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Real Time Eye Blinking and Yawning Detection

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ABSTRACT

Detecting eye blink and yawning is important, for example in systems that monitor the vigilance of the human operator, eg; Driver's drowsiness. Driver fatigue is one of the leading causes of the world's deadliest road accidents. This shows that in the transport sector in particular, where a driver of heavy vehicles is often open to hours of monotonous driving which causes fatigue without frequent rest periods. It is therefore essential to design a road accident prevention system that can detect the driver's drowsiness, determine the driver's level of carelessness and warn when an imminent danger occurs. In this article, we propose a real-time system that uses eye detection techniques, blinking and yawning. The system is designed as a non-intrusive real-time monitoring system. The priority is to improve driver safety without being intrusive. In this work, the blink of an eye and the driver's yawn are detected. If the driver's eyes remain closed for more than a certain time and the driver's mouth is open to yawning, the driver is said to be fatigue.

KEYWORDS: *eye blinking, yawning detection, Viola-Jones Algorithm*

I. INTRODUCTION

Detecting eye blinks is important for instance in systems that monitor a human operator vigilance, e.g. driver drowsiness [1], in systems that warn a computer user staring at the screen without blinking for a long time to prevent the dry eye and the computer vision syndromes [2],

In human computer interfaces that ease communication for disabled people, or for anti-spoofing protection in face recognition systems [2]. In this paper, we are focusing on designing of a system that will monitor the open or close state of driver's eyes and yawning in real time.

The techniques of drowsiness/fatigue detection can be broadly classified into three major categories: Physiological measures, indirect vehicle behavior and directly observable visual behaviors [6], [7]. The best detection accurate techniques are based on physiological phenomena like brain waves, heart rate, pulse rate and respiration. These techniques are intrusive, since they need to attach some electrodes to the drivers, causing annoyance to them.

Driver drowsiness is one of the biggest safety issues facing the road transport industry today and the most dangerous aspect of driver fatigue is falling asleep at the wheel [4]. Fatigue leads to sleep, it reduces reaction time (a critical element of safe driving). It also reduces vigilance, alertness and concentration so that the ability to perform attention-based activities (such as driving) is impaired. The speed at which information is processed is also reduced by sleepiness. The quality of decision-making may also be affected [5].

Developing vision based warning systems for drivers is an increasing area of interest. Computer vision has gained a lot of importance in the area of face detection, face tracking, eye detection, Yawning detection for various applications like security, fatigue detection, biometrics.

Driver falls in micro sleep, results in collision with object or vehicle, or they cannot recognize that he or she has drifted into a wrong lane. The consequences of a drowsy driver are very dangerous and lead to loss of lives, casualties and vehicle damage.

The purpose of this paper is to develop a system to detect eye blinking and yawns. Emphasis will be placed on designing a system to accurately monitor the open or closed state of the eyes and the yawning conditions in real time. By monitoring the eyes and mouth, it is believed that the driver's fatigue symptoms can be detected early enough to prevent a car accident. Fatigue detection involves a sequence of images of the eyes and mouth, as well as the observation of eye movements and movements. It also implies the yawning state of the mouth.

This paper focuses on the position of the eyes, which consists of searching for the entire eye image and determining the position of the eyes using a self-developed image processing algorithm. Once the eye position is identified, the system is designed to determine if the eyes are open or closed and to detect fatigue of driver.

II. METHODOLOGY

In this paper, we represent a methodology for detection of eye blinking and yawning robustly in real time environment. The condition of closed eyes and open mouth to observe yawning are detected simultaneously. This is continuously capturing the real time video using webcam and Viola Jones Algorithm is used to detect the eye and mouth. This work is based on the combination of yawning and eye blink detection technique. This work is composed of various steps as under:

- Face, eyes and mouth detection
- Eye blinking detection (open/close)
- Yawning detection (open)

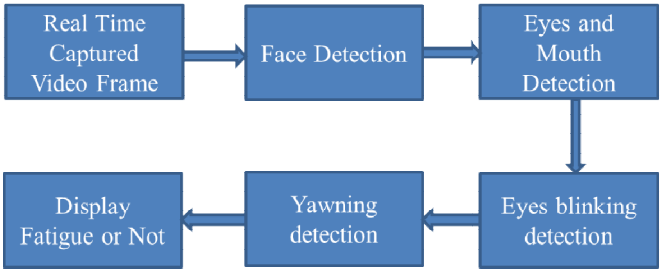

Figure 1 Block diagram of proposed system

A. Video Frames

When the system is initiated a delay of two to three seconds is experienced for capturing the image for the first time. This results in losing the data from the first three frames. The segment of video thus obtained from the camera is then used to extract each segment of video frame. The system runs at 25-30 frames per second for detecting driver's drowsiness considering eye and yawning in the real time. This application is developed in MATLAB in Windows environment with webcam.

B. Face, Eye and Mouth Detection

The system actually starts its execution once the face has been detected. The images obtained from the frames are now subjected to face detection part of the system. The most commonly used algorithm for face detection is the Viola Jones algorithm. This method focuses on detecting objects in images. Object detection is done by Simple rectangular features, called Haar-like features, an integral Image for rapid feature detection , AdaBoost machine-learning method and cascaded classifier to combine many features efficiently. To detection of face and eyes using 'Viola Jones' method with a training set of faces and eyes provided is taken. Since we already get face center, we can estimate the position of eyes based on the common fact that human's eyes are located in the top half of the face. Considering the center of the eye, and taking ROI of the eye with the assumption that both eyes always blink simultaneously, which can detect the motion of single eye. According to the estimated position, a small rectangle around the center of eye is drawn, and creates a corresponding cv::Mat matrix as the eye ROI, for the use in step2.

C. Viola-*Jones's Object Detector*

Face detection is done by Viola-Jones method developed by Paul Viola and Michael Jones. This method focuses on detecting objects in images. Object detection is done by Simple rectangular features, called Haar-like features, an integral Image for rapid feature detection , AdaBoost machine-learning method and cascaded classifier to combine many features efficiently[8]. These methods are described as follows.

1. Haar-Like Features

Haar-like feature considers adjacent rectangular regions at a specific location in a detection window. It sums up the pixel intensities in each region and calculates the difference between these sums. This difference is then used to categorize subsections of an image. The key advantage of a Haar-like feature over most other features is its calculation speed. Due to the use of integral images, a Haar-like feature of any size can be calculated in constant time (approximately 60 microprocessor instructions for a 2-rectangle feature).

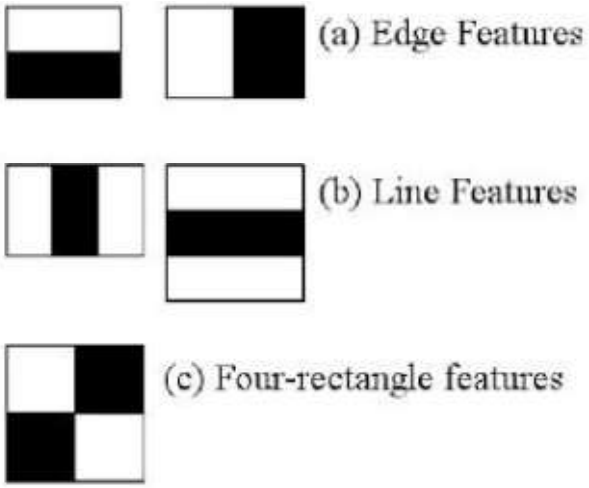

Figure 2 Haar-like features

2. Integral Image

The simple rectangular features of an image are calculated using an intermediate representation of an image, called the integral image. The integral images are an array which consists of sums of the pixels' intensity values located directly to the left of a pixel and directly above the pixel at location (x,y) inclusive. Here, A[x,y] is the original image and Ai[x,y] is the integral image[8].

$$Ai[x,y] = \sum A[x',y'], x' \le x, y' \le y$$

3. AdaBoost

Adaboost, nothing but "Adaptive Boosting ", is a machine learning method given by Yoav Freund and Schapire in 2003. It can be used with many other types of learning algorithms to improve their performance. Adaboost takes a number of positive and negative images features and training sets, The machine creates a set of weak classifiers of Haar-like features. It selects a set of weak classifiers to combine and that assigns lesser weights to good features whereas larger weights to poor features. This weighted combination gives strong classifier.

4. Cascaded Classifier

The cascade classifier consists of number of stages, where each stage is a collection of weak learners. The weak learners are simple classifiers known as decision stumps. Boosting is used to train the classifiers. It provides the ability to train a highly accurate classifier by taking a weighted average of the decisions made by the weak learners.

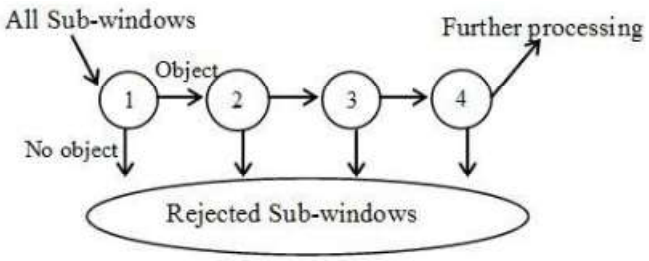

Figure 3 Cascades of Classifiers

Each stage of the classifier shows the region defined by the current location of the sliding window as either positive or negative. Positive indicates an object was found and negative indicates no object. If the label is negative, the classification of this region is complete, and the detector shifts the window to the next location. If the label is positive, the classifier

passes the region to the next stage. The detector reports an object found at the current window location when the final stage classifies the region as positive. It is used to eliminate less likely regions quickly so that no more processing is needed.

D. Eye blinking (open/close) detection

The template matching method is used to detect the eye is open or close. The various conditions of eye images in database are correlated with detected eye image. The template-based methods search for eye image matched to a template of generic eye model designed by eye shape. Since people always blink both eyes at the same time, so in this phase, only right eye is monitored. To detect eye blinking, the current state of the eye is needed as either open or closed. If the state of eye changes from closed to open, it indicates an eye blinking. If the state of the eye keeps closed for a certain amount of time, the eye will be detected as closed.

A ring buffer with a length of 100 is considered in this work here each frame, if eye blinking is detected, 1 otherwise 0 is written into buffer. So, when the system warms up (after the very first 100 frames), it will calculate the eye blinking rate, and keeping update at every frame.

E. Yawning Detection

The yawning motion is detected by correlating the images of mouth in database. The various stage of captured mouth models are collected in database. And then template matching method is used to detect the open or close condition of mouth. With matching method, it is very easy to decide if a person is yawning or not by checking the stage of the mouth keeps open for a certain amount of time, and this is a way we do it.

III. Experimental Results

The performance of eye blinking and yawning detection system has been measured under different conditions. In this work, eye blinking rate and yawning is measured to detect drowsiness. Because when someone felt sleepy at that time his/her eye blinking are different from normal situations and yawning often so that easily detect drowsiness. Fig. 4 to 7 shows the eye blinking and yawning based drowsiness detection. First, the face is detected and tracked in the series of frame shots taken by the camera. In this system the position of eyes and eye states are monitored through time to estimate eye blinking frequency. The next step is to detect and track the location of the mouth. After detection of the mouth, the yawning state is detected.

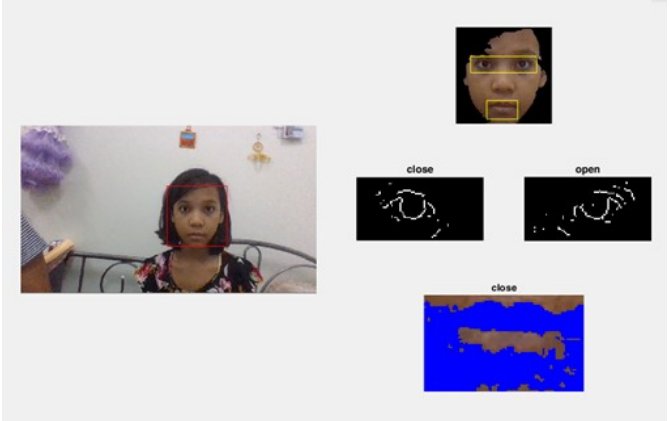

Figure 3 Screenshot showing the eyes open and mouth closed condition

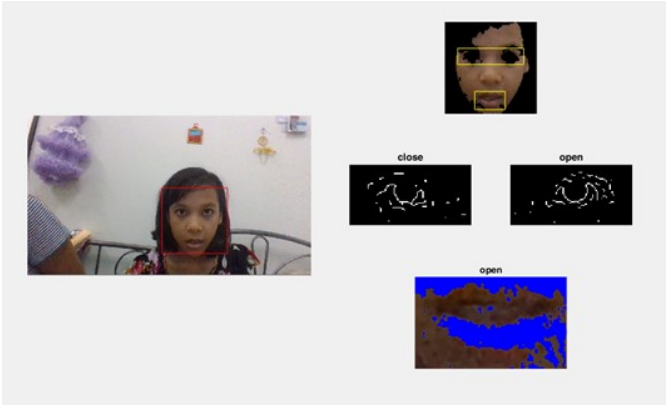

Figure 4 Screenshot showing the eyes open and mouth open condition

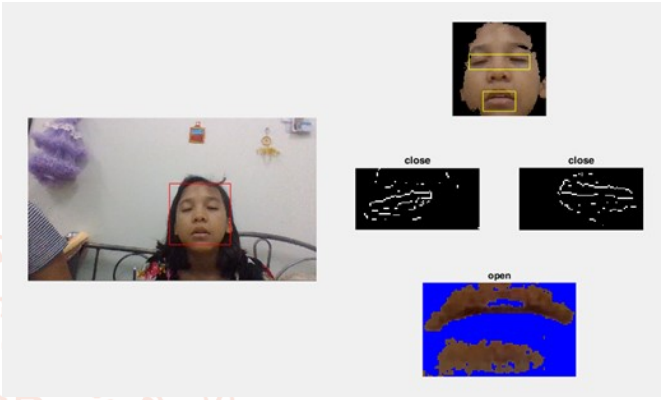

Figure 5 Screenshot showing the eyes close and mouth open condition

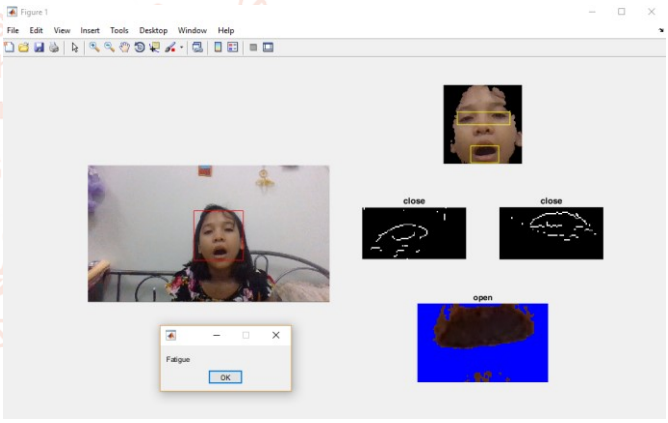

Figure 6 when both eyes are closed and mouth are open frequently showing the warning message '' Fatigue ''

IV. Conclusion

In this article, we presented a low cost yet effective real-time blink and yawning detection system. Through our extensive experimental results, we find that using the Haar classifier and the template-matching method has satisfactory detection speed and accuracy. This application can be implemented in the real time to reduce traffic accidents rate due to drowsy drivers and it can also help drivers to stay awake when driving by giving a warning when the driver is sleepy.

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