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Emission Reduction Strategies in Mixed Traffic: Unveiling the Intersection Control Code

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Abstract

In contemporary urban landscapes, the coexistence of diverse transportation modes within mixed traffic scenarios poses formidable challenges for mitigating emissions and optimizing traffic flow. This abstract explores the innovative approach of the Intersection Control Code (ICC), a dynamic traffic management system designed to address these challenges. Unlike conventional signal systems, the ICC employs real-time data analytics and adaptive algorithms to dynamically adjust signal timings based on vehicle density, transportation modes, and air quality parameters. By prioritizing sustainable modes, integrating with Intelligent Transportation Systems, and monitoring emissions, the ICC aims to reduce pollution, enhance traffic efficiency, and promote a greener urban environment. This abstract provides a concise overview of the key features and benefits of the ICC, highlighting its potential as a transformative solution for emission reduction in mixed traffic scenarios.

Heavy-duty vehicles contribute to most of the emissions regardless of the low proportion in the traffic flows. Afterward, a model is proposed for determining the optimal signal control at an intersection for a specific percentage of heavy-duty vehicles based on the conversion of emission factors of different types of vehicles. Signal control is also optimized based on conventional signal timing, and vehicle emissions are calculated. In the empirical analysis, the changes in CO, HC, and NOx emissions of light- and heavy-

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duty vehicles before and after conventional signal control optimization are quantified and compared. After the signal control optimization, the CO, HC, and NOx emissions of heavy-duty vehicles were reduced. The CO and HC emissions of light-duty vehicles were reduced, but the NOx emissions of light-duty vehicles remained unchanged.

Keywords: Mixed traffic flow; emission; traffic simulation; signal optimization

Introduction

In urban environments worldwide, mixed traffic conditions have become the norm, characterized by the coexistence of various modes of transportation, including cars, bicycles, pedestrians, and public transit. With the rise of urbanization and the increasing demand for efficient transportation, mitigating emissions in mixed traffic has become a critical challenge. One innovative solution gaining traction is the Intersection Control Code (ICC), a sophisticated traffic management system designed to reduce emissions and enhance overall traffic efficiency.

The optimization of intersection signal control is an essential aspect of traffic management that aims to improve the efficiency and safety of intersections. In recent years, researchers have developed various methods and techniques to optimize intersection signal control, including traditional methods such as fixed-time control, actuated control, and adaptive control, as well as more advanced methods such as intelligent transportation systems (ITSs), artificial intelligence (AI), and machine learning (ML) techniques. In the early stages of traffic signal development, researchers developed methods to determine fixed signal timings, assuming that the traffic flow from each intersection is constant. This approach does not consider the uncertainty of traffic flows and has lost relevance in the contemporary traffic climate. Thanks to recognizing the uncertainty, much research has been devoted to improving the analysis of delay models and developing control models. To address these issues, researchers have developed more advanced methods, such as actuated control, which adjusts the signal timings based on the actual traffic demand using various sensors and detectors. Adaptive control is another method that utilizes real-time traffic data to dynamically adjust the signal timings and cycle length. Recent technological advancements have led to the development of more advanced methods such as ITS, AI, and ML techniques. These methods deploy sophisticated algorithms and models to optimize intersection signal control based on various factors such as traffic volume, speed, and congestion levels. For instance, some researchers have used deep reinforcement learning (DRL) to optimize signal timings and reduce delays at intersections. Other researchers have applied a combination of genetic algorithms and fuzzy logic to optimize intersection signal control.

Understanding the Challenge

Mixed traffic poses unique challenges for emission reduction. Traditional traffic control systems often prioritize vehicular flow, leading to inefficient use of road space and increased emissions. In mixed traffic scenarios, finding a balance that accommodates different modes of transportation while minimizing environmental impact is crucial.

The Intersection Control Code

The ICC is a groundbreaking approach that combines real-time data analytics, advanced algorithms, and smart infrastructure to optimize traffic flow and reduce emissions at intersections. Unlike conventional traffic signal systems that rely on fixed timing plans, the ICC adapts dynamically to changing traffic conditions, considering factors such as vehicle density, mode of transportation, and real-time air quality data.

Key Features of the Intersection Control Code

Dynamic signal timing

The ICC employs adaptive signal timing that responds to the current traffic load. By using sensors and cameras, the system constantly monitors the flow of vehicles, pedestrians, and cyclists, adjusting signal timings in real-time.

Prioritizing sustainable modes

One of the key features of the ICC is its ability to prioritize sustainable modes of transportation, such as public transit and bicycles. During peak hours, the system can allocate more green time to dedicated bus lanes or cycling paths, encouraging the use of eco-friendly transportation options.

Integration with intelligent transportation systems (ITS)

The ICC seamlessly integrates with Intelligent Transportation Systems, leveraging data from connected vehicles, smartphones, and public transit systems. This integration allows for a holistic understanding of traffic patterns, enabling more informed decision-making.

Emission monitoring and alerts

The ICC incorporates air quality monitoring systems to assess the environmental impact of traffic. When pollution levels exceed predefined thresholds, the system can automatically adjust signal timings to reduce emissions and mitigate the impact on air quality.

Benefits of the Intersection Control Code

Reduced emissions

By optimizing signal timings based on real-time data, the ICC minimizes unnecessary idling and accelerations, leading to a significant reduction in emissions at intersections.

Improved traffic flow

Dynamic signal timings and mode prioritization contribute to smoother traffic flow, reducing congestion and overall travel times.

Enhanced safety

The ICC enhances safety by accommodating the diverse needs of different road users, including pedestrians and cyclists, reducing the likelihood of accidents.

Encouraging sustainable transportation

Prioritizing sustainable modes of transportation encourages people to choose eco-friendly options, contributing to a reduction in overall emissions.

Conclusion

As cities around the world grapple with the challenges of mixed traffic, innovative solutions like the Intersection Control Code offer a promising path forward. By embracing advanced technologies and adaptive strategies, urban areas can achieve the delicate balance between efficiency and sustainability, ultimately leading to reduced emissions and a healthier environment for all. The Intersection Control Code represents a step towards smarter, more environmentally conscious urban transportation systems.

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