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Optimizing Urban Mobility: An AI and IoT-Based Smart Traffic System

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***Abstract*—- Urban traffic congestion is a major problem for modern cities. It leads to longer travel times, higher fuel use, and more pollution. Traditional traffic management systems, which depend on fixed-time signals, often fail to adjust to real-time changes in traffic. This results in poor traffic flow. This paper suggests a smart traffic management system that uses the Internet of Things (IoT) and digital display boards to improve city mobility and road safety. The proposed system employs IoT sensors, like cameras and infrared devices, to gather real-time information on vehicle numbers, speeds, and traffic conditions at key intersections. This data goes to a central control unit, where a flexible algorithm processes it to adapt traffic signal timings. The system also features Variable Message Sign (VMS) boards, or digital boards, that show real-time information to drivers, including traffic updates, alerts for incidents, and suggestions for alternative routes. This integrated strategy seeks to lower traffic delays by controlling signals dynamically and providing drivers with instant, useful information. The system can also give priority to emergency vehicles by creating clear paths at intersections, which can improve response times and potentially save lives. The main goal is to develop a more effective, responsive, and safer urban transportation network that supports a more sustainable and enjoyable "smart city" environment.**

***Index Terms*—Smart cities; Traffic management; Intelligent Transportation Systems; Artificial intelligence; Internet of Things**

I. Introduction

The rapid growth of cities and the rising number of vehicles have made traffic congestion a serious problem in urban areas. Traditional traffic systems with fixed signal timings and manual control cannot adapt to real-time road conditions, leading to long delays, fuel wastage, and higher pollution. Managing traffic efficiently has become essential for developing smart and sustainable cities. This research proposes an IoT and AI-based Traffic Management System that collects real-time data using sensors,

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cameras, and connected devices. The data on vehicle count and traffic density is analyzed through AI algorithms to adjust signal timings dynamically and predict congestion. The system can also detect accidents or road blockages and alert authorities instantly for quick action.

By combining IoT and AI, the proposed system aims to improve traffic flow, enhance road safety, and reduce fuel consumption. It offers a scalable and cost-effective solution that supports the vision of smart city development and promotes efficient, eco-friendly urban transportation.

Fig. 1: Current Road Traffic Management

A. *Road Traffic Management*

Traffic congestion has become one of the most serious problems faced by modern cities today. As urban areas continue to expand and more people move to cities, the number of vehicles on the road increases every year. Unfortunately, the infrastructure in most cities has not developed at the same pace. As a result, roads become overcrowded, and long traffic jams have become a daily reality for millions of commuters. These traffic jams not only waste people's time but also cause higher fuel consumption, air pollution, and stress among drivers. Traditional traffic management systems rely on fixed-timing traffic signals. In other words, the green, yellow, and red lights at intersections change based on pre-set intervals that rarely adjust according to actual traffic conditions. For example, even if there are very few vehicles on one road and heavy traffic on another, both roads might get the same green light duration. This leads to unnecessary waiting, slower movement, and increased congestion. To overcome these limitations, modern technologies such as Artificial fIntelligence (AI) and the Internet of Things (IoT) can be used to design a smart, adaptive traffic control system that responds to real-time situations.

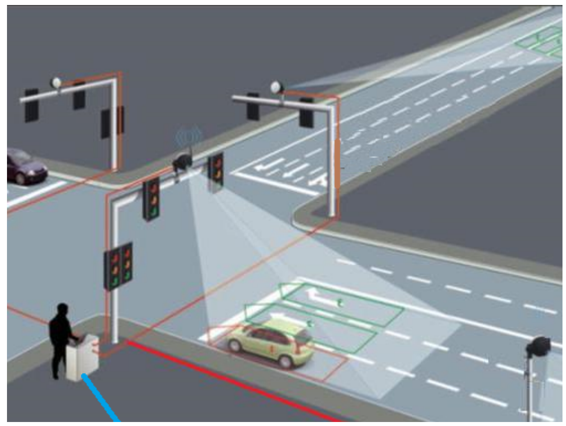

Fig. 2: IoT and AI-based Traffic Management System

B. *How the System Works*

In this proposed smart traffic management system, AI cameras and IoT sensors are placed at intersections and along major roads. These devices work together to continuously monitor traffic conditions and collect useful information. The AI cameras use computer vision algorithms to detect and classify vehicles. They can recognize different types of vehicles — such as cars, trucks, buses, or motorcycles — and count how many are present in each lane. This helps determine how crowded each part of the road is.

At the same time, IoT sensors, which can include inductive loops, infrared sensors, or ultrasonic sensors, collect extra information such as vehicle speed, the distance between vehicles, and the number of vehicles passing through a particular lane. By combining the data from both cameras and sensors, the system gains a complete understanding of what is happening on the road at any given moment. Once collected, the data is transmitted through a

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secure wireless network, such as 5G or LPWAN, to either a central control center or an edge computing node located near the intersection. Edge computing plays an important role because it allows data to be processed locally instead of sending everything to a distant central server. This reduces delay and helps the system react faster.

C. AI Analysis and Decision-Making

The AI algorithms then analyze the data to determine the level of traffic congestion in each lane. They calculate different parameters such as: 1. Vehicle density (how many cars are on a road segment) 2. Average waiting time at the signal 3. The length of the traffic queue

Using this information, the system can identify which lanes are more congested and need a longer green light. For example, if one lane has heavy traffic while another is almost empty, the AI automatically increases the green light time for the busy lane and decreases it for the less crowded one. This dynamic adjustment ensures that vehicles can move through intersections more efficiently, reducing waiting time and improving overall traffic flow.

Over time, the AI system learns from traffic patterns. It can identify daily and weekly trends — for instance, recognizing that traffic is usually heavier toward business districts in the morning and in the opposite direction in the evening. Based on this learning, the system can predict congestion before it happens and adjust signal timings proactively.

D. Network Coordination and Communication

One of the strongest advantages of using IoT technology is interconnectivity. Multiple intersections across the city can be connected to form a coordinated traffic network. This means that if one intersection becomes heavily congested, nearby intersections can automatically adjust their signal patterns to prevent the congestion from spreading further.

In addition, the traffic data collected from these intersections can be shared with navigation applications such as Google Maps or other GPS-based systems. Drivers using these apps can receive real-time traffic updates and suggested alternative routes to avoid busy areas. This not only helps individuals save time but also helps distribute traffic more evenly across the city.

E. Improving Road Safety

Apart from managing traffic flow, AI cameras and IoT sensors can greatly improve road safety. These systems can detect unusual or dangerous events, such as accidents, stalled vehicles, or pedestrians crossing outside designated areas. Once the AI system identifies such an incident, it can instantly send alerts to the central traffic control center or even directly to nearby drivers through connected vehicle systems.

It can also trigger other safety measures, such as changing traffic light signals to red, activating variable message signs (VMS) to warn approaching vehicles, or turning on adaptive street lights to increase visibility. Quick detection and response to such events not only prevent further accidents but also help emergency services reach the site faster.

F. Data Analytics and Long-Term Benefits

Over time, this system continuously collects a huge amount of valuable data. This data can be analyzed to study long-term traffic trends, identify problem areas, and plan improvements. Urban planners and transportation engineers can use these insights to redesign road layouts, add new lanes, or modify signal placements for better efficiency.

By applying machine learning techniques, the system also keeps improving. It learns from historical data and becomes better at predicting traffic congestion, adjusting signals, and preventing bottlenecks before they occur. This makes the system more accurate and intelligent with each passing day.

G. Environmental Impact

The benefits of a smart AI-based traffic system go beyond convenience. By reducing unnecessary idling and stop-start driving, vehicles consume less fuel and emit fewer harmful gases. This leads to a reduction in carbon dioxide (CO) and particulate matter emissions, which are major contributors to

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II. GRAPHICS PREPARATION

This graph shows how the number of vehicles increases over time, indicating rising traffic density and growing congestion levels. This graph illustrates the upward trend in CO2 levels as traffic builds up, demonstrating the direct environmental impact of heavy road usage. This graph presents the gradual rise in noise levels, mainly caused by honking, engine noise, and frequent braking during congestion.

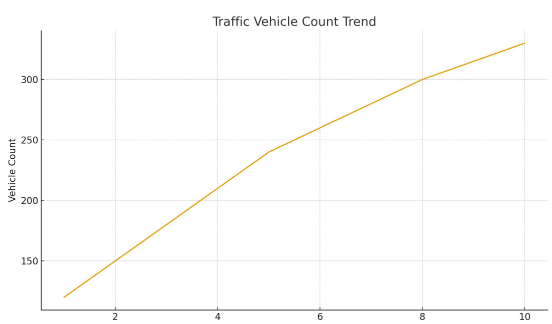

Fig. 3: Traffic Vehicle Count Trend

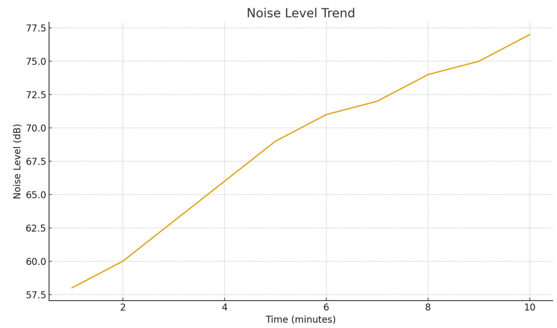

Fig. 4: Pollution Level Trend

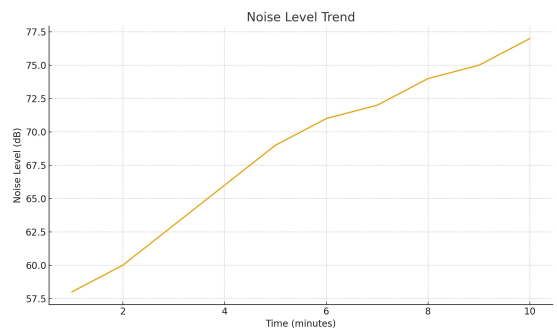

Fig. 5: Noise Level Trend

III. Discussion

The observations gathered in this study show how steadily increasing traffic levels are creating major challenges for urban areas. As cities grow and more vehicles enter the road network, the effects become visible in everyday travel: longer waiting times, slower movement, and frequent bottlenecks during peak hours. These patterns not only disrupt mobility but also contribute to significant environmental concerns. With vehicles spending more time idling in traffic, fuel is wasted unnecessarily, air pollution rises, and noise levels increase, all of which affect both public health and urban life. A key issue that emerged is the continued use of fixed-timing traffic signals at many intersections. These systems operate on preset intervals and do not adjust to actual traffic conditions. As a result, lanes with heavy congestion often receive the same green-light duration as lanes with very little traffic. This mismatch leads

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to extended queues, repeated stop-and-go movement, and overall inefficiency in how vehicles move through the city. The problem becomes even more pronounced when neighboring intersections aren't synchronized, causing congestion to shift and build up in different areas instead of being resolved. Environmental data collected and reviewed supports the connection between heavy traffic and rising pollution levels. CO emissions, particulate matter, and noise levels all tend to increase when traffic flow becomes inconsistent. Noise pollution, in particular, spikes around congested intersections due to honking, engine noise, and constant braking. These environmental effects are often overlooked in daily life, but they have long-term consequences for air quality and community well-being. Existing literature highlights several modern approaches that could help improve these conditions. Many researchers point out that real-time traffic monitoring and intelligent decision-making systems can significantly improve flow and reduce delays. While these solutions require investment and proper infrastructure, they show strong potential for easing many of the problems identified in this research. At the same time, implementing such systems is not without challenges. Reliable data collection depends on well- maintained equipment, good communication networks, and strategic placement of sensors. Traffic patterns vary greatly throughout the day, meaning any advanced traffic system needs to be adaptable and capable of learning over time. Overall, the findings of this study emphasize the need for cities to explore more adaptive and informed approaches to traffic control. The issues associated with high vehicle density are not isolated; they affect environmental health, travel efficiency, and quality of life. Understanding these patterns makes it clear that future traffic systems must gradually shift toward smarter, more responsive methods in order to create cleaner, safer, and more efficient urban environments.

IV. Conclusion

CONCLUSION The integration of Artificial Intelligence (AI) and the Internet of Things (IoT) into traffic management systems has emerged as an effective solution to the escalating issue of urban traffic congestion. Traditional traffic control systems, which depend on pre-determined signal timings and human oversight, frequently fail to adapt to real-time conditions. By employing IoT devices such as sensors, GPS modules, and cameras, substantial volumes of live traffic data can be gathered from roads, vehicles, and intersections. AI algorithms subsequently analyze this data to forecast traffic patterns, identify accidents, and make informed decisions to optimize signal timings. An AI-driven traffic management system can seamlessly adapt to fluctuating traffic volumes, thereby reducing wait times at intersections and enhancing overall traffic flow. It also improves emergency response by identifying and facilitating quicker routes for ambulances and fire trucks. Additionally, by minimizing unnecessary idling and route delays, these systems contribute to lower fuel consumption and reduced air pollution, fostering a cleaner environment. In addition, the use of cloud computing and edge AI allows these systems to process data quickly and provide instant responses. As technology continues to advance, the integration of AI with IoT will lead to even more efficient, scalable, and adaptive traffic solutions. Future developments could include vehicle-to-infrastructure (V2I) communication, autonomous vehicle coordination, and city-wide intelligent transportation networks. Overall, AI-based traffic management systems using IoT devices represent a major step toward building smart cities. They not only improve transportation efficiency but also enhance safety, reduce human errors, and promote sustainable urban living. The continued research and development in this area will play an important role in shaping the future of intelligent transportation systems worldwide

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