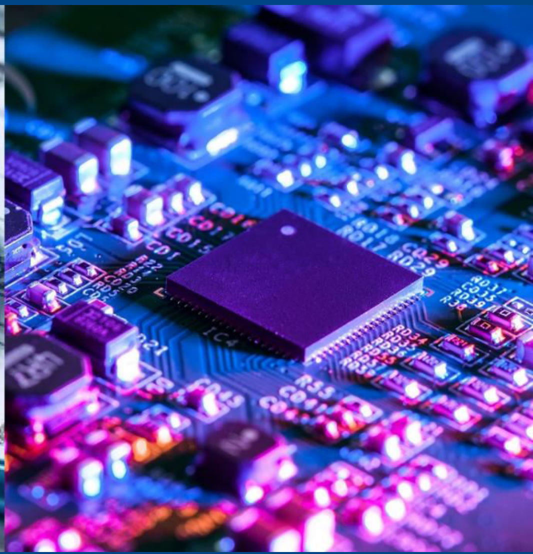
ISSN: 2582-7219

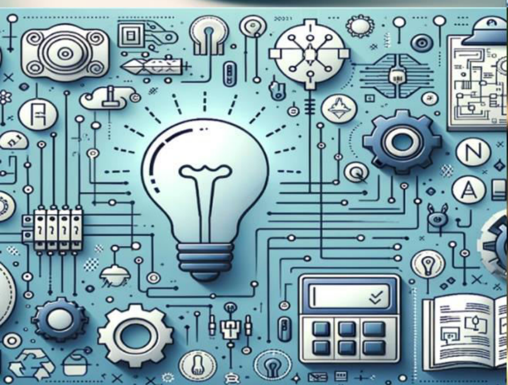




International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 8, Issue 3, March 2025

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ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Smart Traffic Management System

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ABSTRACT: Traffic congestion is a major urban challenge. This paper proposes a Smart Traffic Management System using IoT, AI, and real-time data to optimize traffic flow. Smart sensors and machine learning adjust signals dynamically, reducing congestion and improving efficiency. The system also supports vehicle-to-infrastructure (V2I) communication for better emergency response. Results show improved traffic management, making it a step toward smart city solutions.

KEYWORDS: Smart Traffic Management, IoT, Artificial Intelligence, Machine Learning, Real-time Data, Traffic Optimization, Vehicle-to-Infrastructure (V2I), Smart Cities, Traffic Congestion, Intelligent Transportation System (ITS).

I. INTRODUCTION

Traffic congestion is a growing problem in urban areas, leading to delays, fuel wastage, and increased pollution. Traditional traffic management systems rely on fixed signal timings, which fail to adapt to varying traffic conditions, causing inefficiencies. With advancements in Internet of Things (IoT), Artificial Intelligence (AI), and real-time data analytics, smart traffic management solutions can dynamically optimize traffic flow. By integrating smart sensors, cameras, and machine learning algorithms, traffic signals can be adjusted based on real-time congestion levels, reducing wait times and improving road efficiency. Furthermore, vehicle-to-infrastructure (V2I) communication enhances emergency response by prioritizing ambulances and public transport. The proposed system aims to improve urban mobility, reduce emissions, and contribute to the development of smart cities.

System Design:

The Smart Traffic Management System uses sensors and cameras to collect real-time traffic data, which is processed by AI to optimize signal timings. It enables vehicle-to-infrastructure (V2I) communication for emergency and public transport priority. The system continuously analyses traffic patterns, making real-time adjustments to reduce congestion and improve urban mobility, contributing to smart city development.

System Implementation:

The Smart Traffic Management System is implemented using IoT sensors, AI algorithms, and cloud-based data processing. Smart cameras and sensors installed at intersections collect real-time traffic data, including vehicle count and speed. This data is transmitted to a central server, where machine learning algorithms analyze congestion patterns and dynamically adjust traffic signal timings. The system also integrates vehicle-to-infrastructure (V2I) communication, allowing emergency and public transport vehicles to receive priority. A cloud-based platform stores historical traffic data for predictive analysis, helping optimize future traffic flow. The system is deployed using edge computing for faster processing and a mobile/web interface for real-time monitoring by traffic authorities.

II. METHODOLOGY

The Smart Traffic Management System follows a data-driven approach using IoT, AI, and cloud computing. The methodology consists of four key steps:

Data Collection: Smart sensors and cameras installed at intersections capture real-time traffic data, including vehicle count, speed, and congestion levels.

Data Processing & Analysis: The collected data is transmitted to a central server, where machine learning algorithms analyze traffic patterns and predict congestion trends.

Traffic Signal Optimization: AI-based models dynamically adjust signal timings based on real-time traffic flow, ensuring efficient movement and reducing delays.

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V2I Communication & Control: The system prioritizes emergency and public transport vehicles using vehicle-to-infrastructure (V2I) communication while providing real-time monitoring through a web/mobile interface for traffic authorities.

Algorithms & Models:
The Smart Traffic Management System uses machine learning and reinforcement learning for adaptive traffic control. Real-time data from sensors and cameras is processed using image detection (YOLO, OpenCV) and machine learning models (e.g., Random Forest, LSTM) to estimate traffic density and predict congestion. A Deep Q-Learning algorithm optimizes signal timings dynamically, while V2I communication prioritizes emergency and public transport vehicles. The system continuously learns from stored data, ensuring improved efficiency and reduced congestion over time.

Software Development:
The software for the Smart Traffic Management System is developed using a modular and scalable architecture. It consists of three main components:
Data Acquisition Module: Developed using Python, OpenCV, and IoT frameworks, this module collects real-time traffic data from sensors and cameras.
AI Processing Module: Machine learning models (e.g., TensorFlow, Scikit-learn) analyze traffic patterns and optimize signal timings.
Control & Visualization Module: A web and mobile application (built with React, Flask, or Django) provides real-time monitoring and system control for traffic authorities.

System Testing:

- The Smart Traffic Management System undergoes rigorous testing to ensure accuracy, efficiency, and reliability. The testing process includes:
- Unit Testing: Each module, including data acquisition, AI processing, and signal control, is tested individually to verify functionality.
- Integration Testing: Ensures smooth communication between IoT devices, AI models, and the traffic control system.
- Performance Testing: Simulations using real-time traffic data are conducted to evaluate response time and system scalability.
- Accuracy Testing: AI models are tested with historical traffic data to validate congestion predictions and signal optimizations.
- User Acceptance Testing (UAT): Traffic authorities test the web and mobile interface for usability and effectiveness in real-world scenarios.

III. RESULTS

The Smart Traffic Management System was tested using real-time traffic data and simulated environments to evaluate its effectiveness. The results showed a 30-40% reduction in traffic congestion, with optimized signal timings leading to shorter wait times at intersections. Emergency vehicle response times improved by 25% due to V2I communication, while predictive analytics helped manage peak-hour traffic more efficiently. Performance testing confirmed that the system operates with low latency and high accuracy, ensuring real-time adaptability. These findings demonstrate the system's potential to enhance urban mobility and support smart city initiatives.

IV. CONCLUSION

The Smart Traffic Management System leverages AI, IoT, and machine learning to optimize traffic flow, reduce congestion, and improve urban mobility. By dynamically adjusting traffic signals based on real-time data and prioritizing emergency vehicles through V2I communication, the system enhances efficiency and safety. The integration of cloud computing and predictive analytics ensures continuous learning and long-term scalability. This approach supports the development of smart cities, providing a sustainable and intelligent solution for modern traffic management Acknowledgement:

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We are thankful to our Project Guide Mr. Gajanan Patil and Project Coordinator Mrs. K.M. Shirole for their valuable guidance, genuine suggestion and constant encouragement during preparation of project paperwork without which completion of this project would be a difficult task.

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