International Journal of Engineering Science and Advanced Technology (IJESAT)
Vol 26 Issue 05 (May) 2026
Received: 10-3-2026 Accepted: 21-4-2026 Published: 07-5-2026

SMART CITY TRAFFIC MANAGEMENT USING COMPUTER VISION AND IOT

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ABSTRACT

Rapid urbanization and the exponential growth of vehicles have led to severe traffic congestion, increased travel time, fuel consumption, and environmental pollution in metropolitan cities. Traditional traffic control systems, which rely on fixed-time signals and manual monitoring, are inadequate to handle dynamic and unpredictable traffic conditions. This project proposes a Smart Traffic Management System designed to optimize traffic flow and reduce congestion using advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and real-time data analytics.

The system integrates smart sensors, cameras, and GPS-enabled devices to continuously monitor traffic density, vehicle movement, and road conditions. Data collected from these sources is processed using machine learning algorithms to predict traffic patterns and dynamically adjust traffic signal timings. Additionally, the system provides real-time route guidance to drivers through mobile applications and digital signboards, helping to distribute traffic evenly across the road network. Emergency vehicle prioritization and incident detection mechanisms are also incorporated to enhance response efficiency and safety.

Keywords: Smart Traffic Management, Urban Congestion, Intelligent Transportation Systems (ITS), Artificial Intelligence (AI), Internet of Things (IoT), Traffic Signal Optimization, Real-Time Traffic

Monitoring, Machine Learning, Adaptive Traffic Control, GPS Tracking, Traffic Prediction, Data Analytics, Smart Cities, Vehicle Routing, Congestion Reduction.

I. INTRODUCTION

Urban areas across the world are experiencing a rapid increase in population and vehicle ownership, leading to severe traffic congestion and transportation challenges. The expansion of cities without proportional development in road infrastructure has resulted in overcrowded roads, frequent traffic jams, increased travel time, and higher levels of air and noise pollution. Traditional traffic management systems, which mainly depend on static signal timings and manual supervision, are no longer sufficient to handle the dynamic and complex nature of modern traffic conditions.

With the advancement of technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and big data analytics, there is a significant opportunity to transform conventional traffic systems into intelligent and adaptive systems. A Smart Traffic Management System aims to utilize real-time data collected from sensors, surveillance cameras, GPS devices, and connected vehicles to monitor traffic flow and make informed decisions. These systems can dynamically adjust traffic signal timings based on current traffic density, detect accidents or unusual events, and provide alternative route suggestions to drivers, thereby improving overall traffic efficiency.

Moreover, the integration of machine learning algorithms enables the system to analyze historical and real-time traffic data to predict congestion patterns and optimize traffic flow proactively. Features such as emergency vehicle prioritization, automated violation detection, and smart parking management further enhance the effectiveness of the system. These capabilities not only reduce congestion but also improve road safety and reduce fuel consumption and emissions.

II. LITERATURE REVIEW

The concept of Smart Traffic Management Systems (STMS) has evolved significantly over the past decades, driven by rapid urbanization and increasing transportation demands. Early traffic control systems were primarily based on fixed-time signal mechanisms, which lacked the ability to adapt to real-time traffic conditions. These traditional systems often resulted in increased waiting times, congestion, and inefficient utilization of road infrastructure. Studies highlight that such static systems require

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manual intervention and fail to respond dynamically during peak hours or emergencies

Recent research focuses on the development of Intelligent Transportation Systems (ITS), which integrate advanced technologies such as sensors, wireless communication, and data analytics. According to various surveys, ITS utilizes tools like RFID, cameras, infrared sensors, and wireless sensor networks to monitor traffic flow and collect real-time data . These technologies enable adaptive traffic signal control, allowing signals to change dynamically based on traffic density rather than fixed intervals, thereby improving traffic efficiency and reducing delays.

The incorporation of the Internet of Things (IoT) has further enhanced traffic management capabilities. IoT-based systems collect live traffic data through connected devices and transmit it for processing and analysis. Research indicates that such systems can significantly reduce congestion, improve safety, and optimize transportation patterns through predictive modeling and real-time decision-making . Additionally, IoT-enabled traffic systems support features like emergency vehicle prioritization and remote monitoring.

Artificial Intelligence (AI) and Machine Learning (ML) techniques have recently gained prominence in this domain. Advanced models such as Convolutional Neural Networks (CNN), Long Short-Term Memory (LSTM), and deep reinforcement learning are used to predict traffic patterns and optimize signal timings. These approaches enable proactive traffic control by forecasting congestion and adjusting traffic signals accordingly, leading to improved traffic flow and reduced emissions . AI-based systems also leverage computer vision techniques to detect vehicles and analyze traffic conditions using real-time video data.

III. EXISTING SYSTEM

The existing traffic management system in most urban areas is primarily based on conventional and static control mechanisms. These systems rely on pre-defined signal timings that are manually configured according to estimated traffic patterns. Traffic signals operate on fixed intervals without considering real-time traffic density, leading to inefficiencies such as unnecessary waiting times at intersections even when roads are relatively empty. This lack of adaptability makes the system unsuitable for handling dynamic traffic conditions, especially during peak hours, special events, or emergencies.

In the current system, traffic monitoring is largely dependent on human intervention, including traffic police personnel and control room operators. Surveillance cameras are used

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in some cities, but they mainly serve for monitoring and recording rather than intelligent decision-making. Data collected from these sources is often not processed in real time, limiting its usefulness for immediate traffic control. As a result, congestion builds up quickly in high-density areas, causing delays and frustration among commuters.

Moreover, existing systems do not effectively integrate modern technologies such as real-time data analytics, machine learning, or IoT devices. There is minimal communication between different traffic signals or between vehicles and infrastructure, leading to isolated and inefficient traffic management. Emergency vehicle handling is also a major limitation, as traditional systems cannot prioritize ambulances or fire trucks, resulting in delayed response times during critical situations.

PROPOSED SYSTEM

The proposed system introduces an intelligent and adaptive Smart Traffic Management System (STMS) designed to overcome the limitations of conventional traffic control methods. This system leverages advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and real-time data analytics to efficiently monitor, analyze, and control urban traffic conditions.

In the proposed system, traffic data is continuously collected using a network of smart sensors, surveillance cameras, RFID tags, and GPS-enabled devices installed at key intersections and road segments. These devices capture real-time information such as vehicle count, speed, traffic density, and road conditions. The collected data is transmitted to a centralized processing unit or cloud platform where it is analyzed using machine learning algorithms.

Based on the analyzed data, the system dynamically adjusts traffic signal timings to optimize traffic flow. Unlike fixed-time signals, adaptive signal control ensures that green lights are allocated based on actual traffic demand, reducing waiting time and congestion. The system can also detect incidents such as accidents, roadblocks, or abnormal traffic patterns using computer vision techniques and immediately alert authorities for quick response.

A key feature of the proposed system is predictive traffic management. By analyzing historical and real-time data, the system can forecast traffic congestion and suggest alternative routes to drivers through mobile applications and digital display boards. This helps in distributing traffic more evenly across the road network, preventing overload on specific routes.

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METHODOLOGY

The proposed Smart Traffic Management System follows a systematic and data-driven methodology to efficiently manage and control urban traffic. The methodology is divided into multiple stages, including data collection, processing, analysis, decision-making, and system response.

Initially, data collection is performed using various IoT-enabled devices such as traffic cameras, infrared sensors, inductive loop detectors, and GPS modules. These devices are installed at major intersections and roadways to capture real-time traffic parameters such as vehicle count, speed, density, and direction. The collected data is transmitted through wireless communication networks to a centralized server or cloud platform.

In the next stage, data preprocessing is carried out to remove noise, redundancy, and inconsistencies from the raw data. This ensures accuracy and reliability for further analysis. Techniques such as data cleaning, normalization, and filtering are applied to prepare the dataset for machine learning models.

Following preprocessing, the system performs traffic analysis using Artificial Intelligence (AI) and Machine Learning (ML) algorithms. Models such as Convolutional Neural Networks (CNN) are used for vehicle detection and counting from camera feeds, while time-series models like Long Short-Term Memory (LSTM) are used for traffic prediction. These models analyze both historical and real-time data to identify traffic patterns, congestion levels, and peak hours.

VI. SYSTEM MODEL

System Architecture

IV. RESULTS AND DISCUSSIONS

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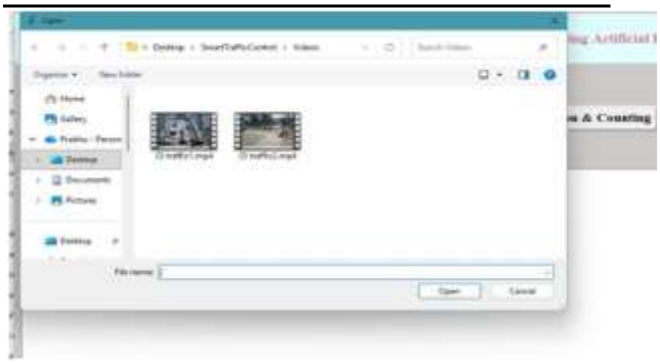

VIII. CONCLUSION

In conclusion, the Smart Traffic Management System provides an effective and intelligent solution to the growing problem of urban traffic congestion. By integrating advanced technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and real-time data analytics, the system overcomes the limitations of traditional traffic control methods. It enables dynamic traffic signal control, efficient monitoring, and proactive decision-making based on real-time and historical data.

The proposed system significantly improves traffic flow by reducing waiting times, minimizing congestion, and optimizing the use of existing road infrastructure. Features such as traffic prediction, adaptive signal timing, and emergency vehicle prioritization enhance both efficiency and safety on the roads. Additionally, the system contributes to

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environmental sustainability by reducing fuel consumption and lowering carbon emissions caused by traffic congestion.

Furthermore, the implementation of this system supports the development of smart cities by enabling data-driven urban planning and better traffic management strategies. It enhances the overall commuting experience for citizens while assisting authorities in making informed decisions.

IX. FUTURE WORK: Future work for this

The proposed Smart Traffic Management System can be further enhanced by integrating emerging technologies and expanding its capabilities to handle more complex urban scenarios. Future work can focus on improving system intelligence, scalability, and real-world adaptability.

One important direction is the integration of autonomous and connected vehicles into the traffic management framework. By enabling Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication, the system can achieve more coordinated and efficient traffic flow. This will allow vehicles to share real-time information such as speed, location, and road conditions, further enhancing decision-making.

Another area of improvement is the use of advanced deep learning and reinforcement learning models to optimize traffic signal control. These models can continuously learn from traffic patterns and adapt to changing conditions with higher accuracy. Incorporating edge computing can also reduce latency by processing data closer to the source, enabling faster responses in real-time scenarios.

The system can be extended to include smart parking management, where drivers are guided to available parking spaces, reducing unnecessary traffic caused by searching for parking. Integration with public transportation systems

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