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OPTIMIZATION OF ROAD TRAFFIC FLOW AND VEHICLE MOVEMENT REGULATIONS FOR IMPROVING URBAN TRANSPORTATION SAFETY AND TRAFFIC EFFICIENCY

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Abstract. Urban traffic congestion and inefficient vehicle movement regulations significantly affect transportation safety and operational efficiency. This study examines road traffic flow characteristics and proposes optimization strategies based on intelligent transportation systems and traffic management approaches. The research evaluates factors influencing congestion, travel time, and road safety through data-driven analysis. The results indicate that adaptive traffic control, real-time monitoring, and optimized movement regulations improve traffic efficiency, reduce accident risks, and support sustainable urban mobility. These findings provide practical guidance for developing safer and more efficient urban transportation systems.

Keywords: traffic, transportation, optimization, mobility, congestion, safety, regulation, infrastructure, sustainability, simulation.

INTRODUCTION

The rapid growth of urban populations and the increasing number of vehicles have created significant challenges for transportation systems worldwide. Traffic congestion has become one of the most critical issues affecting urban mobility, leading to longer travel times, higher fuel consumption, increased air pollution, and greater economic losses. At the same time, inefficient vehicle movement regulations and inadequate traffic management reduce road safety and negatively affect the overall performance of transportation networks. Therefore, optimizing road traffic flow has become an essential objective for transportation engineers, urban planners, and policymakers [1].

Recent developments in Intelligent Transportation Systems (ITS), traffic monitoring technologies, and data analytics have provided new opportunities to improve traffic operations. Adaptive traffic signal control, real-time traffic information, and automated traffic management systems enable authorities to monitor road conditions continuously and respond effectively to changing traffic demand. These technologies contribute to reducing congestion, improving travel efficiency, and enhancing road safety. However, many urban areas still experience serious traffic problems due to outdated traffic regulations, rapid urbanization, and limited road infrastructure.

Traffic flow optimization requires a comprehensive understanding of traffic characteristics, vehicle interactions, road capacity, and driver behavior. The integration of intelligent traffic management strategies with modern transportation technologies can significantly improve traffic performance while supporting sustainable urban development [2]. Furthermore, effective vehicle movement regulations help reduce accident risks, improve traffic discipline, and increase the operational efficiency of road networks.

LITERATURE REVIEW

The issues of traffic flow management, regulation of vehicle movement, and implementation of intelligent transport systems (ITS) have been extensively studied by both local and foreign scholars. In modern research, ensuring road safety, reducing traffic congestion, and increasing the efficiency of the transport system are recognized as key scientific directions.

Among Uzbekistani scholars, B. Khudoyberdiev, Sh. Ergashev, A. Tukhtaev, and F. Karimov have paid special attention in their research to improving urban transport infrastructure, optimizing

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traffic light control algorithms, and modeling traffic flows. Their scientific work is dedicated to analyzing the relationship between traffic flow density, speed, and road capacity. Among foreign scholars, Martin Treiber and Arne Kesting have conducted research on the mathematical modeling of traffic flows and models for controlling the distance and speed between vehicles. The Intelligent Driver Model (IDM) they developed is among the most widely used models for analyzing modern traffic flows [3].

Dirk Helbing studied traffic flows as a complex dynamic system and scientifically substantiated the mechanisms behind the formation of traffic jams. His research has shown that optimizing traffic flows using artificial intelligence and adaptive control systems significantly increases traffic efficiency [4].

The Cell Transmission Model (CTM), developed by Carlos F. Daganzo, is one of the most effective methods for modeling traffic flows at a macroscopic level. Today, this model is widely used in managing urban transport networks and forecasting congestion [5].

Michael Papageorgiou has achieved significant scientific results in developing real-time traffic flow management, ramp metering, and adaptive control algorithms for highways. His research serves to ensure the stability of traffic flow and increase road capacity [6,7].

METHODOLOGY

This study employs a data-driven research methodology to analyze urban road traffic flow and vehicle movement regulations. Traffic flow characteristics, including traffic volume, travel time, congestion level, and road safety indicators, are evaluated using statistical and comparative analysis methods. Intelligent Transportation System (ITS) technologies, such as real-time traffic monitoring and adaptive traffic control, are considered to assess their impact on traffic efficiency. The collected data are analyzed to identify key factors affecting urban mobility and to propose optimization strategies for improving traffic flow, reducing congestion, and enhancing road safety. The findings provide practical recommendations for developing more efficient and sustainable urban transportation systems.

RESULTS AND DISCUSSION

The analysis demonstrates that urban traffic flow is strongly influenced by traffic demand, road network capacity, and the effectiveness of vehicle movement regulations. The findings indicate that conventional fixed-time traffic control systems are less effective under varying traffic conditions, leading to increased congestion and longer travel times.

The implementation of Intelligent Transportation System (ITS) technologies, particularly adaptive traffic signal control and real-time traffic monitoring, significantly improves traffic performance. The results show that adaptive traffic management enables more balanced traffic distribution, reduces vehicle delays, and increases the overall efficiency of road network operations. In addition, continuous traffic monitoring supports faster detection of congestion and allows traffic authorities to respond more effectively to changing road conditions.

The study also reveals that optimized vehicle movement regulations contribute to improved road safety by reducing traffic conflicts and minimizing accident risks. Efficient traffic control strategies promote smoother traffic flow, decrease unnecessary vehicle stops, and lower fuel consumption and emissions, supporting sustainable urban mobility.

Overall, the findings confirm that integrating intelligent traffic management technologies with optimized traffic regulations provides an effective approach to enhancing urban transportation efficiency. These results are consistent with recent studies emphasizing the importance of data-driven traffic management and smart transportation systems for reducing congestion, improving road safety, and achieving sustainable urban development.

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Conclusion. This study analyzed the characteristics of urban road traffic flow and examined strategies for optimizing vehicle movement regulations through Intelligent Transportation Systems (ITS) and modern traffic management approaches. The findings demonstrate that traffic efficiency and road safety are significantly influenced by adaptive traffic control, real-time traffic monitoring, and data-driven decision-making. The implementation of these technologies contributes to reduced congestion, shorter travel times, improved traffic flow, and lower accident risks. Furthermore, the study highlights that optimizing vehicle movement regulations not only enhances the operational performance of urban transportation networks but also supports sustainable urban mobility by reducing fuel consumption and environmental impacts. The results confirm that the integration of intelligent transportation technologies with effective traffic management policies provides a practical and efficient solution for addressing the growing challenges of urban traffic.

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