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EMOTION RECOGNITION IN HUMAN BEINGS BY USING ECG SIGNALS AND HILBERT-HUANG TRANSFORM

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Abstract

Emotion is repeatedly defined as a difficult state of feeling that results in substantial and psychological changes that influence thought and behavior. Emotion modeling and detection has drawn wide attention from disciplines such as psychology, cognitive science and engineering. The purpose of this planned work is to recognize the emotional states of human body using ECG signals, which could transform applications in medicine, entertainment, education, safety etc. A solution based on empirical mode decomposition (EMD) is projected for the discovery of dynamically evolving emotion patterns on ECG. Cataloging features are based on the immediate frequency and the local oscillation within every mode. The proposed system uses the fast Fourier transform to remove the noise from the synthetic generated ECG signal and therefore the emotional states were identified efficiently.

Keywords: Electrocardiogram, emotion recognition, empirical mode decomposition, Hilbert-haung transform, intrinsic mode function, instantaneous frequency, local oscillation.

I. Introduction

Sentiment refers to the cognitive and behavioral approaches people use to control their own emotional experience. It is the basic term for subjective, conscious knowledge that is distinguished mainly by psycho physiological expressions, biological reactions and mental states. Sentiment is frequently linked and considered reciprocally powerful with mood, temperature, personality, disposition and motivation. Sentiments are important in many different areas including normal decision making and decided behavior. The purpose is to recognize the emotional states by using the ECG signals. The anticipated method is the well-organized method to identify the emotional states using ECG signals. In the preceding work the emotional states are recognized by using the bio-signals. The physiological signals comprise vital signs of the human body. Examples of this group include the electrocardiogram (ECG), electromyogram (EMG), electroencephalogram (EEG), galvanic skin response (GSR), blood volume pressure (BVP), heart rate variability (HRV), temperature (T), respiration rate(RR). These signals have usually been used for clinical diagnostics, but there is important evidence to suggest that they are sensitive to and may express information about emotional states. One of the profits of detecting emotions using physiological signals is that they are reflex reactions of the body, and as such are very difficult to mask. Among the initial efforts for emotion differentiation using physiological signals. A total of six emotions were studied using facial expressions and physiological signals such as the HR, left and right hand temperature, skin resistance and forearm muscle tension. Emotion stimulation was based on reliving experiences, which is still considered to be one of the most successful approaches to emotion elicitation. The statistical analysis was based on the change scores principle, while decision trees were used to observe emotion clustering. Despite the lack of complicated statistical tools, this work was a land mark to the establishment of physiological reactivity to emotion. So the next work concentrates on detecting emotions from the ECG signals. It uses the dynamic generation model for generating the synthetic ECG signal. The main drawback of using this method is that, it cannot identify the correct emotional states because of the noisy signals. To overcome this drawback the proposed system uses the fast Fourier transform to remove the noise from the signals.

II. ECG Physiology

Electrocardiogram (ECG) signals are among the most significant foundations of diagnostic in healthcare. The ECG signal is recorded by joining electrodes on the surface of the body by using the standard 12 lead ECG systems. The usual ECG is self-possessed of a P wave, a QRS complex and a T wave shown in Fig. 1. The P wave is the initial wave of the electrocardiogram and represents the stretch of electrical impulse through the atrial musculature (activation or depolarization). There are numerous abnormalities that should be noted. Increased amplitude usually indicates atrial hypertrophy and is found especially in A-V valuvlar disease, hypertension, cor-pulmonale and congenital heart disease. Increased width often indicates left atrial enlargement or diseased atrial muscle. Absence of P waves occurs in A-V nodal rhythms and S-A block. The PR interval is calculated from the beginning of the P wave to the beginning of the QRS complex. It replicates the time taken by the impulse to travel the whole space from the SA node to the ventricular muscle fibers. The usual duration for this is 0.12-0.20 seconds. The maximum amplitudes of the high frequency components are found within the QRS complex. In history years, the term high frequency, high fidelity and wideband electrocardiography have been used by several investigators to refer to the process of recording ECGs with an external bandwidth of up to 1000 Hz. Several investigators have to analyze HF-QRS with the hope that additional features seen in the QRS complex would provide information enhancing the diagnostic value of the ECG.

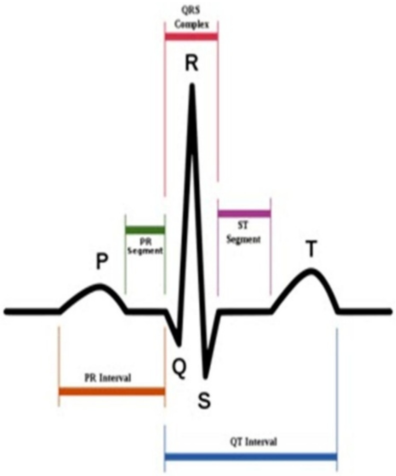

Fig. 1 Normal persons ECG signal

Probably the most important complex in the electrocardiogram is the QRS. It represents the spread of the electrical impulse through the ventricular muscle (depolarization). The upper limit is variable from lead to lead, but generally is between 20 and 30 mm. Many factors can affect the amplitude besides the health of the heart, such as chest size, chest wall thickness, emphysema. The S-Tsegment follows the QRS complex. The T wave represents the period of recovery for the ventricles (depolarization).

III. Methodology

The proposed methodology for ECG feature extraction is based on Empirical Mode Decomposition (EMD) which uses the fast fourier transform to remove the noise from the ECG signal and uses the Hilbert-Haung Transform for extracting the features from the ECG signal. EMD is a method of breaking down a signal without leaving the time domain. EMD filters out functions which form a complete and nearly orthogonal basis for the original signal. Completeness is based on the method of the EMD; the way it is decomposed implies completeness. The functions, known as Intrinsic Mode Functions (IMFs), are therefore sufficient to describe the signal, even though they are not necessarily orthogonal. For some special data, the neighboring components should be orthogonal for all practical purposes. The fact that the functions into which a signal is decomposed are all in the time-domain and of the same length as the original signal allows for varying frequency in time to be preserved. Obtaining IMFs from real world signals is important because natural processes often have multiple causes, and each of these causes may happen at specific time intervals. This type of data is evident in an EMD analysis. The proposed framework is comprised of four independent steps as shown in the fig. 2

ECG synthesis, wherein an ECG signal ( ) is generated. From the data base the ECG data's were collected. From the ECG raw data's the synthetic ECG signal was generated.

The fast fourier transform can be used to remove the noise from the synthetic ECG signal for accurate emotion detection.
Estimation of the oscillatory modes, called Intrinsic Mode Functions (IMF) which can be found by using EMD algorithm.

Extraction of features associated with the instantaneous frequency and the local oscillation of the IMFs and classification among predefined affect states.

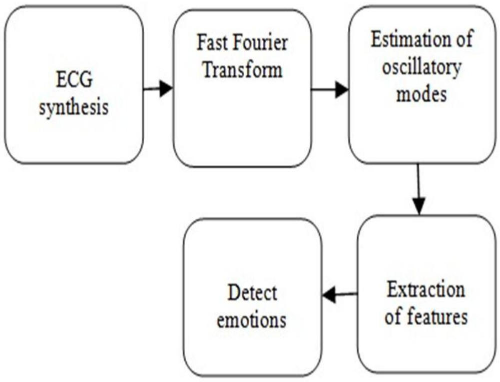

Fig.2 Block diagram of proposed work

A . ECG synthesis

In ECG synthesis the synthetic ECG signal was generated. From the data base the ECG raw data were collected, by using these data's the synthetic ECG signal was generated.

B. Fast Fourier Transform Denoising

The FFT is one of the cornerstone routines use in signal processing as it can be used to eliminate repetitive signals from the source data. The aim of this is to de-noise the ECG signal.

C. Estimation of Oscillatory Modes

In this section, we propose a novel method based on the Hilbert-Haung Transform (HHT) [3] to analyze physiological signals. The fundamental part of the HHT is the empirical mode decomposition (EMD) method. Using the EMD method, any complicated data set can be decomposed into a finite and often small number of components, which is a collection of intrinsic mode functions (IMF). An IMF represents a generally simple oscillatory mode as a counter part to the simple harmonic function. By definition, an IMF is any function with the same number of extreme and zero crossings, with its envelopes being symmetric with respect to zero. The definition of an IMF guarantees a well-behaved Hilbert Transform of the IMF. This decomposition method operating in the time domain is adaptive and highly efficient. Since the decomposition is based on the local characteristic time scale of the data, it can be applied to nonlinear and non-stationary processes.

D. Feature Extraction

The ECG feature extraction system provides fundamental features (amplitude and intervals) to be used in subsequent automatic analysis. In recent times, a number of techniques have been proposed to detect features. The previously proposed method of ECG signal analysis was based on time domain method. But this is not always adequate to study all the features of ECG signals. Therefore the frequency representation of a signal is required. The deviations in the normal electrical patterns indicate various cardiac disorders. Cardiac cells, in the normal state are electrically polarized. ECG is essentially responsible for patient monitoring and diagnosis. The extracted feature from the ECG signal plays a vital in diagnosing the cardiac disease. The development of accurate and quick methods for automatic ECG feature extraction is of major importance. Therefore it is necessary that the feature extraction system performs accurately. The purpose of feature extraction is to find as few properties as possible within ECG signal that would allow successful abnormality detection and efficient prognosis. In this work, we use two types of features—the Hilbert instantaneous frequency and a measure of local oscillation.

E. Instantaneous Frequency

Instantaneous frequency is defined mainly the Hilbert Transformation (HT), and time-frequency techniques. The IMFs have a vertically symmetric and narrow band form, that allow the second step of the HHT to be applied the Hilbert transform of each IMF. As explained below, the Hilbert Transform obtains the best fit of a sinusoid to each IMF at every point in time, identifying an instantaneous frequency (IF), along with its associated instantaneous amplitude (IA). The IF and IA provide a time-frequency decomposition of the data. The transform is defined as the convolution of a signal.

$$H[x(t)] = x * \frac{1}{\pi} = y \qquad (1)$$

Or by using the convolution definition,

$$y(t) = \frac{1}{\pi} P \int_{-\infty}^{\infty} \frac{x(\tau)}{t-\tau} d\tau \qquad (2)$$

Where p designates the Cauchy's principal value. From $y(t)$, it is possible to characterize the analytical signal $z(t) = x(t) + iy(t)$ or, in polar form, $z(t) = a(t)e^{i\theta t}$, in which-

$$a(t) = \sqrt{x^2(t) + y^2(t)} \qquad \theta(t) = arctan\left(\frac{y(t)}{x(t)}\right)$$

Instantaneous frequency is defined using the instantaneous variation of phase,

$$\omega = \frac{d\theta}{dt} \qquad (3)$$

the second part of the HHT (Hilbert spectral analysis, HSA), and it entails writing the signal in the form

$$x(t) = \sum_{j=1}^{n} a_j(t) e^{i \int w_j(t)dt} \qquad (4)$$

IV. RESULT

The ECG raw data was collected from the MIT/BIH data base. Using these ECG raw data's the synthetic ECG signal was generated. The generated ECG was shown in the Fig. 3

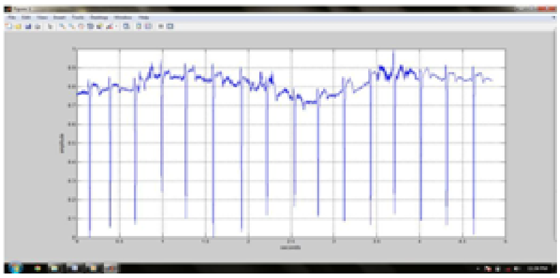

Fig. 3 Generated synthetic ECG signal.

From the synthetic ECG signal the noise are removed by using the fast fourier transform technique. The noise removed ECG signal is shown in the Fig. 4

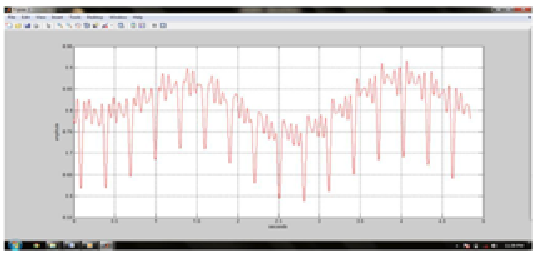

Fig. 4 Noise removed ECG signal.

After noise removing process, the noise removed signal is converted into raw data's, and it is given to the EMD algorithm to generate the IMF signals.

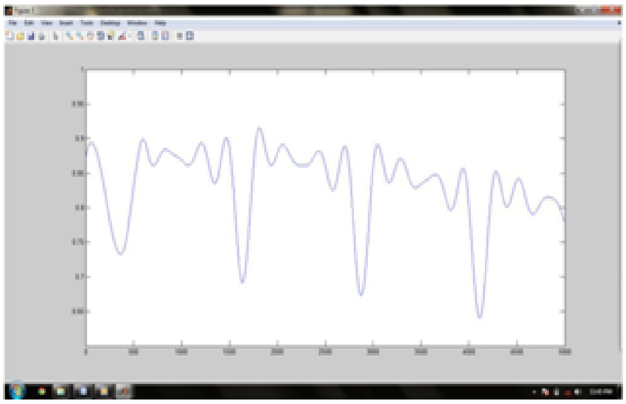

Fig. 5 First IMF signal.

From the IMF signals we will consider any one of the first three IMF signals, because other IMF signals have less oscillatory activity, they will not prevent the instantaneous frequency and local oscillation activity.

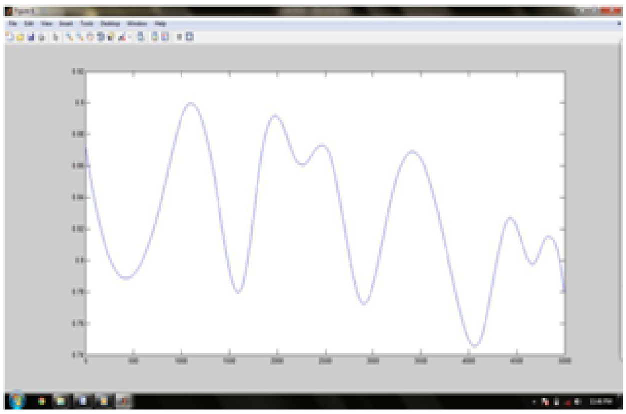

Fig. 6 Second IMF signal.

From the IMF signal we want to find the amplitude and instantaneous frequency. Based on the frequency and amplitude we can classify the emotion of human beings.

For the joy persons ECG signal the instantaneous frequency is between (10 Hz-40Hz) and the amplitude is in between (0.2mv-0.25mv). When the amplitude and instantaneous frequency fall above and below the particular limit, it shows the fear, angry and sad emotional states. For the sad emotional state the instantaneous frequency is below (10-40) Hz, and the amplitude is below (0.2-0.25) mv, and for the anger emotional state the instantaneous frequency and the amplitude is beyond the particular value, ie., the instantaneous frequency is above (40-100) Hz and the amplitude is above 1.5 mv. For the fear emotional state the instantaneous frequency is in between (40-100) Hz and the amplitude is, between the limit (0.3-1.5) mv.

Emotions states	Instantaneous frequency(Hz)	Amplitude (mv)
Joy	(10-40)	(0.2-0.25)
Sad	Below 10	Below 0.2
Fear	(40-100)	(0.3-1.5)
Anger	Beyond 100	Above 1.5

V. Conclusion

In emotion study, it is very imperative to collect significant data. This method is a proficient method to determine the emotional states of human beings. One of the profit of detecting emotions using ECG signals is that these are spontaneous reactions of the body, and as such are very complicated to mask

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