A Vision-Based Driver Drowsiness Detection Framework for Road Safety Enhancement

P. Kavya[1], P. Jayaselvi[2], U. Lavanya[3], N. Rajesh[4] and M. Prashanth[5]
{21691A2869@mits.ac.in[1], jayaselvip@mits.ac.in[2], 21691A2873@mits.ac.in[3], 21691A28D2@mits.ac.in[4], 22695A2812@mits.ac.in[5]}

UG Scholar, Department of Computer Science and Technology Madanapalle Institute of Technology & Science, Madanapalle, Andhra Pradesh, India[1, 3, 4, 5]
Assistant Professor, Department of Computer Science and Technology Madanapalle Institute of Technology & Science, Madanapalle, Andhra Pradesh, India[2]

Abstract. Driver drowsiness and diversion are major causes of traffic accidents, posing significant risks to street security. It points to create a progressed driver observing framework that leverages YOLOv5 object detection to distinguish early signs of fatigue and distraction. The system uses a custom dataset to detect facial features, such as blinking, turning the head, in order to detect fatigue. It also connects three basic features: automatic call discovery, distraction alertness, yawning detection. The system is programmed to detect when the driver is on a call, which helps reduce distractions. The distraction detection feature triggers an alert when abnormal head movements or changes in head position are detected, indicating potential fatigue or distraction. The Excessive yawning is a valuable indicator of fatigue and should be monitored

Keywords: Driver Monitoring, Drowsiness Detection, YOLOv5, Real-Time Alert System, Distraction Detection, Road Safety.

1 Introduction

Driver fatigue and distractions are among the driving causes of traffic accidents, posturing critical dangers to road safety. To address this issue, our venture presents a vision- based driver drowsiness discovery system that utilizes profound learning methods and computer vision [1]. The proposed framework coordinating YOLOv5 for object detection and facial analysis., identifying signs of drowsiness through key pointers such as eye closure, head tilting, and yawning. This framework presents inventive highlights, counting programmed call discovery, diversion readiness, and the system also incorporates seatbelt detection as an additional safety feature, guaranteeing a comprehensive approach to mischance avoidance [2]. By leveraging machine learning calculations like CNN, LSTM, and SSD, the framework precisely recognizes fatigue-related behaviors and cautions the driver in genuine time [3]. The novelty of this research lies in its multi-feature integration, flexibility to different driving conditions, and non-intrusive checking approach, flexibility to different driving conditions, and non-intrusive checking approach [4]. By deploying this innovation in vehicles, able to essentially diminish street mischances caused by tiredness and move forward generally activity security. This work aims to bridge the gap between existing detection methods and real-time, practical execution for enhanced road safety [5].

2 Literature Survey

Ahmet Kolus, ‘A systematic review on driver drowsiness detection using eye activity measures’,

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in IEEE Access, vol. 12, pp. 97969–97993, 2024. The paper presents an Extensive survey on methods developed for driver eye behavior tracking and fatigue detection[6].

A. H. Al-Bayati, A. S. Shakoree, and Z. A. Ramadan, “Factors Influencing Traffic Accidents Rate on Selected Rural Multilane Highways,” Civil Engineering Journal vol. 7, pp. 1183–1202, Jul. 2021. The present study investigates the factors influencing traffic accident densities on multilane rural highways. Drowsy driving, speeding, inadequate lighting, and careless lane changes are identified as the top causative factors through statistical analysis based on actual traffic data. [7]

B. C. Tefft, “Drowsy driving and motor vehicle crashes: a trend evaluation of 1999–2008 National Highway Traffic Safety Administration, Washington, DC,” AAA Foundation for Traffic Safety, 2010. The present research conducted a detailed analysis to assess the frequency and regional distribution of drowsy driving crashes in the US over a 5-year period. Here, a straight face provides evidence showing that the official crash data vastly underrepresents the number of people who drive while sleepy. [8]

O. Gül and R. Yılmaz, “A review of driver drowsiness detection systems: Techniques and future directions,” International Journal of Human-Computer Interaction, 2021. In this review, we have gleaned the literature to provide an essential overview of driver drowsiness detection techniques falling under behavioural, physiological and vehicular based approaches. [9]

Bhardwaj, P., Saha, S.: A study on real-time driver drowsiness detection system using eye and physiological signals. In this study, we proposed and experimentally investigated a real-time design solution to recognize the sleepiness behavior of driving that integrates eye-based features and physiological signals. [10]

Singh, R., & Jain, S. (2021). A Review on Modern Trends in Driver Drowsiness Detection Systems. International Journal of Automotive Technology. In this paper, we present advancements in monitoring driver alertness with a focus on new machine learning and computer vision-based techniques. [11]

Sharma, S. Kumar, A Survey on State-of-the-Art the growing trend of deep learning and computer vision in non-intrusive, camera-based detection systems. It starts by describing the motivation and contributions of the study, qualifying existing work on in-cabin sensing based on functional requirements, before presenting key challenges such as their adaptation to varying illumination conditions or high inter-subject variability among drivers; concluding with multi-modal integration aiming at increased robustness for real-world applications. [12]

Al-Bayati, A. H.; Shakoree, A. S..; Ramadan, Z. A., "Factors affecting traffic accidents density on selected multilane rural highways," Civil Eng., J., vol. 7, pp. 1183–1202, July 2021. In this paper, we investigate the variables influencing traffic crash rates for multilane rural highways. Throwing light on the significance of driver fatigue and drowsiness also played a major role in raising the risk of accidents on these highways. [13]

B. C. Tefft, “Prevalence of Motor Vehicle Crashes Involving Drowsy Drivers, United States, 2009-2013,” A Found. Traffic Saf., Washington DC, USA 2014. Pages 1–10. Description: This report describes the underreporting of sleep-related motor vehicle crashes in official records and offers statistical analyses to show that this problem is particularly acute with regard to drowsy driving, while suggesting the utility of better detection methods. [14]

Salmon, P. M., Read, G. J. M., Beanland, V., Thompson, J., Filtness, A. J., Hulme, A.; McClure,R.and Johnston,I.(2010) "Bad behavior or societal failure? Causes of terminal five views on driving behavior a mixed-methods study, Appl. Ergonom., vol. 74, pp. 162–171, Jan. 2019. The aim of this paper is to examine psychological determinants and social factors involved in dangerous driving behaviors (drowsy, distraction, fatigue), also the manner through which such behaviors are associated with crash risk. [15]

3 Proposed Methodology

The camera monitors the driver, relaying a live video feed, relaying a live video feed to a system that can determine fatigue and inattention. In order to detect and track important facial regions separately for each frame such as eyes and mouth, we use the YOLOv5 object detection algorithm which is a fast and reliable one. After the face is detected, this algorithm extracts the left eye, right eye and mouth regions which are then used in further analysis. The classified features include indicators of open or closed eyes, as well as yawning behavior. The system recognizes that as a human tightens their eyes for longer periods, or begins to yawn with some regularity, he or she is likely falling asleep. It then causes a microcontroller to emit a buzzer alert and can also send commands to stop the motor of the vehicle, in effect making the driver know immediately while enhancing road safety. Fig 1 shows the driver drowsiness detection system workflow.

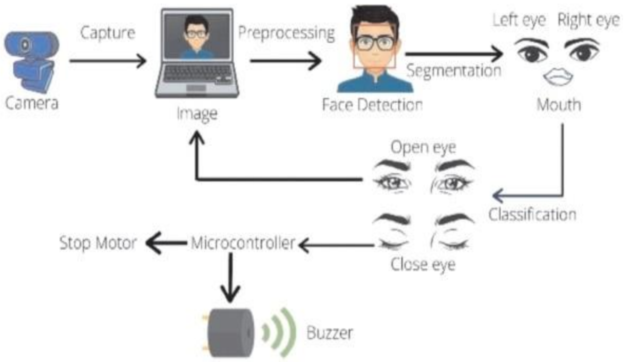

Fig.1. Driver Drowsiness Detection System Workflow.

The feature extraction and model development stage utilize YOLOv5 for real-time question location, centering on facial features, head movements, and hand motions. Within the real-time checking and alarm framework, a camera setup will ceaselessly track the drivers confront and behavior. Alarms will be activated when signs of tiredness, diversion, or phone utilization are recognized. These incorporate:

Step 1: Real-Time Video Capture

A webcam or onboard camera is employed to constantly monitor and record real-time video of the drive face while the vehicle is in motion.

Step 2: Image Preprocessing

The captured video frames are sent to a processing unit (e.g., laptop or embedded system), where they undergo preprocessing operations such as resizing, grayscale conversion, and noise reduction to enhance feature visibility and computational efficiency.

Step 3: Face Detection

Using facial detection algorithms, the system detects and isolates the driver's facial region from each frame. This ensures the focus remains on relevant regions for further analysis.

Step 4: Facial Feature Segmentation

The system isolates key facial components, specifically the left eye, right eye, and mouth, to examine signs of fatigue or drowsiness.

Step 5: State Classification

The eyes are classified as either open or closed based on the shape, pixel intensity, or trained models.

The mouth is monitored to identify potential yawning behavior based on its openness over time.

Step 6: Drowsiness Evaluation

If the eyes remain closed beyond a certain threshold or if the mouth stays open in a yawning pattern for a few seconds, the system flags this as a sign of reduced alertness.

Step 7: Alert and Response Mechanism

Once minute is detected, a signal is transmitted to a microcontroller, which activates: An audio buzzer to wake up the driver at once.

Optionally, the motor stop signal can stop the vehicle or trigger additional safety measures.

Step 8: Continuous Monitoring

The system is in operation at all times and quickly processes every single frame to ensure the driver is alert and ready to takeover if required.

4 Performance Metrix

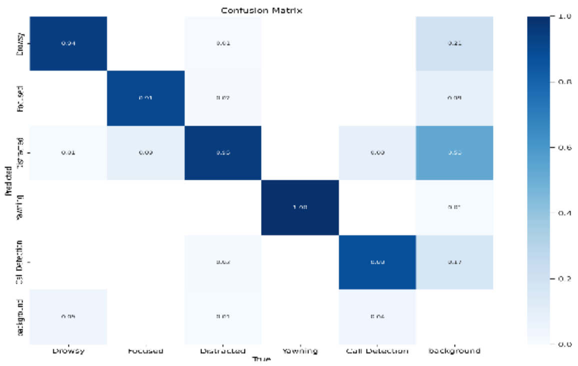

Fig. 2. Confusion matrix.

Fig 2 shows the confusion matrix. To assess the performance of the proposed driver's fatigue detection system, the following key performance metrics will be employed. These measures will assess how accurately, reliably and efficiently the system performs in practice.

Precision– This represents the system's ability to accurately detect situations such as driver drowsiness, distractions, and mobile phone usage, reflecting its overall detection capability.

Formula-1:

Accuracy = (True Positives + True Negatives) / (True Positives + True Negatives + False Positives + False Negatives)

Precision – It is a measure for how good or bad the system was in its drowsy detection. A value of higher precision indicates that the system generates less false drowsiness alarm.

Formula-2:

Precision = (True Positives) / (True Positives + False Positives)

Recall (Sensitivity) – This measure of how well the system does in recognizing true drowsiness is calculated as the ratio of true detected drowsy online instances to the total number of cases of actual drowsy online instances, indicating the model capability to recognize the real fatigue condition.

Formula-3:

Recall = (True Positives) / (True Positives + False Negatives)

F1 Score – A combined measure that incorporates both precision and recall to provide an overall evaluation for the effectiveness of the system.

Formula-4:

F1 Score = 2 × (Precision × Recall) / (Precision + Recall)

Latency – This is how long it takes the system to detect drowsiness and sound the alert. Reduced latency means a faster reaction to driver fatigue and inattention.

These measures could facilitate an evaluation of the dependability and the potential effectiveness of the driving safety function supported by the system.

5 Design & Implementation

Driver fatigue detection is a system that continually checks the face expression of the driver in real time and can detect whether a driver is drowsy or careless. We have used a camera in a car mounted on the front that records a video, which will be used in doing a frame by frame analysis. These frames were fed for some basic operations like resizing, normalization, etc. that helps remove noise or blur in the input data. We have defined a detection algorithm to detecting various features of the face using the YOLOv5 deep learning model, such as eyes, lips, whether a mobile phone has been detected near the ear, and more.

So, for each frame we find a human face and then extract the key facial points like eyes & lips using Dlib & Mediapipe. By monitoring their eye aspect ratio, the system is able to detect a blink closure, and if the eyes remain closed for longer than four seconds an audio chime goes off warning the drowsy driver. Likewise, the time that your mouth stays open is how swallowing is distinguished. If the mouth stays open for more than four seconds then a unique warning sound will trigger for the driver. One detector in the YOLOv5 model tracks where the hand is located near their ears to detect whether drivers may be using their phones and getting distracted. The system issues a reminder for the driver to drive more attentively if there is phone operation on each side.

The system also detects driver distraction through gaze direction and head pose analysis. Behaviors are considered distractions if the driver turns left or right for more than four seconds from the road. The microcontroller then triggers the activation of a buzzer and can interface with the vehicle's control system to slow it down or stop if any of these conditions occur. A log file with timestamps is created for every alert, and the frame that generated the alert is saved as an image. A Graphical User Interface (GUI) presents real-time visualizations from the camera feeds, notifies alerts and summarizes the aggregate count of each type of alert detected during the session. The design with its integrated approach allows for accurate real-time detection and response to unsafe driving, resulting in a safer driving experience.

Drowsiness Caution – Activated when delayed eye closure or over the top yawning is recognized.

Diversion Alarm – Actuated when irregular head developments show inattentiveness.

6 Result

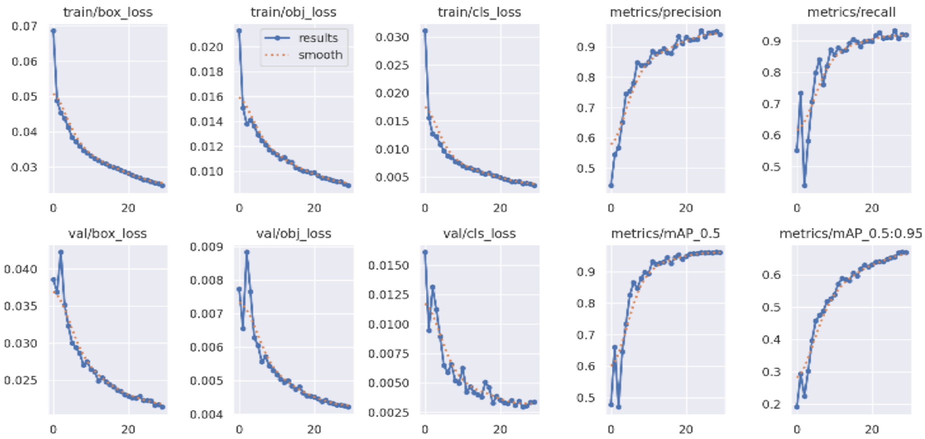

Fig.3. Training and Validation curve.

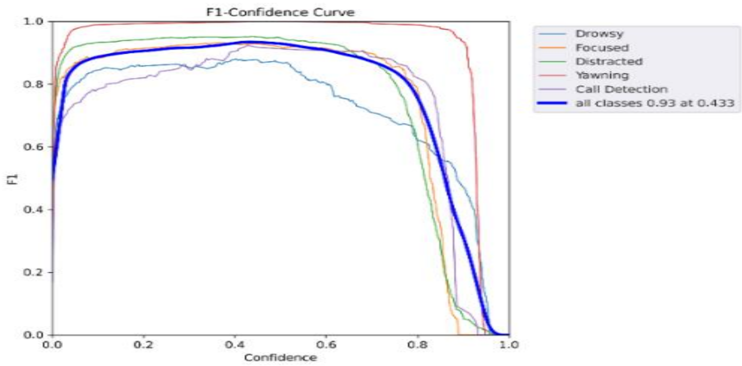

Fig. 4. F1-Confidence Curve.

Fig 3 shows the Training and Validation Loss and Performance Metrics Over Epochs and Fig 4, 5 and 6 shows the f1 confidence, precision and recall curve.

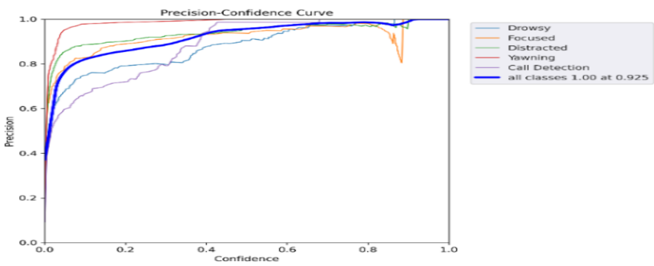

Fig. 5. Precision Confidence Curve.

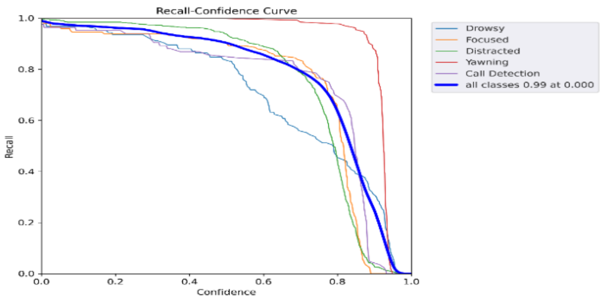

Fig. 6. Recall -confidence Curve.

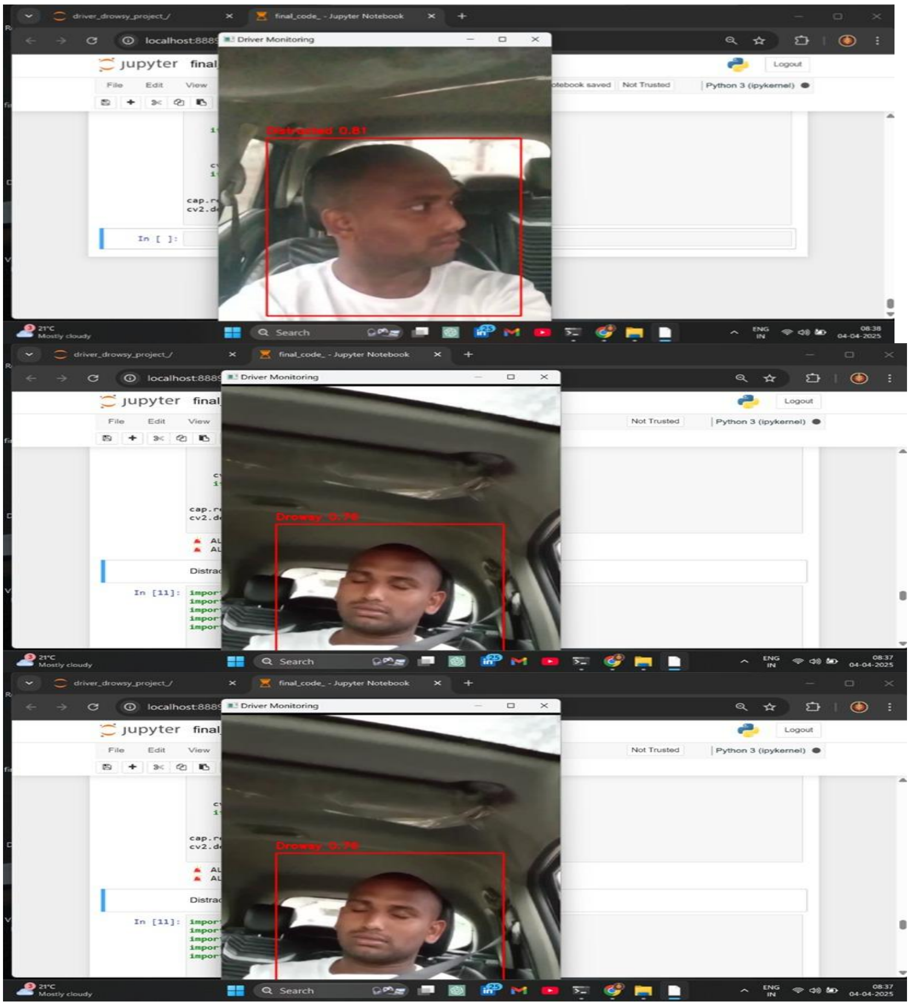

Fig.7. Real-Time Detection of Driver Drowsiness, Mobile Use, and Distraction.

Fig 7 shows the real time detection of driver drowsiness, mobile use and distraction.

7 Conclusion

The Driver Drowsiness Detection system has been successfully developed with the purpose of enhancing road safety by identifying the drowsy or distractive signs accurately and promptly. Drowsiness is detected by computer vision-based methodologies for analysing expressions and eye movements of the driver using the system. In order to make it more functional and smarter in all sense, the system has other features as well like detection of call automatically, alertness of drowsiness and yawn analysis. The automatic call detection mechanism will recognize that the driver is in a phone call while driving, which has most likely led to accidents and will tell and force the driver to concentrate on the road instead. The driver attention distraction alert module monitors head position and eye gaze direction to see whether the driver's not watching the road, and if he isn't it nudges on his arm. Yawning identification, in contrast to eye closings, provides an early sign of fatigue since most rounding of the eyes is accompanied by numerous yawns. With these attributes as a whole the system not only focus on drowsiness identification but also handles all other unsafe actions of the driving. The live alerts mean that the driver can make the necessary corrections immediately, meaning tiredness or distraction-based accidents are greatly reduced. This work presents the idea of a posture alert-n-advice device that is robust and economical which can be extended to form an inbuilt component as part of the now a day’s automobiles so that driving becomes safer and road accidents could be prevented.

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