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Empirical Analysis on Risky Behaviors and Pedestrian-Vehicle Conflicts at Large-Size Signalized Intersections

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Abstract

In this study, we conducted observation surveys and analyzed the risky behavior of both pedestrians and vehicles making left turns at five major intersections in Japan (left hand traffic system). We aggregated the number of risky behavior of pedestrians and clarified the factors by developing a linear regression model. It is found that if the setback distance of the inflow leg is inappropriately-long, pedestrians tend to exhibit a risky behavior after pedestrian green flashing. We also quantified the risky movements of vehicles making left turns and explained the factors using linear discriminant analysis. For left-turning vehicle, if setback distance of outflow leg is long or the curvature radius of the corner curb is gentle, the vehicle tends to not drive slowly when entering an intersection. In addition, we adopted the estimated post encroachment time (EPET) as a surrogate index to evaluate the risk of conflict between pedestrians and vehicles making left turns. At final third part of corner curb, it was clarified that the wider crosswalk relates to safe situation, however, the larger curvature radius of the corner curb relates to severe conflict. Furthermore, we discussed safety countermeasures for pedestrians by using the results of the sensitivity analysis.

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1. Introduction

Approximately four thousand fatal traffic accidents occur in Japan every year. The National Police Agency reported in 2014 that approximately half of the accidents occurred at or near intersections. Although this number has

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been declining recently, the proportion of fatal accidents involving elderly people is increasing yearly. Additionally the percentage of fatal accidents involving pedestrians is noteworthy.

Several large-sized intersections have been designed in Japan by setting the crosswalks at a significant distance from the intersections or by designing gently curved corners, which take the safety of pedestrians into consideration. For example, gently curved corners allow vehicles to make smoother turns. However, vehicles now require more time to pass through the larger intersections. Consequently, the inter-green period, which is defined as the time between two green lights or the time between the amber and red lights, is a longer period of time. In these situations, the concern is that road users waiting for a green signal could try to avoid the long waiting time by exhibiting a risky behavior, such as accelerating into an intersection during the inter-green period. Moreover, vehicles could turn at a high speed at gently curved corners. In such situations, a high probability exists that accidents or collisions will occur. Therefore, preventive measures for large-sized intersections are required to ensure traffic safety. However, since traffic accidents are infrequent events, validation of the efficacy of the countermeasures through statistical analysis of traffic accidents requires significant time. For this reason, the evaluation of potential accident risk by surrogate safety measures is preferred.

There are studies evaluating the relationship between the behavior of users and intersection geometry based on traffic capacity of signalized intersections (e.g., Kawai et al (2002).). In contrast, there are a limited number of detailed studies into the effects of the relationship between behavior of users and intersection geometry based on traffic safety at signalized intersections. For example, Yukawa et al (2010). developed a model for the trajectories of turning vehicles at intersections. Suzuki et al (2009). analyzed the start-up behavior and interaction of the first vehicle entering an intersection with the clearing vehicle in order to forecast traffic safety. Essa et al (2015) analyzed traffic safety at signalized intersection by using microscopic simulation model with the Surrogate Safety Assessment Model and described conflict heat maps.

Studies of risky behavior and traffic conflict at signalized intersections were reviewed as part of this study. Papadimitrioua et al (2016). conducted a field survey combining pedestrian observations and questionnaire and developed sequential mixed logit models for pedestrians crossing choices. It was revealed that pedestrian crossing choices are significantly affected by road type, traffic flow and traffic control. Though analyzing pedestrian risky crossing, they did not explain for traffic conflicts between pedestrian and turning vehicle at signalized intersection. Onelcin et al (2015). focused on pedestrians' illegal crossing behaviors at signalized intersections and conducted ANOVA analyses by using the data extracted from video recordings. They found that pedestrians based their decision on distance rather than time gap. Though they discuss the relationship between pedestrian risky behavior and vehicle movements, they did not consider the effect of intersection geometry on the traffic conflicts and not focus on the turning vehicles risky behaviors. Cantillo et al (2015). analyzed the relationship between pedestrians crossing options and walking distance in urban roads by a discrete choice model based on SP survey data. Though they revealed the effects of socioeconomic characteristics of the individual on their choice decision, they did not analyze the interaction between pedestrian and vehicles. Sasaki et al (2010). examined the conflict incidents between vehicles making right turns, including the traffic patterns, during the inter-green period. Zaki et al (2014). developed and tested an automated system for identifying pedestrian crossing nonconformance to traffic regulations by using pattern matching. However they can grasp pedestrian behavior in detail, it is necessary to analyze the relationship among behavior, intersection geometry and signal control. Otashiro et al (2011). evaluated the degree of conflict risk for vehicle-vehicle interaction at multiple intersections with different sizes. Finally, Ogawa et al (2008). attempted to estimate the vehicle conflict risk based on the probability of vehicles existing within intersections. Though these studies evaluated the conflict risk during the inter-green period at signalized intersections, they did not quantify the relationship between the risky behavior of users, the intersection geometry, and the conflict risk during both the inter-green period and the green signal period. For an analysis of the relationship between the risky behavior of users, intersection geometry, and conflict risk, Suzuki et al (2011). quantified the effect of vehicle speed and rear-end traffic conflict in a compact intersection. However, this study evaluated only one site without evaluating the effect of intersection geometry. Additionally, the traffic conflict pattern was limited.

In this study, we conducted observation surveys by using video-camera recorders at several multiple large-sized intersections. In addition, we analyzed the behavior of pedestrians and movement of left-turning vehicles. We clarified the relationship between risky behavior and intersection geometries through statistical models, including evaluating the efficacy of countermeasures, such as improved intersection geometries in reducing risky behavior.

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