International Co-operation on Theories and
Concepts in Traffic Safety

How severe are interactions at mini, single-lane and a multilane roundabout? An investigation using automated trajectory data analysis

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Introduction

Intersections are recognized as the most dangerous and critical locations, with a higher probability of conflicts and near misses compared to other road facilities (Liu et al. 2020). In safety engineering, a near miss or near crash is an event that might have resulted in a crash but did not due to timely recovery actions by the users involved (Van der Schaaf 1992). Roundabout intersections are considered comparatively safe because they reduce conflict points, including severe right-angled conflicts (Dixon and Zheng 2013). Additionally, roundabouts are self-regulating, as vehicles are forced to move in an orderly and regimented manner. Despite these advantages, past studies have highlighted that due to channelizing measures and the lack of signage for route selection, lane change conflicts resulting in side-by-side and rear-end collisions occur at roundabouts, reducing their safety (Dixon and Zheng 2013, Al-Ghandour et al., 2011). According to road traffic statistics released by the Department for Transport, approximately 9,270 accidents occurred at roundabouts in Great Britain (Road Traffic Stats, 2021).

Due to the limitations in the quantity and quality of crash data, previous studies have advocated for the use of surrogate safety measures (SSM) to evaluate the safety of road facilities (Ismail et al., 2009, 2010). The underlying theory of SSM assumes that a high frequency of severe road user interaction events indicates a high probability of accident occurrence. Extensive discussions on surrogate safety measures and related theories can be found in Laureshyn et al. (2017) and Ashutosh et al. (2021). Laureshyn et al. (2017) compared three surrogate safety approaches to assess how well each safety diagnosis relates to road user interactions at roundabouts. The approaches are the Swedish traffic conflict technique (Hydén, 1987), the Dutch traffic conflict technique DOCTOR (Vander Horst and Kraay, 1986), and the probabilistic surrogate measures of safety (PSMS) technique developed in Canada (Saunier et al., 2010a). Laureshyn et al. (2017) noted some disadvantages of the PSMS approach regarding false alarms but concluded that the Swedish and Dutch traffic conflict techniques offer more versatile illustrations of safety problems when compared with accident records. A key takeaway from the study was to use either the Swedish or Dutch TCT for surrogate safety analysis of roundabouts.

Ashutosh et al. (2021) highlighted that surrogate safety analysis has primarily focused on signalized and unsignalized intersections, with a lack of studies on roundabouts. Although some studies have addressed the surrogate safety analysis of roundabouts (Vasconcelos et al., 2014; Giuffrè et al.), there is still a need for further research due to the increasing number of accidents. To fill this gap, the objective of the present study is to conduct surrogate safety analysis of three different types of roundabouts in the UK: mini, single-lane, and multilane roundabouts.

Specifically, this study aims to (1) identify suitable surrogate safety measures to assess the severity of interactions at roundabouts, (2) propose severity thresholds for roundabouts based on conflict types, (3) compare interaction severity at mini, single-lane, and multilane roundabouts, and (4) propose countermeasures to reduce interaction severity at different types of roundabouts.

Research Methodology

This study employs a methodological framework, as illustrated in Figure 1, to assess the safety of roundabouts. The research begins by observing vehicle-vehicle interactions at three types of unsignalized roundabouts—mini, single-lane, and multilane—located in Newcastle Upon Tyne, UK. The selection of indicators is based on the types of conflicts occurring at each roundabout. Severity threshold estimation of the surrogate safety measures is conducted using a supervised learning approach, specifically the Relevance Vector Machine (RVM), which employs Bayesian inference for classification. The proposed thresholds are then tested on a roundabout to evaluate the severity of the conflicts.

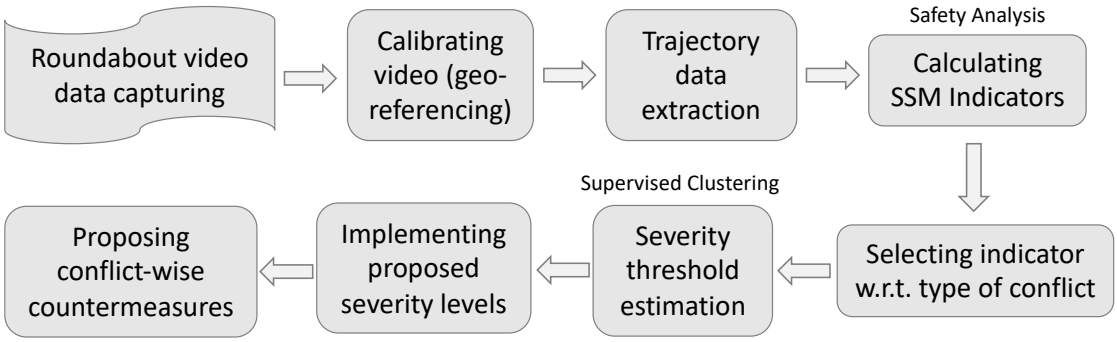

Figure 1. Study methodology

Results

A relevance vector machine classification method was used to estimate severity levels (0-safe, 1-mild, 2-critical) for crossing, merging, rear-end, and side swipe conflicts using the Time to Collision (TTC) indicator. TTC was chosen over Post-Encroachment Time (PET) based on the confusion matrix results obtained from applying the severity threshold to an additional roundabout not included in the initial severity threshold analysis. When comparing conflict types with respect to roundabout types, it was found that rear-end conflicts in multilane roundabouts had the highest severity. In contrast, side swipe conflicts showed the highest severity in mini-roundabouts, while merging conflicts had the highest severity in single-lane roundabouts.

Discussion and Conclusions

Understanding the severity of conflicts with respect to the type of roundabout will enable practitioners to recommend targeted countermeasures to enhance overall roundabout safety by addressing specific issues. While this study will propose several countermeasures to improve safety, testing these countermeasures is beyond the scope of the current research.