Emotion Recognition from Multi-Channel EEG using Deep Learning

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***Abstract*—EEG (electroencephalogram) data-set has been used to measure activities in human brain. The devices used to get these data produces enormous amount of data. In this paper, the different classification models are used on Differential Entropy feature of EEG data to identify best method to recognise emotions using EEG data. The most suitable feature to recognize emotions from EEG data is DE (Differential Entropy) using SVM on all channels which gives 79.1 % accuracy. The other classifiers on all frequencies such as KNN, ANN, ELM and random forest gives 76.09 %, 76.4 %, 58.38 % and 78.2% accuracy respectively. These classifiers has been used with all the individual frequencies to identify best frequency combination to classify the data. Random forest is applied on only all the friquencies all togather.**

***Index Terms*—EEG data, Classification, Deep learning, Differential Entropy, Feature selection**

I. Introduction

Emotion represents behaviour of human in current situation [1]. By getting the information about the emotion, it is possible to predict next steps towards human interaction. This can be very useful in medical field in which it plays critical roles in doctor-patient connection. The brain-machine interaction is also a useful application of this field [2]. The emotion recognition can be done using physiological signals and without using physiological signals. If the emotion recognition done by using facial expressions [3] or using voice [4], it is done without using physiological signals. When the emotion recognition is done using EEG signals, it is done using physiological signals.

The facial expression and voice can be hidden and faked by the user. So, the methods to recognize emotion using facial expression and voice are less reliable then EEG. Because EEG signals represents true nature of brain and can't be faked by the user. There are many research project focusing on EEG based emotion recognition. Li et al. indicated that gamma frequency of EEG signals are best to recognize happiness and sadness [5].

The experiments are focus to used different classifiers on different channels of EEG data to identify best classifier for this kind of data. The classifiers used in this experiment are KNN, ANN, ELM, SVM and random forest. The classifiers were used with all king of EEG channels such as delta: 1-3Hz, theta: 4-7Hz, alpha: 8-13Hz,beta: 14-30Hz, gamma: 31-50Hz.

II. Data Collection

To collect the EEG data, the experiments were conducted by Ruo-Nan Duan, Jia-Yi Zhu and Bao-Liang Lu [1]. In these experiments, three men and three women participated who were aged between 22 and 24. They were all healthy and right-handed, with adequate sleep the day before experiment. Each of them participated the experiment twice at intervals of one week or longer. The participates were aware that equipment were harmless.

In this experiment, movie clips were selected to generate positive or negative emotion. All the clips were in English and 4 minutes long. The clips were from the movies such as Schindler's List, High School Musical, and The Day After Tomorrow. The subject were given squeezable steering wheel to steer tightly when they feel intense emotion. The movie clips were played in a random order with hint of start and rest time before and after the clip respectively.

The experiments were conducted in the morning or early in the afternoon using 62-channel electrode cap. The system was designed to to record data at 1 MHz synchronously. The data generated while the emotion were happening are used in the experiment. The data is down sampled to 2000 Hz and DE features were extracted by Ruo-Nan Duan, Jia-Yi Zhu and Bao-Liang Lu [1]. Their experiment concludes that DE features are most useful to recognize emotions from EEG data and gives the best accuracy then other features, They have provided EEG data set with only DE features.

III. Data Structure

The data provided by researchers contains total of 142,548 rows and 310 columns in numpy array as pickle files. Among them, 84420 data has taken as training set and remaining 58128 data has taken as testing set. 310 columns contains data of 62 electrodes on five different frequencies. The data is already divided between training and testing sets in file train and test respectively. All the data consist of continuous values. The separate column is provided for labels ranging from 0 to 2. That indicates positive, negative or neutral emotion. Among the 310 columns, each group of 5 columns contains data from a single electrodes. These columns contains data of different frequencies such as delta: 1-3Hz, theta: 4-7Hz, alpha: 8-13Hz,beta: 14-30Hz, gamma: 31-50Hz.

IV. Methodology

The data is loaded as numpy array from pickle files. The train and test category are merged as single data. Then the data is scaled from 0 to 1 to remove feature domination and divided into training and testing category again. The corresponding number of columns for different frequencies are divided among frequency lists. First, the KNN model with 5 neighbours are applied to different frequencies and their accuracy are collected into a separate list. The main list contains accuracy of all frequencies from different classifiers. The same procedure is applies to SVM classifier.

The neural network has different requirements of data structure. So, for that purpose the labels are converted into one hot format and supplied to ANN model. The rest of the procedure is same as KNN and SVM model. The ELM model requires some additional files which are provided with the project. The ELM model is used same as KNN.

The random forest is applied to all the frequencies combined. All the accuracy are converted into percentage and then plotted using pyplot at the end of the program. Each bar chart contains accuracy with classifiers used.

V. Results

The program produces following data as results.

The following table contains accuracy of frequencies in percentage.

	KNN	SVM	ANN	ELM
Delta	74.66	76.18	72.47	50.84
Theta	73.71	76.94	75.76	56.29
Alpha	74.85	75.65	75.89	56.66
Beta	74.37	76.76	75.00	55.18
Gamma	74.34	76.67	76.74	58.19

The following graph contains accuracy when all frequencies are combined.

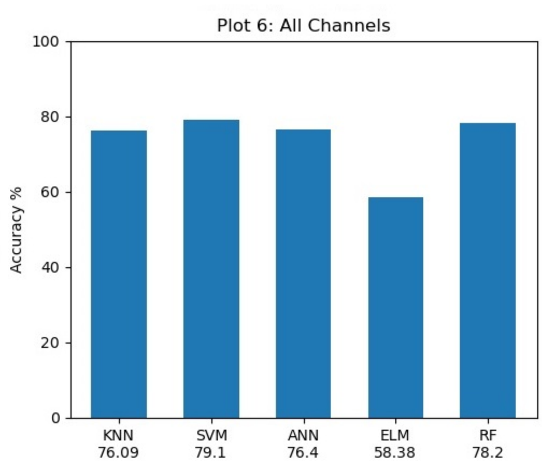

Fig. 1. Accuracy on All Frequencies

VI. Conclusion

From the results, we can conclude that SVM gives best accuracy of 79.10 % among all other classifiers. When all the frequencies are used combined, the accuracy is enhanced by 1-2 %. But, the data is multiplied by five times when all the frequencies are used. This experiment helps to decide which feature to select. If the requirements of the system is accuracy, then all the frequencies must be selected. If the requirement of the system is fast classification using low power, then any individual frequency can be selected.

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