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Review on Accident Detection and Alert System using Edge Computing and Deep Learning

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Abstract: This study presents an innovative Accident Detection and Alert System employing Deep Learning (DL) and Edge Computing. The system leverages DL algorithms to analyze real-time video feeds from surveillance cameras, detecting patterns indicative of accidents. By deploying computations at the edge, near the data source, latency is minimized, ensuring swift response times. The system's autonomous alert mechanism promptly notifies emergency services, enhancing the efficiency of rescue operations. This integration of DL and edge computing optimizes accident detection, reducing response times critical for mitigating injuries and saving lives on the road.

Keywords: Edge Computing, Deep learning, CCTV, Video processing, CNN

I. INTRODUCTION

One of the primary challenges concerning urban traffic management revolves around the conflicts and accidents that frequently arise at intersections. Within the dilemma zone, [3] motorists may find themselves torn between the instinct to speed up during the transition from green to yellow, which in turn creates a breeding ground for collisions from both rear and angle impacts. [1] Despite numerous attempts to curb perilous driving tendencies, the prevalence of individuals running red lights remains distressingly common. Moreover, further peril can manifest in the form of sudden lane changes or erratic movements from pedestrians and cyclists when navigating intersections, often stemming from inadequate traffic control systems or convoluted intersection geometry. Consequently, it becomes crucial to promptly identify these critical juncture conflicts so as to formulate strategic countermeasures and mitigate the potential harm they inflict.

At present, most traffic management systems pale in comparison to the potential of their full capacity. Depend on human observation of surveillance camera recordings. However, Automated identification of traffic accidents utilizing computer vision technology has emerged as a groundbreaking and cutting-edge method. This innovative approach harnesses the power of advanced algorithms and intelligent image analysis to swiftly identify and categorize incidents on roadways. The sophisticated integration of artificial intelligence and machine learning algorithms has revolutionized the field of accident detection, enabling seamless and real-time monitoring of vehicular collisions. By employing this groundbreaking technique, we can proactively respond to accidents, minimize response times, and ensure the safety and well-being of individuals involved in these unfortunate events. technologies, especially through monitoring intersection surveillance cameras [4], would greatly benefit traffic monitoring systems. Many studies have applied computer vision techniques [2] to traffic surveillance systems for various tasks. Automatic accident detection not only saves manual labor but also provides valuable feedback for timely dispatch of paramedics and emergency ambulances. An automatic accident detection framework also offers useful information for intersection signal operation and modifying intersection [8] geometry to prevent severe traffic crashes.

In-order to achieve real-time applicability in edge computing systems, we employ the efficient and precise YOLOv4 methodology for object detection. The subsequent course of action entails tracking the movements of intriguing entities within the scene, thereby enabling the monitoring of their motion patterns. For this purpose, the Hungarian algorithm, in conjunction with the Kalman filter, is utilized for object association. [11] The filter approach is employed to smoothly predict and analyze trajectories, avoiding potential collisions and missed objects. In this intricate process, careful heuristics are applied to identify various forms of conflicts between trajectories that could potentially result in incidents. By meticulously examining the direction and velocity of road-users, a comprehensive understanding of their movements is gained. [3] pairs in close proximity, anomalies that may cause crashes can be identified.

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II. LITERATURE SURVEY

Traditional object detection [01] algorithms like YOLO, Fast R-CNN, and Faster R-CNN are acknowledged for their success, but they come with challenges such as the need for annotated training data and high computational expenses. The text introduces DETR, a Facebook-developed algorithm, as a solution that helps detect and track objects efficiently without the need for extensive annotation.

The proposed DETR architecture with a Convolutional Neural Network (CNN) [2] backbone, encoder-decoder blocks, fully connected layers, and a Random Forest Classifier for accident detection. The DETR architecture is designed to learn residual mappings, emphasizing the difference between the predicted and actual outcomes. The Random Forest Classifier, with 500 decision trees and a depth of 40, is employed for the final accident detection. The usage of entropy in the classification [9] process is highlighted as contributing to improved results. The robustness of the framework is meticulously assessed through the meticulous examination of video sequences, thereby unveiling its true capabilities and effectiveness. from YouTube under diverse illumination conditions, showcasing its effectiveness in handling real-world scenarios. Overall, the paper offers an all-encompassing and meticulous resolution for the automated detection of accidents within the realm of traffic surveillance. leveraging advanced object detection, tracking, and trajectory analysis techniques.[3]

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[4] While not focused explicitly on accidents, this paper discusses Deep Sense, a deep-learning framework designed for time-series data processing on edge devices. The principles can be relevant for processing sensor data in accident detection systems. It discusses the potential of edge devices [1], such as smart cameras, in real-time accident detection through the analysis of video streams. precise object detection using YOLOv4, [3] object tracking with Kalman filter and Hungarian algorithm, and accident detection through trajectory conflict analysis. The framework is demonstrated to be effective in real-time traffic surveillance, showing low false alarm rates[5] and high accuracy in detecting trajectory conflicts, including potential accidents. The robustness of the framework is validated under diverse lighting conditions using real-world video data [14].

Video analytics involves the automated analysis of video content, utilizing techniques such as computer vision machine learning, and deep learning. It enables the extraction of valuable insights from video data, [7] including object detection, tracking, and behavior analysis, enhancing security, surveillance, and operational efficiency in various applications.

Convolutional Neural Networks (CNN) [6][9], renowned for their profound ability to discern and interpret complex visual information, represent a remarkable class of deep learning models meticulously engineered for the intricacies of image recognition and processing. [12] Inspired by the remarkable sophistication of the human brain in perceiving visual stimuli, CNNs ingeniously employ convolutional layers to effortlessly acquire hierarchically structured knowledge, unlocking the power to artistically unravel the enigma of visual data. representations of features from input images. With filters, pooling, and fully connected layers, CNNs excel in capturing spatial hierarchies, making them effective for tasks like image classification [6], object detection, and segmentation. Their ability to learn complex patterns has led to breakthroughs in computer vision, enabling applications in areas such as facial recognitions, medical images analysis, and autonomous vehicles [4].

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Sl. No	**Contributions**	**algorithm / model**	**limitations**
1.	Robinin M.S, Sukanya Mulakalapally, Maha Lakshmi " Car Accident Detection and Notification System Using Smartphone"	Portability can provide accident detection and notification on phones using filters to prevent false positives. It is compatible with all types of vehicles, including bicycles and motorbikes.	It may not be possible to detect all accidents with smartphones due to the filters used to prevent false alarms: there may be instances of minor collisions that the application does not register.
2.	Heting Liu and Guohong Cao, Fellow, "IEEE Deep Learning Video Analytics Through Online Learning Based Edge-Computing"	Predict ng trajectories of traffic per clipart in traffic as well as their future local on. Use of a Convolutional LSTM Auto-Encoder.	This method is unable to detect an accident if participants gets totally occluded.
3.	Ghosh, s., sunny, soju. And Roney "efficient vehicle accident detection system using CNN"	It uses advanced Deep Learning Algorithms CNN in order to analyze the frames taken from the video provided.	Deep cans usually suffer vanishing gradients.
4.	Tianxiang Tan and Gushing Cao "Deep Learning Video Analysis Through Edge Processing and NPU in Mobile"	Use of open sourced a version of TensorFlow, and wide range of Google products and services.	Node scheduling and placement algorithm were not sufficient enough to decide where to execute different node and when to execute.
5.	Sergio Robles-Serrano, German SanchezTorres "Automatic Detect on of TrafficAccidents from Video Using Deep-Learning Techniques"-2021	Use of GSM module and GPS for local on tracking.	Lack of communica on mode with medical on department to provide hospitality to victims at accidental spot.
6	Victor Adewopo, Nelly Elsayed "Smart City Transport on: Deep Learning Ensemble Approach for Traffic Accident Detec on"2023	The detection on method of car accidents is based on CCTVIS.	Real- me performance is low.
7	Loganathan, M.E, G. Ajay Kumar, S.T. Chandru, Hari Rajan "vehicle accidents detection and notification system using lorawanr"	Information about a accidents is transmitted via a GSM modem, eliminating the need for an internet connection to notify the rescue team. This system feature is particularly advantageous in areas lacking 3G or Wi-Fi coverage.	IR sensors detect objects based on the reflection principle. However, a fundamental flaw of IR sensors is their decreased effectiveness with darker colored vehicles. This is due to the absorption of IR rays by darker colors.

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8	Mari kirthima, rishabh verma, chinmayi rajashekar hegde, arundhati s shanbhag "intelligent accident prevention in vanets "	In this system, a vehicular ad-hoc network (VANET) is utilized to transmit accident alerts to rescue services. VANET also assists these services in determining the most efficient route to the accident site through the use of the Abeona algorithm and a traffic signal module. This functionality can significantly reduce the response time for an ambulance to reach the accident location.	Vane may encounter efficiency challenges in various road scenarios such as intersections, underpasses, or tunnels. Additionally, its performance might be affected by diverse environmental conditions, including inclement weather such as rain.
9	Mohd Akram Khan, Nirbhay Pandey, Prof. Ajay Kumar Srivastava, Er. Shadab Ali" accident detection and alert system using android application"	After detecting an accident, the system initiates a countdown for up to 10 seconds, during which you have the option to cancel it. Subsequently, it initiates a CALL to the emergency department. This remarkable feature serves to prevent the system from generating false alarms, ensuring its utmost reliability and accuracy.	Different iterations of mobile phone models exhibit varying degrees of sensitivity, thereby influencing the efficacy of this system across the board. In addition to such sensitivity disparities, the processors embedded in these diverse models are endowed with distinct processing speeds and response times, thereby potentially impeding the timely and accurate detection of accidents.
10	H. C. Impana, M. Hamsaveni, H. Chethana "A Review on Smart Helmet for Accident Detection using IOT	Uses Sensors that are interfaced with PIC through the wires. Sensors such as gas sensor, load sensor, vibration sensor, IR sensor and mems sensors are used.	Ensure good fallen detection of the workers in working place. Exactness and accuracy is high.

III. SCOPE

An accidents detection using deep-learning and edge computing offers a transformative approach to real-time safety. By seamlessly combining advanced video analysis with local processing on edge devices, the system achieves swift, accurate detection, and reduced latency. Its scalability, cost-efficiency, and adaptability make it applicable across diverse environments, with customizable alerting mechanisms ensuring user-centric responses. The integration with IoT devices enhances overall system intelligence, while prioritizing data security and privacy. This comprehensive proposition carries substantial promise in enhancing road safety and bolstering the growth of autonomous vehicles.

IV. CONCLUSION

The integration of deep-learning & edge computing in accident detection systems represents a paradigm shift in enhancing road safety. This synergy enables real-time, accurate detection with reduced latency, improving responsiveness to potential incidents. The scalability, cost-efficiency, and adaptability of this approach make it versatile for diverse environments. Customizable alerting mechanisms prioritize user preferences, while the integration with IoT devices enriches overall system intelligence. Emphasizing data security and privacy, this holistic solution holds great promise in advancing safety measures on roads and aligning with the evolving landscape of autonomous vehicles.

The efficiency and performance of neural networks. It includes techniques such as adjusting hyperparameters, employing advanced optimization algorithms like Adam or Respro, and utilizing regularization methods. Through these approaches, and Techniques of deep learning models are fine-tuned to achieving better accuracy, faster convergence, and improved generalization on diverse datasets, contributing to the overall effectiveness of machinelearning [12] applications.

Firebase Cloud Storage facilitates efficient cloud-based data storage [10] and retrieval. After project setup and authentication, developers integrate the Firebase SDK into their applications. [13] This enables seamless uploading and downloading of files, such as images or documents.

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Security rules and real-time capabilities enhance data control and responsiveness. Firebase Analytics monitors usage, ensuring a comprehensive cloud storage solution with minimal backend management.

An Android-based alerting system is designed to provide timely notifications and alerts to users [13]. Leveraging the capabilities of Android devices, this system utilizes push notifications or in-app alerts to informs users about important events, updates, or emergencies. It can be employed in diverse domain such as security, health, or communication, enhancing real-time information dissemination and user engagement. The system typically incorporates user preferences, enabling customization of alert types and settings. Android's widespread adoption ensures broad accessibility, making this alerting system a versatile solution for keeping users informed and responsive to critical information on their mobile devices.

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