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Design and Implementation of Smart-Alert System with Engine Immobilization

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Abstract: This study introduces a practical, tech- driven approach to tackling road accidents caused by drunk driving—a persistent issue even after speed limits and other preventive measures. While reckless driving, speeding, and alcohol impairment remain leading causes of crashes, our team has designed an innovative IoT- based in-vehicle system using an ESP32 microcontroller. The setup integrates an MQ3 alcohol detection sensor, DC motor and a L298 dual H-bridge motor driver to control vehicle movement At its core, the Alcohol detection sensor continuously tracks the driver's breath for alcohol levels, cleverly embedded into the steering wheel for seamless operation. If the alcohol concentration exceeds the legal threshold of 0.5 mg/mL, the system doesn't just sound an alarm— it automatically alerts designated contacts or authorities via SMS. It also monitors speeding, adding an extra layer of safety. During testing, the alcohol sensor proved both fast and reliable, reacting instantly to alcohol detection and maintaining consistent performance over time. By merging real-time alerts with cloud connectivity, this system offers a user-friendly, proactive solution to curb impaired driving and save lives.

Keywords: ESP32 Microcontroller, MQ3 Alcohol Detection Sensor, A9G GPS/GSM module, L298 Mini Motor Driver

I. INTRODUCTION

The issue of safety remains one of humanity's most critical concerns. Governments worldwide often enact laws to restrict certain behaviors, aiming to protect public safety, reduce healthcare costs, and improve health management [1]. However, recent years have seen a troubling rise in alcohol misuse, paralleling the global increase in drug- related issues. Accurate data on Drink and Drive in India is challenging to obtain as most accident accounted of drink and drive is termed with speeding or negligence while driving. Yet, the impact is undeniable: alcohol-related deaths exceed 10,000 annually in many countries, and alcohol is implicated in over half of all road and workplace injuries, causing significant injuries and property damage yearly.

While drunk driving is a leading cause of road accidents, it's not the only factor. Speeding and reckless driving also contribute to a high number of fatalities. According to the NHAI, alcohol-related crashes claim five lives every hour. In the U.S., driving under the influence remains a major public safety issue. Alcohol impairs driving skills, significantly increasing accident risks. The NHAI reports that alcohol is a factor in nearly half of all traffic accidents. This problem is particularly evident where highway rest stops are often crowded with establishments selling both licensed and local alcoholic beverages. Many commercial drivers, especially on long routes, consume alcohol while driving, further worsening the situation.

According to India's Ministry of Road Transport and Highways, 461,312 road accidents were recorded in 2022, a significant increase from the figure cited by NHAI. While speeding remains the leading documented cause of accidents (accounting for ~67% of cases in 2022), impaired driving due to alcohol consumption is also a critical contributor. The World Health Organization (WHO) 2023 Global Status Report on Road Safety indicates that alcohol impairment is involved in 20-30% of global traffic fatalities, rather than the previously claimed "half" of all accidents. This variance highlights regional differences: for instance, high-income countries report alcohol-related crash rates of ~20%, while some low- and middle-income nations experience rates closer to 35%. Globally, road traffic injuries claimed 1.19 million lives in 2021 (WHO, 2023), with disparities in fatality rates per 100,000 population: 21.5 in low-income countries and 17.3 in middle-income countries, compared to 8.3 in high-income nations. In India, a 2018 study by the Indian Institute of Technology (IIT) Delhi found that 22% of commercial truck drivers admitted to consuming alcohol while driving, underscoring behavioural risks in long-haul transport sectors. However, official Indian government data attributes only 3.3% of 2022 accidents directly to drunk driving, suggesting potential underreporting or differing enforcement standards. The ESP32 microcontroller continuously monitors data from the alcohol sensor to detect drunk driving and triggers a vehicle lock mechanism if necessary. In India, over 16,257 traffic violations in 2023 were directly linked to drivers exceeding the legal blood alcohol limit. Many accidents stem from driver negligence, particularly drinking and driving, which is both illegal and socially irresponsible. Such drivers pose a significant threat to public safety and must be addressed promptly.

Vehicle accidents are alarmingly common, resulting in numerous fatalities and extensive property damage. In India, accidents occur almost daily, causing injuries, loss of life, and destruction of property. Key factors contributing to these accidents include overloading, speeding, illegal road use, poor driving skills, and alcohol consumption. Among these, alcohol consumption is identified as the leading cause of car accidents [6], followed closely by speeding. Some drivers consume alcohol during their journeys, often drinking beer for refreshment or at lunchtime. This behavior can lead to severe accidents, as alcohol impairs perception, vehicle control, and the nervous system.

This research focuses on implementing IoT technology to address two critical factors in road safety: in-vehicle alcohol detection and automated speed regulation. The system integrates sensors (e.g., alcohol detectors) to monitor a driver in real time, paired with a motor driver module to autonomously adjust vehicle speed and direction if unsafe conditions are detected by the ESP32 microcontroller establishes secure Wi-Fi/Bluetooth connectivity, enabling data transmission to a cloud server for remote monitoring.

The system also includes an automated SMS alert system to notify authorities or emergency contacts if violations occur (e.g., drunk driving or speeding). A graphical user interface (GUI) allows users to configure speed limits and receive alerts, positioning this solution as a preventive tool to mitigate accidents caused by impaired driving or excessive speed.

II. MATERIALS AND METHODS

A. Materials

This system employs a dual-microcontroller architecture for coordinated functionality. The primary Control MCU, centered on an ESP 32 microcontroller, manages vehicle motion by interfacing with an L298N dual H-bridge motor driver to control motor operations.

Integration of an AT-09 Bluetooth module enables wireless communication, while a micro servo ensures precise steering adjustments. The platform is built on a modular smart car chassis with four geared motor-wheel assemblies for enhanced maneuverability. Jumper wires, headers, and a Vero board ensure organized connectivity across the compact control unit.

Meanwhile, the Monitoring MCU—built around the versatile ESP32—acts as the project's vigilant guardian. It seamlessly integrates an MQ3 alcohol sensor and an optical speed sensor to detect risks, while a GSM module enables real-time data uploads to the cloud.

Rounding out the build are essential extras: a compact 3.7V battery, a power switch for quick control, and trusty tools like a glue gun and soldering iron to bring it all to life. Together, these components form a smart, responsive system that balances mobility, safety, and connectivity!

The second MCU handles monitoring and safety functions, including alcohol detection, speed sensing, data uploading to a website, and the ability to shut down the vehicle when necessary. This unit is built around an ESP32 development board and includes a relay switch, a BD135 transistor, resistors, an MQ3 alcohol/ethanol gas sensor, and an optical slot motor speed sensor. It also features a A9G GSM/GPS module for communication and for real-time monitoring. Additional supporting components across the system include a 3.7V battery, a power switch, a glue gun for structural assembly, and soldering tools for circuit connections.

B. Methods

The chassis assembly was constructed by securely fastening the structural frame and geared motors to form a rigid mechanical foundation. Speed-encoder-integrated wheels were subsequently affixed to the geared motor shafts to enable motion tracking. The control and monitoring MCU circuitry were methodically soldered in adherence to industry-standard circuit schematics, with essential components precision- mounted to ensure electrical integrity. This assembly was then permanently secured to the chassis using a high-strength adhesive bonding agent.

Interconnect jumper cables were systematically routed between all subsystems to establish robust signal and power transmission pathways. Dual battery compartments were likewise mounted via adhesive bonding, with their output terminals configured in series to combine four 3.7V lithium cells, yielding a nominal 14.8V supply (Fig. 1). Firmware for both MCUs was meticulously programmed and deployed to their respective development boards following rigorous validation protocols. Comprehensive system documentation, including circuit schematics (Fig. 2), architectural diagrams (Fig. 3), and functional block diagrams (Fig. 4), accompanies the technical implementation.

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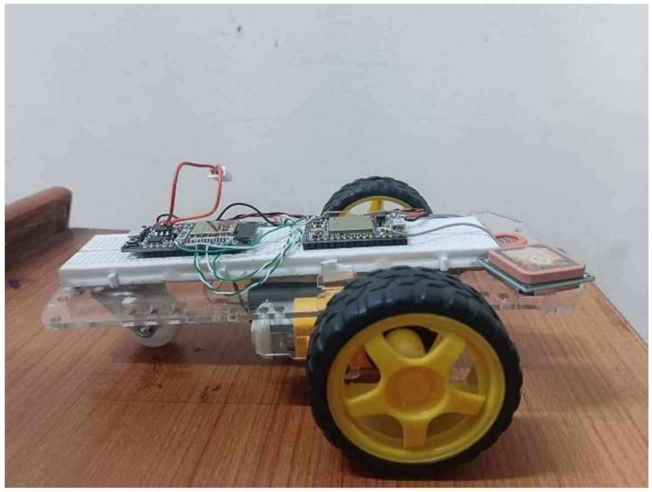


Fig 1. Lateral view of the model

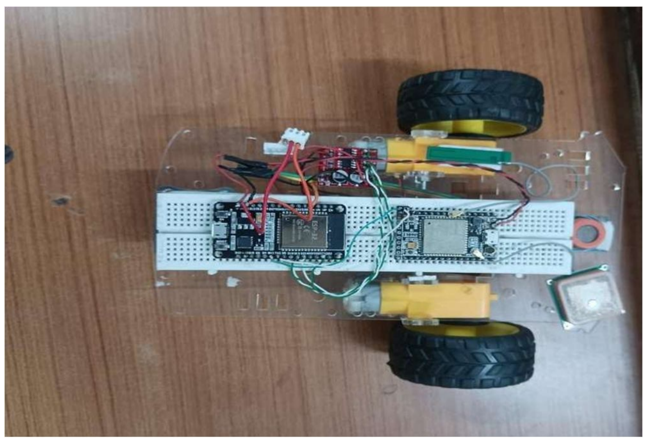


Fig 2. Top view of the model

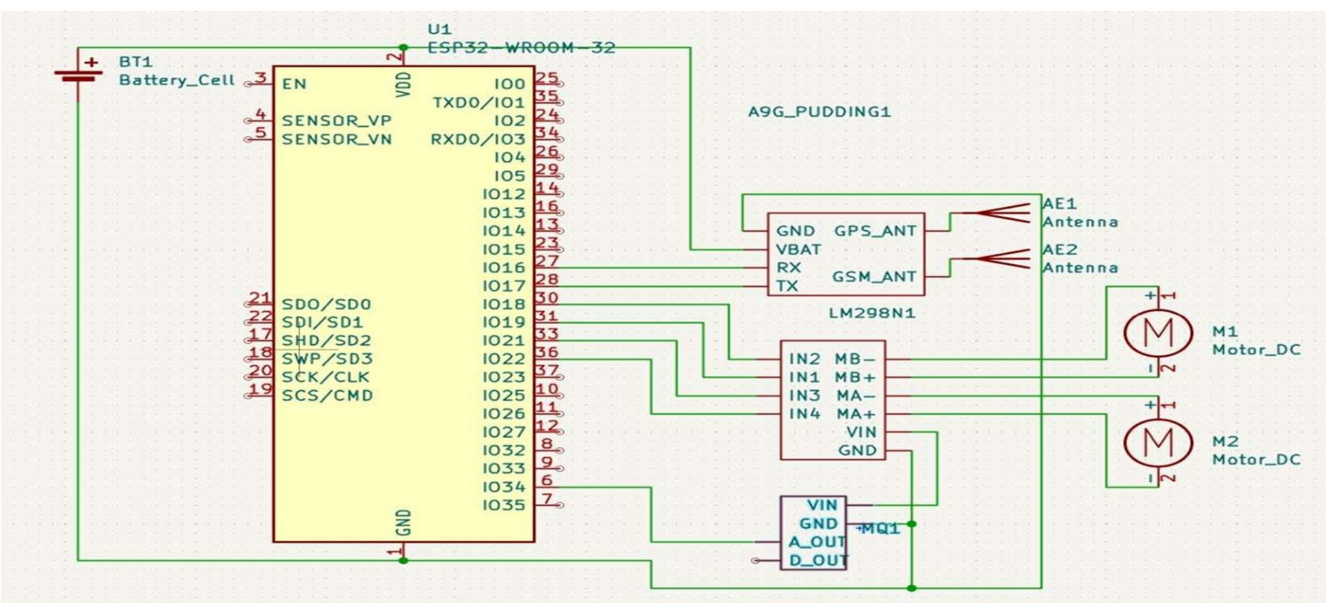


Fig. 3. Circuit Diagram of Model

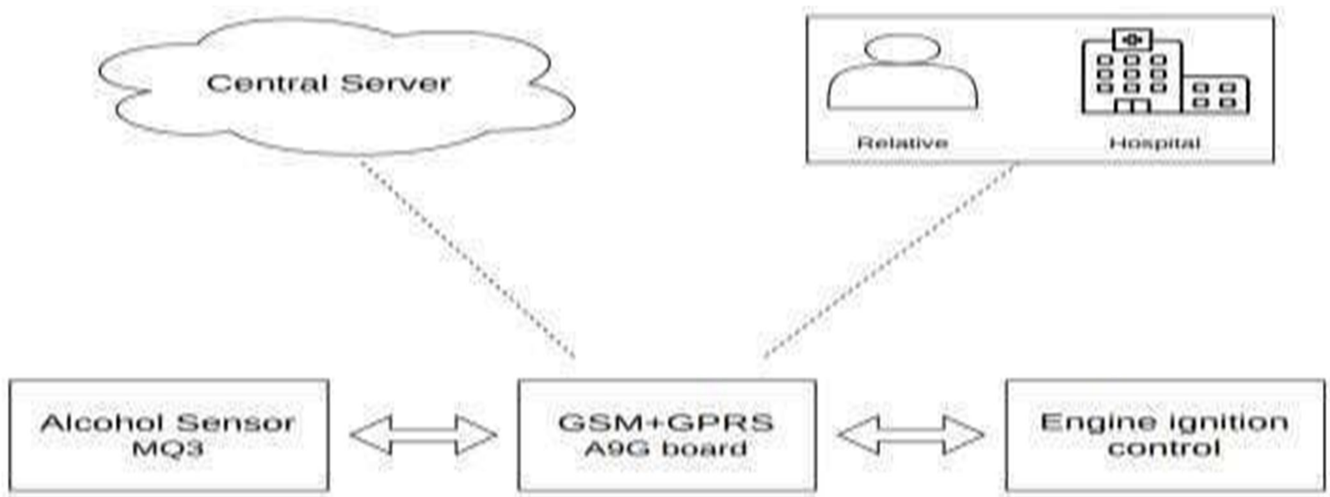


Fig. 4. Flow Diagram of Alcohol Detection and Engine Immobilization System.

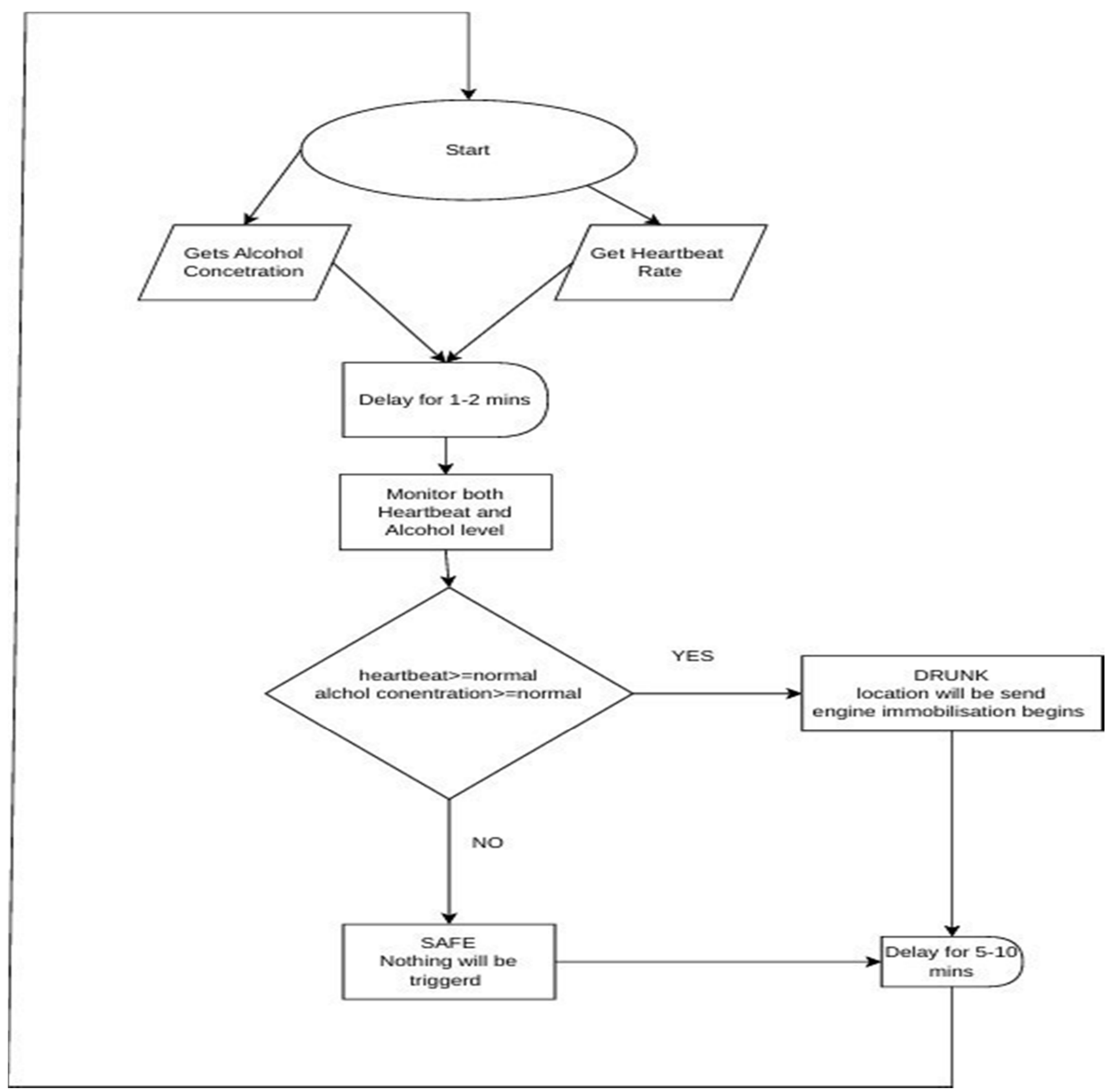


Fig. 5. Block Diagram of the Smart Alert System.

III. RESULT

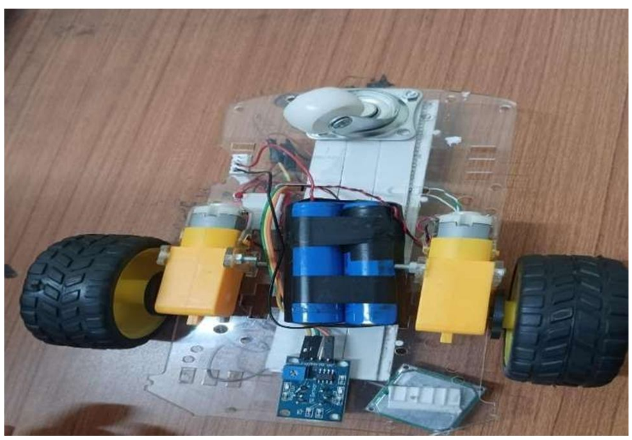
The system was tested under various conditions to verify functionality, reliability, and response time. Key test outcomes include: -

1) The MQ-3 sensor consistently detected alcohol when exposed to breath laced with ethanol or alcoholic beverages. The analog value increased sharply upon detection.
2) The threshold value of 3500 was experimentally chosen to minimize false positives while ensuring reliable detection.
3) The A9G module reliably fetched GPS coordinates in open-sky conditions within 5–10 seconds. In obstructed environments, fallback coordinates were sent.
4) SMS alerts with Google Maps links were successfully received on the registered number. The link could be clicked to open the driver's current location on a smartphone.
5) The ESP32 maintained stable dual-core performance with no observable delays or crashes.
6) The vehicle consistently stopped when the alcohol level exceeded the limit, with the motors halting in a gradual, controlled manner.

The board send real-time data via SMS, while the cloud server shares this information with authorities. If the vehicle exceeds the speed limit, an SMS is sent to registered contacts (e.g., family members) and relevant authorities. In this study, speeds between 100 and 120 km/h are deemed normal, while speeds above 120 km/h are considered excessive, triggering immediate alerts.

IV. DISCUSSION

To determine the system's accuracy, some alcoholic beverages were used to test the system's response for varying alcohol concentrations (Table I). The System is composed of the following: - Alcohol Detector (MQ3 Sensor), ESP32 Module, A 9G GSM/GPS module Breadboard, LEDs, and. The figure below shows the system's result generated. This model senses the presence of alcohol in the air of the vehicle, and then immediately sends the signal, and the LEDs start flicking as. the circuit can sense the alcohol level thus minimizing the chances of accidents.



The system is designed to prioritize driver and public safety. If the sensor detects alcohol levels above the safe limit, it immediately restricts the vehicle's ignition—preventing the driver from starting the car. However, in emergency situations where speeding is necessary for safety (such as escaping danger), the system allows temporary override while automatically alerting authorities and family members via SMS for immediate assistance.

Similarly, when the driver is sober but exceeds speed limits, the system intervenes by cutting ignition—unless an emergency arises. In such cases, the driver can accelerate to safety, and notifications are sent to relevant contacts to ensure help is available if needed.

While the MQ3-based alcohol detection system is engineered to prioritize driver and public safety, its effectiveness relies on thoughtful human interaction and environmental conditions. Like all technology, it may encounter limitations in real-world scenarios.

For instance, if a driver wears a mask or covers their mouth, reduced breath exposure to the sensor could delay or impede accurate blood alcohol content. Similarly, intentional obstruction such as covering the sensor with fabric—or accidental blockages (e.g., dust in the sensor vents) may temporarily disable detection, allowing the vehicle to start despite safety protocols. These scenarios highlight the importance of user awareness and proactive maintenance to ensure system reliability.

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V. CONCLUSION

This project successfully implements a real-time, autonomous vehicle safety system capable of detecting alcohol intoxication and responding appropriately by halting the vehicle and alerting authorities or family with precise GPS-based SMS alerts. Built entirely on ESP32 and A9G modules, the design offers improved processing, dual-core parallelism, and complete automation, including simulated hardware activation. Compared to traditional microcontroller systems, this design stands out in terms of multitasking, communication capability, and reduced manual effort. Future enhancements may include integration with voice-activated interfaces, temperature/humidity compensation in sensor readings, and black-box style trip logging. The proposed solution is highly suitable for practical deployment in regions where impaired driving is a significant threat.

To improve future iterations, we suggest: -.

1) Integrate voice recognition to restrict breath tests to authorized users (e.g., the car owner).
2) Include humidity/temperature sensors to adjust readings for environmental factors.