# Statistical Analysis Of the method to determine the neurological disorders through electrical signals of brain

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*Abstract :* ***This paper talks about the phenomenon of recurrence and using this concept it proposes a novel and a very simple and user friendly method to diagnose the neurological disorders by using the EEG signals. The mathematical concept of recurrence forms the basis for the detection of neurological disorders and the tool used is MATLAB.***
***Using MATLAB, an algorithm is designed which uses EEG signals as the input and uses the synchronizing patterns of EEG signals to determine various neurological disorders through graphs and recurrence plots.Only the statistical analysis of the proposed method has been shown in this paper***

***IndexTerms* - EEG Signals, Recurrence, Order Recurrence Plot, Coupling Index, Signal Processing.**

## I. Introduction

This paper proposes a novel method to detect the neurological disorders like epileptic seizures, Alzheimer's disease etc. The proposed method uses the recurrence method and tells the degree of coupling or synchronism between the EEG signals taken from various different positions from the human brain. A parameter called the "synchronization Index", is used to detect the recurrence patterns in the EEG signals from various channels of EEG machine and a graph is plotted using MATLAB. It is seen that during neurological disorders the synchronism between EEG signals taken from different positions of brain increases. This can be visualized using the graphs [1-4].

## II. Proposed Algorithm

The method is based on the concept of recurrences in biomedical signals.It has been observed that in various neurological disorders like epilepsy, alzheimer's etc,the EEG signals taken from various position of brain are in a same state or in recurrence with each other so a method has been proposed which uses parameter called synchronization index $\rho\pi$. The high value of synchronization index between EEG signals taken from various areas of head(using EEG),ensures that a person is suffering with some kind of fits or seizures.These seizures are the characterstics of various neurological disorders[6]. So ,basically this method gives the mapping of brain signals and helps the doctor to understand if a person is suffering from a neurological disorder. The graphs showing the synchronization are obtained in MATLAB which helps to understand the condition of brain in a better way. In this way the proposed work is a diagnostic method to diagnose the neurological disorders using EEG signals. Moreover these graphs are also easy to understand and analyse as they take and compare data between two different channel of EEG machine.[14]Given below is the diagrammatical illustration of the method for better understanding.

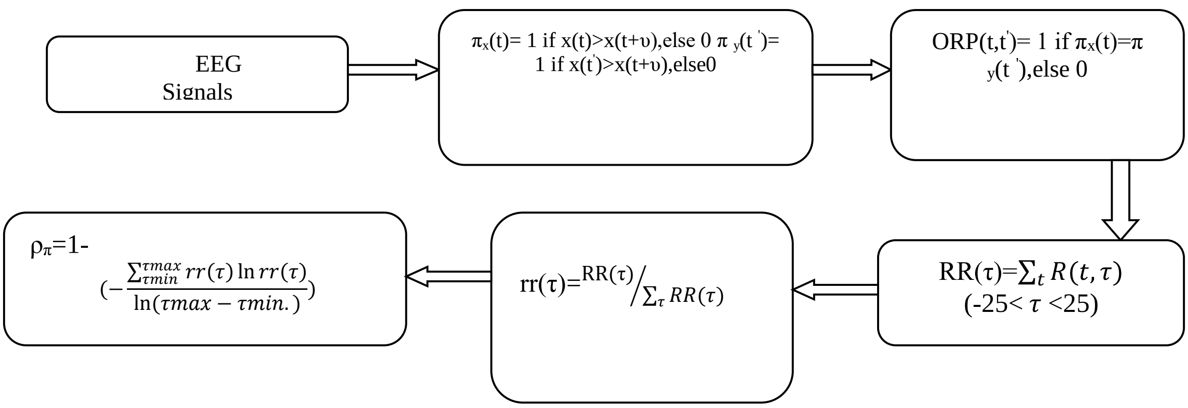


**Figure1:** Algorithm Based on MATLAB

The stepwise explanation of algorithm is given below:[14]

a. The EEG signals are taken from EEG machine and stored in the form of matrix.This matrix serve as the input for the propgram which is developed using the above mentioned algorithm

b. pie x($\pi_x$ ) and pie y ($\pi_y$ ) are termed as the order patterns and they are found out by comparing a value of a sample at time 't' with the sample of same signal series at some other time instant.

c. Then with the values of order patterns of indivisual signal series the order patterns between the two signals taken from different channels of EEG machine is determined by using the formula given below:

$$ORP\ (t, \tau) = 1 \text{ if } \pi_x (t) = \pi_y (t+\tau) \quad (1)$$

$$0, \text{ otherwise}$$

Following the above steps, Recurrence Rate and normalized recurrence rate are found :

$$\text{Recurrence Rate } RR(\tau) = \sum_t R(t, \tau) \quad (2)$$

$$\text{Normalized Recurrence } rr(\tau) = {RR(\tau)}/{\sum_\tau RR} \quad (3)$$

Then "synchronization index" ($\rho_\pi$) is found and plotted. The formula for synchronization index is as follows:

$$\boldsymbol{\ell\pi} = 1 - \left(-\frac{\sum_{\tau min}^{\tau max} rr(\tau) \ln rr(\tau)}{\ln(\tau max - \tau min.)}\right) \quad (4)$$

This parameter "$\rho_\pi$", exhibits either low, moderate or high value. These values are further compared to find out the extent of repetition between the EEG signals recorded from various positions of brain. Moreover the recurrence plots are also plotted which helps in better understanding of synchronism between the EEG signals. [8-14].

## III. COMPARISON WITH VARIOUS MODELS USED EARLIER

**a. Comparison with the Decomposition Model:** Decomposition model for analysis of EEG signal, breaks the signals into their phases and compares the phase between the EEG signals attained from different channels of an EEG machine.

To analyse the phase of such signals phase splitters and additional circuitry is required and moreover sometimes the phase differences are so small that they are hard to find out. Moreover ,the phase splitter devices and additional circuitry makes the method costly. [18-19]

On the contrary the developed method simply finds out the degree of synchronisation( $\boldsymbol{\rho_\pi}$ ) to find out the neurological disorders**.**Since no additional circuitry except an EEG machine and a MATLAB software is required,this method is economical and accurate

**b. Comparison with other algorithms**: Their are few more algorithms like K-nearest neighbor algorithm,which compares a sample with k nearest neighbour,but the problem with such algorithm is that they are application specific i.e. for diagnosing various disorders ,their source codes needs to be modified.In the case of the proposed method,it can be used effectively to diagnose neurological disorders like alzheimer's ,epilepsy etc, without making any changes,so it is far more versatile.[20-22]

## IV. RESULTS AND DISCUSSION

Using the proposed method,the diagnosis of two neurological diseases namely, Alzheimer's disease and Epilepsy are been analysed statistically using ANOVA test.The three groups,namely normal,seizure and post seizure for each disease have been taken and their results are obtained individually.Their individual statistical results are given as under:

a. For Epilepsy

**Descriptives**

| VAR00002 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval for Mean | | | |
| | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
| Normal | 3 | .993867 | .0003055 | .0001764 | .993108 | .994626 | .9936 | .9942 |
| Seizure | 3 | .996333 | .0001155 | .0000667 | .996046 | .996620 | .9962 | .9964 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Post Seizure | 3 | .994967 | .0004933 | .0002848 | .993741 | .996192 | .9944 | .9953 |
| Total | 9 | .995056 | .0011103 | .0003701 | .994202 | .995909 | .9936 | .9964 |

Table 4.1

**ANOVA**

VAR00002

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .000 | 2 | .000 | 39.267 | .000 |
| Within Groups | .000 | 6 | .000 | | |
| Total | .000 | 8 | | | |

Table 4. 2

B. For Alzheimer's Disease

**Descriptives**

VAR00002

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Min. | Max. |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| Normal | 3 | .001667 | .0005774 | .0003333 | .000232 | .003101 | .0010 | .0020 |
| Seizure | 3 | .007000 | .0010000 | .0005774 | .004516 | .009484 | .0060 | .0080 |
| Post Seizure | 3 | .004000 | .0010000 | .0005774 | .001516 | .006484 | .0030 | .0050 |
| Total | 9 | .004222 | .0024381 | .0008127 | .002348 | .006096 | .0010 | .0080 |

Table 4.3

**ANOVA**

**VAR00002**

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| **Between Groups** | **.000** | **2** | **.000** | **27.571** | **.001** |
| **Within Groups** | **.000** | **6** | **.000** | | |
| **Total** | **.000** | **8** | | | |

Table 4.4

**Acknowledgment**

I thank the Prof. S Hasan Saeed, Department of Electronics and communication engineering,Integral University, Lucknow for his continuous guidance and support.

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