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AI-Powered Driver Drowsiness Detection and Smart Accident Alert system

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KEYWORDS

AI, Driver Drowsiness Detection, Accident Prevention, MEMS Sensor, Ultrasonic Sensor, Facial Recognition, Machine Learning, Real-Time Monitoring, IoT Alerts, Vehicle Safety

ABSTRACT

Road accidents caused by driver drowsiness are a major concern affecting road safety worldwide. This project presents an AI-powered driver drowsiness detection and smart accident alert system designed to minimize such accidents. The system uses an Arduino microcontroller as the central control unit, interfacing with MEMS, ultrasonic, and AI-based drowsiness detection modules. Driver alertness is continuously monitored through real-time sensor data and intelligent analysis. When drowsiness is detected, the system immediately activates a buzzer to alert the driver and displays warning messages on an LCD screen. The ultrasonic sensor assists in detecting obstacles and sudden impact conditions. In critical situations, the system triggers automatic safety and alert responses to prevent accidents. A DC motor module is used to simulate vehicle operation during testing. The proposed system is reliable, cost-effective, and suitable for real-time implementation. By combining artificial intelligence with embedded systems, this solution significantly enhances road safety and reduces fatigue-related accidents.

I. INTRODUCTION

Road accidents caused by driver fatigue and reduced attention have become a major concern in modern transportation systems. This project presents a designed to improve road safety through real-time monitoring and intelligent alert mechanisms. The proposed system is developed as an advanced driver assistance solution that continuously observes the driver's behavior and vehicle condition to prevent accidents before they occur. The system uses a camera and sensors to monitor driver facial features such as eye blinking, eye closure duration, head movement, and yawning patterns. Computer vision and machine learning techniques are used to analyze these parameters and detect signs of drowsiness or fatigue. When abnormal driver behavior is identified, the system immediately provides alerts through a buzzer or vibration to wake the driver and avoid potential accidents. In addition to drowsiness detection, the system incorporates a smart accident alert module that uses vibration sensors to detect vehicle collisions or sudden impacts. In the event of an accident, the system automatically sends the vehicle's real-time location and emergency notification to predefined contacts or emergency services through IoT communication. This ensures quick rescue response and reduces the delay in providing medical assistance.

This framework comprises of primary unit

- Vehicle Unit

The vehicle unit introduced in the vehicle senses the accident and sends the area of the accident to the principle server. The principle server finds the nearest rescue vehicle to the mishap spot furthermore the shortest way between the emergency vehicle, mischance spot and the closest healing facility. The server then sends this way to the emergency vehicle. Likewise utilizing this data the server controls all the knobs in the way of emergency vehicle and make it ON, which ensures that the rescue vehicle reaches the hospital without delay. The architecture system is indicated in the figure.1

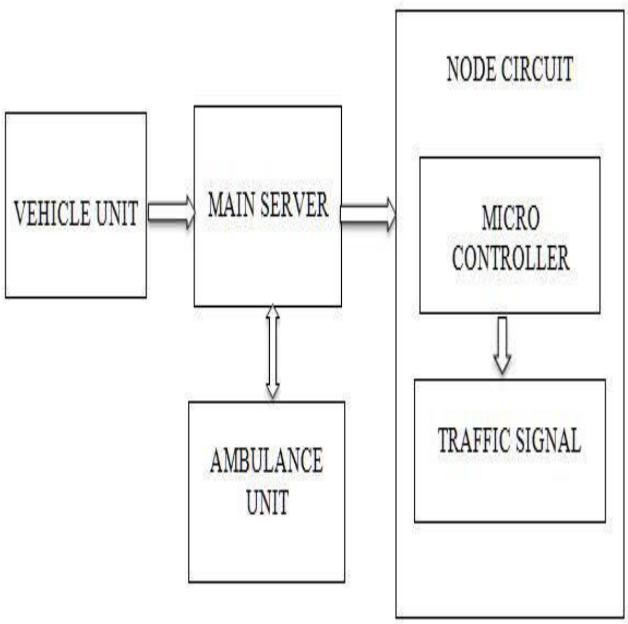

Fig 1. System Architecture

The proposed system enables bi-directional interaction between the driver and the intelligent monitoring system, ensuring minimal interference during normal driving while providing strong intervention during unsafe conditions. By integrating real-time monitoring, machine learning, and AI communication, the system offers a reliable, cost-effective, and robust solution to enhance driver safety, prevent accidents, and enable rapid emergency response.

This project aims to reduce such risks by integrating Artificial Intelligence (AI), Computer Vision, IoT technology, and real-time monitoring systems. The system operates by installing a camera on the vehicle dashboard to continuously capture live video of the driver's face while driving. Using computer vision and machine learning algorithms, the captured frames are analyzed to detect key facial landmarks such as eye position, eyelid movement, mouth opening (yawning), and head tilt. By evaluating parameters like eye closure duration (PERCLOS), blink frequency, yawning rate, and head nodding patterns, the system determines the driver's alertness level. When signs of fatigue or drowsiness are detected, an immediate alert is triggered through a buzzer, vibration motor, or voice warning to regain the driver's attention and prevent potential accidents. In addition to monitoring driver behavior, the system also supervises vehicle motion using accelerometer and vibration sensors. These sensors detect sudden impacts, abnormal movements, or collisions that may indicate an accident. Upon accident detection, the to send alert bot app module retrieves the vehicle's real-time location, and the IoT communication module automatically sends emergency alerts to predefined contacts or nearby emergency services. This ensures quick medical assistance and reduces response time during critical situations.

2. LITERATURE SURVEY

1. Programmed Movement of Emergency vehicle to Accident Spot By Guddi Singh, Jyoti Singh.

People in general or crisis administrations don't have the foggiest idea about the close-by area and the level of administrations. The absence of such data may cause a few causalities. Consequently, the exploration inquiry emerges in a manner to answer how to run the crisis vehicle to achieve the mishap spot in correct time. Thus, directing the vehicle and making movement sign control according to vehicle development is important. There is death toll because of the postponement in the entry of Emergency vehicle to the mischance place. To accomplish these obliged conditions we propose executing a System called Emergency Vehicles Monitoring System (EVMS) Emergency vehicle checking System can incorporate GPS, GSM, GIS administrations. The GPS gadgets convey the information concerning the

Emergency vehicle position and their briefest course. The primary server the Google guide permits to pick briefest course between crisis vehicle and mischance spot.

3. PROPOSED SYSTEM

In the proposed framework, whenever a vehicle meets with an accident, a warning message along with the location coordinates is immediately sent to the control center. From the control center, an alert is forwarded to the nearest rescue vehicle to ensure a quick emergency response. The accident is detected using the MEMS sensor and tilt sensor, which identify sudden impact and abnormal vehicle orientation. The AI-Powered Driver Drowsiness Detection and Smart Accident Alert System is designed as an intelligent safety solution that continuously monitors driver alertness and the vehicle's surroundings using multiple sensors integrated with an Arduino microcontroller. A regulated power supply ensures stable operation of all modules, while the Arduino acts as the central processing unit that receives sensor and AI inputs, processes the data, and activates the appropriate output devices. A MEMS accelerometer detects sudden vibrations, tilt, or impact to identify accidents or abnormal motion. An ultrasonic sensor is used to maintain a safe distance between vehicles by continuously measuring the gap between the vehicle and nearby obstacles. If the distance becomes less than the predefined safety threshold, the system immediately triggers a warning to help prevent collisions. The AI-based drowsiness detection module uses a camera and machine learning techniques to monitor the driver's facial features, including eye closure, blinking rate, and head movement, to identify fatigue or sleepiness.Based on the analyzed data, the Arduino activates the output devices: an LCD displays real-time system status and warning messages, a buzzer provides immediate audible alerts when danger or drowsiness is detected, and a DC motor is used as a prototype to simulate speed reduction or automatic braking during unsafe conditions.

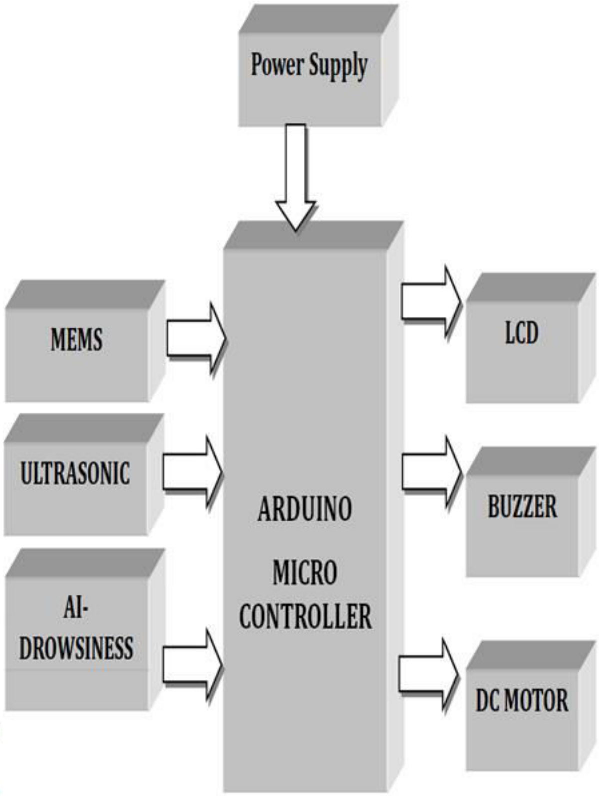

Fig 2: proposed system

In the proposed method The system begins its operation when the power supply energizes the Arduino microcontroller and all connected modules. The Arduino continuously collects data from three input sources: the MEMS sensor, ultrasonic sensor, and the AI-based drowsiness detection module. The MEMS sensor monitors the driver's head movement and tilt, while the ultrasonic sensor measures the distance between the driver and the steering/dashboard to detect abnormal posture changes. Simultaneously, the AI module analyzes eye blink rate and eye closure duration to identify signs of fatigue. The Arduino processes all these inputs in real time and compares them with predefined threshold values to determine whether the driver is alert or drowsy. If normal conditions are detected, the system keeps monitoring continuously. When drowsiness is identified, the Arduino immediately activates the output devices: a warning message is displayed on the LCD, a buzzer sounds to alert the driver, and the DC motor is triggered to simulate vehicle safety control such as reducing speed. This cycle repeats continuously, ensuring real-time driver monitoring and accident prevention.

i) Video Acquisition Module:

This module captures the driver's face in real time using a dashboard-mounted camera. The video stream is converted into frames to monitor eye movement, blinking, and head position.

ii) Pre-Processing Module:

Captured frames are enhanced by resizing, gray scale conversion, and noise reduction. Techniques like normalization improve accuracy under different lighting conditions.

iii) Face Detection Module:

This module detects the driver's face and eyes using algorithms like Haar Cascade or HOG. It analyzes eye closure (PERCLOS) to identify drowsiness based on slow eyelid movement and blinking patterns.

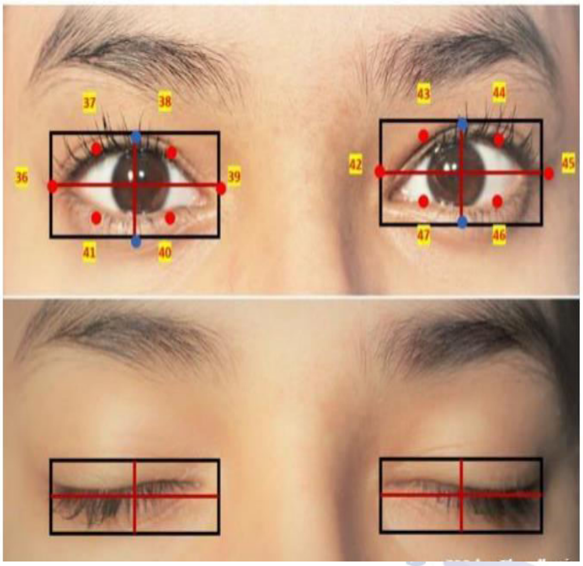

Fig 3: Difference between the eye marks when the eyes are open and the eyes are closed

iv.**Eye Detection and Feature Extraction Module:**

After detecting the face, the system extracts the eye region and calculates features like Eye Aspect Ratio (EAR), blink duration, and frequency. These parameters help identify signs of fatigue such as prolonged eye closure or reduced blinking.

v.**Drowsiness Detection Module:**

This module analyzes the extracted features using thresholds or machine learning models to determine drowsiness. If eye closure exceeds limits or EAR drops continuously, the system classifies the driver as drowsy.

vi.**Alert Generation Module (IoT Bot App):**

When drowsiness is detected, alerts such as buzzer sounds, voice warnings, or vibrations are triggered. Additionally, notifications are sent through an IoT-based bot/mobile app to inform concerned persons and enhance safety.

4. RESULTS AND DISCUSSION

The AI-powered driver drowsiness detection system demonstrated accurate real-time monitoring using MEMS, ultrasonic sensors, and facial analysis. The multi-sensor approach improved detection reliability by identifying head movement, distance changes, and eye fatigue with reduced false alarms. Additionally, the alert system successfully sent emergency notifications, enhancing driver safety and enabling quick response in critical situations.

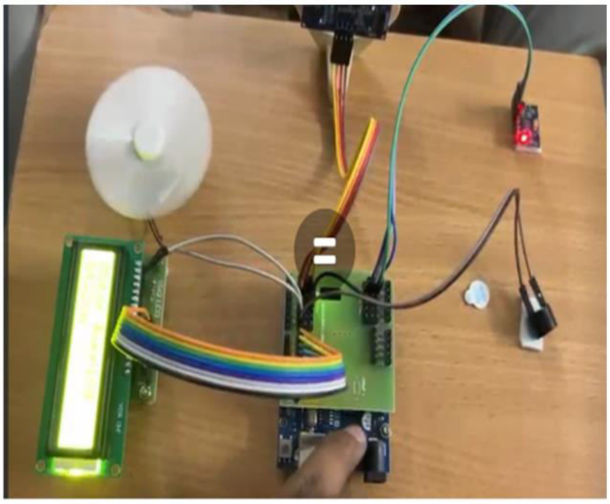

Fig 4: Hardware Implementation

Fig 5: Obstacle Detection Using an Ultrasonic Sensor

The system uses a DC motor to simulate vehicle movement, while a MEMS/tilt sensor monitors orientation and motion. An ultrasonic sensor measures the distance between vehicles to maintain safe spacing and help prevent collisions.

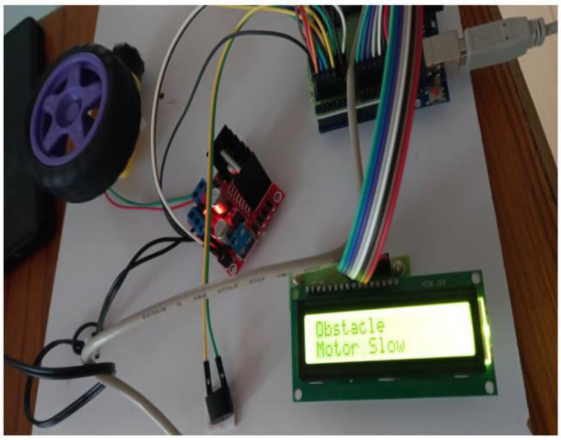

Fig 6: Obstacle Detection Using an Ultrasonic Sensor

The ultrasonic sensor detects nearby obstacles and automatically slows down the DC motor when an object is too close, helping to prevent collisions.

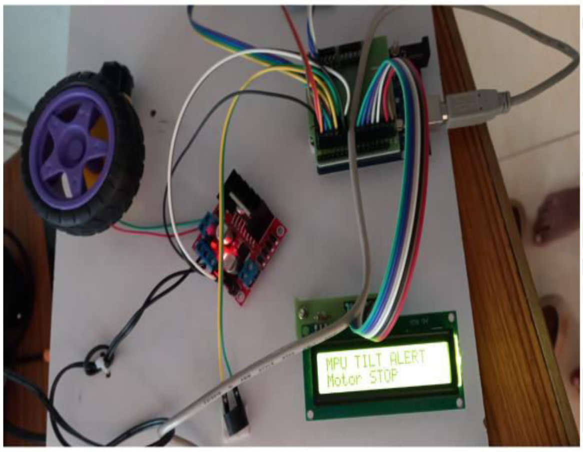

Fig 7: Vehicle Tilt Detection and Safety Control Using MPU Sensor

The MPU tilt sensor detects abnormal vehicle orientation and automatically stops the motor while displaying a warning message to prevent accidents.

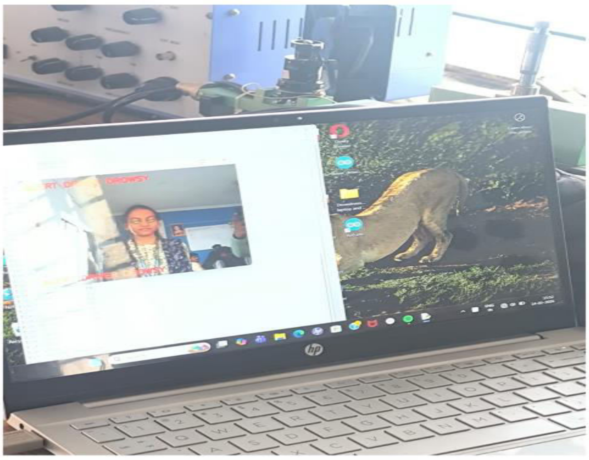

Fig 7: Facial-Based Drowsiness Detection SystemThe system uses a camera to monitor facial features and eye movements, detecting drowsiness and displaying a warning to alert the driver and prevent accidents

Fig 8: LCD Indication of Driver Drowsiness Detection
The LCD displays a "Drowsiness Alert" message when fatigue is detected, notifying the driver in real time.

5.CONCLUSION

The AI-powered driver drowsiness detection and smart accident alert system provides an effective and reliable solution for enhancing road safety by combining AI-based facial analysis with MEMS and ultrasonic sensors. It ensures real-time monitoring, early detection of fatigue, and quick preventive actions, reducing accidents caused by driver drowsiness. The system is cost-effective, accurate, and suitable for integration into modern intelligent transportation systems.

FUTURE SCOPE

The system can be further improved by integrating advanced deep learning models for higher detection accuracy and adaptive learning. It can also be connected with GPS and cloud-based IoT platforms for real-time tracking and emergency response. Additionally, incorporating features like lane detection and vehicle-to-vehicle communication can enhance overall safety and smart driving capabilities.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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