

Mental State Recognition by using Brain Waves

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Abstract

Mental State classification plays vital role in communication between human and computer. It can be classified by brain waves. Brain signals recording methods along scalp are invasive and non-invasive. The advanced common method is non-invasive. The 10-10 and 10-20 electrodes system standards are used in the non-invasive method. It is aimed to find Mental State of a sample by using EEG signals. In this work EEG sample are collected from the DEAP database. 30 preprocessed EEG signals from DEAP data sets are worked to get different frequency band by Welch method. Power spectral density in alpha and beta band is tabulated. The valence arousal points from the pre-processed data is obtained from the matlab files. Four mental states are classified as four quadrants of graph. 30 participants are classified into four mental states namely happy, stressed, depressed and relaxed in MATLAB. As result four mental states are classified as four quadrants of graph.

Keywords: BCI, EEG, MS, MS PSD

1. Introduction

Mental State (MS) is an important aspect of the human life, a mental condition in which the qualities of a state are relatively constant even though the state itself may be dynamic. We experience different kinds of states in our day to day life. It is very difficult to define MS. MS can raise some of the feelings of arousal, Valence, displeasure and pleasure. Physiological EEG signals are developed due to the cause of MS. As we all are aware that the MS can be expressed in non-verbally or in the verbal form. And as a result it can express them through the different movements and actions. MS is the result of human feelings. It reflects human behaviour. Sometimes mood and MS are considered as two faces of a single coin.

MS is a Psycho-physiological process which is associated with the temperature, mood and personality. Daily works are dependent on MS. Emotions are parts of our mind. The response from the mind can produce the physiological alterations. Emotions are produced when a person is active. Some people are able to express their emotions and some people who are mastered over

emotions they can be able to control the expressing emotions. There are different kinds of emotions that humans are able to feel like joy, sad, neutral, fear, surprise, calm, alert, disgust, depress, stress and many others.

Electroencephalography is the important method used to read the brain signals. Brain signals are generated due to the variations in the voltages caused due to the electrical process by the neurons during the information flow; activities of neurons that send some signals in the brain are measured by means of EEG where it is the instrumental measure of electrical activity in terms of different voltage levels. There are categories of EEG in which a recorded signal's amplitude and frequency level lies in different bands. EEG is the important and useful tool for the classification and prediction of MS. True MS can be observed using the brain waves. Available methods for the recording of EEG signals are invasive and non-invasive methods. The non-invasive method is widely used. The two standards 10-10 and 10-20 electrodes system are available for in the non-invasive category¹.

MS classification is very necessary for the Brain Computer Interaction (BCI) and to set a bridge between

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the computers or robots with the actual felt emotions of a person who is communicating with them. In order to study emotion recognition research process is ongoing with the intention to provide human computer interaction. These emotion recognition and classification have a wide range of applications in the fields of Gaming, E-learning, entertainment, human like interaction, healthcare and universal access. For example consider MS based entertainment is like when the MS of a person changes as if he is happy the system needs to play the songs according to his mood as happy songs.

Expansion of DEAP refers to the standard databases for the recognition and the analyzing of emotions using recorded EEG and physiological signals. To construct DEAP non-invasive method is used.

The signals are recorded using standard 10-20 EEG recording method. Geometrical placement positions of electrodes upon the skull will in 10 to 20 %, using 32 electrode values and the recording took place at 512 Hz. Signals are recorded by eliciting the total of 32 participants emotions with the videos where the video selection are done with the online ratings. Total of 40 different videos which are watched by subjects and the response which are developed during experiment are recoded using EEG².

This project aims at providing a better classification of the different emotions obtained from EEG signals. Here the music videos induce a high level of emotions in an individual to analyze the particular intended emotion felt by a person during the experiment. Since the detection of emotion have more number of applications in a system like lie detection, police interrogation and other systems. The system uses more number of participants and during the experiment brain signals are collected. After the experiment the individuals rating per each video are collected to get the true emotions³. EEG samples are collected from a standard database, which are using standard electrode systems to collect the EEG data, pre-processed signal and the ratings from the patients are classified into different emotions using MATLAB.

Emotion recognition is a challenging job of human-computer interface. Emotion recognition from speech has a problem with the quality of the input voice, which is difficult to ensure in the mobile environment. Facial emotion recognition is one of the interesting subjects due to the relevance of the expressions on human emotions⁴.

Literatures shows Cognitive function is related with mental health like as depression. Healthcare provides community health nurses should consider mental health to maintain cognitive function⁵.

2. Scope of the Work

MS is the most vital feature in humans. Robots and computers do not have a tendency to interact or communicate with human beings in a natural form. Human Computer Interaction (HCI) empowers computer to understand human emotions. Examples of MS are bored, tired, sleepy, hungry, excited, afraid, embarrassed and happy. MS is defined as bio-psycho-social reactions and transient particularly designed to aid individuals to adopt and copy the events which have implication for survival. There are four types of basic MSs Self conscious states, positive states, pro-social states and moral states. Basic MSs have unique characteristics which differentiate them from each other.

In this work we are classifying the processed signals which are obtained from the .matlab labels as in four quadrants with respect to x axis valence and y axis arousal as shown in Figure 1. The labels array is consisting of four different ratings of subjects related to 40 videos in a matrix of 40 rows with 4 columns; we are extracting only the 2 columns one as valence and other column arousal. The emotions are classified based on these two values with respect to threshold as selected to the middle of 1 to 9 that is 5.

MSs are classified as Happy when there is an alpha wave have more power and it is find when the person is in active condition and is classified in the first quadrant. Stressed feeling like he is overloaded with MSs, temperature of the finger tip results to cold or little less temperature then the individual's emotion will be stressed it is classified under second quadrant, Depressed third quadrant where in valence values and arousal values fall under the 1 to 5 and 5 to 9 respectively. Relaxed - is the MS when a person is calm; under last quadrant as shown in Figure 1.

By analyzing some literature it is understood that very less works classified MSs with poor classification rate and there was no simple classification. So module is designed to contribute classify MS and to get a graph which divides quadrant as different emotions.

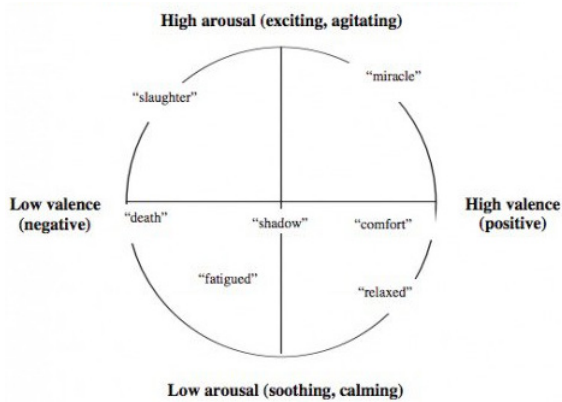


Figure 1. Valence arousal plot.

3. Proposed MS Module

The proposed MS module of the work is as shown in the Figure 2. EEG signals are obtained from the standard DEAP database labels from the pre-processed signals are obtained and features are extracted using MATLAB, classification into 4 MSs is done from the tools of the MATLAB.

Standard EEG database signals are used to classify the different emotions, obtained the brain waves from the Database for Emotion recognition using Physiological signals. 32 individuals participated in this experiment and watched the 40 music videos, the recording of their EEG waves are done with 10-20 electrode system, in Geneva order. Data was recorded at 512 Hz.

Obtained original signal was down sampled to 256 Hz, referenced and kinds of tangible signals from movement of eye are removed and the signal is passed through the filter having band pass filter with 4 to 45 Hz, averaging the signal it is segmented into different time sections. Feature extracted from the EEG signal for the new vectors formation. Classification is done in MATLAB to get 4 quadrants in the graph.

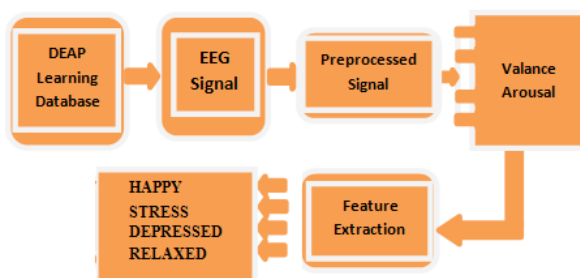


Figure 2. Block diagram of the proposed MS module.

4. Results and Discussion

The EEG samples are collected from the DEAP are the recorded brain signals from the standard 10-20 electrode system which consists of 32 electrode data. 32 data are processed as collected 32 electrode data of a person for a single trial of one video which is in the ".bdf" format.

Database collected from DEAP is a raw data collected at 512 Hz. The F3 and F4 electrode value is extracted. In order to make easier processing of signal the raw EEG is converted to ASCII by using EDF browser tool Conversion process of raw data to ASCII. Raw data is loaded into EDF (European Data Format) Browser. And the RAW data is converted to (.edf) format. Converted EEG signal is opened in the EDF browser is reduced to 256 Hz sampling rate and timing as per the requirement and saved. Reduced signal is exported to ASCII using Export option present in tool. Features are extracted for alpha and beta EEG bands. The feature involves the Power Spectral Density (PSD) in alpha and beta band which are tabulated for each electrode in the Table 1 to Table 4. Valence values beta/alpha ratios are tabulated in Table 5.

In order to classify brain signals in to different MSs pre-processed data from the DEAP database (.mat files); From 32 participants file s01 to s32 the array Labels are extracted. Each labels array is loaded to MATLAB and only the valence and arousal values of all videos are extracted. Each participant valence and arousal values for the 40 videos are taken for the further calculations. Average valence and arousal values are calculated using matlab program and the average valence and arousal for each video and of 32 participants are tabulated in the Table 6.

In the first column is the trial number, average valence and arousal values of each participants forms the 2nd and 3rd column. 4 MSs are classified into four emotions as Happy, Depressed, Stress and Relaxed in the 4 column. We are classifying the MSs in 4 different quadrants as referred to the high/low, valence and arousal values for each video. The numbering followed here for the 4 quadrants are Happy is 1; Stress is 2, Depressed is 3; Relaxed is 4. The classified signals based on valence and arousal is plotted in the quadrants as shown in Figure 3.

Table 1. F3 Electrode beta band PSD

Trial Number	Mean Beta	Standard Deviation Beta
1	-1.0818	0.215541
2	-0.962609	0.203075
3	-1.109129	0.329040
4	-0.930037	0.160974
5	-1.078241	0.258107
6	-0.949132	0.266325
7	-0.975113	0.151935
8	-0.966509	0.245141
9	-0.970672	0.222179
10	-1.032105	0.140689

Table 2. F3 electrode alpha band PSD

Trial Number	Mean Alpha	Standard Deviation Alpha
1	-1.441601	0.316134
2	-1.995175	0.263516
3	-1.792109	0.370911
4	-1.723963	0.244883
5	-1.632859	0.330670
6	-1.649923	0.368634
7	-1.554600	0.272380
8	-1.731385	0.301669
9	-1.425004	0.317584
10	-1.581160	0.276986

Table 3. F4 electrode beta band PSD

Trial Number	Mean Beta	Standard Deviation Beta
1	-1.173890	0.166155
2	-1.173890	0.166155
3	-1.370794	0.567870
4	-1.023541	0.239334
5	-1.226500	0.219559
6	-1.080626	0.214103
7	-1.069807	0.198280
8	-1.087179	0.215838
9	-1.146924	0.230687
10	-1.526138	0.297779

Table 4. F4 electrode alpha band PSD

Trial Number	Mean Alpha	Standard Deviation Alpha
1	-1.689911	0.285525
2	-1.689911	0.285525
3	-1.642859	0.470956
4	-1.597777	0.288042
5	-1.541213	0.380821
6	-1.541374	0.297488
7	-1.606267	0.352927
8	-1.631611	0.335608
9	-1.446184	0.307063
10	-1.645367	0.339245

Table 5. Valence values beta/alpha ratio

Trial No. (video)	F4 Mean Beta PSD/Mean Alpha PSD(Valence)	F3 Mean Beta PSD/ Mean Alpha PSD (Valence)
1	0.6946	0.7504
2	0.6943	0.4825
3	0.8344	0.6189
4	0.6406	0.5395
5	0.7958	0.6603
6	0.7011	0.5753
7	0.6666	0.6272
8	0.6663	0.5582
9	0.7931	0.6812
10	0.9275	0.6528

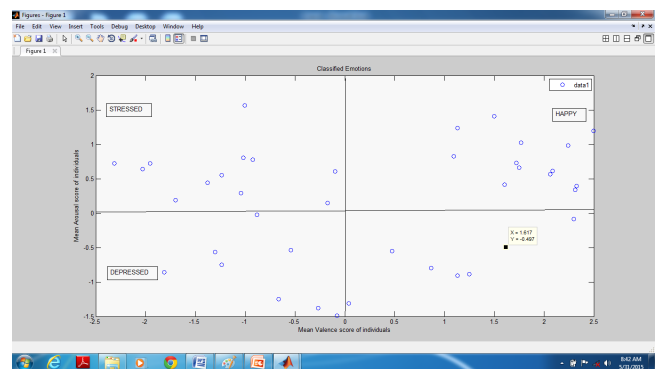
**Figure 3.** Valence arousal plot.

Table 6. Average valence arousal

Trial No	Mean Valence	Mean Arousal	Emotions
1	1.7230	0.7280	1
2	1.5010	1.4097	1
3	2.4983	1.1920	1
4	1.7710	1.0233	1
5	1.1307	1.2367	1
6	1.7507	0.6593	1
7	1.0947	0.8227	1
8	2.0610	0.5660	1
9	2.2440	0.9837	1
10	-0.0970	0.6067	2
11	2.3257	0.3970	1
12	1.2507	-0.8890	4
13	1.6170	-0.4970	4
14	2.3143	0.3413	1
15	1.1307	-0.9053	4
16	0.0380	-1.3117	4
17	0.8670	-0.7990	4
18	2.2990	-0.0823	4
19	2.0883	0.6157	1
20	1.6050	0.4173	1
21	-1.2380	-0.7483	3
22	-0.2670	-1.3820	3
23	-1.8147	-0.8600	3
24	-0.8803	-0.0237	3
25	-0.5400	-0.5410	3
26	-0.0803	-1.4920	3
27	0.4757	-0.5533	4
28	-0.6627	-1.2533	3
29	-1.3020	-0.5617	3
30	-1.6967	0.1867	2
31	-1.2343	0.5533	2
32	-1.0047	1.5673	2
33	-1.0407	0.2907	2
34	-0.9253	0.7803	2
35	-1.9563	0.7240	2
36	-1.0197	0.8030	2
37	-2.0277	0.6420	2
38	-2.3117	0.7213	2
39	-1.3797	0.4413	2
40	-0.1737	0.1440	2

5. Conclusion

In this work we obtained the brain waves from the DEAP database, original signal of one participant is pre-processed and] reduced the sampling rate. Electrodes F3 and F4 values power spectral density in alpha and beta band is calculated. The valence arousal values from the pre-processed data is obtained from the matfiles of DEAP, mean value for each video of all participants are classified into different mental states in a 4 quadrant as happy, stressed, depressed and relaxed.

6. Future Scope

In future based on mental states mobile/computer games can be validated and emotional quotient may be generated. Different mental states may be used to automate applications.

7. References

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