# BRAIN COMPUTER INTERFACE APPLICATION IN STROKE DISEASE DIAGNOSIS

**Igwe J. S. [*1], Inyiama H. C. [2], Ogbu Nwani Henry [3]**
[*1, 3] Department of Computer Science, Ebonyi State University, Abakaliki, Ebonyi State, NIGERIA
[2] Department of Electronics and Computer Engineering, Nnamdi Azikiwe University, AWKA

## ABSTRACT

*Every discovery is geared towards problem solving. This is manifested by the advent of brain computer interface (BCI). Brain computer interface (BCI) is a field of study concern with the detection and utilization of brain signals in establishing the communication path between the brain and the computer system. The knowledge of this science has helped in no small measure in providing solutions to several challenges befalling man and his environment. In this paper, we explored those areas where BCI has proved useful and pointed out as well its possible application in diagnosis of stroke disease. The discourse was centered on detection of electrochemical signals from the brain called electroencephalogram (EEG). The research work also highlighted the technique of recording brain activity via electroencephalogram and using it in making deduction on the status of stroke attack on individual. This can either be normal or abnormal. The presence of delta or theta wave in an awaked adult suggests an abnormal situation. While the observance of alpha, beta and gamma waves are interpreted as normal.*

**Keywords:**
*Brain-Computer Interface (BCI), Electroencephalogram (EEG), Artificial Neural Network (ANN), Neuron, Signal Classification.*

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## 1. INTRODUCTION

A coming together of mother disciplines such as computer science, neuroscience, psychology, computer engineering, bioinformatics, human computer interaction, physiology and robotics gave birth to a new research focus known as brain computer interface. Brain computer interface is a study that detects/ captures the brain signal and translates it into a control command that the computer system can understand and execute. The feedback can as well be used to stimulate

actions in the brain. It is actually a collaboration in which a brain accepts and controls a mechanical device as a natural part of its representation of the body. Brain computer interfaces are built to restore sensory function, transmit sensory information to the brain, or stimulate the brain through artificially generated electrical signals. Earlier before now, researchers had developed Brain Computer Interfaces that decode brain activities from animals and used such devices to reproduce movements in such objects. BCI is a link and control system that does not depend in any way on the brain's normal neural based muscular output channels. [1]

All these communications are possible because of the existence of electroencephalogram (EEG) signals. Electroencephalography is the technique for measuring electrical activity around the scalp. These electrical signals are generated from the current flow between the two neurons. [2] Utilization of these signals is the stimulus that makes the study of BCI relevant. The applications cut across clinical medicine, user interface in games development, device controls for home uses and developing intelligent robots. In medicine, BCI system is used for rehabilitation and treatment, diagnosis and even in prognosis.

The brain is the part of the body located right inside the skull responsible for the emission of electrical signal. The most extensively discussed part of the brain is the neuron. The knowledge of neuron brought the major breakthrough in understanding and usage of the nervous system. There are two different kinds of neurons that constitutes the central nervous system; the sensory neurons that sends signals to the brain and the motor neurons that connects the brain to the muscles, sense organs and different areas of the brain to each other. At the center of the neuron is the cell body called the soma. Connected to the soma is the dendrite that serves as input unit for the neuron and the axon serving as the output unit. The name dendrite is derived from the Greek word "Dendron" suggesting that the shape resembles that of a tree with branches that splits into smaller parts. The number of branches increases from countable few into many thousands. The dendrite is an input connection through which all the information is send to the neuron. The ability of a neuron to differ over time makes learning process occurs.

## 2. REVIEW OF RELATED WORKS

The BCI system is an electronic device built in such way to translate the brain signals produced as a result of brain activity into an instruction in a readable format for the computer to understand and execute. That is to say, the very aim of BCI is to translate brain activity into a command for a computer. [3] BCI does not require muscular activity rather it is stimulated by the electrochemical signals produced by the brain. The system is controlled by the different brain activity signals produced by the user or subject.

### 2.1.UNDERSTANDING BRAIN COMPUTER INTERFACE (BCI) SYSTEMS

The working mechanism is organized into different sections. The discussion on the BCI components below is based on the framework of BCI as proposed by Alwasiti and others. [4] They components are Signal Acquisition, Signal Processing (Feature Extractor & Feature Translator) and the Device Controller.

**Signal Acquisition:** This refers to the units that are responsible for receiving or capturing the signals emitted from brain using the electrodes. This section is also saddle with the task of boosting the signals and filtering out the unwanted artifacts (noise). The EEG raw signals are filtered using a digital band-pass filter. The essence of boosting the signals is to upgrades the amplitude samples to meet up with certain level of power samples. The design is such that virtually all EEG amplifiers have a set of filters integrated in them. [5]

**Signal Processing:** This is made up of feature extractor and feature translator. Extractor section converts the brain signals to be in the form that it will be relevant for the system. At the end the acquired signals from all the trials are aggregated and averaged to get a smoothed signal. The translator section is used for the classification of the signals into logical controls which other machines can understand.

**Control Interface:** This converts logical controls into semantic commands. The semantic commands are changed here into physical device commands. The commands differ from one device to another depending on the application. The block diagram of figure 1 below demonstrates the flow process of BCI system

The information flow depicts a generic BCI system showing how EEG signal is processed from the user end till it gets to the control device. The users brain is used to generate the control signal that operate the BCI system. In some systems, the user is presented with a control platform that displays the signals generated by the BCI. [6]
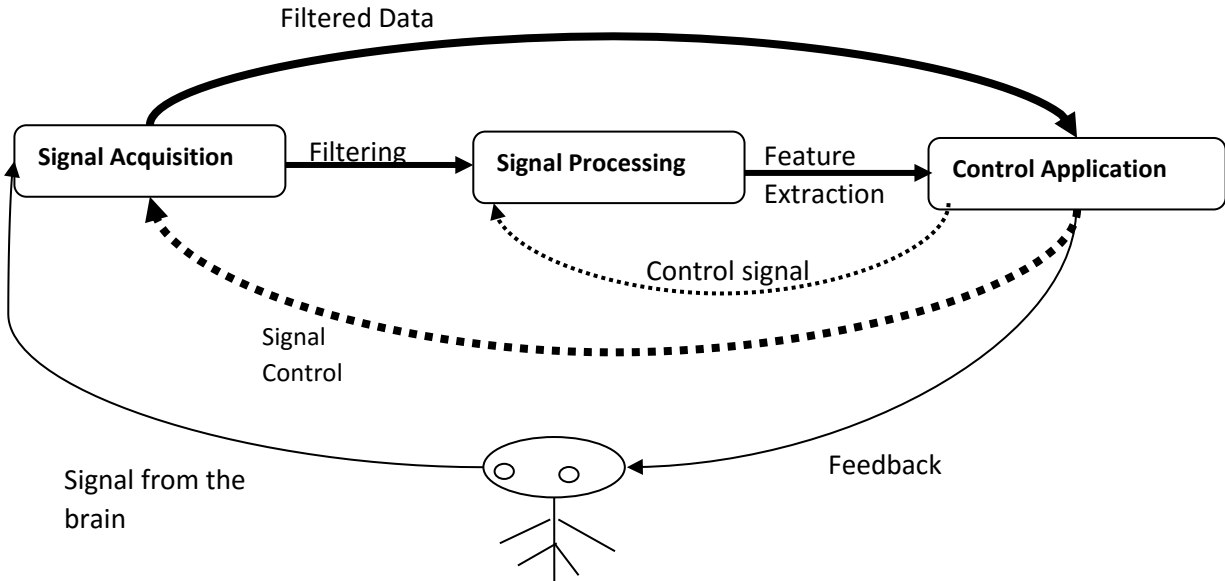


*Figure 1:* The Functional Signal Flow of a BCI System

The summary of the working mechanism of a BCI system is abridged as follows:

- Pre-processing is performed on the brain signal before the extraction of features in order to increase the signal-to-noise ratio of the signal. BCI obtains input from the human brain, mostly its electrochemical signals recorded with electroencephalography (EEG).
- This signal is filtered
- The filtered signals are classified for appropriate usages.
- After classification, the signals are transferred to an output control application. The output signals communicate the brain action of the BCI user and this can help to deduce the respective intention of the user. The user is expected to receive feedback of his or her action. BCIs involve a closed-loop between the computer system and the user. The output signal is used to control an application – in an ideal circumstance, one that meets the need of the user. [7]

The specific aspects of studies that come into play when carrying out BCI experiment include psychology, anatomy, physiology, software, hardware, feedback, and user instruction. Further description shows that anatomy, psychology and physiology research gears toward the human brain. Computer science and Engineering forms the bedrock for the BCI system. The feedback and interaction from the user through the user interface is showcase as the output through the screen or generated in form of hardcopy via printer. Table 1 illustrates the different field of study and their contributions.

*Table 1:* Areas of Specialization in BCI Experiment/Application

| Field of Study | Aspects/Units Involved | Output To |
| --- | --- | --- |
| Psychology | Concentrate attention, motivation mood, visuo-motor coordination, | Brain |
| Physiology | Self-regulation, signal amplitudes, activation of pre motor areas | Brain |
| Anatomy | Neuro-degeneration | Brain |
| **Software(Computer Science)** | **Signal detection, filtering algorithms and signal classification** | **BCI device** |
| Hardware(Computer Engineering) | Amplifier, electrodes, impedances | BCI device |
| Feed Back | Modality, dimensionality, number of targets | Monitor, Printer/plotter |
| User Instruction | Motor imagery | Output screen, Printer |

There are two major procedures adopted in measuring brain activity. They include; structural analysis that analyses the anatomy of the brain and function analysis that tries to measure and locate actual point of brain activity. Structural methods include Magnetic Resonance Imaging (MRI) and Computerized Axial Tomography (CAT). Functional Analysis methods include also Positron Emission Tomography (PET), Electroencephalography (EEG), and Functional Magnetic Resonance Imaging (FMRI). [8]

### 3. APPLICATIONS OF BRAIN-COMPUTER INTERFACE/EEG

Majority of BCI applications have been in medical field. The benefits accrued therein is too numerous as some are highlighted by different researchers quoted herein.

- Important applications of EEG wave classification are diagnosis of sleep disorders and construction of BCIs to assist disabled people with daily living tasks. Sleep staging is essential for the diagnosis and treatment of sleep disorders, which relates closely to the study of brain functions. [9]
- EEG technology is also important in monitoring the effect of particular drug on the central nervous system. "…. Technology allows you to map the activity of cortical brain areas and cortical functional connectivity before and after taking the drug. …… and can therefore provide timely and valuable information on the changes induced by the drug at the level of the central nervous system". [10]
- The knowledge of EEG measurement is also important in development of BCI machines as can be inferred from the work of Jorge Baztarrica Ochoa where he emphasized that "Most attempts to control a computer with continuous EEG measurements work by monitoring alpha or mu waves, because people can learn to change the amplitude of these two waves by making the appropriate mental effort."[11]
- EEG monitoring can help in detecting the extreme fatigue conditions and warning of its vital circumstances such as long way driving and monotonous exercise. [12]
- Also, EEG is also used to monitor blood flow in the brain during surgical procedures. [13]
- In surgery, surgeons used the measurement of EEG to determine the depth of anesthesia in patients before performing operations on them. [14]

### 3.1. A MODEL OF BCI APPLICATION IN DIAGNOSIS OF STROKE DISEASES

The BCI system being proposed for diagnosing the stroke disease will be made up of basic stages as illustrated in figure 2.
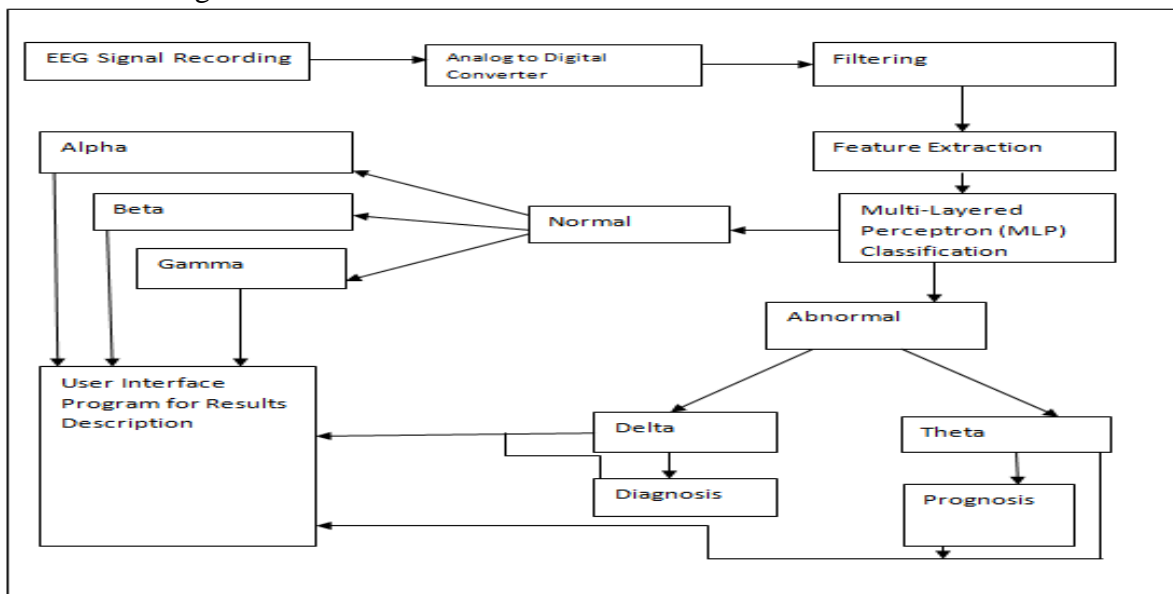


***Figure 2:*** Architectural Diagram of a BCI Based Stroke Diseases Diagnosing System

Firstly, the EEG signals from the subject's brain is captured in the analogous form and converted to digital signals by the use of analog to digital converter (ADC) embedded in the system. The digitized signals are now filtered and features extracted. The multilayered perceptron (MLP) classifier will now serve the purpose of separating the signals based on the observed characteristics (frequency). The outcome can either be interpreted as normal or abnormal depending on frequency obtained value. Table 2 summarizes the grouping for the interpretation of result.

*Table 2:* Interpretation of Stroke Diagnosis Result Based on EEG

| Category | Frequency Range (Hz) | Status | Type of EEG Wave | Interpretation |
|---|---|---|---|---|
| One | 0 to 3.5 | Abnormal | Delta (ɗ) | Delta frequency of 1 or 2 Hz is dominant in someone in coma or under anesthesia. It is observed in the deep stage of sleeping; stage 3 and 4 of sleep. It is normal in infant within one year of age. |
| Two | 4 to 7.5 | Abnormal | Theta (θ) | Theta is classified to have slow activity and always associated with drowsiness, childhood, and adolescence. It is perfectly ordinary in children and sleep but known to be abnormal in adult when awake. |
| Three | 8 to 13 | Normal | Alpha(α) | Alpha is the major rhythm observed in relaxed adults. Present throughout life especially after 13 years. The intensity increases when closing the eyes and are relaxing but disappears when opening the eyes or alerting by action like thinking or computing. In short, it indicates the alert state of consciousness. |
| Four | 13.5 to 30 | Normal | Beta(β) | Beta emanates from Cortex part of the brain. It is regarded as fast activity wave and normal rhythm. It is generally dominant in subject who is alert, anxious or have eyes open. |
| Five | Above 30 | Normal | Gamma(γ) | Many researchers argue that this band is of the group of beta waves since the exhibit the same characteristics. It is a sign of deep meditation, Stream of Consciousness,& Advanced Learning |

## 3.2. HOW THE SYSTEM WILL WORK

The stroke patient visits the doctor who is expected to be a specialist (Neurologist). He examines him and refers him to EEG radiographer for capturing the brain signals. The signals are

analyzed, filtered, classified and deductions made by the computer scientist. Figure 3 demonstrates the high level model.
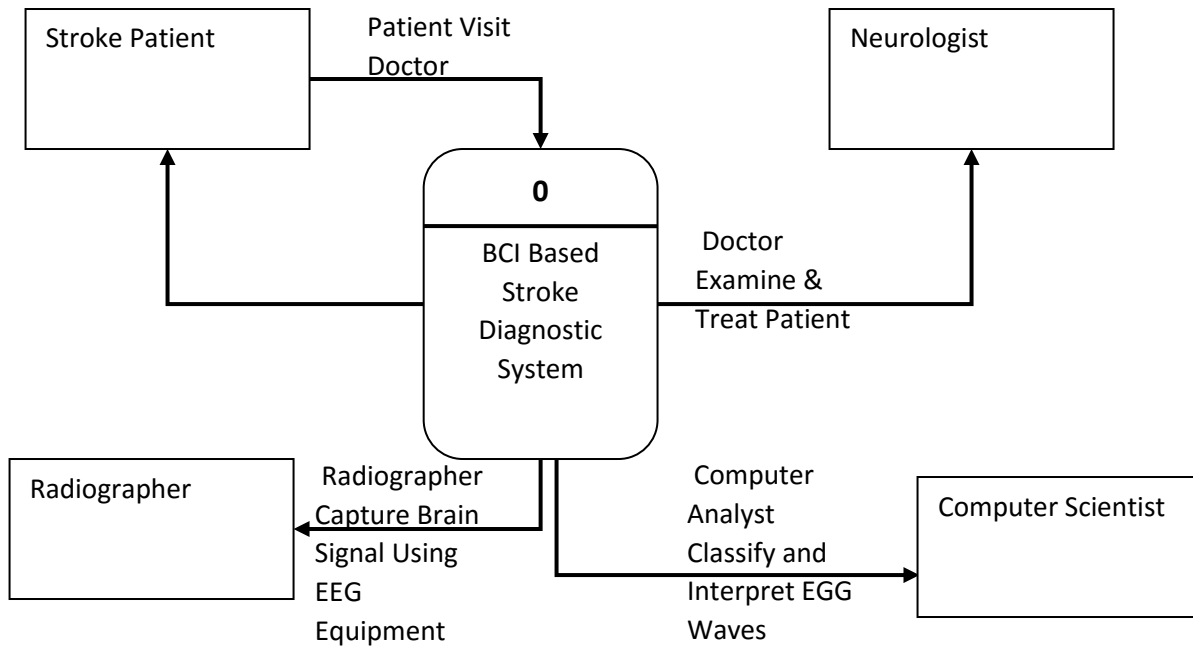


**Figure 3:** Context Diagram Depicting the High Level Model of the System

## 4. CONCLUSION

The computing world has a lot to gain from brain computer interface technology. Its ability to utilized signals from the brain as the primary data made it the number one tool for diagnosis and treatment of ailments that affects the brain or the entire nervous system. It is also a veritable tool in the development of human robotics. The application of neural network in the analyses and processing of these signals also suggested while BCI is a good ground for studying brain behavior especially while neural networks learn by examples.

## 5. *REFERENCES*

[1]  Van Erp, J. B., Lotte, F., & Tangermann, M. (2012). Brain-Computer Interfaces: Beyond Medical Applications. Computer -IEEE Computer Society-, IEEE , 26-34.

[2]  Priyan, P., Uma, M., & Prabhu, S. (2015). Analysis of Brain Computer Interface Based Robot Wheel Chair Control. International Journal of Applied Engineering Research , 171-179.

[3]  Lotte, F., Congedo, M., Lecuyer, A., Lamarche, F., & Arnaldi, B. (2006). A Review of Classification Algorithms for EEG-based Brain-Computer Interfaces. RENNES Cedex, France: PACS.

[4]  Alwasiti, H. H., Aris, I., & Jantan, A. (2010). Brain Computer Interface Design and Applications: Challenges and Future. World Applied Sciences Journal , 819-825.

[5] *Forslund, P. (2003). A Neural Network Based Brain-Computer Interface for Classification of Movement Related EEG. Linkoping: Institute of Technology Linkopins University.*

[6] *Ali, B., Mehradad, F., & Rabab, W. (2007). A Survey of Signal Processing Algorithms in Brain-Computer Interfaces Based on Electrical Brain Signals. Journal of Neural Engineering , 32-57.*

[7] *Kubler, A., Holz, E., Kafumann, T., & Zickler, C. (2013). A User Centred Approach for Bringing BCI Controlled. INTECH , 1-20.*

[8] *MACALESTER COLLEGE. (2014). What is Electro Enchephalo Graphy? Retrieved March 07, 2015, from Mac Incorporates:*
*www.macalester.edu/academics/psychology/UBNRP/Imaging/eeg.html*

[9] *Wani, M., & Gang, L. (2009). Medical Applications of EEG Wave Classification. Chance, pp. 14-20.*

[10] *SAPIENZA. (2014). Clinical Application of EEG. Retrieved March 14, 2015, from SAPIENZA BRAIN SIGNS: http:/www.brainsigns.com/en/portfolio_item/clinical-application-of-eeg/*

[11] *Jorge, B. O. (2002). EEG Signal Classification for Brain Computer Interface Applications. ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE .*

[12] *Zoshk, Y., & Azamoosh, M. (2010, May 2). The Measurement and Processing of EEG Signals to Evaluate Fatigue. Retrieved March 14, 2014, from Springer, Part of Springer Science + Business Media: http:/link.springer.com/book/eeg*

[13] *Johns Hopkins Medicine RSS. (2015). Electroencephalogram (EEG). Retrieved March 12, 2015, from Johns Hopkins Medicine :*
*http:/www.hopkinsmedicine.org/healthlibrarytest_procedures/neurological/electroencephalogram_eeg.htm*

[14] *Al-kadi, M., Reaz, M. B., & Ali, M. A. (2013, May 17). Evolution of Electroencephalogram Signal Analysis Techniques. Retrieved March 11, 2014, from MDPI: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3690072*