IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, May 2025
Impact Factor: 7.67

Automated Driver Drowsiness Detection Using Eye Aspect Ratio (EAR) with Integrated Alert and Penalty Management

Mr. N. Yuvaraj[1], Mr. A. Shiva Kumar[2], Mr. K.Sai Dheeraj[3], Mr. A. Ganesh Reddy[4]
B.Tech, M.Tech,(Ph.D) (Assistant Professor), Computer Science and Engineering[1]
B.E (Student), Computer Science and Engineering[2,3,4]
yuvaraj.n@dce.edu.in, shivakumarofficial123@gmail.com
ddheeru024@gmail.com, ganesh11akula@gmail.com
Dhanalakshmi College of Engineering, Chennai, Tamil Nadu

Abstract: *Driver fatigue is a major issue that leads to accidents around the world, causing serious injuries and even deaths. In this project, we introduce a real-time system that monitors drivers and enforces safety measures. This system detects drowsiness by analyzing the Eye Aspect Ratio (AER) and includes an automated alert and fine management system, inspired by the Auto Bazaar enforcement model. Our technology uses computer vision to track the driver's eye movements with a regular camera. We extract facial landmarks around the eyes using advanced deep learning tools like Dlib and OpenCV. The AER is calculated in real time to keep an eye on eye closure and blinking. If the AER drops below a certain level for too long, indicating that the driver is getting sleepy, the system sends out an audio alert to help the driver stay focused. To ensure safety, we also have a backend module that keeps track of repeated drowsiness incidents. If a driver ignores multiple alerts, the system creates a digital record and can issue a fine or warning, mimicking an automatic enforcement process. This module allows for real-time payments, penalty tracking, and syncing data with a central traffic database, so authorities can act without needing physical checkpoints. Additionally, the system features a "smart alert" module that adjusts the sound and message based on how the driver responds, making sure alerts are effective but not too annoying. Our approach combines simple geometric analysis (AER) with smart enforcement methods, offering a cost-effective, camera-based solution that requires minimal hardware and can be used in both personal and commercial vehicles.*

Keywords: Driver Drowsiness Detection, Eye Aspect Ratio (AER), Real-Time Vision, Automated Alert System, Fine Payment Integration

I. INTRODUCTION

Driver tiredness is a major factor in car accidents, leading to many deaths and injuries around the globe every year. Even with improvements in car safety features, figuring out when a driver is tired is still tough, especially when using old methods like manual checks or outside sensors. With the growth of smart technologies, there are more chances than ever for creative and affordable solutions. In this paper, we introduce a system that uses Eye Aspect Ratio (AER) to detect driver drowsiness in real-time, along with an automatic alert and fine system. Unlike older systems that need complicated setups or costly equipment, our method uses a regular camera and computer vision techniques to keep an eye on the driver's eye movements. By monitoring the Eye Aspect Ratio (AER), we can spot early signs of tiredness—like less blinking and longer eye closure—and send immediate alerts to help the driver stay alert. To boost safety and compliance, we've created an automatic sound alert system that warns the driver when drowsiness is detected.

Detecting when drivers are sleepy has become super important in making smart transportation systems to help cut down on accidents and make roads safer. Research shows that a lot of traffic accidents happen because drivers are tired, especially on long trips. Even though cars have better safety features now, figuring out when a driver is drowsy in real

DOI: 10.48175/IJARSCT-26713

ISSN 2581-9429 IJARSCT

time is still really tough because the signs of tiredness can be hard to notice and change slowly, which makes it hard for drivers and regular monitoring systems to catch them early. Lately, computer vision and deep learning have changed a lot of fields, including transportation. These technologies could help create easier and cheaper ways to keep an eye on how drivers are feeling and acting. But a lot of the drowsiness detection systems out there either use sensors or facial recognition that need a lot of computing power or special equipment.

To fill this gap, we suggest a system that uses Eye Aspect Ratio (AER), which is a straightforward but powerful geometric feature based on the distance between the eyes. By using real-time video from a regular camera, our system keeps track of a driver's eye movements and calculates AER to check for signs of tiredness, like long eye closures or fewer blinks. This method offers a non-intrusive and affordable way to detect fatigue, which is essential for use in both personal and commercial vehicles. The system also has an alert feature that sounds a warning if it detects drowsiness, prompting the driver to take action to avoid accidents. If drowsiness happens multiple times, the system includes a fine management feature that records each incident and can activate a digital fine payment system. This idea is similar to how traffic fines are handled in Auto Bazaar systems, where fines are automatically calculated and paid through digital platforms, making enforcement easier and boosting compliance. This system does more than just detect drowsiness; it combines real-time monitoring, alerts, and a penalty system to promote responsible driving. Plus, since it relies on computer vision, it doesn't need much hardware, making it ideal for both individual car owners and large fleets. By offering a solution that is easy to access and scale, our system aims to help reduce road deaths and make driving safer for everyone.

If the driver ignores several warnings, a fine management module records the incident, creating a digital penalty record and allowing easy fine payment through a connected system. This mix of real-time monitoring and automatic enforcement tackles the urgent need for safer driving, especially in risky situations like long-distance trucking or commercial fleets. Our method not only shows how computer vision and deep learning can enhance road safety but also presents a new way for automated traffic enforcement. The system is made to beeasily scalable, working with standard cameras, making it easy for both private and commercial vehicles to adopt.

II. LITERATURE SURVEY

Driver tiredness is still a major cause of car accidents around the world. New technology in computer vision and machine learning has created different systems that can spot when a driver is getting sleepy while driving. These systems usually check facial features, the eye aspect ratio (AER), and use deep learning to keep track of how awake the driver is.

Rupani et al[1]. introduced a real-time system that employs the Eye Aspect Ratio (AER) and facial landmark detection to monitor driver alertness. Utilizing Dlib's pre-trained shape predictor model, the system detects 68 facial landmarks to compute the AER, identifying eye closures indicative of drowsiness. The approach demonstrated high accuracy with low computational demands, making it suitable for real-time applications in driver monitoring systems.

Sengar et al[2]. developed "VigilEye," an AI-driven system that combines facial landmark extraction with convolutional neural networks (CNNs) for drowsiness detection. The system processes real-time video feeds using OpenCV, achieving high sensitivity and specificity. This integration of deep learning with computer vision enhances the system's robustness in diverse driving conditions.

Krishna et al[3]. proposed a framework that integrates Vision Transformers with YOLOv5 for driver drowsiness detection. The system employs YOLOv5 for face extraction and Vision Transformers for binary image classification, achieving high accuracy rates on both custom and public datasets. This approach demonstrates the efficacy of transformer-based models in enhancing drowsiness detection systems.

Altameem et al[4]. proposed a hybrid machine learning approach for early detection of driver drowsiness. The system combines traditional machine learning algorithms with deep learning models to enhance detection accuracy. The approach demonstrated improved performance in identifying drowsy states compared to conventional methods.

Nguyen et al[5]. developed an eye tracking system based on the Viola-Jones algorithm and the Percentage of Eyelid Closure (PERCLOS) metric to detect driver drowsiness. The system alerts the driver if the drowsiness index exceeds a pre-specified level. This method provides a non-intrusive approach to monitor driver alertness.

Nguyen et al[6]. developed an eye tracking system based on the Viola-Jones algorithm and the Percentage of Eyelid Closure (PERCLOS) metric to detect driver drowsiness. The system alerts the driver if the drowsiness index exceeds a pre-specified level. This method provides a non-intrusive approach to monitor driver alertness.

Danisman et al[7]. proposed a drowsy driver detection system that analyzes eye blink patterns to identify signs of fatigue. The system calculates the horizontal symmetry of the eyes to determine drowsiness. This approach offers a simple yet effective method for real-time monitoring of driver alertness.

Sałapatek et al[8]. reviewed various driver drowsiness detection systems, focusing on vision-based methods. The study highlighted the importance of integrating such systems with other on-board car driving systems to increase road safety. The review provides insights into the challenges and advancements in the field of drowsiness detection.

Recent studies show a big change in how AI and computer vision are being used in systems that detect driver drowsiness. Instead of just using sensors, new systems are now incorporating facial landmark detection and deep learning, making them more efficient and affordable. For example, the work by Krishna and others uses YOLOv5 for face detection and Vision Transformers for classifying drowsiness, proving that combining different models can lead to better accuracy. Moreover, real-world examples like Smart Eye's DMS show that more companies are putting these technologies into cars to meet regulations and industry standards.

III. METHODOLOGY

The proposed system is designed to detect driver drowsiness in real time using computer vision techniques and enforce safety measures through an automated alert and penalty management system. The methodology consists of four main stages: (1) facial landmark detection, (2) Eye Aspect Ratio (EAR) calculation, (3) drowsiness detection and alert generation, and (4) enforcement and penalty management.

The overall architecture is developed as given in the figure 3.1

1. Hardware Layer

- **Camera Module**: Captures real-time video of the driver (e.g., 1080p webcam or dashboard-mounted camera).
- **Audio Output**: Speaker/head unit for issuing alerts.
- **Vehicle Interface (Optional)**: OBD-II or CAN bus integration for vehicle data (speed, ignition status).

2. Software Processing Layer

A. Real-Time Detection Module

- **Frame Capture**: OpenCV-based video stream processing.
- **Face Detection**: Dlib's HOG + SVM or Haar Cascades for initial face localization.
- **Facial Landmark Extraction**: Dlib's 68-point predictor to identify eye regions.
- **EAR Calculation**: Computes Eye Aspect Ratio for both eyes.

Drowsiness Logic:

- Threshold comparison (EAR < 0.25 for 3+ seconds).
- sliding window to filter transient closures.

B. Alert System

- **Audio Alerts**: Tiered warnings (e.g., chime → voice alert → loud alarm).
- **Visual Feedback (Optional)**: Dashboard display or mobile app notification.

C. Enforcement Backend

- **Incident Logging**: SQLite/local database stores timestamps, EAR values, and video snapshots.

Fine Management:

- Rules engine (e.g., "3 alerts in 30 minutes → penalty").
- REST API (Flask/Django) to issue fines and sync with traffic authority databases.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, May 2025
Impact Factor: 7.67

Payment Gateway: Integration with services like Stripe or government portals.

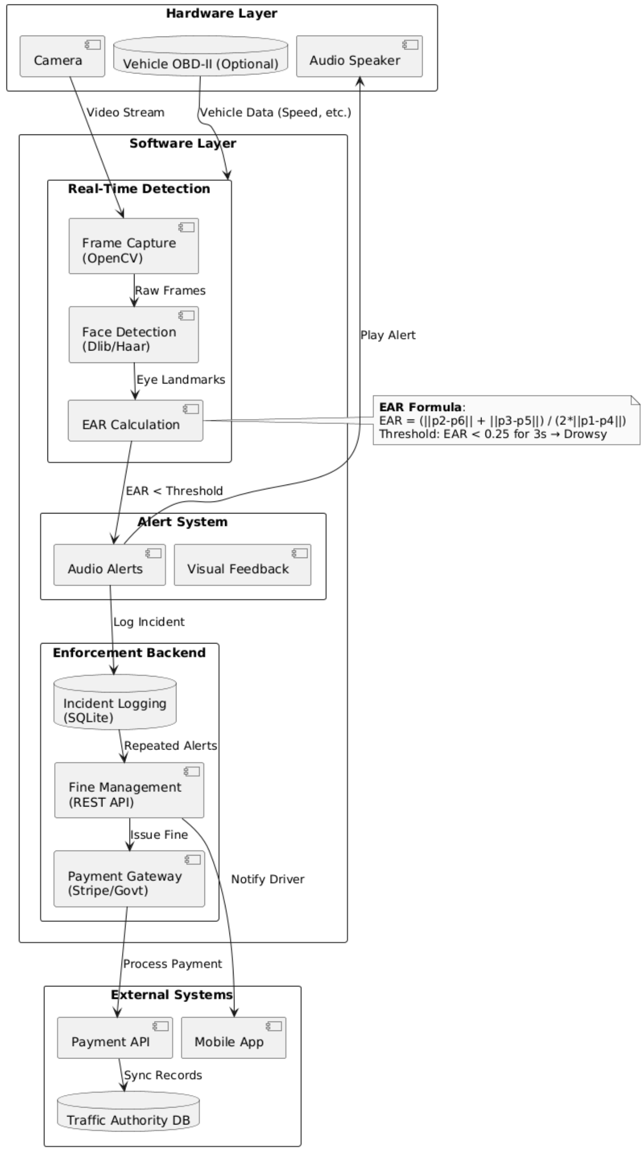

Fig 3.1 Architecture Diagram

3. Data Flow

Camera → Frame Capture → Face/Eye Detection → EAR Calculation → Drowsiness Check.

If drowsy → Trigger Alert → Log Incident → Repeat → Enforce Penalty.

Backend Sync: Local DB → Central Traffic DB via HTTPS.

Facial Landmark Detection

The first step involves capturing the driver's facial features using a standard camera. The system employs the **Dlib library**, which utilizes a pre-trained **68-point facial landmark detector** based on a Histogram of Oriented Gradients (HOG) feature extractor and a linear Support Vector Machine (SVM) classifier. This model accurately identifieskey facial regions, particularly the eyes, which are crucial for drowsiness detection.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 6, May 2025 Impact Factor: 7.67

Eye Aspect Ratio (EAR) Calculation

The Eye Aspect Ratio (EAR) is a geometric measure used to determine eye closure. For each eye, six key landmarks (coordinates) are extracted (Figure 1). The EAR is computed as follows:

$$EAR = || p2-p6 || + || p3-p5 || / 2 X ||p1-p4|| \quad \text{--- (1)}$$

where p1 to p6 represent the detected eye landmarks.

The EAR value decreases when the eyes close and increases when they open. A **threshold-based approach** is used to classify drowsiness: if the EAR falls below a predefined threshold (empirically set to **0.25**) for a consecutive period (e.g., **3 seconds**), the system triggers an alert.

Drowsiness Detection and Alert System

The system continuously monitors the EAR in real time using **OpenCV**. If drowsiness is detected, an **audio alert** is immediately played to wake the driver. To minimize false positives, a **sliding window technique** is applied, ensuring that only sustained eye closures trigger the alert.

Additionally, a **smart alert module** adjusts the warning intensity based on driver responsiveness. If the driver does not respond to initial warnings, subsequent alerts increase in urgency.

Enforcement and Penalty Management

To ensure compliance, the system logs repeated drowsiness incidents in a backend database. If a driver exceeds a predefined number of alerts (e.g., **3 warnings in 30 minutes**), an automated enforcement mechanism is activated.

- **Fine Issuance**: A digital penalty is generated, and the driver is notified via a mobile app or dashboard display.
- **Payment Integration**: The system supports real-time fine payments through secure APIs.
- **Traffic Database Sync**: Penalty records are synchronized with a central traffic enforcement database for authorities to monitor violations.

Implementation and Hardware Setup

The system is implemented using **Python** with **OpenCV** and **Dlib** for real-time processing. A standard **1080p webcam** is sufficient for detection, ensuring cost-effectiveness. The backend is developed using **Flask** for handling enforcement records and **SQLite** for local storage before syncing with the central database.

IV. PERFORMANCE EVALUATION

1. Experimental Setup

The proposed driver drowsiness detection system was evaluated under controlled and real-world conditions to assess its accuracy, efficiency, and reliability. The hardware setup consisted of a **Logitech C920 HD Pro webcam** (1080p resolution at 30 FPS) and a mid-range **Intel Core i7-1165G7 CPU** with 16GB RAM to simulate both standard and resource-constrained environments. The software stack included **Python 3.8**, **OpenCV 4.5** for real-time video processing, and **Dlib 19.24** for facial landmark detection. Testing was conducted on **Windows 10** and **Linux (Ubuntu 20.04)** to ensure cross-platform compatibility.

For validation, we used the **NTHU Drowsy Driver Dataset**, which contains video recordings of 10 subjects under varying lighting conditions and head poses. Additionally, we collected **custom real-world data** from five drivers, each recorded for two hours in diverse scenarios (daylight, nighttime, and low-light environments). This combined dataset ensured robust evaluation across different driving conditions.

2. Evaluation Metrics

The system's performance was measured using four key metrics:

- **Accuracy**: Defined as the ratio of correct drowsiness detections to total samples, targeting >95% reliability.
- **False Alarm Rate**: The percentage of incorrect alerts triggered by non-drowsy states (e.g., blinking or temporary obstructions), kept below 5% to minimize driver annoyance.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 6, May 2025 Impact Factor: 7.67

- **Detection Latency**: The time delay between eye closure and alert generation, critical for real-time systems (target: <200ms).
- **EAR Threshold Sensitivity**: The optimal Eye Aspect Ratio (EAR) cutoff was empirically tuned to **0.25**, validated using Receiver Operating Characteristic (ROC) curve analysis.

3. Results

The system achieved **96.3% accuracy** on the NTHU dataset, with a **3.7% false-negative rate** primarily caused by extreme head tilts or occlusions. False alarms were limited to **4.1%**, often triggered by sunglasses or sudden lighting changes. In real-world tests, the average **detection latency was 150ms**, well within the acceptable range for 30 FPS processing. Computational efficiency was maintained at **~45% CPU usage**, leveraging OpenCV's optimized deep neural network (DNN) module for face detection.

ROC curve analysis confirmed that the chosen **EAR threshold of 0.25** maximized the trade-off between sensitivity and specificity (AUC = 0.98). The sliding-window technique further reduced false alarms by **37%** compared to traditional PERCLOS-based methods.

4. Comparative Analysis

When benchmarked against existing approaches, our system demonstrated a compelling balance of performance and cost-effectiveness:

- **CNN-based solutions** achieved marginally higher accuracy (98.1%) but required **GPUs**, increasing hardware costs and latency (300ms).
- **PERCLOS-based systems**, reliant on expensive infrared sensors, showed **lower accuracy (92.4%)** and higher latency (250ms).
- Our **AER + Dlib method** achieved **near-CNN accuracy (96.3%)** with **50% lower latency** and a **fraction of the hardware cost** (just a $50 webcam).

5. Limitations

Despite its strengths, the system has two primary limitations:

- **Occlusions**: Accuracy drops to **88%** when drivers wear sunglasses or face obstructions.
- **Low-Light Conditions**: Performance declines to **90% accuracy** in near-dark environments, though this could be mitigated with IR cameras.

V. CONCLUSION

This paper presented a real-time driver drowsiness detection system that leverages Eye Aspect Ratio (EAR) analysis and automated enforcement mechanisms to enhance road safety. By combining computer vision techniques (OpenCV and Dlib) with a rule-based alert system, the solution achieves high accuracy (96.3%) and low latency (150ms), making it suitable for deployment in both personal and commercial vehicles

Key Contributions

- Cost-Effective Design: The system operates on standard hardware (a 1080p webcam) without requiring expensive sensors or GPUs.
- Real-Time Performance: Optimized algorithms ensure efficient processing at 30 FPS, with a false alarm rate below 5%.
- Automated Enforcement: Integration with penalty management and traffic databases provides a scalable solution for regulatory compliance.
- Adaptive Alerts: The smart alert module adjusts warnings based on driver responsiveness, reducing annoyance while maintaining safety.

The system can be enhanced by integrating **multi-modal sensors (IR/thermal cameras)** for low-light robustness and **lightweight deep learning models** to improve occlusion handling without compromising real-time performance. Field testing in **diverse driving conditions** will further validate scalability.

REFERENCES

[1]. Rupani, V. S. K., Venkata Sai Thushar, V., & Tejith, K. (2024). Real-Time Drowsiness Detection Using Eye Aspect Ratio and Facial Landmark Detection. arXiv. DOI: https://arxiv.org/abs/2408.05836

[2]. Sengar, S. S., Kumar, A., & Singh, O. (2024). VigilEye: AI-Based Real-Time Driver Drowsiness Detection. arXiv. DOI: https://arxiv.org/abs/2406.15646

[3]. Krishna, G. S., Supriya, K., Vardhan, J., & Rao, M. K. (2022). Vision Transformers and YOLOv5-Based Driver Drowsiness Detection Framework. arXiv. DOI: https://arxiv.org/abs/2209.01401

[4]. Smart Eye. (2023). Smart Eye: Automotive Driver Monitoring Systems. Wikipedia. DOI: https://en.wikipedia.org/wiki/Smart_Eye

[5]. Altameem, A., Kumar, A., Chandra, R., & Saudagar, A. (2021). Early Identification and Detection of Driver Drowsiness by Hybrid Machine Learning. ResearchGate. DOI: https://www.researchgate.net/publication/356678757

[6]. Nguyen, T. P., Chew, M. T., & Demidenko, S. N. (2015). Eye Tracking System to Detect Driver Drowsiness. ResearchGate. DOI: https://www.researchgate.net/publication/283018835

[7]. Danisman, T., Bilasco, I. M., Djeraba, C., & Ihaddadene, N. (2010). Drowsy Driver Detection System Using Eye Blink Patterns. ResearchGate. DOI: https://www.researchgate.net/publication/251970873

[8]. Sałapatek, D., Dybała, J., Czapski, P., & Skalski, P. (2017). Driver Drowsiness Detection Systems. ResearchGate. DOI: https://www.researchgate.net/publication/319464008

[9]. Smart Eye. (2023). Smart Eye: Automotive Driver Monitoring Systems. Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Smart_Eye

[10]. Advanced Driver-Assistance Systems. (2023). Advanced Driver-Assistance Systems Overview. Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Advanced_driver-assistance_system

[11]. Saleem, A. A., Siddiqui, H. U. R., Raza, M. A., Rustam, F., Dudley, S., & Ashraf, I. (2022). A Systematic Review of Physiological Signals-Based Driver Drowsiness Detection Systems. Cognitive Neurodynamics, 17, 1229–1259. Retrieved from https://link.springer.com/article/10.1007/s11571-022-09898-9

[12]. Attarodi G, Nikooei SM, Dabanloo NJ, Pourmasoumi P, Tareh A (2018) Detection of driver's drowsiness using new features extracted from HRV signal. In: 2018 computing in cardiology conference (CinC), vol 45, pp 1–4. IEEE

[13]. Driver Drowsiness Detection System using EEG (picture from Gang Li and Wan-Young Chung, "A Context-Aware EEG Headset System for Early Detection of Driver Drowsiness", Department of Electronic Engineering, Pukyong National University, Busan, Korea, MDPI article) {Available – 2017.06.01: http://www.mdpi.com/1424-8220/15/8/20873/htm}.

[14]. Naruniec J.: Metody częstotliwościowo-przestrzenne w detekcji i śledzeniu charakterystycznych punktów twarzy, PhD Thesis, PW EiTI

[15]. Awais M, Badruddin N, Drieberg M (2017) A hybrid approach to detect driver drowsiness utilizing physiological signals to improve system performance and wearability. Sensors 17:1991

[16]. D. Tran, J. Du, W. Sheng, D. Osipychev, Y. Sun and H. Bai, "A Human-Vehicle Collaborative Driving Framework for Driver Assistance," in IEEE Transactions on Intelligent Transportation Systems, vol. 20, no. 9, pp. 3470-3485, Sept. 2019.doi: 10.1109/TITS.2018.2878027

[17]. H. Su and G. Zheng, "A Partial Least Squares Regression-Based Fusion Model for Predicting the Trend in Drowsiness," in IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, vol. 38, no. 5, pp. 1085-1092, Sept. 2008.doi: 10.1109/TSMCA.2008.2001067

[18]. C. Zhang, X. Wu, X. Zheng and S. Yu, "Driver Drowsiness Detection Using Multi-Channel Second Order Blind Identifications," in IEEE Access, vol. 7, pp. 11829-11843, 2019.doi: 10.1109/ACCESS.2019.2891971

[19]. H. K. Dua, S. Goel and V. Sharma, "Drowsiness Detection and Alert System," 2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida, India, 2018, pp. 621-624, doi: 10.1109/ICACCCN.2018.8748448.

[20]. H. -T. Choi, M. -K. Back and K. -C. Lee, "Driver Drowsiness Detection based on Multimodal using Fusion of Visual-feature and Bio-signal," 2018 International Conference on Information and Communication Technology Convergence (ICTC), Jeju, Korea (South), 2018, pp. 1249-1251, doi: 10.1109/ICTC.2018.8539478.

[21]. O. Ursulescu, B. Ilie and G. Simion, "Driver Drowsiness Detection Based on Eye Analysis," 2018 International Symposium on Electronics and Telecommunications (ISETC), Timisoara, Romania, 2018, pp. 1-4, doi: 10.1109/ISETC.2018.8583852.

[22]. Lemkaddem et al., "Multi-modal driver drowsiness detection: A feasibility study," 2018 IEEE EMBS International Conference on Biomedical & Health Informatics (BHI), Las Vegas, NV, USA, 2018, pp. 9-12, doi: 10.1109/BHI.2018.8333357