

AI-Based Accident Detection System Using CCTV

Prem Modsing

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Abstract

This project focuses on integrating AI-powered accident detection with CCTV surveillance systems to enhance road safety and emergency response efficiency. By leveraging computer vision and deep learning models, the system identifies traffic collisions in real-time and triggers automated alerts to emergency services and registered contacts.

The proposed solution analyses live video feeds to detect anomalies, classify accident severity, and instantly share incident reports with authorities. Beyond technical development, this project also explores a scalable business model, ensuring seamless adoption by government agencies, smart cities, and private transportation networks.

1. Problem Statement

Road accidents are a major cause of fatalities worldwide, with delayed emergency response often leading to severe consequences. Traditional accident detection methods rely on manual monitoring of CCTV footage, which is inefficient, prone to human error, and results in slow response times. Many accidents go unnoticed or unreported, leading to preventable loss of life and property damage.

Emergency response teams rely on calls from witnesses or automated crash detection in vehicles, which is not always available in all locations. Lack of real-time accident detection results in increased response time, reducing the chances of survival for critically injured victims. Additionally, there is no system in place to automatically notify nearby hospitals, police, or emergency contacts, further delaying assistance.

To address these challenges, this project proposes an AI-powered accident detection system that leverages CCTV footage and machine learning algorithms to detect collisions in real-time. The system will automatically classify accident severity and trigger alerts to emergency services and registered contacts. By integrating this technology with smart city infrastructure, traffic management centers, and hospitals, the system aims to improve emergency response efficiency, reduce fatalities, and enhance overall road safety.

2. Market and Customer Needs Assessment

2.1 Market Analysis

The global road safety and intelligent transportation market is rapidly expanding due to increasing urbanization and the need for improved traffic management. Governments and smart city initiatives are investing in AI-driven surveillance and real-time monitoring systems to enhance public safety. The demand for accident detection solutions is growing as cities seek automated systems that can reduce emergency response times and prevent fatalities.

According to recent studies, delayed emergency response is a major factor contributing to accident-related deaths. Many municipalities and traffic management authorities lack an efficient system to detect and respond to accidents in real-time. Insurance companies and logistics firms also require reliable accident data for claims processing and risk assessment, further increasing the market demand for AI-powered detection solutions.

As technology advances, the need for automated, real-time accident detection integrated with emergency response services is becoming a priority. This presents a significant opportunity for AI-based solutions that can improve road safety, optimize traffic monitoring, and enhance emergency response efficiency.

2.2 Customer Segmentation

The primary users of the AI-based accident detection system include government agencies, emergency response teams, insurance companies, smart city developers, and logistics firms. These organizations require real-time accident detection and automated alert systems to improve road safety, optimize emergency response, and streamline insurance claims. Key customer segments include:

Government traffic authorities, including municipalities and national traffic departments, looking to improve accident response times and enhance smart city infrastructure.

Emergency response teams such as hospitals, ambulances, and fire departments that rely on fast and accurate accident detection to reduce casualties.

Insurance companies needing reliable accident reports to process claims efficiently and reduce fraud.

Smart city developers, urban planners, and city administrations working on AI-driven traffic monitoring and automation projects.

Logistics and fleet management companies managing commercial fleets that require real-time accident tracking and automated reporting for operational safety.

These customers need a system that seamlessly integrates with existing CCTV infrastructure, provides automated alerts with location data, and ensures high accuracy with minimal false alarms. Additionally, features such as real-time monitoring dashboards, historical accident analysis, and predictive safety insights are essential for improving urban road safety and optimizing emergency response operations.

3. Target Specification

3.1 Core Functionality and Design

Real-time accident detection using AI-powered computer vision models to analyze CCTV footage and identify traffic collisions instantly.

Automated alert system that sends immediate notifications to emergency services, nearby hospitals, police departments, and registered contacts with accident location and severity details.

Seamless integration with existing CCTV infrastructure, ensuring compatibility with municipal traffic cameras and private surveillance systems.

User-friendly dashboard for traffic management authorities and emergency responders to monitor incidents, analyze accident trends, and access historical data for safety improvements.

Scalable architecture supporting both cloud-based and on-premise deployment for cities with varying levels of technological infrastructure and data privacy concerns.

3.2 Performance Requirements

Speed and Efficiency: The accident detection system must process CCTV footage in real time, ensuring immediate identification of accidents and triggering alerts within seconds.

Reliability and Uptime: The system should maintain at least 99.9% uptime to ensure continuous monitoring and instant emergency response, minimizing downtime in critical situations.

Scalability: The architecture must support high volumes of video data from multiple CCTV cameras across different locations, allowing seamless expansion for smart cities and large-scale deployments.

Accuracy of Detection: The AI model must achieve high accuracy in accident identification while minimizing false positives and false negatives to ensure reliable emergency alerts and response.

4. External Search

The development of an AI-powered accident detection system requires the use of advanced computer vision and machine learning models. Developing these models from scratch is complex and resource-intensive. Instead, we can utilize pre-trained models and apply transfer learning to adapt them to our specific use case. Existing object detection and anomaly detection models such as YOLO (You Only Look Once) and EfficientDet provide a strong foundation for accident identification. Open-source frameworks like TensorFlow, OpenCV, and PyTorch offer robust implementations that can be fine-tuned for real-time accident detection.

4.1. Benchmarking

In our research, we conducted an external analysis of existing accident detection and smart surveillance systems to identify industry trends and best practices. This included:

1. Analysis of Existing Systems

NVIDIA Metropolis: A smart city AI platform that integrates computer vision for traffic monitoring and safety management.

Smart Traffic Management Systems: AI-based solutions used in cities like Singapore and Dubai for real-time accident detection and traffic flow optimization.

2 Exploration of AI Models

Object detection algorithms (YOLO, Faster R-CNN): Used to detect vehicles and accident events in real-time.

Anomaly detection models (Autoencoders, LSTMs): Explored for identifying unusual vehicle behavior leading to accidents.

3 Safety and Emergency Response Features

Automated Emergency Alerts: Inspired by existing crash detection systems in modern vehicles, we will implement instant notifications to hospitals, police, and nearby contacts.

Incident Severity Classification: AI will assess accident severity to prioritize emergency response

4 Integration with Smart City Infrastructure

CCTV and IoT Sensor Integration: Similar to existing smart traffic monitoring systems, our system will leverage real-time video feeds and connected sensors.

Cloud-Based Analytics: Inspired by smart city platforms, accident data will be stored for long-term analysis and pattern recognition.

5 Travel Data Insights and Optimization

Predictive Accident Analytics: Using historical data, the system will help traffic authorities identify accident-prone areas and implement preventive measures.

Automated Traffic Diversion: Integration with navigation systems to suggest alternate routes in case of roadblocks due to accidents.

By conducting this external search, we gained valuable insights into existing AI-powered surveillance and accident detection systems. These findings will guide the development of a scalable and efficient solution tailored for smart city integration and emergency response optimization.

5. Constraints and Regulations

1. Data Privacy and Security

Information Technology (IT) Act, 2000 and IT (Amendment) Act, 2008 mandate that surveillance and data collection systems must ensure strict security protocols to protect sensitive information. The system must comply with regulations regarding the storage and transmission of CCTV footage, ensuring it is encrypted and accessible only to authorized personnel.

Personal Data Protection Bill (PDPB), 2019, once enacted, will regulate how accident detection data is collected and processed. It mandates that certain categories of personal data remain within India, ensuring privacy compliance.

2. **Compliance with Surveillance Laws:** - The deployment of AI-based accident detection must comply with legal frameworks governing public and private surveillance. Many jurisdictions require explicit consent or government authorization before using AI-powered monitoring systems.
3. **Emergency Services Regulations:** - Automated alert systems must integrate with emergency response services without violating operational protocols. Ensuring accurate classification of accident severity is crucial to avoid false alarms that could overwhelm emergency services.
4. **Infrastructure and Compatibility Constraints:** - The system must be compatible with existing traffic surveillance networks, which may vary in resolution, frame rates, and network connectivity. Adapting AI models to different environments is a key challenge.

5. Licensing and Legal Accountability

In case of incorrect accident detection or failure to notify authorities, legal accountability must be clearly defined. Ensuring reliability and reducing false positives is critical to avoid legal disputes.

6. Monetization Strategies for an AI-Based Accident Detection System :

1.Subscription-based Model: -

Basic Features for Free: Offer real-time monitoring and basic accident reporting to government agencies and emergency services at no cost.

Premium Features: Provide advanced analytics, predictive accident insights, and custom reporting as part of a paid subscription:

- AI-driven predictive accident analysis
- Integration with insurance claim systems
- Access to historical accident data for policy planning

2. Government and Municipal Partnerships

Collaborate with traffic departments and smart city initiatives to integrate AI-powered accident detection into urban surveillance infrastructure. Secure government contracts for citywide deployment.

3. Insurance and Fleet Management Services

Offer AI-driven accident reports and real-time monitoring solutions to insurance companies and logistics providers to optimize claims processing and risk assessment.

4. Data Analytics and Insights

Collect and analyze anonymized traffic data to provide insights to urban planners and transportation agencies. Sell analytics-based solutions to cities and private companies to optimize road safety strategies.

5. Hardware Sales and Integration Services

Provide AI-compatible surveillance hardware, such as edge computing devices, to cities and businesses looking to enhance accident detection capabilities. Offer integration and maintenance services as part of the revenue model.

7. Final Product Prototype

The AI-based accident detection system is designed to enhance road safety by providing real-time monitoring, automatic accident detection, and immediate emergency response notifications. The system integrates with existing CCTV infrastructure and uses AI-powered analytics to detect collisions, classify their severity, and alert emergency services.

Key Features:

1. Accident Detection System:

- Uses computer vision and deep learning to analyze live CCTV footage and detect traffic accidents.
- Real-time processing ensures immediate detection and classification of accident severity.

2. Automated Emergency Alerts:

- Sends instant notifications to emergency services, police, and nearby hospitals with accident location and severity details.
- Provides alerts to registered contacts in case of personal vehicle accidents.

3. Integration with Traffic Management Systems:

- Connects with existing smart city traffic surveillance networks to enhance real-time monitoring.
- Allows city officials to access accident data and analyze traffic patterns for improved road safety.

4. Data Logging and Reporting:

- Stores accident records for future analysis and insurance claim verification.
- Provides dashboard insights for authorities to identify accident-prone areas and implement preventive measures.

User Flow:

1. System Activation and Monitoring:

The AI-powered system continuously analyzes video feeds from CCTV cameras installed on roads and highways.

2. Accident Detection and Classification:

When an accident occurs, the system identifies the type and severity using object detection models.

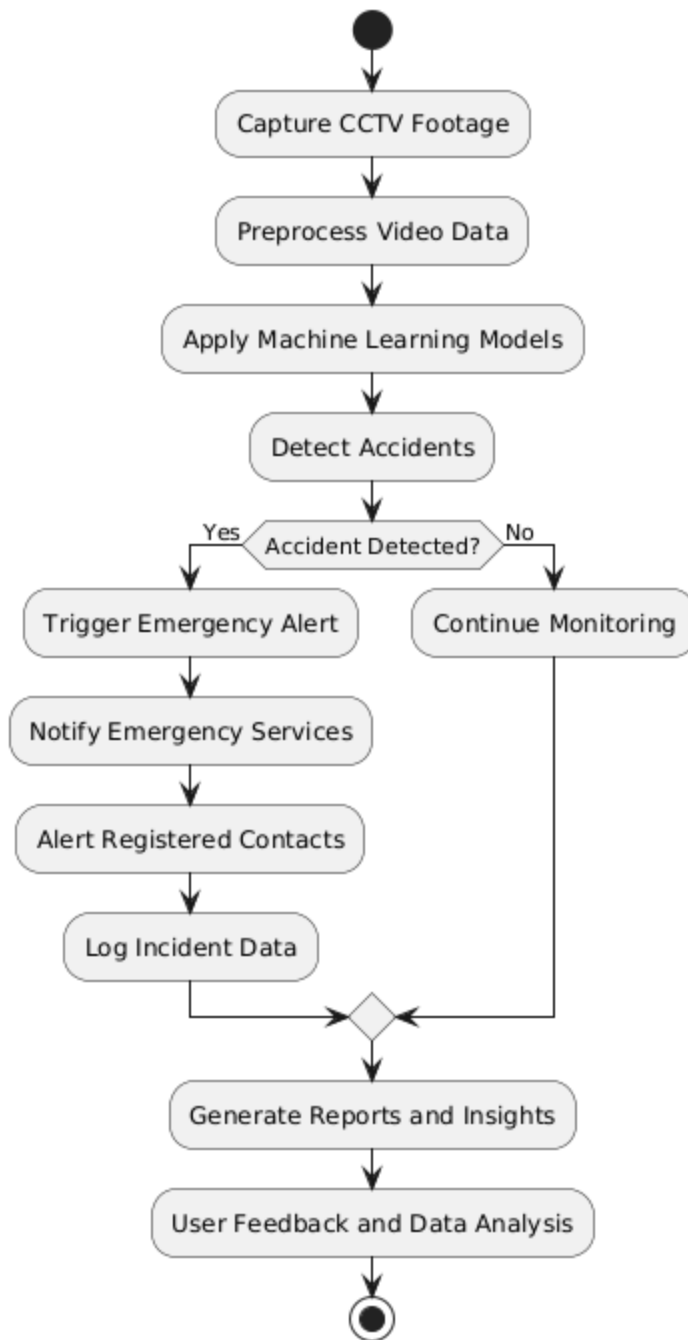
3. Automated Alert Generation:

If a critical accident is detected, emergency services and registered contacts receive an immediate alert with location details.

4. Incident Reporting and Analysis:

The system logs accident data for traffic authorities, insurance companies, and city planners to improve safety measures and policies.

This product aims to reduce emergency response time, improve road safety, and optimize urban traffic management by leveraging AI for real-time accident detection and automated alerting.





8 Conclusion

The AI-based Accident Detection System aims to transform road safety by leveraging advanced machine learning and computer vision techniques. By analyzing real-time CCTV footage, detecting accidents instantly, and triggering emergency alerts, the system ensures faster response times and potentially saves lives. With automated reporting, integration with emergency services, and user feedback mechanisms, the platform enhances safety for drivers, pedestrians, and law enforcement agencies alike.

8. References and Resources

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