International Co-operation on Theories and
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# Investigating interactions between bicycles and vehicles at intersections using real-world trajectories

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Research on interactions between vehicles and vulnerable road users (VRUs) often focuses on critical interactions due to larger accident probability as well as injury and fatality rates. However, normal encounters between motorists and VRUs are also worth exploring. These interactions can be used to improve the calibration and validation of dedicated vehicle or microscopic traffic simulators and help autonomous driving functions emulate human-like behavior when interacting with VRUs in everyday situations.

The aim of the study is to model the interactions between motorists and VRUs and apply the interaction model to microscopic traffic simulators. The model is applied in the Simulation of Urban Mobility (SUMO).

Due to the high exposure rate, the interaction between right-turning vehicles and crossing bicycles was selected as the target scenario. Trajectories were converted from ten days of video recordings from the Application Platform for Intelligent Mobility (AIM) Research Intersection in Braunschweig, Germany, in October 2022. Based on a PET (Post Encroachment Time) threshold of less than 5 seconds, approximately 900 valid interaction cases were identified. We investigated the interactions between bicycles and vehicles at this crossing by modeling the sequence of their passage through the intersection (i.e., bicycle first vs. vehicle first). Considering the availability of trajectories of both road users, the effective range for the model was set to be 5-20 meters before the crossing. This means that data within this range will be used for training, testing, and validation in the simulation. The classifiers, including logistic regression, decision tree, and random forests, were implemented and compared across various feature combinations, with model results being cross-validated.

Cross-validation results showed that all three models, using features such as vehicle and bicycle speed, the distance of the vehicle to the crossing or predicted PET, achieved approximately 90% accuracy, implying that the models are able to predict who will pass the intersection first within a range of 5-20 meters from the intersection. Considering the feasibility of converting the model for SUMO, we adopt the logistic regression with vehicle and bicycle speed and the distance of the vehicle to the crossing as features. In the subsequent part of the study, we attempted to implement this model within the SUMO traffic simulator and compare the results with the default model in terms of yielding rate and PET distribution.

The study revealed the behavioral patterns of both motorists and VRUs during their interactions at intersections. It was also revealed which variables play a decisive role in determining the sequence of passing through intersections. The developed model has the potential to improve the realism of existing models in SUMO, ultimately enhancing accuracy and applicability of such simulations for transportation research and planning.

*Keywords:* vulnerable road users, bicycle, intersection, interaction model, SUMO, trajectory data