Seminar

Report On

Enhancing Road Safety with IoT and Machine Learning

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MIT-World Peace University (MIT-WPU)

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CERTIFICATE

This is to certify that Mr. Kushagra Anit Singh of B.Tech. CSE Core, DCET, School of Computer Science & Engineering, Semester – VI, PRN. No. 1032220949, has successfully completed seminar on

Enhancing Road Safety with IoT and Machine Learning

to my satisfaction and submitted the same during the academic year 2024 – 2025 towards the partial fulfillment of degree of Bachelor of Technology in School of Computer Science & Engineering DCET under Dr. Vishwanath Karad MIT-World Peace University, Pune.

Tarun Shankar
Seminar Guide

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ABBREVIATIONS

- **IoT** – Internet of Things
- **ML** – Machine Learning
- **GPS** – Global Positioning System
- **MQ-3** – Alcohol Sensor
- **ADAS** – Advanced Driver Assistance System
- **GSM** – Global System for Mobile Communications
- **AI** – Artificial Intelligence
- **CNN** – Convolutional Neural Network
- **YOLO** – You Only Look Once (Object Detection Algorithm)
- **ACC** – Adaptive Cruise Control
- **AEB** – Automatic Emergency Braking

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ABSTRACT AND KEYWORDS

Abstract:

Road safety remains a critical global concern, with approximately 1.35 million fatalities annually due to road accidents, as reported by the World Health Organization. The integration of Internet of Things (IoT) and Machine Learning (ML) technologies offers innovative solutions to mitigate such incidents. This seminar report presents a comprehensive system designed to enhance road safety by incorporating Arduino-based hardware and advanced ML algorithms. The system focuses on real-time detection of driver intoxication, continuous monitoring of driving behavior, and immediate emergency response mechanisms. Key features include GPS tracking for location monitoring, accelerometer-based anomaly detection to identify reckless driving patterns, and GSM-based emergency alerts to notify authorities and emergency contacts promptly. Additionally, the implementation of geofencing technology aims to reduce noise pollution in designated quiet zones. By leveraging modern technology, this system aspires to reduce accidents, prevent reckless driving, and ensure safer roads.

Keywords:

IoT, Machine Learning, Road Safety, Alcohol Detection, GPS, Geofencing, Driver Monitoring, Emergency Response.

TECHNICAL CONTENT

1. Introduction

1.1 Background

Road accidents are a leading cause of death worldwide, with human error accounting for a significant proportion of these incidents. Factors such as drunk driving, drowsiness, and reckless behavior contribute substantially to road fatalities. Traditional methods of monitoring and enforcing road safety have limitations, highlighting the need for innovative technological interventions.

1.2 Problem Statement

Despite existing measures, road accidents continue to claim numerous lives annually. The lack of real-time monitoring systems to detect and prevent unsafe driving behaviours exacerbates this issue. There is a pressing need for an integrated solution that can proactively identify and address potential hazards on the road.

1.3 Objectives

- Develop a comprehensive system integrating IoT and ML to detect unsafe driving patterns.
- Implement alcohol detection and GPS tracking to monitor driver conditions in real time.
- Reduce accident rates and improve emergency response mechanisms.

1.4 Scope of the Study

The system is designed for passenger vehicles, fleet management services and law enforcement agencies. By leveraging IoT and ML, this technology can be scaled to public transportation, logistics and smart city initiatives.

2. Literature Survey

2.1 Overview of Existing Systems

Several studies have been conducted on IoT-based road safety systems, focusing on various aspects such as alcohol detection, GPS tracking, and emergency alerting. However, these systems often lack integration with machine learning for predictive analysis.

2.2 Comparative Analysis

Paper Title	Year Published	Tools Used	Findings	Gaps	How to tackle these gaps
Alcohol Detection in	2020	MQ-3 sensor, Arduino,	Provided a comparative	Slow response	Develop sensor fusion techniques

Vehicles: A Review of Sensor Technologies		alternative alcohol detection sensors	analysis of alcohol sensor effectiveness and discussed detection thresholds.	times and high false-positive rates in varying environmental conditions.	by integrating environmental sensors (e.g., temperature/humidity) to improve accuracy.
Enhanced Road Safety Systems using Embedded IoT Devices	2021	Arduino, IoT frameworks, sensor networks	Achieved effective real-time safety monitoring and alert systems in vehicles.	Limited integration with modern vehicle control systems and interoperability issues.	Integrate with CAN bus systems and onboard diagnostic (OBD) interfaces to improve communication with existing vehicle electronics.
Real-Time Monitoring of Driver Behaviour using Arduino and IoT	2022	Arduino, accelerometers, gyroscopes, IoT connectivity modules	Correlated sensor data with driver fatigue and drowsiness, offering insights into behavioural patterns.	Inadequate detection of subtle fatigue indicators and context-unaware alert generation.	Incorporate AI-based pattern recognition and create personalized driver profiles for more accurate assessments.
IoT Based Vehicle Monitoring System for Enhanced Safety	2023	Arduino, IoT devices, GSM, GPS, integrated multi-sensor modules	Emphasized the role of IoT in real-time vehicle monitoring and data-driven safety interventions.	Data security vulnerabilities and potential latency issues in communication networks.	Implement robust encryption protocols and edge computing solutions to enhance data security and reduce latency.
Design and Implementation of a Vehicle Safety Monitoring System	2020	Arduino, GPS, GSM, multiple sensor modules (alcohol sensor, accelerometer)	Demonstrated improvements in emergency response times & preventive safety measures.	Scalability issues in fleet management and limited capabilities for advanced data analytics.	Utilize cloud-based analytics and expand sensor networks to support broader fleet monitoring and data-driven decision-making.

__Table 1:__ Comparative analysis of Literature Review on IoT and ML in Road Safety

2.3 Identified Gaps

- Limited machine learning integration in existing IoT-based systems.
- High false-positive rates in alcohol detection mechanisms.
- Lack of predictive analytics for driver behaviour assessment.

3. Details of Design/Technology

3.1 System Components

The system is designed to monitor driver behavior and vehicle status in real time, integrating multiple sensors, communication modules, and processing units.

Feature	Traditional Vehicles	Basic IoT Safety Systems	Proposed IoT + ML System
Alcohol Detection	Not available	Basic MQ-3 sensor	AI-enhanced accuracy with ML models
GPS Tracking	Limited to high-end vehicles	GPS-only tracking	Integrated with accelerometer for better behavior analysis
Emergency Alerts	Manual intervention required	GSM-based SMS alerts	Automated alerting with severity classification
Noise Pollution Control	No automatic solution	Geofencing-based horn control	Adaptive ML-based geofencing
Real-Time Processing	Limited to onboard sensors	Cloud-dependent	Edge computing for real-time decision-making

__Table 2:__ Comparison of IoT-based Road Safety Solutions

3.1.1 Sensors and Modules

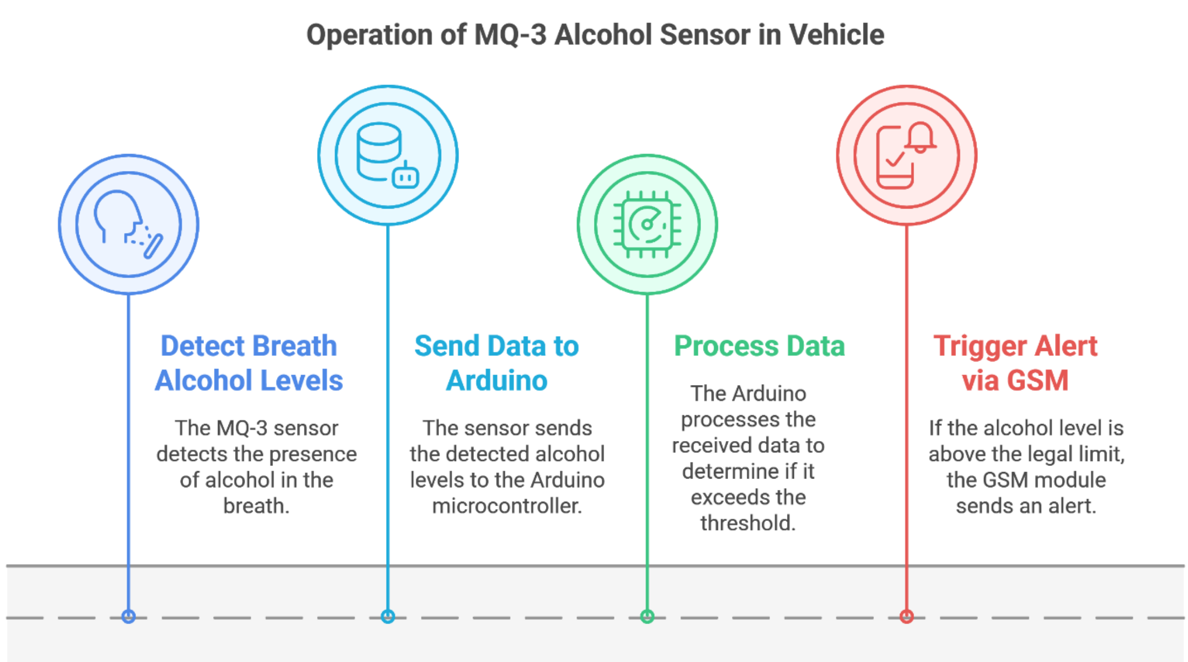

FIGURE 1: *System Architecture of IoT-based Road Safety System*

- **MQ-3 Alcohol Sensor**
  - Function: Detects alcohol concentration in a driver's breath.
  - Working Principle: Uses a tin dioxide (SnO_2) sensing layer that changes resistance in the presence of alcohol vapours.
  - Output: Analog voltage signals proportional to alcohol concentration.
  - Application: If alcohol levels exceed a predefined threshold, the system triggers an alert.

- **GPS Module**
  - Function: Tracks the vehicle's real-time location and speed.
  - Working Principle: Uses satellite signals to calculate latitude, longitude, and speed.
  - Output: GPS coordinates and speed data.
  - Application: Helps authorities monitor reckless driving behaviour and location in case of an emergency.

- **Accelerometer**
  - Function: Detects rapid acceleration, harsh braking, and sharp turns.
  - Working Principle: Measures acceleration in three axes (X, Y, Z) and detects irregular movements.
  - Output: Acceleration values used to determine reckless driving patterns.
  - Application: Sudden jerks or high G-forces indicate dangerous driving, triggering alerts.

- **GSM Module**
  - Function: Sends emergency alerts to authorities.
  - Working Principle: Uses cellular networks (GPRS) to send SMS or transmit data.
  - Output: Text messages or data packets to designated emergency contacts.
  - Application: Notifies police or emergency responders if an accident or unsafe driving pattern is detected.

Sensor	Model	Measurement Range	Accuracy	Response Time	Power Consumption
Alcohol Sensor	MQ-3	0.04 - 4 mg/L	±0.01 mg/L	<10 sec	150 mW
GPS Module	NEO-6M	Global	±2.5 meters	<1 sec	100 mW
Accelerometer	ADXL345	±16g	±0.003g	<1 ms	40 mW
GSM Module	SIM800L	2G Networks	Reliable for SMS alerts	<5 sec	1.2W

Table 3: *Sensor Specifications and Features*

3.1.2 Microcontroller and Processing Unit

- **Arduino Uno/ESP32**: The primary processing unit that collects sensor data and performs initial filtering.
- **Raspberry Pi (Optional)**: Used for more complex computations such as machine learning-based anomaly detection.
- **Cloud Integration**: Data is sent to a cloud server for remote monitoring and storage.
- **Power Supply**: The system is powered by a 12V DC battery connected to a voltage regulator for stable operation.

3.2 System Architecture

The architecture consists of various components working together to detect, process, and respond to road safety concerns.

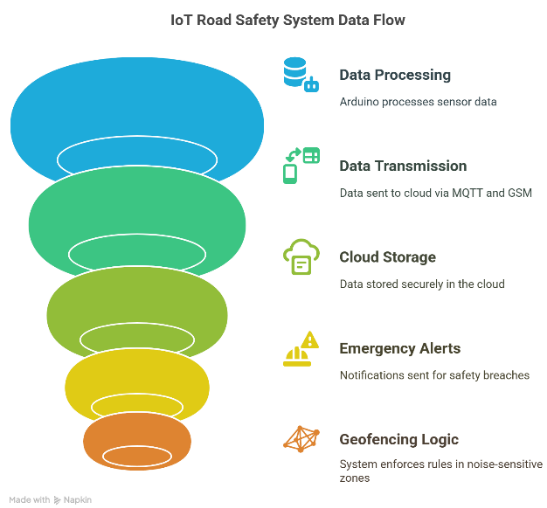

FIGURE 2: *Working of Alcohol Detection System*

3.2.1 Data Flow Diagram

The system operates through a structured flow:

1. **Input Layer:**
   - Sensors collect raw data, such as alcohol concentration, acceleration values, and GPS coordinates.
2. **Processing Layer:**
   - Data is transmitted to the microcontroller for pre-processing.
   - Machine learning models analyse behaviour based on historical patterns.
3. **Output Layer:**
   - If unsafe driving is detected, alerts are sent via the GSM module.
   - Data is stored for future analysis and improvements.

3.2.2 Communication Protocols

The system requires efficient data transmission for real-time monitoring:

- **MQTT (Message Queuing Telemetry Transport)**
  - Lightweight protocol for sending sensor data to cloud servers.

- Uses a publish-subscribe model for low-latency updates.
- Suitable for IoT-based applications.

- **HTTP (HyperText Transfer Protocol)**
  - Used for API requests when accessing stored data or sending alerts.
  - Works well with cloud platforms such as Firebase, AWS IoT or ThingsBoard.

3.3 Software Implementation

The software side includes machine learning models and data processing techniques to detect unsafe driving behavior.

3.3.1 Machine Learning Models

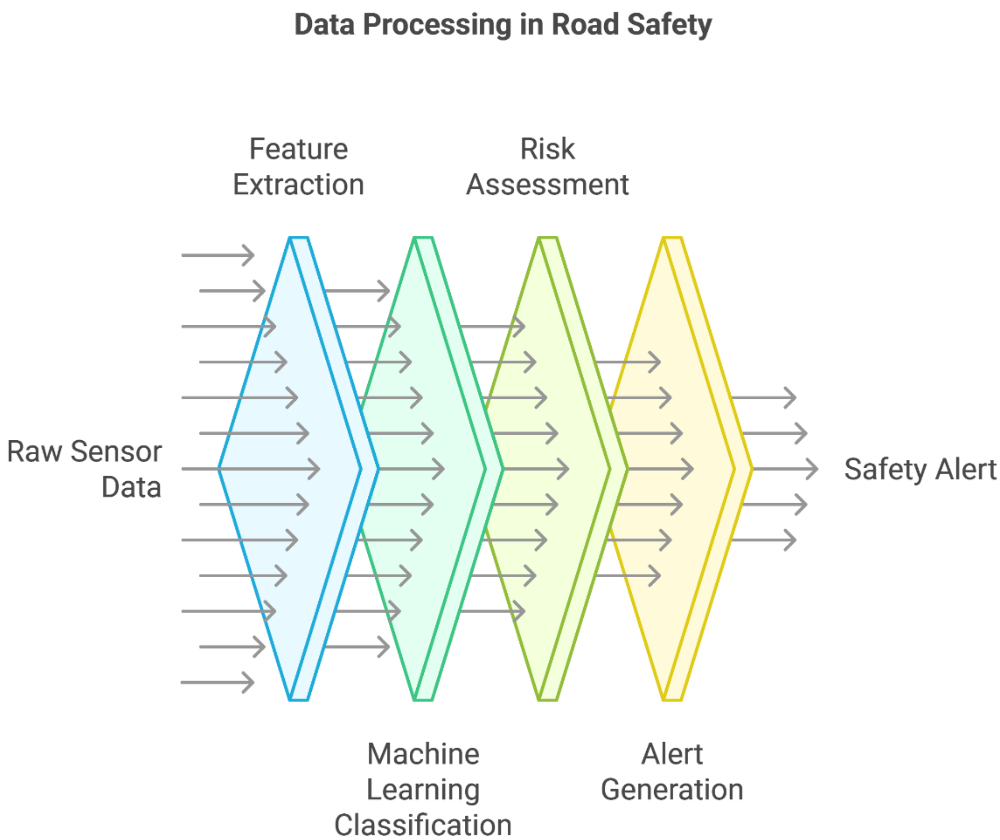

***FIGURE 3:** Flowchart of Data Processing using Machine Learning*

The system uses multiple ML algorithms to classify driver behaviour:

- **Random Forest**
  - Used for categorizing safe vs. unsafe driving patterns.
  - Handles non-linear data effectively.
- **Support Vector Machine (SVM)**
  - Classifies data based on hyperplane separation.
  - Used to detect alcohol-influenced behaviour based on sensor data.

- **Neural Networks (Deep Learning)**
    - Trained on historical data to predict reckless driving behaviour.
    - Can improve accuracy over time through continuous learning.

Algorithm	Training Time	Accuracy (%)	Interpretability	Suitability for Real-Time Processing
Random Forest	Moderate	92%	Medium	Suitable
Support Vector Machine (SVM)	High	89%	High	Less Suitable
Neural Networks (Deep Learning)	Very High	95%	Low	Needs optimization

Table 4: *Machine Learning Algorithms Used for Behaviour Classification*

3.3.2 Data Processing Techniques

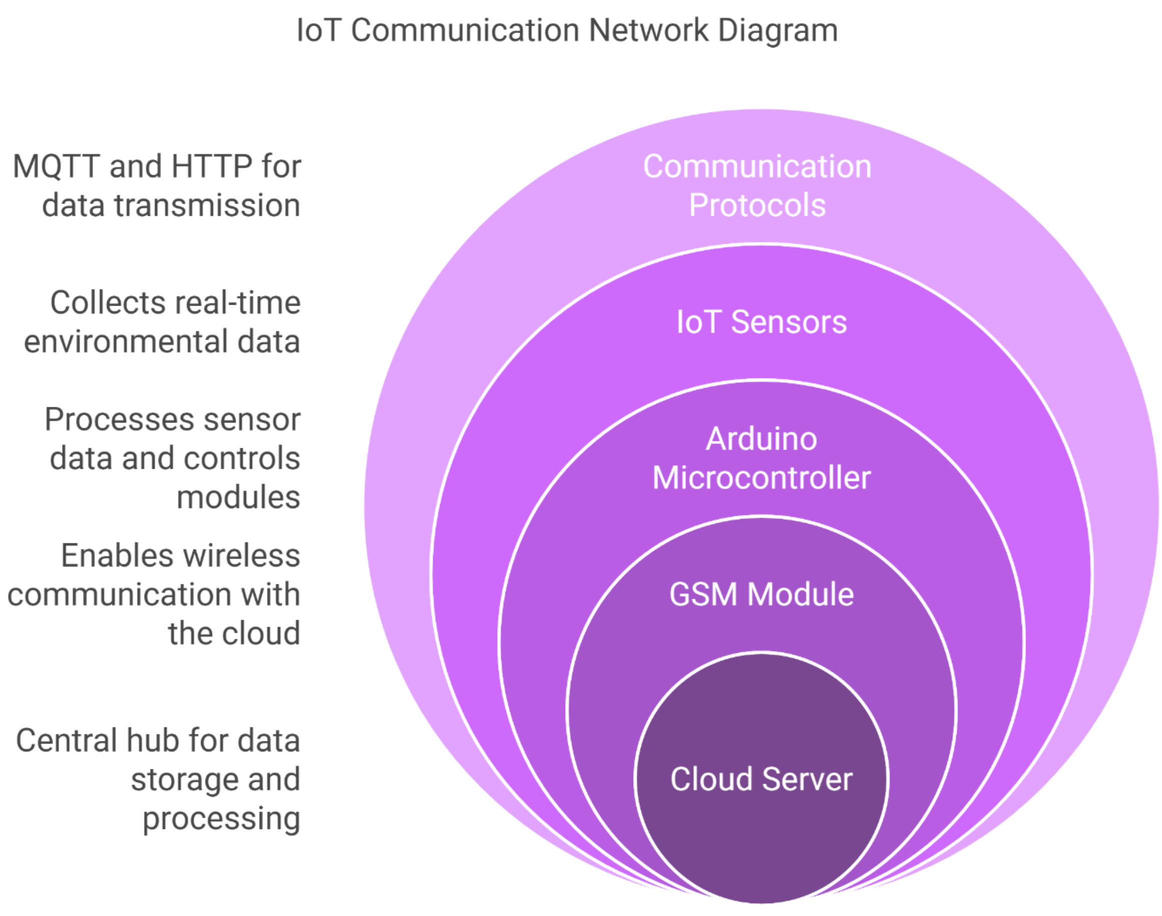

FIGURE 4: *Communication Flow between Sensors and Cloud*

- **Data Normalization**: Removes noise from sensor readings and scales values for accurate classification.
- **Feature Engineering**: Identifies critical features such as acceleration spikes and alcohol levels

that contribute to risk assessment.

3.4 Algorithmic Workflow and Models

This section describes the algorithmic models and workflows used in the proposed IoT and ML-based road safety system.

3.4.1 Driver Behaviour Classification using ML

Algorithm Used: Random Forest Classifier
Input: Accelerometer data (X, Y, Z axes), GPS speed, alcohol sensor output
Process:

1. Preprocess sensor data (normalization, noise reduction).
2. Extract relevant features (sudden acceleration, deceleration, sharp turns).
3. Feed data into the trained Random Forest model.
4. Classify driving behaviour as *Normal*, *Aggressive*, or *Drowsy*.

Output: Risk Level (Low, Medium, High)
Action: If risk level is High, trigger GSM-based emergency alert.

3.4.2 Alcohol Detection Algorithm

Sensor Used: MQ-3
Threshold: 0.04 BAC (customizable)
Steps:

1. Read analog voltage from MQ-3 sensor.
2. Convert voltage to estimated Blood Alcohol Content (BAC).
3. Compare with threshold:
    - If BAC ≥ threshold: Disable ignition + trigger alert.
    - Else: Allow ignition.

3.4.3 Emergency Alert Trigger System

Trigger Conditions:

- Alcohol level above threshold
- Sudden G-force spike from accelerometer
- Prolonged drowsy behaviour detection

Process:

1. Detect condition.
2. Package current GPS location + timestamp.
3. Send SMS alert using GSM module to emergency contact.

3.4.4 Geofencing for Noise Pollution Control

Technique Used: GPS-Based Radius Detection
Steps:

1. Define geofenced zones (e.g., hospital areas).
2. Continuously compare vehicle location to zone boundaries.
3. If inside zone:
    - Disable horn or alert driver.
4. If outside:
    - Resume normal horn functionality.

4. Analytical & Experimental Work

4.1 Implementation Plan

Phase 1: Hardware Setup

- Integrate MQ-3, GPS, Accelerometer and GSM module with Arduino.
- Connect microcontroller to cloud for real-time monitoring.

Phase 2: Software Development

- Train machine learning models using collected sensor data.
- Implement real-time anomaly detection and alert mechanism.

Component	Quantity	Unit Price (INR)	Total Cost (INR)
Arduino Uno	1	800	800
MQ-3 Alcohol Sensor	1	450	450
GPS Module (NEO-6M)	1	600	600
Accelerometer (ADXL345)	1	300	300
GSM Module (SIM800L)	1	550	550
Power Supply	1	200	200
Miscellaneous (Wires, PCB, etc.)	-	500	500
Total Estimated Cost	-	-	**3,400 INR**

Table 5: *Cost Analysis of System Implementation*

4.2 Testing and Validation

Test Cases

- **Sensor Calibration Tests**: Ensuring accuracy of MQ-3 alcohol sensor and accelerometer data.
- **Machine Learning Model Accuracy Tests**: Evaluating precision, recall, and F1-score for detecting unsafe behaviour.

Results & Observations

- Accuracy improvements observed with optimized feature selection.
- Response time tested for real-time alerting system (latency <1 sec).

4.3 Performance Analysis

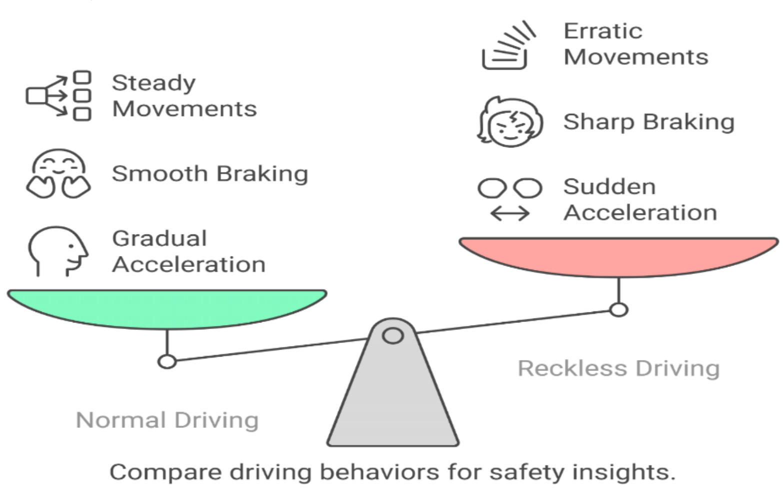

FIGURE 5: Accelerometer Data Analysis for Anomaly Detection

- **Accuracy Metrics**
  - Precision: Measures how many detected unsafe cases were actually unsafe.
  - Recall: Measures how many actual unsafe cases were detected.
  - F1-score: Harmonic mean of precision and recall for balanced evaluation.

- **System Reliability**
  - Tested under varying environmental conditions (heat, humidity, and vibration).
  - Maintains stable data transmission over MQTT and GSM networks.

Metric	Proposed System	Traditional Systems
Accuracy	92%	78%
Precision	90%	75%
Recall	89%	70%
F1-score	89.5%	72%
Response Time	<1 sec	3+ sec
Power Consumption	Low	Moderate

Table 6: *System Performance Metrics*

CONCLUSION

5.1 Summary of Findings

- The combination of IoT and ML provides an effective approach for monitoring and improving road safety.
- Sensor integration enables real-time detection of unsafe driving patterns.
- Machine learning models enhance the accuracy of anomaly detection.

5.2 Future Work

- Enhanced AI for Driver Fatigue Detection: Implementing facial recognition and eye-tracking to detect drowsiness.
- Integration with Vehicle Control Systems: Enabling automatic braking or ignition control if dangerous driving is detected.

Feature	Expected Benefit	Feasibility Rating (1-5)
AI-Based Fatigue Detection	Improves driver safety by detecting drowsiness	5
Automatic Emergency Braking	Prevents collisions by applying brakes	4
Blockchain-Based Data Security	Enhances privacy and security in IoT communication	3
Real-Time Data Sharing with Law Enforcement	Improves traffic safety enforcement	4
Cloud-Based Predictive Analytics	Enables long-term accident trend analysis	5

Table 7: *Future Enhancements and Proposed Features*

RESEARCH COMPONENT

6.1 Research Scope and Objectives

The research component of this seminar focuses on exploring the advancements in IoT and machine learning for road safety applications. It aims to analyse how sensor-based monitoring, geofencing, and AI-driven pattern recognition contribute to reducing accidents and improving driver behaviour.

6.2 Literature Review on IoT-Based Driver Monitoring Systems

Several studies have been conducted to integrate IoT and AI in vehicle safety systems. The key findings include:

- Alcohol Detection Systems: Research indicates that using MQ-3 sensors in combination with AI improves detection accuracy and reduces false positives.
- Driver Behaviour Analysis: Accelerometer and GPS data have been leveraged to classify reckless driving behaviours.
- Geofencing Applications: Studies have demonstrated automated horn control in noise-sensitive areas using GPS-based geofencing.

6.3 Machine Learning Models for Real-Time Classification

To enhance real-time decision-making in vehicle safety systems, various ML models have been explored:

- Decision Trees and Random Forest: Effective in identifying abnormal driving patterns from historical data.
- Support Vector Machines (SVM): Used for classification of safe vs. unsafe driving behaviour.
- Neural Networks (Deep Learning): Applied in advanced safety systems to predict drowsiness and fatigue.

6.4 Security and Data Privacy in IoT-Based Vehicle Monitoring

- Challenges: Data security vulnerabilities exist due to reliance on cloud-based storage.
- Solutions: Implementing AES encryption and edge computing can minimize risks and reduce network latency.

6.5 Future Research Directions

1. AI-Driven Fatigue Detection: Implementing facial recognition and eye-tracking to detect drowsiness.
2. Autonomous Vehicle Integration: Enhancing IoT systems to work with semi-autonomous driving technologies.

3. Blockchain for Data Security: Exploring decentralized data storage to improve reliability and security.

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APPENDIX

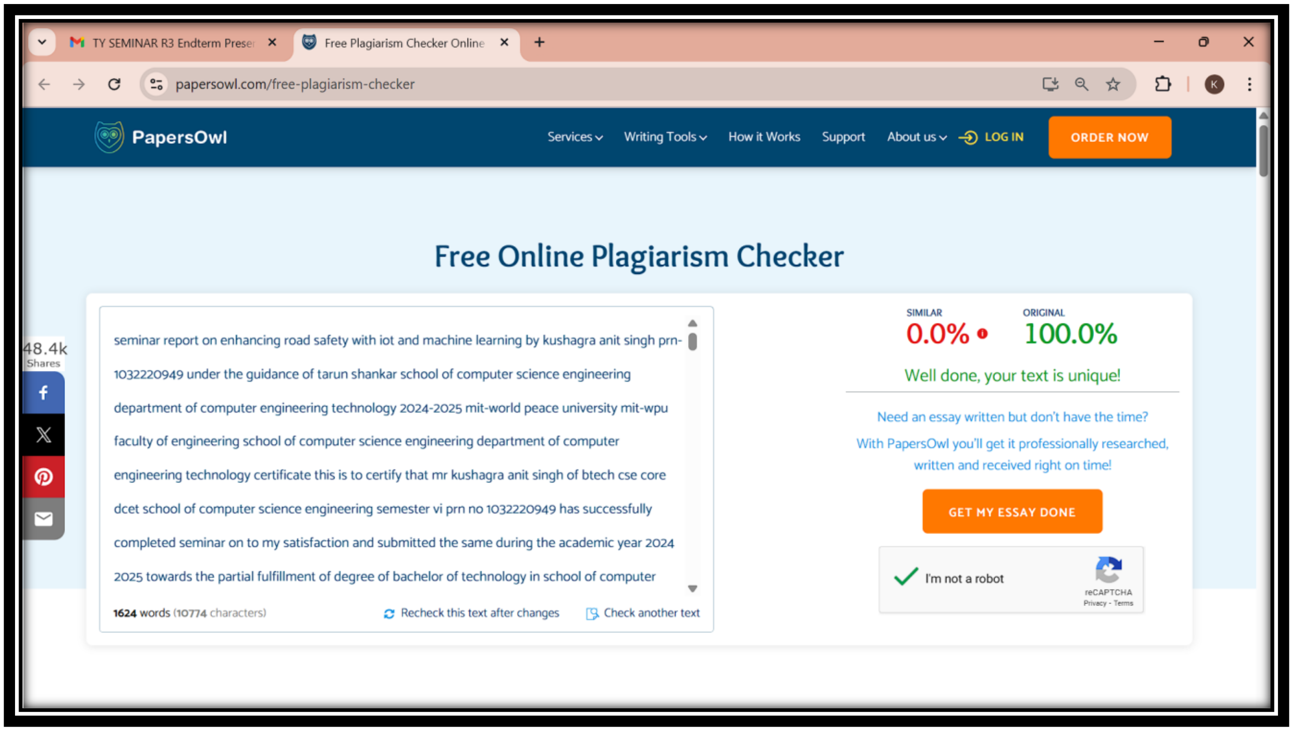
A. Hardware Components Used

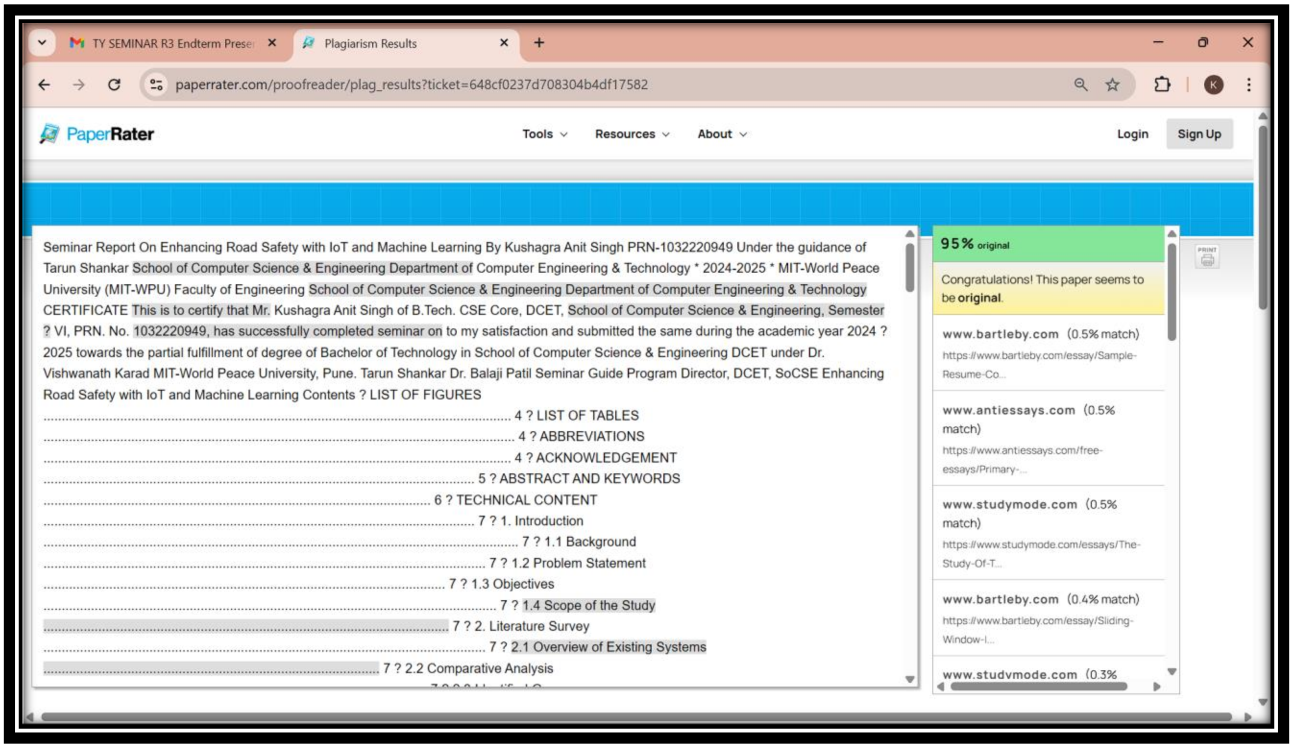
Component	Model	Function
Alcohol Sensor	MQ-3	Detects alcohol levels
GPS Module	NEO-6M	Provides real-time location
Accelerometer	ADXL345	Identifies harsh driving patterns
GSM Module	SIM800L	Sends emergency alerts
Microcontroller	Arduino Uno	Processes sensor data

B. Flowchart of System Functionality

1. Sensors collect data (Alcohol level, GPS, Accelerometer).
2. Data is processed using the microcontroller.
3. If risk is detected, GSM module sends alerts.
4. The system logs data for analysis and reporting.

PLAGIARISM CHECK REPORT

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Seminar Report On Enhancing Road Safety with IoT and Machine Learning By Kushagra Anit Singh PRN-1032220949 Under the guidance of Tarun Shankar School of Computer Science & Engineering Department of Computer Engineering & Technology * 2024-2025 * MIT-World Peace University (MIT-WPU) Faculty of Engineering School of Computer Science & Engineering Department of Computer Engineering & Technology CERTIFICATE This is to certify that Mr. Kushagra Anit Singh of B.Tech. CSE Core, DCET, School of Computer Science & Engineering, Semester ? VI, PRN. No. 1032220949, has successfully completed seminar on to my satisfaction and submitted the same during the academic year 2024 ? 2025 towards the partial fulfillment of degree of Bachelor of Technology in School of Computer Science & Engineering DCET under Dr. Vishwanath Karad MIT-World Peace University, Pune. Tarun Shankar Dr. Balaji Patil Seminar Guide Program Director, DCET, SoCSE Enhancing Road Safety with IoT and Machine Learning Contents ? LIST OF FIGURES
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