International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 03 , March - 2026

Smart Traffic Signal System using AI-Based Vehicle Detection and Emergency Prioritization

Abhinand Mohan ,Akash V, Asiya Shafi ,Farsana AS
Guided by Aleena B S
College of Engineering Attingal

Abstract - Urban traffic congestion and delayed emergency response are critical challenges in modern cities. Traditional traffic signal systems rely on fixed timing mechanisms, which are inefficient under dynamic traffic conditions. This paper presents an AI-based Smart Traffic Signal System that utilizes real-time vehicle detection using YOLO (You Only Look Once) and a decision engine to dynamically control traffic signals. The system prioritizes emergency vehicles such as ambulances through an override mechanism and optimizes traffic flow based on vehicle density. The implementation integrates computer vision, machine learning, and embedded systems using Arduino. Experimental results indicate improved traffic efficiency, reduced waiting time, and faster emergency vehicle clearance.

Keywords: Smart traffic system, YOLO, vehicle detection, ambulance prioritization, Arduino, AI traffic control

II. INTRODUCTION

Traffic congestion is a growing concern in urban areas, leading to increased travel time, fuel consumption, and environmental pollution. Conventional traffic signal systems operate on predefined time intervals without considering real-time traffic conditions. This results in inefficient utilization of road infrastructure and delays, especially during peak hours.

Recent advancements in artificial intelligence and computer vision have enabled the development of intelligent traffic management systems. Object detection models such as YOLO provide real-time detection capabilities, making them suitable for dynamic traffic analysis. By integrating AI with embedded systems, traffic signals can adapt based on vehicle density and prioritize emergency vehicles.

This paper proposes an intelligent traffic control system that uses YOLO-based detection and an Arduino-controlled signal system to improve traffic efficiency and emergency response.

III. LITERATURE SURVEY

Recent research in intelligent traffic systems has focused on AI-based vehicle detection and adaptive signal control. Deep learning models, especially convolutional neural networks (CNNs), have shown high accuracy in object detection tasks, enabling real-time traffic monitoring.

Studies on smart traffic management systems highlight the importance of dynamic signal timing to reduce congestion. Systems using machine learning algorithms can analyze traffic density and adjust signals accordingly. Additionally, research on emergency vehicle prioritization emphasizes the need for automated detection and signal override mechanisms to ensure faster response times.

However, many existing systems lack real-time adaptability, require expensive infrastructure, or do not effectively integrate emergency handling with traffic optimization. This motivates the development of a more efficient and scalable AI-based system.

IV. EXISTING SYSTEM

Traditional traffic signal systems operate on fixed timers regardless of traffic conditions. These systems have several limitations:

- Inefficient traffic flow during low or high density
- Increased waiting time at intersections
- No prioritization for emergency vehicles
- Lack of real-time decision-making

Some modern systems incorporate sensors or rule-based automation, but they still lack flexibility and scalability. AI-based approaches exist but often require high computational resources or complex infrastructure.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 03 , March - 2026

V. PROPOSED SYSTEM

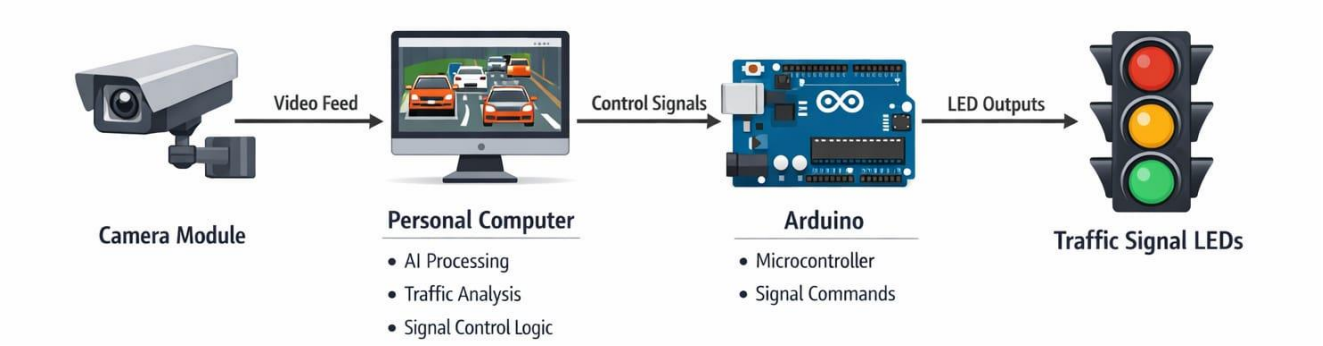

Fig 1 : Block Diagram Of Smart Traffic Signal System

The proposed system introduces an AI-driven traffic control mechanism with the following key features:

1.Real-time Vehicle Detection:
Uses YOLOv8 model to detect and count vehicles from video input.

2.Dynamic Signal Control:
Adjusts signal timing based on traffic density across multiple roads.

3.Ambulance Detection and Priority:
Detects emergency vehicles and overrides normal traffic logic.

4.Decision Engine:
Core module that determines signal changes based on predefined conditions.

5.Arduino-Based Signal Execution:
Encoded signals are sent to Arduino Nano to control physical traffic lights.

Advantages:

- ❖ Improved traffic efficiency
- ❖ Reduced congestion
- ❖ Faster emergency response
- ❖ Scalable and adaptable system

VI. IMPLEMENTATION

System Architecture

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 03 , March - 2026

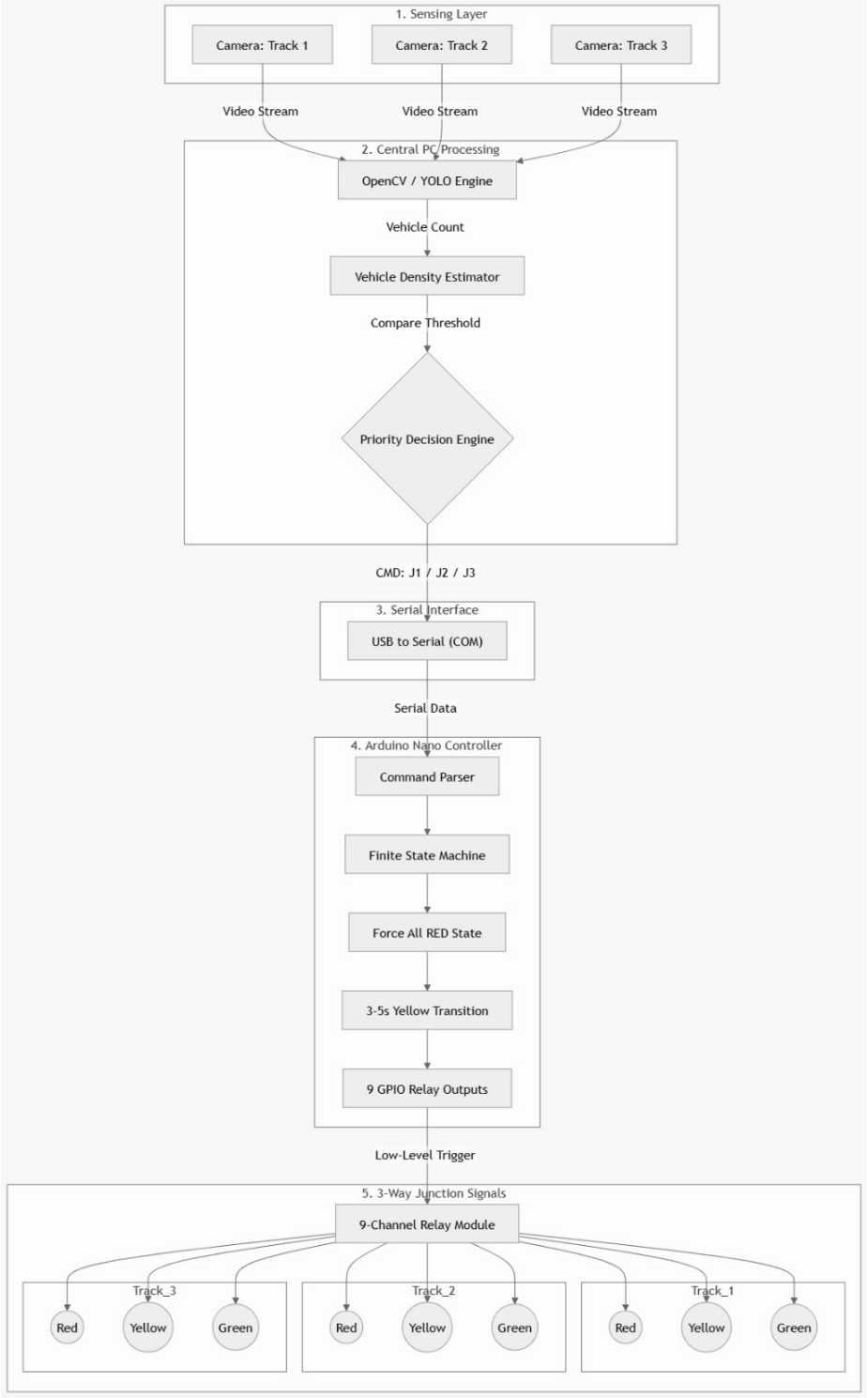

Fig 2: Architecture of Smart Traffic Signal System

The system follows this pipeline:

Input Video → YOLO Detection → Decision Engine → Signal Encoding → Arduino → Output Display

Modules

Module 1: Vehicle Detection

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 03 , March - 2026

Video frames are processed using YOLOv8 to detect vehicles such as cars, buses, and bikes. Detection is optimized by processing every nth frame to reduce computational load.

Module 2: Decision Engine

This is the core logic of the system. It determines signal allocation based on:

- Highest vehicle count
- Equal traffic (round-robin method)
- Low-density roads (shorter green time)
- Idle roads (minimum allocation)

Module 3: Ambulance Detection

A custom detection model identifies ambulances. When detected:

- Current signal → Yellow
- Ambulance road → Green
- Maintained for fixed duration (e.g., 40 seconds)
- System resumes normal operation

Module 4: Signal Encoding and Control

Signals are encoded as strings:

- G = Green
- Y = Yellow
- R = Red

Example: GRR, RGR

These signals are transmitted via serial communication using PySerial to the Arduino Nano.

Module 5: Hardware Interface

Arduino Nano controls LEDs representing traffic lights. It receives encoded signals and switches LEDs accordingly.

Module 6: Software Components

- Python
- OpenCV (image processing)
- NumPy (array operations)
- PyTorch (deep learning framework)
- YOLO (object detection)
- PySerial (communication with Arduino)

VII. RESULTS

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 03 , March - 2026

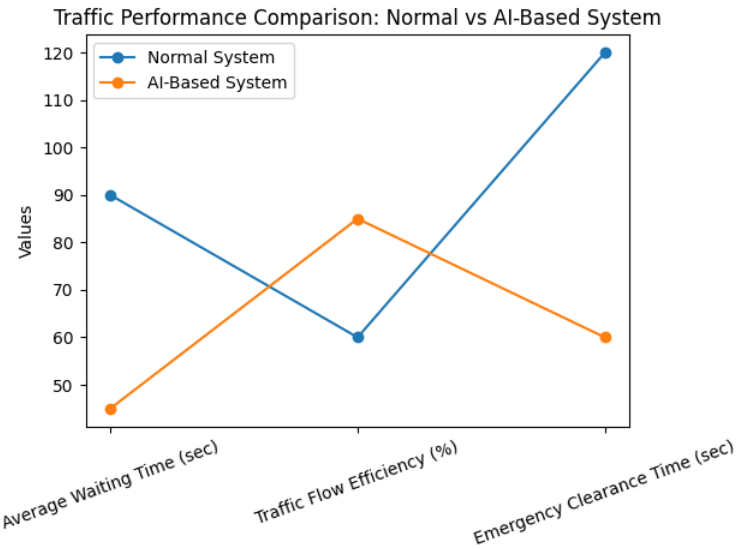

Fig 3:Traffic Performance Graph

The system was tested using recorded traffic video inputs. Observed outcomes include:

- ❖ Significant reduction in vehicle waiting time
- ❖ Efficient allocation of green signals
- ❖ Successful detection and prioritization of ambulances
- ❖ Smooth transition between signals using yellow phase

Compared to traditional systems, the AI-based model showed improved adaptability and responsiveness. However, performance depends on detection accuracy and hardware capabilities.

VIII. CONCLUSION

The proposed Smart Traffic Signal System demonstrates how artificial intelligence can enhance traffic management. By integrating YOLO-based vehicle detection with a decision engine and Arduino control, the system dynamically adjusts traffic signals and prioritizes emergency vehicles.

While the prototype shows promising results, challenges such as real-time deployment, model accuracy, and hardware constraints remain. Future improvements include integration with live CCTV feeds, cloud-based monitoring, and smart city infrastructure.

IX. REFERENCES

[1] S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 4th ed., Pearson, 2021.
[2] R. Sutton and A. Barto, Reinforcement Learning: An Introduction, 2nd ed., MIT Press, 2018.
[3] H. X. Liu, W. Ma, and X. Wu, “A survey of adaptive traffic signal control methods,” IEEE Trans. Intelligent Transportation Systems.
[4] W. Y. Leong, "Generative AI-Powered Traffic and Mobility Solutions for Next-Generation Smart Cities," 2025 IEEE International Conference on Consumer Electronics - Taiwan (ICCE-Taiwan), Kaohsiung, Taiwan, 2025
[5] M. Showribabu, R. Lalitha, K. V. Sudheer, K. K. Sree and S. Sameena, "Big Data–Driven Traffic Congestion Analysis," 2025 International Conference on Sustainable Communication Networks and Application (ICSCN), Theni, India, 2025
[6] S. S. Kiran, A. Venkatesh, K. G. Charan, L. Urmila, M. Sanjay and K. Sireesha, "Design and Implementation of an AI-Controlled Density-Based Signal Light Management System for Sustainable Smart Cities Using STM32-Nucleo," 2025 IEEE 2nd International Conference on Green Industrial Electronics and Sustainable Technologies (GIEST), Jamshedpur, India, 2025