In search of Emotional Manifestation in ECG Signal

Snigdha Madhab Ghosh, Partha Mitra, Sunandan Bhunia

Abstract— Emotion detection recognition in physiological signal and categorization their of, is very challenging. There are many methods for detecting the emotional features from physiological and ECG is one of them.

In this paper we have analyzed sixteen ECG signals of two different groups and tried to find some similarities among the same group and also between these two groups based on two parameters viz mean instantaneous frequency(MIF) and correlation coefficient, with an aim to classify their emotion

Index Terms— Electrocardiogram, emotion, empirical mode of decomposition, intrinsic mode function, mean instantaneous frequency.

I. INTRODUCTION

Emotion is an important aspect of the human life. The positive emotions keep the human beings healthy and the negative emotions create lot of complications in the physical working of the body. Emotions are various bodily feelings or a mental state. This bodily feeling or mental state is caused by numerous cognitive components, which may be internal or external.

Emotion is accepted worldwide as the actions and reactions in the social communication network, day-to-day behavioral adaptations or modifications, motivation, frustration are greatly influenced by the someone's mood and unique emotional state[1].

Emotion is a mental feelings or mood which is experienced by the bodily feelings or mental happiness. This good feelings comes from the biological comfort of the body or from mental peace.

It is also observed [2], [3] that emotional intelligence, that is the ability to identify, assess, and manage emotions of one's self and of others, plays a crucial role in effective communication and learning processes of extracting and imparting information. Furthermore, a number of studies by neuroscientists, cognitive scientists, and psychologists have shown that emotion is of major importance in rational and intelligent thinking. More precisely, it has been shown [3] that patients without emotional brain functioning had severe impairments in everyday activities that require rational and intelligent behavior.

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Snigdha Madhab Ghosh, E&ECE Department, Indian Institute of Technology, Kharagpur, India.

Partha Mitra,, ECE Department, Brainware Group of Institutions, Kolkata, India.

Sunandan Bhunia, ECE Department, Haldia Institute of Technology, Haldia, West Bengal, India.

Emotion can be defined as "A reward is anything for which an animal will work. A punishment is anything that an animal will work to escape or avoid. An example of an emotion might thus be happiness produced by being given a reward, such as a pleasant touch, praise, or winning a large sum of money"[4]. The feelings or emotions are related to heart functions directly or indirectly. It is often seen that during the time of fear the heart beats are increases and during the happiness the heartbeats are normal if the internal body system is subjected to normal stress.

Emotion has been defined as "a subjective, internal experience correlated with a group of physiological reactions arising in response to some situation. In an experience of emotion there is a feeling, or affective, response (e.g. sadness, anger, joy), a physiological response (changes in internal bodily functioning), a cognitive response (an interpretation of the situation), and possibly also a behavioral response (an outward expression) [5].

Since the heart is affected by the emotions, so it is important to study the impact of emotions on the heart. The pattern of the ECG signal during a prolonged positive or negative emotion, the changes in the ECG signal during the transition from positive to negative emotion or vice versa. The effect of emotion and non-emotion stimulus to the physiological signal . There is enormous area to study the connection of emotion to the heart , brain impulses and the human memory.

Latest research emphasized the close relationship between the cardiac signal and emotion and vice versa.[6]. Joris H et al proposes the boosting emotional communication through intimate connections has the potential to reduce loneliness.[7].

The structure of this paper are as follows: section II describes the experimental setup. Section III provides brief description of necessary theory. Section IV provides the details of experiment. Section V display the results and analysis thereof.

II. EXPERIMENTAL SETUP

The aim of this experiment is to collect a ECG data for emotional experiment from economically sound and healthy background subjects, We have recorded sixteen ECG signals and explained them(subjrcts) the purpose of ECG recording and their consents are obtained. The lower age of the this group is 30years and the upper age is 61 and the average is 45.9375. The subjects are interviewed about their mental status, whether they are in good mood or suffer from mental anxieties. So we divide the subjects in two different groups of positive emotion group(I) and negative emotions group(II). We requested the subjects of positive emotion group to listen the most enjoyable songs they like and on the other hand the second group, the negative emotion group subjects are requested to listen most sad songs they like.

The subject requested to listen one liking song to stable

the movements of the artifacts., finally asked him to listen the most songs as instructed and the ECG was taken for one and half minute

III. RELATED THEORY.

A. *Empirical Mode of Decomposition.*

Empirical Mode Decomposition (EMD)[8] is an adaptive signal analysis technique normally applies to non-linear, non-stationary object. It has extensive application in climatory data analysis and to the mechanical vibration and physiological signals.

The ECG signal is a non-stationary and non-linear signal and so EMD applies to decompose ECG signal. The ECG signal is decomposed using EMD to find unique oscillatory nature of the data. EMD is a posteriori in regards to the decomposition of the data into intrinsic mode functions (IMF)[7]. Due to the adaptive nature of EMD, it described the patterns in non-stationary and non-linear systems.

IMF is a function which satisfies the following conditions: (a)The number of extreme (maxima and minima) and the zero crossings must be equal or differ by at least one. (b) The mean of the envelope, interpolated by the maxima and minima is zero for each sample. $e_{min(}$ and e_{max} are the extreme of the signal. $_1$ is the mean.

$$_1 = \frac{e_{min(t)} + e_{max}}{2} \quad \ldots\ldots\ldots(1)$$

$$S_{\ } = \sum\left[\frac{|(h_{1(k-1)}\ (t) - (h_{1(k-1)}\ (t)|^2}{h^2(k-1)(t)}\right. \quad (2)$$

B. *Hilbert-Hung Transform [8],[9].*

The Hilbert transform computes the instantaneous frequency by

$$Y(t) = [X(t)] = \frac{1}{\pi} PV \int_{-\infty}^{\infty} \frac{x(}{t-} d \quad (3)$$

Where PV describes the principal value of singular integral and the analytic signal is defined as

$$Z(t) = x(t) + i(t) = \alpha(t) e^{j\theta(t)} \quad (4)$$

Where $\alpha(t) = \sqrt{x^2 + y^2}$

IV. EXPERIMENTS

In this case we have collected sixteen ECG signals. Each signal is decomposed into number of intrinsic mode functions(IMF). The stopping criterion and number of iteration was same for each signal. The number of IMFs for each signal is different, ranging from eleven to fourteen numbers of IMF. One of the such ECG signal (subject no one) is given in the figure1 and the corresponding IMFs are given In the figure2. and figure3.

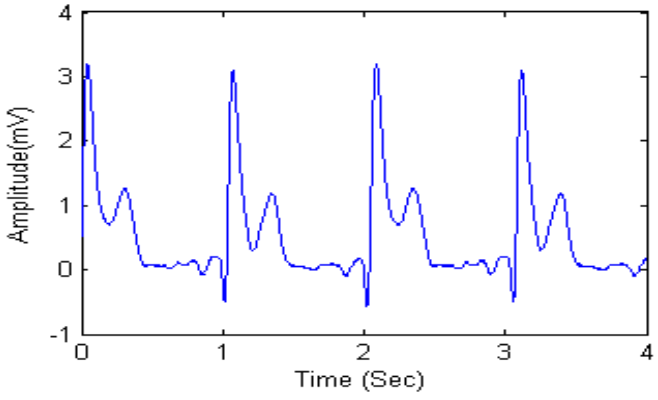

Fig. 1.ECG signal

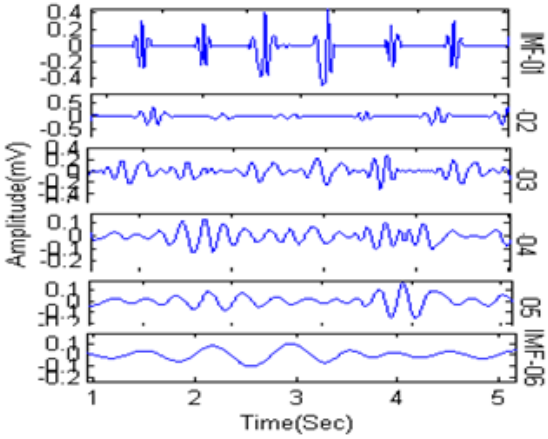

Fig.2. IMFs(1to6) of ECG signal

The IMFs are the components of the and if all the IMFs of a particular ECG signal are added up we get the actual ECG signal with slight error. So it is relevant to investigate the IMFs and to find if any difference is there among subjects.

There are many features associated with the IMFs to find the correlation among the subjects. It is observed mean instantaneous frequency(MIF) of one IMF of a subject's ECG is equal or close to one IMF of other subject. The relevancy of these IMFs with their parent ECG is checked and found that, there are all related with different degrees. Relevancy of IMFs with the parent ECG signal is checked.

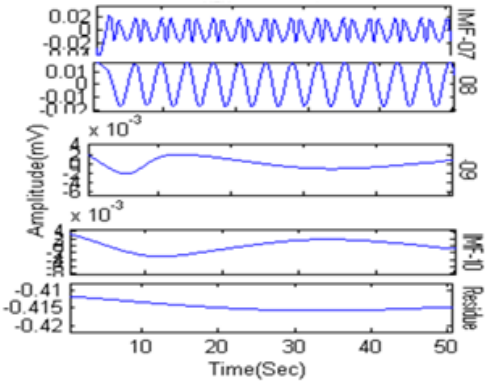

Fig.3. IMFs(7to10) of ECG signal

The mean instantaneous frequency(MIF) and relevancy with parent ECG indicates some correlation among the subjects behavior and more to be investigated. We further measure the correlation coefficient among the subjects of the same group and between the groups.

V. RESULTS AND DISCUSSION

We have chosen those IMFs from each ECG signal which bears the same instantaneous frequency or of closer values. The percentage of correlation coefficient among subjects of each group and between groups are obtained. In group one that is positive emotion group, that contains eight subjects, so total number of combination yields twenty eight, if we take two subjects out of eight subjects leaving combination of same subjects. We find 39.28% subjects qualify the above 60% mark of correlation coefficient and 50% subjects qualify

50% mark of correlation coefficient which is shown in fig 4.

In the second category, that is negative emotion group, where 39.28% subjects are above 60% mark of correlation coefficient and 46% subjects are above 50% mark of correlation coefficient. Which is shown in fig 5.

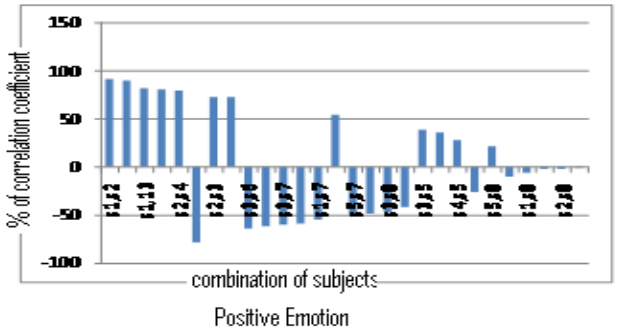

Fig.4.correlation of positive emotion group

The cross correlation between these groups, as shown in fig 6,. that is positive emotion group and negative emotion group reveals that87.5% subjects fail to qualify 60% correlation coefficient mark.

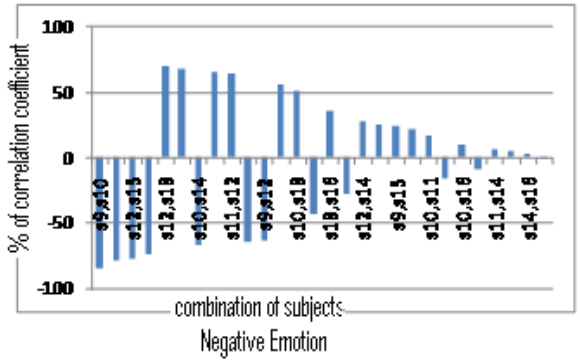

Fig.5 correlation of negative emotion group

The above results support our basic grouping of positive emotion group and negative group in some percents, shown above. These experiments fail to achieve 100% or nearer , because of various reasons such as (a) the average age of the subjects are higher and higher age people can control emotions as are more experience in life (b) subjects hide their facial expression (c) our assumption regarding the emotion of subjects was improper. It is required to test the ECG signal with different method to ascertain a particular emotion.

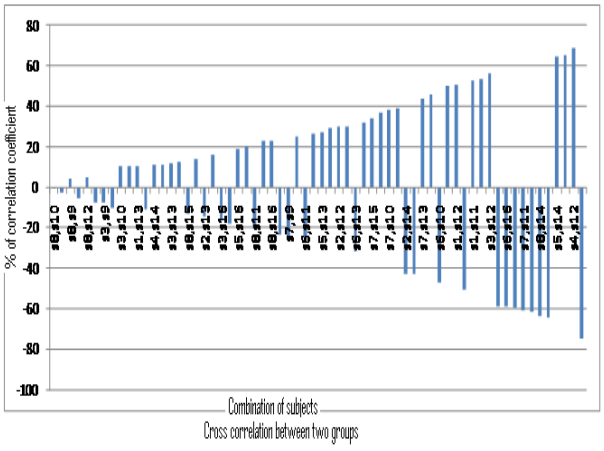

Fig.6cross correlation of two groups

VI. CONCLUSION

The emotion in the ECG signal is as challenging as defining and quantifying the psychological aspect of mind. The controlled external behavior of the human beings make the emotional research more complex. Emotions are generally controlled by the intrinsic and extrinsic properties of the subjects. The emotions are not compared by any physical units, only assessed by subject himself or herself or by other people. So these assessment also varies from participants to participant. A positive emotional stimulus con not create a positive emotion in subject if he or she suffers from anxiety or disgust. Despite various modifiers, emotional research is being carried out in all over the world.

In this paper we tried to extract few features to find if they are of same or closely related. Again every system and method has its own tolerance. The assumption of the subjects based on visual indications are not always correct. Again while interviewing the subjects, they may hide certain emotional contents of the mind, or feel unimportant to inform researcher and this leads to improper accuracy of the result at the end. Emotion is a complex matter as there are various mixed emotions between the two extreme positive and negative emotions.

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Snigdha Madhab Ghosh received his Dip. in ECE , from Communication training Institute (CTI), Indian Air Force, Bangalore (1984) also completes his graduation in ECE from Institution of Engineers (India). He obtained his M. Tech in ECE from West Bengal university of Technology. Presently working in the Digital Signal Processing Laboratory, E&ECE Dept. IIT Kharagpur. His area of research interest includes, wireless communication, VLSI and Biomedical Signal Processing etc.

Partha Mitra obtained his Bachelor degree in Electrical Engineering from The Institution of Engineers (India), Kolkata in 2004 and Master degree in Electronics and Communication Engineering from West Bengal University of Technology, Kolkata in 2011. Presently he is working as Assistant Professor in ECE Dept. at Brainware Group of Institutions, Kolkata. His research interest includes Low Power VLSI design, CAD for VLSI.

Dr. Sunandan Bhunia obtained his B.Tech, M.Tech from institute of Radiophysics and Electronics, Calcutta University in 2002 and 2004 respectively. He obtained PhD degree in engineering from Jadavpur University in 2009. He was awarded gold medal from Vidyasagar University for 1st class 1st in Physics (H) in 1999. He is currently working as Associate professor and Head, Department of Electronics and Communication Engineering, Haldia Institute of Technology, Haldia, under WBUT. He has published about 30 research article in reputed international & national journal and conferences. His area of research interest includes, Microstrip Antenna, Microstrip Filter, and Frequency Selective Surfaces. He is the member of Chief Technical Advisory Board of International Journal of Soft Computing and Engineering (IJSCE) and member of editorial board of International Journal of Computer Technology and Electronics Engineering (IJCTEE). Editorial Board Members of International Journal of Wired and Wireless Technology (RG), Members of Scientific Committees and Editorial Review Boards of World Academy of Science, Engineering and Technology, Chief Technical Advisory Board member of International Journal of Recent Technology and Engineering (IJRTE).