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Survey of Real Time Drowsiness Detection Systems

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Abstract

Driver drowsiness, or getting sleepy while driving, Causes many road accidents every year. To keep road Safe, this paper reviews different way to detect when a driver is getting tired. Two main methods are studied Radar-based systems and Camera –based systems.

Radar can check heart rate and breathing by sensing small Chest movements without touching the driver. Camera systems watch the driver's face and head to see if the eyes are closing or the head is dropping. Using both methods together can give a more complete view of the driver's condition. Studied show radar works well even in low light, and cameras can clearly spot visible signs of tiredness. Combining these methods can make a reliable system that warns drivers before accidents happen. This approach can help reduce accidents, but more work is needed to make it cheaper and easy to use in all cars.

Introduction

Driver drowsiness or feeling sleepy while driving, is one of the leading Causes of road accidents around the world. Detecting fatigue early is very important to prevent crashes and ensure road safety. Researchers have developed several methods to Monitor driver alertness, which can be grouped into three main categories: physiological, behavioural, and vehicular approaches.

Physiological methods track the body's vital signs, such as heart rate, brain activity, and eye blinking, to understand the driver's level of fatigue.

Behavioral methods use cameras and artificial intelligence (AI) to observe the driver's face, eyes, mouth, and head movements. AI techniques like facial CNN
(Convolutional Neural Networks), and other image analysis tools help detect signs of drowsiness in real time. Vehicular methods monitor driving patterns, including steering wheel movements, lane deviation, and vehicle vibrations, which can indicate tiredness or distraction. Recent research shows that combining multiple approaches can improve accuracy and provide timely alerts. For example, IOT-based systems can collect physiological and vehicular data, while AI-based cameras analyze facial behavior. These systems can then alert the driver using sounds, vibrations, or lights to prevent accidents.

The aim of this review paper is to provide an overview of different driver drowsiness detection methods, highlight their strengths and limitations, and discuss how integrating these approaches can create efficient, reliable, and practical systems for real-world applications.

Such systems have the potential to save lives, enhance road safety, and support future intelligent transportation solutions. Over the years, researchers have developed various methods to identify driver fatigue These methods can be grouped into three main types: physiological, behavioral, and vehicular-based approaches. Physiological methods use sensors to measure signals like heart rate, brain activity (EEG), and breathing rate, which change when a person becomes sleepy. Behavioral methods focus on eye blinking, yawning, and head movements, using cameras and image processing techniques such as Haar Cascade and Convolutional Neural Networks (CNN). Vehicular methods analyze steering patterns, lane deviation, and vehicle speed, which can indicate fatigue or distraction. In addition, modern technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) have been used to improve accuracy and response time. AI can quickly analyze facial expressions and driver behavior, while IoT devices can monitor vital signs in real-time and send alerts to the driver or emergency contacts when signs of drowsiness are detected.

Driver drowsiness is one of the leading causes of road accidents worldwide, responsible for thousands of injuries and deaths every year. According to Gupta et al. (2023) [8], most accidents occur due to reduced attention and delayed reaction time caused by fatigue or sleepiness. Therefore, early detection of driver drowsiness has become an important research topic to improve road safety and prevent accidents.

Various studies have proposed different techniques for detecting drowsiness. Chang et al. (2018) [2] introduced a wearable smart-glass system that measures driver fatigue using motion and biomedical sensors. Similarly, Qureshi et al. (2022) [11] designed an IoT-based model that monitors heart rate, eye blinking, and vehicle vibration, alerting drivers and sending emergency notifications using GSM and GPS modules. These systems aim to provide real-time detection and quick alerting mechanisms. In recent years, Artificial Intelligence (AI) and Machine Learning (ML) have been widely applied to driver monitoring. Sanya Gupta et al. (2023) [8] and Titare et al. (2021) [17] used Convolutional Neural Networks (CNN) and Haar-Cascade algorithms for detecting eye and head movements, achieving high accuracy in identifying fatigue levels. However, these methods can be affected by changes in lighting or camera angle. Some researchers, like Ciattaglia et al. (2025) [6], explored radar-based systems that use vital signs such as heart rate and respiration rate to detect drowsiness. Although these techniques are accurate, they are costly and require complex hardware setups. Therefore, integrating AI with IoT offers a more practical and cost-effective solution for real-time fatigue detection. In summary, previous research highlights the importance of combining multiple sensing techniques—behavioral, physiological, and vehicular parameters—to build reliable drowsiness detection systems. This review focuses on comparing these existing models, identifying their limitations, and suggesting improvements for more efficient, real-time driver monitoring systems.

Literature Review

Driver drowsiness detection has been widely studied because it is a major cause of road accidents. Researchers have used different methods, which can be grouped into physiological, behavioral, vehicular, and AI/IoT-based approaches.

i. Physiological Methods

These methods use sensors to measure signals like heart rate, brain Rate, respiratory rate, etc. activity (EEG), and breathing rate.They can detect fatigue accurately because these signals change when a person becomes sleepy. However, these sensors can be uncomfortable for long drives and sometimes difficult to set up.

ii. Behavioral Methods

Cameras are used to track eye blinking, yawning, and head movements. Techniques such as Haar Cascade, Convolutional Neural Networks (CNN), and Dlib help in detecting these signs. Behavioral methods are non-intrusive, but their performance can reduce in poor lighting or if the driver wears sunglasses.

iii. Vehicular Methods

These analyze steering patterns, lane deviations, and vehicle speed to detect fatigue. They are easy to implement and do not require any body sensors. The limitation is they may not detect early signs of drowsiness accurately.

iv. AI and IoT-based Approaches

Combining multiple methods with AI and IoT devices improves detection. These systems can monitor in real-time, alert the driver with buzzers or vibrations, and even notify emergency contacts if needed. They provide a more reliable and efficient solution for safer driving

Methodology

Driver drowsiness detection requires accurate and real-time monitoring to prevent accidents. This system combines physiological, behavioral, and vehicular methods with AI and IoT technologies for better results.

1. System Architecture

The system uses a combination of sensors, cameras, and IoT modules to monitor the driver. Physiological sensors measure heart rate and breathing patterns to detect fatigue. A camera tracks facial features like eye closure, blinking, yawning, and head position.

IoT modules are used to send alerts and notifications to the driver and emergency contacts. All devices work together in a real-time setup, providing continuous monitoring

2. Data Collection and Signal Processing

The system collects three types of data:

i. Physiological signals → Heart rate, breathing rate, EEG if available

ii. Behavioral signals → Eye aspect ratio, mouth aspect ratio, head movements

iii. Vehicular signals → Steering wheel movement, lane deviation, speed variations

Data is processed using machine learning models like CNN, SVM, and RNN to detect early signs of drowsiness.

Image processing techniques are applied to camera data to identify fatigue-related behaviors accurately.

3. Alert Mechanism

When drowsiness is detected, the system immediately alerts the driver using: Buzzer or vibration on the driver seat or steering wheel Audio/Visual signals on the dashboard

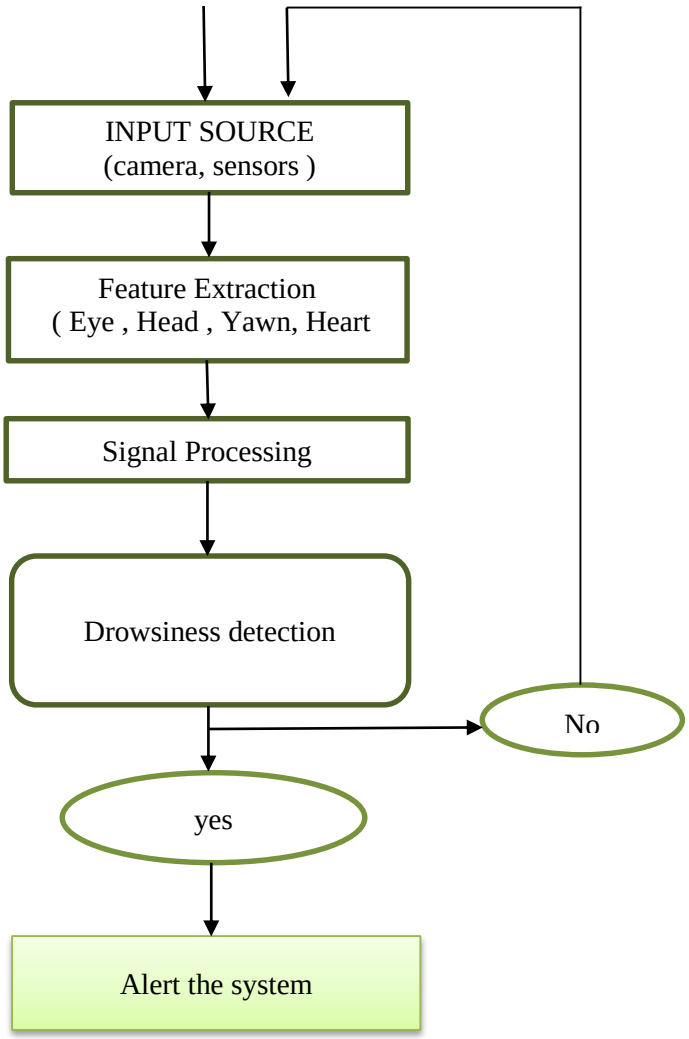
In severe cases, the system can send real-time notifications to emergency contacts via IoT connectivity.

Integration and Real-Time Monitoring

AI, sensors, and IoT devices are integrated to work simultaneously and continuously. The system is portable, cost-effective, and reliable, designed for practical use in vehicles.

By combining multiple methods, it reduces false alarms, improves accuracy, and ensures timely detection of driver fatigue.

BLOCK DIAGRAM:-



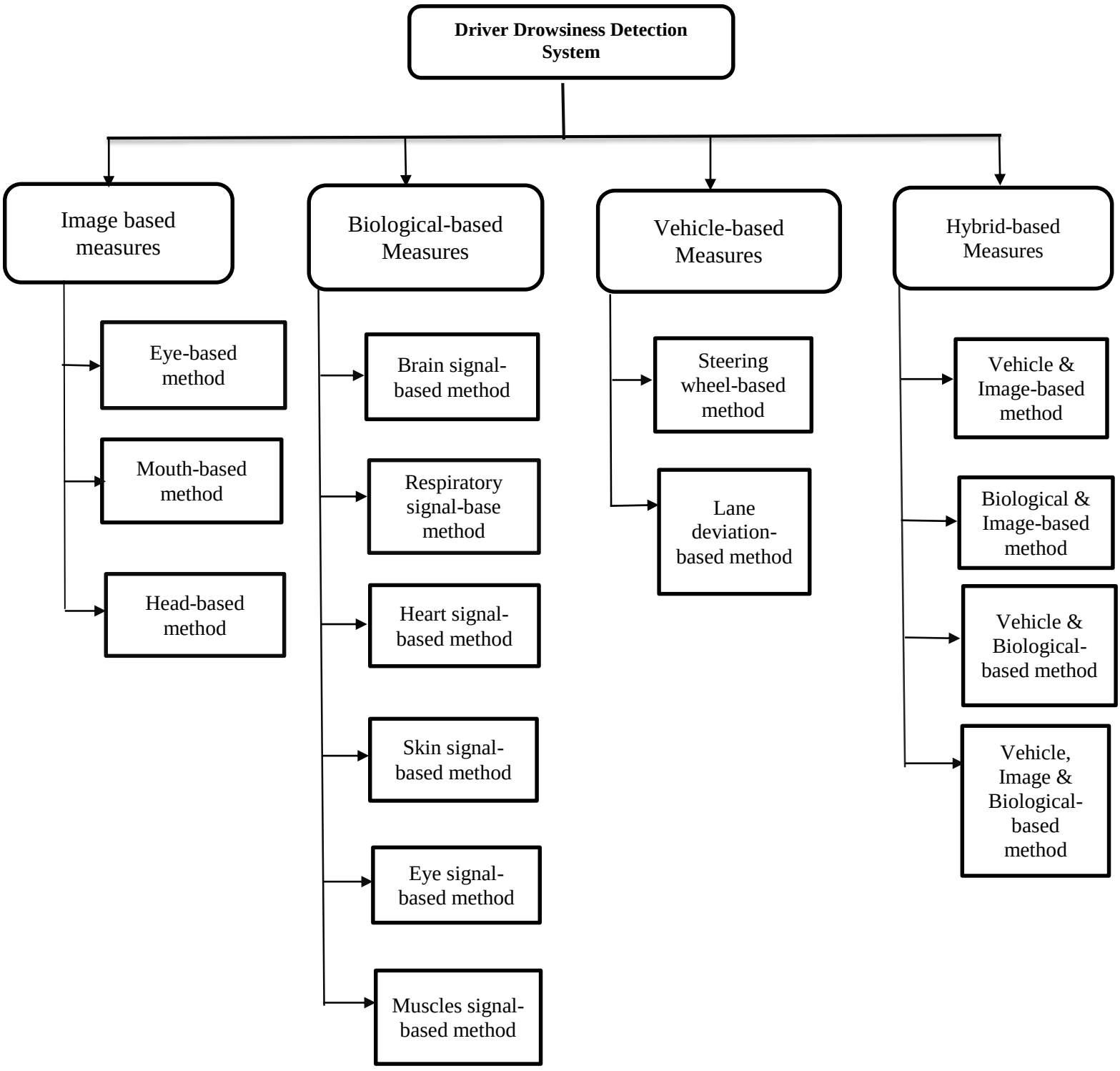


Fig 1: Driver drowsiness detection measures

Methodology Table: Drowsy Detection System Measures

Ref.	Parameters	Extracted features	Description	Accuracy	Dataset
[1]	A real time automotive safety system based on advanced AI facial detection algorithms	3D and 2D head orientation landmarks, Eye and Iris Landmarks	Hybrid AI model using Media pipe +OpenCV for facial eye gaze & head pose tracking	>9%(proposed system), <10% relative error	Real-time camera-based dataset using MediaPipe and OpenCV
[2]	Design and implementation of a drowsiness-fatigue- detection system based on wearable smart glasses to increase road safety	Eye blink rate , head movement, yawning detection, accelerometer	Smart glasses detection drowsiness using eye and motion, yawning, and sensor signals with real-time monitor	94.8%	Real time data from drivers using smart glasses with image and sensor input
[3]	. DrowsyDetectNet: Driver Drowsiness Detection Using Lightweight CNN With Limited Training Data	Eye aspect ratio, facial landmarks, yawning detection ,eye closure patterns	A lightweight CCN model is created to detect driver drowsiness using limited training data ;focus on facial feature to identify sleepy state.	96.9%	Custom driver drowsiness dataset with limited reatworld image and augmented samples for training & validation.
[4]	Smart Vehicle Safety System with Overload Detection and ML-based Driver Monitoring	Eye shape, eyelid position, texture, EAR using mediapipe +CCN	IoT-based safety system detection drowsiness, alcohol, overload & accidents.	92.7%	Open-source Kaggle eye image dataset
[5]	Intelligent Drowsiness Detection System using CNN	Eye and facial feature via CNN layers.	IoT + CNN- based fatigue detection ;tested with multiple CNN architectures.	99.5%	10,000 preprocessed and augmented images(224*224 pixel)
[6]	Multistage Een-to-End Driver Drowsiness Alerting System	Eye Aspect Ration (EAR) facial landmarks.	Raspberry Pi-based multi-stage alert with face, alcohol & fatigue detection.	97%	Real-time camera captured driver images
[7]	EEG-based Hybrid Drowsiness detection .	EEG spectral entropy, energy, zero-crossing and CNN deep features.	Combines EEG signals with deep learning for fatigue detection	92%	EEG dataset (custom experimental)
[8]	FPGA – based real-time eye & head detection	Eye position ,face gradient, head movement via grayscale projection	FPGA -implemented system for real-time eye closure and head lowering detection.	Not stated (tested successfully)	Captured image sequences.
[9]	Hypervigilance Detection & alert system	Physiological (ECG,EMG) and facial image feature	Multimodal system for detecting drowsiness & distraction using sensor and alert	Conceptual, not experimentally stated.	Physiological signal-based experimental data

Conclusion

The review of driver drowsiness detection methods shows that each approach has its own advantages and challenges. Behavioral monitoring using cameras to track eye closure, blinking, and head movement is one of the most effective ways to identify fatigue. These methods are non-invasive and practical for real-world driving, though their performance may reduce in low lighting conditions or when the driver wears glasses. Vehicular-based techniques, such as monitoring steering patterns, lane deviations, and vehicle vibrations, offer a cost-effective alternative. However, they may not detect drowsiness at an early stage and can be affected by road type and driving style.

In recent years, AI and IoT-based systems have shown great potential by combining camera-based behavior analysis with sensor data. These smart systems can process real-time images, detect fatigue symptoms within seconds, and alert the driver through buzzers, seat vibrations, or mobile notifications. This integration improves accuracy, reduces false alarms, and enhances driver safety.

Overall, a hybrid model that merges behavioral, vehicular, and AI-IoT technologies provides the most reliable and practical solution for preventing accidents caused by fatigue. Such systems are cost-effective, user-friendly, and suitable for real-world vehicle integration.

Future Scope

In the future, these systems can be improved by adding more advanced sensors, cloud-based monitoring, and 5G connectivity for faster data transfer. Integration with smart vehicle dashboards and voice-based alerts can make the system more interactive and user-friendly. Machine learning can also help adapt the system to different driving environments and driver habits, ensuring better accuracy and reliability.

Overall, these advancements can lead to the development of intelligent and fully automated driver monitoring systems that will play a major role in improving road safety and reducing fatigue-related accidents worldwide.

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