Road Accident Detection Using Maching Learning

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Abstract - Road accidents are a major cause of fatalities worldwide, necessitating rapid detection and response systems. This project presents an IoT-based road accident detection system using machine learning to automatically identify accidents, assess their severity, and notify emergency services in real-time. The system integrates accelerometers, gyroscopes, GPS, and gas sensors with a microcontroller (ESP32/Raspberry Pi) to collect real-time vehicular data. A machine learning model, trained using Random Forest, SVM, or deep learning algorithms, processes sensor data to distinguish between normal driving behavior and accidents. Upon detecting an accident, the system triggers an alert mechanism, sending real-time location details via SMS, email, or cloud-based notifications to emergency contacts and rescue services. Additionally, a mobile or web application provides a user-friendly interface for monitoring accident reports.

Key words: IoT, Machine Learning, Road Accident Detection, Smart Transportation, Emergency Response, Real-time Monitoring, GPS Tracking, Traffic Safety, AI in Transportation.

1. INTRODUCTION

Road accidents are a leading cause of fatalities and injuries worldwide, often due to delayed accident detection and emergency response. Traditional methods rely on manual reporting, which can be slow and inefficient. To address this challenge, the integration of Machine Learning (ML) and the Internet of Things (IoT) provides a smart and automated approach for real-time accident detection and rapid response.

Grade I. Background & Motivation: Road accidents are a significant global concern, causing millions of fatalities and injuries every year. One of the major challenges in accident management is the delay in emergency response, which can lead to severe consequences.

Grade II. The Need for an Automated System: To address these challenges, an IoT-based accident detection system integrated with machine learning can provide real-time monitoring and automated accident detection. By analyzing sensor data from vehicles, such a system can quickly detect accidents, assess their severity, and send alerts to emergency services, significantly reducing response time.

Grade III. Role of IoT and Machine Learning: The proposed system uses IoT sensors (accelerometers, gyroscopes, GPS, and gas sensors) to collect vehicle movement data. A machine learning model is trained on this data to differentiate between normal driving conditions and accident scenarios. When an accident is detected, the system automatically sends alerts with precise location details to emergency contacts and rescue teams.

Grade IV. Scope & Future Enhancements: This system has the potential to improve road safety by enabling faster emergency response. Future enhancements may include AI- based image processing for severity analysis, voice-activated SOS alerts, and integration with smart traffic management systems.

Grade V. Objectives of the Project: Real-time accident detection using IoT sensors and machine learning.

Accident severity assessment to differentiate between minor and major crashes.

Automated alert system to notify emergency services and contacts.

Integration with mobile or web applications for live monitoring and response.

2. LITERATURE REVIEW

Road accidents are a major public safety concern, leading to significant fatalities and injuries. The integration of machine learning (ML) techniques in accident detection has the potential to enhance real-time monitoring and response systems. This literature review explores various machine learning approaches utilized in road accident detection, including data sources, algorithms, and performance evaluation.

Machine learning-based accident detection relies on various data sources, including traffic surveillance cameras, GPS and mobile sensors, vehicular IoT devices, social media, crowdsourced data, and historical traffic and weather data. Traffic surveillance cameras provide images and videos processed using computer vision techniques, while GPS and mobile sensors collect data from accelerometers and gyroscopes in smartphones. Vehicular IoT devices gather information on speed, braking, and impact data, whereas social media and crowdsourced data from platforms like Twitter and Waze contribute to accident reports. Additionally, historical traffic and weather data are useful for predictive analysis.

Machine learning has demonstrated significant potential in road accident detection, offering real-time monitoring and predictive analytics. However, challenges related to data quality, computational efficiency, and ethical considerations need further research. Future advancements in deep learning, edge computing, and multi-modal data integration can enhance the effectiveness and reliability of accident detection systems.

Future research directions include the integration of edge computing to reduce latency in real-time accident detection, multi-modal data fusion to enhance accuracy, Explainable AI (XAI) to improve transparency, and the incorporation of machine learning into autonomous vehicle systems for predictive accident avoidance.

3. SYSTEM DESIGN

Existing system:

Existing road accident detection systems rely on various technologies to identify and respond to crashes. Traditional methods include manual accident reporting, where witnesses or drivers call emergency helplines or report incidents to traffic authorities. CCTV surveillance and AI-powered video analysis are also used, with cameras installed on roads to monitor traffic and detect sudden collisions. Additionally, IoT and sensor- based detection systems utilize accelerometers, gyroscopes, and vehicle onboard diagnostics to identify crashes based on abrupt changes in motion

Proposed system:

The proposed Road Accident Detection System is developed and evaluated using a dataset comprising approximately 1000 frames of accidents and non-accidents sourced from Kaggle. Preprocessing of the data involved resizing the frames to a standardized resolution and normalizing the pixel values to a common scale. Features relevant to accident detection were extracted from the preprocessed frames to capture meaningful information. The system utilized three deep learning models: a custom-built Convolutional Neural Network (CNN), ResNet50, and VGG16, selected for their feature extraction capabilities. Training the models involved optimizing parameters to minimize loss and enhance accuracy through multiple iterations of the labeled dataset. For Detection, A CCTV footage containing both accidents and non-accidents is given as input, frames are extracted from it, preprocessed and given to the models for prediction. The predictions of the 3 models are compared and majority prediction is taken as the final output.

4. METHADOLOGY

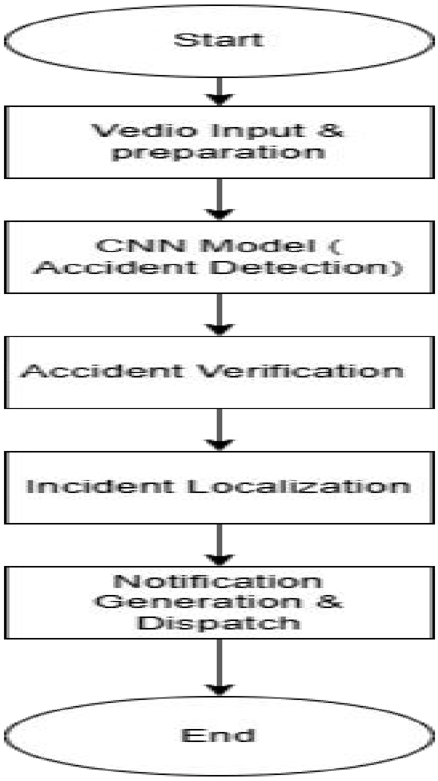

Fig -1: Dataflow Diagram.

The entire Following the detection phase, Accident Verification takes place. This step is crucial for minimizing false positives. It might involve human review of the flagged segments or additional automated checks to confirm the occurrence of an actual accident. Once an accident is verified, the system proceeds to Incident Localization. Here, the system pinpoints the precise location of the accident within the video frame or timestamp, providing crucial spatial and temporal information.

Finally, the system moves to Notification Generation and Dispatch. Based on the confirmed accident and its location, the system generates notifications containing relevant details, such as the time and place of the incident. These notifications are then dispatched to designated recipients, which could include emergency services, relevant personnel, or pre- selected contacts. The process concludes at the End point, signifying the completion of the accident detection and notification sequence.

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5. FUTURE DIRECTIONS

The advancement of IoT-based road accident detection systems using machine learning requires further improvements in several key areas. One major direction is the enhancement of machine learning algorithms by incorporating hybrid models that combine deep learning techniques such as Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) with traditional classification methods like Random Forest and Support Vector Machines (SVM). These models can improve accident detection accuracy by learning complex patterns in real-time vehicular data while minimizing false positives.

Another critical area is real-time edge computing, where lightweight AI models are optimized for deployment on low- power IoT devices such as ESP32 and Raspberry Pi. This can significantly reduce dependency on cloud computing, ensuring faster accident detection and response. The integration of advanced sensor fusion techniques can further enhance the system's reliability by combining data from accelerometers, gyroscopes, LiDAR, radar, and camera modules to accurately assess accident severity. Additionally, image and video-based processing using deep learning algorithms can provide real- time visual analysis of accident scenes, allowing for a more precise evaluation of impact levels.

To improve communication and emergency response, future systems can leverage 5G networks and Low Power Wide Area Network (LPWAN) for low-latency accident alerts, ensuring real-time data transmission even in remote locations. Moreover, blockchain technology can be implemented to enhance data security and integrity, preventing unauthorized tampering with accident records. The integration of accident detection systems with smart traffic infrastructure can further optimize response mechanisms. By establishing Vehicle-to- Infrastructure (V2I) communication, accident alerts can be automatically relayed to smart traffic lights, autonomous vehicles, and emergency services, allowing traffic rerouting and faster medical assistance.

6. CONCLUSIONS

The integration of IoT and machine learning has improved accident detection and severity assessment. However, there is a need for hybrid AI models, low-power edge computing, and 5G-based communication networks to enhance accuracy and real-time performance. Future research should focus on reducing false positives, improving real-time processing, and ensuring reliable communication in remote areas for an effective accident detection and response system. techniques with excellent results for indoor applications.

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