Interpretation Of Eeg Recordings For The Purpose Of Diagnosing Stroke Disease

Igwe J. S., Inyiama H.C., Alo U.R., Ajah I.A.

Abstract: The increasing number of deaths related to stroke diseases in Nigeria is growing at an alarming. This can be attributed to poor diagnosis as well as lack of financial power to administer and undergo appropriate test as may be recommended by the physician. Most of the neurologists (experts) lack high-tech tools that are supposed to be assisting them in diagnosing and treatment of stroke diseases. The scarcely available tools such as Computerized Axial Tomography (CAT), Magnetic Resonance Imaging (MRI), and Positron Emission Tomography (PET) are expensive for most of the patients to access. In this research, EEG which should be a more affordable and effective way of diagnosing stroke disease that will help to mitigate the death rate of stroke patients in Nigeria are suggested and advocated for. A survey was carried out to ascertain the possibility of interpreting the result of EEG recordings to the patient or ordinary person. Questionnaire was designed and distributed to scholars in computer science, computer related fields of study and medical sciences. Brain signals were captured using Brain Computer Interface (BCI) machine. The result was then interpreted using Visual Studio 2012. The result suggests need to scale up the awareness on the benefit of EEG with special emphasis on diagnosis and treatment of stroke disease.

Keywords: Artificial Neural Network, Brain - Computer Interface, Brain Signals, Diagnosis, Electroencephalogram, EEG Recording, Interpretation and Signal Classification

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INTRODUCTION

This paper was written to support the fact that EEG signals recorded from human brain can be an essential ingredient in diagnosis or prognosis of stroke disease in an individual. The number of people affected by stroke in Nigeria is increasing in an alarming rate. There is no gainsaying the fact that the dwindling level of economic development perhaps is a contributing factor to this ugly incidence. The bulk lies on the table of stroke specialists who are always surrounded by the overwhelming number of stroke patients. There is a need to look for solution in order to assist these neurologists attends to the waiting number of patients. Also, the cost of popular methods of diagnosing stroke currently, which include Computerized Axial Tomography, Magnetic Resonance Imaging, is too high for everybody to afford. Though they are popular, they are not easily accessible as they may be situated far away from the point reference. This becomes more problematic when the patient's condition has deteriorated and he or she is expected to travel along distance for any of these scans. One way to move forward and salvage this situation is to use electroencephalography recordings called electroencephalogram (EEG) signals to aid the diagnosis. The EEG machine is portable, simple and cheap. It provides functional value to different brain parts and still useful in determining other body functions such as oxygen circulation in the blood and heart beat rate. This research is to address: (i) Increasing cases of stroke patients especially in Nigeria (ii) Inadequate Equipment for effective diagnosis of stroke diseases especially the one based on the EEG signals generated by the patients (iii) The deficiency of most patients communicating to the neurologists when critically ill in order to ascertain the level of their consciousness.

- *1, 2, &3: Computer Science Department, Ebonyi State University, Abakaliki, Nigeria.*
- **Author with Correspondence*
- *Email: igwejoesun@yahoo.com*

The main aim is to investigate the possibility of interpreting the EEG result as a yardstick for diagnosing stroke disease for the purpose of ascertaining the level of consciousness of the patient. This paper want to bring out the point that the EEG recordings can be further interpreted using other platforms such Microsoft Visual Studio 2012 Edition.

EEG Wave Bands Features

The EEG signal is classified into five distinct frequency bands based on the properties exhibit. In the order of frequency level, they include Delta (δ), Theta (θ), Alpha (α), Beta (β) and Gamma (γ). The major frequencies presences in human being depending on the state of alertness are Delta, Theta, Alpha and Beta". [1] Discussion below highlighted the properties and implications of the different categories of the EEG signalsDelta Wave: this type of wave is generated from the thalamus section of the brain. It has a frequency range between 0 to 3.5 Hz. Its amplitude can be as high as 200μV. The speed is the slowest when compare to other wave bands. Delta wave is observed in the deep stage of sleeping. That is, it is noticeable in stage 3 and 4 of sleep. It is prominent in the posterior part of brain in children. This wave is normal in infant within one year of age. Delta frequency of 1 or 2 Hz is dominant in someone in coma or under anesthesia. Therefore, it is abnormal to found EEG wave less than 3.5Hz. Theta Wave: this frequency range is generated by the hippocampus and neo-cortex part of the brain. The frequencies that are visible under this category lie between 3.5 Hz to 7.5 Hz. The maximum amplitude is 100μV. Theta also has slow activity. It is always linked to drowsiness, childhood, and adolescence. Theta wave is ordinary in children and when sleeping by an adult. However, it is abnormal in adult when in an awaked state. Alpha Wave: this is also called Berger's wave. [1] It can be acquired from the thalamus fraction of the brain. Its ranges cover 8 Hz to 13 Hz with highest amplitude of 60μV. It is the major pattern generated by a relaxed adult. It is present throughout life and more dominance after 13 years. The intensity of alpha wave increases when eyes are closed and are relaxing but disappear when opening the eyes or alerting by action like thinking or computing. In short, it indicates the state of

alertness or consciousness. Beta Wave: beta wave emanates from Cortex part of the brain. The frequency is between 13 Hz and 30 Hz. The amplitude is just 20μV maximum high. It is a fast activity wave with normal rhythm. Beta is dominant with an individual who is on alert, anxious or have eyes open. Gamma Wave: these are frequencies above 30 Hz. The amplitude is of lowest values ranging from 3μV to 5μV. Gamma wave exhibits almost the same characteristics as beta wave. Its presence informs sign of deep meditation, stream of consciousness, and advanced Learning.

Usefulness of EEG in Stroke Treatment

Qiaquinto, Cobianchi, Macera, & Nolfe researched on the usefulness of capturing EEG signals in cases of people that suffered stroke attack. They are of the view that the EEG has been investigated in stroke patients with more emphasizes on the acute phase of the attack. The characteristics appear to differ with the clinical state after recovery. However, they supported that the EEG study in the acute stage could be valuable [2] EEG can be helpful technology for sensitive discovery and monitoring of the affected tissue [3]. Accurate description of stroke-related structural EEG changes is based on sufficient spatial sampling density. EEG may increase the usefulness of information for clinical and imaging-based outcome predictions. This will improve the selection of patients for treatment [4]. The available evidence supports the view that EEG enhances the value of early diagnosis, outcome prediction, patient selection for treatment, clinical management and neurological examination and imaging studies. Home-based robotic technologies may offer the possibility of self-directed upper limb exercise after stroke as a means of growing the intensity of rehabilitation or treatment [5] All these suggest that computer technology especially EEG is veritable technology in the area of medicine particularly in diagnosis and treatment of people suffering from stroke attack. [6]

Research Question and Hypothesis

The research question that guided us in this work is stated thus: Question: How can the result of EEG signal recorded from the brain be interpreted to a layperson? This question led to the formulation of this hypothesis.

H0: Result of EEG signal recordings cannot be interpreted to a layperson using Visual Studio as a platform.

H1: Result of EEG signal recordings can be interpreted to a layperson using Visual Studio IDE.

Data Collection Techniques and Materials

The primary source of data collection for this research is through the signals acquired using the EEG machine. Sample signals were obtained from two subjects. The first was obtained from a male as a control subject (someone who is not under brain attack). The second data was obtained from female stroke patient in the hospital. Also, a questionnaire was used to ascertained people's opinion on the possibility of interpreting EEG recordings. The materials used in each EEG capturing are: EEG-BCI Machine, Computer System, Methylated Spirit, EEG Cap, Skin Preparation Gel, Amplifier, 25 Electrode Plates, 2 EKG Stickers, Jack Box, Cables, Balanced Chair and Elevated Bed.

EEG signals were captured at FP1, FP2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T3, T4, T5, T6, C and SPO2 scalp sites according to the international 10/20 system. The background activity electrode was located at the O1 and O2 site. The EEG signals were filtered (0.5–40 Hz band-pass filter) and amplified. The signals were digitized. The sampling rate was 60 Hz with the amplitude of 100μV. The EEG signal was analyzed and classified using MATLAB version R2013a /Neural Network Kits (Mathworks Inc., USA). An interactive Application Program Interface (API) was developed using Microsoft Visual Studio 2012 Edition. This serves for the purpose of interpreting the outcome of EEG recording. During the capturing, it was observed that the participants were generating signals in waveform that were displayed on the computer screen. Finally, the data was analyzed and classified according to the frequency each subject generated.

Procedure for EEG Recordings

1. Set up the equipment connection using cables in the order of electrodes (EEG cap equipped with electrodes) ➔ jack box ➔ amplifier ➔ BCI machine ➔ computer system (screen).
2. The EEG technician marked area of the scalp to place the electrodes.
3. Technician will rub the scalp area with methylated spirit.
4. The technician will now fix the electrodes on the scalp using gel or cream. Also, he/she may wear the subject EEG special cap.
5. An amplifier connected to the electrodes, will boost the signals and transmit it to computer system.
6. For better recording, the subject is laid on a bed or sat in a comfortable chair.

Questionnaire Analysis and Result

The analysis of the data is among the discussion under data analysis using simple percentages as our descriptive measure. The researcher distributed a total of 90 copies of questionnaires and 81 were completed and returned. The gathered data is as shown in the tables below in agreement with the questions asked in the questionnaire.

Questionnaire Analysis

Table 1: *Respondents view on whether EEG recordings can be interpreted using Microsoft Visual Studio platform*

Opinion	Frequency	Percentages
Strongly Agree	30	37.04
Agree	30	37.04
Neutral	6	7.41
Disagree	6	7.41
Strongly Disagree	9	11.10
Total	81	100

From the table 1 above, 30 respondents representing 37.04 percent strongly agreed that EEG recordings can be interpreted to give a better understanding to an ordinary or stroke patient; 30 respondents representing 37.04 percent agreed; 6 respondents representing 7.41 percent were

neutral; 6 respondents disagreed while 9 of them strongly opposed the idea.
This implies that there is a need to intensify research effort in towards this direction for such idea to materialize. This is illustrated using a chart in figure 1.

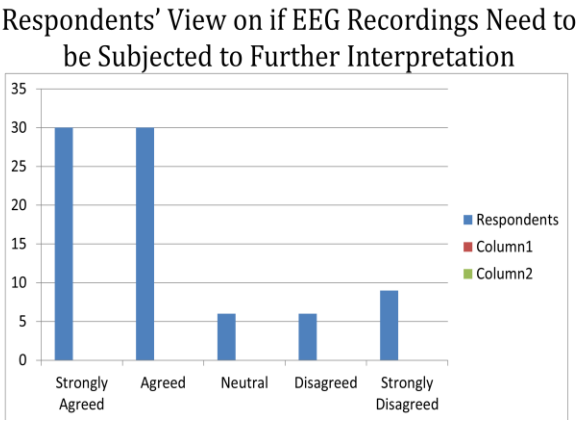

Figure 1: *Response on EEG Technology making Stroke Diagnosis Easier*

Judging by the outcome of the questionnaire illustrated in table 1, though over 74 percent agreed on the possibility of further interpretation, over 18% of the respondents disagrees that EEG recording cannot be further interpreted using Microsoft Visual Studio 2012 platform. This implies that they were not knowledgeable enough in this problem focus and need to be guided. This motivated us to go ahead to carry out this research.

Testing of Hypothesis
Testing Hypothesis :
H0: Result of EEG signal recordings cannot be interpreted to a layperson using Visual Studio as a platform.
H1: Result of EEG signal recordings can be interpreted to a layperson using Visual Studio IDE.

Table 3: *Chi-square Values for Hypothesis 1*

Variables	Observed Frequency(O)	Expected Frequency(E)	$(O-E)^2$	$\frac{(O-E)2}{E}$
Agree	60	27	1089	40.333
Disagree	15	27	144	5.333
Neutral	6	27	441	16.333
Total	81	81	1674	20.667

Note: Chi-Square formula is given as follows: $X^2 = \frac{\sum(O-E)^2}{E}$ where
$\sum = summation$
O = Observed Frequency
E = Expected Frequency
DF = Degree of Freedom = 3 -1 = 2
Alpha Level (Level of Significance) = 0.05
Critical value X^2 based on Chi Square table = 5.991
Computed X^2 value = 20.667
Decision:
Due to the fact that computed value of X^2 value (20.667) is greater than the Critical (Table) value (5.991), the null hypothesis was rejected and accepts the hypothesis which postulates that: Result of EEG signal recordings can be interpreted to a layperson using Visual Studio IDE.

EEG Result Interpretation
Forms were designed in VB.NET IDE using Visual Studio platform. While one form was purposely designed for interpretation, another one provides more information on characteristics of different EEG waves that can be obtained from individual. For the interpretation form, there is a section for accepting the frequency value obtained during recording and the alert state of subject during the experiment. Another section contains a Rich Textbox used for displaying the interpretation result. See figure 2 for better description.

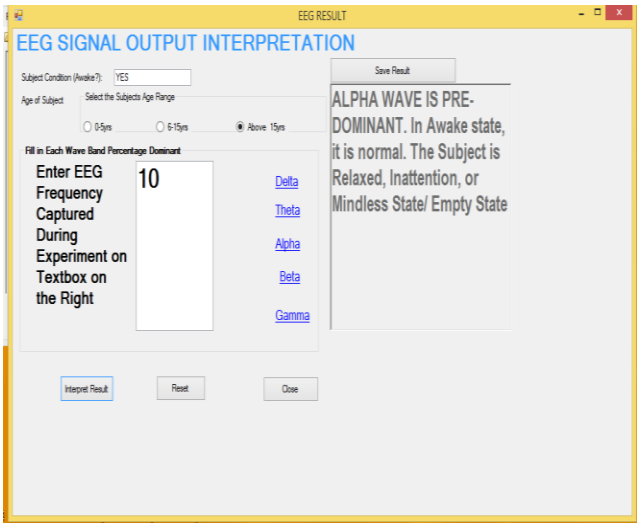

Figure 2: *EEG Recording Interpretation*

Also, Figure 3 is used to demonstrate how more information about the EEG waves was implemented.

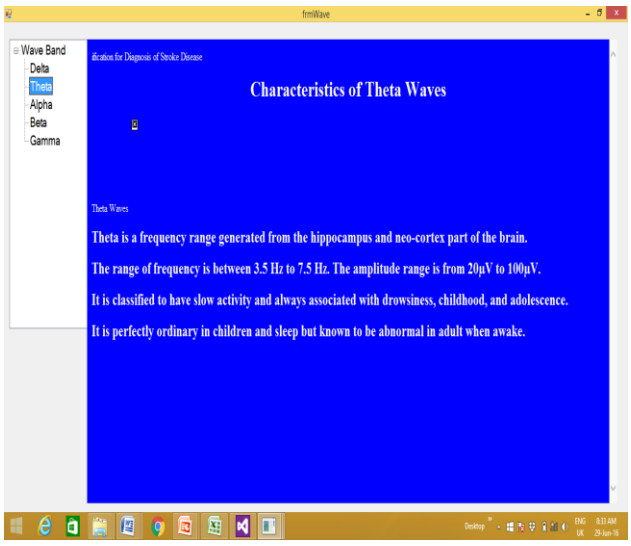

Figure 3: *Sample of EEG Wave Description Form as Implemented in VB.NET*

CONCLUSION

This study aimed at the possibility of interpreting the result of EEG signal recorded from the brain. This is necessary because it will serve as a yardstick for diagnosing and treatment of stroke disease. This is to prove how relevant EEG signals can be. [7] [8] In line with the set out objective,

this paper has adequately demonstrated how this was achieved.

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