Abstract:

Urban traffic congestion has become an increasingly critical issue as the number of vehicle owners continues to rise each year, resulting in increased travel times, fuel consumption, and environmental pollution. Traditional adaptive traffic signal control systems struggle to accommodate this rapid growth in traffic demand, highlighting the need for innovative and efficient solutions to manage traffic in urban environments. Connected vehicle (CV) technology, which enables vehicles to com- municate with each other and infrastructure, has emerged as a promising solution to address these challenges. The integration of CV data can significantly enhance traffic management systems, allowing for more effective traffic signal optimization, improved traffic flow, and increased safety.

This dissertation focuses on the development and evaluation of a novel algorithm for optimizing adaptive traffic signals under platooned CVs. The goal is to harness the potential of CV technology and vehicle platooning to improve traffic efficiency, safety, and environmental sustainability in urban settings. By leveraging the unique characteristics of CVs, mixed traffic scenarios, and the dynamic nature of urban traffic, the proposed algorithm aims to address the limitations of existing traffic signal control systems and provide a more efficient and adaptable solution.

The study begins with a comprehensive literature review to identify the current state of the art in adaptive traffic signal control systems, CV technologies, platooning, and their integration in traffic management. The review serves as a foundation for understanding the research gaps and opportunities in this field, setting the stage for the development of the proposed algorithm.

The main contribution of this dissertation is the development of a robust, efficient, and adapt- able algorithm for optimizing adaptive traffic signals under platooned CVs. A simulation-based framework was designed and implemented to evaluate the performance of the proposed algorithm, considering various performance indicators such as travel times, delays, queue lengths, vehicle stops, fuel consumption, and emissions. The safety implications of the algorithm were also investigated, providing valuable insights into its safety performance.

The performance of the proposed algorithm was compared with existing traffic signal control strategies, including both traditional and connected vehicle-based approaches. The algorithm demonstrated superior performance in terms of various traffic parameters and improved traffic safety compared to existing strategies. A sensitivity analysis was conducted to assess the algorithm’s adaptability and robustness under different traffic conditions, CV penetration levels, and platoon formation scenarios.

The findings of this dissertation have important theoretical and practical implications for the fields of adaptive traffic signal control and CV technology. The study contributes to existing theories, models, and frameworks in the field, while also providing recommendations for traffic engineers, policymakers, and other stakeholders on how to leverage the research to improve traffic management, alleviate congestion, reduce emissions, and enhance safety. Limitations and future research directions are also discussed, offering potential avenues for further investigation and development in the area of adaptive traffic signal control and CV technology. This research lays the groundwork for the next generation of traffic management systems that can effectively accommodate the increasing traffic demand and capitalize on the benefits of connected vehicles and platooning.