Risk Level Optimization and Comparison of Epilepsy in Patient using Chaos-Voxel

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ABSTRACT

This paper aim to optimize and compare the Epilepsy in Patient using Chaos-Voxel. The raw EEG signals are sampled and parameter like energy, variance, peaks, sharp and spikes waves, duration, events and covariance are detected. This classification it provide a better way of treating the epileptic patients. It also aims to safeguard the patient’s life during the critical situations. The aim of this work is to investigate possible metabolic impairment within the thalamus in patients suffering from both focal (mesial temporal lobe epilepsy with hippocampus sclerosis) and generalized epilepsy using Chaos-Voxel.

I. INTRODUCTION

400 years ago, brain was a mystery. Brain has so much complication to understand. No function of brain has been defined till 1600. ‘Descartes’ proposed that “pineal gland is the seat of the soul.” In 1664, ‘Thomas Willis’ gave the brief structure of the brain. Willis application of the scientific methods to the brain was seminal. The primitive scientific tool available at that time was limited to direct observation to anatomy. Willis argued upon that mental functions rise from the brain itself so disease also arises such as epilepsy, placed human suffering within a physical within, though invisible. From ancient times, epilepsy is known as the disease given by god while now it is a window to brain’s anatomy. Epilepsy seizures are the result of brain’s transient and abrupt electrical disturbance. Unfortunately, the occurrence of epilepsy seizure is abrupt so it cannot be easily understood. 25% of world’s epilepsy seizure diseased population cannot be controlled by any treatment.

Electroencephalogram (EEG) contains set of potential differences developed as a result of volume of currents from active tissue (neural) throughout the conductive media of the brain. The measurements can be either by placing special intracranial electrodes or using sensors. Detection of seizure attack traditionally takes 2-4 days. Due to large number of patients, it is impossibly lengthy task to treat every patient. So there is need of new technology which should be sensitive and generate every false alarm so neurologist can easily discard them. The purpose of the proposed system does not mean to replace neurologist but it is to lessen the burden and remove the time consumption. This can help us to lessen the percentage of population highly and rapidly. This false alarm feature can lessen the burden on neurologist and can handle the right seizure and can do treatment by either giving drug or through neuro-stimulation. The neuro-stimulation and drug delivery are better than antiepileptic drugs as in seizure patient cannot push the alarm by own. The uncovering of epilepsy which includes visual scan of EEG recordings for the spikes and seizures Generalised seizure cause effect on child or adolescence. These seizures are generated due to some drugs side-effects. This sometimes happens due to ageing due to hereditary irregularities, development anomalies’ and febrile convulsion. The hallmark of seizures is the recurrent seizures. In some patients these seizures happens more than 100 times a day. Autopsy and craniotomy are no longer to demonstrate the useful correlates of useful deficits. In 20th century, the neuro-imaging’s advancement is helpful to get the more described structure of brain and its functionalities. Bloch and Purcell self reliably demonstrated use of Atomic MR spectroscopy. NMS spectroscopy is getting popular due to its cropped images of delivery. Now Proton MR is being studied for this image delivery.
A. General Technique

Many algorithms are designed to detect seizure using EEG signals. McSharry ET. Al introduced an algorithm using multidimensional probability but it provides less false alarms compared to variance [1]. In [2], chaotic features that include LLE (Lyapunov Exponent) and CD (correlation dimension) from wavelet obtained by EEG signal’s wavelet sub bands are effective in differentiating various classes’ signals including signals of seizures. Liang et al uses Fourier Transformation (using linear and non linear classifiers) to extract autoregressive parameter in conjunction with approximate entropy [3]. Many time-frequency analysis techniques have been devising such as smoothed pseudo-Winger- Ville and reduced interference are used in conjunction with an artificial neural network. This method has great accuracy in finding the seizure.

However, Chaos is tricky thing to define. But if we consider system as chaotic, we can easily list the properties of it. Chaotic is dynamical system displaying sensitive dependence on initial condition on a closed invariant set.

B. Localization Methods

Normally, two opposite are used for proton spectroscopy i.e. SV (Single Voxel) and spectrocopying images (SI) also known as Chaos Voxel or chemical shift imaging. Voxel is defined as capacity element that is being tested. This volume element has width, length and depth. The size of single Voxel generally between 2 to 8 cm³. Smaller Voxel has smaller amount of tissues and produces little signal to voice ratio. So need of small Voxel is increased to get more accuracy. MR spectroscopy can be obtained in duration of 5-15 minutes.

C. Single Voxel Technique

This technique uses fixed amount of tissues as unified signal to gain single spectrum. The volume of Voxel ranges between 2-8 ml in proton in proton MRS. For prolix process 8cm³ Voxel is used. Voxel must be positioned from basis of susceptibility, relics and lipids. The limitation of this technique is anatomic coverage and assessment of single area only during acquisition. So positioning of Voxel is must. The fundamental single Voxel localisation is to use three orthogonal slice selective pulses equally and enterprise the pulse sequence to collect only the echo signal from the Voxel in space where all three shares intersect. The two sequences generally used are called Stimulated Echo Acquisition Mode (STEAM) and Point Resolved Spectroscopy (PRESS). Three 90 degree pulsations are used and stirred echo is serene in STEAM. All other signals should be dephased by the large implement gradient applied during the so called mixing time. While in PRESS, second and third are changed by 180 degree and crusher gradient is applied across the pulses to select the desired spin echo sign arising from all three frequencies.

1) Main Characteristics of STEAM

It is cooler to produce a 90⁰ pulse with a shrill slice profile than an 180⁰ pulse. There is incomplete recapture of signal. A precise volume Voxel is formed. It can be formed with very short echo times.

2) Main Characteristics of PRESS

Rather better signal to noise ratio because the motivated echo is formed from only half the available equilibrium magnetization. There is complete retrieval of signal. It can be performed with little and long TE

II. MR SPECTROSCOPY OF BRAIN TUMORS

The body of existing non function indicates that H-MRS plays crucial clinical role in intracranial neoplastic management. It has distinct terminuses in following areas:

- Diagnosis minus neurosurgery
- Guidance of neurosurgical actions
- Targeting of focal ablative treatments
- Providing an assessment of reply to therapy
- Detecting recurring or progressive disease

Brain tumours are one and only cause of morbidity and humanity in adults. So deserves high attention. Mainly, in clinical practice operational brain imaging as MRI or CT are charity as first step to roughly evaluate intracranial neoplasm. These imaging tools have predictive and diagnostic formation in separate patients limitedly. MR spectroscopy can be used with physical imaging as an addition non-invasive assessing tool to characterise the nature of tumours and to forecast biological behaviour

III. PROPOSED WORK

The EEG records of 347 patients data set has been taken from hospital Mata Channan Devi, Delhi, India who had been under treatment of Neurology.

A. EEG Data Acquisition and Pre-processing

Since there are distinct EES records over 30 seconds, so these are divided into epochs of 2 second duration each by scanning into bitmap image size of 256X 1 pixels. The change in activity can easily noted down in these long 2 seconds also any type of redundancy is reduced. The frequency of EEG signal is 50 Hz so each epoch is sampled at frequency of 200 Hz using Mat Lab Programming. Three continuous epochs
are used to locate variation and difference in epileptic activity. I used random number of EEG records.

B. Chaotic Optimization

This method is so much unpredictable. This behaviour lets it does not react to output disturbance while it reacts in important ways. This method is complex because of its non-repeated nature and continuously displaying of disturbances. In this we have to take threshold value and plot the recurrence plot and also find following parameters

- Energy in each epoch is given by the sum of all sample signals denoted by $E = \sum_{i=1}^{n} X_i$ and total is divided by 1024
- The total number of positive and negative peaks are calculated which exceeds our threshold value. Threshold value is calculated as: $r = 0.5$
- Spikes are detected when duration of very high amplitude peaks in the EEG waveform between 5-10ms and sharp waves are between 15-20 ms.
- Total number of spikes and sharp waves are counted and stored as event
- Variance is computed as $\sigma = \sum_{i=1}^{n} \frac{(x_i - \mu)^2}{n}$ where $\mu$ is average amplitude.
- The average duration is calculated as $D = \sum_{i=1}^{d} t_i \frac{n}{d}$ where $d$ is number of duration and $t_i$ is peak duration

C. Risk Level Estimation

The output of the chaos optimization provides two risk levels i.e. risk level 1 and risk level 2. Since we are dealing with epileptic patients, so exact risk level cannot be found. So this can be done by automated system which can classify the risk level of patient being examined.

The performance of this method is being given by: $PI = \frac{p - m - f}{p} \times 100\%$. Where $p$ is perfect classification and is given when physician and method both agrees; $m$ is missed classification and is true negative of the machine to the physician. (i.e. complement values) and $f$ is false alarm and is false positive of the machine in reference with the neurologist. Since the machine has to be sensitive. So its sensitivity can be calculated as $S = \frac{p}{p + f} \times 100$

C. Chaos Voxel Technique

This system utilised two stage approaches for spike detection. Since epileptic spike consist of two types of patterns i.e. single spike and spikes with small waves, we need to adopt k-neo to detect all the spikes candidates which are then classified by AdaBoost classifier using the feature of newly spike Voxel model. Figure below shows the flow chart of the method in overview.

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>EPOCH 1</th>
<th>EPOCH 2</th>
<th>EPOCH 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY</td>
<td>8.223</td>
<td>14.6563</td>
<td>16.2282</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>1.23</td>
<td>2.141</td>
<td>2.685</td>
</tr>
<tr>
<td>PEAKS</td>
<td>45</td>
<td>124</td>
<td>16</td>
</tr>
<tr>
<td>SHARPS AND SPIKES</td>
<td>8</td>
<td>15.4688</td>
<td>42.3875</td>
</tr>
<tr>
<td>EVENTS</td>
<td>157</td>
<td>186</td>
<td>122</td>
</tr>
<tr>
<td>AVG DURATION</td>
<td>90</td>
<td>2.25</td>
<td>0.19</td>
</tr>
<tr>
<td>COVARIANCE</td>
<td>2.42</td>
<td>12.10</td>
<td>12.10</td>
</tr>
</tbody>
</table>

Table1: Parameter calculated by using Chaotic-Optimization technique.

Fig 2. Wavelet (exact location of disease not detected).

Fig 3. Detecting at different level.

Fig 4. Spike wave.
In figure 4 by taking different scales detection of patients risk level on different positions. Here we calculate risk levels using position of wavelets. Similarly another figure is drawn considering different scale of measurement for more accurate monitoring disease. Spikes are detected at different scale changing different plot and positions. This colours red, blue, etc all came from our sample data that we put. Comparison is done on different wavelet by zooming and finding the exact location of the disease.

![Fig 5. Zooming spike wave to locate exact position of epilepsy disease.](image)

Here in Figure 5 the wavelet is zoomed. The right side spike inside the wavelet epilepsy risk level is detected. In next figure taking the wavelet on high scale locate the exact position of disease.

![Fig 6. Zooming spike wave to locate position of epilepsy disease. In left side.](image)

Here in Figure 6 the wavelet is zoomed. The left side spike outside the wavelet epilepsy risk level is detected. After taking the wavelet on high scale locate the exact position of disease.

![Fig 7. Checking epilepsy at different scale.](image)

![Fig 8. Checking on higher values the epilepsy risk.](image)

Both type of selection i.e. Candidate detection and Feature Point Selection are done by Voxel technique. The performance of spike classification is done by this section. True positives, false positives, True negatives and false negatives are represented by TP, FP, TN, and FN. So accuracy of classification is done by:

\[
\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN}
\]
If sample is not large enough or is inadequate data sets distributed unevenly then it may impact negative system performance. To solve this problem, we employ four-fold cross validation process. This method is based upon the number of trials. Larger fold number means it has too small trials which results less statistically meaningful. The dataset is being divided into four groups (randomly). Each group’s dataset alternatively served as testing dataset with the other three groups combined as training dataset. The testing results from the four groups are added to get testing statistics of four fold test example. This test is to be repeated at least ten times to get final statistics of each experiment. The figure below shows the detailed flow diagram of Voxel technique.

![Detailed flow diagram of Voxel technique](image)

Statistical sensitivity and specificity computed to know the performance of the system. The ability of detection of spike is described by sensitivity while specificity describes the ability to discriminate the non spikes.

\[
\text{Sensitivity} = \frac{TP}{TP + FN} \\
\text{Specificity} = \frac{TN}{TP + FN}
\]

For the two class classification method, 132 candidate patterns include both types of spikes and remaining 111 were the non spikes. AdaBoost was trained by having 100 weak classifiers each consisting of single decision tree then tested via fourfold cross-validation process.

The table below shows the probability of the risk levels:

<table>
<thead>
<tr>
<th>Risk level</th>
<th>Weight</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk level 1</td>
<td>0.0063</td>
<td>0.000052</td>
</tr>
<tr>
<td>Risk level 2</td>
<td>0.0117</td>
<td>0.000103</td>
</tr>
<tr>
<td>Risk level 3</td>
<td>0.0003</td>
<td>0.000227</td>
</tr>
</tbody>
</table>

### IV. RESULT AND DISCUSSION

The output of three epochs for each patient is optimized at single epilepsy level by neural network. The comparative study of the performance is given by performance index and quality value. These are calculated for each set of patients and are to be compared. The performance index obtained by chaotic was 30% and for Voxel it is 47%.

![Result (Chaos-Voxel)](image)

In Figure11 comparison is shown between chaotic optimization technique and Chaos-Voxel technique to detect the epilepsy risk level of patients where red line refers to Chaotic-optimization technique. Blue line shows common energy level for comparing accuracy and performance index of Chaotic and Chaos-Voxel. While Black line shows Chaos-Voxel technique. Black line originate from (0-.4) while red line originate from (-.1-.2) red line extend up to 10 second after that it will disappear. While till than black line reaches common energy level it gives constant value. It mean after some time Chaos-Voxel gives constant result as compared to chaotic optimization that disappear after 10 second that is if we will check for epilepsy risk level it will not tell any value and get disappear at different scale and epoch.

#### A. Quality Value

Goal of this research was to get perfect classification of epileptic patients and get fewer false alarms. This can be done by the calculating following parameters as follows

- Classification rate
Classification delay
- False alarm rate

Quality value can be computed as follows

\[ Q = \frac{c}{(f_a + 0.2 + (t_d \cdot p_{pc}) + 6 \cdot p_{ms})} \]

where \( c \) is the scaling constant.

\( f_a \) is the false alarm rate; \( t_d \) is the delayed time; \( p_{pc} \) is the percentage of perfect classification and \( p_{ms} \) is the percentage of missed classification. The value of constant \( c \) is set to be 10 for convenience. The higher the value of \( Q_v \), the better the method is.

As shown in the table, The Risk Level is higher in this optimization technique also weighted delay is very less. Number of false alarm rate are also reduced by this technique. The quality value is highly increased. Hence it is more reliable than the previous technique.

V. CONCLUSION

This chaos Voxel technique is very successful in detecting epilepsy and is much more perfect than the previous mechanism. Almost negligible false alarm/set is calculated which leads neurologist’s burden much lower. This also has high performance index. The future research can be done on this chaos Voxel technique can rely this system accurately.

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