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Driver Drowsiness Detection System

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Abstract: Drowsiness of drivers are among the critical reasons for accidents. This can be a relatively smaller number still, as among the multiple causes that can lead to an accident. Drowsiness, in general, is not easy to measure unlike drugs and alcohol, which have tests and indicators that are available easily.

In this paper, we are presenting a module for Advanced Driver Assistance System (ADAS) to reduce drowsiness related accidents. The system deals with automatic driver drowsiness detection based on visual information.

We propose an algorithm to track, analyze and locate both the drivers eyes and face to measure PERCLOS, a scientifically supported measure of drowsiness asso- ciated with slow eye closure.

Keywords: Drowsiness detection, ADAS, Face Detec- tion and Tracking, Eyes Detection and Tracking, Eye state, PERCLOS.

I. INTRODUCTION

At present, transport systems are an important aspect of daily human activities. Any one can be victim of fatigue and drowsiness while driving, simply after too short night sleep, during long journeys or altered physical conditions. The sensation of sleep reduces the driver's level of alertness creating risky situations and increases the probability of mishaps. Driver drowsiness and fatigue are among the significant reasons of road accidents. Every year, they increase the number of fatal injuries and deaths globally.

In this situation, utilizing new technologies to design and build systems that are able to monitor drivers and to measure their level of vigilance during the entire time of driving.

In this paper, a module for ADAS (Advanced driv- er assistance System) is presented to reduce

Drowsiness related accidents and thus improving road safety. This system deals with the automatic detection of driver drowsiness based on visual information and artificial intelligence. The remainder of this paper is organized as , 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 shownin section 4 and in the last section conclusions and perspectives are presented.

II. LITERATURE SURVEY

Some efforts have been reported in the literature onthe 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 regionwith 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 set of shape features are calculated and trained using 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 locatesthe 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 above references, the identification of the driver’s eye state is given by the PERCLOS and generally follows the below stages:

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

III. THE PROPOSED SYSTEM

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

A. Face Detection

The symmetry is one of the crucial features of any face.

We idealized the symmetry in a digital image by a one-dimensional signal also called an accumulator vector with the size equal to width of the image, which gives us the corresponding value of the position of the vertical axis of symmetry in the image. The conventional principle to calculate the signal of symmetry is - for two white pixels which are on the same line we increase the value in the medium between these two pixels in the accumulator vector.

We present improvements on the algorithm of calculating symmetry into an image that adapt itself to the face detection, by a set of rules applied to provide a better calculation of symmetry of the face. Instead of computing the symmetry between two white pixels in the image, we calculate the same between two windows (Z1 and Z2) (Figure 2).

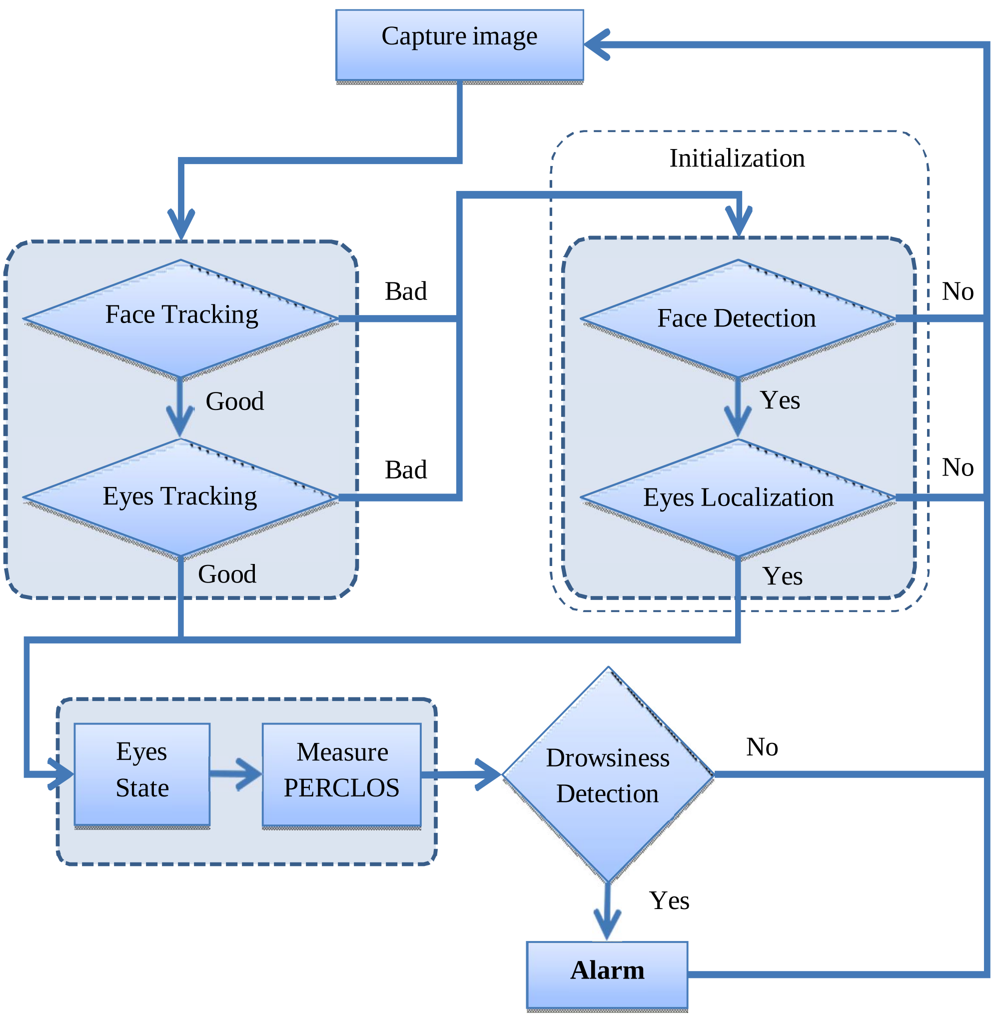


Figure 1 : Flowchart of the proposed framework.

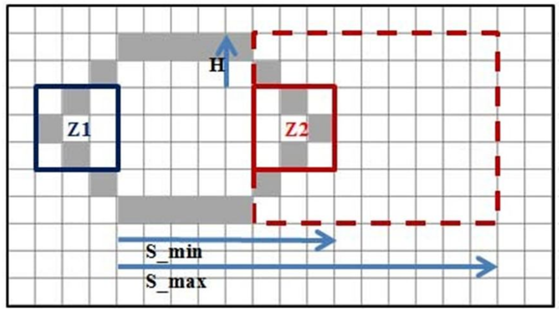


Figure 2 - The new method to improve the calculationof the symmetry in the image.

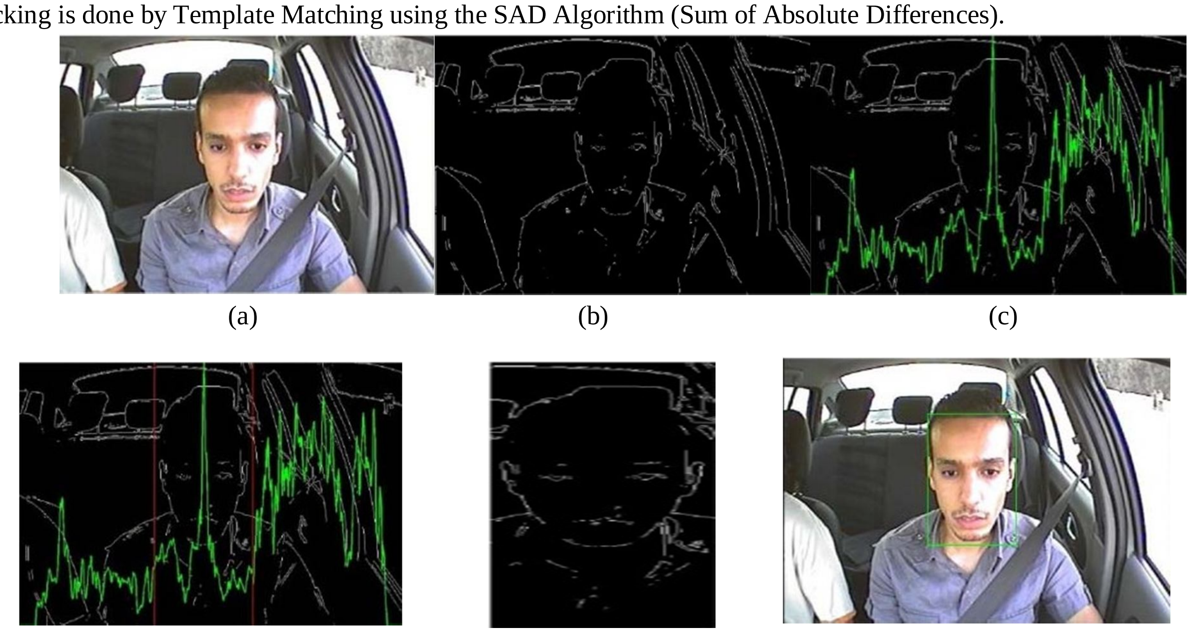
For each window Z1, we sweep the window Z2 in the area determined by the parameters S-min, S-max, and H. Then increment the symmetry between these two windows ,if the sum of white pixels is located between two threshold values S1 (max) and S2 (mini).
Then we takeout the vertical region of the image contours (Region of Interest ROI) that corresponds to the maximum index of the signal of symmetry. Next, we take a rectangle with an estimated size of the detected face and then scan the ROI by searching the region that contains the maximum energy corresponding to the face (Figure 3).
We need to check two axes using 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 limitedof some pixels from a frame to another frame which follows.

B. Eye Localization

Since the eyes are consistently in a characterized region in the face, we limit our research in the Eye Region of Interest 'eROI'(Figure 4.a). So that we benefit from the symmetrical characteristics of the eyes .
First, we sweep vertically the eROI by a rectangular region with an estimated height of the eye and a width that equals to width of the face, and then calculate the symmetry.
The eye area corresponds to the region which has high symmetry. Then, in the 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.

C. 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.

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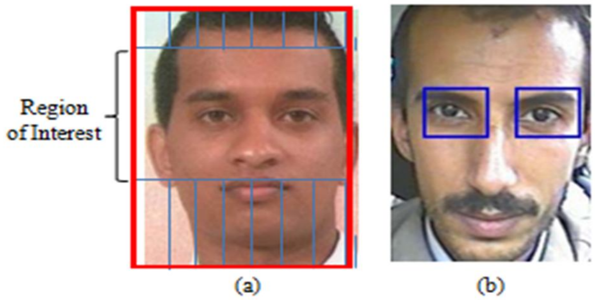

Figure 4 – Eyes localization using symmetry. (a) eROI. (b) Result.

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

We create a regular update of the reference model M to adjust itself every time whenever the lighting changes while driving, from a tracking test:

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

The results are shown in Figure 5.

D. Eyes State

The eye state is determined 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. We apply the HTC to the edge image of the eye to detect the circles and we take at the end thecircle which has the highest value in the accumulator of Hough .

Then, logical 'AND' operation is performed between edge 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 value:

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

E. Driver State

We determine the driver state by measuring PER- CLOS. If the driver closed his eyes in at least 5 successive frames several times over a period of up to 10 seconds, it is considered drowsy.

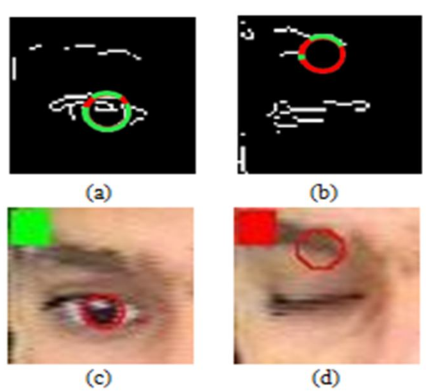

Figure 5 – Eyes states using HTC. (a) and (b) Edge detection. (c) and (d) Eyes states results.

F. Working of the Algorithm
Our system starts with face and eyes detection to extract both face and eyes regions and take them as templates to track them in the following frames. Before each tracking we test if the tracking is good or bad? If it turns out bad we go to the initialization step, else we pass to thefollowing steps which are: eyes states identification and driver state.

IV. RESULTS
To validate our system (Figure 6), we test on several drivers in the car with real driving conditions. Weuse an IR camera with infrared lighting system that operates automatically even under lowlight conditions and even night times.
The results of the eye states are shown in Table1, where the error percentage is the number of frames that have the incorrect eye state divided by the total number of frames multiplied by 100.

Figure 6 - Our system installed in the car based on IRcamera

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 precision.

V. CONCLUSION
In this paper, we presented the concept and implementation of a framework for detecting driver drowsiness based on vision that aims to warn the driver if he is drowsy.
The proposed system is able to determine the driver state under both daylight and night conditions using an IR camera. Face and eyes detection are implemented based on symmetry. Hough Transform for Circles is used for the decision on eyes states.
For future works, the authors can intend to focus on yawning analysis .

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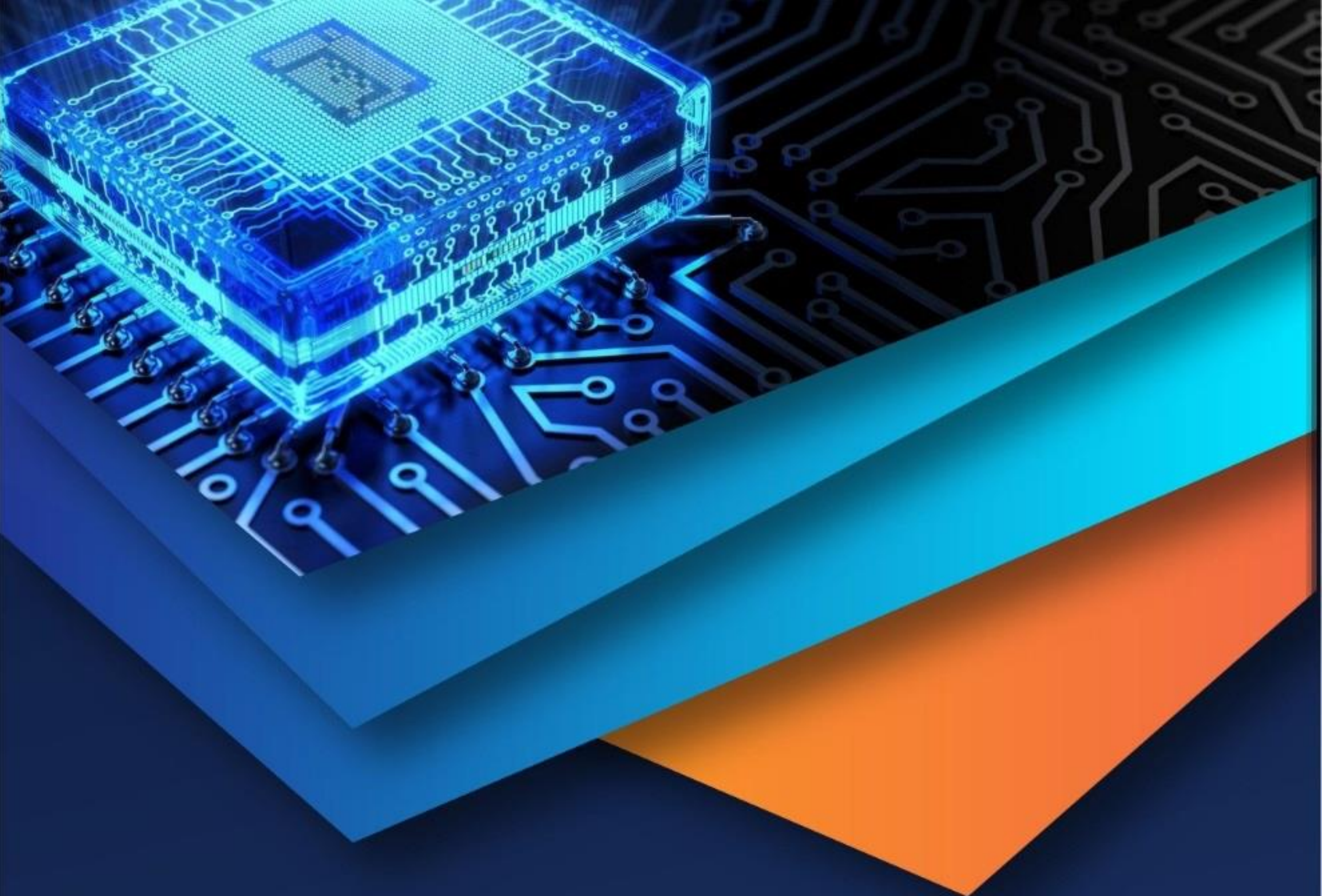

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