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E-Learner's Academic Emotions Based on Facial Expressions : A Survey

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ABSTRACT

This paper presents different technologies and framework used for academic emotion detection using facial recognition in E-Learning. E-Learning is growing day by day for various reasons like distance learning and user is able to do it at anytime and anywhere. But E-Learning lacks in real time feedback from the students to teachers and vice-versa. Academic Emotion plays an important role on detecting whether the students have understood the topic or not. In face to face learning, a skilled teacher achieves affective domain goals by interacting with the students and asking them questions. But in online learning student and teacher are apart so if system itself finds the emotion and take the action accordingly, is really very helpful to teacher and student both. There are various ways like sensors, facial expressions, log usage are used by many scientists to achieve this. We have researched and read many papers about various frameworks used and found that academic emotions play a vital role and also makes big difference in learning if it is properly analyzed and suitable action is taken. A model for the same purpose has been proposed here which will detect emotion and generate feedback accordingly.

Keywords : Academic Emotions, Affective Computing, Data Science, Data Mining, E-learning, Facial Recognition, Machine Learning, Emotion Recognition.

I. INTRODUCTION

In recent years, many new technologies have been adopted by E-learning specialists for enhancing the effectiveness and efficiency of E-learning [1, 11]. E-learning is boosting day-by-day and to make it more effective, use of data mining and data science is been widely used. In a normal class, teachers can get a real time reaction or emotion of students and change or modify their teaching procedure. But, in E-learning this cannot be possible due to distance. So, with the help of data mining and data science teachers as well as students can get a valuable feedback. There are different ways like facial expression recognition, sensors, log file analysis which are widely used to find emotions. Academic emotions are more helpful for post-analysis and generating a valuable feedback. Darwin was the one who has identified and

categorizes a comprehensive range of emotions. He considered emotions to represent the survival of the individual. And this function of emotion is acknowledged by some writers in the field of emotion [2, 12]. There are various advantages of using facial expression recognition for emotion recognition as it is the best way to understand someone's emotion. It does not disturb the user due to its non-intrusive nature.

Naturally, humans and animals as well express emotions unconsciously through face, heartbeat and various other means. Properly examining the various emotions expressed by a human during a particular activity will determine how much the human is involved in that activity. Various conclusions can be drawn from this analysis. In this project, emotion is used to generate feedback during learning. The basic purpose of this project is that the e-learning service provider gets a better understanding of its student's progress just like an actual teacher teaching his/her students in a class.

There are various ways of detecting emotions. Some of them are

1- Recognition from Facial Expressions
2-Using Heart Rate Measurement Sensors
3-Skin Conductance sensors
4- Questionnaires

The most optimal and efficient way for recognizing emotions is using facial expressions. The face of a human expresses various emotions. Facial Emotion Recognition is the most widely used technology. Various companies like Affectiva, Eyeris and Microsoft's Project Oxford use the micro expressions shown by the face for detecting emotions in their services. The major advantages of facial emotion recognition over others are:

1) The resources required for the client device for emotion recognition is available in low cost. An inbuilt web cam is sufficient for recognizing emotions.
2) Unlike heart rate sensor, no extra hardware is required for detecting emotions.

Emotions detected through the facial expressions are more detailed. We can detect more than the 8 common emotions using facial expressions.

II. METHOD AND MATERIAL

A) LITERATURE REVIEW

Facial emotion is description of every human activity. They have evolved as a part of communication function. Facial emotions describe the emotion of an individual and play a key role in successful social communication. It is been observed that the change in facial emotion descriptive should be self-adaptive. Hence the message given through emotions makes it interesting and important. Considering such impact of emotions, we have started the literature survey.

According to authors Fraser W. Smith and Stephanie Rossit academic emotions have various types and they were categorized as positive and negative [3, 21, and 22].

As shown in Table 1, the academic emotions are majorly divided into positive and negative and further they are divided in activating and deactivating each. Positive indicates emotions which are good or give a positive understanding like joy, hope, pride and so on. Negative emotions indicate emotions which are not good or have a negative understanding like anger, sadness and so on.

	Positive		Negative	
Object Focus	**Activating**	**Deactivating**	**Activating**	**Deactivating**
Activity Outcome	Joy	Relaxation	Anger	Boredom
	Enjoy	Contentment	Anxiety	Sadness
	Hope	Relief	Shame	Hopelessness
	Pride			Disappointment

Table1- Classification of Academic Emotions

Authors Nabeela Altrabsheh, Mihaela Cocea, Sanaz Fallahkhair conducted an experiment with Jordanian university students. Students were asked to give feedback through the tweets and later these tweets data was collected and emotion were recognized like Bored, Enthusiasm, Anxiety, Frustration and many more. They have done experimentation on 15 different models. They have done the experiment by training the model using various machine learning algorithms. The data is trained with two levels of preprocessing:

1: High Preprocessing: Here they remove hash tags, special characters and emoticons.
2: Low Preprocessing: Here authors are just using the keywords and not removing hash tags.

Every tweet has many special characters, many emoticons, hash tags and characters which cannot be understand by the models and cannot be used for analysis so a preprocessing of such tweets are required. There are two levels for it (a) High level & (b) Low level. High level preprocessing removes all the special characters and emoticons as well as hash tags and then these data is mostly used for multi emotion models. Low level preprocessing extract the keywords which are descriptive and in context with emotions then these data is used for single emotion model.

All the models were processed by 10 cross validation folds to get accuracy, kappa value and error rate. The observed results state that the accuracy for single emotion model was more accurate as compared to multi emotion model [4].

Main challenge of E-learning is that, due to timing constraints and work load, it may not be possible for teachers to change or modify their content or the video lectures for years. In current scenario they do not get real time feedback of learner's emotions. Learner's emotions influence learning. So capturing emotions can help teachers to modify their content, change teaching strategy or helps to give feedback to the learner.

In many articles experiment is carried out using affective computing which takes help of various third-party apps to recognize emotions and analysis on that data in background.

According to Michael Pelch academic emotions like anxiety and stress are more descriptive [5, 19, and 20].

Kiavash Bahreinia and colleagues has performed an experiment in [6] in which they have used FILTWAM framework for recording the emotions. FILTWAM uses webcam and microphone to capture the data and then analyze that data to find the emotion. They created the data set of emotions which is helpful for recognizing the emotion through face tracker software tool.

This framework consists of 5 layers.
1-Learner: This represents the student or anyone who is reading or watching the lecture.
2-Device: This layer consists of Devices as well as user interface in which the content is present.

3-Network: This layer consists of important networking required for live streaming as well as to transfer the feedback generated through internet.
4-Application: This layer performs important functioning like data storage, data training, Data analysis and Feedback generation.
5-Data: It consists of different Databases, Datasets and all the data required for analysis.

Here authors had split the screen into two windows one with the webcam and other with the content. Due to this they could get real time emotions of E-learner and they were able to generate feedback. For finding accuracy of their module they test it with participants and participants agreed with the feedback generated [6].

Some experiment recognized emotions with the help of bio sensors like heart rate sensors in [7, 15]. The sensors would record various changes in autonomic nervous system (ANS) of the body. They also used Support Vector Machine (SVM) algorithm for training data and recognizing emotions [7, 16, and 17].

Some experiment also took information from biosensor wearable devices like smart watches and fit band. Authors in [8] have used emotionWear Framework. In emotionWear framework a user watches the contents in the Smartphone which includes VR headset and it is connected to the cloud storage. The user wears wireless sensing gloves which generates different signals which are used to detect emotions of the user. The emotions detected here were accurate but there was delay in analysis [8, 18].

Ramanathan Subramanian in [9] and his team has performed the experiment with the help of some commercial sensors like Galvanic Skin Response (GSR), Electrocardiogram (ECG) and Electroencephalography (EEG) to detect emotions. In the methodology used by them, users were shown 36 types of videos which would take 90 min per user. After viewing clip, users reported their emotional state in the form of ratings within 30 seconds. Consistent results were obtained when physiological features are employed for analyses [9].

Emotion recognition can also take place using python and its libraries like opencv, Kairos and many more which gives us emotion directly through our webcams.

Few Experiments done by various authors in [10] included Recognition of emotions using external cameras which have pre-installed recognition sensors like kinnect sensors. Kinnect sensors are motion sensing input devices which gathered an incredible amount of data regarding motion-capture of actual moving things in real-life scenarios. Emotions are detected by analyzing the collected data. Using face positions and their 3D point's emotions are recognized in following way.

Disgust- Inner corner of eyebrows lowered; nose wrinkled; eyelid raised; lower lip rose.
Surprise- Eyebrows raised and curved; eyes wide open; jaw dropped; lips relaxed.
Fear- Eyebrows raised and inner corners together; eyes wide open; mouth open but tense.

Here, the position of various points would decide various emotions and different emotion gave different accuracy. The experiments recognized Anger, Disgust, Surprise, Sadness, Happiness, Fear and Neutral with 94.28 % accuracy rate [10].

There are also some other ways for capturing data and detecting emotions using image processing. Here the machine captures image at different interval and compares with the standard datasets of images to predict the emotion.

From the literature survey it is found that capturing images or videos and finding emotions using facial expression recognition approach is the best way to predict the emotions at real time.

III. PROPOSED METHODOLOGY

Admin and student make use of login credentials to enter into the system. Login credentials will get stored in local database. Once login is done, student will get access to the contents. While exploring contents and watching videos of certain topics, learner will record a video using webcam or screen capturing software. The client can access content at anytime and anywhere and record the video during learning. That video will get stored in database.

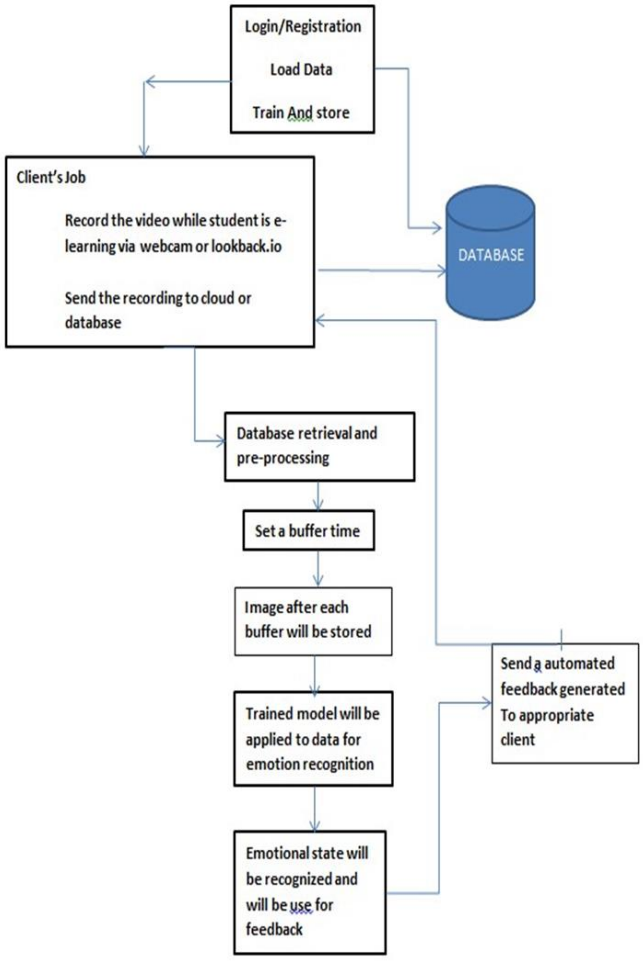

Fig1- Block diagram for proposed methodology

After doing pre-processing of that data, captured frames will sent to trained model for predicting emotion. Team should have carefully set a buffer time in the developing phase. This buffer captures images from the video periodically at certain buffer time. Images captured periodically from video will be inputted to trained model for emotion recognition. The predicted emotions will get stored in the database for further analysis. Based on predicted data, feedback will be given to learner. So that learner will be able to concentrate on learning which will improve the performance.

It is possible to predict these emotions using different modalities like questionnaires, Log file analysis, different sensors, gestures and facial expression. In our method we will detect emotions using facial expression recognition.

Webcam is one of the main constraints. A proper webcam is needed to record the videos which will further be used for emotion recognition at the student end. Some software and library are needed to be installed on teachers end. An accurate analysis is required to generate accurate feedback.

B) ALGORITHMS

1) Emotions Detection is divided into four sub modules-

A. Frame Capturing,
B. Face Detection,
C. Image Pre-processing,
D. Emotion Prediction

) Frame capturing is an important process. A video is consists of thousands of frames. When the video is taken as an input, a frame is extracted after a particular buffer time which is then used for emotion detection. Here we use OpenCV and Videocapture for frame extraction. Here we have defined the buffer time as 20 frames per second we have kept the frames low because more frames per second would lead to slow video processing.

b) After the frame is extracted, we need to detect only the face of the student from the extracted frame. For

this we have used "haarcascade_frontalface" algorithm. This process helps us to make our results more accurate by eliminating unwanted disturbances in the frame.

2) Every image is needed to be pre-processed before using it for prediction .Similarly the frame we extracted need to be processed before passing it to for prediction. Pre-processing contains processes like image resize, gray scaling the image and performing various operations on it. First we have changed the frame to gray scale by using functions like "cv2.COLOR_BGR2GRAY". Then we have resized the image to (30, 30) dimensions with the help of functions like "cv2.CASCADE_SCALEIMAGE"

3) Now the remaining part is of matching the attributes in the frame with attributes in the generated model. The attributes here are the position of the eyes, Eyebrows, lips and nose. We had defined label at the start for our emotions. Now we will predict the probability of the emotions and the one with highest probability will be chosen as the emotion for that frame.

4) At last we will analyze the emotions detected throughout the session. With the help of analysis feedback can be generated. This feedback will be given to both teacher and student so they can understand and act accordingly. This feedback would be in the form of graph.

Tools used: -

- Webcam – for recording student's videos while learning.
- Spyder – for performing python code individually.
- Python (3.6.3) - Language used for data science.
- Microsoft Excel

Technology used: -

- Tenserflow
- Keras
- Pandas
- OpenCV
- MySQL connector

IV. RESULTS AND DISCUSSIONS

1. Firstly, the video is recorded of the students through the webcam and after the video collection from clients which can be used for further processing.

2. Now, the videos are used to extract frames after a buffer time given and the frame is extracted as shown below.

Fig 2- Frame extracted

3. After the frame is extracted we need to detect only the face from frame which will be used for pre-processing as shown below.

4.

Fig 3- Face Detection

Now, after the face has been detected, we have to extract just the face from that. This detected face portion would be used to get precise feature points.

Fig 4- Face Extracted

From the extracted face, we have extracted features to determine the emotions. So using Histogram of oriented gradients, the feature points are extracted. Output of feature extraction is shown below.

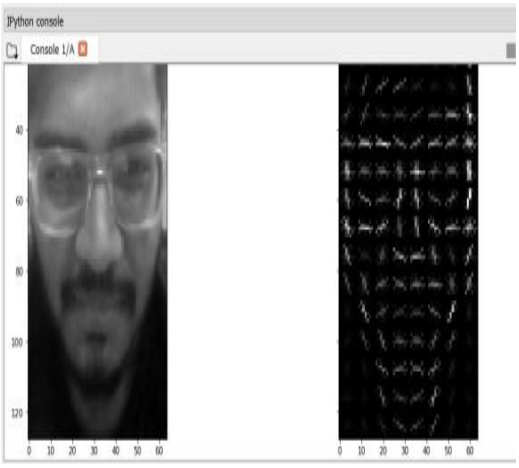

Fig 5- Feature points extracted.

Now, the extracted feature points are given as an input to the trained model to detect the emotion.

Here are some detected emotions.

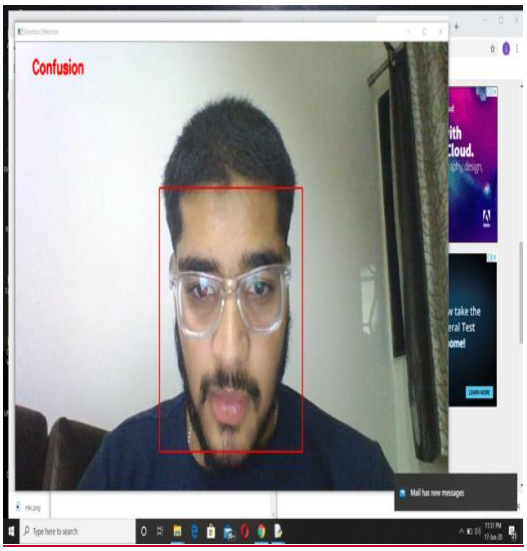

Fig 6- Detection of Confusion emotion

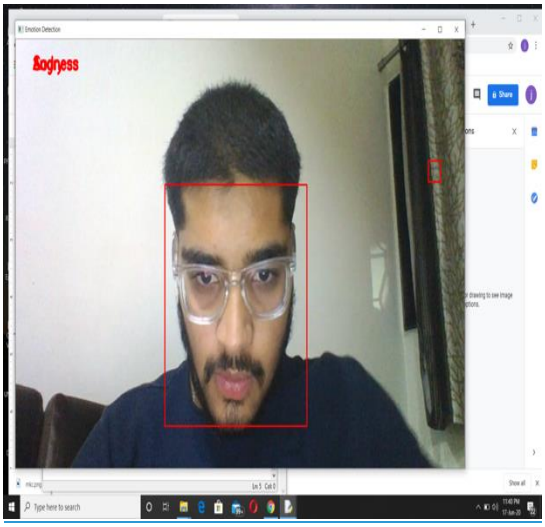

Fig 7- Detection of Sad emotion

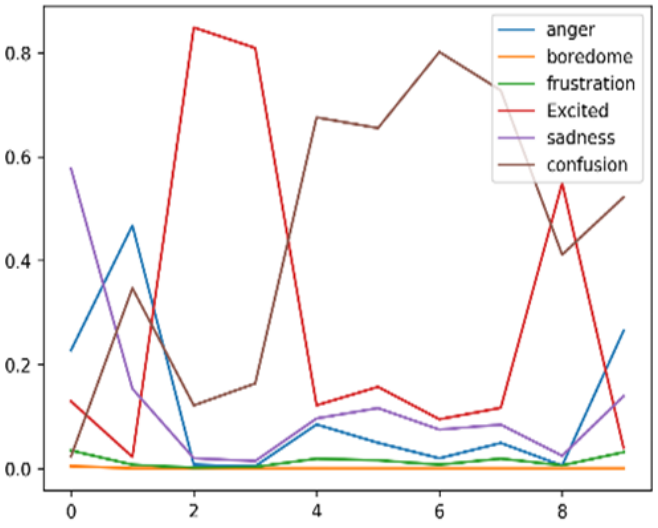

Fig 8- Output of emotions detected in form of graph

Here on the x-axis we have the time-stamps of the video which was an input to the software and on the y-axis we have the probability of the emotion at that particular frame. Different color lines are used to differentiate between the emotions. Each and every emotion has been dedicated a color in graph.

V. CONCLUSION

E-learning with the help of machine learning is very effective and important. There are many sensors, models, libraries and tools available for emotion recognition. Every model gives different accuracy for different emotions. Selection of model can be done according to various factors like cost, accuracy, efficiency and many more factors. And proper analysis would give an effective feedback to teachers as well as students. These are helpful to overcome the limitations of e-learning like real time analysis, two-way communication and so on. Both teacher and students get feedback for their doing. Teachers can update their content and teaching method and students can understand like what they were doing at certain time and why did they not understand that particular topic.

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