

# Accident prevention and alert system using GSM and GPS Modules

**Mr. Srikanth S P**

Department of Computer Science and Engineering  
Acharya Institute Of Technology  
Bangalore, India  
srikanth2503@acharya.ac.in

**Mr. Jawahar Jonathan K**

Department of Computer Science and Engineering  
Acharya Institute Of Technology  
Bangalore, India  
jawahar2393@acharya.ac.in

**Hema T R**

Department of Computer Science and Engineering  
Acharya Institute Of Technology  
Bangalore, India  
hemar.22.becs@acharya.ac.in

**Mohanapriya A**

Department of Computer Science and Engineering  
Acharya Institute of Technology  
Bangalore, India  
mohanapriya.aa.22.becs@acharya.ac.in

**Srujana B**

Department of Computer Science and Engineering  
Acharya Institute of Technology  
Bangalore, India  
srujanab.22.becs@acharya.ac.in

**Sharmila K V**

Department of Computer Science and Engineering  
Acharya Institute of Technology  
Bangalore, India  
sharmilak.22.becs2@acharya.ac.in

**Abstract**— Drowsiness among drivers causes many road accidents worldwide. To tackle this problem, we created a real-time driver drowsiness monitoring system that uses a Raspberry Pi to detect early signs of drowsiness. The system analyzes facial cues like prolonged eye closing, reduced blinking, and yawning to identify drowsiness in real time. When it spots these signs, it gives immediate audio alerts to help the driver stay awake. Besides monitoring the driver, the system has an accident detection feature using a tilt sensor. If it detects a sudden impact or a tilt in the vehicle, the system automatically collects the vehicle's GPS location. It then sends this information via a GSM module to registered emergency contacts. This ensures that help can arrive quickly, even if the driver cannot respond. The combination of early drowsiness detection and instant location sharing in case of an accident makes the system a reliable and low-cost solution for improving road safety.

**Keywords**—drowsiness detection, accident alert system, Raspberry PI, GPS, GSM, tilt sensor.

## I. INTRODUCTION

Road accidents remain a significant issue because of the rising number of incidents linked to driver fatigue, lack of attention, and slow emergency communication. In many situations, accidents turn serious because drivers cannot react quickly or are unable to ask for help after a crash. Traditional safety methods rely heavily on manual reporting, which is often slow and unreliable in emergencies. This creates a greater need for automated systems that can detect unsafe driving conditions and promptly notify the right people without needing human assistance.

The goal of the proposed system is to improve road safety by combining real-time driver drowsiness detection with automatic accident alert features. A camera will connect to a Raspberry Pi, watching the driver and tracking signs of fatigue like prolonged eye closure and yawning. These visual cues help spot early signs of drowsiness, and the system gives a sound warning to bring the driver back to focus before an accident can happen. Additionally, an accident detection module, based on a tilt sensor, monitors sudden movements or vehicle instability that might suggest an impact. When the system detects such an event, it retrieves the current vehicle location using GPS and sends it to a pre-registered contact through the GSM network. This ensures that help can arrive quickly, even if the driver cannot respond.

By combining driver monitoring with automated alert features in one design, the system provides a practical and

affordable way to reduce the severity of accidents. It can be installed easily in various types of vehicles and offers ongoing support for both prevention and emergency response.

## II. RELATED WORK

Research on intelligent vehicle safety systems has increased significantly over the past decade. This growth is especially clear in driver monitoring and automated accident reporting. Current studies emphasize computer vision methods to detect drowsiness. Other studies explore sensor-based systems for identifying accidents and enabling emergency communication. This section discusses research on drowsiness detection, vehicle accident alert systems, and integrated safety systems.

### A. DRIVER DROWSINESS DETECTION

Early studies on monitoring drivers mainly relied on eye-blink frequency, head position, and facial expressions to spot fatigue. Many researchers used image processing techniques with webcams to track the driver's eyes and identify prolonged closure. In many of these systems, facial landmarks are extracted to calculate the Eye Aspect Ratio, which decreases when the driver becomes drowsy. Later research introduced machine learning and deep learning models to improve detection accuracy in various lighting and head-pose conditions.

Convolutional neural networks have been used in recent studies to evaluate real-time video frames and categorize the level of alertness of the driver. When compared to outdated and conventional threshold-based techniques, these models enable superior feature extraction. Additionally, some studies use mouth opening patterns to detect yawning. Despite achieving good accuracy, many of these methods are difficult to integrate into low-cost embedded systems because they require very powerful hardware.

### B. ACCIDENT DETECTION AND ALERT SYSTEM

Studies related to accident detection often use vibration sensors, accelerometers, or tilt sensors to identify sudden impact or vehicle rollover. Global Positioning System modules are commonly used to fetch the location coordinates during an accident, while Global System for Mobile communication modules help send emergency alerts to a stored contact.

Accident detection systems that automatically send messages when abnormal tilt or impact is detected are demonstrated by a number of projects in the literature.

Nevertheless, many of these systems don't try to stop driver fatigue-related accidents; instead, they only concentrate on post-accident alerting.

### C. INTEGRATED DRIVER SAFETY SYSTEMS

More research attempts to combine drowsiness detection with accident alert technologies. These systems aim to provide both preventive alerts and emergency communication. Researchers have created systems that initiate early warnings and send automated messages when a collision occurs by combining camera-based monitoring with sensor-based crash detection.

However, most integrated systems require high-cost hardware, complex installation, or cloud connectivity. This limits their use in low-budget or older vehicles. Therefore, a compact, affordable, reliable solution is still needed for real-time fatigue detection, immediate accident sensing, and location communication without depending on any external networks or advanced vehicle electronics.

## III. PROPOSED METHODOLOGY

The proposed system includes real-time detection of driver drowsiness, along with timely alerts through facial analysis and sensor-based monitoring. The methodology further includes an automatic accident alert sending mechanism, which delivers the vehicle's location via Global Positioning System and Global System for Mobile communication modules. All the processing is done by the Raspberry Pi, acting as a central controller to the camera, sensors, display unit, and buzzer.

### A. SYSTEM OVERVIEW

Indeed, the system assesses the alertness of the driver with the help of three primary parameters, namely EAR, MAR, and head position. These parameters are extracted from facial landmarks detected in the live video feed captured by the night-vision camera. A night-vision camera improves the accuracy during night time and in low-light conditions.

Unlike most traditional image-processing methods for eye detection, EAR utilizes the geometric relationship between certain landmark points around the eye, thus reducing computational load by eliminating the need to perform complex thresholding to capture the white region of the eye. Similarly, MAR is computed, calculating vertical and horizontal distances between the coordinates of the lips to determine openness; this helps in the detection of yawns.

In addition to drowsiness detection, the system continuously monitors the vehicle's orientation using an ADXL tilt sensor. Any unusual or abrupt change in tilt is interpreted as a potential accident. When such an event occurs, the Raspberry Pi retrieves the current vehicle coordinates from the GPS module and sends an emergency message through the GSM module to a pre-registered number or communication channel.

### B. BLOCK DIAGRAM

The block diagram illustrates the interaction between the night-vision camera, Raspberry Pi, sensors, and communication modules. The camera captures video frames, while the Raspberry Pi processes facial features. The tilt sensor, GPS, GSM, LCD display, buzzer, and motor driver remain connected for accident detection, message delivery, warnings, and demonstration.

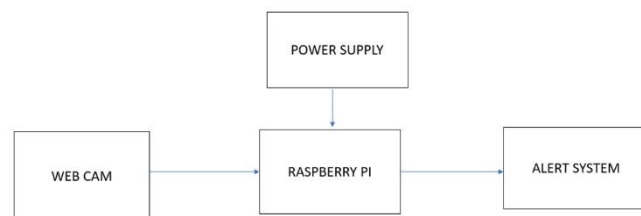


Fig. 1. Block Diagram

### C. FLOW CHART

The flowchart illustrates the complete operational sequence of the driver drowsiness detection module. The process begins with continuous video input captured by the camera. Each incoming frame is first passed through a face detection stage where the system identifies the driver's face region. Once the face is located, the system performs feature extraction, collecting the key facial attributes required for monitoring the driver's alertness level.

The workflow begins with continuous video input captured from the driver's face. This video stream is first processed through a face detection module, which isolates the facial region from each frame. Once the face is identified, the system proceeds to a feature extraction stage, where key facial landmarks are detected and mapped. These extracted features then branch into three parallel analysis paths: eye state, head pose, and mouth state. In the eye state analysis, the system evaluates blinking patterns and eye closure duration by computing the Eye Aspect Ratio. This allows the model to distinguish between open, partially closed, and fully closed eyes, helping identify signs of fatigue. At the same time, the head pose analysis examines the driver's head orientation by calculating the head position angle. Slow nodding, unusual tilting, or downward head movement are commonly associated with drowsiness and are used as supportive indicators. The mouth state analysis focuses on detecting yawning behaviour by observing mouth opening patterns. By calculating the Mouth Aspect Ratio, the system determines whether the mouth remains significantly open across several frames, which is another indicator of reduced alertness.

The outputs from these three analysis branches are then fed into a unified classification module. This decision-making layer evaluates the combined features and determines whether the observed facial behaviour corresponds to drowsiness. After classification, the flow reaches a decision point. If the driver does not exhibit any signs of fatigue, the system loops back to the start and continues real-time monitoring. However, if the driver is classified as drowsy, the system immediately triggers an alert. This alert may include an audio warning or visual display, prompting the driver to regain focus and avoid potential hazards. Through this structured and continuous pipeline, the system ensures a reliable drowsiness detection mechanism by integrating multiple behavioural cues for improved accuracy and timely response.

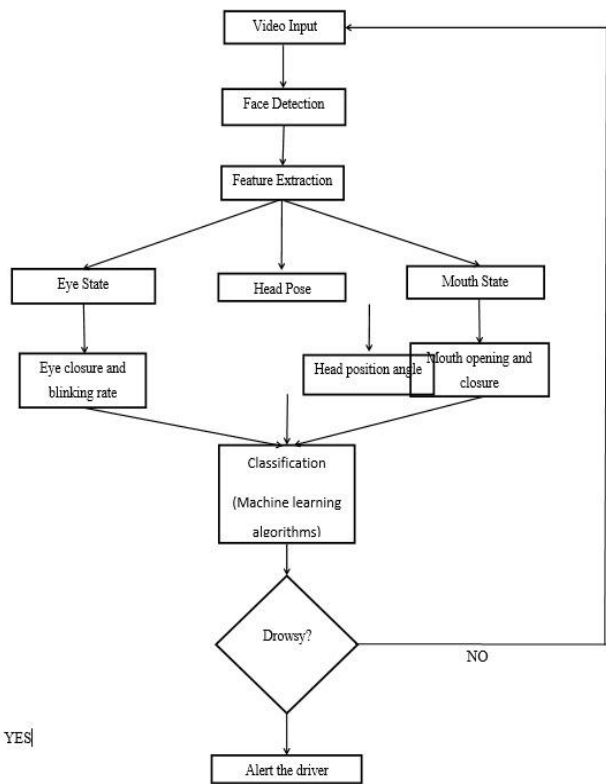


Fig. 2. Flow diagram.

**D. FACIAL LANDMARK BASED FEATURE EXTRACTION**

*a) Eye Aspect Ratio (EAR)*

The EAR metric is computed using six landmark points around each eye. It measures the ratio of vertical eye opening to horizontal width. When the driver begins to fall asleep, eye closure persists for several frames, causing the EAR value to drop below a predefined threshold. This drop is used to classify drowsiness. The EAR method is advantageous because it avoids heavy image-processing steps, reduces memory usage, and works reliably in different lighting conditions.

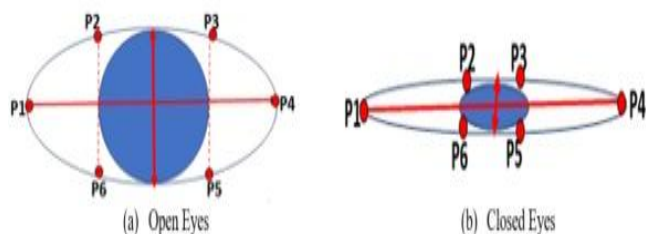


Fig. 3. Calculating the EAR metric

*b) Mouth Aspect Ratio (MAR)*

Yawning is another strong indicator of fatigue. MAR is calculated using the vertical distances between upper and lower lip landmarks, divided by the horizontal lip width. A higher MAR value indicates that the mouth is open. When only the MAR threshold is exceeded, the system issues a warning on the display without generating a loud alarm.

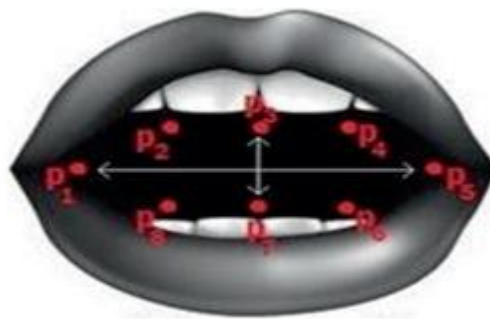


Fig. 4. Calculating the MAR metric.

*c) Head Position Detection*

Drowsy drivers often exhibit irregular or drooping head movements. The system tracks the position and orientation of the head using landmark coordinates. If an unusual tilt or nod is detected, a short buzzer alert and a visual warning are displayed. This also helps identify inattentive driving, such as talking with passengers while failing to focus on the road.

**E. COMBINED ALERT SYSTEM**

The system considers EAR, MAR, and head position collectively for reliable drowsiness detection:

- EAR threshold breached → Audio + LCD warning
- MAR threshold breached → LCD warning only
- Unusual head position → Brief audio + LCD warning
- All three thresholds breached → High-priority alert for driver safety

**F. HARDWARE INTEGRATION**

The proposed system integrates several hardware components that work together to achieve real-time drowsiness detection and accident alerting. The Raspberry Pi functions as the central processing unit, managing camera input, extracting facial features, evaluating eye and mouth metrics, reading sensor values, processing GPS data, controlling motor operations, and sending emergency alerts through the GSM module. A night-vision camera is used to ensure clear and consistent face detection even in low-light and nighttime conditions, allowing the system to operate effectively regardless of lighting variations. A buzzer provides an immediate audio alert whenever drowsiness, yawning, or abnormal head movement is detected, helping the driver regain focus before a potential accident occurs. In addition to audio warnings, an LCD display presents visual messages such as “Drowsiness Detected”, “Yawn Alert”, or “Head Down Alert”, ensuring that the driver receives clear feedback. Together, these hardware components create a reliable, responsive, and continuous monitoring system that improves overall driver safety by combining vision-based detection with real-time alert mechanisms.

**G. SYSTEM ARCHITECTURE**

The system architecture is built around the Raspberry Pi, which serves as the central processing unit responsible for managing all hardware modules and executing detection algorithms. A night-vision camera provides continuous video input, ensuring accurate monitoring in both daylight and low-light conditions. The captured video frames undergo facial landmark extraction, where key regions such

as the eyes, mouth, and head orientation are analyzed to compute the Eye Aspect Ratio (EAR), Mouth Aspect Ratio (MAR), and head pose angle. These extracted features are then passed to a classification module, which determines whether the driver’s behavioural patterns correspond to signs of drowsiness.

When the classification output indicates fatigue, the alert subsystem—consisting of a buzzer and LCD display—issues immediate warnings to refocus the driver's attention. Simultaneously, an ADXL tilt sensor monitors the vehicle’s movement, and in the event of a collision or abnormal tilt, the system activates the GPS and communication module to transmit the vehicle’s location to emergency contacts. The architecture ensures that monitoring, classification, and alert generation operate seamlessly in real time, without requiring manual intervention.

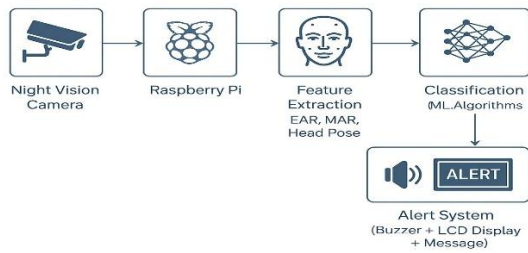


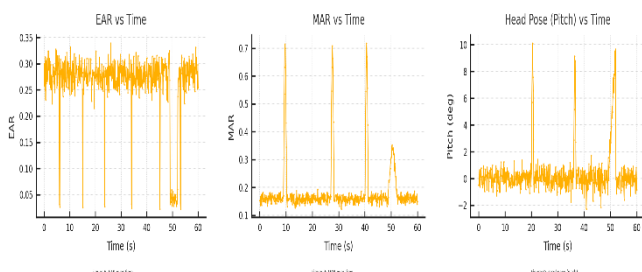
Fig. 6. System Architecture

H. EXPERIMENTAL SETUP

For experimental verification, the system was deployed on a Raspberry Pi environment with the night-vision camera mounted at the driver’s eye level to capture frontal facial features. Multiple test scenarios were conducted, including normal driving, partial eye closure, extended blinking, yawning, and downward head tilt. Environmental conditions such as low light, moderate light, and night-time driving were also tested to validate camera performance.

Testing for accident detection involved manually triggering tilt variations and simulating sudden impacts. GPS accuracy was evaluated by recording coordinates across multiple locations and comparing them to actual map positions. GSM-based messaging was tested on different networks to assess delivery speed and consistency.

IV. USER INTERACTION AND SYSTEM RESPONSE



Metric is computed using six landmark points around each eye. It measures the ratio of vertical eye opening to horizontal width. When the driver begins to fall asleep, eye closure persists for several frames, causing the EAR value to drop below a predefined threshold. This drop is used to classify drowsiness. The EAR method is advantageous because it avoids heavy image-processing steps, reduces memory usage, and works reliably in different lighting conditions.

Rule ID	Feature	Threshold	Action
R1	EAR	< 0.18 for 2 sec	Display warning
R2	EAR	< 0.12 for 4 sec	Sound buzzer
R3	MAR	> 0.5 for 1 sec	Display "Yawn" warning
R4	Head Pitch	> 10° sustained	Audio alert + log event

Fig. 7. Drowsiness Detection Rule-Set Based on EAR, MAR and Head Pose Thresholds

V. ACKNOWLEDGMENT

We are genuinely thankful to our guide and the faculty team for walking with us throughout this project. Their suggestions, corrections, and constant involvement helped us shape our work better than we initially imagined. We also thank our department and college for giving us the freedom, the space, and the time to experiment, test, fail, and improve until we arrived at a working system. Our families and friends deserve equal credit for supporting us through long nights, debugging phases, and every moment of uncertainty. Without their encouragement, we may not have reached this milestone.

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