Real Time Driver's Drowsiness Detection System Based on Eye Conditions

Asad Ullah, Sameed Ahmed, Lubna Siddiqui, Nabiha Faisal

Abstract— This paper presents a design of a unique solution for detecting driver drowsiness state in real time, based on eye conditions. Many approaches have been used to address this issue in the past. But this paper presents a simple algorithm based solution with minimum hardware requirements. Under the controlled environment, the proposed system is successfully operated to generate results with approximately 90% accuracy. The system tends to use a web camera to capture a series of images. These captured images may further be stored as individual frames in our system. The frames so formed, are provided as input to face detection software. In terms, our required feature (eye) is extracted from the image. Individually working on each eye, the system establishes a condition and suggests a specific number of frames with the same eye condition that may be registered. The result of these images may be taken as input to obtain the level of drowsiness that a driver may encounter at any certain stage while driving a vehicle.

Index Terms— Driver's drowsiness, face detection, eye detection, eye condition, intensity values

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1 INTRODUCTION

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 [1]. 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 [2].

Driver falls in micro sleep, results in collision with object or vehicle, or they can not 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 spectra of injuries are insidiously taking a greater toll on human life and property worldwide. Overall 10-15 million people are injured every year in road traffic collisions. It is projected that globally by 2020 RTCs (Road Traffic Crashes) will account for about 23 million deaths and RTIs (Road Traffic Injuries) will be the third leading cause of death and disability as compared to their present ranking of ninth. In Pakistan there are about 26 deaths from road traffic accidents per 100,000 populations, compared to Europe where the death rate averages is 14.5 per 100,000 [2].

As the most important safety factor, it is necessary to make some serious measures, in order to improve working conditions of drivers, so that negative consequences subjected by a drowsy driver can be minimized.

Computer Science and Engineering contributes their responsible role for development and betterment of society by providing their valuable services in various fields belong to different aspects of life. Driver drowsiness detection system is such an example that can be used as a security measure that alerts the drowsy driver while driving, in order to safeguard himself as well as others.

In this paper we proposed a real time driver drowsiness detection system-**RDDDS**. It is non-intrusive system for monitoring driver drowsiness based on open and close conditions of eyes. Eye behaviors provide significant information about driver's alertness and that if visual behavior can be measured then it will be feasible to predict driver's state of drowsiness, vigilance or attentiveness [3]. The acronym **RDDDS** is used for a proposed system throughout the paper.

The paper describes the related work in section 2, proposed architecture in Section 3, Implementation in Section 4. Experimental results in Section 5 and conclusion in Section 6.

2 RELATED WORK

The techniques of drowsiness/fatigue detection can be broadly classified into three major categories: Physiological measures, indirect vehicle behavior and directly observable visual behaviors [4], [5].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. Some representative projects in this line are the MIT Smart Car [6], and the ASV (Advanced Safety Vehicle) project performed by Toyota, Nissan [7].

The electroencephalographic (EEG) algorithm, which is a physiological sleepiness measure, has been studied to detect drowsiness as well. Most of these studies have used EEG to validate the existence of drowsiness when other measures are being evaluated rather than as a fatigue detection measure [8], [9].

Ji and Yang propose a real-time prototype computer vision system for monitoring driver vigilance [10]. The main components of the system consist of a remotely located video CCD camera, a specially designed hardware system for real-time image acquisition and for controlling the illuminator and the alarm system, and various computer vision algorithms for simultaneously, real-time and non-intrusively monitoring various visual bio behaviors that typically characterize a driver's level of vigilance. The visual behaviors include eyelid movement, face orientation, and gaze movement (pupil movement) [3].

Eriksson and Papanikolopoulos present a system to locate and track eyes of the driver. They use symmetry-based approach to locate the face in a gray image, and then eyes are found and tracked. Template matching is used to determine if the eyes are open or closed [11]. Singh and Papanikolopoulos propose a non-intrusive vision-based system for the detection of driver fatigue [12]. The system uses a color video camera that points directly towards the driver's face and monitors the driver's eyes in order to detect micro-sleeps.

Smith, Shah, and Lobo present a system for analyzing human driver alertness [13], [14]. The system relies on an estimation of global motion and color statistics to robustly track a person's head and facial features.

PERCLOS (Percent Eye Closure) methodology, a video based method that measures eye closure, is a reliable and valid determination of a driver's alertness level. PERCLOS is the proportion of total time that the driver's eyelids are closed 80% or more and reflects slow eyelid closures rather than blinks [15].

Liu, Xu and Fujimura present a real-time eye detection and tracking method that works under variable and realistic lighting conditions [16].

Face LAB is a tool that can be used to measure driver visual behavior, including fatigue and inattention [17]. It is different from most other measures f eyes closure and gaze direction [3].

The head position sensor system MINDS (Micro-Nod Detection System) proposed by ASCI is conceptually designed to detect micro-sleep events occurring in association with head nodding through assessing the x, y, and z coordinates of the head through conductivity measurements [18].

3 PROPOSED SYSTEM- RDDDS

Fig 1. Presents the basic architecture for the proposed RDDDS. A web camera capable of capturing a video without blurring them with a resolution of six mega pixel minimum is used. Speakers are used for the proposed system as it generates the output in terms of an alarm.

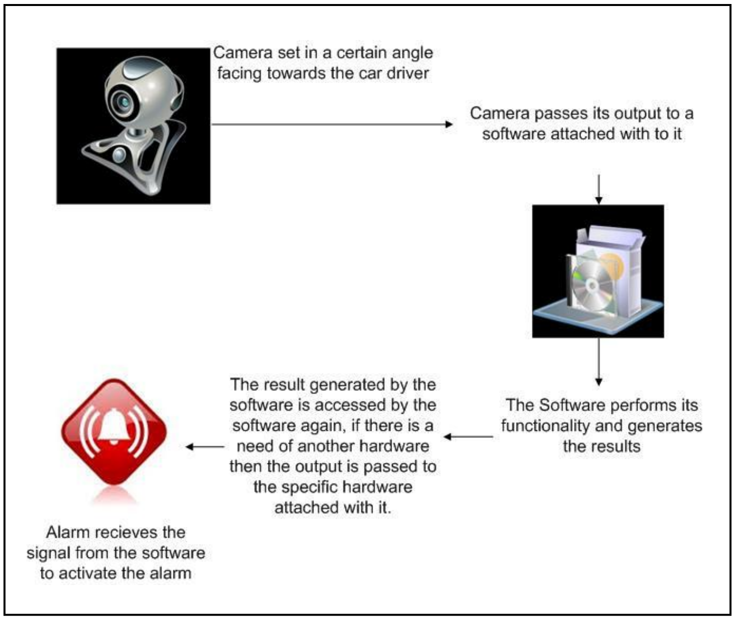
Camera set in a certain angle facing towards the car driver
Camera passes its output to a software attached with to it
The Software performs its functionality and generates the results
The result generated by the software is accessed by the software again, if there is a need of another hardware then the output is passed to the specific hardware attached with it.
Alarm recieves the signal from the software to activate the alarm

Fig 1. Architecture of RDDDS.

Following subsections illustrates the series of steps organized for the proposed system – RDDDS

3.1 Camera settings and initialization

The camera must be placed at a distance of 40 cm to 50 cm from a driver. This distance is approximately equal to the distance between the car steering and the driving seat. The camera must be placed at an angle of 45 degrees from the driver's face. At an angle between 35-50 degrees the face can be captured with perfection and ease.

The first step is initialization of a camera and video processing unit, it acquires an image of the driver's face. Therefore, it is assumed that the eye is a plane Perpendicular to the optical axis of the camera, which is a photo eye 'in the central part of the frame.

3.2 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 i.e. 30 frames per second.

3.3 Face Detection

The RDDDS 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 [19].

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3.4 Eye Detection

Each face detected is stored for half a second to crop the image in order to detect the eye. Our proposed algorithm CropEye is used for eye detection. CropEye algorithm divides the face horizontally into two segments i.e. upper segment and a lower segment. Upper segment contains the image between the forehead to the eyes, and lower segment contains the image between the nose to the chin. We take into account the upper segment and lower segment is discarded. The upper segment again is divided horizontally into 2 segments, this time upper up segment from the forehead to an eyebrow and the upper lower segment from eyebrow to a lower eyelash. After the eyes have been extracted from the image it is then that the current frame is replaced by a new one. The eyes extracted are now categorized in two parts through vertical calibration - the left eye and the right eye.

I=Face segment/2
A=Upper segment
B=Lower segment
A/2
Now we get,
A1=Upper_up segment
A2=Upper_low segment
A2/2
Now we get,
R=Right eye and L= Left eye

3.5 Check condition for open and closed eyes

After the eye has been detected, the next step is to detect the eyes condition either they are open or close, so for this purpose intensity values are used. A graph is plotted which calculates the intensity distance in the eye separately through the eye lashes and eye brow and check the state of an eye on this intensity distance. If distance is large, eye is close and when distance is less, eye is open. The distance can be evaluated by analyzing the samples of images. Both the eyes are binarized to determine the threshold value and then the results are produced. If the system encounters five consecutive frames with the eyes closed the alarm is triggered for the next five frames.

4 IMPLEMENTATION

The work under discussion is implemented in Matlab2012a. The RDDDS minimally uses six mega pixel webcam mounted on the dashboard of a car, without blurring them. The flow model depicted in Fig 2 shows the stepwise execution of RDDDS and will be discussed in the following subsections.

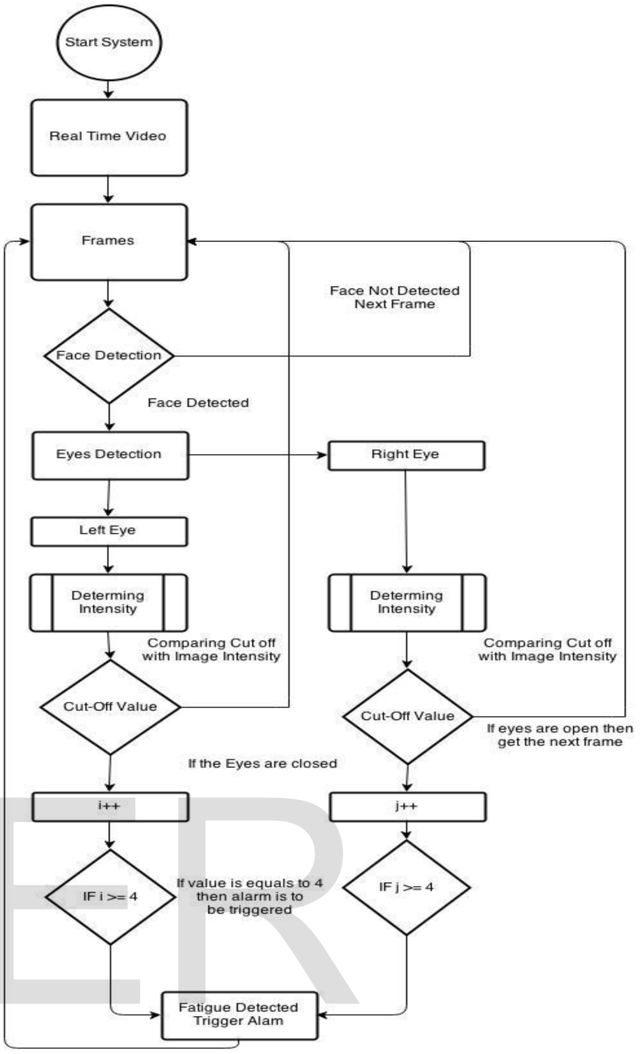

Fig 2. The Process flow of RDDDS. .

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 system actually starts its execution once the face has been detected. Each face detected is stored for half a second to crop the image in order to detect the eye. After the eyes have been extracted from an image, the current frame is replaced by a new one. The eyes extracted are now categorized in two parts - ***the left eye and the right eye***. Both the eyes are binarized to determine the threshold value and then the results are produced. If the system encounters five consecutive frames with the eyes closed the alarm is triggered for the next five frames.

Creating a real time system means high speed processing. Thus it was decided after generating several results that our proposed system will not be storing the old results as they had no significance and consumed a lot of space therefore slowing down the whole system. So we have taken each frame, generating and saving the results and replacing the previous frame with the current new frame.

Once an image is obtained from a real time detection camera its analysis takes a couple of seconds to generate the results and the accumulation of many frames together will only result

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in a degraded real time system, so it was concluded that for each second a frame rate should be decided. A frame rate on the average of four frames per second is taken in for processing.

The algorithm implemented for object detection of this system is Viola–Jones [19] algorithm. It is successfully implemented for the face(s) within a frame. This algorithm is also the most popular and most widely used algorithm for face detection. OpenCV library is used for the detection of a face.

This algorithm has the power of searching 60 frame and image in just 0.09 seconds, so it can search approximately 5940 frames in an image in one second. Fig 3 shows how frames are formed.

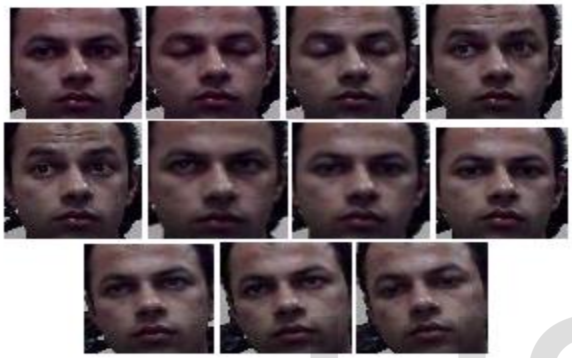

Fig 3. Series of images captured from a webcam and converted to frames.

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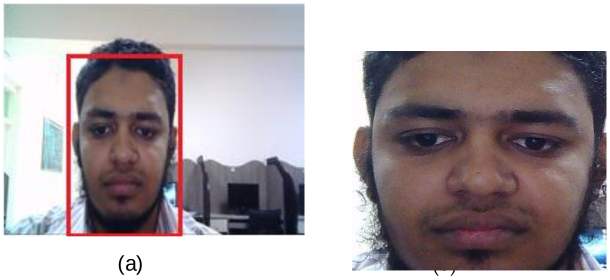
Viola-Jones [19] algorithm is not only significantly used in face detection, but is as useful for facial feature extraction, in our case detecting the eye portion. Initially OpenCV was used to extract the eye portion in a face using the EYEPAIRBIG function [20]. The portion of eyes were successfully detected but we also needed both the eyes identified separately. Even after repeated runs we were not able to get our desired results. Sometimes the eyes were not detected individually, at times any black spot in an image was identified as eyes. Thus it was concluded that even while being one of the most frequently used algorithm for face detection, these algorithms were not able to gather the results we wanted for our calculations. It was then that we designed a new algorithm for eye detection to serve our purpose significantly.



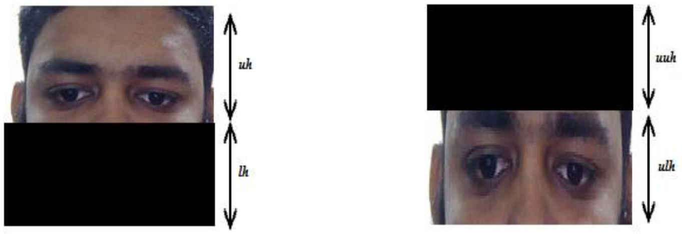
(a)

Fig 4. (a) Face detected in a frame (b) the facial area is separated using Viola Jones algorithm.

The Algorithm thus designed was named as cropper algorithm. The name thus given was on the basis of the fact that this algorithm performed our necessary cropping in an image. The algorithm proceeds in the following steps.

4.1 Selective Cropping of the face

Initially the algorithm crops the face horizontally into two portions as shown in Fig 5(a). The upper half (uh) from head to nose and the lower half (lh) from nose to the chin. The same process is repeated on uh as shown in Fig 5(b), this time the two horizontal regions being upper-upper half (uuh) – from head to lower forehead and the upper-lower half (ulh) – from eyes to upper nose.



(a) (b)

Fig 5. (a) Detected face horizontally divided into 2 halves namely upper half uh and lower half lh , and (b) The upper half selected portion of the image is further horizontally divided into 2 halves namely upper upper half uuh and upper lower half ulh.

4.2 Disseminiating two eyes

The region selected from Fig 5(b) is ***ulh*** which contains the eyes, this portion is now divided vertically into two equal halves i.e the ***lefteye*** and the ***righteye*** regions. This gives us sufficient information for applying our proposed algorithm RDDDS. A function ***CropEye()*** is developed which is applied on Fig 6 to give us threshold values.

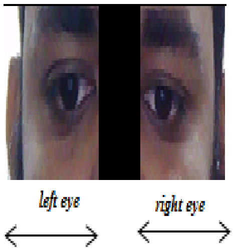


Fig 6. Eyes are extracted by vertical division of ulh and are termed as a left eye and a right eye.

4.3 Threshold Values

The test sample set thus obtained, comprised of 50 random subjects. The proposed algorithm was implemented to find the threshold value of each eye. These threshold values actually played a very important role in identifying the condition of the eye either as completely open or closed. In Table 1 we have included the largely varying values of the threshold of 10 random subjects. As we studied the patterns obtained from Table

1, it was observed that a threshold value of greater than 43 was identified as the absolute condition of drowsiness for a Pakistani face. This value may vary as facial features vary from region to region.

TABLE 1
Threshold Values of 10 Random Persons

Test Images	Threshold Value for left eye	Threshold Value for right eye
Subject 1	43	42
Subject 2	67	66
Subject 3	8	53
Subject 4	34	34
Subject 5	27	30
Subject 6	73	9
Subject 7	56	54
Subject 8	59	2
Subject 9	43	36
Subject 10	62	71

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4.4 Filtered Result

Once the threshold values have been specified, the next task is to filter the results. This is achieved first by converting the colored image into grayscale. A noise 'salt & pepper' of density 0.08 is added to filter the image appropriately. Finally, a median filter of frame size 3x3 is applied to finally obtain a filtered image of the results and remove any insignificant data from the image. Fig 7 depicts two graphs for each state (open eye and closed eye). The first graph gives the average values for all the points identifying the eyes as open/close, whereas the second graph, further averages the values to find the peaks of variations in the curves.

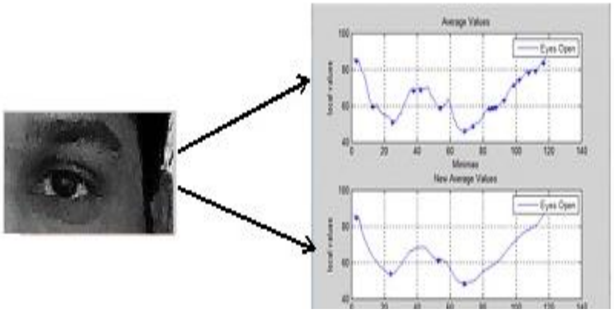


Fig 7(a). An average intensity variation on the face when eyes are open.

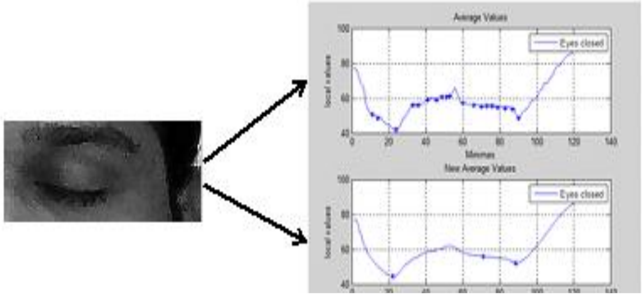
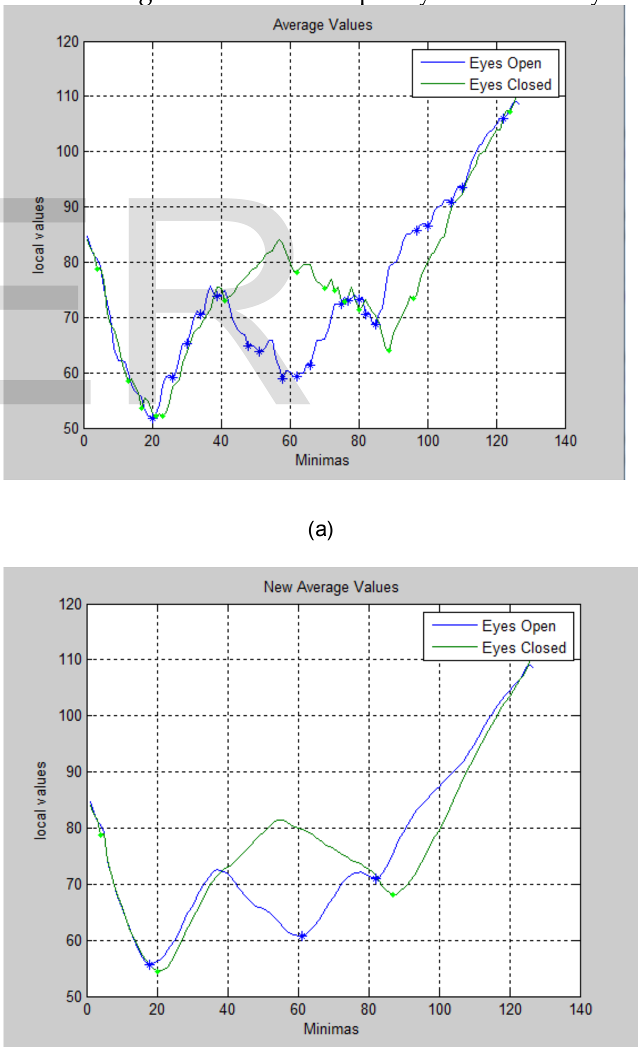


Fig 7(b). An average intensity variation on the face when eyes are closed.

Once we have the average values individually for an open eye and a closed eye state, the final step executed is to find the comparative analysis between the two states. For this purpose we plotted two graphs, Fig 8 (a) with the average values for both the open eye and closed eye states, similarly Fig 8(b) depicts the new average values for both open eye and closed eye.



(a)

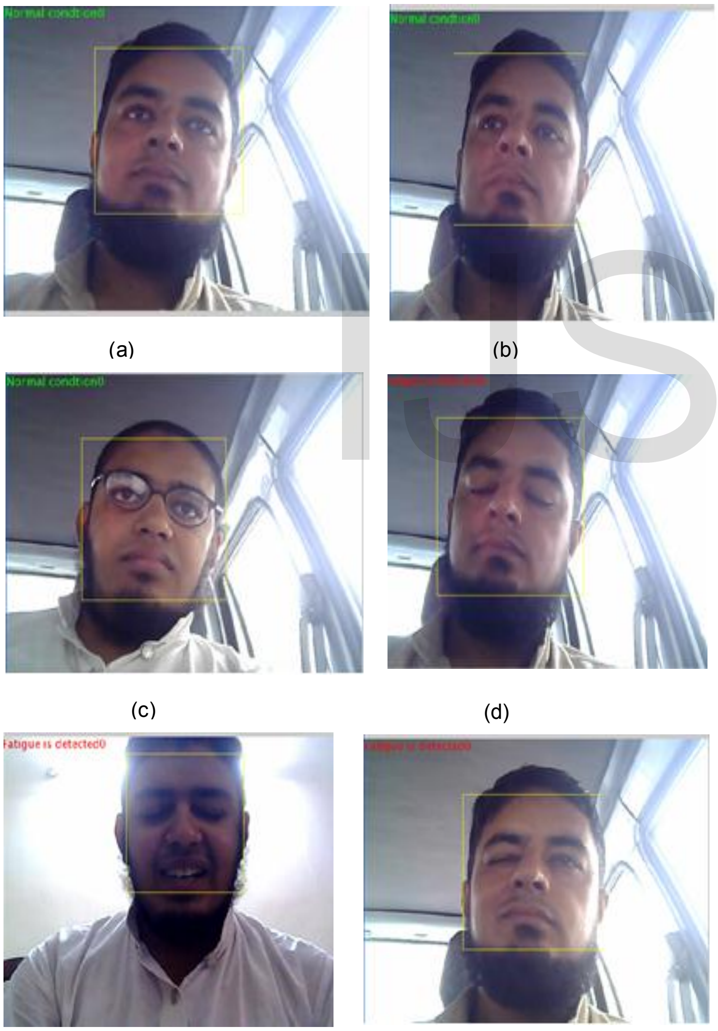
(b)

Fig 8. (a) The average values between minima and local values for both open and closed eye, (b) The new average values between minima and local values for both open and closed eye.

5 RESULT

The system is tested on a PC of Dual Core 1.0 GHz processor with 512 MB RAM. The system can process 15 frames for each second of size 280x140. The system is tested on 1500 sample frames and for 1442 correct result were achieved. The system has got only 58 error frames which were due to a wrong picture capture under the extreme conditions which will be mentioned in conclusion. The system is tested on 50 people and it generates more than 90% accurate results.

Step by step process is already mentioned in implementation section. Fig 9 (a) – (f) depicts the test results of RDDDS with different eye conditions.



(a) (b)

(c) (d)

(e) (f)

Fig 9. Test cases for different eye conditions (a) With ambient light and eyes open, (b) Face titled towards right and eyes open, (c) Eyes open wearing glasses, (d) Driver’s eyes closed, (e) Eyes closed in partial light and (f) One eye closed.

A data set of more than 25 eye conditions have been tested with 90% accuracy. The system detects drowsiness at different levels. These levels may include complete eyes closed, partial closed eyes, one eye closed, right facing imaging, left facing images and many other states.

6 CONCLUSION

The proposed system can be used for driver’s safety and its consequences. The system detects drowsiness of driver through eye conditions. It based on face detection using well known Viola Jones algorithm, eyes are detected through proposed crop Eye algorithm which segments the face in different segments in order to get left and right eye. Conditions of open and close eye are determined by intensity values, distance between eye brow and eye lash is calculated. If calculated distance is greater than threshold value, eyes are closed otherwise open. The threshold 43 and above is set for Pakistani eye feature, it can vary from region to region. An alarm is triggered if eyes are found to be closed for consecutive five frames. The system produces 90% accurate results for 50 different faces. However, its limitation is detecting the eyes of person wearing glasses. Also it does not produce accurate results if any reflective object is found behind the driver.

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