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# Emotion Recognition using Electroencephalography (EEG) Images

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***Abstract*—** In this paper we propose a recognition system to recognize the emotions of a subject on the bases of Electroencephalography (EEG) Images. The study was performed using the data from 10 volunteers experiencing two emotional states happy and sad, while exposed to audio-visual stimuli. The main objective of the study was to extract the emotion indices from EEG images. With the help of emotion indices the happy and sad state of mind were classified. The average values of active electrodes in selected regions were calculated. The obtained result can further be used to monitor the emotions.

***Keywords*—**Electroencephalography (EEG) images; EEG; color-code; Emotion Recognition

## I. INTRODUCTION

Emotion is a mental state that arises spontaneously rather than through conscious effort and is often accompanied by physiological changes: a feeling, the emotions of joy, sorrow, reverence, hate, and love. It plays an important role for communication between people. Emotion recognition using Electroencephalography (EEG) images is a new concept in which we can recognize the emotions of a subject. In psychology, an explicit separation is made between the physiological arousal, the behavioral expression (affect), and the conscious experience of an emotion (feeling).

### *A. Electroencephalography:*

Electroencephalography is the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. It is most often used to diagnose epilepsy, which causes obvious abnormalities in EEG readings. It is also used to diagnose coma, sleep disorders and many more. In figure 1 four different brain waves are described. The Delta (δ) wave ranges from 0 to 4 Hz is found during some continues- attention tasks, Theta (Θ) wave ranges from 4 to 8 Hz and is dominated in drowsiness or arousal in older children and adults, Alpha (α) wave ranges from 8 to 12 Hz and found during relaxed state, Beta (β) wave ranges from 12 to 16 Hz and found in alert/working, active, busy or anxious thinking, active concentration [1]. The standardized placement of scalp electrodes for a classical EEG recording has become common since the use of 10/20 system. The essence of this system is the distance in percentages of the 10/20 range between Nasion/Inion. These points are marked as the Pre-frontal (Fp), Central(C), Parietal (P), Occipital (O), Temporal (T). The midline electrodes are marked with a subscript z, which stands for zero. The odd numbers are used as subscript for points over the left hemisphere, and even numbers over the right which are seen in figure 2 [2].

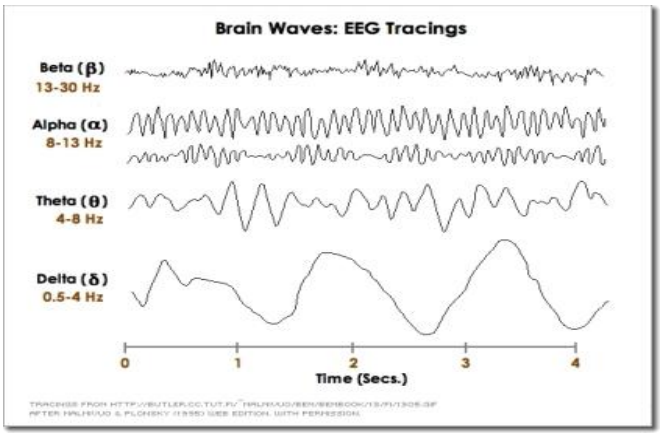


Figure. 1. Brain waves

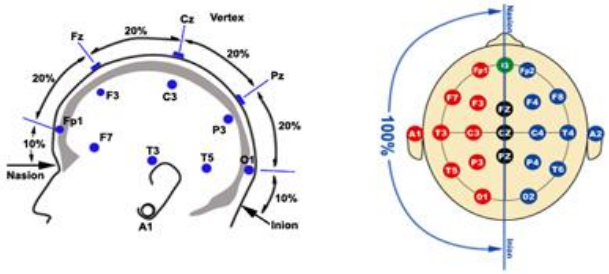


Figure. 2. International 10/20 system

### *B. Emotion Recognition:*

Emotion recognition mainly involves emotional perception of different stimuli like audio and visual. The study of automatic emotion recognition of humans has became an important aspect in behavioral science, medicine etc. called the affection computation, where commonly accepted emotions include happy, sad, fear, anger, surprise, disgust [3]. The 2- dimensional model of emotions are rSASM and 12-PAC model which were proposed using EEG data and was acquired from some preschools students by showing them some emotional faces using the Radboud Faces Database (RafD). Features were extracted from KSDE and MFCC and classified using Multi-layer Perceptron (MLP)[4]. The emotion understanding system based on brain activity and ‘‘GIST’’ to categorize emotions reflected by natural scenes was studied in which emotion recognition

was distinguished between positive emotions and negative emotions of the subject. GIST was used to build the global low-level feature vector to represent a scene image were as techniques such as PCA and SVM were also used for classifications purpose[5].


Figure. 3. Arousal – Valence Model

The Arousal-Valence model in figure 3; shows the emotional indicators in which the positive emotions are seen towards the right and negative emotions are at the left side. The general indication of the positions of certain emotions is based on the emotion indicators used in FeelTrace seen in figure [6].

### *C. EEG images:*

The technique of EEG brain map gives a snapshot of what is going on in brain. There are various brain mapping techniques including –fMRI, PET scans, EEG images. An EEG brain map helps to identify where the brain has specific problems [7]. According to the literature study, the emotion indicators of the subject are calculated using a relative power of the electrode. The relative power of alpha wave is seen to be more prominent in happy emotions in C4 and is mathematical represented as:

$$\text{Happy} = \frac{1}{\text{Relative Power of alpha wave of C4}}$$

It is observed that when the subject is happy the frame of mind changes, where the right part of the brain is seen more prominent. As the subject is going through audio-visual stimuli the Pre-Frontal, right Temporal and Occipital regions are seen more prominent.

It is perceived that the emotion indicators of sad mental state are seen in left part of the brain. According to the literature, it was found that the relative power of alpha wave for some particular electrodes are dominant. The sad indices can be calculated by relative power of alpha wave of T3 and T5. The indicators which are observed in sad state are seen in left temporal, occipital and Pre-Frontal regions of the brain, the mathematical expression for calculating sad indices is represented as:

$$\text{Sad} = \frac{1}{\text{Relative Power of alpha wave of T3} * \text{Relative power of alpha wave of T5}}$$

The active region of the brain images were collected for all subjects. The threshold limit of brain images collected was taken up to 4 sec, first four color-code sequence were studied as it holds the highest activity in the brain [8].

Relative power value is used in EEG signal data analysis method to obtain values. The relative power contribution ratio at each frequency band was calculated from the digitized EEG [9].

We have investigated alpha wave in both happy and sad indices to obtain correct values. Information, feelings, creativity, memories, which are deep down in one's mind, cannot become conscious if there is no bridge (no alpha waves), between the two states of mind [10].

The paper is divided into three sections; section II describes the methodology, Experimental Analysis & Results are presented in section III, section IV includes the conclusion.

## II. METHODOLOGY

### *A. Experimental Setup:*

RMS EEG 32 channel data monitoring equipment was used to acquire the signals. There are 19 electrodes which are placed on the scalp with the help of gel, using the international 10-20 system [11]. The software called "Acquire" is used to collect the data, and the "Analysis" software is used to analyze the whole data in different forms. The machine also provides Brain mapping color coding as per international standard.

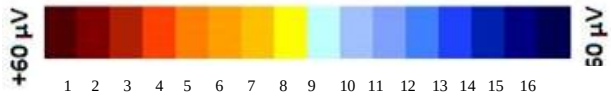


Figure. 4. Color-code of EEG images

The software provides default 2 sec data which is used for analysis, figure 4 describes color-code. The activity in color code ranges from +60µV to -60µV.Thus the +60µV represent intense activity, were as -60µV indistinct lesser activity. There are in all 16 color shades in the color-code from 1 to 16 i.e. the first color shade consist of highest activity so we have considered first 4 color shades to analysis the emotion activity in brain.

In the first stage the participants have gone through Emotional Intelligence Inventory (EII) Test by which we were able to select the subject more easily. For experimental purpose 10 volunteers with profound emotion, no physical or mental disorders were selected.

### *B. Experimental Procedure:*

The audio-visual stimulus was provided to the volunteers to evoke happy and sad emotional state .The presentation shown to the subjects included 10 images related to happy state , the pictures includes smiling babies, close friends, red roses, known images of children's etc, which changes the frame set of mind in happy state whereas sad images of old people, poor children, physically handicap people etc, were displayed to subject in sad state, the duration of each image shown was about 10 seconds.

The happy videos of Charlie Chaplin, small baby playing with toy were shown, whereas for sad videos a person getting accident under the train and an emotionally thoughtful video of Swami Vivekananda was shown to the subjects, each video was of about the duration of 3 to 5 minutes.

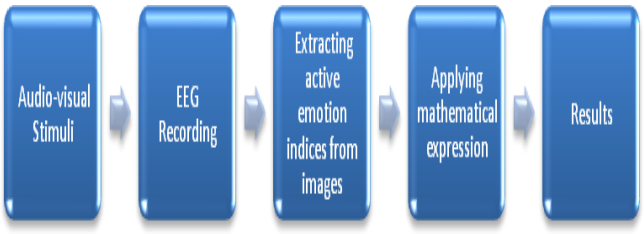


Figure. 5. Flowchart for Emotion Indices

The subject was provided the audio-visual stimuli while experiment was performed. The extraction of images was done for calculating emotion indices of the subject; applying mathematical expression on extracted values the results were elaborated, figure 5 shows the flowchart for emotion indices

In figure 6 shows the flowchart for experiment, the audio-visual stimuli was provided to all 10 volunteers while EEG recording were taken. After the EEG recordings, the active regions were selected from the images which were considered, and on those bases the electrodes were sorted. The results were elaborated according to the time in which the activity is seen, we have exhibit the data of 4 subjects and in the same way the graph are shown in which the active electrodes are calculated which are seen in figures from figure 8 to figure 15.


Figure. 6. Workflow for the extraction of active regions from EEG Images

## III. EXPERIMENTAL ANALYSIS AND RESULTS

The calculation were performed using the analysis software which provides the relative power value of about 2 sec, considering the same we have analyzed the results as below in Table I and II.

Table I: Emotion Indices For Happy State

| | **Happy PPT** | | **Happy Video** | |
|---|---|---|---|---|
| | ***Time (in sec)*** | ***Result*** | ***Time (in sec)*** | ***Result*** |
| Subject 1 | 1:37 | 0.83 | 18:49 | 1.42 |
| | 2:03 | 0.45 | 18:57 | 2 |
| | 2:55 | 10 | 19:04 | 5 |
| | 2:57 | 1.6 | 19:15 | 10 |
| Subject 2 | 4:00 | 1.4 | 24:48 | 10 |
| | 4:21 | 1.6 | 25:31 | 5 |
| | 5:19 | 2 | 27:43 | 2 |
| | 6:48 | 2.5 | 28:29 | 5 |
| Subject 3 | 3:26 | 10 | 24:48 | 10 |
| | 3:40 | 5 | 25:31 | 5 |
| | 3:42 | 2.5 | 27:43 | 2 |
| | 4:07 | 10 | 28:29 | 5 |
| Subject 4 | 1:24 | 10 | 8:52 | 10 |
| | 1:29 | 10 | 9:03 | 10 |
| | 1:36 | 10 | 9:25 | 5 |
| | 1:45 | 5 | 9:26 | 5 |

Table 2: Emotion Indices For Sad State

| | **Sad PPT** | | **Sad Video** | |
|---|---|---|---|---|
| | ***Time (in sec)*** | ***Result*** | ***Time (in sec)*** | ***Result*** |
| Subject 1 | 6:39 | 100 | 25:35 | 100 |
| | 6:41 | 50 | 26:27 | 25 |
| | 6:45 | 50 | 26:28 | 100 |
| | 6:46 | 11.1 | 26:29 | 100 |
| Subject 2 | 10:25 | 8.3 | 30:20 | 25 |
| | 12:28 | 3.3 | 30:21 | 16.6 |
| | 12:33 | 50 | 30:25 | 3.33 |
| | 12:36 | 100 | 30:50 | 1.78 |
| Subject 3 | 6:55 | 100 | 28:10 | 5 |
| | 7:56 | 25 | 28:13 | 100 |
| | 8:35 | 25 | 28:16 | 25 |
| | 8:41 | 100 | 28:19 | 25 |
| Subject 4 | 2:58 | 100 | 14:03 | 25 |
| | 3:00 | 0.76 | 14:09 | 25 |
| | 3:38 | 100 | 14:10 | 4 |
| | 4:17 | 3.3 | 14:36 | 100 |

The time considered in the table I and II is according to the activity seen in the brain during the time of reading. We have calculated the active electrodes of all 10 subjects. During comparative study of happy ppt and happy video, we have observed that when the subject goes through happy ppt the activity is seen in prefrontal and occipital region and on the other hand in happy video the prefrontal, occipital and right temporal regions are more prominent. The statistical analysis of happy state of mind is seen in table I. We have distinguished that more activity is seen in happy videos rather than happy ppt. In the same way when we switch to Table II, in the sad state it is observed that for ppt the prefrontal and occipital region are dominating and for videos the prefrontal, occipital and left temporal regions are seen to be dominating.

As the subject is going through audio-visual stimuli the Pre-Frontal, right Temporal and Occipital regions are seen more prominent in happy mental state as seen in figure 7, and the prefrontal, left temporal and occipital region are seen dominating in figure 8 as shown below:

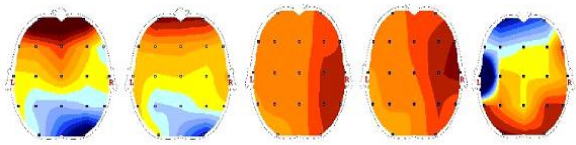

Figure. 7. Example of Happy EEG Images

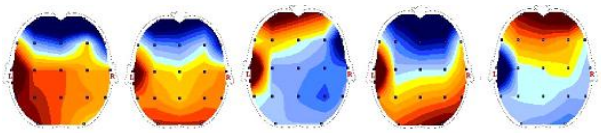

Figure. 8. Example of Sad EEG Images

Figure 9 to 15 represents the graphical representation average percentage of active regions for ppt and videos for subject 1 to subject 4 respectively. The active thinking is prominently seen in sad emotions for ppt as well as for videos.

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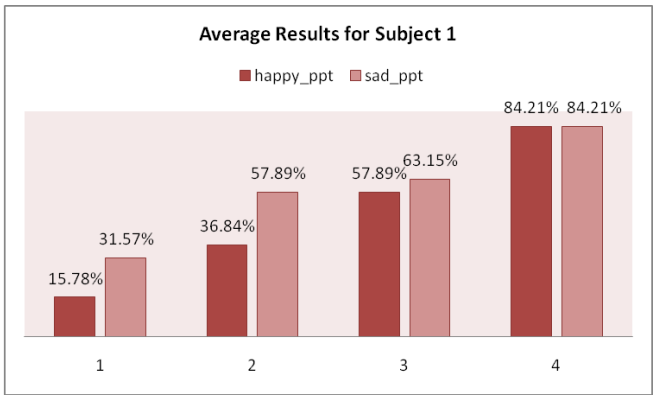


Figure. 9. Average percentage value of active region for happy & sad ppt of subject 1

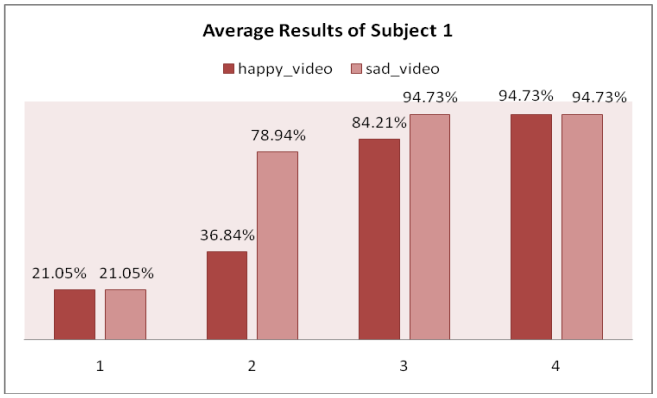


Figure. 9. Average percentage value of active region for happy & sad video of subject 1

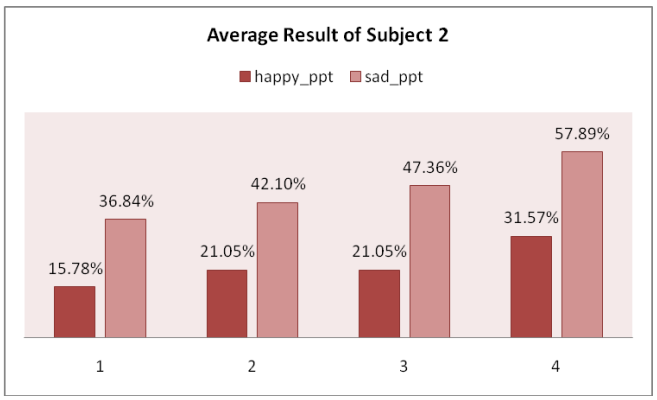


Figure. 10. Average percentage value of active region for happy & sad ppt of subject 2

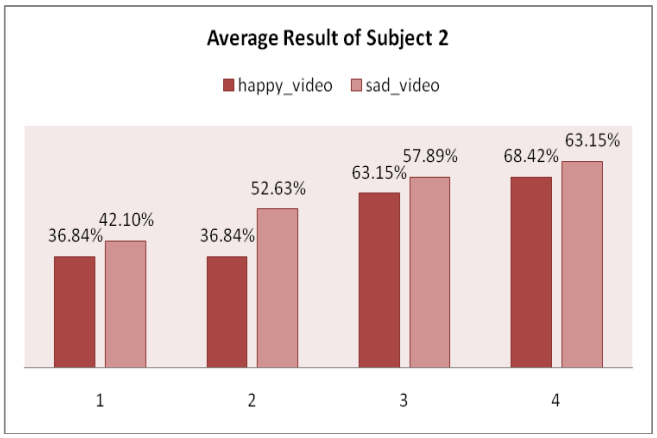


Figure. 11. Average percentage value of active region for happy & sad video of subject 2

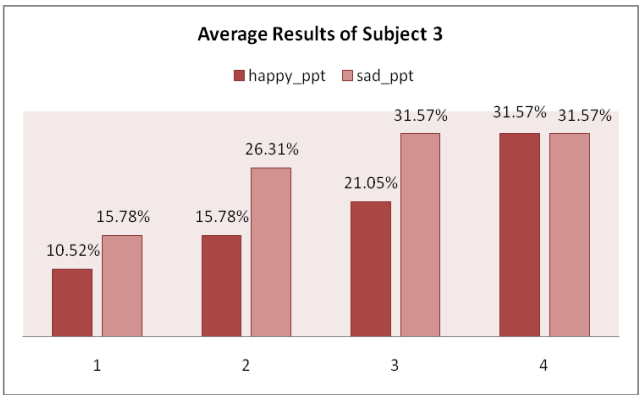


Figure. 12. Average percentage value of active region for happy & sad ppt of subject 3

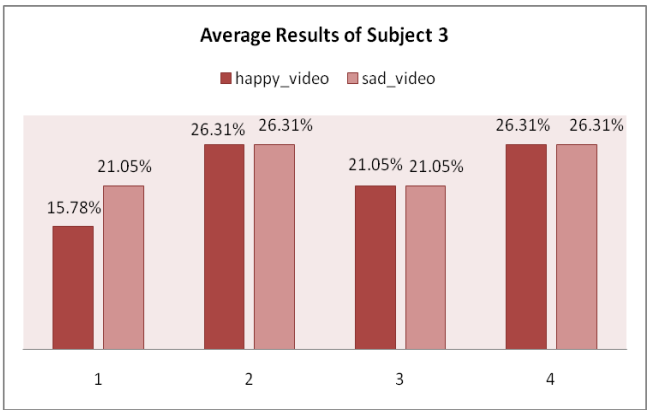


Figure. 13. Average percentage value of active region for happy & sad video of subject 3

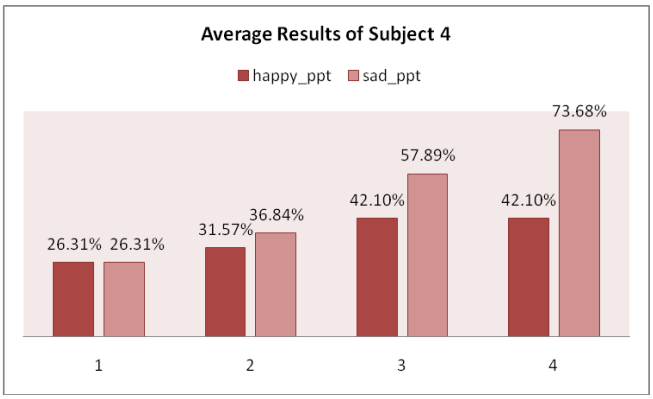


Figure. 14. Average percentage value of active region for happy & sad ppt of subject 4

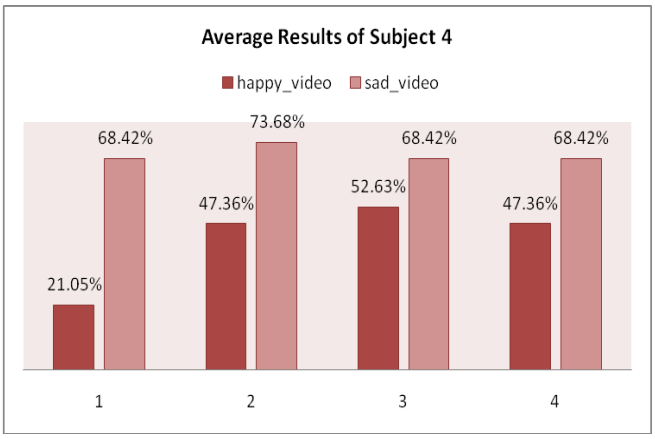


Figure. 15. Average percentage value of active region for happy & sad video of subject 4

## IV. CONCLUSION

This paper represents Emotion recognition of a subject through EEG Images; following observation was seen after the experiment:

a) The relative power is found to be less in happy and sad states for ppt and more for happy and sad videos.
b) The active regions are more prominent when subjects were exposed to video then ppt.
c) It is observed that in happy state the prefrontal,occipital and right temporal regions were prominent, and in sad state it is observed that the prefrontal, occipital,left temporal regions were seen to be dominating.

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