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Accident Detection Through CCTV Surveillance

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Abstract

Timely accident detection and emergency response play a crucial role in reducing fatalities and mitigating injuries caused by road accidents. Traditional surveillance systems primarily rely on manual monitoring, which is often inefficient in detecting accidents in real time. "Accident Detection through CCTV Camera Surveillance" presents an AI-powered approach to automate accident identification using deep learning techniques. The system utilizes “Mask R-CNN” and “YOLO v8” to analyse live CCTV footage, accurately detecting accidents and differentiating them from regular traffic events. Once an accident is identified, automated alerts are generated and dispatched to emergency services, including ambulance providers, fire departments, and law enforcement agencies. By minimizing human dependency and response delays, this solution enhances the efficiency of emergency management systems. The proposed framework integrates artificial intelligence with real-time surveillance, providing a scalable and cost effective accident detection mechanism. This research aims to improve road safety, optimize emergency response times, and reduce the loss of life due to delayed medical and rescue assistance. The implementation of this system can significantly contribute to the development of smart cities, reinforcing AI's role in intelligent traffic monitoring and public safety enhancement.

Keywords: CCTV Camera Surveillance, AI-powered, Deep Learning, Mask R-CNN, YOLOv8, Intelligent Traffic Monitoring

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1. Introduction

Road accidents are a significant global concern, leading to thousands of fatalities and severe injuries each year. A major contributing factor to these casualties is the delay in emergency response due to a lack of real-time accident detection and reporting. "Accident Detection through CCTV Camera Surveillance" aims to bridge this critical gap by leveraging advanced computer vision and deep learning techniques to detect accidents in real-time and ensure prompt emergency intervention. This system utilizes “Mask R-CNN” and “YOLO v8” to accurately identify accidents from live CCTV footage, distinguishing them from normal traffic incidents with high precision. Upon detection, automated alerts are sent to emergency services, including medical responders, fire departments, and ambulance

services, reducing the response time significantly. By integrating AI-driven accident recognition with automated alert mechanisms, the goal is to minimize the loss of life and property damage caused by delayed interventions.

This approach not only enhances road safety but also contributes to the development of smart cities by utilizing existing surveillance infrastructure efficiently. With real-time processing and automated reporting, this system has the potential to revolutionize emergency response management, ensuring that help reaches victims at the most crucial moments, ultimately saving countless lives.

2. Methodology

The proposed accident detection system is designed to leverage existing CCTV infrastructure for real-time monitoring and automated response. The core of the system relies on AI-powered detection mechanisms, specifically utilizing YOLOv8 and Mask R-CNN, to ensure accurate identification of accidents within the CCTV footage. The process initiates with the input of video feeds from CCTV cameras. These video feeds are then processed using the mentioned AI models to detect and identify vehicular accidents.

Upon the detection of an accident, the system is designed to perform a series of automated actions to facilitate a rapid emergency response. Firstly, the system generates instant emergency alerts. These alerts are automatically disseminated to relevant emergency services, including fire force, police, ambulance services, and nearby hospitals. This automated alert system eliminates the need for manual reporting, thereby reducing delays in response times. In conjunction with the alerts, the system also sends automated messages containing crucial accident details to the responders. To further enhance the efficiency of rescue operations, the system captures images of the accident and shares precise GPS locations.

This image-based verification aids responders in quickly assessing the severity of the situation. For comprehensive monitoring and future analysis, the system incorporates real-time monitoring and data logging capabilities. This enables the tracking of accident-prone areas, which can be invaluable for safety analysis and the implementation of preventive measures and road improvements.

A website integration is also included in the system's design, providing real-time updates and response tracking capabilities for authorized users. The data flow diagram visually represents the sequence of these processes, from CCTV input to emergency response coordination.

2.1 Accident detection through CCTV architecture

The accident detection system employs a multi-stage architecture that starts with continuous video input from CCTV cameras. This video is processed in real-time using advanced AI, specifically YOLOv8 and Mask R-CNN, to accurately identify accidents. Upon detection, the system automatically generates emergency alerts and notifications. These alerts are disseminated to relevant services including the fire force, police, ambulance services, and hospitals, ensuring a coordinated and rapid response. Simultaneously, accident details and real-time updates are provided through a website. Throughout this process, the system logs and stores data, including video footage, timestamps, and location information. This data logging is crucial for post-accident analysis, system improvement, and traffic management strategies. In essence, the architecture integrates CCTV infrastructure with AI-driven analysis and communication technologies to achieve automated accident detection, efficient emergency response, and comprehensive data management. The system's design prioritizes speed, accuracy, and automation to minimize

response times and enhance road safety.

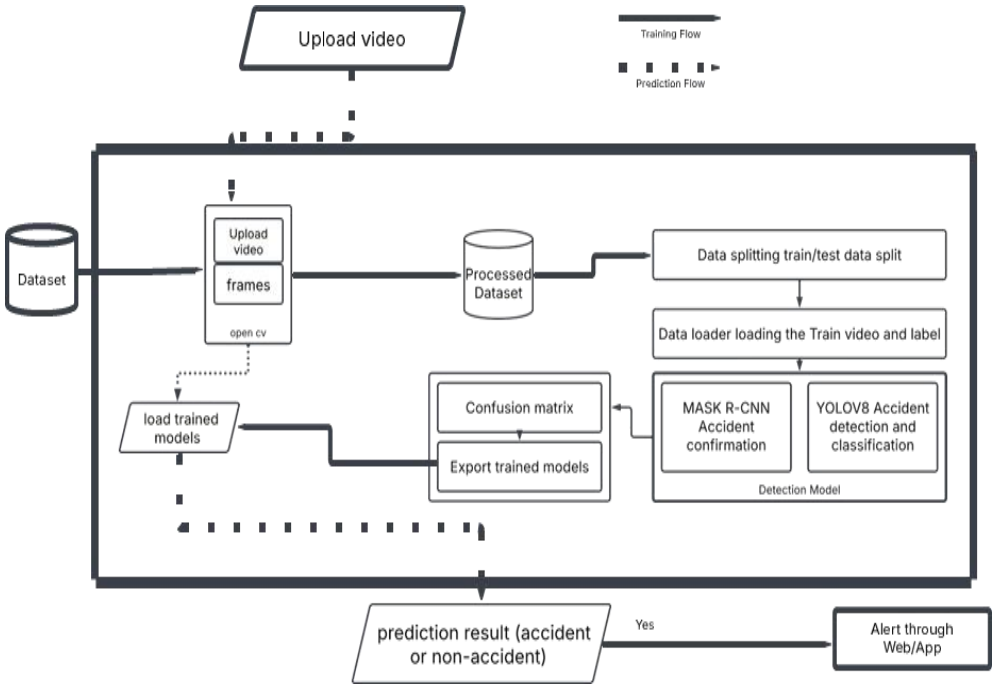


Figure 1: System Design (Video Detection)

2.2 Deployment and Frontend

The accident detection system features a web-based frontend built with React and TypeScript, enabling users to monitor CCTV feeds and access real-time accident alerts. The system is designed for cloud-based deployment, allowing for scalability and integration with existing traffic management and emergency response systems. The backend utilizes technologies like MongoDB, Node.js, Socket.io, and Express.js to manage data processing, alert dissemination, and communication with relevant services.

3. Module Description

The accident detection system comprises several interconnected modules designed for effective accident monitoring, detection, and response coordination. The CCTV Input Module captures real-time video streams from surveillance cameras. The Accident Detection Module employs YOLOv8 and Mask R-CNN to analyze video frames and identify accidents. The Alert Generation Module automatically creates and sends alerts to relevant emergency services, including fire force, police, ambulance, and hospitals. The Mobile App Integration Module provides real time updates and tracking capabilities for responders and stakeholders. The Data Logging and Storage Module records accident related data, including video, timestamps, and location details, for analysis and system improvement.

4. Implementation

4.1 Tools and Technologies Used

Category	**Tools & Technologies**
Programming Language	Python, Type script, Java script

Framework	React, Node.js ,Express.js
IDEs	PyCharm, Vs Code
Accident Detection Libraries/AI Models	YOLOv8, MASK R-CNN

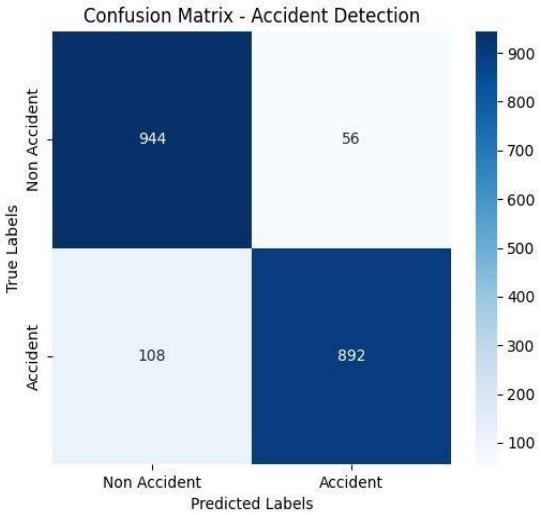
Table 1: Tools & Techniques

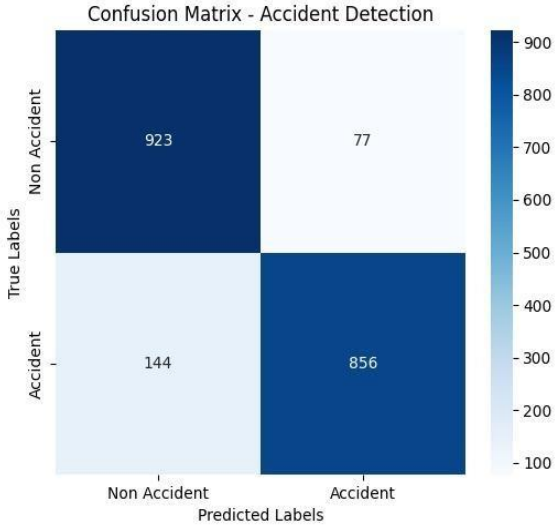
4.2 Algorithm Details

To analyse CCTV footage for real-time accident detection, the system leverages a combination of deep learning models. The core algorithms employed are YOLOv8 and Mask R-CNN. YOLOv8 is utilized for accurate object detection within the video frames, enabling the system to identify vehicles and other relevant components of a scene. Complementing this, Mask R-CNN is used for instance segmentation, providing pixel-level masks of detected objects, thereby facilitating precise accident identification. The system is designed to process live video feeds sourced from CCTV cameras. The system's output involves the identification of accidents. Upon detecting an accident, the system generates instant emergency alerts containing precise location details, which are disseminated to nearby hospitals. Additionally, the system is engineered to notify the fire force, police, and ambulance services. Automated messaging is employed to send spontaneous alerts with accident details to responders. This algorithmic approach aims to achieve real-time accident detection, facilitate immediate emergency alerts, and ultimately improve the efficiency of emergency response times.

5. Results and Discussion

The evaluation of the proposed accident detection system focuses on its accuracy in identifying traffic incidents using CCTV footage. The results demonstrate the system's capability to accurately detect accidents and its potential to improve emergency response.





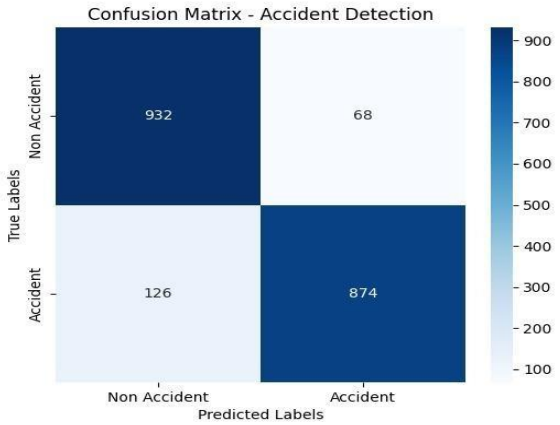


Figure 2: YOLOv8 and MASK R-CNN combined Matrix: 90.2%

The confusion matrices illustrate the performance of the accident detection system using Mask R-CNN, YOLOv8, and a combined approach. The Mask R-CNN model achieved an accuracy of 91.6% in identifying accident instances, demonstrating its effectiveness in accurately segmenting and classifying accident-related objects within the video frames. The YOLOv8 model achieved an accuracy of 88.8%, highlighting its strengths in real-time object detection and localization of accident events within the CCTV footage. The combined YOLOv8 and Mask R-CNN system achieved an overall accuracy of 90.2%. By integrating the object detection capabilities of YOLOv8 with the instance segmentation of Mask R-CNN, the system demonstrates a balanced performance in both localizing and accurately classifying accident events, leveraging the strengths of each model to enhance the overall reliability of the accident detection system.

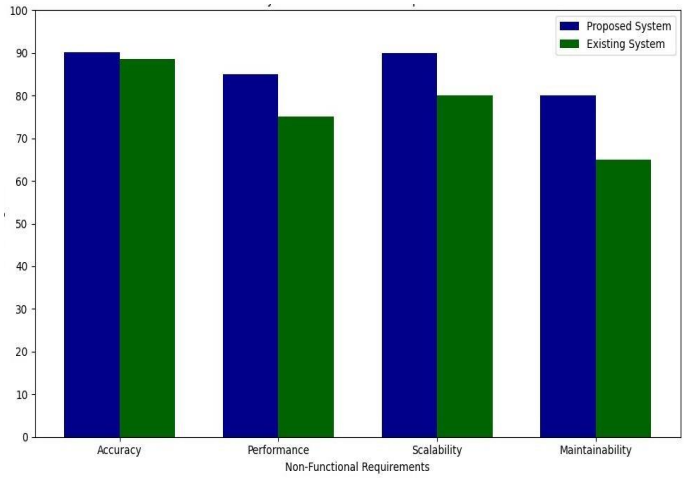


Figure 3.: System performance comparison

The proposed system demonstrates enhanced capabilities with notable scores of 90.2% in Accuracy, 85% in Performance, 90% in Scalability, and 80% in Maintainability. These metrics highlight its potential to outperform the existing system, which achieves 88.6% in Accuracy, 75% in Performance, 80% in Scalability, and 65% in Maintainability. This comparison underscores the proposed system's improved efficiency and reliability across critical non-functional requirements.

6. Conclusions

This work presents an accident detection system that analyses CCTV footage using YOLOv8 and Mask R-CNN to provide real-time alerts. The system employs YOLOv8 for accurate object detection and Mask R-CNN for precise instance segmentation. By processing live video feeds from CCTV cameras, the system effectively detects accidents and promptly notifies emergency services, including hospitals, fire force, police, and ambulance, with precise location details. This automated approach enhances road safety by significantly reducing delays in emergency aid and ensuring faster response.

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