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AFFECTIVE E-LEARNING USING EMOTION DETECTION

Neha G. Prabhu [1], Neha S. Singh [2], Shweta V. Singh [3], Professor Nilima Patil [4]
Department of Computer Engineering
K.C. College of Engineering Management Studies & Research
Thane, India
[1]nehagprabhu1@gmail.com
[2] singhnehasp@gmail.com
[3]singhshweta758@gmail.com
[4]nilima.patil7@gmail.com

***Abstract*— Emotions are intrinsic to the way humans are interacting with each other. A human being can understand the emotions of another human being to a certain extent and behave in the best manner to improve the communication in a certain situation however a machine cannot. To understand one another's emotions and act accordingly is what affection is. This paper aims to make a normal e-learning system affective to human emotions. Certainly this paper deals with the detection of emotions using EEG signals and based on the emotion detected, learning process will take place. In this project an Electro-Encephalogram (EEG) headset will be used to record the brain signals of an individual by analyzing his/her brain state and to detect his/her emotions using algorithms and database. Using EEG-based emotion recognition, the computer can literally observe the user's mental state. As a result, this will help to improve user's learning experience. To get good learning outcomes and to engage learners in the learning process are the main objectives of this paper. This kind of e-learning system using wearable natural user interfaces will have widespread potential applications in future smart environments.**

***Index Terms*— E-Learning; Correntropy Spectral Density; Auto-regressive model; Emotion Detection**

I. INTRODUCTION

E-learning consists of instructional methods which are designed to build knowledge and skills related to individual or organizational goals. The e-learning is the paradigm shift in education and training, that is in progress [1]. Thus, there has been noticeable rise in e-learning systems to enable people to learning anytime and anywhere. It enables people to deliver content and methods that build new knowledge and skills or to improve performance. In e-learning systems, emotions are important to foster positivity among students [2]. The education using emotional analysis can help students to form a right attitude thus creating an incentive, and an interest in learning [2].

Emotion is important in education—it drives attention, which in turn drives learning and memory. For these reasons, it is important to create a positive classroom environment to provide for optimal learning. The unique melding of the biology and psychology of emotion promises to suggest powerful educational applications [3]. Learning how to manage feelings and relationships constitutes a kind of "emotional intelligence" that enables people to be successful. Goleman has mentioned in the book, Emotional Intelligence, that expert teachers are those who can recognize a student's emotional state and adopt a teaching pattern accordingly thus making positive an impact on the student's learning process [4].

The Electro-Encephalogram is a biosensor which is a receptor-transducer device, that provides both selective quantitative and semi-quantitative analytical information using EEG signals [1]. We used this Electro-Encephalogram for measurement of emotion of learner. The focus of this paper is to design learning environment enhances study and avoids states such as boredom, anxious, anger etc.

II. THEORETICAL FRAMEWORK AND PREVIOUS STUDIES

E-learning had become a learner centered, personalized learning technology. There were only a few exploratory reports about emotions associated with e-learning. The past research has only been focusing on the traditional class room face to face learning [1]. In the past e-learning has been depicted as less emotional and lacking the psychological factor as compared to face-to-face learning. However, now the things relating to cognition in learning process have been reiterated using the already established theories on human emotions [2].

Robert Plutchik's psycho-evolutionary theory of emotion is one of the basic most influential classification approaches for general emotional responses. He considered there to be eight primary emotions—anger, fear, sadness, disgust, surprise, anticipation, trust, and joy [4].

In Russell's Circumplex model unlike Plutchik's model emotions were not clustered along the axes but were arranged in a circular pattern around the dimensions. The Circumplex model invented by Russell in 1979-80, has shown the way in which emotions are affected during the learning process [1].

III. The Proposed System

We have proposed a system to detect human emotions using EEG headset and the using those emotions to enhance the learning process with the e-learning software for computer engineering syllabus to make user get acquainted with the best study materials as per his/her mood. The paper focusses on designing e-learning system for computer undergraduate students. The project is divided into three broad sections:

1. 1.First section deals with interfacing EEG with software for real time detection of emotion signals.
2. The second section focuses on the design and maintenance of the database using which we can match the frequency of brain signals to detect emotions efficiently. Also we need to maintain a database to keep a track of subjects, allotted hours and so on for the E-learning software. The algorithms used will be Correntropy Spectral Density and Auto-Regression.
3. The third section deals with the design of E-learning software. We want to make E-learning software that works on emotion detection such that the system detects emotion of the user (learner) continuously and adapts according to it.

For signal acquisition the user wears the headset i.e. NeuroSky MindWave Mobile. It uses Bluetooth for interfacing. After the EEG headset is interfaced with PC, the signals are acquired using MATLAB. The signals related to certain emotions are obtained as samples. They are stored to form the emotion database.

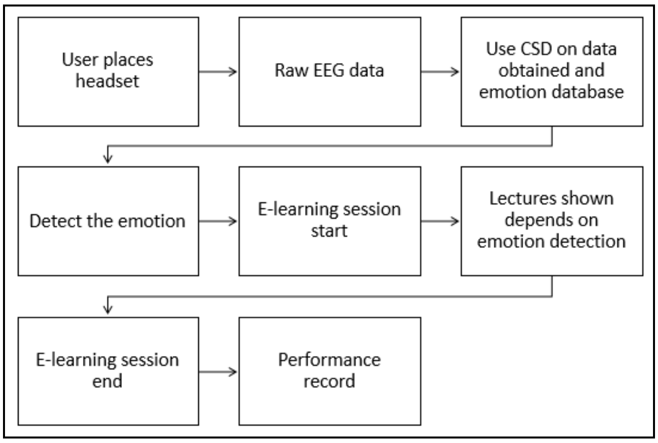

Fig. 1. Block Diagram of Proposed System

TABLE 1. Emotions considered for the project

Sr. No.	Emotion Type	Meaning
1.	Happy or Excited	Positive – Excited
2.	Concentrated or Focussed	Positive – Calm
3.	Confused or Worried	Negative – Excited
4.	Sleepy	Negative – Calm
5.	Anger	Frustration

During the e-learning using emotion detection, the EEG signals are obtained from users in real time. The Correntropy Spectral Density is performed on the signal obtained and each and every sample of emotion database. The emotion to which the signal obtained matches, the current emotion of user is detected. All this comes under signal processing unit. After the emotion detection e-learning session will start. It will consist of video lectures which will be played according to user's emotions. The user's performance will be recorded as to how many video lecture watched of a particular subject.

IV. Methodology

We have used the following technology and algorithms for implementation of affective e-learning of emotion detection.

A. Technology

The technology that will be used by us is Electro Encephalogram. An electroencephalogram (EEG) is a device that measures and records the electrical activity of your brain. Special sensors in form of electrodes are attached to the head and connected by wires to the computer [5]. We will be using NeuroSky MindWave Mobile headset for measuring brain waves. The MindWave Mobile headset safely measures brainwaves and outputs the EEG power spectrums. It provides processing and

Fig. 2. Neurosky MindWave Mobile (EEG Headset)

output of EEG power spectrums (Alpha, Beta, etc.) [4]. Our brainwaves change according to what we're doing and feeling. Due to slower brainwaves we feel tired, sleepy and drowsy. The higher frequencies make us feel alert and active [7].

B. Algorithms

The algorithms that will be used by us in emotion detection are Correntropy Spectral Density and Auto-Regression.

- Correntropy Spectral density

Correntropy is introduced by Santamaria et al. [8]. Correntropy uses kernel parameter space. It provides information on both the time as well as the statistical distribution. Correntropy is efficient since it can be computed directly from the data. The Correntropy spectral density is a generalization of the conventional power spectral density. It is based on the Fourier transform [9],

$$P_v(\omega)=\sum_{m=-(N-1)}^{N-1} V_c(m)\cdot e^{-j\omega m}, \quad (1)$$

where $V_c(m)$ is the centred correntropy function, in which the root mean square (rms) is used to subtract the output DC component that affects the CSD [9].

It is estimated by $V_c(m)=V(m)-\bar{V}$

where $V_c(m)$ is the correntropy function and $\bar{V}$ the correntropy mean [7]:

The Correntropy function is defined as:

$$V(m)=\frac{1}{N-m+1}\sum_{n=m}^{N}\kappa(x(n)-x(n-m)), \quad (2)$$

The Correntropy mean is defined as:

$$\overline{V}=\frac{1}{N^2}\sum_{m=1}^{N}\sum_{n=m}^{N}\kappa(x(n)-x(n-m)). \quad (3)$$

The Gaussian kernel function, is given by

$$\kappa(x(n)-x(n-m))=\frac{1}{\sqrt{2\pi}\sigma}e^{\left[-\frac{(x(n)-x(n-m))^2}{2\sigma^2}\right]}, \quad (4)$$

where σ is the kernel parameter [9].

- Autoregressive (AR) model

Autoregressive (AR) spectral analysis based on the Yule-Walker method is applied to improve spectral resolution compared to conventional techniques [9]. The autoregressive coefficients were estimated from the correntropy function, using the Yule Walker equations [10]. The Yule-Walker AR method of spectral estimation computes the AR parameters by solving the following linear system, which give the Yule-Walker equations in matrix form:

$$\begin{pmatrix} r(0) & r^*(1) & \dots & r^*(p-1) \\ r(1) & r(0) & \dots & r^*(p-2) \\ r(p-1) & r(p-2) & \dots & r(0) \end{pmatrix}\begin{pmatrix} a(1) \\ a(2) \\ \vdots \\ a(p) \end{pmatrix} = \begin{pmatrix} r(1) \\ r(2) \\ \vdots \\ r(p) \end{pmatrix}.$$

The use of a biased estimate of the autocorrelation function ensures that the autocorrelation matrix above is positive definite. Hence, the matrix is invertible and a solution is guaranteed to exist [11].

V. Implementation

The paper is based on making affective e-learning system by detecting learner's emotion. The brainwaves are captured using NeuroSky MindWave Mobile headset. They are interfaced to the computer using Bluetooth. ThinkGear.dll is used to obtain the eeg signals in the form of numerical value. It can also be used to read hexadecimal value. The EEG emotion database is made which are in the form of '.mat' files. Around ten samples of data related to every emotion will be considered. The student database consists of students' year, semester and roll number. It is used to store the information of number of video lectures viewed by the students of particular subjects. The subjects are numbered in between 1 to 5 which also represents the type of emotions. The video lectures are of '.mpeg' format converted using XiliSoft video converter and stored in form of conventional file system i.e. folder – file system. When the user will apply the headset the brainwaves will be gathered. Now the gathered brainwaves are compared with all the emotion samples collected. Correntropy Spectral Density and Auto-regressive model using Yule Walker method is applied. Depending upon the emotion detected a number between 1 to 5 corresponding to that emotion is selected. Now, taking the student's year, roll number and the number selected the video is shown. The record is kept of all the videos seen and report can be generated.

VI. Results

Initially, the brainwaves of the user are captured using NeuroSky MindWave Mobile, plotted and then fitted into polynomial function of degree 5. Using this recorded data, we use correntropy function on it and the database of EEG samples. This is then compared with each dataset present in EEG database to get the minimum distance. The first minimum distance is considered and corresponding emotion is taken into account. Semester and roll number of that user is taken. Depending upon the information entered by the user and the emotion detected the corresponding video will be played.

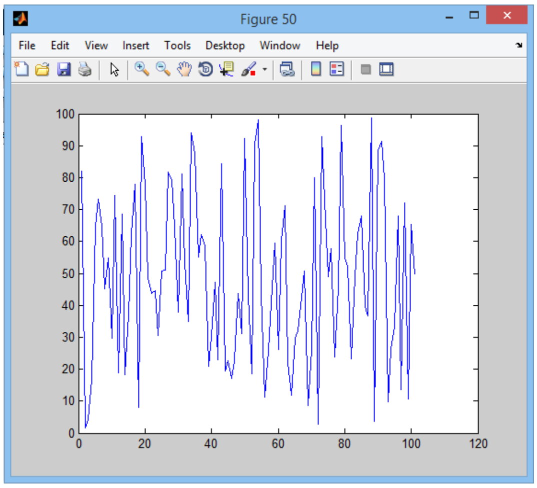

Fig. 3. Brainwaves of user.

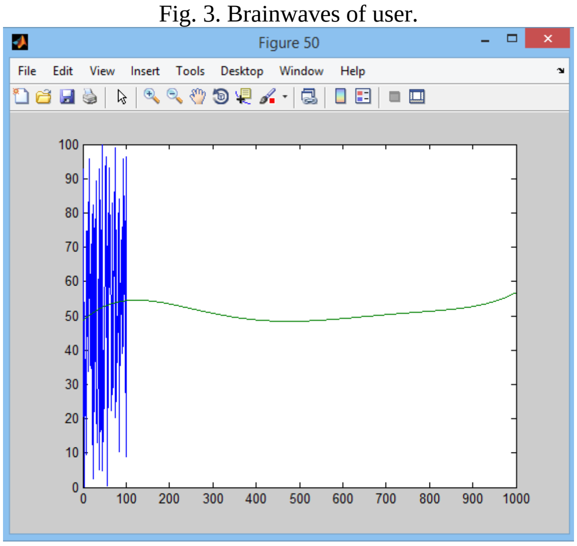

Fig. 4. EEG signal is fitted using polynomial function

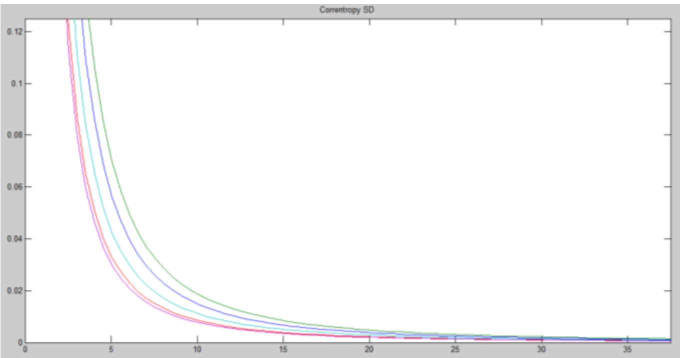

Fig. 5. Correntropy Spectral Density function applied on the recorded data

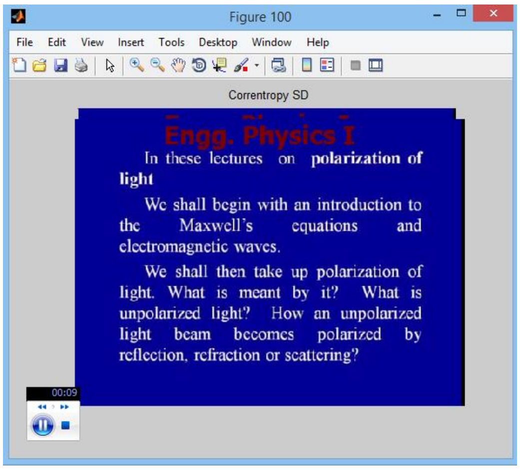

Fig. 6. Video playing

The efficiency of this system depends on the accuracy and connectivity of the NeuroSky MindWave mobile headset. NeuroSky uses ThinkGear technology which is 96% accurate as claimed in NeuroSky's white paper [12].

VII. Conclusion

An emotion comprises of various brainwave signals to different levels and making difference between them is a complex process. As a result, accuracy is the major problem when it comes to brainwave detection and emotion recognition. Accuracy is directly proportional to the number of electrodes used in EEG. Increasing the electrodes on EEG increases the complexity of circuit and cost associated with such device is very high. Hence, the design of EEG plays an important role in making the system effective and efficient. Affective e-learning will play a major role in future learning environment. The further research will involve to find out what is the most effective in students' learning to develop the system.

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