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A Method for Detection and Reduction of Stress using EEG

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Abstract - *World health organization says that, nowadays people mental health problems and also physical problems are because of stress. This stress is major problem of our times. There are many stress detection methods are available. To study the human behavior there are many techniques are available which monitors the human brain. However, there is less research available on reduction of stress methods in terms of technology but studies are available on stress detection methods. This research proposes a method that uses the EEG signals for detecting the stress in humans and introduces the stress reduction techniques by adding interventions into the method. K-means clustering method used in the research to measure the stress which help in dividing the subjects into different classes and detect the stress level. Product for human stress reduction can be developed by using this method. The success of implementation and development of this research expected to help in reducing time consumed and human power in determining best recommendation and solution for stress management.*

Key Words: **Stress, Electroencephalography, Stress measurement, Monitoring**.

1. INTRODUCTION

Stress is a body's method for reacting to a challenge. Human stress can have an impact on a person's mental and physical well - being. Stress can lead to a change in behavior and in physiology. Many people suffer from stress in everyday life. Stress is related to human work in one way or other. Originates of stress have different sources such as time pressure while working in company, responsibility, economic problem or physical factors such as noise. Signs of stress are human fell tension, anxious, angry, frustrated or irritated by things over which he has no control.

Stress detection is an on-going research topic among both psychologists and engineers. Wearable sensors and bio signal processing technologies are developed for detecting the human stress. There are various bio signal processing technologies use for human stress detection such as Electroencephalography (EEG), Electrocardiography (ECG), Electromyography (EMG), Blood Pressure (BP), Blood Volume Pulses (BVP), Galvanic Skin Resistance (GSR), Respiration and Skin Temperature (ST) etc. Also to measure the stress level human physiological features are used for that human physiological signal processing technology is used. There is difference between Individuals physiological features. Person physiological features are changes when he/she response to stressful events. By considering various physiological features occur in human while he/she is in stress the estimation of stress are done by using cluster based analysis method [1].

In proposed method EEG stress detection technology is used. EEG is one of the most reliable sources to record electrical activity of the brain along the scalp. To measure the voltage fluctuation resulting from ionic current within the neurons of the brain EEG is used. To diagnose the epilepsy, coma, sleep disorders, encephalopathy and brain death EEG is most often used. EEG is used as first line method to identify stroke, focal brain disorder, and tumors. Hardware cost of EEG is significantly lower than other techniques. Near the patient's bed patient bio signals can be recorded by using EEG also EEG can monitor long term sleep stages or epilepsy; this is the reason why EEG is most preferable. Compare to other technique, EEG is most superior choice because it is convenient tool for physiological research. When subject perform some behavioral or it is out of laboratory EEG can be used as wearable sensor. EEG can track brain changes during different phases of life without disturbing a patient for e.g. EEG sleep analysis.

2. LITERATURE SURVEY

A literature review conducted over analysis of stress using physiological signals and evaluation of stress level.

2.1 Related Research

Previous work on stress measurement has been focused on the collection and analysis of physiological data and the identification of the correlation between perceived stress and multiple physiological features.

Qianli Xu, Tin Lay Nwe, and Cuntai Guan (2015) [1], Proposes a novel Cluster-Based Analysis method to measure stress using physiological signals, which accounts for intersubject differences. This research uses the clustering process that assigns the subject into subgroups, so as to exploit the inherent homogeneity of subject's stress response within the cluster. Thus the intersubject differences are automatically accommodated, and the overall accuracy of stress evaluation is improved.

Chee-Keong Alfred Lim and Wai Chong Chia (2015) [2], Focuses on evaluating to what extent a single electrode EEG headset – NeuroSky MindWave is able to classify brainwave in terms of subject's stressor level. In this study they use the MATLAB environment for processing the EEG signals. By reducing the number of electrodes needed, it also means cheaper EEG headset can be used to diagnose various mental disorders.

Tong Chen, Peter Yuen, Mark Richardson, Guangyuan Liu, and Zhishun She (2014) [3], Present a method to detect psychological stress in a non-contact manner using a human physiological response. In this paper they use a Hyper Spectral Imaging (HSI) camera to obtain tissue oxygen saturation (StO2) data as a feature for detecting human stress.

Cornelia Setz, Bert Arnrich, Johannes Schumm, Roberto La Marca, Gerhard Tr¨oster, and Ulrike Ehlert (2010) [4], Developed a personal health system for detecting the stress. They use the discriminative power of electro dermal activity (EDA). This EDA power is use for distinguishing stress from office work load. They do the analysis on EDA data and evaluate the information about stress level of a person.

Awanis Romli, Arnidcha Peri Cha (2009) [5], Suggested a system which deals with stress management. They change the manual system into computerized one. This system does the stress management for particular individual based on their activity interest and provides a solution for stress management. This system using combination of rule based technique and Holland's Self Directed Search Model to determine the best solution for managing the stress. This system use Rule-Based technique. In this technique user is given a test to develop the system's knowledge-based. From this test system can determine the user's interest, behavior and through their thinking, the system gives the best solution to manage user's stress according to their interest.

Jennifer A. Healey and Rosalind W. Picard (2005) [6], Shows how physiological data is useful during real-world driving task to determine a driver's relative stress level. In this study they show how physiological sensor can be used to obtain electrical signals that can be processed automatically by an on-board computer to give dynamic indications of a driver's natural state under natural driving conditions. The experiment was design to monitor the driver's physiological reaction during real-world driving situation under normal condition.

2.2 Existing System

Existing system proposes a novel cluster based analysis method to measure perceived stress using physiological signals, which accounts for the intersubject differences [1].

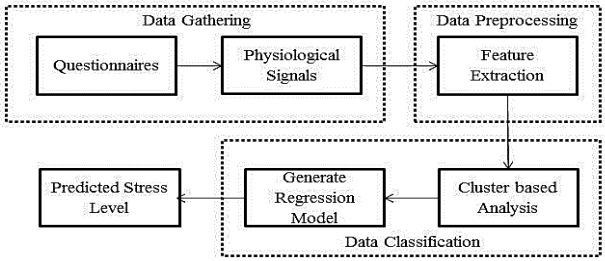

Fig -1: Architecture of Existing System

The system contains three stages Data Gathering, Data Preprocessing and Data Classification. Data is collected by using wireless sensor. Wireless sensor was used to collect a subject's physiological signals. Data preprocessing discover the useful information. This is responsible for collecting raw data and converting it into information useful for decision making by users. It does the feature extraction on data means redundancy in the dataset is reduced by this process. In Data classification mode feature extracted data are used to classified subjects into different classes.

2.3 Limitations of the Existing System

There are various researches are going on human stress detection and estimation of stress. For detecting human stress various methods is use such as EEG (Electroencephalography), EMG (Electromyography), GSR (Galvanic Skin Response), BVP (Blood Volume Pulses), BP (Blood Pressure), ST (Skin Temperature) etc. Some researchers estimate the stress by using various classification methods but not implement the reduction technique yet. There are studies which also done on stress management. They change the manual system into computerized one. This system does the stress

management for particular individual based on their activity interest and provides a solution for stress management. From this test system can determine the user's interest, behavior and through their thinking, the system gives the best solution to manage user's stress according to their interest. But these studies are also time consuming to manage the stress.

From the survey it has been seen that, none of the proposal provide a method for human stress reduction using technology. Till now work is done on detecting the stress and evaluating it [2], [3], [4], [7], [10], [9], and [11]. Also some works are done on identifying the stress level [1]. But only few studies have been done on stress management [5]. However, it makes the process complex and time consuming. Therefore to control the health related issues generate from stress, stress reduction technique is important in relation to technology. It would be beneficial to propose a method for developing products for human stress reduction.

3. PROPOSED SYSTEM

Proposed system design and develop a method that analyze the stress level effectively and also tackle the intersubject difference of human stress and provide techniques for reducing the stress among individuals for improving their performance in work. Fig -2 shows the architecture of proposed system.

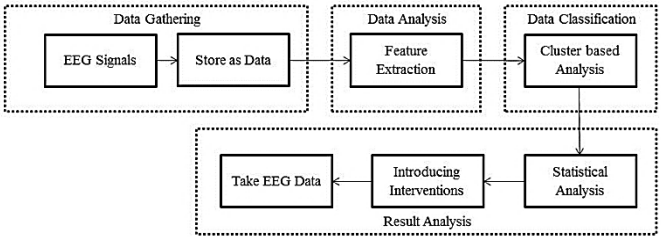

Fig -2: Architecture of Proposed System

In the proposed approach, the goal is to reduce the human stress after detecting the stress by using the EEG signals. The objective of this research is to accurately estimate the human stress and diagnose the human stress level. The estimation of stress can be done by analysing the EEG features and the human stress level i.e. stress or relaxed mode is shown by using clustering process [1]. The k-means clustering will be used for dividing the subjects into subgroups for predicting the human stress level [1]. The aim is to reduce stress by introducing the interventions into the system if stress level of human is high and do the statistical analysis for checking that stress level is reduced or not. In the proposed approach, a method will be implemented to reduce the human stress, so that they can efficiently improve his/her performance in the work.

Stress reduction is an objective of proposed approach. To achieve this objective steps used in this study are describe below.

1. Get the test data for checking the stress.
2. Do the data preprocessing on collected data.
3. Classifying data using clustered based analysis method.
4. If stress is high then introducing the intervention into the system.
5. Perform statistical analysis on data for getting the results.

4. PROPOSED WORK

4.1 Data Collection

Data Collection module contains the data related to patients. This patient data contains Name of patient, doctor's name who gives the treatment to that particular patient, age of patient, gender, admit date of patient etc. This information will be stored into the database for further processing. Also data collection module stores the patient's EEG data which will be useful for detecting the stress and analyzing it. The EEG data will be collected from lab study by involving subjects. Eight channel EEG is used here for collecting the brain signals. Once the signals are collected by using EEG, then stored that signals into dataset.

EEG can track brain changes during different phases of life without disturbing a patient [13]. Eight channel EEG is adopted in our study for collecting the brain signals. EEG is used to capture the brain signal in order to detect the stress and analyse it. Through EEG monitoring, individual's stress level can be detected and quantified in an efficient manner. Once the signals are collected by using EEG, then stored that signals into dataset.

4.2 Data Analysis

Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of discovering useful information, suggesting conclusions, and supporting decision making. Analysis refers to breaking a whole into its separate components for individual examination. Data analysis is a process for obtaining raw data and converting it into information useful for decision making by users. Data is collected and analyzed to answer questions. This module will be responsible for analyze the data for discovering useful information. For analysis phase, there are two sub phases a) Stress Indices and b) Feature Extraction.

EEG is an electronic record of the oscillations in the human brain, recorded from multiple electrodes attached to the scalp. Depending on the individual's state of relaxation, EEG can vary in shapes [14]. In healthy adults, the amplitudes and frequencies of such signals change from one state of a human to another, such as wakefulness and sleep. The characteristics of the waves also change with age [15]. Therefore, In Stress Indices phase, subject's threshold value will be calculated. This value will be used as subject's normalized stress indices value. This stress indices value computed as using formula

$$s_{ij} = \frac{S_{ij} - \min(S)}{\max(S) - \min(S)}$$

Where s_{ij} is, normalized stress indices of subject i.

S_{ij} Is, Average value of subject i.

$\min(S)$ is smallest value of the subject.

$\max(S)$ is largest value of the subject.

Human's EEG signal is a kind of weak electrical signal. Without processing, we will get EEG signals with a variety of noise interference, especially ocular artifacts [15]. Eye-blinks and movement of the eyeballs produce electrical signals that are collectively known as Ocular Artifacts (OA) [16]. Signals recorded from electrodes will be mixed with noises such as: blinks, eye movement artifact etc. Therefore, in order to meet the requirements of data analysis and processing, we should do noise reduction processing to original EEG signal at first [8], [15]. In order to clean EEG signal data, algorithm based on discrete wavelet transformation (DWT) is designed to identify and remove ocular artifacts from EEG signal [14]. Denoising EEG using this algorithm yields better results, in terms of ocular artifact reduction [17], [18]. In Feature Extraction phase, data preprocessing will be done on EEG dataset. This process will be useful for avoiding over fitting and improving the model performance. This process provide us noise-filtering feature.

4.3 Data Classification

Classification of data is the process of sorting and categorizing data into various types, forms or any other distinct class. Data classification enables the separation and classification of data according to data set requirements for various objectives. The Data Classification Module will be performed to show whether the subject is in stress or relaxed mode. Data classification is diverse process that involves various methods and criteria for storing data. In this module clustering process is use for doing the data classification. The features extracted data are used for classified subjects into different classes. Clustering process is used to divide subjects into a set of subgroups. K-means clustering process is used for dividing the subjects into subgroups [12].

4.4 Statistical Analysis

Statistics is a term used to summarize a process that an analyst uses to characterize a data set. Statistical analysis involves the process of gathering and evaluating data and then summarizing the data. Statistics studies methodologies to gather, review, analyze and draw conclusions from data. Statistical analysis is a component of data analytics. Statistical analysis involves collecting and scrutinizing every data sample in a set of items from which samples can be drawn.

After doing the cluster based analysis the perceived stress effectively reflects the changes in subject's stress level. By getting the subject's stress, statistical analysis is done on individual subject's stress level. This module implemented as first by introducing interventions into the module for getting low stress. After that taking new EEG data of patient and then calculating subject's new stress indices value. New stress indices value will compare with old stress indices value for showing that now stress of patient is low or high.

5. SNAPSHOTS

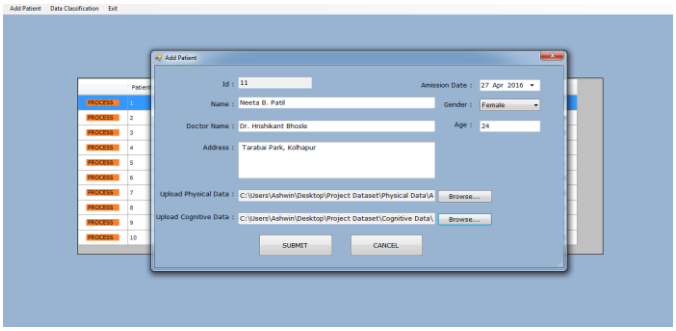

Fig -3: Add Patient Information

Fig 3. shows the form which is useful to add new patient information into the database. In this form user have to fill Name of particular patient, patient' Doctor name, Patient's Address, Patient Admission Date, it's Gender and Age and also have to upload patient's collected Physical data and Cognitive data. Submit button saves patient information into the database. From this form user can save individual patient information into the database for future use.

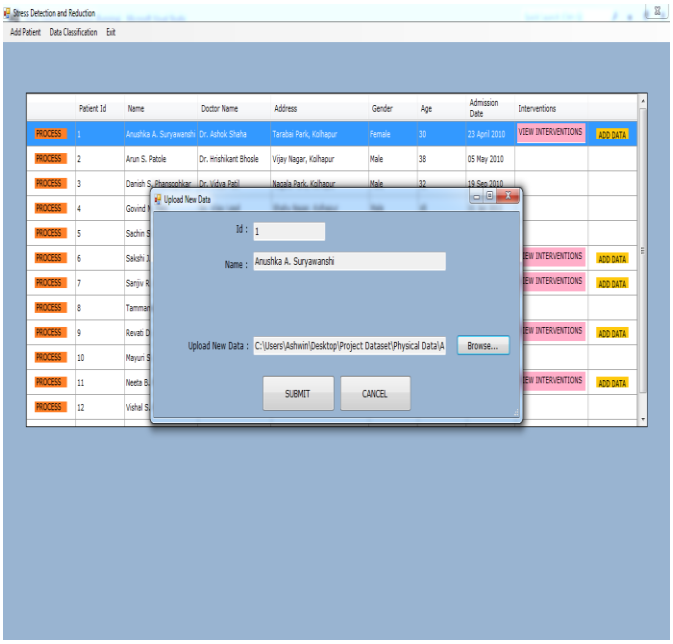

Fig -4: Add Patient New Data

Fig 4 shows add patient new data window. When user clicks on Add Data button which then this window opens for adding new patient data after going through interventions phase. This window shows patient ID and Name and contains browse button, Submit button and Cancel button. When user clicks on browse button it shows the window. From that window user select patient new data for further processing and click on submit button which saves data into system and user can now use that data for further processing.

6. RESULT ANALYSIS

6.1. Stress Level

The first process within the system is to calculate the stress indices value of subject. After collection of data first process is to calculate stress indices value of cognitive data and physical data. This subject's stress indices value is used as threshold value of that subject. EEG data of subject can vary depending on subject's behaviour. Therefore, its need to calculate individuals threshold value which used for calculating individuals stress level.

We calculate individuals stress indices value for establishing stress level. We analyse collected data and calculate this value. By this analysis we get following graph. This graph indicates individual subject's stress indices value.

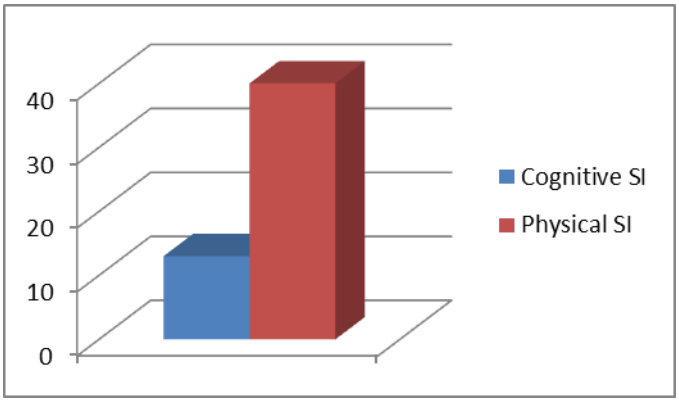

Chart -1: Stress Indices in two stages

This graph reflects the change into the stress indices value. This graph showed a stress indices value before task and after the task which are cognitive SI and physical SI. Stress indices value after the task was higher than before task load.

6.2. Data Classification

To improve the overall performance clustering procedure were used. Subjects EEG data were pre-processed using DWT with the aim to reduced noise from data. Based on subjects stress classification was done using K-means clustering. We analyze the reduced data for establishing stress level of subject. By this analysis we get following graph which shows stress level of subjects.

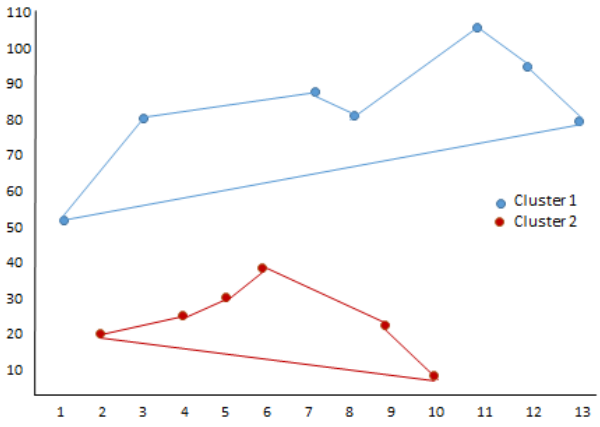

Chart -2: Data Classification outcome

This graph showed two clusters of subject's high stress subject's cluster and other one is low stress subjects cluster. From this classification we can easily differentiate subjects between high stress and low stress.

6.3. Statistical Analysis

After data classification system is responsible to calculate new stress indices value of high stress subject. This stress indices value was used for comparing with previous stress indices value.

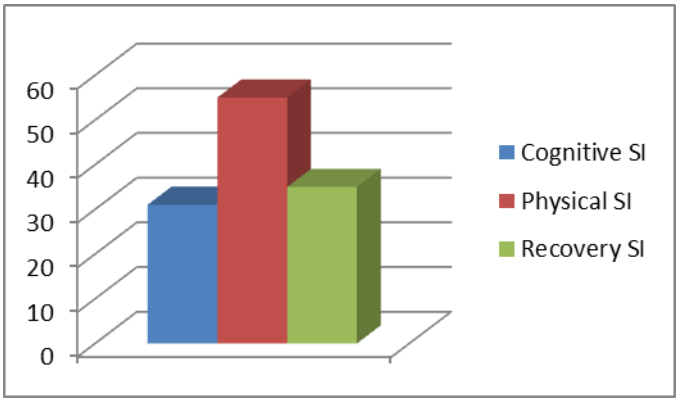

Chart -3: Stress Indices in three stages

This graph reflects the change into the stress indices value. This graph showed a stress indices value into three stages before task load, after the task load and after the recovery. This graph showed comparison between three stages and gives the results.

7. CONCLUSIONS

We have made survey of different literatures and studied different techniques for establishing stress. For analyzing the human stress level there are different techniques are used. In the various researches, it uses data pre-processing technique and proper classification technique to identify stress level in human. But there are fewer researches which provide the stress reduction technique.

However, this system consist stress reduction techniques by introducing interventions into the system. In this work first we calculate the stress indices value which is used as threshold value for comparison. This work improves the accuracy of data by analyzing data DWT technique which reduces the noise from data. Also data classification technique is used for identifying the stress level of subject. Clustering is used for classifying the subjects. After classification we get the stress level of each subject. After that interventions are added into the system and new data is collected for processing and we get the results that stress is reduced or not.

Form our experiments we found that our technique is better than other techniques. In this system we identify stress level of human and also this system provides stress reduction technique. This system provides easy process of data and it is not time consuming.

Thus, the proposed system is helpful for analyze the stress level effectively and provide techniques for reducing stress among individuals for improving their performance.

8. FUTURE WORK

As future work, first we can implement this same system by using other stress detection technologies like, ECG, EMG, and GSR etc. For further research we can go through additional reference paper which can helpful to look on advanced research like. Advance research on adding detail into the data which can be helpful for obtaining the results. It is needed that design the database more detail so that detail analysis on data is easier and it is understandable to the developer to find the effective solution for stress reduction. Second we can increase the classification accuracy by adding other classification techniques. Also other feature extraction technique can be used instead of DWT like DCT. Third we can improve the accuracy of the system by adding more subject data and also can check the accuracy of data using alternative detection techniques such as blood pressure or heart rate.

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