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Detection of Drowsy Driver's through Eye *State Analysis*

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Abstract: ***The increasing number of traffic accidents due to a driver's diminished vigilance level has become a serious problem for society. Some of these accidents are the result of the driver's medical condition. However, a majority of these accidents are related to driver fatigue, drowsiness of drivers. Car accidents associated with driver fatigue are more likely to be serious, leading to serious injuries and deaths. In this paper, an algorithm for drivers' drowsiness detection based on eye states tracking is presented. I 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 I use color space for drivers' face detection and crop the face from background. In the next step, I 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 canny operator for edge detection. In the last step I count the number of white and black pixels and compare the distance between these coordinates for recognition of the driver's fatigue.***

Keywords: Face detection, eye detection, eye state analysis, drowsiness detection.

1. Introduction

According to the National Highway Traffic Safety Administration (NHTSA), driving while drowsy is a contributing factor to 22 to 24 percent of car crashes. This record shows that car accidents caused by fatigue drivers is four- to six-times higher than near-crash/crash risk relative to alert drivers [1] as fatigue drivers fail to take correct actions prior to a collision. Ontario Ministry of Transportation's Driver's Handbook also mentions that "Drowsiness has been identified as a causal factor in a growing number of collisions resulting in injury and fatality. This is mainly due to the fact that driver fatigue impacts the alertness and response time of the driver thus increases the chances of getting involved in car accidents. Drowsy drivers may fall asleep at the wheel or tend to make serious – sometimes fatal – driving errors. Drowsiness and fatigue can often affect drivers' ability long before they notice that they are getting tired. Studies have shown that collisions involving drowsiness tend to occur during late night/early morning hours (between 2:00 a.m. and 6:00 a.m.) or late afternoon (between 2:00 p.m. and 4:00 p.m.) Studies also indicate that shift workers, people with undiagnosed or untreated sleep disorders, and commercial vehicle operators, are at greater risk for such collisions." An important irony of driver drowsiness is that the driver may be too tired to realize his own level of inattention. Hence, driver monitoring systems which can detect lack of attention and alert the driver will play an important role in the automation system of future vehicles to prevent accidents and save lives.

There are different signs and body gestures that can be monitored as indicators of driver fatigue. These include daydreaming while on the road, driving over the center line, yawning, feeling impatient, heavy eyes and slow reaction. A number of related works in the field have addressed the problem of detecting driver drowsiness based on the expressions of the driver's face (i.e. eye motion, yawning, etc.).

2. Existing System

Driving with drowsiness is one of the main causes of traffic accidents. Driver fatigue is a significant factor in a large number of vehicle accidents. The development of technologies for detecting or preventing drowsiness at the wheel is a major challenge in the field of accident avoidance systems. Due to the hazard that drowsiness presents on the road, methods need to be developed for counteracting its affects.

Even each driver thinks that he can control the vehicle very Ill in any time, there still are some risks happened because of the drivers' tiredness, drowsiness, or inattention. In order to prevent their being tired in the driving, some driver assistance systems have been developed to bring the attention of a driver.

There are three kinds of techniques used for detecting a driver's consciousness. The first of all is to detect the driving state [2][3], such as the change of speed, the frequency of turning wheel, or the frequency of braking. Since the traffic cases are so complex, it is not correct enough for real applications. In the second method, I may detect the driver's mental status by the medical instruments [4][5]. Even the detecting results is better than the first method, however, the driver should be asked to wear some instruments in their driving, which will influence their driving and is hard to implement. In the last method, I may install a camera to capture the driver's image continually, and then based on these images to detect their eyes blinking. This is because some researches [6][7] show that eyes blinking have strong relationship with the medical status. In addition of that, this method is more applicable than the others mentioned above.

Since detecting a driver's eye is more applicable than the others, there are many approaches for eyes detection methods proposed in the recent years [8] [9] [10] [3]. In this topic, face detection and eyes locating are often the two main steps. For face detection, there are about three kinds of methods could be utilized, such as machine learning (neural networks [11], principal component analysis [12], support vector machines [13], Kullback-Leibler boosting [14], Gaussian mixtures [15]), shape fitting (ellipse fitting [16], geometrical modeling [17], template matching [18]), and color analysis. For surveys on face detection, I may see [19] and [20].

In the above methods, the machine learning methods need many training data for applying, and the shape fitting methods need more computation than the others, so the color analysis method is more applicable than the others. The only problem is that it could be influenced by the illumination, and the vehicle moving conditions cannot help to face this problem.

3. Proposed System

The purposed algorithm is based on changes of eyes state. It considers 6 steps shown in Fig.1. In the first step I convert video film of drivers' face to consecutive frames of images as input of the algorithm.

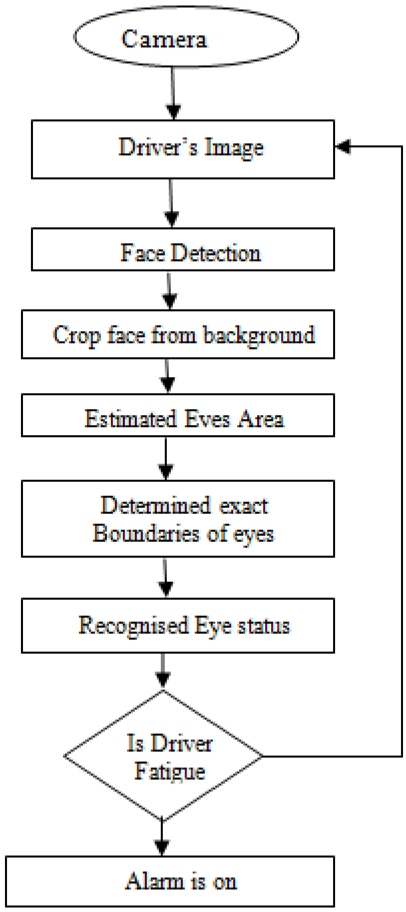


Figure 1: Diagram of the proposed driver fatigue detection system

3.1 Face Detection

There are different techniques for face detection, but I can divide all of them into two major categories: face features and face colors. For face features I 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 I have some color space like HSI space, YCbCr space, CMYK and YIQ space. I test HIS color space and YCbCr color space and according to experimental results YCbCr color-space has the better results for face detection. I used a CCD camera for capture images, our images are in the RGB color space, so at first I should change it to YCbCr color space white.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112 \\ 112 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

In this space Y didn't change between various skin color. Chai and Ngan [21] 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 [22]:

$80 \leq Cb \leq 120$ and $133 \leq Cr \leq 173$

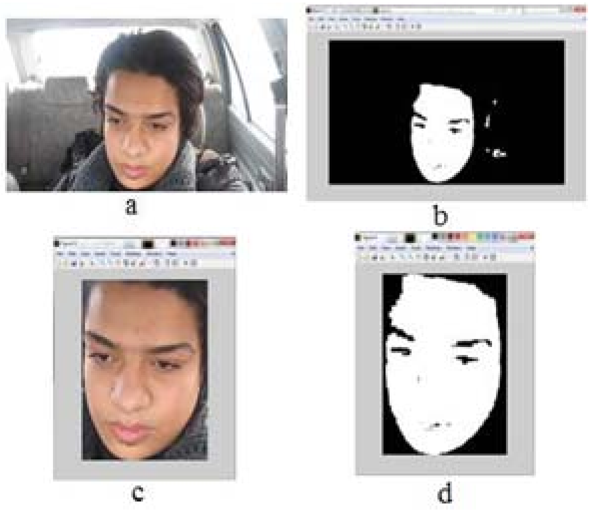
So, for each pixel I should check amount of Cb and Cr if it being in above limitation, amount of this change to1 else change to 0.so I have a black and white image that face detect in it, now should found left and right boundaries of it. In each column of image added amount of whole pixels white (2) [23]:

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

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 I have two sudden changes that they are exactly left and right boundaries of face. For horizontal boundaries I can use the same method whit the difference that here I should calculate amount of all pixels in each row white (3) and last found max and min difference of these:

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

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



3.2 Extracting Exact Eyes Locations

As I know eyes are located in the top middle of face, so for limited the area searches and increasing our speed, at first I estimated eyes region and then determine the exact area of eyes. For this issue I 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.

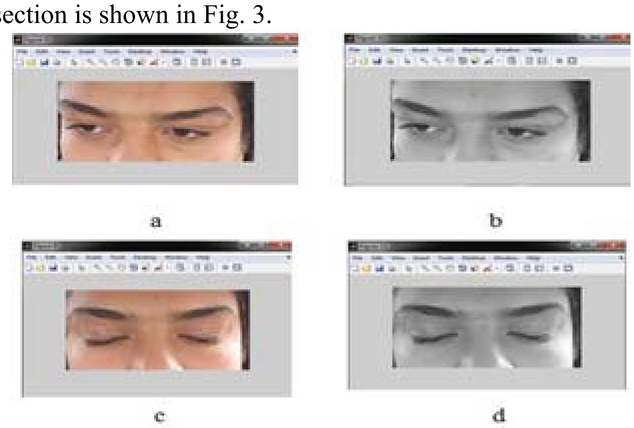


Figure 3: (a) Open eye detection, (b) open eye detection in gray level, (c) close eye detection, (d) close eye detection in gray level

According to our ability to recognize eyes state from one of them, so I 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 I use canny operator edge detection for recognize exact coordinate of eyes region. For this issue before using canny operator at first I retrench skins region around eyes, then change RGB image to GRAY level. Now employ canny 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.

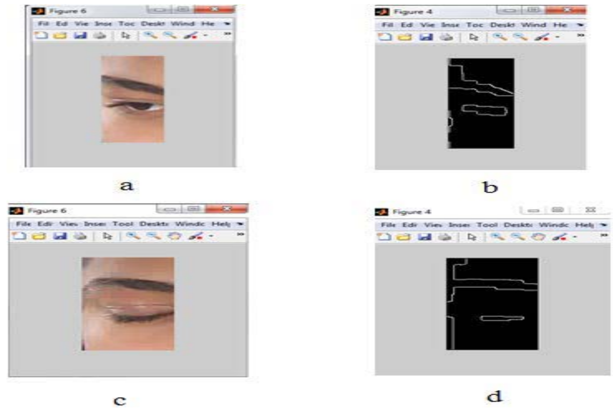


Figure 4: (a) Open eye estimation, (b) open eye with canny operator, (c) close eye estimation, (d) close eye with canny operator

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 I 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. I can crop image from these coordinates and find exact location of eyes. The result of this section is shown in Fig. 5.

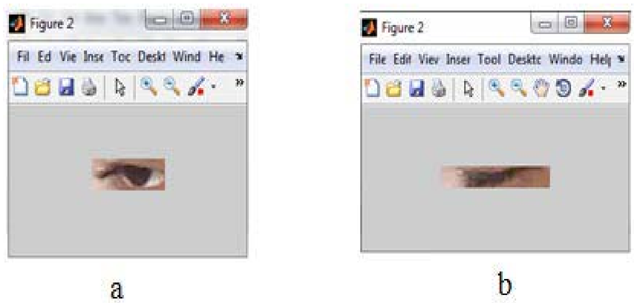


Figure 5: (a) Open eye detection, (b) close eye detection

3.3 Fatigue Detection

I 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 zero, so I 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 I should go in next step and check the number of white pixels. For this issue I should change the RGB recognized images to YCbCr, whit this I can convert the skins pixels that they related to eyelid to gray level pixels. Then in reminder area I start to counter white and black pixels, I have an experimental threshold for the number of these pixels in open and closed eyes that if they 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.

4. Experimental Result

The codes are written in MATLAB. At first, I fix a camera on a car in front of the driver. Then I 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 %

5. Conclusion

In the present research I have presented a new method for eye detection and localization and a new method for fatigue detection. At first, I 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 canny 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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