Real Time Data Collection and Interpretation of EEG Signals

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***Abstract*—** In human nervous system one neuron carries messages from any part of the body to brain. The brain processes these signals to perform any body task. These signals from the brain can be recorded with the help of electroencephalography (EEG). The different task performing activities evolving from the brain are reflected as the difference of surface potentials on the scalp. These variations in the surface potentials can be recorded by placing an arrangement of electrodes at the scalp of the brain. This paper presents the study of EEG signal observations and its interpretation based on artefacts and abnormalities.

Keywords—EEG, artefacts, brain waves, dendritic potentials, PNS, CNS.

I. INTRODUCTION

Nervous system comprises of a complex network of nerves cells, brain and the spinal cord. These nerve cells carry messages from different body parts to the brain and spinal cord and vice versa. The spinal cord and brain together make Central Nervous System (CNS) while nerve cells make Peripheral Nervous System (PNS). The nerve cells are also known as neurons. These neurons are the processing unit of data and thus precepts the data from synaptic terminal and process it in the cell body. Then the processed signal is passed on to another neuron connected through dendrites. According to a study every neuron is connected to 10000 other neurons through dendrites or axon [1]. Thus, in this way neuron helps in carrying messages to brain and spinal cord i.e. from PNS to CNS. The messages carried by these neurons are in the form of electrical pulses and can be read with the help of electroencephalography (EEG). Thus, the electrical nature of human brain can be recorded for study with the help of EEG [2].

The different task performing activities evolving from the brain are reflected as the difference of surface potentials on the scalp. These variations in the surface potentials can be recorded by placing an arrangement of electrodes at the scalp of the brain. The recording of the measurements of these potentials results in EEG. The EEG is supposed to be the harmonized sub-threshold dendritic potentials formed by the synaptic activity of many neurons summed [3].

II. PROCESS OF DATA COLLECTION

EEG is done so as to diagnose whether a person has any neurological disorder or not.

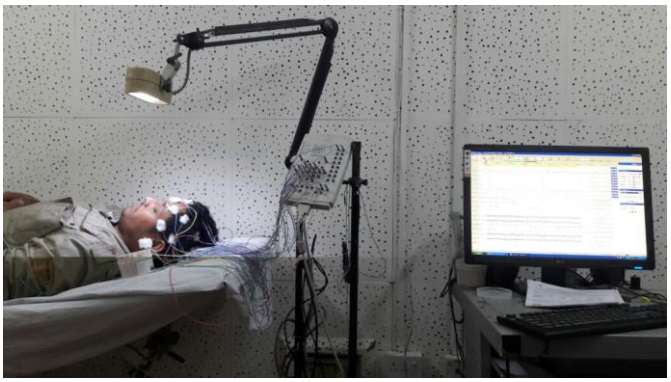


Figure 1: EEG Setup

For this the patient have to lie down keeping their head near the EEG setup. The electrodes are placed to the scalp of the patient's brain by wires attached to the hardware setup and the reflections of activities of the brain will get recorded as a series of electrical pulses to a computer. These electrodes are placed with the help of conducting gels according to the "10-20 Standard System of Electrode Placement". This system is built according to the area of brain underlying cerebral cortex and the position of electrode, as shown in figure.

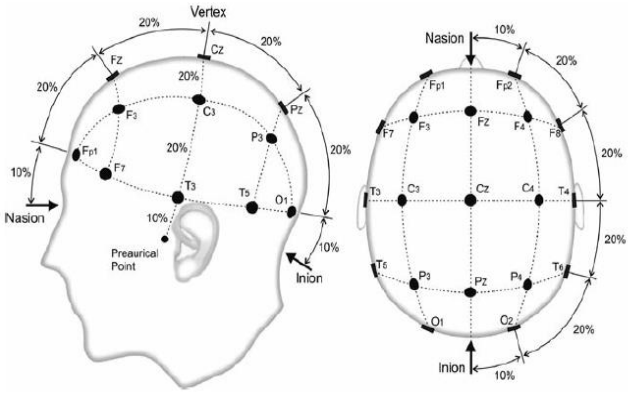


Figure 2: The 10-20 Standard System of Electrode Placement [4].

Here each node where electrode can be placed is represented by a name which includes a number and a letter. The letters are used to identify the lobe i.e. F for frontal, T for temporal, C for central, P for parietal, O for occipital and the numbers are used to identify the location of a hemisphere. Here odd numbers i.e. 1, 3, 5, 7 refers to left hemisphere and even numbers i.e. 2,4,6,8 refers to right hemisphere. The letter z refers to an electrode placed on the midline and we need to

note that no "central lobe", actually exists but used only for identification purposes. The distance between adjacent electrodes is represented by the numbers 10 and 20 which mean either 10% or 20% of the total right-left or front-back area of the skull. The point shown in the figure 2 called Nasion is a point between nose and forehead and the point called Inion is a Bump at back of skull [5].

The placement of electrodes can also be done by using EEG cap made according to the "10-20 Standard System of Electrode Placement". Patient just have to wear that cap and can sit calmly as the recording is done. But generally, the cap is not used because according to the observations fixed electrodes in the cap are not comfortable to wear for long duration of recordings. Thus, electrodes are placed manually. The conducting gel used here is the paste of fullar earth and glycerin. It is used so as to obtain maximum signal to noise ratio (SNR) and also acts as the binder as it helps to keeps the electrode in position.
The wired connections are made connecting electrodes to the amplifier at the different ports marked on the headbox as shown in figure 3.

Figure 3: Amplifier and Headbox

Once the electrodes are placed the recording is started. The inputs from the electrodes to the hardware EEG machine are then used by the software to constitute a montage. A montage is defined as a particular arrangement of electrodes that helps to display the EEG signal. Here bipolar longitudinal montage [6] is used for recording patient's EEG test which includes 16 channels of the brain i.e. FP1-F3, F3-C3, C3-P3, P3-O1, FP2-F4, F4-C4, C4-P4, P4-O2, FP1-F7, F7-T3, T3-T5, T5-O1, FP2-F8, F8-T4, T4-T6, T6-O2, and one extra channel is used for ECG for simultaneous heartbeat monitoring of the patient. Figure 4 shows how these selected channels form a bipolar transverse montage in which potential between the two electrodes is measured.

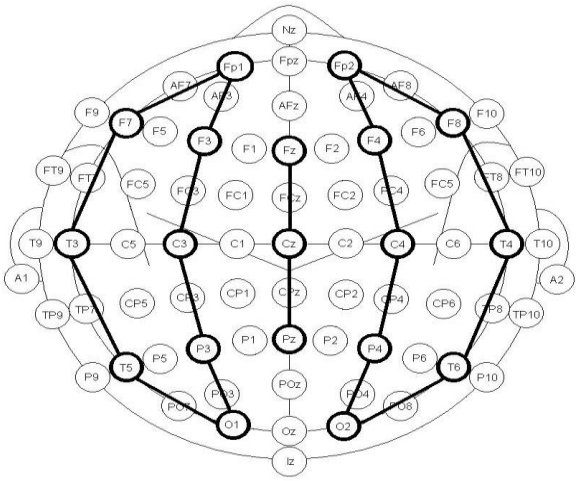


Figure 4: Bipolar Longitudinal Montage

After placing the electrodes, the electrical activity of the brain will get recorded as the potential difference between the two electrodes which will be shown as a series of wavy lines drawn as an image on the computer screen as shown in the figure 5. Patients are generally advised to close their eyes and be calm. But if he/she becomes restless during the recording, it may be stopped to allow the patient for stretching and repositioning. During the recording patient is asked to do different things like breathing rapidly and deeply for few minutes called hyperventilation and looking at flashing bright light for checking the stimulation called photic. This is done to stimulate any abnormality which may not be recorded as it is [7].

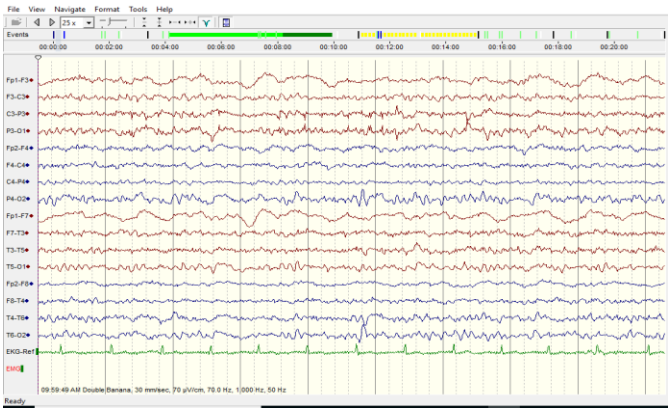


Figure 5: Recording Screen

The amplitude of these wavy signals is measured in microvolts (μV) which are determined by measuring the brainwave deflection in milli-meters (mm) at specified machine sensitivity (μV /mm). Here the EEG recordings are made at the sensitivity of 70 μV /cm, deflection of 100mm and time base of 30mm/sec. Low- pass and high- pass filters are used for smoothening and sharpening the brainwaves respectively in order to make the signals clearer to the viewer. The frequency range used for low pass filter is 1Hz and for high pass filter is 70Hz. The notch filter of 50Hz is used to reject noise due to power supply. The values of potential are

recorded at a frequency of 128Hz. The spontaneous activity of brain is observed for about 20 minutes. The patients involved during recording belonged to all the age groups and could be either male or female.

The signal obtained during this process is called raw EEG signal which comprises some non-cerebral signals known as artefacts. These are actually adulterations in the signal. These adulterations can be due any movement related potentials, movement of facial muscles, eye blinks, etc. These are biomedical artefacts and are the most difficult to remove because of their resemblance to the actual EEG signal. Another group of artefacts are the environmental artefacts like external noise in the surroundings, noise due to power supply, electrode popping i.e. when electrode connection is not proper, temperature etc. It is very important to remove these artefacts as a small mistake in the diagnosis of EEG signal can turn deadly to the patient. Environmental artefacts are the externally generated and therefore can be removed with the improving technology in which different types of filters can help. But biomedical artefacts can only be removed by applying different signal processing techniques after the recording is done [8].

III. DIFFERENT WAVE GROUPS OF EEG SIGNAL

Based on different frequency ranges, EEG signal can be categorized as delta, theta, alpha, beta and gamma. Table 1 shows the different frequencies related to these types of waves and how these waves are related to different types of mental states and region of activity.

Table 1: Different Wave Groups of EEG Signal [9]

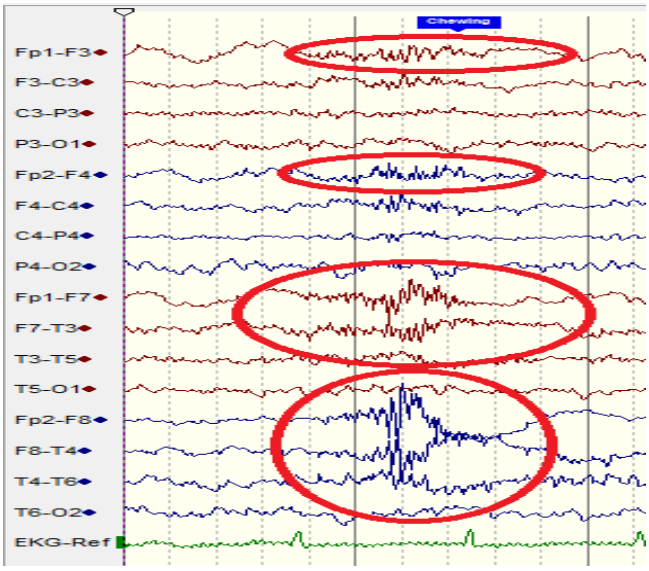
Brain Wave	Frequency Range	Mental State	Region of Activity
Delta	.5 to 4 Hz	Serious Organic Brain Disease, Deep Sleep (Infancy)	Inside the Cortex
Theta	4 to 7 Hz	Frustration, Disappointment, Emotional Stress	Temporal and Parietal Regions
Alpha	8 to 13 Hz	Quiet, Resting, Awake States	Occipital Also, From Frontal and Parietal Regions of the Scalp
Beta	13 to 30 Hz	High Mental Activity (Tension)	Temporal and Parietal Regions
Gamma	31 to 100 Hz	Consciousness	Whole Brain

IV. OBSERVATIONS

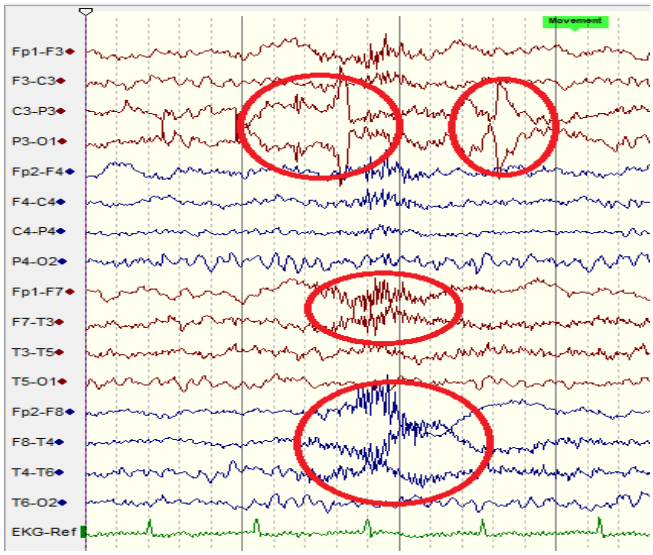
It is observed that most of the patients recording showed the wave nature to be alpha which justifies the resting and awake state of the patient during the test.
Also, during recording various artefacts and abnormalities were observed as shown below:

1) Artefacts

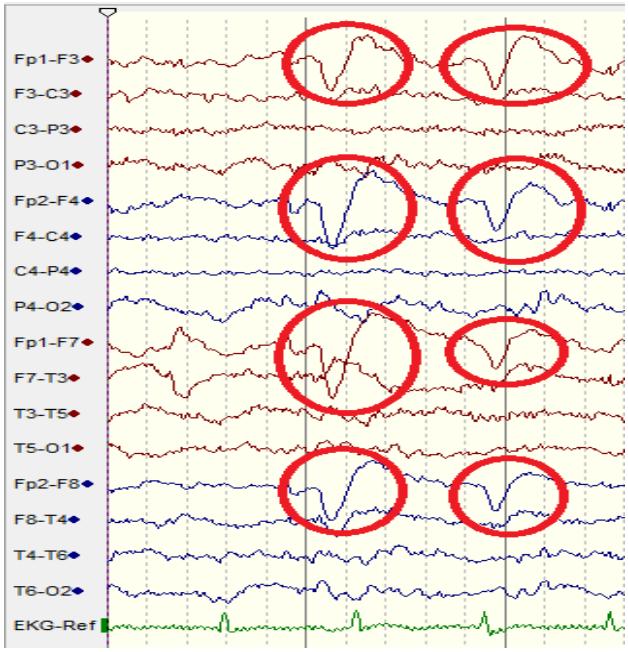
a) Chewing: The effect of moving jaw muscles can be seen dominantly on frontal and temporal lobe as shown in the figure: -



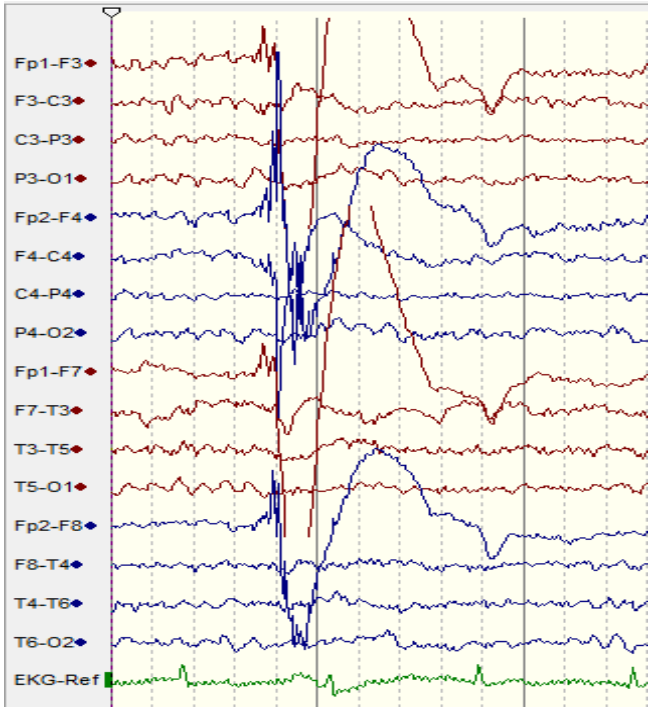
b) Muscle Movement: this occurs due stretching of the head muscles. Different type of stretching movements affects different channels during recording. As in the shown figure central and parietal on the left hemisphere and frontal and temporal on the right hemisphere got effected.



c) Eye Blinks: eye movements are usually observed in frontal electrodes i.e. FP1-F3, FP2-F4, FP1-F7, FP2-F8 as shown below: -

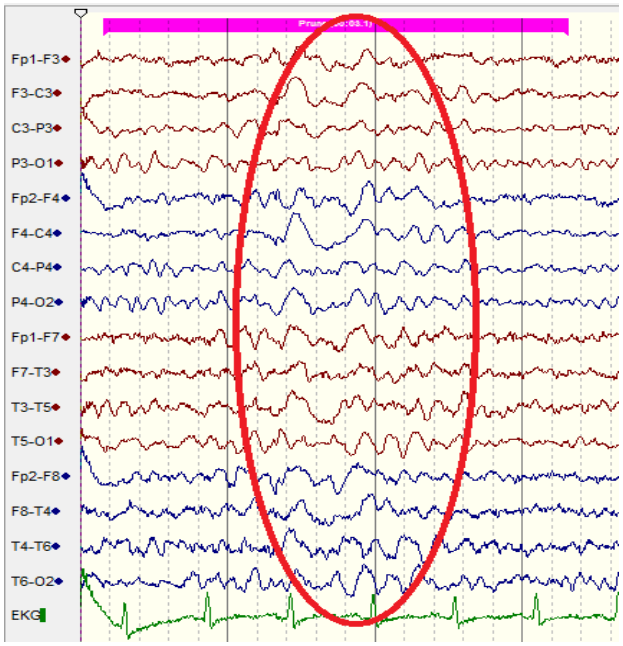


d) Electrode Popping: It can be due to lose connection of a single or multiple electrode. Due to this there is a sharp waveform because of abrupt impedance change. Here waveform is due to electrode popping of FP1 and FP2.

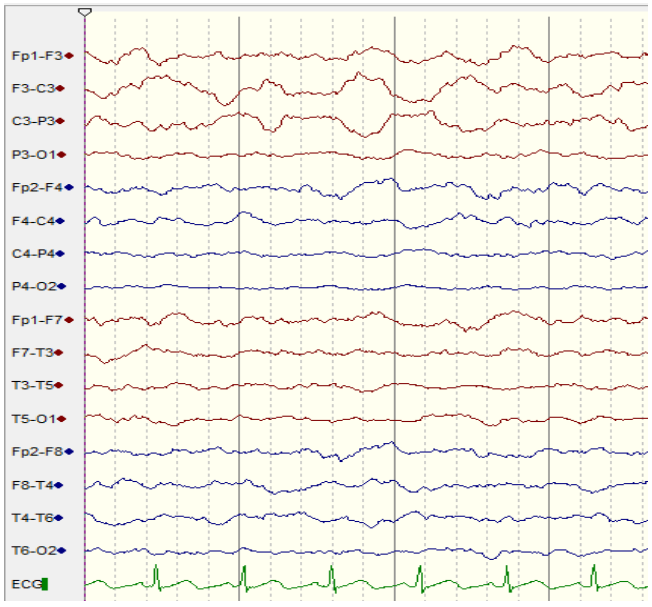


2) Abnormality

a) Spiked Wave: It corresponds to abnormality. Here all the channels are showing the spiked waves thus it can be said that the whole brain is affected by the disorder.
If these spikes appear at some particular channel then only the area corresponding to those channels can be considered as the effected part.



b) Theta slowing: It is the condition related to stress and frustration. Here the complete recording will show theta EEG waves.



V. CONCLUSION AND FUTURE SCOPE

The different task performing activities evolving from the brain are reflected as the difference of surface potentials on the scalp. These surface potentials get affected a lot if there are muscular movements like chewing, eye blinking etc or any abnormality in the brain. Thus, Electroencephalography (EEG) is the brain signal processing technique that helps in understanding the complex mechanisms of the brain and abnormal brain waves related with specific brain disorders. The study of these brain waves plays a vital role in diagnosis of different brain disorders like meningitis, epilepsy, Altered Sensorium, Schizophrenia, Dementia, etc.

Thus, further this work can be extended by analyzing this raw EEG data collected for removing biomedical artefacts also can be further processed for the diagnosis of various neurological disorders.

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