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ENHANCED VIOLA-JONES DETECTION ALGORITHM IN A MOBILE-BASED DROWSINESS DETECTION WITH FACIAL LANDMARKS, ANALYSIS AND DETECTION

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Abstract

Drowsy driving stands as a significant contributor to road-related accidents, leading to a substantial toll of severe injuries and fatalities, along with economic repercussions. The primary aim of this study revolves around identifying and addressing drowsiness through the analysis and detection of facial landmarks. Moreover, the study capitalizes on the sensors, including GPS, integrated into Android phones, harnessing their potential for advancements in machine learning technology. The ultimate objective is the creation of an Android application catering to driver assistance during their journeys. This research delves into an improved Viola-Jones detection algorithm, bolstered by the incorporation of local binary pattern (LBP) features, particularly for detecting faces from multiple angles. The proposed approach aims to replace, significantly enhancing the algorithm's accuracy. The system's robustness was tested across diverse scenarios, encompassing daytime and nighttime conditions, varying distances and angles between the mobile device and the driver, as well as the driver's facial movements. In the event of identifying a drowsy driver, the system triggers both a voice message and an alarm, supplemented by an SMS notification conveying the driver's status and location. The system's assessment of drowsiness hinges on calculating the Percentage of Eye Closure (PERCLOS), a metric that proved highly effective in detecting drowsiness throughout the experimental evaluation. The accuracy of alarms during both daytime and nighttime conditions consistently achieved a perfect rate of 100%. Notably, the accuracy of distance and eye type assessments was optimal within a range of 9 feet between the phone and the driver's face. Furthermore, the accuracy of angle assessment proved most reliable between 0 to 90 degrees, employing the enhanced Viola-Jones algorithm. In terms of reliability, the system demonstrated unwavering performance in gauging the driver's drowsiness level even after 30 minutes, attaining a reliability rate of 100%. The research outcomes carry significant implications, extending to the realm of intelligent transportation systems. By enhancing driver safety and curtailing the losses associated with drowsy driving, these findings serve to refine and elevate intelligent transportation systems. `

Keywords: Drowsiness, Eye aspect ratio, Facial landmarks, Mobile-based application, Viola Jones algorithm.

1. Introduction

In the fast-paced modern world, where mobility and technology intersect to shape our daily lives, the issue of road accidents resulting from drowsy driving has become a growing concern. The increasing number of vehicular mishaps caused by driver fatigue necessitates innovative solutions capable of real-time monitoring and detection of this dangerous condition [1]. Driving while drowsy not only puts the driver at risk but also endangers other road users.

One effective method to detect drowsiness is by observing the driver's eye condition. If the driver's eyes remain closed for extended periods, it indicates sleepiness. Face detection technology, widely used in emerging technologies like Android phones, holds significant potential for enhancing security, monitoring, and other aspects of human life [2]. Simply having facial recognition on our phones is not enough; instead, we should utilize this technology to address important societal issues. By leveraging evolving technologies and their proper application, we can develop an application that detects drowsiness in drivers, potentially leading to a reduction in car accidents caused by this condition [3]. Implementing such a solution has the potential to save numerous lives and make our roads safer.

In response to the urgent concern of drowsy driving, this research presents an innovative approach to detect drowsiness using a mobile-based system that utilizes facial landmarks analysis. The system incorporates an enhanced version of the well-known Viola-Jones detection algorithm. The focus of this thesis is to develop a novel strategy that harnesses the widespread usage of smartphones, transforming them into effective tools for monitoring driver drowsiness.

The proposed system aims to provide a discreet, cost-effective, and easily deployable solution for detecting sleepiness by leveraging the computational capabilities and built-in cameras of modern smartphones. It relies on facial landmarks analysis, which provides valuable insights into a person's facial expressions and movements [4]. Notably, the system pays attention to facial markers such as drooping eyelids, prolonged blinking, and changes in head posture, as these subtle signs can indicate drowsiness [5].

By combining the facial landmarks approach with the Viola-Jones detection method, the system becomes more adept at recognizing and interpreting signs of drowsiness accurately. This integration enhances the system's effectiveness in detecting early stages of sleepiness, potentially contributing to improved road safety. The purpose of this research is to enhance the Viola-Jones detection algorithm for drowsiness detection in a mobile-based application. The research will incorporate facial landmarks to improve accuracy and efficiency [6]. The study aims to develop a real-time, reliable, and robust drowsiness detection system for use in various contexts, such as in-car driver monitoring or fatigue detection in other scenarios.

The research aims to achieve the following objectives: a) Improve the Viola-Jones detection algorithm by integrating facial landmark detection. b) Create a mobile-based application for real-time drowsiness detection. c) Assess the performance of the enhanced algorithm by comparing it to the traditional Viola-Jones algorithm. d) Validate the system's accuracy and efficiency in detecting drowsiness effectively.

The researchers are confident that the combination of mobile-based computing and facial landmark analysis in this study will significantly advance drowsiness detection technology, leading to safer roads and the protection of lives. They envision that their findings will pave the way for a better and more secure future for drivers as they embark on this transformative journey.

2.Related Works

According to the 2016 Metro Manila Accident Recording and Analysis System report, human error emerges as the leading cause of road accidents in the Philippines, contributing to 87% of fatal injuries, 85% of nonfatal injuries, and 87% of property damage. The report emphasizes that around 90% of road accidents are attributable to driver carelessness, physical limitations, or distractions, all classified as forms of human error. This concern extends beyond the Philippines, affecting the global community, which has spurred governments and non-governmental organizations to collaborate in earnest to mitigate and, if possible, eradicate such incidents.

The report mentions various examples of human errors, including medical issues, alcohol impairment, and driver drowsiness, which contribute to road accidents. Notably, driver fatigue was cited as the leading cause of 50% of road accidents, as reported [7]. Detecting drowsiness in drivers has become an interesting and crucial challenge in present times, aiming to prevent accidents and enhance road safety.

To tackle this concerning issue, a mobile phone-based system was developed to detect driver drowsiness, starting with facial detection as the initial step. According to the findings in the article [8], face detection is crucial for further facial analysis, recognition of different facial features, and other related processes.

Originally intended and mainly employed for face detection, the Viola-Jones algorithm has expanded its utility to various applications, as noted in the article [9]. In a separate study [10], the Viola-Jones algorithm showcased exceptional performance when compared to LBP face detection and Haar cascade detection methods. Table 1 offers a comprehensive comparison of the Viola-Jones algorithm alongside other detection algorithms, including LBPH and the Haar-Cascade detection algorithm.

Table 1. Face detection algorithm comparison.

Face Detection Method	Accuracy	Number of Detection Errors
LBP	91%	15
HAAR	92%	12
VIOLA JONES	96%	8

The Viola-Jones algorithm has certain limitations that include difficulties in detecting multiple faces and accurately identifying facial landmarks, as well as challenges in fast and precise detection, as discussed in the article [11]. The primary concern with the original Viola-Jones algorithm for face detection is its false detection rate.

In response to these limitations, researchers sought to enhance the Viola-Jones algorithm by considering additional facial features to improve facial detection. One such feature is eye blinking, which has proven significant and has been utilized in various applications, including drowsiness detection [12]. However, it is worth noting that the accuracy of blinking detection may be affected by factors such as shadows from glasses or poor lighting. To address this, other drowsiness symptoms, such as yawning and nodding, can also be considered, along with the frequency of blinking.

As discussed in article [13], a straightforward yet efficient technique for detecting eye blinks involves utilizing a newly developed facial landmark detector with a modified Eye Aspect Ratio (EAR) to identify spontaneous eye blinks. This method can be executed using a regular camera with a frame rate of 25-30 frames per second (fps) for motion tracking within the eye region, enabling eye blink detection. The condition of the eyes, whether open or closed, plays a crucial role in detecting driver fatigue, as emphasized in the article [14]. When drowsy, the eyelid muscles unconsciously tend to hasten the process of falling asleep.

Numerous researchers have pursued accurate drowsiness detection, presenting successful approaches. In the article [15], they leveraged the highly effective Eye Aspect Ratio and face landmarks methods, leading to an algorithm that achieved remarkable outcomes. Additionally, other researchers proposed an arithmetic-based method for addressing drowsiness detection, which involved three stages: face detection, eye position detection, and eye tracking [16]. This paper introduces an efficient approach to determining the driver's drowsiness state.

3. Methodology

The research titled "Enhanced Viola-Jones Detection Algorithm in Mobile-Based Drowsiness Detection with Facial Landmarks Analysis" aims to introduce and assess a new approach for detecting drowsiness using mobile devices and facial landmarks analysis.

The study employed an experimental research approach to develop the proposed system, as described in "Enhanced Viola-Jones Detection Algorithm in Mobile-Based Drowsiness Detection with Facial Landmarks Analysis." In the method under consideration, a live video stream captures an image, which is then subjected to the Viola-Jones algorithm for face and eye detection. Afterward, the system evaluates whether the eyes are open or closed, facilitating the identification of drowsiness, and prompting the driver to open their eyes. Figure 1 illustrates the block diagram of the proposed system.

Figure 1 outlines the image-capturing process through an Android phone's camera, which necessitates a minimum Android version of Jellybean (version 4.3) and a front camera with a resolution of at least 640x480 (0.3 megapixels). The phone must meet the minimum requirements of 3 GB RAM and a screen resolution of 1280x800.

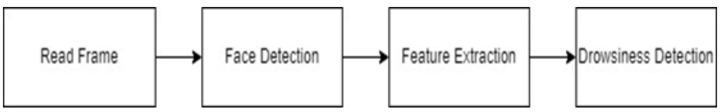

Fig. 1. Schematic representation of the proposed system.

Upon capturing the image, it undergoes resizing and conversion to grayscale. Subsequently, the Viola-Jones algorithm comes into play, detecting the face in the image. Before classification, feature extraction is performed, with the chosen feature in this study being the Eyes Aspect Ratio (EAR).

To ascertain drowsiness, the system tallies the occurrences of closed and open eyes within a specific timeframe, utilizing the PERCLOS formula shown in the Equation. If, during this period, 60% or more of the eyes remain closed, the system issues a warning.

3.1. Mobile phones

The researchers opted for Android Studio in their application development endeavors and seamlessly integrated Google's Mobile Vision API to facilitate face detection. In the course of crafting the Android application, specific modules played a pivotal role. The application's primary device prerequisites encompass a) An Android phone, which should feature a minimum Android version of Jellybean (version 4.3) and a front camera boasting a resolution of no less than 640x480 (0.3 megapixels). b) The inclusion of a car phone mount, tailored to the specific car or vehicle model, constitutes another imperative requirement.

As for the software requisites, the researchers centred their efforts around the Mobile Vision API for drowsiness detection. The official documentation for Mobile Vision highlights its capability to furnish detectors that empower devices to recognize objects in both photos and videos [17]. Furthermore, this API extends its proficiency to tracking the spatial coordinates of key facial landmarks, encompassing the eyes, nose, and mouth. It also delivers insightful data regarding the status of these facial features, encompassing the probability of eyes being open and the potentiality of the detected individual exhibiting a smile. These attributes proved instrumental in the researchers' pursuit of drowsiness detection. Additionally, Google Text-To-Speech was harnessed to relay voice messages to the driver. As detailed in the Official Android documentation, this tool orchestrates the synthesis of speech from textual content, rendering it for immediate playback.

The system was materialized through the medium of Android Studio. Conforming to the stipulations outlined in the Official Android documentation, Android Studio mandates a minimum configuration encompassing 3 GB RAM and a screen resolution of 1280x800.

3.2. Voice messages and alarm

In the event of the driver being identified as drowsy, the system will activate both a voice message and an alarm. The warning sound will be set at 70 decibels, specifically designed to rouse the driver without causing disruption to the passengers.

3.3. SMS notification

The device is designed to dispatch an SMS notification to designated contact numbers, furnishing details about the driver's condition and present whereabouts. Nevertheless, it is crucial to acknowledge that the system's GPS functionality could encounter limitations within expansive covered environments, such as tunnels. This hindrance may disrupt the GPS signal's effectiveness, potentially impeding its proper functioning.

3.4. Algorithm enhancement

3.4.1. Face detection

The concept of face detection entails the identification of a human face within an image [18]. This technique finds widespread application in real-time surveillance and the tracking of individuals or objects [19]. It can be employed with either a pre-existing model or images acquired through cameras, including mobile phones and other compatible devices.

Within this study, the Viola-Jones object detection algorithm was chosen as the method for feature extraction. One of the algorithm's notable strengths lies in its swift detection capability, even though its training process is relatively time-consuming [20]. Specifically, the cascade object detector embedded within this algorithm serves to recognize diverse biometric attributes of individuals, encompassing the face, eyes, nose, mouth, and upper body.

To expedite the detection of the driver's face, the captured images are rescaled to varying dimensions and processed through the fixed-size detector [21]. By implementing this algorithm within an Android phone, leveraging its inherent face recognition functionality, the identification of drowsiness in drivers becomes more accessible and dependable.

Pseudocode of enhanced viola-jones algorithm

Input ⟶ test image

Output → image with detected angled face drawn with rectangles

Convert image/frame to grayscale

Flip image/frame horizontally Function angled face detector

for i ← 1 *to num of scales in pyramid of images do Downsample image to create imagei*

Compute integral image, imageii

For j ← 1 *to num of shift steps of sub-window do*

for k ← 1 *to num of stages in LBP profile cascade classifier do for l* ← 1 *to num filters of stage k do*

Filter detection sub-window Accumulate filter outputs end for

if accumulation fails per-stage threshold then Reject sub-window as face

Break this k for loop end if

end for

if sub-window passed all per-stage checks then Accept this sub-window as a face

end if

end

for

end for

end function

Reflip image/frame horizontally

Repeat function angled face detector

Draw a rectangle to detect angled faces

3.4.2. Feature extraction

Before the classification stage, feature extraction takes place, and in this research, the Uniform Eyes Aspect Ratio (EAR) is the chosen feature.

Facial landmarks serve as indicators for specific parts of the face. Commonly used key points include the eye angle, the tip of the nose, the angle of the nostril, the corner of the mouth, the endpoint of the eyebrow arc, the outline of the ear, and the chin, as depicted in Fig. 2. Facial landmarks, especially those in the eye area, offer valuable insights into the eye's condition, whether it is open or closed. The rapid process of closing and reopening the eyes is known as eye blinking [22]. Each individual exhibits characteristic eye blinking patterns, with blinking time typically lasting between 100 to 400 milliseconds.

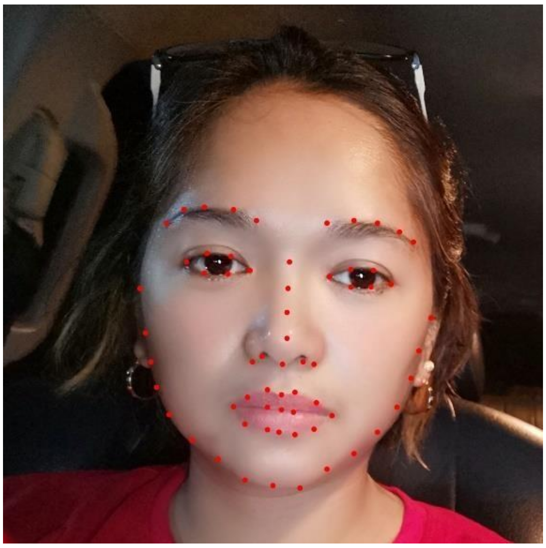

Fig. 2. Face with landmarks.

Figure 3 presents the eye aspect ratio (EAR) based on the landmarks of the eye. The EAR value is consistently higher for open eyes compared to closed eyes. Using landmarks P1 through P6 for each eye, the EAR is calculated as specified in Equation (4). As emphasized in the article [11], the state of the eyes, whether open or closed, plays a vital role in detecting driver fatigue. During drowsiness, the eyelid muscles involuntarily tend to accelerate the process of falling asleep.

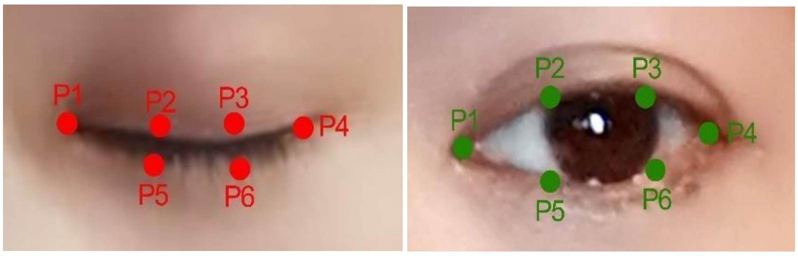

Fig. 3. Closed eye image (left); Open eye image (right).

3.4.3. Eyes aspect ratio (EAR)

The extracted eye landmarks are evaluated using the EAR (Eyes Aspect Ratio) [23] using Eq. (1). The EAR represents the distance between specific points on the eye landmarks. When the eyes are closed, the EAR approaches zero, while it moves away from zero when the eyes are open.

$$EAR = \frac{|P2-P6|+|P3-P5|}{2|P1-P4|} \tag{1}$$

When the eyes are open, the EAR value remains relatively constant, hovering around 0.30. However, if the eyes are closed, the EAR value approaches 0. Closed eyes typically exhibit EAR values of approximately 5%.

3.4.4. Eyes blink detection

The system is required to effectively distinguish between closed and open eyes in video data that was not utilized during the model's training [24]. The model employed for this purpose underwent training using a dataset comprising 1192 instances of closed-eye facial data and 1231 instances of open-eye facial data. To achieve blink detection, a fusion of ULBP (Uniform Local Binary Pattern) and EAR features is applied, and the classification process is conducted using the Support Vector Machine (SVM) methodology [25].

3.4.5. Drowsiness detection

If a person's eyes remain closed after an initial attempt to open them, it indicates that they are asleep. To ascertain drowsiness, the system records both closed and open eyes within a specific timeframe using the PERCLOS formula, as depicted in the equation. If, during this period, 80% or more of the eyes are closed, the system will issue a warning.

Image processing-based drowsiness detection is acknowledged as one of the most effective methods, as noted in article [13]. This approach enables the evaluation of the driver's sleepiness by monitoring eye closures. The duration of eye closure is measured to determine the driver's current state, whether they are awake or asleep. Among the various indices utilized to calculate drowsiness, PERCLOS (percentage of eye closure) stands out as particularly significant. According to a study conducted [26], PERCLOS is considered one of the key real-time warning indicators in vehicle drowsiness detection systems. The PERCLOS formula is provided in Eq. (2)

$$\text{PERCLOS} = \frac{\text{Closed eye time}}{\text{Closed eye time}+\text{Open eye time}} \times 100\% \tag{2}$$

This module encompasses the identification of drowsiness. it leverages facial recognition to determine whether the driver is experiencing drowsiness. The frame within the facial recognition interface changes its colour based on the driver's level of drowsiness. It adopts a green hue when one of the eyes is open between 61% and 100%, indicating full wakefulness. The colour shifts to orange when one eye registers an openness of 31% to 60%, suggesting slight sleepiness. Conversely, it turns red when one eye's aperture ranges from 0% to 30%, signifying drowsiness. Remarkably, the face recognition system maintains its effectiveness across varying light conditions as seen in Fig. 4, even during nighttime as shown in Fig. 5, ensuring the driver's drowsiness level can be reliably detected.

The placement of the Android phone varies depending on the vehicle type. For cars, the recommended position is within the air vent, permitting drivers to utilize navigation apps alongside drowsiness detection as can be seen in Fig. 6. This configuration allows for the minimization of the app, creating ample room for navigation apps. For bus drivers, placing the Android phone in the lower part of the left window ensures an unobstructed view for the driver while employing the drowsiness detection system.

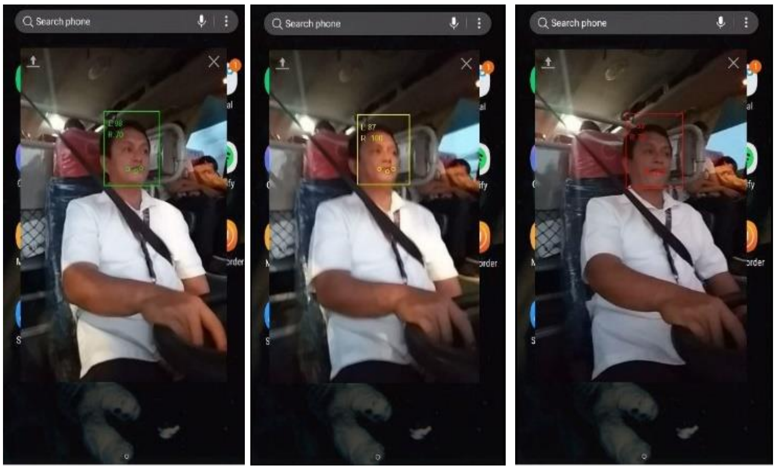

Fig. 4. Detection of faces during daytime by drivers in provincial areas.

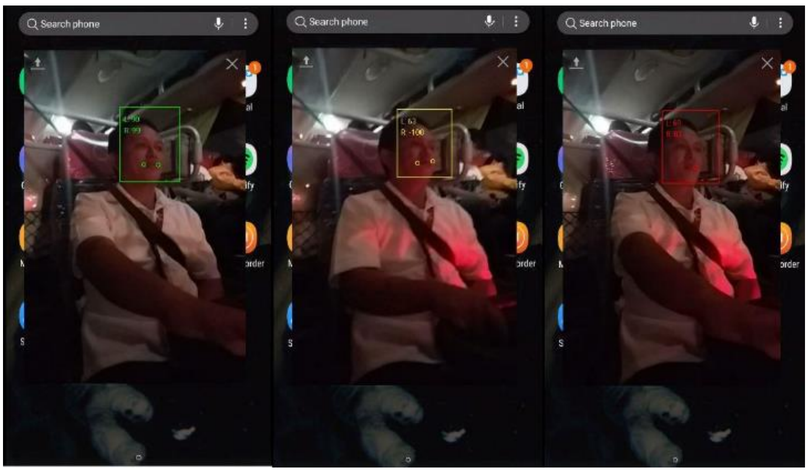

Fig. 5. Detection of faces at night by drivers in provincial areas.

Fig. 6. Detection of faces during both daytime and nighttime employed by car drivers.

4. Results and Discussion

Detecting drowsiness in real-time using mobile devices has become a critical research area, given the increasing prevalence of smartphone usage and its potential applications in ensuring safety during tasks such as driving and operating machinery. In this section, we present the results and discuss the findings of our study focused on detecting drowsiness using an enhanced version of the Viola-Jones algorithm specifically optimized for mobile devices.

Table 2 illustrates the three warning levels that were tested for both day and night modes. Each warning level corresponds to a specific driver's status. The matching of frame colour and driver's status was also part of the testing process.

Table 2. Five (5) Test cases were encountered in day mode and night mode.

Trials	Frame Colour	DESC	Voice Message	Alarm	SMS Notification	Remarks
			Day Mode			
1	Green	Awake	Inactive	Active	Active	Passed
2	Orange	Yawning	Active	Inactive	Inactive	Passed
3	Red	Drowsy	Inactive	Active	Active	Passed
4	Red	Drowsy	Inactive	Active	Active	Passed
5	Red	Drowsy	Inactive	Active	Active	Passed
			Night Mode			
1	Green	Awake	Inactive	Active	Active	Passed
2	Orange	Yawning	Active	Inactive	Inactive	Passed
3	Orange	Yawning	Active	Inactive	Inactive	Passed
4	Red	Drowsy	Inactive	Active	Active	Passed
5	Red	Drowsy	Inactive	Active	Active	Passed

The drowsiness detection system's Day Mode and Night Mode were subjected to testing with Provincial Bus Drivers, who often face drowsiness challenges during long journeys. The three colours serve as indicators of the driver's status. A green frame colour signifies that the driver is alert and awake. A yellow frame colour indicates that the driver is yawning, prompting a voice message trigger. A red frame colour suggests that the driver is drowsy, resulting in an alarm activation and an SMS notification sent to registered contact numbers.

Table 2 also presents the accuracy remarks concerning the voice message, alarm, and SMS notification of the drowsiness detection application. Based on the primary functionalities of the notification system, the accuracy of the voice message, alarm, and SMS notification is deemed to have met the required standards.

Table 3 displays the face recognition accuracy concerning different eye types and phone-to-driver distances. The two eye types - normal and slanted, were subject to testing, considering the distance between the phone and the driver. Despite the confined space within a vehicle, this experimental assessment aims to demonstrate the face recognition threshold is achievable.

Table 3. Face recognition accuracy based on eye features.

Number of trials	Distance between the phone and the driver	Types of the eye	
		Normal	Slanted
1	1 meter	Recognized	Recognized
2	2 meters	Recognized	Recognized
3	3 meters	Recognized	Recognized
4	4 meters	Recognized	Recognized
5	5 meters	Recognized	Recognized
6	6 meters	Not recognized	Not recognized

Within the range of 1 meter to 5 meters, drowsiness detection continues to operate effectively, irrespective of the eye type. However, at 6 meters, the face cannot be recognized, rendering the drowsiness detection ineffective at that point.

Table 4 illustrates the precision of angle determination essential for the drowsiness detection system, employing both the Viola-Jones and enhanced Viola-Jones algorithms. The angle's accuracy was examined to identify the optimal phone placement within the vehicle.

Table 4. Angle accuracy for drowsiness detection with viola-jones and enhanced viola-Jones.

Number of trials	Angle of the phone toward the driver	Face recognition using viola jones	Face recognition using enhanced viola jones
1	0 degrees	Recognized	Recognized
2	5 degrees	Recognized	Recognized
3	10 degrees	Recognized	Recognized
4	15 degrees	Recognized	Recognized
5	20 degrees	Recognized	Recognized
6	25 degrees	Recognized	Recognized
7	30 degrees	Recognized	Recognized
8	35 degrees	Recognized	Recognized
9	40 degrees	Not recognized	Recognized
10	45 degrees	Not recognized	Recognized
11	50 degrees	Not recognized	Recognized
12	55 degrees	Not recognized	Recognized
13	60 degrees	Not recognized	Recognized
14	65 degrees	Not recognized	Recognized
15	70 degrees	Not recognized	Recognized
16	75 degrees	Not recognized	Recognized
17	80 degrees	Not recognized	Recognized
18	90 degrees	Not recognized	Recognized

With the conventional Viola-Jones algorithm, the drowsiness detection system effectively operates within angles ranging from 0 to 35 degrees, while beyond 40 degrees, the system ceases to detect the driver's face, subsequently failing to ascertain the drowsiness status.

In contrast, leveraging the enhanced Viola-Jones Algorithm enables the detection of face angles spanning from 0 to 90 degrees.

Table 5 provides an overview of the reliability percentage pertaining to the drowsiness detection system. It encompasses the outcomes of two distinct trials centred around drowsiness detection, reliant on the driver's condition and the visible percentage of eye openness within the frame. The duration between these trials amounted to 5 minutes, allowing ample time for the driver to potentially encounter drowsiness once more.

Table 5. Experimental evaluation results of the reliability of the drowsiness detection system with enhanced viola jones

Trials	Proposed System		Margin of error
	First Detection	Second Detection	
1	40%	40%	0
2	58%	50%	13.79
3	66%	64%	3.03
4	70%	72%	-2.86
5	75%	74%	1.33
6	80%	80%	0
7	85%	82%	3.53
8	90%	91%	1.11
9	99%	99%	0
10	100%	100%	0

These two trials aptly showcase the system's effectiveness in identifying the driver's drowsiness status. The cumulative average reliability rate of 98.01% attests to the system's reliability and commendable performance.

5. Conclusions

Based on the findings derived from both the survey and experimental testing, the researchers compiled pertinent insights for their study. In the context of experimental evaluation, the system's applicability was established for cars, jeepneys, and buses, while encountering limitations in tricycles due to factors such as uncontrollable background noise and restricted angle depth. The survey-based assessment yielded notably favourable ratings, with Driving Professionals attributing a total mean score of 4.51 for both Accuracy and Functionality, while Provincial Bus Drivers awarded a total mean score of 4.35 for the same criteria.

In terms of the experimental assessment for face recognition, the system proficiently identifies faces within a 5-meter distance between the phone and the driver, regardless of the driver's eye type. Employing the Viola-Jones algorithm, the phone angle within the vehicle is accurately recognized within a range of less than or equal to 35 degrees to the left and right, whereas the enhanced Viola Jones extends recognition capability from 0 to 90 degrees. Furthermore, face recognition exhibits commendable effectiveness across varying light conditions. Nonetheless, certain vehicle types posed challenges to the system's operation, particularly tricycles due to factors such as noise interference, inadequate nocturnal illumination, and suboptimal phone mount placement.

In the context of reliability testing, a meticulous evaluation involving two consecutive assessments of 10 drivers within a 5-minute interval showcased an impressive overall reliability rate of 98.01%. Drawing from the amassed data, the researchers concluded that the drowsiness detection device holds substantial potential in averting drowsiness-related accidents, serving as a convenient and widely accessible tool for drivers. The study opens up possibilities for future research and development. Enhancements could involve incorporating vital statistic monitoring to address drowsiness caused by various factors in the human body. Additionally, making the device smaller than traditional Android phones without compromising functionality could be explored. Moreover, efforts could be made to make the system applicable to a wider range of vehicle types. Lastly, improving drowsiness detection could involve considering both face and eye ratio in the analysis.

The study opens possibilities for future research and development. Enhancements could involve incorporating vital statistic monitoring to address drowsiness caused by various factors in the human body. Additionally, making the device smaller than traditional Android phones without compromising functionality could be explored. Moreover, efforts could be made to make the system applicable to a wider range of vehicle types. Lastly, improving drowsiness detection could involve considering both face and eye ratio in the analysis.

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