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Analysis of Centre Tendency Mode Chaotic Modeling for Electroencephalography Signals Obtained from an Epileptic Patient

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Abstract

The Electroencephalogram (EEG) is a measure of the cumulative firing of neurons in various parts of the brain. From a given set of recording electrodes, the EEG contains information regarding changes in the electrical potential of the brain. These data include the characteristic waveforms with accompanying variations in amplitude, frequency, phase etc, as well as brief occurrence of electrical patterns such as spindles, sharps and spike waveforms. By a wide range of variables which includes circulatory, metabolic, biochemical, hormonal, neuro electric and behavioral factors, EEG patterns have shown to be modified. In the past even by visual inspection, the encephalographer was able to qualitatively distinguish the normal EEG activity from localized or generalized abnormalities contained within relatively long EEG records. The most important activity possibly detected from the EEG is the epilepsy. Epilepsy is characterized by uncontrolled excessive activity or potential discharge by either a part or all of the central nervous system. This paper discusses about the performance analysis of continous chaotic modeling in terms of Centre Tendency Moment (CTM) for a single epileptic patient obtained EEG Signals.

Keywords: EEG, Epilepsy, Continuous Chaotic Modeling, CTM

1. Introduction

With the help of real-time monitoring for the detection of epileptic seizures which has gained a widespread recognition, the application of computers has made it practically possible for the implementation of a group of methods to validate the changes occurring based on the EEG Signals [1]. Neurological disorders related to epilepsy can be diagnosed and monitored with the help of EEG signals and therefore it is proved to be an important clinical tool [2]. When sudden transient and recurrent disturbances of mental function occurs then the disorder can be epilepsy which leads to the over discharge of the brain cells. If the epileptiform activity is present in the EEG Signals then it confirms the diagnosis of epilepsy but sometimes such activity can be confused and wrongly related to other seizure related disorders also [3]. Between seizures, the EEG of a patient with epilepsy may be characterized by occasional epileptic form transients-spikes and sharp waves [4]. Generally the seizures are characterized by very short a episodic neural synchronous discharge which usually has an enlarged amplitude. This type of uneven synchrony may happen in the brain also where only a few seizures are made visible in few channels of the EEG Signal or generalized seizures are seen in every channel of the EEG signal involving the whole brain [5]. The organization of the paper is as follows, Section 2 discusses the Materials and Methods, and Section 3 discusses the Chaos Theory following by the results and discussions in Section 4.

2. Materials and Methods

2.1 Data Acquisition of EEG Signals

For this exhaustive study and to analyze the performance of the continous chaotic modeling we have obtained the raw EEG data of a single epileptic patient in European Data Format (EDF) who was under treatment in the Neurology Department of Sri Ramakrishna Hospital, Coimbatore. An issue that has been given great attention is the preprocessing stage of the EEG signals because it is important to use the best technique to extract the useful information embedded in the non – stationary biomedical signals. The obtained EEG records were continuous for about 30 seconds, each of them were divided into epochs of two second duration. A two second epoch is long enough to detect any significant changes in activity and presence of artifacts and also short enough to avoid any redundancy in the signal. For a patient we have 16 channels over three epochs.

Having a frequency of 50Hz, each epoch was sampled at a frequency of 200Hz. Each sample corresponds to the instantaneous amplitude values of the signal, totaling to 400 values for an epoch. Four types of artifacts were present in our data. They included, eye blink, electromyography (EMG) artifact, chewing and motion artifacts. Approximately 1% of the data was artifacts. We did not make any attempt to select certain number of artifacts and of a specific nature. The objective of including artifacts was to have spikes versus non spike categories of waveforms. The latter could be normal background EEG and/or artifacts. A neurologist's decision regarding EEG features (or normal EEG segment) was used as the gold standard. We choose a sample window of 400 points corresponding to 2seconds of the EEG data. This width can cover almost all types of transient epileptic patterns in the EEG signal, even though Seizure can often last longer.

3. Chaos Theory

Chaos theory is a versatile and popular method for the analysis of non-linear data. For this chaos theory, all the mathematical models associated with it will definitely provide intractable solutions. Only in the field concerning the applications of meteorology, this chaos theory was first applied. A commendable amount of work is done in developing the theoretical methods, conditions and aspects of chaos theory [6]. A plenty of applications have been found in medicine, biology and especially cardiology. Chaos can even represent the healthy or diseased state if the diseases concerned with the heart have been addressed. Due to the nature of the chaotic models, both the computer simulation and discretization can lead to the propagation if errors which may deviate from the actual solution. The Centre Tendency Mode (CTM) is a parameter that quantifies the degree of variability. It is always used as a parameter in decision models. The most striking feature of chaos is that it measures the degree of variability. If the seemingly simple functions are recursively evaluated, then the most unexpectedly complex results are produced. From the stage of convergence it goes to a single value to a bifurcation or it usually converges to two values. All of a sudden, the iterative function does not become chaotic at all. The additional bifurcation occurs and finally chaos results. The lack of periodicity and a sensitivity to initial conditions are two most important properties of a chaotic system. A good example of a standard chaotic equation is expressed as follows:

$$g_n = G g_{n-1}(1 - g_{n-1}) \qquad 2 \le G \le 4$$

where G is a constant whose value changes the behaviour of the function.

The above expression can also be written as Poincare's equation and is an example of a chaotic system. The amount of recursion depends on the selection of g_0, which usually ranges between 0 and 1. If the value of G increases, the equation progresses from single-value convergence to chaos. The function exhibits chaotic properties if the value of $G > 3.57$. The regions of stability may appear unexpectedly within the chaotic areas.
The method which is used to solve the logistic equation can be expressed as follows:

$$g_{n+1} = 16 g_n (1 - g_n)(1 - 2g_n)^2$$

where G in the logistic equation is no longer a constant but a function of g_n and is expressed as follows:

$$g_n = \frac{1}{2}[1 - F_{2^{2n}}(1 - 2g_0)]$$

Again for integer values of n, the function appears mostly chaotic.

3.1 Measure of Central Tendency Moment

CTM is used to quantify the degree of variability in the plots concerning the second-order difference. The CTM is usually computed by selecting a particular circular region of radius r, and we should count the total number of points that fall within the radius, divided by the entire number of points.
Let t be the total number of points and r be the radius of central area, then
CTM can be computed as follows:

$$CTM = [\sum_{i=1}^{t-2} \delta(q_i)]/(t-2)$$

where $\delta(q_i) = 1 \quad if \quad [(g_{i+2} - g_{i+1})^2 + (g_{i+1} - g_i)^2]^{0.5} < r$

and $\delta(q_i) = 0 \quad otherwise$

4 Results and Discussion

The Table 4.1 shows the CTM values for the single Epileptic Patient obtained from the EEG Signals. The total number of points inside follows an ascending order and the total number of points outside follows a descending order. The CTM Values are computed for different combinations of total number of points inside and the total number of points outside. It is concluded that when the number of points inside are very high and the number of points outside are very low then the obtained CTM equals to one. The Figure 4.1 shows the sample CTM output for the single epileptic patient obtained from Electroencephalography Signals.

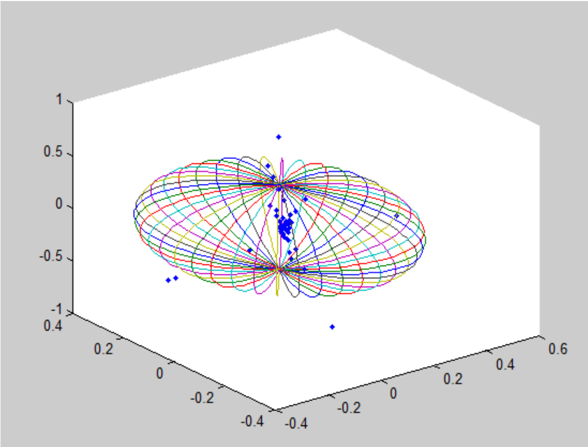

Figure 4.1 CTM Output for a Single Epileptic Patient Obtained from EEG Signals.

Table 4.1 CTM Values Obtained for a Single Epileptic Patient Obtained from EEG Signals

No. of Points Inside	No. of Points Outside	CTM
33	25	0.5690
40	18	0.6897
45	13	0.7759
49	9	0.8448
51	7	0.8793
52	6	0.8966
52	6	0.8966
53	5	0.9138
54	4	0.9310
54	4	0.9310
54	4	0.9310
55	3	0.9483
55	3	0.9483
55	3	0.9483
56	2	0.9655

Table 4.1 (Continued): CTM Values Obtained for a Single Epileptic Patient Obtained from EEG Signals

56	2	0.9655
56	2	0.9655
56	2	0.9655
56	2	0.9655
56	2	0.9655
56	1	0.9655
57	1	0.9828
57	1	0.9828
57	1	0.9828
58	0	1
58	0	1

Reference

[1] Alison A. Dingle, Jones R. D., Caroll G. A. and Fright W. R., ‘A Multistage System to Detect Epileptic form Activity in the EEG’, IEEE Transactions on Biomedical Engineering’, Vol.40, No.12, pp. 1260-1268, 1993. http://dx.doi.org/10.1109/10.250582

[2] Czarn, Mac Nish C., Vijayan K. and Torlach B ‘Statistical Exploratory Analysis of Genetic Algorithms', IEEE Transaction of Evolutionary Computation, Vol.8, No.4, pp. 405-421, 2004. http://dx.doi.org/10.1109/tevc.2004.831262

[3] Celement C. Pang, Upton A.R.M., Shinge G. and Kamath M.B. ‘A Comparison of Algorithms for Detection of Spikes in the Electroencephalogram', IEEE Transaction on Bio Medical Engineering, Vol.50, No. 4, pp. 521-26, 2003. http://dx.doi.org/10.1109/tbme.2003.809479

[4] Gabor A.J, ‘Seizure Detection using a Self Organizing Neural Network: Validation and Comparison with Other Detection Strategies', Electroenceph. Clin. Neuro Physiol., Vol.107, pp. 27-32, 1998. http://dx.doi.org/10.1016/s0013-4694(98)00043-1

[5] Li Gang, Ye. Weniyu, Lin Ling, Yuqilian and Yuxuvemin, 'An Artificial -Intelligence Approach to ECG Analysis', IEEE EMB Magazine, Vol.19, pp. 95-100, 2000. http://dx.doi.org/10.1109/51.827412

[6] Mark van Gils, Rosen Falck A., White S., Piror P. and Gade J, 'Signal Processing in Prolonged EEG Recordings During Intensive Care', IEEE EMB Magazine, Vol.16, No.6, pp. 56-63, 1997. http://dx.doi.org/10.1109/51.637118

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