Driver Drowsiness Detection Using Smartphone Application

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***Abstract*—The risk of road accidents increases due to tiredness resulting from long-distance driving and sleep deprivation, leading to tiredness in the driver. To address this issue, a proposed framework suggests a smartphone-based system that uses a three-stage approach for detecting drowsiness. In the first stage, the front camera captures images and uses a modified eye state classification method to measure the percentage of eyelid closure (PERCLOS), which is supplemented with near-infrared lighting for night driving. In the second stage, the microphone records speech data to determine the voiced to unvoiced ratio if PERCLOS crosses a threshold. In the third stage, the driver is required to touch the screen within a certain time to confirm their alertness, triggering an alarm if deemed drowsy. The device also maintains a file of the metrics and coordinates. When compared to the existing systems, the proposed method has three advantages: a more reliable three-stage verification process, implementation on readily available Android smartphones, and SMS alerts to the control room.**

I. INTRODUCTION

The safety of drivers, passengers, and other road users is at risk due to driver drowsiness, a serious issue that can lead to decreased reaction time, impaired judgment, and an increased risk of accidents. To tackle this problem, several technologies have been developed, including eye tracking, facial recognition, and EEG sensors, to detect signs of fatigue and alert the driver to take a break. Eye tracking monitors the driver's eyes for signs such as heavy eyelids, reduced blinking, and droopy eyes, while facial recognition captures an image of the driver's face and analyzes it for signs of fatigue, such as yawning and rubbing of the eyes. EEG sensors detect changes in brain waves associated with drowsiness, and sensors monitor the driver's steering behavior and road conditions. By utilizing these technologies, we can increase road safety and prevent drowsy driving-related accidents. All drivers must be aware of the dangers of drowsy driving and take breaks when necessary to avoid putting themselves and others at risk.

II. OBJECTIVES

The main goal in front of us is to devise a solution for detecting drowsiness via a three-stage process using a smartphone. The three-stage approach entails the following steps: 1) capturing images using the smartphone's front camera and calculating PERCLOS, 2) determining the VUR (which is the voice to unvoiced ratio) once PERCLOS crosses the limit, and 3) designing a reaction time test to confirm the findings. This proposed solution offers several advantages, such as: i) Eliminating the need for additional hardware as smartphones are ubiquitous and easily available to drivers or car owners. ii) Leveraging high-quality sensors for image and speech data acquisition that are already present in smartphones, negating the requirement for external add-ons. iii) Utilizing cellular networks and internet facilities available on smartphones for emergency situations that can be conveniently dealt with through SMS and online services.

III. COMPONENTS

The proposed system utilizes a smartphone, a Near-Infrared (NIR) module, and a connecting cable as its hardware components. When driving at night, the NIR module is placed around the smartphone and is activated through a power cable. The driver is required to connect the above mentioned cable to turn on the LEDs, and if the intensity drops below 10 lux, the system issues a warning

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and sends an SMS containing the driver's details and coordinates to the police control room, if they become inattentive.

If the driver's PERCLOS exceeds a set threshold, they are prompted to speak, and the system records their voice to calculate the VUR. If the VUR falls below a designated level, the driver is considered drowsy, and an alarm sounds for both the driver and passengers. A log file is kept to monitor the driver's drowsiness, including their level of drowsiness, GPS coordinates, vehicle registration number, and driver's name. Once the drowsiness level passes a certain threshold only then is the central room server is notified. The log file is saved on the smartphone and can be accessed by authorities after the journey. One advantage of the system is that it only requires a smartphone, NIR module, and cable, making it a convenient and cost-effective solution.

IV. LITERATURE SURVEY

In the paper [8] , the authors present a drowsiness detection system based on a cardiorespiratory system [8]. The cardiorespiratory system refers to the physiological system that involves the heart, blood vessels, and lungs. Key responsibilities include transporting oxygen and nutrients to the cells of the body, it also helps in removing waste products. The cardiorespiratory system can be monitored using various sensors, such as pulse oxime- ters and heart rate monitors, to detect changes in the driver's heart rate, oxygen saturation, and respiration rate. Changes in these physiological parameters can indicate changes in the driver's level of alertness, such as decreased oxygen saturation or increased heart rate, which can indicate drowsiness.

The authors have developed a monitoring system for detecting driver drowsiness, which is characterized by decreased vigilance and concentration while driving [2]. To address this issue, various drowsiness detection applications have been developed, utilizing electrical signals from the body, such as HRV and EEG, to alert drivers when they are becoming drowsy. However, these methods can be invasive due to the use of electrodes on the driver's body.

The paper [4] proposes a system for monitoring driver attention levels using computer vision techniques . The system uses different methods to detect the driver's eyes depending on the lighting conditions. During the daytime, the system uses principle component analysis to detect the eyes, while at nighttime, it uses block local-binary pattern features. The system also uses the Bright Pupil Dark Pupil (BPDP) method to detect the pupils in the driver's eyes, which can be an indicator of drowsiness or fatigue.

In the paper [5] ,it states that drowsiness detection is performed using dlib's facial landmark detection algorithm . The algorithm detects specific points on the driver's face, such as the corners of the eyes, mouth, and eyebrows, which are then used to create a feature vector representing the driver's face in numerical format.

Similarly, the paper [6] presents a real-time drowsiness detection system that uses computer vision algorithms to detect signs of drowsiness in drivers . The system captures video of the driver's face and extracts specific features, such as the shape of the eyes, mouth, and eyebrows, to determine the driver's level of alertness. These features are then used to create a feature vector representing the driver's face in a numerical format. The system operates by capturing video of the driver's face using a webcam or a specialized camera and then processing the video in real-time to detect specific facial features.

The paper [7] explains about a computer vision-based method that uses both algorithms to detect signs of drowsiness in drivers. LBP is a method used for texture analysis that extracts features from images, while the Haar algorithm is used for object detection. The detection process involves recording video of the driver's face, and then utilizing the Haar algorithm to identify the face in the video. Subsequently, LBP is employed to extract features from the detected face such as the shapes of the eyes, mouth, and eyebrows. These features are utilized to generate a feature vector that represents the driver's face in a numerical format.

According to the article [9] drowsy driving is a critical safety concern that can endanger the lives of drivers, passengers, and other individuals on the road [9] . To mitigate this issue, several drowsy driver detection systems have been developed to recognize signs of fatigue and alert drivers to take a rest. These systems use various technologies, including eye movement analysis, head position monitoring, and heart rate monitoring, to track the driver's actions and physiological responses. The primary objective of drowsy driver detection systems is to identify indicators of drowsiness and encourage drivers to take a break to minimize the risk of fatigue-induced accidents and ensure safer driving conditions.

In paper [10] the authors presented a study on a wearable EEG-based drowsiness detection system that measures brain activity and analyzes blink duration and alpha waves to detect signs of drowsiness . This technology alerts drivers to take a break or rest, enhancing road safety and minimizing the risk of accidents caused by drowsy driving. The system is convenient for drivers as it does not require any vehicle modifications.

In paper [11] the authors proposed a smart system for drowsiness and accident detection that uses sensors and algorithms to monitor the driver's behavior, including eye movements, head posture, and physiological signals, to detect drowsiness and prevent accidents.

In [12] the authors developed a driver drowsiness detection system that utilizes cameras and computer vision algorithms to analyze the driver's facial features and eye movements to detect signs of fatigue.

V. PROPOSED METHOD

The system consists of an app that is installed in the vehicle and utilizes a working camera and Haar algorithms to capture images. These images are then uploaded to a cloud service where further processing occurs with the Haar algorithm and PERCLOS method. The system has been trained with a pre-existing dataset of both drowsy and non-drowsy images. Based on the results of this training, the driver is classified as either drowsy or non-drowsy. If the driver is classified as non-drowsy, the system returns to its original state. However, if the driver is classified as drowsy, the system proceeds to the next stage.

During the next stage, the system generates an alarm through the car's Bluetooth-connected speaker for ten seconds to alert the driver that they have been detected as drowsy. If the driver does not manually turn off the alarm, the system proceeds to the next stage. However, if the driver does turn off the alarm, the system will consider them to be non-drowsy and return to its initial state.

In the third stage, the system prompts the driver to recite a specific sentence. If the driver fails to do so, the system will produce an alarm and move on to the next step.

The touch response test is the ultimate measure to detect drowsiness, requiring the driver to touch the screen within a ten-second timeframe. In case the driver fails to touch the screen within the given time, the system will categorize them as drowsy and activate a more extended alarm compared to the first stage. Along with that, the control room and emergency contacts will receive a notification that includes the driver's contact number, vehicle registration number, and location. To provide illumination during nighttime driving, an external NIR module is used by the system. The method is mainly divided into three steps:

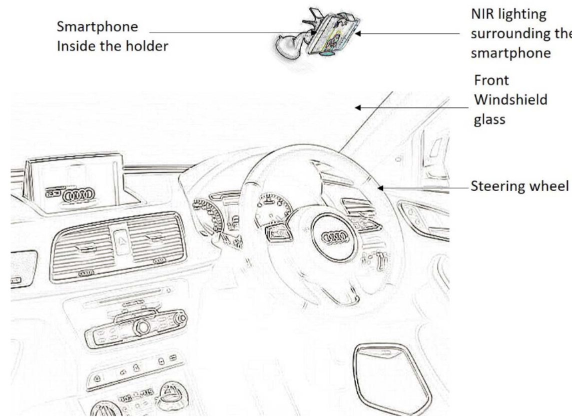

Fig. 1. Model of system

1) PERCLOS computation
2) Speech-based framework
3) Touch response and alarm generation

The PERCLOS calculation is a drowsiness detection method that is based on the rate of eye closure. It has been recognized as an important indicator of drowsiness. Essentially, PERCLOS here refers to the percentage of time in which the eyelids are closed over at least 80% of the pupil.

A. Preprocessing

Real-world driving conditions present certain challenges such as uncontrollable lighting conditions and variations in the driver's head pose. This issue is addressed in the paper by incorporating preprocessing techniques that correct for geometric and photometric distortions.

1) Photometric Correction :The photometric correction process involves partitioning the image into smaller blocks and performing histogram equalization on each block. Next, a 5x5 Gaussian filter is applied for smoothing. The filter size is carefully selected to reduce noise while preserving the image's sharp features.
2) Geometric Correction :When the driver's face is tilted beyond ±30° from the vertical upright position, a geometric correction is implemented. To

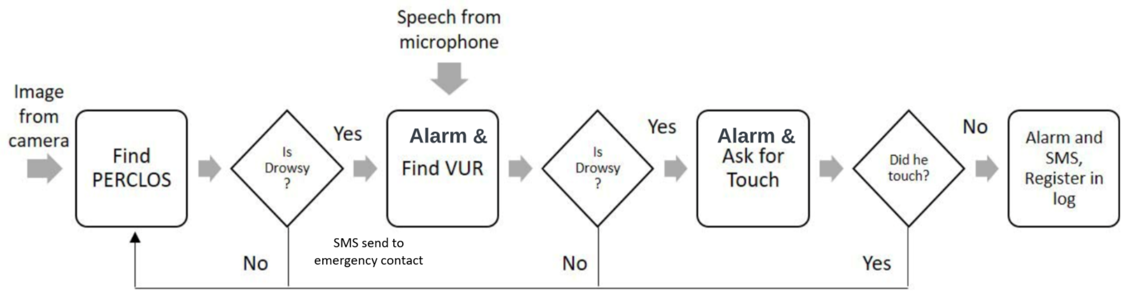

Fig. 2. Three stages of the system

achieve this correction, an affine rotation is performed on the pixels in the pre-processed image, denoted as I. The outcome is a new image where the face is oriented in a perpendicular position.

B. Face and Eye Detection and Classification

Determination of the location of the eye in the image is done by detecting the face region from the preprocessed image. For face detection, a classifier based on Haar-like features is utilized with optimal parameters. Once the face region is detected, the system searches for the eyes within the upper half of the face region. This is achieved using a Haar classifier that has been trained with eye images. For this purpose, there are two classifiers that were trained, one for daytime driving which contains visible images, and during nighttime driving, NIR images will be implemented.

C. Speech based framework

PERCLOS is a reliable signal for sleepiness, but the accuracy of the drowsiness detection system depends on the algorithm implemented for the classification of the estate which is used to estimate the sleepiness. Therefore, incorporating auxiliary features such as speech signals can improve the reliability of the system. The speech signal's VUR (Voiced-unvoiced ratio) has been validated to act as an indicator of drowsiness.To utilize this,system captures speech signals using the built-in microphone of the smartphone, sampled at 20 kHz, which is within the speech information range of up to 7.5 kHz. To process the speech data frame-wise, Singular Value Decomposition is performed to remove noise and redundant information. The SVM algorithm is then used to classify the speech as voiced or unvoiced based on Mel frequency cepstral coefficients (MFCC).The SVM returns the voiced speech vs(n) and unvoiced speech us(n) of lengths Nv and Nu, respectively.

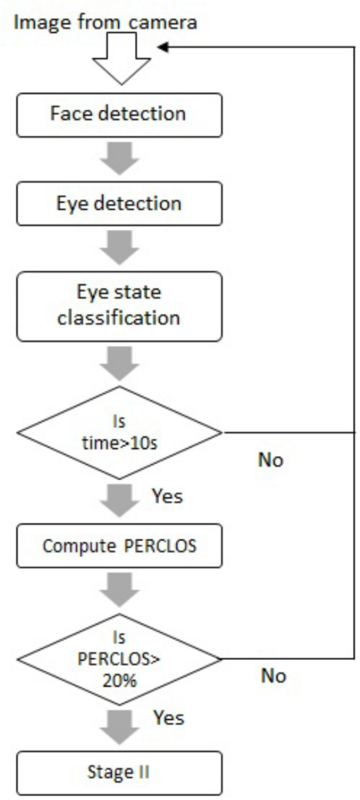

Fig. 3. Perclos computation framework

D. Response to touching the screen and alarm generation stage

In the final step of the framework, the driver is required to touch the smartphone screen within 10 seconds of receiving a voice instruction to confirm their attentiveness. This stage is activated only when both the voice and vision-based classification methods detect that the driver is drowsy. If the driver fails to respond within the given time, an alarm goes off, and the system determines that the driver is drowsy. Additionally, to ensure timely assistance in the event of an emergency, the drowsiness detection system sends an SMS message to a previously designated emergency number. This message includes the driver's contact information, vehicle registration number, and current location. Emergency responders can use this information to locate the driver quickly and provide the necessary assistance.

Moreover, the system records each drowsy event in a log file that is stored in the smartphone's internal memory. This file can be accessed later by authorized personnel for analysis and review. By keeping a record of drowsy events, the system can provide insights into the frequency and severity of driver drowsiness, which can be used to develop strategies for preventing accidents caused by fatigue.

E. App

The primary interface between the user and the underlying intelligence is served by the Android application, which is designed to be compatible with versions 8 and higher.

1) Camera: A front-facing camera is required to capture the driver's face and track their eye movements to detect signs of drowsiness.
2) Power management: The app should have power management features to minimize battery usage and prevent it from draining the device's battery.
3) Integration with vehicle systems: The app should be able to integrate with the vehicle's systems, such as the infotainment system, to provide a seamless user experience and minimize distractions.
4) Security: The app should have secure data storage and transmission to protect the privacy of the driver's data.

F. DRIVER DROWSINESS DATASET

The dataset has the following properties:

1) RGB images
2) 2 classes (Drowsy & Non-Drowsy)
3) Size of image: 227 x 227
4) More than 41,790 images in total
5) File size: 2.32 Gb

G. NIR Module

The acronym ”NIR” is commonly used to refer to ”near-infrared,” a segment of the electromagnetic spectrum that lies just beyond the range of visible light. In the context of this discussion, ”NIR” may pertain to a particular technology or device that is intended to sense or emit near-infrared radiation, such as an NIR camera or an NIR sensor. Alternatively, it may refer to a software module that is integrated into a larger system and designed to analyze or manipulate data that is associated with near-infrared signals.

Fig. 4. NIR Module

H. Advantages

1) Smartphones is provided with minimum two cameras and several sensors that helps to collect various visual parameters when fixed to a driver's dashboard. The front camera of a mobile phone, for instance, can capture eye aspects, mouth aspects, and head motions.
2) Data about the driver can also be gathered using the microphone on the phone.
3) Detecting drowsiness through smartphones is a convenient method to monitor sleep patterns as it can be done from any location and at any time, using just the phone.
4) Compared to traditional sleep monitoring devices, utilizing a smartphone for drowsiness detection is a more economical option.
5) Integrating drowsiness detection with other functions of the smartphone, such as the camera, Bluetooth, and GPS, can offer a more comprehensive analysis of sleep patter

VI. CONCLUSION

A smartphone-based application implementing a three-stage verification system is proposed as a solution for detecting driver drowsiness. The system activates each stage based on the results of the previous stage and utilizes PERCLOS, VUR, and a reaction test as measures. A log is maintained, recording events where the driver is detected as drowsy based on the three measures. The log file can be uploaded to a cloud server, enabling cab service providers to monitor driver performance. Each sub-operation was tested and cross-correlated with standard cues to assess the combined measures' effectiveness. The application serves as an interface between the user and the underlying intelligence and is compatible with Android versions 8 and above.

REFERENCES

[1] **F. Guede-Fernández, M. Fernández-Chimeno, J. Ramos-Castro and M. A. García-González** ”Driver Drowsiness

Detection Based on Respiratory Signal Analysis," in IEEE Access, vol. 7, pp. 81826-81838, 2019, doi: 10.1109/ACCESS.2019.2924481.

[2] **G. Soares, D. de Lima and A. Miranda Neto** "A Mobile Application for Driver's Drowsiness Monitoring based on PERCLOS Estimation," in IEEE Latin America Transactions, vol. 17, no. 02, pp. 193-202, February 2019, doi: 10.1109/TLA.2019.8863164.

[3] **M. Sunagawa, S. -i. Shikii, W. Nakai, M. Mochizuki, K. Kusukame and H. Kitajima**, "Comprehensive Drowsiness Level Detection Model Combining Multimodal Information," in IEEE Sensors Journal, vol. 20, no. 7, pp. 3709-3717, 1 April1, 2020, doi: 10.1109/JSEN.2019.2960158.

[4] **A. Dasgupta, A. George, S. L. Happy and A. Routray**, "A Vision-Based System for Monitoring the Loss of Attention in Automotive Drivers," in IEEE Transactions on Intelligent Transportation Systems, vol. 14, no. 4, pp. 1825-1838, Dec. 2013, doi: 10.1109/TITS.2013.2271052.

[5] **A. Shome, A. Jain, V. Choudhary, P. Garg, R. Chopra and D. Vii**, "Driver Drowsiness Detection System using DLib," 2022 2nd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), 2022, pp. 193-197, doi: 10.1109/ICACITE53722.2022.9823848.

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

[7] **Y. Suryawanshi and S. Agrawal**, "Driver Drowsiness Detection System based on LBP and Haar Algorithm," 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2020, pp. 778-783, doi: 10.1109/I-SMAC49090.2020.9243347.

[8] **L. Pugliese, M. Violante and S. Groppo**, "A Novel Algorithm for Detecting the Drowsiness Onset in Real-Time," in IEEE Access, vol. 10, pp. 42601-42606, 2022, doi: 10.1109/ACCESS.2022.3167708.

[9] **Adithya Sajikumar, Anandu Prasad, Aravind Aji, Arun K Stanly, Jibin Baby, Neethu Maria John, 2021**,"Save The Drowsy Driver Drowsy Driver Detection", INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT) ICCIDT – 2021 (Volume 09 – Issue 07).

[10] **V. Kartsch, S. Benatti, D. Rossi and L. Benini**, "A wearable EEG-based drowsiness detection system with blink duration and alpha waves analysis," 2017 8th International IEEE/EMBS Conference on Neural Engineering (NER), 2017, pp. 251-254, doi: 10.1109/NER.2017.8008338.

[11] **Indu R. Nair and Nadiya Ebrahimkutty and Gopu Darsan** "Smart System for Drowsiness and Accident Detection" International Journal of Computer Science Trends and Technology (IJCST) – Volume 5 Issue 3, May – Jun 2017.

[12] **R.Sasikala, S.Suresh, J.Chandramohan, M.Valanrajkumar** "Driver Drowsiness Detection System using Image Processing Technique by the Human Visual System" International Journal of Emerging Technologies in Engineering Research (IJETER) Volume 6, Issue 6, June (2018)

[13] **R. Alharbey, M. M. Dessouky, A. Sedik, A. I. Siam and M. A. Elaskily**, "Fatigue State Detection for Tired Persons in Presence of Driving Periods," in IEEE Access, vol. 10, pp. 79403-79418, 2022, doi: 10.1109/ACCESS.2022.3185251.