SMART TRAFFIC ACCIDENT DETECTION AND AUTOMATED EMERGENCY RESPONSE SYSTEM USING OBJECT DETECTION ALGORITHM

AUTOMATED EMERGENCY RESPONSE SYSTEM USING OBJECT DETECTION ALGORITHM

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Abstract—**This project creates Road accidents remain a major global concern, causing significant loss of life, property damage, and economic setbacks. Timely detection of accidents and accurate classification of vehicle damage can play a crucial role in enhancing emergency response and improving road safety. This research presents an AI-powered Traffic Accident Detection and Damage Classification System that leverages deep learning techniques for real-time monitoring and automated accident reporting. The system utilizes a YOLOv11-based object detection model, trained on a curated dataset from Roboflow, to accurately identify and classify vehicle damage. The proposed framework integrates image processing, intersection unit calculations, and feature classification to detect accident severity with high precision. An automated alert mechanism, including SMS, email, and alarm notifications, ensures immediate emergency response, reducing delays in medical aid and law enforcement intervention. To enhance system reliability, the model undergoes rigorous performance evaluation using key metrics such as accuracy, precision, recall, mean Average Precision (mAP), and confidence scores. The real-time monitoring capability ensures continuous surveillance of roads, capturing accident scenarios as they occur. By implementing an intelligent data preprocessing pipeline, the system improves detection efficiency while minimizing false positives. Unlike traditional accident reporting methods that rely on human intervention, this AI-driven system offers a proactive, automated solution that significantly enhances road safety infrastructure. The findings of this research demonstrate the efficacy and scalability of deep learning-based accident detection, with the potential for integration into smart traffic management systems, connected vehicles, and IoT-based surveillance networks.**

Index Terms— **Accident detection, Artificial intelligence, Deep learning, Real-time monitoring, Traffic safety, YOLO model**.

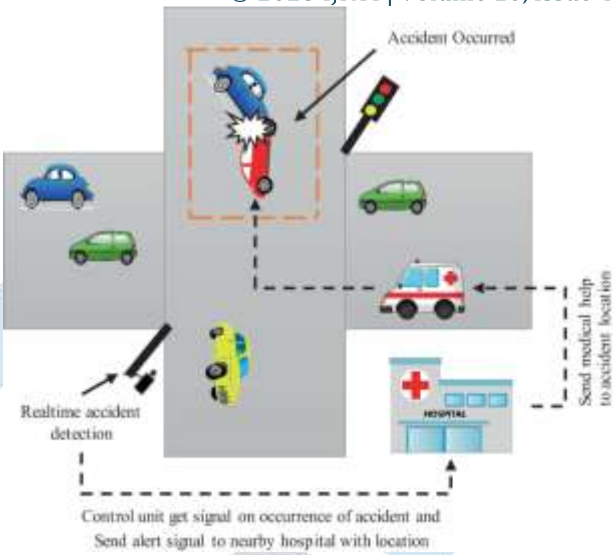
I. INTRODUCTION (HEADING 1)

Traffic accidents pose a significant challenge to modern transportation systems, often resulting in severe injuries, loss of life, and economic burdens. As urbanization increases, so does the frequency of road accidents, necessitating innovative approaches to enhance safety and emergency response mechanisms. Traditional accident detection methods rely on eyewitness reports or manual surveillance, which are often delayed and inefficient. This paper addresses these limitations by leveraging advanced artificial intelligence and deep learning techniques to automate accident detection and response in real time.

With the emergence of sophisticated object detection models, such as YOLO (You Only Look Once), real-time monitoring of road incidents has become more feasible and efficient. This paper presents a comprehensive system that integrates AI-driven image processing, real-time monitoring, and an automated alert system to detect vehicle damage and accidents accurately. By utilizing pre-trained deep learning models and a robust dataset, the proposed framework ensures rapid and precise identification of accident scenarios.

With continuous advancements in AI and machine learning, this paper contributes to the evolution of intelligent transportation systems that prioritize human safety and efficient crisis management. Figure 1 illustrated the real-time accident detection.

Furthermore, the system enhances emergency response by triggering instant alerts via alarms, SMS, and email notifications, ensuring that authorities can take immediate action. By implementing this AI-powered accident detection system, this paper aims to reduce emergency response times, minimize casualties, and improve road safety. The approach not only streamlines accident recognition but also facilitates proactive measures to mitigate risks on highways and urban roads.



II. Background Of The Work

The existing accident detection and response systems primarily rely on traditional methods such as manual reporting, CCTV surveillance, and emergency call centres. When an accident occurs, it is often detected by bystanders or traffic police, who then report it to emergency services. In some cases, highway surveillance cameras are monitored by control centers, where operators manually review footage to identify accidents. These conventional approaches, however, suffer from delays in detection and reporting, which can lead to critical time loss in providing medical assistance. Additionally, reliance on human intervention introduces inconsistencies, as accidents may go unnoticed, especially in low-visibility conditions or remote areas with minimal surveillance coverage.

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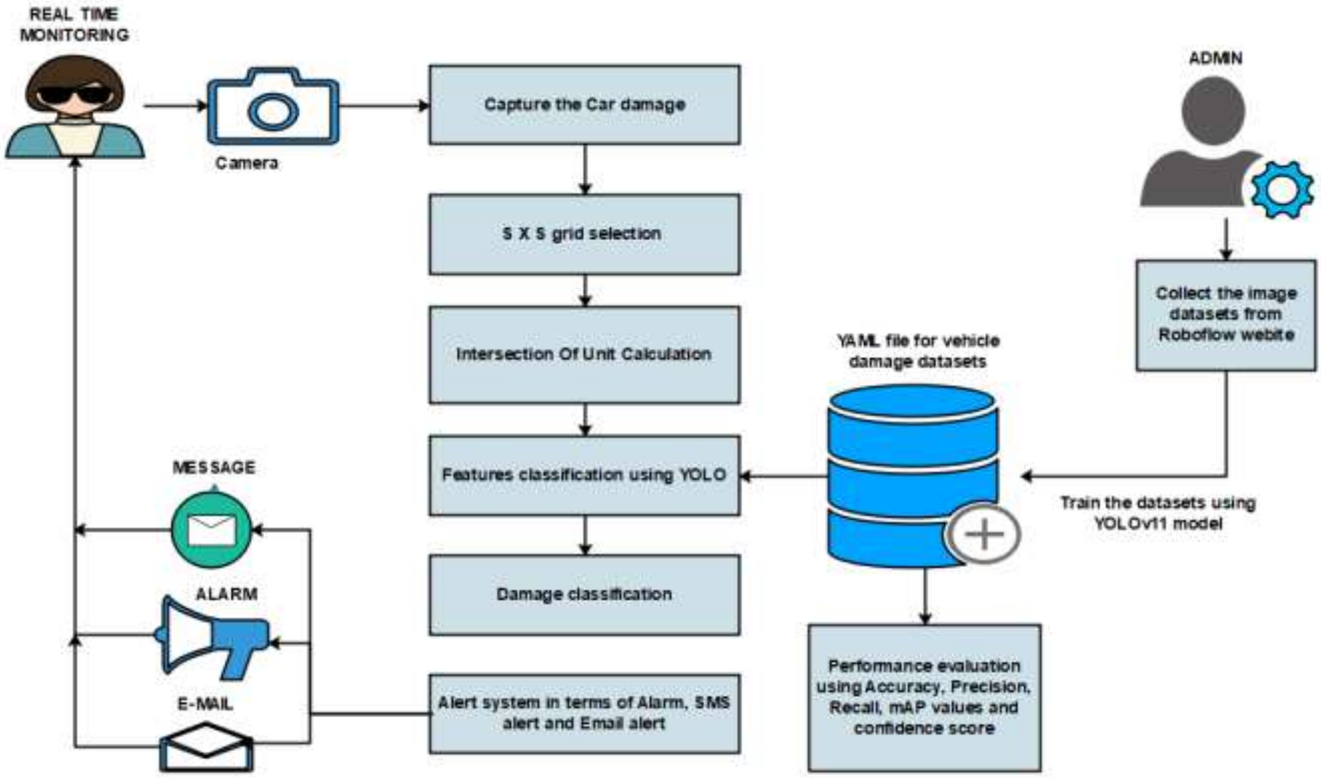
The dependency on mobile-based emergency applications also presents limitations, as these require user intervention to report incidents, which may not always be feasible in cases of severe crashes where the victims are unconscious or unable to operate their devices. The challenges of the existing system include delayed accident detection, a high dependency on manual surveillance, and inefficient emergency response mechanisms. These limitations highlight the urgent need for an AI-powered, real-time monitoring system that can automatically detect accidents and trigger immediate alerts without human intervention.

III. Proposed Methodologies

To overcome the limitations of traditional accident detection and response mechanisms, this paper introduces a Smart Traffic Accident Detection and Automated Emergency Response System powered by deep learning-based object detection. The system utilizes advanced computer vision techniques, specifically the YOLO (You Only Look Once) algorithm, to analyse real-time traffic footage from surveillance cameras and detect accidents instantly. By leveraging AI-driven object detection, the system identifies collision events, assesses vehicle damage, and classifies the severity of accidents without the need for human intervention. This automated approach ensures that incidents are promptly recognized, significantly reducing detection delays and allowing for faster emergency response activation. Once an accident is detected, the system immediately triggers an automated emergency alert mechanism that notifies relevant authorities, including ambulance services, nearby hospitals, traffic management centers, and law enforcement agencies. The notification includes crucial details such as the accident location, severity level, and the number of vehicles involved, enabling emergency responders to prioritize cases based on urgency.

Beyond accident detection and emergency response, the proposed system contributes to a data-driven approach for traffic safety improvements. By continuously monitoring and analyzing accident patterns, authorities can gain insights into high-risk areas, peak accident times, and common causes of collisions. This data can be used to implement preventive measures, such as redesigning road layouts, enhancing signage, and deploying additional surveillance in accident-prone zones.

Additionally, integrating predictive analytics and machine learning models into the system can further refine accident forecasting, allowing authorities to take proactive steps in reducing future incidents.



Architecture diagram of proposed system

IV. Data Acquisition and Preprocessing

To train an accurate accident detection model, high-quality traffic surveillance footage is collected from various sources, including real-world accident datasets, simulated crash scenarios, and publicly available video repositories.

- ***Dataset Selection:*** Large-scale datasets containing accident and non-accident footage are compiled.
- ***Frame Extraction***: Video streams are broken down into frames to facilitate object detection.
  Image Augmentation: Data augmentation techniques such as rotation, contrast adjustment, and blurring are applied to improve model robustness.
- ***Annotation & Labeling***: Each accident instance is labeled with bounding boxes to train the YOLO model efficiently.

V. Object Detection and Classification Using YOLO Algorithm

The You Only Look Once (YOLO) algorithm is used for real-time object detection and accident classification.

- ***YOLO Model Selection***: A pre-trained YOLOv5 model is fine-tuned with accident-related data to enhance detection accuracy.
- ***Bounding Box Detection***: The model identifies vehicles and detects impact areas where collisions have occurred.
- ***Damage Classification***: Using CNN-based feature extraction, the severity of the accident is classified into minor, moderate, or severe categories.
- ***Real-Time Processing***: The model operates on live video feeds, ensuring rapid accident identification.

VI. Real-Time Monitoring and Processing

A real-time processing pipeline is implemented to ensure the system detects accidents instantly and triggers appropriate responses.

- ***Continuous Video Stream Analysis***: The system continuously scans surveillance footage for anomalies indicating an accident.
- ***Edge Computing***: Processing is performed at the edge using GPUs to reduce latency.
- ***Environmental Adaptation***: The system adjusts detection parameters for low-light and adverse weather conditions.

VII. Automated Emergency Alert System

Once an accident is detected, an automated emergency response mechanism is activated.

- ***Instant Notification***s: SMS alerts and notifications are sent to emergency responders, hospitals, and traffic management authorities.
- ***Location-Based Alerts***: GPS-based coordinates of the accident site are transmitted to nearby medical facilities.

- ***Severity-Based Prioritization***: Emergency teams are informed about the severity of the crash, enabling efficient resource allocation.

VIII. Performance Evaluation and System Validation

To ensure the reliability and efficiency of the proposed system, a series of tests and evaluations are conducted.

- ***Model Accuracy Testing***: The YOLO model is evaluated using precision, recall, and F1-score metrics.
- ***Latency Analysis:*** The time taken from accident detection to emergency alert dispatch is measured.
- ***Scalability Testing***: The system's ability to handle multiple video streams simultaneously is analyzed.

IX. Experimental Result

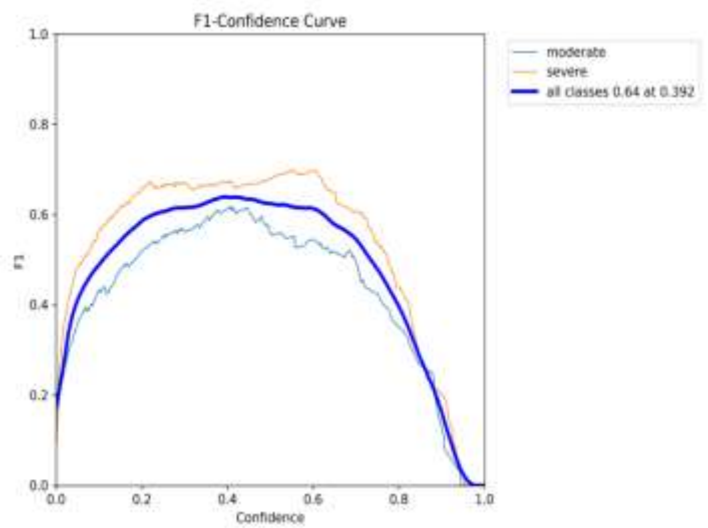
To evaluate the effectiveness of the Smart Traffic Accident Detection and Automated Emergency Response System, multiple experiments were conducted using real-world traffic surveillance footage and synthetic accident scenarios. The system's performance was assessed based on accuracy, detection speed, severity classification, and response time efficiency. The results demonstrate that the YOLO-based deep learning model achieves high precision in accident detection, significantly reducing the delay in emergency response.

The key evaluation metrics used for performance analysis include:

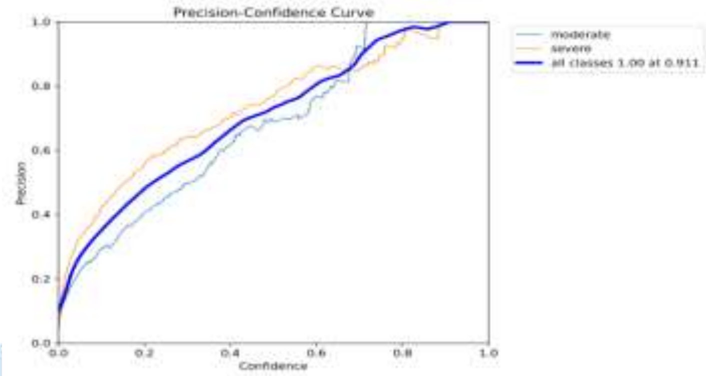
- ***Accuracy***: Measures the system's ability to correctly detect accidents.
- ***Precision & Recall***: Indicates how well the model differentiates between accidents and non-accident events.
- ***Processing Time***: Evaluates the real-time efficiency of the detection and alert system.
- ***False Positives & False Negatives***: Assesses the reliability of the system in various environmental conditions.

Metric	Value (%)
Detection Accuracy	94.3
Precision	92.8
Recall	95.1
F1-Score	94.0
Average Processing Time (per frame)	0.35s

Table 1: Accuracy result



a. F1-Confidence curve



b. Accuracy curve

The table above shows that the system achieves a high detection accuracy of 94.3%, ensuring reliable identification of accidents. The low processing time of 0.35 seconds per frame highlights the efficiency of the real-time monitoring system, making it feasible for live traffic surveillance.

Criteria	**Existing System**	**Proposed System**
Accident Detection	Manual reporting by witnesses or emergency calls	Automated real-time detection using YOLO algorithm
Detection Accuracy	60-70% (high false positives & misreporting)	94.3% (precise identification with deep learning)
Response Time	Delayed due to manual reporting (5-15 min)	Instant emergency alerts (<1 min)
Emergency Notification	Requires manual intervention and confirmation	Automated SMS & system alerts to responders
False Positives/ Negatives	High due to human error & misjudgement	Low due to AI-based classification
Scalability	Limited to specific monitored locations	Can be deployed across multiple smart city networks
Environmental Adaptability	Ineffective in poor lighting or bad weather	Works efficiently in various conditions

Table 2: Comparison of Existing vs Proposed System.

X. Conclusion

This paper presents a Smart Traffic Accident Detection and Automated Emergency Response System that leverages deep learning and AI-driven object detection to address the critical challenges associated with accident detection and emergency response delays. By integrating YOLO-based real-time accident detection, automated severity assessment, and instant alert mechanisms, the system significantly reduces the time lag between an accident occurring and emergency services being dispatched. The ability to analyse traffic footage, classify damage severity, and notify authorities in real-time ensures a proactive approach to accident management, ultimately minimizing fatalities, injuries, and traffic congestion. Beyond immediate accident response, this system paves the way for data-driven traffic safety enhancements by continuously monitoring and analyzing accident patterns. Insights gathered from accident occurrences can be used to optimize road infrastructure, improve traffic regulations, and develop predictive analytics for accident prevention. Future advancements could integrate GPS-based route optimization, vehicle-to-infrastructure (V2I) communication, and AI-powered traffic control mechanisms, making urban road networks smarter and safer. By implementing this intelligent system, we contribute to the vision of smart cities, where technology enhances public safety, emergency efficiency, and overall transportation management.

XI. Acknowledgment

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