Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IMPACT FACTOR: 5.258

IJCSMC, Vol. 5, Issue. 5, May 2016, pg.555 – 562

LiveEye: Driver Attention Monitoring System

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Abstract— A large majority of road accidents are relative to driver fatigue, distraction and drowsiness which are widely believed to be the largest contributors to fatalities and severe injuries, either as a direct cause of falling asleep at the wheel or as a contributing factor in lowering the attention and reaction time of a driver in critical situations. Thus to prevent road accidents, a countermeasure device has to be used. This paper illuminates and highlights the various measures that have been studied to detect drowsiness such as vehicle based, physiological based, and behavioural based measures.

The main objective is to develop a real time non-contact system which will be able to identify driver's drowsiness beforehand. The system uses an IR sensitive monochrome camera that detects the position and state of the eyes to calculate the drowsiness of a driver. Once the driver is detected as drowsy, the system will generate warning signals to alert the driver. In case the signal is not re-established the system will shut off the engine to prevent any mishap.

Keywords— Drowsiness, Road Accidents, Eye Detection, Face Detection, Blink Pattern, PERCLOS, MATLAB, Arduino Nano

I. INTRODUCTION

In the past decade, development of transportation system and increase in vehicles on road has imposed a great threat on the road safety of passers-by. Increased number of road accidents and deaths occurring has made road safety a major research topic. The various causes identified include driver fatigue, drowsiness, distraction, improper management at crossings and lack of awareness among the travellers. Driver drowsiness represents an important risk on the roads, leading to accidents or near-missed accidents. It mainly depends on the quality of last sleep, the circadian rhythm (time of day) and increase in the duration of driving task. Several studies have tried to model the behaviour of a drowsy driver, by establishing links between drowsiness and certain parameters related to the vehicle and to the driver (e.g., steering wheel position, speed of the vehicle, etc.) [1][2][3].

Figure 1: Drowsy Driver

Driver fatigue is a significant factor in a large number of vehicle accidents. In today's competitive world, people make their schedule so hectic that they start compromising on precious sleep. By consuming caffeine or other stimulants people continue to stay awake. The lack of sleep builds up over a number of days and the next thing that happens is that the person feels fatigued while driving. Recent statistics estimate that annually 1,200 deaths and 76,000 injuries can be attributed to fatigue related crashes [4]. From the fatigue, inattention is caused which finally results in drowsiness. Another cause for road accidents i.e., driver distraction occurs when an object or event draws a person's attention. It is caused by random and unavoidable circumstances. Unlike distraction, drowsiness involves no triggering event but, instead, is characterized by a progressive withdrawal of attention from the road and traffic demands. Both driver drowsiness and distraction, however, might have the same effects, i.e., decreased driving performance, longer reaction time, and an increased risk of crash involvement [5].

A driver who falls asleep at the wheel loses control of the vehicle which often results in a crash with either another vehicle or stationary objects. In order to prevent these devastating accidents the state of drowsiness of the driver should be monitored.

Many different systems have been analysed following a non-intrusive approach to monitor the driver's drowsiness, all of which have their own pros and cons. Some efforts on the development of such systems based on the vision are discussed.

Vitabile et al. [6] 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 [7] use the Otsu thresholding [8] 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 Kmeans is used for accurate eye segmentation. Then a set of shape features are calculated and trained using non-linear SVM to get the status of the eye.

Hong et al. [9] 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. The eye area is obtained by a horizontal projection. Finally, a new complexity function with a dynamic threshold to identify the eye state.

Tian et Qin [10] build a system that checks the driver eye states. Their system uses the Cb and Cr components of the YCbCr colour 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:

- Face detection,
- Eyes Location,
- Face and eyes tracking,
- Identification of the eyes states,
- Calculation of PERCLOS and identification of driver state.

The proposed driver attention monitoring system implements a non-intrusive machine vision based concept. The system uses a small monochrome security camera that points directly towards the driver's face and monitors his eyes in order to detect fatigue. This system will analyse the state of driver's attention through a sequence of images of his face, with real time eye movements and blink patterns.

The percentage of time the pupils of the eyes are 80% or more occluded over a specified time interval is termed as PERCLOS and this method is used for early detection of drowsiness. The behaviour is then analysed and classified as normal, slightly drowsy or highly drowsy using MATLAB. In case when fatigue is detected, the LiveEye warns the driver through a special indication in the front panel and a loud alarm which ensures that the driver is alerted before any mishap.

II. THEORY

A. Driver Attention Monitoring Measures

The following measures have been used widely for monitoring drowsiness:

1) Vehicle-based measures: A number of metrics, including deviations from lane position, movement of the steering wheel, pressure on the acceleration pedal, etc., are constantly monitored and any change in these that crosses a specified threshold indicates a significantly increased probability that the driver is drowsy [11][12].

2) Physiological measures: The previously described vehicle-based measures become apparent only after the driver starts to sleep, which is often too late to prevent an accident. However, physiological signals start to change in earlier stages which is suitable to monitor attention with few false positives.
The correlation between physiological signals (electrocardiogram (ECG), electromyogram (EMG), electrooculogram (EoG) and electroencephalogram (EEG)) and driver drowsiness has been studied by many researchers [13]-[17].

3) Behavioural measures: The behaviour of the driver, including yawning, eye closure, eye blinking and head pose is monitored through a camera and the driver is alerted if any of these drowsiness symptoms are detected [18]-[20].

B. Method

Implementation of behavioural measures is the most advantageous method as it detects fatigue in a real time environment. It is non-intrusive and almost instantaneous. While the vehicle-based measure is too dependent on the geometric characteristics of the road and on external factors like road marking, climatic and lighting conditions, the physiological method requires the driver to attach some electrodes to monitor their bio-signals that makes it intrusive.

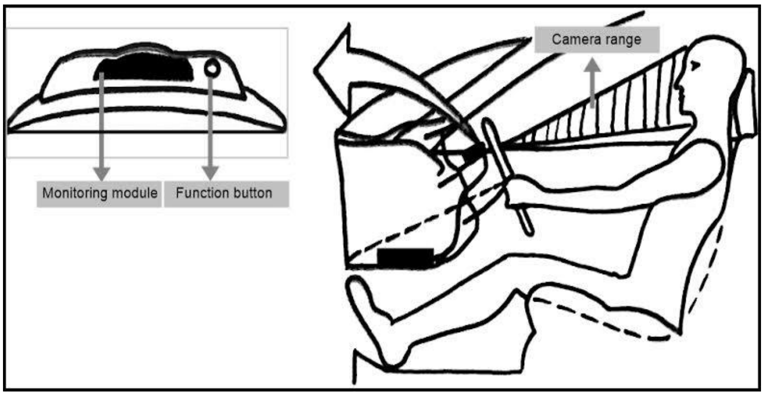

Figure 2: LiveEye Setup

The limitation that behavioural technique imposes is poor lighting conditions, which can be solved by using an IR light source along with an IR sensitive monochrome security camera. The main reason of using an IR source is that the human eye cannot see IR light. If the LiveEye system detects the driver to be fatigued, it will gently alert the driver by a beep sound and will alert other drivers on road by flashing the parking lights. If the PERCLOS signal is still not retrieved i.e., the driver is still sleeping or keeps on driving regardless of being drowsy, this system will switch off the engine. Another constraint to this technique is people wearing spectacles [21][22] as the eye detection is not accurate due to reflections from lens.

C. Algorithm

The algorithm used in the proposed driver attention monitoring system:

- The camera takes a picture with an interval of 5 seconds in between every picture.
- From each frame the facial area is detected, and the remaining is discarded.
- From the remaining area, the eyes are detected. The remaining area is again discarded.
- Template matching is done to determine if the eyes are open or closed.
- If the eyes are open, the next image is processed.
- If the eyes are determined to be closed, the LED is turned OFF, and the flag is set to '1'.
- If two consecutive frames determine that the eyes are closed, it is estimated that the driver is asleep, and the buzzer and LED both are turned on.

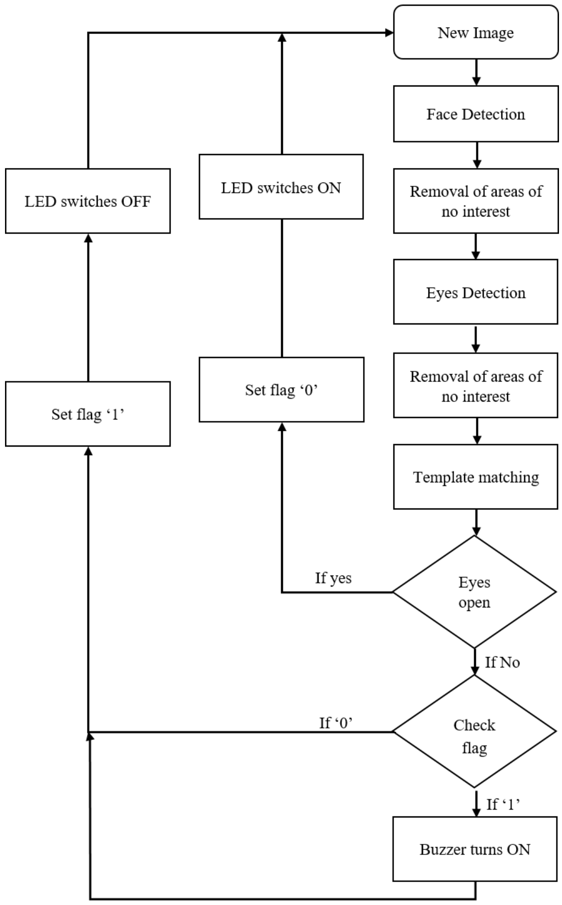

Figure 3: Scheme of the proposed algorithm for LiveEye

D. Working

The LiveEye working can be explained with the help of a block diagram as shown below:

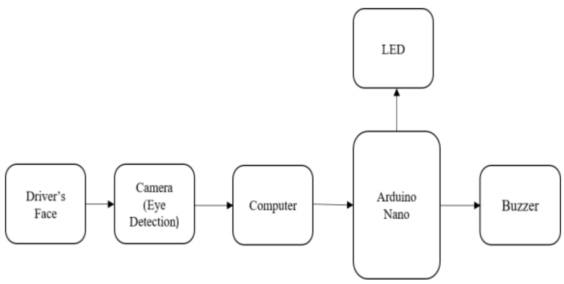

Figure 4: LiveEye block diagram

The primary purpose of the entire system is to detect the level of attention of a driver. The system does this by monitoring the eyes of the driver in a real time situation to prevent any mishap from happening by judging the driver's attention. An IR sensitive camera is connected to the computer system, which is focused on the face of the driver. The camera continuously feeds the input (images with a time difference, of the drivers face) to the system. MATLAB has a program working in the background for the detection of the face and the eyes of the driver, and then with the data acquired from the input, it judges the drowsiness of the driver.

The program utilizes some pre-defined templates, a set of predefined features of any kind, with which the data is compared to judge the similarities between the original and the provided data. Here, the templates contain data regarding the facial features, closed eyes, and open eyes features. The code first detects the location of the face in the video using the facial features. It then removes the entire area where the face was not detected because it contains data of no use. The state of the eyes, whether they are closed or open is detected using the eye templates classifiers.

The video is nothing but a set of still images taken in quick succession with very little difference in time between them. MATLAB compares their features with each of the captured frame. When the compared features conclude that the eyes of the driver are closed for a time longer than it takes a casual blink to register, the code turns on visual alarm (LED) to catch back the attention of the driver. If the driver still does not get conscious, the code turns on the buzzer to alert the driver.

E. Circuitry

The LiveEye circuit consists of the following components:

- IR Sensitive Camera, a small monochrome camera used for capturing the video of driver’s face used as input to the system.
- Arduino Nano, a microprocessor used for interfacing the LED and the buzzer to the system.
- Buzzer, an audio signalling device used to indicate the shutting off the engine.
- LED, a light source used as an indication that the driver is inattentive.

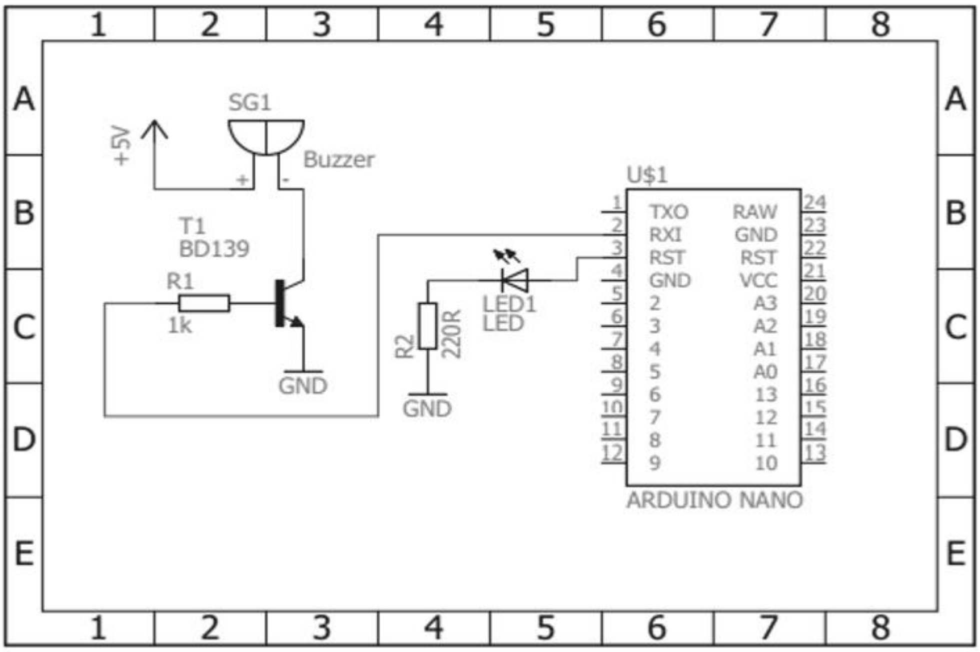

Figure 5: LiveEye Interfacing Circuit

III.EXPERIMENTAL RESULTS

The experimentation was done on MALTAB software. The following are the experimental results observed while monitoring the state of the eyes that whether they are open or closed:

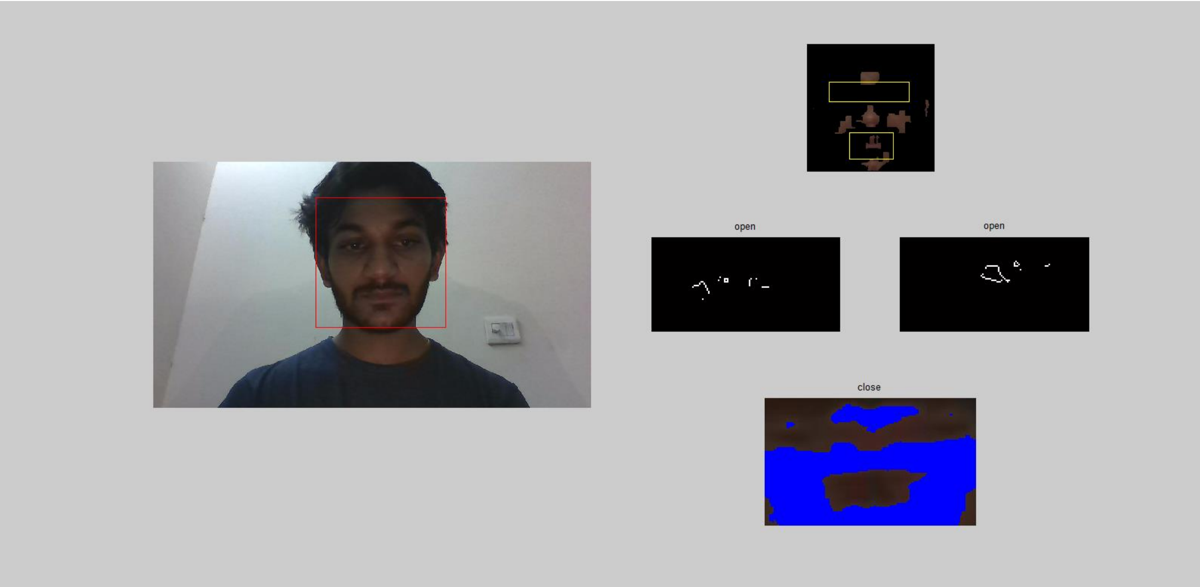

Figure 6: When eyes are open

In fig. 6, the system has analysed the state of the eyes as open, which means that the driver is awake.

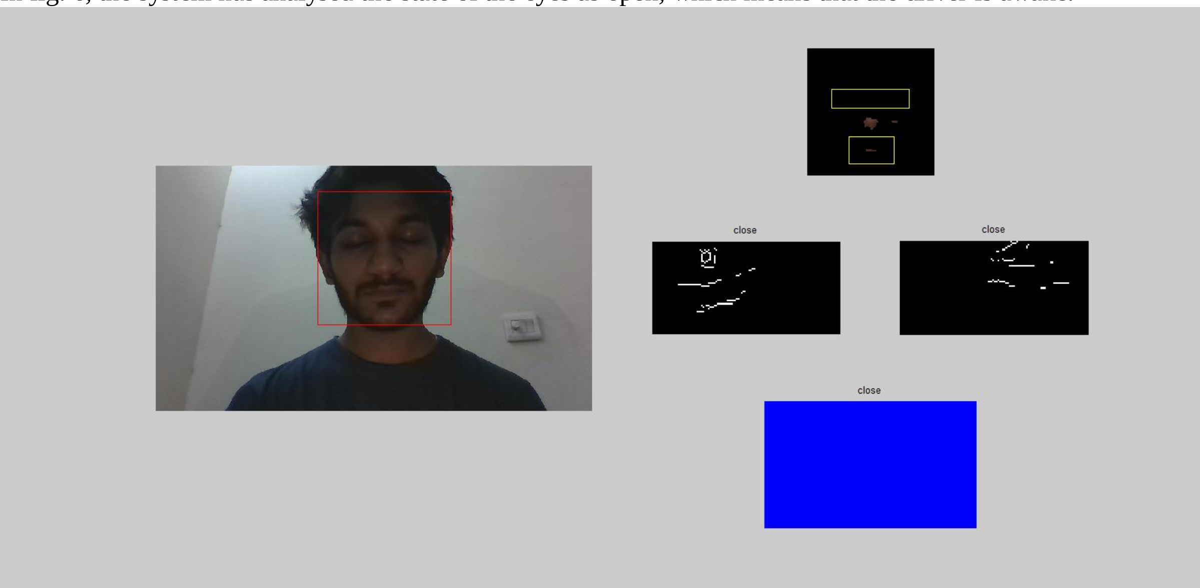

Figure 7: When eyes are closed

In fig. 7, the system has analysed the state of the eyes as closed, which means that the driver is drowsy. This will alert the driver with the help of a buzzer alarm.

Figure 6 and 7 show the detection of face and eyes and the monitoring of state of both the left and the right eye. Both the figures show the detection and monitoring of state of mouth as well but that is for analysing the mouth of the driver for yawning which is a future aspect of the LiveEye system.

IV.CONCLUSION

A non- invasive, cost effective and efficient LiveEye system has been developed which is highly accurate and reliable in monitoring the driver's attention in real time. During monitoring if the driver is inferred to be inattentive, the system issues the required signals to make the driver attentive while driving. LiveEye is successfully able to extract eyes and detect the state of the eyes by comparing the features with a pre-defined templates. The system has a success rate of more than 95% when the eyes are successfully detected, with different subjects under various lighting condition.

Although the system is not perfect, since it has a time difference of 3-5 seconds between every frame. The absence of attention detection during these crucial seconds may be of severe consequences. The system shows some minute errors which are unavoidable during real-time implementation of the project. One reason for the occurrence of error is due to the time gap between each frame. Another cause for such error is due to improper lighting condition, because of which the camera might not be able to capture a clear frame. This drawback maybe encountered with an artificial infrared light source, which can be detected by a camera, but is invisible to human eye. Spectacles may also be a cause of error in this project's functioning as they reflect light and add another feature to be detected and removed as useless data.

V. FUTURE ASPECTS

The future aspects of the LiveEye system can be the integration of various other methods of monitoring a driver's attention with the used method to increase the efficiency of the system. The system can be made very compact by using microcomputers such as Raspberry Pi because of its small size (size of a debit card) so that it is feasible to install it in vehicles. In addition, the system will be more useful and lifesaving if it actually prevents accidents besides alerting the sleepy driver. For this to happen, the system needs to flash the parking lights of the vehicle to make other drivers aware and further, autonomously park the vehicle at the roadside while giving the appropriate indicator.

ACKNOWLEDGEMENT

The authors wish to acknowledge Ms. Kriti Jain for her persistent guidance and support, The Mathworks, Inc. for their MATLAB computing environment and programming language that helped in easy development of the technology and Eagle Camera Support Systems Ltd. for their schematic and simulation software that helped in easy simulation for verification of the technology.

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