Received: November 14, 2023 | Revised: January 5, 2024 | Accepted: January 9, 2024

JOURNAL OF APPLIED RESEARCH ON SCIENCE AND TECHNOLOGY
JARST
INSTITUTE OF RESEARCH AND DEVELOPMENT
RAJAMANGALA UNIVERSITY OF TECHNOLOGY THANYABURI
ISSN ONLINE: 2773-9473
https://ph01.tci-thaijo.org/index.php/rmutt-journal

Drowsiness detection using Raspberry Pi for EVs and smart cars

Wichian Ooppakaew, Jakkrit Onshaunjit and Jakkree Srinonchat*

Department of Electronics and Telecommunication, Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Pathum Thani 12110, THAILAND

*Corresponding author: jakkree_s@rmutt.ac.th

ABSTRACT

Drowsiness detection is highly significant in assuring the safety and effectiveness of intelligent automobiles and electric vehicles (EVs). It used to be that managing driver fatigue was only a question of comfort for contemporary transportation systems. However, with the rapid improvements that have been made in automotive technology and the growing prevalence of autonomous features, this need has developed into a fundamental requirement. Sleepiness detection systems perform the role of watchful co-pilots by continually monitoring the driver's behavior and sounding alerts or taking other appropriate actions when indicators of tiredness are identified. They are an effective strategy to limit the dangerous practice of sleepy driving, which is responsible for many motor vehicle accidents. These accidents are caused by a combination of factors, including fatigue, distraction, and inattention. In the current investigation, a Raspberry Pi is a real-time monitoring system to determine drowsiness. The dataset had one thousand unique images, each depicting a different feature of a real-world driving event. These images have been organized into the following four categories: open eyes (250 images), closed eyes (250 images), open mouth (250 images), and closed mouth (250 images). During this investigation, the experimental circumstances were looked at during daylight and the evening hours. For the system to function correctly, it relies on the Eye Aspect Ratio (EAR) algorithm and the facial landmarks method. The recommended strategy showed a higher degree of accuracy when put into practice. However, the study found that false negative blinks were noticed due to noise that could not be repaired within the collected signal. In the future, we want to concentrate our research efforts on determining whether or not the recommended technique is effective in a broader variety of contexts.

Keywords: Drowsiness detection, Eye aspect ratio, Facial landmarks technique

INTRODUCTION

The automotive industry is now experiencing a rapid transformation, characterized by the emergence of electric cars and intelligent autos as the frontrunners in this significant change. The increasing incorporation of connection, autonomy, and advanced technology in automobiles has led to a redefined and broader understanding of safety. One crucial aspect of promoting vehicle safety is recognizing and mitigating drowsy driving, a hazardous condition that presents a significant danger to the overall security of roadways. Drowsiness detection systems have emerged as a pivotal component in enhancing road safety, particularly in the context of electric vehicles and intelligent autos. Drowsy driving is a pervasive occurrence that has significant consequences, including not just fatal accidents but also economic repercussions and emotional distress for those immediately affected and their families. Integration of tiredness detection systems in these vehicles is optional and imperative, driven by various compelling causes. Sleepiness detection systems serve as vigilant co-pilots, continually monitoring driver behavior and promptly notifying or executing corrective actions when signs of drowsiness are detected. Specific advanced iterations of these systems have the potential to provide partial or complete autonomous control, hence potentially reducing the likelihood of accidents. In addition, the implementation of tiredness detection systems plays a significant role in enhancing the overall driving experience in electric cars (EVs) and intelligent autos. Extended journeys, often associated with electric vehicles, may potentially lead to fatigue, making drivers susceptible to tiredness. These technologies contribute to the overall comfort and enjoyment of the trip by motivating drivers to take regular breaks, efficiently managing their fatigue levels, and optimizing vehicle settings to ensure heightened levels of alertness are maintained.

Moreover, according to J. Singh, individuals who engage in prolonged driving activities exhibit a deterioration in their overall physical well-being. As a result of this occurrence, drivers commonly encounter feelings of fatigue and are frequently on the verge of

DOI: 10.60101/jarst.2023.254725

experiencing exhaustion. This mechanism gives rise to the manifestation of microsleep, a term that describes tiny periods of somnolence ranging from a fraction of a second to a maximum duration of 30 seconds. During these episodes, people cannot react to environmental stimuli and undergo a transient state of unconsciousness. As a result, road accidents have become a widespread occurrence globally. This research aims to provide a system for efficiently alerting drivers experiencing weariness while operating a vehicle. The present study tried to address the issue by devising a specialized module tailored for detecting ocular fatigue. A unique system for face region recognition has been devised using a collection of 68 crucial features.

Consequently, these facial regions are crucial for evaluating the driver's state. The degree of accuracy attained was 92.5%. Furthermore, it has been noted that a considerable proportion of persons perish each year due to deadly traffic collisions that transpire on a global scale. Significantly, drowsy driving has emerged as a key contributing cause to these incidents and resultant deaths. The predominant factor contributing to significant accidents often arises from driver weariness and instances of microsleep encountered during vehicle operation. However, it is feasible to identify early signs of fatigue before the onset of a disastrous event. As a result, the ongoing exploration of driver tiredness detection and its associated symptoms continues to be a topic of academic interest. The predominant methods used in the identification of drowsiness mainly depend on behavioral cues, while some techniques may be intrusive and could distract drivers.

Moreover, specific methodologies need the use of expensive sensor technologies. Therefore, this research introduces and executes the creation of a lightweight, real-time system for detecting driver's tiredness via an Android application. The system employs image processing algorithms to acquire and analyze motion pictures, emphasizing identifying the driver's facial features in every frame. The system can detect and determine certain places on the face, often referred to as facial landmarks. Subsequently, these prominent points are used to compute two metrics: the Eye Aspect Ratio (EAR) and the Eye Closure Ratio (ECR). The measures used in this study assess the degree of fatigue a driver shows using an adaptive thresholding methodology. Machine learning techniques have been used to evaluate the efficacy of the proposed approach. The empirical results suggest that the model being examined demonstrates a degree of precision of 84% when using the random forest classifier.

It is accepted that any system that tracks the physiological features and the vehicle behavior tends to be more dependable as acquiring the physical signals is relatively more accessible and reliable regarding the results it generates. However, what marks a drawback to an otherwise very effective system is the number of signals and the difficulty in processing them, thus making the system all the more complex and complicated. Another fact that cannot be undermined is the bulky size that defeats the importance of compactness for ease of installation in the vehicle. Another classification of the weariness of the vehicle operator detection system is determined by observation using the image processing technique. The point to be reiterated here is that it does not use sensors to trace the driver's signals but tries to estimate fatigue by capturing the data about the blinking of the eye. Research in this area has repeatedly affirmed that the driver's fatigue starts with its effect on his eyes and mouth. Thus, the non-intrusive systems for fatigue detection take into account the features of the face using a computer vision approach. The facial Analysis technique is commonly used for real-time applications such as airport security checks, electronic gadgets for authentication, legal issues, and surveillance systems.

Our research framework investigates the EAR algorithm and the facial landmarks technique on the Raspberry Pi to evaluate whether they can operate in real-time. The examination will be conducted both during the day and night. In addition, the dataset included a total of one thousand unique images. These photographs are utilized in the process of configuring and updating the system.

MATERIALS AND METHODS

The experiment was carried out and proved that monitoring the pupil based on the appearance of the eye gave positive results, given that there were no obstructions to the eyes and that the eyes were in an open state. In addition, it has been shown that using a filter that performs subtraction in real time may effectively alleviate problems caused by lighting. Despite this, the problem of visual organ obstruction remains a continuing worry. In the realm of eye tracking, it has been shown that the combination of appearance-based approaches with active infrared illumination has a synergistic influence, leveraging the unique benefits of each methodology. However, there were still limitations due to boundaries, visual aids, and the general illumination in the area. According to the findings of the research, these systems have the potential to provide input images of an exceptionally high standard and integrate some distinct methods that are complimentary in order to precisely identify the pupil, making the most of their respective advantages while minimizing their drawbacks.

Eye detection is a method used in computer vision that focuses mainly on the localization and identification of areas within an image that correspond to the eyes. Eye detection is often used in facial recognition software. The present work makes use of a few different stages that follow one another in order to improve the identification of ocular traits.

DOI: 10.60101/jarst.2023.254725

1. The initial stage in eye detection is often identifying the facial region within the given picture or video frame. This may take place either manually or automatically. As was noted previously, face recognition algorithms are utilized to identify the approximate location of a face, which acts as an initial point of reference for subsequent eye detection. In other words, a face's eyes are detected after the approximate position of the face has been determined.

2. The step of recognizing the face, which is the first step in extracting the region of interest (ROI), is followed by isolating a smaller area inside the facial region that is anticipated to include the eyes. The region of interest, also called the designated area on occasion, serves as the input for the subsequent algorithms used in the eye recognition process.

3. It is common practice to do preprocessing to improve the Region of Interest (ROI) quality and make reliable eye identification more straightforward. Scaling, converting to grayscale, changing contrast, and reducing noise are typical examples of preprocessing methods used in image analysis.

4. Various methods and procedures are used to identify and localize the ocular structures in a certain region of interest (ROI). The algorithms may be divided into two primary groups: traditional computer vision approaches and more modern methodologies based on either machine learning or deep learning. Each of these categories has its subcategories.

5. After the eyes have been found, the next step in eye localization is determining the precise location of each eye within a designated region of interest (ROI). Either the development of bounding boxes or other visual representations around the eyes or the calculation of exact eye coordinates may be part of the technique.

The structure of the experiment can be set up as shown in Figure 1-2.

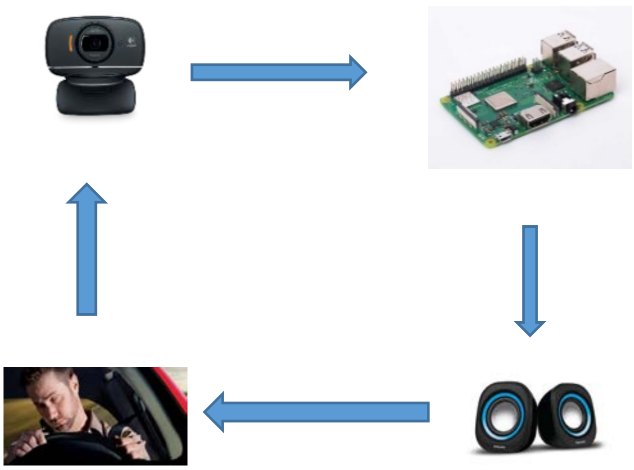


Figure 1 The proposed structure installed.

The suggested methodology may be executed following the specified approach, as followed.

1. The camera monitors the driver's facial expressions to assess if the driver has shown signs of tiredness during the vehicle's operation.

2. The Raspberry Pi's processing component calculates the camera input it receives. The occurrence often known as "drowsy driving" pertains to situations when a person operating a motor vehicle exhibits signs suggesting the onset of drowsiness.

3. The auditory indication functions as a cautionary alert for the motorist. When healthcare practitioners see the emergence of indications related to the abuse of opiates and the resulting repercussions, they often refer to this phenomenon as "the opiate crisis".

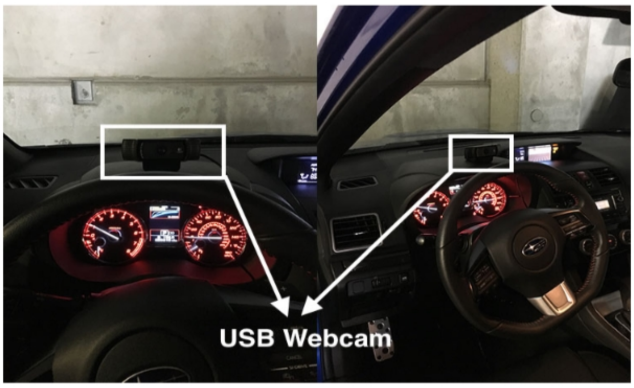


Figure 2 Camera installed.

The sample code used in the image processing process is shown in Figure 3. The hardware and software are installed and operated according to the process diagram shown in Figure 4.

After collecting a dataset of one thousand images that each showed a different aspect of a real-life driving situation, images were separated into the following categories: open eyes (250 images), closed eyes (250 images), open mouth (250 images), and closed mouth (250 images). In addition, the technology now under consideration has been tested in a nighttime environment. The next part contains detailed information on all the outcomes discussed before.

The proposed methodology effectively accomplishes precise and efficient eye blink detection via the Eye Aspect Ratio (EAR) algorithm and the facial landmarks technique. The user's text lacks sufficient information to be rewritten academically. The essential elements and procedural stages of the EAR algorithm are followed.

1. The first stage of the EAR algorithm involves the identification of distinct facial landmarks that play a crucial role in the computation of the eye-aspect ratio. The landmarks above are often situated at the outermost points of the ocular area and along the upper and lower peripheries of said region. A frequently used option for this purpose involves using the library, renowned for its proficiency in identifying facial landmarks.

DOI: 10.60101/jarst.2023.254725

```
sudo apt-get update
sudo apt-get install python3-opencv
```

```
import cv2

# Initialize the camera
cap = cv2.VideoCapture(0)

# Load the pre-trained eye cascade classifier
eye_cascade = cv2.CascadeClassifier('haarcascade_eye.xml')

while True:
    ret, frame = cap.read()

    # Convert the frame to grayscale
    gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)

    # Detect eyes in the frame
    eyes = eye_cascade.detectMultiScale(gray, scaleFactor=1.1, minNeighbors

    for (ex, ey, ew, eh) in eyes:
        cv2.rectangle(frame, (ex, ey), (ex + ew, ey + eh), (0, 255, 0), 2)

    cv2.imshow('Eye Detection', frame)

    if cv2.waitKey(1) & 0xFF == ord('q'):
        break

cap.release()
cv2.destroyAllWindows()
```

Figure 3 Example of code that connected camera and Raspberry Pi.

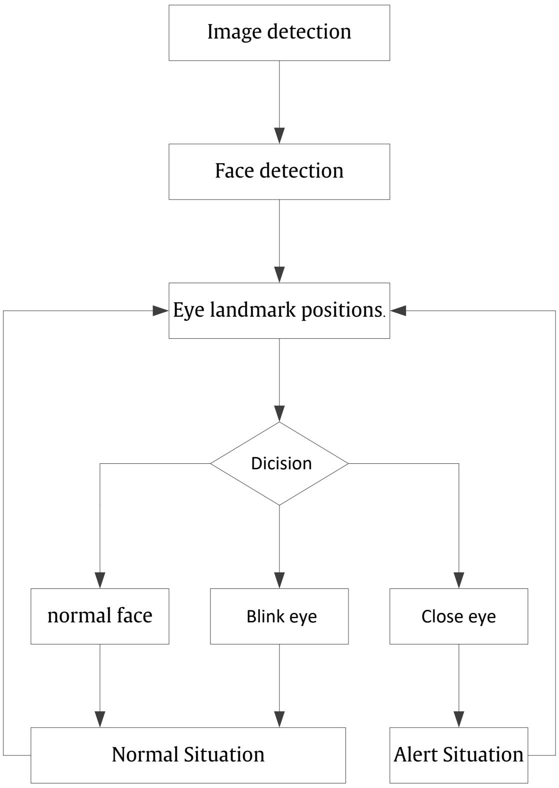


Figure 4 Diagram of the proposed system.

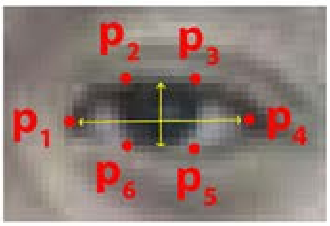


Figure 5 Eye landmark positions.

2. Calculating the effective area ratio (EAR) involves using the coordinates of specific facial landmarks. The measurement is determined by the horizontal separation between the two groups of prominent features located at the upper and lower regions and the vertical separation between the features positioned at the corners of the eyes. The equation representing the Effective Annual Rate (EAR) is as follows:

$$EAR = \frac{||P_2 - P_6|| + ||P_3 - P_5||}{2||P_1 - P_4||} \quad (1)$$

3. The thresholding process entails using a pre-established threshold to identify whether the eye is open or closed based on the calculated EAR. When the EAR lowers to a certain threshold, it indicates the closing of the eye, suggesting the presence of either

DOI: 10.60101/jarst.2023.254725

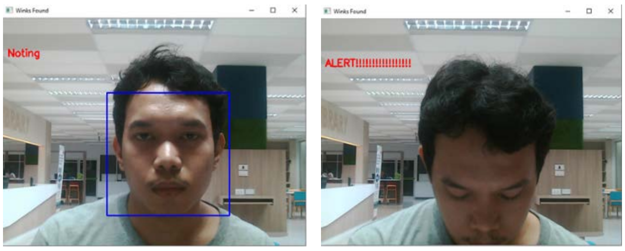
a blink or a state of drowsiness.

4. The proposed approach involves continuous monitoring of the EAR for a specified duration in order to identify instances of blinking. When the system detects a quick and substantial change in EAR values, particularly suggesting a blink, it triggers a blink event or alerts the system appropriately. The criteria used for blink detection, such as the rate of EAR change, might vary depending on the specific situation or objective.

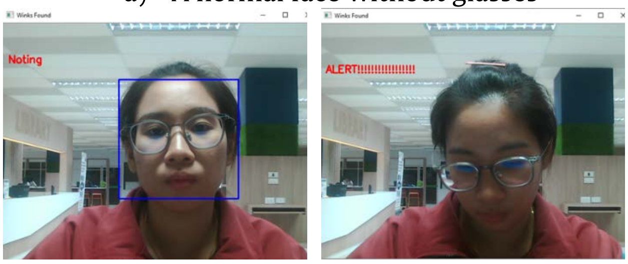
RESULTS AND DISCUSSION

The findings of the experiments that were conducted to determine whether or not weariness was present using a Raspberry Pi are shown in Figures 6 through 10. The principal experiment, which uses face detection, may be shown in Figure 6. This experiment is carried out in both daylight and nighttime settings. The gadget delivers acceptable performance in both regular and abnormal operating environments. The apparatus has the capability of determining whether or not the face is inclined in a downward position.

An experiment to detect the blinking of the eye is shown in Figure 7. It has come to our attention that the suggested system has the potential to function very effectively. In addition, Figure 8 displays the length of the blink, which varies from subject to subject since the amplitude represents the degree to which one's eyes are open. It comes to around 0.3 EAR in total.



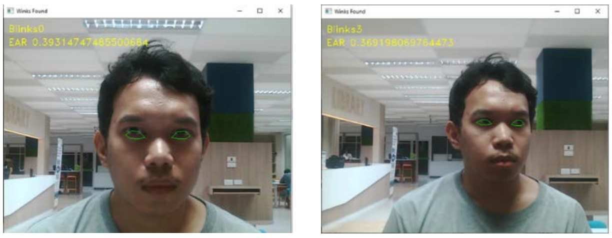
a) A normal face without glasses



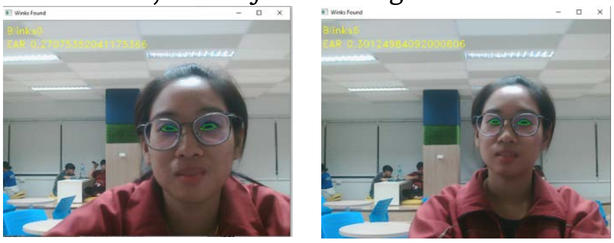
b) A normal face with glasses

c) A normal face without glasses at nighttime

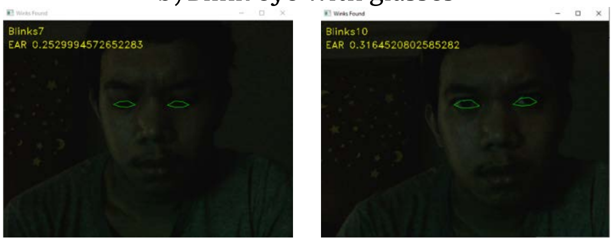
Figure 6 Face detection.



a) Blink eye without glasses



b) Blink eye with glasses



c) Blink eye without glasses in the nighttime

Figure 7 Blink eye detection.

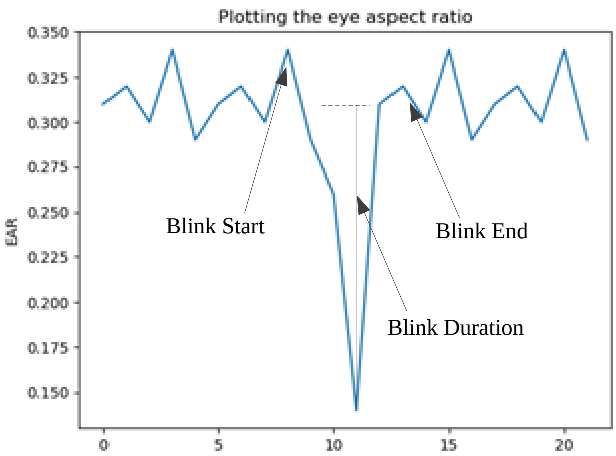


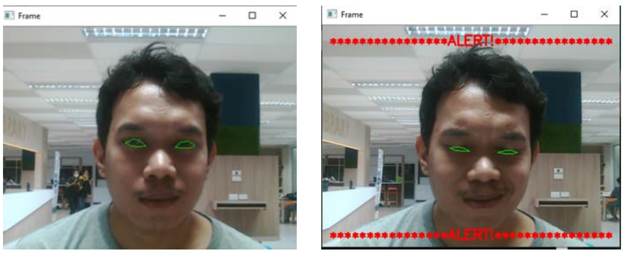
Figure 8 Blink eye illustration.

Figure 9 demonstrates that the approach effectively identifies squint eye problems, especially in conditions with limited light. The temporal extent of the syndrome known as squint eye is shown in Figure 10, which may be found here. The graph that illustrates the EAR demonstrates behavior that is analogous to the quick motion of an eye blink, although it persists for longer.

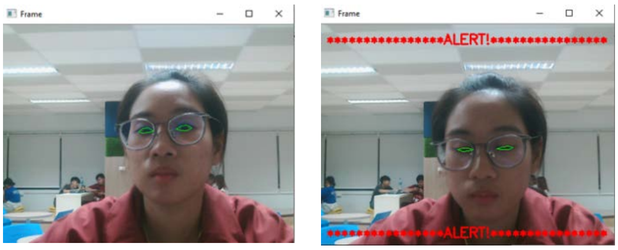
The proposed approach consistently generates correct outcomes via comprehensive assessment and testing, effectively detecting and alerting a fatigued motorist with a 96% success rate, regardless of the time of day. The accuracy is determined by analyzing 1000 photos, which were categorized into four groups: open eyes (250 images), closed eyes (250 images), open mouth (250 images), and closed mouth (250 images).

DOI: 10.60101/jarst.2023.254725

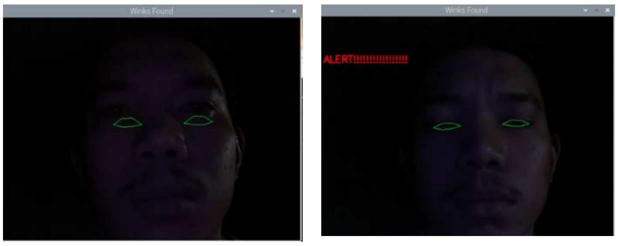
However, other research findings may be compared to this proposed technique. In their study, M. Miranda et al. [10] suggested that the Internet of Things allows car owners to monitor driver fatigue effectively during work. The suggested technique employs the surveillance of eyelid movements to identify driver weariness. The technology sporadically notifies fatigued drivers. The online application expeditiously sends the report to the car owner. Testing demonstrated that the program warned driver experiencing sleepiness in 95% of cases. The research undertaken by Ashlin Deepa, R. N., et al. [11] focuses on the identification of tiredness and alcohol consumption by the use of an MQ3 sensor specifically built for alcohol detection. The car slows down when the driver's breath emits the scent of alcohol. The sensors are connected to the Arduino UNO. When experiencing weariness, the use of alcohol causes the LED to light up and the buzzer to activate. These conditions alter the car's speed. This system works on the Arduino UNO platform. Furthermore, G. Jung [12] introduces a prototype Internet of Things (IoT) system that improves the detection of sleepiness and alertness to avoid driving when fatigued. Sleepiness-detection technology included in wristbands monitors the driver's pulse rate and oxygen saturation levels. The stimulation persists until the RCS verifies the reinstatement of driver vigilance. In practical terms, the suggested system can detect driver weariness and reduce occurrences of driving while fatigued.



a) Squint eye without glasses



b) Squint eye with glasses



c) Squint eye without glasses in the nighttime

Figure 9 Squint eyes.

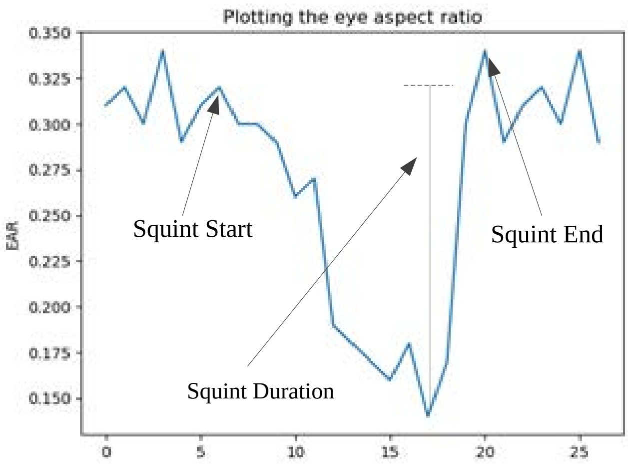


Figure 10 Squint eye illustration.

CONCLUSIONS

There has been an increasing academic focus on advancing and using eye blink detection algorithms for various purposes, such as identifying driver fatigue and evaluating cognitive workload. This article offers an overview of notable methodologies for eye blink detection and proposes an automated technique for identifying eye blinks via a face tracker. The implementation of this approach involves using a Raspberry Pi as a real-time system. The proposed approaches were subjected to rigorous experimental testing and qualitative assessment using datasets that included nighttime circumstances. The proposed approach consistently produces precise results via thorough evaluation and experimentation, efficiently identifying and notifying a drowsy driver with a success rate of 96%, irrespective of the time of day. The recommended technique exhibited a higher degree of precision. However, the study found the occurrence of false negative blinks due to the existence of unfixable noise in the collected signal. The observed auditory disturbance was ascribed to deliberate eye blinks, which tend to display an extended length.

Furthermore, the participants' use of spectacles with a high refractive index led to an amplified occurrence of light reflection, hence exacerbating the noise level. Finally, it was determined that the distance of the subjects from the camera had a role in the occurrence of this noise. In order to investigate the dynamics of eye movement, data was collected on the duration, frequency, and intensity of eye blinks. In future research, we aim to evaluate the proposed technique's effectiveness across more contexts. Furthermore, we want to conduct further analyses using other digital filters or their combination to attenuate signal interference efficiently. Also, we will conduct tests on the system under various weather situations, road kinds, and driving scenarios in order to assess its resilience and dependability.

DOI: 10.60101/jarst.2023.254725

ACKNOWLEDGEMENT

The present research received financial assistance from NRIIS No. FRB66E0720 and the NSRF via the Program Management Unit for Human Resources & Institutional Development, Research and Innovation [grant number B04G640045]. Furthermore, we would like to express our sincere gratitude to Watanya Jiranuwong and Kanissorn Phasuk, who conducted their studies at the Signal Processing Research Laboratory under the Faculty of Engineering at Rajamangala University of Technology Thanyaburi, for their valuable expertise and insights.

REFERENCES

1. Deng W, Wu R. Real-time driver-drowsiness detection system using facial features. IEEE Access. 2019; 7:118727-38.
2. Hussein MK, Salman TM, Miry AH, Subhi MA. Driver drowsiness detection techniques: A survey. In: 2021 1st Babylon IEEE International Conference on Information Technology and Science (BICITS); 2021 Apr 28; Babil, Iraq: IEEE; 2021. p. 45-51.
3. Albadawi Y, Takruri M, Awad M. A review of recent developments in driver drowsiness detection systems. Sensors. 2022;22(5):2069.
4. Singh J. Learning-based Driver Drowsiness Detection Model. In: 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS); 2020 Dec 3-5; Thoothukudi, India: 2021. p. 698-701.
5. Mehta S, Dadhich S, Gumber S, Jadhav Bhatt A. Real-time driver drowsiness detection system using eye aspect ratio and eye closure ratio. Proceedings of International Conference on Sustainable Computing in Science, Technology and Management (SUSCOM); 2019 Feb 26; Jaipur, India: 2019. p. 1333-9.
6. Laxmi V, Rao PS. Eye detection using Gabor Filter and SVM. 2012 International Conference on Intelligent Systems Design and Applications (ISDA); Kochi, Japan: 2012. p. 880-3.
7. Vijayalaxmi S. Knowledge based template for Eye detection. In: National Conference on Microwave Antenna & Signal Processing; 2011 Apr; 2011. p. 90.
8. Soukupova T. Eye blink detection using facial landmarks [dissertation]. Czech Republic: Czech Technical University; 2016.
9. Dewi C, Chen RC, Jiang X, Yu H. Adjusting eye aspect ratio for strong eye blink detection based on facial landmarks. Peer J Computer Science. 2022;8:e943.
10. Miranda M, Alonica V, Jomar Buo M, Merabite R, Paulo PS, Rodriguez JM. Portable prevention and monitoring of driver's drowsiness focuses to eyelid movement using Internet of Things. In: 2018 IEEE 10th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM); 2018 Nov 29-Dec 2; Baguio City, Philippines: IEEE; 2019. p. 1-5.
11. Ashlin Deepa RN, Sai Rakesh Reddy D, Milind K, Vijayalata Y, Rahul K. Drowsiness Detection Using IoT and Facial Expression. In: Proceedings of the International Conference on Cognitive and Intelligent Computing; 2021; Singapore: Springer Nature Singapore; 2023.
12. Jung G, Bok S, Lee Y, Kwak M, Kim H, Kim J, et al. Drowsy Driving Prevention IoT System: Waking Up the Driver Through Responsiveness Check. In: IEEE 13th International Conference on Information and Communication Technology Convergence (ICTC); 2022.

DOI: 10.60101/jarst.2023.254725