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Safety First: ML-Based Driver Drowsiness & Yawn Alert System

[1]Suyash Belote, [2]Anuj Benke, [3]Shivshankar Barkund, [4]Prof. Ishwar Bharambe

[1]Student, [2]Student, [3]Student, [4]Professor
[1]Department of Computer Engineering,
[1]Dr. D. Y. Patil SOE&T, Charholi Bk, Lohegoan, Pune, India

Abstract: Driving under the influence poses a substantial risk to public safety since they are a major contributing factor to traffic accidents. The goal of this research is to use deep learning and advanced computer vision techniques to create a sophisticated real-time system that can accurately identify driver sleepiness. Through an in-car camera, the technology continually scans the driver's face features. First, powerful computer vision algorithms identify and track the facial region in the video feed. Then, the areas around the eyes and mouth are separated, and their conditions are examined to find indicators of exhaustion, such as closing the eyes and yawning.

Our method combines contour analysis for yawning detection with convolutional neural networks (CNNs) for accurate eye state categorization. These machine learning algorithms are applied to the obtained data in order to identify correlations and patterns that are suggestive of sleepiness. The device instantly alerts the driver with an auditory alarm when it detects sleepiness.

The development process of the detection system, including data collection, preprocessing, training the model, and real-time deployment, is described in this study. The system's great accuracy and efficacy under many situations are demonstrated by our testing findings, underscoring its potential to drastically lower the incidence of accidents associated with sleepiness. This device seeks to improve road safety and provide a useful tool for averting accidents caused by fatigued drivers by sending out real-time notifications.

I. INTRODUCTION

It is essential to identify and address driver fatigue in order to maintain road safety and avoid collisions. Because it makes it more difficult for a motorist to respond quickly, being sleepy increases the risk of accidents. This research employs cutting-edge computer vision and machine learning techniques to construct an enhanced system for real-time driver sleepiness detection. By examining the driver's facial expressions—particularly eye closure and yawning—as recorded by an in-car camera, the system attempts to detect indications of fatigue.

Numerous variables, such as sleep loss, extended driving hours, and boring driving conditions, might contribute to driver sleepiness. Conventional approaches to sleepiness detection, such self-reporting and human observation, are not only unworkable for real-time deployment, but also unreliable. Promising approaches for automatic sleepiness detection are provided by recent developments in machine learning (ML) and artificial intelligence (AI).

In this project, we use sophisticated contour analysis techniques to detect yawning and convolutional neural networks (CNNs) for precise eye state categorization. The system can effectively recognize sleepiness indicators thanks to the integration of various techniques. Through ongoing facial expression analysis, the system can promptly issue warnings to avert possible collisions. This study's main goals are to create a reliable drowsiness detection algorithm, assess how well it works in different contexts, and make sure it can be used in everyday situations. Our method entails gathering and preprocessing video data, training deep learning models, and putting the system through testing and implementation in real time. This device promises to improve road safety and assist drivers in staying alert during lengthy trips by offering dependable drowsiness detection.

In conclusion, the goal of this research is to develop a deep learning and state-of-the-art computer vision system for the identification of driver drowsiness. Our approach is to alleviate the serious problem of driver weariness in order to lower the number of accidents caused by intoxication and raise general traffic safety.

II. PROBLEM STATEMENT

Due to its detrimental effects on reaction times and decision-making skills, driver drowsiness increases the probability of accidents on the road. For real-time intervention, traditional techniques like self-reporting and physical observation are unreliable for identifying driver weariness. Thus, the challenge is to create a sophisticated, real-time system for detecting driver drowsiness that monitors and analyses the driver's facial features using cutting-edge computer vision and deep learning algorithms. In order to identify indicators of tiredness, such as yawning and closing of the eyes, the system must effectively gather live visual data from an in-car camera, evaluate this data, and instantly notify the driver when it detects fatigue. Convolutional neural networks (CNNs) are used in this to classify eye states, while contour analysis is used to detect yawning. The objective is to develop a strong, precise detection system that fits into cars smoothly, giving drivers a dependable tool to keep alert and avoid situations involving drowsiness, improving overall road safety.

III. SOFTWARE REQUIREMENT

A. Software Requirement

- Programming Languages:

Python: Utilized for backend development, machine learning, and data processing.

- Web Framework:

Tkinter: Employed for creating the graphical user interface (GUI) of the application.

- Database Management System:

MySQL: Utilized to store and manage user data and login information.

- Machine Learning and Data Analysis Tools:

OpenCV: Used for capturing live video data and performing image processing tasks.
TensorFlow, Keras: Utilized for loading and executing pre-trained convolutional neural network (CNN) models for eye state classification.

- Data Sources:

Webcam: Captures live video data for drowsiness detection.

- Development Environment:

Integrated Development Environment (IDE): Python IDE such as Visual Studio Code, PyCharm, or Spyder.

B. Hardware Requirement

Webcam: Required for capturing video data.
CPU: A computer with sufficient processing power to handle data processing and model execution. A multi-core processor is preferable for faster computation.
RAM: A minimum of 8GB RAM is recommended, but higher RAM capacity will smooth application performance. Storage: Adequate storage space to store the application code, trained models, and other resources. SSD storage is preferable for faster read/write speeds.
Graphics Processing Unit (GPU) (Optional): While not strictly required, a GPU can significantly accelerate deep learning model training.

IV. SYSTEM DESIGN

A. System Architecture

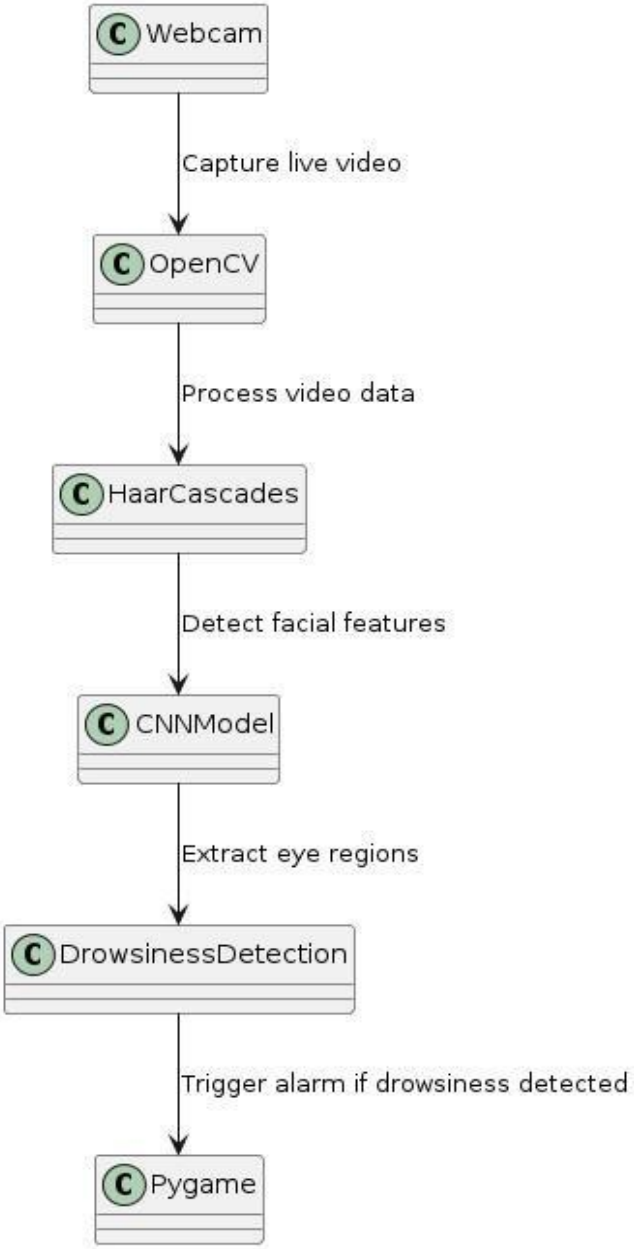


Figure: System Architecture

B. Data Flow Diagram

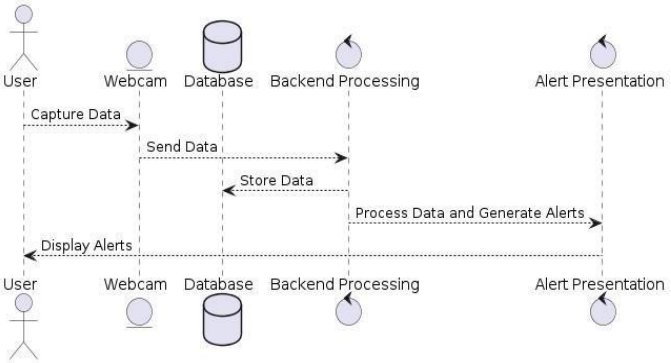


Figure: Data Flow Diagram

C. UML Diagram 1 (Algorithmic flow Diagram)

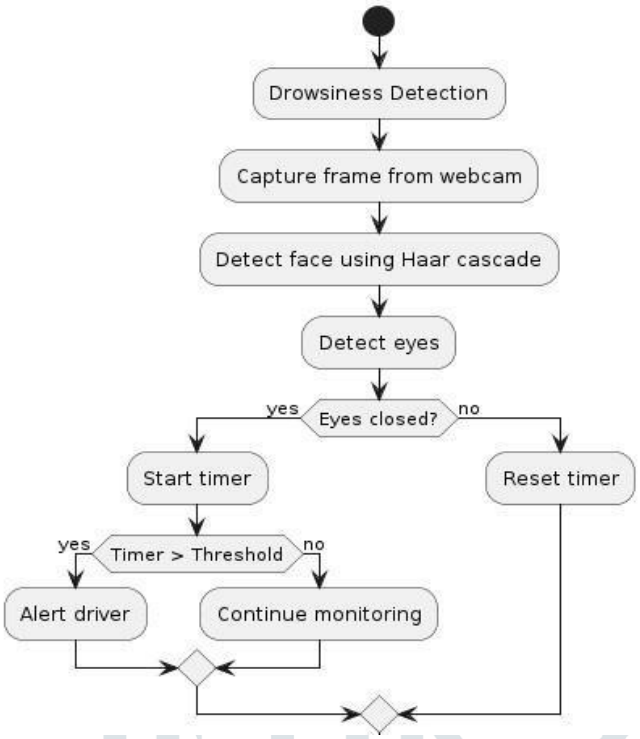


Figure: UML Diagram 1

D. UML Diagram 2 (System Architecture 2)

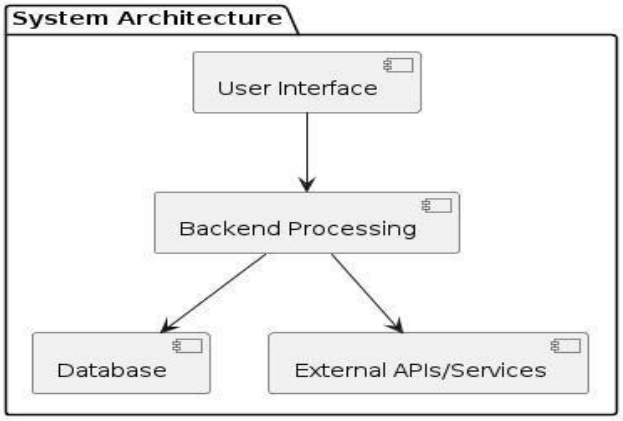


Figure: UML Diagram 2

E. UML Diagram 3 (Diagram of Alert)

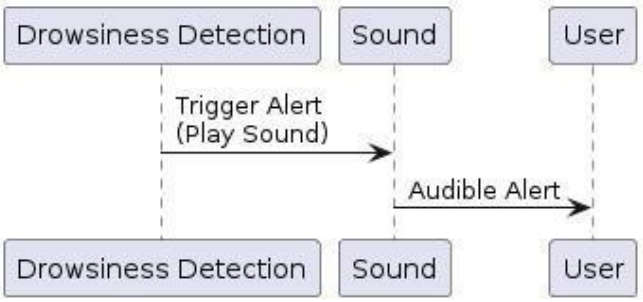


Figure: UML Diagram 3

F. UML Diagram 4 (Diagram of Implementation)

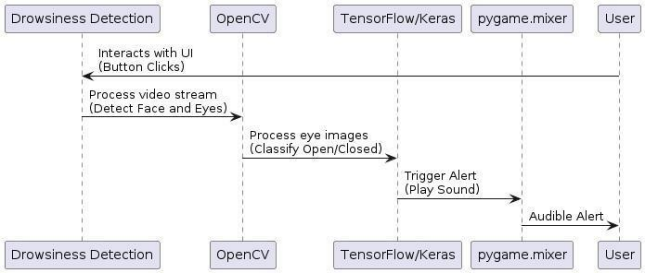


Figure: UML Diagram 5

G. UML Diagram 5(Class Diagram Figure)

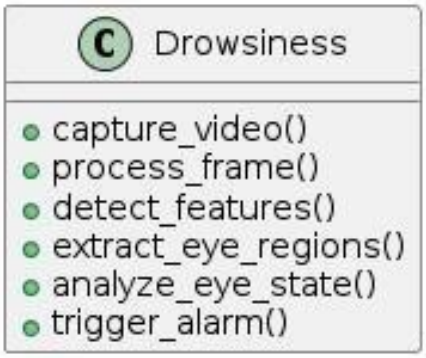


Figure: UML Diagram 5

V. Related Work

In order to identify driver fatigue and provide the driver with appropriate alerts to prevent potential issues, driver monitoring systems have been the subject of extensive research in recent years. There are various methods for identifying driver weariness and drowsiness. As head position tilt is the final stage of sleep, head position detection is a technique to identify changes in head position tilt [3], frequently too late to warn the driver.

The alternative method of detecting aberrant driver behavior involves having the system learn the driver's behavioral traits and then compare the driver's usual and present reaction times to issue an alarm in the event of drowsiness detection. This method is dependent on the driver and requires system training [4, 5]. Although these techniques are complex, speech detection techniques may also be used to identify a potential tired voice in the automobile [6].

Additionally, a driver's biometrics may be tracked and identified using various in-car sensors, and exhaustion can be identified based on the driver's posture and vital signs [7]. However, these techniques can be bothersome to the driver and are a little invasive. Using one or more cameras to watch the driver's facial characteristics in order to identify signs of exhaustion is one of the most often used techniques. These systems have the ability to track and analyze behaviors including yawning, eye closing, and irregular head movements in order to identify and alert the driver to tiredness [8–10]. These systems may make use of stereo, spectrum, and infrared cameras [11].

Despite much study in this field, there is still no precise way to quantify tiredness. Some techniques, which use data from several sensors, including webcams, combine two or more tiredness indicators to improve the efficacy of sleepiness detection [12–14].

The advantages of using the fusion approach based on face traits are utilized in this study. We have put forth a technique that operates regardless of the surroundings or the driver. In order to decrease incorrect decisions and boost the system's resilience, we have also employed the yawn and eye closure characteristics as indicators of drowsiness. Because of the straightforward techniques we used, the concept can be used for real-time commercial applications.

VI. Algorithm Implementation

The suggested method for identifying driver sleepiness is presented in this section. Figure 1 illustrates the four phases involved in determining whether or not a motorist is fatigued. The facial region of the photographed should be removed first. Second, the face contains the ocular region. Third, the mouth ought to be noticed in the facial region. Together, these two challenges help to enhance the face detection outcomes. The excised mouth and eye are then subjected to yawn and eye closure detection tests.

After combining the data, a determination is produced on the driver's level of tiredness. Ultimately, the motorist receives an alarm if they are found to be in a drowsy condition. The process is then repeated with the face tracked in the subsequent frames that are taken. We go into further depth about each stage in the next four subsections.

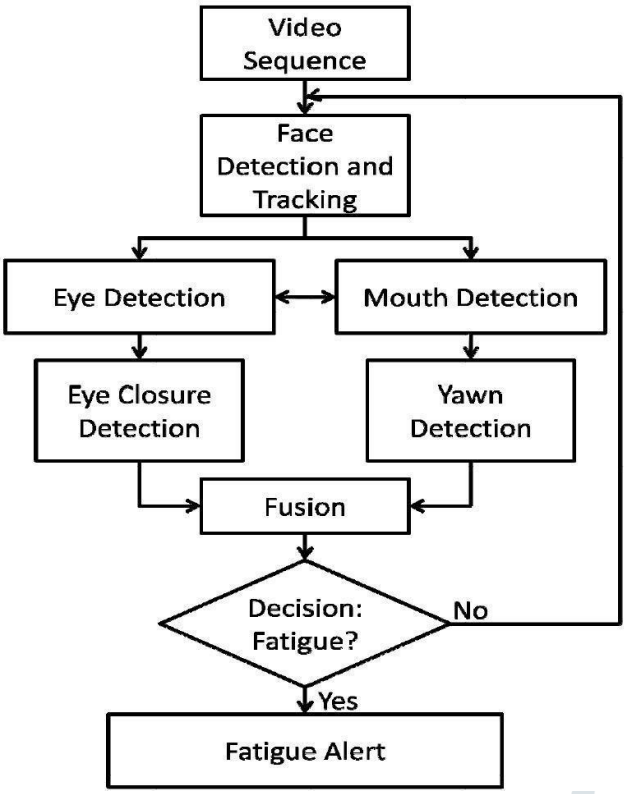


Figure 1. The proposed drowsiness detection system.

A. Face Detection

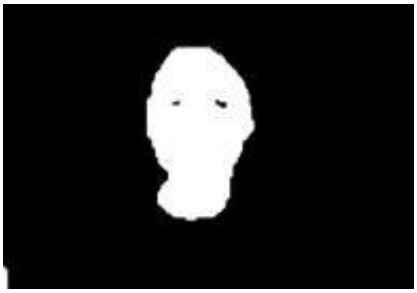
In addition to the face's size, position, color, and form, face detection looks for the face region inside the image under various lighting situations. A suitable face extraction algorithm has to have the capability to identify the facial region for diverse human expressions, including hair, glasses, beards, and mustaches. Extensive study has been conducted in this field; further information is available at [16, 17].

In order to extract the face region from the acquired picture, the skin region is first chosen using the YCbCr and HSV color spaces boundary criteria described in [15]:

$$C_r \leq 1.5862C_b + 20$$
$$Cr \geq .3448C_b + 76.2069$$
$$C_r \leq -1.15C_b + 301.75$$
$$Cr \geq -4.5652C_b + 234.5653$$
$$C_r \leq -2.2857C_b + 432.85$$
$$H < 25$$
$$H > 230$$

where logical "AND" is used to apply the five first criteria on the Cr and Cb components, and logical "OR" is used to combine the two latter requirements for the H component. The identified skin area is then turned white, while the backdrop turns black. The largest and most linked component of the identified skin area is ultimately determined to be the facial region after a few morphological procedures.

(a) Original Image



(b) Processed Image

(c) The Biggest Component (d) Extracted Face

Figure 2. Illustration of face detection algorithm

An example of a face detection process is shown in Figure 2. The eye and mouth are taken out of the detected face in the next two subsections. The next largest component is chosen as the face region if these regions cannot be discovered, and the detected component is omitted. This step serves to increase the accuracy of face identification, particularly in situations when there are other objects in the image that have components of skin tone or in locations with uneven lighting.

B. Eye Detection

Using the Structural Similarity Measure, we were able to extract the eyes from the face (SSIM). A new technique for determining how similar two photos are is called SSIM. This measure is more compatible with the Human Visual System (HVS) model and boosts the efficacy of the video quality assessment. It uses statistical features of the image, such as mean and variance, as demonstrated in [19]. Recent tests have shown that SSIM performs better than traditional metrics like Mean Squared Error (MSE) and Peak Signal to Noise Ratio (PSNR). This is how it is described:

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

$$C_1 = (K_1 L)^2$$

$$C_2 = (K_2 L)^2$$

$$K_1 = .01, K_2 = .03$$

where the similarity measure is computed between two images, x and y. L is the dynamic range of the image's pixel values. HS stands for the variances of x and y, respectively. μ and μ 6 are their means. The range of the SSIM values is -1 to 1. When two photos are identical, the maximum value of one is obtained. A template and SSIM are utilized to determine the optimal fit for the eyes. Additionally, the selection accuracy is verified using the eye map method described in [16].

1.) Eye Closure Detection

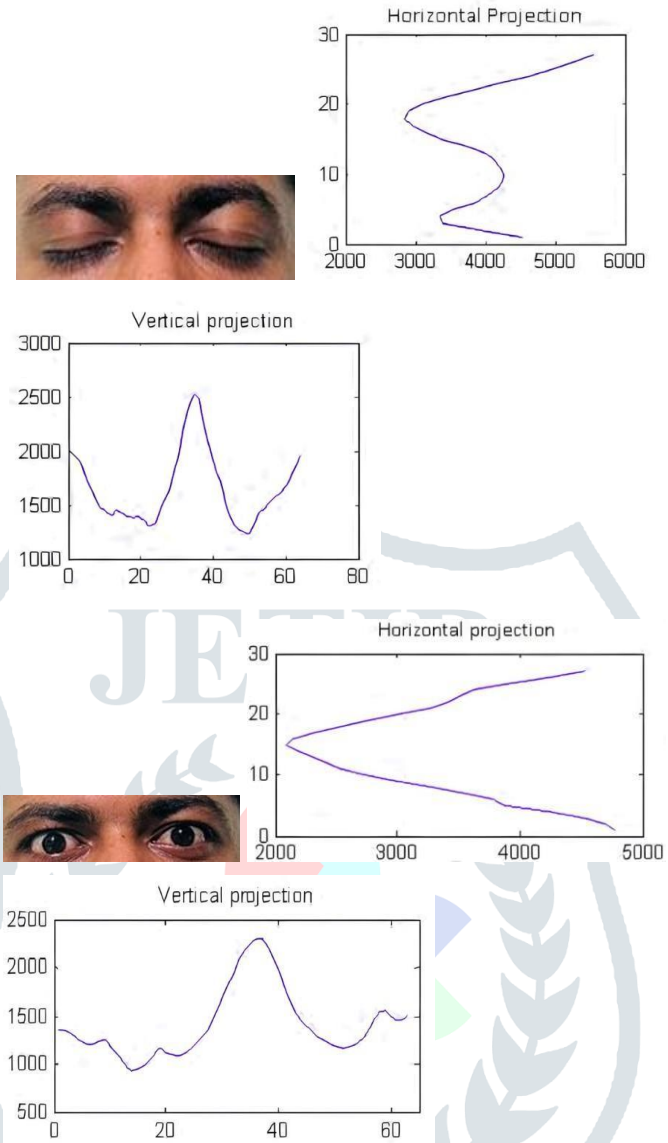


Figure 3. The extracted eyes and their horizontal and vertical projections.

The area's horizontal projection is used to ascertain the eyes' closure after they have been removed. There is a local maximum in the middle of the plot in the event of ocular closure. In addition, the vertical projection is used to match the identified eye region, where the curve should have local minima as it moves away from the center and a local maximum in the middle.

C. Mouth Detection

The technique suggested in [16] is applied to separate the mouth region from the facial area. This is an easy approach that operates in the YCbCr color space. The mouth map is computed, then binarized and morphological operators are applied. The largest linked part will be the mouth region.

1.) Yawn Detection

When yawning, the extracted mouth's aspect ratio exceeds a threshold, which is how the yawn is identified. Experimentally, a threshold of.65 is chosen. In order to strengthen this step further, the mouth region is examined to determine whether there is a hole in its map; if so, the yawning state is verified. Figure 4 presents two instances

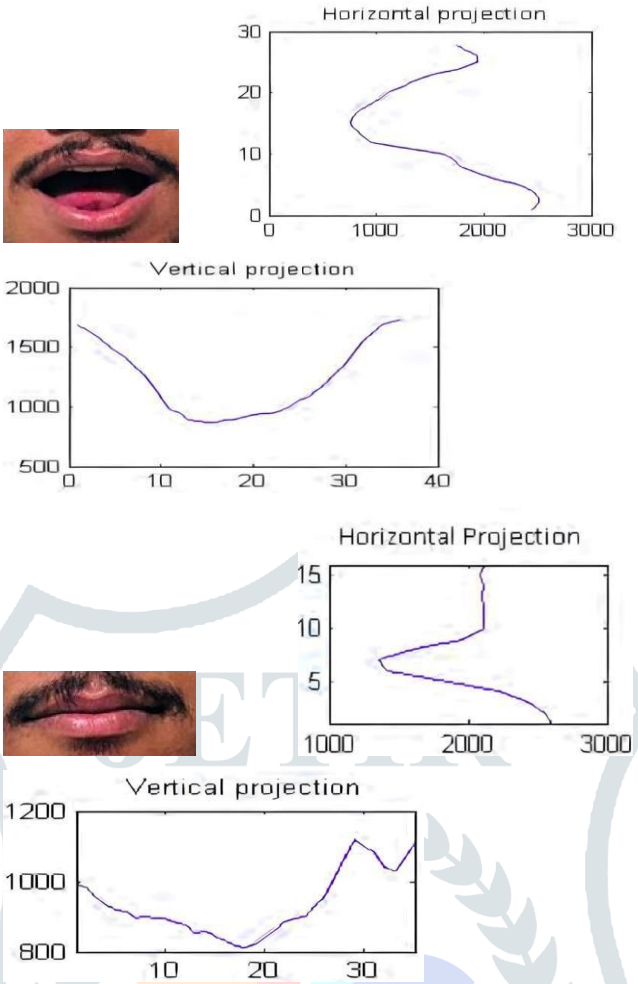


Figure 4. The extracted mouths and their horizontal and vertical projections.

Figure 5. Some examples of face detection.
Right column: Original image. Left column: extracted face

D. Fusion and Decision Making

Fusion can be used in recognition systems at three different stages: feature extraction, judgment, or similarity scoring [18]. Fusion has been used in the decision-making step, where driver fatigue is identified and the driver receives an appropriate alert if any of the following occurs:

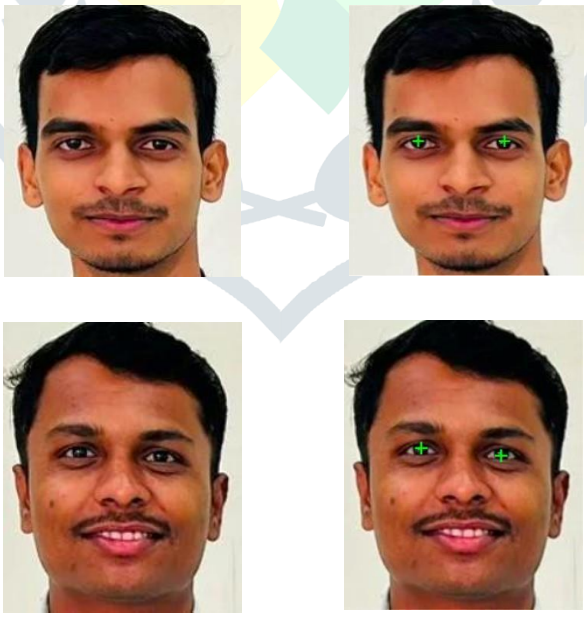
- Both eye closure and yawning are observed simultaneously.
- The eye closure (eye closure lasting longer than a second) is observed in several subsequent frames.
- A single second's worth of consecutive frames are used to detect and repeat yawning.

For our findings, we took three degrees of sleepiness into account. Normal characteristics may be identified in state 0, which is known as the "Alert" state. In this stage, there is no discernible yawning symptom, and eye closure occurs solely when blinking, lasting less than a second. The first condition is referred to as "semi drowsy," during which yawning is observed and blinking frequency increases. The "drowsy state," or state 2, is characterized by largely closed eyelids and prolonged yawning.

E. Face Tracking

The best match is chosen as the face area candidate. This process is used to track the face in the video sequence by computing SSIMs between the identified face in the previous frame and its surrounding blocks in the current frame. The mouth and eye region is taken as the new face template to be utilized in the subsequent computations if they are successfully picked from the candidate area. In the event that the mouth and eye extraction step is unsuccessful, a wider surrounding area will be examined.

VII. Experimental Results



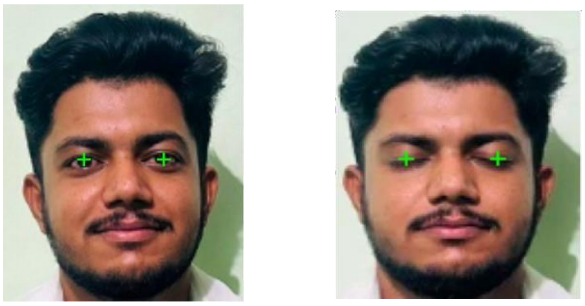


Figure 6. Samples of eye detection results

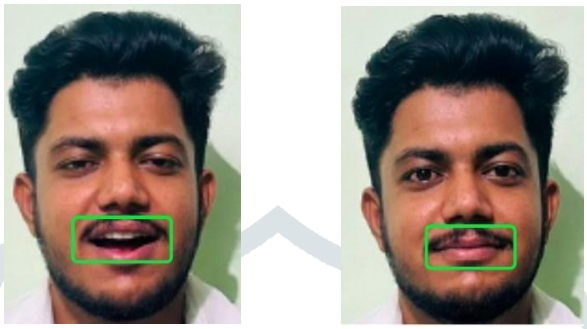


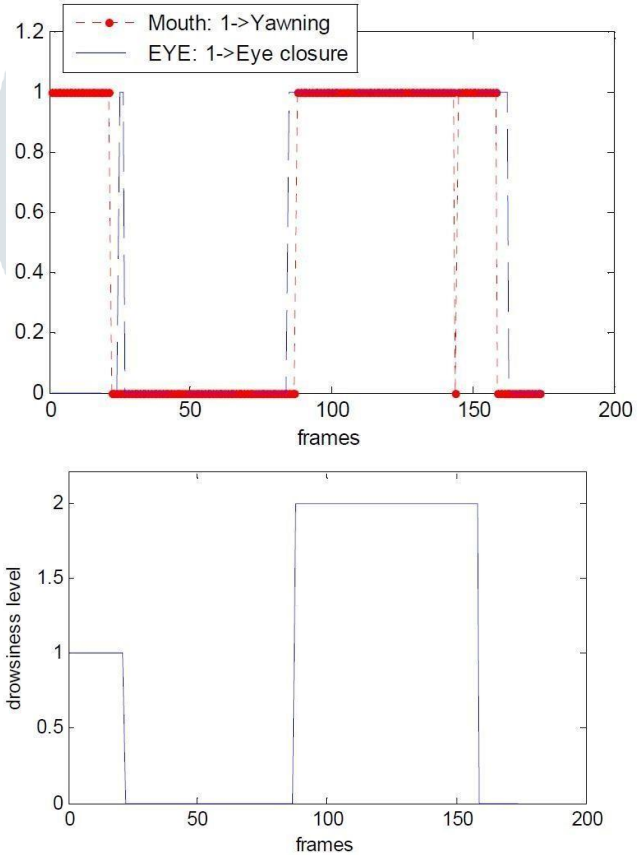
Figure 7. Two examples of Mouth detection results

We have used our concept on many video clips that were taken on various subjects. For the testing, ten video sequences with ten thousand video frames were used. Every film is shot in a variety of lighting settings and from different angles. The temporal sampling rates were 30 frames per second, with spatial sizes of 480x640 and 320x568.

The facial region of the picture is first removed. For the database in [20], the accuracy of face detection is 98%. Figure 5 displays a few samples of the retrieved faces. Following the extraction of the face, the eye and mouth are separated, and the methods outlined above are used to estimate the yawning and eye closure. Figures 6 and 7 display a few instances of the eyes and lips that were found.

Figure 8. Face tracking examples.

Ultimately, the degree of tiredness shown by the driver is ascertained by analyzing their historical performance in prior frames and the current eye closure and yawning detection data. Figure 9 shows an example of the eye closure and yawn detection findings. One instance of face tracking is seen in Figure 8, where the face block in each subsequent frame is properly matched using the SSIM measure. Despite its modest complexity, this approach finds the best match rather effectively.



(b)Drowsiness level

Figure 9. One Example of Determining of Drowsiness Level

VIII. Other Specification

A. Advantages

- Accurate Drowsiness Detection: The system utilizes advanced image processing techniques and machine learning algorithms, particularly Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), to accurately detect signs of driver drowsiness, such as yawning and eye closure.
- User-Friendly Interface: The application provides a user-friendly interface where users can easily interact with the system. Users can receive real-time alerts and warnings about their drowsiness status, enhancing safety during driving.
- Visualizations and Explanations: The system includes visualizations and explanations of the drowsiness detection process, helping users understand how their facial features are analysed to determine their drowsiness level. This transparency increases users' confidence in the system's warnings and promotes safer driving practices.
- Real-Time Warnings: Users receive real-time warnings when signs of drowsiness are detected, allowing them to take immediate corrective actions, such as taking a break or pulling over, to prevent potential accidents.
- Scalability: The system is designed to be scalable, allowing for future enhancements and integration with additional sensors or features to further improve drowsiness detection accuracy and usability.

B. Limitation

- Dependency on Image Quality: The accuracy of drowsiness detection may be affected by the quality of the captured images, such as low lighting conditions or obscured facial features, which could lead to false positives or false negatives in drowsiness alerts.
- Individual Variability: The effectiveness of the drowsiness detection algorithm may vary depending on individual differences in facial features and behavior patterns, leading to occasional inaccuracies in detecting drowsiness for certain users.
- Processing Latency: There may be a slight processing latency in analyzing facial features and generating drowsiness alerts, particularly in situations where the system experiences high computational load or limited hardware resources

C. Applications

- Driver Safety Enhancement: The system serves as a critical tool for enhancing driver safety by providing timely warnings and alerts to prevent accidents caused by drowsy driving.
- Fleet Management: Companies operating vehicle fleets can integrate the system into their vehicles to monitor driver drowsiness in real-time and implement proactive measures to ensure the safety of their drivers and assets.
- Regulatory Compliance: The system can help organizations comply with regulations related to driver safety and drowsiness detection, reducing the risk of regulatory penalties and liabilities associated with accidents caused by fatigued driving.
- Research and Development: Researchers and developers can use the system as a platform for further research and development in the field of driver monitoring systems, contributing to advancements in automotive safety technology.
- Public Awareness Campaigns: The system's capabilities can be leveraged in public awareness campaigns to educate drivers about the dangers of drowsy driving and promote safer driving habits and behaviours.

IX. Conclusion

In our project, we offer an advanced approach for intelligently detecting driver drowsiness through a fusion-based method. Our technology monitors a driver's behaviour patterns and alerts them to their awareness level in an attempt to reduce the major risk that driver weariness poses. weariness can cause delayed reactions and potentially catastrophic accidents. Our approach improves robustness and reliability by merging the yawn and eye closure detection processes, resulting in precise sleepiness detection. Especially, our algorithms are made to be simple and easy to use in business settings. Our approach's independence from particular disciplines, which does away with the requirement for in-depth system training, is another significant benefit. Experiments verify our suggested scheme's better efficacy and efficiency in practical situations.

X. Literature Survey

Year	Title Of Paper	Author	Conclusion
2021	Monitoring Driver's Drowsiness Status at Night Based on Computer Vision	Vidhu Valsan A; Paul P Mathai; Ierin Babu	Drowsiness and fatigue decreases the vehicle management skills of a driver. The operator driving vehicles at night has become a significant downside today. Driver in a drowsiness state is the one among the important reasons for the increasing amount of road accidents and death. Hence the drowsiness detection of drivers is considered as the most active research field. Many ways are created recently to detect the drowsiness of driver

2018	Portable Prevention and Monitoring of Driver's Drowsiness Focuses to Eyelid Movement Using Internet of Things	Menchie Miranda; Alonica Villanueva; Mark Jomar Buo; Reynald Merabite; Sergio Paulo Perez; John Michael Rodriguez	This paper includes a drowsiness prevention device since recently vehicular count of accidents increases yearly in the Philippines. Current safety measures are followed to increase the driver's awareness which includes the use of standard rumble strips on road reference, installation of GPS, speed limiters.
2015	Safe driving by detecting lane discipline and driver drowsiness	Yashika Katyal; Suhas Alur; Shipra Dwivedi	In the modern day world, road accidents have become very common. They not only cause damage to property, but also keep at risk the lives of people traveling. Road safety is an issue of national concern, looking at its magnitude and the incidental negative impacts on the economy, public health, safety and the general welfare of the people.
2011	Intelligent driver drowsiness detection through fusion of yawning and eye closure	M. Omidyeganeh; A. Javadtalab; S.Shirmohammadi	Driver drowsiness is a major factor in most driving accidents. In this paper we present a robust and intelligent scheme for driver drowsiness detection employing the fusion of eye closure and yawning detection methods. In this approach, the driver's facial appearance is captured via a camera installed in the car. In the first step, the face region is detected and tracked in the captured video sequence utilizing computer vision techniques.

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