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ORIGINAL CONTRIBUTION

Smart Drunk Driving Prevention Using IoT and Computer Vision

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ABSTRACT

Drunk driving is a major preventable cause of road fatalities, prompting increased regulatory attention to in-vehicle impairment detection. This paper presents a low-cost Smart Drunk Driving Prevention System using two independent detection channels. An MQ-3 alcohol sensor interfaced with an ESP32 DevKit V1 detects alcohol above a preset threshold and activates an alarm while inhibiting the ignition through a relay. In parallel, an ESP32-CAM streams driver video to a host application using OpenCV and MediaPipe Face Mesh to calculate Eye Aspect Ratio and Mouth Aspect Ratio for drowsiness and yawning detection. A NEO-6M GPS module provides vehicle location, transmitted to a cloud dashboard during impairment events. Bench tests demonstrated reliable engine locking, drowsiness and yawning detection, and location-data transmission. The prototype costs approximately ₹2,475. Key limitations include MQ-3 cross-sensitivity and dependence on Wi-Fi connectivity.

KEYWORDS: Drunk Driving Prevention, Drowsiness Detection, GPS Tracking, Embedded Systems, Vehicle Safety.

1. INTRODUCTION

Road traffic collisions are a major cause of death and injury worldwide, and a substantial proportion of them involve drivers impaired by alcohol. Alcohol degrades judgement, lengthens reaction time, and reduces the precision with which a driver controls a vehicle, placing at risk not only the driver but every other road user. Conventional countermeasures are enforcement-based: roadside checkpoints, breath testing by police officers, and legal sanction applied after an offence or a collision has already occurred.

Such measures depend on the presence of an officer, are applied intermittently, and cannot scale to the number of vehicles in use. Present-day vehicles possess no intrinsic mechanism for verifying driver sobriety before ignition, so there is a clear need for an affordable, automated, in-vehicle system that screens the driver continuously, prevents the vehicle from being operated when an unsafe condition is detected, and communicates the event without depending on external intervention.

Regulatory attention has moved in the same direction. Section 24220 of the United States

Infrastructure Investment and Jobs Act of 2021 directs the National Highway Traffic Safety Administration (NHTSA) to prescribe a Federal Motor Vehicle Safety Standard requiring new passenger vehicles to be equipped with advanced drunk and impaired driving prevention technology, defined as a system able to passively detect impairment and then prevent or limit vehicle operation [1]. As of the time of writing the rulemaking has reached only the advance notice stage [2]; NHTSA has attributed the delay to the immaturity of passive impairment-detection technology and to the absence of objective test procedures. The direction of travel, however, is established, and low-cost experimental platforms that combine several independent impairment indicators are of direct relevance to it.

This paper presents a low-cost prototype that addresses the problem through three complementary subsystems. A breath-alcohol sensor detects alcohol above a preset threshold and inhibits the ignition circuit. A camera and a facial-landmark algorithm assess whether the driver is showing signs of drowsiness or yawning, and inhibit the ignition on the same basis. A satellite positioning module supplies the vehicle location, which is relayed to a cloud dashboard

when an impairment event occurs. The objective is an affordable solution that unifies alcohol detection, driver-state monitoring, engine control, and emergency alerting in a single system.

The remainder of this paper is organised as follows. Section II reviews related work and identifies the research gap. Section III describes the proposed system and its hardware. Section IV sets out the firmware and vision methodology, and Section V the implementation. Section VI reports the experimental results, Section VII the limitations of the prototype, and Section VIII concludes with the future scope of the work.

2. LITERATURE REVIEW

Rafidi and Nik Ismail [3] developed an alcohol detection and ignition-locking system using an MQ-3 sensor, an Arduino Mega 2560, an LCD, and motor-control circuitry. The system disabled vehicle operation when the detected alcohol level exceeded a predefined threshold, demonstrating the effectiveness of sensor-based ignition control while also identifying the calibration limitations of MQ-3 sensors. Berad et al. [4] presented an Arduino-based drunk-driving detection system incorporating an MQ-3 sensor and GSM communication, which could detect alcohol, prevent ignition, and transmit an alert to a remote user, marking the transition from standalone detection towards connected vehicle-safety systems.

Nossam et al. [5] extended this approach with an alcohol-triggered accident detection and alert system integrating GSM, GPS, and an ESP32, so that the combination of sensing, communication, and location tracking provided improved situational awareness during potentially dangerous driving events. Mountzouris et al. [6] more recently described a smart vehicle safety and security system based on Arduino and the Internet of Things that addresses both drunk driving and theft, establishing a foundation for IoT-enabled vehicle safety applications.

A parallel body of work addresses driver state rather than blood alcohol. Yan et al. [7] investigated real-time drowsiness detection using PERCLOS and image-processing techniques, monitoring eye state and generating an alert when prolonged closure indicated fatigue. Kim et al. [8] developed a real-time driver monitoring system combining facial-landmark-based eye-closure

detection with head-pose recognition, and Zambrano et al. [9] applied facial landmarks and deep learning to the simultaneous detection of fatigue, distraction, and emotion. This line of work is important because unsafe driving occurs in the absence of alcohol as well as in its presence.

A third and smaller group combines the two modalities. Muiz et al. [10] reported an IoT-based driver safety system performing real-time drowsiness and alcohol monitoring through vision and multi-sensor integration, and Rani et al. [11] presented an IoT-enabled real-time driver monitoring system for drowsiness and alcohol detection built on Arduino and OpenCV. These works demonstrate the value of multimodal sensing but generally stop short of combining it with vehicle immobilisation and location-aware alerting in one platform.

Table 1 summarises the capabilities of the representative systems discussed above. Alcohol-centred designs provide ignition control but no assessment of driver state, and vision-centred designs assess driver state but exercise no control over the vehicle. Where the two are combined, the resulting systems generally lack either the engine-inhibit path or the location-reporting path. Remaining challenges across the literature include sensor calibration, false detection, varying illumination, computational limits, and reliable multimodal decision-making. The system proposed here addresses this gap by integrating alcohol sensing, computer-vision-based driver monitoring, vehicle immobilisation, and GPS-based cloud alerting within a single real-time framework.

Table 1. Capabilities of representative driver-safety systems. Alc. = breath-alcohol sensing; Drows. = drowsiness monitoring; GPS = location reporting; Lock = engine inhibition.

Work	Alc.	Drows.	GPS	Lock
Rafidi & Nik Ismail [3]	Yes	–	–	Yes
Berad et al. [4]	Yes	–	–	Yes
Nossam et al. [5]	Yes	–	Yes	–
Mountzouris et al. [6]	Yes	–	Yes	Yes
Yan et al. [7]	–	Yes	–	–
Kim et al. [8]	–	Yes	–	–
Zambrano et al. [9]	–	Yes	–	–
Muiz et al. [10]	Yes	Yes	–	–
Rani et al. [11]	Yes	Yes	–	–
This work	Yes	Yes	Yes	Yes

3. PROPOSED SYSTEM

3.1. System Architecture

The system uses an ESP32 DevKit V1 as the central processor, interfaced with an MQ-3 alcohol sensor, ESP32-CAM, 16×2 I2C LCD, two-channel relay, and NEO-6M GPS module. Alcohol sensing is performed at the edge, while facial video is processed on an external host using OpenCV and MediaPipe to detect drowsiness and yawning. When impairment is detected, the relay interrupts the ignition, GPS location is sent to the cloud dashboard, and the LCD displays the system status.

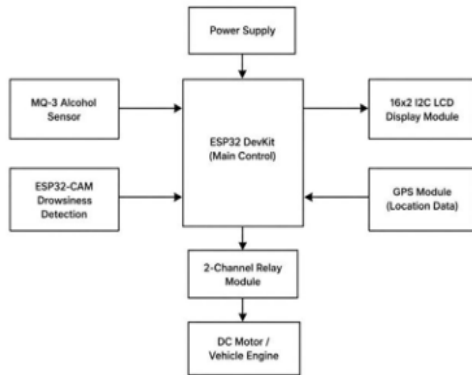


Figure 1: Block diagram of the proposed system.

3.2. Hardware Components

Table 2 lists the principal hardware components and their functions in the prototype.

Table 2. Key hardware components.

Component	Function
ESP32 DevKit V1	Main controller
MQ-3 sensor	Breath-alcohol sensing
ESP32-CAM	Vision unit
NEO-6M GPS	Location tracking
2-channel relay	Engine-lock actuation
16×2 I2C LCD	Status display
BO motor + 9 V battery	Engine surrogate

3.3. Control Unit

The ESP32 DevKit V1 is the decision-making element of the system. It receives the alcohol flag from the MQ-3 sensor and the drowsiness status from the vision subsystem, evaluates both, and determines whether the vehicle may be operated or whether a safety action is required. The controller drives the relay that inhibits the engine, updates the 16×2 I2C LCD to reflect the current state, and reads the GPS receiver, forwarding

position data to the cloud whenever a valid fix is available.

3.4. Alcohol Detection and Engine Locking

The alcohol-detection subsystem is built around the MQ-3 gas sensor, which requires a warm-up interval of approximately 30 seconds after power-up before its output is treated as valid. Once ready, the ESP32 samples the sensor continuously. When the measured concentration exceeds the configured threshold, the controller de-energises the relay, interrupting power to the ignition circuit so that the BO motor representing the engine stops, and writes the corresponding status message to the LCD.

3.5. Vision-Based Drowsiness Detection

The drowsiness subsystem uses the ESP32-CAM to observe the driver's face and stream the video to a host application built with MediaPipe Face Mesh. The application locates the facial landmarks around the eyes and mouth, and uses them to determine whether the eyes have remained closed for a sustained period, which indicates the onset of sleep, and whether the mouth is open in the characteristic pattern of a yawn. When drowsiness is confirmed, the host signals the ESP32, which locks the engine and activates the alarm through the same output path used for the alcohol channel, so that either indicator alone is sufficient to immobilise the vehicle.

3.6. GPS and Communication Unit

The NEO-6M GPS module supplies the vehicle position. The ESP32 parses the incoming NMEA sentences to extract latitude and longitude. When an impairment event occurs and a valid fix is available, the coordinates are formatted and transmitted over an HTTPS connection to a cloud dashboard, allowing the location associated with an alcohol or drowsiness event to be viewed remotely. The positioning and communication subsystem therefore adds an emergency-notification capability to the engine-locking function.

4. METHODOLOGY

4.1. Firmware

The ESP32 firmware is developed in the Arduino IDE and uses the WiFi.h, HTTPClient.h, TinyGPS++.h, HardwareSerial.h, Wire.h, and LiquidCrystal_I2C.h libraries. The alcohol-

detection routine reads a digital threshold flag from the comparator output of the MQ-3 module. When the flag indicates the presence of alcohol, the firmware sets the relay pin low, disengaging the simulated ignition, updates the LCD, and, if a valid GPS fix is available, serialises the latitude and longitude into a JSON payload delivered by HTTPS POST to the cloud endpoint.

4.2. Vision-Based Drowsiness Detection

The ESP32-CAM streams MJPEG video over Wi-Fi to a host application built with OpenCV and MediaPipe Face Mesh. Six landmark points per eye are used to compute the Eye Aspect Ratio (EAR):

$$EAR = (|p_2 - p_5| + |p_3 - p_6|) / (2 \times |p_1 - p_4|)$$

where p_1 and p_4 are the horizontal eye corners and p_2 , p_3 , p_5 and p_6 are the vertical eyelid landmarks. An open eye typically yields an EAR between 0.28 and 0.38; a sustained EAR below 0.22 for 20 consecutive frames is classified as drowsiness. A parallel Mouth Aspect Ratio (MAR) computed over 20 mouth landmarks flags yawning when it exceeds an empirically determined threshold. When drowsiness is confirmed, the host sends an HTTP GET request to the /drowsy endpoint exposed by the ESP32, which the firmware treats as an independent trigger for engine locking and alarm activation, mirroring the alcohol-detection response path.

4.3. System Operation

The complete operating cycle is shown in Fig. 2. On power-up the firmware initialises the peripherals, connects to the Wi-Fi network, and waits for the MQ-3 warm-up interval to elapse. It then enters a continuous sense–decide–act loop: the alcohol flag is read first, and if no alcohol is present the drowsiness status reported by the vision subsystem is evaluated. If neither indicator is raised, the engine remains enabled and the LCD reports normal operation. If either indicator is raised, the relay is de-energised, the alarm is activated, and, when a valid GPS fix is available, the vehicle position is transmitted to the cloud dashboard. The loop then repeats so that a change in the driver's condition is acted upon promptly.

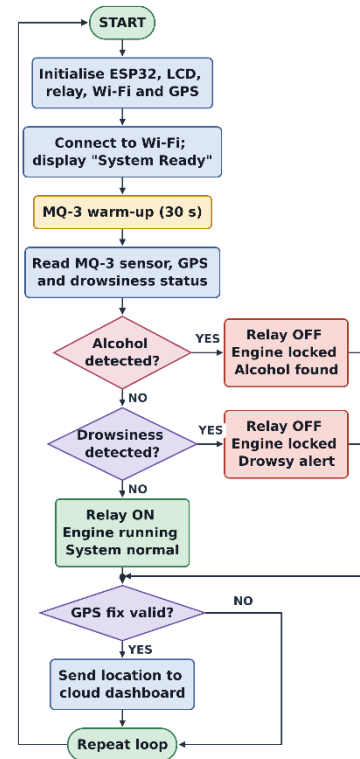


Figure 2: Operational flowchart of the proposed system.

5. IMPLEMENTATION

The prototype was constructed as a low-cost proof of concept on a breadboard, using an ESP32 DevKit V1 as the controller. The ESP32-CAM, MQ-3 alcohol sensor, two-channel relay module, 16 × 2 I2C LCD, and NEO-6M GPS module were connected according to the circuit-level design shown in Fig. 3. A BO motor powered by a 9 V battery was used in place of an engine to demonstrate the ignition-inhibit function. All components are readily available, and the total cost of the assembly was approximately ₹2,475 (about US\$28).

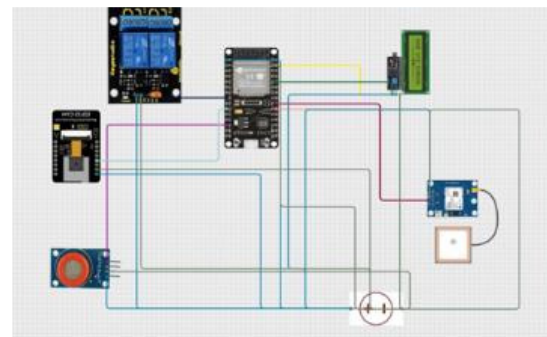


Figure 3: Circuit-level wiring diagram of the prototype.

The relay was wired to act as the ignition switch for the BO motor, so that when the MQ-3 sensor

reported an alcohol concentration above the configured threshold the ESP32 changed the relay state to stop the motor and displayed the corresponding status on the LCD. The ESP32-CAM was configured to stream MJPEG video over Wi-Fi to the host computer, where the Python application located the eye and mouth landmarks and applied the EAR and MAR criteria described above. The NEO-6M module supplied the coordinates that were serialised and posted to the cloud dashboard. The assembled prototype was then exercised under controlled alcohol-vapour exposure and simulated fatigue in order to test the alcohol detection, engine-locking, drowsiness detection, and location-logging functions together.

6. RESULTS AND DISCUSSION

6.1. Alcohol Detection and Engine Control

With the relay energised by default, the BO motor operated continuously in the absence of alcohol. On exposure of the sensor head to an alcohol source, the firmware consistently de-energised the relay within the response window of the sensor, halted the motor, and updated the LCD to indicate that alcohol had been found and the engine locked. The two states are shown in Fig. 4 and Fig. 5.

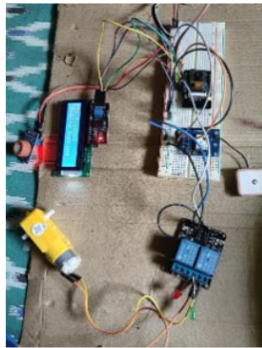


Figure 4: Engine running, no alcohol detected.

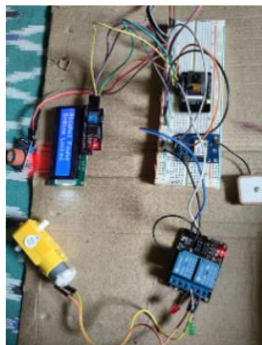


Figure 5: Engine locked, alcohol detected.

6.2. Drowsiness and Yawning Detection

Across the bench trials, sustained eye closure reliably drove the EAR below the 0.22 threshold within the 20-frame observation window, and exaggerated mouth opening reliably raised the MAR-based yawning flag. Fig. 6 shows a representative frame in which an EAR of 0.13 and a MAR of 1.56 produced simultaneous drowsiness and yawning classifications.

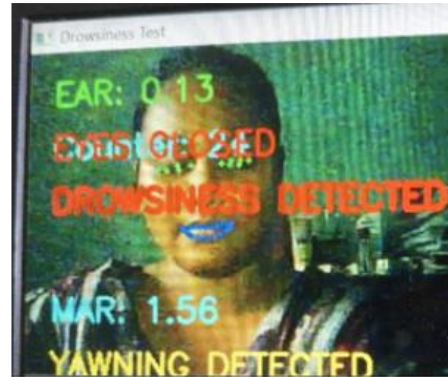


Figure 6: Live EAR and MAR based drowsiness and yawning classification during bench testing.

6.3. GPS Tracking and Cloud Relay

Whenever an alcohol event coincided with a valid GPS fix, the latitude and longitude were successfully relayed to the cloud dashboard, confirming the end-to-end telemetry path from the on-board receiver to the remote viewer.

6.4. Discussion

The results indicate that a bill of materials below US\$30 can support a functioning multi-stage interlock suitable for classroom demonstration and early-stage research. Compared with the single-modality designs surveyed in Section II and summarised in Table 1, the addition of an independent EAR and MAR cross-check means that the two impairment indicators are derived from physically unrelated measurements, so a transient false positive on the alcohol sensor is not corroborated by the vision channel.

7. CONCLUSION

The proposed low-cost Smart Drunk Driving Prevention System integrates alcohol sensing, vision-based drowsiness monitoring, engine locking, and GPS telemetry into a unified safety framework. Experimental results demonstrated effective alcohol detection, drowsiness and yawning classification, and reliable location-data transmission. Future work will focus on

multimodal physiological sensing, improved onboard AI processing, secure telemetry, driver authentication, and ethanol-selective sensing to enhance reliability and support vehicle-grade deployment.

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