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VEHICLE ACCIDENT PREVENTION AND DETECTION ALERT SYSTEM

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Abstract: Road traffic accidents are one of the major causes of mortality and morbidity around the world, where India contributes a relatively higher number of deaths compared to other countries. One of the major reasons leading to fatalities after accidents is the delay in the arrival of help. The Vehicle Accident Prevention and Detection Alert System, presented here, helps bridge this gap and save lives by providing an advanced warning system based on IoT technology.

For accident detection, this system incorporates an ADXL335 three-axis accelerometer that senses rapid vibration due to any kind of impact, GSM 900L module sends instant messages about any crash detected to emergency numbers, a GPS chip for determining location, an ultrasonic sensor works as pre-impact warning system at close distances and MQ-3 alcohol sensor detects presence of alcohol in the blood of the driver before starting the engine. These sensors are interfaced with a microcontroller board (Arduino or ESP32), which processes all the data received from the sensors. The results show that the system is able to detect accidents in just 2-3 seconds and can send geo-referenced instant message alerts to the concerned numbers along with giving sound alerts just one meter away from impact.

Index Terms **– IoT, GPS Tracking, GSM 900L, ADXL335 Accelerometer.**

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1. INTRODUCTION

Road traffic injuries are public health emergencies that affect the entire world. It was reported by the World Health Organization that about 1.35 million fatalities result from road crashes each year; therefore, road traffic injuries account for the eighth highest cause of death in the world. In persons aged between 5 and 29 years old, road traffic crashes account for the single highest cause of death. On average, road accidents inflict about 3% of the Gross Domestic Product of countries all over the world.

This is particularly shocking in India. According to the Ministry of Road Transport and Highways (MoRTH), over 4,40,000 road accidents occur in a year resulting in over 1,50,000 fatalities. Road traffic crashes account for about 11% share in fatalities among road accidents in the whole world with a negligible 1% share in the number of vehicles. The majority of fatalities result from lack of provision of pre-hospital treatment within the "Golden Hour", which occurs in the first hour after the trauma accident; up to 55%. Though improvements have been made in vehicle design and technology, the basic problem of quick action after an accident has yet to be solved for most road users in India. In the countryside and semi-urban areas, accidents often remain unreported for several hours due to low traffic, lack of bystanders, and poor connections. Most vehicles do not have an automatic real-time system to alert emergency services or family members when a crash is detected. Also, drunk driving is responsible for almost 4-5% of all road accident deaths in India; this is something that can be prevented proactively. Critical Gap: More than 20 minutes is taken on average by emergency responders in India to reach an accident scene in cities and over 60 minutes in the countryside. Root Cause: There is no automated accident detection and real-time alert system present in conventional vehicles. Consequence: A life that could have been saved within the Golden Hour if medical intervention were more timely.

2 Data and Sources of Data

2.1 In India, traffic crashes claim approximately **19 lives every single hour**. Comprehensive surveys on major expressways reveal that **nearly 40% of fatalities occur not from the impact itself, but because emergency response teams reached the crash site too late** due to lack of real-time monitoring (Law Commission of India and & Save LIFE Foundation Reports).

2.2 Globally, **approximately 10% of all road traffic deaths are directly caused by drunk driving**. In higher-risk categories, such as motorcycle operations, alcohol-impaired riding is responsible for **30% to 40% of all fatal crashes** (World Health Organization & Grant Thornton International Report).

2.3 Research tracking emergency response systems establishes that implementing an automated embedded system (GPS + GSM tracking loop) drops emergency notification latency down to under micro seconds. Conversely, the *absence* of this loop delays notifications by an average of 25 to 45 minutes, which pushes victims past the survival threshold, directly resulting in an unrecoverable loss of life (**IEEE Xplore Digital Library / Science and Technology Publications)**

3 Research and Methodology

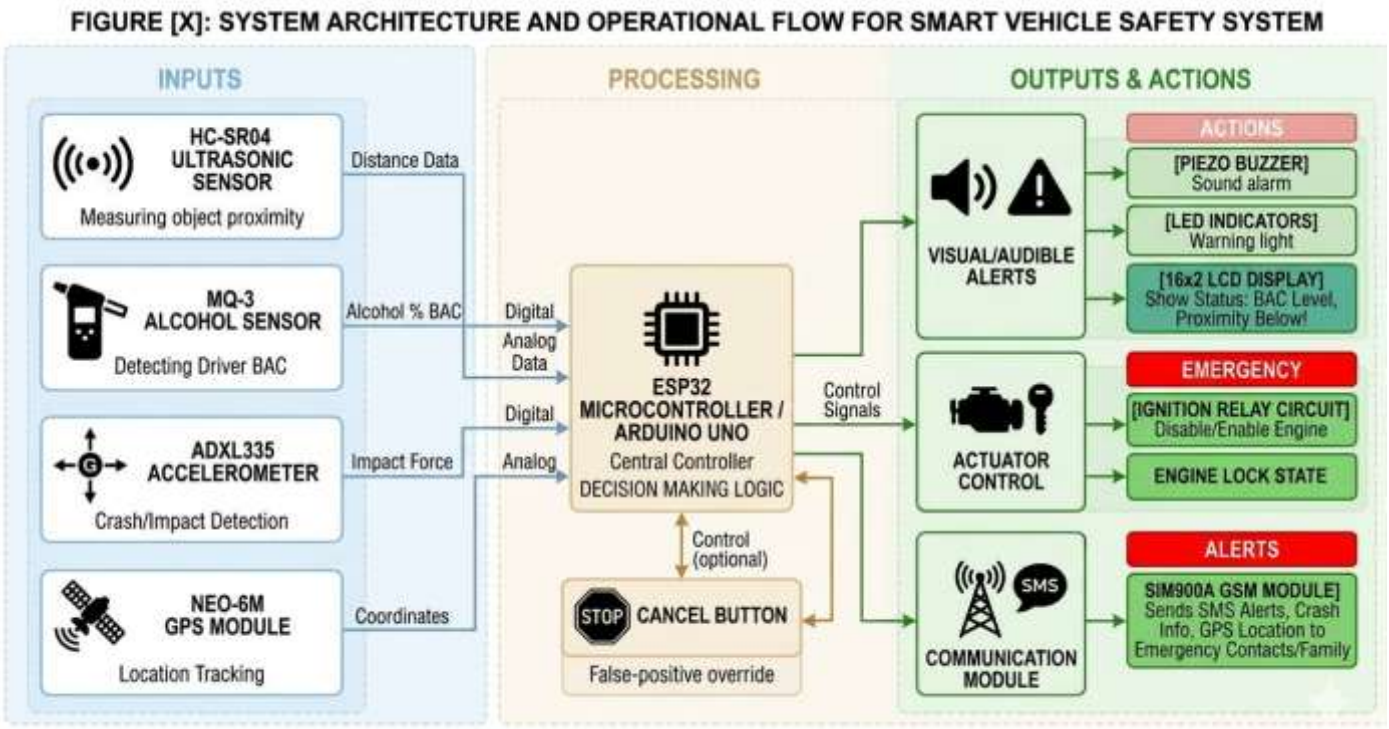

FIGURE [X]: SYSTEM ARCHITECTURE AND OPERATIONAL FLOW FOR SMART VEHICLE SAFETY SYSTEM

Fig. 3.1 System Architecture

3.2 Hardware Design and Specification

COMPONENT	SPECIFICATION & ROLE
ARDUINO UNO / ESP32 MICROCONTROLLER	Central processing unit; reads sensor inputs, applies decision logic, triggers GSM alerts
ADXL335 Accelerometer	3-axis analog (±3g); detects crash-induced vibration on X, Y, Z axes
GSM 900L (SIM900A)	Dual-band 900/1800 MHz; sends SMS alerts and GPRS location data
GPS Module (Neo-6M)	UART interface; provides latitude/longitude with ±2.5m accuracy
HC-SR04 Ultrasonic Sensor	Range: 2cm–400cm; triggers proximity warning below 80cm threshold
MQ-3 Alcohol Sensor	Analog output; detects ethanol concentration; inhibits ignition above 0.05 BAC
LCD Display (16x2)	Real-time system status display on dashboard
Buzzer & LED Indicators	Audible and visual proximity/alcohol warnings
Push button (cancel switch)	Allow accupant to cancel false positive alert

Table 3.2. Hardware Components

Arduino UNO / ESP32 Microcontroller

The core of the system relies on the ESP32 microcontroller (or Arduino Uno) operating at a clock speed of up to 240 MHz. The ESP32 features dual-core processing pipelines, allowing parallel execution of the safety critical loop (obstacle tracking and impact sensing) alongside communication tasks (GPS parsing and GSM network handshakes). Its 12-bit Successive Approximation Registers (SAR) Analog-to-Digital Converters (ADCs) capture raw voltage variations from the sensors with high quantization precision**.**

ADXL335 Accelerometer

The ADXL335 is a complete 3-axis acceleration measurement system configured to capture dynamic acceleration resulting from impacts, shocks, or rollovers. It uses a polysilicon surface-micromachined structure (MEMS) suspended over a silicon wafer. Acceleration deflects the structure, changing the differential capacitance. This change is converted into an analog voltage output proportional to gravity (g) along the X, Y,and Z axes.

GSM 900L (SIM900A)

The SIM900A is a popular, ultra-compact dual-band GSM/GPRS module designed by SIMCom. It enables embedded systems (like Arduino or Raspberry Pi) to connect to cellular networks to make voice calls, send SMS messages, and transfer data. It is highly favored in India for IoT and remote automation projects

GPS Module (Neo-6M)

The NEO-6M GPS module is a highly popular, low-cost global positioning receiver manufactured by u-blox. It is widely used in DIY electronics, robotics, drones, and vehicle tracking projects. The module calculates your exact geographic coordinates anywhere on Earth by listening to signals from orbiting GPS satellites.

HC-SR04 Ultrasonic Sensor

The HC-SR04 is a highly popular, low-cost ultrasonic sensor that measures distance by emitting high-frequency sound waves and timing how long they take to bounce back, much like echolocation used by bats. It is widely used in robotics, obstacle avoidance, and liquid level monitoring.

MQ-3 Alcohol Sensor

The MQ-3 alcohol sensor is a Metal Oxide Semiconductor (MOS) gas sensor designed to detect alcohol and ethanol vapor. It is widely used in DIY breathalyzers, automotive safety interlocks, and industrial alcohol alarms because of its high sensitivity, fast response time, and low cost.

LCD Display (16x2)

A 16x2 LCD display is a basic, popular electronic module used to show text and numbers, capable of displaying 16 characters per line across two lines (32 characters total). It operates using a built-in controller (often the HD44780) and uses a 5x8 pixel matrix for each character, ideal for Arduino and IoT projects requiring simple user interfaces.

Buzzer & LED Indicators

Buzzer and LED indicators are standard sensory components used in electronic circuits and devices to provide immediate visual and audible feedback. They translate machine states (like on, off, error, or warning) into human-readable signals.

Push button (cancel switch)

A push-button cancel switch is an electrical switch used to instantly abort, reset, or override a previously initiated command or process. When pressed, it typically breaks an active circuit to stop a machine, deactivate an alarm, or reset a system to its resting state.

3.3 Proposed Design

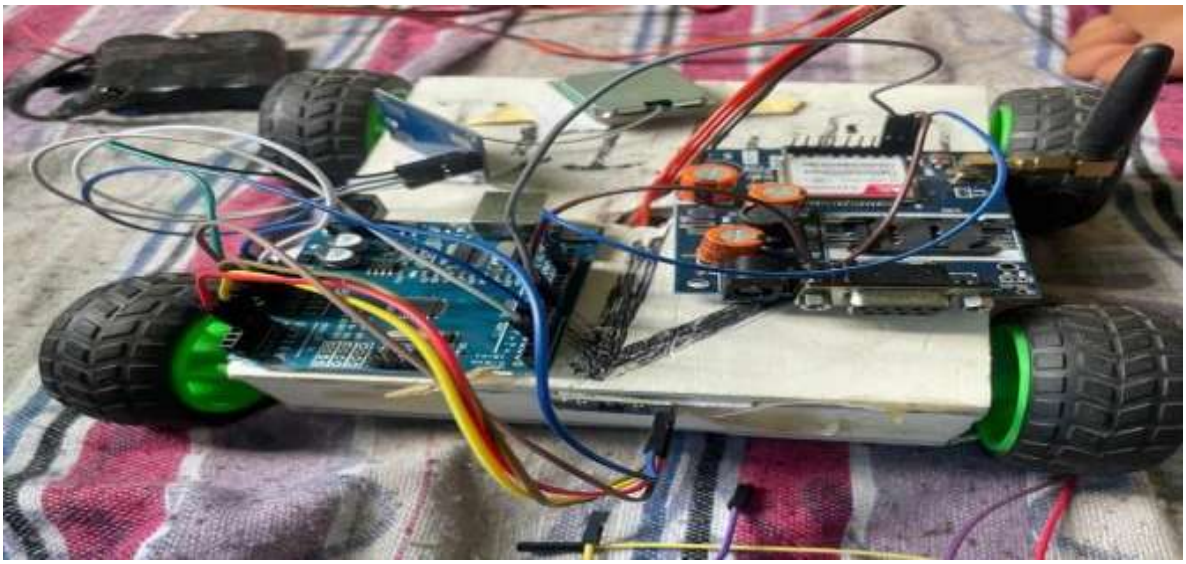

Fig. 3.3- Final Proposed Design

4. Result and Discussion

Sample Emergency SMS Generated by the System

TO: +91-XXXXXXXXXX
FROM: VEHICLE ALERT SYSTEM

ACCIDENT DETECTED!
Date/Time: 14-Apr-2025, 15:32:07 IST
Vehicle Location: https://maps.google.com/?q=30.3165,78.0322
Impact Severity: HIGH (G-force: 3.7g)
Nearest Landmark: Rajpur Road, Dehradun

Please contact Emergency Services: 112
This is an automated alert from the Vehicle Safety System.

5. Advantages and Limitations

The designed bot has many advantages which makes it unique like: Human Action Required Post-Crash; System Triggers Automatically Fully Automated Response Dual Mode: Prevention + Detection Pre-Accident (alcohol, proximity) and Post-Accident Phases Addressed Real-Time GPS Tracking No Time Wasted in Searching Accident Site, Exact Location Delivered Low Cost & Scalable Estimated Hardware Cost INR 1800–2500 Mass Deployment Feasible Network Independent Standard 2G GSM Works. Also Works in Rural Areas with No Low Connectivity. Power Resilient Li-Ion Backup Works After Electrical Failure of Vehicle. It also includes some drawbacks which are: This system may generate false warnings due to its use of static threshold in case of very rough terrain like off-road paths and potholes, For GSM-based SMS communications, the coverage of the mobile network becomes a crucial factor, since messages cannot reach their destination in dead zones, The accuracy of location tracking using GPS technology will be poor in urban settings, subterranean environments, and dense forests, since GPS signals become blocked, The alcohol sensor (MQ-3) requires calibration from time to time, as it may be influenced by high temperatures and humidity, The existing design does not distinguish between BAC values of the driver and passengers, as MQ-3 detects alcohol concentration in the air inside the vehicle.

6. Future Scope

Future Development Roadmap

1. AI/ML Integration: Use an LSTM/CNN trained classifier instead of the fixed G-force threshold to decrease false positives to less than 0.5% without lowering true positives below 99%.
2. Dashboard Linked to the Cloud: Create a dashboard linked to the cloud where vehicle data and accidents can be monitored by fleets, insurance companies, and traffic authorities.
3. Drowsy Driver Alert System: Incorporate an alert system that will notify the driver in case of drowsiness.

7. Conclusion

Thus, in the present paper, the design and development process of the Vehicle Accident Prevention and Detection Alert System using IoT technology have been elaborated. The Vehicle Accident Prevention and Detection Alert System consists of the following components: ADXL335 three-axis accelerometer crash sensor, Neo-6M GPS sensor used for continuous location detection, GSM 900L module for auto-sending SMS alerts, HC-SR04 ultrasonic sensor used for pre-crash notification, and MQ-3 alcohol sensor used to ensure that the driver is sober.

Based on the findings from experimentations, it may be stated that the developed system successfully identifies a crash with average time taken equal to 2.3 seconds and delivers geo-tagged SMS alerts to the predetermined emergency contacts within 4.7 seconds, thus belonging to the category of the Golden Hour period. As such, due to the two-mode functioning principle of the proposed system (preventive and responsive), our study differs from others related to vehicle crash alerting.

Finally, taking into consideration the total price of the hardware components used in the Vehicle Accident Prevention and Detection Alert System equal to INR 1,800–2,500, the implementation of the system is extremely easy because of its cost-effectiveness.

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