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# Smart Safety Monitoring System for vehicles on roads using IOT Sensors and Machine Learning

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*KEYWORDS*

*Vehicle Safety, IoT Sensors, Machine Learning, Real-time Monitoring .*

**ABSTRACT**

*Road safety is a critical concern globally, with increasing accidents due to poor road conditions, driver negligence, and lack of real-time monitoring systems. The Smart Safety Monitoring System for Roads and Vehicles using IoT and Machine Learning aims to enhance road safety by integrating deep learning, machine learning, and sensor based monitoring. This system is implemented using Raspberry Pi, leveraging pothole detection, accident severity analysis, alcohol detection, and crash detection to provide real-time alerts and preventive measures. The pothole detection feature uses deep learning algorithms to analyze road conditions and identify potholes. This data is processed and stored, enabling authorities to take corrective actions and alert drivers in advance. Additionally, the accident severity detection module uses machine learning algorithms to assess the impact level of accidents, helping in quick emergency response. To enhance driver safety, the system integrates an alcohol sensor, which detects into dictated driving and prevents the vehicle from starting. In case of an accident, the crash sensor immediately detects the impact and triggers an alert system. GPS coordinates of the accident location are sent in real-time to Telegram, allowing emergency services to take immediate action. An LCD display is used to show alerts, sensor readings, and warnings to the driver, ensuring an interactive safety mechanism. The system is designed to be cost effective, scalable, and efficient, making it ideal for both urban and rural deployment. By combining IoT with deep learning and machine learning algorithms, this system provides a smart and automated approach to road safety, helping reduce accidents, improve emergency response, and assist government authorities in road maintenance and traffic management. This solution can be further enhanced by integrating cloud storage, AI-based traffic analysis, and real-time data sharing*

## 1. INTRODUCTION

Road accidents and poor road conditions are major challenges affecting transportation safety and infrastructure maintenance worldwide. Every year, thousands of lives are lost due to vehicle collisions, reckless driving, road damages, and lack of real- time monitoring systems. Addressing these issues requires an intelligent and automated approach that utilizes modern technologies like IoT, machine learning, and deep learning to enhance road safety and accident prevention. The Smart Safety Monitoring System for Roads and Vehicles using IoT and Machine Learning aims to provide an advanced accident detection, pothole detection, and road monitoring solution using Raspberry-Pi. This system integrates multiple sensors and intelligent algorithms to detect potholes, analyze accident severity, identify alcohol-impaired driving, and send real-time alerts to emergency services and authorities.

### 1.1 Literature survey:

1. Pothole Detection: Deep learning models,like CNNs, have been used to detect potholes through image and sensor data, improving road maintenance. Notable work by Zhang et al. (2018)Learning, and Deep Learning to enhance road and Jang et al. (2020) demonstrated the effectiveness. These system aims to detect potholes, assess accident of these methods in real-time monitoring and early detection.

2. Accident Severity Detection: Machine learning algorithms, such as Random Forests and SVM, have been applied to assess accident severity. Guerra et al. (2019) and Shin et al. (2021) explored predictive models using sensor data, improving emergency response times by analyzing accident impacts.

3. Alcohol Detection: Systems that integrate alcohol sensors in vehicles to prevent intoxicated driving have been developed, such as Choi et al. (2017), who embedded breathalyzer sensors in ignition systems to prevent the vehicle from starting if the driver is over the legal alcohol limit.

4. Crash Detection: IoT-enabled crash detection systems, like those proposed by Bai et al. (2016) and Zhao et al. (2019), detect collisions using accelerometers and GPS, instantly sending real-time alerts to emergency services, thus speeding up response times.

5. Real-Time Data Sharing and Traffic Management: Cloud-based IoT systems, explored by Kumar et al. (2020) and Patel et al. (2022), collect and analyze traffic data to optimize traffic flow and assist in road maintenance, enhancing both safety and efficiency.

6. Integrated Systems: Research by Zhao et al. (2021) and Sharma et al. (2023) suggests combining pothole detection, accident analysis, alcohol sensors, and crash detection into one system to provide a holistic, scalable approach to road safety.

In conclusion, these advancements highlight the potential of IoT, ML, and DL in improving road safety through early detection, real-time monitoring, and rapid emergency response. Future work can focus on refining these systems for broader, more scalable deployment

### 1.2 Objective of the Project:

The objective of this paper is to design a Smart Safety Monitoring System using IoT, severity, prevent drunk driving, and trigger crash alerts with real-time GPS coordinates for emergency services. It seeks to provide cost-effective, scalable solutions for both urban and rural areas, improving road conditions, driver safety, and emergency response. Additionally, the system can be integrated with cloud storage and traffic analysis for smarter road management.

### 1.3 Overview of the Paper:

Road safety is a growing concern worldwide due to increasing accidents caused by poor infrastructure, driver negligence, and lack of real-time monitoring. The Smart Safety Monitoring System for Roads and Vehicles aims to address these issues by integrating IoT, Machine Learning (ML), and Deep Learning technologies to create an intelligent, real-time road safety solution. evaluation metrics to assess the effectiveness of the proposed system.

The system is designed to be cost-effective, scalable, and efficient, making it suitable for both urban and rural environments. By leveraging IoT, ML, and DL, this system aims to improve road safety, reduce accidents, and enhance emergency responses. Future expansions could include cloud storage integration, AI-based traffic analysis, and collaboration with government agencies for better road maintenance and traffic management.

## 2. PROPOSED APPROACH

Alcohol Detection: The system uses alcohol detection technologies to prevent drunk driving and encourage responsible driving. Advanced sensors monitor alcohol levels in the car interior and send notifications if found

Accident Alerting: The suggested system provides fast accident detection capabilities. It uses sensors and collision detection algorithms to quickly identify accidents and send out fast notifications. Sending SMS notifications to registered cell phone numbers can speed up reaction time and perhaps save lives.

• Real-time vehicle tracking system: Real-time GPSbased vehicle tracking improves security and simplifies fleet administration. This technology remotely monitors automobiles, deterring theft and serving as a useful tool for businesses .

• Seat Belt Alert: Using seat belts is essential for occupant safety. The device has a seat belt warning feature to remind drivers and passengers to buckle their seatbelts. This simple effective reminder improves seat belt compliance and safety .

The suggested solution focuses on integrating an embedded system that uses Internet of Things (IoT) technology with Global System for Mobile Communication (GSM) capabilities. A fundamental aspect of this technology is the use of a pressure sensor to continually monitor the state of the seat belt, reducing the danger of an accident. As a safety measure, if the driver fails to secure their seat belt, the system will turn off the engine automatically. In addition, the device has an alcohol sensor to detect the presence of alcohol consumption. If alcohol is found, the engine is immediately disabled, significantly improving safety precautions.

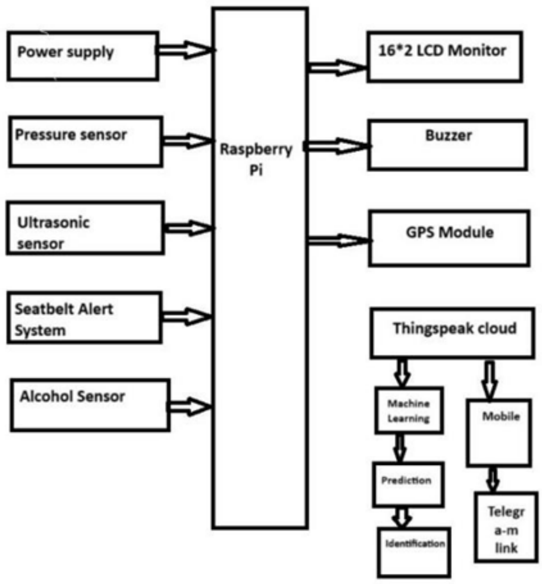


Fig 1 .: Block diagram

The Smart Safety Monitoring System for Roads and Vehicles using IoT and Machine Learning introduces an intelligent, real-time, and automated approach to road safety and accident prevention. This system is implemented using Raspberry Pi and integrates deep learning, machine learning, and IoT technologies to enhance road monitoring. One of the key features is pothole detection using deep learning, where road images are analyzed in real- time to identify potholes and alert drivers and road maintenance authorities for quick action. Additionally, accident severity detection is implemented using machine learning algorithms, which process crash sensor data to classify the severity of an accident, enabling emergency responders to prioritize critical cases. To prevent drunk driving, the system includes an alcohol sensor, which detects intoxicated drivers and prevents the vehicle from starting if alcohol levels exceed a certain threshold. A crash sensoris also integrated to detect sudden vehicle impact, triggering an automated emergency alert system that immediately sends the GPS location of the accident site to authorities and emergency contacts via Telegram notifications. Furthermore, an LCD display provides real-time updates on road conditions, accident warnings, and sensor readings, ensuring driver awareness and safety.

## 3. HARDWARE COMPONENTS

### 3.1 RASBERRY PI :

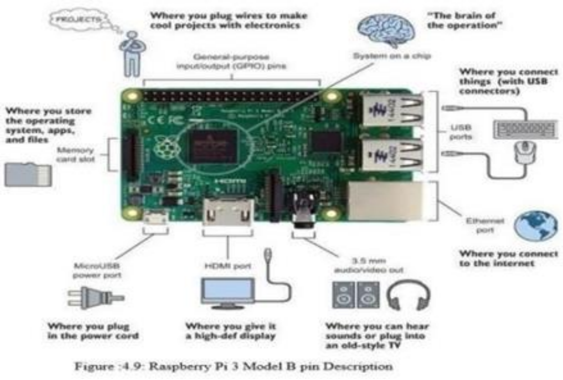

Figure :4.9: Raspberry Pi 3 Model B pin Description

Figure 3: Raspberry- PI

The Raspberry Pi is a small, affordable single-board computer designed for learning programming and electronics. It features an ARM processor, RAM, USB ports, HDMI output, and GPIO pins for connecting hardware. It runs Linux-based operating systems and is used in a variety of projects like robotics, home automation, and media centers. Popular models include the Raspberry Pi 4 (powerful with up to 8GB RAM) and Raspberry Pi Zero (compact and cheap). Its versatility and low cost make it a favorite for hobbyists and educators.

3.2. GPS MODULE: A

GPS module receives signals from satellites to determine location and time. It's used in navigation, tracking, and location-based applications.

Figure 4 : GPS Module

3.3. BUZZER

A buzzer is an electronic device that produces sound, often used for alarms or notifications. It can be active (sounds when powered) or passive (requires an external signal). Buzzers are commonly used in alarms, timers, and feedback systems.

Figure 5 : Buzzer

3.4. ALCOHOL SENSOR (MQ 3):


Figure 6 :Alcohol Sensor

An alcohol sensor detects the presence of alcohol (usually ethanol) in the air or breath. It's commonly used in breathalyzers, safety equipment, and vehicles to prevent drunk driving. The sensors can be semiconductor-based (measuring resistance changes) or electro chemical (detecting chemical reactions). They are fast, sensitive, and portable, ensuring safety in various applications.

3.5. WI-FI MODULE (ESP8266):


Figure 7: WI-FI Module (ESP8266)

The ESP8266 is a low-cost Wi-Fi module that adds wireless connectivity to micro-controllers. It supports internet communication and is widely used in IoT projects, smart homes, and wireless applications.

3.6. LIMIT SWITCH:

Figure 8: Limit Switch

A limit switch is an electrical device that detects the position of an object by activating when a mechanical part makes contact. It's used in automation, safety systems, and position sensing for machinery.

3.7. LCD DISPLAY:


Figure 9: LCD Display

An LCD (Liquid Crystal Display) is a low-power screen used to display text, numbers, and graphics. It's commonly found in electronics, appliances, and embedded systems for clear visual output.

## 4. SOFTWARE COMPONENTS:

### 4.1 VNC Viewer :

VNC Viewer can be used for pothole detection in scenarios where remote monitoring or control of a vehicle's camera system is involved. In this case, the VNC Viewer would allow an operator to remotely access and view the live feed from cameras mounted on a vehicle (like a drone or car) used for pothole detection.

How it works:

1. Remote Monitoring: The vehicle or drone with a camera scans roads for potholes.

2. VNC Viewer: Operators use VNC Viewer to access and control the camera's live feed, allowing them to detect potholes in real time from a remote location.

3. Data Analysis: The system can also be connected to software that analyzes the footage to identify potholes.

This setup would be helpful for municipal or road maintenance teams, allowing them to detect and monitor potholes remotely without physically inspecting each area.

### 4.2 Deep-learning:

Deep learning for pothole detection uses neural networks, especially CNNs (Convolutional Neural Networks), to automatically identify potholes in images or videos of roads. Cameras or drones capture road footage, which is processed by a trained model to detect potholes in real-time. This method is highly accurate and automates road inspections, making it easier to detect and repair potholes quickly. It's used in smart city infrastructure, autonomous vehicles, and road maintenance applications.

### 4.3 Machine learning using python:

Machine learning for accident severity involves using algorithms to predict the severity of accidents based on factors like location, weather, road conditions, and driver behavior. By analyzing historical accident data, machine learning models can help identify patterns and predict the outcomes of future accidents.

Key Steps:

1. Data Collection: Data from past accidents (e.g., weather conditions, time of day, traffic volume, road type) is gathered.

2. Feature Selection: Relevant factors influencing accident severity (e.g., speed, weather, vehicle type) are chosen.

3. Model Training: Machine learning algorithms (e.g., random forests, support vector machines, or neural networks) are trained on the data to predict accident severity (e.g., minor, moderate, severe).

4. Prediction: The trained model is used to predict the severity of new accidents based on real-time or historical data.

Applications:

Road Safety: Identifying high-risk locations and conditions to prevent severe accidents.

Traffic Management: Helping authorities deploy resources where they're needed most.

Insurance: Assisting in claims assessment and risk analysis.

Machine learning helps improve safety, optimize emergency response, and reduce accident severity by providing data-driven insights.

## 5.OUTPUT:

The Smart Safety Monitoring System for Roads and Vehicles uses IoT, machine learning, and deep learning to improve road safety. It integrates features like pothole detection, accident severity analysis, alcohol detection, and crash detection to provide real-time alerts. The system helps detect hazards, assess accident impact, prevent drunk driving, and alert emergency services with GPS data. It's cost-effective, scalable, and ideal for both urban and rural areas, enhancing road safety, emergency response, and road maintenance. Future improvements include cloud storage, AI-based traffic analysis, and real-time data sharing with authorities.

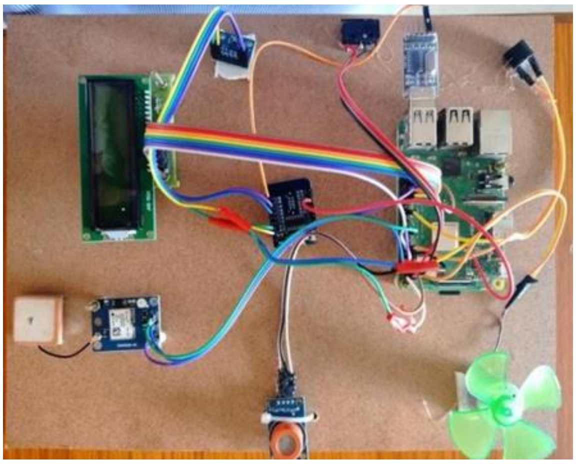

Fig 10: Hardware kit Output

Fig 11.1

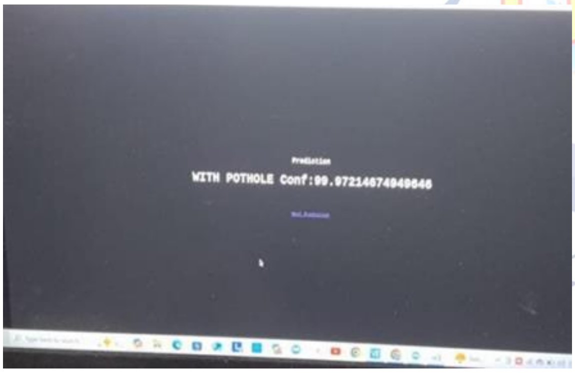


Fig 11.2

Fig 11.1 & 11.2: Output showing with pothole

Figure 12.1

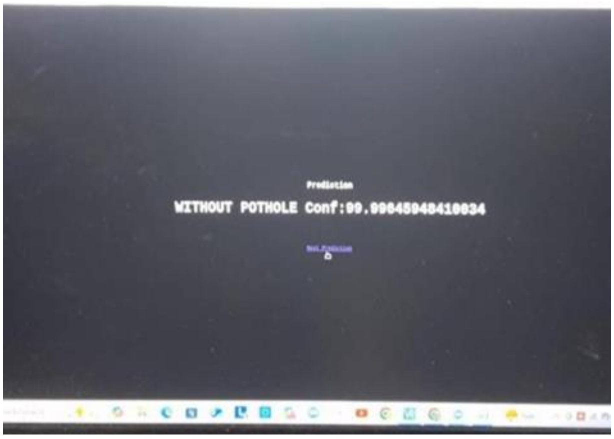


Figure 12.2

Fig 12.1 &12.2 : Output showing without pothole

## 6. CONCLUSION AND FUTURE SCOPE :

The Smart Safety Monitoring System for Roads and Vehicles using IoT and Machine Learning presents an innovative and automated approach to road safety, accident prevention, and emergency response. By integrating deep learning for pothole detection, machine learning for accident severity analysis, IoT- based monitoring, and real-time alert mechanisms, this system significantly enhances road infrastructure management and driver safety. The incorporation of alcohol sensors, crash sensors, GPS-based location tracking, and Telegram notifications ensures that accidents and road hazards are detected and addressed in real time. Unlike traditional road safety measures, this system provides a proactive approach, allowing authorities and emergency responders to take immediate action, thereby reducing fatalities and injuries. The real-time LCD display alerts drivers about road hazards, enhancing their awareness and reducing accident risks. This project serves as a cost-effective, scalable, and reliable solution for modern transportation safety, ensuring safer roads and improved emergency response mechanisms.

Future Scope

The future of smart road safety monitoring lies in further advancements and enhancements in AI, IoT, and automation. Future improvements in this system could include edge computing for faster data processing, allowing real-time analysis directly on the Raspberry Pi without reliance on cloud servers. Additionally, 5G technology could enhance the system's connectivity, ensuring instant data transmission and real-time response. Integrating vehicle-to-vehicle (V2V) and vehicle-to- infrastructure (V2I) communication could further improve accident prevention by enabling autonomous alerts between vehicles and traffic management systems. Another area of expansion is predictive road maintenance, where historical pothole detection data can be used to predict potential road damage and assist municipalities in proactive infrastructure management. Moreover, advanced image processing and AI models can improve pothole classification, differentiating between minor cracks and severe damages, allowing better decision-making. The system could also be integrated with automated traffic management systems to divert traffic in case of accidents or hazardous road conditions. In the long term, the integration of autonomous vehicles with this safety system could lead to fully automated road monitoring and accident prevention, reducing human errors and enhancing overall transportation efficiency. Governments, city planners, and transportation agencies can adopt this system to create a safer, smarter, and more efficient road network, ultimately leading to a significant reduction in accidents, improved road conditions, and enhanced public safety

### Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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