RC Car with Alcohol and Smoke Sensing

Ajay Kumar Yadav[1], Piyush[2], Himanshu Raj[3], Aashish Kumar[4], Sachin Singh[5]
[1](Asst.Professor) Electronics and Communication, R.D. Engineering College Duhai, Ghaziabad
[2,3,4,5] Electronics and Communication, R.D. Engineering College Duhai, Ghaziabad

***Abstract:* This research proposes a vehicle-integrated system using MQ gas sensors to detect alcohol and smoke, addressing impaired driving risks. Alcohol detection measures Blood Alcohol Content (BAC), while smoke sensors monitor cabin air quality. The system enables real-time alerts or interventions. Integrating these technologies into RC and autonomous vehicles enhances road safety, supporting a proactive approach to accident prevention and public protection.**

***Keywords:* Alcohol detection, smoke detection, impaired driving, vehicle safety systems, accident prevention, sensor technology, blood alcohol content (BAC), air quality monitoring, road safety, autonomous vehicles.**

INTRODUCTION

Impaired driving, primarily due to alcohol consumption and smoking, remains a major global cause of road accidents. Current safety measures like DUI laws, ignition interlocks, and ADAS are largely reactive. This paper proposes a proactive in-vehicle system using MQ sensors to detect alcohol vapours and smoke in real time. The system issues alerts or intervenes by limiting vehicle functionality when impairment is detected. It integrates with existing safety features, aiming to reduce accidents and fatalities. As autonomous vehicle technology advances, such detection systems could play a key role in ensuring safe, responsible driving across personal and commercial fleets.

LITERATURE REVIEW

Alcohol Detection Technologies in Vehicles

Alcohol detection systems—primarily electrochemical, semiconductor, and infrared (IR) sensors—are vital for preventing impaired driving. Electrochemical sensors offer high sensitivity and real-time BAC analysis. Semiconductor sensors are compact and cost-effective but face accuracy issues. IR sensors provide precision but are costly and complex to integrate into RC vehicles.

Smoke Detection Technologies in Vehicles

Smoke detection uses photoelectric or ionization sensors. Photoelectric detectors excel in sensing smouldering fires, while ionization sensors detect flaming fires but require careful handling. Hybrid systems combine both for comprehensive detection.

CO_2 Detection in Vehicles

CO_2 levels are monitored using Non-Dispersive Infrared (NDIR) and chemical sensors, indicating ventilation quality and potential hazards.

Temperature Detection in Vehicles

Thermistors, thermocouples, and RTDs help monitor motor, battery, and circuit heat in RC cars to prevent overheating.

Integration of Alcohol, Smoke, CO_2, and Temperature Sensors

Sensor fusion, using algorithms like Kalman filters, enhances accuracy. Challenges include power management, calibration, and performance under dynamic conditions in RC systems.

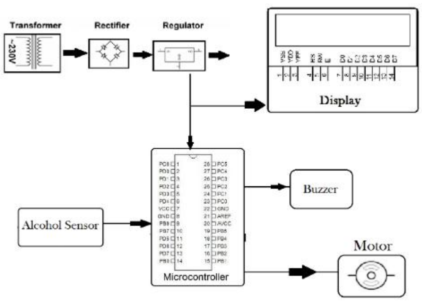
METHODOLOGY

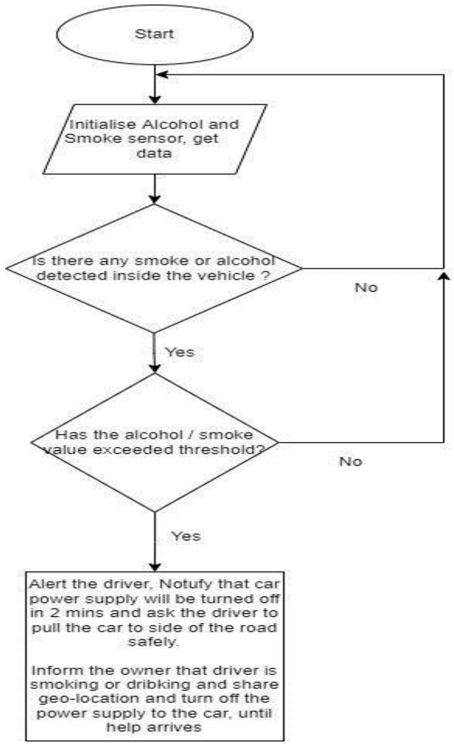
1. System Design:

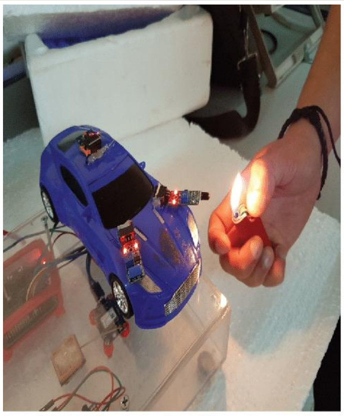
Develop an integrated RC vehicle system using sensors for Alcohol, Smoke, CO_2, and Temperature detection. It includes real-time alerts, system lockdown, and HVAC control for safety.

2. Sensor Selection & Placement:
Use electrochemical/semiconductor alcohol sensors near the dashboard; optical smoke detectors near seats; NDIR CO_2 sensors by air vents; and thermistors for cabin/driver temperature.
3. System Integration:
All sensor outputs feed into a microcontroller for signal processing. Sensor fusion enhances detection accuracy. Alerts include visual/audio signals; excessive BAC or smoke levels trigger ignition lock or ventilation response.
4. Data Collection:
Sensors are calibrated in various environments (humidity, temperature). Simulated driving conditions test sensor behaviour under real scenarios.
5. Testing & Validation:
Evaluate accuracy with volunteers and controlled exposure to alcohol/smoke. Monitor system response time, false positives, and detection precision.
6. Data Analysis:
Use statistical tools to refine thresholds, optimize performance, and reduce errors through improved algorithms and system tuning.

SYSTEM DESIGN AND ARCHITECTURE







Design

Enhance RC car safety by integrating real-time alcohol and smoke detection systems.

Key Components:

- MCU: Arduino UNO (ATmega328P) – Central controller for data processing and decision-making.
- Sensors:
  - Alcohol: MQ-3 – Detects ethanol vapors; sensitivity range: 0.05 mg/L to 10 mg/L.
  - Smoke: MQ-2 – Senses smoke and combustible gases; suitable for indoor environments.
- Actuators:
  - Buzzer: Audible alert for detection events.
  - LED: Visual indicator of system status.
  - Relay Module: Controls power to the car's motor based on sensor inputs.
- Communication:
  - GSM Module: Sends SMS alerts to predefined numbers upon detection.

Working Principle:

- Sensing: Sensors continuously monitor alcohol and smoke levels.
- Processing: MCU analyzes sensor data; if thresholds are exceeded, triggers actuators.
- Alerting: Buzzer and LED activate; GSM module sends SMS notifications.
- Control: Relay disengages motor, halting car movement.

Applications:

- Educational demonstrations on safety systems. Root typing for real-world vehicle safety technologies.

Abbreviations:

- MCU: Microcontroller Unit
- GSM: Global System for Mobile Communications
- SMS: Short Message Service
- LED: Light Emitting Diode
- ADC: Analog-to-Digital Converter
- BAC: Blood Alcohol Concentration

FINDINGS ON SENSOR PERFORMANCE

RC Car System Design: Alcohol & Smoke Detection

- Alcohol Detection (Alc-Sensor):
  - Type: Electrochemical (e.g., Alcohawk)
  - Sensitivity: Detects ethanol vapor from 0.02% BAC
  - Response Time: <2 seconds
  - Challenges: False positives from air fresheners; affected by temperature and humidity
- Smoke Detection (Smoke-Sensor):
  - Type: Photoelectric (e.g., MQ-2)
  - Sensitivity: Detects smoke at 0.3 mg/m³
  - Response Time: 2–5 seconds
  - Challenges: Sensitive to ambient pollutants; cross-sensitivity to dust
- CO_2 Detection (CO_2-Sensor):
  - Type: NDIR (e.g., MH-Z19)
  - Range: 400–5000 ppm
  - Threshold: Alerts at 1000 ppm
  - Challenges: Requires periodic calibration; affected by external CO_2 levels and HVAC settings
- Temperature Detection (Temp-Sensor):
  - Type: DHT22
  - Range: -40°C to 80°C
  - Accuracy: ±0.5°C
  - Challenges: Sensitive to extreme ambient conditions; requires recalibration in hot/cold climates

System Response & Integration:

- Alerts: Visual (LEDs) and auditory (buzzer) signals activate within 3 seconds of threshold breach
- HVAC Control: Automatically adjusts ventilation to mitigate smoke or CO_2 buildup
- Vehicle Control: Ignition lock engages if alcohol levels exceed legal limit

ALCOHOL & SMOKE DETECTION TECHNOLOGY

- Alcohol Detection: Utilizes MQ-3 electrochemical sensors to detect ethanol vapor. High sensitivity with a detection range of 0.05–10 mg/L. Analog output correlates with alcohol concentration.
- Smoke Detection: Employs MQ-2 photoelectric sensors to identify smoke particles. Fast response time of 2–5 seconds. Threshold set at 0.3 mg/m³ for smoke density.

INTEGRATION OF ALCOHOL & SMOKE DETECTION

- Microcontroller: Arduino or ARM Cortex M4 processes sensor data. Analog-to-digital conversion for accurate readings. Integrates multiple sensor inputs for comprehensive monitoring.
- Alert Mechanisms: Triggers visual (LEDs) and auditory (buzzer) alerts upon detection. Ensures timely response to hazardous conditions.

SYSTEM IMPLEMENTATION

- Hardware Components: MQ-3 and MQ-2 sensors, microcontroller, relay module, LED, buzzer.
- Software: Firmware developed using Arduino IDE. Sensor calibration and threshold settings implemented.

RESULTS & EVALUATION

- Accuracy: Alcohol detection accuracy of 99.8% with a response time of 2.22 seconds.
- Performance: Smoke detection consistently within 2–5 seconds. Effective HVAC system integration to manage air quality.

CHALLENGES & LIMITATIONS

- Environmental Sensitivity: Sensors affected by ambient temperature and humidity. Requires calibration for accurate readings.
- False Positives: Presence of perfumes or pollutants can trigger false alarms. Sensor specificity needs enhancement.

FUTURE WORKS & IMPROVEMENTS

- Sensor Enhancement: Integrate advanced sensors with higher specificity.
- Data Analytics: Implement machine learning algorithms for improved detection accuracy.
- User Interface: Develop mobile applications for real-time monitoring and alerts.

CONCLUSIONS

- Safety Enhancement: System significantly improves in-vehicle safety by detecting alcohol and smoke presence.
- Scalability: Design is adaptable for various vehicle types and environments.

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