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SMART VEHICLE IMMOBILIZATION SYSTEM WITH INTEGRATED ALCOHOL DETECTION AND REAL- TIME GPS MONITORING

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Abstract:

This paper addresses the critical need for enhanced road safety by preventing drunk driving through automated vehicle immobilization. It also enables real-time GPS tracking for better vehicle monitoring and swift response in emergencies. By integrating IoT, it ensures remote access to safety data, promoting smarter and safer transportation systems. This project proposes a Smart Vehicle Immobilization System with Integrated Alcohol Detection and Real-Time Gps Monitoring. This system presents a Smart Vehicle Immobilization System with integrated alcohol detection and real-time GPS monitoring. At its core is an Arduino Uno (ATmega328P), interfaced with various sensors and modules to ensure safe and controlled vehicle operation. The MQ-3 sensor detects the driver's alcohol level, and if it exceeds a predefined threshold, the system immediately initiates a vehicle immobilization process. A GPS module enables real-time location tracking, providing vital data for monitoring and safety. The MPU6050 sensor monitors motion and orientation, adding further vehicle stability analysis. The data is processed by the Arduino Uno and displayed on an LCD screen. The Node MCU Wi-Fi module ensures IoT integration, transmitting information such as alcohol levels and motor status to a cloud-based platform for remote access. A relay driver controls an electronic relay, which, when triggered, deactivates the vehicle's DC gear motor to prevent operation under unsafe conditions. A buzzer alerts nearby individuals when alcohol is detected. This integrated system ensures that vehicles remain safe and non-operational in high-risk situations, enhancing road safety. Through IoT connectivity, it offers enhanced monitoring and control capabilities, making it a comprehensive solution for smart transportation safety management.

***Index Terms* - Arduino Uno, Integrated Alcohol Detection, MQ-3 alcohol sensor**

INTRODUCTION

Alcohol detection is the process of identifying ethanol in the body, crucial for law enforcement, healthcare, workplace safety, and transportation. Alcohol impairs judgment, slows reaction time, and reduces coordination, making accurate and fast detection vital to prevent accidents. After consumption, alcohol is absorbed in the stomach and small intestine, transported to the liver, and partially metabolized, with the remainder excreted via breath, sweat, urine, and saliva. This enables multiple detection methods. Breath analysis using a Breathalyzer is common for roadside checks, offering quick, non-invasive BAC estimates but requiring regular calibration and being prone to some interference. Blood tests are the gold standard for accuracy, used in legal and medical contexts, though invasive and time-consuming. Urine tests are easy and non-invasive, useful for past consumption detection in workplaces or rehab, but less reliable for current intoxication. Saliva tests use swabs for quick roadside or workplace screening, though less accurate and with a short detection window. Sweat testing with wearable transdermal sensors provides continuous monitoring, often for probation compliance, but is unsuitable for urgent BAC readings. Technological advances such as infrared spectroscopy, fuel cell sensors, smartphone-linked wearables, and vehicle-integrated systems improve reliability and accessibility, with smart vehicles potentially preventing operation above legal BAC limits. In many countries, the legal BAC limit is 0.08%, with stricter rules for certain drivers. Legal use requires proper protocols, maintenance, and calibration for court admissibility. Beyond enforcement, alcohol detection aids medical diagnosis of poisoning, informs treatment, supports sobriety monitoring in rehab, and ensures workplace safety in high-risk industries through random testing. Challenges include false positives or negatives, with factors like health conditions, medications, and diet affecting results. Ethical issues of privacy and consent also arise. The future promises AI and machine learning for more precise data interpretation, contactless sensors, and integrated safety systems in vehicles and wearables. Overall, alcohol detection remains an essential safeguard for public safety, legal enforcement, healthcare, and responsible behavior.

METHODS OF ALCOHOL DETECTION

Alcohol detection plays a vital role in public safety, law enforcement, workplace policies, and medical treatment, helping determine intoxication levels and ensuring individuals are fit for tasks like driving or operating machinery. Ethanol, the intoxicating compound in alcohol, can be measured through breath, blood, urine, saliva, or sweat, each with distinct advantages, drawbacks, and applications. Breath analysis using a breathalyzer is the most common roadside method, estimating Blood Alcohol Concentration (BAC) by measuring ethanol in exhaled air after it reaches the lungs via the bloodstream. Breathalyzers include semiconductor sensors, which are cheaper but less accurate, and fuel cell sensors, which are more precise and preferred by law enforcement. While quick, non-invasive, and easy to use, breath tests can be affected by residual mouth alcohol, poor calibration, or environmental factors, but remain reliable with proper maintenance. Blood testing directly measures ethanol in the bloodstream via venepuncture and lab analysis, offering the highest accuracy and minimal influence from external factors. It is the legal gold standard, used in court cases, emergencies, or disputed breath tests, though it is invasive, requires skilled staff, and is slower, making it unsuitable for immediate roadside use. Urine testing detects alcohol metabolites like ethyl glucuronide (EtG) and ethyl sulphate (EtS) hours to days after drinking, making it useful for workplace screening, rehabilitation, or probation monitoring. It is easy, low-cost, and non-invasive, but less effective for determining current intoxication and can be influenced by hydration and kidney function. Saliva testing offers quick, non-invasive results within minutes using strips or electronic analyzers, detecting alcohol shortly after consumption. It is common in roadside, workplace, and home testing, though less accurate than blood tests and with a shorter detection window, making it better for identifying recent use rather than past consumption. Sweat-based or transdermal alcohol monitoring is a newer technology that continuously measures ethanol excreted through the skin using wearable devices like ankle bracelets or patches, transmitting real-time data for legal, correctional, or recovery programs. It enables passive, round-the-clock monitoring but can be costly and influenced by environmental factors. Each method's suitability depends on the needed accuracy, detection window, cost, and testing context: breath analysis is ideal for fast roadside checks, blood testing for legal or medical precision, urine testing for past use detection, saliva testing for quick screening, and transdermal monitoring for continuous compliance tracking. Together, these tools form a comprehensive alcohol detection framework balancing speed, accuracy, and practicality across diverse settings.

LITERATURE REVIEW

Vitiello et al. (2025) explore integrating smart card readers into vehicle ignition systems to boost security, compliance, and road safety. The system uses real-time driver verification, AES-256/RSA encryption, and multifactor authentication to curb unauthorized use and prevent accidents. A major innovation is automated drug and impairment detection, targeting illicit and prescription substance influence. Risk models suggest a potential 7.65% reduction in drug-related accidents with high compliance. Sensor-based monitoring also enables real-time medication tracking for medical transport and assisted driving applications.

Sapthami et al. (2024) emphasize the need for advanced safety measures in today's fast-paced, hazardous driving environment. Rising alcohol-related accidents highlight the urgency for innovative solutions. The study proposes an IoT-based integrated system for alcohol detection and control in commercial vehicles. Specialized sensors detect alcohol and interface with vehicle control systems. When alcohol is detected, the system restricts vehicle operation to prevent impaired driving.

Sathish et al. (2024) propose a "Smart Vehicle Monitoring System" to improve road safety and user authentication. The system monitors helmet usage, detects alcohol consumption, and authenticates users via fingerprint and RFID. It also tracks vehicle parameters like tire pressure and fuel levels. Accident detection is achieved using a vibration sensor, triggering GSM alerts for rapid emergency response. Wireless communication via ESP and Arduino Mega enables real-time data exchange, with an LCD displaying status updates.

Hebsur et al. (2024) present an integrated vehicle safety system to enhance road safety, deter impaired driving, curb rash driving, and prevent theft. An MQ3 sensor detects alcohol in the driver's breath, triggering engine immobilization and alerts when thresholds are exceeded. Accelerometers and gyroscopes monitor vehicle motion to identify rash driving. The engine locking mechanism activates upon detecting alcohol or unsafe driving behaviors. GPS tracking provides real-time location data to contacts or authorities during emergencies or accidents.

Vaishnav et al. (2024) developed a Vehicle Tracking and Accident Detection system to combat high-speed and intoxicated driving accidents. It uses vibration sensors for collision detection and ultrasonic/IR sensors for distance monitoring to prevent crashes. In an accident, airbags and automatic braking are activated, and alerts are sent to emergency services. A black box records critical vehicle data like speed, braking, and steering for crash analysis. The system aims to reduce fatalities and enhance emergency response efficiency.

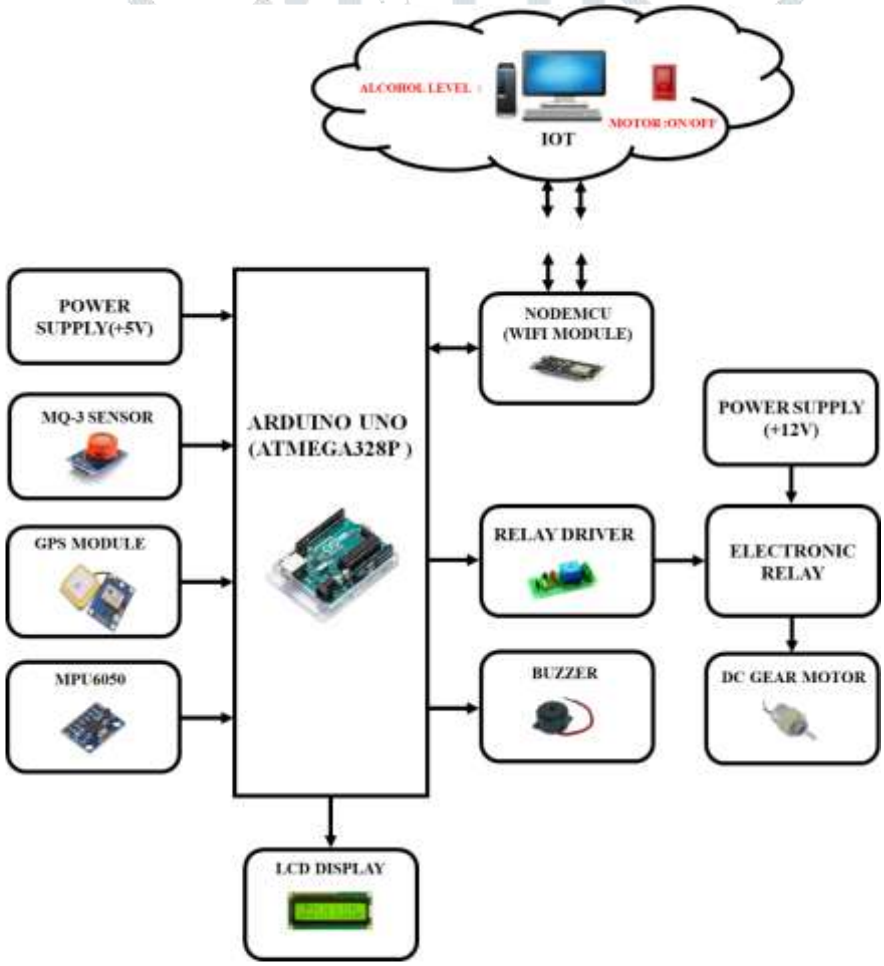
EXISTING SYSTEM

In 2020, drunk drivers were responsible for 8,355 road incidents, with a study by Goa Medical College revealing alcohol as a contributing factor in 12.7% of all automotive accidents. The persistently high rate of such accidents underscores the urgent need for effective technological solutions to combat drunk driving. This research focuses on an Arduino-based Alcohol Detection and Vehicle Control System designed to enhance public safety by reducing risks associated with driving under the influence of alcohol or drugs. The system creatively integrates sensor technology with the flexibility of the Arduino microcontroller to determine a driver's sobriety and execute preventive measures in real time. Using an MQ-3 alcohol sensor, it measures alcohol levels with high accuracy, displaying results on an LCD screen and instantly responding if levels exceed the safety threshold. Upon detection, the system can immobilize the vehicle, preventing it from starting or continuing to operate, thereby reducing accident risks. Supporting modules such as GPS, GSM, and Wi-Fi enable the system to transmit location and alert information to designated contacts or authorities, improving surveillance and emergency response.

Powered by a 12V battery for uninterrupted operation, the system incorporates multiple safety mechanisms—buzzers to alert drivers and bystanders, GSM alerts to parents, emergency services, or fleet monitoring centers, and GPS tracking to provide real-time coordinates. The LCD display offers drivers useful feedback on alcohol levels, system status, GPS location, and alerts. This integrated design makes the system suitable for public transport, school buses, logistics fleets, and private vehicles where driver behavior must be continuously monitored. Testing (Figure 3.2) demonstrated the system's high forecast accuracy, ranging from 93% to 100%, with only minor deviations at higher BAC levels. The vehicle immobilization feature engages when BAC meets or exceeds 0.08%, with response times between 0 and 1.10 seconds, ensuring swift action against unsafe driving conditions. Despite its strengths, the research acknowledges drawbacks in existing comparable systems: commercial breathalyzer interlocks and advanced driver assistance features are expensive and require professional installation, limiting adoption; environmental conditions can cause detection errors; biometric immobilization systems raise privacy concerns and are ineffective against drunk driving; and wearable alcohol sensors face accuracy, privacy, and stigma challenges. This Arduino-based approach offers a cost-effective, adaptable, and accurate alternative. The conclusion emphasizes that while the current model is a significant first step in accident prevention, further refinements—particularly through integration with artificial intelligence and machine learning—could greatly enhance precision, reliability, and decision-making capabilities. As part of the broader field of intelligent transportation systems, this research aims to establish a safer, more efficient transportation environment by leveraging low-cost hardware, modular sensors, and real-time control strategies to detect and address hazardous driving behaviors before they cause harm. Ultimately, the system represents a proactive, scalable, and potentially lifesaving tool in the ongoing effort to curb alcohol-related road accidents and protect lives.

PROPOSED SYSTEM

The Smart Vehicle Immobilization System with Integrated Alcohol Detection and Real-Time GPS Monitoring is designed to prevent drunk driving and improve road safety. It uses an MQ-3 alcohol sensor to detect alcohol in the driver's breath and automatically immobilizes the vehicle if levels exceed a set threshold. A GPS module provides continuous location tracking, while a GSM module sends alerts or updates via SMS to authorized contacts in case of route deviations or unauthorized access. Managed by an Arduino Uno microcontroller, the system coordinates alcohol detection, GPS, GSM, engine control, buzzer, and LCD display for real-time monitoring and alerts. This solution is ideal for public transport, school buses, logistics fleets, and private vehicles, offering an automated and proactive approach to sobriety enforcement and vehicle security.



In the proposed system Smart Vehicle Immobilization System that integrates alcohol detection, real-time GPS tracking, and IoT-based control using an Arduino Uno (ATMEGA328P) microcontroller. The system is designed to prevent drunk driving and monitor vehicle status remotely, ensuring safety and accountability in transportation. The core of the system is the Arduino Uno, which interfaces with several essential modules. The MQ-3 alcohol sensor detects alcohol presence in the driver's breath. If alcohol is detected above a preset threshold, the Arduino triggers a response by sending signals to the relay driver circuit, which in turn controls the electronic relay. This relay regulates the DC gear motor responsible for engine ignition. If alcohol is detected, the motor is turned off, preventing vehicle movement.

The system also includes a GPS module, which provides real-time location data. This data, along with alcohol detection information, is transmitted via the NodeMCU (Wi-Fi module) to an IoT cloud platform. The IoT platform displays the alcohol level and the motor status (ON/OFF) on a remote computer or smartphone, allowing remote monitoring and data logging. This feature is crucial for fleet managers, parents, or authorities to track vehicle and driver behavior. An MPU6050 accelerometer and gyroscope module is integrated to detect motion, orientation, or any unusual vehicle movement, such as tilting or impacts. A buzzer is included to provide an immediate audible alert in case alcohol is detected or if any abnormal behavior is sensed.

Power supplies are divided into two segments: +5V for the Arduino and sensors, and +12V for operating higher-power components like the relay and DC motor. An LCD display is used to provide real-time feedback to the driver inside the vehicle, such as system status, alcohol detection alerts, or engine lock conditions. Overall, this system effectively combines hardware sensors, wireless communication, and IoT to enhance vehicle safety. It prevents drunk driving, allows real-time monitoring, and offers a scalable and practical solution for smart transportation and road safety enforcement.

HARDWARE IMPLEMENTATION

POWER SUPPLY

There are many types of power supply. Most are designed to convert the Voltage AC Mains electricity to a suitable low voltage supply for electronic Circuits and other Devices. A power supply can by broken down into a series of blocks, each of which performs a particular function. Here the AC supply main is given to the step down transformer. The transformer having the different voltages. The output from the transformer is given to the rectifier circuit. In this rectifier circuit the AC voltage is converted to DC voltages. The rectified DC voltage is given to the regulator circuit. The output of the regulator is depends upon the regulator IC chosen in the circuit.

BRIDGE RECTIFIER

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier. Smoothing is performed by a large value electrolytic capacitor connected across the DC Supply to act as a reservoir, supplying current to the output when the varying DC Voltage from the rectifier is falling

REGULATOR

Voltage regulators ICs are available with fixed (typically 5, 12 and 15V) or variable Output voltages. They are also rated by the maximum current they can pass. Negative Voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and Overheating ('thermal protection'). Many of the fixed voltage regulator ICs has 4 leads and look like power transistors, Such as the 7805 +5V 1A regulator

ARDUINO

The Arduino Compute Module (CM1), Compute Module 3 (CM3) and Compute Module 3 Lite (CM3L) are DDR2-SODIMM-mechanically-compatible System on Modules (SoMs) containing processor, memory, eMMC Flash (for CM1 and CM3) and supporting power circuitry. These modules allow a designer to leverage the Arduino hardware and software stack in their own custom systems and form factors. In addition these module have extra IO interfaces over and above what is available on the Arduino model A/B boards opening up more options for the designer

SOFTWARE

- ARMv6 (CM1) or ARMv7 (CM3, CM3L) Instruction Set
- Mature and stable Linux software stack
- Latest Linux Kernel support
- Many drivers up streamed
- Stable and well supported userland
- Full availability of GPU functions using standard APIs

RESULTS AND DISCUSSIONS

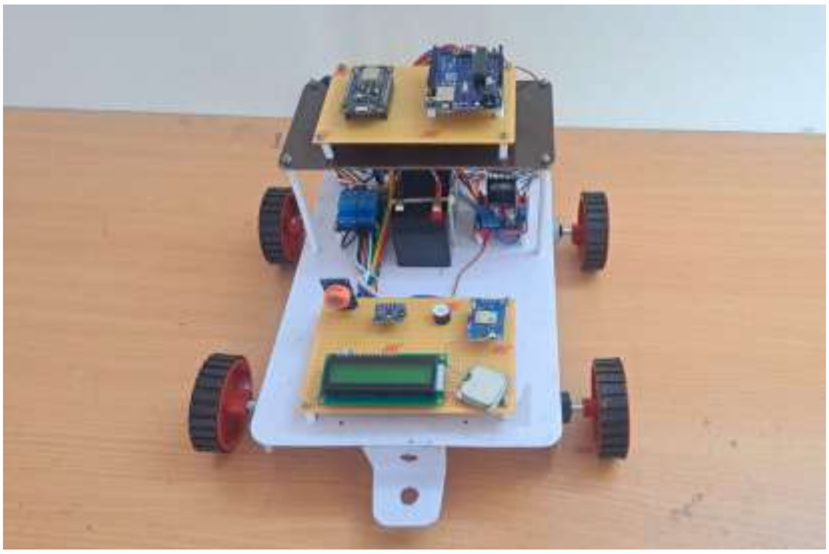


Figure shows a prototype demonstrates a smart vehicle system with alcohol detection, GPS tracking, and IoT monitoring. It uses an Arduino UNO, MQ-3 sensor, GPS module, and NodeMCU to detect alcohol levels, track location, and transmit data online. The motor is controlled via relay based on sensor input, enhancing road safety by preventing vehicle operation under intoxication

CONCLUSION AND FUTURE SCOPE

CONCLUSION

The Smart Vehicle Immobilization System with Integrated Alcohol Detection and Real-Time GPS Monitoring represents a significant advancement in vehicle safety technology. By combining multiple sensors and IoT capabilities, this system ensures that vehicles cannot be operated under the influence of alcohol, thereby reducing the risk of accidents and enhancing road safety. The real-time GPS tracking and data transmission features provide valuable insights for both vehicle owners and monitoring agencies, creating a safer driving environment.

Overall, this project showcases how technology can effectively address pressing safety concerns in transportation.

FUTURE SCOPE

- Future Work Integrate additional sensors like fatigue detection and biometric monitoring to assess driver alertness and health.
- Create a user-friendly mobile app that allows vehicle owners to monitor alcohol levels, receive alerts, and access vehicle status in real time.
- Utilize machine learning algorithms to analyse driving patterns, enabling predictive insights and proactive safety measures.
- Integrate with smart city infrastructure for improved traffic management and communication between vehicles, traffic signals, and emergency services

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