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Efficient Method for Stress Detection and Analysis

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ABSTRACT

ECG is an interpretation of the electrical activity of the heart over time captured and externally recorded by skin electrodes. They are important for diagnostic and research purposes of the human heart. In this paper we discuss a method of detecting stress from a human body using ECG signal sample. A web application has been developed for the same, which works in four basic steps, 1) Signal acquisition, 2) Feature extraction, 3) Classification and 4) Remedies suggestion. This application extracts features of acquired ECG signal and uses these features for categorizing a person basically into stressed mode or relaxed mode. The application is built using a decision support system formed by extensive learning of behavior of the signals of various persons. Algorithm for feature extraction, which is an ineluctable step in most approaches in diagnosing aberrant activities in the heart, is also itemized in this paper.

Keywords

Electrocardiogram, classification, feature extraction, ischemia, myocardial infarction, stress.

Academic Discipline And Sub-Disciplines

Computer Science, Signal Processing

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INTRODUCTION

Assessment of mental stress under different workload conditions is a recurrent issue in many engineering and medicine fields [1]. Signs of stress include being easily irritated by things over which you have no control, such as feeling frustrated or helpless because of not being able to keep up with the pace of life. Scientists consider human heart as the most relevant body organ for appraisal of mental stress. And therefore, electrical activity of heart is captured in order to detect stress and analyze it [2]. There are two major types of stress - Acute stress and Chronic stress. Acute stress is a mundane stress which comes on quickly and is usually ephemeral. It is the most vehement type of stress whereas chronic stress is not so intense. Chronic stress arises out of long-lasting events and circumstances beyond ones control. The hardest part of chronic stress is that people just get used to it. Electrocardiogram (ECG) signal can be used in order to detect whether the person is suffering from acute stress or chronic stress on the basis of various stress related features. ECG is a way to measure different rhythms of the heart, and helps to diagnose properly the abnormal rhythms caused by electrolyte imbalances [2]. The ECG records the electrical activity that results when the heart muscle cells in the atria and ventricles contract. The standard 12-lead electrocardiogram is a representation of the heart's electrical activity recorded from electrodes on the body surface. It is called a 12-lead ECG because it examines the electrical activity of the heart from 12 points of view [3].

ECG signal's single cycle structure and its important rhythms are shown in figure 1. Each rhythm has some significance and contributes in some or the other extent to the health of heart. These rhythms are formed due to various activities which are observed in a human heart. Hence, it is important to extract these features very accurately for further analysis [7]. Also in the figure below, the standard measures of ECG graph paper which is used for tracing the wave are also stipulated.

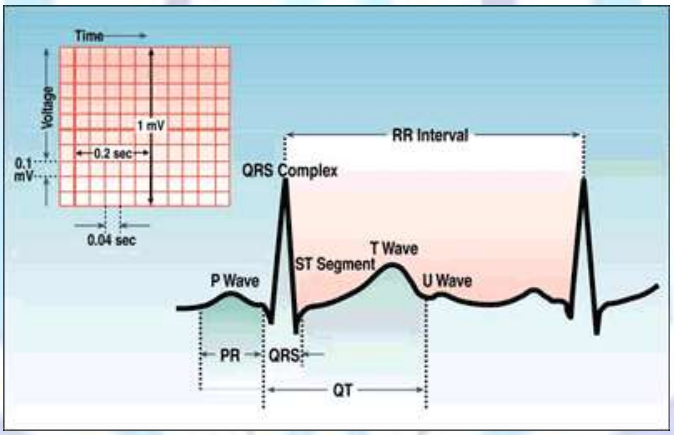

Fig 1: Single cycle ECG waveform and its standard measures

Table 1: ECG Features

Features	Depiction	Period
RR interval	Spell between two R waves.	0.6 to 1.2 s
P wave	Propagation of SA node results in depolarization, producing P wave.	80ms
QRS complex	Expeditious depolarization of the ventricles.	80 to 120ms
PR interval	Interval between onset of P wave and onset of Q wave. It is the duration of conduction through the ventricles.	120 to 200ms
T wave	It results from the repolarization of the ventricles.	160ms
ST segment	Represents duration of the ventricular depolarization and the repolarization.	80 to 120ms
QT interval	Interval between the onset of Q wave and T wave. Its duration varies	Up to 420ms

	with the heart rate.	

The cardinal steps used in this web application for stress detection and its assay are shown in Fig 2:

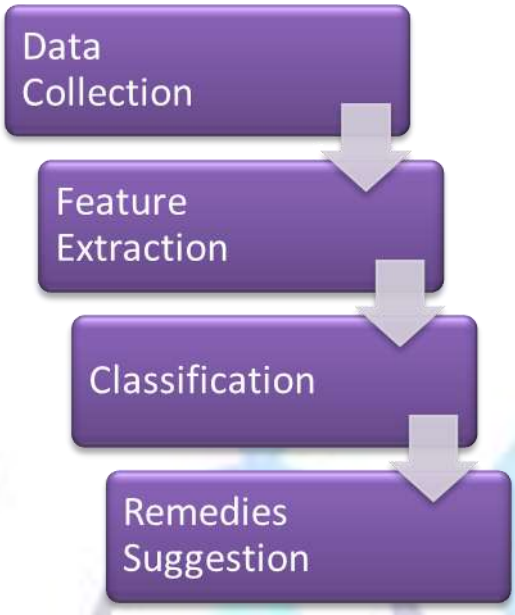

Fig 2: Flow of the proposed system

DATA COLLECTION

A galvanometer along with electrodes is used for recording ECG waveform of any person. It gives a graphic recording of the electric forces generated by the heart during depolarization and repolarization. The ECG signal is traced on a graph paper with standard divisions. Horizontal axis represents time and large blocks on the ECG graph paper are 0.2 seconds in duration whereas, small blocks are 0.04 seconds in duration. Vertical axis on the graph represents voltage. Large block's size is 5mm, while small block is of measure 1mm. For this web application, ECG signals in .csv format have been used. CSV format is nothing but Comma Separated Values which can be viewed in tabular form. Further working on these files, we applied feature extraction technique in order to acquire stress kindred features. Around 100 to 150 ECG sample files of different patients were downloaded from PTB Database which has the most relevant stress related samples available on the internet.

FEATURE EXTRACTION

The ECG is a realistic record of the direction and magnitude of the electrical commotion that is generated by depolarization and repolarization of the atria and ventricles [6]. The research of the ECG has been extensively used for detecting acute or chronic stress. Therefore opportune approach should be followed in order to draw precise values. One cardiac cycle in an ECG signal consists of the P-QRS-T waves. In this paper, the proposed method of feature extraction will be first used to detect the R point value from QRS-complex. R peak is the point which has the highest value of voltage and thus it can be used as a reference point to calculate the values of the remaining rhythms. Points Q and S can be found by considering a specific window horizontally and then computing the lowest points in that window. For point Q, we consider a window of some definite points before R peak whereas for point S, we consider a window of definite points after R peak. Point T is the highest point below R peak in the window considered ahead of point S. Now all the features or rhythms of the particular ECG signal have been evaluated. The following algorithm shown in table 2 was used in this project implementation for feature extraction.

Table 2: Algorithm for Feature Extraction and Classification

No.	Step	Description
1.	Detecting R peak value	Highest value of the signal
2.	Q peak value detection	Lowest value of the signal before R peak (window of 50 sample values from point R)

3.	Detection of S peak value	Lowest value of the signal after R peak (window of 50 sample values from point R)
4.	Detection of T peak value	Highest point on curvature (window of 200 sample values from point S)
5.	Checking the ST segment	ST segment elevation or depression

CLASSIFICATION

Signal classification is done by correlating the elicited values with the adroit rules. So, the extracted rhythms from the acquired signal are compared with standard values in order to identify whether the person is in stressed mode or controlled mode. The four different categories of stress detected in this project implementation are:

1. Myocardial Infarction
2. Acute stress
3. Ischemia
4. Chronic Stress

Basically, first to determine whether the person is stressed or relaxed, we need to calculate ST segment value with the help of previously extracted S and T point values. ST segment can be estimated by calculating the difference between the voltage values between S and T. Secondly, by obtaining the difference between Q and S features classification can is performed. First we check whether S is greater or lower than Q feature. If the calculated difference between S and Q feature is greater than 0.6mV [by considering y co-ordinate values] then we classify the person is suffering from Hyper Acute Stress and Myocardial Infraction or Hyper Chronic Stress and Ischemia. If the difference is less than 0.6mV we calculate ST segment and depending on its elevation or depression we classify the levels of Acute or Chronic Stress.

TECHNOLOGICAL OVERVIEW

The platform on which this application or system can be implemented is Windows XP and higher versions. The technology which is used to deploy the application is C# and .Net framework.
The reason behind working with C# as our programming language is that, it is a multi-prototype programming language encompassing the procedural, functional, object oriented [class based] programming disciplines. As a result, there was no need to work on different languages, as C# incorporated all the elements we required for developing this software. C# was developed by Microsoft within its .Net framework. The language is intended to be simple and modern, general purpose programming language. This language is proposed for the use in developing software suitable for deployment in distributed environment.
.NET is a server side web application framework designed for web development to produce dynamic web pages. It was developed by Microsoft. It allows programmers to smoothly build dynamic websites or web applications.

RESULTS

The input sample signals are taken from online PTB database. Snapshots of results are exhibited in the figures below. The sample signal's features and classification to indicate the category of stress the person is suffering from are shown in the figure. The application will also provide a few temporary remedies according to the class of stressed person. Also while specifying these remedies, various factors will be considered like the person's age, weight and medical history etc.

Stress Detector And Analyzer

ECG Analysis Details

R-Peak	Q-Peak	S-Peak	T-Peak	Q - S	ST-Difference
-1.437	-1.377	-1.431	0.697	0.054	0.467
-1.431	-1.437	-1.387	0.697	0.050	0.463
-1.412	-1.395	-1.377	0.697	0.018	0.411
-1.407	-1.407	-1.365	0.626	0.042	0.421
-1.395	-1.319	-1.412	0.697	0.093	0.419
-1.387	-1.333	-1.381	0.712	0.048	0.423
-1.387	-1.355	-1.367	0.693	0.012	0.403
-1.383	-1.395	-1.335	0.670	0.060	0.414
-1.379	-1.322	-1.375	0.645	0.053	0.416
-1.377	-1.412	-1.335	0.697	0.077	0.415

Fig 2: **Results - Features Extracted**

Fig 3: **Results - Classification and Remedies**

CONCLUSION AND FUTURE WORK

The obtained efficiency of the designed algorithm for feature extraction has been verified by the esteemed doctors. The main advantage of this algorithm is that it is very simple to understand and involves no intricacies. The proposed system performs analysis of various ECG signals and evaluates the person's stress category. It is developed in such a way so as to handle normal as well as abnormal cardiac conditions. The extracted features are compared with the expert rules which help in determining the risk of stress level of the patient. The person as well as the doctor will be at ease as the device is portable and handy.

The next step of the studies shall lead to determine how the system can be made a real time system. The results of multiple physiological signals, like ECG as well as EEG signal, of same person can be combined. This will also increase the accuracy of the final outcome. This project will eventually lead to the development of further detecting various different diseases. Also different types of depression in a person like Major Depression, Atypical Depression, Psychotic Depression, Dysthymia and Manic Depression can be determined in the future by enhancing the software. This system can also be applied to different fields in our society for welfare of the community.

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