International Journal of Recent Development in Engineering and Technology
Website: www.ijrdet.com (ISSN 2347-6435(Online) Volume 2, Issue 3, March 2014)

Yawning Detection of Driver Drowsiness

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***Abstract*-- Drowsiness in driver is primarily caused by lack of sleep. However, it can also be induced by extended time on task, obstructive sleep apnea and narcolepsy. "Drowsy drivers usually do not 'drop off' instantaneously. As a substitute, there is a preceding period of quantifiable performance decrement with associated physiological signs." In this paper, we discuss a method for detecting driver's drowsiness and subsequently alerting them. The aim is to reduce the number of accidents due to drivers fatigue and hence increase the transportation safety. Many special body and face gestures are used as sign of driver fatigue, including yawning, eye tiredness and eye movement, which indicate that the driver is no longer in a proper driving condition.**

***Keywords*--Face Detection, Mouth Detection and Yawning Detection.**

I. Introduction

Driving with drowsiness is one of the main reasons for increase in road accidents. Drowsiness will impair drivers' abilities of reaction, information processing, and judgment. It is very helpful to remind them of resting or improving vigilance when drowsiness comes. Visual detection of driver's fatigue as a non-intrusive method is a promising but challenging work. Micro sleep is a typical characteristic of driver drowsiness, which features on seconds of eye closure. So most of previous research focuses their methods on eye blinking detection. The system will be more robust if yawning together with eye blinking is integrated to make joint decision. To the best of our knowledge, little research has been made on this aspect. Yawning detection is obstinate because of inter-person difference of appearance, variant illumination, and especially complex expression and widely changing pattern of mouth. Lip corners are detected and tracked in, but yawning is not used as a cue for determining driver inattention.

Face region is located using a method proposed which runs in real time. According to the inter-frame relations of video, face region is tracked to further improve the real-time capability of the system. And mouth window is localized within face region, which is slightly extended as the searching space for mouth feature analysis.

II. Proposed Methodology

The driver fatigue detection procedure consists of different phases to properly analyze changes in driver's physical gestures and each phase will lead us to detect drivers yawning state accurately. These phases are introduced in detail in the following sections:

- Face Detection
- Eye Detection
- Mouth Detection
- Face Tracking
- Yawning Detection

The overall system diagram is shown in Fig[1]. The details of every single step will be further explained in the following subsections.

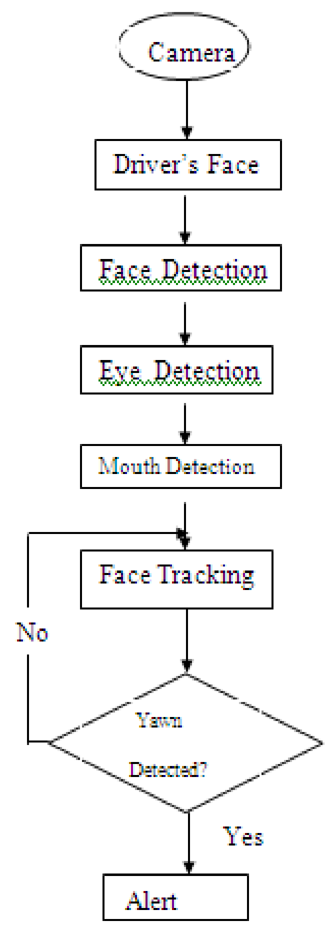

Figure 1: driver fatigue detection [1]

A. Face Detection

The goal of face detection is to locate all image regions, which contain a face regardless of its position, orientation and lightning conditions. Such a condition is challenging because faces are non-rigid. There is a great degree of variance among faces including size, shape, color, and texture. It is basically assumed that the camera is installed inside the vehicle facing the driver. Presence of facial features such as beards, mustaches, and glasses can also make a great deal of difference. The other important factor is the lightning conditions. This is mainly affected by the light in our background that can change depending on the time and weather conditions.

Keeping all the above considerations in mind, the most functional way to detect face is by detecting the skin color and texture. However, it should be noted that the detections scheme should be invariant to skin type and change in lightning conditions. Therefore we take advantage of a set of bounding rules for different color space (RGB, YCbCr and HSV) in order to improve the detection efficiency. RGB color space is used to detect skin color at uniform or lateral day light illumination and under flashlight illumination. Cb-Cr color space is a strong determination of skin color. The following rules apply to this color space:

[1] (Cr <= 1.5862 * Cb + 20) AND
(Cr >= 0.3448 * Cb + 76.2069) AND
(Cr >= -4.5652 * Cb + 234.5652) AND
(Cr <= -1.15 * Cb + 301.75)AND
(Cr <= -2.2857 * Cb + 432.85)…(2)..[1]

The last space to be used is the HSV space. Hue values exhibit the most noticeable separation between skin and non-skin regions.

H < 25 and H > 230 ……………… (3)

The face is detected by finding the biggest white connected component and will cut that area. The result of the skin location technique is a black and white image which focuses the skin location by converting the face region to white and the background region and the areas around the driver to black. This background elimination reduces the subsequent errors due to false object detection in the background.

B. Face tracking

For tracking the face in the upcoming frames, we can use the detected face as a template. The basic idea used in the tracking algorithm is to find the location of the face.

We can now assume that the face is located in the neighborhood of the estimated location. In order to find the real position of the face, we use the template from face tracking and perform template matching. The location of the face is then found as the point where the association of the template and the image located around that point is maximum. If the association results go below a certain threshold, the system loses track of the face and it goes back to face tracking step.

C. Eye detection

The next step towards proposed methodology is to detect the location of the eyes. The main reason behind locating the eyes is to use them as a confirmation to assure that the location of the mouth in face is correctly detected (using the geometrical relation between eyes and mouth in human face).To detect the location of the eyes, the eye maps based on chrominance components are built according to the following equation[1]:

[1] Eye_Location=

$$\frac{1}{3}\{(C_b)^2 + (C_r)^2 + \left(\frac{C_b}{C_r}\right)\} \qquad (4)$$

The eye map highlights the eyes regions. Using proper thresholds, we can then convert the eye map image to a black and white image. This new image includes the eyes in white while the rest is all black. Thus, numerous pre-processing steps including erosion, dilation and finding the biggest connected components as eyes are required. Also, some geometrical features of the eyes are used in the final step to eliminate the false detections.

D. Mouth detection

The next step towards proposed methodologies is to find the location of mouth and lips. The region containing mouth, i.e. mouth window, can be detected using method based on intensity or color information .A region is roughly estimated from face location based on prior knowledge, 1) mouth residing lower half of face region; 2) Lip corners have some distance from the border of face region and 3) Lower lip has certain distance from chin. The estimated region is searching space for mouth region detection, which decreases the searching space and avoids the disturbing of the background pixels with similar color. The following equation is used to generate the mouth map [1]:

[1] Mouth_Map=

$$(C_r)^2 \times \left((C_r)^2 - \frac{\omega \times C_r}{C_r}\right)^2 \quad (5)$$

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$$\omega = 0.95 \frac{\frac{1}{n}\sum_{(x,y)} C_r(x,y)^2}{\frac{1}{n}\sum_{(x,y)} \left(C_r(x,y) | C_b(x,y)\right)} \quad (6)$$

The further steps of mouth map are black and white conversion, erosion, dilation and finding the biggest connected components in the same way as the eye detection method.The further steps of mouth map are black and white conversion , erosion , dilation and finding the biggest connected components in the same way as in the eye detection method.

E. Yawn detection

Yawning detection can be performed in two steps: 1) Detect the yawn component in the face independent of the mouth location. This component is mainly the hole in the mouth as the results of wide mouth opening. 2) Use mouth location to verify the validity of the detected component. . After this, the largest area located inside the face is selected as the component for a yawning mouth. This area is actually related to a non-skin region inside the face that can be related to eyes, mouth or open mouth. It can be assumed that the open mouth will be the largest of the three in a yawning state. In this way a component for yawning mouth is located. The information obtained from the detected mouth is used for verification of the yawning mouth. The criteria for the verification are the number of pixels located in the yawning mouth with respect to the number of mouth pixels as well as relative location of the open mouth with respect to the lips.

III. Experimental Evaluation

We have considered around a hundred images with different characteristics. The images are captured with several different conditions such as lightning conditions with different directional lightning .Several facial features are also taken into consideration in our evaluation which involves the skin color, beard, haircuts and eye colors. Figure [2] shows the result of the algorithm on various images. Following the detection of the facial region, the eyes and the lips, the next phase is the detection of a yawning mouth. Figure [2] exhibits the result of face detection as well as detection of a yawning mouth. By using this technique we can reduce the number of car accidents and can build a better transport system. The only demerit following this system is it is highly light intensive and it detects drowsiness 70% of the times and it is yet to be made more efficient.

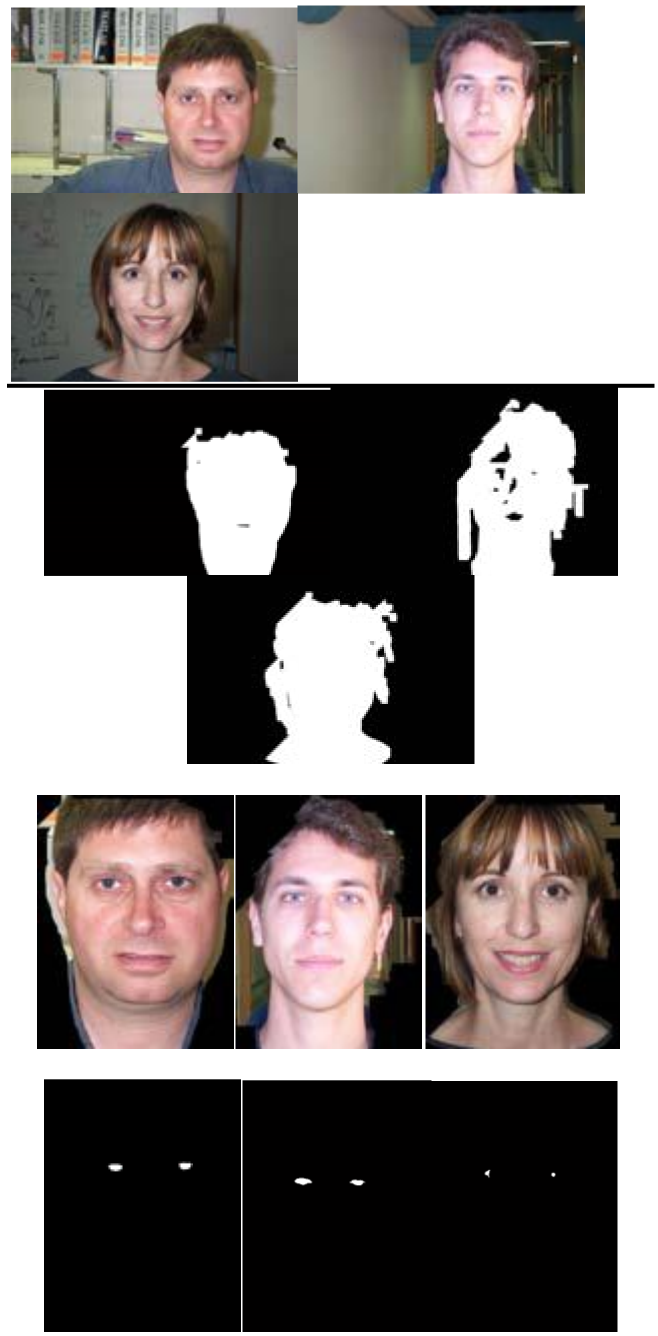

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Figure 2: Face Feature Detection [1]

IV. CONCLUSION

The methods proposed which are to be used in implementing the software are based on a set of algorithms , which are intensive to any slight change in skin type, lightning condition and geometrical facial features. The robustness of the techniques implemented depends on the fact that false detection is avoidable by using various verification criteria. Moreover, we have made sure to avoid complex algorithm in order to be a step closer to the real implementation of the system.

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