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Driver Drowsiness Detection System

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ABSTRACT: Driver drowsiness is a significant factor contributing to road accidents, leading to severe injuries and fatalities. This project proposes a web-based Driver Drowsiness Detection System that utilizes computer vision and machine learning techniques to monitor a driver's alertness in real time. The system captures facial features using a webcam, analyzing eye closure duration, yawning frequency, and head position to detect signs of drowsiness and distracted driving.

If drowsiness is detected, the system triggers an alert mechanism (such as an alarm or visual warning) to wake the driver. This system aims to improve road safety by reducing driver fatigue-related accidents, offering a cost-effective and accessible solution for both individual drivers and transportation industries. Additionally, the platform includes a secure user dashboard to record historical alerts and track driver statistics over time.

KEYWORDS: Driverdrowsiness, eyedetection, yawndetection, fatigue, computervision, MediaPipe, Eye Aspect Ratio, Mouth Aspect Ratio, Distracted Driving.

I. INTRODUCTION

Road accidents caused by drowsy driving are a growing concern worldwide, leading to severe injuries, fatalities, and economic losses. Studies indicate that driver fatigue contributes to a significant percentage of traffic accidents, especially on highways and during long-haul transportation. Several real-world incidents highlight the devastating impact of drowsiness behind the wheel, emphasizing the need for an effective solution to detect and prevent fatigue-related crashes.

According to the U.S. National Highway Traffic Safety Administration (NHTSA), drowsy driving is responsible for nearly 100,000 road crashes and 1,500 deaths annually [1]. Fatigue-related accidents occur due to lack of sleep, long driving hours, alcohol consumption, and mental stress. Reports indicate that human error accounts for 94% of all accidents, emphasizing the need for automated driver fatigue detection systems [2]. A study in China revealed that drowsiness contributed to 8.1% of total highway collisions in 2003, while the Society of Automotive Engineers (USA) states that 1 in 8 road deaths is linked to driver drowsiness [3]. In Bangladesh, 4,580 fatalities occurred due to road accidents in 2018, marking a 7% increase from 2017 [4]. In India, although specific data on driver fatigue-related accidents has been limited since 2017, earlier statistics indicate that in 2015, there were 3,081 accidents due to sleep, fatigue, or sickness of the driver, resulting in 706 fatalities and 3,383 injuries [5].

Sleep consists of three main stages: Wakefulness, Non-Rapid Eye Movement (NREM), and Rapid Eye Movement (REM). The first stage of NREM is the transition from wakefulness to sleep, commonly known as the drowsy state, where micro-sleeps and unconscious transitions occur. Studies suggest that drowsiness-related accidents often happen between 12AM to 7AM and during mid-afternoon hours [6]. Fortunately, it is possible to detect driver drowsiness in its early stages and alarm the driver to avoid any potential accident. Drowsy drivers exhibit various signs, which include repeated yawning, frequent eye closure, and repeatedly departing street lanes. [7]

To address this issue, Driver Drowsiness Detection Systems utilize Computer Vision and Artificial Intelligence (AI) to continuously monitor a driver's facial expressions and behavioral patterns. By analyzing eye movements, blink rate, yawning frequency, and head position, the system can determine signs of fatigue. If drowsiness is detected, an alert mechanism is triggered to wake the driver and reduce the risk of accidents.

This research paper focuses on the development of a web-based Driver Drowsiness Detection System using Machine Learning and OpenCV. The proposed system aims to provide a cost-effective and efficient solution for improving road safety.

In this study, we propose a comprehensive, real-time Driver Drowsiness and Distraction Detection System. Our approach utilizes OpenCV and Google's MediaPipe Face Mesh to continuously process real-time webcam video frames. By extracting precise facial landmarks, the system calculates the Eye Aspect Ratio (EAR) for objective blink rate analysis and Mouth Aspect Ratio (MAR) for yawning frequency detection. Furthermore, we integrated head pose estimation (Pitch and Yaw) to detect distracted driving behaviors, such as the driver looking away from the road [8].

Unlike traditional standalone scripts, our solution is deployed as a full-stack web application built with React and Flask. It utilizes a Firebase database to provide a secure user dashboard, enabling drivers and fleet managers to track historical drowsiness alerts and driving statistics seamlessly [8].

To systematically evaluate stages of drowsiness and facilitate the development of automatic early drowsiness detection systems, a precise measurement scale for drowsiness levels is necessary. Many methods have been proposed in that direction. One of the widely used scales in the literature is the Karolinska sleepiness scale (KSS) [11,12,13]. Shahid et al. define KSS as “a scale that measures the subjective levels of sleepiness at a particular time during the day” KSS is a nine-point scale that measures drowsiness through verbal descriptions of drivers [11]. The nine KSS scores are summarized in table 1.

Karolinska sleepiness scale, adapted from [11].

Scale	Verbal Description
1	Extremely alert
2	Very alert
3	Alert
4	Fairly alert
5	Neither alert nor sleepy
6	Some signs of sleepiness
7	Sleepy, but no effort to keep alert
8	Sleepy, some effort to keep alert
9	Very sleepy, great effort to keep alert

Wierwille and Ellsworth proposed another drowsiness evaluation scale [21]. They defined drowsiness stages on a five-level scale, as shown in Table 2. According to Saito et al., at level one, rapid eye movement and a stable eye blinking period can be observed [22]. At level two, slow eye movement occurs. The driver may touch his face at level three, as well as yawn and slowly blink. As for level four, the driver’s unnecessary movements are observed; he frequently yawns, blinks more, and breathes deeply. Finally, the eyes are almost closed at the fifth level, and the head nods.

This scale is also widely used because these levels are determined based on analyzing the driver’s facial expressions. When comparing this scale results with the subjective reports of the drivers, they show a high correlation, which indicates that this evaluation scale could be an alternative to the KSS scale [22,23].

II. LITERATURE REVIEW

Drowsy driving is one of the common causes of fatalities in car accidents. Truck drivers that travel for lengthy periods of time (especially at night), long-distance bus drivers, and overnight bus drivers are more vulnerable to this condition. Passengers in every country face the nightmare of drowsy drivers. Fatigue-related traffic accidents result in a substantial number of injuries and deaths each year. As a result, due to its wide practical application, detecting and indicating driver drowsiness is a hot topic of research. Driver drowsiness is defined as the detection of any abnormal change in these parameters. Nonintrusive driver tiredness detection uses cameras to analyze behaviors like blinking, yawning, and head movement. [9]

Several factors, including the drivers' age, marital status, annual mileage, number of daily trips, and ordinary and aggressive infractions, were found to impact accident involvement in the study. [10].

III. DROWSINESS DETECTION TECHNIQUES

Over the years, researchers have proposed various techniques to monitor driver fatigue using non-intrusive camera feeds. These methods are primarily categorized based on the specific facial features they track, such as eye states, head postures, and mouth movements. A brief review of the major detection categories used in recent studies is discussed below.

A. EYEBLINK IN GBASE DTECHNIQUES

In this eye blinking rate and eye closure duration is measured to detect driver's drowsiness. Because when driver feels sleepy at that time his/her eye blinking and gaze between eyelids are different from normal situations so they easily detect drowsiness. In this system the position of iris and eye states are monitored through time to estimate eye blinking frequency and eye closure duration. [14]. And in this type of system uses a remote camera to acquire video and computer vision methods are then applied to sequentially localize face, eyes and eyelid positions to measure ratio of closure. [15]. Using these eye closure and blinking ratio one can detect drowsiness of driver.

B. FACE BASED TECHNIQUES

Teyeb et al. [18] proposed the Drowsy Driver Detection using Eye Closure and Head postures. Firstly, video is captured using webcam and for each frame of video, following operations are performed. To detect the ROI (face and eyes), Viola-Jones method is used. The face is partitioned into three areas and the top one presenting the eye area is browsed by the Haar classifier. Then to detect the eye state, Wavelet Network based on neural network is used to train the images then the coefficients learning images is compared with the coefficients of the testing images and tells which class it belongs. When the closed eye is identified in the frames then the eye closure duration is calculated, if the value exceeds the pre-defined time then the drowsiness state is detected. Then the developed system estimates the head movements which are: left, right, forward, backward inclination and left or right rotation. The captured video is segmented into frames and extract the images of head and determines the coordinates of image. Then the images are compared to determine the inclined state of head and same case with other head postures. Finally, the system combines the eye closure duration and head posture estimation to measure the drowsiness. To evaluate the system, experiment is performed on 10 volunteers in various situations. And results show that the systems achieve the accuracy of 80%

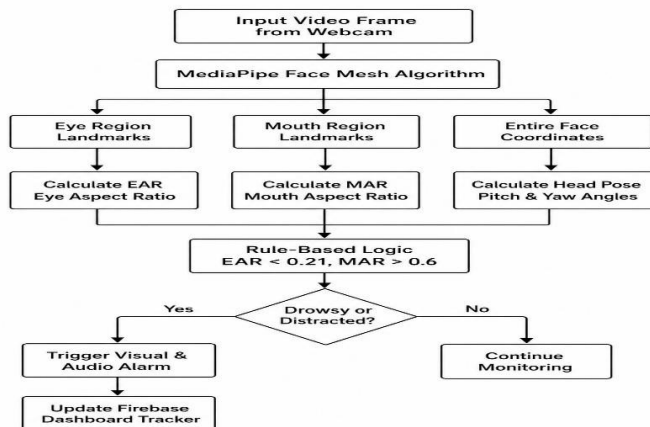
C. YAWNING BASED TECHNIQUES

This technique involves calculating the Mouth Aspect Ratio (MAR), which is the ratio of the vertical distance between the upper and lower lips to the horizontal distance between the mouth corners. By monitoring changes in the MAR, the system can detect when the driver's mouth is open, indicating a yawn. An increase in the MAR beyond a certain threshold signifies a yawning event. [16] Advanced systems employ Convolutional Neural Networks (CNNs) to analyze visual data and detect yawning. These models are trained on datasets containing images of yawning and non-yawning individuals, enabling the CNN to learn distinguishing features associated with yawning. This approach allows for real-time detection of yawning by processing video frames captured from in-vehicle cameras. [17]

When the MAR exceeds the threshold, it means the driver has yawned. In this way, the system analyzes video frames to detect the driver's drowsiness.

IV. SYSTEM ARCHITECTURE

The system uses webcam input and MediaPipe to extract facial features. EAR, MAR, and head pose are computed to detect drowsiness, triggering alerts and updating the dashboard [8].



V. COMPARATIVE STUDY OF DROWSINESS DETECTION

The number of motor vehicles has increased steadily in emerging countries during the last ten years. Traffic accident reports indicate that risky driving behaviours, such as drunk driving or fatigued driving, are responsible for most accidents. According to studies, sleepy driving is a contributing factor in 20% of all accidents. Drowsiness is a condition when the level of consciousness is lowered as a result of fatigue or sleep deprivation, and it can make a driver fall asleep silently. Drowsy driving results in a loss of control by the driver, which can cause the vehicle to drift off the road, hit an obstacle, or overturn.

In order to extract and synthesize the methods and features that have been utilized in the drowsiness detection process, past studies have conducted Systematic Literature Reviews (SLR). According to comparative analyses, the most used features are facial expressions like yawning, closing of the eyes, and head motions. These insights show that techniques ranging from Eye Aspect Ratio (EAR) and Haar Cascades, to Support Vector Machines (SVM) and facial landmark libraries (like dlib and MediaPipe) are frequently utilized [19].

With the improvement in Computer Vision technologies, various intelligent systems are developed to determine drowsiness. For instance, some previous studies [20] suggested frameworks utilizing Viola-Jones detection algorithms combined with deep convolutional semantic networks to extract active features. While deep learning offers strong results, it often requires high processing power. This paper provides a comparative assessment between traditional deep-learning methods and real-time geometric-based fatigue detection systems.

A concise summary of the major technologies compared in recent detection systems includes:

- Eye Aspect Ratio (EAR): Monitors eye closure by calculating accurate geometric distances between eye landmarks; a decreasing EAR directly indicates drowsiness.
- Mouth Aspect Ratio (MAR): Analyzes the ratio of lip distance to precisely detect yawning frequency in real-time.

- MediaPipe & dlib Libraries: Provides robust facial landmark tracking (like 468 facial points) to monitor eye, mouth, and head orientations instantly.
- Deep Learning & SVMs: Employs heavy neural networks to classify complex behavior, offering high accuracy but requiring substantial training data and much higher computational resources compared to rule-based geometric thresholding [5].

VI. CONCLUSION

Driver drowsiness detection is a critical area of research aimed at reducing road accidents caused by fatigue. Our proposed system leverages machine learning and computer vision to analyze facial expressions, including eye-blinking, yawning, and head pose variations to detect both drowsiness and distracted driving in real-time. By utilizing OpenCV and deep learning models, our approach ensures high accuracy without requiring additional external hardware. The system provides instant alerts when drowsiness is detected, helping drivers stay awake and preventing potential accidents.

Deploying this system as a web-application with a secured database dashboard separates it from traditional scripts. This method offers a cost-effective, efficient, and scalable solution compared to traditional techniques, making it highly suitable for real-world applications. With further advancements in AI and real-time processing, our system can be integrated into modern vehicles to enhance road safety and reduce drowsy driving incidents.

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