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Analysis of Facial Expressions for Predicting Student's Learning Level

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***Abstract*—** In today's scenario, there is an explosion of knowledge and the context of what is learnt and how it is learnt by the students become very important to understand. Student needs to develop their higher order thinking skills which would help them understand and apply concepts in the right manner. This research work specifically focuses on emotion detection of the students by analysing their facial expressions while they are answering a set of questions asked by an instructor for different subjects. The aim is to identify the cognitive learning level of the Bloom's Taxonomy and map the emotions set to each learning level. This is achieved by capturing the emotions of students from an emotion classifier based on CNN (Convolutional Neural Networks) and further classifying them using various classification algorithms which in turn predicts the Accuracy of the proposed system.

***Keywords*—** Biometrics, Emotions, Cognitive learning level

I. INTRODUCTION

An emotion is a mental reaction experienced as a feeling directed towards an object. It is usually accompanied by physiological & behavioural changes in the body. Emotional aspects have a great impact on intelligence like communication, understanding as well as the behaviour. They can be expressed in many different forms which may not be visible to the eye. Emotion recognition can be performed using various biometric traits like face, speech, text, etc. Facial expressions are more popular as they have useful features for emotion recognition.

Our goal is to understand the learning ability of the students by detecting their emotions based on their facial expressions. In this paper, we are trying to identify physical behaviours of the face that are linked to emotional states further linking them to the cognitive learning levels of the student. Facial expressions are rich in information about an individual and also about their mood and mental state. Studies reveal that the most expressive way humans display emotions is through facial expressions. Facial expressions are the primary source of information in determining an individual's internal feelings. Thus, a facial expression can help the instructor visualize and assess the learning ability of the student looking at their expressions and emotions. In this paper, we present a novel idea of detecting emotions of a UG student group from their facial expressions which are identified as their Biometric Traits captured through a HD camera under suitable conditions.

II. RELATED WORK

Education Philosophy is a field of psychology concerned with the scientific study of human learning. The study of the process of learning from both of the domains viz, the "Cognitive Domain" and the other being the "Behavioural Domain". The field of educational psychology involves the study of memory, conceptual processes, and individual differences (via cognitive psychology) in conceptualizing new strategies for learning processes in humans. The Cognitive perspective is more widely used than the behavioural perspective as it is related to traits, beliefs and emotions. Cognitive theories claim that the structure of memory determines how the information is perceived, processed, stored, retrieved and forgotten. The field of Academics also capitalizes on cognitive change, because the construction of knowledge presupposes effective teaching methods that would move the student from a lower to a higher level of thinking.

The Bloom's Taxonomy focuses on the principle of what the educators intend for students to learn can be hierarchically organized from less to more complex. Levels within the hierarchy are presumed to be successive, so that students must master a given level before they can proceed to the next, more complex level. The cognitive domain includes the levels of: Remember (R), Understand (U), Apply (A), Analyse (AN), Evaluate (E) and Create (C) [1]

When various levels or outcomes of learning are involved, Bloom's taxonomy [1][3]of educational objectives may be

used to develop instructional goals, to design and present lectures, and to evaluate student performance. Unless such classification is performed, there is a risk that the educator will focus on one level of learning while neglecting others. For instance, an exam might unintentionally overemphasize factual knowledge even though the teacher sought to challenge students to demonstrate their abilities to analyse and synthesize [6]

III. METHODOLOGY

For performing this experimentation, Final Year Computer Engineering UG students have been identified as the sample set. The question papers have been designed based on the concept of Bloom's Taxonomy. The following are the subject details:

Table 1: Subject Details

Subject ID	Subject Name
SUB 01	Parallel & Distributed Systems
SUB 02	Data Warehousing & Mining
SUB 03	Human Machine Interaction
SUB 04	Machine Learning
SUB 05	Big Data Analytics
SUB 06	Digital Forensics

The subject experts have prepared the question papers for assessing the students during their tests. Each question is mapped to particular suitable cognitive learning level (CLL) such as Remember (R), Understand (U), etc.

Table 2 given below depicts a sample of a subject's question

Table 2: Sample Question Set

Name of the Subject: Big Data Analytics **Subject ID:** SUB 05							
Question no.	**Questions**	**Cognitive Learning Levels**					
		R	**U**	**A**	**AN**	**E**	**C**
Q1	Explain Big Data characteristics	√	V				
Q2	State limitations of Hadoop				√		
Q3	What is NoSQL? Discuss any one architectural pattern of NoSQL	√	√	√			
Q4	Define core components of MapReduce	√					
Q5	Explain Jaccard similarity measure with the help of an example		√	√	√	√	
Q6	Why is finding similar items is important in Big Data				√	√	√
Q7	What is Big Data? Explain any two case studies of Big Data Solutions in detail	√	√	√	√		
Q8	What is Hadoop? Explain Physical Architecture of Hadoop	√	√	√			
Q9	Describe characteristics of NoSQL Database	√	√				
Q10	What is MapReduce? Explain Wordcount example using MapReduce	√	√	√	√	√	

In same fashion, the question set is prepared for all six subjects mentioned in table 1. The dataset is prepared by capturing the videos of 52 Final Year Computer Engineering students facing a HD camera, who are instructed to answer the questions asked by the instructor. The details of the question mapped with Cognitive learning levels (CLL) are shown in the table 3 given below:

Table 3: Details of questions mapped to each CLL

Questions per CLL for each subject	No. of Questions mapping to CLL	Total number of Questions
Remember	11	61
Understand	15	
Apply	10	
Analyze	12	
Evaluate	7	
Create	6	

I. DATASET GENERATION

The videos are recorded while the student is answering to the questions asked by the instructor for each subject separately. Since the questions are mapped to every CLL of the Bloom's Taxonomy, the videos are clipped for every CLL and stored in the format shown below in table 4. Clipping is done to separate the videos of each subject as per its CLL questions answered by the student. The total 435 such videos are clipped for experimentation purpose.

Table 4: Sample Snapshot of video clipped

Sr.No.	Subject ID_Student no.	Name of the Student	Question no.	CLL	Snapshot of the video
1.	SUB 05_STD 01	BHAGAT DHRUVI	4	R	

II. EMOTION DETECTION PROCESS

After each clipped video is sent to the Emotion Classifier based on convolutional neural network CNN [8]. The video is processed for detection of emotions and the output is obtained as follows:

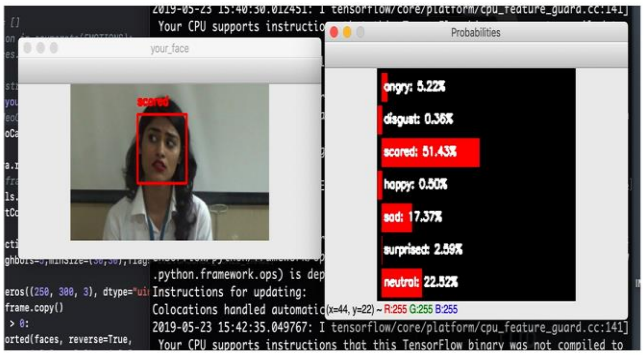

Figure 1: Emotions detected for a sample video clipping

A convolutional neural network (CNN) is a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data. Convolutional neural networks work like local filters. The first step in image analysis is often to perform some local filtering of the image, for example, to enhance edges in the image.

For this, the neighborhood of each pixel is taken and convolved it with a certain mask (set of weights). A linear combination of those pixels is computed. Each node in the output layer is connected to a pixel and its neighborhood in the input layer. In a convolutional neural network, the weights are shared, that is, they are the same for different pixels in the image (but different with respect to the position relative to the center pixel). CNNs are made up of learnable weights and biases. CNNs are very similar to ordinary neural networks but not exactly same. They are primarily used in image recognition, image clustering and classification, object detection etc. CNNs use relatively less preprocessing when compared with other algorithms of image processing. The connectivity pattern of the CNN resembles the structure of animal visual cortex.

In the same manner all the 435 samples are analyzed for emotions whose output is generated after identifying the transition of Emotions while the student is answering the questions and the end of the video, it gives out the average emotion value as shown below:

Table 6: Sample output of Emotions detected from face

Student ID	Question No.	CLL	Angry (%)	Disgust (%)	Scared (%)	Happy (%)	Sad (%)	Surprised (%)	Neutral (%)
STD 13	Q4	R	4.5	0.5	17.1	70.1	6.9	0.6	0.4

It has been found that there are six universal facial expressions and features which are identified. The table below explains about the motion of the facial part for the Universal Emotions. This research work offers novel contribution to the field of Facial Expression Recognition. Facial expression presents key mechanism to describe human emotion. From starting to end of the day human changes plenty of emotions, it may be because of their mental or physical circumstances.

Although humans are filled with various emotions, modern psychology defines six basic facial expressions: Happiness, Sadness, Surprise, Fear, Disgust, and Anger as universal emotions [2]. Facial muscles movements help to identify human emotions. Basic facial features are eyebrow, mouth, nose & eyes. The Universal Emotions mapped to the facial movements are presented in table 7.

Table 7: Universal Emotion Identification [9]

Emotion	Definition	Motion of facial part
Anger	Anger is one of the most dangerous emotions. This emotion may be harmful so, humans are trying to avoid this emotion. Secondary emotions of anger are irritation, annoyance, frustration, hate and dislike	Eyebrows pulled down, Open eye, teeth shut and lips tightened, upper and lower lids pulled up
Fear	Fear is the emotion of danger. It may be because of danger of physical or psychological harm. Secondary emotions of fear are Horror, nervousness, panic, worry and dread	Outer eyebrow down, inner eyebrow up, mouth open, jaw dropped
Happiness	Happiness is most desired expression by human. Secondary emotions are cheerfulness, pride, relief, hope, pleasure, and thrill	Open Eyes, mouth edge up, open mouth, lip corner pulled up, cheeks raised, and wrinkles around eyes
Sadness	Sadness is opposite emotion of Happiness. Secondary emotions are suffering, hurt, despair, pitty and hopelessness	Outer eyebrow down, inner corner of eyebrows raised, mouth edge down, closed eye, lip corner pulled down
Surprise	This emotion comes when unexpected things happens. Secondary emotions of surprise are amazement, astonishment	Eyebrows up, open eye, mouth open, jaw dropped
Disgust	Disgust is a feeling of dislike. Human may feel disgust from any taste, smell, sound or tough	Lip corner depressor, nose wrinkle, lower lip depressor, Eyebrows pulled down

III. CLASSIFICATION ALGORITHMS FOR PREDICTION

The Emotion based biometric data is now used to classify and predict the category of the student's learning which has been already done based on the traditional (manual) assessment and student evaluation method. The students are categorized under "High", "Medium" & "Low" categories.

The idea of Classification Algorithms can predict the target class by analysing the training dataset. It is used to get better boundary conditions which could be used to determine each

target class. Once the boundary conditions are determined, the next task is to predict the target class. The whole process is known as classification.

IV. RESULTS AND DISCUSSION

As an input, the Biometric Trait value is provided to the training model along with the CLL, Category (High/Medium/Low) & the marks obtained by the students in each question. The videos are evaluated by the subject expert & marks are allotted to the students.

The Results & findings are found on the basis of the Emotions detected using Facial Expressions. The Students are classified under 3 categories, viz. "High", "Medium" & "Low" category. The Classification Algorithms are executed to predict under which category, the student would lie. This is quite evident from the fact that the Accuracy is checked for when the marks obtained by the student is compared with their facial expressions.
Accuracy is given by the formula:

$$\text{Accuracy} = \frac{\text{Number of Correct Predictions}}{\text{Total number of predictions made}}$$

The Classification is done per CLL & the Total Accuracy in percentage is presented in the table shown below:

Table 8: Classification done per CLL & Total Accuracy in percentage

Classification Algorithms	R	U	A	AN	E	C	Accuracy in Percentage
Logistic Regression	65.91	63.64	61.36	61.36	61.36	54.55	68.18
SVM	59.09	72.73	61.36	61.36	65.91	54.55	65.91
Random Forest	77.27	77.27	61.36	61.36	65.91	68.18	72.73
NLP	77.27	70.45	54.55	61.36	54.55	68.18	65.91

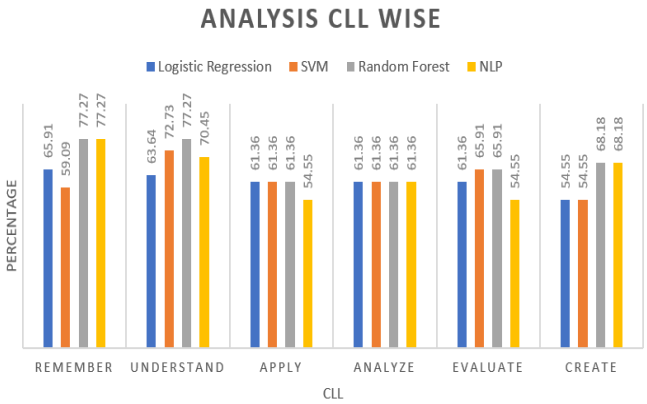

Figure 2: Comparison of Classification Algorithms

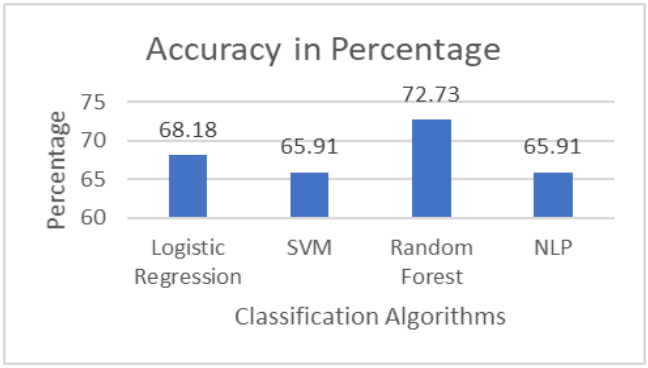

Figure 3: Overall Accuracy in percentage of Classification Algorithms

Findings:
As far as the Classification Algorithms are concerned, based on the dataset provided, Random Forest is proven to have given the best of the result. Although the other algorithms have also showcased a good accuracy, 72.73% Accuracy being the highest value obtained, it is considered for better prediction results. The Cognitive learning levels have also been taken as the input along with the marks obtained by the student during the traditional assessment & evaluation process. Due to this, the accuracy level is being obtained which seems to be satisfactory.

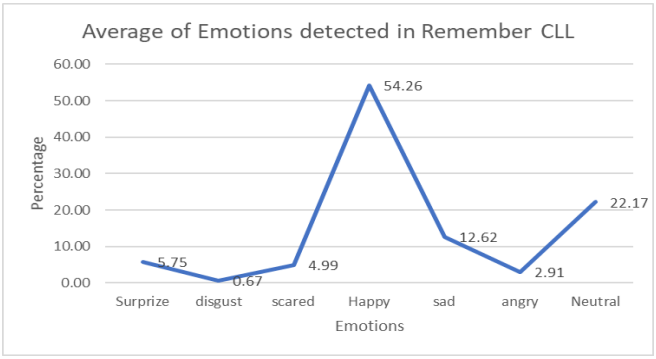

Figure 4: Average Emotions for Remember CLL

Finding: The above graph (Figure 4) represents "Remember" cognitive learning level which has "Happy" emotion that is dominant as compared to other emotions.

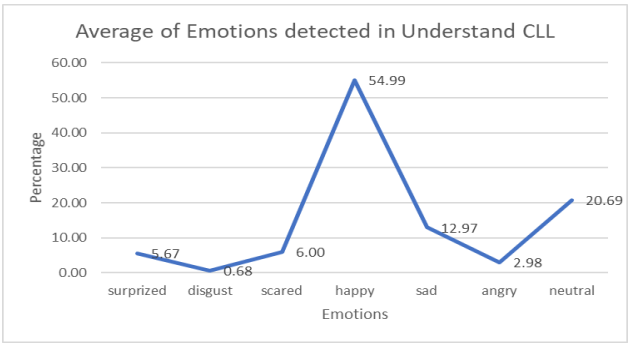

Figure 5: Average Emotions for Understand CLL

Finding: The Figure 5 represents "Understand" cognitive learning level which alike the "Remember" level has "Happy" emotion that is dominant as compared to other emotions.

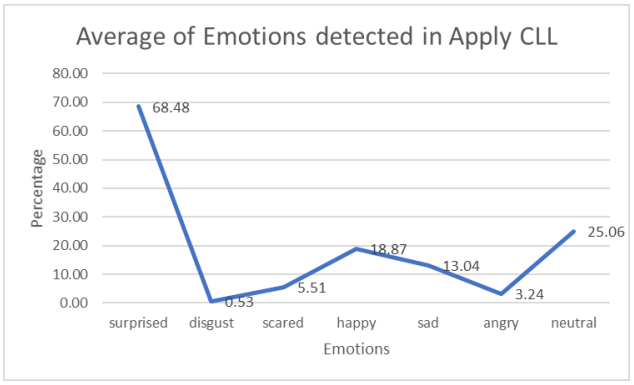

Figure 6: Average Emotions for Apply CLL

Finding: The above graph given in Figure 6 represents "Apply" cognitive learning level which has more of "Surprised" element that is dominant as compared to other emotions.

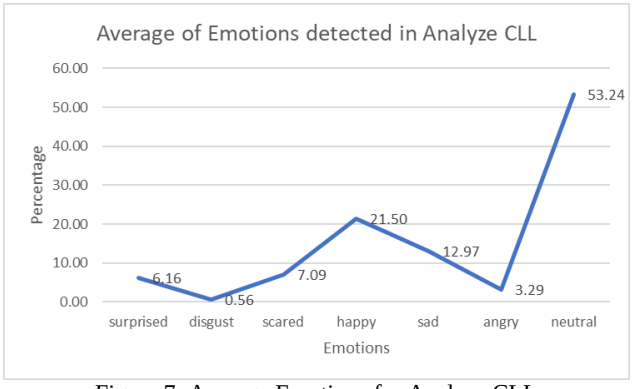

Figure 7: Average Emotions for Analyse CLL

Finding: Figure7 represents "Analyse" cognitive learning level which has the "Neutral" emotion dominant over other emotions.

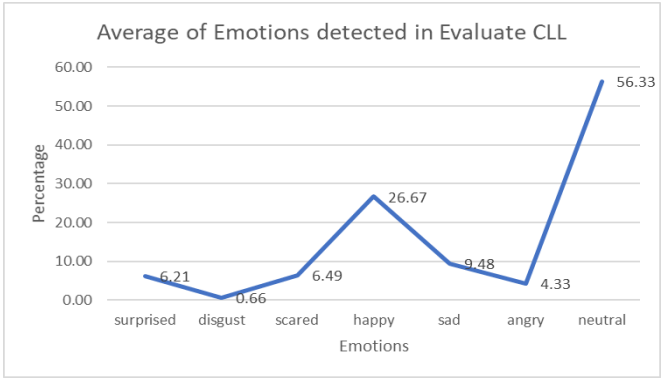

Figure 8: Average Emotions for Evaluate CLL

Finding: The Figure 8 represents "Evaluate" cognitive learning level which also has the "Neutral" emotion dominant over other emotions.

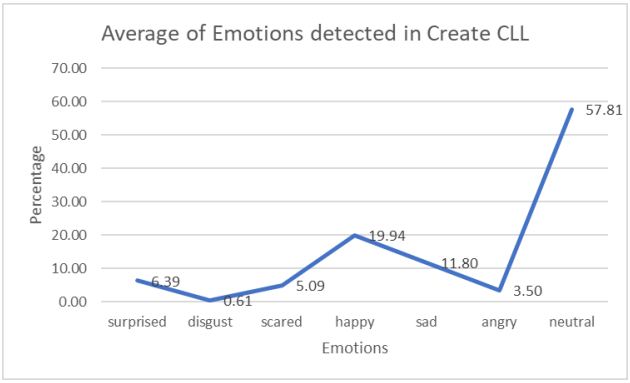

Figure 9: Average Emotions for Create CLL

Finding: The above graph given in Figure 9 represents "Create" cognitive learning level which alike the "Analyse" and "Evaluate" CLL has the "Neutral" emotion dominant over other emotions.

The average emotions for all the CLL is tabulated as shown below in table 9:

Table 9: Average Emotions for all CLL

CLL	Angry (%)	Disgust (%)	Scared (%)	Happy (%)	Sad (%)	Surprised (%)	Neutral (%)
R	5.7	0.7	9.2	68.8	9.7	1.8	4.4
U	5.67	0.68	9.44	69.11	9.78	1.84	5.08
A	5.6	0.5	9.1	1.8	9.5	68.5	5.5
AN	6.2	0.6	9.7	6.9	10.3	2.2	67.1
E	6.2	0.7	10.3	13.5	10.7	2.0	70.1
C	6.4	0.6	9.7	6.4	8.6	1.7	69.8

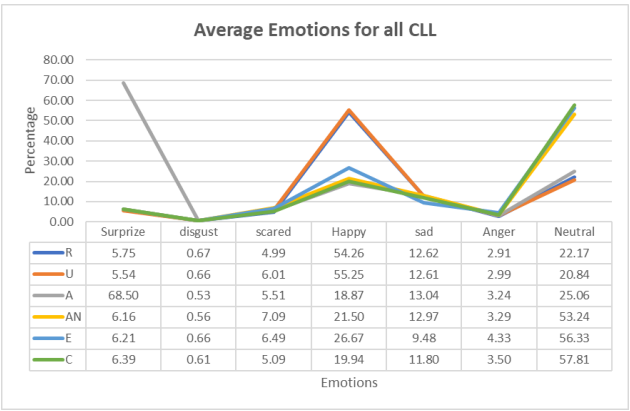

Figure 10: Average Emotions for all CLL

Result Analysis & Findings (Figure 10):

i.) The above graph depicts the Emotions value averaged across all the Universal emotions like Angry, Sad, Disgust, Happy, Surprised & Neutral.

ii.) It has been found that "Neutral" has been dominant enough at many places but equivalently other emotions have also been produced.
iii.) The "Angry" emotion is lying between 35-45% whereas except for the "Sad" Component under Remember level, the range is from 10-14 % only.
iv.) "Surprised" & "Happy" components are high in the lower cognitive learning levels and are quite visible in almost all the other learning levels.
v.) "Surprised" & "Happy" could be combined together along with the "Neutral" expression as most of the Indian population are highly possess "Neutral" emotion in majority of the situations.
vi.) Figure 25 showcases the average of all Cognitive learning levels for the Universal Emotions. It has been calculated by obtaining the average value for every emotion (face & voice) across all the samples.
vii.) Student learning level is predicted when compared with their marks during their traditional assessment & evaluation.

V. CONCLUSION AND FUTURE SCOPE

It has been quite evident that Bloom's Taxonomy plays a significant role in understanding the order of thinking amongst the students. The students can be categorised under the categories & well guided through developing the reason to think & be able to Apply the knowledge to develop the higher order thinking skills & move up to the higher Cognitive learning levels.

The emotions in an individual decide the future action of the person. It is obvious that the performance of the student is also dependent on these factors. The attempt to develop this hypothesis which suggests that by analysing the facial expressions and observing the biometric traits, a person's actions and performance could be predicted.

To improve the Accuracy of the predictions obtained for the samples, there could be enhancement methods which could be applied that can optimize the prediction model and improve the results which can in turn increase the accuracy levels obtained through the analysis of the Biometric traits.

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