IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14664

SMART TRAFFIC SYSTEM – Life Saving Traffic Management Using AI

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Abstract: The increasing sophistication of urban roadways necessitates innovative approaches to tackle traffic congestion, enhance public safety, and streamline emergency interventions. This project introduces a YOLOv8-powered intelligent traffic system specifically engineered to identify emergency vehicles (like ambulances and fire trucks) for priority lane access. Crucially, it also features accident detection and immediate alert capabilities.

Keywords: Research Paper, Technical Writing, Science, Engineering and Technology

I. INTRODUCTION

Urbanization in the 21st century has dramatically intensified traffic congestion, extended travel durations, and heightened the risk of road accidents. The growing number of vehicles on the roads, coupled with outdated static traffic management systems, has rendered conventional methods ineffective in ensuring timely emergency responses and maintaining road safety. Emergency vehicles such as ambulances and fire trucks frequently face delays due to congested intersections, potentially endangering lives during critical situations. Traditional traffic systems lack the intelligence to prioritize emergency vehicles or detect accidents in real time. This shortfall not only delays emergency medical aid during the vital golden hour but also contributes to increased fatalities and secondary accidents. Therefore, there is an urgent need for intelligent, adaptive traffic management solutions capable of dynamically responding to such critical events. Recent advancements in artificial intelligence (AI) and computer vision have opened promising avenues for real-time traffic monitoring and response systems. In particular, deep learning-based models like YOLOv8 (You Only Look Once, Version 8) have shown significant potential in object detection tasks due to their high speed and accuracy. These models can effectively identify emergency vehicles in complex urban traffic and detect anomalies indicative of accidents. This project proposes a smart traffic management system that leverages YOLOv8 for emergency vehicle detection and accident recognition. By processing real-time video feeds from traffic cameras, the system can dynamically adjust traffic signals to create clear paths for emergency vehicles and immediately alert authorities in the event of an accident. The integration of machine learning, Internet of Things (IoT), and real-time analytics ensures a responsive and efficient urban mobility framework. The overarching goal is to enhance public safety, optimize emergency response times, and reduce urban traffic congestion. By deploying such AI-driven systems, cities can transition towards smarter, more sustainable, and life-saving traffic infrastructures.

II. METHODOLOGY

Live Webcam Feed: The system uses a real-time webcam to capture continuous video footage of the road network.

Pre-processing: The captured video feed is pre-processed to enhance clarity and remove noise, ensuring accurate object detection.

YOLOv8 Object Detection: YOLOv8 (You Only Look Once) deep learning model is applied to detect emergency vehicles, such as ambulances and fire trucks, by analysing the pre-processed feed.

Accident Detection: Anomaly detection algorithms are employed to identify unusual movements or patterns in vehicle behaviour, such as sudden stops, collisions, or erratic motions, indicating an accident.

Traffic Signal Control: Upon detecting an emergency vehicle or an accident, the system dynamically adjusts traffic signals to prioritize the passage of emergency vehicles and clear the path for rapid response.

Emergency Alert System: Once an accident is detected or an emergency vehicle is identified, an alert is sent to the relevant emergency services to ensure a swift response.

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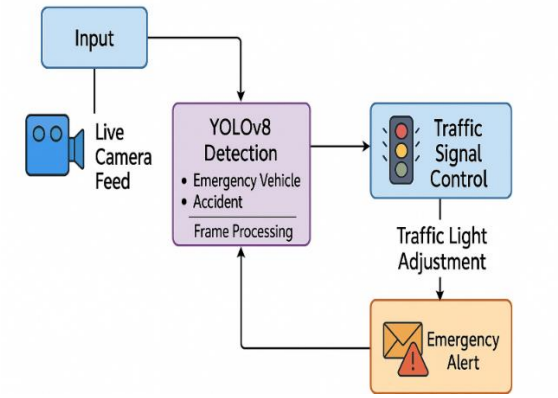

Fig 1: block diagram of smart traffic system

III. OBJECTIVES

The primary objective of this project is to develop an intelligent traffic management system that prioritizes life-saving measures through real-time emergency vehicle (EV) detection and accident alert mechanisms. The system aims to leverage advanced AI and computer vision techniques to identify emergency vehicles and dynamically adjust traffic signals, ensuring their uninterrupted passage. It will also detect traffic accidents promptly, triggering instant alerts to emergency services to expedite response during the critical golden hour. By integrating these functionalities, the solution seeks to enhance public safety, minimize response delays, and reduce traffic congestion. This approach not only optimizes urban mobility but also contributes to saving lives by streamlining emergency operations and ensuring swift assistance in critical situations.

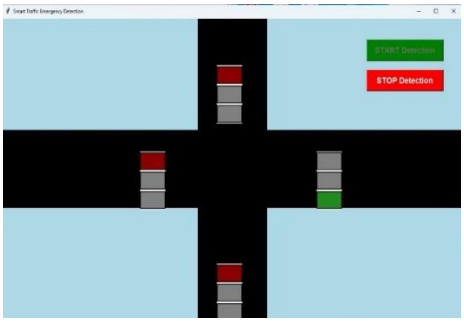

Fig 2: traffic signal looping at fixed time durations(5sec) instance from one signal to another signal.

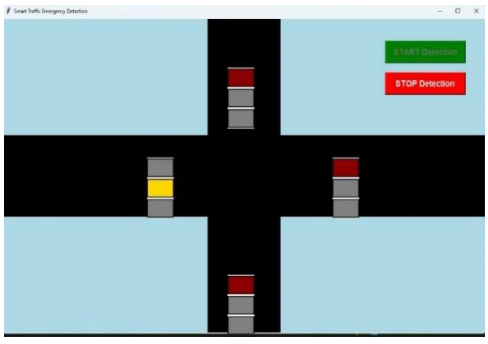

Fig 3: Similar mechanism as Fig 2.

HARDWARE REQUIREMENT:

I5 processor: It is a mid-range Intel CPU that balances performance and Efficiency for computing tasks. 8GB RAM: Allows smooth multitasking and supports moderate to heavy applications.

SOFTWARE REQUIREMENT:

Python IDLE (Integrated Development and Learning Environment) is a simple editor for writing, debugging, and running Python programs. It includes a built-in interpreter and syntax highlighting for easier coding.

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OpenCV is an opensource library tool of different programming functions mainly aimed at real-time computer vision. OpenCV runs on various platforms like Windows, Linux, MacOS, OpenBSD, IOS and Blackberry. It is used in the diverse purpose for facial recognition, gesture recognition, object identification, mobile robotics, segmentation, etc.

Twilio is a cloud communications platform that enables developers to build and integrate various communication functionalities into their applications. These include SMS, voice calls, video, email, and other messaging services through APIs.

Tkinter is the standard GUI (Graphical User Interface) library in Python, providing a simple way to create desktop applications. It is built on the Tcl/Tk GUI toolkit and comes pre-installed with Python on most distributions, making it a convenient option for building lightweight GUI applications.

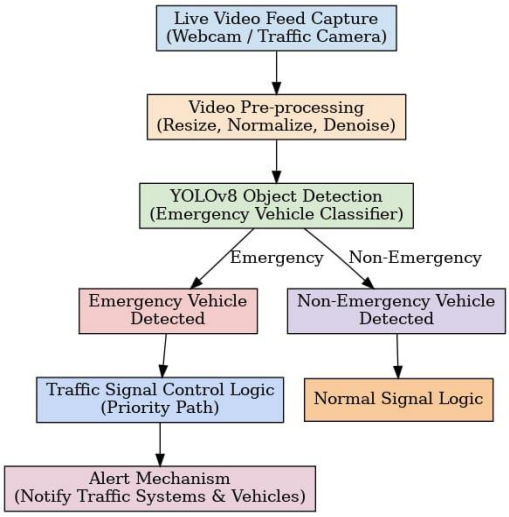

Fig 4: flow chart architecture of emergency vehicle detection.

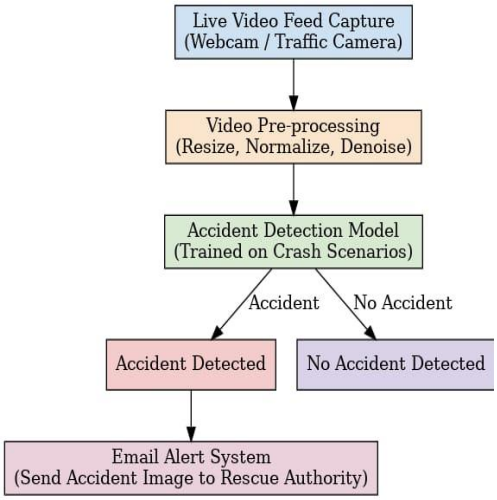

Fig 5: flow chart architecture of accident detection model.

IV. RESULTS AN DISCUSSION

The system uses computer vision to manage traffic in real time. This is the foundation of the system's intelligence. Computer vision involves training computers to "see" and interpret images or videos, much like humans do. In this context, the system uses computer vision algorithms to analyze the live video feed from cameras and extract meaningful information about the traffic scene. This analysis happens continuously and in real-time, enabling the system to react instantly to changing traffic conditions.

It captures live video from a webcam. For development and testing, a webcam serves as a convenient and cost-effective way to simulate a traffic camera. The webcam captures a continuous stream of images, which are then fed into the system for processing.

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It's important to remember that in a real-world deployment, the webcam would be replaced by more robust and strategically positioned traffic cameras designed for outdoor use and continuous operation. "YOLOv8, accessed through the Roboflow API, detects emergency vehicles and accidents." YOLOv8 is a cutting-edge object detection model. "YOLO" stands for "You Only Look Once," which signifies that the algorithm processes the entire image in a single pass, making it very fast and efficient. Object detection models are trained on vast datasets of images to identify specific objects within a scene. In this case, YOLOv8 is trained to recognize emergency vehicles (ambulances, police cars, fire trucks) and indicators of traffic accidents. Roboflow provides an API (Application Programming Interface) that allows the system to easily access and use the YOLOv8 model without needing to handle the complex computations locally. The system sends video frames to the Roboflow API, and the API returns the locations and types of detected objects.The system uses separate model IDs for emergency vehicle and accident detection. This suggests a design choice to optimize performance and accuracy. Having separate model IDs could mean: Two different YOLOv8 models are used: one specifically trained to excel at emergency vehicle detection and the other at accident detection.

This specialization can lead to higher accuracy for each task. The same YOLOv8 model is used with different configurations or settings for each task. This allows fine-tuning the model's parameters to achieve the best results for each type of detection. By separating the detection tasks, the system can potentially improve its ability to distinguish between emergency vehicles and other vehicles, as well as accurately identify accident scenarios. Detected emergencies trigger traffic lights to turn green in the direction needed. This is a core function of the system: dynamic traffic light control. When YOLOv8 detects an emergency vehicle, the system calculates the direction the vehicle is traveling. It then sends a signal to the traffic light controller to change the lights to green in that direction, providing a clear path for the emergency vehicle to proceed through the intersection. This is crucial for safety. Simultaneously with turning the light green in the emergency vehicle's path, the system turns the lights red in all other directions.

This prevents other vehicles from entering the intersection and ensures the emergency vehicle can pass through without obstruction or the risk of collision. An alert sound is played (buzzer) when an emergency is detected. This provides an immediate, audible notification of a detected event. This sound alert can serve several purposes: Alerting traffic operators in a control room. Notifying personnel near the intersection. Drawing attention to the event .This feature enhances communication and provides valuable information to emergency responders or traffic management centers. The system automatically generates and sends an EMAIL containing: A timestamp of the event. An image captured from the video feed, showing the emergency vehicle or the accident scene.

This visual information helps authorities quickly assess the situation, determine the appropriate response, and allocate resources effectively. A GUI simulates a crossroad with traffic signals. The Graphical User Interface (GUI) provides a visual representation of the traffic intersection and the system's operation. This simulation is useful for: Development and testing: It allows developers to visualize and debug the system's behavior. Monitoring: In a real-world setting, it would allow traffic operators to monitor the system's performance and intervene if necessary. The GUI includes control elements that allow users to: Start and stop the detection and traffic management processes. The GUI also provides real-time feedback by visually updating the state of the traffic lights (green, yellow, red) to reflect the system's actions.

Fig 6: Ambulance or any emergency vehicle being detected by YOLOV8 tool at 0.94 accuracy.

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Fig 7: Accident being detected by YOLOV8 tool at 0.80 accuracy.

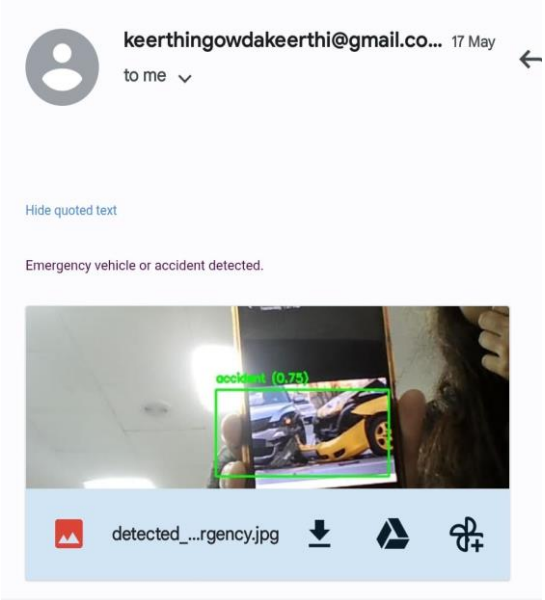

Fig 8: email sent to the authorised user as soon as Ambulance or any emergency vehicle or any accidents being detected by YOLOV8 tool.

V. ADVANTAGES

The proposed AI-driven intelligent traffic management system offers numerous advantages that significantly enhance urban mobility and public safety. By leveraging YOLOv8 for real-time detection, the system ensures prompt identification and prioritization of emergency vehicles, facilitating faster clearance through traffic signals and reducing critical delays during emergencies. This leads to substantial improvements in emergency response times, which can be life-saving in scenarios involving ambulances or fire services. Furthermore, the integration of anomaly detection allows for the early identification of accidents, enabling immediate alerting of authorities and minimizing the impact of road incidents. The system also contributes to reducing traffic congestion by dynamically controlling signals based on real-time inputs, thus improving overall traffic flow. With automated alerts, enhanced situational awareness, and a responsive control mechanism, the solution promotes safer roads, lowers carbon emissions due to decreased idling, and sets the foundation for smarter, more sustainable cities.

VI. CONCLUSION AND FUTURE SCOPE

The development of an AI-powered intelligent traffic management system marks a significant advancement in enhancing road safety and urban mobility. By employing YOLOv8 for real-time detection of emergency vehicles and traffic accidents, the system effectively reduces emergency response times and mitigates the impact of road incidents.

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Its ability to dynamically control traffic signals based on live data ensures smoother traffic flow, decreased congestion, and improved efficiency across the transportation network. Through automated alerts and responsive decision-making, the solution not only saves lives but also lays the foundation for future smart city innovations. Overall, this project demonstrates how integrating artificial intelligence and computer vision technologies can transform traditional traffic systems into proactive, life-saving infrastructures.

The intelligent traffic management system encompasses a range of features designed to enhance emergency responsiveness and road safety. Key features include real-time emergency vehicle detection using the YOLOv8 deep learning model, which identifies ambulances, fire trucks, and police cars with high accuracy. The system also provides dynamic traffic signal control, automatically adjusting signals to prioritize the movement of emergency vehicles. Another critical feature is accident detection, which utilizes anomaly recognition algorithms to identify collisions or unusual vehicle behavior and trigger instant alerts. The automated alert system notifies relevant authorities via email with image evidence for prompt action. Additionally, the system integrates a graphical user interface (GUI) that simulates a crossroad with real-time signal status and detection controls. These features work together to create a responsive, data-driven traffic control solution suited for deployment in smart city environments.

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