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Brain Activity Detection and Analysis Using EEG

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ABSTRACT: A challenge faced by millions of people all over India is accessible and affordable healthcare. Be it villages or cities, this issue is prevalent. The least diagnosed body part happens to be the brain which is because of expensive and bulky equipment required to study it. Brain related illnesses are rarely diagnosed on time and timely treatment is unexecuted. This paper aims to discuss a feasible and accessible EEG device that captures brain signals generated on the head skin and analyze them to determine concentration level and faults. Brainwaves are produced by many neurons firing at the same time; how often that firing occurs determines the activity's frequency or wavelength, which is measured in hertz. The brain signals are captured using gold-cup electrodes attached on head skin. These captured signals which have very small amplitude (in microvolts) are passed through the EEG system. The system has low pass filters and precise high gain amplifiers to eliminate noise for obtaining the required information. This output is fed to the controller that gives the concentration levels and brain faults and is displayed on a monitor. The extracted information is used to identify possible brain illness or brain damage for further treatment, the concentration of a person can be monitored for identifying his/her ability to focus or in rehabilitation of a person suffering from concentration deficiency.

KEYWORDS: EEG, Brain Waves, Brain Activity, Concentration, Faults

I. INTRODUCTION

Interests on the human body have never decreased and research on it has never ceased. A study of EEG for analysis of cognitive processes for biomedical applications is ongoing topic for research. EEG is a non-invasive way of looking into a human's brain [1]. These brainwaves are produced by many neurons firing at the same time; how often that firing occurs determines the activity's frequency or wavelength, which is measured in Hertz (Hz). Neurologists have used EEG to monitor consciousness in patients with traumatic injuries, and in studies of epilepsy and sleep. For that, the accurate analysis of EEG signals is essential. In addition, to enhance the efficacy of Brain Computer Interface (BCI) systems, it is required to determine methods of increasing the signal-to-noise ratio (SNR) of the observed EEG signals. The EEG helps in understanding the brain along with its activity at several locations giving detailed information of the current status of the brain. This is essential information as it can help preventing or identifying various diseases or damages or abnormalities. In addition to this when there is an aberration in the signal we can identify the problem depending on the dissimilarity between the signals. This aids the neurologist in treating the patient. The rising costs and associated hazards of medical treatment in India are paving a path for innovation. This project is a self-made version of the EEG machine which costs a fraction of the actual machine's cost. The purpose of making this project stems from the necessity of moving one step closer to real time detection of brain activity and increasing portability of EEG.

II. LITERATURE REVIEW

Suhas S. Patil et. al. [1] discusses ways of reducing the noise in the signals obtained from the brain. Brain signals contain lots of noise from atmosphere, blinking of eyes, movements in the body or improper connection of electrodes to scalp. Removal of this noise is essential for correctly obtaining the signals. Since the signals are in microvolt range, thresholding process and wavelet transform are applied to separate the signal from the noise. First thing that is suggested is that the electrodes should be placed on the scalp without interference from the hair. They can also be placed on certain regions on the forehead and behind the ears for good results.

Effects of a subject's wakefulness state on approximated entropy during eye opening and closing test were studied by Suhas S. Patil et. al. In their method[1], DWT was used to decompose the EEG band (0 - 60 Hz) related to eyes

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opening periods and eyes closing periods into the gamma (30 - 60 Hz), beta (13 - 30 Hz), alpha (8 - 13 Hz), theta (4 - 8 Hz) and delta (0 - 4 Hz) EEG sub bands. The obtained results indicate that the complexity of gamma band increased significantly when the subject is patient during eyes opening and closing over temporal region. The results revealed that the normal state was associated with significantly greater complexity of several EEG band frequencies (all EEG bands except the gamma band), during eyes closing and opening. The results indicated that patient-status was associated with greater complexity of gamma band activity over temporal region, regardless of the subject's wakefulness state. The results indicated that the fully awake state in patient subjects did not increase the complexity of the theta band as much as in normal subjects over the temporal region during eyes opening.

Lee et. Al. [3] studied Concentration Power Index Transmission. In their research they have detected the concentration signals from 2-channel EEG to move a small Lego car using a Bluetooth module. They have detected the state of concentration by identifying low-beta waves which have frequency in the range of 13-20 Hz. It has been reported that beta wave increases and theta decreases during concentration.They have calculated the concentration power index using the below expression.

$$\boldsymbol{Concentration\ Index} = (\boldsymbol{\beta} + \boldsymbol{SMR})/\boldsymbol{\theta} \tag{1}$$

Where SMR refers to mid beta signals in the range of 12-15 Hz related to minimal body movement and sensory activity, mid beta are in the range of 15-20 Hz related to concentration such as mental arithmetic and Theta is related to meditation.

EEG results are useful in various neurological conditions as has been discussed by Smith [4]. In hypoglycaemia there may be generalised slow activity or focal/lateralised δ rhythms, and these may be associated with focal neurological deficits. EEG can be useful for early detection of dialysis dementia or encephalopathy (occurring in about 1% of dialysis patients), as abnormalities can precede clinical symptoms by several months in this disorder. Even most drugs or toxins have diffuse effects on the EEG. Some agents, particularly benzodiazepines and barbiturates, induce fast or beta (β) rhythms and the EEG may be a useful pointer to drug intoxication when this is clinically unsuspected. Generalised slow activity can alert to hyperammonaemia in a confused or obtunded patient who has epilepsy treated with sodium valproate. In HIV encephalopathy, the usual finding is mild EEG slowing. These results are helpful in understanding the obtained EEG signals and identifying what they represent.

Table 1: Brain signals and associated state of body or mind

Indicator	Frequency Definition (Hz)	State
Alpha (α)	8-12	Awake, eyes open
Low Beta(β)	13-20	Concentration
Mid Beta/SMR	15-20	Anxiety, energy
Theta (θ)	4-7	Sleep
Delta(δ)	0.5-3.5	Deep sleep

III. METHODOLOGY

Human brain is similar to a voltage source. It generates pulses or signals for communicating with the parts of the body and hence these signals can be tapped into as an EMF signal and can be used to study the brain. Next is the location where we can have strongest signal. There are many test points on our head from where the readings can be taken but we will be focusing on points with least hair as the signal is in the microvolts range and hair tends to store static electricity and can produce disturbance. So for easy and accurate measurement we will be using region behind the ear or the temporal region and forehead. The signal is taken from the human brain with the help of electrodes which generates a low frequency and low voltage signal (unknown). This signal is given to the low pass filter made with instrumentation amplifier which conditions the signal i.e. reduces the noise interference and is given to the op-amp (IC 741) which amplifies the signal.

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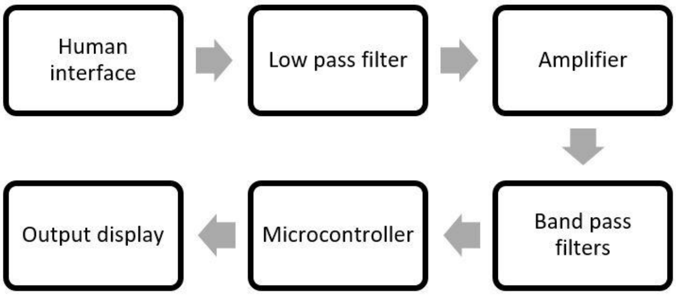

Figure 1: Block Diagram of EEG system

The brain signals are contaminated by various sources of noise such as static electric charges in the hair, blinking of eyes, twitching of the body, misplaced electrodes and external EM waves. So the low pass filter tries to remove noise which is greater than 60Hz because brain signals have frequency less than this level. We separate the signals of different frequencies of Table 1 using banks of band pass filters and the output of this network is given to one of the analog inputs of the Atmega 328p-pu that maps the input signal between the values from 0 to some value. There is an inbuilt timer in the controller using which we can fetch the value of time at the occurrence of a 0. The difference of the values at the successive 0's gives the time period of the signal. The reciprocal of this time period gives the frequency of the input signal which was taken from the brain. This is basically using the consecutive zero crossing points of the signal and measuring the time between them. Since these rapidly changing values can give confusing results, we take a delay of 1 second between noting these values. As we take the reciprocal of the time period, we get the frequency. These waves can be classified into their respective categories depending on their frequencies. As we get the continuous stream of data, it is used to find aberrations in the brain along with the concentration and focus levels. For finding out faults in brain, we look into the waves at a certain frequency and to check for abnormality in the amplitude levels of that signal. The obtained results are displayed on the monitor. If it gives a blank output then it might be due to tumour or any injury. This can be done for each point. The signal obtained from both sides of the brain should be same [5], if it's different, that means there is some problem and we can compare these signals to the expected value to know more about the problem. All these tests are done in eyes closed state. For concentration, the amplitude of the waves is taken into account as the increase in concentration leads to an increase in voltage. For example, the voltage range for brain signal is around 2.7uV and when in concentration, it increases to 3.7uV. This range can be divided into segments and be used to set as benchmarks for concentration for persons doing a certain task according to a person's mental health. This helps in monitoring damage effects and suggests appropriate treatments for better recovery and also detects disorders at early stage and can help to determine course of treatment to cure them.

IV. RESULTS

To observe the brain wave activities, a demo android app EEG Analyser is considered. With the help of the android app, the various real time brain wave signals are obtained in the combined and individual form.

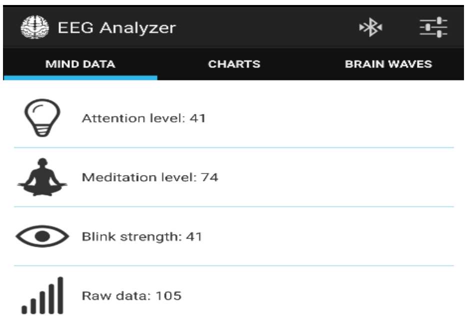

Figure 2: Different brain activities detected and displayed in the application

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Figure 2 displays the various strengths of the brain such as the Attention Level, Meditation level, the Blink strength on a scale of 1 to 100. The Raw Data comprises of all the signals that together comprise of the brain wave.

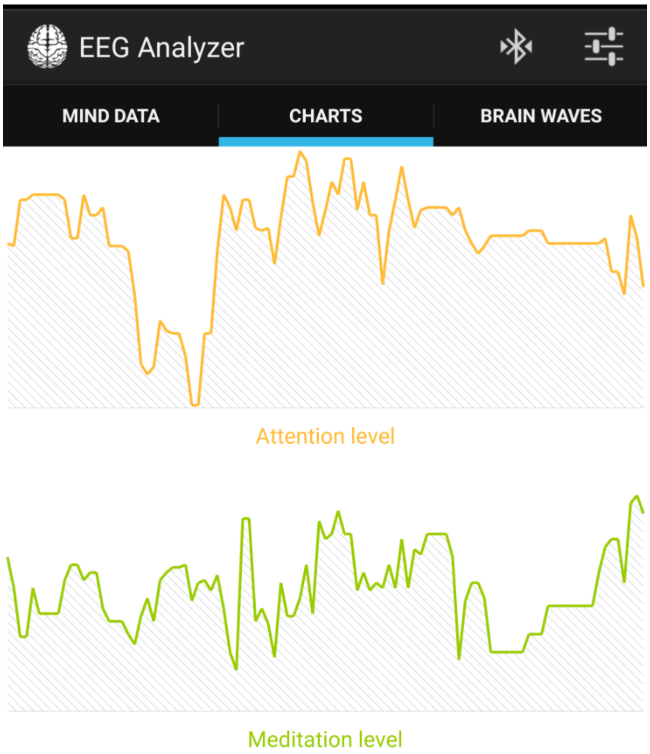

Figure 3: Graphical representation of the levels observed

Figure 5 displays the waves of attention level and the meditation level of the brain in a graphical representation which were observed in Figure 4.

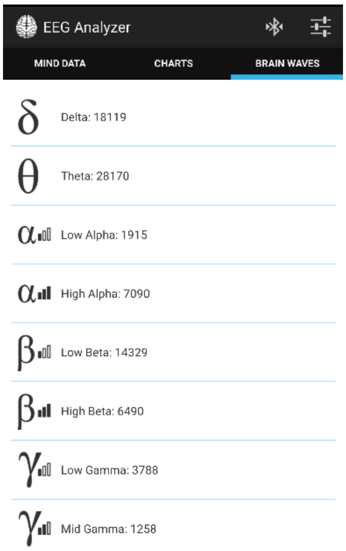

Figure 4: Brain waves strength

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The brain wave comprises of 3 waves mainly which are the Alpha, Beta and Gamma waves. The combined strength is observed as Raw Data in Figure 2. Figure 4 provides the individual strength of all the waves that the Raw Data showed as a combined value. The individual strength of each frequency (signal) is displayed in the Brain Waves section.

V. CONCLUSION

There are many avenues which can be explored with such initiatives. This attempt makes an EEG much more versatile than it has been so far. An EEG is generally an expensive preliminary diagnostic tool for detecting brain illnesses. Another aspect that is targeted is cheaper access to quality healthcare encompassing brain related illness for all people. This paper highlights a way to use the EEG more efficiently so that patient monitoring, EEG wearables, thought to speech/text conversions and brain controlled automation can be made possible.

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