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REAL TIME EEG MEASUREMENT

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Abstract*—Electroencephalography(EEG) signal plays an important role in the diagnosis of brain and mental diseases, anesthesia depth monitoring, sleeping test, as well as the brain machine interface(BCI).The term EEG is used to denote electrical neural activity of the brain. An EEG signal is a measurement of currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex[1].EEG signal processing is a process of extracting EEG signals by applying suitable electrodes on kinds of noises could be recorded. Noise in EEG are due to eye movement, patient or object motion artifacts, EMGs (electro-myo-gram) which is an electrical signal caused by the muscle motion, power line interface. This study paper includes what is EEG, measurement and recording of EEG signals and various brain rhythms associated with these signals.[1]

***Keywords*— Electroencephalography, Electromyogram, BCI, Brain rhythms, Power line interface**

I. INTRODUCTION

The brain represents not only the brain function but also the status of the whole body. Electro-(referring to registration of brain electrical activities) encephalo-(referring to emitting the signals from the head), and gram (or graphs), which means drawing or writing, the term EEG is used to denote electrical neural activity of the brain[1]. An EEG signal is a measurement of currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. [2]When brain cells (neurons) are activated, the synaptic currents are produced within the dendrites. This current generates a magnetic field measurable by Electromyogram (EMG) machines and a secondary electrical field over the scalp measurable by EEG systems[2].

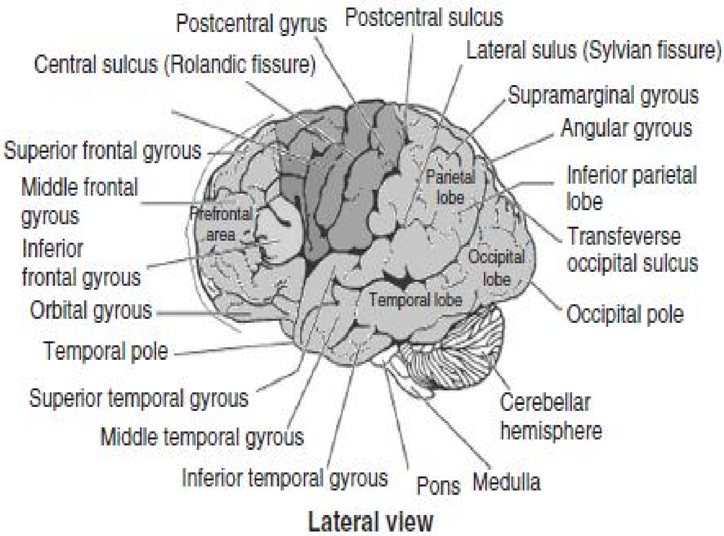

Fig. 1 *Lateral view of Brain*

II. DEFINATION OF EEG

According to Webster online dictionary, the term EEG means:

-electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media

- electrical neural activity of the brain.

- recording of electric potentials produced by the local collective partial synchrony of electrical field activity in cortical neuropile[1].

An EEG signal is a measurement of currents that flow during synaptic excitations of the dendrites of many pyramidal neurons in the cerebral cortex. When brain cells (neurons) are activated, the synaptic currents are produced within the dendrites[2]. This current generates a magnetic field measurable by Electromyogram (EMG) machines and a secondary electrical field over the scalp measurable by EEG systems. EEG is the most widely known and studied portable noninvasive brain imaging modality; another, less developed and not considered here, is functional near-infrared spectroscopy (FNIR)[3].

The first report of signals originating in the human brain and recorded non-invasively from the scalp was that of Berger in 1924. The current generates a magnetic field measurable by Electromyogram (EMG) machines and a secondary electrical field over the scalp measurable by EEG systems.[1][2]. EEG activity patterns correlate with changes in cognitive arousal, attention, intention, evaluation, and the like, thereby providing a potential B window on the mind. We believe that in the coming decades adequate real-time signal processing for feature extraction and state prediction or recognition combined with new, noninvasive, and even wearable electrophysiological sensing technologies can produce meaningful applications in a wide range of directions[3]

III. BRAIN RHTHYMS

Many brain disorders are diagnosed by visual inspection of EEG signals. The clinical experts in the field are familiar with manifestation of brain rhythms in the EEG signals.[2] In healthy adults, the amplitudes and frequencies of such signals change from one state of a human to another, such as wakefulness and sleep. The characteristics of the waves also change with age. [2] There are five major brain waves distinguished by their different frequency ranges. These frequency bands from low to high frequencies respectively are called alpha (a), theta (ɵ), beta (ß), delta (d), and gamma (r)[3].

TABLE I- BRAIN RHTHYMS[3]

Rhythm	***Freq (Hz)***	***Amp(µV)***
Alpha	*8-13*	*20-200*
Beta	*13-30*	*5-10*
Delta	*1-5*	*20-200*
Theta	*4-8*	*10*
Gamma	*30-45*	*10-100*

A. Alpha

The alpha wave is the most prominent rhythm in the whole realm of brain activity and possibly covers a greater range than has been previously accepted. Most subjects produce some alpha waves with their eyes closed, which is why it has been claimed that it is nothing but a waiting or scanning pattern produced by the visual regions of the brain. It is reduced or eliminated by opening the eyes, by hearing unfamiliar sounds, by anxiety, or mental concentration or attention. In general, the alpha rhythm is the prominent EEG wave pattern of an adult who is awake but relaxed with eyes closed.[2][3].

Alpha waves appear in the posterior half of the head and are usually found over the occipital region of the brain. They can be detected in all parts of posterior lobes of the brain. For alpha waves the frequency lies within the range of 8–13 Hz, and commonly appears as a round or sinusoidal shaped signal. However, in rare cases it may manifest itself as sharp waves. In such cases, the negative component appears to be sharp and the positive component appears to be rounded, similar to the wave morphology of the rolandic mu (µ) rhythm.An alpha wave has a higher amplitude over the occipital areas and has an amplitude of normally less than 50 µV.

B. Beta

A beta wave is the electrical activity of the brain varying within the range of 14–26 Hz . A beta wave is the usual waking rhythm of the brain associated with active thinking, active attention, focus on the outside world, or solving concrete problems, and is found in normal adults. A high-level beta wavemay be acquired when a human is in a panic state. Rhythmical beta activity is encountered chiefly over the frontal and central regions. Amplitude of beta rhythms normally under 30 µV.

Beta rhythms occur in individuals who arealert and attentive to external stimuli or exert specific mental effort, or paradoxically, beta rhythms also occur during deep sleep, REM (Rapid Eye Movement) sleep when the eyes switch back and forth. This does not mean that there is less electrical activity rather that the “positive” and “negative” activities are starting to counterbalance so that the sum of the electrical activity is less. Thus, instead of getting the wave-like synchronized pattern of alpha waves, desynchronization or alpha block occurs. So, the beta wave represents arousal of the cortex to a higher state of alertness or tension. It may also be associated with “remembering” or retrieving memories.

C. Delta

Delta and theta rhythms are low-frequency EEG patterns that increase during sleep in the normal adult. As people move from lighter to deeper stages of sleep (prior to REM sleep), the occurrence of alpha waves diminish and is gradually replaced by the lower frequency theta and then delta frequency rhythms.Delta waves lie within the range of 0.5–4 Hz. These waves are primarily associated with deep sleep and may be present in the waking state. It is very easy to confuse artifact signals caused by the large muscles of the neck and jaw with the genuine delta response. [1][3].

This is because the muscles are near the surface of the skin and produce large signals, whereas the signal that is of interest originates from deep within the brain and is severely attenuated in passing through the skull. Nevertheless, by applying simple signal analysis methods to the EEG, it is very easy to see when the response is caused by excessive movement.

D. Theta

Theta waves lie within the range of 4–7.5 Hz. The term theta might be chosen to allude to its presumed thalamic origin. Theta waves appear as consciousness slips towards drowsiness. Theta waves have been associated with access to unconscious material, creative inspiration and deep meditation. A theta wave is often accompanied by other frequencies and seems to be related to the level of arousal. [3]

Although delta and theta rhythms are generally prominent during sleep, there are cases when delta and theta rhythms are recorded from individuals who are awake. . Delta waves may increase during difficult mental activities requiring concentration. In general, the occurrence and amplitudes of delta and theta rhythms are highly variable within and between individuals.

E. *Gamma*

The frequencies above 30 Hz (mainly up to 45 Hz) correspond to the gamma range (sometimes called the fast beta wave). Although the amplitudes of these rhythms are very low and their occurrence is rare, detection of these rhythms can be used for confirmation of certain brain diseases. The regions of high EEG frequencies and highest levels of cerebral blood flow (as well as oxygen and glucose uptake) are located in the fronto central area.[3]. The gamma wave band has also been proved to be a good indication of event-related synchronization (ERS) of the brain and can be used to demonstrate the locus for right and left index finger movement, right toes, and the rather broad and bilateral area for tongue movement .[2]

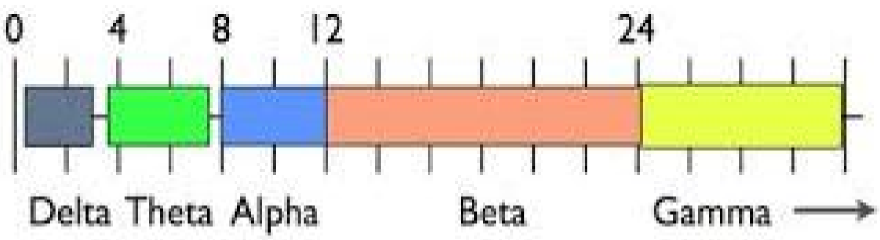

Fig. 2*Brain Rhthyms[1]*

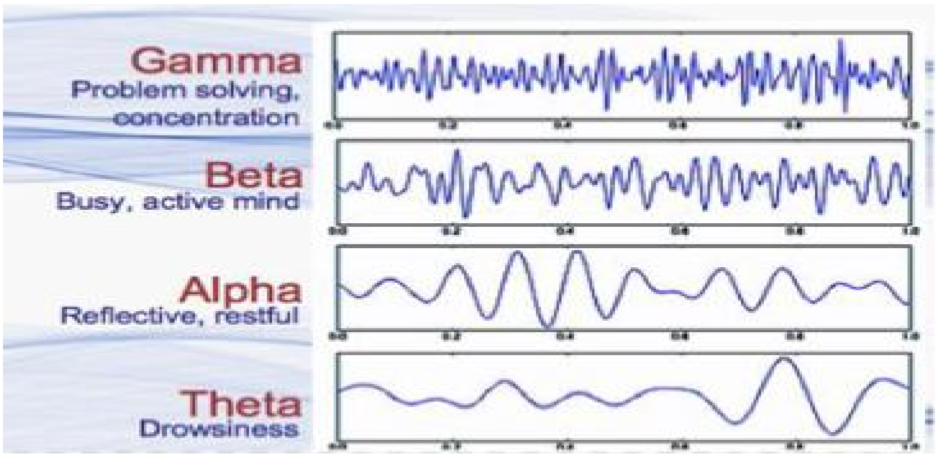

Fig. 3*EEG Recordings[2]*

IV.EEG RECORDING AND MEASUREMENT

Acquiring signals and images from the human body has become vital for early diagnosis of a variety of diseases. Such data can be in the form of electro biological signals such as an electrocardiogram (ECG) from the heart, electromyogram (EMG) from muscles, electroencephalogram (EEG) from the brain, Magnetoencephalogram (MEG) from the brain, Electrogastrogram (EGG) from the stomach, and electroocclugram (or electrooptigram, EOG) from eye nerves. Measurements can also have the form of one type of ultrasound or radiograph such as sonograph (or ultrasound image), computerized tomography (CT), magnetic resonance imaging (MRI) or functional MRI (fMRI), positron emission tomography (PET), and single photon emission tomography (SPET).[5]

More recent EEG systems consist of a number of delicate electrodes, a set of differential amplifiers (one for each channel) followed by filters and needle (pen)-type registers.

The multichannel EEGs could be plotted on plane paper or paper with a grid. Soon after this system came to the market, researchers started looking for a computerized system, which could digitize and store the signals. Therefore, to analyses EEG signals it was soon understood that the signals must be in digital form. This required sampling, quantization, and encoding of the signals. As the number of electrodes grows the data volume, in terms of the number of bits, increases. The computerized systems allow variable settings, stimulations, and sampling frequency, and some are equipped with simple or advanced signal processing tools for processing the signals. [5]

The conversion from analogue to digital EEG is performed by means of multichannel analogue-to-digital converters (ADCs). Fortunately, the effective bandwidth for EEG signals is limited to approximately 100 Hz. For many applications this bandwidth may be considered to be even half of this value. Therefore, a minimum frequency of 200 samples/s (to satisfy the Nyquist criterion) is often enough for sampling the EEG signals. In some applications where a higher resolution is required for representation of brain activities in the frequency domain, sampling frequencies of up to 2000 sample/s may be used. [6]

In order to maintain the diagnostic information the quantization of EEG signals is normally very fine. Representation of each signal sample with up to 16 bits is very popular for the EEG recording systems. This makes the necessary memory volume for archiving the signals massive, especially for sleep EEG and epileptic seizure monitoring records.[5]

V. ELECTRODES

A. *Surface Electrodes*

Surface Electrodes have an integrated ribbon cable made of polyimide. This cable is very flexible in all directions and can be folded if needed. Crimping should be avoided as it may compromise probe insulation.Holes are designed to allow for implantation with depth probes, but can also function as perforation or anchor/suture holes. Regions without interconnect traces or metal sites can be cut to allow for better conformation to the brain surface. This may damage the probe if done incorrectly.[4]

Fig. 4 *Electrodes*

VI. ELECTRODE POSITIONS ON HUMAN SCALP

Electrode positions have been named according to the brain region below the area of the scalp:*frontal, central (sulcus), parietal, temporal,* and *occipital.* In the bipolar method, the EEG is measured from a pair of scalp electrodes[4]. The pair of electrodes measures the difference in electrical potential (voltage) between their two positions above the brain. A third electrode is put on the earlobe as a point of reference, 'ground', of the body's baseline voltage due to other electrical activities within the body.[2][4]

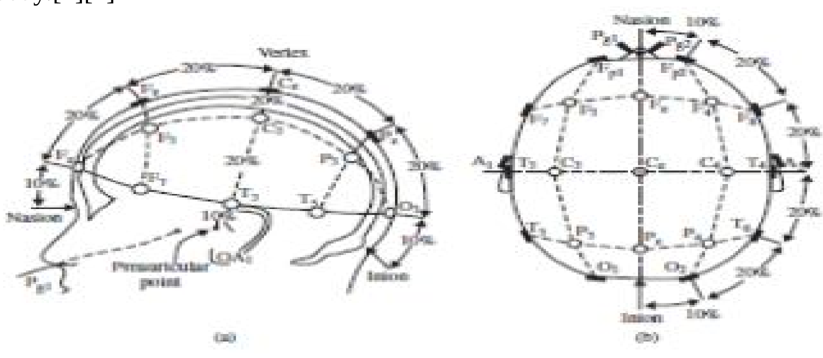

Fig. 4*Electrode Position on human scalp*

VII.APPLICATIONS OF EEG

(1) Monitor alertness, coma and brain death
(2) Locate areas of damage following head injury, stroke, tumour, etc.
(3) Test afferent pathways (by evoked potentials)
(4) Monitor cognitive engagement (alpha rhythm)
(5) Produce biofeedback situations, alpha, etc.;
(6) Control anaesthesia depth ("servo anaesthesia")
(7) Investigate epilepsy and locate seizure origin;
(8) Test epilepsy drug effects
(9) Assist in experimental cortical excision of epileptic focus
(10) Monitor human and animal brain development
(11) Test drugs for convulsive effects
(12) Investigate sleep disorder and physiology.

VIII`. CONCLUSIONS

This paper will enable the students to get familiar with real time signals & gain the experience of processing real world signals, and learn how to acquire and analyze EEG signals as well as how to program with processors and other third party programming software. In future, this project will be advanced for developing more sophisticated algorithms to process the EEG signals in real-time for the applications such as BCI, anesthesia depth monitoring, sleep testing, hearing aid etc.

REFERENCES

[1] E. Niedermeyer, F. H. Lopes da Silva. 1993. Electroencephalography: Basic principles, clinical applications and related fields, 3rd edition, Lippincott, Williams & Wilkins, Philadelphia.
[2]The university of Sydney, Fundamentals of Biomedical Engineering, Electroencephalogram, notes at http://www.eelab.usyd.edu.au/ELEC3801/notes/Electroencephalogram.htm.
[3] J.D.Bronzino.1995.Principles of Electroencephalography.In:J.D.Bronzinoed.THE BIOMEDICAL ENGINEERING HANDBOOK, PP. 201-212, CRC PRESS, FLORIDA.
[4] Effects of Electrode Placement, http://www.focused-technology.com/electrod.htm, California.
[5] D. Brunet, G. Young et al.. 2000. Electroencephalography, Guidelines for Clinical Practice and Facility Standards, College of Physicians and Surgeons of Ontario, Canada.
[6] Sanjit K Mitra James F Kaiser "Handbook for Digital Signal Processing",John Wiley & Sons Inc 1993