Driver Drowsiness Detection to Reduce the Major Road Accidents in Automotive Vehicles

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Abstract - *Driver errors and carelessness contribute most of the road accidents occurring nowadays. The major driver errors are caused by drowsiness, drunken and reckless behavior of the driver. This paper focuses on a driver drowsiness detection system in Intelligent Transportation System, which focuses on abnormal behavior exhibited by the driver using Raspberry pi single board computer. In the proposed system a non-intrusive driver drowsiness monitoring system has been developed using computer vision techniques. Based on the simulation results, it was found that the system has been able to detect drowsiness in spite of driver wearing spectacles as well as the darkness level inside the vehicle. Moreover the system is capable of detecting drowsiness within time duration of about two seconds. The detected abnormal behavior is corrected through alarms in real time.*

Key Words: Raspberry pi, Eye tracking, Yawning, Image processing, Driver Drowsiness, Harr classifier.

1. INTRODUCTION

Automotive population is increasing exponentially in the country. The biggest problem regarding the increased traffic is the rising number of road accidents. Road accidents are undoubtedly a global menace in our country. The Global Status Report on Road Safety published by the World Health Organization (WHO) identified the major causes of road accidents are due to driver errors and carelessness. Driver sleepiness, alcoholism and carelessness are the key players in the accident scenario. The fatalities and associated expenses as a result of road accidents are very serious problems. The related dangers resulted have been recognized as a serious threat to many families in every country.
All these factors led to the development of Intelligent Transportation Systems (ITS). Taking into account of these factors, the driver's behavioral state is a major challenge for designing advanced driver assistance systems. The major driver errors are caused by drowsiness, drunken and reckless behavior of the driver. The real time detection of these behaviors is a serious issue regarding the design of advanced safety systems in automobiles.

2. Background

Several works have been done in the field of driver abnormality monitoring and detection systems using a wide range of methods. Among the possible methods, the best techniques are the ones based on human physiological phenomena .These techniques can be implemented by measuring brain waves (EEG), heart rate (ECG) and open/closed state of the eyes. The former two methods, though being more accurate are not realistic since sensing electrodes to be attached directly onto the driver's body and hence be annoying and distracting the driver. The latter technique based on eye closure is well suited for real world driving conditions, since it can detect the open/closed state of the eyes non-intrusively using a camera. Eye tracking based drowsiness detection systems have been done by analyzing the duration of eye closure and developing an algorithm to detect the driver's drowsiness in advance and to warn the driver by in-vehicle alarms.

3. System architecture

The proposed system comprises of three phases.
1 .Capturing: Eye Camera mounted on the dashboard is used for capturing the facial image of the driver.

2. Detection: The analysis of the captured image is done to detect the open/closed state of the eyes. The driver's current driving behavior style is deduced using inbuilt HARR classifier cascades in OpenCV.

3. Correction: This phase is responsible for doing the corrective actions required for that particular detected abnormal behavior. The corrective actions include in-vehicle alarms and displays. The Raspberry pi single board computer which is connected serially to the PC performs the necessary corrective actions.

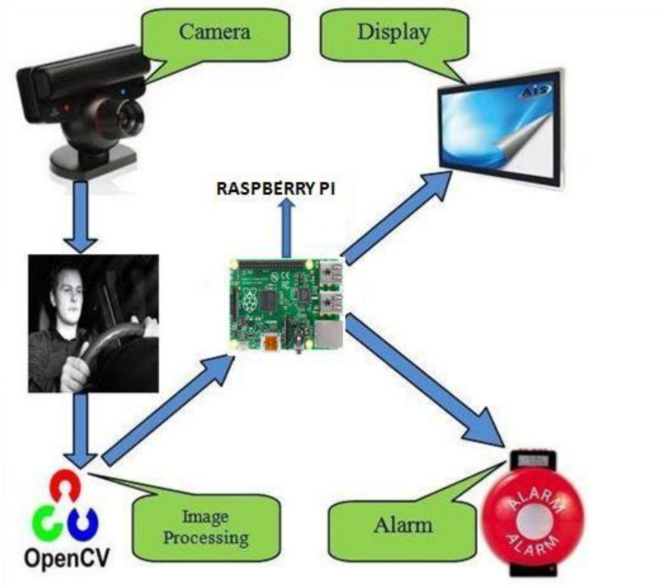

Fig -1: Block Diagram of the Proposed System.

4. RASPBERRY PI SINGLE BOARD COMPUTER

Raspberry Pi (represented in Figure 2) is a credit card sized single-board computer. It has 5 models. Model A, Model A+, Model B, Model B+, Generation 2 Model B. Model A has 256Mb RAM, one USB port and no network connection. Model A+ has 256Mb RAM, one USB port and network connection. Model B has 512Mb RAM, 2 USB ports and an Ethernet port. Model B+ has 512Mb RAM, four USB ports, Ethernet port and HDMI and camera interface slot. Generation 2 Model B also has 4 USB ports, 1 GB RAM, 2 camera interface and 1HDMI interface. We implemented raspberry pi tablet using Model B+. IT has a Broadcom BCM2835 system on chip which include an ARM1176JZF-S 700 MHz processor, Video Core IV GPU, and an SD card. The GPU is capable of Blu-ray quality playback, using H.264 at 40MBits/s. It has a fast 3D core accessed using the supplied Open GL ES2.0 and Open VG libraries. The chip specifically provides HDMI and there is no VGA support. The foundation provides Debian and Arch Linux ARM distributions and also Python as the main programming language, with the support for BBC BASIC, C and Perl.

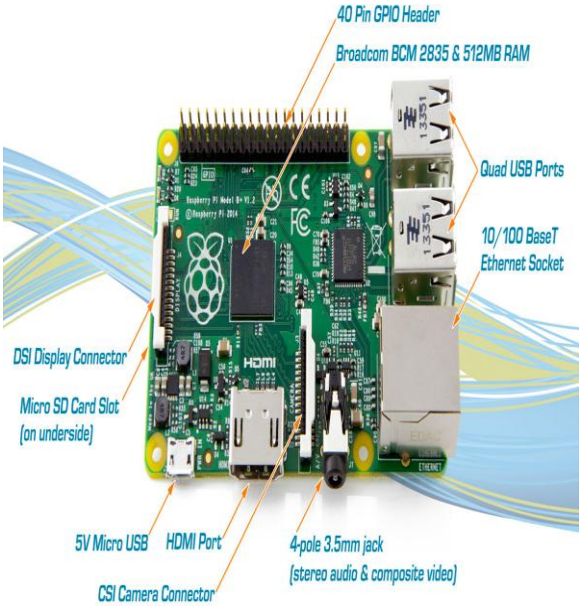

Fig -2: Raspberry Pi Model B+

5. VISION TO RASPBERRY PI

The Raspberry Pi Camera Board plugs directly into the CSI connector on the Raspberry Pi. It's able to deliver a crystal clear 5MP resolution image, or 1080p HD video recording at 30fps as shown in figure 3.

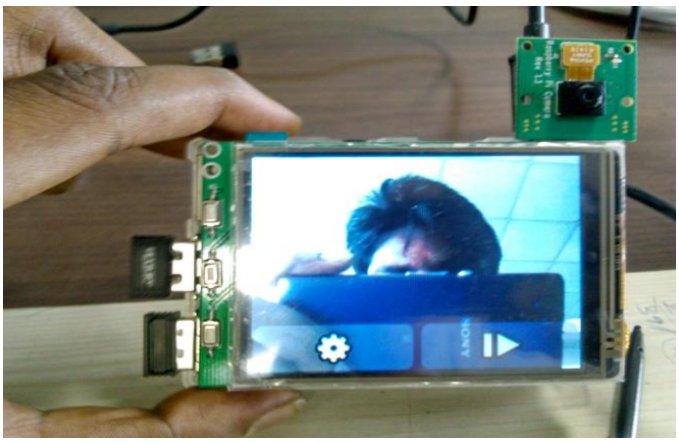

Fig -3: Vision to Raspberry Pi

The Raspberry Pi Camera Board features a 5MP (2592×1944 pixels) Omni vision 5647 sensor in a fixed focus module. The module attaches to Raspberry Pi, by way of a 15 Pin Ribbon Cable, to the dedicated 15-pin MIPI Camera Serial Interface (CSI), which was designed especially for interfacing to camera. The camera module is shown in figure 4.

The CSI bus is capable of extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor.

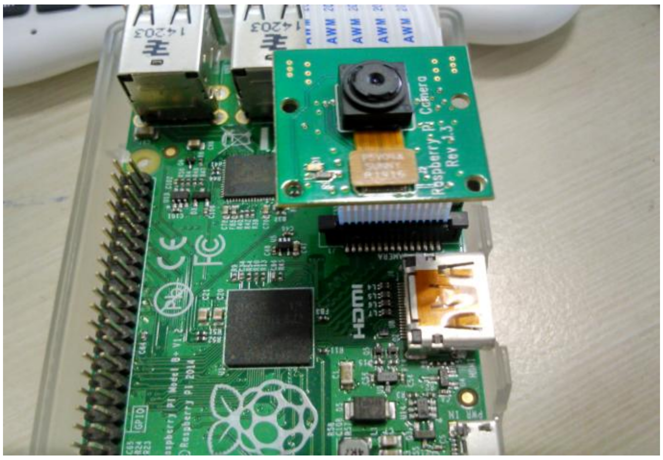

Fig -4: Camera Module

A. Interfacing Camera

The following are steps to be used for interfacing the camera:

1. Power up raspberry pi and login as “pi" and password as “raspberry”.

2. At the command prompt enter the following command as “sudo raspi-config” and navigate to “ENABLE”. Configuring camera module is shown in the figure 5.

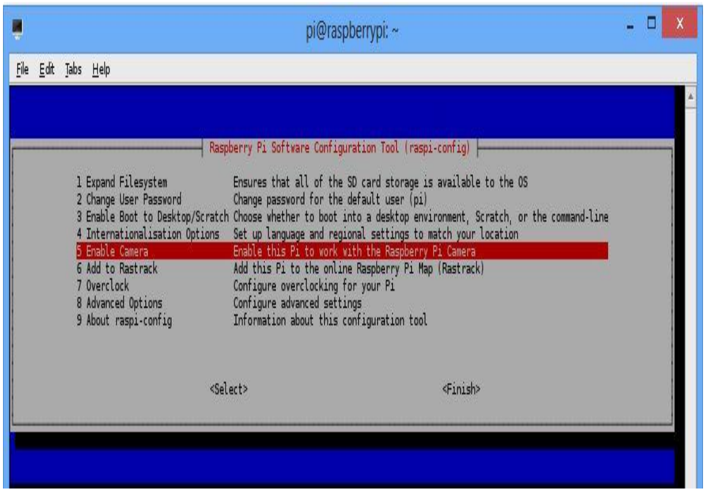

Fig -5: Configuring Camera Module

B. Capturing Image

“Raspistill” is the command line tool for capturing still photographs with the camera module. With the camera module connected and enabled, enter the following command in the LX Terminal to take a picture:

“raspistill -o cam.jpg”

A sample snapshot from camera module is shown in figure 6.

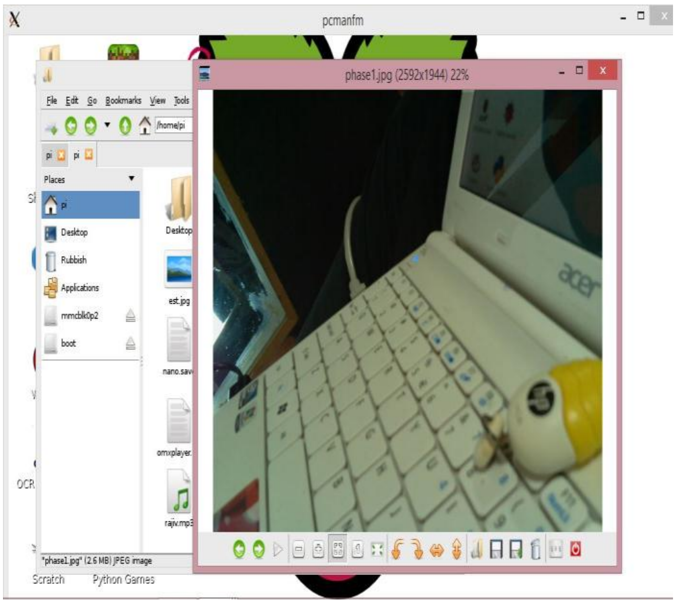

Fig-6: Sample Snapshot from Camera

C. Capturing Video

“RaspiVid” is the command line tool for capturing video with the camera module. With the camera module connected and enabled, enter the following command in the LX Terminal to capture video.

raspivid -o test video.h264 –t 10000 as shown in figure 7

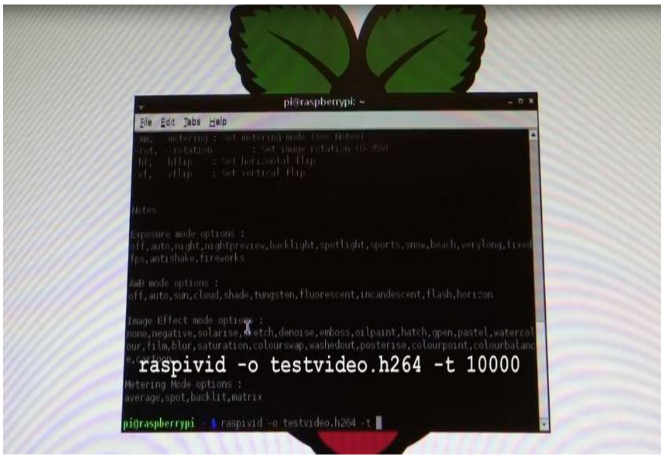

Fig-7: Capturing the Video

5. PROCEDURE

In the proposed system shown in Fig.1, the primary focus is given to the faster drowsiness detection and processing of data. The number of frames in which the eyes are kept closed is monitored and then counted. If the number of frames exceeds a threshold value, then a warning message is generated on the display showing that the drowsiness is detected. The system should be capable of detecting drowsiness in spite of the skin colour and complexion of the driver, spectacles used by the driver and the darkness level inside the vehicle. All these objectives have been well satisfied by choosing the system using appropriate classifiers in OpenCV for eye closure detection.

In this algorithm, first a driver's image is acquired by the camera for processing. In OpenCV, the face detection of the driver's image is carried out first followed by eye detection. The eye detection technique detects the open state of eyes only. Then the algorithm counts the number of open eyes in each frame and calculates the criteria for detection of drowsiness. If the criteria are satisfied, then the driver is said to be drowsy. The display and buzzer connected to the system perform actions to correct the driver abnormal behavior.

For this system, the face and eye classifiers are required. The HARR Classifier Cascade files inbuilt on OpenCV include different classifiers for the face detection and the eyes detection . The inbuilt OpenCV xml "haarcascade_frontalface_alt2.xml" is used to search and detect the face in individual frames. The classifier "haarcascade_eye_tree_eyeglasses.xml" is used to detect eyes in the open state from the detected face. The system does not detect in the closed state of the eyes. The face detection and open eye detection have been carried out on each frame of the driver's facial image acquired from the camera. The variable Eyestotal is assigned to store the number of open eyes (0, 1 and 2) detected in each frame. The variable Drowsycount is assigned for storing the number of successive frames in which the eyes have been kept closed (0, 1, 2, 3, 4, etc.). Initially, Drowsycount is set to 0. When both the eyes are in an open state, Drowsycount is 0.

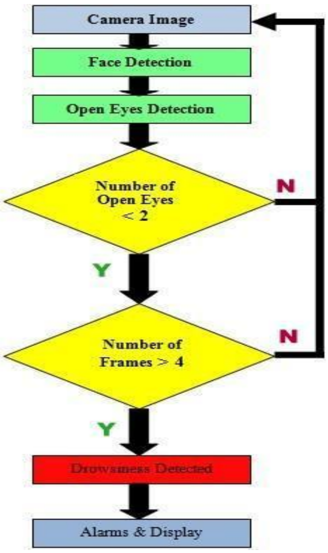

Fig-8: Flow Diagram of the Proposed Algorithm

Drowsycount gets incremented when Eyestotal < 2. For an eye blink, Drowsycount value gets incremented to 1. If the eyeblink occurs for more than 4 frames, i.e. Drowsycount >=4, then the criterion for drowsiness is satisfied. The display shows, "Please take some rest." Tickstart shows the real time duration in which eyes have been kept closed.

5. RESULTS

The proposed drowsiness detection system detects the drowsiness of the driver when the eyes are closed for 4 frames or more (i.e., more than 2 seconds). The detection system differentiates the normal eye blink and drowsiness. The system is non intrusive and can be easily equipped with any vehicle.

The Visual Studio Express simulation results of the drowsiness system are illustrated in the following figures. In Fig.9, the normal state of the driver is shown in which the open eyes are detected. In Fig.10, the driver eyes have been kept closed for successive 4 frames. The display shows "Please take some rest." The system is capable of detecting drowsiness in spite of the spectacles worn by the driver. The condition of the driver wearing spectacles is shown in Fig 11. In normal driving conditions, the open eyes are detected. The drowsiness is detected when the eyes have been kept closed for successive 4 frames as shown in Fig.12.

Fig-9: Normal state

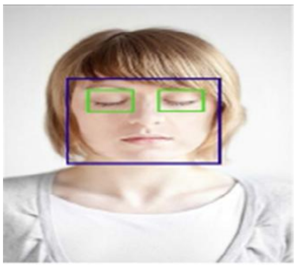

Fig-10: Drowsiness state

Fig-11: Normal State with Glass Fig-12: Drowsiness State with Glass.

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eye count = 2  0
eye count = 2  0
eye count = 2  0
eye count = 2  0
eye count = 2  0
eye count = 0  0
eye count = 0  1
eye count = 0  2
eye count = 0  3
Drowsiness detected for 2.058237 secs
eye count = 0  4
Drowsiness detected for 2.592939 secs
eye count = 0  5
Drowsiness detected for 3.116029 secs
eye count = 2  6
eye count = 2  0
eye count = 2  0
```

Fig.13: Execution Window for Drowsiness

In normal driving condition, both the eyes are open. Hence the system could detect the open eyes. Open eyes detection was illustrated by drawing rectangles around the eyes
as shown in Fig. 9 & Fig. 11. In the drowsiness condition, the eyes get closed. Hence open eye detection could not be performed in that case shown in Fig.10 &Fig. 12.

In Fig.13, it is shown that for normal driving, the number of open eyes is 2 and the number of successive frames for closed eyes is 0. When the eyes are closed in one frame, the number of open eyes becomes 0 and number of closure frames increment by 1. If this condition persists for continuous 4 frames and more, the execution window shows drowsiness detected. Also, it calculates the duration for which the eyes have been kept closed. The system is capable to detect drowsiness in the case of closed eyes for more than 2 seconds.

5. CONCLUSION AND FUTURE WORK

The drowsiness detection and correction system developed here is capable of detecting drowsiness in a rapid manner. The system which can differentiate normal eye blink and drowsiness can prevent the driver from entering the state of sleepiness while driving. The system works well even in case of drivers wearing spectacles and under low light conditions also. As a complete abnormality detection system, this system can be further developed by adding different sensors and lane detection camera with appropriate hardware units and controller, which can deliver highly accurate detection techniques. The system can be commercially generalized and well employed in today's vehicles with comparatively fewer expenses. As a whole, the system when equipped with the vehicles can reduce the traffic collisions occurring, related dangers and expenses in our country.

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