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Minimizing Truck-Car Conflicts on Highways

Introduction

Trucks represent the most frequently used transportation mode for domestic freight movement in terms of both shipment values and weight. The increase in the number of trucks and the distance traveled by trucks has been substantial over the past three decades. While the freight truck transportation sector is a key part of the economic lifeline of the nation, trucks also play a disproportionate role in the context of crashes, congestion, and infrastructure deterioration. In Indiana, this has been identified as a key issue in several heavily traveled commercial corridors characterized by a significant percentage of truck traffic. Also, drivers in some rural areas of Indiana have expressed concern about driving discomfort due to the presence of high percentages of truck traffic. While there is a rich body of literature on truck characteristics and crash data, and on models to understand truck safety issues, corresponding progress on the modeling to analyze traffic flow interactions with other vehicles has been rather limited. This highlights methodological gaps in terms of: (i) providing capabilities to analyze the difference in the behaviors of truck and non-truck drivers when they interact in a traffic stream, and how these interactions affect traffic performance, and (ii) analyzing the effectiveness of strategies to mitigate car-truck interactions. The study uses the terms "car" and "non-truck" interchangeably. Car-truck interactions are viewed here as the driving actions of non-truck drivers in the vicinity of trucks due to psychological discomfort. The methodological limitations manifest as the non-consideration or cursory acknowledgement of truck characteristics and effects in analytical and traffic simulation models used in practice.

In this study, a fuzzy logic based modeling framework is proposed to capture car-truck interactions from a non-truck driver perspective using measurable variables. This is done by introducing the notion of "discomfort" in the vicinity of trucks, and using it to extend existing microscopic traffic flow modeling logic. A new parameter called driver discomfort level is proposed to incorporate the various factors that affect individual driver actions/interactions in this regard. Further, it is important to characterize the effects of these interactions at a system level to address real-world problems. Hence, there is a need to benchmark alternative mitigation strategies from the perspective of driver discomfort in addition to system performance and safety. Alternative supply-side strategies to mitigate car-truck interactions on freeways are identified and evaluated using an agent-based simulation platform. Insights are obtained using a case study involving the Borman Expressway (I-80/94) in northwest Indiana.

Findings

This research proposes models to capture car-truck interactions in a traffic stream to more robustly incorporate the impacts of non-truck driver actions in the vicinity of trucks, and to analyze the effectiveness of strategies to reduce car-truck interactions. It represents a first step in developing traffic flow modeling components that are sensitive to the differential driver behavior/actions in the vicinity of trucks. Thereby, it bridges a key methodological gap in the traffic flow modeling arena where trucks are not differentiated from other vehicles, especially from a driver behavior perspective. It proposes some

methodological tools and modeling components for the next-generation of traffic simulation models that seek increased realism in modeling traffic flow. In this context, the fuzzy logic based approach can be advantageous as it can be calibrated using measurable data. Further, the explicit incorporation of driver behavior is a robust mechanism to address other modeling limitations in the traffic flow arena. For example, the influence of road geometry on driving actions is fundamentally based on driver behavior.

Non-truck driver behavior and actions in the vicinity of trucks are solicited through a survey. A majority of drivers believe that they would keep a wider gap with a truck ahead. This is a primary premise for the truck-following model developed in this study. Similarly, drivers state that they drive faster to overtake trucks implying that they prefer to avoid being in the vicinity of trucks, and hence move away from them as soon as possible. Also, drivers state that they are more likely to pass a truck than a car. This influences the lane-changing model when following a truck. The survey also seeks reasons for driver discomfort. More than half the survey respondents state that their discomfort towards trucks is due to trucks blocking the line of sight. Hence, a primary factor for non-truck driver discomfort to trucks is the physical characteristics of trucks. Other reasons identified are the perceived discomfort due to truck driver blind spot and truck size. The various significant reasons for discomfort suggest that truck size and characteristics tend to increase the uncertainty in perceiving the traffic ahead by non-truck drivers, making them more cautious. This cautiousness is reflected through the "discomfort" in the vicinity of trucks, and motivates our hypothesis on driver discomfort.

Car-truck interaction mitigation strategies are analyzed for different congestion levels and truck percentages in the ambient traffic. Under low congestion levels and low truck percentages, restricting trucks to the right-most lane can significantly reduce car-truck interactions without negatively impacting traffic performance. Under high congestion levels and truck percentages, allowing trucks on all lanes may represent the best strategy for some traffic scenarios. For other scenarios, adding a new lane may represent the best strategy, though this entails significant monetary investment. A general caveat when seeking to reduce car-truck interactions is that trade-offs exist among the traffic performance, safety and monetary investment. This implies that the effectiveness of a strategy should be viewed more holistically than just focusing on reducing the discomfort level.

Implementation

The survey of INDOT personnel as part of this study suggests that interstate freeways, especially urban highways, are problematic from the perspective of car-truck interactions. The various locations identified are illustrated in the study. Since the transportation demand and supply conditions vary across problematic locations, INDOT should consider implementing the proposed procedure for specific segments of roadways where the problems are perceived to be acute. The geometric and demand characteristics of the specific segment, in conjunction with the characteristics inferred from the non-truck driver behavior survey conducted in this study, can be used to quantify the level of car-truck interactions. The various mitigation strategies suggested and analyzed in the study may not all be feasible for all problematic segments. Hence, the implementation should first identify the feasible mitigation strategies for a specific location. Further, some strategies may require legislative approval and others may require significant monetary investments. In addition, the implementation should consider trade-offs among multiple performance measures in addition to the car-truck interaction aspects so as to ensure that the strategies implemented are sustainable.

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