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Driving Fatigue Detection System using Haar Cascade Technique

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Abstract

This research addresses the escalating issue of motor vehicle accidents in Malaysia, specifically focusing on the critical challenge of driver fatigue. The study highlights the prevalence of road accidents attributed to tiredness, emphasizing the need for effective detection and prevention methods. Current sleepiness detection technologies are critiqued for their expense and impracticality during driving. The primary objective of this research is to develop a driving fatigue detection system using the Haar Cascade technique, specifically analyzing the closure of the driver's eyes. Additionally, the research aims to design an emergency notification system triggered by the detection of driver fatigue and to evaluate the system's performance. The study employs a Python-based platform and utilizes Raspberry Pi 4 Model B, Raspberry Pi Camera, and Buzzer for hardware implementation. The flow chart outlines the sequential steps, from image acquisition to the activation of the buzzer and notification system. The results indicate prompt and accurate eye closure detection, with an average response time of 0.4 milliseconds. However, limitations, particularly false detections involving spectacles, are identified, yielding an overall accuracy of 83%. The future work suggests incorporating machine learning techniques, adjusting Haar Cascade parameters based on real-time factors, and integrating supplementary sensors for a more comprehensive fatigue detection approach. Collaboration with automotive manufacturers, continuous system calibration, and user-friendly interfaces are proposed for the advancement and wider adoption of the driving fatigue detection system.

1. Introduction

The rise in traffic accidents in recent years that have been linked to fatigued drivers has sparked a lot of research and attracted the attention of the car industry. A large percentage of these occurrences include drunk driving, which poses a serious risk to public safety [1]. As a result, creating reliable technologies for detecting driver tiredness has become crucial. Because it is effective at identifying facial features and expressions in real-time video streams, the Haar Cascade algorithm stands out among the other methods [2]. Since it was first proposed, this technique has been well-known for its effectiveness and precision in object detection applications.

Although there are many uses for the Haar Cascade technique, its applicability in detecting driver drowsiness offers potential to reduce accidents by swiftly announcing drowsy drivers [3]. The system is especially useful for tracking indicators of tiredness since it can interpret facial visual cues, such as eye closure.

The application of the Haar Cascade algorithm for the identification of driver sleepiness is the focus of this research project. The system assists in detecting moments of tiredness by analyzing eye conditions, allowing for prompt action to avert possible mishaps. To shed light on the algorithm's efficacy in practical circumstances, this research methodically examines its workings, advantages, and disadvantages [4]. The ensuing sections offer a thorough comprehension of the fundamental concepts of the Haar Cascade algorithm, its application in detecting driver drowsiness, and an exhaustive assessment of its efficacy [5].

Nowadays, cultures all around the world are very concerned about safe driving. Driver fatigue is one of the causes of road accidents. Current sleepiness detection technologies monitor the driver's condition are expensive, however they are uncomfortable to wear while driving and are not appropriate for driving circumstances.

Driver fatigue and distractions can induce a lack of attentiveness when driving, leading to driver inattention. When something or someone draws the driver's attention away from the task of driving, this is referred to as driver distraction. Driver tiredness, unlike driver distraction, has no identifiable cause and is characterized by a progressive loss of attention on the road and traffic demands. Driver fatigue and distraction, on the other hand, may have comparable consequences, including longer response times, impaired driving skill, and an increased chance of being involved in an accident. The identification or prevention of driver sleepiness is a critical challenge in the development of accident-avoidance systems. Because of the risk it causes on the road, methods for decreasing the consequences of sleepiness must be devised. This study will analyze all previous research and approaches to present a solution to detect weariness using the Haar Cascade technique.

This research project seeks to achieve the following objectives. Firstly, the development of a driving fatigue detection system by analyzing the driver's eye closure using the Haar Cascade technique; second, the design of an emergency notification system triggered when driver fatigue is detected; and third, the assessment of the overall performance of the developed system.

2. Literature Review

Most of the research is based on behavioral-driving fatigue detection techniques. The yawning extraction method proposed in this study offers a unique approach to detecting driver fatigue [6]. It involves a series of steps including wide open mouth detection, mouth region localization, and face detection using SVM technology. The system relies on the circular Hough transform (CHT) to identify yawning, considering it as a potential indicator of tiredness [6]. A notable advantage is the independence from specific cameras or training data, with performance validation conducted on actual video clips recorded under varying lighting conditions. However, challenges arise when subjects cover their mouths while yawning, potentially hindering accurate detection. While yawning is a common sign of drowsiness, its reliability as a sole indicator might be questioned, warranting further investigation into complementary methods.

The PERCLOS-based system aims to detect driver drowsiness by analyzing eye blinks and the percentage of eye closure [7]. It utilizes a method to learn the pattern of eyelid closure duration and sets thresholds for identifying prolonged closures indicative of drowsiness [8]. Despite its direct focus on physiological indicators, challenges emerge regarding the need for fixed threshold values and specific camera angles for accurate performance. While PERCLOS provides a direct measure of drowsiness, its real-time applicability may be limited due to implementation challenges. Nonetheless, it offers a promising avenue for detecting fatigue based on physiological signals and warrants further exploration for practical deployment.

The steering operation technique offers an alternative approach to fatigue detection by monitoring behavioral indicators such as steering wheel movement patterns [9]. This method integrates sensors into the vehicle's steering system to capture parameters like steering angle, rate of rotation, and torque applied by the driver [10]. It provides insights into the driver's behavior, offering a complementary perspective to physiological indicators. However, challenges exist in optimizing time windows for data analysis and selecting appropriate indicators. While this method may not directly measure physiological signals, it holds promise for real-time fatigue detection in driving scenarios. Further research is needed to refine the technique and assess its practical viability in mitigating driver fatigue-related risks.

3. Material and Method

The implementation of the Driving Fatigue Detection System using the Haar Cascade technique involves key hardware components, including the Raspberry Pi 4 Model B, Raspberry Pi Camera, and a Buzzer, each serving specific roles in real-time image analysis. Software components encompass Python for coding, OpenCV for Haar Cascade algorithm implementation, and the Telepot library for Telegram interaction.

3.1 Block Diagram

Fig. 1 shows the block diagram of the driver's fatigue detection system employing a camera connected to Raspberry Pi, functioning as a small computer. The Raspberry Pi runs a program utilizing Haar Cascade coding, which analyzes real-time video frames to discern the driver's eye status, distinguishing between open and closed eyes. Upon detecting closed eyes, indicative of driver fatigue, the system initiates a dual-alert mechanism. Firstly, a buzzer is activated, providing an audible warning within the vehicle. Simultaneously, the system triggers a notification to a pre-specified emergency contact number via the Telegram messaging platform. This integration with Telegram involves the Raspberry Pi accessing the internet and utilizing the Telegram API to transmit a message, ensuring timely communication of the alert. The system aims to address the potential risks associated with driver fatigue by promptly alerting the driver and notifying a designated contact who can respond to the situation.

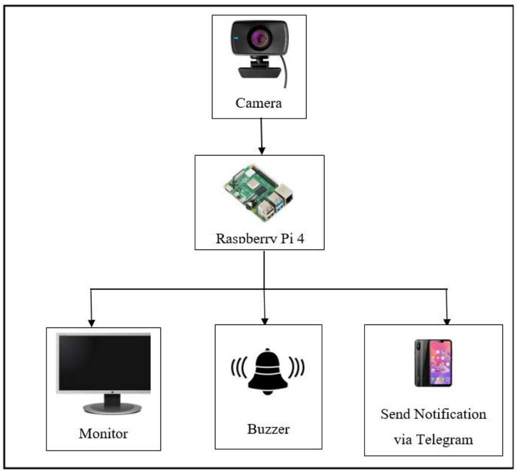


Fig. 1 *Block diagram of system*

3.2 Flowchart

Fig. 2 shows the flowchart of the driver's fatigue detection. It begins with image acquisition initiated through the Pi Camera. The system then checks for the presence of a face using a Haar Cascade classifier; if a face is detected, the flow proceeds to the next step, which involves detecting eyes using another Haar Cascade classifier. After successfully detecting eyes, the system calculates the coordinates of the eyes. If the eyes are closed, indicating potential drowsiness, the system activates a buzzer and sends a notification. The process continues in a loop until an exit condition is met.

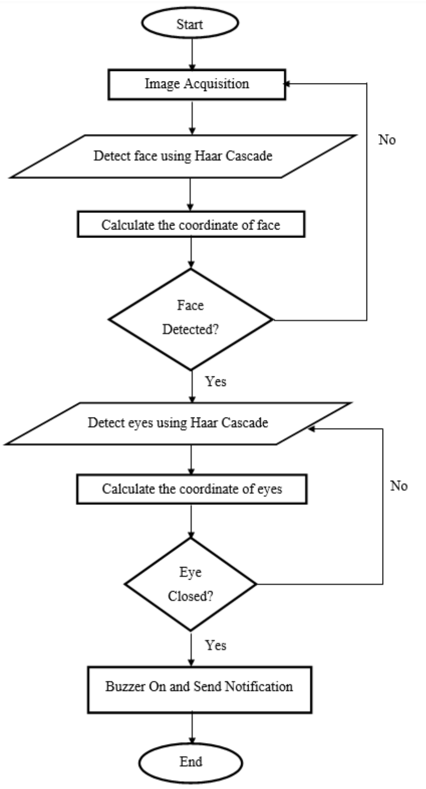


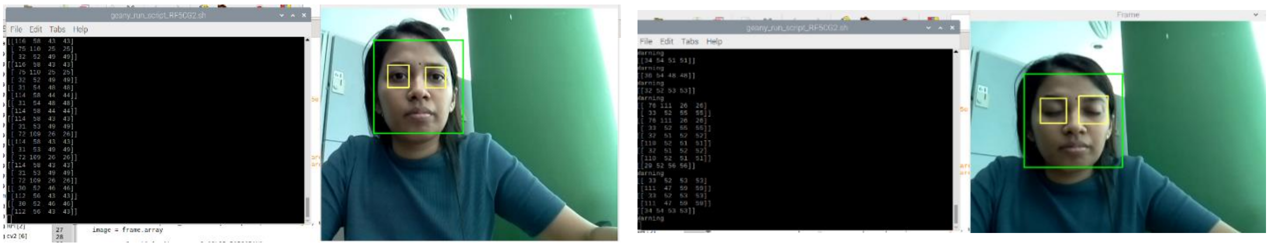
Fig. 2 *Flowchart of the system*

4. Result and Discussion

The results and discussion offer a thorough analysis of the data and its significance in relation to the research question and hypothesis, and it emphasizes the potential of image processing for driver's fatigue detection. The experiment was conducted to test the functionality of the project. The build platform successfully achieved the project objectives. The platform can detect the driver's eyes open and closed correctly. The examination of the driver's fatigue detection system, conducted through rigorous testing on a dataset of 100 images featuring diverse eye conditions, provides valuable insights into its overall performance. The scenarios included 50 images of open eyes, with 25 featuring individuals wearing spectacles, and 50 images of closed eyes, with 25 devoid of spectacles.

4.1 Analysis Eye Detection Using Haar Cascade

Based on Fig. 3(a), the output coordinates of the detected eyes within the face region. Each line in the output corresponds to a distinct set of eyes and is represented in the format (x, y, w, h), where x and y denote the top-left corner of the bounding box, while w and h represent the width and height of the bounding box, respectively. For the first set of eyes, the top-left corner is situated at coordinates (x=116, y=58), with a bounding box measuring 43 units in both width and height. The second set of eyes is defined by the top-left corner at (x=75, y=110), and a bounding box with dimensions 44 units in width and height. These coordinates offer precise information about the location and size of the detected eyes within the face region.



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[[116  58  43  43]
 [ 75 110  25  25]
 [ 32  52  49  49]]
[[116  58  43  43]
 [ 75 110  25  25]
 [ 32  52  49  49]]
[[ 31  54  48  48]
 [114  58  44  44]]
[[ 31  54  48  48]
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[[114  58  43  43]
 [ 31  53  49  49]
 [ 72 109  26  26]]
[[114  58  43  43]
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[[114  58  43  43]
 [ 31  53  49  49]
 [ 72 109  26  26]]
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[[ 30  52  46  46]
 [112  56  43  43]]
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image = frame.array
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(a) **(b)**

Fig. 3 *Eyes detected using Haar Cascade (a) eyes open; (b) eyes closed*

Based on Fig. 3(b), there is no output coordinate, signaling that the eyes are considered closed. The absence of coordinates triggers a warning mechanism in the script. The warning includes turning on a buzzer, printing a "Warning" message to the console, and sending a notification through Telepot. This behavior is designed to alert the system when it perceives that the driver's eyes are closed.

4.2 Time Taken to Detect Eyes, Buzzer On and Notify via Telegram

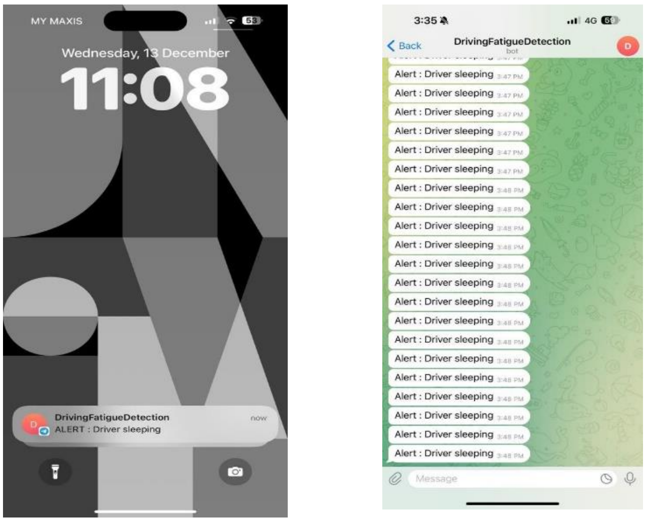
The duration it takes for the driver's fatigue detection system to complete the entire process of detecting closed eyes, activating the buzzer, and sending a notification via Telegram. This duration is a crucial metric that reflects the system's responsiveness in addressing potential safety concerns related to driver fatigue.

Table 1 *Time taken to detected eyes open*

Eyes Test State Open	Time Taken to Detect Eyes (ms)
Test 1	0.4
Test 2	0.3
Test 3	0.3
Test 4	0.4
Test 5	0.4
Test 6	0.4
Test 7	0.5
Test 8	0.4
Test 9	0.4
Test 10	0.4
Average	0.4

Based on Table 1, in the evaluation of open eyes detection, the system consistently demonstrated a prompt and accurate response across multiple tests. The average time taken to detect open eyes was determined to be 0.4 milliseconds, reflecting a uniform performance. Individual tests, labeled from Test 1 to Test 10, consistently yielded results within this average range, with specific durations ranging from 0.3 to 0.5 milliseconds. This remarkable level of consistency underscores the reliability of the open eyes detection system, ensuring swift and precise identification in various scenarios. Overall, the results suggest a robust and effective performance in the timely recognition of open eyes, with an average response time of 0.4 milliseconds.

Based on Fig. 4, The message sent to Telegram serves as an alert, notifying the designated contact about the detected drowsiness.



DrivingFatigueDetection now
ALERT : Driver sleeping

Alert : Driver sleeping 3:47 PM
Alert : Driver sleeping 3:47 PM
Alert : Driver sleeping 3:47 PM
Alert : Driver sleeping 3:47 PM
Alert : Driver sleeping 3:47 PM
Alert : Driver sleeping 3:47 PM
Alert : Driver sleeping 3:48 PM
Alert : Driver sleeping 3:48 PM
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(a) **(b)**

Fig. 4 *Notification via Telegram (a) notification on interface of phone; (b) notification on Telegram*

Based on Table 2, the average time taken to detect closed eyes was found to be 0.5 milliseconds, with a uniform duration of 0.2 milliseconds for activating the buzzer. Additionally, the system displayed a stable response time of 1.24 milliseconds for receiving notifications via Telegram. Individual tests, labeled from Test 1 to Test 10, consistently demonstrated these patterns, further emphasizing the reliability of the closed-eye detection system. This comprehensive analysis provides valuable insights into the consistent and efficient functioning of the system, ensuring timely and accurate detection of closed eyes across various scenarios.

Table 2 *Time taken to detected eyes closed*

Eyes Test State Closed	Time Taken to Detect Eyes (ms)	Time Taken to Buzzer On (ms)	Time Taken to Received Notification via Telegram (ms)
Test 1	0.5	0.2	1.2
Test 2	0.6	0.2	1.2
Test 3	0.5	0.2	1.2
Test 4	0.4	0.2	1.2
Test 5	0.4	0.2	1.3
Test 6	0.5	0.2	1.3
Test 7	0.5	0.2	1.5
Test 8	0.5	0.2	1.2
Test 9	0.5	0.2	1.2
Test 10	0.5	0.2	1.2
Average	0.5	0.2	1.24

Based on Table 3, the examination of the driver's fatigue detection system, conducted through rigorous testing on a dataset of 100 images featuring diverse eye conditions, provides valuable insights into its overall performance.

However, the findings reveal certain limitations, particularly in cases of false detections. Four false detections were observed in images of open eyes with spectacles, while eight false detections occurred in images of closed eyes with spectacles. Additionally, two false detections were noted in images of closed eyes without spectacles. Intriguingly, in all instances of false detections, neither the system activated the buzzer nor did it dispatch notifications via Telegram.

Overall, 83% the system is accurate. This metric indicates a moderate level of accuracy in determining the driver's eye state across the diverse set of test scenarios. The false detections, especially prevalent in scenarios involving spectacles, point to potential challenges such as reflections, shadows, or specific features associated with individuals wearing eyeglasses.

Table 3 *Testing buzzer on and receiving notification when eyes closed*

Output Images	Detect Eyes	Buzzer On	Received Notification via Telegram
20	True	True	True
40	True	True	True
56	True	True	True
62	True	True	True
75	True	True	True
80	False	False	False
85	False	False	False
89	True	True	True
92	True	True	True
93	False	False	False

5. Conclusion

In summary, this year-long research project successfully met its objectives, resulting in the functional implementation of the "Driving Fatigue Detection System Using Haar Cascade Technique." The system exhibited proficiency in accurately identifying signs of driver fatigue through real-time image acquisition, fulfilling the first objective. The integration of a Telegram-based emergency notification system enhanced overall responsiveness, meeting the second objective. Noteworthy findings include the open eyes detection system's consistent prompt and accurate responses, averaging 0.4 milliseconds, and the closed eyes detection system's reliability, maintaining a stable 0.2 milliseconds for activating the buzzer. While the system demonstrated an overall accuracy of 83%, challenges such as false detections, particularly with spectacles, highlight areas for improvement. Moving forward, addressing these challenges and refining closed eyes detection are essential for maximizing the system's impact on road safety. Therefore, further research with various forms of design can be done by integrating machine learning techniques alongside Haar Cascade could improve adaptability and accuracy, especially in diverse driving conditions. Exploring dynamic adjustments of Haar Cascade parameters based on real-time environmental factors is essential for robust performance.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Sasmita, Nik Shahidah;* ***data collection:*** *Sasmita;* ***analysis and interpretation of results:*** *Sasmita, Nik Shahidah, Suhaila;* ***draft manuscript preparation:*** *Sasmita, Nik Shahidah. All authors reviewed the results and approved the final version of the manuscript.*

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