A Review: EEG Signal Analysis With Different Methodologies

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ABSTRACT
The encephalography has undergone massive progress during 100’s of year. The existence of electrical currents in the brain was discovered in 1875 by an English physician Richard Caton. In 1924 Hans Berger, a German neurologist, used ordinary radio equipment to amplify the brain's electrical activity measured on the human scalp. The electroencephalogram (EEG) is defined as electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media [2]. Electroencephalography (EEG) is the recording electrical activity of the brain, which is obtained by firing of neurons within the brain. The Research applications are. EEG signals in neuroscience, in cognitive science, EEG signals can be used for the psycho physiological research and EEG signals can be used for the study of the responses to auditory stimuli.

Keywords: Electroencephalography (EEG).

1. INTRODUCTION
1.1 EEG Signal
The electroencephalogram (EEG) is defined as electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media [2]. Electroencephalography (EEG) is the recording electrical activity of the brain, which is obtained by firing of neurons within the brain. EEG signals are recorded in a short time, normally for 20-40 minutes. The recordings by placing the electrodes at various positions on the scalp reading will be obtained. The EEG signal represents the brain signal as well as the status of the whole body. The group of electro biological measurements comprises items as electrocardiography (ECG, heart), electromyography (EMG, muscular contractions), electroencephalography (EEG, brain), magneto encephalography (MEG, brain), and electrogastrography.

1.2 EEG generation
An EEG signal is generated due to the currents that flow between the brain cells in the cerebral cortex region of the brain. When the neurons are activated, current flows between dendrites due to their synaptic excitations. This current generates a magnetic field and a secondary electric field. The magnetic field is measurable by electromyogram (EMG) machines and the electric field is measured by EEG systems over the scalp [2].During recording EEG signals noise can be internal (generated within the brain) or external (over the scalp).Large number of activated neurons can generate enough potential to have a recordable signal. These signals have to be amplified and process [3].

1.3 EEG recordings
EEG systems consist of a number of electrodes, differential amplifiers, filters and needle (pen) type registers [3]. The EEG signals can be easily plotted on paper. Recent systems use computers for digitization and storing purpose. For digitization sampling, quantization and encoding is done. The effective bandwidth of the EEG signals is about 100 Hz. Thus a minimum of 200 samples per second is necessary for sampling (Nyquist criterion).The conventional electrode arrangement recommended by the International Federation of Societies for Electroencephalography and Clinical Neurophysiology for 21 electrodes (called 10-20 electrode position) [4]. Figure 1.3 shows the Conventional 10–20 EEG electrode positions for the placement of 21 electrodes.

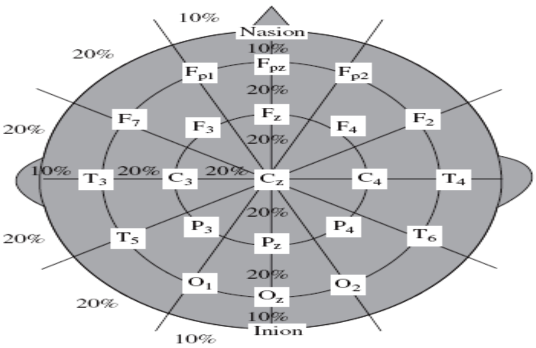

Figure 1.3 Conventional 10–20 EEG electrode positions for the placement of 21 electrodes

2. BRAIN WAVE CLASSIFICATION
Brain rhythm Many neurological disorders can be easily identified by brain rhythms which can be easily recognized by visual inspection of the EEG signal. The amplitude and frequency of these signals varies with human asleep or awake state, age, health etc.
There are four major brain waves with their frequency ranges. These are alpha (α), theta (θ), beta (β), delta (δ), and gamma (γ).
Alpha waves frequencies lie within the range of 8-13 Hz. They can be detected in the posterior lobes of the brain. In the whole realm of brain activity alpha waves are the most prominent rhythm. They are detected in a normal person when person is in a relaxed state without any attention or concentration. Closed eye state also produces some alpha waves [5].

A beta wave lies in the range 14-26 Hz. It is encountered in frontal and central regions. It is the usual waking rhythm of the brain associated with active concentration, active thinking, problem solving, focusing on things. When a person is in a panic state a high level beta wave is generated [6].

Theta waves lie within the range 4-7.5 Hz. It is assumed that it has origins in the thalamic region. When a person is slipping into a drowsy state from conscious state theta waves are observed. They play a crucial role in infants and young children. Creative thinking, deep meditation, access to unconscious material is associated with theta waves [7].Within the range 0.5-4 Hz. They are 5.2 RESEARCH found frontally in adults and posteriori in children. They are associated with deep sleep and may be present in waking state.

Gamma waves are also called fast beta waves and they have frequencies above 30 Hz. The amplitude of these waves is very low and they have rare occurrence. They are associated with certain cognitive and motor functions. Detection of these rhythms can be used to confirm certain neurological diseases. It is also a good indicator of event related synchronization (ERS) of the brain [8].

3. METODOLOGIES

3.1 Electroencephalographic signal analysis using EEGLAB Tool

For analysis of EEG signal EEGLAB is interactive menu-based and scripting software for processing EEG signal data based under the Matlab interpreted programming script environment. EEGLAB provides an interactive graphical user interface allowing users to flexibly and interactively process their high-density electrophysiological data (of up to several hundreds of channels) and/or other dynamic brain time series data. EEGLAB implements common methods of electroencephalographic data analysis including independent component analysis (ICA) and time/frequency analysis. EEGLAB has become a widely used platform for applying and sharing new techniques for biophysical signal processing [15].

.3.2 Lab view

Lab view is developed by National Instruments. It is useful for the register signal from different stages. The importing capability allows the user to analyze self-made datasets because it supports ASCII or MAT datasets which can be generated using MATLAB or Lab View. It is important to point that this tool only reads datasets that were previously processed; this means that EEGLAB cannot read data directly of an acquisition card like other software tools such as Lab View. Based on the fact that Lab View was able to register signals directly from a data acquisition stage, the program that is being developed is able to register the signals coming from the EEG amplifier and registering them to an ASCII dataset.

3.3 Simulink

Simulink is useful for optimized pre-processing; signal processing, feature extraction and classification blocks. It helps to design your real-time application rapidly. Code can be used for off-line and on-line bio signal analysis. Algorithms for fast, accurate, flexible simulations and estimations can be combined with g.RTsys and "High-Speed Online Processing for SlMULlNK"for real-time parameter estimation

3.5 EEG MatlabToolbox- Getting Started

This document is an initial attempt to help new users gets started with the toolbox. It is unlikely to cover all aspects of the toolbox, but it appears to be a reliable starting point on several installations to date. The toolbox provides some easy ways to visualize data. This document works entirely with the example data provided with the toolbox and finishes with some clear suggestions on the next steps to getting your data to work

4. OUTCOMES OF LITERATURE SURVEY.

4.1 Agta Warwrocka, Andrzez Kot [10], deals with method for measuring biomedical signal and may be used as a signal control. The filters are used for biomedical signal. In this research, they had problem with generation and analysis of EEG signal.

4.2 D. Easwaramoorting and R.Uthayakumar [9], focuses on the novel method which is useful to indicate the state of illness of epileptic patient from EEG recording. Analysis based on GFD and wavelet decomposition through DWT With this analysis they checked the patient state .This is very effective tool to analysis the signal.

4.3 Xiaoveri [15], has suggested EEGLAB software for Brain Computer Interface development that provides an accessible solution to the EEG signal processing problem, it act as a reference point for the development of a Lab View based program. In BCI development is necessary to be able to visualize brain signals in one way or another. EEGLAB provides visualization, analysis and processing for EEG signals.

4.4 A.Khorshidtalab, M.J.E. Salami [12], had mentioned the current state of research and to compare the performance of different algorithms for real-time classification of BCI-based electroencephalogram signals. Effective BCIs demand for accurate and real-time EEG signals processing. Recent advances in real-time signal processing have made BCI a feasible alternative for controlling robot and for communication as well. They came to conclusion that among neural networks models, SOFNN shows a better agreement with EEG signals nature. Therefore, it reduces the preprocessing and processing time and is suitable for online applications.

4.5 Shim-Yih Tseng, Rong-Chi Chen+, Fok-Ching Chong and Te-Son Kuo [14], had worked to evaluating efficiency of parametric methods in EEG analysis. Both autoregressive (AR) and autoregressive-moving average (ARMA) modeling have been successfully used by many investigators for EEG signal analysis. However, it is found that about 96% of the 900 segments can be efficiently represented by the AR model, and only about 78% of them can be efficiently represented by ARMA model. Therefore they concluded that the AR model is preferred for estimating EEG signal.

4.6 Rangraj.M. has taken a problem approach to biomedical signal analysis as well as development of algorithm for biomedical signal analysis.

4.7 Prof.P.V. Ramaraju [11], has proposed signal analysis through system orientation which eliminates the human

indiscretion which may be allied with doctor in EEG psychoanalysis.
From above study, it is very clear that the scope of research is for analysis of EEG signal, real time signal processing, and generation of EEG signal.

5. APPLICATIONS

5.1 CLINICAL

- EEG signals are used to characterize the seizures for the purpose of treatment.
- EEG signals are used to monitor the depth of anesthesia.
- EEG signals are used to determine the wean-epileptic medication.
- EEG signals Monitor alertness, coma and brain death.
- EEG signals locate areas of damage following head injury, stroke, tumor, etc.

5.2 RESEARCH

- EEG signals are used in neuroscience.
- EEG signals are used in cognitive science.
- EEG signals can be used for the psycho physiological research.
- EEG signals can be used for the study of the responses to auditory stimuli.

6. ADVANTAGES OF EEG SIGNAL

- Temporal resolution of the EEG signal is high.
- EEG measures the electrical activity directly.
- EEG is a non-invasive procedure.
- The greatest advantage of EEG is speed.
- It has the ability to analyze the brain activity; it unfolds in real time at level of milliseconds, i.e. thousands of a second.

7. REFERENCES

[1] J.D.Bronzino.1995.Principle of Electroencephalography. InJ.DBronzinoed.TheBiomedicalEngeneering Handbook, pp. 201-212, CRC Press, Florida.

[2] Saeid Sanei and J.A. Chambers, EEG Signal Processing, John Wiley & Sons Ltd, England, 2007.

[3] Attwood, H. L., and MacKay, W. A., Essentials of Neurophysiology, B. Decker, Hamilton, Canada,1989.

[4] Jasper, H., „Report of committee on methods of clinical exam in EEG", *Electroencephalogram Clin. Neurophysiology*. vol. **10**, 1958, 370–375.

[5] Niedermeyer, E., "The normal EEG of the waking adult", Chapter 10, in Electroencephalography, Basic Principles, Clinical Applications, and Related Fields, Eds E. Niedermeyer and F. Lopes da Silva, 4th ed, Lippincott, Williams and Wilkins, Philadelphia, Pennsylvania, 1999, 174–188.

[6] Sterman, M. B., MacDonald, L. R., and Stone, R. K.Biofeedback training of sensor motor EEG in man and its effect on epilepsy", *Epilepsies*, **15**, 1974, 395–416.

[7] Ashwal, S., and Rust, R., „Child neurology in the 20th century", *Pedia. Res*., **53**, 2003, 345–361.

[8] Pfurtscheller G, Flotzinger, D., and Neuper, C., "Differentiation between finger, toe and tongue movement in man based on 40 Hz EEG", *Electroencephalogram. Clin. Neurophysiol*. vol.**90**, 1994, 456–460.

[9] Easwaramoorthy & R. Uthayakumar,IEEE2010.Analysis of Biomedical EEG Signals using Wavelet Transforms and multiultifractal Analysis"

[10] Agata Warwoka,IEEE2011.Methods of EEG signal analysis

[11] Prof. Ramaraju & Dr. Malleshwar,IEEE2011.Relevance of wavelet transform of EEG signals

[12] A.Khoshidtalab international conference IEEE2011EEG signal classification for real time brain computer interface application: A review.

[13] Xiaover,IEEE2011,EEG based Attention based recognition

[14] ShinyinTsens, Sciencedirect, Vol.17.Jan.1995. Evaluation of parametric methods in EEG signal analysis

[15] Xiaoveri, IEEE2011EEGLAB software for brain computer interface,