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An SVM-Based Approach for Emotion Identification Using EEG Signals

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Abstract: Emotions are the requisites in our day-to-day life. Emotions are the psychophysiology states that are coupled with thoughts, feelings, behavioral responses, and a degree of satisfaction or dissatisfaction. There are various methods for achieving psychophysiology data from human beings such as Electroencephalography (EEG), Electrocardiography (ECG), Photoplethysmogram (PPG), blood volume pulse (BVP). In this paper, we have mainly focussed on EEG device for getting this data. Electroencephalography (EEG) is an electrophysiological monitoring method to note the electrical activity of the brain by the electrodes that are placed on the scalp. With the help of the deep dataset, we trained the Support Vector Machine (SVM), which is a classifier. The raw EEG data should be further processed to reduce the artifacts and features are selected to give the input to the SVM classifier. The outputs are in the form of valency and arousal values. The acquired results are having an accuracy of 83% in the detection of emotions.

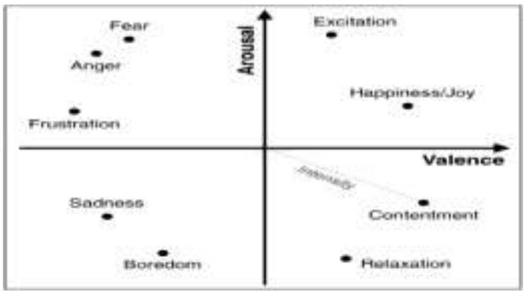
Key Words: EEG, SVM, Deep dataset, Valency, Arousal.

I. Introduction:

Emotions play a crucial role in every human's life. Emotions are conveyed in a manner, such as facial expressions, voices, biosignals, sentimental analyses, physiological, and psychological signals. Emotions inspire people to acknowledge rapidly to stimuli in the environment, which helps improve the chances of survival and success [1]. Humans experience emotion, with evidence used that they influence action, thoughts, and behavior. Emotions are categorized into various ranges of feelings experienced. These may be positive, negative, and neutral. Positive emotions are identified by Frederickson and include joy, gratitude, serenity, interest, hope, pride, amusement, inspiration, awe, and love. Negative emotions are identified by Robert Plutchik and include fear, anger, disgust, sadness, rage, loneliness, annoyance. Neutral emotion includes surprise, astonishment, bored, and drained.

Brain-Computer Interface (BCI) is a method to obtain and classify brain signals into emotions [2]. BCIs are the systems that authorize any user to interchange information with the environment and devices are controlled by using brain activity that means without the neuromuscular output

pathways of the brain. Brain signals can be obtained by employing invasive or non-invasive techniques [3]. Despite the existence of various methods to obtain brain signals, the most used technique is Electroencephalography (EEG) because it is non-invasive, portable, inexpensive, and utilized in almost all environments. This BCI system is based on EEG signals.



Electroencephalography (EEG) is an electrophysiological observing technique to note the electrical activity of the brain with the help of the electrodes that are placed on the scalp. EEG calculates the voltage variation generated from ionic current within the neurons of the brain. EEG continued to be a significant device for research and diagnosis [4]. Surveying EEG signals is a fascinating approach that incorporates various fields like neuromarketing, social interaction, biometrics, health applications, and custom solution. In general, we have wired and wireless headsets to transfer the data to the computer systems via various methods like cables, Bluetooth connections [5]. The data from the EEG device can be processed by various classifiers like Support Vector Machine (SVM), K-Nearest Neighbour (KNN), Logistic Regression, Decision tree, Naive Bayes [6]. The classifiers may be trained with datasets like the Deep dataset, Seed dataset. In this paper, we used a deep dataset for finding emotions. A deep dataset was provided by Koelstra et al., in the year 2012, which is a database carrying a group of physiological EEG signals of emotions from various subjects for negative, positive, and neutral emotions.

A. SVM Classifier:

SVM or the Support Vector Machine is the best and popular algorithm in Supervised Learning algorithms. These are used in categorizing problems in Machine Learning. The main aim of the Support Vector Machine (SVM) is to create the best boundary region or line that can separate the N-dimensional model into a group of classes so that it can easily plot the new data point in the exact category [7]. This decision line or boundary is known as Hyperplane.

Hyperplane can be created by the points or vectors that are chosen by the SVM. The extreme cases in this section are known to be Support vectors. Therefore, this algorithm is coined as the Support Vector Machine. The distance between hyperplane and vectors is known as Margin.

This SVM algorithm is mainly used in various applications.

- Bioinformatics
- Face detection
- Image Classification
- Text and Hypertext categorization
- Handwriting recognition.

SVM can be classified into two types. They are

- ➢ Linear SVM
- ➢ Non-Linear SVM

A. Linear SVM:

If a dataset is labeled into two groups or classes with the help of a single straight line, then such type of data is defined to be Linearly separable data. Hence, this classifier is known as a Linear SVM classifier.

B. Non-Linear SVM:

If a dataset cannot be grouped by using a single straight line, then such type of data is defined to be non-linear data. Hence, this type of classifier is known as a Non-Linear SVM classifier.

B. Applications of EEG signals:

A. Psychology and NeuroScience:

These EEG signals are used in psychology and neuroscience to process the brain for determining attention, memory, and learning status. The event-related potentials (ERP) can be obtained from the continuous stream of EEG data. ERP can be calculated by the amplitudes and voltage distribution over the electrodes [8]. The evaluation of the patient's cognitive states, deficits in behaviour, attention in clinical and psychiatric fields uses these EEG signals [8].

B. Brain-Computer Interface (BCI):

The communication between the human brain and computer system without depending on the brain's normal output path of muscles and nerves is defined to be a Brain-computer interface. Human operates their thoughts instead of motor movements in BCI [8]. BCI mainly involves

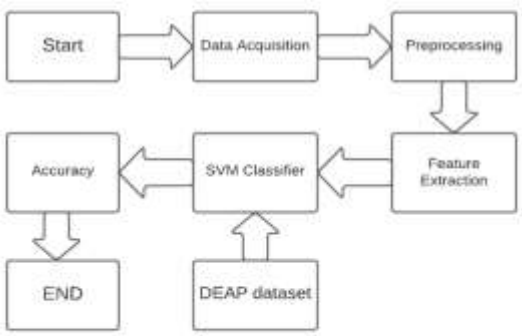
- Object Controlling
- Object Recognition
- Rehabilitation and Human assistance

C. Medical use:

In the treatment of mental and brain diseases and abnormalities, EEG signals are required. These EEG signals are mainly helpful for physicians in determining an accurate diagnosis. In the neurology field, the important diagnostic application is in the term of epilepsy [8]. This includes the applications like

- Brain tumor
- Sleeping disorders
- Seizure detection

D. Block Diagram:



II. MATERIALS AND METHODOLOGY:

From the study, it was observed that the models evolved for identifying emotion states are ideally supervised algorithms. The pre-processing DEAP dataset is analysed using various features in frequency and time domain. A Supervised machine algorithm that includes an SVM classifier is evolved to determine the emotional states [7]. The DEAP dataset was specially designed for emotions-related experiments in two-dimensional model of valency and arousal values [8].

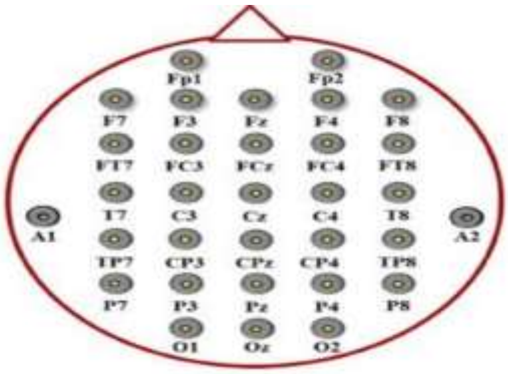


FIG 1: 32 channel location

The first and the most key thing is Data Acquisition. The EEG signals are obtained from the high-level performance systems under the various sampling rates. The EEG signals are collected from 32 locations. They are ‘Fp1’, ‘AF3’, ‘F3’, ‘F7’, ‘FC5’, ‘FC1’, ‘C3’, ‘T7’, ‘CP5’, ‘CP1’, ‘P3’, ‘P7’, ‘PO3’, ‘O1’, ‘Oz’, ‘Pz’, ‘Fp2’, ‘AF4’, ‘Fz’, ‘F4’, ‘F8’, ‘FC6’, ‘FC2’, ‘Cz’, ‘C4’, ‘T8’, ‘CP6’, ‘CP2’, ‘P4’, ‘P8’, ‘PO4’, and ‘O2’. To study the emotional states from EEG signals, the DEAP dataset is used. In the DEAP database, the signals are obtained from 32 subjects from 32 channel device having a particular sampling rate [9].

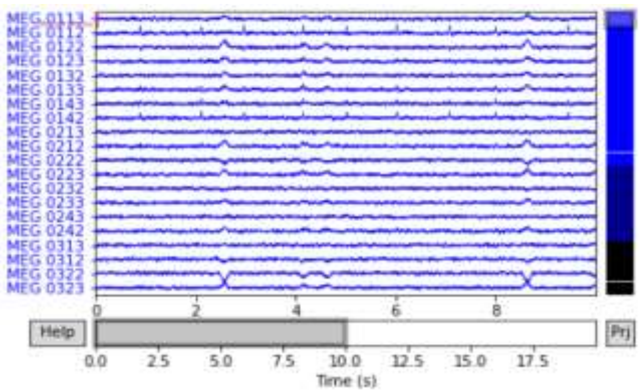


FIG 2: Raw EEG signal with Artifacts

In order to pre-process the EEG signals, the signals must be passed through the filters for

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the removal of various types of artifacts from the raw signals obtained by the EEG. In the pre-processing method, we used IIR filters for removing artifacts. Feature Extraction is a method of obtaining significant features from the pre-processed data to accomplish classification. In feature extraction, we will come to know about the 4 frequency bands. They are alpha(8-13Hz), beta (14-30 Hz), gamma (31-60 Hz), and delta bands (1-3 Hz) [10]. The two steps pre-processing and feature extraction are performed with the help of the MNE tool in python.

III. SVM ALGORITHM:

STEP 1: Set up the parameters or values and initializes position with the method or function of good point set and vector is composed of SVM attributes or parameters.

STEP 2: Train the SVM model and calculate the fitness.

STEP 3: Rank the positions or locations according to the fitness

STEP 4: On considering the sorting, it is classified into 3 groups. The first one is the fine solution and second to fourth is taken to be suboptimal solution, and the remaining is taken as a normal solution. Update the positions and produce a new position for the chaotic map.

STEP 5: If the conditions are met then update the position.

STEP 6: Finally we get the output optimum parameter.

A. Mathematical equations:

CASE 1:

$$\mathrm{St}+1\mathrm{at}=\begin{cases}\mathrm{FStat}+\mathrm{dg}\times\mathrm{Gc}\times(\mathrm{FStht}-\mathrm{FStat}) & \mathrm{R1}\geq\mathrm{Pdp}\\ \text{Random location} & \text{otherwise}\end{cases}$$

CASE 2:

$$\mathrm{St}+1\mathrm{nt}=\begin{cases}\mathrm{FStnt}+\mathrm{dg}\times\mathrm{Gc}\times(\mathrm{FStat}-\mathrm{FStnt}) & \mathrm{R2}\geq\mathrm{Pdp}\\ \text{Random location} & \text{otherwise}\end{cases}$$

CASE 3:

$$\mathrm{St}+1\mathrm{nt}=\begin{cases}\mathrm{FStnt}+\mathrm{dg}\times\mathrm{Gc}\times(\mathrm{FStht}-\mathrm{FStnt}) & \mathrm{R3}\geq\mathrm{Pdp}\\ \text{Random location} & \text{otherwise}\end{cases}$$

IV. RESULTS:

The predicted valency: 47.03125

The predicted arousal: 53.28125

The accuracy obtained from the SVM classifier: 83.47109375000002

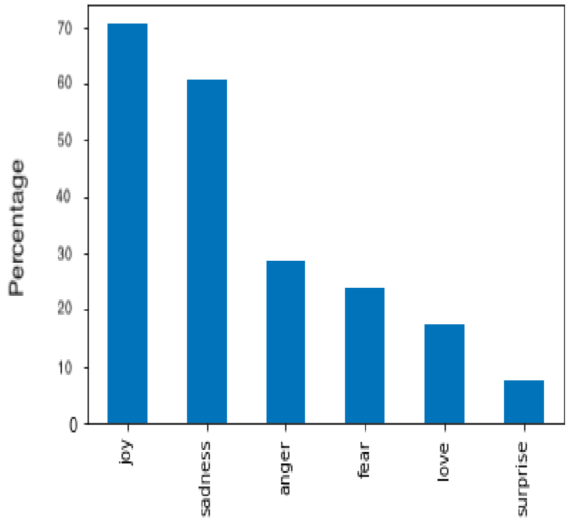

Fig 3: SVM classification results

V. CONCLUSION:

We had developed a technique for recognizing the emotions through the signals obtained from the brain using 32 channels. The research result depicts the emotions from the EEG signals should be possible. However, the research study is based on the feature extraction and classification methods that should be used for processing the EEG signal.

The results for the classification are presented in Fig.3. The classifier model used in this paper was SVM (Support vector Machine). The obtained graph contains the emotions on X-Axis and on Y-Axis. The classified emotions are joy, sadness, anger, fear, love and surprise. These emotions are classified based on valency and arousal values. The accuracy of the SVM model is determined and it is printed on the output console. The accuracy that obtained for the SVM classifier was 83%.

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