Asian Research Journal of Current Science

Volume 6, Issue 1, Page 132-138, 2024; Article no.ARJOCS.1636

Driver's Drowsiness Detection System Based on Facial Expression Recognition

Oladunjoye John Abiodun [a], Okwori Anthony Okpe [a*] and Anthony Otiko [b]

[a] Department of Computer Science, Federal University Wukari, Nigeria.
[b] Department of Computer Science, University of Cross River State, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://prh.globalpresshub.com/review-history/1636

Original Research Article

Received: 16/05/2024
Accepted: 21/07/2024
Published: 29/07/2024

ABSTRACT

The advancement in the integration of computer vision and machine learning for solving practical problems of man has motivated various researchers to develop solutions in the domain of drowsy driving using different technological advancements. This paper aims at developing a Driver Drowsiness Detection System to enhance road safety by leveraging facial expression analysis for real-time detection of drowsiness in drivers. It monitors facial cues such as eyelid closure, head nodding, and yawning to detect drowsy driving. The key features of this system include non-intrusiveness, adaptability to varying road conditions, and seamless integration with existing vehicle systems. Through the synergistic application of machine learning algorithms and advanced facial recognition techniques, the system offers robust and timely alerting mechanisms to drivers, for effective prevention of road accidents thereby saving lives. The proposed system was implemented

**Corresponding author: Email: okwori@fuwukari.edu.ng;*

Cite as: *Abiodun, Oladunjoye John, Okwori Anthony Okpe, and Anthony Otiko. 2024. "Driver's Drowsiness Detection System Based on Facial Expression Recognition". Asian Research Journal of Current Science 6 (1):132-38. https://jofscience.com/index.php/ARJOCS/article/view/112.*

using Python programming language due to its ability to provide platform independence, community support, Machine Learning capabilities, integration with OpenCV, Prototyping and iterative development. The programming language is equally versatile and relatively easy to development software hence providing an ideal environment for implementing the driver drowsiness detection system. The system was evaluated using three test cases and the result shows that the system is very efficient in detecting driver drowsiness status.

Keywords: Computer_vision; machine_learning; drowsiness_detection; facial_expression; road accidents.

1. INTRODUCTION

"Road traffic accidents causes the deaths of over 1.3 million people each year (World Health Organization" [1]. "In addition to causing death or injury, road traffic accidents cause economic losses that arise from the treatment costs and productivity losses of those killed or disabled by their injuries. In addition, the WHO stated that 93 % of worldwide road fatalities occur in low- and middle-income countries like Nigeria, although these countries account for only approximately 60 % of the world's vehicles. The causes of traffic accidents can be grouped into factors related to drivers, vehicles, and the environment" [2]. "Accident-causing factors associated with drivers include inexperience, a lack of driving skills, and risk-taking behaviour including drowsy driving. Drowsiness among drivers is a significant contributing factor to traffic injuries, leading to a yearly toll of severe injuries and fatalities" [2]. Drowsy driving is a critical issue globally, and Nigeria is no exception. Drowsy driving, characterized by driver fatigue or sleepiness, significantly impairs reaction times, alertness, and increases accident risks. Nigeria faces unique challenges that contributes to drowsy driving for instance, the vast expanse of the country results in long travel distances between cities, exposing drivers to extended periods of continuous driving, increasing the likelihood of fatigue. Additionally, poor road conditions and inadequate lighting make night driving riskier, exacerbating drowsy driving accidents. Moreover, the scarcity of rest areas in Nigeria compels drivers to push their limits without adequate breaks, further enhancing drowsiness risks. Urban areas experience road congestion, leading to mentally taxing stop-and-go traffic that contributes to driver fatigue. Cultural factors like a lack of emphasis on rest before long journeys and substance use can worsen fatigue levels among drivers. The consequences of drowsy driving in Nigeria are severe, including increased road accidents resulting from impaired judgment and delayed reaction times. These accidents lead to injuries, fatalities, property damage, loss of productivity due to delays and disruptions in daily activities, and strain on the healthcare system with increased medical costs. To address this issue, a sophisticated Driver Drowsiness Detection system is needed to alert the driver in case of abnormal behaviour and prevent potential catastrophes [3]. This research aims to develop an efficient driver drowsiness detection system using computer vision and machine learning to monitor driver behaviour for signs of drowsiness and provide real-time alerts through features such as eye tracking to detect closed eyes or signs of fatigue, facial recognition for identifying tiredness cues, and immediate auditory alerts to prompt drivers to take breaks. The developed system is capable of monitoring the driver's vital signs, facial expressions, and eye movements in real-time using cameras as well as to accurately detects and alerts drivers about their drowsiness status. The implementation of this driver's drowsiness detection system in Nigeria can promote safer driving practices, encourage timely rest breaks, and ultimately reduce accident rates on the roads.

2. RELATED LITERATURE

The positive effect of driver drowsiness detection system on prevention of road accidents has motivated various researchers to develop driver drowsiness detection system using different technological advancements. [4] described 'A Partial Least Squares Regression-Based Fusion Model for Predicting the Trend in Drowsiness'. "They proposed a new technique of modelling driver drowsiness with multiple eyelid movement features based on an information fusion technique—partial least squares regression (PLSR), with which to cope with the problem of strong collinear relations among eyelid movement features and, thus, predicting the tendency of the drowsiness. The predictive precision and robustness of the model thus established are validated, which show that it

provides a novel way of fusing multi-features together for enhancing our capability of detecting and predicting the state of drowsiness. Driver drowsiness detection system is an essential tool that contributes significantly to the progress of road safety technology and accident prevention [5] on Nigerian roads". [4] In like view, [6] described 'Camera-based Drowsiness Reference for Driver State Classification under Real Driving Conditions'. "They proposed that measures of the driver's eyes are capable to detect drowsiness under simulator or experiment conditions. The performance of the latest eye tracking based in-vehicle fatigue prediction measures are evaluated". [6] "These measures are assessed statistically and by a classification method based on a large dataset of 90 hours of real road drives. The results show that eye-tracking drowsiness detection works well for some drivers as long as the blinks detection works properly. Even with some proposed improvements, however, there are still problems with bad light conditions and for persons wearing glasses. As a summary, the camera based sleepiness measures provide a valuable contribution for a drowsiness reference, but are not reliable enough to be the only reference. Driver drowsiness detection system under infrared illumination for an intelligent vehicle" was described by [7]. "They proposed that to reduce the amount of such fatalities, a module for an advanced driver assistance system, which caters for automatic driver drowsiness detection and also driver distraction, is presented. Artificial intelligence algorithms are used to process the visual information in order to locate, track and analyze both the driver's face and eyes to compute the drowsiness and distraction indexes. This realtime system works during nocturnal conditions as a result of a near-infrared lighting system. Finally, examples of different driver images taken in a real vehicle at nighttime are shown to validate the proposed algorithms. Driver Drowsiness Recognition Based on Computer Vision Technology" was proposed by [8]. They presented a nonintrusive drowsiness recognition method using eye-tracking and image processing. A robust eye detection algorithm is introduced to address the problems caused by changes in illumination and driver posture. Six measures are calculated with percentage of eyelid closure, maximum closure duration, blink frequency, average opening level of the eyes, opening velocity of the eyes, and closing velocity of the eyes. These measures are combined using Fisher's linear discriminated functions using a stepwise method to reduce the correlations and extract an independent index. Results with six participants in driving simulator experiments demonstrate the feasibility of this video-based drowsiness recognition method that provided 86% accuracy [9] described 'Visual Analysis of Eye State and Head Pose for Driver Alertness Monitoring'. "They presented visual analysis of eye state and head pose (HP) for continuous monitoring of alertness of a vehicle driver. Most existing approaches to visual detection of non-alert driving patterns rely either on eye closure or head nodding angles to determine the driver drowsiness or distraction level. The proposed scheme uses visual features such as eye index (EI), pupil activity (PA), and HP to extract critical information on non-alertness of a vehicle driver. They used a support vector machine (SVM) to classify a sequence of video segments into alert or non-alert driving events. Experimental results show that the proposed scheme offers high classification accuracy with acceptably low errors and false alarms for people of various ethnicity and gender in real road driving conditions". In June, 2014, Eyosiyas et al. [10] described 'Driver Drowsiness Detection through \HMM based Dynamic Modeling'. "They proposed a new method of analyzing the facial expression of the driver through Hidden Markov Model (HMM) based dynamic modelling to detect drowsiness. They have implemented the algorithm using a simulated driving setup. Experimental results verified the effectiveness of the proposed method. In August 2014, García et. al. described 'Driver Monitoring Based on Low-Cost 3-D Sensors'. They proposed a solution for driver monitoring and event detection based on 3-D information from a range camera" [11]. "The system combines 2-D and 3-D techniques to provide head pose estimation and regions-of-interest identification. Based on the captured cloud of 3-D points from the sensor and analyzing the 2-D projection, the points corresponding to the head are determined and extracted for further analysis. Later, head pose estimation with three degrees of freedom (Euler angles) is estimated based on the iterative closest points algorithm. Finally, relevant regions of the face are identified and used for further analysis. The resulting application is a 3-D driver monitoring system based on low-cost sensors. It represents an interesting tool for human factor research studies, allowing automatic study of specific factors and the detection of special event related to the driver, e.g., driver drowsiness, inattention, or head pose" [10,12] presented "a system to detect drowsiness based on eye aspect ratio (EAR) combined with PERCLOS,

which calculates the percentage of eye closure for a period of time. They used Dlib for eye point extraction, which is necessary for EAR. Their system had an 80% accuracy for their presented method". In the research of [13], they proposed a CNN architecture for detecting drowsiness using MRL eye database that provide images of a single eye. The authors obtained 94% average accuracy in drowsiness detection by focusing on the eye state.

3. METHODOLOGY

The driver drowsiness detection system using facial expression recognition aims to enhance road safety by addressing current limitations. This system integrates facial expression analysis to detect drowsiness, offering a non-intrusive method for real-time monitoring of drivers. By utilizing advanced technologies like OpenCV and neural networks, it can accurately identify signs of drowsiness through facial features like eye and mouth movements. The system's architecture involves capturing driver images, extracting facial landmarks, and analyzing features to classify the driver's state. It then triggers an alarm if drowsiness is detected, ensuring timely intervention to prevent accidents. The proposed system provides a comprehensive solution for proactive drowsiness detection, contributing significantly to road safety efforts.

In the below architecture, the system sequentially detects a person's face, focuses on the eye region, refines it to isolate key features, precisely locates the pupil and iris, analyzes eye state to determine drowsiness, and issues a warning message if drowsiness is detected. To show the interaction between actor and system functionalities, a use case diagram was used. Use Case diagram is a pictorial representation of the interactions between system actors and the system functionalities. The user "Driver" could "Start Monitoring," "Switch Camera," and "Receive Alert." Each use case represents a distinct functionality or feature of the system from the user's perspective as shown in figure.

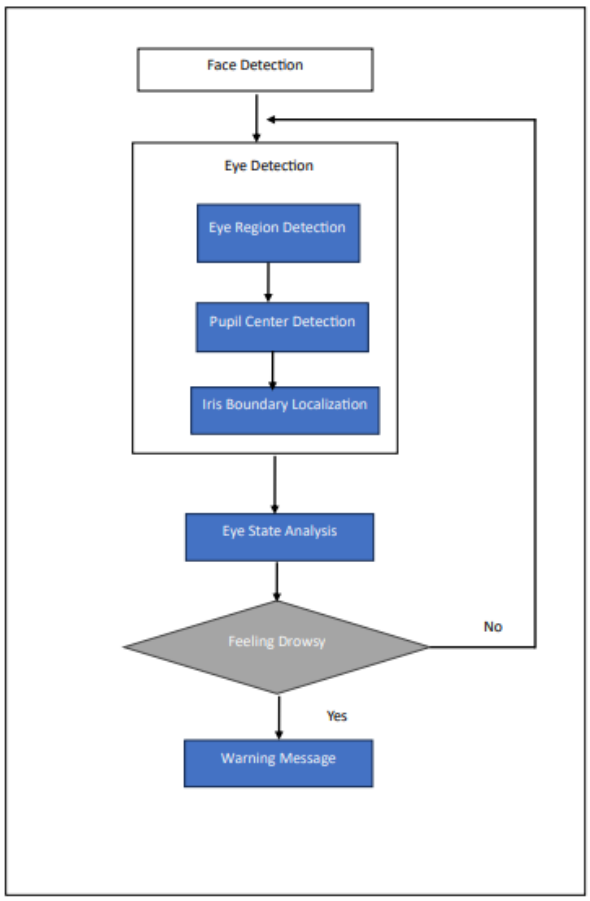

Fig. 1. Proposed system architecture

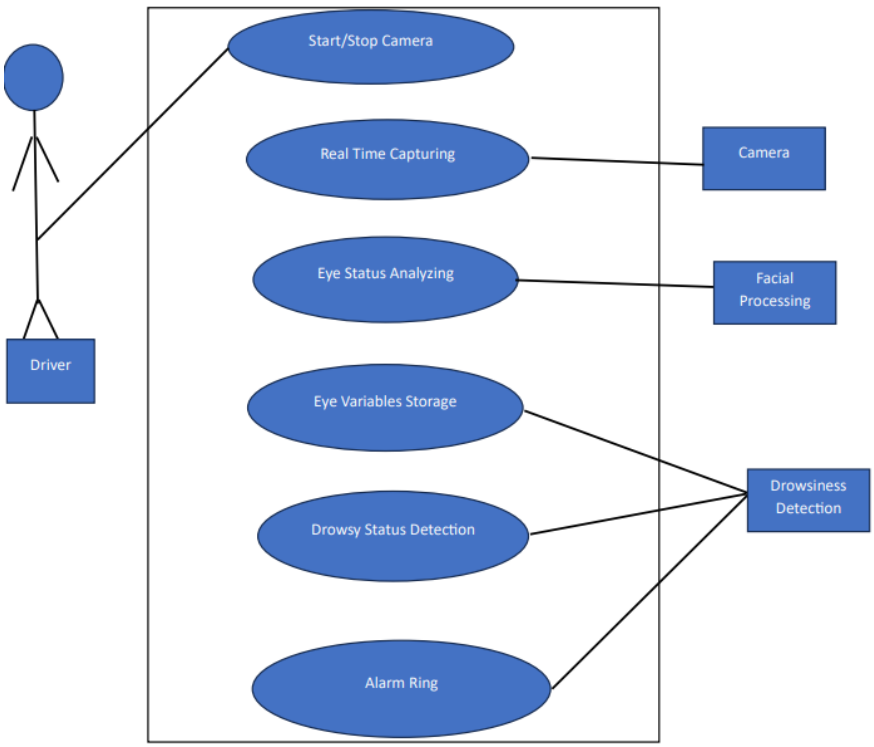

Fig. 2. Use case diagram of the proposed system

The proposed system user interface was designed to ensure simplicity and effortlessly usability by the drivers using some design principles such as Visual Clarity**.** The user interaction is made more simpler through the control centre which enables intuitive user interaction for efficient management of the drowsiness detection process. It incorporates the Start Button, Camera Selection, Alert Handling as well as Stop/End Functionality. The overall system is subdivided into various subsystems: (1) The image Acquisition Subsystem for providing high-quality image acquisition under varying lighting and environmental conditions, (2) Preprocessing Subsystem for preprocessing of the captured images to enhance their quality using some preprocessing techniques such as image filtering and normalization to ensure accurate facial feature extraction, (3) Feature Extraction Subsystem for extracting relevant facial features from pre-processed images, such as eye closure, head position, and facial movements using techniques like Haar cascades and feature detection algorithms, this subsystem identifies key facial attributes essential for drowsiness detection, (4) Classification Subsystem which utilizes the Support Vector Machines (SVM) machine learning algorithms for the classification of extracted facial features and determine the presence or absence of drowsiness. This subsystem analyzes feature vectors generated from the extracted features, applying trained models to make accurate classification decisions, (4) Alert Generation Subsystem the generates alerts based on classification results to notify the driver or relevant stakeholders about detected drowsiness, (5) User Interface Subsystem that provides an intuitive interface for users to interact with the system and access system settings. All the subsystems were integrated using the system Integration Module that ensures seamless operation of the system by integrating all subsystems and facilitating communication between components for efficient data exchange and processing, enabling cohesive functionality and collaboration among the various elements of the driver drowsiness detection system.

4. SYSTEM EVALUATION RESULT

The system is evaluated using a Use Case Test data which is the input given to software by a system user. Poorly designed test data may not test all possible test scenarios which will hamper the quality of the software. Table 1 shows the values of the Actual Test Result versus Expected Test Result for the developed driver drowsiness detection system.

Table 1. Test cases and test results

Test ID	Test case title	Test condition	System behavior	Expected result
T01	NSGY	Straight Face, Good Light, with Glasses	Non-Drowsy	Non-Drowsy
T02	YTGN	Tited Face, Good Light, No Glasses	Drowsy	Drowsy
T03	YTGY	Tited Face, Good Light, with Glasses	Drowsy	Drowsy

Table 1 shows the results obtained from three (3) test cases under the following subheadings: Test ID, Test Case Title, Test Condition, System Behaviour and Expected Result. In all the three test scenarios, the system was able to penetrate the expected result as specified in the system performance specifications.

5. SUMMARY AND CONCLUSION

The Driver Drowsiness Detection System utilizes advanced technology to enhance road safety by detecting signs of driver drowsiness. The system integrates facial recognition algorithms and real-time monitoring to analyze driver behavior. The development of a drowsiness detection system using Haar cascades for feature extraction and support vector machines (SVM) for classifying driver status as drowsy or non-drowsy is a significant advancement in road safety technology. This project addresses the issue of drowsy driving, a major cause of accidents globally. By utilizing computer vision and machine learning, the system can accurately detect drowsiness in real-time, alerting drivers to prevent accidents. Through testing, the system showed high accuracy in detecting drowsiness across different scenarios. Real-time alerts like auditory alarms enhance its effectiveness in preventing accidents due to drowsy driving. Deploying this system in vehicles and infrastructure can help mitigate risks associated with drowsy driving, ensuring safety for, both drivers and pedestrians. In Conclusion, the development and implementation of the drowsiness detection system are crucial for enhancing road safety and preventing accidents due to driver fatigue. The successful integration of Haar cascades and SVM algorithms showcases the effectiveness of using computer vision and machine learning for real-time drowsiness detection.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Health Organization; 2021.
Available:https://www.who.int/news-room/fact- sheets/detail/road-traffic-injuries
2. Rolison J, Regev S, Moutari S, Feeney A. What are the factors that contribute to road accidents? An assessment of law enforcement views, ordinary drivers' opinions, and road accident records; 2018.
Available:https://www.mendeley.com/catalogue/491d2c7b-d9f7-3341-86de-b09ac2eeb69c/
Accessed on 8th April, 2024.
3. Gupta A, Abhinav T, Atul SC, Sachi G. A Comprehensive review of driver drowsiness detection systems and applied technologies, IEEE International Conference; 2024.
Available:https://ieeexplore.ieee.org/document/10486282
Accessed on 19th July, 2024.
4. Turki A, Sirine A, Mohamed K, Mohamed K. Facial expression-based drowsiness detection system for driver safety using deep learning techniques, 16th International Conference on Agents and Artificial Intelligence. 2024;3:726-733.
5. Hong S, Gangtie Z. A Partial least squares regression-based fusion model for predicting the trend in drowsiness, IEEE Transactions on Systems Man and Cybernetics - Part A Systems and Humans. 2008;38(5):1085–1092.
6. Ahmed T, Oishi J, Tamanna HM. Drivers' drowsiness detection system enhancement using deep learning: CNN-based Approach, IEEE 26th International Conference; 2023.
Available:https://ieeexplore.ieee.org/abstract/document/10441229
Accessed on 19th July, 2024.
7. Friedrichs F, Bin Y. Camera-based drowsiness reference for driver state

classification under real driving conditions. In Intelligent Vehicles Symposium (IV), 2010 IEEE. 2010;1-6.
DOI: 10.1109/IVS.2010.5548039

8. Flores MJ, Armingol JM, de la Escalera A. Driver drowsiness detection system under infrared illumination for an intelligent vehicle. IET Intelligent Transport Systems. 2011;5(4):241-251.
9. Mbouna RO, Kong SG, Chun M-G. Visual analysis of eye state and head pose for driver alertness monitoring, IEEE Trans. Intell. Transp. Syst. Sep. 2013;14(3):1462-1469.
10. Zhang W, Cheng B, Lin Y. Driver drowsiness recognition based on computer vision technology. Tsinghua Science & Technology. 2012;17(3):354-362.
DOI: 10.1109/TST.2012.6216768
11. Tawseef Yousuf Bhat, Shaminder Singh. A driver drowsiness detection system. IJRECE. July. -Sept 2019; 7(3).
ISSN: 2393-9028 (PRINT) | ISSN: 2348-2281 (ONLINE).
12. Singh A, Bhardwaj N, Yadav MK. A Comprehensive Review on Driver Drowsiness Detection Systems. IEEE Access. 2021;9:58564-58585.
13. Tibrewal M, Srivastava A, Kayalvizhi R. A deep learning approach to detect driver drowsiness. Int. J. Eng. Res. Technol. 2021;10:183-189.

Peer-review history:
The peer review history for this paper can be accessed here:
https://prh.globalpresshub.com/review-history/1636