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AI-DRIVEN REAL-TIME TRAFFIC AND EMERGENCY MANAGEMENT USING YOLO

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Abstract. With rapid urbanization and increasing vehicle ownership, traditional traffic management systems that rely on fixed schedules and basic sensors are no longer sufficient to handle growing congestion. These outdated systems often result in longer travel times, frequent bottlenecks, and delayed emergency responses. To address these issues, AI-driven solutions powered by deep learning (DL) provide an intelligent alternative by dynamically adjusting traffic signals based on real-time conditions. This project presents an AI- powered traffic monitoring and management system that utilizes YOLO for real-time vehicle detection and accident monitoring, deployed through a lightweight and interactive Streamlit interface. The system analyzes live traffic feeds, counts vehicles, detects accidents, and adjusts signal timings to improve flow and reduce delays. In emergencies, it identifies active ambulances or fire trucks and prioritizes their movement, while triggering automatic alerts through APIs like Twilio for rapid response. A web- based Streamlit dashboard enables centralized monitoring and visualization for traffic authorities, while the mobile application delivers live traffic updates and safety alerts to the public. By integrating deep learning with intuitive user interfaces, the system enhances urban traffic efficiency, boosts public safety, and lays the groundwork for smarter city infrastructure.

Keywords: AI, Yolo, Real time detection, Traffic signal optimization, Emergency vehicle prioritization, Mobile Application, Urban Traffic Management

INTRODUCTION

Artificial intelligence (AI) is revolutionizing traffic management by enabling data-driven decision-making for traffic control. AI enhances road safety through its ability to identify traffic patterns and make rapid adjustments to systems. YOLO is utilized in this project for real-time accident detection, emergency prioritization, and object recognition. System control is managed via a Streamlit dashboard, while alerts are communicated through a mobile application. AI is increasingly recognized as a critical infrastructure component in smart cities, not only optimizing present traffic flow but also enabling predictive planning for future needs [1].

However, analyzing CCTV footage for traffic applications presents challenges due to inconsistencies in video quality. Accurate object detection depends significantly on high-quality video content, as low resolution, poor lighting, and adverse weather impair model performance. Specialized algorithms have been developed to enhance low-light CCTV footage, allowing models to adapt better to varying visual conditions. An image-adaptive YOLO implementation that uses a small convolutional neural network can adjust processing parameters dynamically. This integration enhances the reliability of object detection systems across diverse CCTV footage qualities, thereby boosting their effectiveness in surveillance and traffic monitoring applications [1]. In India, road type plays a significant role in traffic accidents. Up to June 2023 (Provisional), National Highways accounted for 31.8% of accidents, State Highways for 24.8%, and other roads for 43.4%. A Road Safety Audit is essential for identifying dangerous infrastructure elements such as untreated intersections and high embankments. Specifically in Tamil Nadu, State Highways recorded the highest percentage of fatalities at 35%, followed by National Highways under NHAI at 29%. This indicates that targeted safety interventions on State and National Highways are critical [2]. Vehicle type also significantly contributes to accident statistics. As of June 2023, two-wheelers were involved in 45% of accidents and accounted for 43% of fatalities, mainly due to helmet non-compliance. Four-wheelers, including cars, jeeps, taxis, vans, and LMVs, were responsible for 29% of accidents and 23% of fatalities. Goods vehicles such as trucks and lorries contributed to 15% of the fatalities. These figures highlight the urgent need for stricter safety regulations and enforcement, particularly for two-wheeler users [2].

To optimize traffic flow at complex intersections, the Smart Dynamic Traffic Light System (DTLS) has been introduced. Unlike traditional traffic lights with fixed schedules, DTLS adjusts signal timings dynamically based on real-time traffic data. Using sensors and advanced algorithms, the system evaluates vehicle density and movement to allocate green phases more efficiently. This real-time adaptive control reduces traffic congestion, waiting times, and idling-related emissions, thereby improving both traffic efficiency and environmental impact [3].

LITERATURE SURVEY

Peelam et al. (2024) provide an extensive overview of Emergency Vehicle Management (EVM) within Intelligent Transportation Systems (ITS), focusing on the growing necessity for effective emergency responses in dynamic and densely populated urban environments. Their research highlights core EVM components such as driver inattention detection, accident detection, patient data retrieval, and real-time route planning. The study emphasizes the critical need for advanced ITS technologies to enhance safety and emergency vehicle efficiency, while also identifying key challenges like heterogeneous network integration and the demand for real-time data analytics. They suggest future research directions aimed at developing more reliable and adaptive EVM solutions for smart city ecosystems [5].

Another study explores the application of edge machine learning techniques in ITS to improve traffic management performance. By integrating edge computing with the YOLO object detection model, the researchers created a real-time traffic density monitoring system capable of adaptively controlling signals. This system processes data closer to the source, thereby reducing response time and enhancing system speed. Their findings demonstrate that edge-based ML implementations significantly help reduce congestion and improve traffic flow, although further research is needed to develop cost-effective deployment strategies [6].

A separate research effort applies game theory to smart traffic management through the Internet of Vehicles (IoV), enabling vehicles to make strategic decisions based on real-time traffic conditions. By exchanging data such as location and destination, and analyzing this with game-theoretic models, vehicles collectively optimize intersection control and reduce congestion. Simulation results show this method outperforms conventional traffic systems, offering a promising solution for managing traffic in complex urban areas while allowing autonomous decision-making and collaborative behavior [7].

Karamanlis et al. (2023) underscore the role of black spot analysis in enhancing road safety and supporting sustainable transportation goals. Roads with high accident frequencies, or “black spots,” are analyzed through statistical models such as Poisson distribution and severity indexes. The study emphasizes that addressing black spots effectively can significantly reduce fatality rates. Insights from European case studies also stress the importance of selecting proper analysis units and maintaining accurate data to improve road safety outcomes [8].

Further work proposes a black spot area alert system that uses machine learning to analyze traffic and accident data, identifying dangerous zones and notifying drivers in advance. This early-warning system helps drivers take preventive actions, while also providing real-time updates and automated accident reports to authorities. The research suggests that such a system can significantly reduce accidents and enhance road safety [9].

Humayun et al. (2022) focus on improving vehicle detection under varying weather conditions by combining YOLOv4 with a Spatial Pyramid Pooling (SPP) network. Their framework enhances detection accuracy in fog, rain, and snow, using heavy data augmentation and the multi-weather DAWN dataset. The system achieves 81% mean average precision, outperforming other YOLO variants. This approach showcases the effectiveness of integrating deep learning with enhanced pooling techniques for robust traffic surveillance systems [10].

Lastly, an IoT-based intelligent traffic management system is proposed to combat urban congestion by collecting real-time data on vehicle density, speed, and count through cameras and sensors. Using GIS technology, the system provides users with real-time updates for optimal route planning, aiming to reduce emissions, shorten travel times, and improve overall traffic efficiency. This smart city approach addresses the limitations of traditional traffic systems by introducing adaptability and responsiveness through real-time data processing [11].

PROJECT DESCRIPTION

In contemporary cities, delayed emergency response and urban traffic congestion are significant issues, largely driven by rapid urbanization, increasing vehicle density, and poor traffic signal management. These challenges have led to more frequent road accidents and prolonged delays in medical assistance, especially for emergency vehicles navigating congested routes. The lack of real-time traffic monitoring and accident detection systems further hampers road safety and efficiency. Therefore, there is an increasing need for a system that dynamically manages traffic while enhancing public awareness and enabling prompt emergency responses in high-risk areas. The current traffic management systems fall short in intelligence and adaptability, leading to inefficient signal timings, delayed emergency services, and a lack of real-time alerts for hazardous zones. Existing solutions do not provide adequate communication of accident events nor do they support timely location-based emergency assistance. To overcome these limitations, a comprehensive, integrated solution is necessary to enable dynamic traffic control, real-time accident detection, emergency alerts, and improved coordination between the public and traffic authorities.

The primary aim is to improve road safety and traffic efficiency through an intelligent traffic and accident management system. This includes developing a mobile application that alerts users about accident-prone zones and nearby hospitals, implementing real-time vehicle counting for adaptive signal control, using deep learning for accident detection and emergency vehicle identification, sending automated SOS alerts to medical facilities and authorities, and creating a web-based dashboard for traffic officials to monitor and manage real-time incidents effectively. The system’s architecture is modular, integrating hardware and software components to enhance emergency response and traffic flow. The mobile application, built using Android Studio, leverages the Google Maps API to deliver location-based alerts and navigation. This integration ensures accurate geolocation and provides users with real-time insights into traffic patterns, dangerous zones, and optimal routes based on their current position.

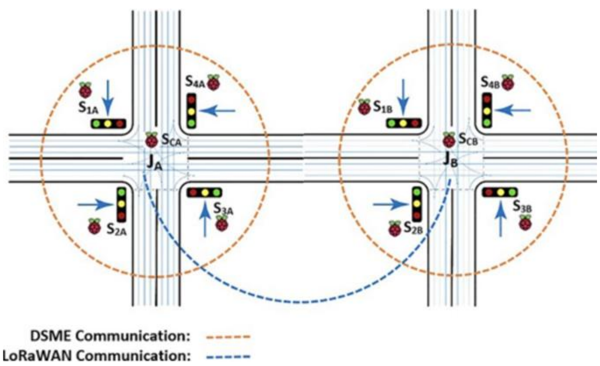

Figure 1: Smart Dynamic Traffic Light System for Multi-Lane Junctions

A YOLO (You Only Look Once) deep learning model powers the real-time vehicle and accident detection component. With its high speed and accuracy, YOLO processes live video feeds to quickly identify vehicles and potential collisions with minimal latency. This is implemented using the Streamlit framework, which offers an interactive web interface for real-time monitoring and visualization. In the event of an accident, the system employs Twilio API to initiate emergency protocols, including automated voice calls and location sharing with emergency services or contacts. The system continuously processes live video to assess vehicle density, which is then used to dynamically adjust traffic signal timings to optimize flow and reduce congestion. A dedicated web interface for traffic authorities enables real-time supervision of all components. Through this dashboard, authorities can monitor traffic conditions, receive system updates, and exercise direct control over emergency and traffic signal operations.

The experimental plan involves simulating a camera-based traffic intersection to test real-time vehicle detection using YOLO under varying traffic densities, verifying the effectiveness of the system's dynamic signal control. Simulated accidents are used to evaluate the system's emergency alert mechanisms. Additionally, the mobile app is tested for its accuracy in identifying accident zones and recommending nearby hospitals, while the Twilio-based SOS system is assessed for reliability and response times. Each component undergoes individual evaluation to ensure optimal performance before integration.

This project combines machine learning, computer vision, and intelligent transportation system concepts. YOLO enables real-time vehicle and accident detection in video streams, while adaptive signal control mechanisms use live data to adjust traffic light timings dynamically. Integration with Twilio, GPS, and mobile GIS allows real-time alerts and navigation, enhancing both public awareness and emergency response. Core system concepts include object detection through YOLO, dynamic signal control based on vehicle count, emergency vehicle recognition for prioritized routing, geofencing-based alerts and hospital navigation, and immediate emergency notifications via Twilio. These integrated technologies collectively form an intelligent and responsive traffic management system that significantly enhances urban roadway safety and emergency response capabilities.

WORKING PRINCIPLE

The system develops an integrated solution containing mobile application interfaces for citizen use together with traffic enforcement dashboard software that operates through web platforms. It tackles vital road transportation problems, including traffic jams, delayed emergency support, and unsafe driving conditions. By combining Android platforms and Google Maps services with the Streamlit framework, YOLO deep learning algorithms, and Twilio API integration, the system enables intelligent traffic management and real-time incident response capabilities. The application functions on Android devices with a simple interface that requires minimal user interaction.

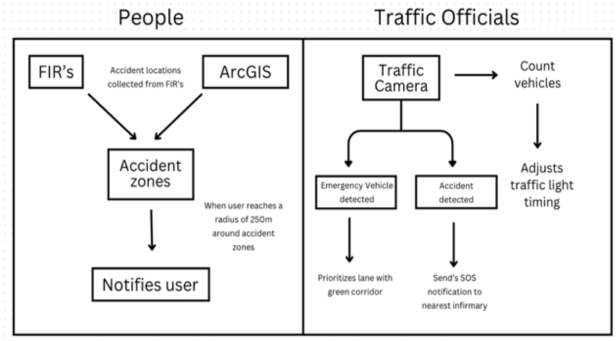

Figure 2: Architecture of the proposed model

Users receive GPS-based alerts about dangerous areas and are guided to nearby hospitals in emergency conditions. Meanwhile, the web platform provides traffic authorities with real-time vehicle traffic statistics at intersections, allowing automated signal adjustments and emergency vehicle recognition. Twilio integration ensures instant SOS communication to the nearest medical facilities during accidents. Through its intelligent framework, the project boosts traffic management efficiency and road safety while enabling rapid emergency response. The system architecture consists of two main components: the public and traffic officials. Accident location data is collected via ArcGIS mapping services and FIRs, helping identify and map accident zones. Users within a 250-meter radius of such zones receive immediate alerts to promote safe driving. Traffic officials deploy cameras at junctions to perform real-time vehicle tracking and dynamically adjust traffic signals to reduce congestion. Emergency vehicles like ambulances are detected and granted a priority green corridor for uninterrupted passage. Upon detecting an accident through image processing or sensors, the system sends an automated SOS alert to the nearest medical facility. The mobile application alerts users when they approach accident-prone zones, identifies nearby hospitals in emergencies, and sends SOS notifications when needed. Simultaneously, the web dashboard allows traffic officials to monitor traffic in real time, adjust signal timing based on vehicle density, detect accidents for quick medical response, and distinguish between active and inactive emergency vehicles to ensure appropriate signal prioritization. Overall, the system enhances road safety, reduces delays, and improves emergency responsiveness through real-time monitoring, intelligent automation, and minimal user effort.

CONCLUSION

The system represents a vital advancement in urban transportation by harmoniously combining live traffic data and deep learning accident alert systems with intelligent traffic signal management. The integrated system built with Android, Streamlit, Google Maps, YOLO, Twilio technologies develops a useful solution that controls traffic better and speeds up emergency response through mobile applications for the public and web-based tools for traffic officials. Future prospects for the system indicate its capability for wide deployment in smart city environments. Smart city systems strengthen interdepartmental coordination through their connection to environmental sensors and both public transport networks as well as smart parking solutions. Through predictive modeling combined with advanced data analytics the traffic authorities gain the ability to foresee and eliminate traffic congestion as well as accidents prior to their occurrence. The system's capabilities would improve through an enlarged sensor array that takes advantage of both cloud and edge computing technologies. The future advancement of this system enables cities to adopt an integrated method for smart city planning which generates safer and more efficient along with more resilient urban areas.

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