iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** III **Month of publication:** March 2026

DOI: https://doi.org/10.22214/ijraset.2026.78803

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue III Mar 2026- Available at www.ijraset.com

AI-Based Smart Traffic Management System with Mobile Notification

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Abstract: ***Traffic congestion is one of the most critical challenges faced by modern urban environments, leading to increased travel time, fuel consumption, environmental pollution, and economic loss. Conventional traffic signal systems operate on fixed time intervals without considering real-time traffic conditions, which results in inefficient utilization of road infrastructure.***
To overcome these limitations, this paper proposes an AI-based smart traffic management system that utilizes computer vision and deep learning techniques for real-time traffic monitoring and intelligent signal control. A camera captures continuous traffic video, which is processed using OpenCV [14] and analyzed using the YOLO (You Only Look Once) object detection model [1], [2] to detect and count vehicles. Based on vehicle density in each lane, the system dynamically adjusts traffic signal timings to optimize traffic flow. Additionally, emergency vehicles such as ambulances and fire trucks are detected and given immediate priority to ensure faster movement. The system also integrates the Telegram Bot API [13] to send real-time mobile notifications regarding traffic congestion and emergency situations. Experimental results demonstrate improved efficiency, reduced waiting time, and better traffic management. The proposed system provides a scalable, intelligent, and cost-effective solution for smart cities.

I. INTRODUCTION

Traffic congestion has become a major issue in urban areas due to rapid population growth and increasing vehicle usage. In cities like Chennai, traffic congestion not only affects daily commuting but also leads to increased fuel consumption, air pollution, and delays in emergency services.

Traditional traffic signal systems operate using fixed timers, which are not efficient in handling varying traffic conditions. These systems do not adapt to real-time traffic density, resulting in longer waiting times and inefficient traffic flow.

Recent advancements in Artificial Intelligence (AI) and computer vision have enabled the development of intelligent traffic management systems. Deep learning models such as YOLO [1], [2] and Faster R-CNN [5] can detect objects in real time with high accuracy. These technologies allow automated traffic monitoring and decision-making.

Moreover, IoT-based systems enable communication between devices and remote monitoring [12]. By integrating AI with IoT, traffic systems can become more efficient, adaptive, and user-friendly.

This paper proposes an AI-based smart traffic management system that dynamically controls traffic signals based on real-time vehicle detection and provides mobile notifications for monitoring and decision-making.

II. LITERATURE REVIEW

Traffic management has evolved significantly over the years. Traditional systems rely on fixed-time signals and basic sensors, which lack adaptability and intelligence.

Recent research has focused on AI-based traffic systems using deep learning models such as YOLO [1], [3], CNN [4], and Faster R-CNN [5]. YOLO is particularly effective for real-time detection due to its speed and accuracy. CNN models provide high performance in classification tasks [4].

Traffic flow prediction using deep learning techniques has also gained importance. Studies show that deep learning models can effectively predict traffic patterns and improve signal control [8], [9].

IoT-based traffic systems allow real-time data collection and communication between devices [12]. These systems enable remote monitoring and automation, improving efficiency.

However, many existing systems lack features such as real-time mobile alerts and emergency vehicle prioritization. This paper addresses these gaps by integrating AI detection, IoT communication, and Telegram notifications [13].

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III. METHODOLOGY

The proposed system follows a structured approach consisting of multiple stages:

Initially, a camera captures real-time video from a traffic intersection. The captured frames are processed using OpenCV [14], where preprocessing techniques such as noise reduction, resizing, and normalization are applied.

The processed frames are then passed to the YOLO model [1], [2], which detects vehicles and generates bounding boxes with confidence scores. The system identifies different types of vehicles such as cars, buses, trucks, and motorcycles.

Table 1: Vehicle Detection and Priority Levels

Vehicle Type	Detection Accuracy	Priority
Car	High	Medium
Bus	High	High
Truck	High	High
Motorcycle	Medium	Low
Ambulance	Very High	Emergency

The system counts vehicles in each lane and calculates traffic density. Based on this density, signal timings are dynamically adjusted. Lanes with higher traffic density receive longer green signals. Emergency vehicles are detected separately and given highest priority. When detected, the system immediately switches the signal to green for that lane.

IV. SYSTEM ARCHITECTURE

The system consists of the following modules:

1) Video Capture Module
2) Vehicle Detection Module
3) Traffic Analysis Module
4) Signal Control Module
5) Notification Module

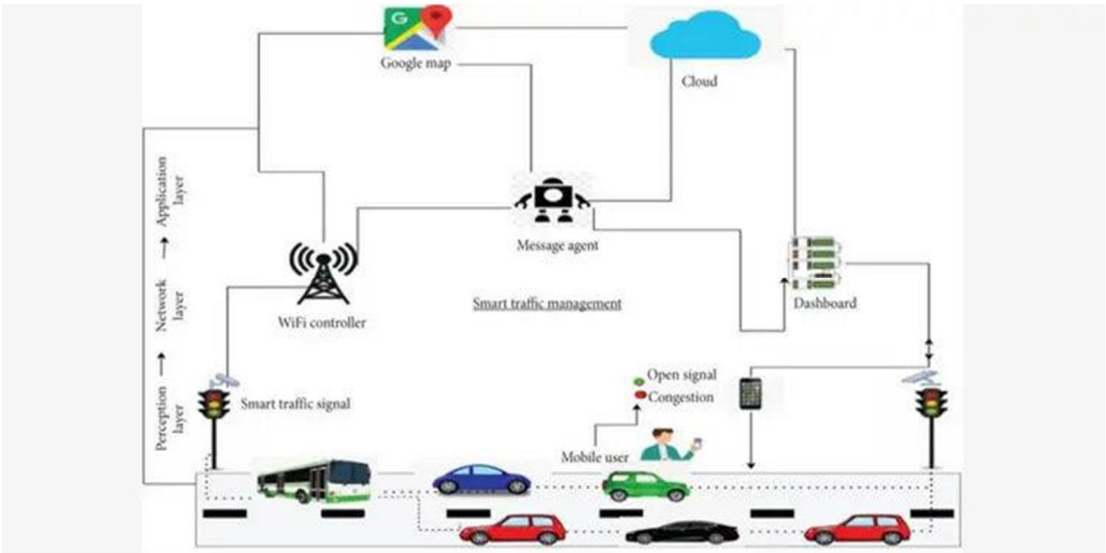
The camera captures traffic data and sends it to the processing unit. The AI model processes the data and detects vehicles.

The traffic analysis module calculates vehicle density and determines congestion levels. The signal control module implemented using Arduino [16] or ESP32 [17], controls traffic lights dynamically.

The notification module uses Telegram Bot API [13] to send alerts.

Data Flow: Camera → AI Processing → Traffic Analysis → Signal Control → Notification

Figure 1: System Architecture of AI-Based Smart Traffic Management System



V. FLOWCHART OF THE SYSTEM

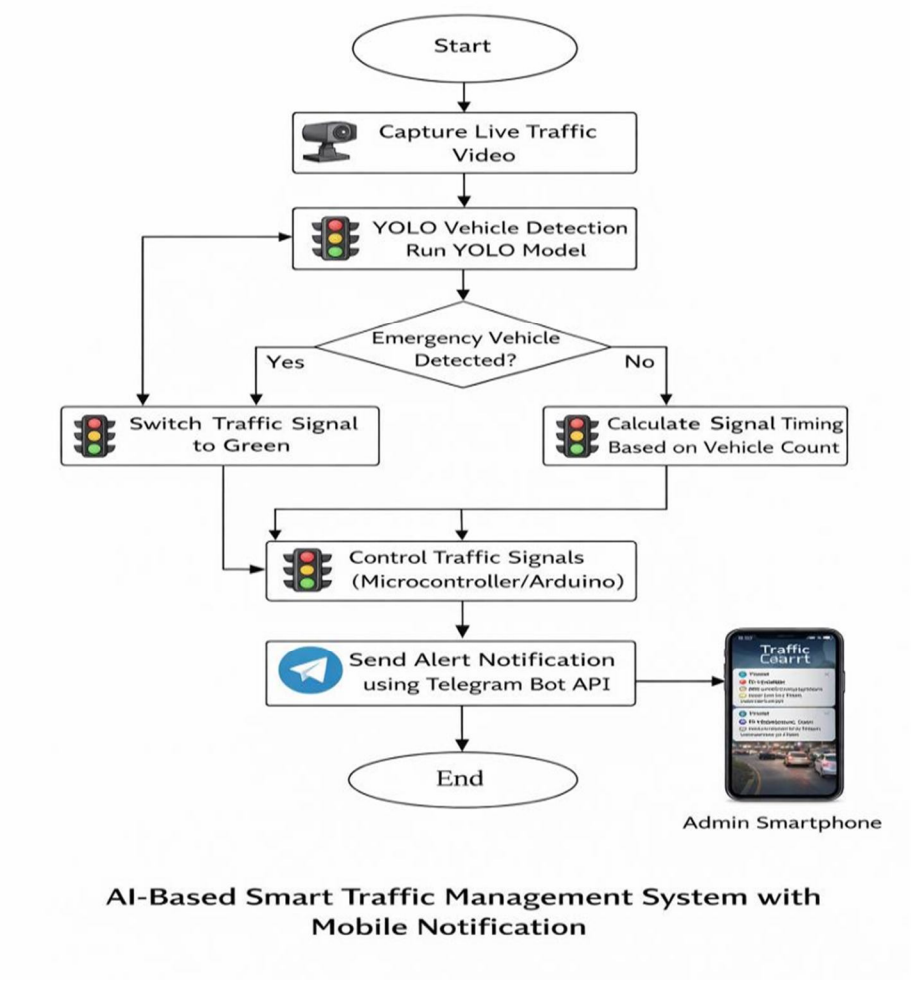
The working flow of the system is illustrated as follows:

Step 1: Start
Step 2: Capture live traffic video
Step 3: Preprocess frames using OpenCV
Step 4: Detect vehicles using YOLO
Step 5: Count vehicles in each lane
Step 6: Check for emergency vehicle

- If YES → Give green signal + send alert
- If NO → Continue normal process

Step 7: Analyze traffic density
Step 8: Adjust signal timing dynamically
Step 9: Send Telegram notification if congestion detected
Step 10: Repeat process

Figure 2: Flow Chart of AI-Based Smart Traffic Management System



VI. IMPLEMENTATION

The system is implemented using both hardware and software components.
Hardware includes camera, Raspberry Pi/laptop, Arduino [16]/ESP32 [17], LEDs, and internet connection.
Software includes Python, OpenCV [14], YOLO [3], Telegram API [13], and Arduino IDE.

Table 2: Sample Traffic Data

Lane	Vehicle Count	Traffic Level
Lane 1	10	Medium
Lane 2	20	High
Lane 3	5	Low
Lane 4	15	Medium

The system processes real-time video and sends results to the microcontroller for signal control. Telegram notifications are sent when congestion or emergencies are detected.

VII. RESULTS AND EVALUATION

The system is evaluated using performance metrics such as accuracy, precision, recall, and F1-score.

Table 3: Performance Metrics

Metric	Value (%)
Accuracy	92%
Precision	90%
Recall	91%
F1-Score	90.5%

Table 4: Traffic Improvement Analysis

Scenario	Before	After	Improvement
Peak Hour	120 sec	80 sec	33%
Normal	60 sec	40 sec	33%

The results show improved traffic flow and reduced waiting time.

VIII. DISCUSSION

The proposed system improves traffic efficiency using AI-based decision-making. Unlike traditional systems, it adapts dynamically to real-time traffic conditions. IoT integration enables remote monitoring [12], while Telegram notifications provide instant alerts [13]. Emergency vehicle prioritization improves safety and response time. Limitations include dependency on lighting conditions and camera quality. Despite these challenges, the system is effective and scalable.

IX. OUTPUT

Figure 3: Vehicle Detection Output



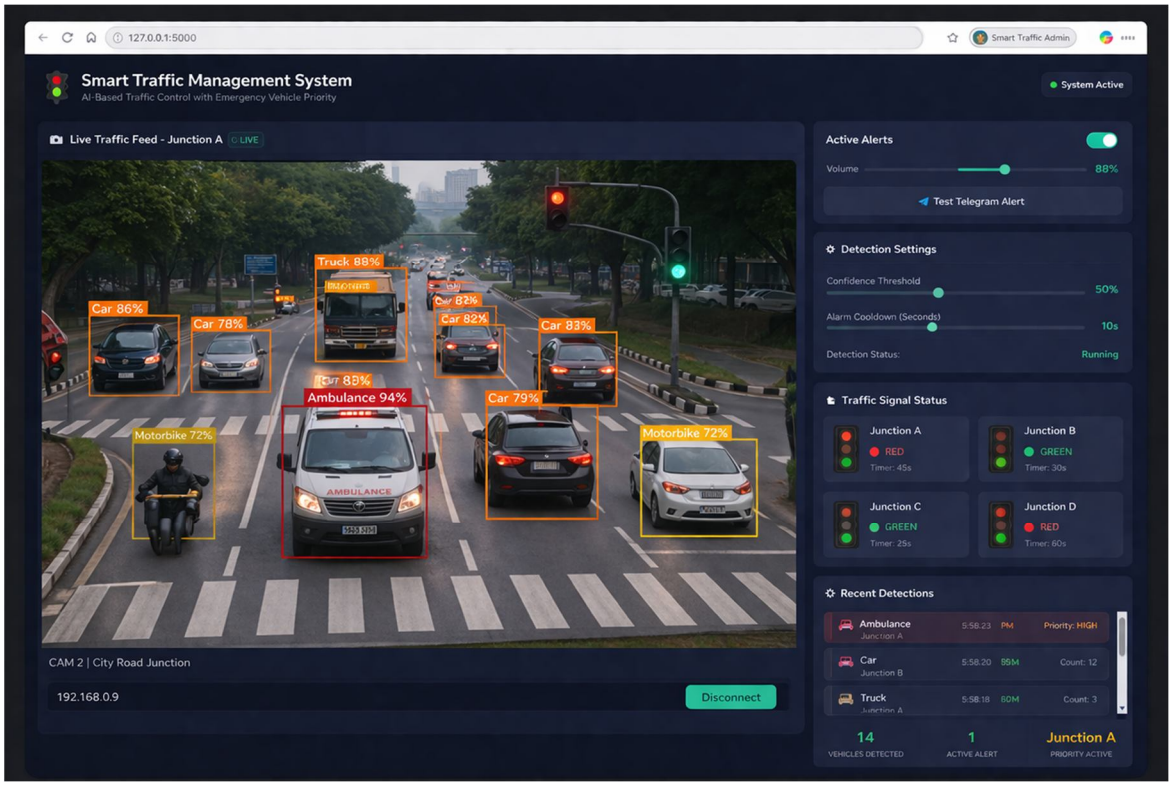
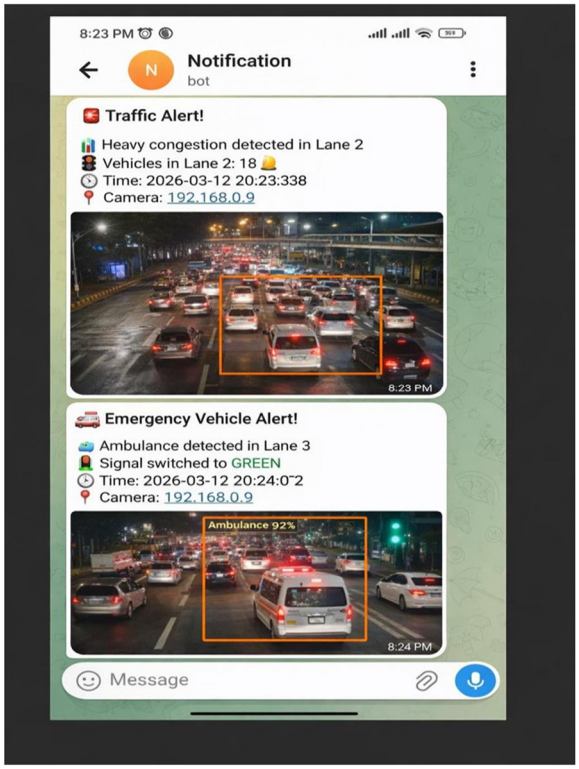


Figure 4: Telegram Notification Alert



X. CONCLUSION

The AI-based smart traffic management system provides an intelligent and efficient solution for modern traffic problems. By integrating AI, computer vision, and IoT, the system dynamically controls traffic signals and reduces congestion.

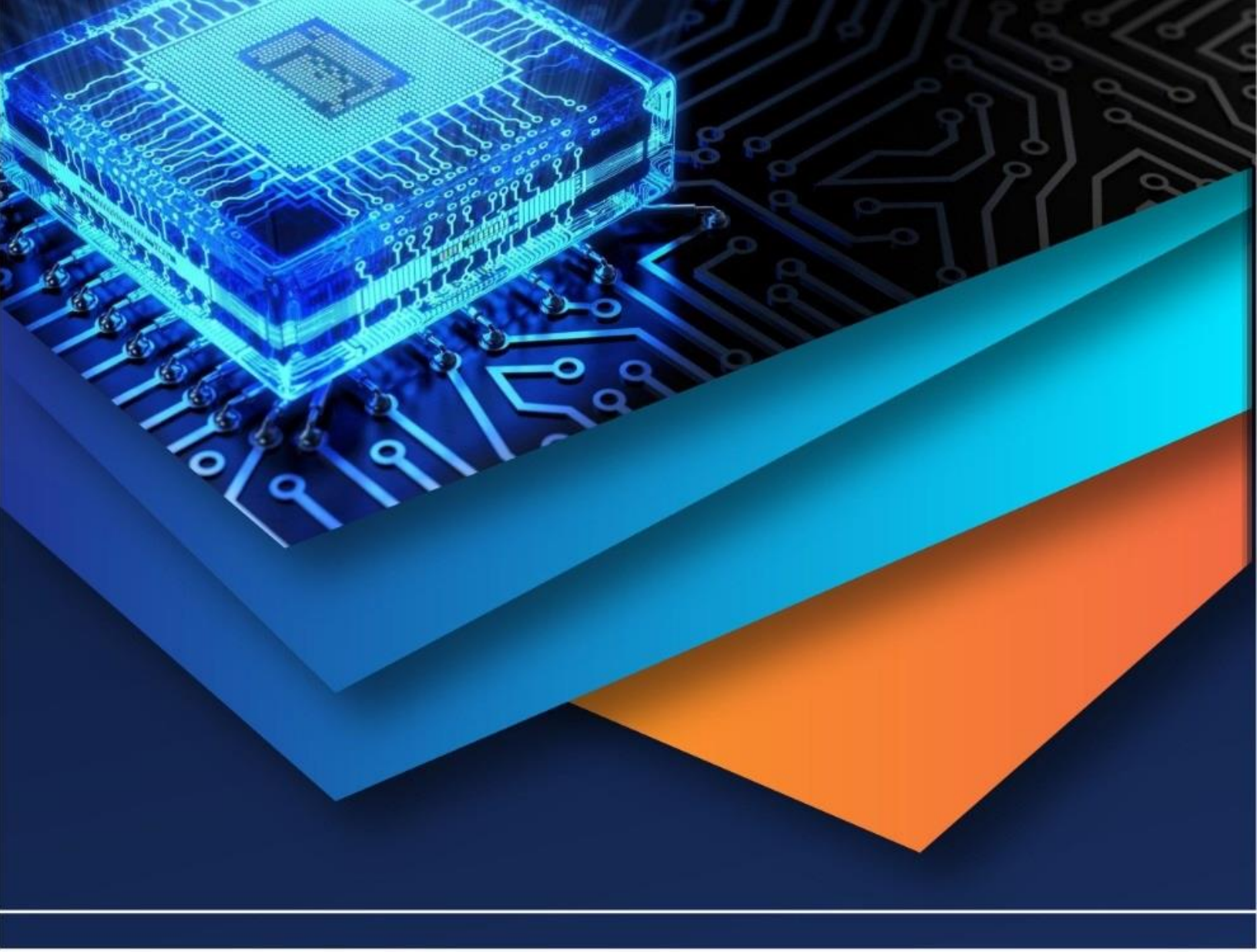
The system improves traffic flow, reduces waiting time, and enhances emergency response. It is scalable and suitable for smart city applications.

Future enhancements include cloud integration, predictive analytics, and mobile applications [20].

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