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A Machine Learning Approach for Ecg Analysis for Emotions

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***Abstract**: Emotions are feelings which one can feel and are hard to be put in a form by a person .However they reflect the mental state of a person. Emotions like joy and sadness can be somehow detected from the facial expressions or through the body language. But these emotions do have an impact upon our system. An individual's electrocardiogram is a way through which one can know the impact of different parameters such as stress, joy, sadness, anger on the mechanism of our body. The emotions such as anger, sadness have an adverse effect on the cardio system and is seen in the form of abnormal ECG which can be a good pointer to a counselor when finding out the reasons and diagnosis. The decomposition technique along with the Hilbert transform can be used for feature retrieval. The different emotions are detected through the binary classification technique*

Keywords: denoised, mean frequency, fission, fusion, decomposition, classifier

I. INTRODUCTION

Human being are susceptible situations , surrounding atmosphere, family and workspace environment. It is the inherent quality which will cause them to emote their feeling through various emotions. There are certain emotions which are easily detected through language or expressions. These emotions could be because of some external stimuli. The emotions expressed by viewers could give an insight to the mental status of any individual. This analysis of human emotions can be used in medical field, education and so on. Through analysis a doctor will be able to put his diagnosis more in sync with the mental status of his patient. The greatest difficulty in correlating the emotions and the reasons giving rise to these emotions is that these factors or reasons are not visible . Also one cannot be certain of the emotions using the facial or behavioral responses as maybe the individual could very well suppress ones true emotions. So we cannot be certain that a person is emoting the expressions as he is exactly feeling at that particular instance, hence the exact emotion cannot be inferred in such cases. In such case exact reason for debacle in the health cannot be related to stress ,anger or too much excitement or joy In this work, our main aim is to detect the emotions in a person based on their physiological response. The various signals such as the electroencephalogram(EEG),heart rate, galvanic skin response and blood pressure constitute the physiological signals. These signals are used for the clinical analysis but the amount of information they carry regarding the emotional status of an individual is a very small percent. Using them could hamper the accuracy of the analysis The response or the emotions are to be recognized using the electrocardiograph (ECG) obtained from the subjects. Most of the time we are used to reading the P-QRS-T wave at the cardiac center. The ECG signals are to be analyzed .for different emotions such as joy, sadness anger and fear. The ECG signal is a result of a stimuli from the circumstances or situations and is a cardiovascular original. The PQRS signal is a nonlinear signal. The most difficult task related to this analysis is the gathering of data or signal. The reason being that most subjects are not willing to share their medical history. The other technical issue is the collection of the non stationary signal .One can have a laboratory set up where the response is gathered by applying various emotional stimulus. The standard data bank is used for training and creating model. The aim of this work is to detect emotions from ECG signals . The utilized data set consists of a set of ECG images collected from multiple subjects. The ECG signals carry noise in addition to the information so one has to remove the noise and smooth the ECG signals. To remove the noise and smooth out the ECG signal it needs to be de-noised. The Fourier transform was the most commonly used method previously for a nonlinear signal, such as the electroencephalogram, the electrocardiogram, However it was found that this method did not give good resolution It then became imperative that a new method need to be used that would be able to handle the nonlinear and non stationary signal such as the ECG. The Huang Hilbert Transform(HHT) is a new tool for such type of non stationary data. A combination of advanced signal processing and machine learning techniques can be used for the characterization of physiological signals. The characteristics or features of a signal will be the instantaneous amplitude and frequency and further statistical derived features. In feature extraction one has to be careful of selecting the features that will constitute the contributing information and form a part of the feature data set. The feature set can be reduced to select the right or significant features and then put to task in analyzing. After computation of large number of features the best ones can be evaluated.

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For de-noising the signals an adaptive low pass filters are used For an ECG(PQRST) signal we need to determine the peaks and their time intervals between the peaks .The sampling frequency for this time interval is irregular, hence the need arises for the resampling of the signal with a proper resampling frequency. For The ECG signals carry noise in addition to the information.

So as to remove the noise and smooth out the ECG signal it needs to be denoised. The Fourier transform was the most commonly used method previously for a nonlinear signal, such as the electroencephalogram, the electrocardiogram, However it was found that this method did not give good resolution It then became imperative that a new method need to be used that would be able to handle the nonlinear and non stationary signal such as the ECG. The Huang Hilbert Transform(HHT) is a new tool for such type of non stationary data. The characteristics or features of a signal will be the instantaneous amplitude and frequency and further statistical derived features. In feature extraction one has to be careful of selecting the features that will constitute the contributing information and form a part of the feature data set, The feature set can be reduced to select the right or significant features and then put to task in analyzing. After computation of large number of features the best ones can be evaluated. For de-noising the signals an adaptive low pass filters are used For an ECG(PQRST) signal we need to determine the peaks and their time intervals between the peaks .The sampling frequency for this time interval is irregular, hence the need arises for the resampling of the signal with a proper resampling frequency. an R-R wave a resampling frequency of 4Hz is used. Only the relative amplitude is considered by deleting the baseline signal. The signal is normalized by its mean and standard deviation

After the physiological signal is noise free it is ready for the next stage of the process. Such a noise free(Figure 1) signal is a better means from which the feature retrieval can be done

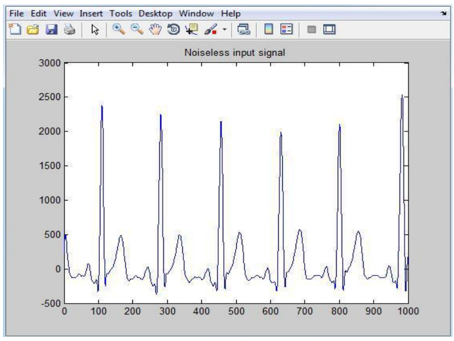

FIGURE 1. NOISE FREE SIGNAL

II. METHODOLOGY EMPLOYED

In this section of we discuss in short the methodology of the analysis. The analysis is carried out in two stages. The training and the testing..In the training phase the machine learning model is built. This model learns to relate the output to the input. To build the model, attributes of ECG signal are extracted to form the feature vector. The number of attributes can be reduced for better accuracy . The feature extraction and reduction is done using the empirical mode decomposition (EMD) and Hilbert Transform. The testing phase uses the support vector machine(SVM) for classification.

III. EMPERICAL MODE DECOMPOSITION

The EMD method is a part of the HHT utilized in breaking down the noise free signal In this process the data vector can be broken down into a finite and small number functions known as Intrinsic Mode Functions(IMF). The functions thus generated from breakup must meet the two condition in order to be termed as the harmonics to be used in the data set. a)The number of times the upper extrema or maxima and the number of times lower extrema or minima crosses zero must be equal or they can have a difference by one at the maximum. b) the average or mean value of envelopes needs to be zero. These envelopes have the upper envelope and the lower envelope . The upper envelope is made by joining all the local maxima. The lower envelope is made by joining all the local minima. The decomposition is carried out through the following steps as given below.

x(t) is a given ECG input signal which is a varying amplitude and time signal ,carrying all the characteristics used in analysis

1. Find out all the minima. of the input signal.

Find out all the minima of input signal..

$$d0\ (t) = X\ (t) \qquad (1)$$

2. Interpolate between the maxima to obtain the upper envelope eu (t)
3. Interpolate between the minima to obtain the lower envelope el (t).
4. To calculate the average use equation

$$m\ (t)=[eu(t)+el(t)]/2 \qquad (2)$$

5. We subtract the mean value from the original signal to extract the details

$$d1\ (t) = d0\ (t)-m\ (t) \qquad (3)$$

If the calculated value meets the two criteria as defined for the function then d1 (t) is the first function. It is assigned to a new variable ,that is imf1(t)= d1 (t). The remnant is found by deducting the imf1(t) from the signal(t)

$$Rem1(t)=x(t)-imf1(t) \qquad (4)$$

The steps 2 to 5 are repeated with the previous remnant becoming the new x(t) to find out then next IMFs.

If the stopping criteria in not met by the first d1 (t) then steps 1 to 5 are repeated till one finds the first function.

To find out the extent to which the IMF's could affect other IMF components the stopping criteria is used. In fact the stopping criteria is a means to conclude the number of intrinsic functions having sufficient and contributing information required for analysis. A criteria based on two thresholds ϴ1 and ϴ2. Which agrees for small fluctuations in the mean value is employed. The value of ϴ1 =.o5 and ϴ2=10ϴ1 .The mode amplitude is given by a(t)=eu(t) – el (t). The evaluation function is ∝ (t). The iteriation function is carried till ∝ (t) <ϴ1 for a time (1-∝) while ∝ (t)<ϴ2 for remaining period. The original x(t) can be reconstructed using superposition

$$x(t)=\sum_{i=1}^{n} c1(t) + rn(t) \qquad (5)$$

where n= number of IMFs

IV. FISSION

Each IMF has their own specific characters which are the features. These characteristics are extracted from each of the IMF using the fission method.

All these features retrieved go to constitute the feature vector. The second step in HHT is the Hilbert transform which is applied to each IMF component.

$$H[ci(t)]=1/\pi[PV\int_{-\infty}^{+\infty} c(t')/(t-t')] \quad (6)$$

where PV is the Cauchy principal value

To obtain the instantaneous frequency information for every IMF the derivative of the phase is calculated

Fi(t)=1 dΘi(t)

2π d(t)

The number of IMFs for each biosignal can be varied from nmax to nmin. We can calculate the root mean square, maximum amplitude (Figure 2) mean instantaneous frequency and weighted mean instantaneous frequency of each IMF.

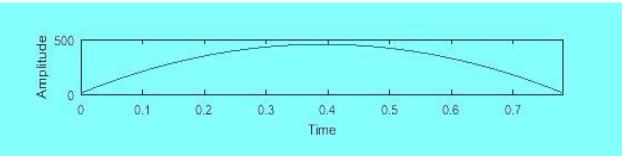

Fig 2. Amplitude

Features can be extracted from each IMF. The feature vector is formed from the features of the first(1…. n_{min}) IMFs. Comparing the performance of features based on different number (1…. n_{min}) of IMFs we choose the feature of the first m

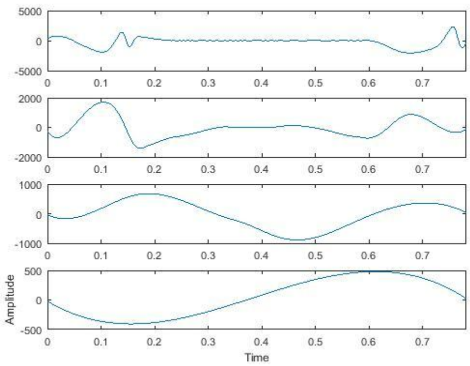

Figure 3. Intrinsic Mode Functions

V. FUSION

In the fusion process the information from the different IMFs are combined to form a composite and this is calculated from the weighted mean frequency(WMNF) of signal. Fission, fusion of signals are the two steps on which the classification system is based upon. When fusion method is compared with fission one can know that the main difference between them is the estimation of MNF. Each signal is segmented using half overlapped windows Each segment is decomposed using the EMD. The weighted mean instantaneous frequency of each IMF with N samples is found out using the equation:

$$WMIF(i) = \frac{\sum_{j=1}^{N} f_i(j) A_i^{2}(j)}{\sum_{j=1}^{N} A_i^{2}(j)} \quad (7)$$

To obtain the mean value of frequency the weighted mean frequency is used. It is calculated from the equation:

$$MNF = \frac{\sum_{i=1}^{n} ||a_i|| WMIF(i)}{\sum_{i=1}^{n} ||A_i||} \quad (8)$$

Besides these features we calculate the minimum, maximum and standard values of deviation and median values .One can always go for feature reduction considering the most contributing and significant features that help in the analysis.

VI. SUPPORT VECTOR MACHINE

Support vector machine (SVM) is one of the most popular machine learning algorithm. It is a classifier that observers the information and classifies based on statistics arrived through observation and gives good accuracy .Hence it is discrimination formally defined by a separating hyperplane. From the information the features are extracted and then further used for classification. The algorithm generates an optimal hyperplane which categorizes data into two categories .A good margin is the important characteristic of an SVM classifier .A good margin is one where this separation is larger for both the classes. A good margin will help the points to be separated in their respective classes .A sufficient good margin will avoid crossover of points to other class. This aspect can be reliably applied in emotion recognition from using the physiological signal The SVM is done by transforming the problem using linear algebra. We can use linear kernel, polynomial kernel or the exponential kernel. In the linear kernel method of SVM the discriminant function is given by:

$$F(x) = sgn(\sum_{j=1}^{M} yj(\alpha jK(xj,x) + b) \quad (9)$$

Where M =number of training examples

Xj =training example

Yj=correct sample of SVM of the i_{th} training example.

K=kernel function

αj =lagrange multipliers

VII. RESULT AND COMPARISON

The analysis carried out by Wang Bin & Liu Guang-Yuan[3] as described in their paper ,was carried out for two emotions joy and sadness. The algorithm they used for feature selection was the Genetic simulated annealing algorithm while the fisher classifier was used for classification. The average recognition rate for the two emotions are 88.9%. The analysis by Amjad M R Alzeer Alhouseeni, Imad Fhakri Al Shaihli ,Abdul Wahab Bin ABul Rehman[2] used fourier transform for emotion detection .Kernel density estimation and mel frequency were utilized for for feature extraction. The classifier used by them was Multilayer Perceptron. The overall accuracy was 66.11%. The analysis by as put in their paper by A .N Paithane, D S. Bormane & Ujwala Patil[1] using the HHT method and SVM as classifier used the six IMFs for feature extraction. The overall accuracy was found to be around 65%. The analysis in this paper uses support vector machine algorithm for classification. The overall accuracy for the technique used was 85%.

VIII. RESULT & ANALYSIS

The ECG signal was first recorded .It is found that the recorded signal has noise signal. The signal has to be denoised. The denoised signal is then decomposed. Only the first four IMFs are considered as they sufficient information that can be used to extract the features. The features that we have used are the instantaneous frequency and instantaneous amplitude. This is shown in Fig 3.. The SVM classifier is used here as it gives better results. In our analysis we have used a data bank with around 80 ECG signals. For the training phase we have fifty percent of the signals that is about 40.The model we have created using feature vector of mean frequency and amplitude. The testing phase uses the remaining fifty percent of data bank signals. These signals included signals obtained through stimulation of anger , joy sadness and pleasure. Figure 5 shows the classification using the SVM .

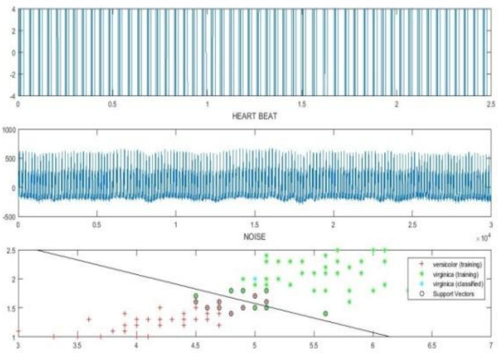

Figure 5 classification

The accuracy parameter that defines the efficiency of our system is calculated through the measures of precision and recall. The accuracy calculated for a threshold value of 70% is around 85 % .

Table 1. Accuracy in percentage

IMFs	Accuracy
IMF (only first four contributing)	85%

IX. CONCLUSION

Different human emotions can be recognized through the analysis of the physiological signal. Here the analysis used the electrocardiogram. The method of empirical decomposition along with two methods fission and fusion are used. These methods of transform and decomposition are based on the Hilbert-Huang transform (HHT) .The feature extraction scheme supports to analyze the heterogeneous signals. Using instantaneous amplitudes and frequencies the calculation of mean frequency is done which are the parameters used in analysis . The SVM classifier is basically used as a binary classifier as it helps give improved accuracy for emotion recognition.

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