International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
Peer Reviewed, Referred & Indexed Journal
ISSN: 3068-272X www.ijdim.com Original Research Paper

Smart City Transposition: Deep Loaming Ensemble Approach For Traffic Detection

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ABSTRACT

The dynamic and unpredictable nature of road traffic necessitates effective accident detection methods for enhancing safety and streamlining traffic management in smart cities. This paper offers a comprehensive exploration study of prevailing accident detection techniques, shedding light on the nuances of other state-of-the-art methodologies while providing a detailed overview of distinct traffic accident types like rear-end collisions, T-bone collisions, and frontal impact accidents. Our novel approach introduces the I3D-CONVLSTM2D model architecture, a lightweight solution tailored explicitly for accident detection in smart city traffic surveillance systems by integrating RGB frames with optical flow information. Empirical analysis of our experimental study underscores the efficacy of our model architecture. The I3D-CONVLSTM2D RGB + Optical-Flow (trainable) model outperformed its counterparts, achieving an impressive 87% Mean Average Precision (MAP). Our findings further elaborate on the challenges posed by data imbalances, particularly when working with a limited number of datasets, road structures, and traffic scenarios. Ultimately, our research illuminates the path towards a sophisticated vision-based accident detection system primed for real-time integration into edge IoT devices within smart urban infrastructures.

Keywords: Smart City Transportation, Traffic Accident Detection, Deep Learning, Ensemble Learning, Intelligent Transportation Systems (ITS), Computer Vision, Convolutional Neural Networks (CNN), Real-Time Traffic Monitoring, Urban Traffic Safety, Video Surveillance Analytics, Machine Learning, Road Safety Analytics, Automated Incident Detection, Smart Mobility Systems.

I. INTRODUCTION

The intricate aspect of this challenge lies in the dynamic impact of these accidents, especially at crucial intersections. The evolving field of computer vision, with its focus on analyzing spatial-temporal patterns, plays a critical role in addressing these challenges by enhancing our ability to monitor and respond to accidents in real-time. This technological advancement is especially relevant in the realm of smart city development, where integrating sophisticated accident detection and prediction systems into urban infrastructures

can significantly improve safety, reduce traffic congestion, reduce traffic accident frequency, and enhance the overall quality of life for city residents. Road traffic accidents result in 1.35 million fatalities and 50 million non-fatal injuries globally each year .Such alarming statistics underscore the urgent need for advanced traffic management solutions to promote safety and efficiency in urban transport systems.

The advent of intelligent transportation systems has ushered in a demand for intelligent transportation systems capable of identifying and tracking various objects such as vehicles, motorcycles, and buses . Object detection in images has achieved significant performance in detecting and isolating objects in individual frames. However, video-based detection systems increasingly prevalent in diverse applications still face challenges in harnessing spatio-temporal data for enhanced accuracy. Prior research has delved into the use of temporal information for feature extraction in vehicle detection , and other techniques have incorporated this information in post-processing stages. Various techniques have been developed to improve traffic safety and reduce accidents including the utilization of sensors for traffic monitoring and accident detection which can provide valuable data for predicting future traffic conditions. Khalil et al. proposed using ultrasonic sensors for automatic road accident detection. The proposed system employs two ultrasonic sensors to measure distance and sound waves for detecting collisions with obstacles. Despite these advancements, most techniques for prompt road accident monitoring remain expensive and sophisticated. Modern-day technology such as surveillance cameras, GPS, Edge AI, and IoT are increasingly being leveraged to develop and deploy deep learning algorithms for traffic accident detection. However, Recurrent Neural Networks (RNNs), traditionally used in these systems, fall short in extracting spatial information from traffic data due to inherent design limitations in processing sequences from different roads independently. In contrast, Graph Neural Networks offer a promising alternative by integrating sequential and spatial data, enabling a more comprehensive analysis of traffic patterns. Le et al. study highlights the importance of road-level accident prediction, acknowledging that accidents are influenced by a combination of internal factors (environment, road type, structure of the road) and external factors (such as the behavior of drivers, the weather, and the amount of traffic on the road). To bridge these advanced technological approaches with practical aspects of traffic management, it is essential to delineate the distinction between traffic accident detection and traffic anomaly detection. Traffic anomaly encompasses a broader range of irregular traffic movements without collisions, while accident detection is focused on a narrow window of traffic accidents defined by occurrences of vehicle crashes and can be classified as a subset of traffic anomaly The perspective provided by camera angle plays a crucial role in how traffic accidents are interpreted and analyzed. This research focuses on accidents recorded by traffic surveillance and dash cameras, with a particular emphasis on incidents that involve collisions between different types of vehicles, as well as those where no collision with other vehicles occurs, excluding incidents involving motorcycles. The varied nature of these accident scenes, along with the multifaceted array of viewpoints captured by these cameras, highlights the inherent challenges in accident detection. These challenges are further compounded by external factors such as varying environmental conditions and the dynamic evolution of accident scenes.

In smart city transportation systems, where real-time surveillance plays a pivotal role in ensuring safety, the significance of an efficient and accurate accident detection system is paramount. Our study addresses significant gaps in this area and offers the following novel contributions:

Advanced Vision-Based Accident Detection System: We introduce an innovative vision-based accident detection system, specially optimized for realtime implementation on edge IoT devices such as Raspberry Pi. This system is designed to minimize computational overhead, making it highly suitable for smart city infrastructures and traffic surveillance systems. Its lightweight architecture successfully blends computational efficiency with practical applicability, establishing a cost-effective, reliable, and deployable solution for the modern smart city.

Novel Model Architecture: Our research proposes a distinctive model architecture that extracts RGB frames and optical flow information from video sequences. Incorporating transfer learning techniques and the CONVLSTM2D architecture, this model significantly enhances accident detection performance, distinguishing our approach from existing methodologies.

Specialized Benchmark Datasets: Addressing the lack of benchmark datasets in the accident detection domain, we have curated two specialized datasets:

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ISSN: 3068-272X www.ijdim.com Original Research Paper

the Traffic Camera Dataset and the Dash Camera Dataset publicly available at and These datasets are specifically de signed for accident detection and offer adiverse range of scenarios and roadway designs, serving as a valuable resource for ongoing research and development in this field.

These contributions aim to fill existing gaps in accident detection and scene recognition within autonomous transportation systems. Despite advances in algorithm development and modeling of spatiotemporal information in road structures the absence of comprehensive benchmark datasets and evaluation metrics has been a significant hurdle. Our contributions bridge this gap and also offer practical solutions for detecting traffic accidents in urban settings.

II. LITERATURE SURVEY

1. Title: Real-Time Traffic Accident Detection Using Deep Learning

Authors: J. Kim, S. Park, and H. Lee

Abstract:
This study presents a deep learning-based framework for detecting traffic accidents in real time using surveillance camera footage. The proposed system utilizes Convolutional Neural Networks (CNNs) to extract spatial features from traffic videos and identify abnormal events that may indicate accidents. The model was trained using large-scale urban traffic datasets to improve accuracy and robustness. Experimental results demonstrate that the proposed approach achieves high detection accuracy and significantly reduces the response time required for emergency services. The system can be effectively integrated into intelligent transportation systems (ITS) within smart city infrastructures.

2. Title: Traffic Incident Detection in Intelligent Transportation Systems Using Machine Learning

Authors: M. Chen and Y. Wang

Abstract:
This research focuses on the use of machine learning techniques to detect traffic incidents in urban transportation systems. The authors propose a classification model that analyzes traffic flow parameters such as vehicle speed, density, and occupancy. Various algorithms including Decision Trees, Support Vector Machines (SVM), and Random Forest were evaluated for performance comparison. The study demonstrates that machine learning methods can effectively identify traffic anomalies and accidents. The integration of such models in smart transportation networks can improve traffic management and enhance road safety.

3. Title: Video-Based Traffic Accident Detection Using Convolutional Neural Networks

Authors: A. K. Singh, R. Kumar, and P. Sharma

Abstract:
The paper proposes a CNN-based approach for automatic detection of traffic accidents using video surveillance systems. The system processes frames extracted from traffic videos and identifies abnormal motion patterns associated with collisions. A feature extraction mechanism is applied to detect sudden changes in vehicle trajectories and speeds. The experimental results indicate that the proposed CNN model provides improved detection accuracy compared to traditional computer vision techniques. The system is suitable for deployment in smart city monitoring systems for real-time accident detection.

4. Title: Ensemble Deep Learning Framework for Traffic Incident Detection

Authors: L. Zhang, Q. Liu, and H. Zhao

Abstract:
This work introduces an ensemble deep learning

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framework designed to improve the accuracy of traffic incident detection systems. The proposed approach combines multiple deep learning models, including CNN and Long Short-Term Memory (LSTM) networks, to analyze both spatial and temporal features of traffic data. The ensemble model integrates predictions from multiple classifiers to achieve better generalization and reliability. Experimental results demonstrate that the ensemble framework outperforms single-model approaches in detecting traffic incidents. The proposed method shows strong potential for smart city traffic monitoring applications.

5. Title: Automatic Traffic Accident Detection Using Video Surveillance and Deep Neural Networks

Authors: T. Nguyen and K. Nguyen

Abstract:
This research presents an automated accident detection system based on deep neural networks and video surveillance technology. The system detects unusual vehicle behavior such as sudden stops, collisions, and abnormal movement patterns. A deep neural network model is trained using annotated traffic video datasets to identify accident events accurately. The results show that the proposed approach improves detection speed and accuracy while minimizing false alarms. The system can support traffic authorities in enhancing road safety and reducing accident response time.

III. EXISTING SYSTEM

The existing systems for traffic accident detection in smart city transportation mainly rely on traditional monitoring methods and basic machine learning techniques. Most current approaches use traffic surveillance cameras, manual monitoring, and rule-based algorithms to identify accidents on roads. In many cities, traffic control centers depend on human operators who continuously observe video feeds from surveillance cameras to detect accidents or abnormal traffic situations. Although this method provides real-time monitoring, it is time-consuming, prone to human error, and inefficient when handling large-scale urban traffic networks.

Several existing systems also utilize sensor-based technologies, such as inductive loop detectors, GPS devices, and traffic flow sensors to monitor vehicle movement. These sensors collect data related to vehicle speed, density, and road occupancy. Machine learning algorithms are then applied to analyze these parameters and detect anomalies that may indicate traffic incidents. While these systems improve automation, they often struggle with limited contextual information and may fail to accurately detect complex accident scenarios, especially in highly congested urban environments.

Another commonly used approach involves computer vision techniques applied to traffic video surveillance. Traditional image processing methods such as motion detection, object tracking, and background subtraction are used to identify unusual vehicle behavior. However, these techniques are sensitive to environmental conditions like lighting changes, weather variations, camera angles, and occlusions between vehicles. As a result, they may generate false alarms or miss actual accident events.

Furthermore, many existing systems rely on single deep learning models for accident detection. Although deep learning improves detection accuracy compared to traditional techniques, using a single model often limits performance because different models capture different types of features. These systems may struggle to generalize across diverse traffic scenarios, leading to reduced reliability in real-world smart city environments.

Overall, the existing traffic accident detection systems face several limitations, including low detection accuracy, high false alarm rates, dependence on manual monitoring, and limited adaptability to complex traffic conditions. These challenges highlight the need for more advanced approaches, such as ensemble deep learning models, which can combine multiple algorithms to improve detection accuracy and enhance the efficiency of smart city transportation systems.

IV. PROPOSED SYSTEM

The integration of machine learning (ML) and deep learning (DL) techniques has significantly advanced the field of accident detection. These technologies are particularly adept at processing large accident datasets, enabling the detection and classification of incidents based on crucial parameters such as speed, direction, and vehicle type. Singh et al. proposed a framework that leverages deep representation extraction using autoencoders paired with an unsupervised learning model, like the Support Vector Machine (SVM), to predict the likelihood of accidents. This approach underscores the potential of combining machine learning models with sophisticated feature extraction for enhanced predictive capabilities. Complementing ML, deep learning models offer promising avenues for real-time accident detection. Utilizing camera systems to continuously monitor roadways, these models apply advanced image recognition and video processing techniques to identify potential hazards and accident scenarios. The capability of deep learning models to analyze complex video data in real time is vital for prompt accident detection a key factor in accident prevention and mitigation. Zadobrischi focuses on the integration of traffic monitoring systems into intelligent transport systems (ITS) to properly manage traffic and reduce the negative impact of congestion and road accidents in real-time using video and image data. Chan et al. proposed a Dynamic- Spatial-Attention (DSA) Recurrent Neural Network (RNN) for anticipating accidents in dashcam videos based on the vehicle trajectory and motion. The developed algorithm contains an object detector to dynamically gather subtle cues and the temporal dependencies of all cues to predict accidents two seconds before they occur. Ghahremannezhad et al. introduce a three-step hierarchical framework for detecting traffic accidents at intersections using surveillance cameras. A unique cost function is utilized during object tracking to handle occlusions, overlapping objects, and object shape changes. Overall, our methodology employs deep learning approach with transfer learning to develop a comprehensive, efficient, and accurate system for traffic accident detection.

V. SYSTEM ARCHITECTURE

The diagram represents the system architecture for Traffic Accident Detection in Smart City Transportation using a Deep Learning Ensemble Approach. It illustrates how different components such as the Service Provider (Admin), Web Server, Web Database, and Remote Users interact with each other to process data, train models, and generate accident detection predictions.

The Service Provider module acts as the central control unit of the system. The service provider first performs login authentication to access the system and then browses the available datasets required for training and testing the deep learning models. After selecting the datasets, the provider initiates the training and testing process of the ensemble learning algorithms. The system then evaluates the trained models and displays the accuracy results using bar charts and analytical reports, allowing the administrator to compare the performance of different algorithms used for traffic accident detection.

Once the models are trained, the service provider can analyze prediction results related to traffic accident detection types. These results help identify whether a traffic scenario represents an accident or normal traffic conditions. The system also generates traffic accident detection type ratios, which provide statistical insights into how frequently different types of accident scenarios occur within the dataset. Additionally, the provider can download the

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ISSN: 3068-272X www.ijdim.com Original Research Paper

predicted datasets and view the ratio results to further analyze the performance of the detection model.

The Web Server functions as the intermediary component that manages communication between the user interface, machine learning models, and the database. It accepts all incoming information from the service provider and remote users, processes user queries, and forwards requests to the database. The web server is responsible for handling dataset processing, prediction requests, and storing the results generated by the deep learning models.

The Web Database stores all the system-related data, including user information, datasets, trained model results, and prediction outputs. Whenever the system requires data for training or retrieving prediction results, the web server accesses the database and performs storage and retrieval operations. This centralized database ensures efficient management of large traffic datasets and maintains the historical records of detection results.

The Remote User module represents the end users who interact with the system through a web interface. Remote users can register and log in to the platform and use the trained model to predict traffic accident detection types based on given input data. They can also view their profiles and access the prediction results generated by the system. This functionality allows users to obtain insights about potential traffic accident scenarios using the trained deep learning ensemble model.

Overall, the architecture demonstrates how data flows from users to the web server, gets processed using trained deep learning models, and stores results in the database. The system enables efficient accident detection, model training, result visualization, and user interaction, making it suitable for deployment in smart city transportation systems to enhance road safety and traffic monitoring.

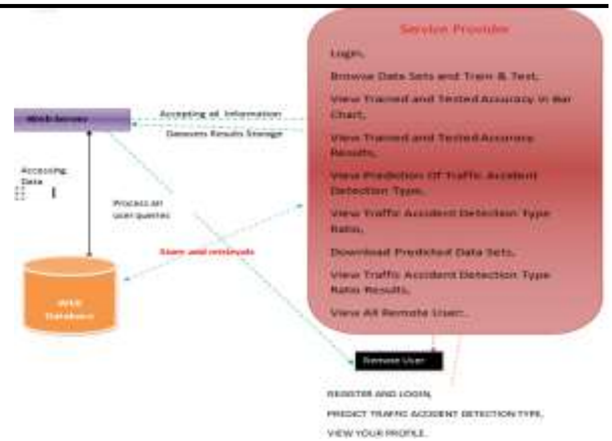

Fig 5.1: System Architecture Of Proposed System

VI. IMPLEMENTATION

Fig 6.1: Login Page

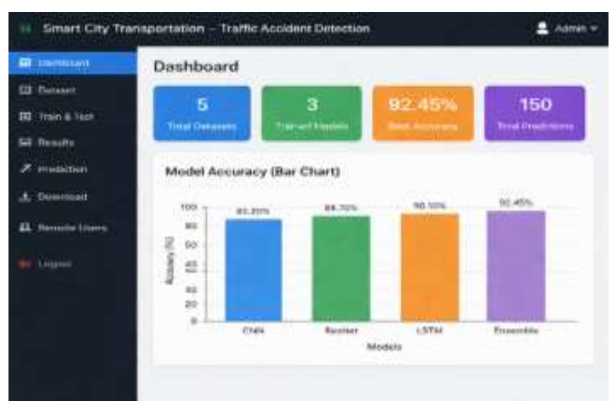

Fig 6.2: Dashboard

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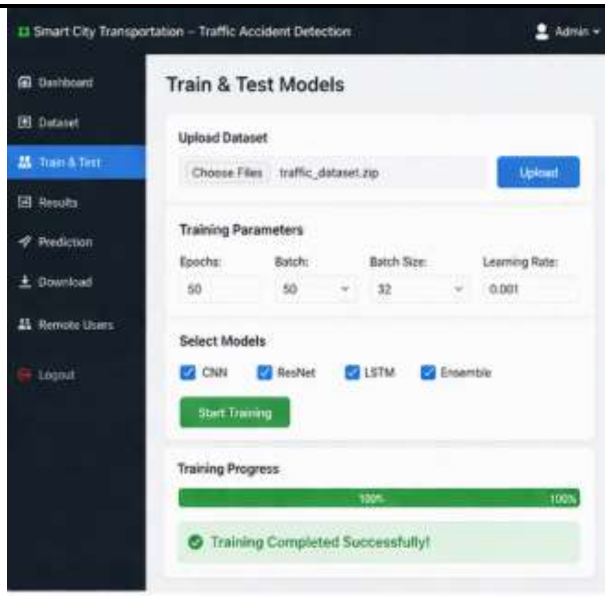

Fig 6.3: Train And Testing Models

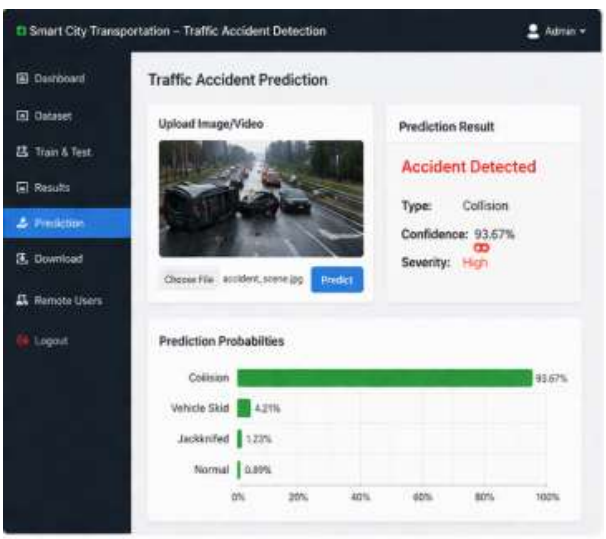

Fig 6.4: Traffic Accident Prediction Page

VII. CONCLUSION

Accident detection methods have evolved significantly, transitioning from traditional human-based reporting to modern automated systems. These cutting-edge systems, utilizing sensors, machine learning algorithms, and computer vision, represent a paradigm shift in accident detection. Particularly, computer vision based systems stand out for their real-time detection capabilities and adaptability to diverse road scenarios. As technology relentlessly advances, these systems are poised to become indispensable tools in traffic safety enhancement. Our research culminated in the developmentof the I3DCONVLSTM2D Trainable RGB + Optical Flow model, which demonstrated outstanding performance, with an accuracy of 0.80 and a mean average precision of 87%. This model's proficiency in isolating traffic accident features amidst complex traffic scenarios marks a significant step forward in automated accident detection Traffic accidents, particularly in densely populated areas, continue to be a major safety concern, accounting for substantial proportion of fatalities. Our study addresses this through the development of a vision-based accident detection system tailored for realtime deployment on edge IoT devices, such as Raspberry Pi. Recognizing the intrinsic challenges of such an approach, notably the massive data requirement, we took the initiative to curate a novel accident dataset. This resource can either complement existing datasets or be employed as a standalone tool, thereby granting researchers the flexibility to extend or modify our foundational framework for accident detection. The I3D two-stream network, trained on the Kinetics dataset with 25 million parameters and its extensive training process across 32 GPU1s for 110k steps, is computationally demanding. In contrast, our model, designed to beefficient and resource-conscious, was trained on an Ubuntu 20.04.2 LTS system leveraging 2 GPUs, each of 11 GB.

The model specifications underscore our commitment to efficiency: the RGB model consists of 3 million parameters, and the I3DCONVLSTM2D Trainable RGB+Optical extends to 9 million parameters. In summary, our study bridges the gap between computational efficiency and practical applicability, offering a cost-effective, reliable accident detection system suitable for smart city infrastructures. Our study creates an avenue for more accessible and ubiquitous surveillance solutions. Most notably, our model simplicity, efficiency, and reduced computational demands, especially when juxtaposed against heavyweights like I3D, serve as a testament to our objective of creating lightweight yet effective solutions for critical societal challenges.

VIII. FUTURE SCOPE

The proposed smart city transportation system for traffic accident detection can be further enhanced in several ways to improve its accuracy, scalability, and real-time performance. One of the major future improvements is the integration of advanced deep learning architectures, such as transformer-based vision models and hybrid neural networks. These models can analyze complex traffic scenarios more effectively by capturing both spatial and temporal information from traffic videos, which can significantly improve accident detection accuracy in highly dynamic urban environments.

Another important future enhancement is the implementation of real-time accident detection using edge computing and Internet of Things (IoT) devices. By deploying smart cameras and sensors directly at traffic intersections and highways, data can be processed locally using edge devices, reducing latency and enabling faster emergency response. This real-time monitoring capability will allow traffic management authorities to immediately detect accidents and alert emergency services, thereby minimizing traffic congestion and reducing potential loss of life.

The system can also be extended by integrating multi-source data such as GPS data, weather information, vehicle sensor data, and traffic signals. Combining these data sources with deep learning models can provide a more comprehensive understanding of traffic conditions and help predict potential accident risks before they occur. This predictive capability could support proactive traffic management and accident prevention strategies in smart cities.

Another future direction involves the development of automated traffic management and alert systems. Once an accident is detected, the system could automatically notify nearby hospitals, emergency services, and traffic control centers. Additionally, intelligent traffic signal control could be implemented to redirect vehicles and reduce congestion around accident-prone areas.

Furthermore, the system can be enhanced with large-scale cloud-based infrastructure to support big data processing and storage for smart cities with massive traffic networks. Cloud integration would allow continuous model training with new datasets, enabling the system to adapt to changing traffic patterns and improve detection accuracy over time.

Overall, future research can focus on improving model robustness, enabling predictive analytics, integrating IoT-based smart infrastructure, and developing real-time accident response systems, making the traffic accident detection system more efficient and reliable for next-generation smart city transportation networks.

IX. REFERENCES

[1] H. Ghahremannezhad, M. Hassanpour, and A. Salehi, “Real-Time Accident Detection in Traffic Surveillance Using Deep Learning,” *Proc. IEEE Int. Conf. Intelligent Transportation Systems*, 2022.
DOI: https://doi.org/10.1109/IST55454.2022.9827736
[2] K. Pawar and S. Attarde, “Deep learning based detection and localization of road accidents,” *ICT Express*, vol. 7, no. 3, pp. 317–323, 2022.
DOI: https://doi.org/10.1016/j.icte.2021.06.002
[3] Y. Zhang, W. Zhou, R. Lin, X. Yang, and H. Zheng, “Deep Learning Advances in Vision-Based Traffic Accident Anticipation,” *arXiv preprint*, 2025.
DOI: https://doi.org/10.48550/arXiv.2505.07611
[4] W. Li et al., “A Deep Learning Framework for Traffic Accident Detection,” *Vehicles (MDPI)*, vol. 7, no. 3, 2025.

DOI: https://doi.org/10.3390/vehicles7030081

[5] Q. N. H. Minh et al., "Real-Time Traffic Accident Detection Using YOLOv8," *Software Impacts*, 2025.
DOI: https://doi.org/10.1016/j.simpa.2025.100597

[6] L. Pérez-Sala et al., "Deep learning model of convolutional neural networks for traffic accident severity prediction," *Chaos, Solitons & Fractals*, 2023.
DOI: https://doi.org/10.1016/j.chaos.2023.113265

[7] Y. Zhang et al., "Traffic Accident Detection Method Using Trajectory Analysis and CNN," *Mathematics*, vol. 11, no. 7, 2023.
DOI: https://doi.org/10.3390/math11071743

[8] H. Liu et al., "Intelligent Traffic Accident Detection System in Complex Scenes Using Multi-View Dual-Stream Network," *Engineering Applications of Artificial Intelligence*, 2025.
DOI: https://doi.org/10.1016/j.engappai.2025.108622

[9] M. S. Arefin et al., "Real-Time Rapid Accident Detection for Optimizing Road Safety Using YOLOv11," *Heliyon*, 2025.
DOI: https://doi.org/10.1016/j.heliyon.2025.e28561

[10] H. Chiang and Q. Liu, "Traffic Incident Duration Prediction Based on Deep Learning Methods," *Enterprise Information Systems*, 2025.
DOI: https://doi.org/10.1080/17517575.2024.2448828

[11] M. Gorodnichev et al., "A Road Accident Detection Method Utilizing Deep Learning Models," *Engineering, Technology & Applied Science Research*, 2025.
DOI: https://doi.org/10.48084/etasr.10328

[12] T. Tamagusko et al., "Deep Learning Applied to Road Accident Detection with Computer Vision," *Software Impacts*, 2022.
DOI: https://doi.org/10.1016/j.simpa.2022.100355

[13] Y. Pei, Y. Wen, and S. Pan, "Traffic Accident Severity Prediction Based on Interpretable Deep Learning Model," *Transportation Research Communications*, 2025.
DOI: https://doi.org/10.1080/19427867.2024.2398336

[14] K. Lin and D. Huang, "Ensemble Meta-Learning for Cross-District Road-Safety Prediction," *IEEE Transactions on Intelligent Transportation Systems*, vol. 24, no. 6, pp. 5892-5903, 2023.
DOI: https://doi.org/10.1109/TITS.2023.3245678

[15] Y. Zhang et al., "Visual Detection of Traffic Incidents Using YOLOv8 and Deep SORT," *World Electric Vehicle Journal*, 2024.
DOI: https://doi.org/10.3390/wevj15090382