International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 4 Apr. 2021, pp: 619-625 www.ijaem.net ISSN: 2395-5252

Driver Drowsiness Detection Using Computer Vision and Heart Rate Variability

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Submitted: 15-04-2021 Revised: 28-04-2021 Accepted: 30-04-2021

ABSTRACT : Drowsy motoring is a consolidation of driving and sleepiness or weariness. It is a major problem in road accidents. Fatal car accidents caused by drowsy driving can be mitigated and prevented with Driver drowsiness detection. In this proposal machine learning is employed to detect drowsiness episodes. It focuses primarily on the state of the eye. The alert signal is spawned from a combination of devices, the Raspberry Pi is teamed up with Raspbian camera and is used to identify the sluggishness of the driver in problem-solving time by tracking the eye blink. The HRV (Heart Rate variability) sensor is used for validating the drowsiness of the driver. The HRV pulse sensor can measure the heart rate by detecting changes in light that passes through it as blood is pumped. This work proposes a model to detect and notify drowsy driving and could naturally reduce the number of road accidents.

I. INTRODUCTION

Car is one of the popularly used vehicles for transportation. People prefer the car as it is efficient when pooled for long-distance travel. Driving a car requires undistracted attention and rapid response, loss of any such attribute may have severe consequences such as accidents, injury and even loss of life. Road accidents claim more lives rather than deadly diseases like HIV/AIDS, tuberculosis or diarrhoeal diseases. Road traffic crashes accounts for 1.35 million deaths each year, the eighth prominent mainspring of mortality for all ages and paramount matter of casualty for juvenile and younglings amongst 5-29 years. Car accidents are increasing at an alarming rate every year due to human errors.

Automakers are investing in the prevention of drowsy driving as it stands out to be a potential threat to the driver and his surroundings. They combat this with many modern technologies to ensure the early detection and prevention of such incidents.

II. LITERATURE REVIEW

Driver drowsiness is used to detect whether the driver is drowsy or not. Because of drowsiness most of the people lost their lives. A study says that road accidents claim more lives rather than deadly diseases like HIV/AIDS,tuberculosis or diarrhoeal diseases. In this article to present a survey on the work that has been done in the area of Driver drowsiness. Ji Hyun Yang et al (2009) says that it revealed the characteristics of drowsy driving through simulator-based human-in-the-loop experiments. They have observed that drowsiness has greater impact on rule-based driving tasks than on skill based tasks. They have confirmed this by finding inferring driver alertness using the BN paradigm. Akalya Chellappa et al (2018) says that In their system through the

detection of the Eye and face fatigue is measured by adapting Haar Cascade Classifier, especially facial landmarks are identified using the shape-predictor and Eye ratio (EAR) by determining the Euclidean distance between the eyes. Detection of eyes and faces accurately in each frame will aid to determine the degree of drowsiness. The major disadvantage of this system is that the operational complexity is high. Chin-Teng Lin et al (2010) says that a real-time wireless EEG-based BCI system was designed for drowsiness detection in car applications. It contains of a wireless physiological signal acquistion module and an embedded signal processing module. Their module is small enough to be embedded into a headband as a wearable EEG device. Sukrit Mehta et al (2019) says that their system monitors and detects the loss of attention of drivers of vehicles is proposed in their system. The face of the driver has been detected by capturing facial landmarks and warning is given to the driver to avoid accidents. In their proposed system Non-intrusive methods have been preferred over intrusive methods to prevent the driver from being distracted due to the sensors attached on his body. Hossein Naderi et al (2018) says that it shows 12-item Driver Behavior Questionanaire and 17-item ARDES are two appropriate and confirmed tools for assessing heavy vehicle driver characteristics. Some reasearchers also use GSD, driver exposure,the price of the truck and driver daily fatigue as a good index to evaluate heavy vehicle and driver behaviour.

III. EXISTING SYSTEM

Detecting and mitigating fatal road accidents caused by the virtue of drowsy driving is the key technology. A study by Gottlieb et al., shines the light that the risk of vehicular accidents due to drowsy driving increases regardless of the driver‟s idiosyncratic sleepiness, when they hiatus their sleep or sleep for an insufficient duration. The existing work urges a system for the disclosure of driver drowsiness established on heart rate variability (HRV) analysis. Heart rate variability is a phenomenon in which the difference in the time interval between each heartbeat is noted. The HRV analysis is used to monitor the real-time conditions for some useful insights about the psychological state of the person. In the existing system, validation is done with electroencephalography (EEG) which monitors the electrical activity of the brain based on which sleep score is obtained.

IV. PROPOSED SYSTEM

This work focuses on the eye blink and heart rate variability using Raspberry Pi 3 Model B and Pi Camera Module to provide an efficient and economic system for detecting the drowsiness of the driver. LBP cascade, HAAR cascade, Custom Blink cascade is used to detect face, eyes and eye blinks of the driver. The Python environment with OpenCV is used for processing the frames captured by the Raspberry Pi camera. After the eye blink is detected the drowsiness is validated by checking the heart rate using the HRV sensor. The heart rate when sleepy driving is 81.5 ± 9.2 beats/min. Upon successful validation of drowsiness using eye blink and heart rate, the driver is alerted via alert sound using Bluetooth speaker integrated with Raspberry Pi. The entire setup can be placed in the dashboard of the car as it occupies minimal space.

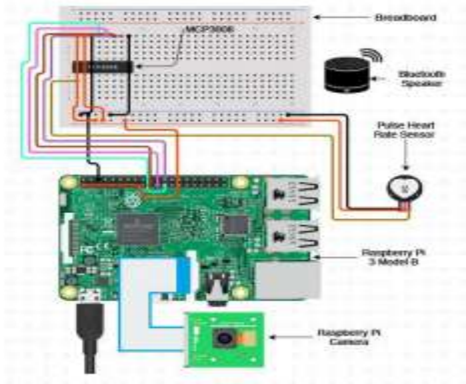

Fig 1. Proposed System Circuit Diagram

V. METHODOLOGY

5.1 CASCADE CLASSIFIER

Classifiers (Cascade of advanced classifiers functioning on HAAR like features) are trained with a lot of "positive" specimen views of a target object and random "negative" images of a similar size. Once training is done, it is applied to an image for searching the trained object by moving the search window across the locality of space prior to some phase where the candidate passes the ensemble of steps or is rejected. This can be normally utilized in image processing for object detection, facial detection, and recognition. Training a cascade in OpenCV is also possible. This training is completed with either haar_training or train_cascades strategies

5.2 LBP CASCADE

LBP Cascades are used to recognize the face. The face is classified from a non-face by the process of extraction of LBP features from an LBP vector. To train the classifier Tufts-Face-Database is used which consists of 500 face images(positive) and negative images are random images that are other than the face. The idea behind the local binary pattern is dividing the complete image into smaller parts then scrutinizing every element with its neighbour element, by taking the centre element as a threshold. This smaller part will be represented as a 3 X 3 matrix. For every surrounding value of the central value (threshold), binary Value will be assigned. " 1 " for values that break even or are more than the threshold and " 0 " for values less than the threshold. Now, then it contains only 0 / 1 (neglecting the central value). Then chain all binary values from every coordinate of the matrix. Then, the Decimal value is converted from the binary values and set it to the middle value of the

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matrix. At the end of this process (LBP procedure), we have a replacement image that serves as higher the properties of the initial image. Then, it changes over every block value into a histogram like this.

Performing the face detection
Several methods are used to check the histograms (Determine the space among 2 histograms). For instance, Euclidean distance, chi-square, etc.

$$D = \sqrt{\sum_{i=1}^{n} (hist1_i - hist2_i)^2}$$

Fig 2. Euclidean distance formula

The output of the equation is employed as a „confidence" measure.

5.3 HAAR CASCADE
This procedure is based on Haar Wavelet to study pixels within the image into squares by function. This uses machine learning procedures to activate a tall degree of exactness from "training data". These employ "integral image" concepts to calculate the "features" identified. It uses the Adaboost learning calculation which chooses less important highlights from an expansive set to provide an effective output of classifiers.

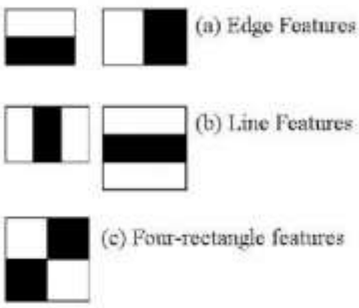

Fig 3.Feature Extraction in HAAR Cascade Algorithm

Training Data Preparation:
For training, a set of samples are used from the MRL Data set. There are two sorts of samples: negative and positive. Affirmative images are images with faces and the contrary images are non-faces. Here the classifier is trained using Cascade trainer GUI and required output XML classifier is obtained

Process
The input video image is converted into grayscale. And then find the faces in the image using the trained classifier. The localized position of the face is given by rect(x-position, y-position,width,height). This location is used for eye detection.

5.4 BLINK CASCADE
Eye status detection is a fundamental step for driver drowsiness detection. In this module, HAAR cascade discloses the status concerning eyes. The efficiency of the object detection method highly depends on the training dataset. MRL Dataset consists of over 15,000 images of eyes, among which the closed eyes are taken as our positive images. The negative images consist of random images that do not contain eyes. The model is trained by giving these images as input. We get an XML file as output which can be used in OpenCV to detect the status of the motorist"s eyes.

Process
The coordinates of the eye. The status of the eye is detected and if the eye is closed the colour of the bounding rectangle turns from green to cyan.

S.No	Cascade Name	Positive Images	Negative Images
1	LBP	500	1000
2	HAAR	500	1000
3	Custom Blink	1000	2000

Table 1.Cascade Specification
* Trained using Cascade Trainer GUI (Open source)

5.5 DETECT HEART RATE
In this proposed project heart rate is used as a second parameter to validate the drowsiness of the driver. The sensor is mounted to the steering wheel where the driver is required to place a finger on top of the LED. The LED emits light which passes through the finger and reaches the blood inside the capillary blood vessels. During the systole(contraction) period of the cardiac cycle, the heart contracts to pump the blood into the arteries which will increase the blood flow inside the capillary blood vessels. As a result, more light is absorbed by the blood when compared to the diastole(relaxation) period where the reflection will be high

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due to the lower volume of blood flow.
The variation in the blood flow causes the difference in the transmission and reflection of the light. This variation is captured as output from the sensor and represented in beats per minute(bpm) unit.

5.6 GENERATE ALERT SIGNAL

Alert signal is usually triggered to inform the user about avoiding some catastrophic situation. In this project, an industrial alert sound is used to enlighten the user about drowsy driving. A Bluetooth speaker is used to play the alert signal if the heart rate threshold is below 81.5 ± 9.2 beats/min. Generally, most of the cars will have an inbuilt audio system which is capable of Bluetooth connectivity hence it can be paired with Raspberry Pi to generate the alert signal.

VI. RESULTS

6.1 EFFECTS OF LBP CASCADE AND HAAR CASCADE

Input

Image captured from the Pi Camera Module

Output

Image captured from the Pi Camera Module is shown and detection of facial features.

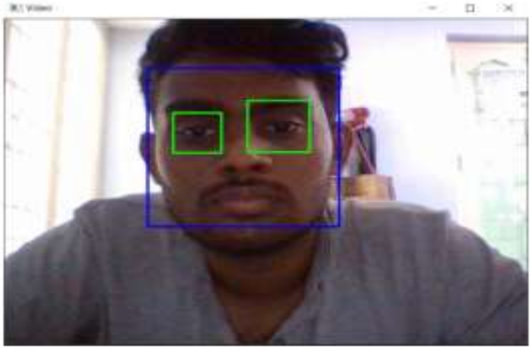

Fig 4.LBP Cascade and HAAR Cascade

6.2 EFFECT OF HEART RATE SENSOR

Fig 5. Output of Heart Rate Sensor

6.3 PERFORMANCE METRICS

Subjects	Time taken to alert after eye blink & HRV validation (s)
1	1.7404
2	1.5497
3	1.6689
4	2.0503

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5	1.5974
6	1.6927
7	1.6212
8	1.5497
Average response time	**1.6837**

Table 2.The average time taken for alert sound generation

Subjects	**Heart Rate (bpm)**
1	83
2	80
3	81
4	81
5	80
6	82
7	84
8	82
Average Heart Rate when drowsy	**81.625**

Table 3. The average heart rate value when drowsy

Gender	**Accuracy rate of face and eye blink detection**			
	Total Blinks	**True Positive (%)**	**False Positive (%)**	**False Negative (%)**
Male 1	39	97.43	0.00	2.56
Male 2	44	100	0.00	0.00

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Male 3	37	100	0.00	0.00
Male 4	38	97.36	2.63	0.00
Male 5	34	100	0.00	0.00
Female 1	33	100	0.00	0.00
Female 2	41	97.56	2.43	0.00
Female 3	45	95.55	2.22	2.22
Total	**311**	**98.3**	**0.96**	**0.64**

Table 4. Accuracy rate of face and eye blink detection

Parameters	**TP**	**FP**	**TN**	**FN**
Driver	Blink	No Blink	No Blink	Blink
System	Alert	Alert	No Alert	No Alert

Table 5. Confusion Matrix Parameters

50 (TN)	10 (FP)	60
5 (FN)	95 (TP)	100
55	105	160 (N)

Table 6. Confusion Matrix for the model

Testing Conditions
Number of test subjects = 8
Number of readings/subject = 20 (10 reading at morning, 10 readings at night) Total number of readings = 160

Metrics
Accuracy = (TP + TN) / (TP + TN + FP + FN) = (50 + 95) / (160) = 90.6%
Recall = TP / (TP + FN) = (95) / (100) = 95%
Precision = TP / (TP + FP) = (95) / (105) = 90.4%
Fmeasure = (2 * Recall * Precision) / (Recall + Presision) = (2 * 0.95 * 0.904) / (0.95 + 0.904) = (1.7176) / (1.854) = 92%

VII. CONCLUSION AND FUTURE WORK

Drowsy driving is caused due to sleepiness or fatigue; it contributes a major part in road accidents. Hence a robust system is required to detect and notify the driver during such episodes to avoid incidents and make the roads safer. The proposed system is quick and efficient in detecting and alerting such episodes with a high degree of accuracy. The system is also quite inexpensive and easy to install. It is to be noted that the system can be improved with the addition of an IR camera which enables better accuracy in low light conditions.

The current system makes use of the vehicle‟s stereo system via Bluetooth for alerting the driver, Future versions can have their buzzer system to alert the driver. The system can be further enhanced with the addition of the SMS module which can be used to alert the driver‟s status to the authorities if the driver is unresponsive even after being alerted.

REFERENCES

[1]. WHO global status report on road safety. https://apps.who.int/iris/bitstream/handle/10665/277370/WHO-NMH NVI-18.20-eng.pdf?ua=1, 2018.

[2]. Global status report on road safety: The Southeast Asia Story WHO. https://www.unescap.org/sites/default/files/Road%20Safety%20Data%20Management%20%20WHO%20Global%20Status%20Report%20on%20Road%20Safety% 20-%20WHO_0.pdf, 2019.

[3]. Drowsy Driving, Facts and Stats: Drowsy Driving – Stay Alert, Arrive Alive. https: / / drowsydriving.org/about/ facts- and stats/, 2016.

[4]. Koichi Fujiwara , Member, IEEE, Erika Abe , Member, IEEE, Keisuke Kamata, Chikao Nakayama, "Heart Rate Variability-Based Driver Drowsiness Detection and Its Validation With EEG" IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 66, NO. 6, JUNE 2019

[5]. J. H. Yang, Z. Mao, L. Tijerina, T. Pilutti, J. F. Coughlin and E. Feron, "Detection of Driver Fatigue Caused by Sleep Deprivation," in IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, vol. 39, no. 4, pp. 694-705, July 2009, doi: 10.1109/TSMCA.2009.2018634.

[6]. A Chellappa, M S Reddy, R Ezhilarasie, S Kanimozhi Suguna, A Umamakeswari "Fatigue detection using Raspberry Pi 3" International Journal of Engineering andTechnology(UAE), volume 7, issue 2, p. 29 – 32.

[7]. C.-T. Lin et al., "A real-time wireless brain–computer interface system for drowsiness detection," IEEE Trans. Biomed. Circuits Syst., vol. 4, no. 4, pp. 214–222, Aug. 2010.

[8]. Sukrith Mehta et al., "Real-Time Driver Drowsiness Detection System Using Eye Aspect Ratio and Eye Closure Ratio".

[9]. W. Deng and R. Wu, "Real-Time Driver-Drowsiness Detection System Using Facial Features," in IEEE Access, vol. 7, pp. 118727-118738, 2019, doi: 10.1109/ACCESS.2019.2936663.

[10]. O. Khunpisuth, T. Chotchinasri, V. Koschakosai and N. Hnoohom, "Driver Drowsiness Detection Using Eye-Closeness Detection," 2016 12th International Conference on Signal Image Technology & Internet-Based Systems (SITIS), Naples, 2016, pp. 661-668, doi: 10.1109/SITIS.2016.110.

[11]. F. You, X. Li, Y. Gong, H. Wang and H. Li, "A Real-time Driving Drowsiness Detection Algorithm With Individual Differences Consideration," in IEEE Access, vol. 7, pp. 179396-179408, 2019, doi: 10.1109/ACCESS.2019.2958667.

[12]. F. Guede-Fernández, M. Fernández Chimeno, J. Ramos-Castro and M. A. García-González, "Driver Drowsiness Detection Based on Respiratory Signal Analysis," in IEEE Access, vol. 7, pp. 81826- 81838, 2019, doi: 10.1109/ACCESS.2019.2924481.

[13]. M. A. Tanveer, M. J. Khan, M. J. Qureshi, N. Naseer and K. Hong, "Enhanced Drowsiness Detection Using Deep Learning: An fNIRS Study," in IEEE Access, vol. 7, pp. 137920-137929, 2019, doi: 10.1109/ACCESS.2019.2942838.

[14]. C. Zhang, X. Wu, X. Zheng and S. Yu, "Driver Drowsiness Detection Using Multi-Channel Second Order Blind Identifications," in IEEE Access, vol. 7, pp. 11829-11843, 2019, doi: 10.1109/ACCESS.2019.2891971.

[15]. H.Naderi et al., "ASSESSING THE RELATIONSHIP BETWEEN HEAVY VEHICLE DRIVER SLEEP PROBLEMS AND CONFIRMED DRIVER BEHAVIOR MEASUREMENT TOOLS IN IRAN".

[16]. National Center for Biotechnology Information, https://www.ncbi.nlm.nih.gov/pmc/articles/ PMC6393761/, 2019.

[17]. The Tufts Face Database, Weblink: http://tdface.ece.tufts.edu/.

[18]. MRL Eye Dataset, Weblink: http://mrl.cs.vsb.cz/eyedataset .