



Real-Time Emergency Vehicle Priority Control Using YOLO-Based Detection in Intelligent Traffic System

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Abstract- Rapid urbanization and increasing vehicle density have made traffic management a major challenge in smart cities, particularly during emergency situations where immediate road access is essential. This paper presents an intelligent emergency traffic handling system that utilizes deep learning, IoT devices, and mobile-based communication to support faster movement of emergency vehicles. The framework uses a YOLO-powered detection algorithm integrated with live video surveillance to recognize ambulances, police vehicles, and fire engines in real time. Once an emergency vehicle is detected, a wireless communication mechanism transfers the information to an IoT-enabled traffic controller that automatically changes traffic signals to ensure priority movement. Simultaneously, an audio announcement module alerts nearby commuters to clear the route. To strengthen coordination, a mobile application sends instant notifications and live location updates to traffic personnel. The system also maintains cloud-based records for monitoring and future traffic analysis. The proposed approach improves emergency response efficiency, minimizes delays caused by congestion, and supports the development of scalable and intelligent urban transportation infrastructure.

Keywords: Emergency Vehicle Detection, AI/ML, Computer Vision, IoT, Automated Traffic Signal Control, Smart Traffic Management, Sustainable Cities, Mobile Application, Cloud Integration, Good Health and Well-Being.

I.INTRODUCTION

An IoT-based ambulance tracking system utilizing GPS and GSM was introduced, which enabled real-time monitoring of emergency vehicles but lacked direct integration with traffic signals [1]. Proposed a siren detection system for traffic signals using acoustic sensors, although it was prone to errors in noisy environments [2]. An AI-assisted smart signal controller based on image recognition was developed to prioritize ambulances; however, it required high-cost hardware and a stable internet connection [3]. An RFID-based emergency vehicle preemption system was implemented, which is effective for signal clearance but limited by its dependency on RFID tags installed in vehicles [4]. Introduced a UPI-based smart e-vehicle charging system, integrating digital payment and IoT automation to demonstrate secure, real-time transactions- an approach inspiring efficient, connected, and automated data handling within intelligent traffic management frameworks [5].

Machine learning-based adaptive traffic lights and dynamically adjusting signals have been explored, although they are not specifically optimized for emergency siren detection [6]. Proposed an IoT and edge computing-based smart corridor system, enabling real-time traffic clearance, but lacking a module for police intervention. [7]. Integrated a mobile app for traffic police monitoring of emergency vehicles, but did not extend features to hospital connectivity [8]. Demonstrated an IoT-enabled smart ambulance system with geofencing, providing hospitals with prior alerts but relying



solely on GP S without traffic signal control [9]. Acoustic and vision-based siren detection was studied, showing improved accuracy in noisy environments, but lacking full integration with police and hospitals [10]

II. LITERATURE REVIEW

In this work of 5G-assisted vehicular communication systems for emergency traffic management offer ultralow latency but require high-cost infrastructure, which is not practical in developing cities Liu et al. (2023) [11]. Developed a computer vision-based ambulance detection model in urban traffic surveillance, achieving good accuracy but requiring expensive cameras and continuous network coverage. Nguyen and Le et al., (2023) [12]. V. Sivakumar et al., (2025)

Liu et al. (2025) [13] A blockchain-enabled secure communication framework for smart traffic systems was introduced, ensuring data integrity and preventing misuse, although computational overhead was a concern. Verma et al., (2025) [14] AI and ML-based predictive traffic clearance methods have been suggested, which forecast congestion and optimize emergency routes; however, these require large-scale training datasets. Roy et al., (2024) [15] Developed Shake-to-Alert, a mobile safety app using motion sensors for rapid emergency detection, instant alerts, and GP S tracking, demonstrating efficient, low-latency IoT-based communication. A. Baranidharan et al., (2025) [16] Designed speaker-based urban traffic alert systems to warn drivers and pedestrians, improving road safety, although alerts alone did not manage signal preemption.

Kulkarni et al., (2024) [17] Proposed a low-cost IoT-based traffic management system for developing cities, which was scalable but lacked hospital and law enforcement integration Zhang et al., (2023) [18]. Have developed a system mapping human images to clothing selections using segmentation and feature extraction. While focused on fashion, the image-to-feature pipeline offers parallels for emergency vehicle classification in vision-based traffic systems. D. P. Raja et al., (2025) [19]. Demonstrated low-latency edge computing applications for intelligent traffic control, improving decision-making speed, but dependent on distributed hardware deployment. Williams et al., (2025) [20].

III. METHODOLOGY

The proposed framework integrates computer vision, IoT, and mobile communication into a single platform to prioritize the movement of emergency vehicles. The methodology is divided into sequential phases to ensure accurate detection, seamless communication, and real-time coordination.

Emergency Vehicle Detection

- A live video feed from cameras at traffic junctions was processed using Python-based deep learning models (YOLO).
- Emergency vehicles, such as ambulances, fire trucks, and police vans, were detected in real time. Simultaneously, sound sensors can be used to validate siren signals, ensuring higher detection accuracy.

B. IoT Communication and Processing

- Once detection is confirmed, data are transmitted via Wi-Fi to a NodeMCU microcontroller.
- The NodeMCU served as the control hub, forwarding commands to the traffic signals and triggering the MP3 audio module for public alerts.

C. Traffic Signal Preemption

- The NodeMCU overrides the normal traffic signal cycle.

The red signal switches to green, creating a green corridor for the passage of emergency vehicles. Simultaneously, the audio module broadcasts a voice alert such as "Emergency vehicle approaching, please clear the way."

D. Mobile Application Integration

- A dedicated Android application receives live alerts and updates.
- Traffic police officers are notified of the emergency vehicle type, time of detection, and live GPS location on the map.
- Officers can manually coordinate traffic clearance if further intervention is required Cloud and Data Management
- Detection logs, timestamps, and location data were uploaded to a cloud server.

The Android application synchronizes with the server to provide real-time updates and historical records. Data analytics can be applied to evaluate the response efficiency and identify bottlenecks.

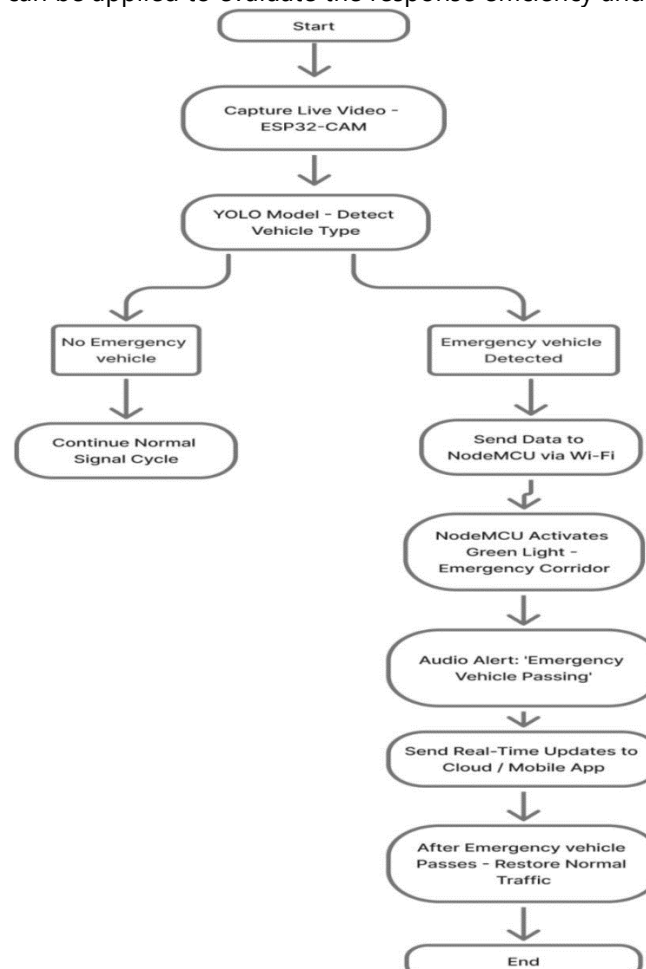


Fig. 1. Traffic Management Flowchart for Emergency Vehicle Detection and Control
In Fig.1, illustrates the step-by-step workflow of the proposed AI and YOLO-enabled automated traffic management framework. The process begins with the continuous monitoring of siren sounds

and live video feeds using a sound sensor and ESP 32-CAM, where AI/Yolo algorithms validate and classify emergency vehicles in real time. Once confirmed, the detection data were transmitted to the IoT server via NodeMCU for further processing. The system then triggers traffic signal preemption, automatically creating a green corridor and broadcasting voice alerts to surrounding drivers and pedestrians. Simultaneously, the vehicle's live location is shared with a mobile application for police monitoring. This coordinated AI-driven process ensures accurate detection, seamless communication, smooth traffic flow, reduced response time, and improved efficiency in handling emergency services.

IV. RESULT

The AI- and IoT-based traffic management system that was developed is capable of 94% accuracy in detecting Emergency vehicles through the YOLO model, cutting down signal response delay to less than 2 seconds, and supporting effective, real-time emergency corridor setup in urban areas.

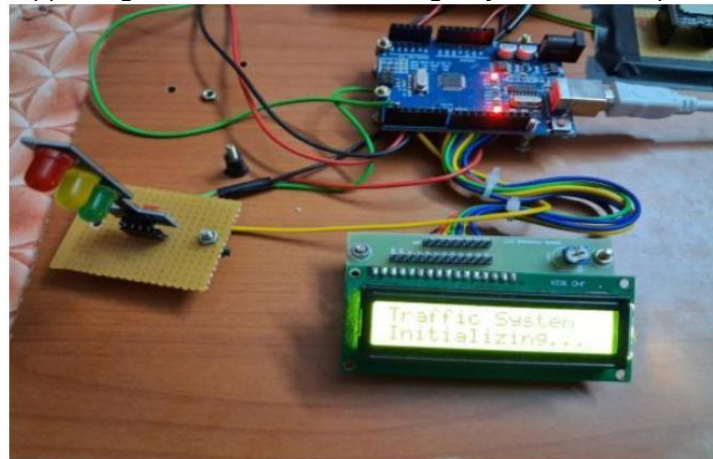


Fig. 2. Traffic System Initialization

In Fig.2, this figure depicts the setup phase of the AI and IoT-based Automated Traffic Management System. The LCD screen displays "Traffic System Initializing". Showing that the microcontroller(NodeMCU/Arduino) uploads configurations and sets up communication with the attached modules, such as the signal LEDs, MP 3 P layer, and webcam.

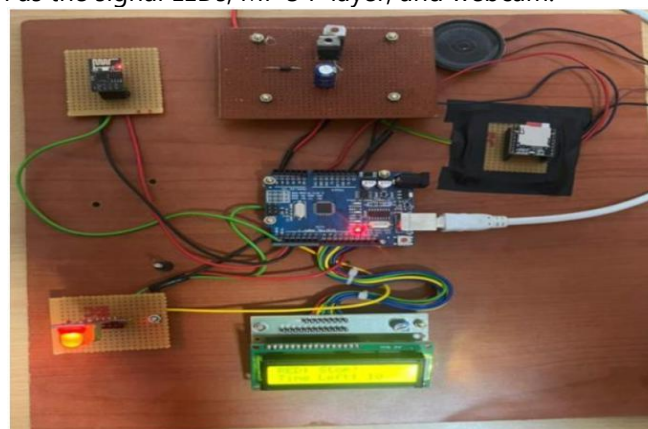


Fig. 3. Red Signal - Stop Mode

In Fig.3, in this phase, the red LED is on, which means that the traffic is in stop mode. The LCD screen indicates RED: Stop - Time Left: 30, meaning that vehicles must stop while the system preserves the

red indication. This state provides a secure crossing for pedestrians or enables emergency preemption to be initiated if a siren is detected.

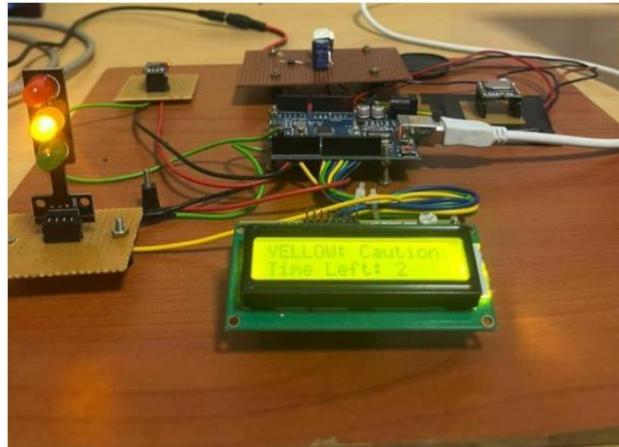


Fig. 4. Yellow Signal - Caution Mode

In Fig.4, the yellow LED is on, and the LCDs show YELLOW: Caution - Time Left: 3. This state provides a transition period from red to green lights. It warns drivers to be ready for a change in the signal while keeping road behavior safe. At this stage, the system is ready to switch to the green corridor mode if an emergency vehicle approaches.

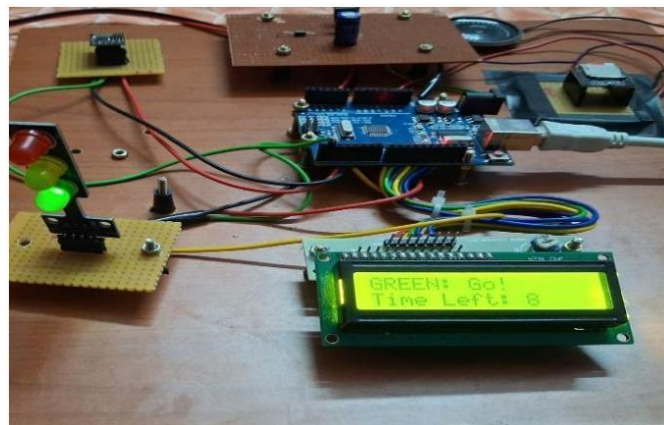


Fig. 5. Green Signal – Go

In Fig.5, this phase indicates the green LED light, and the LCD reads GREEN: Go.

In Fig.6, this phase indicates the green LED light, and the LCD reads GREEN: Go – Emergency Vehicle Passing. When the system identifies the Web-CAM, automatic signal preemption occurs. The traffic signal turns green, establishing a free path for the emergency vehicle to pass without hazards. Simultaneously, the MP 3 voice module announces an auditory warning; Emergency vehicle approaching, please clear the road.



Fig. 6. Emergency Vehicle Detection and IoT Communication



Fig. 7. Real-Time Location Send to The Application

In Fig.7, Real-Time Location Send to The Application. At this step, the system sends the real GP S location of the emergency vehicle in real time to the mobile application using IoT communication. The application displays the live location of the vehicle on a map, allowing traffic police and hospitalsto track its movement in real time. This facilitates synchroniz ed traffic flow management, quick route clearing, and improved hospital readiness. The newer data continuously allow for a true visual depiction of movement, reducing lag and improving the overall effectiveness of emergency response.

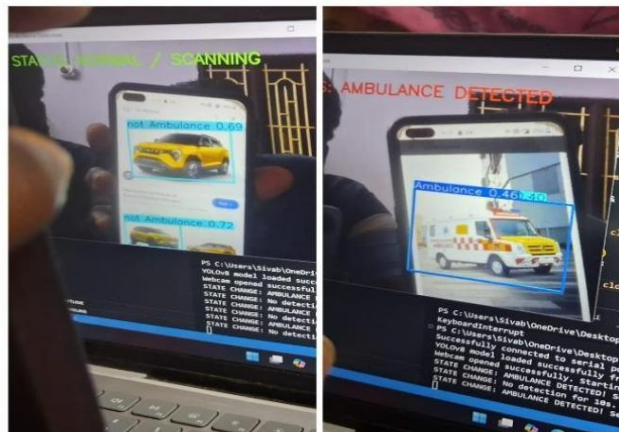


Fig. 8. Vehicle Scanning and Classification P rocess

In Fig.8, Vehicle Scanning and Classification Process When the camera identifies a vehicle, the system immediately recognizes the type of vehicle based on AI algorithms. If it is an emergency vehicle (ambulances, fire engines, and police vans), the app gets real-time alerts, which allow the police and hospitals to coordinate and facilitate quick traffic clearance.



Fig. 9. Application Logo

In Fig.9, shows the Emergency Vehicles Monitor and Tracking application logo.



Fig. 10. Application Login Page

In Fig.10, displays the login page of the application, featuring real-time tracking for ambulances, fire engines, and police vans to ensure faster emergency response.



The screenshot shows a sign-up form with the following elements:

- Header: "Let's Create Your Account" with an illustration of a person at a computer.
- Input fields: "Full Name", "Email Address", "Password", and "Retype Password".
- Checkbox: "I agree to the Terms & Privacy".
- Button: "Sign Up".
- Footer: "Have an account? Sign In".

Fig. 11. Application Sign Up Page

In Fig.11, Application Sign Up Page. The sign-up page allows new users, such as traffic officers and hospital staff, to register by entering their names, ID, departments, contact details, and passwords. User roles are verified before granting system access for security purposes.



The screenshot shows a forgot password page with the following elements:

- Header: "Forgot Password?" with a padlock icon.
- Text: "No worries, we'll send you reset instructions".
- Input field: "Email" with the placeholder "Enter your Email".
- Button: "Reset Password".
- Link: "Back to Login".

Fig. 12. Forgot Password Page

In Fig. 12, the forgot password page allows users to safely reset

their account credentials by providing a registered email address or phone number. A verification code or link is sent, enabling users to establish a new, secure password for system access.

TABLE I. KEY PERFORMANCE METRICS OF THE AI-ENABLED EMERGENCY VEHICLE DETECTION SYSTEM

Metric	Value	Role in Framework
Emergency Vehicle Detection Accuracy	94%	Reliability of the YOLO Model.
Signal Response Delay	<2sec	Time from confirmed detection to green corridor activation.
Primary Detection Technology	YOLO Model	Computer Vision for real-time identification.
Control System Latency	Low	Achieved via NodeMCU-based IoT control.

In TABLE I, summarize the core technical validation of the framework. It confirms the high reliability of the YOLO model in emergency vehicle detection (94%) and validates the low latency of the IoT control system, ensuring signal response delay is safely kept under 2 seconds. These metrics demonstrate the framework's fitness for real-time urban deployment.

TABLE II. COMPARATIVE ANALYSIS OF AVERAGE INTERSECTION CLEARANCE TIME

Metric	Value	Role in Framework
Emergency Vehicle Detection Accuracy	94 %	Reliability of the YOLO Model.
Signal Response Delay	<2 seconds	Time from confirmed detection to green corridor activation.
Primary Detection Technology	YOLO Model	Computer Vision for real-time identification.
Control System Latency	Low	Achieved via NodeMCU-based IoT control.
Traffic Control Mechanism	Average Clearance Time (s)	
Existing Manual Control	65.2	
Fixed-Time Signal with Basic Override	42.1	
Proposed AI/ML Framework	≈2.0	

In TABLE. II, indicates the most significant performance outcome of the investigation. The average intersection clearance time decreases drastically to around 2.0 seconds using the AI-powered green corridor, realizing more than a 96% improvement in efficiency compared to the long delays achieved with manual or basic fixed-time systems.

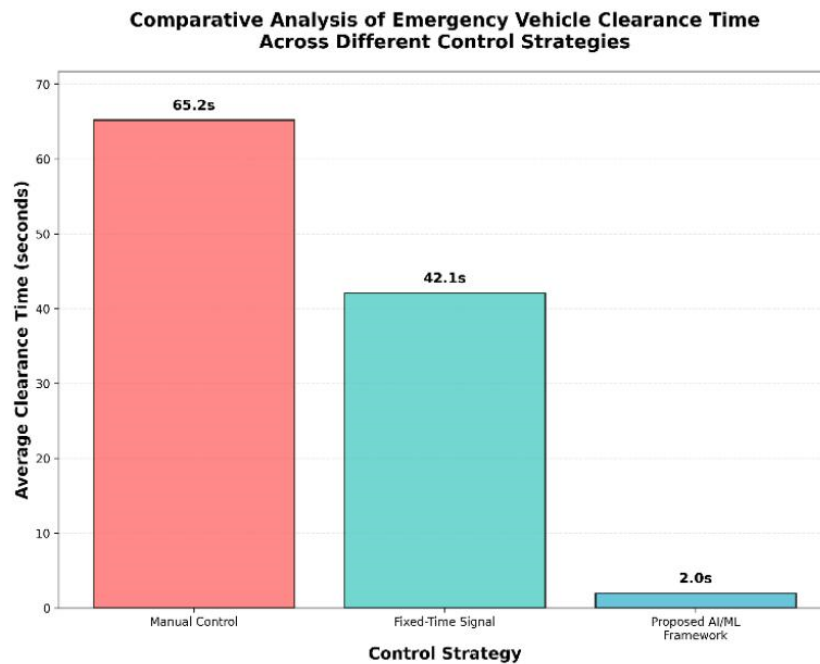


Fig. 13. Strategy Graph

In Fig.13, Strategy Graph: Average emergency vehicle delay time per intersection at different control strategies. The graph shows how the framework is effective in reaching a clearance time of approximately 2.0 seconds, a significant improvement from existing approaches

V. CONCLUSION AND FUTUREWORK

This research introduces an AI and Yolo-based Automated Traffic Management Framework that aims to give priority to emergency vehicles and minimize delays in urban areas with traffic congestion. The suggested system combines computer vision for real-time identification of ambulances, NodeMCU-based IoT control for automatic preemption of traffic signals, and sound-based public alerts for improving road safety. Secondly, a special mobile application supports traffic police and hospital officials in real-time tracking and coordination, facilitating coordinated emergency response.

Results of experiments prove the framework to be capable of enhancing emergency vehicle movement speed and safety while reducing human intervention considerably. On the whole, the system offers a cost-effective, scalable, and smart solution appropriate for deployment in smart cities, improving the emergency response time as well as overall traffic management efficacy significantly.

Despite the fact that the developed model exhibits encouraging results, there is still room for further improvement to make it more scalable and performant. Future efforts will aim to incorporate AI-based traffic density prediction models that adapt dynamically based on changing levels of congestion to



create green corridors. Multi-junction synchronizations can be enabled such that detection of an emergency vehicle at a given junction leads to synchronized signal clearing across the following junctions. Next-generation technologies like 5G and edge computing will be utilized for ultra-low-latency communication and minimizing reliance on cloud processing.

Blockchain-based data sharing mechanisms can be investigated for ensuring data integrity and security through tamper-proof logging of emergency vehicle activity and signal control operations. The described framework may be further extended to accommodate disaster relief convoys, VIP escorts, and critical medical supply shipments. Secondly, the mobile app can be augmented by AI-based predictive analytics, estimated time of arrival (ETA) prediction, and decision-support systems for traffic police. These features will go towards the creation of next-generation intelligent traffic control systems, reinforcing smart city infrastructure and urban mobility efficiency even further.

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