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A Review on Driver Drowsiness Detection Systems Using Image Processing and AI Techniques

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Abstract: *Because of its close connection to road safety, driver fatigue detection has become a major area of study in intelligent transportation systems. Drivers who are tired or distracted cause hundreds of accidents each year. This review research looks closely at the methods, difficulties, and most recent developments in the field of real-time sleepiness detection. Recent developments like as Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) are contrasted with more conventional physiological, behavioural, and vehicle-based approaches. The study evaluates sensor modalities, comparative studies, performance measures, and real-world applications, highlighting both current inadequacies and accomplishments. In order to increase resilience, the study also looks into hybrid.*

Keywords: *Machine Learning*

I. INTRODUCTION

Driver fatigue and drowsiness are significant contributors to road accidents worldwide. Studies indicate that fatigue-related crashes are among the top causes of highway accidents, particularly during long-distance and night-time driving. Drowsiness impairs visual perception, reaction time, and cognitive decision-making, making it essential to develop systems capable of early detection and prevention. Traditional techniques such as driver self-reporting, physiological signal measurement (EEG, ECG, EOG), or behavioral observation have proven effective under specific conditions but face challenges regarding cost, comfort, and practicality

The study of tiredness detection has evolved as a result of the quick development of artificial intelligence and the integration of computer vision and machine learning. Deep neural networks and machine learning algorithms are appropriate for embedded automobile applications because of their great accuracy in classifying awareness levels. In order to create reliable sleepiness detection systems, this study examines important research trends, techniques, and technologies while pointing out unresolved issues for further development. Using image and video analysis, current systems are able to recognise facial cues, yawning, head movements, and blinking patterns.

II. LITERATURE SURVEY

S. No	Author(s)	Year	Title	Journal / Source	Notes
1	Fonseca, T., and Ferreira, S.	2025	A thorough analysis of models based on deep learning for identifying driver fatigue A thorough analysis of models based on deep learning for identifying driver fatigue	Applied Sciences, 15(16), 9018	thorough examination of accuracy, datasets, CNN, RNN, hybrid models, and real-time difficulties
2	Lin, C.-T., Damer, N., Fu,	2024	A Summary of Drowsiness Detection: Current	arXiv:2408.12990	Overview of computer vision, eye tracking,

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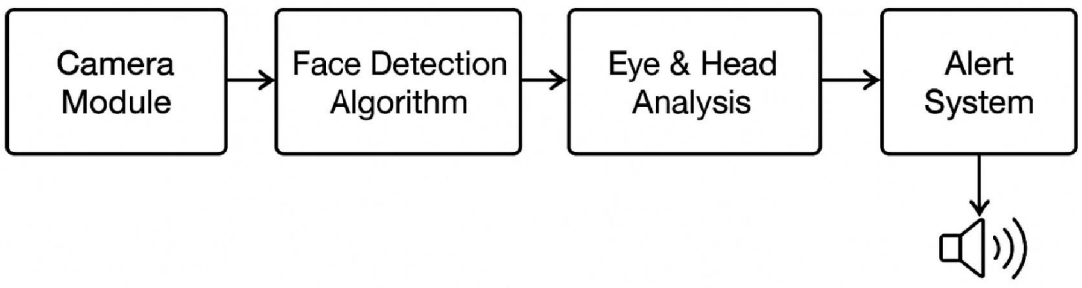
	B., and Boutros, F.		Applications		and EEG techniques; transition from conventional to deep learning systems
3	Maleh, Y., Ouahbi, I., Filali Bouami, M., Essahraui, S., Lamaakal, I., El Hamly, I.	2025	Real-Time Machine Learning and Facial Analysis Methods for Driver Drowsiness Detection	25(3), Sensors, 812	Real-time facial expression-based detection system utilising ML for precise alert generation
4	Jia, Z., Xiao, J., Chang, L., Zhou, X., Lin, D., Liu, C., and Zhai, L.	2023	A Structure for Choosing Interpretable EEG Channels The Guidance-Based Driver Drowsiness Detection	rXiv	maintains detection performance while optimising EEG channel selection.
5	Qian, Y., Zheng, G., Xie, Y., Lv, X., & Zhang, W.	2024	identified fatigued driving.Science and Technology Journal	Journal of Science and Technology Academic	RNNs are used by academics to detect weariness by analysing dynamic face changes over time

PROPOSED METHODOLOGY

Aim Build and implement a real-time driver tiredness detection system with an ESP32 and webcam that monitors the driver's eye movements, identifies signs of drowsiness, and sounds an alert to prevent crashes. Fatigued drivers are one of the primary causes of traffic accidents. The proposed system continuously monitors the driver's face and eyes using computer vision techniques. By calculating the Eye Aspect Ratio (EAR), the system can detect symptoms of fatigue, such as prolonged eye closure or frequent blinking patterns.

1. The ESP32 microcontroller receives a signal from the system when drowsiness is detected.
2. An alert device (LED, buzzer, or vibration motor) is linked to a relay module that is activated
3. By instantly alerting the driver, the warning helps avoid sleep-related collisions.



1. Acquisition of Video

The goal is to record the driver in real time.

Method:

• Make use of a camera module that is attached to a computer or microcontroller, or a regular USB webcam.
• Make sure there is enough resolution and frame rate (at least 15–30 fps) for precise face and eye detection.
• Adequate lighting is necessary; in low light, infrared cameras can be useful.

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2. Facial Recognition
The goal is to identify the driver's face in every video frame.

Method:
Either the OpenCV Haar Cascade Classifier or Dlib Facial Landmarks can be used for face detection; the latter is faster but less accurate for facial features.
• To minimise computation, extract the eyes' region of interest (ROI) after the face has been identified.

3. Eye Detection and Eye Aspect Ratio (EAR) Calculation
The objective is to locate the eyes and measure eye closure.
Approach: Use Dlib's pre-trained face landmark model (68-point model) to recognise eye landmarks. Calculate the Eye Aspect Ratio (EAR):
EAR = (2·||p_1-p_4||)/(||p_2-p_6||+||p_3-p_5||)
And the six key spots around the eye are denoted by p_1 through p_6. EAR is nearly constant when the eye is open and significantly lowers when the eye is closed.

4. Identification of Blinks and Evaluation of Drowsiness
Goal: Ascertain whether the motorist is blinking normally or whether they are displaying symptoms of fatigue.
Method: • Establish a threshold EAR value, usually around 0.25.
• Determine how many consecutive frames have EAR

5.Transmission of Signals to ESP32
Goal: Provide the ESP32 with the detection status so that an alert can be generated.
Method: o If the PC and ESP32 are linked via USB, send a signal via serial communication (UART) when drowsiness is detected.
o If the ESP32 is network-enabled, MQTT or Wi-Fi.
• The signal may be a coded message signalling tiredness or a straightforward digital HIGH/LOW.

6. Activation of the ESP32 Relay Module
Goal: Set off an alert mechanism to let the driver know.
Method: The sleepiness signal is sent to the ESP32.
• Turn on a relay module that is attached to an alert gadget, like a buzzer.
o LED warning light o vibrating motor
• To ensure safe operation, the relay separates the ESP32 from high-power alarm devices.

IV. CONCLUSION

The software Machine Learning for Drowsiness Detection effectively demonstrates how artificial intelligence could enhance road safety and reduce the frequency of fatigue-related events. With the help of Jupyter Notebook, Visual Studio Code, and Anaconda, along with Python modules like OpenCV, TensorFlow/Keras, Pandas, and Scikit-learn, the system successfully managed feature extraction, data preprocessing, model training, and performance evaluation.
The algorithm evaluated key visual and behavioural cues, such as eye closure, yawning, and head movement, using a range of machine learning approaches to accurately categorise driver states as alert or sleepy. In contrast to conventional manual or rule-based detection techniques, this data-driven approach delivers real-time monitoring, lowers the chance of accidents, and promotes safer driving practices.

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