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RESEARCH ARTICLE

Detection of Automobile Drivers Stress from Physiological Signals

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Abstract— ***This project gives an analysis of various physiological signals of a person with respect to the stress developed within him/her. The analysis of stress was done using ECG, EEG and respiratory signals acquired from the automobile drivers who were made to drive on different road conditions to get different stress levels. As a part of analysis, two features were extracted from the physiological signals and it clearly shows the changes in the feature with respect to the stress of the driver. From the extracted feature, stress is classified using SVM classifier. The performance of the networks was tested and compared with other physiological signal and produce better result with high accuracy.***

Keywords— ***Stress, ECG, EEG, respiratory signal, Support Vector Machine (SVM)***

I. INTRODUCTION

American Psychological Association defines stress as “any uncomfortable emotional experience accompanied by predictable biochemical, physiological and behavioral changes”. Reaction of a person from a normal state to an exited state in order to preserve his/her integrity can also be defined as stress. An extreme amount of stress can produce extreme health issues and it can affect the cardiovascular and central nervous system. Analysis of stress of a person has got many applications. Modern automobiles incorporate an intelligent system to monitor the stress level of the driver inside it to ensure the safety [1].

Driving is one of the most stress causing activities. And stress is mainly caused by change in environment. Whenever we are behind the wheel we are exposed to unbelievably fast changing circumstances like road conditions, vehicular traffic, speed limits, traffic lights, on road obstacles etc. Driving also requires several decision-making operations involving complex information processing. These operations often lead to high mental stress. Stress is a physiological condition in which the body becomes excited to face an emergency situation. A number of physiological changes including increase in heart rate, breathing rate, pupil dilation, muscle contraction, sweating etc. occurs during a high stress state[2].

Driver’s stress is an important factor in a large number of accidents. There has been much work done in driver stress detection. The methods of stress detection mainly focused on measures of the driver’s state, driver performance and combination of driver’s state and performance. Stress can be quantified from human bio-signals such as EEG, Electrocardiogram (ECG), Electromyogram (EMG), Galvanic Skin Response (GSR), Blood Volume Pulse (BVP), Blood Pressure (BP), Skin Temperature (ST) and Respiration. Among these bio-signals, the changes in ANS system due to stressors can be apparently and effectively represented by EEG signals.

In this paper QRS power was the feature signal extracted from the ECG signal of the driver. Breathing rate was the feature signal extracted from the respiratory signals. The signals required for the analysis through ‘Physionet’ database.

II. METHODOLOGY

In this work, physiological signal features are used to detect stress of the person. The block diagram of the overall methodology used in this study is shown in Figure 1.

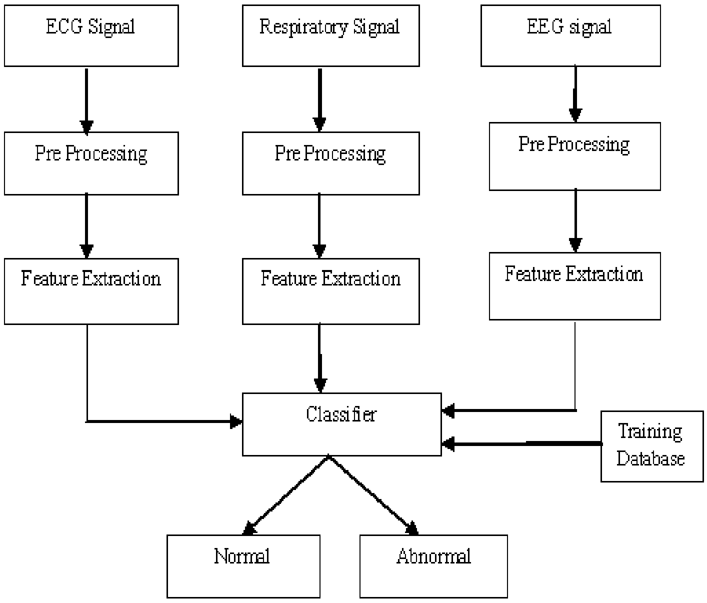


Fig 1. Over all flow diagram of stress detection

A. *Physiological Signals*

Physiological signals are generated by the body during the functioning of various physiological systems. Hence physiological signals hold information which can be extracted from these signals to find out the state of the functioning of these physiological systems. The process of extracting information can be very simple as feeling the pulse to find the state of heart beats and it can be complex which may require analysis of the structure of tissue by a sophisticated machine. Depending on type of energy, the physiological signals can be:

- Bioelectrical signals
- Biomechanical Signals
- Bioacoustic Signals
- Biomagnetic Signals
- Biochemical signals
- Bioimpedence Signals
- Bio optical Signals

B. ECG Signal

Electro Cardio Gram is the graphical plot of electrical activity of the heart. The important parts of an ECG are P wave, QRS complex and T wave. Each wave has its own biological importance. P wave corresponds to the atrial depolarization, QRS complex corresponds to ventricular depolarization along with atrial re polarization and finally T wave represents ventricular re polarization. Since pumping of the heart to all parts of the body via aorta takes place during ventricular depolarization, QRS complex has got the maximum amplitude. Hence QRS complex is a good feature that can be extracted from the ECG for the studies of pumping of heart. In this paper, QRS power from each cycle of ECG is used as the feature. This analysis will help to know about the pumping variation of the heart with respect to the stress of the person [5].

C. Respiratory Signal

Respiratory signals are the reflections of breathing of a person. Here, the respiratory signals were acquired in response to the expansion of the chest using a Hall Effect transducer tied on the diaphragm area of the person [6].

Exchange of gases (O_2 $and\ CO_2$) in humans is commonly termed as respiration. It involves inspiratory cycle in which oxygenated air is taken in and exchanged with CO2 and same is transported in to atmosphere in expiratory cycle. The metabolic process by which living cells absorb oxygen and release carbon dioxide. In general respiratory signals are recorded by specialized equipment and most of them working on the principle of sensing the volumetric changes of the thoracic cage in every breathing cycle [9].

D. EEG Signal

Electroencephalography (EEG) is a neurophysiological examination based on the registration of brain bioelectrical activity at baseline sleep, waking or sleeping, at mental stress and during various activations by a set of electroencephalography's instruments. With EEG signals the behavior of the brain can be studied on many different situations and even brain diseases, or something like that, can be detected. The EEG signal has different frequency ranges.

- Delta (δ) Less than 4 Hz
- Theta (θ) 4 - 8 Hz
- Alpha (α) 8 - 13 Hz
- Beta (β) 13 – 31 Hz

This thesis focuses in the analysis and study of these EEG signals to detect drowsiness in drivers in order to the experts can sleeping conditions and try to provide a possible solution to this problem which is the causative of some accidents on road.

E. Preprocessing

Raw physiological signals (ECG, EEG and respiratory signals) are of extremely small magnitude, so that they are easily contaminated by noise and interferences. It is for this reason, the first link in the chain of processing involves a set of steps intended to clean raw signals and remove any interference component. This stage consists of several phases. First, raw signals are filtered using a digital band pass filter on each channel. These filters have the advantage of removing any interference of 50 Hz from the mains. Then, an algorithm is applied, to remove from the raw signal unwanted artifacts that result from the user's muscle activity.

F. Feature extraction

The goal of features is to characterize data by measurements whose values are very similar for objects in the same class, and very different for objects in a different class. As well as providing discriminatory information, one of the most important functions of feature extraction is dimensionality reduction of the data. Local binary pattern technique is used to extract the features from the physiological signals.

G. Local binary pattern

Local binary pattern (LBP) is a type of feature used for classification in computer vision. The LBP feature vector, in its simplest form, is created in the following manner:

- Divide the examined window into cells (e.g. 16x16 pixels for each cell).
- For each pixel in a cell, compare the pixel to each of its 8 neighbors (on its left-top, left-middle, left-bottom, right-top, etc.). Follow the pixels along a circle, i.e. clockwise or counter-clockwise.
- Where the center pixel's value is greater than the neighbor's value, write "1". Otherwise, write "0". This gives an 8-digit binary number (which is usually converted to decimal for convenience).
- Compute the histogram, over the cell, of the frequency of each "number" occurring (i.e., each combination of which pixels are smaller and which are greater than the center).
- Optionally normalize the histogram.
- Concatenate (normalized) histograms of all cells. This gives the feature vector for the window.

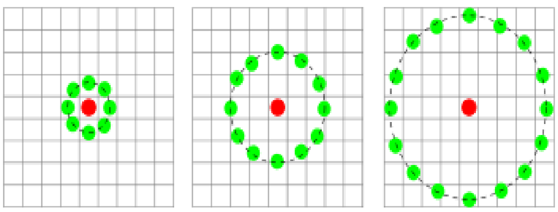


Fig.2 Three neighborhood examples used to define a texture and calculate a local binary pattern (LBP)

The feature vector can now be processed using the Support vector machine or some other machine-learning algorithm to classify images. Such classifiers can be used for face recognition or texture analysis.

A. H. Support vector machine

The SVM is a supervised machine-learning framework for discriminative classification that has gained popularity due to its computational efficiency and robustness. The method of signals linear classification it is going to use is SVM (Support Vector Machine). SVM is one of the simplest classifiers and its empirical and generalization error is quite poor. SVM is a classify algorithm of binary patrons. The objective is separate each patron to one class. SVM builds a hyper plane or set of hyper planes in a dimensional space very high and it can use to classification and regression of signals. This hyper plane is created perpendicularly to points and it has to separate a set of points optimally. An algorithm based in SVM takes a set input data (in SVM a data point is viewed as a dimensional vector) and builds a model which can classify that set of points, which they have been given, in one category or another.

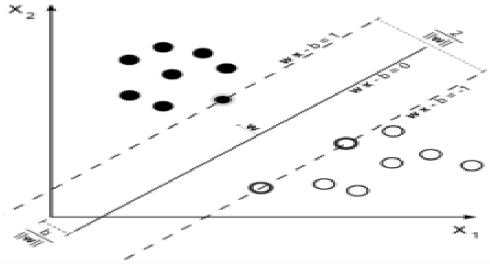
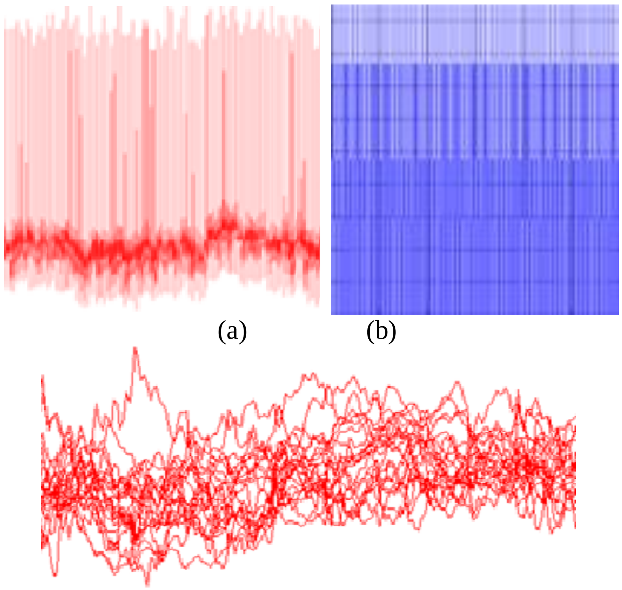


Fig.3 Maximum-margin hyper plane and margins for an SVM trained with samples from two classes

SVM is also known as maximum margin classifiers because it is looked for the hyper plane which is further away of points which are nearer than that hyper plane. With a set of training examples (samples) it can label classes and train a SVM to build a model that predicts the class of a new sample [10].The classifier compares the original data and stored data. Then it decides which normal or abnormal stress is.

III. RESULTS AND DISCUSSION

The Proposed method was implemented in Mat lab. Based on the feature extraction, the SVM is trained for normal and abnormal signals. The signals are taken from the 'physionet' database. It can be taken from the automobile drivers while during driving.



(a) (b)

(c)

Fig.3 Input signals

(a). ECG signal, (b). Respiratory signal, (c). EEG signal

Figure.3 shows the three input signals and each of them are filtered in the preprocessing step. In this stage the unwanted signals and artifacts are removed by using band pass filter.

In feature extraction stage, the filtered signals were segmented into 256 data per frame (corresponding to 1 second). The features from the physiological signals are extracted by using local binary pattern. It labels the pixels of an image by thresholding the neighborhood of each pixel with the value of center pixel. It considers the result as a binary number. Then it computes the histogram and produce feature vector. These vectors are now processed using the svm classifier. Support vector machine is a classify algorithm of binary patrons. With a set of training examples it can label classes and train a svm to build a model that predicts the class of new sample. If there are any changes that signal is not a normal signal.

IV. CONCLUSION AND FUTURE WORK

The analysis done in this project clearly proved the variation of physiological parameters with respect to the stress developed. It is a scientific explanation for the cardiac and respiratory problems occurring in the persons who are stressful. Persons with stressful minds are prone to heart diseases since their ventricles take an extra power to pump the blood and this will increase the blood pressure which will cause the problems of hypertension. In the present days most of the people are undergoing stress and it is good to perform practices which can reduce their stress which will make them healthy.

In this paper only a single category of subject was taken i.e. automobile drivers. The comparison of stress between different categories of subjects also will help to study about the stress in a better way. That also can be taken as a future aspect of the research. As a part of future research, it is possible to analyze other physiological signals like EMG and GSR which can give a higher metric for stress analysis.

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