Novel Algorithm for Feature Extraction and Feature Selection from Electrocardiogram Signal

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ABSTRACT
It has been seen that emotion recognition is an important research topic in the field of Human and computer interface. A novel technique for Feature Extraction (FE) has been presented here, further a new method has been used for human emotion recognition which is based on HHT method. This method is feasible for analyzing the nonlinear and non-stationary signals. Each signal has been decomposed into the IMF using the EMD. These functions are used to extract the features using fission and fusion process. The decomposition technique adopted is a new technique for adaptively decomposing signals. In this perspective, the potential usefulness of EMD based techniques is reported here. The algorithm developed is based on the Augsburg University Database; the manually annotated database.

Keywords
Intrinsic Mode Function (IMF), Hilbert-Huang Transform (HHT), Empirical Mode Decomposition (EMD), Emotion Detection, Electrocardiogram (ECG).

1. INTRODUCTION
The Human emotion is a key part to interact between a person and intellectual machine. For instance in classroom learning or conference settings the response of the listener will be greatly improved if a machine interprets the listener emotional state for the machine to provides an appropriate solution to the problems the listener is currently facing [1, 2]. The knowledge of patient's emotional state is also helpful for the psychologist to diagnose any disease. This application will be useful for the elders, newborns and those who have difficulties in expressing their particular emotions [3, 4].

Feature Extraction can be considered an important step to extract useful information from ECG signal to detect emotional contents. In order to perform the necessary task, the proper information should be extracted from the input data of the feature set. In this work, the machine learning and signal processing techniques are proposed for characterising the physiological signals. HHT was designed and developed to describe nonlinear waves and non-stationary signals that naturally occur in real world processes [5]. From the past literature, various techniques for extracting the features of physiological signals have been considered. [5,6,7]. Most of the methods found in the literature are linear [8]. However, it has been observed that HHT works better for both nonlinear and non-stationary signals which justified the method chosen for this work [14,15].

The remaining sections are as follows. Section II presents the Hilbert Haung Transform Section III describes actual experimental results and section IV conclusion.

2. HILBERT-HUANG TRANSFORM
Real electrocardiogram (ECG) signal taken from the human body contains noises and external interferences. This real-time ECG signals resulted from electrostatic devices and muscular movements of the human body [9]. Therefore, noise and repetitive signals should be eliminated from the raw physiological signal before processing by using HHT itself [12]. The aim of this stage is to de-noise the ECG signal. The data analysis by using the HHT is an empirical method to decompose the signal and separate into several intrinsic mode functions (fission process), and then useful Intrinsic Mode Function (IMF) with the fission process combined to estimate mean frequency using Hilbert Transform (HT) [10, 11]. The important features are extracted in fission approach from IMF. The fusion approach is mainly used to compute the feature vectors to find Mean Frequency (MNF). The algorithm presented here is a novel one for the detection and extraction of IMF. A stopping criteria must be set so that the iteration number will not be too large to break the physical meaning of the signal and to keep the operation time of the signal be acceptable [13,14,15].

The equation used in our work to compute a mean is [8]:

$$m_{n1}(t) = (u_{max(t)} + l_{min(t)})/2 \qquad (1)$$

Similarly, the equation to calculate first component is [8]:

$$f_1(t) = X(t) - m_{n1}(t) \qquad (2)$$

2.1.Fission Approach
Lets X(t) is a given input signal.

Step 1 Trace out all maximum values of input signal X(t).

Step 2 Obtain $u_{max(t)}$ and $l_{min(t)}$, upper swirl, lower swirl respectively as by Interpolating X(t)

Step 3 Compute the mean as equation (1)

Step 4 Compute the first component $f_1(t)$ as given in (2)

Step 5 Iterate to satisfy the condition of IMF.

Step 6 Compute residual signal as equation $r_{e1}(t) = X(t) - c_1(t)$.

To check IMF function as a monotonic function repeats all above steps. In this process, the estimation of IMF is very much depending on the stoping criteria, so stoping criteria is important here. Because of that iteration number will not be too large to break the physical meaning of the signal and to keep the operation time of the signal be acceptable. Two conditions must be fulfilled by IMF [5,13].

Here we used standard deviation criterion [8]:

$$SD = \sum_{i=0}^{n}\left[\frac{|r_{e\ n-1}(t)-r_{e\ n}(t)|^2}{r^2_{e\ n-1}(t)}\right] \qquad (3)$$

Where, n is the number of IMFs.

Here, a linear superposition is used to reconstruct the original signal X (t):

$$X(t) = \sum_{i=1}^{n} c_i(t) + r_{en}(t) \qquad (4)$$

HT is applied on each IMF ($c_i(t)$) [11,12], which is defined using Cauchy Principal Value (PV) explicitly, the HT of an IMF function is given by,

$$H[c_i(t)] = \frac{1}{\Pi}\, PV \int_{-\infty}^{\infty} \frac{c_i(t')}{t-t'}\, dt' \qquad (5)$$

An analytic signal is defined to figure out the Instantaneous frequency and amplitude is,

$$Z_i(t) = c_i(t) + jH[c_i(t)] = \alpha_i(t)\, e^{j\emptyset}\, i(t) \qquad (6)$$

For IMFs the instantaneous amplitude $A_i(t)$ and instantaneous frequency $fr_i(t)$ can be computed as,

$$A_i(t) = abs(H[c_i(t)]) \qquad (7)$$

$$fr_i(t) = \frac{1}{2\Pi}\frac{d\emptyset_i(t)}{dt}$$

Four features extracted from each IMF. Finally, by analysing performance of the extracted features from different IMF, choose the required features set which gives the best throughput for all bio-signal.

2.2.Fusion Approach

In fusion process, features extracted in fission process are used to find MNF from WMIF [6]:

$$WMIF(i) = \frac{\sum_{j=1}^{N} fr_i(j) A_i^{\,2}(j)}{\sum_{j=1}^{N} A_i^{\,2}(j)} \qquad (8)$$

The mean frequency is defined from WMIF is as:

$$MNF = \frac{\sum_{i=1}^{n} ||A_i|| WMIF(i)}{\sum_{i=1}^{n} ||A_i||} \qquad (9)$$

3. RESULTS AND DISCUSSION

The database recorded in the University of Augsburg contains four different emotions. This database is processed to find out different features like instantaneous frequency, amplitude and mean frequency from their IMF.

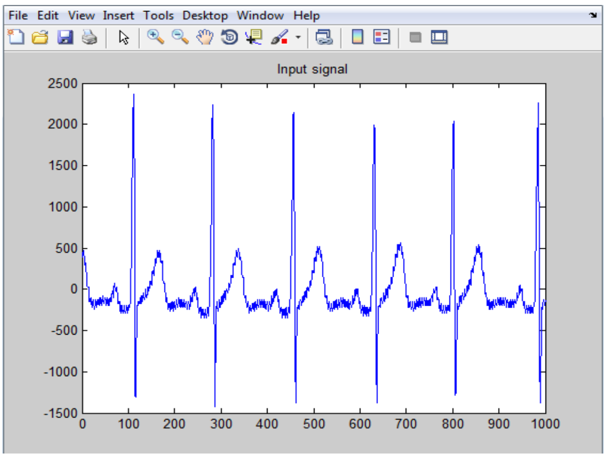

Fig. 1: Recorded ECG Signal.

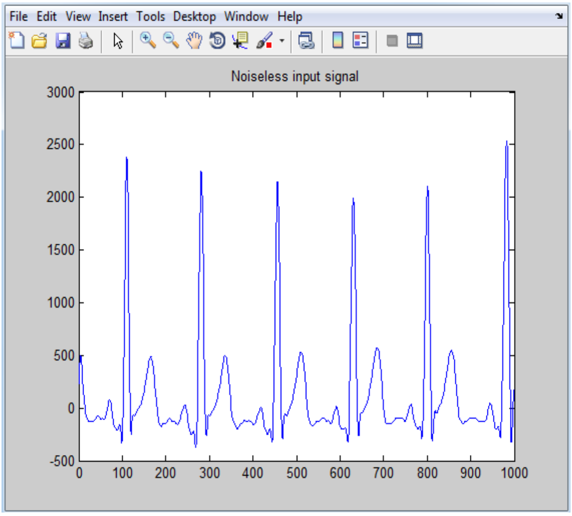

Fig. 2: Noise removed ECG signal

Fig.1 shows recorded ECG signal from this the noise is removed by using Hilbert-Huang Transform. The Fig.2 shows the ECG signal free from the noise and this signal is used to calculate IMF using fission process as shown in Fig. 3. First four IMF contain oscillatory activity greater than last four IMFs. Therefore, last four Intrinsic Mode Functions IMF 5 to IMF 8 shown in Fig. 3 will not prevent the instantaneous frequency.

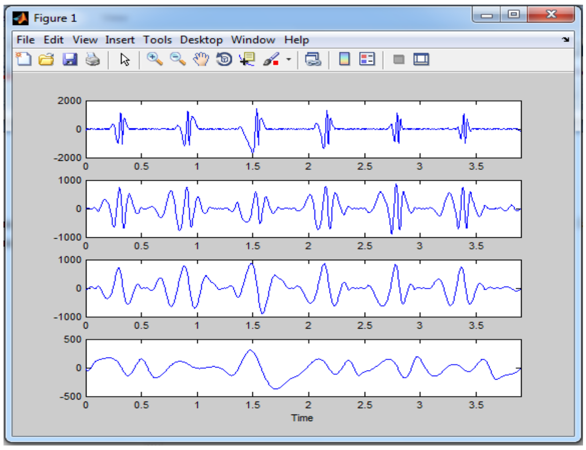

Fig. 3b: Intrinsic Mode Function (IMF)

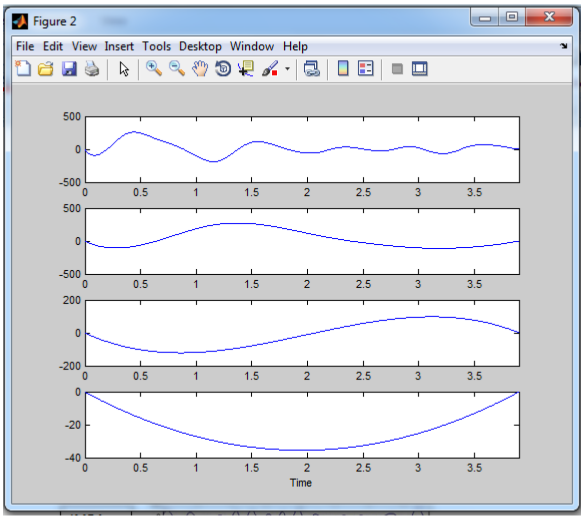

Fig. 3a: Intrinsic Mode Function (IMF)

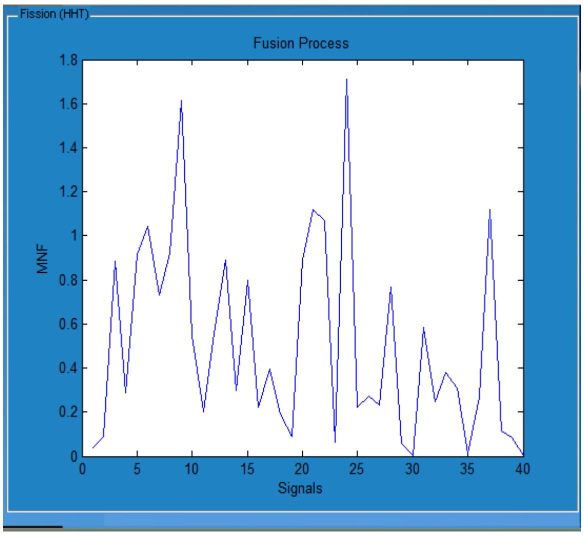

Fig. 4 MNF signals using fusion process

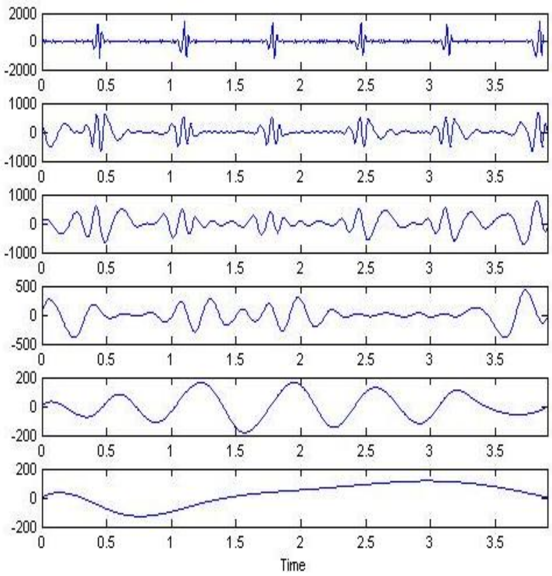

Fig. 5 First six IMF signals

We want to find the instantaneous frequency and amplitude, which is used to find MNF as shown in Fig. 4, based on that we can classify the emotion of human beings. For the joy persons the calculated average of MNF as 73Hz, for angry emotion the calculated MNF as 386Hz and this value fall above and below a particular limit, it shows the sad and pleasure emotional states as 51Hz, 55Hz respectively. Also, we calculated static features, such as max, min, standard deviation, range, median and mean frequency from first four IMFs and compared results for analysis.

4. CONCLUSION

The extracted ECG features like, instantaneous frequencies, amplitude and mean frequency are feasible to recognize human emotions (Sad, anger, Joy Pleasure,) by using HHT. It can be seen that instantaneous frequencies, amplitude and mean frequency of intrinsic mode functions have important information which reflects the differences in all human emotions. The adopted decomposition technique is a new technique for adaptively decomposing signals. In this way, the potential usefulness of EMD based techniques is presented in this work.

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