Driver Fatigue and Distraction Detection System

Bahaa Hussein Taher

Abstract— Driver monitoring system is a real-time system that can detect driver fatigue and distraction using image processing tools. In this paper, an algorithm is introduced for driver fatigue and distraction detection based on the relation between face and eye regions. We used the position of the face as indicator for distraction through tracking the face of the driver in the image taken by camera placed on the front upper mirror while for fatigue the eyes state was used to index sleeping situation ,the eyes state detected by the size and matching templates for opened and closed eyes .The algorithm tested laboratory and using of recorded videos and approved to be efficient in application for estimating the driver fatigue and distraction.

Index Terms- Driver monitoring system, driver fatigue, distraction detection.

I. INTRODUCTION

The distraction during driving or driving with fatigue jeopardizes the live of the driver and the people as well as, it costs lives and money .Too many kind of distractions such as eating during driving ,texting ,talking on cell phone or doing anything destruct the driver increasing the chances of a serious crash because they keep your attention away from the road ,the eyes , the mind and mainly your hands leave the wheel ,in another hand fatigue slows reaction time and has a negative affects toward driver performance .A fatigue driver is all about to crash or near to crash so that too many searches have been studied and many systems have been developed to alert fatigue driver ,most of them targeted the eye as an indexing of the drowsing and fatigue [1,4,11]while some others take in account the mouth to as in yawing to detect drowsing[3] and there are a few researchers use an observation on the environment around the driver and the head movement as well as used regular alarm to prevent drowsing at all [2,7,9].

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. In this topic, face detection and eyes locating are often the two main steps .Detecting the face require an understanding to the skin color and the appropriate color space .

Instead of the traditional color spaces (ex. *RGB* or *HSI*), some color spaces have been proposed for solving , and showed that would be not influenced for skin color in different illumination. For all of these color spaces, *YCrCb* color space is the most famous. This is because the skin color in this space has a clear range [14]. Furthermore, Chai et al. [15] indicate that the skin color of the different human beings would locate *Cr* and *Cb* value in a specific range. However, in the strong illuminating environment, all color spaces would be failed for detecting skin color, even if the *YCrCb* space [11]. Detecting the skin location in an image followed by another steps to detect while this skin is a face or not .Many ways were used to give the decision about that such as Feature_based Approaches that depends on facial features of the face such as eyes and mouth that uses the presence of the holes in the skin piece such as Euler number ,Other approaches may depends on Appearances which is away to search inside images for all parts that may content a face after training to detect faces in all types and positions, most famous way is eigenface to decide face and no face [12,16,17].

After detecting the face ,eyes and other faces' features it is easy now to follow the behavior of the driver as closing the eyes , yawing or even lying the face down for a time enough to lose the attention on the road, releasing for that an alarm to wake him up and worn him from danger.

The driver face monitoring system is a real-time system that investigates the driver physical and mental condition based on the processing of driver face images. The driver state can be estimated from the eye closure, eyelid distance, blinking, gaze direction, yawning, and head rotation.

The proposed system is a method for detecting driver fatigue and some kind of inattention like turning the face away of the road by tracking the eyes for fatigue as well as the position of the head.

II. HISTORY REVIEW

Too many studies had been presented and systems had been built to manage the issue of driver fatigue and inattention with a broad range of techniques, some of these techniques uses an infrared camera to detect eyes in the face and track them or ordinary camera with an algorithms to find face and eyes ,while other techniques observe the electrical changes in the brain, measured with a series of electrodes placed in the scalp called Electroencephalograms (EEG) [18]. The voltages produced by the brain cortex are small but it comes with different frequencies including drowsiness and the different sleep stages. These measurements provide the best data for detection of drowsiness, and as such have been used by several drowsiness detection systems, usually in conjunction with heart and breathing rate. The problem of these techniques is that they annoying the driver by placing sensors on the head, face and chest , also it requires external help for placed carefully and also usually expensive.

On the other hand a driver's state of attention could be measured and indicated as a dangerous state if ignored that causes crashes ,It detected by using indirect information such as the lateral position of the vehicle inside the lane, steering wheel movements and time-to-line crossing are commonly used, and some commercial systems have been developed[1]. These systems do not monitor the driver's condition, but its driving. Others techniques monitor eyes and gaze movements using a helmet or special contact lens [19].

There is a "*Driver Fatigue Monitor System"* by Attention Technologies, Inc. It is based on the PERCLOS (PERcent of the Time Eyelids are CLOSed) measure of driver fatigue. These systems detect the eyes state open or close and determine if it is blinking or sleeping as well as detecting

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Bahaa Hussein Taher, Department of Mathematical Science, University of Basrah, College of Science, Basrah, Iraq.

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other factors of drowsiness such as yawing or head leaning .

Cho et al. [20] designed a special car seat to improve the alertness of the driver by adjusting the temperature and humidity of the driver's thighs and hips to reduce the degree of drowsiness.

Muhammad Fahad Khan and Farhan Aadil [1] have developed a system that can monitor the alertness of drivers in order to prevent people from falling asleep at the wheel. By using low quality webcam and without the use of infrared light which is harmful for the human eye determined that whether the eyes are closed or open. On the basis of this result the warning is issued to the driver to take a break.

Mandalapu Saradadevi and Dr. Preeti Bajaj [3]presented a driver fatigue detection system based on tracking the mouth to study , monitor and recognize yawning. The authors proposed a method to locate and track driver's mouth using cascade of classifiers proposed by Viola-Jones for faces. SVM is used to train the mouth and yawning images. During the fatigue detection mouth is detected from face images using cascade of classifiers. Then, SVM is used to classify the mouth and to detect yawning then alert Fatigue.

Harini Veeraraghavan and Nikolaos P. Papanikolopoulos [4] presented an approach for real-time detection of driver fatigue. The system consists of a video camera directly pointed towards the driver s face. The system monitors the drivers eyes to detect micro-sleeps (short periods of sleep lasting 3 to 4 seconds).

There is also Mr. Swapnil V. Deshmukh *et.al.* [8] shows the new fatigue detection technique using strain gauge sensor. In this technique the fatigue will be detected immediately and regular alert the driver. The system consists of a sensors directly pointed towards the driver's face. The input to the system is a continuous stream of signals from the sensors. The system monitors the driver's eyes to detect micro-sleeps (short periods of sleep lasting 3 to 4 seconds), monitors the driver's jaw to detect jaw movement and monitors to detect driver pulse from finger using LED & LDR assembling. The system can analyze the eyes lid movement, jaw movement, variation in pulse rate from the driver compute it as well as compare signal. Accordingly, we can be obtained the driver's fatigue level based on the response signals and alert driver.

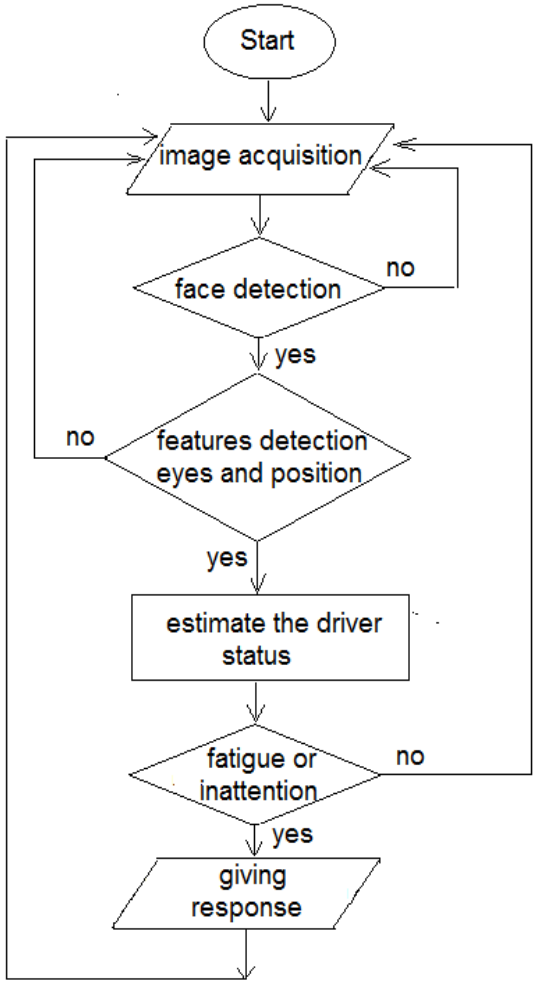
Luke Fletcher *et.al.* [7] we develop and evaluate a road scene monotony detector. The detector can be used to give context awareness to fatigue detection tools to minimize false positives. The approach could also be used by road makers to quantify monotony on fatigue prone stretches of road. The detector uses MPEG compression to measure the change in information content of the road scene over time. We show that the detector correlates highly with human identified monotonous scenes. The technique is consistent over time and applicable for day and night operation. The compression is augmented with lane tracking data to distinguish between otherwise difficult cases. The detector is integrated into a Fatigue Management Driver Assistance System.

A wearable computing system has been envisioned By Mahesh M. Bundele and Rahul Banerjee [9] to be worn by the driver. A complex set of noninvasive and nonintrusive sensor-compute element integrated with appropriate e-textile would form the primary part of this wearable computer. Out of the initial set of physiological parameters such as Skin Conductance, Oximetry Pulse, Respiration, SPO2, the current work focuses on the first two parameters to detect and monitor the mental fatigue / drowsiness of a driver. Using Neural Network approach, Multilayer Perceptron Neural Networks (*MLP NN*) have been designed to classify Pre and Posting driving fatigue levels. The performance of single hidden layer and two hidden layers based MLP NN have been discussed using the performance measures such as, Percentage Classification Accuracy (*PCLA*), Mean Square Error (*MSE*), Normalized Mean Square Error (*NMSE*), Area under Receiver Operating Characteristic Curve (*AROC*), Area under Convex Hull of ROC (*AHROC*). It was discovered that the performance of one hidden layer based MLP NN is comparable to the two hidden layers based MLP NN and there is slight rise in PCLA from One hidden layer to two hidden layer.

In this paper an algorithm was presented to detect driver fatigue and some kind of inattention with a simple wepcam camera taking a series of images for monitoring the states of driver through some information such as eyes and head movement and position.

III. PROPOSED SYSTEM

The proposed system is a system of monitoring the driver face for detecting any fatigue and distraction, in fig(1) a flowchart shows the algorithm of the system:



Fig(1) a flowchart of the System

1. Face detection:

The frames are processed to detect the face of the driver, Performing the face detection algorithm for all frames is computationally complex. Therefore, we produce a simple

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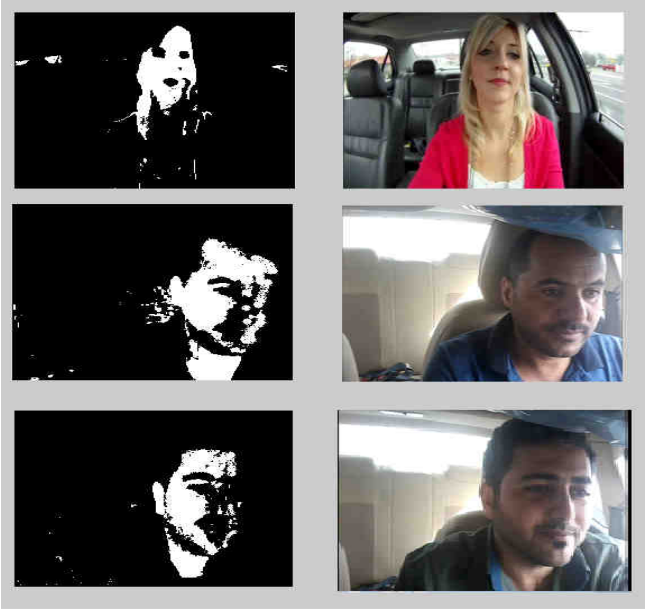
algorithm to detect the face illustrated in bellow:

- ***Detect skin object in the frame :***

This done by converting the color space from RGB to YCBCR and then denoting the point *P(i,j,:)* as a skin point if and only if it accede some creteria :

$$(140<=P(i,j,2)<=165)OR(140<=P(i,j,3)<=195)$$

and farming a new 2-dimansional matrix as black and white , if *P(i,j,:)* is a skin point then BW(i,j)→1 else 0
the result of this step is showed in fig(2):



Fig(2)a skin objects in the images

- Test the skin object if it is a face or not :

The white object in a picture is a skin object but it could be any part of the body such as hand or it could be a thing like skin color so we need to test if it is a face or not by testing another condition which is Euler Number that is the number of objects in a picture subtracted the number of holes in that objects as in eq(1) .

$$E=O-H \qquad (1)$$

E : Euler number , O : number of object , H: number of holes

Since , the face has a number of holes that formed the eyes ,nose and mouth in darker color showed as a black spaces in a face and it only one object so the eq(1) becomes:

$$E=1-H \qquad (2)$$

And because the face has at lest two or more holes (eyes, nose ,ears and mouth) we take the number of Euler that less than zero by three or less:

$$E <=-3 \rightarrow face \qquad (3)$$

After detecting the face in the image moving to other step to detect features or else back to take another frame to search for the face.

2. Detecting features :

After locating the face we need to determine two features: the position of face and eyes.

- Face position: if the face position becomes down in the frame or face disappears , a counter raises to account the number of cascaded frames that the driver keeps face down or disappears. If the number of these frames is about 5 seconds or more a sound of alarm is turned on with a sentence " Please pay attention to the road " , fig (3).

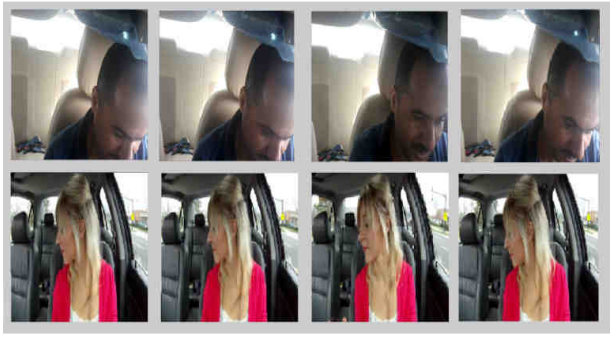


Fig (3) a series of cascaded frames show the drivers inattention (a) recorded video (b) downloaded video, the frame rate is the number of frames in a second so we take from each second four frames to exam, these frames was taken through 4 second one from each second.

- Eye detection : If the face in the center of image then we start searching about the eyes .As we know the eyes located in a upper part of the face ,using the variance in lighting in that part after transforming the face to Black and White as in fig (4) .

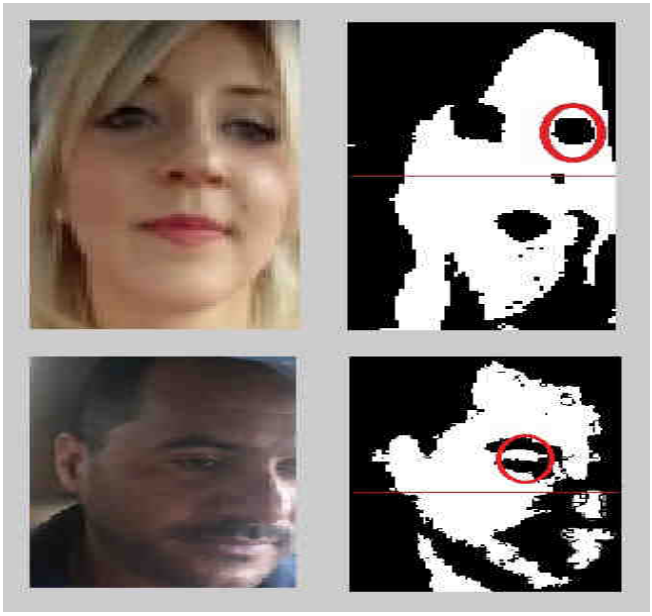


Fig (4)detecting the eye position in the upper part of the face

Locking for an object in the upper part with some conditions such as size(less than or equal 30*30 pixel) when face dimension is about (150*230 pixel) and position in the face image in the left or right pert as first object with that size close to the middle of the face. After locating the eye,it is isolated and transformed to grayscale image for farther testing, fig(5).

The Grayscale eye image is projected on two other images of eye, one is open while the other is close by taking Euclidian distance between the extracted eye and the patterns then taking the least result as indicator to the situation of the eye, fig(6).

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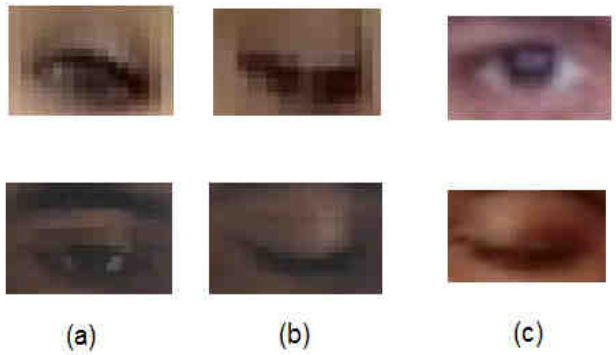

fig (5) (a) (b) eyes images of drivers (c) The eye pattern as open and close

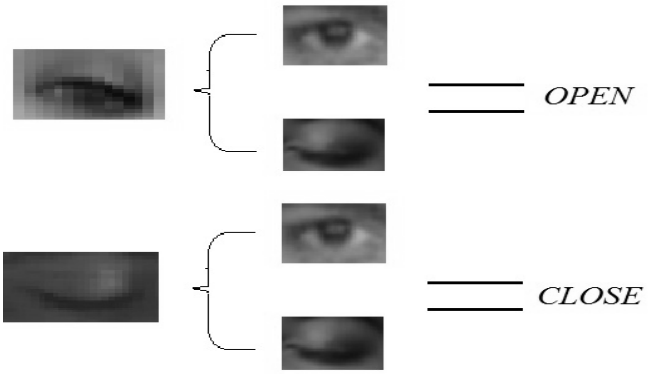

Fig (6) projection of the eye on eye patterns

When eye is decided to be open the decision is made that the driver is attentive and the process is moved back to take another frame. The eye is kept tracked in all frames to detect driver fatigue or drowsiness, when the eye become closed for several cascaded frames more than 3 second it trigged that the driver is fatigue and need to be alarmed, so a sound of alarm with massage " Please pay attention to the road " is released .

IV. Experiments and Results

The system was simulated on PC with matlab language and digital camera placed in the front mirror of the car to be able to take as possible as clear image without any constraining either by hand movement or steering wheel, the video was taken for drivers in many situation drowsing , attentive and inattention as well as some other video was downloaded from the web for farther testing.

V. Conclusions

This system was provided with less complicated process and gives a high accuracy and detection for driver in fatigue and inattention .Detecting the face was the most sensitive issue ether in time consumption or in importance of the face in this system ,it should be as fast as possible and accurate so we tend to use a simple but effective algorithm to find it ,the other important issue is the eye that represent the key of fatigue detection and also need to be quickly find .The affectivity of this program and ease of algorithms could be embedded in casteless system with minimum requirements or to mobile phone as a driver invigilator .

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