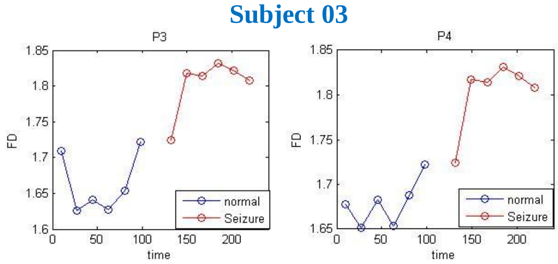

Subject 04

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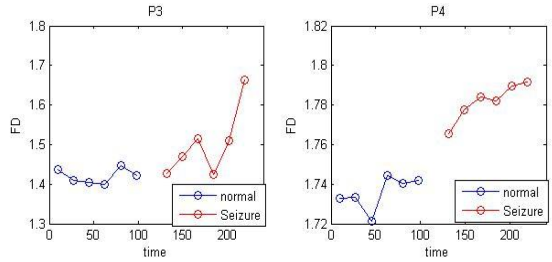

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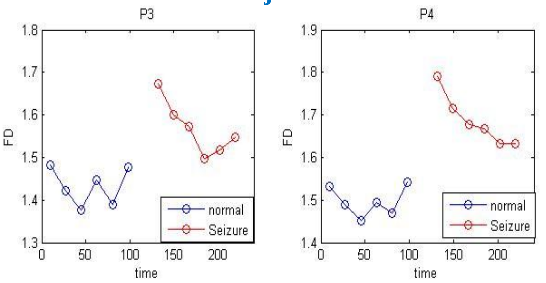

Subject 06

Fig3.3: Change of fractal dimension from normal to seizure state

3.4 Results of Genes Involved in Epilepsy

The genes responsible for epilepsy CHRNA4, KCNQ2/KCNQ3, SCN1B, LGI1,CSTB and EPM2A was identified with their function structures, specificity as obtained from Uniprot and NCBI. Structures were available only for CHRN4 and CSTB genes.

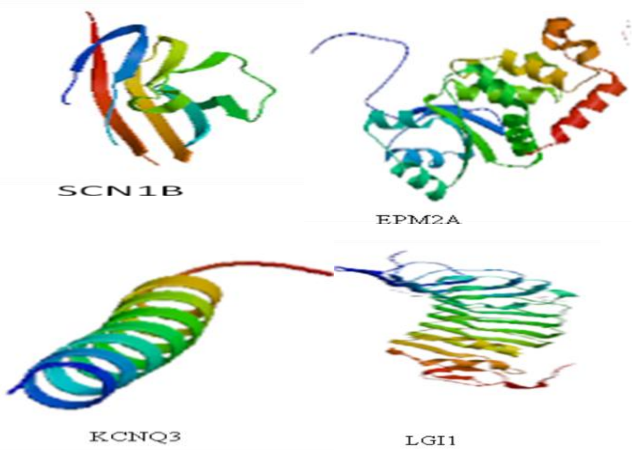

Fig 3.4: Predicted Protein Structures of SCN1B, PM2A, KCNQ3 and LGI1.

After analytical runs in Automated Swissmodel prediction tool, the gene SCN1B based on the template 4l1dA size of 2.50A°, the gene EPM2A based on the template 4kyrA size of 2.30A°, the gene KCNQ3 based on the template 2ovcA size of 2.07A° and the gene LGI1 based on the template 4p91A size of 2.10A°.

IV. CONCLUSION

This is a high detection system which is 100% efficient and tolerant to various inaccuracies pertaining in practical situations. Analysis of EEG was done by calculating all parameters that are completed in various states of subject - like normal and seizure conditions and in different regions such as frontal (F3,F4), parietal (P3, P4) and central (C3, C4). Among these, parietal region is found to be the best region in reflecting the signature of seizure effectively. However, increase in fractal dimension from normal to seizure state infers that activity parameter and fractal dimension can be used to develop an index by normalizing the values.

The genes SCN1B, KCNQ3, EPM2A and LGI1 for which, protein structures were not available but predicted using Automated Swissmodel. The predicted protein structures in PDB were 4l1dA for SCN1B, 2ovcA forKCNQ3, 4kyrA for EPM2A and 4p91A for LGI1.

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REFERENCES

i. *N. Pradhan and D. N. Dutt,(1993) "Use of running fractal dimension for the analysis of changing patterns in electroencephalograms," Computers in Biology and Medicine, vol. 23, no. 5, pp. 381–388*

ii. *Harrison (2008),"Harrison's Principles of Internal Medicine" -18th edition ,6421-6463.*

iii. *Ganong(2012), "Ganong's Review of Medical Physiology",24th edition,273-290.*

iv. *Dr.Dejan Stevanovic(2012), "A Review Study, Epilepsy - Histological, Electroencephalographic and Psychological Aspects", 1st edition.*

v. *Iscan, Z., Dokur, Z., & Tamer, D. (2011). Classification of electroencephalogram signals with combined time and frequency features. "Expert Systems with Applications",vol-38, 10499–10505.*

vi. *J Dauwels, E. Eskandar, and S. Cash(2009), "Localization of seizure onset area from intracranial non-seizure EEG by exploiting locally enhanced synchrony", "Engineering in Medicine and Biology Society" pp. 2180–2183,*

vii. *M. Katz(1988), "Fractals and the analysis of waveforms," Computational. Biology Med., vol. 18. 145–156.*

viii. *T. Higuchi(1988), "Approach to an irregular time series on the basis of the fractal theory," BioPhysical J, vol. 31, no. 2, pp. 277–283.*

ix. *H. Hinrikus, M. Bachmann, D. Karai(2011), "Higuchi's fractal dimension for analysis of the effect of external periodic stressor on electrical oscillations in the brain," Medical and Biological Engineering and Computing, vol. 49, no. 5, pp. 585–591.*

x. *G. Nicosia, G.Stracquadanio(2008)," Generalized Pattern Search Algorithm for Peptide Structure Prediction", Biophysical Journal, 95(10):4988-4999.*

xi. *Lehnertz, K. Non-linear time series analysis of intracranial EEG recordings in patients with epilepsy an overview. Int. J. Psychophysiol. 34:45-52, 1999.*

xii. *Dumont G.A,Zandi, A.S,Javidan M , Tafreshi, R, "Automated Real-Time Epileptic Seizure Detection in Scalp EEG Recordings Using an Algorithm Based on Wavelet Packet Transform"Biomedical Engineering, IEEE Transactions on (Volume:57 , Issue: 7) July 2010, Page(s):1639- 1651.*

xiii. *H. Hinrikus, M. Bachmann, D. Karai et al., "Higuchi's fractal dimension for analysis of theeffect of external periodic stressor on electrical oscillations in the brain," Medical and Biological Engineering and Computing, vol. 49, no. 5, pp. 585–591, 2011*

xiv. *Debora S Marks, Thomas A Hopf & Chris Sander, "Protein structure prediction from sequence variation"Nature Biotechnology γ0,107β–1080 (2012)*