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Tracking Eye State for Fatigue Detection Using Skin Color Segmentation

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Abstract**—**In this paper, an algorithm for drivers' drowsiness detection based on eye states tracking is presented.We use a database which contains 150 images captured from different people in various conditions for better results. These images are captured using a camera located in a car in front of the driver. These images are used for tracking as input of the proposed method. In first step we use color space for drivers' face detection and crop the face from background. In the next step, we estimate the area of the eyes and crop image from this region. Then top and bottom coordinates of the eyes are located using retrench the face pixels from this area and prewitt operator for edge detection. In the last step we count the number of white and black pixels and compare the distance between these coordinates for recognition of the driver's fatigue.

Keywords**—***fatigue detection, face detection, eye detection.*

I.INTRODUCTION

FATIGUE is a major safety concern in many fields, but especially in transportation, because fatigue can result in disastrous accidents. Driver fatigue is very dangerous condition created when a person is suffering symptoms of fatigue while drivingIn 2010, India recorded 1,34,000 road accident deaths highest in the world. The World Bank trends put this figure at 2,00,000 annually ¾ About 5,20,000 road accident injuries and 4,90,000 road accidents occurred in 2010. ¾ About 56 accidents per hour (one accident per minutes). ¾ If a person meets with a road accident in India, there is an over 30 per cent chance of death.

•93% of all accidents are caused due to human factors.

- 80% crashes involve driver inattention within 3 second before the event.
- 30 % talking on phone.
- 300 % dialing phone.
- 400 % drowsiness.
- 28% accidents are rear-end collision.
- 67% of accidental cases to rise by 2020 as per WHO.

So driver fatigue is one of the main ingredients in accidents and criminal casualty in roads. Recently, for these reason there are many researches in this subject for increasing the safety in vehicles. Generally driver drowsiness is main factor in 25percent accidents and 60 percent in accidents that they redound to death. So designing Intelligent Driver Monitoring System that can recognize driver fatigue is so important.

In the past two decades many researchers have begun to pay great attention to the driver safety problem. We can divide most of used techniques for driver fatigue detection to three generic sections. First one consist the systems that investigate physiological information of drivers.

This method focuses on measuring physiological changes of drivers. It can accurately, validly, and objectively to determine fatigue and sleep of the drivers. A significant effort has been made to measure them in laboratory. The popular physiological parameters include electroencephalogram (EEG) electrocardiogram (ECG), and electromyography (EMG). EEG is found to be useful in determining the presence of ongoing brain activity, and its measures have been used as the reference point for calibrating other measures of sleep and fatigue. The second method consist of systems that they use vehicles behavioral for detect driver drowsiness. Such as steering wheel movements, driver's grip force on the steering wheel, speed, acceleration, lateral position, turning angle, changing course, braking and gear changing, etc.

The last one use image processing for detecting driver's physical changes during fatigue. We can observe these physical changes in facial features. Visual behaviors like: eyelid movement, yawing, gazing, nodding and open or closed eyes. The researchers show that the last method is better than the other one. In the last method we focus on detecting fatigue driver based on eye state. It is indicated that the change regularity of eye states have high relativity with the driver's mental states.

II.PROPOSEDALGORITHM

The purposed algorithm is based on changes of eyes state. It considers 6 steps shown in Fig below

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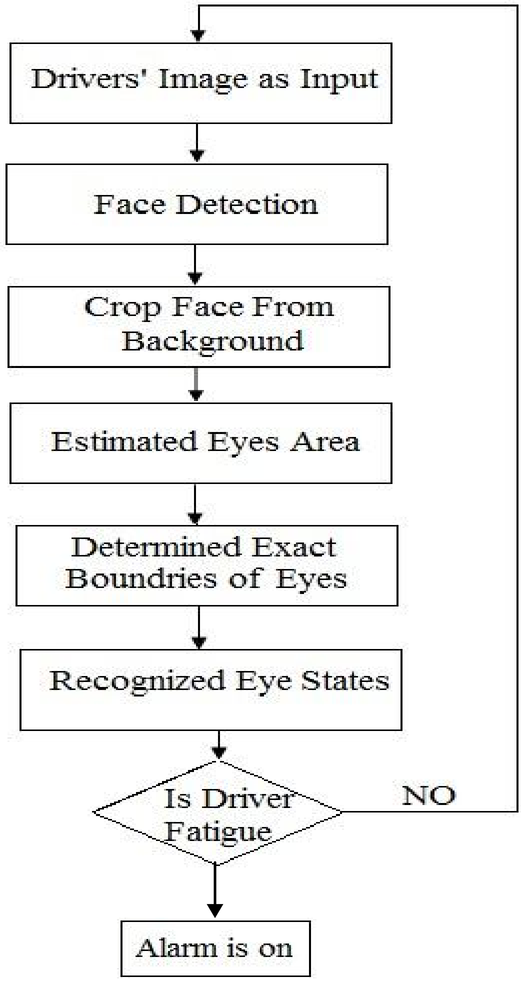

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Fig. 1. Flowchart of the proposed driver fatigue detection system

In the first step we convert video film of drivers' face to consecutive frames of images as input of the algorithm.

A. Face Detection

There are different techniques for face detection, but we can divide all of them into two major categories: face features and face colors. For face features we used distance of two eyes, distance eyes and mouth, distance eyebrow and eye and some other features that are fixed in the face. For second method we have some color space like HSI space, YCbCr space, CMYK and YIQ space. We test HIS color space and YCbCr color space and according to experimental results YCbCr color-space has the better results for face detection.

Face recognition is a field of biometrics together with fingerprint recognition, iris recognition, and speech recognition and so on. Automatic extraction of human head, face boundaries, and facial featuresis critical in the areas of face recognition, criminal identification, security, surveillance systems, human computer interfacing, and model-based video coding. In general, the computerized face recognition includes four steps [1]. First, the face image is enhanced and segmented. Second, the face boundary and facial features are detected. Third, the extracted features are matched against the features in the database. Fourth, the classification into one or more persons is achieved.

We used a CCD camera for capture images, our images are in the RGB color space, so at first we should change it to YCbCr color space whit (1).

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

In this space Y didn't change between various skin color. Chai and Ngan have developed an algorithm that exploits the spatial characteristics of human skin color. A skin color map is derived and used on the Chrominance components of the input image to detect Pixels that appear to be skin. Working in this color Space Chai and Ngan have found that the range of Cb and Cr most representatives for the skin–color Reference map are:

$$80 \leq Cb \leq 120 \text{ and } 133 \leq Cr \leq 173$$

So, for each pixel we should check amount of Cb and Cr if it being in above limitation, amount of this change to1 else change to 0.so we have a black and white image that face detect in it, now should found left and right boundaries of it. In each column of image added amount of whole pixels whit (2) [15]:

$$PV(y) = \sum_{x=1}^{M} F(x, y) \quad - \quad (2)$$

That PV is vertical curve and F(x,y) is input image and it size is M*N(M represented to row and N represented to column).here we have two sudden changes that they are exactly left and right boundaries of face. For horizontal boundaries we can use the same method whit the difference that here we should calculated amount of all pixels in each row whit (3) and last found max and min difference of these:

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$$PH(x)=\sum_{y=1}^{N} F(\text{x}, \text{y}) \text{-} \quad (3)$$

The results of the face detection and boundaries are shown in Fig. 2.

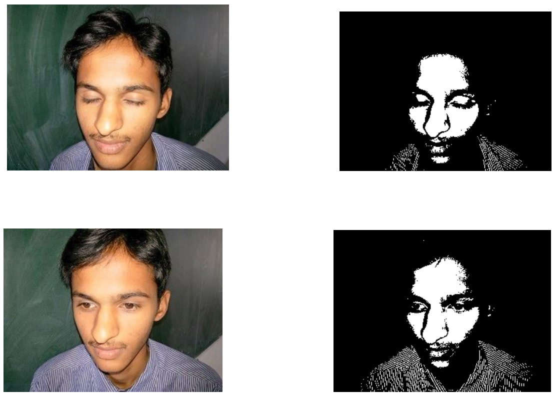

Fig. 2. (a) An input image in RGB, (b) an input image in YCbCr, (c) detected face, (d) detected face in black and white

B.Extracting Exact Eyes Locations

As we know eyes are located in the top middle of face, so for limited the area searches and increasing our speed, at first we estimated eyes region and then determine the exact area of eyes. For this issue we should crop the image from two-fifth and three-fifth areas in the face detection picture. Result of this section is shown in Fig. 3.

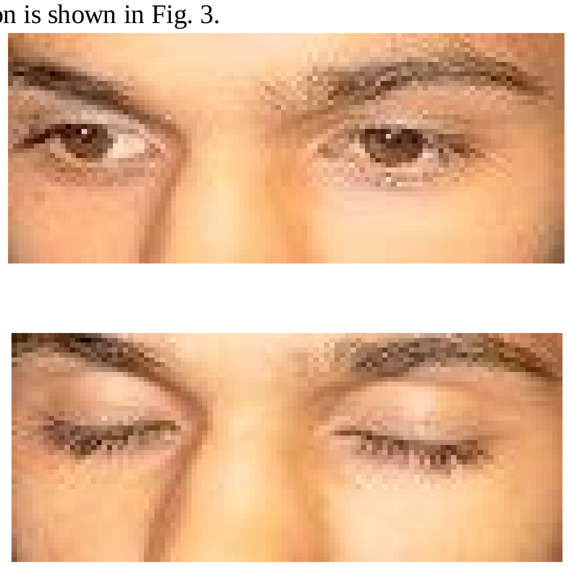

Fig. 3. (a) Open eye detection, (b) close eye detection

According to our ability to recognize eyes state from one of them, so we can crop images from the middle and search exact eye location in this area. Now in this area just eyebrow and eye exist. In this paper we use prewitt operator edge detection for recognize exact coordinate of eyes region. For this issue before using prewitt operator at first we retrench skins region around eyes, then change RGB image to GRAY level. Now employ prewitt operator in gray level images. In this image up and down lines of eyebrow and eye are shown as white lines as can be seen in Fig. 4.

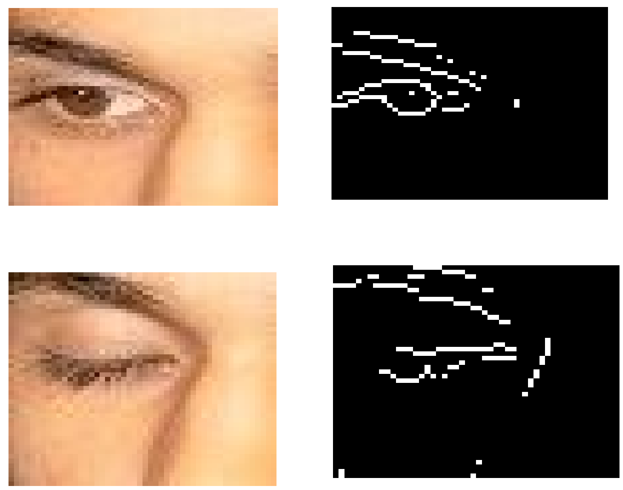

Fig. 4. (a) Open eye estimation, (b) open eye with prewitt operator, (c) close eye estimation, (d) close eye with prewitt operator

Because distance of eyelid in the corner of eyes is small so these lines here are more than the lines in the middle of eyes. So, at first we find the middle axis (M) of image and for M-5 to M+ 5 moves from up to down of image and search for white pixels. Third white pixels are top coordinate of eye, and then repeat this from down to up of image and in this case the first pixel is down coordinate of eye. We can crop image from these coordinates and find exact location of eyes. The result of this section is shown in Fig. 5.

Fig. 5. (a) Open eye detection, (b) close eye detection

C.Fatigue Detection

We use two items for fatigue detection. At first the difference between up and down coordinates of eye is calculated. When the eyes are closed this distance is almost

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zero, so we find threshold for open or close eyes and for each image calculate this distance and recognize eyes states.

If the distances shown those eyes are open we should go in next step and check the number of white pixels. For this issue we should change the RGB recognized images to YCbCr, whit this we can convert the skins pixels that they related to eyelid to gray level pixels. Then in reminder area we start to counter white and black pixels, we have an experimental threshold for the number of these pixels in open and closed eyes that if the number of white pixels more than threshold it means that eye are open and in against way it means that eyes are closed. If eyes are closed for 5 consecutive frame recognized that driver is sleepy.

III.EXPERIMENTAL RESULTS

Table1 shows the experimental result for each section. The codes are written in MATLAB. At first, we fix a camera on a car in front of the driver. Then we capture some videos from 5 drivers in normal conditions. The proposed method has been tested on the resulting 150 images. The whole input image format is 720*1280 and they are in RGB color space.

TABLE 1
The experimental results

	Total number	Correct number	Failed number	Results in percent
Face detection	150	149	1	99.33%
Eye detection	150	149	1	99.33%
Eye localization	150	146	4	97.33%
Fatigue detection	150	144	6	96 %

IV.CONCLUSION

In the present research we have presented a new method for eye detection and localization and a new method for fatigue detection. At first, we convert the images to YCbCr color space and detect the drivers' face and then crop the face from this image. Then eyes area are estimated and exact location of eyes are estimated using a prewitt edge detector. Finally, in this region the algorithm counts white pixels and checks them against a predefined threshold of distance between two coordinates of eyes . The method detects driver fatigue and if the driver is sleepy then it turns the alarm system on.

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