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A Driver Drowsiness Detection System using Cascaded Adaboost

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Abstract*: With the progress of science technology and the vehicle industry, there are more and more vehicles on the road. As a result, the heavy traffic often leads to more and more traffic accidents. In common traffic accident, the driver's inattention is usually a main reason. To avoid this situation, this paper proposes a sleepy eye's recognition system for drowsiness detection. First, a cascaded Adaboost classifier with the Haar-like features is utilized to find out the face region. Second, the eyes region is located by Active Shape Models (ASM) search algorithm. Then the binary pattern and edge detection are adopted to extract the eyes feature and determine the eye's state. Experimental results demonstrate the comparative performance, even without the training stage, with other methods.*

Keywords*- Face Detection; Eye's State; Drowsiness.*

1. Introduction

For the last few decades, the rate of traffic accidents becomes higher with the development of vehicular technology. The driver's drowsiness is considered to be an essential factor. Many studies have revealed that the danger of long time driving is equivalent to the drunk driving. Therefore, the driver's drowsiness has become a popular issue. As a result, a lot of researches have worked on the detection system of unsafe driving.

Safe driving systems can be summarized in two categories. One is "vehicle-based" [1] [2] method which focuses on the state of vehicle, such as vehicular position on the road, the variability of speed, and so on. The other category is "human-based" method which focuses on the state of driver. This method analyzes the driver's face image with image processing and/or pattern recognition, such as the frequency of eye blinking and the time of eyes closure [3]. The proposed method is based on this category

Liu ,Tan. [4] evaluated several feature sets and classifier for eye closeness detection. They employed gray values, Gabor wavelets, Local Binary Pattern (LBP) and Histograms of Oriented Gradient (HOG) to represent feature sets, and compared with three types of classifiers (i.e., Nearest Neighbour (NN), Support Vector Machine (SVM) and Adaboost). Experimental results showed that the combination of various feature descriptors significantly improves the accuracy.

Wu et al. [5] proposed a method to recognize the state of eyes. They used the Haar-like features and Adaboost classifiers [6] to find out the face region. LBP is considered as features of the image and the features were trained by SVM. Then SVM was utilized to identify the eye's state. They demonstrated that the proposed method can effectively detect the drowsiness of driver by calculating PERCOLS (Percentage of Eye Closure).

In this paper, we propose a sleepy eye's recognition system for drowsiness detection without the training stage. A cascaded Adaboost classifier with Haar-like features [7] and Active Shape Models (ASM) [8] are utilized to find out the face location and eyes region. Then the binary pattern and edge detection are adopted to extract the eyes feature and determine the eye's state. Experimental results will demonstrate the comparative performance with other methods, which have the training stage.

This paper is organized as follows. The proposed method is described in Section 2. Section 3 demonstrates experimental results. Finally, the conclusion is drawn in Section 4.

2. The Proposed Method

The proposed method has four main steps: 1) image pre-processing; 2) face detection; 3) eyes detection; 4) recognition of eye's state. Fig. 1 illustrates the flowchart of the driver's drowsiness detection system. The detail of the proposed method is presented in the following sub-sections.

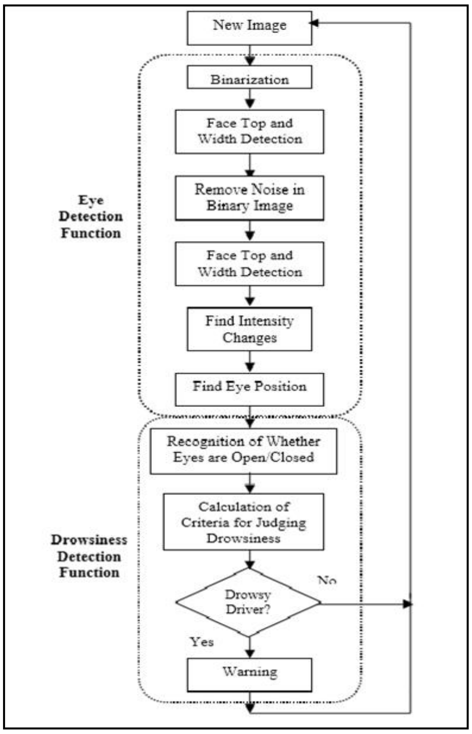

Fig. 1. The flowchart of the proposed method

A. Image Preprocessing

The change of luminance would influence the accurate rate of the system. Thus, the proposed method initially applies histogram equalization [9] to the light compensation. In this step, shown in Fig. 2, we divide the color image into Red, Green and Blue components and apply histogram equalization to each component, respectively. Then a compensated image is obtained. After the light compensation, we reduce the resolution of compensated image to enhance the efficiency of the system.

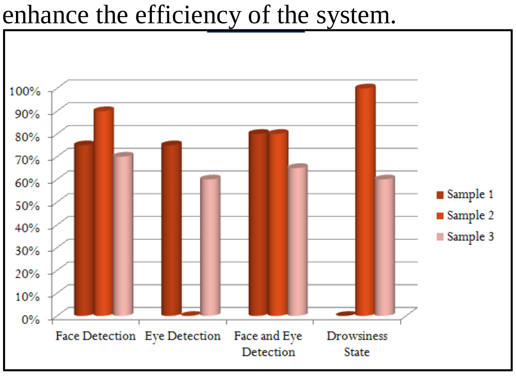

Fig. 2. Histogram equalization scheme for light compensate

B. Face Detection

A cascaded Adaboost classifier with the Haar-like features [10] is exploited to find out the face region. First, the compensated image is segmented into numbers of rectangle areas, at any position and scale within the original image. Due to the difference of facial feature, Haar-like feature is efficient for real-time face detection. These can be calculated according to the difference of sum of pixel values within rectangle areas. As shown in Fig. 3, the features can be represented by the different composition of the black region and white region.

A cascaded Adaboost classifier is a strong classifier which is a combination of several weak classifiers. Each weak classifier is trained by Adaboost algorithm. If a candidate sample passes through the cascaded Adaboost classifier, the face region can be found. Almost all of face samples can pass through and non-face samples can be rejected. Fig. 4 shows the face detection with cascaded Adaboost classifier.

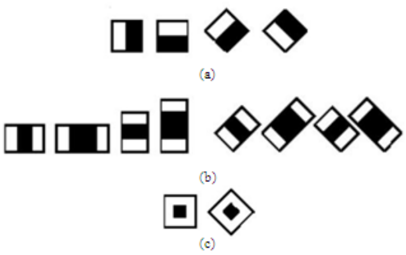

Fig. 3. Haar-like features: (a) Edge features (b) Line features (c) Center-surrounded features

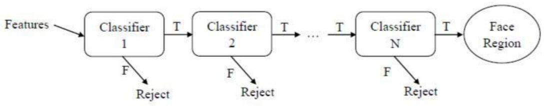

Fig. 4. The face detection with cascaded Adaboost classifier

C. Eyes Detection

Active Shape Model (ASM) [8] is a algorithm for facial feature extraction based on statistical learning models. It aims to match the model for a new image. In the proposed method, ASM is trained from facial contours with a set of
points which are marked manually. Then the algorithm selects the main variation in the training data by the Principal Component Analysis (PCA) method. After establishing ASM, the eyes location is obtained as shown in Fig. 5

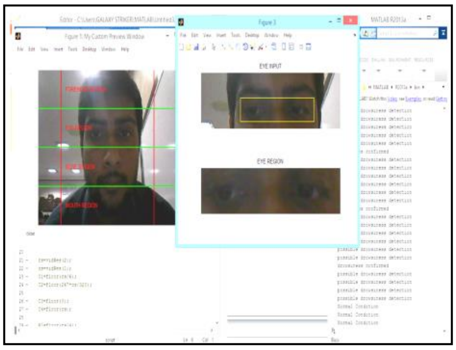

Fig. 5. The detection result of the face region and eyes' location

D. Recognition of Eye's State

The characteristic feature of the eye is extracted to recognize the eye's state. In general, the state of left eye is equal to right one at the same time. Therefore we only consider one eye’s state in one frame. This consideration is also useful to the reduction of computational complexity. In this step, two schemes are adopted: (1) binary pattern and (2) the Canny’s edge detection [11].

The eye image is converted to binary pattern based on the threshold value T.

$$T = \frac{\sum_{i=1}^{n} x_i}{n} \quad (1)$$

In (1), n is the number of pixels in the eye region and x_i is the pixel value of the position i in the region.

There are n pixels in the eye region. If the pixel value of P is greater than the threshold T, P will be set as white, 1. Otherwise P will be set as 0. Its definition is shown as (2).

$$P(x, y) = \begin{cases} 1, & gray(x, y) \,\varepsilon\, T \\ 0, & gray(x, y) < T \end{cases} \quad (2)$$

Fig. 6 shows some binary pattern of open eye and closed eye. When the conversion of eye image is completed, the height of the eyelids is utilized to determine the eye's state.

(a) (b) (c) (d)

Fig. 6. Binary pattern : (a)-(b) open eye and (c)-(d) closed eye

The Canny’s edge detection algorithm is well known for its ability to generate continuous edge. First, the image is smoothed by Gaussian convolution.

$$g(x, y) = I(x, y) * G_{\sigma}(x, y) \quad (3)$$

$$G_{\sigma}(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{(x^2+y^2)}{2\sigma^2}} \quad (4)$$

Where is a scale parameter. Then, the magnitude andorientation of the edge are calculated by the differential filter. The final edge image is obtained by edge information of multiple scale . Finally, the numbers of edge points are summed for recognizing the eye's state.

3. Experimental Results

In the experiment, ‘Eye blink Database’ [12] is employed to evaluate the performance. It contains real-time video from webcam and extract frames from that and detect eye state i.e open or close.. There are four types of clips: 1)frontal view without glasses, 2)frontal view and thin rim glasses, 3)frontal view and black frame glasses, 4) upward view without glasses. Each individual blinks with normal speed and varies 1 to 6 times in a video clip. Some frames are shown in Fig. 7.

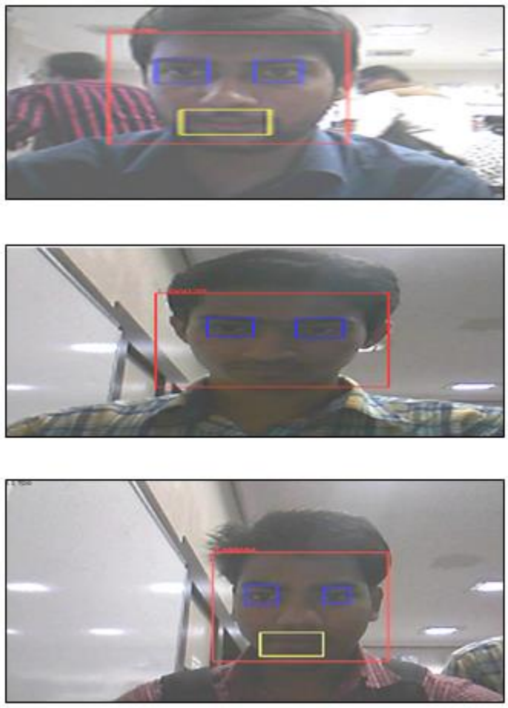

Fig:7 Samples of the eye blink database.

Results

No.	Evaluation Parameters				
	Camera Resolution (MP)	*Lighting Conditions*	*Missed Detections*	*Positive Detections*	*Accuracy*
1.	3.2	Normal	1	15	94%
2.	3.2	Bad	14	2	12.5%
3.	3.2	Bright	2	14	87.5%
4.	1.3	Normal	16	0	0%
5.	1.3	Bright	5	11	69%
6.	1.3	Bad	16	0	0%

4. Conclusion

This paper presents a drowsy eye's recognition for drowsiness detection without the training stage. In the beginning, an Adaboost classifier with Haar-like features is utlized to find out the face area. Then the eyes region is located by Iris Detection of Cascade vision toolbox. Finally, the binary pattern and edge detection are adopted to recognize the eye’s state. Experimental results prove that the proposed method could accurately detect the sleepy eyes. In addition, the comparative performance shows that the proposed recognition system with the training stage is useful for driver’s drowsiness detection.

5. Acknowledgment

The research of this paper is completed by utilizing ' Eyeblink monitoring' [12]. And also a new face to drowsiness detection by dividing the face into regions.

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