Margadarshi AI: A Guiding Intelligence for Real-Time Traffic Signal Efficiency for the Department of Science and Technology

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Abstract:
Traffic congestion and road safety violations are major challenges in urban areas, leading to delays and increased risk of accidents. This project proposes an intelligent traffic management system that improves road safety and traffic flow through smart monitoring. At its core, the system manages traffic lights in a normal anti-clockwise sequence, allowing each direction of vehicles to move in a fair and predictable order, ensuring smooth traffic flow even without advanced control mechanisms. To further reduce congestion, the system incorporates density-based traffic light control and prioritizes emergency vehicles such as ambulances, fire trucks, and police cars by interrupting the normal cycle to provide an immediate green signal. This enables faster response times and ensures timely arrival during critical situations. In addition to traffic management, the system monitors road safety violations using cameras to detect helmet usage and identify triple-seat riding on two-wheelers. These detections are performed automatically without manual intervention. The system operates in real-time and minimizes the need for continuous human supervision, making it more reliable and scalable. All violations are reported to an admin panel, where authorities can view alerts, review evidence, and take appropriate actions such as issuing fines or warnings. By integrating smart traffic control with automated safety monitoring, the system reduces congestion, supports emergency services, and promotes safer road practices.

Keywords: Smart Traffic Control, Emergency Vehicle Priority, Helmet Detection, Violation Reporting, Density-Based Signals, Triple Seat Detection.

INTRODUCTION

In today’s rapidly growing urban environments, traffic congestion and road safety have become critical concerns. The continuous increase in the number of vehicles has put significant pressure on existing road infrastructure, resulting in longer waiting times, increased fuel consumption, and a higher risk of accidents. Traditional traffic management systems, which rely on fixed signal timings and manual monitoring, are not efficient in handling dynamic and unpredictable traffic conditions, highlighting the need for intelligent and automated solutions. With the advancement of technologies such as sensors, cameras, and intelligent control systems, modern traffic management can become more efficient and responsive. However, many existing solutions focus only on traffic movement and do not adequately address road safety violations or emergency situations. To overcome these limitations, this project presents a smart traffic control and road safety system that integrates multiple functionalities into a single framework. The system is designed to manage traffic signals efficiently while also monitoring safety violations and prioritizing emergency vehicles. The system operates by managing traffic flow in an organized manner and adjusting signal timings based on real-time vehicle density. It also ensures that emergency vehicles receive priority and enhances road safety by detecting violations such as helmet absence and triple-seat riding using camera-based monitoring. All detected information is made available to authorities through a centralized dashboard for further action. By integrating these features, the proposed system improves traffic efficiency and promotes safer driving practices, contributing to smarter and safer urban transportation systems.

LITERATURE SURVEY

1. Smart Traffic Control Using Deep Learning: J. Smith and A. Kumar (2021): This paper presents a deep learning-based traffic control system using computer vision techniques. The system analyzes live video feeds to estimate traffic density and dynamically adjust signal timings. It uses the YOLO algorithm for vehicle detection and reinforcement learning for optimizing signal control. The results show improved traffic flow and reduced congestion compared to traditional fixed-timer systems.[1]
2. AI-Based Traffic Signal Optimization: S. Williams and M. Chang (2022): This study proposes an AI-driven traffic signal optimization model that uses vehicle detection and traffic density analysis. Convolutional Neural Networks (CNNs) are applied to detect vehicles in real time from surveillance cameras. The system dynamically adjusts signal duration based on traffic load, reducing waiting time and improving overall efficiency.[2]
3. Intelligent Traffic Management Using Density Estimation: R. Patel and F. Ahmed (2019): This paper introduces an intelligent traffic management system based on vehicle detection and density estimation using computer vision techniques. It incorporates edge computing to process data locally, enabling real-time response to traffic conditions. The system adapts signal timings based on traffic density, effectively reducing congestion at intersections.[3]
4. Despite these advancements, most existing systems mainly focus on traffic flow optimization and do not fully address emergency vehicle prioritization and road safety violation detection. The proposed system aims to overcome these limitations by integrating adaptive traffic control with emergency handling and automated safety monitoring, providing a more comprehensive traffic management solution.

METHODOLOGY

The proposed system is designed to control traffic signals and monitor road conditions using real-time data. Initially, traffic lights follow a predefined anti-clockwise sequence to ensure systematic vehicle movement. To improve traffic efficiency, cameras are used to detect vehicle density at each lane. Based on this data, the signal timing is dynamically adjusted, giving longer green signals to lanes with higher traffic density. For emergency situations, the system detects vehicles such as ambulances, fire trucks, and police vehicles, and temporarily overrides the normal signal cycle to provide a clear path. In addition, camera-based monitoring is used to identify traffic rule violations, including helmet absence and triple-seat riding. These violations are automatically recorded and sent to a centralized admin panel for further action. The overall process enables efficient traffic management by combining adaptive signal control with automated monitoring and reporting.

OBJECTIVE

1. To manage traffic lights efficiently to reduce waiting time and congestion.
2. To prioritize emergency vehicles like ambulances and fire trucks for faster travel.
3. To automatically detect road safety violations such as no helmets or triple riding.
4. To provide a central dashboard for traffic authorities to monitor alerts and take action.

PROBLEM DEFINATIONS

In rapidly growing cities, traffic congestion and long waiting times at intersections have become major challenges. Traditional traffic signal systems operate on fixed timings and cannot adapt to real-time traffic conditions, resulting in delays, increased fuel consumption, and pollution. Emergency vehicles often face difficulties in moving through traffic, while road safety violations such as not wearing helmets and triple-seat riding are common. These issues highlight the need for an intelligent system that can efficiently manage traffic, prioritize emergency vehicles, and automatically detect safety violations to improve road safety and traffic flow.

SYSTEM ARCHITECTURE

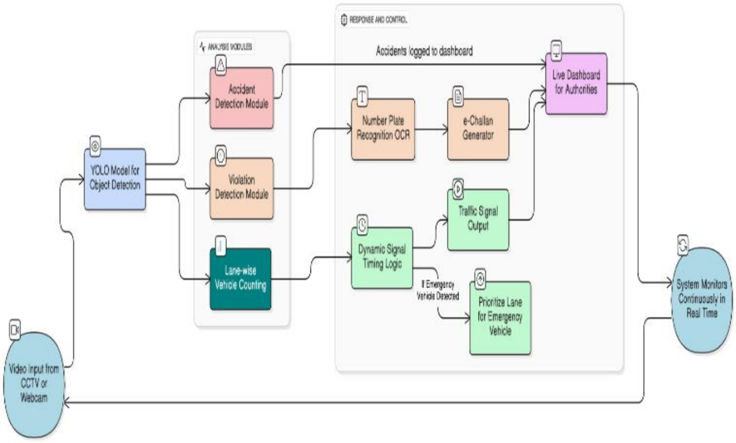


Fig: System Architecture

Module 1: Traffic Light Control Module
This module controls traffic signals using a predefined anti-clockwise sequence to ensure systematic and fair vehicle movement from all directions. It maintains smooth and predictable traffic flow at intersections under normal conditions.

Module 2 Density-Based Signal Management Module
This module uses cameras to detect the number of vehicles waiting on each side of a junction. Based on traffic density, it adjusts the green light duration for busier lanes, reducing congestion and saving time for drivers.

Module 3: Emergency Vehicle Priority Module
When an emergency vehicle like an ambulance, fire truck, or police car is detected, this module interrupts the normal traffic sequence to give it an immediate green light. This helps emergency services reach their destination quickly, potentially saving lives.

Module 4: Road Safety Monitoring Module
This module uses camera-based detection to monitor traffic rule violations, including helmet absence and triple-seat riding. Detected violations are automatically recorded and transmitted to a centralized admin dashboard, enabling authorities to review and take appropriate actions such as issuing fines or warnings.

FUNCTIONAL REQUIREMENTS

Functional requirements define the core operations and capabilities of the system. The system is expected to perform the following functions:

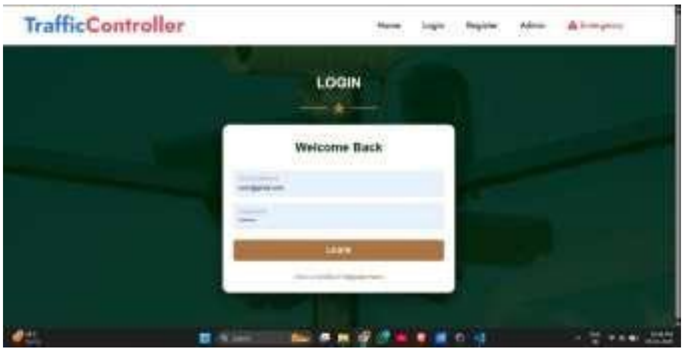
1. The application shall regulate traffic signals using a predefined sequencing mechanism to ensure efficient and orderly vehicle movement at intersections.
2. It shall analyze real-time traffic density through cameras and dynamically adjust signal timings accordingly.
3. The system shall detect emergency vehicles and prioritize their movement by providing immediate green signals.
4. It shall identify traffic violations, including helmet non-compliance and unsafe riding practices, using automated detection techniques.
5. The system shall generate and transmit alerts along with violation data to a centralized administrative dashboard for monitoring and enforcement.

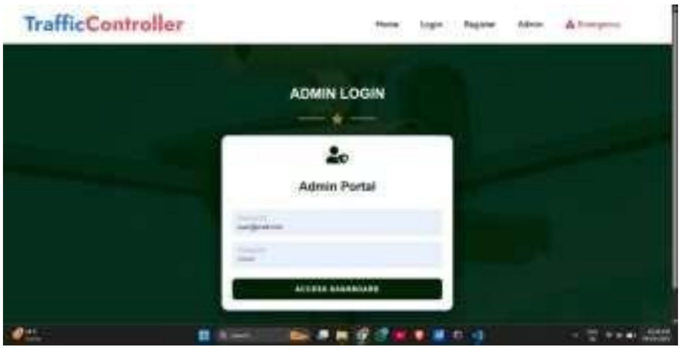
NON-FUNCTIONAL REQUIREMENTS

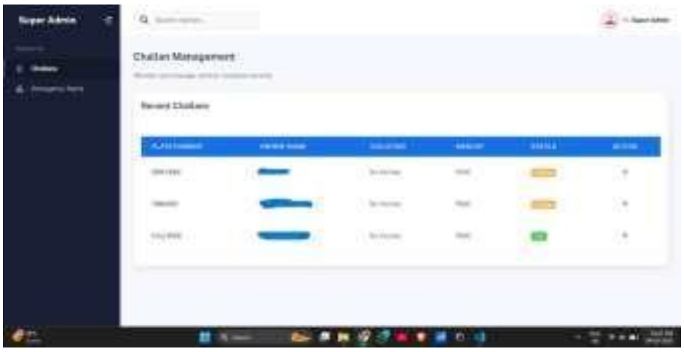
1. Performance: The system should respond in real- time to traffic conditions and emergency vehicles without noticeable delay.
2. Reliability: The system should operate continuously and accurately, even during peak traffic hours.
3. Scalability: The system should be able to handle multiple intersections and increasing traffic volume as

the city grows.
4. Usability: The admin dashboard should be user- friendly, allowing traffic authorities to easily view alerts and take action.
5. Security: The system should protect data from unauthorized access and ensure that violation reports and camera feeds are secure.
6. Maintainability: The system should be easy to update and maintain, including adding new features.

IMPLEMENTATION







CONCLUSION

The smart traffic and road safety system enhances traffic flow, reduces congestion, and improves intersection safety through real-time monitoring and adaptive signal control. By prioritizing emergency vehicles and automatically detecting violations such as helmet non-compliance and unsafe riding, it supports efficient traffic management and enforcement. Overall, the system creates a safer, more organized, and efficient road environment for both commuters and emergency services.

REFERENCES:

1. T. Wu, Y. Shi, L. Xie, H. Yu, and M. Shahidehpour, “Multi-agent deep reinforcement learning for urban traffic light control in vehicular networks,” *IEEE Trans. Veh. Technol.*, vol. 69, no. 11, pp. 12761–12773, Nov. 2020, doi: 10.1109/TVT.2020.3026954.
2. P. Khule, V. Mendhkar, S. Shinde, S. Shinde, and Y. R. Chikane, “Real-time traffic monitoring and management using video surveillance,” *Int. J. Adv. Res. Sci. Commun. Technol.*, vol. 5, no. 11,

pp. 322–327, Apr. 2025, doi: 10.48175/IJARSCT-25851.

3. S. Li, C. Wei, X. Yan, L. Ma, D. Chen, and Y. Wang, “A deep adaptive traffic signal controller with long-term planning horizon and spatial fluctuations,” *J. Transp. Eng., Part A: Syst.*, vol. 147, no. 9, Sep. 2021, Art. no. 04021052, doi: 10.1061/JTEPBS.0000536.
4. Paul, ”Intelligent Traffic Signal Management using DRL for a Real-Time Road Network in ITS,” ACM Transactions on Intelligent Systems and Technology, vol. 12, no. 1, pp. 1–20, 2021.
5. M. Li et al., ”Federated Deep Reinforcement Learning-Based Urban Traffic Signal Control,” Scientific Reports, vol. 15, no. 1, Article 91966, 2025.
6. J. Shen et al., ”Hierarchical Reinforcement Learning-Based Traffic Signal Control,” Scientific Reports, vol. 15, Article 18449, 2025.
7. W. Jia and M. Ji, ”Multi-Agent Deep Reinforcement Learning for Large-Scale Traffic Signal Control with Spatio-Temporal Attention Mechanism,” Applied Sciences, vol. 15, no. 15, Article 8605, 2025.