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A Novel Approach to Identify Student's Attentiveness Based on Drowsiness Detection During Online/ Live Classes

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Abstract **- This paper proposes a novel and comprehensive approach to identifying student's attentiveness based on drowsiness detection during online/ live classes.**

The trend and necessity of online and live classes in education have got popularity in the last three months' dues pandemic of COVID-19.

Teachers are putting a lot of effort into taking online classes. Still, at the same time, they should also monitor the vigilance level of students to help them not to lose any critical material delivered by a teacher.

The proposed system uses time-efficient image processing techniques to identify nap detection and yawning as the parameters to conclude student drowsiness.

The proposed system continuously captures the subject's image on-site using the web camera and detects the face region, then focuses on eyes and lips using efficient image processing techniques to monitor their behavior. If abnormality either in the behavior of eyes or mouth is detected, it indicates that the student is falling asleep or having a state of drowsiness; therefore, drowsiness is detected, and a warning alarm is generated which can be listened to by a teacher so that he/she may ask the student to be vigilant.

The system is developed using the DIP library of Python and tested in different scenarios and gave satisfactory results.

Index Terms - face detection, edge detection, Sobel filters, eye closer count, yawning, threshold value

INTRODUCTION

Since the starting of 2020, almost all educational institutes have started online classes because of pandemic caused by COVID-19.

At the same time, there is need of research to monitor vigilance level of students because teachers can monitor attentiveness of student when they are physically present but in online classes it is challenging, though required very much.

Drowsiness detection in the user can be generally divided into the following categories:

1. Sensing of physiological characteristics of the user,
2. Sensing of user operation,
3. Sensing of machine response,
4. Monitoring the response of the user.

Among these methods, the best techniques in terms of accuracy are the ones that are based on Human physiological phenomena [1].

They are implemented in two ways:

a.) measuring changes in physiological signals, such as brain waves, heart rate, and eye blinking and
b.) measuring physical changes such as sagging posture, leaning of the user's head and the open/closed states of the eyes [1].

The first technique, while most accurate, is not realistic, since sensing electrodes would have to be attached directly onto the user's body, and hence be annoying and distracting to the user. In addition, long time usage would result in perspiration on the sensors, diminishing their ability to sense accurately. The second technique is well suited for real world conditions since it could be non-intrusive by using optical sensors of video cameras to detect changes.

User operation and machine behavior is good indicator of detecting alertness level of user. These are non-intrusive ways of detecting drowsiness, but unfortunately are limited to machine type and user conditions. The final technique for detecting drowsiness is by monitoring the response of the user. This involves periodically requesting the user to send a response to the system to indicate alertness. The problem with this technique is that it will eventually become tiresome and annoying to the user.

The proposed system is altogether different from discussed techniques. It is based on duration of eye closure (nap detection) and yawning detection of the user. By monitoring the eyes and mouth, it is believed that the symptoms of user drowsiness can be detected. Duration of eye closure is also a significant parameter in detecting drowsiness because in drowsiness state eye closure duration increases to 3-4 seconds (micro sleeps). But it is difficult to predict alertness level based only on eyes functioning because previous researches have proven that eye detection has several limitations like if user is wearing eyeglasses then eye detection becomes a problem [2], [3], [4][31]. Also, eye detection is difficult for users having smaller eyes.

Moreover, if we only look at the number of consecutive frames where the eyes are closed, then at that point it may be too late to issue the warning. To overcome this, proposed system also considers yawning detection as a second parameter to detect drowsiness. Yawning is a very good indicator to detect drowsiness state [4][30][33].

This system has been designed to be deployed in real time environment at very less cost because it does not require additional hardware. Previous works requires extra hardware like frame grabbers [2][29][28][32], infra red camera [3] to detect drowsiness which increases the cost of system to a great extent.

Ideally any software proposed to help us should not affect our normal course of interaction with the system otherwise the usability and acceptability gets hampered adversely.

This system has been proposed take cares of this issue as it is light weight software and used non intrusive approach.

Hence, proposed system identify drowsiness accurately and efficiently while incurring minimized time complexity, space complexity, cost and overheads of using it.

PROPOSED ALGORITHM

1. Take new image from video stream. and convert the image into grayscale.
2. Face detection
3. Cut the image of face into two halves horizontally to get image of eyes and mouth separately.
4. For the image of eyes do the following:
   a. Find edges
   b. Calculate Edge Density.
   c. Compare it with threshold value
      (i) If edge density < threshold value, then generate alarm.
      (ii) If edge density > threshold value, then go to step 1.
5. For the image of mouth do the following:
   a. Find edges
   b. Calculate Edge Density.
   c. Compare it with threshold value
      (i) If edge density > threshold value, then generate alarm.
      (ii) If edge density < threshold value, then go to step 1.
6. then generate alarm, else go to step1.

2.1 Take new image from video stream. and convert the image into grayscale.

```
import cv2

import sys


cascPath = sys.argv[1]

faceCascade = cv2.CascadeClassifier(cascPath)

video_capture = cv2.VideoCapture(0)

while True:

   # Capture frame-by-frame

   ret, frame = video_capture.read()
```

Here, we capture the video. The read() function reads one frame from the video source(webcam)

```
   # Capture frame-by-frame

   ret, frame = video_capture.read()


   gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
```

2.2 Face Detection

```
 faces = faceCascade.detectMultiScale(

      gray,

      scaleFactor=1.1,

      minNeighbors=5,

      minSize=(30, 30),

      flags=cv2.cv.CV_HAAR_SCALE_IMAGE

   )


   # Draw a rectangle around the faces

   for (x, y, w, h) in faces:

      cv2.rectangle(frame, (x, y), (x+w, y+h), (0, 255, 0), 2)


   # Display the resulting frame

   cv2.imshow('Video', frame)
```

FIG 2.1 FACE DETECTION

2.3 Cut the image of face into two

2.4 Finding the edges

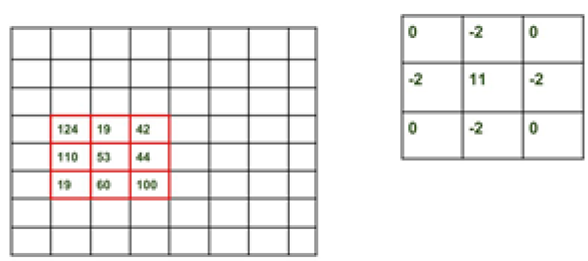
```
import cv2
import numpy as np

#Capture livestream video content from camera 0
cap = cv2.VideoCapture(0)

while(1):

    # Take each frame
    _, frame = cap.read()

    # Calcution of Sobelx
    sobelx = cv2.Sobel(frame,cv2.CV_64F,1,0,ksize=5)

    # Calculation of Sobely
    sobely = cv2.Sobel(frame,cv2.CV_64F,0,1,ksize=5)

    # Calculation of Laplacian
    laplacian = cv2.Laplacian(frame,cv2.CV_64F)

    cv2.imshow('sobelx',sobelx)
    cv2.imshow('sobely',sobely)
    cv2.imshow('laplacian',laplacian)
    k = cv2.waitKey(5) & 0xFF
    if k == 27:
        break

cv2.destroyAllWindows()

#release the frame
cap.release()
```

Calculation of the derivative of an image

A digital image is represented by a matrix that stores the RGB/BGR/HSV(whichever color space the image belongs to) value of each pixel in rows and columns.

The derivative of a matrix is calculated by an operator called the Laplacian. In order to calculate a Laplacian, you will need to calculate first two derivatives, called derivatives of Sobel, each of which takes into account the gradient variations in a certain direction: one horizontal, the other vertical.

- Horizontal Sobel derivative (Sobel x): It is obtained through the convolution of the image with a matrix called kernel which has always odd size. The kernel with size 3 is the simplest case.
- Vertical Sobel derivative (Sobel y): It is obtained through the convolution of the image with a matrix called kernel which has always odd size. The kernel with size 3 is the simplest case.
- Convolution is calculated by the following method: Image represents the original image matrix and filter is the kernel matrix.



Factor = 11 – 2- 2- 2- 2- 2 = 3
Offset = 0

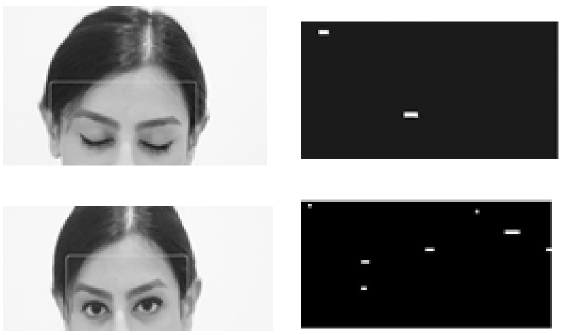
Weighted Sum = 124*0 + 19*(-2) + 110*(-2) + 53*11 + 44*(-2) + 19*0 + 60*(-2) + 100*0 = 117
O[4,2] = (117/3) + 0 = 39

So in the end to get the Laplacian (approximation) we will need to combine the two previous results (Sobelx and Sobely) and store it in laplacian.

Parameters:

cv2.Sobel(): The function cv2. Sobel(frame,cv2.CV_64F,1,0,ksize=5) can be written as cv2. Sobel(original_image,ddepth,xorder,yorder,kernelsize) where the first parameter is the original image, the second parameter is the depth of the destination image. When depth=-1/CV_64F, the destination image will have the same depth as the source. The third parameter is the order of the derivative x. The fourth parameter is the order of the derivative y. While calculating Sobel x we will set x order as 1 and yorder as 0 whereas while calculating Sobel y, the case will be reversed. The last parameter is the size of the extended Sobel kernel; it must be 1, 3, 5, or 7.

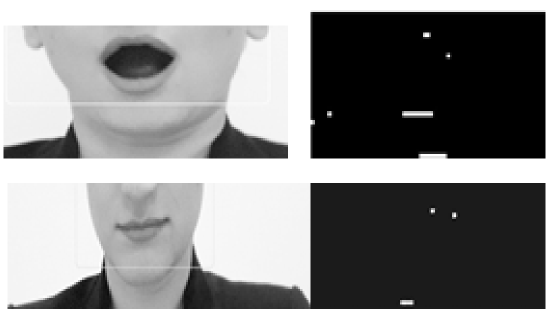
cv2.Laplacian: In the function
cv2. Laplacian (frame,cv2.CV_64F) the first parameter is the original image and the second parameter is the depth of the destination image. When depth=-1/CV_64F, the destination image will have the same depth as the source.



More number of edges were recorded when eyes are open as compared to when eyes are closed.

If eyes are found to be close for 4-5 consecutive frames, then snap is detected and hence warning signal is generated.

Similarly, we calculate edge density in image of mouth to detect yawning. If the number of edges are less than the threshold value, it indicates mouth is closed else it is open. This is shown in fig



If mouth is found to be open for 3-4 consecutive frames then yawning is detected ,hence warning signal is generated

2.5 Need to for Threshold values

Since the proposed system is tested with different users having distinguished characters, system needs to be set to some threshold value for each user.

When we say edge density is more, it should have some value to compare to conclude or state that it is more. Similarly, when we say edge density is less, it should have some value to compare to conclude or state that it is less.

Edge density in images differs from person to person depending on various parameters like gender, skin one, skin color etc.

RESULTS

The Proposed system is implemented in real time and work successfully. A small sample of participants was used to introduce varying levels of stimuli, such as eyewear, eye color, and skin complexion, age and to observe the effects on the system's operational performance. It was tested with people of different features like face shape, complexion, age and skin types and gave high accuracy.

The analysis included data from four different users with various characteristics.

Subjects1 was classified as is middle aged boy with oval face having dark complexion.

Subject 2 was classified as middle aged girl with oblong face having fair complexion.

Subject 3 was classified as old aged man with sqaure face type with whitish complexion

Subject No	Gender	Age	Complexion	Face Shape	Eye Color	Eye glasses	Contact lens
1	Male	31	Dark	Oblong	Dark Brown	Yes	No
2	Female	27	Fair	Square	Brown	No	Yes
3	Male	50	Whitish	Oval	Black	No	No
4	Male	10	Fair	Round	Black	No	No

Subject 4 was classified as little boy with round face having fair complexion.

The proposed algorithm was implemented in Pyhton using Image DIP library.

CONCLUSION

Student alertness detection system has been proposed based on drowsiness detection. The proposed system is based on eyes closer duration, & yawning detection of the user.

The system continuously captures the image of the student attending online classes and detects face region, then eyes and lips are detected in the face under consideration to determine if eyes are closed or open, if eyes found to be closed for 4-5 consecutive frames or lips are found to be open for long duration (yawning), for 3-4 consecutive frames then it is concluded student is feeling sleepy or having state of drowsiness therefore alarming signal will be notified to teacher in the form of alarm signal.

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