AutoWake: AI-Powered Real-Time Drowsiness Detection and Alert System for Drivers

Technical Domain: Automotive Safety, Computer Vision, and Edge AI Monitoring Systems

The present invention relates to driver safety and driver-assistance systems in the automotive field. More specifically, it pertains to intelligent vehicle monitoring and alert systems that Machine Learning(ML) and computer vision to detect driver drowsiness in real time. The disclosed invention finds application in automotive electronics, intelligent transportation systems, and accident-prevention technology for road vehicles.

Comparative Analysis of Existing Drowsiness Detection Systems and Technologies

- **Smartphone-Based Detection Apps:** It uses phone cameras and sensors to analyze facial features and head movements.
- **Steering Behaviour Monitoring Systems:** It analyses erratic steering patterns as an indicator of drowsiness.
- **Wearable Drowsiness Detection Devices:** It uses smart headbands or glasses to track brain activity and fatigue levels.
- **Eye-Tracking-Based Detection Systems:** It monitors eye movements and blinks to detect drowsiness.

Technical details of the invention

Problem Statement and Technical Need for Real-Time Fatigue Detection in Vehicles

Drowsy driving causes around 30% of road accidents annually, according to the WHO. These fatigue-related crashes are often severe due to delayed reactions and microsleeps, where drivers momentarily lose consciousness without warning.

Fatigue commonly occurs during night driving, long trips, or monotonous routes, with early signs like yawning, prolonged eye closure, and head nodding—often missed by traditional safety systems that only monitor vehicle movement.

Modern driver-assistance technologies are increasingly focused on real-time, non-intrusive fatigue detection, capable of functioning in different lighting conditions. Such systems are essential for improving road safety without affecting comfort, privacy, or driving performance.

Drawbacks in Current State-of-the-Art and Technical Advancements Offered by the Invention

Drowsiness detection technologies typically fall into four types: vision-based systems, wearables, vehicle behavior monitors, and smartphone apps. Each has limitations—vision systems struggle in low light or with eyewear, wearables are intrusive and costly, behavior monitors react too late, and phone apps are unreliable due to variable placement and lighting.

AutoWake overcomes these issues with a non-intrusive infrared (IR) camera that works in all lighting, including darkness. It uses a CNN-LSTM model to analyze spatial and temporal signs of fatigue like blink rate, yawning, and head tilt. The system runs locally on an edge device, needing no internet, and gives real-time alerts via audio and optional haptics, ensuring timely driver responses and improved safety.

Key Differentiating Features and Technical Advantages over Prior Art

The AutoWake system enhances drowsiness detection by using a CNN-based image processing model to monitor facial cues like slow blinking, yawning, and head nodding. It incorporates an infrared (IR) camera with active illumination, enabling accurate facial tracking even in low-light environments such as nighttime driving or tunnels—overcoming a major limitation of visible-light cameras.

Unlike many existing solutions, AutoWake operates entirely on an on-board edge processing unit, ensuring real-time performance without internet dependency. It also provides multi-mode alerts—including audio, visual, and vibration feedback—to ensure the driver is promptly alerted. These combined features make AutoWake a reliable, non-intrusive, and effective solution for preventing fatigue-related accidents.

Primary Advantages of the Disclosed Invention in Real-World Automotive Contexts:

- **Real-time monitoring and alerting:** Continuously analyzes driver behavior on-board for immediate drowsiness detection and alerts.
- **High detection accuracy:** CNN-LSTM model captures both facial features and movement patterns for better fatigue detection.
- **Enhanced safety:** Alerts via sound, lights, and vibration ensure quick driver response..
- **Privacy and security:** All processing is done locally, with no external data transmission.
- **Driver convenience:** Non-intrusive IR camera; no wearables needed; easy to install without affecting comfort.

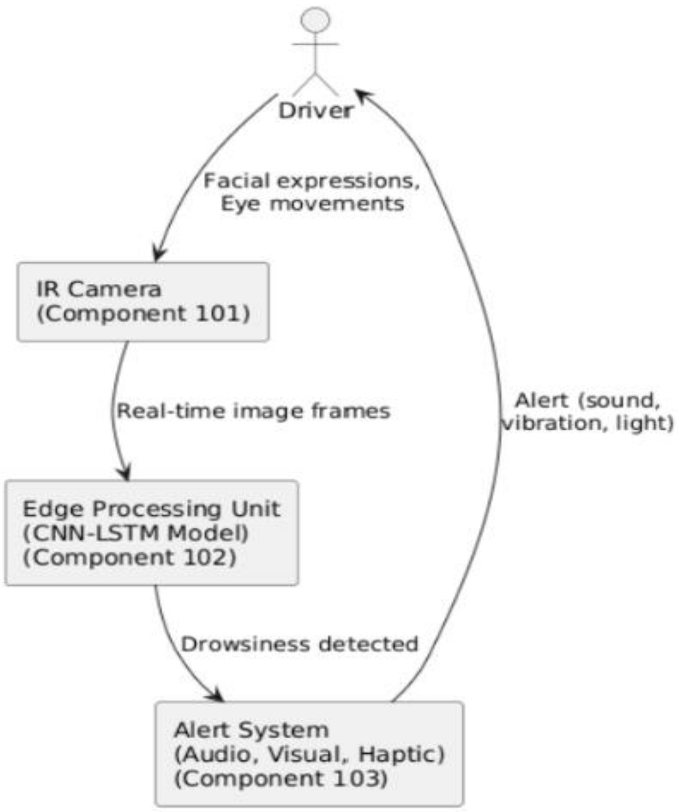
System Overview, Embodiments, Component-Level Description, and Functional Integration

a) Technical Description of Core Hardware and Software Elements: The system includes an infrared (IR) camera, mounted on the dashboard or near the rear-view mirror, equipped with active IR illumination (IR LEDs) to capture facial images in low-light conditions. The camera's real-time image stream is sent to the edge processing unit, which may be an embedded processor or microcontroller. This unit runs the CNN-LSTM model, where the CNN extracts facial features like eye closure and mouth movements, while the LSTM analyzes temporal patterns of these features to detect signs of fatigue. When the system detects drowsiness, based on metrics such as blink duration or yawning frequency, the alert mechanism, which includes an audible alarm, is triggered to warn the driver immediately

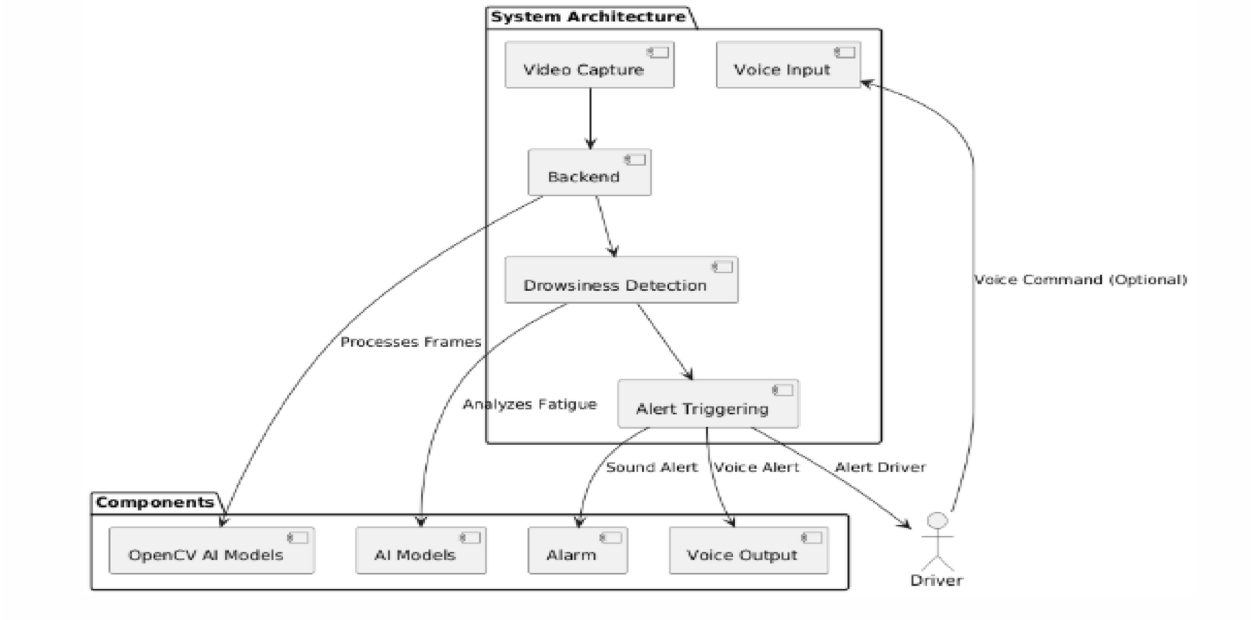
b) System Integration, Mounting Structure, and In-Vehicle Deployment Strategy: The IR camera is installed on the dashboard or windshield pillar with an unobstructed view of the driver's face. The edge processing unit is housed behind the dashboard or center console and connected to the vehicle's power supply. A direct wired connection (such as USB or CAN bus) links the camera to the processor. The alert outputs are integrated into the vehicle cabin: the speaker or buzzer is connected to the audio system, LED indicators are mounted on the instrument panel, and the vibration actuator is mounted on the steering wheel or driver's seat. All components are fixed securely and positioned to minimize obstruction and ensure reliable operation under normal driving conditions.

c) Figures: The following figures illustrate various aspects of the AutoWake system:

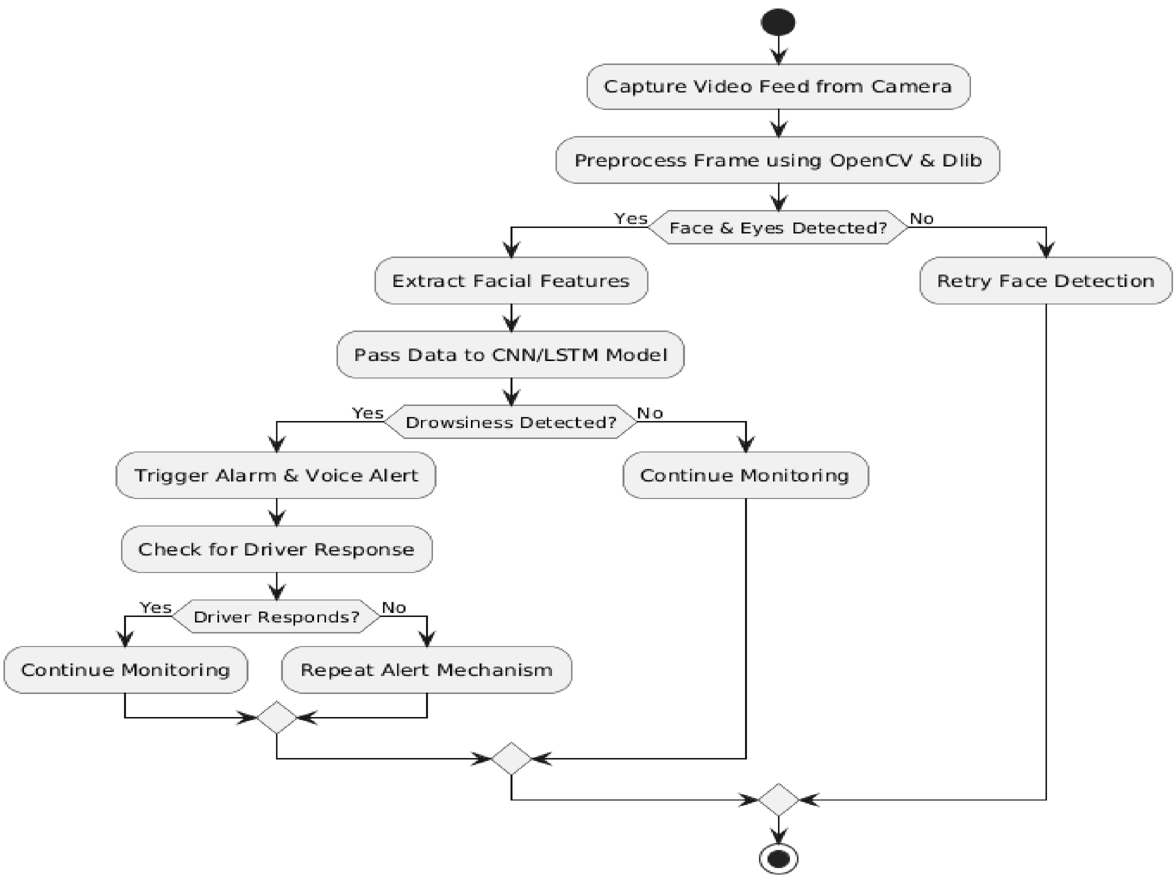
Data Flow Diagram:



System Architecture-



System Overview:



List of novel features in the invention:

- **CNN and LSTM analytics**: The system separately uses a convolutional neural network (CNN) to analyze spatial features like eye closure and mouth movements, and a long short-term memory (LSTM) network to detect temporal patterns, improving the detection of progressive drowsiness.
- **Infrared imaging for all-light conditions:** The dedicated IR camera with active illumination enables reliable operation at night or in low-light, unlike existing camera-based monitors.
- **On-board edge computing**: The AI model is deployed on a local embedded processor within the vehicle, enabling real-time analysis without reliance on cloud services. This reduces latency and preserves driver privacy, which is a novel operational aspect.
- **Multi-modal alert mechanism:** The system integrates multiple feedback modes (auditory, visual, and haptic) in one solution. Combining these alerts for immediate driver wake-up is a unique feature that enhances safety.
- **Adaptive personalization:** The system can adjust its sensitivity based on individual driver characteristics. Automated calibration of fatigue detection thresholds for different users is an advanced feature that distinguishes the invention from fixed-threshold alarms.

List of keywords relevant to the invention:

- Driver drowsiness detection
- Driver fatigue alert system
- Convolutional neural network (CNN)
- Long short-term memory (LSTM) network
- Infrared camera
- Real-time driver monitoring

Any other relevant details:

The embodiments are examples, and the invention allows for variations, such as using different cameras or neural networks (e.g., GRU instead of LSTM). It can interface with vehicle electronics (e.g., CAN bus, OBD-II) and is compatible with all vehicle types and ADAS. The invention's scope is defined by the claims.

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