Detection of Human Stress using Short Term ECG and HRV Signals

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ABSTRACT

The paper reflects upon the issue of human stress detection using Electrocardiogram (ECG) and Heart Rate Variability (HRV) signals. This includes pre-processing of ECG signal, HRV signal extraction, feature selection and their classification. Pre-processing includes removal of power line interference, baseline wander etc. from the raw ECG. Pan-Tompkins algorithm is used for extraction HRV signal from ECG signal.The ECG is classified as stress or normal by setting appropriate threshold value. Short term ECG needed for stress detection produces a reliable output of great accuracy.

Key words: *HRV signal, Pan Tompkins algorithm, ECG,ANS*

1. INTRODUCTION:

Stress is an important factor in several diseases, and everyone may experience stress once due to the enormous psycho-physiological demands during day-to-day activities. Stress is a form of Controllable unsteady state which is managed by using relaxation and management techniques . Many studies show that stress is very common factor for the indication of many diseases. Psychologists or medical experts calculated human stress levels by various set of psycho-physiological questionnaires. Several research investigations have been done to develop a desirable scientific tool for measuring stress.

1.1 Basics of ECG: Electrocardiography is mainly the process of electrical activity of heart over a period of time with electrodes placed being recorded. The electrodes senses the minute changes in electrical signal on the skin which develop from the heart's muscles pattern during the depolarizing and repolarizing of heartbeat.

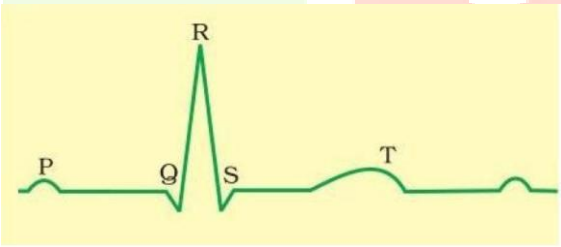


Fig.1. ECG waveform

In a 12-lead ECG, 10 electrodes are mounted on the patient's hands and feet and on the chest. The heart's electrical potential is measured from 12 leads and is recorded in a time interval. The overall magnitude and direction of heart's electrical depolarization is obtained throughout the cardiac cycle. The voltage versus time graph produced by this method is called an electrocardiogram.

For each heartbeat, a healthy heart depolarization starts with pacemaker cells in the Sino atrial node, spreads out through the atrium, passes through the atrio ventricular node down into the bundle of His and into the Purkinje fibers, spreading down and to the left throughout the ventricles. This pattern of depolarization gives rise to ECG tracing.

1.2 **About HRV Signal Extraction:** ECG in specific heart rate variability (HRV) signals plays a vital role in stress assessment research. For this signal being a major consideration, there are obstructions, mainly (i) validity of short-term HRV signals, (ii) optimization of stress relevant features, (iii) frequency band selection and (iv) improving stress detection rate

The European Society of Cardiology has suggested that a minimum of 5min duration is essential for measuring the heart rate (HR) from ECG signals, and time less than 5min is of no use.

Generally, regulation in autonomic nervous system (ANS) indicates the reflection of normal HR and its variability (HRV). The ANS is classified in two branches: sympathetic nervous system (SNS) and parasympathetic nervous system (PNS). The balance between the two branches reflects HR's normal value, skin conductance, BP, RR, and muscle activations. During the process stress and relaxation, the SNS increases, or the PNS is decreases. This effect is known as cardio acceleration and retardation. The acceleration of the SNS and HR is referred to stress.

2. METHODOLOGIES

2.1 HRV signal for stress detection: HRV signals are the measure of identification and analysis of change in human stress. Stress-related HRV signals are analyzed in a laboratory environment.

In laboratory-based studies, HR signal with other physiological signals are frequently measured for stress identification. HRV is a more efficient signal and have more complex steps involved in its analysis because it shows how long the HR was elevated due to stress.

Due to study, stress is mainly caused for a period of a few seconds to minutes, stress inducement depends on the efficacy of protocol. This method is applicable to the active state assessment research mainly stress and emotions.

2.2 ECG signal in stress detection: The ECG signal reflects the cardiac function through its unique (PQRST) characteristics. In contrast to HRV signal analysis researchers have formed an interest in analyzing the ECG signal more efficiently for forming the relation between emotion and stress. The majority of the meaningful information about cardiac functionality in between 0 and 100Hz.

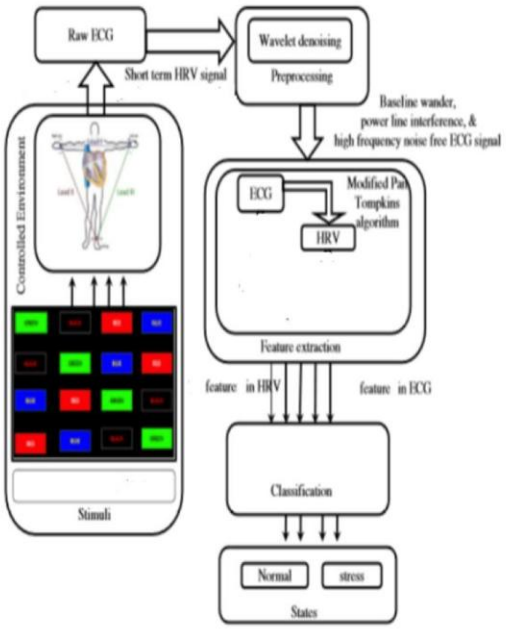
3. PROPOSED-METHODOLOGY:

3.1Research methodology: Stress assessment consisted of several steps, from stress inducement to its classification. The cardiac signals (ECG and HRV) are used for improving the detection rate of signals, which are dominant and solve the issues in case of acute stress.

A wavelet de-noising algorithm preprocesses ECG signal.

The pre-processed signals were on time and frequency domain in two ways: (i) extracted HRV signal from ECG signals and (ii) directly analyzing ECG for different frequency ranges. Time domain features skewness is extracted from HRV and for ECG standard deviation is chosen as the factor. The complete research methodology is given below in figure 2.

Fig. 2. Research methodology for stress detection.



3.2Pre-processing using wavelet de noising: The different methods which are adopted for pre-processing of the ECG signals basically to remove the noises, artifacts, baseline wandering, and power line frequency interference. The researchers used a simple impulse infinite response (IIR) filtering for ECG signal pre-processing.

3.3 HRV signal detection from ECG: The statistics shows the characteristics of physiological signal. In the paper , several types of statistical features have been investigated for stress assessment through ECG signal.

This paper shows the required steps to identify the required feature in the ECG and HRV signals for both frequency and time domain. Figure 3 all the features used in this work. In 1985, Pan and Tompkins showed that HR can be used to detect from an ECG signal.

Pan and Tompkins initilally used low pass and high-pass filters for identifying the QRS complex in ECG signals. Recently, band pass filter, DWT, and empirical mode decomposition (EMD) are used for improving HR detection in an ECG signal

The Pan Tompkins algorithm with DWT was used to extract QRS complex from ECG signals. Pan Tompkins algorithm for HR detection and extraction of HRV signals deriving from an ECG signal, as given in Fig. 3.

The raw ECG signal is passed through discrete derivative, moving average, and smoothing filter such that it reduces the effects of baseline wander and other noises. The filtered signal is further decomposed into eight levels in order to extract peaks of the QRS complex.

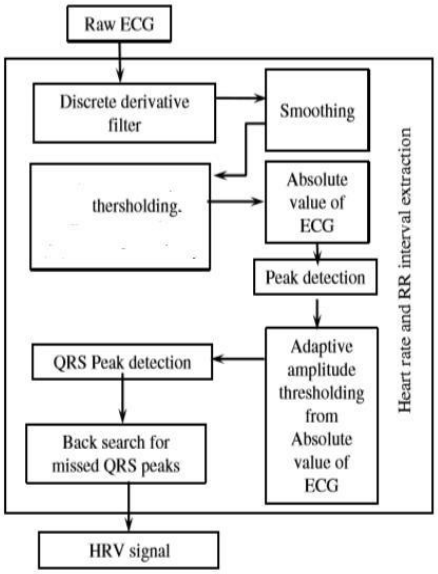


Fig. 3. HRV signal detection algorithm

Figure 4 is the output of the HRV signal obtained by discrete wavelet transform based on the Pan-Tompkins algorithm on ECG signals.

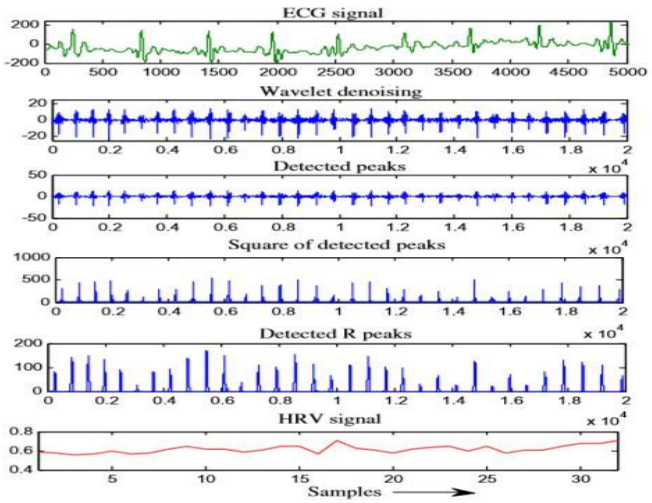


Fig. 4. HRV signal detection from ECG

3.4 Feature Extraction and Classification of ECG: The standard deviation is chosen to distinguish the ECG data is having stress or not.. The standard deviation value classifies as stress ECG, and as normal ECG. In statistics, the standard deviation is a measure, which is used to quantify the amount of variation for the given set of values. A low standard deviation shows that data points tend to be closer to the mean value of the set and a high standard deviation indicates data points are over a wider range of values.

3.5 Feature Extraction and Classification of HRV Signal: Skewness is obtained from the HRV signal and displays noticeable difference between stress ECG and normal ECG. The skewness is taken as feature for classifying between normal ECG and stress.

In probability theory and statistics, skewness is a measure of the asymmetry of the probability distribution of real-valued random variable about its mean. The skewness value can be positive, negative, or even undefined. The qualitative interpretation of the skew is complicated.

4. CONCLUSION

The highlight of this study is to test relevant information regarding stress is identified during stress-inducing stimuli using ECG signal and short-term HRV signals. The standard deviation value greater than 0.152 is c stress ECG, below that particular value is normal. The skewness below 2.5 is normal ECG and above is stressed ECG. And the result is classified accordingly as normal or stress based on output.

To optimize the stress-related features, time of HRV and ECG were investigated and the results of dominant features are reported. The results will be helpful in the consideration of short-term HRV signal in computing research such as stress level detection, emotion classification, drowsiness detection, etc.

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