Boredom Level Detection Using Machine Learning

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Abstract – In a world that is constantly changing, our education systems have more or less stayed the same. The adoption of smartboards and smart-classroom setups have been the only innovation in teaching methodology. The chalk – and – talk style of teaching, is still the most widely used method in Indian Education. Although teaching methodologies have been a part of the growing innovation, there is no way to measure or identify the emotions of a student during a lecture. The entire purpose of a lecture is to impart knowledge to the students and ensure maximum retention of the concept being taught. But, if a student is bored during or half-way through a lecture, it is very rare that he/she has been able to retain more than 50% of the contents taught during that lecture. In this paper, we attempt to discuss potential solutions, based on Machine Learning, that can help track and identify student emotions during a classroom lecture. They have been derived from various methodologies and ideas that have been presented in the literature and portray a view of the current state-of-the-art research in this exciting field.

Index Terms – Machine Learning, Boredom, Identify Emotions, Smart-Classroom, Maximum Retention.

I. INTRODUCTION

It is very common for any person to be caught daydreaming in a class, when the professor has been talking incessantly about a topic which is at the bottom of their interests. The wait for a delayed flight at an airport seems like an era has gone by, looking at the clock that just doesn't seem to be moving. So, it is safe to say that we have all experienced boredom at some point in our lives.

Psychologically speaking, boredom is the cumulative effect of a few conditions that come together. [1] In an attempt to keep their mind engaged, bored people generally resort to daydreaming and tend to let their mind wander off. One of the most influential elements of boredom is control. Boredom often is the result of a situation in which one has little control over the situation. It is natural human tendency to respond to an unpleasant situation by changing the situation. Like, while reading a book, if it gets unpleasant, one can always stop reading the book. Boredom is an outcome of a situation which cannot be changed, like the environment we have selected, a classroom.

Eventually, in the long-term, boredom tends to develop a negative feeling towards the source of that boredom. In the context of education, this can be a disastrous long-term result, especially if the student starts disliking the subject or the course just because it wasn't taught in an engaging manner.

Recent advancement in machine learning, internet of things and nanotechnology, has helped to quantify the signs and signals that can be used to identify the emotions of a person. The most popular of them all being the use of image processing, which comprises of face detection and tracking. This paper introduces various ideas that have been implemented in this domain, combining emotion detection and machine learning techniques.

II. RELATED WORKS

An emotion is generated by humans on perceiving certain distinct changes in their immediate environment or in their bodies. It is a psychological process that has been designed to maintain a balance between all the information that is processed by the brain and the goals that have been categorized as the most important ones, that the brain must achieve at any cost. **[**2**]**

Facial expression and its correlation with emotions has been one of the more sought after topics of discussion. Over the years, a lot of research has been carried out in this field and the advent of machine learning techniques has helped in obtaining meaningful and efficient results. [3] The system proposed by Michel and Kaliouby [4] focusses on real-time emotion detection with the input source being a live video. Initially, the system identified and extracted 22 facial features from the live video stream and calculated displacements for each feature between a neutral and representative frame. A Support Vector Machine (SVM) classifier was trained using these displacements and its labels respectively. The fully trained SVM classifier model was used to categorize emotions amongst the six basic emotions: anger, fear, happiness, sadness, surprise and disgust. The accuracy achieved by this model ranged from 60.7% for inexperienced users and 87.5% for professionals.

In another attempt for real-time facial expression identification, Yousef *et al.* [5] aim to identify the aforementioned six basic emotions with the help of a Microsoft Kinect sensor. The system extracts 4D facial points which was the input to a multiclass

SVM classifier. The training was done from a database of 4D data, collected from 14 different people, who were asked to act out the six basic emotions. The accuracy of the system for people who did not participate in the training phase was 38.8%. For comparison purposes, the authors also resorted to the k-Nearest Neighbour (k-NN) classifier, which resulted in an accuracy of 34.0%. In case of revaluating the individuals who participated in the training phase, the accuracy levels rose to 78.6% for SVM and 81.8% for k-NN.

In a system proposed by Vinicius Silva *et al.* [3] they carried out their emotion detection process using Intel's RealSense 3D sensor, which is a platform for implementing gesture based computing, also known as Human-Computer Interaction techniques. [8] They too made use of the SVM classifier model and had a database of 43 participants. The Intel RealSense 3D sensor, when coupled with the Intel RealSense SDK, provided up to 78 unique facial landmarks and 16 facial expression definitions. Since at the time, the sensor was still under development, the accuracy for some expressions was still quite low. The facial landmarks were used as geometric features, extracting shape and movement of these features. The system implemented multiclass SVM using the Linear Kernel and RBF Kernel, with the RBF kernel achieving the best performance with 93.6% accuracy in its offline evaluation and 88% in real-time evaluation.

The system proposed by Alexandra Cernian *et al.* [2] had a different approach to emotion detection. They did not opt for an image or a video as their input for emotion detection. Instead, they went ahead and measured three physical parameter, Pulse, Skin Electro-conductivity and body temperature. The data was captured via 3 sensors connected to an Arduino UNO board, namely the Pulse Sensor, Temperature Sensor and Galvanic Skin Response Sensor. The data collected from these sensors was sent to a database on a Raspberry Pi server. Then, the data was sent to a mobile application using the HTTP POST and HTTP GET methods. They too, made use of the SVM classifier model and had categorized the emotions from 0-3, for Happy, Sad, Nervous and Bored respectively. The app would then predict the emotion of the person and if correct, would also suggest a YouTube playlist to pep-up their mood. The authors have cited a positive result in predicting the emotions and boast of a high accuracy by using SVM.

Galvanic Skin Response (GSR), also known as Skin Conductance or Electro-dermal Response, is a phenomenon where-in the human skin temporarily becomes a slightly better conductor of electricity when exposed to either an internal or external stimulus, which is psychologically arousing. Arousal is simply an umbrella term that is used to refer to an overall activation and is widely considered to be one of the two major dimensions of any emotional response. Hence, measuring arousal is not necessarily the same as measuring one's emotion, but is an important aspect of the same. Arousal has been found to be a very strong indicator of attention and memory. [6] Skin conductance sensitivity to various stimuli is manifold, which includes events that are significant or even intense in nature. In general, arousal tends to be low for a person who is sleeping and extremely high in activated states such as rage or mental workload. When any individual is tasked with a few mathematical problems, which may not be particularly hard, the arousal level tends to shoot up and then gradually decline, as these problems are attributed to some kind of mental workload. Events where one feels strong emotions, an event that startles you or any demanding task, be it physical or mental, tend to elevate one's skin conductance. For these reasons, it is very difficult for someone from the outside to tell your skin response, until one participates in a highly controlled experiment.

There are only few places where skin conductivity can be measured: the palms and the soles of ones feet. The reason for this is the density of the eccrine sweat glands, which are best known to respond to emotional or psychological stimuli. In both these areas, the conductance is measured with the help of two electrodes placed next to the skin and passing a tiny electric charge between these two points. It has been observed that when the participant's arousal increases, the skin immediately responds and becomes a better conductor of electricity. [6]

In the systems proposed by Cernian *et al.* [2] and Feng Lui *et al.* [7] the use of Galvanic Skin Response is the centre of their emotion detection systems. The system proposed by Feng Lui *et al.* [7] makes use of the Galvanic Skin Response Sensor in order to evaluate the emotional intensity of a person when subjected to video clips, identified to make a person feel happy or sad. The functional relation between emotional intensity and the GSR was established by fitting the feature values and the emotional intensity values of each emotional activity and emotional intensity was calculated in real-time. The results accurately calculated the emotional intensities and was confirmed with the actual emotions.

In another similar attempt for human emotion recognition, the system proposed by Mingyang Liu *et al.* [8] also made use of the GSR signals and with the help of feature selection, and the use of the SVM machine learning algorithm, the experimental results indicated a positive result, leading to satisfactory results in identifying the human emotions, with a recognition accuracy of more than 66.67%.

In most of the literature related to Emotion detection, the basis of their categorization of emotions has been the 'Valence-Arousal Model', which is also known as the 'Circumplex Model' developed by James Russell. The model indicates that emotions are distributed in a two-dimensional circular space, containing two dimensions, namely: arousal and valence. The arousal dimension is represented by the vertical axis and the valence dimension is represented by the horizontal axis. The centre of the circle represents a neutral valence and a medium level of arousal. In this model, emotional states can be represented at any level of valence and arousal, or at a neutral level of one or both of these factors. Circumplex models have been used most commonly to test stimuli of emotion words, emotional facial expressions, and affective states. [9] **Fig. 1** below is a representation of the Valence-Arousal Model.

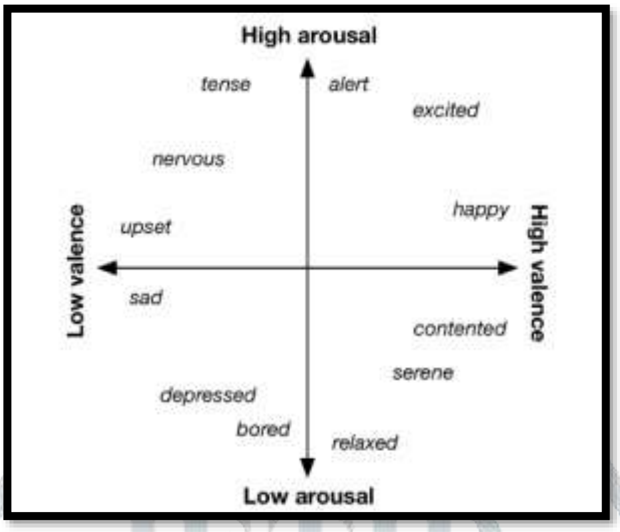

Figure 1: Valence-Arousal Model

III. PROPOSED SYSTEM

The proposed system intends to maximize the retention of the content taught in each lecture by the professor, by monitoring emotions of the students, such as their boredom and then discerning the emotion, which is analysed with the help of a Machine Learning Algorithm.

The system contains a smart wristband of our own making, which contains a Galvanic Skin Response Sensor, which measures the skin electro conductance of a student. A Temperature Sensor, in order to measure the temperature of the student. A heartrate monitor, used to measure the heartrate of the student. These three bodily characteristics for the crux of our input data. These values have a direct co-relation with the mood or the emotions felt by the student at the time of measurement. This data is sent to an Arduino Uno chipset with the help of a Bluetooth Transmitter in the wristband.

The Arduino Uno device acts a mediator of data. It collects the data from the smart wristband with the help of the Bluetooth Sensor and transfers the data to the main computer server, via the Wi-Fi Adapter attached to it.

The computer mainframe (Raspberry Pi 3) contains the Machine Learning Algorithm and the database to which the measured data is first analysed using the supervised learning machine learning algorithm, SVM (Support Vector Machine) by testing the new data and labelling it according to the values of the three features(Skin electro conductance, temperature and heartrate). The data is also added to the database so that the machine can learn on the go as well. The system then gives an output of the level of boredom of the classroom and sends that back to the Arduino Uno device.

The Arduino Uno device then relays the boredom level to the LED Indicator in a way which has two possibilities:
1. If the LED Indicator is 'GREEN', the boredom level of the class is still below the threshold value.
2. If the LED Indicator is 'RED', the boredom level if the class has now breached the threshold value and more than half of the class is now bored.

The computer system also generates a detailed report of the range of emotions felt by the students during the lecture and are sent to their mobile app, which the can access anytime by logging-in to the application. **Fig. 2** below is a diagrammatic representation of the components in the system and the communication that will take place among them.

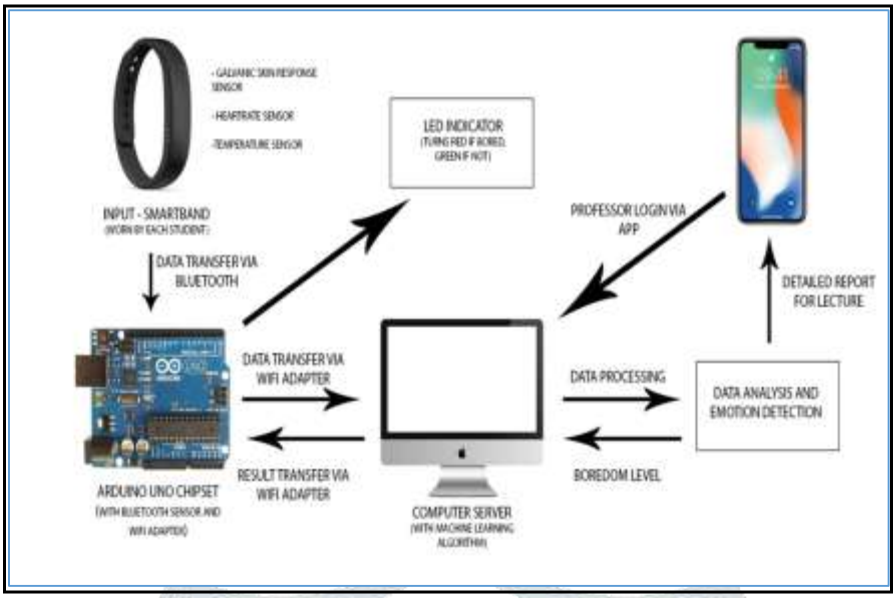

Figure 2: Proposed System Overview

IV. CONCLUSION AND FUTURE SCOPE

The project 'Boredom Level Detection Using Machine Learning' aims to help professors and speakers actually identify the mood of the room and make well-informed decisions, in-order to create an engaging learning environment inside the classroom where the average student does not get bored by the subject. This will eventually prevent students from developing negative emotions towards a particular teacher and subject and help them fall in love with learning, as the professors will then have to go the extra mile to make the lectures more interactive and exciting.

The major challenge we face is in the fabrication of a chip that can help us develop a portable model of our prototype and can be manufactured and provided to each and every student of our college. Hence, the 'smart-band' in our proposed system is currently left under the future scope of this project.

The GSR Sensor, the temperature sensor and the Pulse Sensor have all been connected physically to the Arduino Uno Board. Another challenge we face is in the creation of a dataset for the SVM machine learning algorithm, to facilitate the classifier and obtain an efficient output in the form of an emotion that is detected. The use of the GSR Sensor and SVM classifier is based on the literature that we have surveyed, which has proven to give an accuracy of at least 80%.

V. REFERENCES

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