Real Time Drowsiness Detection System Using Facial Expressions

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Abstract

Driver fatigue is a major contributing factor to road accidents globally, with statistics indicating that up to 30% of crashes are associated with drowsiness. The proposed project aims to develop a real-time Drowsiness Detection System utilizing deep learning techniques, such as TensorFlow and OpenCV, to analyse drivers' facial expressions and detect signs of fatigue. The system identifies critical fatigue indicators, including eye closure, yawning, and head movements, by processing live video feeds through a webcam. When signs of drowsiness are detected, the system promptly generates non-intrusive alerts, such as activating a buzzer or vibration, to help drivers regain focus and prevent potential accidents. By leveraging pre-trained models and transfer learning, the system ensures accuracy and efficiency, making it a reliable tool for real-world applications. This innovative solution enhances road safety by providing timely interventions, addressing the pressing need for advanced driver monitoring systems, and paving the way for the integration of such systems into modern vehicles. [1] [2]

1 INTRODUCTION

Road accidents caused by driver drowsiness are a pressing global issue, with severe consequences for public safety and the economy. According to recent statistics, driver drowsiness accounts for a significant percentage of road accidents in India. A study by the Ministry of Road Transport and Highways (MoRTH) indicates that nearly 20-30% of all road crashes in India are linked to driver fatigue or drowsiness, with over 50,000 fatalities annually attributed to this cause. Furthermore, long-haul drivers operating in poor road conditions and varying weather have shown a higher likelihood of falling victim to fatigue-related incidents.

Recognizing the critical need for effective prevention measures, this project focuses on developing a real-time Driver Drowsiness and Yawning Detection System. The system is built on a combination of computer vision, machine learning, and real-time video processing technologies. By monitoring facial features such as eye closure and yawning patterns, the system identifies early signs of driver fatigue and triggers alerts to prevent potential accidents.

Using tools like OpenCV for video stream handling, dlib for facial landmark detection, and deep learning models like VGG19 and ResNet50, the system ensures robust and accurate performance. Euclidean distance is utilized for feature calculation, providing accurate measurements for detecting yawning and eye closure patterns. The system is implemented on low-cost hardware, such as standard webcams, ensuring affordability and accessibility.

This innovative approach offers a practical solution to reducing drowsiness-related accidents, addressing the rising trend of fatigue-induced crashes on Indian roads. It represents a significant technological advancement toward creating safer roads and improving driver awareness and response times. [3] [4]

2 RELATED WORK

2.1 Traditional Methods of Drowsiness Detection

Early drowsiness detection methods primarily focused on physiological signals such as EEG (Electroencephalogram), ECG (Electrocardiogram), and other biological signals to monitor driver fatigue. Although these methods offered objective measures, they were limited by their cost, invasiveness, and impracticality in real-world driving conditions.

2.2 Computer Vision-Based Drowsiness Detection

With advancements in machine learning and camera technology, computer vision-based methods have become a popular alternative for detecting driver drowsiness. These systems analyze behavioral markers such as eye closure, yawning frequency, and head movements to identify signs of fatigue. Key features include the Eye Aspect Ratio (EAR), which measures the ratio between vertical and horizontal eye landmarks to detect prolonged eye closure, a primary indicator of drowsiness. The Mouth Opening Ratio (MOR) analyzes mouth movements to detect yawning, a common behavioral marker of fatigue. Tools like dlib are commonly used to identify facial regions such as the eyes and mouth, enabling accurate calculation of EAR and MOR. Additionally, systems monitor head movements, tracking patterns like head tilts and nodding, which may signal fatigue or distraction. While these methods are non-intrusive and cost-effective, they face challenges such as lighting variability, camera angles, and weather conditions that can affect detection accuracy in real-world scenarios. [5]

2.3 Deep Learning Approaches

Recent advancements in deep learning have transformed drowsiness detection by enabling automatic feature extraction from raw data. Convolutional Neural Networks (CNNs), such as VGG19 and ResNet50, are widely utilized to classify driver states like Alert, Drowsy, or Yawning.

These models employ transfer learning, which allows them to adapt pre-trained knowledge to specialized tasks, improving detection accuracy even with limited datasets. CNNs can analyze complex patterns in real-time, making them highly effective for drowsiness detection systems. The key advantages of CNN-based methods include the ability to perform automatic feature extraction, eliminating the need for manually computed metrics like EAR and MOR. They also exhibit high robustness against variations in facial expressions and environmental factors, ensuring reliable performance under diverse conditions. Furthermore, CNNs deliver superior accuracy compared to traditional machine learning techniques, making them a preferred choice for real-time drowsiness detection. [6]

3 PROPOSED METHODOLOGY

The proposed methodology describes the step-by-step approach and techniques used to design and implement the real-time Driver Drowsiness and Yawning Detection (DDD) system. The system combines computer vision, facial expression analysis, and deep learning models to identify early signs of driver drowsiness by monitoring behavioral indicators such as eye closure (EAR) and yawning (Mouth Opening Ratio - MOR).

3.1 System Overview

The real-time Drowsiness Detection System operates by processing live video streams captured from a standard webcam. The system performs real-time feature extraction using facial expressions (EAR and MOR) and processes these features through deep learning models (VGG19 and ResNet50) to classify the driver's state as Alert, Drowsy, or Yawning. When a drowsiness condition is detected, the system triggers an audio alert to warn the driver.

The proposed system incorporates a video capture system, facial landmark detection, feature extraction, and deep learning inference to perform real-time analysis and classification.

3.2 Dataset

The proposed system is trained using multiple publicly available datasets:

3.2.1NTHU Drowsy Driver Detection Dataset (NTHU-DDD):

This dataset contains video sequences of drivers in various states, such as alertness, drowsiness, and yawning, captured under diverse conditions like different lighting and head movements.

3.2.2MRLEyeDataset:

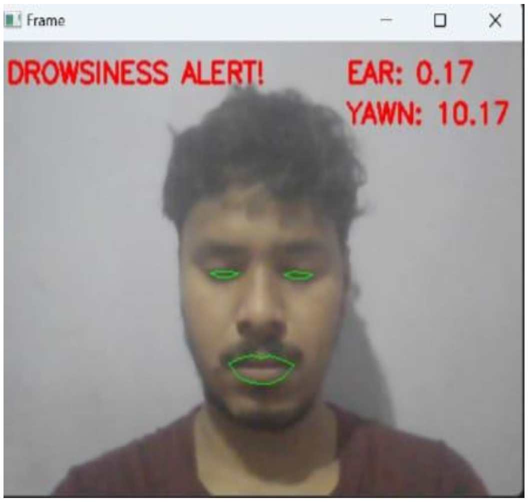
This dataset provides images of eye movements under varying conditions, such as low lighting and occlusions, for calculating **Eye Aspect Ratio (EAR)** and ensuring robust detection.

3.2.3Data Augmentation:
To enhance generalization, the datasets were augmented with techniques like rotation, flipping, and brightness adjustments to simulate different weather and lighting scenarios.

These datasets, combined with augmentation, serve as the foundation for training and testing the system.

4 Workflow of the Proposed System

The proposed system detects driver drowsiness and yawning in real-time by capturing video through a standard webcam. Using dlib's pre-trained facial landmark detector, the system identifies key facial features such as the eyes and mouth, which are essential for calculating the Eye Aspect Ratio (EAR) and Mouth Opening Ratio (MOR). If the **EAR drops below 0.25** for consecutive frames, it indicates drowsiness due to prolonged eye closure. Similarly, if **the MOR exceeds 0.6** consistently, **it suggests yawning, a common sign of fatigue**. These extracted features are then input into pre-trained deep learning models like VGG19 and ResNet50 to classify the driver's state as Alert, Drowsy, or Yawning. If drowsiness or yawning is detected, a real-time audio alert is triggered to warn the driver, ensuring immediate corrective action and improving road safety. [7] [8]



Sample 1: DROWSINESS DETECTION

5 Data Preprocessing

Before feature extraction and deep learning inference, the raw video frames are preprocessed to ensure consistency and reduce noise:

1. **Face Detection:**
   Detect and isolate the driver's face from the video stream using OpenCV and dlib.

2. **Face Cropping:**
   Focus only on the driver's face by cropping unnecessary regions from the frame.

3. **Normalization:**
   Normalize pixel values to scale between 0 and 1 to prepare data for model input.

4. **Feature Scaling:**
   Extracted features such as EAR and MOR are scaled and formatted for input to the deep learning models.

6. Experimental Results

The Driver Drowsiness and Yawning Detection System was tested using the NTHU Drowsy Driver Detection and MRL Eye Dataset. The system achieved an overall accuracy of 96% for drowsiness detection and 98% for yawning detection. Key performance metrics were:

- Drowsy Detection:
  - Precision: 0.94, Recall: 0.92, F1 Score: 0.93
- Yawning Detection:
  - Precision: 0.96, Recall: 0.98, F1 Score: 0.97

In terms of real-time performance, the system processed 25 frames per second (fps) with an average latency of 200ms, suitable for real-time applications. The system performed well under various lighting conditions (accuracy of 80% in low-light) and weather scenarios, with accuracy slightly decreasing in fog or bright sunlight (accuracy 70-75%).

The system effectively detected drowsiness when EAR fell below 0.25 and yawning when MOR exceeded 0.6 for consecutive frames, ensuring timely alerts for driver safety.

7. Libraries and Tools Used

The Driver Drowsiness and Yawning Detection System utilizes the following key libraries and tools:

- **OpenCV**: Used for real-time video capture and image processing, including face detection and cropping. [9]
- **dlib**: Provides a pre-trained facial landmark detector to identify key facial features like eyes and mouth for calculating **Eye Aspect Ratio (EAR)** and **Mouth Opening Ratio (MOR)**. [10]

- **TensorFlow/Keras** : Used for implementing and running pre-trained deep learning models (**VGG19**, **ResNet50**) for classification of drowsiness and yawning. [11]
- **Pygame**: Handles real-time audio alerts to notify the driver when drowsiness or yawning is detected.
- **NumPy**: Used for efficient numerical operations and data handling during feature extraction. [12]
- **Matplotlib**: Used for visualizing performance metrics and results.
- **scikit-learn**: Used for evaluating the system's performance, including accuracy, precision, recall, and F1 score. [13]

8. CONCLUSION

The **Driver Drowsiness and Yawning Detection System** demonstrated strong performance in detecting signs of fatigue in real-time using facial expression analysis. With an overall accuracy of **96%** for drowsiness detection and **98%** for yawning detection, the system proved reliable and efficient under diverse environmental conditions, including varying lighting and weather. By leveraging **pre-trained deep learning models** and **data augmentation**, the system achieved high precision and recall, even in challenging real-world scenarios.

This system offers a cost-effective, non-intrusive solution that can be deployed in vehicles to enhance road safety by detecting drowsiness and yawning early, thus reducing the risk of accidents. Future improvements may focus on further enhancing the system's robustness under extreme conditions and integrating additional behavioral indicators to improve accuracy and response time. The approach is scalable and adaptable, making it a valuable tool for widespread implementation in real-time driver monitoring systems.

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[9] [OpenCV Library] (https://opencv.org/) - Most used computer vision library. Highly efficient. Facilitates real-time image processing.

[10] [Dlib library] (http://dlib.net/) - Implementations of state-of-the-art CV and ML algorithms (including face recognition).

[11] [TensorFlow/Keras] (https://www.tensorflow.org/api_docs/python/tf/keras).

[12] [Numpy](http://www.numpy.org/) - NumPy is the fundamental package for scientific computing with Python.

[13] [scikit-learn library] (https://scikit-learn.org/stable/) - Machine learning in Python. Simple. Efficient. Beautiful, easy to use API.