Mental Stress Level Classification: A Review

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ABSTRACT
Electroencephalography (EEG) is the tool to record electrical activity over the scalp. This technique is widely used in clinical or research setting, since it is user friendly and non – invasive. In clinical setting, the EEG signal is used to diagnose the disease related to brain. In research setting, the usage of EEG signal is focused on rehabilitation; mental stress study .This paper presented the review on different methods for mental stress level classification. There are four methods for investigation such as principal component analysis, artificial neural network, discrete wavelet transform and spectral centroid technique. The features obtained from methods were extracted from recorded EEG signals and modeled using various classifiers like k-NN and ANN classifier. Based on this four method, we concluded that principal component analysis is better method and it has high accuracy.(98%).

Keywords
EEG; KNN; Mental Stress; Modified Covariance; Principal Component Analysis (PCA); Neural Network, discrete wavelet transform, spectral centroid technique.

1. INTRODUCTION
Electroencephalography (EEG) is the tool to record electrical activity over the scalp. This technique is widely used in clinical or research setting since it is user friendly. EEG signal is used to diagnose the disease related to brain such as seizure, brain tumour in clinical setting. The usage of EEG signal is focused on mental stress study in research setting. The processing of EEG signals is the most critical part in today's studies. EEG signal is highly complex, highly random, non-stationary in nature. In addition, analysis of EEG signal by visual inspection is impossible in real time. To compensate this problem, advanced signal processing techniques are needed to extract the hidden features from brain signal. The most suitable features represent the character of the signal and bringing the information of the brain state.

Generally, there are three main steps in EEG signal processing: 1) preprocessing 2) Feature extraction/Feature Selection and 3) Classification (Fig.1). Firstly, in the preprocessing stage, the signal originating from non-cerebral Systems are filtered using filter. Secondly is the feature extraction part. Feature extraction part is the most crucial part where the characteristic or behavior of the signal is extracted.

Finally, for classifying the features, numerous classifier such as neural network, k-nearest neighbor, genetic algorithm are used for classification purpose. Feature extraction plays vital role in producing a reliable classifier. For example, Discrete Wavelet Transform (DWT) was used to extract features from EEG signals before feeding to k-NN to classify human emotion in term of disgust, happy, surprise, fear and natural with classification accuracy of 83.26%[2]. k-NN is trained with the features obtained from combination of EEG Power Spectrum Ratio with Spectral Centroids technique to detect and classify human stress. Here, EEG Power Spectrum from all EEG frequency bands is measured. Next, Spectral Centroids are applied to EEG Power Spectrum from all frequency bands. After extracting frequency bands, the input is fed to KNN classifier for classification. Thus, the purpose of this paper is to search for the feature extraction techniques and classifier which are able to detect human stress with a good accuracy.

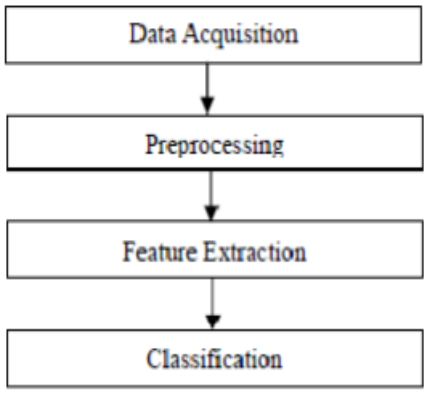

Fig.1Flowchart of signal processing stage

The application of Auto Regressive (AR) modeling namely Modified Covariance on spectral analysis introduces. The statistical features such as maximum, minimum, standard deviation, average was employed to represent the entire dataset produced by modified covariance. Then, Principal Component Analysis (PCA) was applied to reduce the dimension of features and this feature is fed to KNN classifier for classification purposes. Therefore, the main objective of this paper is to classify the mental stress level from EEG signals.

2. A SURVEY
2.1 Mental Stress Level Classification Using Principle Component Analysis
2.1.1 Experiment:
The ten healthy subjects (5 males and 5 females) are selected on some standard criterions. All the subjects are the under graduate engineering students. The selection of the subjects is based on the standard criterions as follows: 1) Subject is right handed; 2) Subject must be free from any health problem such as high blood pressure 3) Nonsmokers; 4) Native speakers; 5) Normal vision; 6)Not expose to general anesthesia in the last year; 7) Enough sleep. Mindset 24 Topographic Neuro-Mapping Instrument by Nolan Computer System LLC was used to record EEG signal. A 19 electrodes was placed over the scalp. The subjects were given 10 minutes for relaxation before starting experiment. Sampling frequency set 256Hz and threshold range set 80µv.EEG signal were collected from subjects in controlled environment using mental arithmetic test .This test was based on 3 levels. Each level consist thirty simple questions. In order to obtain optimum quality of EEG signal, subjects were asked to minimize movement except during hand writing.

Three minutes are given to answer the questions. The stress state and intensity level specified in self assessment questionnaire by subjects was used to validate stress level experienced by subject when answering the mental arithmetic question.

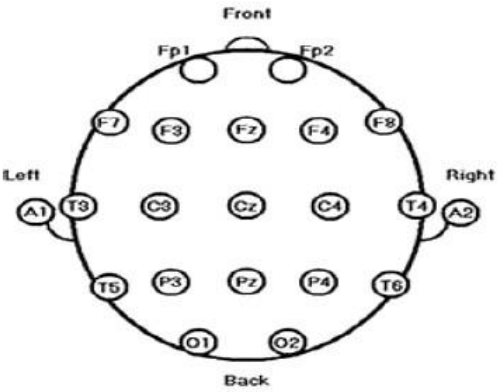

Fig 2 .The position of 19 electrodes EEG cap based on International 10-20 system

2.1.2 Algorithm:

- In preprocessing, the signal originating from non-cerebral systems are filtered using elliptic bandpass filter. During data acquisition , subject generate eye blink or body movement such as electrical interferences. This interferences has been eliminated from EEG output signal using filtering. The signals can be into Delta(0.5-4Hz),Theta(4-7Hz),Alpha(7- 13Hz) and Beta(13-38Hz).

- In feature extraction stage, filtered signal cab be segmented into 128data per frame. Modified covariance was employed to obtain PSDs of each frame. The four statistical features such as maximum, minimum, average, standard deviation can be obtained. After obtaining statistical features, PCA is conventional and statistical method to reduce the dimension of features.

- Finally, this reduced dimension of features can be fed as input to KNN classifier for classification purpose. The main objective is to classify mental stress level from EEG signals. In this way, the characteristic of EEG signal can be studied and EEG features that relate to stress were identified and classified using signal processing.

2.2 Mental Stress Level Classification using Neural Network for EEG Signal Analysis

2.2.1Experiment:

The ten healthy subjects (6 males and 4 females) aged between 23-24 years old can be selected in this study. All the subjects are the under graduate engineering students. The selection of the subjects is based on the standard criterions as follows: 1) Subject is left handed; 2) Subject must be free from any health problem such as high blood pressure:

3)smokers; 4) Native speakers; 5) Normal vision; 6)Not expose to general anesthesia in the last year; 7) Enough sleep. Mindset 24 Topographic Neuro-Mapping Instrument by Nolan Computer System LLC was used to record EEG signal. A 19 electrodes can be placed over the scalp. The subject were needed 10 minutes for relaxation before starting test. Sampling frequency set 256Hz and threshold range set

80µv.EEG signal were collected from subjects in controlled environment using mental arithmetic test .This test was based on 3 levels. Each level consist thirty simple questions such as addition, subtraction, multiplication or division. In order to obtain optimum quality of EEG signal, subjects were asked to minimize movement except during hand writing. Three minutes are given to answer the question. The stress state and intensity level specified in self assessment questionnaire by subjects was used to validate stress level experienced by subject when answering the mental arithmetic question.

2.2.2 Algorithm:

- The signal originating from non-cerebral systems can be filtered using elliptic bandpass filter in preprocessing stage. During data acquisition, subject generate eye blink or body movement such as electrical interferences. This interference has been eliminated from EEG output signal using filter. The signal can be into Delta(0.5- 4Hz),Theta(4-7Hz),Alpha(7-13Hz) and Beta(13- 38Hz).

- In feature extraction stage, filtered signal were segmented into 128data per frame. Spectral analysis can be applied. Three types eigenvector methods namely Pisarenko, multiple signal classification, and modified covariance can be employed to obtain power spectral density for EEG signal. After comparing three methods, modified covariance is best method in discriminating the task relaxation and writing task with achievement more than 90% accuracy[3]. The four statistical features(maximum, minimum, average, standard deviation) can be obtained. After obtaining above features, PCA is conventional and statistical method to reduce the dimension of data set.

- Finally, this reduced dimension of feature was fed as input to ANN classifier for classification purpose. From this, it can be concluded that modified covariance is best method

2.3 Mental Stress Level Classification Using Discrete Wavelet Transform

2.3.1Experiment:

In this study, 10 subjects can be selected based on some standard criterions. None of them had undergoing any medication, drugs and do not have any smoking habit. Initially, subjects should have to sit comfortably on the chair & after relaxation, MAT is taken. MAT is designed to increase the stress level gradually from one level to another by increasing mental demand from easy to hard. The protocol consists of 4 different levels such as normal (relaxation with soft music), low level (low difficulty), medium level (medium difficulty), and high level (high difficulty). Each level consist 30 arithmetic problems like addition, subtraction, multiplication and division. The subject has to choose the correct answer on LCD screen. 10s is given to solve each question. EEG signal can be obtained simultaneously along with other physiological signals.

2.3.2Algorithm:

- The acquired EEG data was sampled at lOOOHz; the raw EEG signal was denoised using "coif5" wavelet, and soft thresholding method in preprocessing stage. This noise free EEG signal was passed to the feature extraction. The preprocessed EEG signal was passed to the DWT and which performs the first level decomposition of a signal into approximation (CA1) and detail (CD1) coefficients using "db4" mother wavelet function and reconstructed to derive low frequency and high frequency bands using Inverse Discrete Wavelet Transform. Hence, the analysis can be possible through normalized statistical feature analysis.

• During features computation and normalization, eight different statistical features were selected.

• This features were classified by using KNN classifier. Specifically, in the LF band gives the maximum classification accuracy 96.3%. Similarly, HF band gives the 75.9% in covariance itself[2].

2.4 Mental Stress Level Classification using Spectral Centroids Technique

2.4.1Experiment:

In this study, 185 EEG data from different experiments were categorized into 4 groups. All data were taken from healthy subjects. Group 1 consisted of 51 EEG data representing EEG data during CE state. Group 2 consisted of 50 data which representing EEG data during OE state. Group 3 and 4 consisted of 42 data each which representing EEG data during CE state. However, due to data corruption, some data were removed. Hence, data re-generation technique can be used to generate more data to each group yielding 180 EEG data; 50 EEG data for Group 1, 50 EEG data for Group 2, 40 EEG data each for Group 3 and 4 by adding acceptable noise to the original data . The EEG signals can be recorded using EEG Data Acquisition instrument. The bipolar EEG gold-plated EEG electrodes were placed at prefrontal area of brain region, and references to earlobes . The recording period was 3 minutes for CE state and 10 minutes for OE state which requires more time since subjects needed to answer IQ test while their brain activities were recorded at the same time. The captured EEG signals were given to Personal Computer or Laptop through Bluetooth.

2.4.2Algorithm:

• The EEG data from channel 1 and channel 2 were analyzed in off-line manner. The eye movement and excessive body movement can be avoided. The EEG data can be filtered using band pass filter set from 0.5 Hz to 30 Hz to produce Delta , theta ,alpha and beta band.

• The power for EEG frequency band was calculated by performing Fast Fourier Transform (FFT) with Hamming window. Energy spectral density was calculated by dividing area of spectral power density. Spectral Centroids can be employed to each group and their frequency bands. The Spectral Centroids is used to find the centre value of the groups for each EEG frequency bands.

• It can be represented as an input features for classifier in term of target or class for classification process.

3. CONCLUSION:

Various methods were investigated such name are principal component analysis, artificial neural network, discrete wavelet transform and spectral centroid technique. The PSD values were extracted from EEG signal .The features obtained from methods were extracted from recorded EEG signals and classified using various classifiers. From experimental study of principle component analysis, it is observed that higher classification accuracy has 98.33% according to[6], from artificial neural network, it is observed that classification accuracy has 90% above according to[3], from discrete wavelet transform, classification accuracy has 96.3% according to[2], from spectral centroid technique, classification accuracy has 88.89% according to[1].From above, PCA is better method when compared to other methods.

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