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# Smart Drowsiness Detection and Safety System using Machine Learning

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## I. ABSTRACT

Abstract—According to National Highway Traffic Safety Administration (NHTSA), drowsy driving leads to over 71,000 injuries, 1,500 deaths, and $12.5 billion in monetary losses per year. Drowsy driving poses a significant risk, resulting in numerous injuries, fatalities, and economic losses annually. This paper presents a novel solution to address this issue by introducing a system capable of detecting driver drowsiness and issuing timely warnings. Utilizing a non-intrusive approach based on Eye Aspect Ratio (EAR), the system monitors and analyzes the driver's eyes, even in low-light conditions. By comparing real-time EAR with baseline values, the system accurately predicts drowsiness. Moreover, it incorporates a smart alarm system that can be deactivated through hand gestures. In addition to warning the driver, the system includes location tracking and the capability to send text messages to emergency contacts, enhancing safety measures. Experimental results demonstrate high accuracy in detecting drowsiness across various conditions, including different facial features and lighting environments.

***Keywords— Drowsiness Detection, Eye Aspect Ratio, Facial Landmarks, Hand Gesture Detection, Smart Alarm System,LocationTracking,EmergencyContact Messaging.***

## II .INTRODUCTION

Drowsiness poses a significant hazard to road safety, especially among drivers, as it diminishes cognitive abilities and increases the likelihood of accidents. With road traffic injuries on the rise globally, effective strategies to detect and counteract drowsy driving are imperative.Traditionalmethods such as Electroencephalography(EEG) and Electrocardiography (ECG) are cumbersome and unsuitable for driving conditions. Therefore, there is a pressing need for non-intrusive, real-time drowsiness detection systems.

This paper addresses this need by introducing a novel smart driver drowsiness detection and safety system. Leveraging advancements in machine learning and computer vision, the system monitors driver behavior to identify signs of drowsiness promptly. By analyzing facial expressions and eye movements, it detects subtle indicators of fatigue**,** enabling timely intervention to prevent accidents.

Motivated by a commitment to enhancing road safety, this research aims to develop a comprehensive solution to the pervasive issue of drowsy driving. The introduction sets the stage for further exploration into the system's design, implementation, and evaluation, emphasizing its potential to contribute to a safer transportation environment.

## III. LITERATURE REVIEW

- The real-time driver drowsiness detection system developed by Ritish H in 2021 utilizes OpenCV, a renowned computer vision library, to monitor signs of fatigue in drivers. Through image capture, eye detection, and yawning detection processes, the system identifies drowsiness-related cues. Upon detecting such signs, the system issues timely audio alerts to keep the driver vigilant and mitigate the risks associated with drowsy driving. This approach aligns with existing literature on drowsiness detection systems, which emphasizes the importance of monitoring driver behavior, particularly eye movements and facial expressions, to prevent accidents caused by fatigue-induced impairment. The system's successful implementation of key components, including image capture and feature extraction, highlights its effectiveness in addressing drowsiness-related concerns and enhancing driver safety.

- In the pursuit of addressing the perilous issue of driver drowsiness, Tawanda .M's 2022 study employs a multifaceted strategy, amalgamating various techniques and technologies. Through the analysis of eye blinking, facial landmark detection, mouth movement tracking, and pulse rate monitoring, alongside the application of machine learning algorithms like Random Forest and Linear Regression, the research endeavors to comprehensively detect and predict instances of drowsiness. Notably, the utilization of machine learning algorithms for classifying eye and mouth states yields promising results, showcasing remarkable accuracy rates. By integrating video processing, machine learning, and physiological parameter monitoring, the study offers a holistic solution to bolster road safety. The findings underscore the potential of these methods in mitigating the hazards associated with drowsy driving, ultimately fostering safer road conditions for all motorists.

  Jyothika's 2021 study introduces an innovative drowsiness detection system tailored for drivers, combining OpenCV with deep learning methodologies. This pioneering system relies on webcam imagery analysis to detect faces and eyes accurately. At its core lies a Convolutional Neural Network (CNN) model, capable of real-time prediction of eye closure status. By computing a score indicative of closed-eye duration, the system triggers an alarm when this score exceeds a predefined threshold, crucial for timely driver alertness. The study confirms the system's effectiveness in discerning typical eye movements from drowsiness-related closures, thereby demonstrating its potential to prevent fatigue-induced accidents. Positioned as a pivotal tool in road safety, the system offers significant promise in mitigating the dangers associated with drowsy driving, ultimately fostering a safer driving environment.

## IV.DROWSINESS DETECTION AND SAFETY SYSTEM

### Data

Images in the dataset were captured under diverse range of conditions, including variations in lighting, distance, resolution, face angle, and eye angle. These factors contribute to achieving favorable outcomes while minimizing the likelihood of low accuracy.

OPEN EYE CLOSED EYE

The dataset comprises multiple versions, each containing different quantities of images. Version 1 consists of 10,000 images, evenly split between 5,000 images of closed eyes and 5,000 images of open eyes. Version 2 includes 5,000 images, with 2,500 images of closed eyes and 2,500 images of open eyes. Version 3 also contains 10,000 images, distributed as 5,000 images of closed eyes and 5,000 images of open eyes. Lastly,Version4comprises 4,000 images, with 2,000images of closed eyes and 2,000 images of open eyes.

### Faciallandmarks

Utilizing established facial landmark recognition features, weemploy pre-existing annotations to identify signs of drowsiness and fatigue. Leveraging the dlib open-source Python library, we detect 68 facial landmarks, aiding in the prediction of facial shape by delineating key regions such as eyebrows, eyes, nose,and mouth (illustrated in Fig. 1). Variations in the characteristics of these specific points reflect the individual's range of expressions.

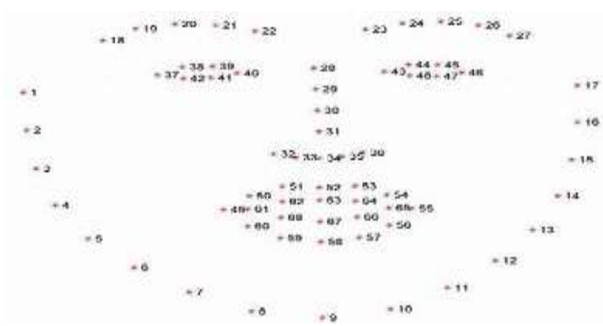

Figure 1: 68- points facial landmark

### EAR Algorithm

Eye Aspect Ratio (EAR) is a metric that evaluates the openness of the eyes by considering the ratio of width to height. Each eye is defined by six (x, y) coordinates, starting from the upper left corner and proceeding clockwise around the eye's perimeter (as depicted on the left). This innovative approach involves computing the ratio of the sum of vertical distances to twice the sum of horizontal distances between these points. Notably, EAR is computed independently for each left and right eye.


Figure 2: 6-coordinates

$$EAR = \frac{||p2 - p6|| + ||p3 - p5||}{2||p1 - p4||}$$

Formula to calculate EAR

Fatigueness of the driver is one of the most casual factors for traffic accidents. Almost 1.2 million people lose their lives in traffic accidents every year around the world . Thus, this paper proposes a non-intrusive system to detect and keep a track of driver’s fatigue level based on its facial features.

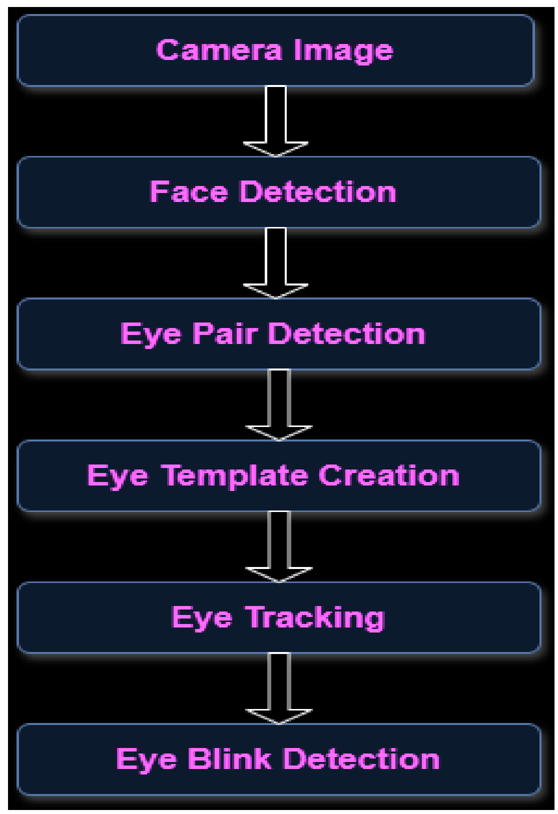


Figure 3: Drowsiness Detection FlowGraph

### A) PREPROCESSING

In the pre-processing stage of capturing the driver's video, the system utilizes a camera installed within the vehicle cabin. This camera is strategically positioned to have a clear view of the driver's face, ensuring optimal capture of facial expressions and movements. Before recording begins, the system may adjust camera settings such as focus, exposure, and frame rate to optimize video quality and reduce potential distortions or blurriness. Additionally, any ambient lighting conditions may be taken intoaccount to ensure adequate visibility of facial landmarks. Once the camera is properly configured, the system initiates video capture, continuously recording the driver's face throughout the duration of the journey. This video data serves as the input for subsequent processing stages, including facial landmark detection and drowsiness analysis.

## B) DATA GATHERING

The process of gathering data begins with image preprocessing to ensure clear visibility of the driver's face. Dlib's face detector is then employed to accurately locate and delineate the facial region within the image. Utilizing the pre-trained facial landmark detector from the Dlib library, the system estimates the positions of 68 (x, y) coordinates corresponding to key facial features. These coordinates facilitate the establishment of a bounding box around the face, ensuring focused analysis.

Proceeding from facial landmark localization, the system extracts the coordinates of the eyes and mouth, encapsulating this focused region into a polygon using a convex hull. Contours are then drawn around the eyes and mouth regions by connecting the coordinates along the boundary for visual shape analysis, aiding in feature extraction.

Following this, the initial Eye Aspect Ratio (EAR) of the driver is computed promptly upon system activation, typically upon starting the vehicle and detecting a face. This approach addresses individual variations in EAR due to factors such as genetic diversity and facial structure, which can affect drowsiness detection accuracy. By calculating the driver's EAR at the onset, the system adapts to the unique characteristics of the individual, minimizing false alarms and optimizing performance.

## C)DETECTION SYSTEM

The detection system operates with a meticulous approach to ensure accurateidentification of driver fatigue. Initially, the system computes and stores the driver's baseline Eye Aspect Ratio (EAR). Subsequent frames are then captured in clusters of 30,this means that the system captures and analyzes 30 consecutive frames of video data at a time. This approach allows for a more comprehensive assessment of the driver's alertness levelsover a short period. By analyzing a cluster of frames rather than individual frames, the system can observe changes and patterns in the driver's behavior more effectively, providing a more accurate understanding of their level of alertness. This method enables the system to detect subtle changes in the driver's eye movements, such as blinks or prolonged eye closures, which may indicate drowsiness or fatigue.enabling comprehensive monitoring of the driver's alertness levels. Through real-time analysis of EAR fluctuations, the system discerns instances of eye closure and reopening, thus facilitating the detection of blinks.

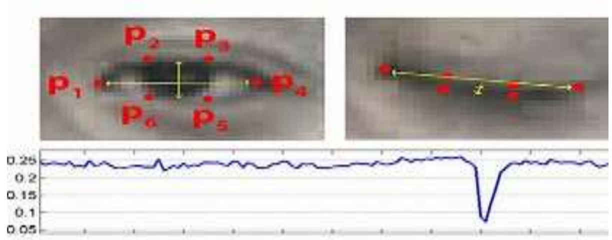

Figure 4: Change in EAR on opening and closing of eye

By comparing the current EAR with the initial baseline, the system initiates a text warning if the real-time EAR remains below 20% of its baseline counterpart for more than 20 consecutive frames, indicative of frequent blinking. Recognizing the correlation between drowsiness and increased blink frequency, prolonged eye closures prompt the system to trigger an alarm if the driver's eyes remain shut for more than 20% of the initialEAR value across 48 frames.

To account for variations in individual physiology and environmental factors, a conservative EAR threshold is maintained, ensuring reliable detection even in scenarios where the EAR does not reach zero during complete eye closure. This comprehensive monitoring process continues seamlessly until the vehicle engine is deactivated, ensuring continuous vigilance over the driver's alertness levels throughout the journey.

## D)ALARM SYSTEM

The alarm system provides dual notification methods—text messages and audible alarms—to effectively alert the driver to potential drowsiness. However, these alerts are activated only when the system detects extreme drowsiness, defined by prolonged eye closure exceeding 20% of the initial EAR value across a span of 48 frames. To deactivate the alarm and restore normalcy, the system integrates a sophisticated smart alarm system that relies on hand gesture recognition. Upon activationof the alarm, the system immediately initiates the process of capturingframes to analyze hand gestures within a defined Region of Interest (ROI). By capturing and processing 30 frames from the live video stream and employing resizing and flipping techniques, the system ensures precise detection of hand movements. Utilizing Convex Hull, the system identifies the shape of the object within the ROI, enabling the drawing of contours using extreme points as coordinates to distinguish foreground from background. Upon confirmation of a detected hand, the audible alarm ceases, enabling the system to resume its primary function of monitoring the driver's drowsiness. Furthermore, to enhance the user experience and minimize distraction, any text warnings triggered by excessive yawning or blinking disappear automatically once the system detects that the driver has regained alertness or become active. This adaptive feature underscores the system's commitment to safety and user convenience. This proactive approach to alerting the driver encourages timely intervention and helps prevent potential accidents due to driver fatigue.

### E)LOCATION TRACKING

The location tracking process, integrated with geocoder technology, enhances the safety features of the system by enabling real-time monitoring of the driver's whereabouts. Geocoding, a process that converts addresses into geographic coordinates, allows the system to accurately pinpoint the driver's location using GPS data. By continuously updating the driver's coordinates, the system can precisely track their movements throughout the journey. Leveraging this geolocation data, the system is equipped to respond swiftly in case of emergencies.

In the event of a critical situation such as a detected instance of extreme drowsiness or a collision, the system activates its emergency protocol. This protocol includes sending automated text messages to designated emergency contacts via Twilio, a cloud communications platform. These text messages contain vital information, including the driver's current location obtained through geocoding. By promptly alerting emergency contacts with the driver's precise coordinates, the system facilitates rapid assistance and intervention in emergency situations.

The integration of geocoder technology and Twilio's messaging capabilities enhances the system's effectiveness in ensuring driver safety. Geocoding enables accurate location tracking, while Twilio facilitates immediate communication with emergency contacts, thereby streamlining emergency response efforts. This proactive approach to safety empowers both drivers and their loved ones with timely information and support, enhancing overall peace of mind and mitigating potential risks on the road.

## V.RESULT AND DISCUSSION

| Sample | Time of Day | Ini. EAR | Rec. EAR | Detected Drowsy | Actual Drowsy |
|---|---|---|---|---|---|
| S1 | Day | 0.31 | 0.24 | Yes | Yes |
| S2 | Day | 0.33 | 0.26 | Yes | Yes |
| S3 | Day | 0.28 | 0.21 | Yes | No |
| S4 | Day | 0.32 | 0.30 | No | No |
| S5 | Day | 0.34 | 0.29 | No | No |
| S6 | Night | 0.35 | 0.28 | Yes | Yes |
| S7 | Night | 0.34 | 0.26 | Yes | Yes |
| S8 | Night | 0.29 | 0.28 | No | No |
| S9 | Night | 0.32 | 0.24 | Yes | Yes |
| S10 | Night | 0.30 | 0.23 | Yes | Yes |

Table:Drowsiness Detection Statistics

From the embedded drowsiness detection system tested on a car dashboard, observations were gathered from 10 adults with varying initial Eye Aspect Ratio (EAR) values, recorded in Table II. Utilizing high-resolution cameras, the system captured video frames even during nighttime, ensuring effectiveness in low-light conditions. The study accounted for factors such as time of day and facial features like beards or spectacles. Results revealed the system's ability to detect drowsiness accurately in diverse conditions, showcasing its reliability in real-time monitoring and prediction of driver alertness levels.

We notice that the system can plot facial landmarks and detect drowsiness even wearing spectacles(shown in below fig) while driving with the same precision and pace as the one who does not have either.

Figure: Facial coordinates' detection with glasses

This system gains an edge by detecting drowsiness even when the face is at an angle that is not directly in front of the camera, provided maximum part of both eyes is visible(shown below)

Figure: Facial coordinates' detection from a side angle

## VI.CONCLUSION

In summary, the system effectively fulfills its objectives by tackling issues related to driver fatigue and improving overall road safety. Through eye movement detection, the system reliably identifies signs of drowsiness and promptly alerts the driver. Additionally, it automatically notifies emergency contacts of the vehicle's location if the driver fails to respond to the alarm. The inclusion of hand gesture recognition allows for easy deactivation of the alarm, enhancing usability and safety. This comprehensive approach ensures that even standard vehicles can benefit from advanced safety features, ultimately reducing the risk of accidents and ensuring the well-being of drivers and passengers alike.

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