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Drowsiness Detection for Online Classes

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ABSTRACT: Drowsiness is a major reason for the poor performance of the students during online classes and has significant effect in their learning. These can be prevented by warning the students by certain techniques if they found drowsy during the class. This paper proposes monitoring Visual Behaviour of a student in real time to detect the drowsiness of a student. The required features are drawn out from the facial expressions like movement of the head, eye closure, yawning for detecting the state of drowsiness. OpenCV and Dlib were used to detect the expressions in students face and facial expressions were trained under SVM algorithm. If the drowsiness detected over the threshold limit, then the application will detect drowsiness and alert the student by triggering an alarm and with a warning message on the screen if they are not concentrating on the class. The screenshots will be taken automatically as a proof when the student is detected drowsy and those will be saved in a file.

KEYWORDS: Dlib, SVM, drowsinessdetection, online class, Ear Aspect Ratio, Mouth Aspect Ratio.

1. INTRODUCTION

Online classes are happening currently these days. But they seem not as effective as classroom teaching. So, to overcome this problem and make the online courses interactive a drowsiness detection system is implemented which uses the concept of Machine Learning. The online teaching method is not a new one, but with the outbreak of the COVID-19 pandemic, the use of the online platforms has been introduced with better features. In today's scenario, we can a lot of opportunities to learn from anywhere in the world by online teaching and learning platforms and vast scope for gaining knowledge. Every teacher during the online class may face the challenge of monitoring the students. Especially it is a particular challenge if you or your students are new to online classes.

To ensure that students are attentive when you are not together in a physical classroom Some new useful techniques can be used to monitor online students using proctors to monitor student behavior which minimizes the need for monitoring manually. To overcome this issue, we have developed a system which is capable of detecting drowsiness during the online class. When the student is detected drowsy, the alarm will be raised until the student if found to be in a normal state.

II. RELATED WORK

There are many ways for detecting drowsiness. The non-image-based technique that uses physiological signals like Electrooculography (EOG), pulse rate, heartbeat are monitored. By calculating these metrics drowsiness is detected [1]. The electric signals are used to analyze eye movement. With the use of this non-image-based the data can be collected faster.

This is intrusive as the sensors will distract the student. The equipment cost will also increase with the use of sensors in the system. Also, the sensors catch noises and can lead to lower accuracy.

However, including more parameters will help us to increase the efficiency of the detection a bit more. Considering all these details a low-budget student's drowsiness detection system in real time is developed. Here,

we used an image-based method using webcam to detect student’s drowsiness from the visual behavior by using machine learning and image processing techniques which is easy to use and cost effective.

The image-based method using Dlib library which has pre-trained landmark predictor and HOG based face detector are used along with SVM classifier. Subsequently, Facial landmark points are applied to extract EAR (eye aspect ratio) and mouth aspect ratio. The SVM classifier is used to classify the state of the eye and the mouth to detect the yawning and alert [4].

III.METHODOLOGY

Opencv is used here to capture video in real time and analyze features like face detection. Dlib library for mapping facial landmarks on the face with 68 coordinates.

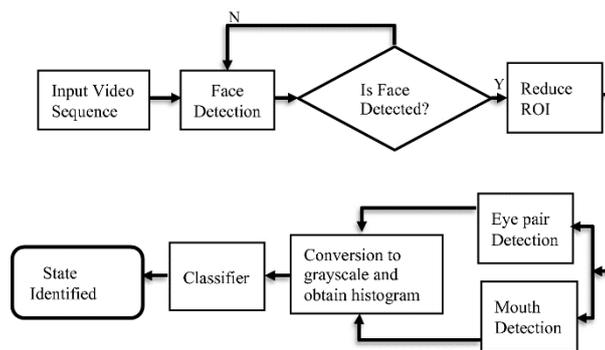


Figure 1. Block diagram

The steps involved in Drowsiness detection are [2-8]:

- i. **Input video:** Opencv is used to connect Video captured using webcam to application and broken into a sequence of images and then extract each image frame by frame and convert image into 2-d array.
- ii. **Face Detection:** The Dlib library is used to detect faces as it contains pre-trained facial landmark predictor and HOG based face detector. The implemented facial landmark detector of dlib produces 68 coordinates which map to specific facial structures. By using iBUG 300-W dataset these 68-point mappings were obtained by training a shape predictor.

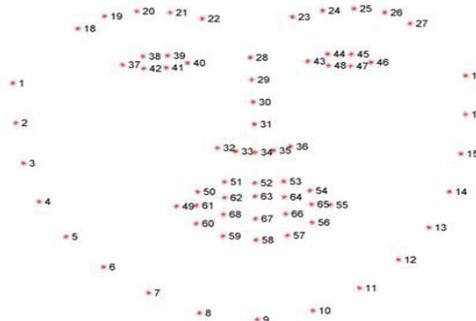


Figure 2. Visualization of 68 facial landmark coordinates from the iBUG 300-W dataset.

- iii. **Face Extraction:** Dlib uses HOG based face detector. A HOG (Histogram of Oriented Gradients) based detector works well for human face detection in images which makes it good for drowsiness detection. In this method, gradient frequencies of image are calculated using hog descriptor in localized regions to form histograms. It can illustrate contour and edge features extraordinarily in various objects to extract face features.
- iv. **Feature Analysis:** Once the face is extracted the attributes of the face can be used as is the case for yawning detection or for eye aspect ratio (EAR) for eye analysis. The RGB images are transformed to the gradation image and then the eyes are detected. The eye aspect ratio algorithm is used in calculating

the ratio of the distances between the eye coordinates.

- v. **Classification:** At this stage classifiers will help in decision making for detecting drowsiness. It detects fatigue with the aid of weighted parameters. The image of eye will be pre-processed by converting the image into greyscale and then the image will be classified using a classifier to judge whether the eye was open or closed. Here SVM classifier is used to classify the state of the eye and the mouth to detect the yawning and alert.

3.1 Eye Aspect Ratio

First, the eye regions are extracted and compute the EAR to determine the position of eyes i.e., closed or open. The six coordinates will represent the eyes from the left side of the eye (like how we look at the other person) to the entire eye in clockwise direction around the remainder of the region [5].

Index list for Left side of eye is from 36 to 41

Index list for Right side of eye is from 42 to 47



Figure 3. (i)Right EAR (ii)Left EAR

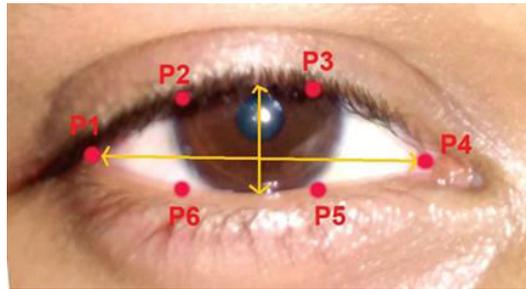


Figure 4. The 6 facial landmarks of the eye.

From this image, we can understand key point that there is a relation between the height and the width of the coordinates of the eyes.

From the 2016 paper by Soukupová and Čech, *Real-Time Eye Blink Detection using Facial Landmarks*, we can then derive an equation (*eye aspect ratio*) EAR that reflects the relation between the coordinates:

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|}$$

Here p_1 to p_6 are 2-dimensional facial landmark locations [8].

The Euclidean distance is calculated for vertically opposite points p_2 to p_6 and p_3 to p_5 and horizontally opposite points p_1 to p_4 .

EAR (Eye Aspect Ratio) is described as the ratio between the distance of the horizontally and vertically opposite points [8-10].

A threshold is set for the eye aspect ratio and mouth aspect ratio and for number of frames. If EAR is less than the limit set and if MAR is greater than the limit for longer than consecutive frames limit the drowsiness alert is given.

EAR for Right eye and left eye are calculated separately for each eye.

$$\text{Eye}_{\text{Blink_Detect}} = (\text{EAR}_{\text{Left_Eye}} + \text{EAR}_{\text{Right_Eye}}) / 2$$

3.2 Mouth Aspect Ratio

Similarly, the coordinates of the mouth are used to determine mouth aspect ratio.

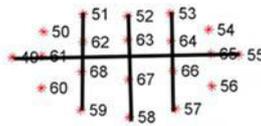


Figure 5. Coordinates of the mouth.

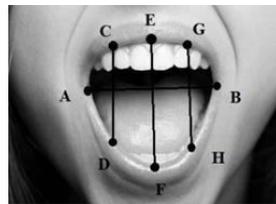


Figure 6. Mouth aspect ratio (MAR)

The coordinates from 49 to 68 represents facial landmark's locations. With these coordinates the mouth state is identified, we can calculate the count of yawn over a period of time [7].

The horizontal and vertical distance of the mouth is calculated as:

$$\text{MAR} = \frac{|CD| + |EF| + |GH|}{3 * |AB|}$$

A threshold is set for the mouth aspect ratio. If MAR is greater than the limit for longer than consecutive frames limit the drowsiness alert is given along with the number of yawns detected.

Head detection: It gives an alert if the student's face cannot be detected by the webcam for 10 seconds (the student does not concentrate on class). The screenshots will be taken automatically as a proof when the student is detected drowsy and those will be saved in a file.

3.3 Support Vector Machine (SVM)

Machine learning algorithms helps in classifying and predicting data so we use various machine learning algorithms as per the dataset. Here SVM classifier is used to classify whether the student is drowsy or not. SVM is a linear model for classification and regression problems. It can solve non-linear and linear problems and can solve practical problems. SVM is a classification algorithm used in the field of pattern recognition and separating data items [11]. The purpose of the SVM is to look at the best hyperplane and to distinguish the data given as two-class or multiclass and creates a hyperplane which divides the data into classes. Here the data was separated in two classes as 0 and 1. Where 0 means student is drowsy and 1 means not drowsy. Thus, it distinguishes drowsy students from non-drowsy students.

IV. RESULTS AND DISCUSSION

The test was performed on publicly available YAWDD and MRL Eye Datasets. The data is divided into 2 sets: 80% training dataset and 20% test data set. The results of drowsiness detection were classified using SVM classification algorithm. The accuracy obtained is 96.71 % for yawn detection and by 93.25% for blink detection on 10 test dataset videos.

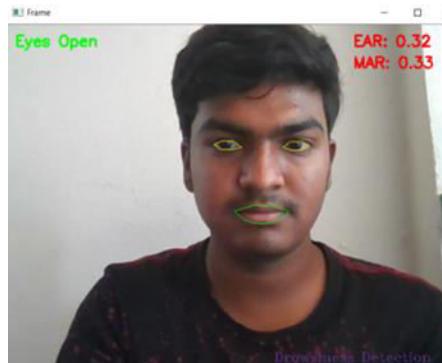


Figure 7. Eyes open



Figure 8. Eyes closed and drowsiness is triggered and alerted.



Figure 9. Yawn detection and the yawn count are shown here.

V. CONCLUSION

With the rise of pandemic online classes are become very common. However, online courses are less interactive as compared to physical classroom teaching. So, to make it interactive a design is implemented to monitor the students and make them active during the online class by warning them using certain techniques by observing the facial features. The implemented system has yawn count, eye blinking and head detection to extract characteristics from video recordings. Finally, the SVM classifier is used to classify data in to two classes (Drowsy /not drowsy). The module automatically captures the image if the student is found drowsy. It tries to make online classes more effective and interactive.

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