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Quantitative analysis of Epileptic EEG signals- An Information Theoretic Approach

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Abstract-Computational neuroscience is a new area of research which deals with neuron responses carrying stimulus for a particular process. Different approaches and researches had applied frameworks, measures & techniques to know & analyze the fundamental understanding of the process. Defining information in a quantitative manner is the major constraint for researchers. Information measure is the only way which can give some inside into the complex world of neuroscience as these stimulus or spikes generated are random in nature & many times lead to chaotic behavior. Any such study/model/framework will be of high interest which can be able to bring some facet about the process.

Keywords- Computational Neurosciences, Information Theory, Electroencephalogram, Epilepsy

I. INTRODUCTION

Computational Neurosciences have a wide scope for researchers as it deals with the information processing in the brain. In computational neuroscience, Information theory quantifies how much information a neural response carries about stimulus. Information theoretic methods have been widely used to analyze and understand the fundamental information processing task performed by the brain.

Epilepsy is a common & diverse set of chronic neurological disorders characterized by seizures. An EEG recording remains a major source for analyzing epilepsy disease in the human being. Analyzing EEG signals visually is very complex process because it is a clinical process so that only experts can analyze these signals. There are various challenges associated with analyzing signals. So we need such methods by which we can quantify the EEG signals. Epileptic seizures result from abnormal, excessive or hyper synchronous neuronal activity in the brain. The occurrence of seizure is unpredictable and the process is very random in nature. The EEG signals are representation of brain activity in form of graph. The obtained EEG graph is then analyzed but the visual scanning of EEG graph is very time consuming. So Information theoretical method is used for analyzing the graph effectively.

Analysis of EEG recordings is one of the methods which are widely used for diagnosis of epilepsy. These recordings are used for classification & assessment of patient having epilepsy. EEG signals are electrical impulses within the brain sense by the electrodes placed on the scalp. It is a recording of brain activity, which is the result of the activity of billions of neurons in the brain.EEG signals are the measure of electric potential within the brain. This electric potential is very variable and random in nature. Analysis of these random signals obtained by EEG recordings provides a basis for clinical predictions related to epilepsy stage, type and scope of survival of the patient. In recent years, there has been a change from rule based purely clinical diagnosis to diagnostics utilizing Information theoretical methods for parametric analysis of EEG recordings.

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To build a sophisticated model to analyze the EEG recordings or EEG graph has become a major need in biomedical area. The Information theoretical model can be further leveraged for drawing epilepsy diagnostic inferences such as classification of epilepsy & their survival models. In this paper, we proposed a method in terms quantifying results of EEG signals through entropy based statistical analysis.

We propose a technique towards quantifying these signals by using information theoretic approach. The proposed methodology utilizes information theoretic approach associated with EEG recordings of epilepsy in developing a model with enhanced inferences with respect to measure the EEG signals.

II. PROPOSED TECHNIQUE AN INFORMATION THEORETIC APPROACH

Shannon presents a general theory for measuring the transformation of information from source to destination across a noisy channel. This theory is known as Information theory.

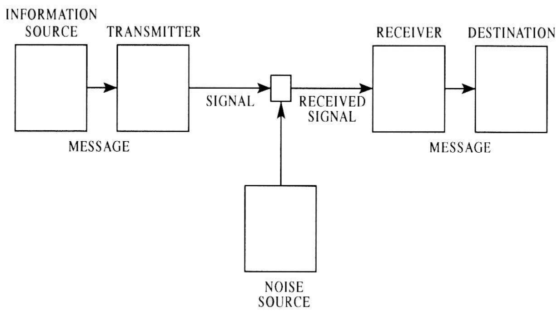

Fig 2.1 Shannon's general communication system

Information theory can be used as an important tool for quantifying the communication of information by neurons. Now the question arises how is the brain processing information? Our central nervous system enables us to interact with our environment in a remarkable way in spite of continuously changing conditions. The information is processed in different stages. Input is received through various senses, external objects are recognized, and memorized, retrieved and new information is integrated into existing knowledge. This information is then available for planning and executing actions.

In computational neuroscience, Information theory quantifies how much information a neural response carries about stimulus. Information theoretic methods have been widely used to analyze and understand the fundamental information processing task performed by the brain. The concept of Entropy is used as a main measure for quantifying the amount of information transmitted between neurons, via spike trains generated by neurons. This measurement is totally depends on the distribution of sensory inputs.

The number of variable may be large which leads to different complexities and dealing with such complexity is always a challenge. Further as these responses can vary from trial to trial, person to person, this further increases the diversity & variability of this bio-physical process. The randomness associated with this variability affects neuron & other cognitive process. So that we are proposing a technique to quantify the EEG signals.

III. SCOPE OF PROPOSED WORK

To define clearly our objective & scope we have to first explain about the behavior of neurons. In order to investigate information processing in the brain we need to be familiar with the structure of the nervous system. The nervous system is comprised of an enormous number of neurons, which are highly connected. A neuron in turn consists of a cell body, a dendrite tree and a single axon. The axon is long in comparison to the other parts of the neuron and predominantly connects to the dendrite trees of many downstream neurons. We know that the nervous system represents time dependent signals in sequences of discrete, identical action potentials or spikes; information is carried only in the spike arrival times. In such situations the output of the neuron is completely characterized by the temporal train of spikes that the neuron emits. Likewise, the output of a population of neurons is fully described by the simultaneous spike trains of these neurons.

The behavior of spike trains can be analyzed with the help of EEG. An EEG recording remains a major source for analyzing epilepsy disease in the human being. EEG stands for Electroencephalogram. It senses electrical impulses within the brain through electrodes placed on the scalp and records them on paper using an electroencephalograph. It is a recording of brain activity, which is the result of the activity of billions of neurons in the brain. EEG can help diagnose conditions such as seizure disorders, strokes, brain tumors, head trauma, and other physiological problems.

As the area of Computational Neuroscience is very vast and can be applied in different areas & problems. However, we will be confining our study to the objective discussed in previous paragraph. Further, the scope of project is not limited to quantifying the information in spikes but to the areas like competitive learning, decoding & encoding of stimulus variance, rate of spike train, analysis of neural spikes & different simulation methods.

The objective of the proposed study is to apply a measure to quantify the information passed from neuron through the spikes to the brain. Different information theoretical framework based on entropy will be applied on the behavior of a spike train for a particular Disease/Phenomenon. Based on the parametric estimations and quantification received from such pattern will be tested for different trials and a comparative study will be done to draw a conclusion.

IV. CONCLUSION

In the proposed work we have introduced the information theoretic measure based on entropy to quantify the neural activity during epilepsy. The proposed measures are shown to be effective to quantify the type of seizure based on mathematical framework over times as well as determining the difference between cognitive states. As the area deals with the randomness and unpredictable behavior present in the process. No single or a particular framework can be suitable for finding out the new information from the spike trains or the patterns.

If EEG analysis would be more widely used in clinical practice, new properties will have to be taken into consideration, such as the development of large data sets for EEG analysis. One of the difficulties encountered in such a study concerns the lack of published objective comparisons between the different techniques available for EEG classification. Visual inspection of scalp recordings of these events is often troublesome because the signal is obscured by muscle artifacts. The proposed work uses entropy leading to a much better, accurate and closed model for capturing the real behavior of the spikes.

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