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Songs induced mood recognition system using EEG signals

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KEY WORDS

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ABSTRACT

Background : Brain computer interfacing is a system that acquires and analyzes neural signals to create a communication channel directly between the brain and the computer. The EEG records the electrical fields generated by the nerve cells. With the help of Fourier Transformation the EEG signals are classified into four different frequency bands. Purpose : The main purpose of the present paper is to report results related to classification of EEG signals of different people subjected to different conditions. Methods : The experiment has been done on 10 subjects having activities related to hearing music chosen from categories of patriotic, happy, romantic and sad songs along with relaxation activity. 19 electrodes have been used under (10-20) International Standard. The δ, θ, α and β components of EEG signals to these activities have been determined. Different statistical methods including linear discriminate analysis have been tested for classification. Results: Result of the Linear Discriminant Analysis (LDA) made four groups of all modes (Relaxation, Happy, Sad, Patriotic and Romantic Song) labeled group1, Group2, Group3 and Group4 of all ten electrodes for Delta, Theta, alpha and Beta frequencies. Conclusion: The study may be used for the development of activities induced mood recognition (AIMR) system from the EEG signal.

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Introduction

The Brain computer interfacing (BCI) is a direct communication channel with the external world.[1] BCI is a system that acquires and analyzes neural signals with the goal of creating a communication channel directly between the brain and the computer. The electroencephalogram (EEG) was first recorded by Hans Berger in 1924 by attaching electrodes on human skull. The EEG signals are measured using electrodes placed on the scalps is noninvasive method, which records the electrical fields generated by the nervous cells.[2] With the help of Fourier Transformation, the EEG signals are classified into four different frequency bands: Delta (<4Hz), Theta (4-8 Hz), Alpha (8-12 Hz) and Beta (13-30 Hz). The Alpha rhythms is dominated in a relaxation state of consciousness and eye closed over the occipital cortex. The Beta rhythms is related with active, busy or anxiety and active concentration. The Delta rhythm is often associated with young and underlying lesions. Theta rhythm is associated with drowsiness, childhood, adolescence, and early adulthood.[3]

The various methods have been proposed to BCI in the past decade. These include support vector machine (SVM), Artificial Neural Network (ANN) and Principle Components Analysis (PCA). The PCA method has been used to classify the EEG mental tasks for left hand movement imagination, right hand movement imagination and word generation. PCA technique achieved a linear transformation of a high dimensional data into a lower-dimensional.[4]

In this paper, we propose a method to classify the EEG of mental tasks given to the subject like listening various songs i.e. Happy, Patriotic. Romantic and sad songs along with relaxation. These four mental tasks have classified with the help of Linear Discriminate Analysis (LDA) with the achievement of effect clustering.[5]

Methods

In this study, we have designed EEG dataset containing data of four mental tasks of ten different subjects. All subjects were in the age of 22-24, without any mental history. Subject sleep was conducted on a normal bed, relaxed arms resting on their legs. The electrodes were placed on scalp of the subject as per the International 10-20 standard. The test was conducted for 20 minutes, with eye closed and each subject was asked to perform these tasks. For all modes, the subjects were asked to lie on the bed along with the head phones. The signals were recorded after asking questions and stopped when the subject responded with an answer.[6]

The recording, for each mode, was captured for 5 minutes. The different parameters of the EEG machine were set as follows: lower filter 1Hz, higher filter 70Hz, sensitivity at 7μV, channel 17, sweep speed 30mm/s, Montage set BP PARA (R) for all the experiments. The cleaning the skin surface is recommended for low impedance and optimal recording.[7] Relevant ethical committee approvals were obtained.

Preprocessing

The Fourier Transform was applied on every 2 second of data by the interval of every 1 second of data. The Delta (δ), Theta (θ), Alpha (α) and Beta (β) components have been separated according to their given frequencies for every task. Initially, all

the electrodes have been selected for the experiment depending on their intensity and regions i.e. Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1 and O2, as shown in Figure 1.

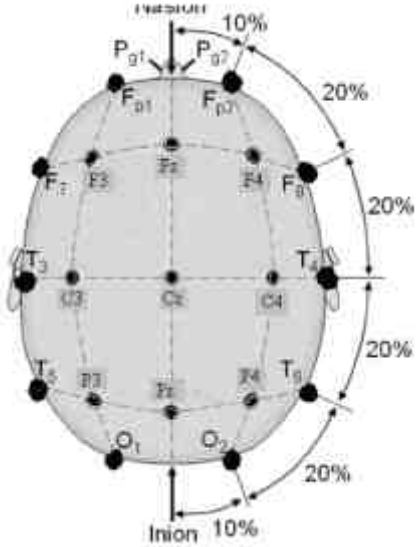

Fig. 1 : The all Nineteen dark Corner Electrodes

The frequency domain data of 5 minutes has been normalized and prepared with four frequency components of the selected electrode as shown in Table 1.

Table 1 Delta, Theta, Alpha and Beta Frequency Components

Time	Delta	Theta	Alpha	Beta
1	1.51	0.85	0.33	0.81
5	2.72	0.58	2.41	0.64
10	4.52	0.57	0.98	0.53
15	2.94	0.58	3.6	0.63
20	4.16	1.75	5.18	1.44
25	10.5	1	2.81	1.13
30	1.49	0.51	1.3	0.36
35	6.15	3.11	6.5	0.72
40	3.16	3.91	4.91	1.05
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
300	3.46	0.77	3	2.84

Results

The matrix dataset was created into different four classes for the entire subject on the bases of different mode for all the different frequency components for training purpose. Feature of the different modes were subjected to the Linear Discriminant Analysis (LDA). The aim of LDA is to use hyperplanes to separate the data representing the different classes. The Linear discriminant function g(x) can be written as equation (1).

$$g(x) = \omega_0 + \sum_{i=1}^{d} \omega_i x_i, \ldots.(1)$$

where the coefficients $\acute{\omega}_i$ are the components of the weight vector w. By involving the products of pairs of components of x the quadratic discriminant function is obtained and written as equation (2).

$$g(x) = \omega_0 + \sum_{i=1}^{d} \omega_i x_i + \sum_{i=1}^{d} \sum_{j=1}^{d} \omega_{ij} x_i x_j \ldots.(2)$$

Since $x_i x_j = x_j x_i$ and $\acute{\omega}_{ij} = \acute{\omega}_{ji}$ with no lose thus, the quadratic descriminant function has an additional d(d+1)/2 coefficients at its disposal with which complicated separating surface.[8]

For the classification and clustering purpose, we have created appropriate different classes of dataset. The four separate classes of dataset has been created according to four different frequency component (Delta, Theta, Alpha and Beta) including all different modes (Relaxation, Happy, Sad, Patriotic and Romantic Song Mode) of all subject as shown in table 2. The Linear Discriminant (Fishers Algorithm) has been implemented on class-within class matrix dataset.[9,10] Result of the LDA are made four groups of all modes (Relaxation, Happy, Sad, Patriotic and Romantic Song) labeled group1, Group2, Group3 and Group4 of all ten electrodes for Delta, Theta, alpha and Beta frequencies, as shown in table 2. The graphical representation of Sensitivity and Clustering of these groups has been shown in the figure 2.

Figure 2, 3, 4 and 5, shows Sensitivity and Clustering of different groups of all Bands for all ten Electrode.

Conclusion

From the results visible in the figures 2, 3, 4 and 5 for a particular subject, all the ten electrodes are more crowded at a particular point is the sensitivity at centre of these groups. More distances among these groups mean more recognition. In figure 2, 3, and

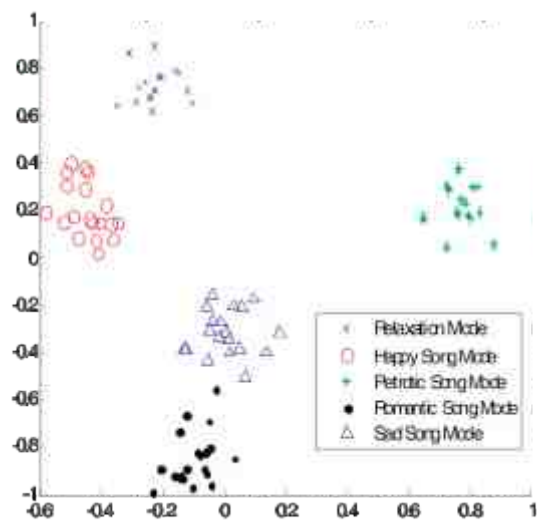

Fig. 2

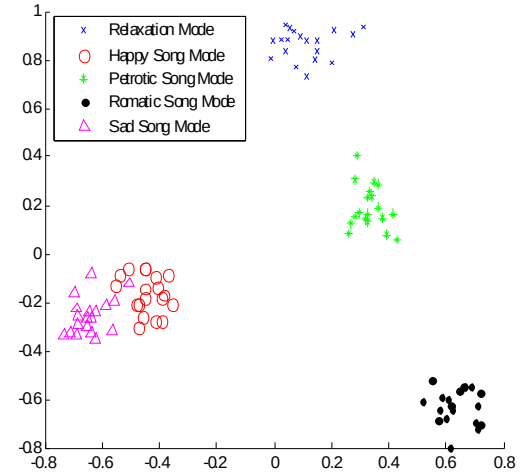

Figure 3

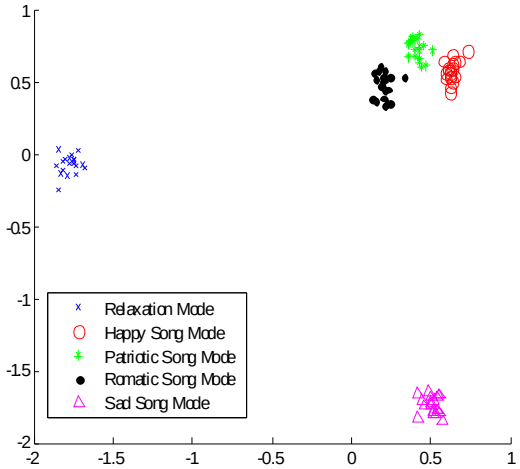

Figure 4

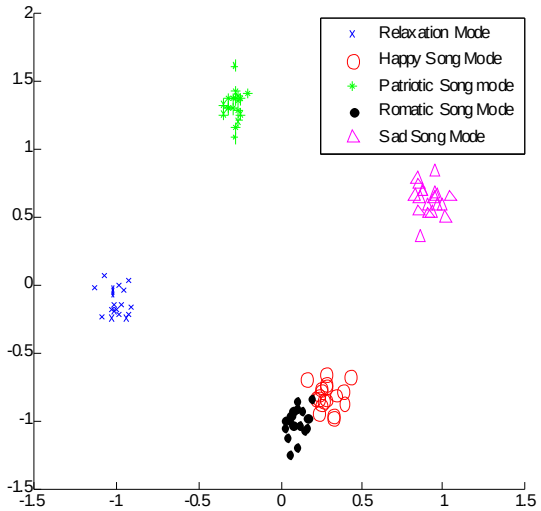

Figure 5

Table 2 : Four Group of Delta component of All Ten Electrodes

Alpha Frequency								
	Group 1		Group 2		Group 3		Group 4	
Electrode	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
Fp1	0.746	-0.022	-0.314	-0.470	-0.192	-0.021	-0.244	0.506
Fp2	0.744	-0.033	-0.307	-0.431	-0.194	-0.008	-0.242	0.517
F7	0.742	0.007	-0.321	-0.415	-0.193	-0.046	-0.237	0.524
F8	0.749	-0.052	-0.309	-0.477	-0.191	-0.078	-0.241	0.496
T3	0.748	-0.021	-0.304	-0.434	-0.197	-0.040	-0.248	0.515
T4	0.751	-0.036	-0.311	-0.421	-0.188	-0.007	-0.245	0.499
T5	0.748	-0.030	-0.315	-0.495	-0.192	0.013	-0.245	0.517
T6	0.750	-0.040	-0.312	-0.501	-0.194	-0.028	-0.244	0.525
O1	0.746	-0.042	-0.308	-0.407	-0.190	-0.076	-0.242	0.509
O2	0.749	-0.024	-0.309	-0.462	-0.202	-0.038	-0.242	0.528

Table 3 : Four Group of Theta component of All Ten Electrodes

Alpha Frequency								
	Group 1		Group 2		Group 3		Group 4	
Electrode	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
Fp1	0.389	0.639	-0.694	0.299	-0.181	-0.614	0.484	-0.342
Fp2	0.388	0.627	-0.700	0.273	-0.176	-0.595	0.487	-0.297
F7	0.392	0.618	-0.699	0.284	-0.177	-0.583	0.487	-0.335
F8	0.388	0.654	-0.698	0.306	-0.176	-0.618	0.480	-0.331
T3	0.391	0.625	-0.694	0.290	-0.178	-0.626	0.482	-0.274
T4	0.395	0.593	-0.697	0.273	-0.178	-0.605	0.488	-0.315
T5	0.390	0.624	-0.697	0.275	-0.176	-0.547	0.489	-0.325
T6	0.387	0.646	-0.696	0.296	-0.177	-0.605	0.484	-0.311
O1	0.389	0.624	-0.691	0.303	-0.180	-0.658	0.482	-0.288
O2	0.394	0.629	-0.707	0.281	-0.179	-0.579	0.483	-0.309

Table 4 : Four Group of Alpha component of All Ten Electrodes

Alpha Frequency								
	Group 1		Group 2		Group 3		Group 4	
Electrode	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
Fp1	-1.548	-0.109	0.765	-0.578	0.430	0.293	0.351	0.370
Fp2	-1.543	-0.132	0.764	-0.544	0.428	0.300	0.365	0.395
F7	-1.546	-0.108	0.761	-0.564	0.430	0.278	0.365	0.381
F8	-1.553	-0.081	0.757	-0.571	0.427	0.285	0.355	0.366
T3	-1.548	-0.100	0.760	-0.571	0.429	0.315	0.349	0.366
T4	-1.540	-0.127	0.766	-0.545	0.429	0.276	0.355	0.377
T5	-1.543	-0.110	0.766	-0.552	0.437	0.296	0.350	0.379
T6	-1.554	-0.106	0.755	-0.563	0.431	0.315	0.349	0.386
O1	-1.548	-0.108	0.754	-0.566	0.423	0.298	0.360	0.387
O2	-1.546	-0.102	0.766	-0.564	0.433	0.273	0.360	0.366

Table 5 : Four Group of Beta component of All Ten Electrodes

Alpha Frequency								
	Group 1		Group 2		Group 3		Group 4	
Electrode	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis	X-axis	Y-axis
Fp1	-0.263	0.203	-0.168	0.144	-0.153	-0.385	0.584	0.020
Fp2	-0.262	0.233	-0.167	0.140	-0.154	-0.386	0.584	0.037
F7	-0.264	0.199	-0.168	0.151	-0.153	-0.364	0.586	0.041
F8	-0.263	0.171	-0.171	0.140	-0.153	-0.360	0.585	0.032
T3	-0.263	0.227	-0.168	0.127	-0.152	-0.391	0.585	0.015
T4	-0.263	0.200	-0.168	0.147	-0.153	-0.425	0.583	0.049
T5	-0.262	0.194	-0.168	0.148	-0.154	-0.329	0.585	-0.018
T6	-0.263	0.218	-0.168	0.122	-0.153	-0.333	0.585	0.044
O1	-0.263	0.184	-0.168	0.124	-0.152	-0.370	0.585	0.078
O2	-0.263	0.204	-0.169	0.140	-0.154	-0.406	0.584	0.034

4 Relaxation mode is clearly recognized compare to Happy, Sad, Patriotic and Romantic Song Mode.

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