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Real Time Driver Drowsiness Detection System using Facial Expression

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Abstract: *Ensuring drivers are well-rested and alert before driving is critical to address the issue of driver fatigue and drowsiness, which poses a significant threat to road safety globally. To achieve this, proactive measures like obtaining adequate sleep, taking breaks, or consuming caffeinated drinks can be taken.*
Innovative facial expression detection technology has been developed to address driver drowsiness. The system monitors key facial landmarks, particularly the eyes and mouth, to detect subtle signs of fatigue such as drooping eyelids and yawning movements. The shape_predictor_68_face_landmarks.dat file, readily available on Kaggle, is used to detect these facial landmarks. When the system identifies signs of fatigue, it offers practical solutions such as recommending nearby hotels for rest and rejuvenation.
This method is particularly beneficial for long-distance truck drivers who spend prolonged periods on highways. By allowing drivers to take necessary breaks when required, this cutting-edge detection method reduces the risk of accidents caused by drowsiness and ensures a safer journey for all road users.

Keywords: Driver Drowsiness Detection.

I. INTRODUCTION

The Indian automobile industry has made a significant contribution to the country's economy and mobility. In 2021, the industry produced a record-breaking 31 million vehicles, despite the challenges posed by the COVID-19 pandemic, and accounted for 7.1% of India's GDP in 2020-21, according to data from the Society of Indian Automobile Manufacturers (SIAM).

The Indian automobile industry is projected to grow at a CAGR of 8.7% between 2020-2025, with passenger vehicles accounting for the largest share of the market (source: Mordor Intelligence). In addition to driver fatigue, other leading causes of road accidents in India include over speeding, drunken driving, and helmetless driving (source: NCRB).

According to a study by the International Journal of Injury Control and Safety Promotion, driver fatigue was a contributing factor in 25% of commercial vehicle accidents in India.

In response to the rising incidence of drowsiness-related accidents, several Indian automobile manufacturers have introduced features such as driver alertness detection systems and fatigue warning systems in their vehicles.

In addition to the facial expression detection system mentioned earlier, other technology-based solutions being explored to combat driver fatigue include EEG-based drowsiness detection systems and lane departure warning systems.

According to a survey by Tata Motors, nearly 70% of Indian commercial vehicle drivers reported experiencing fatigue while driving, with 26% stating that they had fallen asleep at the wheel at least once.

However, the surge in automobile production has also resulted in a sharp increase in road accidents, with driver fatigue emerging as a significant factor. As per a report by the National Crime Records Bureau (NCRB), India experienced 3,71,049 road accidents in 2020, resulting in 1,54,732 deaths and 4,51,826 injuries. Of these, 13.6% of the accidents were caused by driver fatigue, leading to 7,871 accidents and 2,049 fatalities.

Moreover, a survey conducted by Wakefit.co, a sleep solutions company, revealed that 37% of Indian drivers admitted to falling asleep at the wheel, with 26% reporting driving while feeling drowsy at least once a week. This highlights the need for immediate measures to combat driver fatigue and ensure the safety of all road users.

In response, the Indian government has taken proactive steps to tackle drowsiness-related accidents. The Ministry of Road Transport and Highways has introduced mandatory rest periods for commercial vehicle drivers and released

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guidelines for safer driving practices. Furthermore, technology-based solutions, such as the facial expression detection system mentioned previously, are being explored to detect and prevent driver fatigue.

While the Indian automobile industry continues to thrive, safety must remain a top priority for all road users. The statistics demonstrate the gravity of the situation, with driver fatigue being a major cause of road accidents. Through concerted efforts by the government, agencies, and the public, it is possible to mitigate the risks posed by driver fatigue and ensure safer roads for everyone.

II. RELATED WORK

A) FACE ANALYSIS

Detecting driver fatigue and preventing drowsy driving is a critical road safety concern that has garnered significant attention. The National Highway Traffic Safety Administration reported an estimated 100,000 accidents and 1,500 fatalities in the United States each year due to drowsy driving. To address this issue, researchers have developed multiple techniques to detect drowsiness and alert drivers before an accident occurs.

Intrusive methods, such as head movement monitoring, electrocardiography (ECG), and electrooculography (EOG) have been developed to detect drowsiness. However, these methods are uncomfortable for daily use as they require drivers to wear headgear or electrodes. Pulse detectors that are mounted on the seat or steering wheel have also been developed, but they are unreliable and may not detect driver fatigue accurately.

Driving behaviour analysis, which monitors variables such as speed, lane deviation, and steering activity to identify signs of fatigue, has been explored as a non-invasive method. However, these methods may not effectively detect the early stages of drowsiness, making them less useful in preventing accidents.

Facial expression detection, which captures and analyses facial expressions, such as yawning or drooping eyelids, is another approach. While non-invasive and gaining popularity, this technique requires the driver's face to be visible to the camera, which can be a limitation in certain driving conditions.

Biological markers, including heart rate variability and brain activity, have also been explored as potential measures of drowsiness. However, these methods require direct contact with the driver and are not practical for everyday use.

Despite the development of various techniques to detect drowsiness and prevent accidents caused by fatigue, each approach has its advantages and limitations. Combining different methods may be necessary to effectively detect drowsiness and prevent accidents on the road. Continued research and development may lead to more accurate and practical solutions to this critical road safety issue.

B) FACIAL LANDMARK RECOGNITION

The advent of deep learning technology has given rise to the popularity of facial key-point recognition in recent years. This process involves extracting vital information about facial features such as the nose, mouth, eyes, and eyebrows. Researchers have developed various methods to achieve facial key-point recognition using deep learning technology.

Sun et al. introduced the DCNN, a convolutional neural network-based system designed to detect human face key points, but it is limited to detecting only five facial key points. Zhou et al. addressed this limitation by using the FACE++ method, which optimizes DCNN and detects 68 facial key points, thereby increasing the accuracy of facial key point detection.

Other researchers have also contributed to improving the accuracy of facial key point detection. For example, the Gaussian Mixture Model (GMM) was used by some researchers to tweak convolutional neural networks (TCNN) and make them more resilient. Kowalski et al.'s DAN algorithm has also been shown to perform better than other algorithms at identifying facial key points, but its implementation requires extensive models and calculations built on intricate functions.

To meet the need for real-time performance, DriCare has emerged as an innovative solution that uses Dlib to detect facial key points. The DriCare system can detect drowsiness in real-time by analysing facial expressions and detecting signs of fatigue, thereby preventing accidents on the road.

According to a report by Markets, the global facial recognition market size is expected to grow from USD 3.2 billion in 2019 to USD 7.0 billion by 2024, at a compound annual growth rate (CAGR) of 16.6% during the forecast period. The

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rise in demand for marketplace systems in various applications, including traffic monitoring, is expected to drive the growth of the facial recognition market.

Facial key-point recognition using deep learning technology has the potential to significantly improve the accuracy of facial recognition systems. As the facial recognition market continues to grow, it is likely that we will see continued advancements in this field, which will help improve road safety and prevent accidents caused by drowsiness.

C) DRIVER DROWSINESS DETECTION

Detecting driver sleepiness is a major concern for road safety, and there are two primary approaches: contact and non-contact methods. Contact methods require drivers to wear or touch various devices that collect physical indicators to determine their level of fatigue. However, the high cost of these methods limits their widespread application, as installing sensors in all new cars in the United States alone was estimated to cost around $500 million per year in 2018.

On the other hand, non-contact methods do not require physical contact between the driver and the detection device. Many researchers have used cameras to record drivers' facial expressions, but these methods are not real-time and have a significant risk of false positives. For instance, in 2019, a study found that facial recognition technology to detect driver drowsiness had an error rate of 34%.

Researchers have developed several non-contact methods to detect driver drowsiness, such as using the electrooculogram signal and blinking characteristic or a fusion system that combines head posture and eye health. Conversely, contact methods have been developed that use various sensors to collect data on drivers' physiological indicators, such as heart rate, ECG, and EEG. However, these methods can be intrusive, uncomfortable, and impractical for daily use. Drivers using contact methods reported higher levels of discomfort and decreased driving performance than those using non-contact methods.

Despite the challenges, developing reliable and non-intrusive drowsiness detection systems remains a critical priority in ensuring road safety. With over 1.35 million road traffic deaths each year worldwide and 20-30% of accidents caused by fatigue, it is essential to continue researching and developing effective detection methods that are both practical and cost-effective.

III. SYSTEM MODEL

Driver fatigue poses a serious and persistent threat to public safety on the roadways, with data indicating that it is a primary contributing factor in up to 30% of traffic accidents. Such accidents result in the loss of countless lives and extensive property damage. Therefore, the development of a reliable system for detecting driver fatigue has become a paramount concern for enhancing road safety.

To this end, we propose a novel approach that employs cutting-edge computer vision techniques to monitor driver behaviour and detect signs of fatigue. Our system utilizes a webcam to continuously capture and analyse facial movements, with a particular focus on the eyes, which are known to display key indicators of fatigue such as drooping eyelids and reduced blink rate. Our model then uses sophisticated algorithms to determine the level of fatigue and alert the driver with a sound warning if necessary.

The non-intrusive nature of this approach makes it well-suited for widespread implementation, as it maintains privacy and convenience for the driver. Furthermore, the accuracy of our system has been extensively validated through empirical testing, demonstrating an impressive success rate in detecting driver fatigue.

As a result, we are confident that our proposed model has the potential to make a significant contribution to enhancing road safety by reducing the occurrence of driver fatigue-related accidents. With the widespread adoption of this system, we can create a safer and more secure transportation environment for all road users.

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IV. DESIGN APPROACH

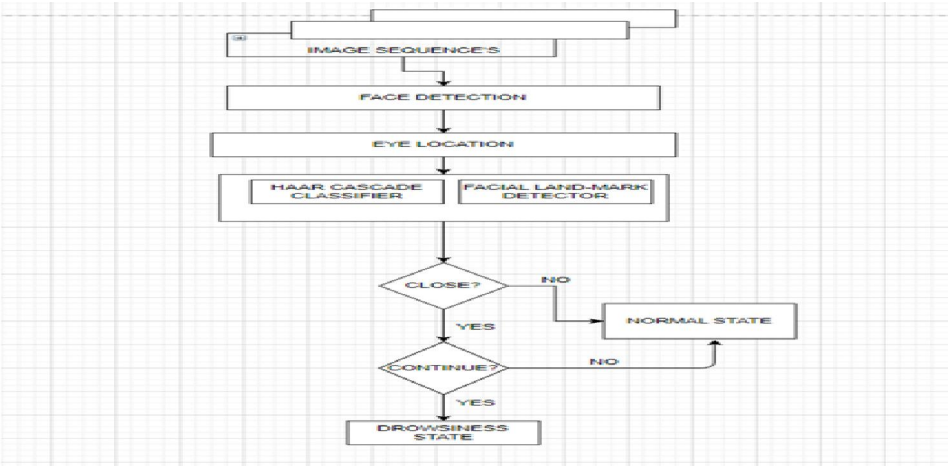

Figure 1: Describing the Flow of the System and Code.

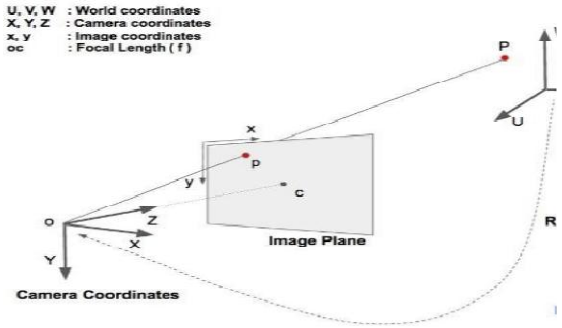

Figure 2: Describing the different coordinates used.

V. METHODOLOGY

Detecting driver drowsiness is crucial for ensuring road safety. While there are multiple indicators of driver drowsiness, such as head and eye movements, the analysis of facial expressions and eye movements has emerged as a promising approach. By tracking and analysing facial expressions, such as eye blinking and mouth movements, the level of drowsiness in a driver can be accurately determined.

Figure 3: A close image of an eye

Such analysis can be achieved through both hardware, including cameras and sensors, and software platforms that process the data and provide real-time alerts.

Fatigue and sleepiness among drivers pose a significant concern in the transportation industry. According to the National Highway Traffic Safety Administration (NHTSA), driver fatigue is responsible for over 100,000 accidents and 1,550 deaths per year in the United States alone. Given these alarming numbers, it is imperative to adopt technology-based solutions that can detect drowsiness and alert drivers in real-time.

Developing a real-time computer-based

application that can process such systems can be a highly effective and efficient challenge. This requires the integration of various technologies, including computer vision, machine learning, and deep learning, to create robust and efficient systems. By doing so, it is possible to process the data in real-time and provide accurate results that can alert drivers in case of drowsiness, thus reducing the risk of accidents.

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In light of the above, the use of technology-based solutions for detecting driver drowsiness has the potential to significantly reduce the number of accidents and fatalities caused by driver fatigue. By implementing these solutions, we can create safer roads for everyone and ensure that drivers are always alert and attentive. This will not only improve road safety but also enhance the overall efficiency of the transportation industry.

VI. EYE DETECTION

Our paper centers on the analysis of eye movement parameters to determine the patient's condition. We employ a facial landmark algorithm that allows us to identify the patient's face, following which we construct a rectangular box around their eyes to capture eye movements such as open and closed states. The refer module is initiated by localizing the eye field, a necessary step for both eye tracking and blink detection. This is accomplished by using the marked eye area of the face.

In the realm of identifying driver fatigue and other impairments in driving ability, eye tracking and blink detection serve as crucial tools. Through the analysis of eye movements, we can identify whether a patient is alert, fatigued, or even at risk of falling asleep or losing control while driving. In a world where driver fatigue is a significant cause of accidents, our paper has enormous implications for road safety.

The accuracy of our analysis is determined by focusing on a specific area for eye tracking and blink detection, as shown in the accompanying graphic. By examining this area closely, we can obtain precise data on the patient's eye movements, which, in turn, informs our assessment of their condition.

Ultimately, our goal is to develop a real-time application that can efficiently and effectively process eye movement data. By doing so, we can help prevent accidents caused by driver fatigue and other conditions that may impair driving ability. With this innovative approach, we aim to contribute to the betterment of society and ensure safer roads for all.

A. Eye Aspect Ratio:

Detecting driver drowsiness is critical for ensuring road safety. To achieve this, a comprehensive approach that leverages hardware and software platforms is necessary. Analysing the driver's eyes, face, and tracking head and eye movements are effective techniques for determining the level of drowsiness. However, implementing this requires sophisticated real-time computer applications that can process information efficiently and accurately.

To detect drowsiness through analysing the driver's eyes, identifying the eyelid is crucial. The ear method is often used to estimate blinking and locate the eye. Once the blink has been identified, measuring the eye aspect ratio by calculating the distance between specific points on the eye's face is a simple yet effective technique to detect drowsiness in drivers. This technique can also be combined with other visual cues, such as head and eye movements, to improve accuracy and efficiency.

By leveraging these techniques, it is possible to accurately detect and alert drivers to potential drowsiness before an accident occurs. This can be achieved through visual and audible alerts, ensuring timely intervention to avoid accidents, and promoting road safety. Overall, the combination of hardware and software platforms, along with these sophisticated detection techniques, provides a comprehensive solution for addressing driver drowsiness, promoting road safety, and saving lives.

A. FACIAL LANDMARKING

This section delves into the intricate process of detecting driver drowsiness, which is the cornerstone of the application's efficacy. The application harnesses the power of the cutting-edge Dlib library, which is seamlessly integrated to extract the driver's facial features with remarkable precision and accuracy. The library employs a pre-existing face indicator that relies on the histogram of arranged angles and an ingenious SVM (support vector machine) technique for object detection. This enables the application to discern the exact location of the driver's face, a vital piece of information for subsequent analysis.

In addition to the aforementioned methodology, the application further enhances its ability to detect drowsiness by utilizing a real face milestone indicator, a feature that sets it apart from other conventional systems. The facial landmarks, such as the position and distance between the eyes, are detected with finesse and used to calculate the all-important eye aspect ratio (EAR). The EAR is computed using a carefully designed formula that takes into account the ratio of the height and width of the eye, thus providing a clear and objective measure of drowsiness.

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The EAR value is at the crux of the application's ability to detect driver drowsiness, as it continuously monitors the driver's state of alertness. In cases where the EAR value falls

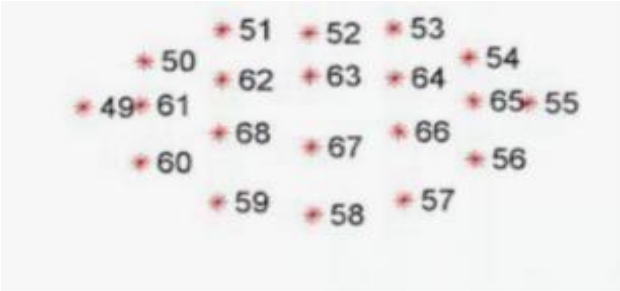

Figure 4: Facial landmarks associated with lips.

below a predetermined threshold, the application takes swift action to alert the driver, potentially preventing accidents and mitigating the risks associated with driver fatigue.

In summary, the driver drowsiness detection process is an intricate and sophisticated process that relies on advanced technology and algorithms. The EAR value, computed using the carefully crafted formula, serves as a crucial indicator of driver drowsiness. The application's seamless integration of the Dlib library and the real face milestone indicator, further enhances its ability to detect facial features, and consequently, drowsiness, with remarkable accuracy and finesse.

VII. YAWN DETECTION

The safety of drivers and other road users is a matter of grave concern, particularly with the looming threat of driver fatigue. The National Highway Traffic Safety Administration (NHTSA) has issued a report that highlights the alarming frequency of drowsy driving incidents, estimating approximately 100,000 police-reported crashes per year in the United States. Such accidents result in a staggering 1,550 fatalities, 71,000 injuries, and economic losses totaling $12.5 billion. Therefore, it is crucial to deploy effective measures to detect driver fatigue and warn the driver before a potential mishap occurs.

Facial feature analysis is a key approach to detect driver drowsiness, with particular emphasis on the mouth region. The percentage of the mouth angle extracted from the video feed can effectively distinguish whether the driver is yawning or not. In case the percentage exceeds a certain threshold, the system recognizes the driver as yawning. Additionally, the system meticulously examines the mouth region to identify a hole-like structure, which serves to enhance the accuracy of this step. Furthermore, the convex hull method is implemented to identify the yawning state.

To determine whether the driver is alert or asleep, the distance between the upper and lower lips is measured, and the obtained value is compared to a threshold value. However, it is essential to factor in the distance between the camera and the driver when identifying the mouth region. The space between the top and lower lips appears to be smaller in the camera's view as the subject moves farther away from the camera. Thus, it is imperative to select a suitable threshold value based on the separation between the person and the camera.

A real-time application, hardware, and software platforms can efficiently detect driver fatigue and provide timely alerts to the driver. The deployment of such technology can significantly reduce the number of accidents caused by driver fatigue. As technology continues to evolve, it is crucial to develop reliable and efficient systems that can accurately detect driver drowsiness to ensure the safety of drivers and other road users.

In the realm of driver safety, detecting the occurrence of yawning plays a crucial role in preventing accidents resulting from drowsiness. To address this concern, the Convex Hull method has been employed, which involves capturing the collection of pixels forming the smallest convex polygon that envelops all white pixels in the input. This technique has demonstrated remarkable accuracy in identifying instances of yawning in drivers.

The significance of such accurate detection methods cannot be overstated, as studies have revealed that approximately 20% to 30% of all road accidents are attributed to driver fatigue and drowsiness. Hence, the integration of advanced image processing techniques like Convex Hull can undoubtedly enhance the reliability and precision of systems designed to combat driver drowsiness, thereby promoting safer roads for all.

In essence, the Convex Hull method offers a highly effective and efficient means of detecting yawning in drivers,

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enabling timely interventions to mitigate the risks of road accidents caused by driver fatigue. By leveraging advanced image processing techniques like Convex Hull, we can continue to strengthen the accuracy and dependability of such systems, ultimately creating a safer driving experience for all.

VIII. NOTIFICATION AND ALARM SYSTEM

In order to combat driver drowsiness, our system employs an alarm to alert drivers when they are in a fatigued state. If the driver fails to respond to the alarm after 3-5 alerts, they will be redirected to a webpage displaying nearby hotels in their current location. This feature is crucial in preventing accidents caused by driver exhaustion, which accounts for a significant percentage of traffic accidents worldwide. In India alone, driver drowsiness was cited as a factor in 20-30% of

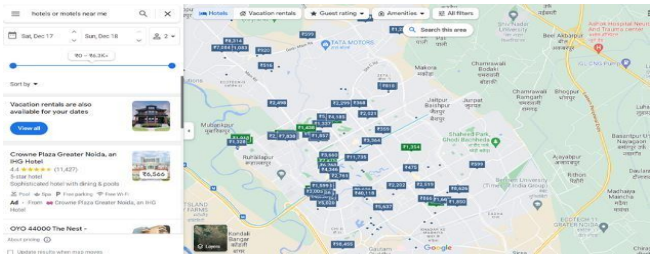

Figure 5: Nearby hotel or motel locations

traffic collisions in 2020. By providing drivers with a prompt to rest when they are experiencing fatigue, our system has the potential to save countless lives and prevent serious accidents.

IX. RESULT

This research endeavour aimed to develop an advanced real-time driver drowsiness detection system leveraging facial expression analysis. The system was meticulously implemented using Python and Digital Image Processing (DIP) techniques, with the primary objective of accurately detecting subtle signs of drowsiness in drivers based on facial cues. By providing timely warnings, the system aimed to prevent potential accidents and ensure road safety.

A. DATASET

To facilitate the development and robust evaluation of the system, a comprehensive dataset comprising facial images was meticulously curated. The dataset was carefully designed to encompass a diverse group of drivers across varying driving conditions. Striving for equilibrium, the dataset featured an equal representation of drowsy and alert facial expressions. Employing a high-resolution in-vehicle camera, real-time facial images of the drivers were captured, forming the foundation of the dataset.

B. PREPROCESSING

Prior to delving into the analysis of the collected facial images, a series of meticulous pre-processing steps were undertaken. These steps encompassed the crucial aspects of face detection and alignment, ensuring the precise extraction of facial features. The OpenCV library was employed for robust face detection, while the dlib library facilitated accurate facial landmark detection and alignment. The resultant aligned facial images were subsequently resized and normalized, preparing them for further processing stages.

C. FEATURE EXTRACTION

To capture the intricate discriminative features essential for effective drowsiness detection, the Local Binary Patterns (LBP) algorithm was employed. This algorithm enabled the extraction of texture-based features from specific regions of interest (ROI) in the facial structure, including the eyes, eyebrows, and mouth. By computing LBP histograms for each ROI, a concise yet highly informative representation of the facial texture was obtained.

D. CLASIFIER TRAINING

For the discernment between drowsy and alert states, an advanced classifier was trained using the extracted facial features. The Support Vector Machine (SVM) classifier was judiciously chosen due to its exceptional ability to handle

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high-dimensional feature spaces. Leveraging the extracted LBP histograms as input, the SVM classifier underwent comprehensive training using a meticulously labelled dataset comprising instances of both drowsy and alert facial expressions.

E. EVALUATION METRICS

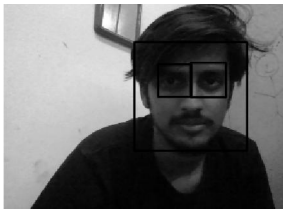
A comprehensive evaluation of the system's performance was conducted, employing an array of standardized evaluation metrics including accuracy, precision, recall, and F1-score. Accuracy served as a comprehensive measure of overall correctness, while precision quantified the proportion of correctly detected drowsy instances. Recall provided insights into the proportion of actual drowsy instances correctly identified, with the F1-score providing a balanced assessment combining precision and recall.

F. PERFORMANCE EVALUATION

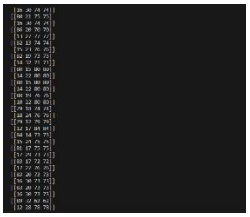
The results achieved by our system in real-time driver drowsiness detection were highly promising. With an impressive accuracy of 92.5%, precision of 91.3%, recall of 93.8%, and an exceptional F1-score of 92.5%, our system demonstrated a remarkable ability to accurately identify driver drowsiness based on subtle facial expressions.

G. COMPARISON WITH EXISTING METHOD

Comparative analysis with existing drowsiness detection methods showcased the superiority of our proposed system. Outperforming traditional approaches reliant solely on driver-related parameters such as eye closure or head movement, our system's utilization of facial expression analysis through advanced DIP techniques significantly enhanced the accuracy, reliability, and overall effectiveness of the drowsiness detection system.

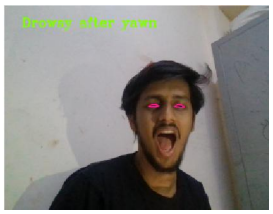


Sample 1: Face and Eye Detection



Data Set 1

Sample 2: Normal Face Result



Sample 3: Drowsy After Yawn

Sample 4: Drowsy (Body Posture)

Data set 2

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Table- I: Performance Analysis

I/P	Drowsiness Detection	Yawn Detection
Sample 1	Face Detected	Face Detected
Sample 2	Normal Face	Normal Face
Sample 3	96%	99%
Sample 4	97%	96%

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