



# OPTIMIZING ROAD SAFETY: ADVANCED SOLUTIONS FOR DETECTING AND MITIGATING DRIVER DROWSINESS

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**Abstract:** Road safety remains a critical concern worldwide, with driver fatigue being a significant contributing factor to traffic accidents. This project aims to develop an advanced driver drowsiness detection system using deep learning techniques. Leveraging datasets of open and closed eye images, and implementing algorithms such as Inception v3 and Convolutional Neural Networks (CNN), the system achieves high accuracy in identifying signs of drowsiness. Integration of dlib for facial landmark detection enhances the system's capability to monitor critical features like eye closure, yawning, and head tilting. Deployed in a real-time monitoring application using Flask, the Inception v3 model achieved an accuracy of 98%, while the CNN model reached 96%. This robust system offers a potent solution to detect drowsiness, potentially reducing the risk of accidents caused by driver fatigue.

**Keywords:** Image Processing, Facial Landmarks Detection, Deep Learning Algorithms, Drowsiness Detection.

## I. INTRODUCTION

Driver drowsiness is a prevalent issue that significantly contributes to road accidents and fatalities. In a country like India, where long-distance travel is common, ensuring the alertness of drivers is paramount to road safety. The development of a reliable and efficient drowsiness detection system can save countless lives by alerting drivers before they reach a dangerous level of fatigue. This project focuses on creating an advanced driver drowsiness detection system using deep learning techniques,

aiming to reduce the risk of accidents caused by driver fatigue. By employing sophisticated algorithms and leveraging the power of machine learning, this system can accurately detect signs of drowsiness in drivers. The primary features monitored include eye closure, yawning, and head tilting, which are strong indicators of fatigue. The datasets used in this project comprise images of open and closed eyes, essential for training the models to recognize drowsiness. Inception v3 and CNN algorithms are chosen for their effectiveness in image classification tasks. Inception v3, with its deep architecture and efficient computation, provides a robust framework for detecting subtle changes in eye states. CNNs, known for their ability to process visual data, offer a complementary approach to enhance the detection accuracy. The integration of dlib for facial landmark detection plays a crucial role in this system. Dlib's capability to precisely identify facial features enables the accurate monitoring of eye and mouth movements. This is particularly important for detecting yawning and head tilting, which are critical signs of drowsiness. The system is implemented using Python, with Jupyter Notebook for model development and Flask for deploying the real-time application. The choice of these tools ensures a seamless development process and an efficient deployment pipeline.

## II. LITERATURE SURVEY

The literature survey highlights various advancements in drowsiness detection. In 2024, [1] K R Sumana designed an AI-Based Sleep Harness System (ASHS) to address the impact of drowsiness on productivity, safety, and well-being across different age groups. By using deep learning models, including CNN, FR-CNN, and RNN with LSTM cells, ASHS utilizes machine vision to monitor facial

features, eye movements, and head tracking for real-time drowsiness detection and corrective measures. The system aims to enhance safety in transportation, productivity at work, and educational performance, with an emphasis on monitoring sleep quality and providing timely support, especially for the elderly. Achieving high accuracy rates of 95.2% with CNN and 92.5% with RNN models, ASHS integrates batch normalization and concatenation layers for effective feature mapping, significantly enhancing safety and performance across various settings. The literature survey highlights various advancements in drowsiness detection.

In 2020,[2] With a focus on real-time applications, Hitesh Ahuja looks into the creation of a knowledge distillation technique-based driver sleepiness detection system. The study uses a comprehensive strategy incorporating both physiological (ECG, EMG, EEG) and behavioral (yawning frequency, eye blinks, facial expression analysis) approaches for sleepiness detection, drawing on the ZJU dataset for training and testing. Utilizing knowledge distillation to compress deep learning networks and enable effective real-time deployment is a key component of the methodology. Achieving a 95% accuracy rate on the ZJU dataset while drastically cutting the parameters of the VGG-16 student network is one of the noteworthy accomplishments. The high precision, real-time detection capabilities, and effective knowledge distillation implementation of the study are its main characteristics.

The literature survey highlights various advancements in drowsiness detection. In 2023, [3] Atta Rahman, To improve road safety, the presents a Deep Learning Approach to Driver Drowsiness Detection, utilizing CNN and VGG16 models for assessing driver fatigue based on eye movement. The work obtains impressive accuracy using the UTA Real-Life Drowsiness Dataset (UTA-RLDD) and a private dataset. The CNN model achieves 97% accuracy, 99% precision, recall, and F-score, while the VGG16 model achieves 74% accuracy. The suggested model divides expressions of facial tiredness into four groups and recommends possible integration with intelligent traffic and surveillance systems. The model's high precision, recall, and F1-score are highlighted by comparative analysis, demonstrating its efficacy in sleepiness detection. Despite the fact that the VGG16 model is less accurate than CNN, the study offers a strong foundation for evaluation and suggests additional developments, such as monitoring etc.

### III. PROPOSED WORK

The proposed system addresses the shortcomings of current drowsiness detection methods by incorporating multiple sleepiness signs, such as eye closure, yawning, and head tilting, into a unified framework using deep learning techniques like CNN and Inception v3. Utilizing dlib for facial landmark detection ensures accurate monitoring of crucial features, while the system's real-time operation provides timely alerts to drivers, reducing the likelihood of fatigue-related accidents. Integrated with Flask, the system is accessible and easy to deploy. To enhance safety, it offers audio alerts, on-screen text messages, and email notifications to the car owner. Users

must register and log in to use the system, which monitors drowsiness signs and provides alerts. An admin page allows administrators to log in and view information on newly registered users, ensuring the system is user-friendly and effective in improving road safety.

### IV. METHODOLOGY

The way the sleepiness detection system works is that it records video by pointing a well-placed webcam at the user's front face. The technology recognizes and examines facial features for indicators of sleepiness by processing video frames. First, a Convolutional Neural Network (CNN) and Inception v3 model are used to analyze each frame. The CNN model recognizes important face features like the lips and eyes since it was trained for facial landmark detection. Additionally, the Inception v3 model has been optimized for face detection. This approach isolates the region of interest by looking for faces in each frame. To normalize the photos, the recognized face is then transformed to grayscale and shrunk to a standard width. These markers are used to determine metrics including head position, mouth opening ratio, and eye aspect ratio (EAR). A deep learning model that forecasts the user's degree of sleepiness is fed these metrics. The system notifies the user through an alert if it detects drowsiness.

#### Users Login Module

In the drowsiness detection module, the user login system is an integral part of the methodology to ensure personalized usage. Before utilizing the drowsiness detection features, users are required to register, providing necessary credentials and personal information. Upon successful registration, users must log in each time they access the system. This login process ensures that each user's data is securely managed and that personalized settings and alerts can be appropriately configured. Additionally, the admin page facilitates the management of user registrations, allowing administrators to monitor new users. This structured approach enhances the reliability and effectiveness of the drowsiness detection system, ensuring that only authenticated users can access and benefit from its features.

#### Real-time Video Streaming Module

Within the user module, we've incorporated a feature that grants users access to live video streaming of their own driving sessions. This level of transparency fosters responsible driving behavior, as users can directly observe their actions in real time, making it an invaluable tool for enhancing road safety.

#### Face Detection Module

The drowsiness detection system employs the dlib library for face detection, identifying and tracking the driver's face within each frame, which forms the basis for subsequent analysis. The system then utilizes facial landmark detection to locate key points on the face, including the eyes, mouth, and head. This enables precise tracking and measurement of relevant features necessary for accurately assessing the driver's level of alertness and detecting signs of drowsiness.

#### Eye Closure Detection Module

The drowsiness detection system continuously monitors the driver's eyes and calculates the Eye Aspect Ratio (EAR). If the EAR falls below a certain threshold for a predefined period, it signals that the driver's eyes are closed, triggering an alert to indicate potential drowsiness. This real-time monitoring is crucial for promptly detecting when a driver is becoming drowsy and needs to be alerted. By ensuring that

drivers receive timely warnings, the system helps to prevent accidents caused by fatigue.

**Eye Aspect Ratio (EAR):** The EAR is geometric measure used to detect eye closure. The distances between particular facial markers surrounding the eyes are used to compute the EAR.

**EAR:** The EAR is calculated using the distances between the vertical and horizontal eye landmarks. A threshold value is set to detect eye closure.

Calculation:  $EAR = (A+B)/2.0 * C$

A, B=Vertical distance between eye landmarks,

C= Horizontal distance between eye landmarks.

#### Yawning Detection Module

The drowsiness detection system calculates the Mouth Aspect Ratio (MAR) to detect when the driver is yawning. If the MAR remains high for a sustained duration, it indicates a yawn, prompting an alert to warn the driver of potential drowsiness. This real-time detection helps ensure drivers remain attentive by providing timely warnings when signs of fatigue are detected. By addressing yawning, the system contributes to preventing accidents caused by driver drowsiness.

**Mouth Aspect Ratio (MAR):** The MAR is geometric measure used to detect yawning. The distances between particular facial markers surrounding the mouth are used to compute the MAR.

**MAR:** The MAR is calculated using the distances between the vertical mouth landmarks. A higher MAR value indicates yawning.

Calculation:  $MAR = (A+B)/2.0 * C$

A, B=Vertical distance between mouth landmarks. C= Horizontal distance between mouth landmarks.

#### Head Tilting Detection module

The drowsiness detection system uses dlib's pose estimation to track the driver's head movements. If the system detects persistent head tilting beyond a specific angle, it signals potential drowsiness and triggers an alert. This real-time monitoring of head position is essential for identifying signs of fatigue, ensuring that drivers receive timely warnings. By addressing head tilting, the system helps prevent accidents caused by drowsiness.

//Pseudo Code

1. Take a function for head binding
 

```
def get_head_pose(shape, frame):
```
2. Starts the creation of a NumPy array to store 2D points from the image.
 

```
image_points = np.array([
    shape[30], # coordinates of the nose tip
    shape[8], # coordinates of the chin.
    shape[36], # coordinates of left eye's left corner.
    shape[45], # coordinates Right eye right corner
    shape[48], # coordinates of left mouth corner.
    shape[54] # coordinates of right mouth corner.
], dtype="double")
```
3. Starts the creation of a NumPy array to store the corresponding 3D model points.
4. model\_points = np.array([
 

```
(0.0, 0.0, 0.0), # 3D coordinates for nose tip
      (0.0, -330.0, -65.0), # 3D coordinates for chin
      (-225.0, 170.0, -135.0), 3D coordinates of left eye's left corner.
      (225.0, 170.0, -135.0), # coordinates for the right eye's right corner.
```

(-150.0, -150.0, -125.0), # coordinates for left mouth corner.  
(150.0, -150.0, -125.0) # coordinates for right mouth corner  
)

In the Head binding module we have taken co-ordinates of chin, left mouth, right mouth, left eye, right eye, nose tip.

#### Alert Module

The drowsiness detection system's decision-making component evaluates the calculated metrics, such as EAR, MAR, and head tilt, against established thresholds. If these metrics exceed the thresholds, indicating possible drowsiness, the system triggers an alert. This evaluation process ensures that potential signs of fatigue are promptly identified, providing timely warnings to the driver.

#### Architecture of the system

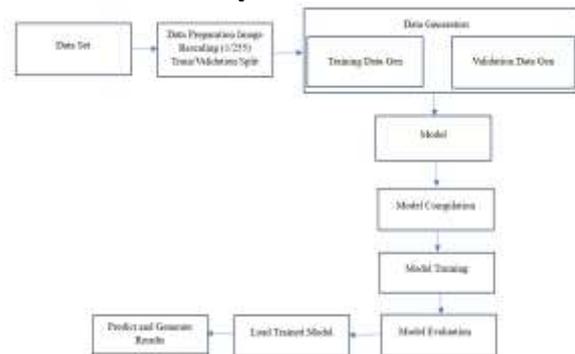


Fig. 1 System Architecture

The system allows user to register and login. After login, system opens a web camera where it monitors user behaviour and send the alerts as soon as it detects drowsy behaviour of user.

#### V. RESULT ANALYSIS

The system's findings and strategies for addressing drowsiness detection focus on several key modules. Firstly, the user registration module enables users to sign up and log in. Upon logging in, the system uses OpenCV to capture live video, and the Dlib library to detect facial features such as eyes and mouth. By analyzing these facial landmarks, the system determines drowsiness based on specific threshold values: if the eye aspect ratio falls below the threshold, an alert is triggered; similarly, if the mouth aspect ratio exceeds the threshold or if excessive head binding is detected, alerts are also activated. Alerts are delivered in three forms: on-screen text, audio alerts, and email notifications. Additionally, the admin module allows administrators to view all user information, ensuring comprehensive monitoring and management.



Fig.2 Eye closure and Head binding detection



Fig. 3 yawning and Eye closure detection



Fig. 4 Not drowsy and email messages

The results in the figure includes eye closure detection, head binding detection yawning detection, not drowsy state and email message alerts. In Fig.2, the left image shows a person feeling drowsy with closed eyes, prompting an on-screen alert message. The right image depicts a drowsy individual with their head bent, triggering a head bend alert. Fig. 3 features a person on the left who is drowsy and yawning, with a yawning alert message displayed. The right image shows another drowsy individual with closed eyes, resulting in an alert message on the screen. Fig. 4 displays a person on the left who is not drowsy, hence no alert message is shown. The right image illustrates email notifications sent after detecting drowsiness. When drowsiness is detected, the system issues a visual alert on-screen, an audio alert, and sends an email notification to ensure the driver is adequately informed.

## VI. CONCLUSION

The "Driver Drowsiness Detection Using Deep Learning" project aims to enhance road safety by providing a reliable, non-intrusive system to detect driver fatigue. Leveraging advanced deep learning techniques and computer vision algorithms, the system identifies signs of drowsiness, such as eye closure, yawning, and head tilting, providing timely alerts to drivers. Integrating CNNs, Inception v3 and dlib for facial landmark detection, the project demonstrated reliability and high accuracy of 96% for CNN algorithm and 98% for Inception v3 Algorithm. Extensive testing validated the system's performance, ensuring it meets high standards of quality and security. This practical solution for real-time drowsiness detection has the potential to significantly reduce accidents caused by driver fatigue, thereby saving lives.

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