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Classification of Emotions through EEG Signals using SVM and DNN

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Abstract: ***Emotions are important for Humans both at work place and in their life. Emotions helps us to communicate with others, to take decisions, in understand others etc., Emotions recognition not only helps us to solve the mental illness but also are important in various application such as Brain Computer Interface , medical care and entertainment This paper mainly deals with how Emotions are Classified through EEG Signals using SVM (Support Vector machine) and DNN (Deep Neural Networks) . Applying the most appropriate algorithm to detect the emotional state of a person and play the corresponding song in the playlist. Brain signals can be collected using EEG (electroencephalography) devices.***

Keywords: Emotions. SVM, DNN, EEG, Emotions

I. INTRODUCTION

Brain Computer Interface (BCI) mainly deals with hardware and software that allows brain activities to control external devices. BCI creates a non-muscular channel for the communication between the brain and the computer or devices. Here, we aim at providing aid to disabled people and help them live their life as regular people. BCI technology is particularly helpful for people who are cognitively intact but without useful muscle function. BCI has been really advantageous for able-bodied. The data is collected from the human brain based on the individual's imagination. These signals are collected through a head gear which consists of a cap and electrodes placed on the scalp of the human brain. These signals are called as Electroencephalography signals or EEG signals [1][2]. These collected data are filtered and analyzed with reference to the real-time data. And hence, we can categories the signals into the type of diseases based on the analysis. BCI has been used in various applications such as driver state monitoring, medical, neuroergonomics, games and entertainment, security and authentication fields. BCI plays a major role in medical field. Today, BCI has influenced the physically challenged in restoring their moving ability by replacing the lost functionality of the organs. The scope of research is not limited to only medical applications but also extended to non-medical applications such as games and hands-free applications. On the other hand, BCI has been really advantageous for able-bodied. It has been used in various safety applications as well. It has contributed in various fields, such as industry, education, advertisement and smart transportation.

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Personalized interaction is given to each learner based on their response recorded. Most commonly used technology under BCI is Electroencephalography (EEG). EEG records the electric signals generated by neurons in the brain. The signals are captured through electrodes that are placed on the scalp surface. Neurofeedback has given optimistic results in the past few years and has been really promising in rehabilitating cognitive functions. A motor imagery-based BCI has been used to assist people with stroke rehabilitations. Neurofeedback training (NFT) with a motor imagery based BCI could enhance cognitive ability of a human related to ageing effects. It could help slow down the effects of ageing, which is the most common concern of elderly people, by studying how neurons behave in different aged people [3] [4]. NFT could enhance brain's plasticity by increasing neurophysiologic features (visuospatial, intellectual, memory and language - where brain activity plays a major role.)
There has been researches where NFT has utilized fMRI (functional magnetic resonance imaging) to analyze emotional intelligence and to teach the learner to fight back depression as well. fMRI is used by BCI technology for self-learning and skill learning. It has also been used on athletes and sports person to analyze the stress level and to control them to enhance their performances.

II. DATASET

Here our dataset has mainly nine features such as participant_id, Trial, Experirment_id, start_time, valence, Arousal, Dominance, liking and familiarity. Dataset has 1252 instances. The Emotion which are considered in this paper are Happy , Anger, Relaxed and Sad, which are decided by using valence and Arousal feature as below:

```
 if aurosal> 5 && Valence >5 then
            Happy (0)
if aurosal>5 && Valence <=5 then
            Anger (1)
if aurosal<=5 && Valence >5 then
            Relaxed (3)
else
            Sad (2)
```

So in the dataset we have identified the above four emotions for the data set and totally 431 data set instances were happy, Anger is 289, Sad is 266 and Relaxed is 265 as figure below:

Happy	431
Anger	289
Sad	266
Relaxed	265

Fig.1: Emotions in the dataset

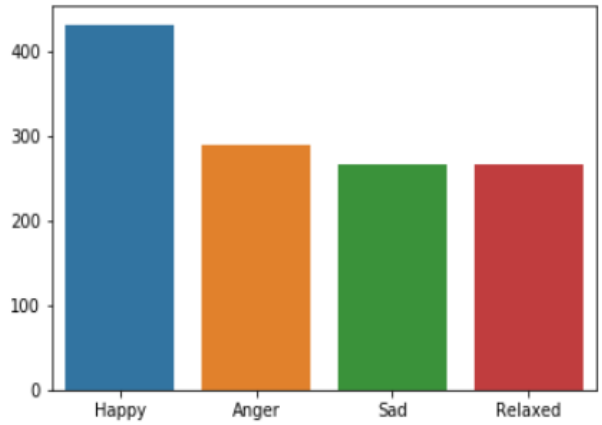

Fig. 2. Graphical representation of emtion instances in dataset

The classification is done using machine learning algorithms such as SVM and DNN. Later, both the algorithms are compared with each other to find the most efficient algorithm. Also, based on the classification, an application is to be created that will play the songs according to the emotions detected.

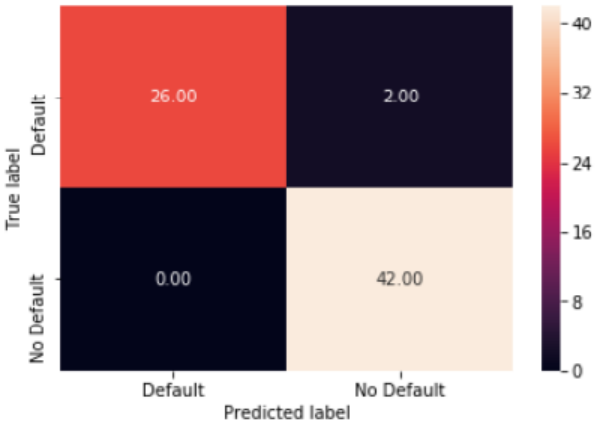

Fig. 3.Heatmap of the dataset

III. RESULTS

In this paper we have used machine learning techniques for feature extraction and classification of data. The two techniques used are:

A. Support vector machine (SVM):

1. SVM is a linear classification technique, that is used to find a hyperplane in an n-dimensional space where n is the number of features.
2. The hyperplane with the maximum margin is then used to distinctly classify data points the four major human emotions - happiness, sadness, calmness and anger.
3. Hyperplanes are linear boundaries on either side of which the data points fall into different classes.
4. The dimension of the hyperplane depends upon the number of features, which, in this case is, 4. The points which are classified close to the hyperplane are called the support vectors.
5. They influence and position the placement of the hyperplane.
6. Here, we use non-linear kernel function that is the Radial bias function for the multi-class classification.
7. For SVM classification, we are using the in-built function called SVC which is imported from the sklearn python library.
8. SVC has parameters such as kernel, gamma, decision_function_shape etc. for building the SVM classifier.
9. The kernel used is RBF, the decision_function_shape is the 'ovo', gamma value is scale and the probability is given as true to show the probabilities.
10. The training data is 90% and the testing data is 10%
11. The accuracy obtained is 92% (average).

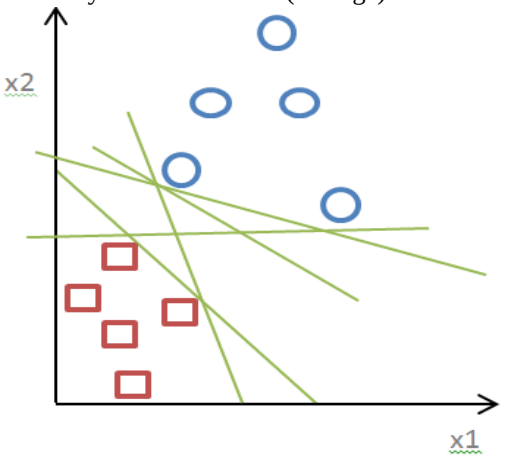

Fig. 4. Possible Hyper Plane-1

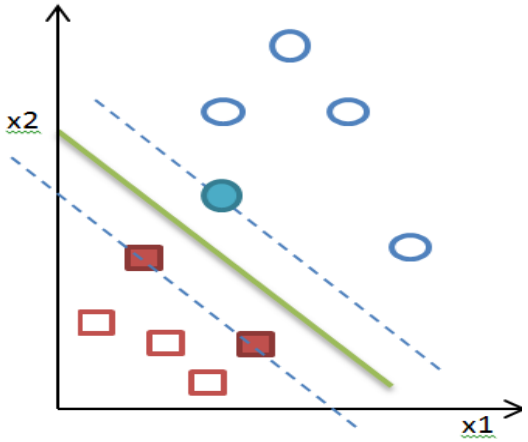

Fig. 5. Possible Hyper Plane-2

The thick green line is the optimal hyperplane and the distance between them is maximum.

Performance of SVM is measured using parameters such as precision, recall,f1-score and support as below:

	precision	recall	f1-score	support
0	0.88	1.00	0.93	42
1	0.90	0.90	0.90	29
2	0.79	0.81	0.80	27
3	0.90	0.68	0.78	28
micro avg	0.87	0.87	0.87	126
macro avg	0.87	0.85	0.85	126
weighted avg	0.87	0.87	0.86	126

Fig. 6. Result of SVM

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B. Deep neural networks (DNN):

1) Firstly, the algorithm is built by dividing the data into training data and testing data. Usually the training data is 80% and testing data is 20%.
2) The deep neural networks algorithm mainly is based on two models, TensorFlow and Keras. TensorFlow, a machine learning framework is used to build, train and design deep learning models. Keras, on the other hand is a python library which is ran on the top of TensorFlow.
3) There is a loss entropy function called categorical_crossentropy which is used for single label categorization. Here, the optimization tool used is adam.
4) In our case, we designed a neural network with three hidden layers with varying weights and bias to get a better predictive accuracy in extraction of various features which are then used in identification of the major human emotions - Happiness, sadness, anger and calmness.
5) There are 4 neurons at input, 7 neurons at each of the two hidden layers, 4 output neurons corresponding to each emotion.
6) A dense function is used to build the neural network using the keras library
7) Depending on the level of match the output neuron predicts the emotion of the user.
8) The training data is 80% and the testing data is 20%.
9) The accuracy obtained is 94%(average).

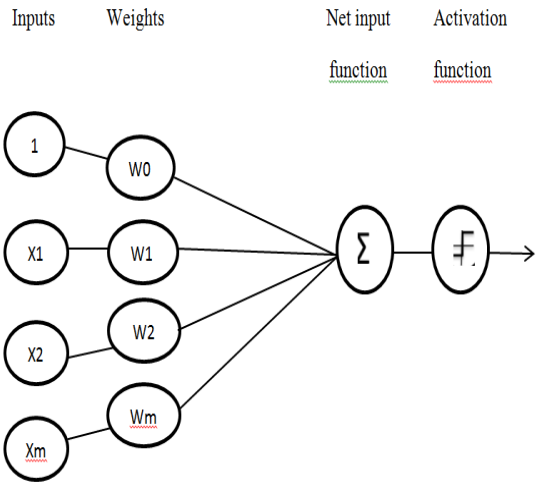

Fig. 7. Structure of Neural Network

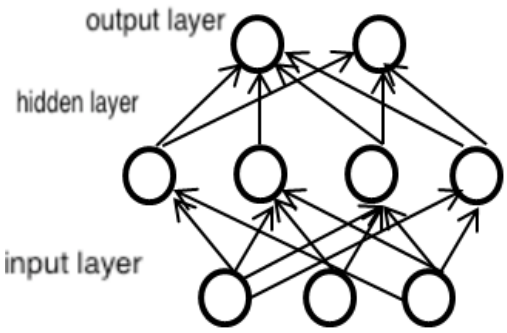

Fig. 8. Layers of DNN

	precision	recall	f1-score	support
0	0.95	1.00	0.98	79
1	0.95	0.97	0.96	59
2	0.90	0.79	0.84	57
3	0.83	0.86	0.84	56
micro avg	0.91	0.91	0.91	251
macro avg	0.91	0.90	0.90	251
weighted avg	0.91	0.91	0.91	251

Fig. 9. Result of DNN

IV. APPLICATIONS AND OBSERVATIONS

The execution is done by two algorithms that is, Support vector machine and deep neural networks. The accuracy of each of it found out. The accuracy of support vector machine is 92% and that of deep neural networks is 94%. Hence, we find that deep neural networks are more accurate compared to support vector machine [9][10]. Now the classified emotions are detected and the corresponding song is played.
Music is played for each emotion detected. There is a playlist for each of the emotions happy, sad, relaxed and anger. A function is defined to play songs randomly from the playlist. The input to this function is the index assigned to represent the emotions. The final output will be user id of the record from the dataset, the emotion detected, total number of songs in the playlist and the song which is currently being played from the playlist [11].

V. CONCLUSION AND FUTURE WORK

The application is created using DEAP dataset which is filtered and extracted according to our requirement. It will detect the emotions of an individual which are happy, sad, relaxed, and anger. This prediction happens using a classification model which consists of Support Vector Machines and Deep Neural Network algorithms. Both the algorithms are compared and provide an accuracy of 92% and 94% respectively. Music is played for each emotion detected. There is a playlist for each of the emotions happy, sad, relaxed and anger [5]. A function is defined to play songs randomly from the playlist.
The input to this function is the index assigned to represent the emotions [6]. The final output will be user id of the record from the dataset, the emotion detected, total number of songs in the playlist and the song which is currently being played from the playlist.
Various songs are categorized based on these emotions.
The application plays the songs based on the emotion detected. This application will help physically challenged people who would like to entertain themselves, by being independent. The application can recognize the emotion of the person and play the songs accordingly.
Future Enhancements are that the accuracy of prediction of the emotions will be improved, and that the application of playing music for the detected emotion will be embedded in a device such as a headset so that real time data is collected and music is played accordingly[7][8]. The number of emotions detected will be increased and also the playlist for each emotion will be created with a greater number of songs.

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AUTHORS PROFILE

Veena N completed her B E is Computer Science and Engineering from Visvesvaraya Technological University, and M. Tech. in Software Engineering from Visvesvaraya Technological University. She has secured 2nnd rank holder in her PG from VTU in 2008. Presently she is pursuing her Ph. D in Brain Computer Interface under Visvesvaraya Technological University.

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