UNITED ARAB EMIRATES
MINISTRY OF ECONOMY

الإمارات العربية المتحدة
وزارة الاقتصاد

شهادة تسجيل مصنف

رقم (577-2020)

تشهد وزارة الاقتصاد بأن المصنف موضوع هذه الشهادة قد تم تسجيله بإدارة المصنفات الفكرية بتاريخ2020/05/19 وذلك وفقا للنسخة المسجلة لدى الإدارة

1) **إسم المصنف** : Real-Time Drowsiness Detection Using Computer Vision and Raspberry Pi to Prevent Car & Road Accidents

2) **نوع المصنف** : المصنفات المكتوبة

3) **وصف المصنف** : عبارة عن مادة مكتوبة تتضمن بحث باللغة الإنجليزية ، وذلك حسب النسخة المسجلة لدينا.

4) **إسم المؤلف** : اديتيا محيط ساكسينا الجنسية: الهند

5) **إسم صاحب حقوق المصنف** : نفس البيانات اعلاه

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حررت في : 19/05/2020

مدير إدارة المصنفات الفكرية

Real-Time Drowsiness Detection Using Computer Vision and Raspberry Pi to Prevent Car & Road Accidents

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Abstract

In recent years, drowsiness and distraction during driving has been a major cause for several road accidents worldwide. This has led to loss of both,human life and money. This paper represents an affordable real-time drowsiness and distraction detection system using Computer Vision and Raspberry Pi 4 B+ model with NoIR-V2 Pi camera for drivers. The proposed system, designed specifically for four-wheelers, captures the driver's face and eyes, processes the facial features associated with Face and Ear Aspect Ratio (EAR). If found distracted or drowsiness, the model alerts the driver by generating a warning SMS to the driver along with registered car number and turning on an alarm buzzer to ensure vigilance. The model was trained using OpenCV's Haar Cascade Classifier and message is sent to the driver using Twilio API. Raspbian Operating System has been used for the following project.

Keywords: Drowsiness and Distraction Detection, Raspberry Pi 3+, Computer Vision, Facial Features, Face and Eye Aspect Ratio (EAR), OpenCV

1. INTRODUCTION

1.1 Background of The Problem

Distracted driving has grown into a major cause of car accidents in recent years across the global. The phrase describes any diversion of a driver's attention from operating his vehicle. More than 90% of car crashes around the world involve human error. In U.S. alone, 2,841 people died of car accidents involving distraction. According to The National Highway Traffic Safety Administration (NHTSA), there were 3092 fatal distraction driving accidents across U.S. and another 416,000 distracted driving caused personal injuries. As per National Safety Council (NSC) analysis of National Highway Traffic Safety Administration (NHTSA), distracted driving includes:

- Talking on a cell phone
- Texting via a cell phone
- Talking to passengers
- Eating
- Reading
- Grooming (i.e., combing hair, applying makeup, etc.)
- Adjusting radios, GPS units or other devices
- Watching videos.

Drowsiness during driving reaction time, which is critical element of safe element. This leads to low level of vigilance, alertness and concentration, affecting the ability to perform attention-based activities. Decision making quality is also affected. Driver fatigue is a serious problem resulting in many thousands of road accidents each year.

It is estimated that driver fatigue contributes up to a factor of 20% in road accidents, and around one quarter of fatal and serious accidents including physical injuries. 50% of these crashes most likely result in death or serious injury due to high speed impacts and collisions.

A survey conducted by The National Highway Traffic Safety Administration (USA) shows that:

- An estimated 1 in 25 adult drivers (aged 18 or older) report having fallen asleep while driving in the previous 30 days.
- Drowsy driving was responsible for 72,000 crashes, 44,000 injuries, and 800 deaths in 2013. However, these numbers are underestimated, and up to 6,000 fatal crashes each year may be caused by drowsy drivers.

Drowsiness was also a major factor in 10.6% to 10.8% of crashes resulting in significant property damage and loss of money.

1.2 Objective

The objective of this research is to build an affordable real-time drowsiness and distraction detection system powered by Computer Vision for four-wheelers by alerting them instantly if found distracted or drowsy. The model aims to reduce future car accidents at an affordable rate.

1.3 Hypothesis

A camera can be installed in front of the steering wheel of the driver's seat where it continuously analysis and monitors the face of the driver. The video will be processed by the OpenCV's Haar Cascade Classifier which analysis the facial features of the driver. If found drowsy or distracted, the device alerts the driver instantly.

The second feature of the device is turn on the installed buzzer alarm thereby physically alerting the driver to prevent any causality. The device also has a build in SMS system which triggers with the alarm, sending a warning message to the driver's cell phone along with registered car number.

2. METHODOLOGY

Even though the problem of car accidents is not new, researchers are still looking out for new and cheaper methods and techniques. Some of the different methodologies developed for detecting driver concentration while driving in order to prevent road accidents are:

- Vehicle based approach- It is the most common method to monitor driver's driving behaviour. The technique continuously monitored position of lane, steering wheel position and pressure on acceleration pedal. If it crosses the threshold values then it indicates that the driver gets drowsy.

- Physiological based approach-In this technique, driver's pulse rate, heart rate and brain activity information are continuously monitored. ECG is used to calculate the variation in heart rate and also detect different conditions for drowsiness. For this method, electrodes are placed on the scalp of the car driver. These electrodes detect the voltages produced in the cortex of the brain. This voltage contains three frequencies related to alpha, beta and gamma waves. These frequencies can be further processed to calculate drowsiness and different sleep stages.

- Behavioural based approach-This approach includes yawning (opening area of mouth), eye closure, eye blinking frequency and head pose. This can be done by placing camera in front of the car driver. The camera continuously captures images of the car driver. The car driver's image is further processed for detecting drowsiness of the driver.

3. METHODOLOGY OF IMPLEMENTATION

In terms of practical implementation, physiological based approach is not suitable for drowsiness detection as it is unsafe for driver and environmental conditions also affected the electrode.

Vehicle based approach is not suitable. This is because vehicle-based approach is based on monitoring the driving pattern of the car. But the problem is, it is difficult to determine when the driver is in micro sleep or in a deep sleep? This situation is dangerous for the driver and also car.

Hence, we are using Behavioural based approach in our project.

3.1 Haar Cascade Classifiers

The Haar Cascade Classifiers is developed using a lot of data consisting of images belonging to subset of drowsiness and fatigue of the driver in real-time environment. The dataset is then stored into separate database consisting of facial features. These face and eye images with several other positive and negative images have face pointing towards other directions, eyes being closed and different set of facial features for all the worst-case scenarios. The algorithm was built on top of OpenCV which is contains trained dataset.

3.2 Face and Eye Aspect Ratio (EAR)

Once the camera is set and starts to monitor the facial features of the driver, the algorithm begins the calculation of face direction and drowsiness level of the driver based the pupil size and eye blink rate. The Eye Aspect Ratio (EAR) formula, proposed in 2016, detects the eye blink rate by converting the values into scalar value. If the driver blinks eyes frequently, it means that the driver is either in the state of drowsiness and distracted. Thus, it is necessary to detect the eyes shape accurately in order to calculate the eye blink frequency. From the landmarks detected in the image with face, the EAR is used as an estimate of the eye openness state. For every video frame, the eye landmarks are detected between height and width of the eye that had been computed. The formula for the calculation of Eye Aspect Ratio (EAR) is –

$$\textbf{E.A.R} = \frac{||p2-p6||+||p3-p5||}{2\,||p1-p4||} \qquad \ldots(1)$$

Equation (1) shows the eye aspect ratio formula where p1 until p6 are the 2D landmark locations. The p2, p3, p5 and p6 are used to measure the height whereas p1 and p4 are used to measure width of the eyes in meter (m) as shown in Figure 1(a). The eye aspect ratio is a constant value when the eye is opened, but rapidly falls approximately to 0 when the eye is closed as shown in the Figure 2(b).

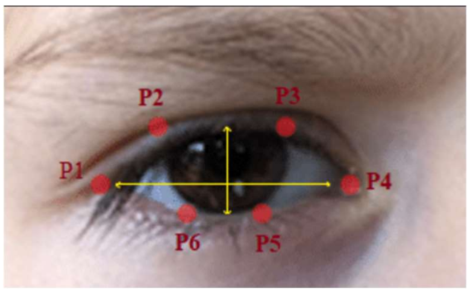


Fig.1:(a)

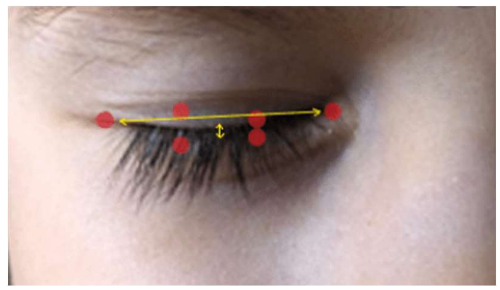
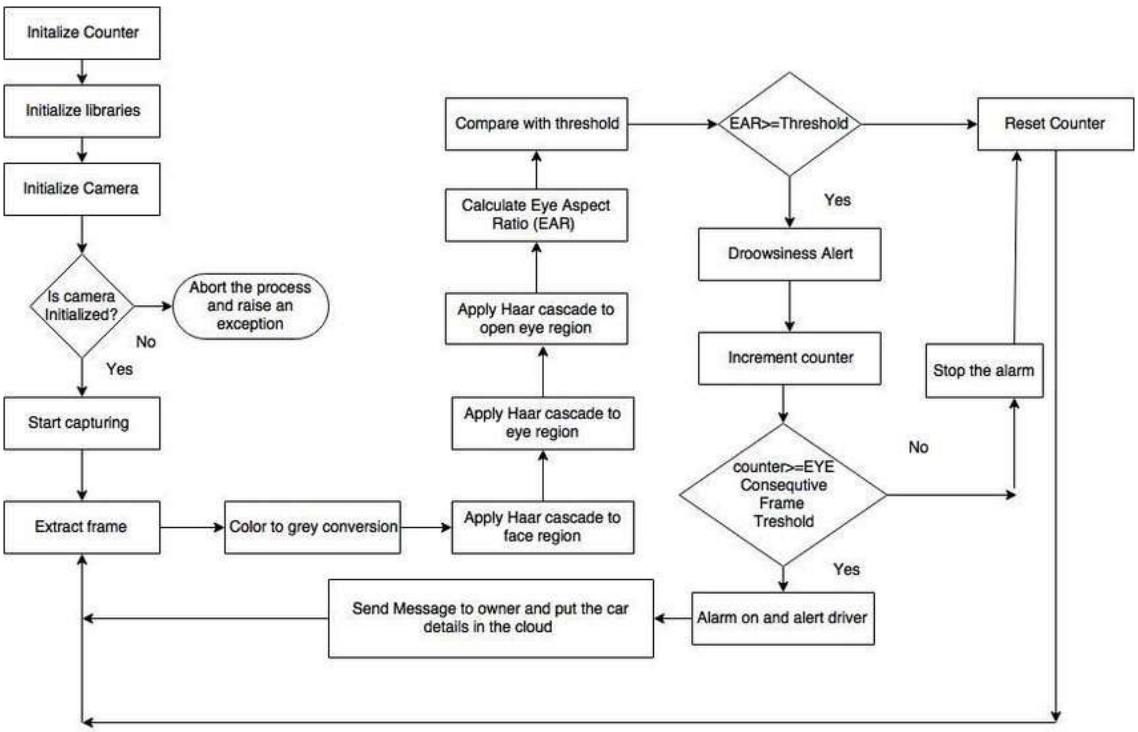


Fig.1:(b)

The EAR is mostly stable when an eye is open and is getting close to zero while the eye is not in open state. If the person viewing the camera continuously, the Eye Aspect Ratio (EAR) is found to be normal and it reaches low value when he/she closing the eye for a longer time. When the lower value is reached, then drowsiness is detected.

3.3 Architecture



4. HARDWARE APPARATUS

The main hardware component used to develop the distraction and drowsiness detection system is Raspberry Pi 4+ and NoirV2 Pi camera. The Raspberry Pi 4+ Model B is the 4th generation of Raspberry Pi. Whilst maintaining its affordability, it has Quad Core GPU which is four times better than the first-generation models. The core of model 4 B+ is Cortex-A72 (ARM v8) 64-bit as compared to ARM 1176JZF-S and Cortex-A53 64-bit core found in first- and second-generation models respectively. This significantly reduce the computational power and electricity consumption for the working device, thereby reducing net heat output. The board has inbuild wireless LAN and Bluetooth connectivity making it the ideal solution for powerful connected designs.

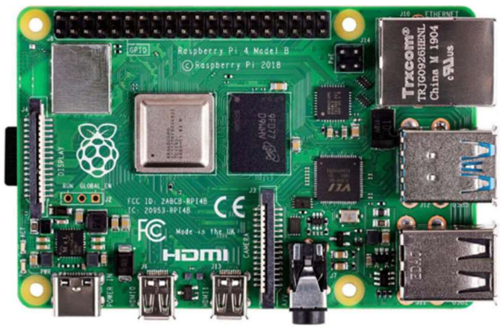


Fig. 2: Raspberry Pi 4+

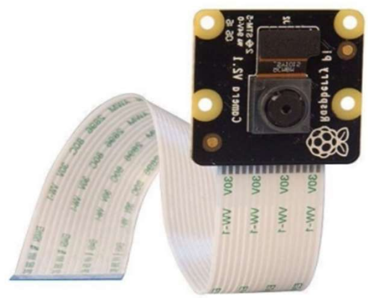


Fig. 3: NoirV2 Pi Camera

The Raspberry Pi NoIR Camera Module v2 is a high quality 8-megapixel Sony IMX219 image sensor custom designed add-on board for Raspberry Pi, featuring a fixed focus lens. It's capable of 3280 x 2464-pixel static images, and also supports 1080p30, 720p60 and 640x480p60/90 video. It attaches to Pi by way of one of the small sockets on the board upper surface and uses the dedicated CSi interface, designed especially for interfacing to cameras.

The board itself is tiny, at around 25mm x 23mm x 9mm. It also weighs just over 3g, making it perfect for mobile or other applications where size and weight are important. It connects to Raspberry Pi by way of a short ribbon cable.

The NoIR Camera has No InfraRed (NoIR) filter on the lens which makes it perfect for doing Infrared photography and taking pictures in low light (twilight) environments.

Features	Raspberry Pi Model 4+	Raspberry Pi Model 3
CPU (Speed/Type)	1.5 GHz ARM Cortex-A72	1.2 GHz ARM Cortex-A53
RAM Size	4 GB LPDDR4	1 GB LPDDR2
Integrated Wi-Fi	5 GHz	2.4 GHz
Bluetooth	5 BLE	4.1 BLE
Video Decode	H.265(4kp60)	H.264(1080p30)
OpenGL ES	3.0 graphics	2.0 graphics
Market Price	35$	35$

Fig. 4: Comparison between Raspberry Pi 4+ and previously used Raspberry Pi Models

5. SOFTWARE

Raspbian operating system has been used for the following model. Raspbian is a Debian-based (32 bit) computer operating system for Raspberry Pi. Raspbian uses PIXEL, Pi Improved X-Window Environment, Lightweight as its main desktop environment as of the latest update. It is composed of a modified LXDE desktop environment and the Openbox stacking window manager, perfect to run low to moderate computational programs.

Twilio API allows the generation and sending of SMS from the Raspberry Pi to the driver's cell phone. It is specifically used for cloud-to-device and device-to-cloud communications, thus allowing providing proper database for generated SMS.

6. RESULT AND DISCUSSION

The proposed model measured the driver's drowsiness and distraction pattern using the Eye Aspect Ratio (E.A.R./Eye) By analysing the facial landmarks and pupil's size, the algorithm predicted the driver's current state. The proposed model was experimented on 5 different individuals. Eye closing rate was calculated was every half a second. If the Eye closing rate exceeds the pre-set threshold value or the face failed to make video contact with the Pi camera, the Raspberry Pi automates the buzzer connected to it through the inbuild GPIO pins of the Raspbian Board. The build in buzzer brings the driver out of the unconscious state of mind, sleepiness or being distracted by other environmental factors. Along with alarm being set on, a warning message in the form of SMS is send to owner driver along with the registered car number plate.

6.1 Without Spectacles/Sunglasses

The figure _, shows two states of the person. In figure 5(a), the person's Eye Aspect Ratio (E.A.R/Eye) which is 0.330, is well above the threshold value. Thus, no alert message is generated on the screen and no buzzer alarm was set on. However, in figure 5(b), the Eye Aspect Ratio (E.A.R/Eye) which is 0.211, is below the standard threshold value. The model then classifies the state of the person as drowsiness and thereby generated a warning message and sets on the buzzer along with SMS, sent to the car driver.

(a)

(b)

Fig 5: Figure 5(a) shows the normal state of the individual with Eye ratio above threshold ratio. In figure 5(b), Drowsiness alert message with Eye ratio below the threshold ratio has been shown.

6.2 With Spectacles

The proposed model is successfully able to classify the state of the individual with spectacles on. In figure_(a), the person's Eye Aspect Ratio (E.A.R/Eye) which is 0.330 (Spectacles on), is well above the threshold value. Thus, no alert message is generated on the screen and no buzzer alarm was set on. However, in figure _(b), the Eye Aspect Ratio (E.A.R/Eye) which is 0.211 (Spectacles on), is below the standard threshold value. The model then classifies the state of the person as drowsiness and thereby generated a warning message and sets on the buzzer along with SMS, sent to the car driver.

(a) (b)

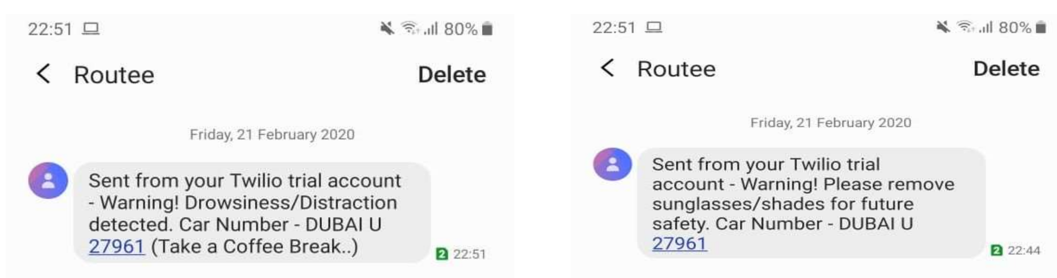
Fig.6: Figure 6(a) shows the normal state of the individual (With Spectacles) with Eye ratio above threshold ratio. In figure 6(b), Drowsiness alert message with Eye ratio below the threshold ratio has been shown.

6.3 With Sunglasses

The proposed model is able to classify whether the individual, driving the car is wearing sunglasses /shades or not. If no Eye Aspect Ratio/Eye was detected, the model declares the driver wearing sunglasses/shades while driving and sends an SMS to the car driver, saying to remove the sunglasses/shades to prevent future car accidents.

CONCLUSION

The purpose of this paper was to devise a cheap and affordable way to alert drowsy and distracted drivers in the act of driving. The proposed distraction and drowsiness system were built to prevent future car accidents caused due to surrounding distraction or sleepiness. The system calculates the Eye Aspect Ratio (E.A.R/Eye) of the driver by detecting Eye and face using Haar Cascade Classifier, especially facial landmarks through the Euclidean distance between the eyes and compares with the set threshold value. If the ratio calculated is found to be below the threshold value, the Raspbian Pi model triggers an inbuild loud buzzer alarm along with a generated SMS message sent to the registered car driver with the car number plate.



(a) (b)

Fig.7: Figure 7(a) shows the SMS received by the car driver found in state of drowsiness/distracted. Figure 7(b), shows SMS received by the car driver for wearing sunglasses/shades while driving.

The following model was successfully tested on three individuals with different conditions - Without spectacles/sunglasses, With spectacles on and With sunglasses/shades on. The model was able to calculate the state of the driver in all the conditions successfully with triggering an alert message along with the alarm whenever the drowsiness/distraction state was detected regardless of the background lighting conditions.

In future the proposed model implementation can be done on far more worse case scenarios, with different surrounding lighting conditions like night vision. The model can also be implemented for 2-wheelers in future with the advancement in Computer Vision technologies.

ACKNOWLEDGEMENT

This work was supported by Birla Institute of Technology and Science, Pilani, Dubai Campus, Dubai, UAE. Special thanks to Dr. Tamizharasan Periyasamy, Computer Science and Engineering Department, BITS Pilani Dubai Campus.

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