

A Computer Vision Based Approach for Real-Time Drowsiness Detection Using Eye Aspect Ratio Analysis

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ABSTRACT

Drowsiness can cause significant problems in conducting tasks that require ultimate attention like driving or operating heavy machines. It is important to detect the symptoms timely in order to ensure safety as it might lead to accident. The study revolves around introduction of a new method to identify drowsiness by analysing the eye aspect ratio (EAR) using computer vision technique. EAR measures eye openness by calculating distance between facial landmarks like the corners of the eyes and nose. As drowsiness sets in, eye lids sloop, causing EAR to drop this system uses pre trained deep learning models for real time landmark detection and ear calculation. EAR changes over time are tracked with a rolling window technique to detect drowsiness. Built with Python, open CV and Dlib, the system process accurately and quickly with minimal false alarms. It has been tested on various data sets and is effective in applications like transport, healthcare where alertness is of prime importance. Future improvement will involve adapting to different environment and integrating additional sensors for better accuracy. This approach helps preventing accidents caused by drowsiness.

Keywords: EAR Analysis, Python, Open CV, CNN, Drowsiness Detection

1. Introduction

Drowsiness which results in reduced alertness and impaired cognitive functions can seriously affect a person's ability to perform tasks that require focus and attention. When a person is engaged in activities like driving, operating heavy machinery or managing critical systems drowsiness can be extremely dangerous leading to accidents, injuries and even fatalities. NHTSA has reported that drowsy driving alone causes a significant number of deaths and accidents each year emphasizing on the need for detecting and preventing drowsiness. Traditional method of detecting drowsiness have focused on measuring psychological signals such as brain activity through EEG or observing behavioural science like steering wheel movements or lane drifting. However, these approaches often require invasive sensors and are not practical for real time monitoring in everyday situations.

In recent years computer vision has emerged as a promising alternative for detecting drowsiness. Computer vision is a branch of artificial intelligence and computer science that enables machines to interpret and understand visual information from the world around them. It includes tasks such as image recognition, object detection, facial recognition and scene analysis. By allowing computers to "see" and process visual data, computer vision system can replicate and even enhance human visual perception providing valuable solutions in many fields. At the core of computers vision is the analysis of digital images or video streams captured by cameras and similar devices. These images are made up of numerical values representing pixel intensities which are then processes by algorithms to extract meaningful information. Key task in computer vision include image pre-processing, feature extraction, object segmentation, and pattern recognition. One of the biggest challenges in the field is extracting useful pattern from visual data, which involves detecting and identifying objects, images, shapes, edges, textures and other important visual details.

To address this challenge a range of methods have been developed from traditional image processing technique to more advanced deep learning techniques .in particular deep learning and CNN have



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transformed the field of computer vision. CNNs can automatically learn to recognize pattern in images from raw pixel data achieving impressive results in tasks like image classification and object detection with minimal human input. In the case of drowsiness detection, computer vision offers an effective way to monitor facial features especially eye movements and expressions to detect signs of fatigue. by analysing visual cues such as EAR computer vision systems can issue timely alerts and take preventive, measures to reduce the risk of accidents and improve safety in various situations. This study explores the use of computer vision to develop a drowsiness detection system based on EAR analysis demonstrating the potential of visual data processing to address real world challenges related to human behaviour monitoring and safety.

2. Literature Review

Drowsiness detection plays a crucial role in ensuring safety across various industries leading to significant research into effective methods one common approach uses computer vision to analyze facial features especially eye movements and expressions to detect the signs of drowsiness. Earlier studies introduced real time methods for detecting eye blinks based on facial landmarks which served as a foundation for further research in this area. For example, a system was designed to detect driver drowsiness by analyzing eye blinks pattern from in vehicle video streams advancing the field further. More recently a real time drowsiness detection system has been developed that combined facial landmarks with machine learning algorithms. This system has the accuracy of distinguishing normal blinks from those caused by drowsiness. The integration of computer vision with machine learning in these systems represents a promising direction for drowsiness detection. In addition to this, researchers have also explored using EEG signals combined with deep learning showcasing the potential of combining different types of data for a more comprehensive approach to detecting drowsiness. More recent advancements have expanded the use of drowsiness detection system to areas such as health care. For instance, a real time detection system has been developed for IOT based healthcare application systems demonstrating the flexibility and adaptability of computers vision technologies. Additionally, a system using CNNs and eye tracking has been shown to effectively detect drowsiness particularly in automative safety application incorporating multiple sensing modalities; the fusion of visual and thermal imaging for robust drowsiness detection was explored showcasing the potential for enhanced accuracy and reliability. Further, a real-time drowsiness detection approach utilizing 3D facial landmarks and recurrent neural networks (RNNs), highlighted the continuous innovation in this field. A cumulative study for recent years for drowsiness detection is carried out and is listed in table 1 stating the key findings of the work done, methodologies used, pro and cons of the study with its applications.

Table 1: *A cumulative study for drowsiness detection*

Author & Year	Methodology	Techniques Used	Key findings of the work	Pros	Cons	Application
Rajasekaran, Rajkumar, et al., 2024 [1]	Images of drivers' eyes were collected. Images were processed to detect eye regions. Eye Aspect Ratio was calculated. Eye state was analyzed using CNN. Drowsiness was classified.	-	High Accuracy Real-Time Detection Robustness	Improved Safety Real-Time Detection High Accuracy	Data Limitations Computational Requirement Variability	Automotive Industry Transportation Safety Fatigue Monitoring
Minhas, Riaz, et al., 2024 [2]	EEG and visual data were collected from drivers with OSA. Features were extracted from EEG and visual data. Patterns were analyzed to detect drowsiness.	-	Improved Accuracy OSA-Specific Detection Real-Time Detection	Enhanced Accuracy OSA-Specific Solution Real-Time Detection	Complexity Equipment Requirement Individual Variability	Automotive Industry Transportation Safety Healthcare

Fu, Biying, et al. , 2024 [3]	Existing studies on drowsiness detection were reviewed. Methods were classified into physiological, behavioral, and hybrid approaches.	-	Multimodal Approaches Deep Learning Real-Time Detection	Comprehensive Overview Modern Application Future Directions	Rapidly Evolving Field Complexity	Automotive Industry Transportation Safety Healthcare
Lian, Zequan, et al. , 2024 [4]	EEG and eye tracking data were collected from drivers. Features were extracted from EEG and eye tracking data. Fatigue was classified using machine learning algorithms.	Electroencephalography (EEG) Eye Tracking Machine Learning Algorithms Feature Extraction	High Accuracy Improved Robustness Real-Time Detection	High Accuracy Robustness Fatigue is detected in real-time	Equipment Requirement Complexity Calibration	Automotive Industry Transportation Safety Healthcare
Safarov, Furkat, et al. , 2023 [5]	Video data of drivers' faces were collected. Face detection and eye localization. Eye-blink patterns were analyzed. Convolutional Neural Network (CNN) was used for classification.	Computer Vision Eye-Blink Analysis Deep Learning (CNN) Real-Time Processing	High Accuracy Real-Time Detection Robustness	High Accuracy Real-Time Detection Non-Intrusive	Data Quality Computational Requirement Variability	Automotive Industry Transportation Safety Fatigue Monitoring
Suhendra, Agung, et al. , 2023 [6]	Images of drivers' eyes were collected. Images were processed to detect eye regions. EAR was calculated and adapted to individual variations.	Eye Aspect Ratio (EAR) Adaptive Algorithm Real-Time Processing Computer Vision	Improved Accuracy Robustness Real-Time Detection	High Accuracy Real-Time Detection Adaptive	Data Quality Computational Requirement	Automotive Industry Transportation Safety Fatigue Monitoring
Khadki kar, Prajakta , et al. , 2023 [7]	Existing studies on drowsiness detection were reviewed. Techniques were classified into physiological, behavioral, and hybrid approaches.	Physiological Signals (EEG, EOG, HRV) Behavioral Signals Hybrid Approaches	Hybrid Approaches Deep Learning Real-Time Detection	Comprehensive Overview Comparative Analysis Future Directions	Rapidly Evolving Field Complexity	Automotive Industry Transportation Safety Healthcare
Youwei, Lu , 2023 [8]	Detected facial landmarks using a pre-trained model. Extracted eye-related landmarks. Detected eye blinks based on landmark movement.	Facial Landmark Detection Eye Landmark Extraction Real-Time Processing Computer Vision	High Accuracy Real-Time Detection Robustness	High Accuracy Real-Time Detection Non-Intrusive	Data Quality Computational Requirement	Drowsiness Detection Fatigue Monitoring Human-Computer Interaction
Hossain et.al, 2023 [9]	Detected driver's face using Haar cascade classifier. Detected eyes using circular Hough transform. Calculated EAR to detect drowsiness. Triggered alert when drowsiness was detected.	Image Processing Face Detection Eye Detection Eye Aspect Ratio (EAR) Calculation Real-Time Processing	High Accuracy Real-Time Detection Robustness:	High Accuracy Real-Time Detection Non-Intrusive	Data Quality Computational Requirement	Automotive Industry Transportation Safety Fatigue Monitoring
Florez,	Collected images of drivers'	Convolutional Neural	High	High Accuracy	Data Quality	Automotive

Ruben, et al. , 2023 [10]	eyes. Preprocessed images for CNN input. Trained a CNN model for eye state classification. Detected eye state in real-time.	Network (CNN) Computer Vision Real-Time Processing Eye State Classification	Accuracy Real-Time Detection Robustness	Real-Time Detection Non-Intrusive	Computational Requirement	Industry Transportation Safety Fatigue Monitoring
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3. Proposed Methodology

This section delineates a method for detecting driver drowsiness employing a two-step approach. The system is tailored to function on Android devices integrated into vehicles. Initially, it captures real-time images using the device's camera, transmitting them to a local server. At the server's end, the Dlib library is employed to identify facial landmarks, facilitating the assessment of whether the driver exhibits signs of drowsiness based on a predefined threshold. These facial landmarks are then utilized to compute the Eye Aspect Ratio (EAR), which is subsequently communicated back to the driver. In this setup, the received EAR value is compared to a predetermined threshold value, typically set at 0.25. A value below this threshold signifies potential fatigue. In such instances, an alarm is activated to alert both the driver and passengers. Subsequent sections elaborate on the operational intricacies of each module, as illustrated in the Methodology Flowchart, Figure 1.

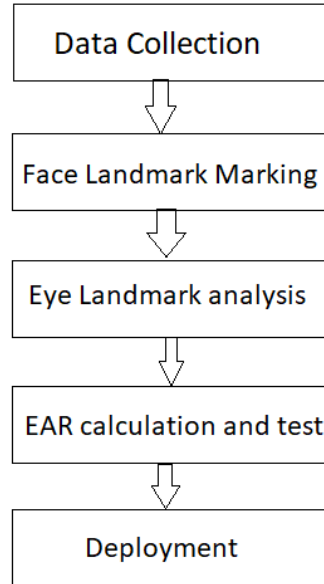


Figure 1: Methodology Flowchart

3.1 Data Calculation

To use the application, the driver undergoes a registration process, particularly if it's their initial use. Following registration, the driver inputs the origin and destination for the ride. Similarly, passengers have an interface through which they can connect with the ride initiated by the driver. Once the ride commences, the application continuously captures real-time images of the driver, with images taken each time the server responds. This process continues until the ride concludes. To assess the method's effectiveness, a dataset comprising 50 volunteers was compiled. Each participant was instructed to intermittently blink while facing the camera, allowing for the capture of EAR values. The recorded results from the application logs were then gathered and subjected to analysis using machine learning classifiers.

$$EAR = \frac{(|p2 - p6| + |p3 - 5|)}{2 * |p1 - p4|}$$

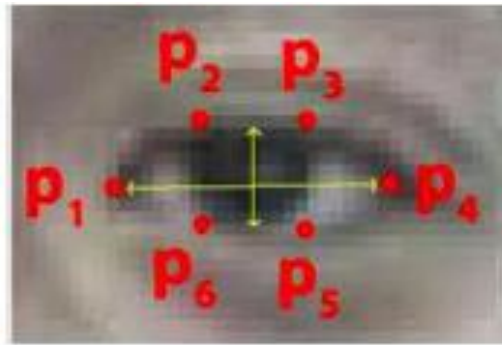


Figure 2 : Eye Landmark Points

3.2 Facial Landmark Marking

For facial landmark extraction, the application integrates the Dlib library, which utilizes a pre-trained face detector based on a modified histogram of oriented gradients and linear SVM method for object detection. Following this, the actual facial landmark predictor is initialized, and the captured facial landmarks are employed to determine inter-landmark distances. These distances are then utilized to calculate the Eye Aspect Ratio (EAR) value, defined as the ratio of the eye's height to its width. The EAR values of the left and right eyes are computed and averaged. In the context of drowsiness detection, monitoring the Eye Aspect Ratio helps identify instances where the value drops below a predefined threshold and does not subsequently rise above it in the following frame, indicating eye closure due to drowsiness. Figure 2 depicts the eye landmark points considered for carrying out the result. Then, figure 3 depicts a snapshot of facial landmark points obtained using the Dlib library, essential for EAR computation.



Figure 3 : Facial Landmark Points according to Dlib library

The specific facial landmark points used for calculation for both the eyes are enumerated in Table 2.

Table 2 : Facial Landmarks

Part	Landmark Points
Left Eye	[37-42]
Right Eye	[43-48]

3.3 Classification:

After obtaining facial landmark points, the server computes the EAR value, which is then transmitted to the driver's Android device for comparison against the predetermined threshold value. Should the value fall below the threshold, a counter is incremented; otherwise, it resets. Once this counter reaches three, an alarm activates on the Android device. Additionally, a "Sleep Counter" monitors instances where the EAR value dips below the threshold, while a "Total Counter" records all server responses. These counters facilitate the calculation of the Eye Closure Ratio (ECR), defined as the ratio of the "Sleep Counter" to the

"Total Counter". ECR calculation occurs every 15 consecutive frames, with counters resetting after the 16th frame. If the ECR surpasses a predefined threshold (typically 0.5), indicating a high likelihood of drowsiness, a notification is triggered within the Android application to alert the driver.

$$EAR = \frac{SLEEP\ COUNTER}{TOTAL\ COUNTER}$$

When referencing the equation, the numerator computes the vertical distance between the upper and lower eyelids, while the denominator represents the horizontal span of the eye.

In this drowsiness detection system EAR has been used to monitor the Driver’s alertness level. The EAR value increases when the eye opens as the distance between the eyelids become larger and decreases when the eye closed as the distance between the eye lids reduces. To check the drowsiness, the author checks the EAR for each eye and then takes the average. Then tracks the EAR value to check if it falls below a threshold and if it stays below the threshold in the next frame it suggest that the eyes are closed and the driver may be drowsy. If the EAR value goes back up it indicate a blink rather than drowsiness..

4. Result

This section presents an evaluation of the proposed drowsiness detection system through real time testing with live video streams the system performance was assessed under various conditions including subjects with open and closed eye and those wearing glasses or not. The results confirm that the system accurately detects drowsiness and timely alerts. Its fast response time ,high user satisfaction and strong performance highlights its potential to improve safety in critical situations by reducing the risk associated with drowsy behaviour.

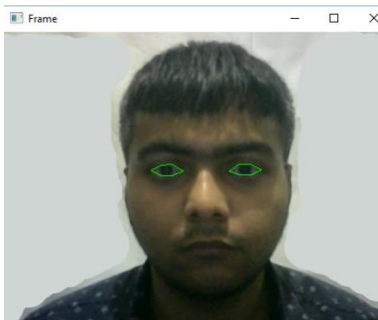


Figure 4 : Open eyes without specs



Figure 6 : Open eyes with specs

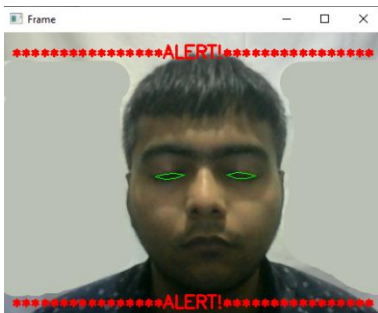


Figure 5 : Closed eyes without specs

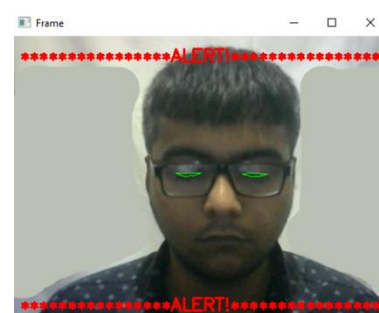


Figure7 : Closed eyes with specs

The results are summarized in four different cases. Case 1 shown in figure 4 illustrated the landmark for open eyes without glasses. Case 2 shown in figure 5 shows the landmark for closed eyes without glasses. Case 3 shown in figure 6 shows landmark for open eyes with glasses and case 4 shown in figure 7 shows landmark for closed eyes with glasses.

5. Conclusion

This study proposed a real time system designed to detect and track driver distraction in vehicles. To reduce the distractions caused by sensors attached to the drivers body the system relies son facial landmarks to locate the driver’s face .to detect the driver fatigue in real time it uses adaptive thresholding along with EAR and ECR. This technology is particularly useful for drivers with demanding jobs or long commutes as these

conditions increase the risk of accidents due to tiredness. The author has tested suggested approach on a range of datasets in a variety of scenarios. The author employed machine learning techniques to classify data and achieved 84% accuracy with a random forest classifier. It is noted that with increase in accuracy, the ambient brightness increases. Potential avenues for future study could entail incorporating the provided system with popular services like Ola and Uber, which could potentially lower the number of accidents and injuries caused by sleepy drivers. To evaluate this integration's efficacy in various circumstances, it might be tested in several geographical locations. Additionally, the author proposes to broaden the scope of proposed methodology that include additional user groups, including cyclists, and investigate applications in other industries, such as aviation and railroads.

Declarations

Competing Interests

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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