DOI: 10.21917/ijsc.2011.0027

INTELLIGENT EEG ANALYSIS

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Abstract
Brain is the wonderful organ of human body. It is the agent of information collection and transformation. The neural activity of the human brain starts between the 17th and 23rd week of prenatal development. It is believed that from this early stage and throughout life electrical signals are generated by the brain function but also the status of the whole body. Understanding of neuronal functions and neurophysiologic properties of the brain function together with the mechanisms underlying the generation of signals and their recording is, however, vital for those who deal with these signals for detection, diagnosis, and treatment of brain disorders and the related diseases. This research paper concentrated only on brain tumor detection. Using minimum electrode location the brain tumor possibility is detected. This paper is separated into two parts: the First part deals with electrode location on the scalp and the second part deals with how the fuzzy logic rule based algorithm is applied for estimation of brain tumor from EEG. Basically 8 locations are identified. After acquiring the pure EEG signal Fuzzy Logic Rule is applied to predict the possibility of brain tumor.

Keywords:
Brain, Brain Tumor, Electroencephalogram (EEG), Electrooculogram (EOG), Fast Fourier Transform (FFT), Fuzzy Logic, Fuzzy Controller

1. INTRODUCTION

The living brain produces a continuous output of small electrical signals, often referred to as brain waves. The recording of these signals called an electroencephalogram (EEG) is the summation of all post synaptic potentials of neurons in the cerebral cortex. [1]. The amplitudes of these signals are so small that they are measured in microvolt which is millionths of a volt or thousands of a millivolts.Though they are small, the signals can be accurately detected and recorded. [2]. The patient presents with focal or diffuse neurological symptoms and signs, disturbance of the alpha rhythm may be observed. Slowing of the alpha rhythm ipsilateral to a tumor is more common and significant than asymmetry of amplitude. However, disturbance of alpha rhythm depends on the site of the tumor [3]. An electroencephalograph is the instrument that generates a record of the electrical activity of the brain by measuring electric potential using electrode attached the scalp. Alpha waves are detected at the eight electrode positions indicate by O1, O2, C3, C4, F3, F4, T3 and T4. O is for Occipital is for Central is for Frontal and T is for Temporal [4]. Electroencephalograms (EEGs) are becoming increasingly important measurements of brain activity and they have great potential for the diagnosis and treatment of mental and brain diseases and abnormalities. With appropriate interpretation methods they are emerging as a key methodology to satisfy the increasing global demand for more affordable and effective clinical and healthcare services.

Developing and understanding advanced signal processing techniques for the analysis of EEG signals is crucial in the area of biomedical research. This paper focuses on these techniques, providing expansive coverage of Fuzzy algorithms and tools from Matlab [5]. The pattern of electrical activity obtained from the EEG signal is chiefly valuable as well utilized to examine other conditions that might affect brain function, like head injuries, brain tumors or bleeding on the brain (hemorrhage).

One important application of EEG signals is the detection of brain tumors. Brain tumor is the uncharacteristic growth of cells inside the brain or the skull that can either be cancerous or non-cancerous [6]. A very important aspect in clinical practice is the early detection and classification of brain tumors. Several researchers have proposed assorted techniques for the classification of brain tumors based on varied sources of information [7, 8, and 9]. Diagnosis of brain tumor in most cases necessitates experienced physicians and is a nontrivial, time-consuming task, irrespective of the techniques established thus far for the extraction of information, analysis and visualization of EEG [10].

This research paper is an enhancement of our previous work [20] that performed brain tumor detection in EEG signal using Support Vector Machine. Here, we present an efficient system to perform early detection of brain tumors from EEG signals, with the aid of matlab Fuzzy tool. The proposed research makes use of the Fuzzy Controller has proved largely to provide better performance in performing low signal identification from EEG signal. Generally, EEG records bear information about abnormalities or responses to certain stimuli in the human brain. In addition, EEG signals are extremely contaminated with an assortment of artifacts. Artifacts in EEG records are caused by various factors, like line interference, EOG and ECG (electrocardiogram). These EEG artifacts augment the intricacy of EEG analysis and thus hinders in obtaining effective clinical information. The aforesaid problem necessitates a preprocessing step that removes artifacts in EEG records. To start with, the proposed research employs electrode location to detect the alpha waves from the scalp. The set of 8 signals are extracted from the scalp and fed into the fuzzy controller. With organized rule based fuzzy logic controller to predict the low signal. Once the low signal is identified there is a clear idea how much percentage is possible of primary tumor. The proposed system enables the early detection of brain tumors in the EEG signals.

The paper is organized as follows: In Section II, the proposed system for detection of brain tumors from EEG signal using Fuzzy Logic is detailed. Section III presents the experimental results of the proposed system and section IV sums up the conclusion.

2. PROPOSED SYSTEM FOR BRAIN TUMOR DETECTION IN EEG SIGNALS

An extensive survey over the literature [7, 10, 17] shows that there have not been a lot of effectual schemes for brain tumor

detection from EEG signals probably because of a number of difficulties,

1. Symptom variability among diverse subjects and exhibition of varied brain electric behavior for different lesions
2. Symptoms being most reliable under gliomas and less obvious under brain stem tumors
3. Slow waves

Fuzzy Logic (FL) has been extensively utilized as pattern and statistical classifiers in biomedical engineering [REF]. A graph that defines how each point in the input space is mapped to membership value between 0 and 1. Input space is often referred as the universe of discourse or universal set (u), which contain all the possible elements of concern in each particular application. Suppose we have a set of heavy weight people ranging 80-200 kg in weight. In this case the universe of discourse is the weight (80-200kg). We might say that people heavier then 80kg are heavy. But such distinction is clearly absurd, as it is not clear that by what degree one is heavier then other. The right way of defining the set of heavy people will be the graphical representation, showing a smooth varying cure that passes from not heavy to heavy [11]. The output axis is a number known as membership value, between 0 and 1.The transition from non heavy to heavy is known as membership function, and is often given designation (μ). Both people can heavier to same degree, but one significantly heavy then other. This is formed by the combination of straight lines. The function is name as "trimf" .We considers the above case i.e. fuzzy set Z to represent the "number close to zero". So mathematically we can also represent it as

$$\mu z(x) = \begin{cases} 0 \text{ if } x < -1 \\ x + 1 \text{ if } -1 \le x < 0 \\ 1 - x \text{ if } 0 \le x < 1 \\ 0 \text{ if } 1 \le x \end{cases}$$

The proposed research devises an efficient and automated brain tumor detection system for EEG signals, by employing Fuzzification and Defuzzification. The proposed research is composed of three phases namely; 1) Brain Tumor Symptoms, 2) Electrode Location and 3) Brain tumor detection using Fuzzy Logic. Primarily, symptoms are identified from the EEG Signals by means of literature survey. Subsequently, electrode locations are identified. The clean or artifact removed EEG signal attained is fed to the fuzzy controller for organized controller. Based on the degree of signal, the fuzzy controller algorithm accurately identifies those EEG signals with abnormal signals, indicating the presence of brain tumor.

2.1 BRAIN TUMOR SYMPTOMS

An EEG (electroencephalogram) is a test that records the electrical activity in the brain. Brain cells create tiny electrical impulses for communicating with each other. The EEG picks up these impulses through tiny wires (electrodes) placed on your scalp. The impulses are amplified and digitally recorded by a computer. The recordings look like wavy lines (sometimes called brain waves). An EEG may be done when you are awake, asleep, or both. A brain tumor is a mass of abnormally growing cells in the brain or skull. It can be either benign (noncancerous and unlikely to spread) or malignant (cancerous and likely to spread). Whether benign or malignant, all brain tumors are serious because a growing tumor eventually will compress and damage other structures in the brain. There are two categories of brain tumors: primary and secondary. Primary tumors start in brain tissue, while secondary tumors have spread to the brain from another area of the body. The symptoms of a brain tumor often are the same as those of other diseases and also may develop gradually, so they often are overlooked for a long time before diagnosis. Although a brain tumor rarely causes headache, headaches in someone with no previous history of them should be evaluated by a professional. Headaches from a brain tumor tend to be worse upon waking and ease during the day. Other symptoms of brain tumor include:

- Vomiting and nausea.
- Seizures
- Weakness in the arms or legs
- Speech difficulties or changes
- Lack of coordination while walking
- Changes in vision or abnormal eye movements
- Drowsiness Memory or personality changes
- Slow Waves

The specific symptoms of a brain tumor depend on its size and location within the brain. They can be caused by a number of factors, including: Increased pressure inside the skull Damage to vital tissue Swelling and fluid buildup (edema) around the tumor Hydrocephalus, sometimes called "water in the brain," which results when the flow of cerebrospinal fluid is blocked and builds up in the brain [10].

2.2 ELECTRODES LOCATIONS

Generally EEG signal is acquired with the help of standard 12 or 24 electrodes. More no. of EEG frequency bands are available (Delta 1-4 Hz; Theta 4-8Hz; Alpha 8-13Hz; and Beta 13-40Hz). Particularly alpha wave is considered. There are eight locations are identified from scalp.

The proposed system employs Fast Fourier Transform (FFT) for signal Analysis used to determine the frequency of a signal.

$$F(\text{Hz}) = 1/\ t(\text{sec})$$

$$F(w) = \int_{-\infty}^{\infty} x(t) e^{iwt}\, dt$$

where $$x(t) = \int_{0}^{\infty} A \sin 2\pi f_0(t)$$

$$t = t + t_0$$

The absolute band power for prominent EEG spectral bands (Delta: 1-4 Hz, Theta: 4-8 Hz, Alpha: 8-13 Hz and Beta: 13-30 Hz) is computed following the application of the Fast Fourier Transform [12]. By the time the patient presents with focal or diffuse neurological symptoms and signs, disturbance of the alpha rhythm may be observed. Slowing of the alpha rhythm ipsilateral to a tumor is more common and significant than asymmetry of amplitude. However, disturbance of alpha rhythm depends on the site of the tumor. The more posterior the

location, the more alpha tends to slowed, nonpersistent, or disturbed by admixed theta waves. Rarely, the alpha rhythm also may fail to block to eye opening on the side of the neoplasm. There are 8 locations are identified like O1, O2, C3, C4, F3, F4, T3 and T4 for Alpha wave detection.

2.3 BRAIN TUMOR DETECTION USING FUZZY CONTROLLER

In the proposed research, effective estimation of brain tumors from EEG signals is accomplished by an FC Fuzzy Controller. Traditional control systems are based on mathematical models in which the the control system is described using one or more differential equations that define the system response to its inputs. Such systems are often implemented as "proportional-integral-derivative (PID)" controllers [14]. They are the products of decades of development and theoretical analysis, and are highly effective.

If PID and other traditional control systems are so well-developed, why bother with fuzzy control? It has some advantages. In many cases, the mathematical model of the control process may not exist, or may be too "expensive" in terms of computer processing power and memory, and a system based on empirical rules may be more effective. Furthermore, fuzzy logic is well suited to low-cost implementations based on cheap sensors, low-resolution analog-to-digital converters, and 4-bit or 8-bit one-chip microcontroller chips. Such systems can be easily upgraded by adding new rules to improve performance or add new features. In many cases, fuzzy control can be used to improve existing traditional controller systems by adding an extra layer of intelligence to the current control method. Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

In the proposed system EEG signals are categorized into five, VERY LOW, LOW, MEDIUM, HIGH, and VERY HIGH. The signal corresponding to possible cases of brain tumor. For testing, the input to the Fuzzification The fuzzy rule based system examines the EEG signals based on the amplitude and if any one signal gets reduced immediately tumor in the EEG signal, or else not.

2.3.1 Fuzzy Rule Based System:

In the real world, variables are measured in numerical values. In a fuzzy logic system, the numerical values have no significance and so these values cannot be used. Hence in a fuzzy logic system, Crisp inputs are to be converted into fuzzy variables for further processing. Thus, the process of converting a fuzzy singleton into a membership grade one or more fuzzy sets is termed as fuzzification.In this proposed research the alpha wave is considered. The range of alpha wave is 8-13 Hz. The implication is given below (Fig.1).

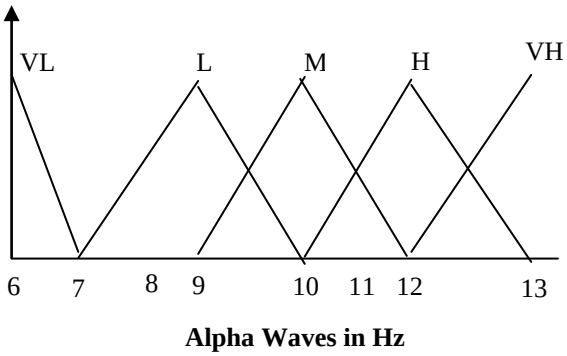

Fig.1. Structure Fuzzy Logic Implication

Here, the alpha wave is described by five fuzzy sets VERY LOW, LOW, MEDIUM, HIGH and VERY HIGH. At the instant of measurement, when the fuzzy logic system is actually put into the operation, the signal frequency is say 9.8Hz. As can seen from Fig.2 this crisp input variable has a membership grades will be used in the fuzzy logic Processing system and no significance will be attached to the crisp value of 9.8 Hz.

2.3.2 Fuzzy Inference Engine:

Inference engine mainly consists of two sub-blocks, namely fuzzy rule base and implication and it is shown in (Fig.2).The inputs, which are now fuzzified, are fed into the inference engine and the rule base is then applied. The output fuzzy sets are then identified using fuzzy implication method.

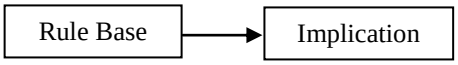

Fig.2. Fuzzy Implication Method

The heart of the fuzzy logic system is the rule base. The rule base consists of a set of fuzzy propositions and is derived from the existing knowledge of the system. A fuzzy proposition or a statement establishes a relationship between different input fuzzy sets and output fuzzy sets. A conditional propositions is one that is qualified by if statement. If 8 inputs is LOW then the output is HIGH. If anyone input is LOW then the Output is MEDIUM. This implication method is used with the system where input and output fuzzy sets are more than one. Thus the rule base has several propositions. It is important to mention that this implication method has to be compulsorily followed by defuzzification procedure. After fuzzy implication, output fuzzy region is located. The extraction of the numerical vale corresponding to the output from the output fuzzy region is termed as defuzzification. A few important and commonly employed defuzzification methods are given below.

1. Centre of gravity method
2. Centre of sums method
3. Centre of largest method
4. Height method

In this proposed method centre of gravity method is used.

3. EXPERIMENTAL RESULTS

The results obtained from experimentation of the proposed system are presented in this section. The proposed system is

programmed in Matlab 7.5. The proposed system takes as input an EEG signal recorded from the patients. EEG signals in figures 3 & 4 represent the signals obtained with and without brain tumor respectively.

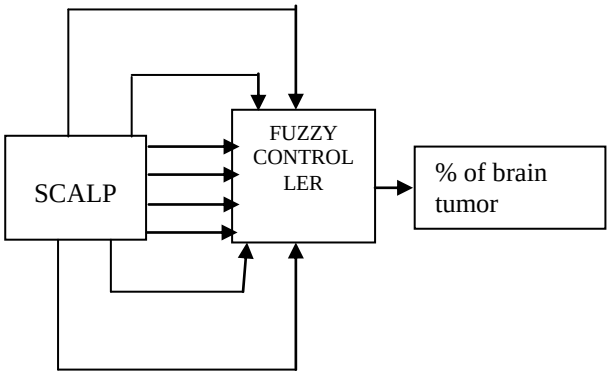

Fig.3. The Proposed System

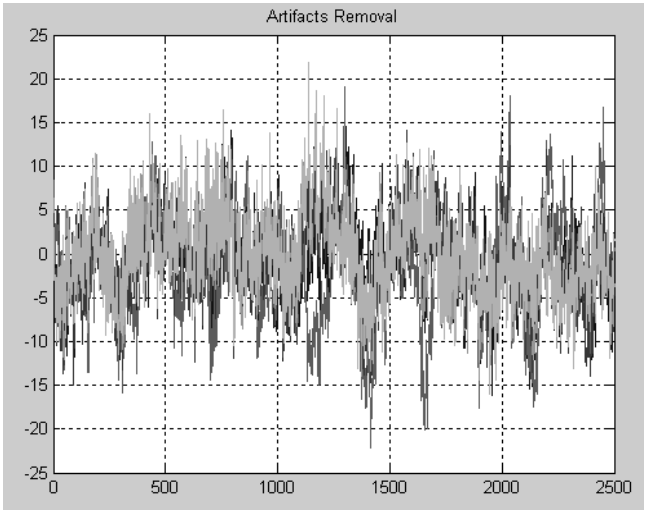

Fig.4. Artifacts removed EEG signal

The clean data obtained is fed as fuzzy input to the fuzzy controller. The experimental results portray the effectiveness of the proposed system in detection of brain tumor from the EEG signals.

As shown in Fig.4, one important aspect of any system devised for clinical diagnosis is its ability or rate of accurately detecting the presence or absence of a medical phenomenon. The proposed system was evaluated with 325 samples of EEG data recorded from patients of which, 163 samples. Correspond to EEG data with brain tumor and the remaining 162 samples correspond to EEG data without brain tumor. The fuzzy implication employed with those 325 samples of EEG data. For every input five membership function is given. Nearly 65,536 rules are implemented. Once the input is given the corresponding rule is fired and estimate the % of brain tumor. If all signals are low that is less than 8 Hz. The expected tumor level is given in Fig.5. From Fig.5 if all signals are less than 8 Hz the expected brain tumor is 68.9%.

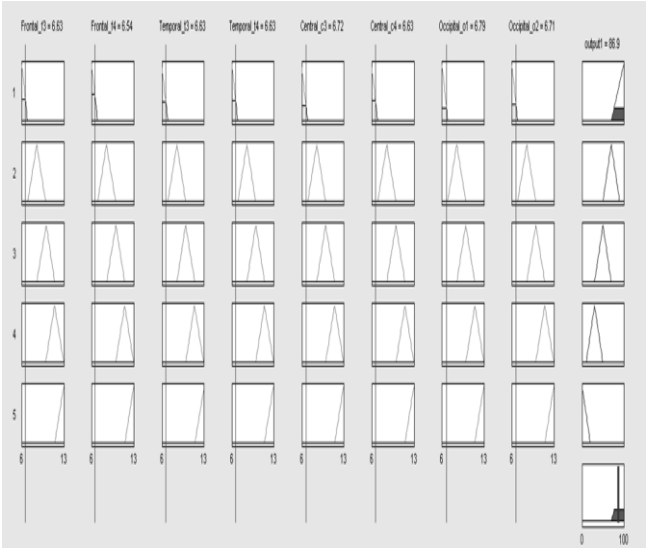

Fig.5. Fuzzy Rule Implementation

4. CONCLUSION

In this research paper, we have devised an automated system for efficient detection of brain tumor in EEG signals using fuzzylogic. The proposed system has taken an EEG signal as input. Firstly, the inputted EEG signal is subjected to artifacts removed. Subsequently, the FC employed, the triangular membership function is used. Finally, when a EEG signal is fed as input, the fuzzy controller detected the presence of brain tumor percentage in the EEG signal. The experimental results have demonstrated the effeciency of the proposed system to perform brain tumor detection.

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