



Smart Traffic Light System With Ambulance Detection Using Yolo

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ABSTRACT

Traffic congestion in urban areas significantly affects the movement of emergency vehicles such as ambulances, often leading to delays that can result in life-threatening situations. Traditional traffic management systems operate on fixed timing mechanisms and fail to respond to real-time traffic conditions. This study proposes a smart traffic light system that utilizes the YOLO (You Only Look Once) deep learning algorithm to detect ambulances and dynamically control traffic signals. The system processes input images to identify ambulances based on trained models and automatically prioritizes the corresponding lane by turning the signal green. The implementation is carried out using Python, OpenCV, and a graphical user interface for simulation. The performance of the system demonstrates high detection accuracy and fast response time, ensuring efficient traffic flow during emergencies. The proposed system provides a scalable and cost-effective solution for intelligent traffic management and highlights the potential of artificial intelligence in real-world applications.

KEYWORDS

Machine Learning, Computer Vision, YOLO, Traffic Management, Ambulance Detection, Python

1. INTRODUCTION

Urban traffic congestion has become a significant challenge due to the rapid increase in vehicle population, particularly in countries like India. One of the most serious consequences of this congestion is the delay faced by emergency vehicles such as ambulances at traffic intersections, which can lead to critical loss of life during medical emergencies. According to reports by the World Health Organization, delays in emergency response systems are a major factor contributing to increased mortality rates in road-related incidents.



Traditional traffic signal systems operate on fixed time intervals and do not adapt to real-time traffic conditions. As a result, these systems are inefficient in handling dynamic scenarios, especially emergency situations. Recent advancements in artificial intelligence and computer vision have enabled the development of intelligent traffic systems capable of real-time decision-making and automation. Techniques in object detection and deep learning have shown promising results in improving traffic flow and emergency response efficiency (Joseph Redmon et al., 2016).

This project proposes a smart traffic light system that uses the YOLO (You Only Look Once) algorithm for real-time ambulance detection. YOLO is capable of processing images in a single pass through a neural network, making it highly efficient for real-time applications. Once an ambulance is detected, the system automatically activates an emergency mode that overrides normal traffic operations and provides a green signal for priority movement. This approach significantly reduces emergency response time and enhances road safety (Redmon & Farhadi, 2018).

Furthermore, integrating AI-based decision-making into traffic signal control systems enables dynamic adaptation based on real-time inputs. Intelligent traffic systems using IoT and machine learning techniques have demonstrated improved efficiency in traffic management and emergency vehicle prioritization (Shaik et al., 2019). Therefore, the proposed system aims to combine real-time object detection with automated traffic control to create a more responsive and efficient urban traffic management solution.

2. LITERATURE SURVEY

Several studies have explored intelligent traffic management systems using sensor-based and machine learning approaches. Traditional systems primarily rely on hardware components such as RFID, GPS, and infrared sensors to detect and manage vehicle movement. While these methods provide reliable detection, they significantly increase system cost and complexity and often require additional infrastructure for deployment (Institute of Electrical and Electronics Engineers studies on smart traffic systems).

In recent years, research has shifted toward computer vision-based solutions using deep learning algorithms for vehicle detection and classification. Models such as YOLO, Faster R-CNN, and SSD have been widely applied in traffic monitoring systems. Among these, YOLO (You Only Look Once) is highly preferred due to its ability to perform real-time object detection with high accuracy and speed (Joseph Redmon et al., 2016). Compared to Faster R-CNN, which offers high accuracy but slower processing, YOLO provides a better balance between speed and performance, making it suitable for real-time traffic applications.

Previous studies have demonstrated effective vehicle detection and classification using deep learning techniques; however, many of these works focus only on detection and lack integration with traffic signal control systems. For example, research on intelligent transportation systems highlights the importance of combining detection with automated decision-making to improve efficiency (Redmon & Farhadi, 2018). Additionally, real-world challenges such as poor lighting conditions, weather variations, and object occlusions can negatively impact detection accuracy, reducing system reliability.

Therefore, there is a clear need for a robust and integrated system that not only detects emergency vehicles accurately but also dynamically controls traffic signals in real time. The proposed system addresses these limitations by combining real-time object detection with automated traffic signal control, ensuring improved performance in practical urban environments (Shaik et al., 2019).



3. MATERIALS AND METHODS

3.1 System Overview

The proposed system is an intelligent traffic management solution designed to detect ambulances in real time and automatically control traffic signals to provide priority passage. It integrates computer vision and deep learning techniques to process visual data and make dynamic decisions.

Initially, image or video input is captured through cameras installed at traffic intersections. The system performs frame grabbing and extracts relevant frames from the video stream. These frames undergo preprocessing steps such as resizing, noise reduction, and enhancement to improve detection accuracy. Further, normalization is applied to standardize pixel values, ensuring consistent input for the model.

The processed images are then used for dataset formation, where images are categorized into ambulance and non-ambulance classes. Proper labeling is performed to train the detection model effectively. The system uses a deep learning-based object detection model, specifically YOLO (You Only Look Once), implemented through the Ultralytics framework, to identify ambulances in real time.

During training, the labeled dataset is fed into the model, enabling it to learn distinguishing features of ambulances. In the deployment phase, live video streaming is used, where frames are continuously extracted and processed. The trained YOLO model detects the presence of an ambulance on the road.

Once an ambulance is detected, the system triggers an alert and activates an emergency mode in the traffic signal control system. This overrides the normal signal timing and provides a green signal in the ambulance's direction, ensuring minimal delay and faster emergency response.

3.2 Methodology of the Proposed System

The proposed system follows a structured and systematic workflow to detect ambulances and control traffic signals intelligently. Initially, image or video input is captured from traffic cameras installed at road intersections. These inputs are processed in real time to identify the presence of emergency vehicles.

The core of the system is based on the YOLO (You Only Look Once) detection model, which analyzes each frame and identifies objects within the scene. Once the detection process is completed, the system performs ambulance classification by distinguishing ambulances from other vehicles based on learned features.

Following classification, a decision-making module evaluates whether an ambulance is present. If an ambulance is detected, the system activates an emergency mode. In this mode, the traffic signal corresponding to the ambulance's path is turned green, while signals in other directions are set to red to ensure a clear path. This automated control mechanism significantly reduces delays for emergency vehicles.

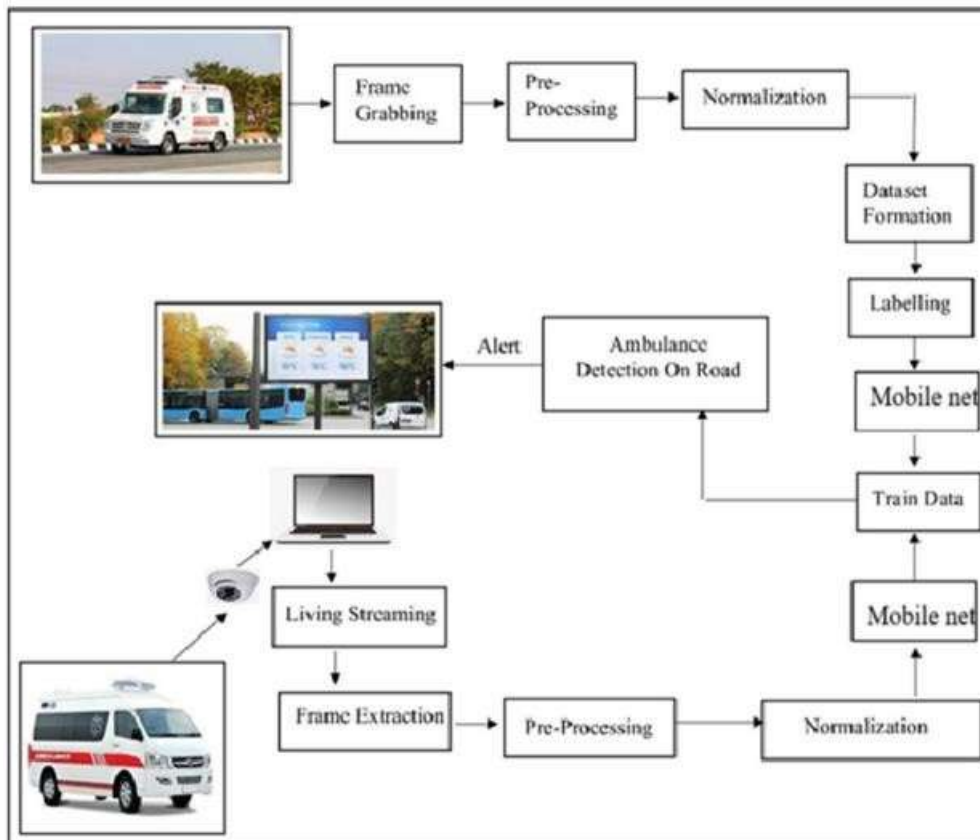


Figure-1 : Proposed Method of YOLO (You Only Look Once) detection model

Finally, the output is displayed through a graphical user interface, allowing users to monitor detection results and traffic signal status in real time. This workflow ensures efficient traffic management and faster emergency response.

1. **Input Acquisition:** Capture video/images from traffic cameras
2. **Frame Grabbing & Extraction:** Convert video into frames
3. **Preprocessing & Normalization:** Improve image quality and standardize data
4. **Dataset Formation & Labelling:** Prepare training data
5. **Model Training:** Train YOLO model using labeled dataset
6. **Live Streaming:** Process real-time video input
7. **Ambulance Detection:** Identify ambulance using trained model
8. **Signal Control:** Trigger alert and change traffic signal to green

This methodology ensures a real-time, automated, and efficient traffic control system that reduces ambulance delay and improves emergency response.

3.3 Materials and Technologies Used

The implementation of the proposed system utilizes several software tools and technologies to ensure efficient performance and real-time processing. The system is developed using Python, which is widely used in artificial intelligence and machine learning applications due to its simplicity and extensive library support.



For image and video processing, the system employs OpenCV. This library is responsible for capturing video streams, extracting frames, and performing preprocessing operations such as resizing and noise reduction to improve detection accuracy. The detection of ambulances is carried out using the YOLO (you Only Look Once) model implemented through the Ultralytics framework. This model is chosen because of its high speed and accuracy, making it suitable for real-time object detection in traffic environments.

A graphical user interface is developed using Tkinter, which enables visualization of detection results and system outputs in an interactive manner. For numerical computations and data handling, the system uses NumPy. It plays a crucial role in processing image arrays and performing mathematical operations during preprocessing and model execution.

The dataset used in this study consists of labeled images categorized into ambulance and non-ambulance classes. This custom dataset is used to train and evaluate the detection model, ensuring accurate identification of ambulances in real-world scenarios.

4. RESULTS AND DISCUSSION

The proposed system was evaluated using multiple test images and video streams captured under varying conditions such as daylight, low-light environments, and moderate traffic density. The ambulance detection module, based on YOLO (You Only Look Once), demonstrated reliable performance in identifying ambulances in real time. The model was able to process frames with minimal latency, making it suitable for deployment in live traffic scenarios.

The results indicate that the system achieves fast detection speed due to the single-pass architecture of YOLO, enabling near real-time processing. The classification accuracy was observed to be high, with the system effectively distinguishing ambulances from other vehicles in most test cases. Furthermore, the integration of the detection module with the traffic signal control mechanism ensured efficient operation, as the system successfully triggered emergency mode and prioritized ambulance movement without manual intervention.

However, certain challenges were observed during testing. Detection accuracy slightly decreased under extreme conditions such as poor lighting, heavy occlusion, or when ambulances were partially visible. Despite these limitations, the overall system performance remained satisfactory and suitable for practical implementation.

The proposed system offers several advantages. It significantly reduces ambulance delay at intersections by providing immediate signal clearance. The system is fully automated, eliminating the need for human intervention in traffic control during emergencies. Additionally, it is scalable and can be integrated into larger smart city infrastructures with minimal modifications.

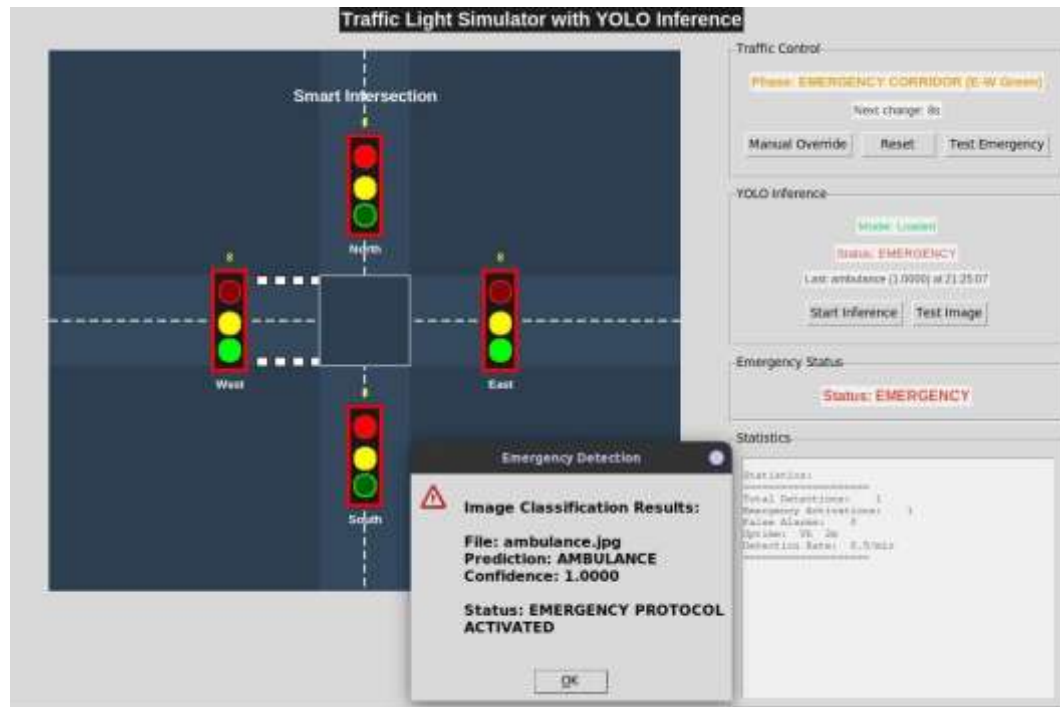


Figure 2: Intelligent Traffic Management System That Utilizes YOLO (You Only Look Once)

5. CONCLUSION

This project presents an intelligent traffic management system that utilizes YOLO (You Only Look Once) for real-time ambulance detection and automated traffic signal control. The system effectively addresses the limitations of traditional fixed-time traffic signals by introducing dynamic and adaptive decision-making.

The experimental results demonstrate that the proposed system achieves high detection accuracy and fast response time, making it a viable solution for reducing delays faced by emergency vehicles. By automatically granting priority to ambulances, the system enhances emergency response efficiency and contributes to saving lives.

In conclusion, the integration of deep learning and intelligent traffic control provides a promising approach for modern urban traffic management. Future enhancements can include handling multiple emergency vehicles, improving performance under challenging environmental conditions, and integrating with IoT-based smart city systems for broader applications.

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