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TOWARDS THE IMPLEMENTATION OF DRIVER'S DROWSINESS DETECTION SYSTEM USING ANDROID PHONE

[1]Odikayor-Ogbomo. I.F., [2]Nwaogwugwu. G.C., [3]Ukueje O.P, [4]Ukaoha, K.C & [5]Malasowe, B.

[1,2,3]Dept. of Computer Science, Benson Idahosa University, Edo State, Nigeria

[4]College of Science and Computing, Wigwe University, Isiokpo, Rivers State

[5]Dept. of Cyber Security, University of Delta, Agbor, Delta State

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ABSTRACT

The occurrence of vehicle accidents due to driver drowsiness has become a major concern globally. This study presents the development of an Android-based drowsiness detection system utilizing smartphone front cameras combined with machine learning algorithms to track facial features such as eye closure, yawning, and head movement. The Google Firebase Machine Learning (ML) Kit was employed for real-time facial detection, and the Object-Oriented Analysis and Design Methodology (OOADM) was used for system development. The system alerts drivers via visual and audio signals when drowsiness is detected. Compared to traditional physiological-based methods, this approach is non-intrusive, cost-effective, and easily deployable. The study also evaluates system performance under varying lighting conditions and with drivers wearing glasses.

1. INTRODUCTION

The tremendous number of fatality, casualties, injuries and property damages caused by drowsiness call for a notable initiative in developing an effective system that can detect drowsiness and take proper measures before accidents could occur. Though recently some limited models of cars have added features for detecting drowsiness using physiological variations brain waves, heart rate, pulse rate measurements to determine or detect the level of drowsiness of driver. However, this requires some sort of physical connection with the driver such as connecting the electrode to the driver body while driving. This can be very uncomfortable, and not flexible, as it will restrict the driver to a particular spot while driving.

*Corresponding author: Ukaoha, K.C.

E-mail address: kingsley.ukaoha@wigweuniversity.edu.ng

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Also these cars that have these features are usually very expensive and limited to the rich, hence it's unaffordable.

Drowsiness (also referred to as sleepiness) can be defined as "the need to fall asleep". This process is as a result of normal human biological rhythm and its sleep-wake cycles. The longer the period of wakefulness, the more pressure builds for sleep and the more difficult it is to resist it. Vehicle driver who feel drowsy while driving do not really know the exact level of drowsiness he or she is in, and as a result serious accident occurs. The number of vehicle accident due to driver drowsiness can be prevented if a system can be developed for warning the driver of drowsiness prior to any accident occurrence. Eye blinking, head movement and facial expression can be used to determine driver's distraction. The development of technologies for detecting or preventing drowsiness at the wheel is a major challenge in the field of accident-avoidance systems. Drowsiness detection is one of those common problem needed to be solved in order to prevent road accidents.

Real time driver drowsiness detection is one of the best technologies that can be implemented to assist drivers to make them aware of their drowsy state when driving. Driver behavioral state such as opening and closing of eyes, yawning, head nod, and head turning can help in catching driver drowsy conditions early and can possibly avoid mishaps. This research presents a technique to detect driver drowsiness with the use of Open computer vision (CV) library, android device camera and image processing. The system adopts the Google firebase Machine learning (ML) image and vision processing algorithm using the android device camera to capture image of drivers, while checking for behavioral changes at real time.

2 RELATED WORKS

Drowsiness is a term which can be defined as a feeling of being sleepy. Due to drowsiness, a driver can fall asleep while driving. Drowsiness is a state of decreased awareness or alertness associated with a desire or tendency to fall asleep. Drowsiness is therefore the brains last step before falling asleep Azim (2007). Eriksson and Papanikolopoulos (2007) define drowsiness detection as a system that captures, processes, recognizes and provides results to a user, wherein the user can take actions on the events. Forsman *et al.,* (2003) measured driver's drowsiness through analyzing the different controller signals of the vehicle such as steering wheel movement, the pressure from the gas and brake pedal, speed of the vehicle, change in shift lever and the deviation from lane. (Khushaba *et al.* 2011, Akin *et al.,* 2008). Measured the physiological activities of the human body such as brain wave (Electroencephalogram - EEG), heart rate (Electrocardiogram – ECG), electric signals from muscle cells (Electromyogram – EMG) or eye movement (Electrooculography – EOG) The electrodes were attached to specific parts of the body and the electric signal is measured and analyzed to determine the drowsiness state of the driver. However, Physiological signals are weak and can easily be distorted with noise. To minimize the noise, researchers have used different techniques to preprocess the raw data. Fu-Chang *et al.,* (2012) performed similar experiments on EEG data to determine drowsiness of a driver. They used Independent Component Analysis (ICA) to segregate and localize mixed EEG data to distinct brain activities. From the preprocessed data, features are extracted in frequency domain using FFT and classified using a Self-organizing Neural Fuzzy Inference Network. Hu and Zheng (2009) also implemented drowsiness detection system by making use of EOG data. They initially identified the eye blinks from the recorded EOG data and extracted the eye lid movement parameters as features to be classified using Support Vector Machines (SVM). According to Dinges and Grace (2008). Initially, video sources such as a webcam, digital video camera, or infrared camera are used to collect a stream of pictures of the driver. Preprocessing the pictures to recognize the driver's face and eyes is the next stage. The output from the preprocessing stage will be used to extract certain features needed to determine the changes in behavior of the driver. Li *et al.,* (2011) performed successive image filtering techniques such as image subtraction, morphologically closed operations and binarization, and finally counted the number of pixels around the eyes region to detect eye closure. Liu *et al.* (2010) extracted simple features from the temporal difference of consecutive image frames and used them to analyze the rules of eyelid movement during drowsiness. Garcia *et al*. (2012) have also presented a non-intrusive approach to drowsiness detection. They used an IR illumination system and a high-resolution camera to accept a stream of images and perform face and eye detection. They applied filters on the eyes region and performed horizontal and vertical projections of the pixel values of the detected eye area. The vertical projection corresponds to the eye height which is used to evaluate. Zutao and Jiashu (2010) initially performed face and eye detection and tracked the eye pupils using non-linear Kalman and mean-shift tracking. They also performed vertical and horizontal projections of the pixels around the eyes region. Since the eye ball color is much darker than the surrounding, they calculated the pixel values in the vertical projection to determine the percentage of eyelid closure. According to Fu-Chang *et al*. (2012) mere analysis of eye closure may not be enough to predict drowsiness as the driver may not necessarily close his eyes throughout the drowsy episodes especially during the early stages. A drowsy driver usually does not go to deep sleep immediately rather alternates between nodding off and opening his eyes. The opening of the eyes in such transitions can empirically be misinterpreted as being awake if eye closure is the only parameter being analyzed. Hence, in recent years, some researchers are considering other facial movements in addition to eye closure such as eyebrow raise, yawning and head or eye position orientation. Haisong and Qiang (2004). used facial expressions which were represented by single or a combination of individual muscle movements called action units. These action units have been carefully coded with a unified description method of expression called Facial Action Coding System (FACS). Vural *et al.,* (2010) employed machine learning methods to analyze facial movements during drowsy episodes. These facial motions include blinking, yawn motions, eye-gaze, eyebrow raise and other movements that are represented by action units of FACS. They trained SVM classifiers for each action unit with a training dataset which is coded by certified FACS coders. Flores M.J. *et al.,* (2011) described 'Driver drowsiness detection system under infrared illumination for an intelligent vehicle'. 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. Kong G. *et al.,* (2013) 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. A support vector machine (SVM) classifies 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. Driver Drowsiness Detection via HMM based Dynamic Modeling' was described by Eyosiyas *et al.,* (2014). They presented a novel technique for detecting sleepiness by monitoring the driver's facial expression using a Hidden Markov Model (HMM) based dynamic modeling. They used a simulated driving setting to build the method. The proposed method's efficacy was confirmed by experimental findings. Jabbar *et al.,* (2020) proposed Convolution Neural Network (CNN) technique of the ML algorithm to detect micro-sleep and drowsiness. In this paper, detection of driver's facial landmarks can be achieved through a camera that is then passed to this CNN algorithm to properly identify drowsiness. Here, the experimental classification of eye detection is performed through various datasets like without glasses and with glasses in day or night vision. So, it works for effective drowsiness detection with high precision with android modules. Jemai *et al*. (2013) Used Wavelet networking to develop a sleepy warning system. That network follows the movements of people's eyes using classification algorithms like Wavelet Network Classifier (WNC), which uses the Fast Wavelet Transform (FWT) to make binary decisions (conscious or not). Heart rate and ECG are two physiological characteristics that are retrieved periodically. Babaeian *et al*. (2019). Used wavelet's transformation with regression approach for tiredness diagnosis This concept was used to classify heart rate data using a wavelet network in order to discover an average way to detect sleepiness. Arefnezhad *et al.* (2019) used a neuro-fuzzy system with support vector machine and particles warm optimization technique to present a non-interfering sleepy detection system based on vehicle steering data. Mutya *et al.* (2019) developed a method that uses a steering wheel algorithm to tackle the problem of sleepiness. The CN is based mostly on image-formed or pictorial-based steering action.

3. METHODOLOGY

The methodology adopted for the development of this system was the Object-oriented analysis and design methodology (OOADM). This methodology was chosen due to its ability to provide users with clear, easily understandable documentation consisting of various diagrammatic representations of the system.

3.1 System Design

The system design illustrates how the system fulfills the objectives or requirements identified during the analysis of the system. It also illustrates the overall architecture of the system and the setting of standards. The system is structured in three layers:

- **Presentation Layer:** User interface on the Android device
- **Business Logic Layer:** Processes facial recognition data using Firebase ML Kit
- **Data Layer:** Stores driver profile data and detection history

Architectural Overview: The smartphone serves as the central processing unit, capturing live images and running facial analysis algorithms.

3.1.1 Architectural view of the proposed system

The architectural view depicts the system's organization or structure, and provides an explanation of how it behaves. The system architecture of the proposed system comprises of three (3) main layers under the server-side logic: Presentation, Business and Data Layers.

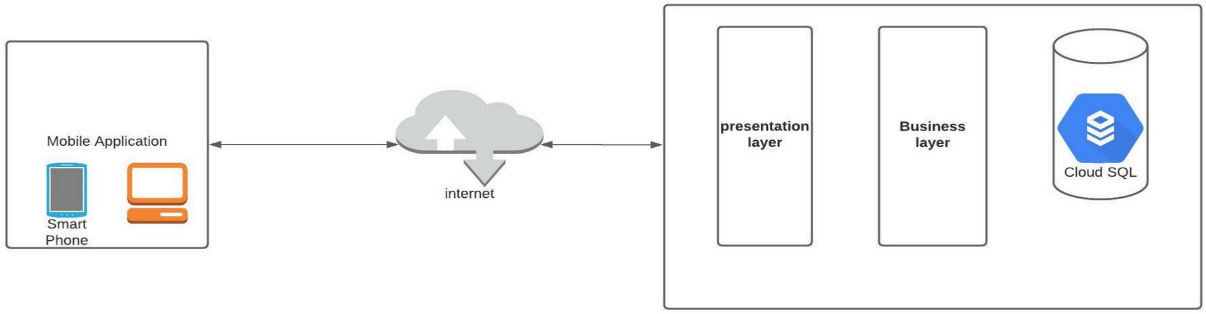

Figure 1 Architecture of the proposed vehicle monitoring system

Here, different components like desktop computers, smart phones, tablets and laptops will be used as a bridge into the core business logic. The Business Layer represents the core functionality of this android application working with some development tools and environments to build applications. In business layer, languages like PHP, Java, Python, were used. JAVA programming language was used to implement the android studio in IDE (integrated developer's environment).

The Data Layer represents access to data hosted within the boundaries of the web application using database management system (DBMS) and implemented using MySQL database.

3.1.2 Input Design

The input design for the system consists of forms links and buttons that take in data into the system for further processing. The data's includes: Username, password, driver's personal details, car model, Phone number. The other input to the system is a mobile device camera for capturing live image of the driver at real time.

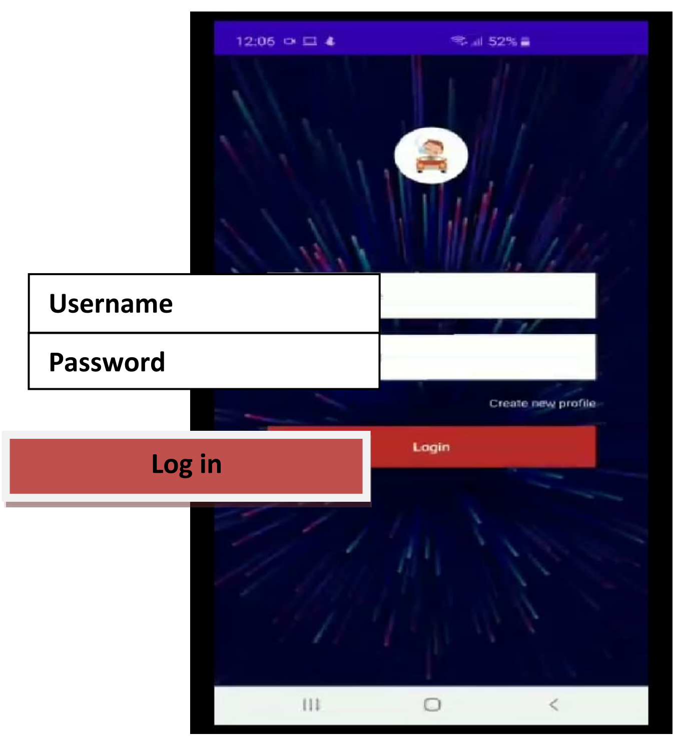

Figure 2 Input design of the system

3.1.3 Output Design

The output design was structured based on the input format, so as to enable quick retrieval and display of information earlier inputted into the system. The outputs to the developed system are of information of drivers and their vehicle model entered into the system. Other output are models showing notification when driver drowsiness is detected or when an input fails to validate.

Table 1 Showing information of driver displayed in a table

User id	Full name	email	Phone number	Car model	Password
10234	John Doe	Johndoe1999 @gmail.com	07034256173	Toyota	Tehydi
10235	Jane Bishop	Jane245@gma il.com	08143253671	Lexus	Fghtjy4
10236	Mary Sam	Marysam65@ gmail.com	09087265342	sedan	Dsgdg53

3.2. Use Case Diagram of the system

The use case diagram shows the interaction between the system and the various system users (drivers).

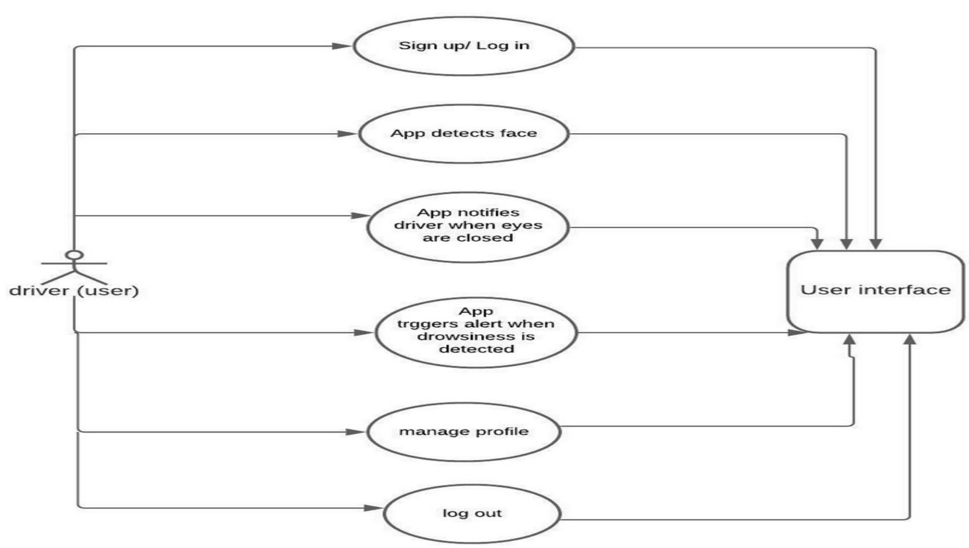

Figure 3: Use case diagram of the system

3.3. Sequence diagram of the system

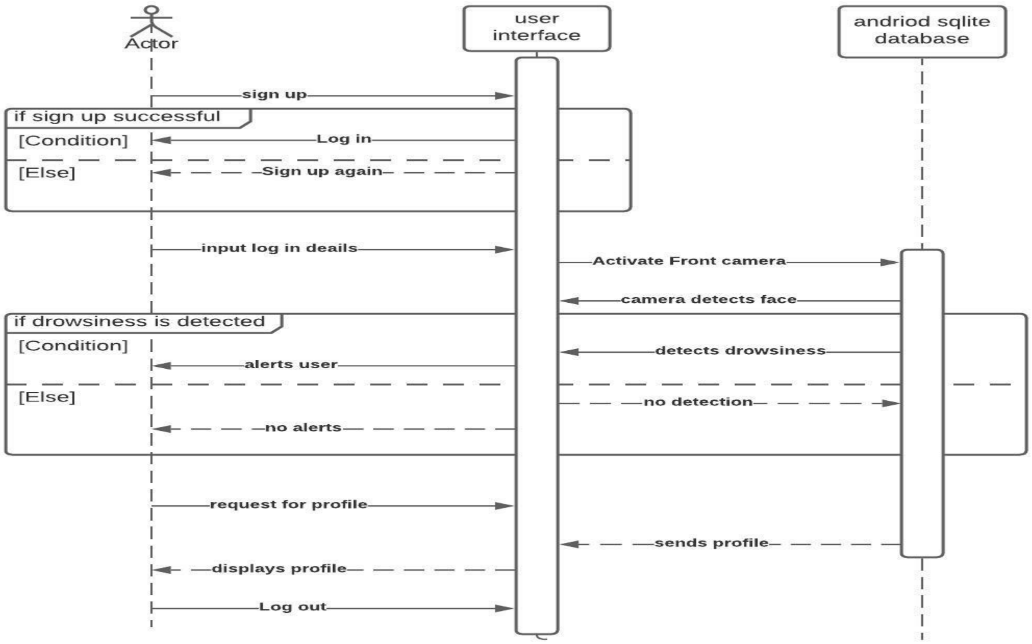

Figure 4 sequence diagram of the system

3.4 Activity Diagram

The activity diagram expresses the system's dynamic properties. The behavior of the system is depicted by showing the different decision pathways that exist while the activity is being carried out. The control flow from a start point to a completion point is shown in Figure 5.

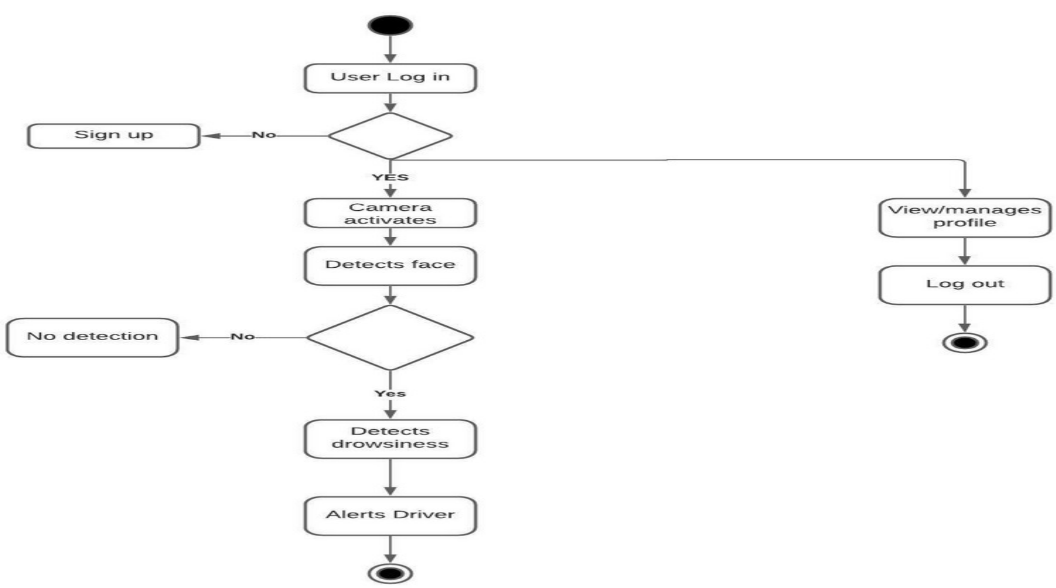

Figure 5 Activity diagram of the system.

3.5 Flowchart for the system

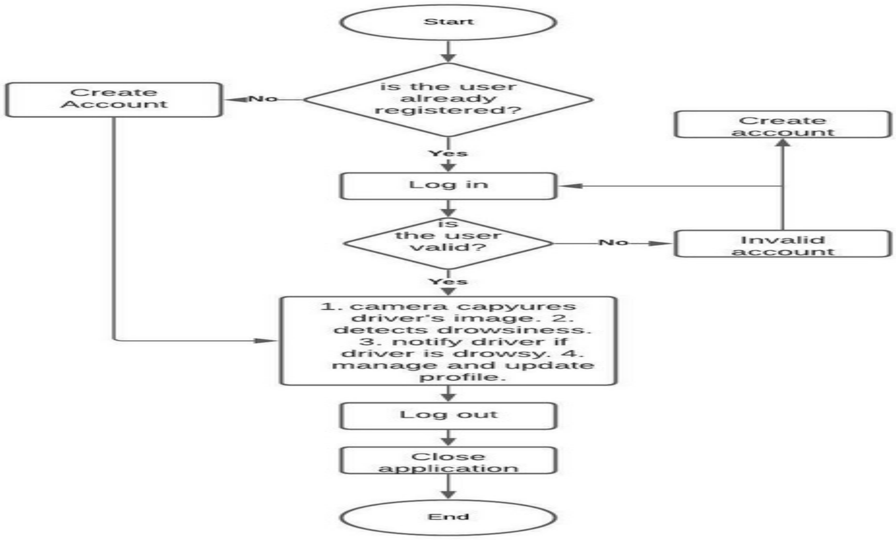

Figure 6. Flowchart for the system

RESULTS AND DISCUSSION

4.1 The user sign up page

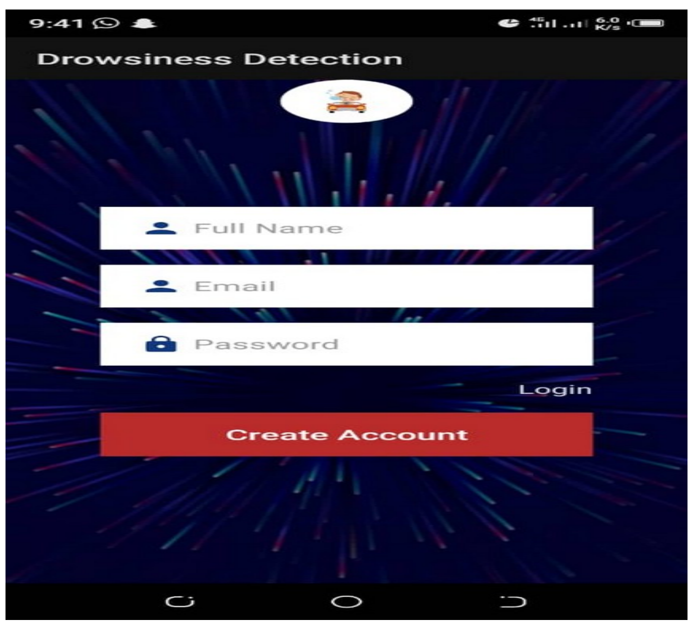

Figure 7. Sign up Page.

4.2. The user log in page

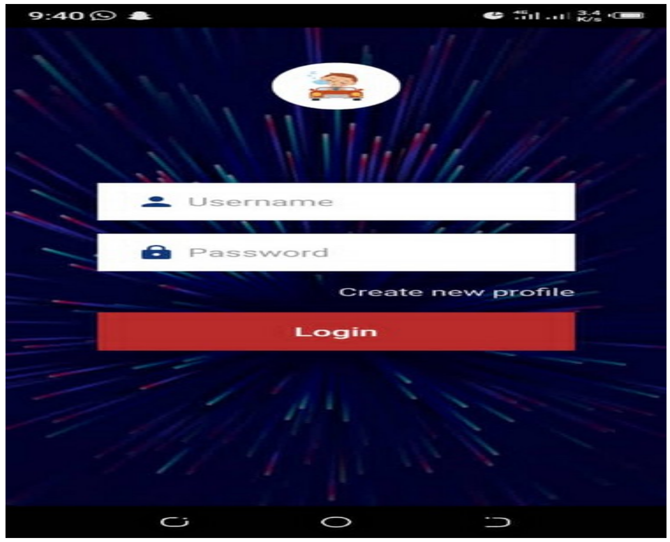

Figure 8. Log in Page

4.3. The camera captures the face of the user (driver)

4.3.1 Camera Settings

The camera was configured to:

- Capture frames at **30 FPS** for real-time detection
- Utilize **IR-enhanced night vision mode** to work in low-light conditions
- Adjust brightness using automatic exposure control to accommodate varying lighting environments

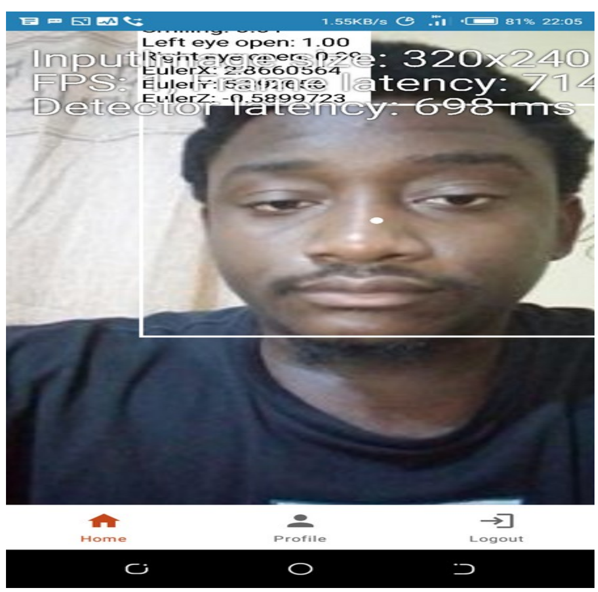

Figure 9. The user face as captured by the camera.

4.4. The application detecting drowsiness

4.4.1 Handling Poor Lighting & Glasses:

- The Firebase ML Kit includes adaptive learning models that compensate for dim lighting by enhancing facial contrast.
- Special filters were integrated to recognize facial features even when the driver wears glasses.

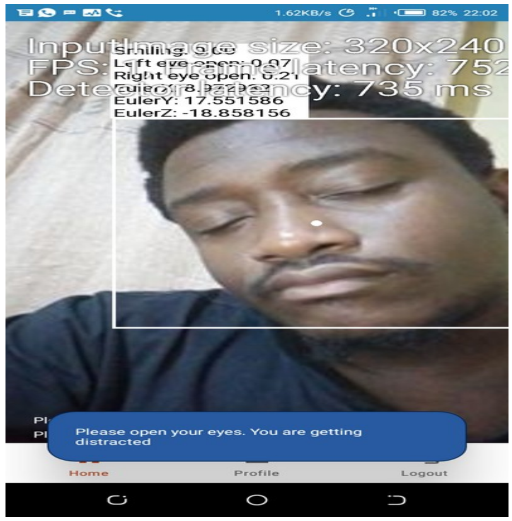

Figure 10. Drowsiness Detected.

4.5 Decision-Making Algorithm

The algorithm follows these steps:

1. **Face Detection:** Identifies the driver's face and tracks it continuously
2. **Eye Tracking:** Measures eye blink duration and frequency
3. **Head Movement Detection:** Identifies nodding patterns
4. **Yawning Detection:** Tracks mouth opening size and duration
5. **Classification & Alert:** A threshold-based classification system issues alerts when drowsiness indicators exceed predefined limits

4.6 Threshold Values:

- Eye closure longer than **2 seconds** triggers an alert
- Head nodding exceeding **three occurrences in 15 seconds** triggers an alert
- Yawning detected more than **three times in 30 seconds** triggers an alert

4.7. The Application sends an alert

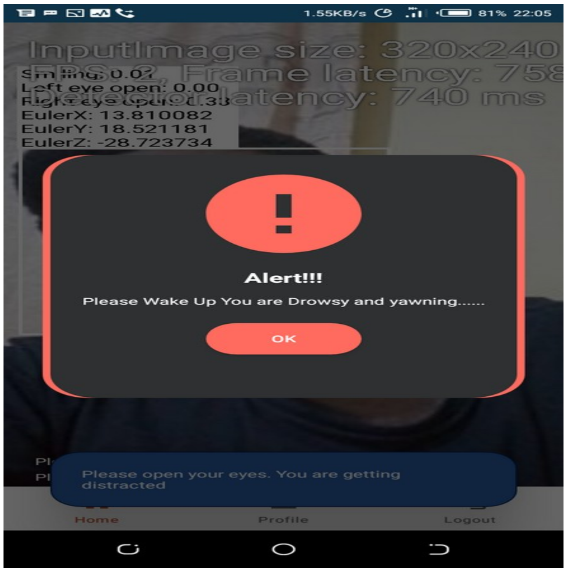

Figure 11. Alert message.

RESULTS AND DISCUSSION

5.1 Accuracy and Performance Evaluation

- **Detection accuracy:** Achieved an **89% accuracy rate** in controlled environments
- **Performance under poor lighting:** Accuracy dropped to **76%** without night vision enhancement
- **Effect of glasses:** Detection accuracy was **85%** for users wearing glasses

Table 5.1: Comparison with Existing Systems

Feature	Proposed System	Physiological Signal-Based Systems	Traditional Image Processing
Cost	Low (uses smartphone)	High (requires EEG/ECG sensors)	Medium (infrared cameras)
Usability	High (mobile and portable)	Low (invasive sensors)	Medium (fixed installations)
Accuracy	89%	95%	80%
Adaptability	Works with different lighting & eyewear	Limited to biological data	Requires optimal lighting

5.2 Advantages and Limitations of the System

Some benefits or advantages of the system are given as follows:

a. Non-intrusive and easy to deploy

b. Cost-effective compared to physiological methods

c. Works on widely available Android smartphones

However, some noticeable limitations or shortcomings are:

a. Less accurate in extreme low-light environments

b. Performance may vary based on smartphone camera quality

CONCLUSION

This study successfully developed a smartphone-based drowsiness detection system leveraging Firebase ML for real-time facial tracking. The system effectively detects drowsiness through eye blink duration, yawning frequency, and head nodding movements. Compared to existing systems, this approach is cost-effective, portable, and requires no additional hardware. Future improvements will focus on enhancing detection accuracy under extreme lighting conditions and optimizing battery usage.

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