論 文 内 容 の 要 旨

The dissertation addresses congestion mitigation and traffic performance enhancement in motorcycle-dependent mixed traffic environments by developing traffic control strategies that leverage insights into motorcycle riders' route choice behaviors. Motorcycles dominate the traffic landscape in many regions, especially in Southeast Asia, due to their smaller size and agility. These attributes allow motorcycles to navigate through traffic in ways that cars cannot, significantly affecting overall traffic flow. The research begins with a comprehensive literature review of the unique characteristics of motorcycles compared to other vehicles. Unlike four-wheeled vehicles, motorcycles maneuver with agility, exploiting smaller gaps, which impacts traffic dynamics, especially in regions where they constitute a large proportion of the vehicle population. In such environments, motorcycles account for a significant share of the traffic, which is typically driven by their economic benefits, operational flexibility, and ability to navigate congested urban areas more efficiently than larger vehicles. However, such dominance also brings challenges such as increased congestion concerns, necessitating tailored traffic management strategies. The research underscores the importance of developing tailored traffic control measures that address the specific behaviors and needs of motorcycle riders.

Despite the critical role of motorcycle route choices, research in this area remains scarce, with existing studies predominantly focusing on passenger cars. One sub-objective of the present dissertation aims to understand the decision-making processes underlying riders' route selection and their subsequent impact on traffic systems. This analysis involves investigating external stimuli, including the provision of real-time traffic information systems, which are seldom available in countries heavily reliant on motorcycles. A novel approach is introduced by dynamically incorporating real-time traffic reports into traffic management, focusing on the strategic use of Variable Message Signs (VMS) in non-highway contexts—an area typically overlooked. The methodology involves multiple phases, beginning with the modeling and analysis of the route choice behavior of motorcycle riders. These phases consider road topology, travel attributes, and the availability of VMS. Significant findings from this phase discover the impactful role of traffic information on motorcycle route selection, with 35.6% of study participants altering their routes in response to VMS recommendations, indicating the strong influence of traffic information on motorcycle route selection. Expanding information coverage from toll roads to urban roads encourages more informed decision-making and equitable traffic distribution. The route choice modeling and analysis also integrate individual socioeconomic and motorcycle riding characteristics into the model, highlighting the heterogeneity among motorcycle riders. Factors such as gender, age, occupation, purpose of travel, and driving frequency were discovered to significantly affect their routing decisions. Riders using motorcycles for professional services like taxi and delivery prefer shortcuts to save time, while senior riders prioritize safety by avoiding narrow and high-disruption areas. This nuanced understanding of diverse rider preferences is essential for developing more effective and responsive traffic management systems that cater to the varied needs of motorcycle users. Overall, the findings reveal how targeted measures for motorcycles can lead to more informed route choices, better travel performance, and broader traffic improvements. To enrich the understanding of motorcycle route selection behavior, the current research also explores a link-based choice model, marking another key academic contribution. Such dynamic decision-making route choice behavior is then integrated into the microscopic simulation model using AIMSUN Next 23 software, which captures individual vehicle behaviors and interactions, accurately reflecting the mobility patterns of specific network regions. This integration allows for a nuanced analysis of how individual decisions impact broader traffic patterns, providing a deeper insight into the collective effects of individual route choices on overall traffic congestion and flow. The dissertation successfully presents a reliable micro-simulation model tailored for motorcycle-dependent areas by modifying various crucial aspects in this instance, including road network topology, traffic demand, and driver behavior, to align with empirical observation data. The iterative calibration and validation processes confirm the model's accuracy, effectively demonstrating its capacity to represent traffic dynamics in environments with significant non-lane-based two-wheeled vehicles. The simulation model also includes a pre-defined route choice function derived from the previously formulated link-based discrete choice model. Such adaptability was substantiated by a 27.59% improvement in the statistical accuracy measures during the model's validation, underscoring the importance of an accurate route choice function. The increase in the model's accuracy reveals that motorcycles dynamically adjust their routes in response to evolving traffic conditions rather than merely following the shortest path. This improvement revealed a more realistic representation of the decision-making process in route selection, further illustrating how traffic information profoundly influences travel decisions and enabling the traffic microscopic simulation model to describe this adaptable route choice behavior effectively.

The dissertation not only extends beyond theoretical exploration but also applies practically, demonstrating how route choice modeling and traffic simulations can significantly enhance traffic management strategies in typical traffic patterns found in this context. A macroscopic analysis then becomes imperative for understanding network performance. The Macroscopic Fundamental Diagram (MFD) serves as an effective tool not only for modeling the traffic performance of large-scale 'neighborhoods' but also for assessing traffic control measures by aggregating the behavior of traffic flow and density. Utilizing the MFD allows for a thorough assessment of the current traffic infrastructure and the identification of improvement areas to optimize traffic flow. This strategic application aids in pinpointing specific areas where interventions could yield the most benefit, thus facilitating targeted enhancements in traffic management. However, the standard MFD has not yet been fully adjusted to conditions in regions dominated by motorcycles. Adapting the MFD to these specific conditions is essential, particularly where conventional homogeneous traffic measurements fall short, such as the tendency of motorcycles to disregard lane markings. This adaptation integrates Motorcycle Equivalent Units (MEU) and area occupancy metrics, creating a framework for analyzing traffic dynamics in environments where motorcycles are predominant. The MFD concept allows for a macroscopic view of traffic performance, capturing the relationship between traffic density and flow at a network level. By integrating MEU and area occupancy metrics, the recalibrated MFD offers a more accurate representation of traffic dynamics in environments where motorcycles are predominant.

The data analysis within the study area revealed an extreme surge in traffic during the morning peak, leading to significant congestion and delays. Such tendencies in traffic distribution underscore the need for effective traffic control strategies tailored to manage the distinct behaviors of motorcycles. As the study focuses on dynamic control strategies, traffic information provision is proposed, assessing scenarios based on the scope of its coverage, availability, and accessibility of these reports. This approach aims to bridge the gap between current traffic management practices and the unique demands of motorcycle-heavy traffic, fostering a more responsive infrastructure. Subsequently, the microscopic simulation model evaluates existing conditions and the effectiveness of proposed scenarios, using the recalibrated MFD to identify the most effective traffic control measures. The outputs of the simulation run across various scenarios led to the findings that without specific traffic interventions, network capacity remains limited. However, targeted information, when made universally accessible and available, notably improves network performance, highlighting the necessity of comprehensive real-time traffic reports. While targeted information on major roads rapidly enhances traffic flow, broader dissemination takes longer but eventually leads to substantial systemic improvements. This gradation in response times underscores the importance of strategic placement of traffic advisories to optimize their effectiveness. Importantly, higher compliance rates notably enhance network performance, achieving peak efficiency at full compliance with maximized trip production and network utilization. The effectiveness of traffic control measures heavily depends on drivers' adherence to provided traffic information. The analysis showed that as compliance rates increased from 0% to 100%, network capacity improved significantly, with an 84% increase in overall capacity. Partial compliance already yielded notable benefits, while full compliance led to optimal traffic distribution and utilization. The study also explored the distinct behaviors of motorcycles and their impact on traffic systems, with car compliance held constant at 30%. The findings revealed that at lower compliance levels, network capacity was higher when motorcycle compliance fluctuated. However, at higher compliance rates, greater capacities were observed when both motorcycles and cars had fluctuating compliance. This interaction highlights the delicate balance needed in traffic management systems to accommodate the varying compliance levels of different vehicle types. This suggests that managing motorcycle behavior can significantly improve network performance even without altering car compliance rates. Consistent improvements in compliance for both motorcycles and cars were shown to maximize traffic efficiency and capacity. To sum up, the strategic integration of advanced traffic systems, focusing on dynamic control and behavioral adjustments, can substantially enhance traffic management in motorcycle-dependent cities. However, it should be noted that accurate, timely traffic information and strong compliance rates play a crucial role in achieving efficient traffic management. Effective communication and engagement with all road users are vital to maintaining high compliance rates and ensuring the success of these traffic management strategies. These findings advocate for strategic education and the integration of advanced traffic systems, which are critical for maximizing network efficiency.