Euclidean Distance Analysis to Detect Eye Movements for Accident Prevention using Face Mapping and Computer Vision

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Abstract— **Increase in road accidents lately is a predicament to irregular sleep patterns. Sleepy drivers pose a risk not only to themselves but also to others around them. Hence anti-sleep mechanisms for vehicles are the need of the hour. These mechanisms are one of the essential features to prevent micro sleep and should be accommodated in all vehicles to ensure road safety. The proposed paper thus highlights one such system that uses face mapping and Computer Vision to identify the facial features of the driver and hence generate an alert whenever fatigue is detected. In the scope of this research, Euclidean distance is calculated for both eyes between the eyelids to identify if the eyes are closed or not. Once closed eyes are detected, audio and textual alerts are generated to draw the driver's attention. According to this research, once sleepiness is detected audio alerts initiated at regular time intervals show the best results to ensure road safety.**

Index Terms— sleep, computer vision, alert system, accident prevention, face detection.

I. INTRODUCTION

Sleep deprivation and fatigue can be triggered by a variety of reasons including long working hours, the effect of medication, insomnia, exam stress, and even watching a movie all night long. According to recent surveys by The Times of India newspaper, 57% of Indian citizens stay up late at night to deal with their daily tasks and commitments. However staying up late at night comes with its own consequences, namely fatigue, and lethargy. An adult body requires at least 7 hours of sleep on a regular basis, anything less than this falls in the category of sleep deprivation. Sleep deprivation not only leads to mental and emotional stress but also to physical lethargy. One's body tends to shut down to re-energize and recharge after prolonged hours without sleep. This shutting down of the body is spontaneous and non-voluntary and hence can turn actions like driving a car into a challenge. A sleepy driver is not only of fatal damage to himself but also to others around him.

Many car accidents are caused by sleep deprivation because tired drivers are unable to make quick decisions. Drowsiness and exhaustion are common causes of serious or deadly accidents because they slow down the body, making it difficult to accomplish jobs that call for concentration, like driving. The scope of this research provides a constructive solution for the problems aforementioned. The paper describes an anti-sleep mechanism to alert drivers when they feel sleepy. This mechanism not only aims at keeping drivers awake at the wheel but also to protect against any damage to life and property.

The algorithm proposed in the scope of this paper uses a front-mounted camera to generate a stream of images of the driver's face and then feeds them to a python module called face-utils which then detects the facial features. Out of these features, eyes hold the most significance to the proposed paper. The boundaries of the eyes are then detected using computer vision and the Euclidean distance between both eyelids is hence calculated. The analysis of this Euclidean distance on an instantaneous basis helps to detect when the driver is sleepy. Once found sleepy the algorithm issues an alert in both visual and audio manners. This entire process was checked in different experimental setups to find maximum accuracy. The scope of this research further extends to the probability of accident avoidance and alerting emergency contacts to check on the driver. This in turn can be achieved by applying the concepts of computer networks to the current system.

The present article is structured as:

- Section I is introduction,
- Section II is literature review.
- Section III illustrates the methodology.
- Section IV describes results and discussion.
- Section V summarizes the conclusions and gives ideas for future work.

II. LITERATURE REVIEW

Making a driver's sleepiness detection system, work in real-time in an embedded system is a challenging task; in the meantime, issues such as the driver's head tilt and an inadequately sized eye image remain.[1] Fouzia et al propose a system where the form predictor algorithm is the foundation of the mechanism. It offers a non-intrusive method for alertness monitoring. In the future, a criterion to measure drowsiness could be the frequency of yawning according to this research.[2]

The technology proposed by Hardeep Singh et al monitors eye movement to identify fatigue. A camera is used to detect eye movement. This is done in order to identify the signs of weariness. Its foundation is the idea of eye tracking [3]

The primary goal of the study conducted by Lorraine Saju et al is to provide a software tool for fatigue state detection. It was discovered to be a practical and precise method. Here, a camera provides the input, a Raspberry Pi module processes it, and an output that warns the user as and when drowsiness is identified is issued.[4]

The tracking of the driver's face, the driver's level of exhaustion, and the identification of important facial regions based on yawning are the primary components that should be taken into account for analysis.[5] The tracking of drivers' steering wheel movements (SWM), for instance, achieved a respectable level of accuracy.[6] Researchers of [7][8] also tracked driver's face and eye features using cameras and computer vision methods to identify signs of driving fatigue.

III. METHODOLOGY

Driving is an essential life skill but it comes with its own risks. The risk of micro-sleeping while driving is one of these. Drivers who are sleep deprived or fatigued, present a risk not just to themselves but also to those around them. So, in such situations, safety precautions are essential. Anti-sleep mechanisms can therefore address this issue. These systems can guard against microsleep and guarantee safe driving. One such mechanism is discussed in the scope of this paper.

Hardware and Software Requirements

The research was done on a system with the following specifications: Processor - 2 GHz Quad-Core Intel i5 and Memory - 16 GB RAM & 512 GB storage. The model was constructed on Jupyter Notebook with Python version 3.8.2. The libraries used were OpenCV, imutils, playsound, dlib, SciPy, and gTTS(Google Text-to-Speech) in Python programming language.

Flow Diagram

The following illustration illustrates the functioning of the system that has been suggested and put into practice in this study. This flow representation showcases each of the stages encompassed in the operation of this mechanism.

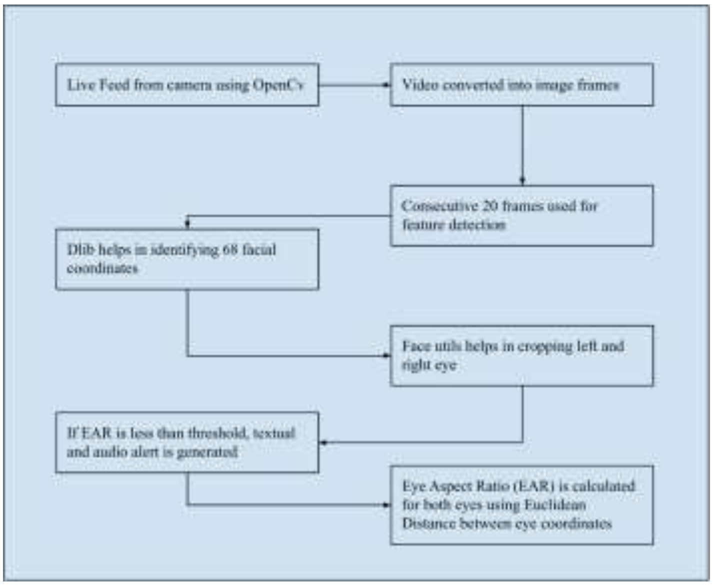

Fig 3.1 The Flow Diagram

The model has five parts working together to identify sleepy drivers. The parts being:

Extracting Data - In the context of this research, the required data was taken in real-time through a camera placed facing the driver with the help of OpenCV[9] python. OpenCV is an open-source library that caters to problems related to Computer Vision and helps in grayscaling images and extracting objects from them. The system takes live video of the driver, which further divides into image frames. These image frames undergo segmentation for facial feature detection to identify sleepiness in the driver.

Face and Feature Boundary Detection - The dlib library detects the face of the driver from the input image frames and estimates the location of the 68 facial coordinates(x,y). These coordinates help in identifying the facial features of a person. Further, the face_utils library crops the left and right eye post-detection by dlib[10]. The left and right eye are the norm for identifying sleepiness in drivers. Hence, this step separates the eyes since they are crucial for sleep detection.

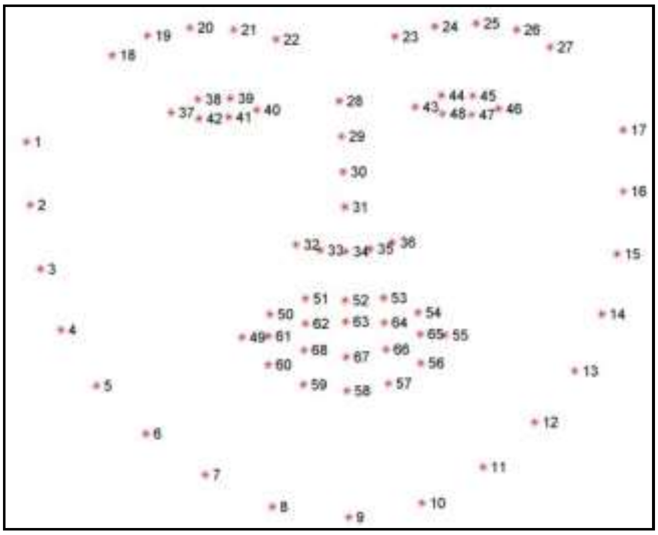

Fig 3.2 The 68 coordinates that help in detecting facial features

Euclidean Distance Analysis - After the eyes are identified, the eye aspect ratio of both eyes is calculated using the Euclidean distance between the eye coordinates. Six (x,y) coordinates represent each eye. Starting from the left corner and moving clockwise around the eye. There are a total of four points on the upper and lower eyelids and two are present on the opposite ends of the eye. Referring to the above figure, points 37- 42 and 43 - 48 represent the left and right eye respectively. The eye aspect ratio represents the amount by which the eyes are shut. The higher the value, the more alert the driver is. To check for sleepiness, 20 consecutive image frames are taken and if the eye aspect ratio is found lower than 0.25 then the system generates an alert.

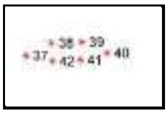

Fig 3.3 Left eye coordinates

Eye Aspect Ratio (EAR) = (|p38 - p42| + |p39 - p41|) / 2|p37 - p40|

Alert Generation - The driver's eyes are constantly monitored. And if they are not open wide enough to surpass the threshold value, a textual and audio alert is generated immediately. The audio alert is issued four times with a 1-second pause between consecutive alerts to ensure more awareness and safety.

IV. RESULTS AND DISCUSSIONS

The present study has demonstrated the effectiveness of using the eye-aspect ratio (EAR) as a feature for detecting drowsiness in drivers. To assess the accuracy and real-time performance of this driver alert system, various experimental setups were developed. The system displayed impressive accuracy and was capable of processing 30 frames per second in real time, making it suitable for practical applications. One of the benefits of using EAR is its robustness and generalizability. This feature is less sensitive to variations in lighting, head orientation, and ethnicity. In comparison to other existing methods such as PERCLOS and SVM classifiers, EAR proved to be a more reliable feature for detecting drowsiness.

The proposed driver alert mechanism has the potential for various applications in transportation, healthcare, and military domains. The EAR-based system can be integrated into vehicles, wearable devices, and other monitoring systems to enhance driver safety.
Despite its high accuracy and performance, there are still some limitations that need to be addressed. For instance, the system may not be effective in detecting drowsiness caused by factors other than eye closure, such as intoxication or reduced vigilance due to cognitive overload. Additionally, individual differences in sleep patterns or fatigue levels can also affect the performance of the system. Further research is needed to explore ways to address these limitations and enhance the effectiveness and practicality of the system. This can involve combining EAR with other features or using machine learning algorithms to improve the system's ability to detect drowsiness accurately.

Table 1 Experimental Setups

S.No	Experimental Test Cases		
	Test Case Description	*Drowsiness detected*	*Alert Generated*
1.	Face Properly Aligned to the Camera	yes	yes
2.	Face Improperly Aligned to the Camera	yes	yes
3.	With a Wearable Object (Hat)	yes	yes
4.	With a Wearable Object on Eyes (Glasses)	yes	yes

Fig 4.1 Face Improperly Aligned

Fig 4.2 With a Wearable Obstacle (Glasses)

Fig 4.3 With a Wearable Obstacle (Hat)

Fig 4.4 Face Properly Aligned

V. CONCLUSION AND FUTURE SCOPE

In conclusion, the driver alert system using eye aspect ratio (EAR) is a promising approach to detect drowsiness and alert drivers in real-time. The EAR is a reliable and non-invasive measure of eye movement that can accurately predict the onset of drowsiness in drivers. This technology has the potential to save many lives by preventing accidents caused by driver fatigue.

Several studies have shown that the EAR-based driver alert system has high accuracy and sensitivity in detecting drowsiness in drivers. Moreover, this system can be integrated with other sensors such as steering wheel sensors, heart rate sensors, and brain activity sensors to provide a more comprehensive analysis of driver fatigue

There are several potential areas for future research and development in the field of driver alert systems using eye aspect ratio:

Integration with other sensors: As mentioned earlier, integrating the EAR-based driver alert system with other sensors such as heart rate and brain activity sensors can provide a more comprehensive analysis of driver fatigue. Future research could explore the potential benefits and limitations of such an integrated system.

Personalization: The effectiveness of the EAR-based driver alert system may vary depending on individual differences such as age, gender, and driving experience. Future research could explore the potential benefits of personalized systems that adapt to individual differences and provide customized alerts.

Field testing: While several studies have demonstrated the effectiveness of the EAR-based driver alert system in laboratory settings, more research is needed to evaluate its performance in real-world driving conditions. Future studies could focus on conducting field tests to evaluate the system's effectiveness and reliability in real-world scenarios.

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