WORK LOAD ANALYSIS AND CLASSIFICATION OF EEG USING ADVANCED DATA ACQUISITION SYSTEMS

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Abstract: EEG (Electroencephalogram) signal is considered as one of the most complicated signal having low amplitude which makes its analysis very difficult. The EEG signal properties can be magnified by using the wavelets which helps in performing much closer analysis of the signal. The various brain waves like alpha, beta, theta, gamma and delta can be studied and related with the abnormalities which further relate analysis of workload detection. Recently various research approaches have been progressed and proposed for analyzing EEG signal. According to these proposed papers EEG signals were recorded from the scalp of the brain and are measured in response to various workloads. The EEG signal features are extracted and the analysis of the system has to be done to separate the pattern of the signal and correlate with the predefined features. For this reason, different Quantization methods are selected and then the particular wave pattern is identified by comparing with Memory based tasks like a Cognitive task, mathematical tasks, past memory and memory remembrance in EEG which are extracted from a normal subject. After feature extraction, the EEG signals are delivered in to the processor and processed using BIOPAC data acquisition systems and MATLAB. MATLAB provides a cooperative graphical user interface (GUI), which allows users to openly an interactively analyze their high-density EEG dataset and then additional signal information using dissimilar methods like ICA and time/frequency analysis (TFA). In addition to fixed averaging methods, the research work resolves dissimilar brain signals through associating, analyzing and simulating datasets which is before restrained in the MATLAB software to practice EEG signals. The results have shown the potential of EEG signal to envision the different levels of workload through final validation of the brain signal.

I. Introduction

The Electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp. The very first eeg recordings were done by Hans Berger in 1929, although these kind of studies had been carried out in animals in early 1870’s.These waveforms which are recorded are expected to reflect the functioning of the surface of the brain, the cortex. This activity is influenced by the electrical activity from the brain structures underneath the cortex. The nerve cells in brain produces signals called action potentials. These action potentials or signals travel from one cell to another through a gap called the synapse. Special chemicals called neurotransmitters help the signals to move across the gap. There exists two types of neurotransmitters, first one will assist the action potential to move to the next cell, the another neurotransmitter will stop it moving to another nerve cell. The brain usually works very hard to keep an equal amount of these neurotransmitters in the brain. EEG activities are very less, and are measured in micro-volts (µV) with the main frequencies ranging up to approximately 30-39 Hertz (Hz) [4].

EEG activity is very small and measured in micro volts (mV) and the most important frequencies of the human EEG waves are:

Delta: these waves have a frequency of 3 Hz or less. These waves are referred to be the largest in amplitude and the slowest waves. These waves may reveal deep sleep (slow waves), background thinking, astral travelling, dreaming etc.…

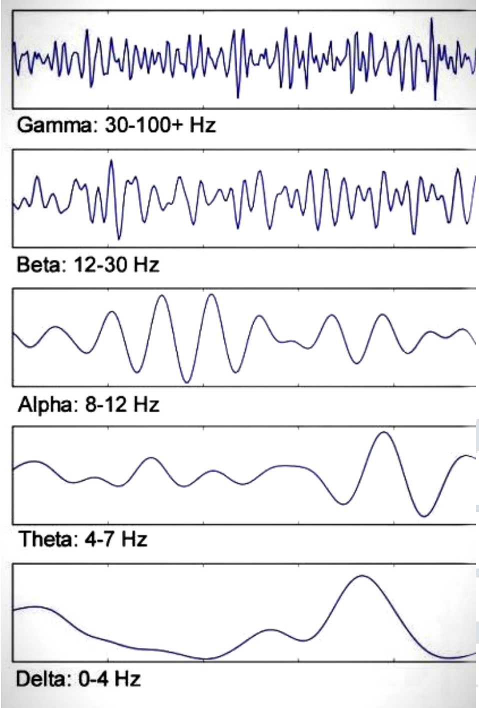
Theta: These waves possess a frequency of 3.5 to 7.5 Hz and is distinguished as "slow" activity like that of delta waves. It is perfectly normal in children of the ages up to 13 years and also in sleep but its abnormal in awake adults. It is a bit of unconscious state, and these waves may reveal drowsiness, tranquility, light sleep, non-ordinary reality (NOR).

Alpha: These waves have frequency from 8 to 13 Hz and is more generally observed in the posterior regions of the head on each side, as these are higher in amplitude on the dominant side. It appears while closing the eyes and while getting relaxed, and it disappears when the eyes are opened or getting alerted by any functionality. These waves may reveal the various states like deeply relaxed state, meditation, biofeedback, daydreaming etc.…

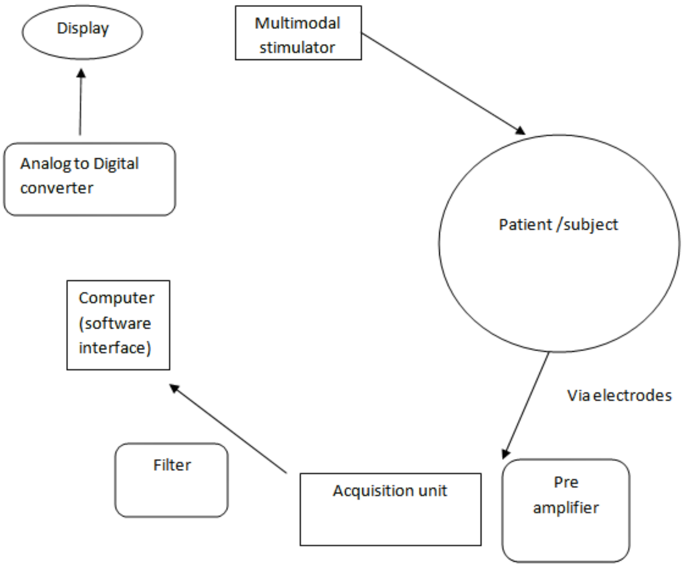
Beta: Beta activity is referred as a "fast" activity. It possesses a frequency of 14 Hz and more. It is more generally seen on both the sides of head in symmetrical distribution and is most evident frontally. These states can reveal the consciousness of the subjects also it can reveal whether the subjects are fully awake, alert, ordinary reality etc.

EEG is a vital measurement of the activity of brain and has great capability in assisting the diagnosis and treatment of neurophysiologic diseases and disorders. Automated Workload systems cannot, and these are not predetermined to, fully replace neurologists, nonetheless, the primary aim is to support the evaluation of medical doctors and to take the decisions accurately and efficiently.

Wave patterns of all the brain waves namely alpha, beta, theta, delta are shown in the fig.1 and basic hardware unit for eeg schematic model is shown in the fig 1(b).



(a)



(b)

Figure 1: (a) Comparison of EEG bands, (b) Schematic diagram of an EEG Hardware Unit

1.1 Basic Data Acquisition:

The EEG signals are an estimation of the potential difference between the two electrodes. Similar to the voltage in a battery, it is defined as the difference between positive and negative poles. So, it is mandatory that two electrodes are needed to record a signal. In our work we used three electrodes but EEG signal is always the difference between two or more electrodes.

BIOPAC is a tool which provides a high-quality physiological computation and explanation with higher compatibility. The MP data acquisition unit is the most important unit among all BIOPAC Student Lab System packages. It contains microprocessor internally to control data acquisition and communication with respect to the computation device and receives incoming signals and the signals are converted into digital form which can be further processed by the computer. There are four analog input channels on MP45 and two input channels on MP35, among which one channel can be used as input trigger.

Various kinds of inputs: The three input devices in MP unit are connected to the computer are: transducers, electrodes, and I/O devices.

- Electrodes are very simple instruments that are attached to the skin surface and acquire electrical signals from the body.
- Transducers are used for converting physical signal into a proportional electrical signal.
- Input and Output devices are devices designed like pushbutton switches and headphones

The electronic filtering can be done in the process

Low pass filter is used to provide anti-aliasing for the digital IIR &FIR filters in order to decrease high frequency noise, the MP unit uses a low pass filter. These filtering options are put into each MP unit channel:

- MP36: Low pass filter is fixed at 20 KHz
- MP45: Low pass filter is fixed at 8 KHz

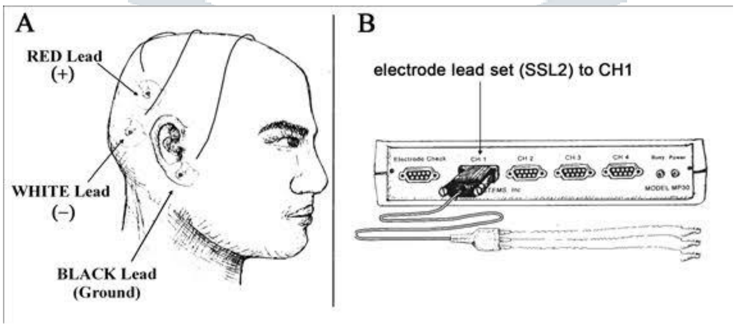


Figure 2: Basic electrode set placement on the scalp using BIOPAC data acquisition systems

- High pass filter: To serve the DC offsets associated with a range of bio-potential and transducer signals, the MP unit uses a switchable bank of single pole high pass filters. These filtering options are incorporated into each MP unit channel:
- MP 35/45: High pass filter option of DC (HP filter off), 0.05Hz, 0.5Hz and 5 Hz.
- Band pass filter: A 50-Hz band pass filter can prevent the signals from distortion or attenuates the electrical noise and eliminates all the distortion in the EEG signals.

Specifications:

A/D Sampling Resolution: MP36: 24-bit
: MP45: 16-bit
Input Voltage Range : Adjustable from ± 200 µ V to ± 2 V
Signal to Noise Ratio : MP36: > 89 dB min MP45: > 75 dB min
Input Noise Voltage : 9 n V rms /sqrt (Hz) and 0.1 µ V RMS noise (0.1 Hz to 35 Hz) - nominal
Input Noise Current : 100 f A rms /sqrt (Hz) and 10 p A p-p noise (0.1 Hz to 10 Hz) - nominal
CMRR : 85 dB minimum
Sample Rate : MP36: 100,000 samples /sec each channel
MP45: 48,000 samples /sec each channel
Serial Interface Type : USB 2.0 full speed

1.2 Simulation

The main aim of EEG signal processing in MATLAB is to study different parameters like peak-to-peak value, mean value, median, standard deviation and maximum value. Hence it involves

The following steps:

1. Collection of databases (brain signal data).
2. Constructing an effective algorithm for denoising of EEG signal.
3. Processing the data using effective algorithm.
4. Construct an effective algorithm for analyzing the EEG signal in Time and Frequency.
5. Classify EEG signal by time and frequency analysis.
6. Signal processing and analysis will be done by using MATLAB.

EEG machine electrodes are placed on the head of the subjects with wires which sends all electrical activity to a computer. But still we all know that EEG is still a type of electrical signal, in the sense it is susceptible to noise, artifacts, and interference. By taking help of MATLAB, these can be easily rectified by implementing signal filtering algorithm, such as removing low frequency components in frequency domain of the signals. moreover, MATLAB's signal processing functions can be utilized to make these signals more readable and easier to be analyzed

MATLAB provides an interactive graphic user interface (GUI) which allows users to flexibly and interactively process their highly complicated EEG signals or other dynamic brain data using independent component analysis

1. several EEG signals are collected as a form of dataset in the MATLAB.
2. Load the data into the software for brain signal processing.
3. Process the datasets
4. Extract and select the specific features for different EEG datasets.
5. In the matlab tool box we use the plot function for the observation of different plots like periodogram, histogram, PSD, Window visualization tool for the analysis of time and frequency domain and System ID parametric model for the validation of the EEG signal [3].

II. Existing System

Existing system suggests a unique cluster-based analysis method for measuring the physiological signals based on the inter-subject differences. The existing system is mainly consisting of the Data gathering, Data pre-processing and Data classification. In the data gathering stage the data is gathered using a sensor and the collected data is used for the generation of subject's physiological signals. Here the Data pre-processing is responsible for the discovery of useful information and this information is converted accordingly for the decision making. The proximity in the dataset is reduced by this process. The pre-processed data is used to classify the subjects into various classes in the Data classification mode [1].

2.1 Limitations of the Existing System

Various researches are going on detection and estimation of the human stress. The detection and the estimation of human stress has various methods like EEG(Electroencephalography), EMG(Electromyography), GSR (Galvanic skin response), BVP (Blood volume pulses), ST (skin temperature) etc., In this classification methods the reduction technique is not implemented yet. The manual stress management system is changed into computerized one for the particular individual based on the interest and provides the test solution for the stress management. This gives the best solution for the management of the user's stress accordingly to the user's interest. but this is more time consuming for the stress management. From this system none provided a technology for the reduction of the human stress [1].

III. Proposed Approach

In the proposed system, EEG signals are measured through the electrical voltage which is proposed based on the activities of the brain. An experiment is performed and observations of the brain functions of the various subjects are analyzed while performing different tasks such as Normal state, Memory learning, Memory remembrance, Mathematical task, Cognitive task, Past memory. These tasks produce several differences in frequencies including alpha, beta, theta, delta waves.

We have performed the experiment on 11 different subjects of the ages ranging between 18 to 55. The subjects are carried out with the tasks with their approval under the proper guidance with the presence of an expert. The experimental procedure is carried out after placing the single channel surface electrodes on the scalp of the various subjects. Further the various data signals from the brain are recorded using the advanced BIOPAC data acquisition devices like MP45 and MP35 which are interfaced with BIOPAC software which is specially designed for analyzing bio-signals. Now the recorded dataset are analyzed through various parameters like peak-peak value, mean value, median value, standard deviation, maximum value for specified time intervals. Thus the data signals for different memory tasks for all the 11 subjects are recorded and analyzed through above mentioned parameters to infer the results.

The EEG signal is a very low amplitude signal and can be easily affected by little disturbances like movement of head and blinking of eye etc... hence the entire EEG signal recording of the subject is filtered by using digital FIR band pass filter using HANNING window technique. The Frequency cutoff of the hanning window is taken from 5hz-50hz. Hence the filtered EEG signal is used for further MATLAB analysis. In MATLAB we analyzed the EEG signal data using various plots like plot graph, power spectral density estimation, window visualization tool, system parametric id evaluation. After analyzing the various plots and system id parametric evaluation model, we infer the validation percentage of each subject, which indicates brain activity of the subjects under various workloads as mentioned above.

IV. Result and Discussion

EEG signals are measured by non-invasive methods i.e. surface electrodes are used for measuring the EEG signals. Ag-Agcl, EEG electrodes are popular as the standard in measuring electrodes. Through the cables EEG signals passes to the EEG amplifier. This amplifier is connected to the BIOPAC Data Acquisition Unit MP45/MP35 through the Universal Interface Module. Data acquisition unit is directly connected to the computer for further analysis of the signals.

The signals are collected by placing the electrodes above left ear on scalp of the head and have been taken into consideration for measurement. 11 persons of age group between 18-54 have been taken into consideration for EEG signals measurement. Fig.4 shows the measurement of Surface EEG signals from the Brain. Pair of electrodes of white and red colors has been used on the respective left side occipital and a reference electrode of black colour has also been used to reduce the interference and noise effects. Before starting each measurement, at least 3-7 seconds preparation time has been taken which is also called delay time. After that the action time for 6 different tasks (Normal, memory learning, memory remembrance, mathematical task, cognitive task and Past memory) in sequence with respect to time, a total of 0-400 seconds.

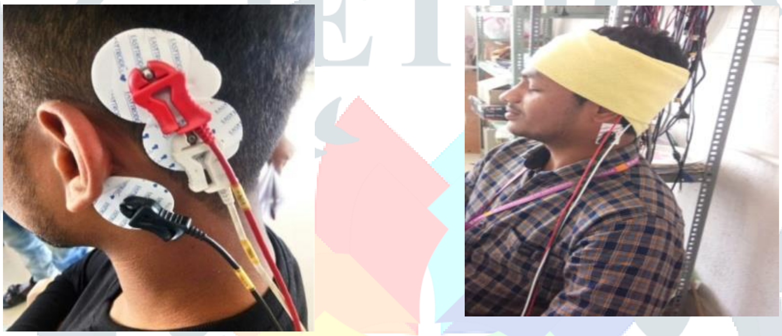
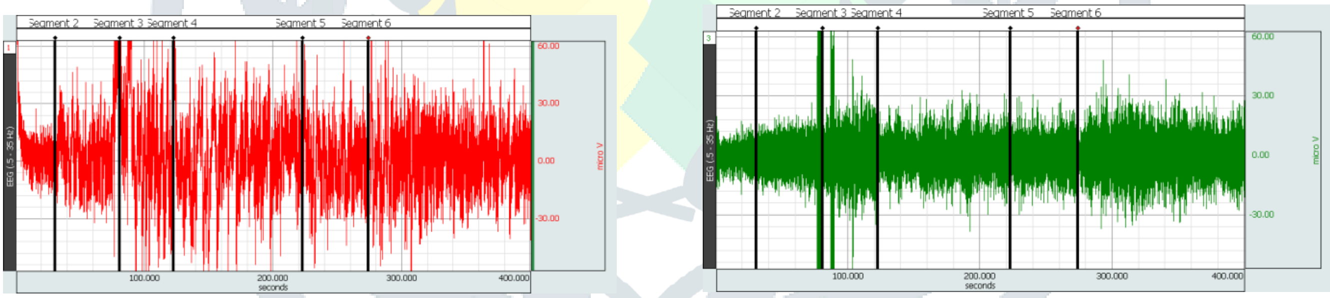


Figure 3: Measurement of EEG and Placement of Electrodes

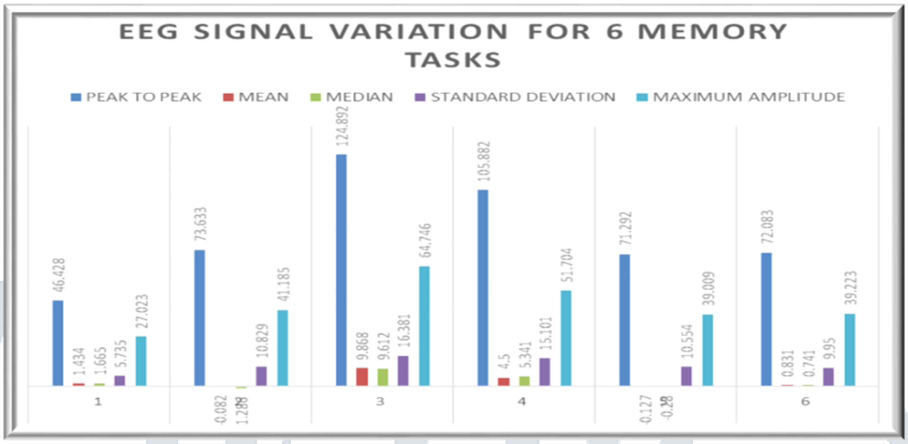


(a) EEG signal measured from biopac for different tasks

(b) Filtered EEG signal after removing noise

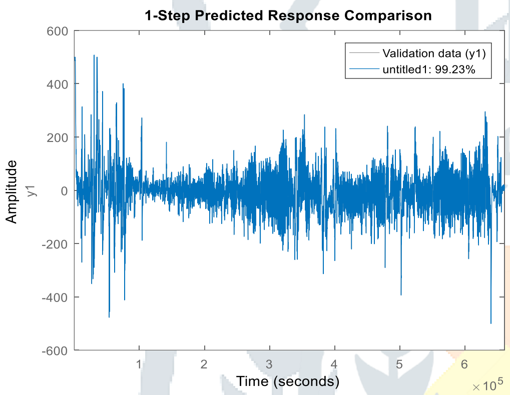
Figure 4: fig (a) and (b) represents the entire EEG signal with and without noise respectively

The filtering techniques are applied by using digital FIR bandpass filter using HANNING window with frequency ranges from 5Hz to 50Hz.To make analysis easy with characteristics or features which are extracted from the EEG signals shown in the Fig.5. A Software Analysis module has been developed for the whole processing (feature classification) of the EEG signals. After analysis of EEG signals from BIOPAC for all 11 people for all six memory tasks, it is clear that the simulation is working very accurately. After calculating all the five parameters Mean, peak to peak, median, standard deviation and maximum values in six

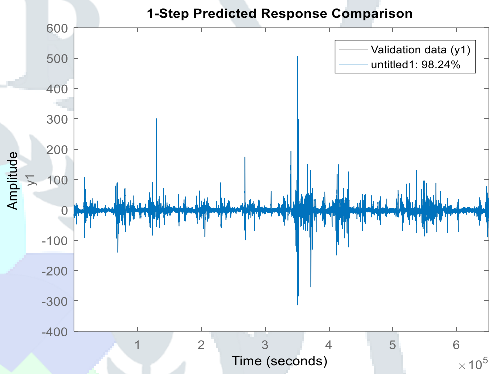


different tasks for all 11 people, the simulated data representing various plots and spectrums are analyzed and conclusions are inferred.

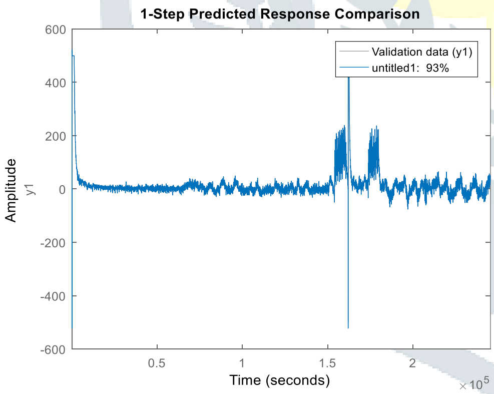
Figure *5*: Feature extracted from eeg signal



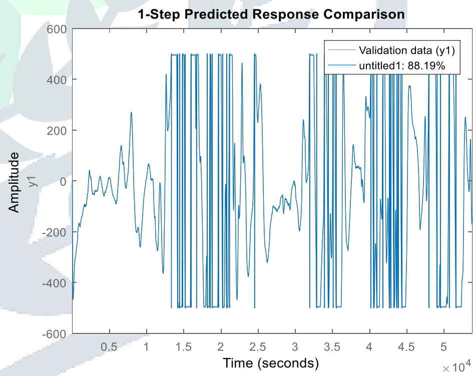
6 (a)



6 (b)



6(c)



6(d)

Figure 6: Represents the validation percentage of the subjects with the ages 20, 21, 33, 55 respectiv**ely**

Table 1: output validation of the EEG signal of different subjects with different ages

Reference Subject	Age	Validation
1	20	99.23%
2	21	98.24%
3	33	93%
4	55	88.19%

The above fig 6 indicates the system id parametric model along with validation percentage of the eeg signal. The plots 6(a),6(b), 6(c), 6(d) represents the parametric model plots of the eeg signal of different subjects with ages 20,21,33,55 respectively.

Similarly, table 1, represents the above analysis in a tabular format. The validation percentages of the subjects are decreasing with increase in their age, this system id parametric model validation percentage indicates the brain activity from which we can analyze the workload on each subject which may helpful for further researches.

V. CONCLUSION

In this work, an attempt has been taken to develop a robust prediction model for workload detection which may assist radiologists in making differential diagnosis and provide better prognosis by providing second opinion in case of voluminous and highly complex brain signals. The work has approached the problem of designing of workload system by considering the relevant features, in different task from brain signals, BIOPAC and MATLAB learning methods and incorporating the statistical analysis in the procedure of classification of Neuro physiological signals. This work presents a new approach to the use of algorithm in this sense. The study presents a different analysis, both in the identification of the most effective features used for the representation of the problem and also in the identification of the most efficient algorithm in the classification of the problem from among the 5 different tasks. This work includes inspection of a comprehensive feature set indicating their usefulness in the representation of EEG signals and to find out, what features delineates the EEG signals of a normal patient from a workload patient. The novelty of this objective lies in the exhaustive statistical analysis of extracted features to come up with prominent feature set for classification purposes and to the author's knowledge is the first of its kind. Various statistical tests are applied exhaustively to verify that the extracted features are distinct and uncorrelated to each other. The chosen features are simple but robust for the morphology of EEG data for the classification problem.

A novel hierarchical Workload EEG system is modeled for classification. We conclude that EEG based information is sufficient for the proposed method that has higher potential in designing EEG based diagnostic system for detection of electroencephalographic changes. The final part of this work demonstrates usage of epochs to assess the non-stationarity of the signals. Selection of features and module size ensure the best accuracy that can be achieved in practice. The research findings indicate that this proposed approach can distinguish the categories of EEG signals in two and three-class very efficiently. Taken together, on the basis of our results and our cooperation with BIOPAC trainer, it can be concluded that the research presented in this dissertation has found successful methods for the reliable classification of EEG signals and can facilitate more effective evaluation of the complex biomedical signals.

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