# REAL-TIME EMERGENCY VEHICLE DETECTION USING MACHINE LEARNING

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## ABSTRACT

*Emergency vehicle detection in heavy traffic can be challenging due to the presence of multiple vehicles and occlusions. However, we can develop an effective solution to this problem using machine learning and computer vision techniques. Traffic congestion significantly impacts emergency response times, making early detection of emergency vehicles at signals crucial in preventing delays. To address this, the proposed model detects emergency vehicles at a traffic signal and sends real-time alerts to the signal-regulating authorities, enabling the creation of a green corridor for seamless passage. Additionally, when multiple emergency vehicles are stacked at a signal, the system alerts the surrounding traffic police to provide assistance. Once the emergency vehicles are released from the congestion and proceed to another road, a follow-up message is sent, ensuring that unnecessary resources are not deployed in the previous location. This dynamic communication enhances response efficiency and optimizes traffic management. One approach to achieving this involves using the YOLOv5s model to detect and classify emergency vehicles in live video feeds. YOLOv5s is well-suited for real-time object detection tasks and has shown promising results in accurately identifying objects. A diverse dataset containing emergency vehicles in various traffic conditions is used to train the model, ensuring robustness across different environments. Once deployed, the trained model continuously monitors video feeds, detecting emergency vehicles as they approach traffic signals and triggering automated alerts for immediate action. By integrating real-time emergency vehicle detection with intelligent alert messaging, this system enhances emergency response coordination, reduces delays, and optimizes traffic police deployment, contributing to safer and more efficient urban traffic management.*

**Keyword:** *vehicle detection, machine learning, computer vision, YOLOv5s, and real-time alerts.*

## INTRODUCTION

Emergency vehicle detection in heavy traffic conditions is a major challenge due to the high number of vehicles and frequent visual obstructions. Delayed responses during such situations can impact emergency services significantly. To overcome this, a machine learning and computer vision-based solution is proposed to detect emergency vehicles in real-time and improve traffic management. The system uses the YOLOv5s (You Only Look Once version 5 small) model, which is well-known for its high accuracy and speed in object detection tasks. A diverse dataset consisting of images of emergency vehicles under various traffic scenarios is used to train the model, making it reliable in real-world conditions. Once trained, the model continuously monitors live video feeds from traffic signals to detect emergency vehicles as they approach intersections. Upon detection, real-time alerts are sent to signal-controlling authorities to create a green corridor, allowing the emergency vehicles to pass through with minimal

delay. If multiple emergency vehicles are found waiting, the system also notifies the nearest traffic police for assistance. After the vehicles have exited the congested area, the system sends a follow-up message to ensure that resources are not wasted at the previous location. This dynamic alert system not only reduces emergency response times but also helps in optimizing the deployment of traffic personnel. By combining real-time detection with smart communication, the proposed system significantly enhances urban traffic management and ensures timely assistance in emergency situations.

## 1 RESEARCH CHALLENGES

Detecting emergency vehicles in real-time amid heavy traffic presents several critical challenges that must be addressed to ensure efficient emergency response and road safety. One of the primary difficulties lies in handling occlusions, where emergency vehicles are partially or fully blocked by other vehicles or infrastructure, making detection difficult. Varying lighting conditions, such as night-time, fog, shadows, or glare, further complicate the accuracy of detection systems. Additionally, the diverse visual characteristics of emergency vehicles, including differences in shape, size, color, and markings across regions, demand a highly adaptable detection model.

Traditional detection systems often lack the robustness and flexibility to maintain high accuracy in such dynamic environments. The core research challenge is to develop an advanced, real-time model that can accurately identify emergency vehicles across various traffic densities, angles, and environmental conditions. Deep learning techniques like convolutional neural networks (CNNs) and real-time object detection frameworks such as YOLO or SSD offer promising results but require optimization for speed and precision. Moreover, integrating this detection model with a responsive, real-time alert system that communicates directly with traffic management authorities adds complexity. Minimizing false positives while ensuring low latency and high throughput is essential for reliable deployment. The system must also support scalability and continuous learning for long-term effectiveness.

### 1.1 OBJECTIVE

The primary objective of this project is to design and implement a real-time emergency vehicle detection system using advanced machine learning and computer vision techniques, specifically leveraging the YOLOv5s model. In densely populated urban areas, traffic congestion often delays emergency response vehicles such as ambulances, fire engines, and police vans. This system aims to address that challenge by accurately detecting emergency vehicles approaching traffic signals and promptly sending real-time alerts to traffic control authorities. Upon detection, the system enables the creation of a dynamic green corridor, allowing emergency vehicles to pass through intersections without delay. Additionally, in scenarios where multiple emergency vehicles are queued at a signal, the system notifies nearby traffic police to assist in managing the situation. Once the emergency vehicles exit the congested zone, a follow-up message is sent to avoid unnecessary deployment of resources at the previous location. This intelligent communication enhances coordination and ensures efficient use of traffic management personnel. To ensure robust performance, the YOLOv5s model is trained on a diverse dataset that includes various traffic conditions, lighting scenarios, and vehicle types. Ultimately, this project aims to reduce emergency response times, enhance road safety, and improve the overall efficiency of urban traffic systems.

### 1.2 SCOPE OF THE PROJECT

This project focuses on developing an intelligent emergency vehicle detection and alert system to improve emergency response in high-traffic urban areas. Using the YOLOv5s model, known for its real-time object detection capability, the system identifies emergency vehicles like ambulances, fire engines, and police vehicles as they approach traffic signals. Once detected, it sends real-time alerts to initiate a green corridor, ensuring the vehicle's swift passage. The model is trained on a diverse dataset featuring emergency vehicles in varying traffic conditions, angles, and lighting, ensuring high accuracy. In cases with multiple emergency vehicles, alerts are also sent to nearby traffic authorities for manual support. Once the vehicles exit the area, a follow-up message is sent to free up resources. The system integrates seamlessly with existing traffic infrastructure and supports future upgrades like GPS tracking and app-based coordination. This solution enhances urban traffic efficiency, emergency response, and lays the groundwork for intelligent transport systems.

## 2 EXISTING SYSTEM

The existing traffic management systems in most urban areas are largely manual and lack automation, especially when it comes to identifying and prioritizing emergency vehicles in real time. Currently, traffic control at intersections is primarily managed by traffic police, who rely on their vision and hearing to detect sirens or flashing lights from emergency vehicles such as ambulances, fire trucks, or police cars. This manual method becomes highly ineffective in densely populated cities with heavy traffic congestion and high levels of ambient noise, where sirens may go unnoticed and vehicles may be blocked due to poor coordination. While many intersections are equipped with CCTV cameras for monitoring, these cameras are typically used for surveillance and post-incident analysis, not for proactive emergency vehicle detection or traffic signal control. Some modern systems incorporate GPS tracking in emergency vehicles to monitor their routes, but these systems are usually limited to central monitoring and do not directly interact with signal controls to prioritize vehicle movement. Siren-based detection systems, which use audio sensors to recognize the sound of an approaching emergency vehicle, have also been introduced in a few areas. However, their accuracy is questionable in noisy environments, and they fail to distinguish between multiple sirens or emergency scenarios. Existing traffic lights operate on fixed cycles or use basic vehicle detection sensors to manage flow but lack the intelligence to adapt dynamically in real-time based on emergency needs. This results in delays for emergency responders, which can be critical in life-threatening situations. The absence of a fully automated, real-time, intelligent system that detects and prioritizes emergency vehicles at traffic junctions remains a significant gap. Therefore, the existing systems are not sufficient to meet the growing demand for faster emergency response and efficient urban traffic management.

### 2.1 PROPOSED SYSTEM

The proposed system is designed to enhance emergency response efficiency by detecting emergency vehicles in real-time within congested traffic environments, especially at traffic signals. It leverages the YOLOv5s algorithm, a state-of-the-art machine-learning framework known for its high accuracy and speed in object detection tasks. A large and diverse dataset of emergency vehicle images is used to train the YOLOv5s model, ensuring reliable classification even in complex traffic conditions. Once an emergency vehicle is identified through live CCTV video feeds, the system instantly sends a real-time alert to the traffic signal control unit and nearby traffic police. Upon receiving the alert, officers are dispatched to the exact location to clear the way, ensuring smooth and swift passage for the emergency vehicle. Simultaneously, the system adjusts the traffic signal timings to create a green corridor, minimizing delays. In scenarios where multiple emergency vehicles are stacked at a signal, the system sends additional alerts to mobilize more traffic personnel for assistance. After the emergency vehicle exits the congested area, a follow-up message is sent to inform authorities, preventing unnecessary deployment of resources. This intelligent integration of real-time detection, automated alerts, and dynamic communication significantly improves traffic flow, reduces response delays, and optimizes urban emergency vehicle management.

### 2.2 ARCHITECTURE DIAGRAM

The diagram represents the functional architecture of an emergency vehicle detection system using machine learning and cloud integration. The process starts with a vehicle dataset that includes a wide range of images. Initially, irrelevant data is removed, and the remaining images are labelled to identify emergency vehicles accurately. This labeled dataset is then used to train and test the YOLOv5s model, a powerful and efficient object detection algorithm. Once the model is trained, it is evaluated using performance metrics such as accuracy, precision, recall, and F1-score to ensure reliability. The final model is deployed on a cloud-based server, such as AWS, which supports scalable and fast processing. A Flask RESTful API is used to bridge the trained model with a user-friendly web application, enabling real-time interaction and prediction. Users can submit live video feeds or input data through the web interface. This input is stored in a database and simultaneously sent to the model for prediction. The system analyzes the input and detects emergency vehicles, triggering alerts and notifications for immediate action. The output is displayed to traffic authorities or users, assisting in creating green corridors and improving emergency response. This integrated system ensures smooth traffic management and faster emergency services.

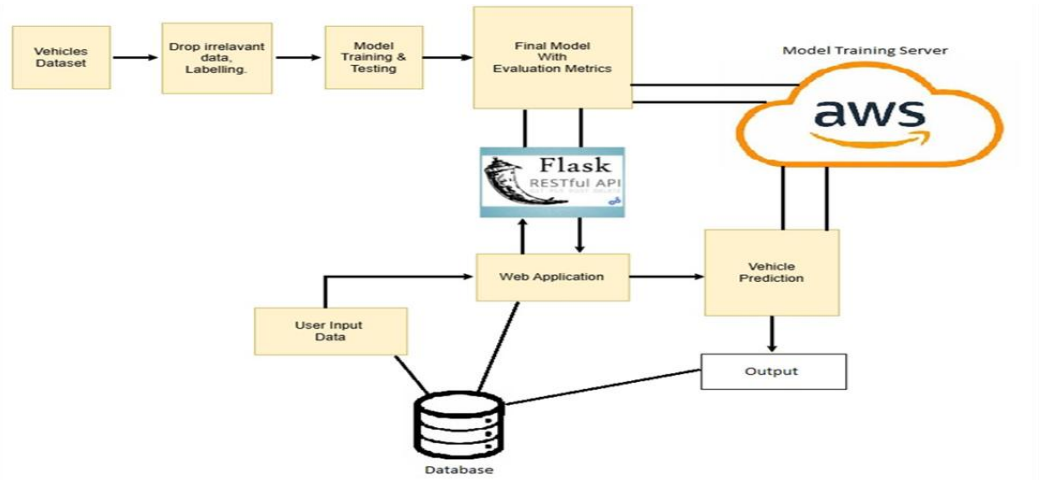


**Fig 1: Architecture Diagram**

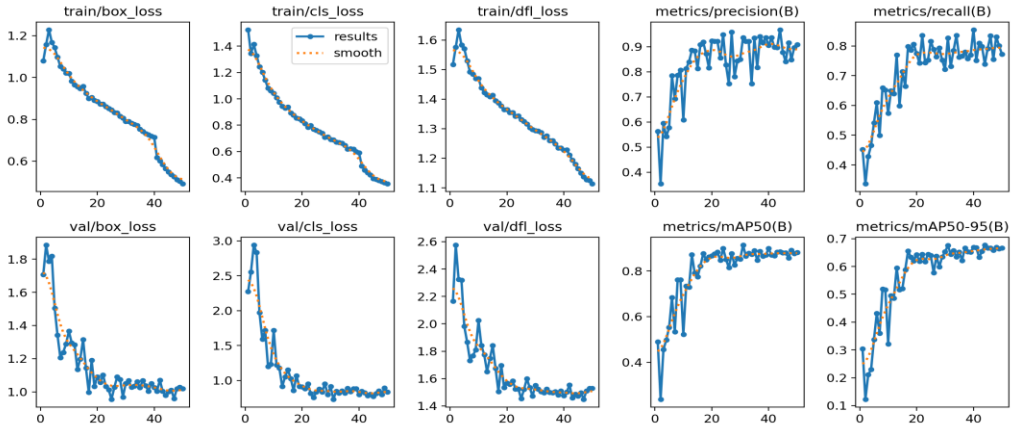


**Fig 2: Model Training Features**

The image illustrates the training and validation performance of the YOLOv5s model used for emergency vehicle detection. The graphs show a steady decline in training and validation losses—box_loss, cls_loss, and obj_loss—indicating effective learning. Evaluation metrics such as precision and recall improve consistently, proving the model's accuracy in detecting emergency vehicles. The increasing mAP@0.5 and mAP@0.5:0.95 scores confirm that the model is generalizing well across various traffic scenarios. These results show the model is both accurate and reliable, making it suitable for real-time implementation in smart traffic systems to support emergency response.

## 3 IMPLEMENTATION DETAILS – PREREQUISITES

| | |
|---|---|
| **Environment** | Visual Studio |
| **Languages** | Python 3, JavaScript |
| **Packages** | Numpy, Tensorflow, Pandas, Matplotlib, Sklearn, Tdqm, Flask, OS, Librosa, Cv2, Yolov5, sqlalchemy. |
| **Dataset** | 1025 images of Emergency and Non-Vehicles - Kaggle |

### 3.1 RESULT AND DISCUSSION

The emergency vehicle detection system, utilizing YOLOv5s for real-time object detection, effectively identifies emergency vehicles within heavy traffic, even amidst occlusions. By analyzing live video feeds, the system detects ambulances, fire trucks, and police cars and sends immediate alerts to signal-regulating authorities, allowing them to adjust traffic lights and create green corridors. Additionally, the system alerts nearby traffic police to assist when multiple emergency vehicles are stacked. Once the vehicles clear congestion, follow-up messages prevent unnecessary resource deployment. This integration of real-time detection and intelligent alerting improves response times, optimizes traffic management, and enhances overall urban safety and efficiency.

### 3.2 IMPLEMENTATION AND SCREENSHOT

**Home Page:**

The homepage of the Real-Time Emergency Vehicle Detection System offers a modern, user-friendly interface designed to optimize traffic flow and enhance emergency response. Featuring a dynamic background, it sets the tone for real-time operations. A bold title and "Start Detection" button allow instant access to image or video-based detection. Powered by YOLOv5s and OpenCV, the system ensures fast and accurate identification of emergency vehicles. Navigation is seamless across Home, Image Detection, Video Detection, and Contact pages. Optimized for all devices, it provides responsive interaction with clear instructions. The homepage blends sleek design and intelligent functionality, making emergency detection fast and accessible.


**Fig 3: Home Page**

**User Interface for image attachment:**

The Image Attachment UI is designed for a smooth, user-friendly experience across all devices. Featuring a central "Attach Image" button, it supports both drag-and-drop and file browser uploads. Users receive real-time image previews with options to replace or remove files easily. The interface supports common formats like JPEG, PNG, and GIF, with built-in validation for file type and size. Instant feedback alerts users to issues, while tooltips and progress indicators guide the process. High-contrast design, keyboard navigation, and screen reader support ensure accessibility. Fully responsive, the UI delivers consistent functionality for all users, from casual uploaders to professionals.

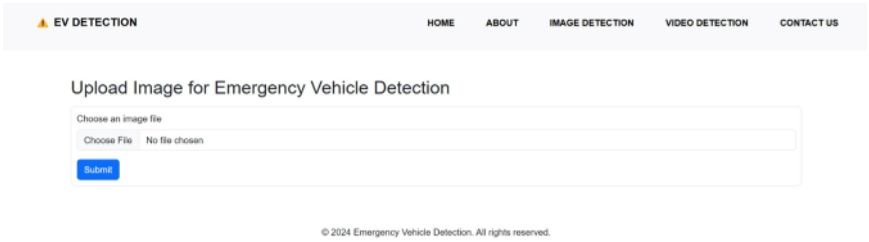


**Fig 4: Image Upload Page**

**EV image detected page**

The Emergency Vehicle Prediction UI provides a responsive and user-friendly interface for real-time traffic monitoring. Featuring a live video or image feed, it uses the YOLOv5 model and OpenCV to accurately detect emergency vehicles such as ambulances and police cars. Detection results are instantly displayed with clear messages and visual cues like color changes and icons. Optimized for desktops, tablets, and mobile devices, the UI requires no technical expertise, enabling quick adoption by traffic authorities. With intuitive navigation, real-time alerts, and accessible design, the interface enhances situational awareness, reduces emergency response times, and supports efficient traffic management in urban areas.

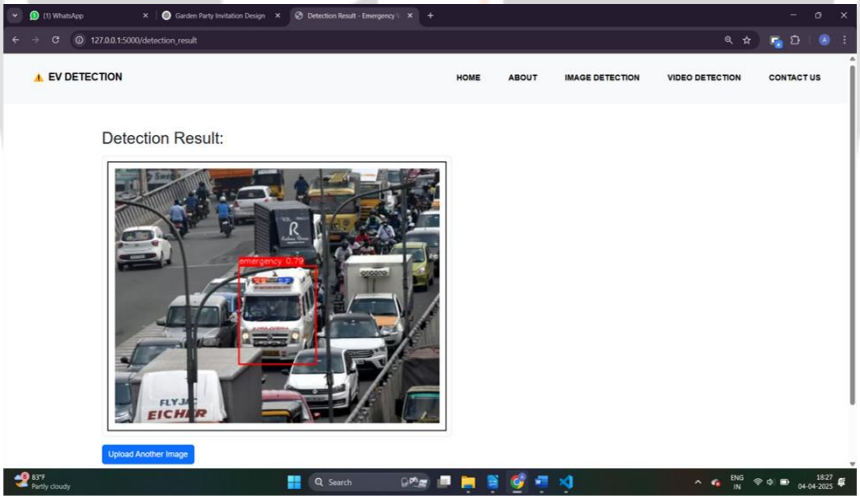


**Fig 5: Image Detection Page**

**User interface for video attachment:**

The Video Attachment UI is designed to provide a seamless and intuitive experience for uploading videos. Featuring a clear “Attach Video” button, it supports both drag-and-drop and manual file selection methods. Once uploaded, users receive a real-time preview to confirm the correct file. Compatible with formats like MP4, AVI, and MOV, the interface includes instant alerts for errors such as unsupported formats or large file sizes. Step-by-step guidance

ensures ease of use, even for non-technical users. Fully responsive across devices, the UI maintains clarity and functionality, making it ideal for real-time video analysis in emergency detection and smart city systems.

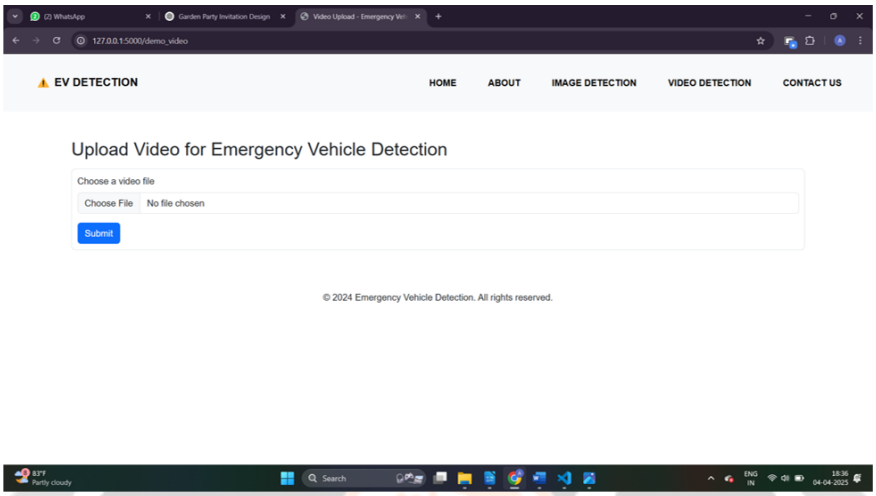


**Fig 6: Video Upload Page**

**EV video detected page:**

The Real-Time Emergency Vehicle Detection System accurately identifies emergency vehicles in uploaded videos using YOLOv5 and OpenCV. In the analyzed video, two emergency vehicles were detected with confidence levels of 76.7% and 71.3%. Red bounding boxes clearly highlight detected vehicles, enabling quick identification by users. Supporting both live feeds and pre-recorded videos, the system is ideal for traffic management and emergency response. An "Upload Another Video" button allows users to continue analysis effortlessly. With high accuracy and real-time processing, the system enhances road safety, reduces delays, and supports effective traffic monitoring through automated emergency vehicle detection.

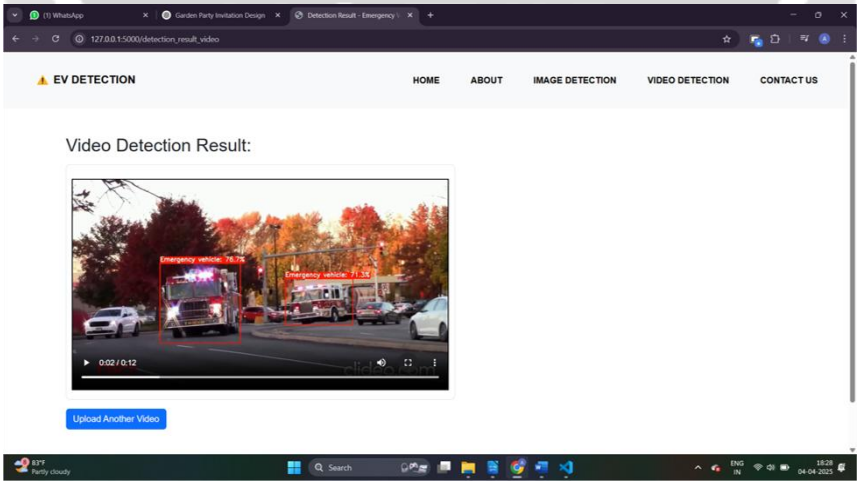


**Fig 5: Video Detection Page**

**Alert Message Process**

The Real-Time Emergency Vehicle Detection and Alert System improves traffic management by detecting emergency vehicles using YOLOv5 and OpenCV. It analyzes video frames in real time, highlighting detected vehicles with red bounding boxes and displaying confidence levels. Upon identifying an emergency vehicle, the system sends instant SMS alerts via the Twilio API to nearby traffic police, including the vehicle type and location, such as " 📍 Pallikaranai, Chennai." These alerts prompt immediate action to clear the path. Supporting live feeds and recorded videos, the system combines intelligent detection with real-time communication, reducing response times and ensuring swift passage for emergency vehicles.

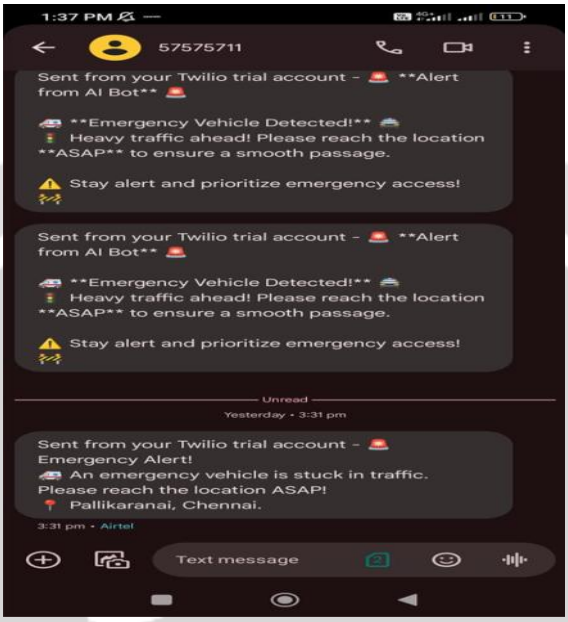


**Fig 6: Alert Message Output**

## 4 CONCLUSION AND FUTURE WORK

### 4.1 CONCLUSION

The Emergency Vehicle Detection System enhances urban traffic management and public safety by identifying emergency vehicles in real time using YOLOv5s and OpenCV. Designed for congested environments, it processes live video feeds to detect ambulances, fire trucks, and police cars, even under poor visibility. Upon detection, the system sends instant alerts to traffic authorities to create a green corridor and notifies nearby traffic police to assist. A follow-up alert ensures efficient resource use once the vehicle passes. With high detection accuracy and a user-friendly interface, this system improves emergency response times, reduces delays, and supports the vision of smarter, safer cities.

### 4.2 FUTURE WORK

The Emergency Vehicle Detection System has strong potential for future enhancements to boost efficiency and adaptability in smart cities. Integrating AI-based traffic prediction can enable proactive green corridors, while IoT connectivity allows seamless communication between traffic signals and emergency vehicles. Adding voice alerts, siren detection, and thermal imaging can improve detection in low-visibility conditions. A mobile app can support real-time alerts and analytics for traffic officers. Cloud storage and AI reporting will offer insights for better planning. Multi-zone coordination ensures uninterrupted vehicle movement, and integration with hospitals can streamline emergency responses. These upgrades will create a smarter, faster, and more responsive traffic system.*

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**BIOGRAPHIES (Not Essential)**

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| STUDENT<br>ARAVINTHKUMAR A<br>aravindkumarit2021@jerusalemengg.ac.in | I am Aravinthkumar, a final-year B.Tech Information Technology student at Jerusalem College of Engineering. As part of my final-year project, I am working on a system titled Real-Time Emergency Vehicle Detection Using Machine Learning. This project leverages advanced algorithms to detect emergency vehicles in traffic, aiming to enhance response times and improve urban traffic management. The solution contributes to smart city initiatives by enabling the efficient and automated prioritization of emergency vehicles. |
| STUDENT<br>MUGIBALAN T<br>mugibalanit2021@jerusalemengg.ac.in | Mugibalan is a final-year B.Tech Information Technology student at Jerusalem College of Engineering. For his final-year project, he is developing a system titled *"Real-Time Emergency Vehicle Detection Using Machine Learning."* This innovative project focuses on identifying emergency vehicles in traffic using advanced algorithms to support faster response times and improve traffic flow. His work contributes to smart city development by enabling automated and efficient emergency vehicle prioritization<br>And function. |
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| AUTHOR 2<br>SHANMUGAPRIYA K<br>shanmugapriya.it@jerusalemengg.ac.in | Shanmugapriya is an Assistant Professor in the Department of Information Technology at Jerusalem College of Engineering. She guides and mentors students in advanced technologies, fostering innovation and research. Currently, she is supervising a final-year project titled Real-Time Emergency Vehicle Detection Using Machine Learning, which aims to enhance emergency response systems through intelligent traffic monitoring. Her expertise and guidance play a crucial role in shaping impactful, real-world solutions. |