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Brainwave Asymmetry Influenced by Radio Frequency Waves Emitted by Mobile Phones at Different Charging levels of Battery using EEG

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Abstract - A mobile phone, also known as cell phone or hand phone is among the most popular electrical devices used by people all over the world. During recent years, the use of mobile phones has increased substantially and long time exposure to the electromagnetic fields produced by them and their base stations is a matter of concern. So it has become very important to study the effect of radiations emitted by mobile phone on human head. Brainwaves due to numerous neurons are a kind of electrical activity. This electrical activity of brain can be recorded with the help of poly somonography EEG (electroencephalogram) machine. EEG is used to acquire the brain signals. Brain signals are measured by placing electrodes on the scalp. These EEG signal give the micro voltage difference between different parts of brain in a non-invasive manner. The brain activity measured in this way is being currently analyzed for a possible diagnosis and psychiatric diseases. This research discussed on the analysis conducted to study the effect of mobile phone at different charging levels on human brain. The experiment was conducted in a laboratory using. This discusses the effect of EM radiations emitted from mobile phone (GSM GT S7392) at high battery level and at low battery towards human brain. Electroencephalogram machine is used to monitor and capture the brain signals at different stimuli. The signals were obtained under four conditions. (1) Mobile phone ringing at high battery level (2) Call ongoing at high battery level (3) Mobile phone ringing at low battery level (4) Call ongoing at low battery level. The signals obtained under four different conditions are analyzed and processed using different signal processing techniques. The experimental findings show that the effect of mobile emitted EM radiations is more intense at low battery level especially during ringing mode P3-O1 and T5-O1 channels are more affected and when call is ongoing then P4-O2 and T6-O2 channels are severely affected.

I. INTRODUCTION

Wireless technologies are ubiquitous now days and people are heading more towards this technology. Earlier we were using only the wired devices but now there is a move away from the wired phones. The familiarization and dependency on mobile phone is increasing day by day. Cellular systems have experienced exponential growth over last decade and there are currently many billion users worldwide. Mobile phones have been an important tool and a part of everyday life not only in developed countries but its use and craze is also increasing in developing countries. India ranked second after China in using mobile phones (data from Wikipedia). From here we can conclude that mobile phones are the most popular thing for today's generation. Every industry is using cell phones and other mobile devices to explore new ways of communication. The increase of cell usage at such an alarming rate forced us to have a look into the important issue related to negative effect of this technology on human brain. Various studies indicate that the radiation emission from the cell phone can be extremely harmful causing genetic damage, cancer, memory loss, headache, tumor, increased blood pressure, weakening of the immune system, neurological effect and neurodegenerative diseases, allergic and inflammatory responses and some cardiovascular effects. Today most of the population relies on mobile phones for daily communication. Therefore increasing exposure to mobile phone and radiations from base station is growing concern of possible adverse health effects. A cellular phone is a low power, single-channel, two-way radio. EMFs emitted by cell phones are harmful for the human brain and it is more pronounced in children than adults, indicating that the children may be more vulnerable to the adverse health effects of mobile phones than adults, probably because absorption of microwaves is greatest in an object about the size of a child's head. The radiation can penetrate the thinner skull of an infant with greater ease. Cell phone frequencies vary according to the system used ranging around 900 or 1800 MHz and 2200 MHz [Universal Mobile Telecommunication System (UMTS)] [14]. While using mobile phone, electromagnetic wave is transferred to the body which causes health problems especially as the place near ear skull region where they are known to affect the neurons.

II. RELATED WORK

[1] Dayang Azra, Awang Mat et al. (2009) had done the research work on "The effect of Bluetooth Headset and Earphone on Reducing Electromagnetic Radiation from Mobile phone towards Human Head". In this research work thermal imaging technique is used to detect the effect of electromagnetic radiations from mobile phone serving GSM 900 and GSM 1800 on human brain. This technique is used to measure and capture the temperature distribution during the experimental analysis for every 5 minutes interval.

[2] Heow Pueh Lee*, Siak Piang Lim et al.(2014) conducted study on Comparative studies of perceived vibration strength for commercial mobile phones shows Among the five mobile phones for the survey, most of the student volunteers or participants felt that product E and product C had better vibration perception than the remaining phone models, be it holding in palms or putting in their pockets. Product A had the weakest vibration perception level when putting inside the pocket.

[3] Supriya Goel, Manoj Duhan, Geeta Singh et. al (2013) have done a study on "Comparative Analysis of impact of Mobile Phone Radiations on Human Brain: GSM 2G Vs GSM 3G". In this study they have conducted the experiment on 5 volunteers to examine the effect of electromagnetic radiation on human brain while using the mobile phone for 10 minutes. The result shows that the 2G has more effect than 3G.

[4] Christoph Augner, Timo Gnambs, Robert Winker, Alfred Barth et al (2012) study acute effects of electromagnetic fields emitted by GSM mobile phones on subjective wellbeing and physiological reactions: A meta-analysis gives provides evidence that short term exposure of RF-EMF emitted by mobile phones do not affect well-being and related parameters.

[5] Hillert et al., (2008) found a significant effect for headaches it is intriguing that despite the small number of studies and the short exposure duration the overall meta-analytical effect for headaches was 0.08 with a standard error of 0.05. Considering the experimental situation that is often aversive especially for subjects that consider themselves EHS and the short exposure duration and stressing that any exposure related effect on wellbeing must be small (otherwise there would be no controversy about this issue) headaches deserve further study.

[6] V.I. Thajudin Ahamed, N.G. Karthick, Paul K. Joseph(2007) study Effect of mobile phone radiation on heart rate variability on Neurological effect of the electromagnetic field emitted from MP, using HRV measures is examined. The indices, namely sample entropy and scaling exponent, indicate an increase when MP is placed near the chest and a decrease when MP is placed near the head. It can be concluded that the variation is not significant as the 'p' value is high, compared to 'without MP condition'.

[7] Li Yang, Lu Guizhen(2008) study on The research on biological effects of mobile phone radiation to human body so that The research about the biological effect of mobile phone radiation belongs to interdisciplinary subjects, and relates to microwave technology, biology, medicine and physics. Although there are many experiments and theories, there is not any important breakthrough yet.

[8] Dennisj. Mc Farland, A.Toddle Fkowicz et al.(1997) study on Design and operation of an EEG-based brain-computer interface with digital signal processing technology. Development and implementation of EEG-based brain-computer communication requires a system that is highly flexible and capable of rapid and complex real time processing and that provides comprehensive top graphic a land spectral data.

III. PROBLEM IDENTIFICATIONS

From the study of various research papers we have obtained the following problems:

- Comparative study of behavior of EEG signal in three different conditions, while talking on a GSM 2G phone, while using earphone and while using a Bluetooth headset.
- Application of digital signal processing tools and various mathematical functions to determine which communication technology has the highest effect on the behavioral characteristics of EEG signal.

IV. RESEARCH OBJECTIVES

- Study of behavior of EEG signal when RF power is emitted by a GSM 2G phone.
- Study of behavior of EEG signal while attending a call with the use of earphone.
- Study of behavior of EEG signal while attending a call with the use of Bluetooth headset.
- Analyzing the behavioral characteristics of EEG signal obtained under specified conditions.

V. METHODOLOGY

- The Electroencephalogram (EEG) is defined as a technique which provides measurement of the electric activity is the brain, translating the chemical currents into voltage recordings. In this technique, electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media. The medical imaging technique that reads scalp electrical activity generated by brain structures is called Electroencephalography.
- The EEG measured directly from the cortical surface is called Electrocardiograms while when using depth probes it is called Electro gram. It has high temporal resolution in that it is able to characterize fast changes in current flows, but poor spatial resolution because measurements

are limited by the number of electrodes, their placement and properties of the head.

- Thus electroencephalographic reading is a completely non-invasive procedure that can be applied repeatedly to patients, normal adults, and children with virtually no risk or limitation.
- The EEG was originally developed as a method for investigating mental processes. Clinical applications soon became visible, most notably in epilepsy. EEG visual patterns were correlated with functions, dysfunctions and diseases of central nervous system, then emerging as one of the most important diagnostic tools of neurophysiology.

Electrodes conduct voltage potentials as microvolt level signals, and carry them into amplifiers that magnify the signals approximately ten thousand times. The use of this technology depends strongly on the electrodes positioning and the electrodes contact.

VI. RESULT & ANALYSIS

A. SIGNAL PROCESSING TECHNIQUES

To examine the effect of electromagnetic radiations on human brain digital signal processing techniques are applied. The signals obtained are analyzed using digital signal processing techniques like power spectral density, autocorrelation, Fast Fourier transform. Fast Fourier transform is calculated to obtain the power spectrum density of the acquired electrical signals originated in the brain in response to the stimuli impinged in the form of radiations emitted by the mobile phone at high battery level and at low battery level. Various signal processing techniques like autocorrelation, cross correlation, power spectral density, average, max & min operations are used.

B. AUTOCORRELATION

Autocorrelation refers to the correlation of a time series with its own past and future values. Autocorrelation is also sometimes called “lagged correlation” or “serial correlation”, which refers to the correlation between members of a series of numbers arranged in time. Positive autocorrelation might be considered a specific form of “persistence”, a tendency for a system to remain in the same state from one observation to the next. Autocorrelation can be exploited for predictions: an auto correlated time series is predictable, probabilistically, because future values depend on current and past values. Autocorrelation is the similarity between observations as a function of the time lag between them. For continuous functions f, the autocorrelation is defined as:

$$f(t) * f(t+\tau) = \int_{-\infty}^{+\infty} f * (t) f(t+\tau) d\tau$$

Three tools for assessing the autocorrelation of a time series are (1) the time series plot, (2) the lagged scatter plot, and (3) the autocorrelation function.

C. AUTOCORRELATION FUNCTION

An important guide to the persistence in a time series is given by the series of quantities called the sample autocorrelation coefficients, which measure the correlation between observations at different times. The set of autocorrelation coefficients arranged as a function of separation in time is the sample autocorrelation function, or the acf. An analogy can be drawn between the autocorrelation coefficient and the product moment correlation coefficient. Assume N pairs of observations on two variables x and y. The correlation coefficient between x and y is given by

$$\mathbf{r} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{[\sum(x_i - \bar{x})^2]^{\frac{1}{2}}[\sum(y_i - \bar{y})^2]^{1/2}}$$

D. CROSS CORRELATION

The cross-correlation (CC) function represents the similarity of two signals as a function of a time-lag applied to one of them. It is also known as sliding dot product. Usually it is used to find occurrences of a known signal's sequence in an unknown one. For continuous functions f and g, the cross correlation is defined as:

$$f(t) * g(t) = \int_{-\infty}^{+\infty} f * (t) g(t+\tau) d\tau$$

Where f* denotes the complex conjugate of f (Wikipedia, 2014b). Similarly, for discrete functions, the cross correlation is defined as:

$$f(n) * g(n) = \sum_{m=-\infty}^{\infty} f * [m] g[n+m]$$

The Cross correlation is similar in nature to the convolution of two functions.

E. POWER SPECTRAL DENSITY

Power Spectral Density (PSD) is the frequency response of a random or periodic signal. It tells us where the average power is distributed as a function of frequency. The PSD is deterministic, and for certain types of random signals is independent of time. This is useful because the Fourier transform of a random time signal is itself random, and therefore of little use calculating transfer relationships (i.e., finding the output of a filter when the input is random). The PSD of a random time signal x(t) can be expressed in one of two ways that are equivalent to each other

F. MIN & MAX

This gives us the minimum and maximum values of the given data. PSD of continuous analogue EEG signal is a set of approx. 1000 values. Min & Max function gives o/p out of large set of data.

G. COHERENCE

Coherence is a linear correlation measure between two signals represented as a frequency function. It uncovers the correlation between two signals at different frequencies and is often applied for the EEG signal analysis at hospitals. Usually it is used for analysing the condition of different cognitive disorders. It has already been proved that EEG-based coherence analysis can be used in biometrics. The formula below represents the magnitude of the squared coherence estimate, which is a frequency function with values ranging from 0 to 1, quantizes how well x corresponds to y at each frequency. The coherence Cxy(f) is a function of the power spectral density Pxx and Pyy of x and y and the cross-power spectral density Pxy of x and y, as defined in Formula below:

$$C_{XY}(f) = \frac{(|P_{xy}(f)|)^2}{(P_{xx}(f)P_{yy}(f))}$$

In our case, the EEG feature is represented by a set of points of the coherence function. The values x and y are de-trended and filtered raw EEG values in microvolts (μ) from two different electrodes. This function should be applied to all pairs of the data from EEG electrodes. Thus, if the number of electrodes exceeds, the size of the feature table exceeds exponentially. So we must keep in mind that we have to limit the number of sensors for the coherence analysis.

AUTOCORRELATION VALUES OF BRAIN ACTIVITY OF SUBJECTS IN HIGH BATTERY RINGING MODE (TABLE 4.2.1 –TABLE 4.2.4)

TABLE 4.2.1 AUTOCORRELATION VALUES OF SUBJECT FOR P3-O1 CHANNEL

SUBJECT A	SUBJECT B	CORRELATION
SUB1	SUB2	0.845056528
SUB1	SUB3	0.705127255
SUB1	SUB4	0.868334929
SUB1	SUB5	0.859973398
SUB2	SUB3	0.649742631
SUB2	SUB4	0.831482316
SUB2	SUB5	0.876267703
SUB3	SUB4	0.818628465
SUB3	SUB5	0.595567117
SUB4	SUB5	0.776518764

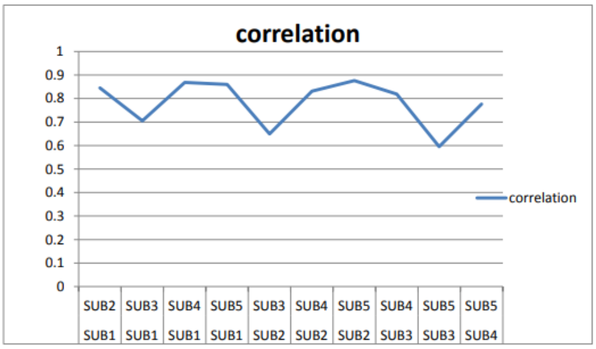

Fig 1: PLOT OF AUTOCORRELATION VALUES OF SUBJECT FOR P3-O1 CHANNEL

AUTOCORRELATION VALUES OF SUBJECT FOR P4-O2 CHANNEL

SUBJECT A	SUBJECT B	CORRELATION
SUB1	SUB2	0.746343014
SUB1	SUB3	0.664698088
SUB1	SUB4	0.88892281
SUB1	SUB5	0.886236502
SUB2	SUB3	0.345691453
SUB2	SUB4	0.603732296
SUB2	SUB5	0.58594325
SUB3	SUB4	0.826609856
SUB3	SUB5	0.76878633
SUB4	SUB5	0.918903109

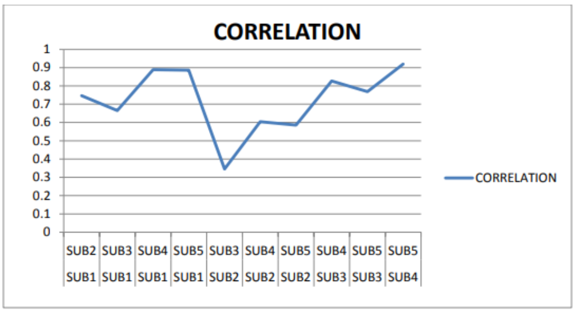

FIG 2: PLOT OF UTOCORRELATION VALUES OF SUBJECT FOR P4-O2 CHANNEL

VII. CONCLUSION

After completing this research work it can be concluded that the mobile phone adversely affects the human brain. , we conclude that the impact of radiation is not same at all the areas of brain. This very fact indicates the variable impact of radiations on our brain cells. As we can see from the table 1-2 and figures 1-2 that the value of autocorrelation is greater than 0.6 for most of the channels. In most of cases it lies between 0.7-o.9. This indicates a strong linear relationship between present and past values. It is concluded that it is more dangerous to use mobile phone when its battery is at low level. When it is in ringing mode, at low battery, P3-O1 and T5-O1 channels (backleft part of brain) are more affected. When call is ongoing, at low battery, P4-O2 and T6- O2 channels (back-right portion of brain) are severely affected. Mobile phone has its own advantages and disadvantages.

VIII. FUTURE WORK

(1) EEG can be used for biometric authentication process. These include the combination of facial recognition and EEG-based authentication, as well as using eye artifacts and facial expressions as extra context data. In a future version of the system, it would be relevant to use more unique features, which are complementary to each other, and cover all of the five EEG characteristics (frequencies, amplitudes, wave morphology, spatial distribution, reactivity), so that behavioral and physiological data is covered for authentication reasoning. Furthermore, we suggest using emotional states (which can be extracted from the Emotive research package) as extra context, in order to avoid emotional states influencing the authentication result, by adjusting features accordingly.

(2)Analysis and Classification of EEG signals using Mixture of Features and Committee Neural Network. Wavelet transform can improve the accuracy.

(3)Study of EM waves emitted by mobile phones of different companies of approximate same price. Comparison of strength EM waves emitted by different cellphones.

(4)Effect of mobile vibrations on heart during silent mode or in general mode with vibration on, when kept near to heart.

(5)Is there a difference in radiation pattern produced by cell phone during a call and when it is in idle mode.

(6)Are cell phones dangerous to use near gas stations??

(7)Test for microwave leaks by putting a cell phone inside a microwave and calling it.

(8)Does a mobile phone plugged into the charger produce more radiation??

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