DRIVER DROWSINESS DETECTION SYSTEM

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ABSTRACT

Drowsiness and Fatigue of drivers are amongst the significant causes of road accidents. Every year, they increase the amounts of deaths and fatalities injuries globally.
In this paper, a module for Advanced Driver Assistance System (ADAS) is presented to reduce the number of accidents due to drivers fatigue and hence increase the transportation safety; this system deals with automatic driver drowsiness detection based on visual information and Artificial Intelligence.
We propose an algorithm to locate, track, and analyze both the drivers face and eyes to measure PERCLOS, a scientifically supported measure of drowsiness associated with slow eye closure.
Keywords—Drowsiness detection, ADAS, Face Detection and Tracking, Eyes Detection and Tracking, Eye state, PERCLOS.

1. INTRODUCTION

Currently, transport systems are an essential part of human activities. We all can be victim of drowsiness while driving, simply after too short night sleep, altered physical condition or during long journeys. The sensation of sleep reduces the driver's level of vigilance producing dangerous situations and increases the probability of an occurrence of accidents. Driver drowsiness and fatigue are among the important causes of road accidents. Every year, they increase the number of deaths and fatalities injuries globally.

In this context, it is important to use new technologies to design and build systems that are able to monitor drivers and to measure their level of attention during the entire process of driving.

In this paper, a module for ADAS (Advanced driver assistance System) is presented in order to reduce the number of accidents caused by driver fatigue and thus improve road safety. This system treats the automatic detection of driver drowsiness based on visual information and artificial intelligence.

We propose an algorithm to locate, track and analyze both the driver face and eyes to measure PERCLOS (percentage of eye closure).

The remainder of this paper is organized as follows, Section 2 presents the related works, Section 3 presents the proposed system and the implementation of each block of the system, the experimental results are shown in section 4 and in the last section conclusions and perspectives are presented.

2. RELATED WORKS

Some efforts have been reported in the literature on the development of the not-intrusive monitoring drowsiness systems based on the vision.

Malla et al. [1] develop a light-insensitive system. They used the Haar algorithm to detect objects [2] and face classifier implemented by [3] in OpenCV [4] libraries. Eye regions are derived from the facial region with anthropometric factors. Then, they detect the eyelid to measure the level of eye closure.

Vitabile et al. [5] implement a system to detect symptoms of driver drowsiness based on an infrared camera. By exploiting the phenomenon of bright pupils, an algorithm for detecting and tracking the driver's eyes has been developed. When drowsiness is detected, the system warns the driver with an alarm message.

Bhowmick et Kumar [6] use the Otsu thresholding [7] to extract face region. The localization of the eye is done by locating facial landmarks such as eyebrow and possible face center. Morphological operation and K-means is used for accurate eye segmentation. Then a

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set of shape features are calculated and trained using non-linear SVM to get the status of the eye.

Hong et al. [8] define a system for detecting the eye states in real time to identify the driver drowsiness state. The face region is detected based on the optimized Jones and Viola method [2]. The eye area is obtained by an horizontal projection. Finally, a new complexity function with a dynamic threshold to identify the eye state.

Tian et Qin [9] build a system that checks the driver eye states. Their system uses the Cb and Cr components of the YCbCr color space. This system locates the face with a vertical projection function, and the eyes with a horizontal projection function. Once the eyes are located the system calculates the eyes states using a function of complexity.

Under the light of what has been mentioned above, the identification of the driver drowsy state given by the PERCLOS is generally passed by the following stages:

1) Face detection,
2) Eyes Location,
3) Face and eyes tracking,
4) Identification of the eyes states,
5) Calculation of PERCLOS and identification of driver state.

3. THE PROPOSED SYSTEM

In this section, we discuss our presented system which detects driver drowsiness. The overall flowchart of our system is shown in Figure 1.

3.1 Face Detection

The symmetry is one of the most important facial features.

We modeled the symmetry in a digital image by a one-dimensional signal (accumulator vector) with a size equal the width of the image, which gives us the value corresponding to the position of the vertical axis of symmetry of objects in the image. The traditional principle to calculate the signal of symmetry is for each two white pixels which are on the same line we increment the value in the medium between these two pixels in the accumulator vector. (The algorithm is applied on an edge image, we called a white pixel: the pixel with value 1).

We introduce improvements on the calculation algorithm of symmetry into an image to adapt it to the detection of face, by applying a set of rules to provide a better calculation of symmetry of the face. Instead of computing the symmetry between two white pixels in the image, it is calculated between two windows (Z1 and Z2) (Figure 2).

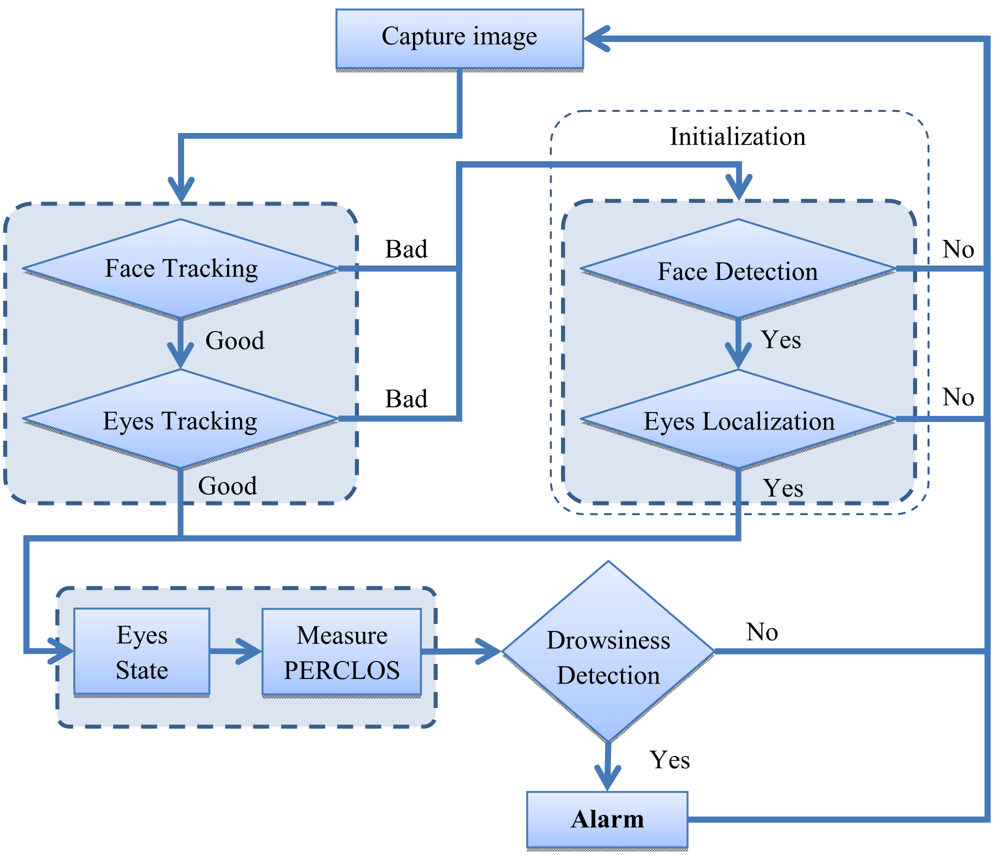


Figure 1 : Flowchart of the proposed system.

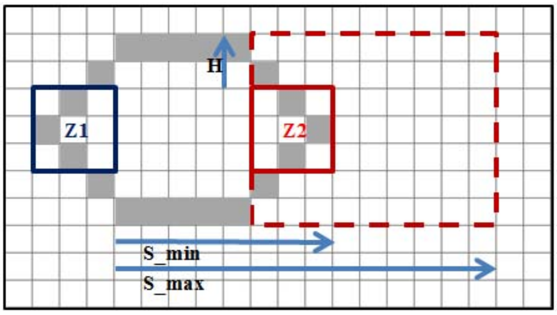


Figure 2 - The new method to improve the calculation of the symmetry in the image.

For each window Z1, we sweep the window Z2 in the area determined by the parameters S_min, S_max, and H. We increment the signal of symmetry between these two windows if the sum of white pixels is located between two thresholds S1 (maximum) and S2 (minimum).

Then we extract the vertical region of the image contours (Region of Interest ROI) corresponding to the maximum index of the obtained signal of symmetry. Next, we take a rectangle with an estimated size of face (Because the camera is fixed and the driver moves in a limited zone so we can estimate the size of the face using the camera focal length after the step of camera calibration) and we scan the ROI by searching the region that contains the maximum energy corresponding to the face (Figure 3).

We propose a checking on two axes: the position variance of the face detected according to time; i.e., in several successive images, it is necessary that the variance of the positions of the detected face is limited; because the speed of movement of the face is limited of some pixels from a frame to another frame which follows.

3.2. Eyes Localization

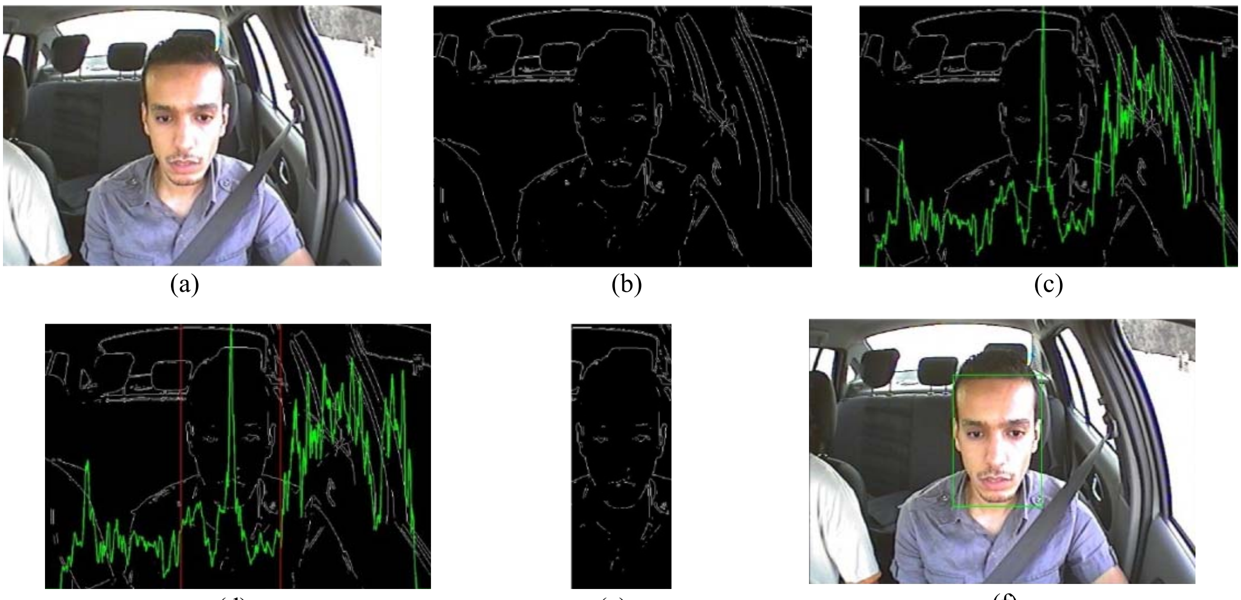
Since the eyes are always in a defined area in the face (facial anthropometric properties), we limit our research in the area between the forehead and the mouth (Eye Region of Interest 'eROI') (Figure 4.a). We benefit from the symmetrical characteristic of the eyes to detect them in the face.

First, we sweep vertically the eROI by a rectangular mask with an estimated height of height of the eye and a width equal to the width of the face, and we calculate the symmetry.

The eye area corresponds to the position which has a high measurement of symmetry. Then, in this obtained region, we calculate the symmetry again in both left and right sides. The highest value corresponds to the center of the eye. The result is shown in Figure 4.b.

3.3. Tracking

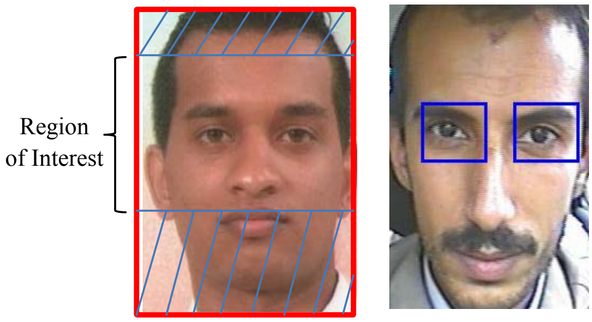
The tracking is done by Template Matching using the SAD Algorithm (Sum of Absolute Differences).



(a) (b) (c)

(d) (e) (f)

Figure 3 – Face detection using symmetry. (a) Original image, (b) Edge detection, (c) Symmetry signal, (d) Localization of the maximum of symmetry, (e) Region of interest ROI (f) Result.



(a) (b)

Figure 4 – Eyes localization using symmetry. (a) eROI, (b) Result.

$$SAD(x,y) = \sum_{j=1}^{N} \sum_{i=1}^{M} | I(x+i, y+j) - M(i,j) | \quad (1)$$

We proposed to make a regular update of the reference model M to adjust it every time when light conditions changes while driving, by making a tracking test:

$$Tracking \begin{cases} good & if\ SAD \leq Th \\ bad & if\ SAD > Th \end{cases} \quad (2)$$

3.4. Eyes States

The determination of the eye state is to classify the eye into two states: open or closed.

We use the Hough transform for circles [10] (HTC) on the image of the eye to detect the iris. For that, we apply the HTC to the edge image of the eye to detect the circles with defined rays, and we take at the end the circle which has the highest value in the accumulator of Hough for all the rays.

Then, we apply the logical 'AND' logic between edges image and complete circle obtained by the HTC by measuring the intersection level between them "S".

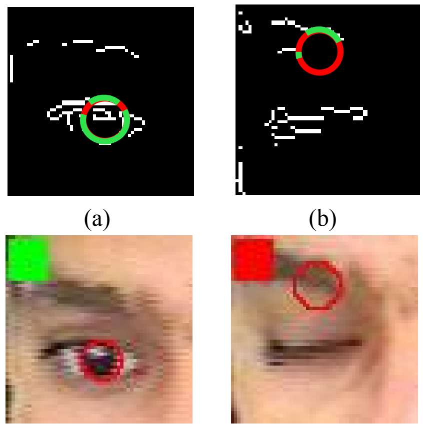
Finally, the eye state "$State_{eye}$" is defined by testing the value "S" by a threshold:

$$State_{eye} = \begin{cases} Open & if \quad S \geq Th \\ Closed & if \quad S < Th \end{cases} \quad (3)$$

The results are shown in Figure 5.

3.5. Driver State

We determine the driver state by measuring PERCLOS. If the driver closed his eyes in at least 5 successive frames several times over a period of up to 5 seconds, it is considered drowsy.



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

Figure 5 – Eyes states using HTC. (a) and (b) Edge detection , (c) and (d) Eyes states results.

3.6. How the Algorithm Works

Our system starts with the initialization phase, which is face and eyes detection to extract both face and eyes regions and take them as templates to track them in the following frames. For each tracking we test if that tracking is good or bad? If the tracking is bad we return to the initialization step, else we pass to the following steps which are: eyes states identification and driver state.

4. EXPERIMENTAL RESULTS

To validate our system (Figure 6), we test on several drivers in the car with real driving conditions. We use an IR camera with infrared lighting system operates automatically under the conditions of reduced luminosity and night even in total darkness.

The results of the eye states are illustrated in Table1, where the percentage error is the number of frames that have a false state of eye divided by the total number of frames multiplied by 100.

Figure 6 - Our system installed in the car based on IR camera

TABLE 1 – RESULTS OBTAINED FROM THE SYSTEM.

Driver	frames Number	False Eyes sates		false rate
		Open	Closed	
D1/day	420	17	0	4 %
D2/day	430	15	0	3.5 %
D3/day	245	7	1	3.2 %
D1/night	200	3	1	2 %
D2/night	200	1	0	0.5 %
D3/night	200	6	3	4.5 %

According to the obtained results, our system can determine the eye states with a high rate of correct decision.

5. CONCLUSION AND PERSPECTIVES

In this paper, we presented the conception and implementation of a system for detecting driver drowsiness based on vision that aims to warn the driver if he is in drowsy state.

This system is able to determine the driver state under real day and night conditions using IR camera. Face and eyes detection are implemented based on symmetry. Hough Transform for Circles is used for the decision of the eyes states.

The results are satisfactory with an opportunity for improvement in face detection using other techniques concerning the calculation of symmetry.

Moreover, we will implement our algorithm on a DSP (Digital Signal Processor) to create an autonomous system working in real time.

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