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Assessing the influence of visibility components in interactions between bicyclist and car drivers

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1. Introduction

The simulation of bicyclists' movement and interactions with other road users finds application in many different domains, including the development and evaluation of emerging automated vehicle technologies. As Twaddle et al. (2014) point out, bicycle movement simulation is possible by different approaches. Besides implementations as agent-based simulations (Valentin and Loidl 2015) or microscopic traffic simulations, there are studies that aim to include more realism into the simulated traffic. One often-used option is to include real movement data of acquired moving entities on road networks. This comes often together with critical decision making of selecting representative movement for bicyclists and any other tracked entity. Additionally, it is feasible to include additional sensor information into the data analysis step that only is indirectly connected with the object movement in geographic space, as for example measuring the heart rate or the inertial movements of the objects as gestures and eye movements (Zeile et al. 2016). Data acquisition and analysis steps might help improving realism of microscopic traffic simulation, by including parameter values representing real traffic conditions, which is measurable in subsequent evaluations. It is

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possible to find typical parameter values from real movement data for adjusting various microscopic traffic simulations. In a similar way, Twaddle (2017) introduce a framework for extracting real world bicycle movement trajectories from video acquisition, for the subsequent inclusion into traffic simulation. Although models describing individual road users are becoming more precise, the possibility to accurately simulate interactions between different types of road users, for example bicyclists and car drivers, remains limited. One important aspect for the simulation of interactions between road users is the quantification of the visible space and the continuous change of this visibility (Benedikt 1979, Davis and Benedikt 1979). The purpose of this work is to develop an approach for integrating visibility into behavior models. Starting from typical or averaged bicycle movement trajectories at road intersections, our aim is to enrich every trajectory position of different turning maneuvers with respective visibility polygons. Based on the overlapping and intersection patterns of these polygons for different time windows at road intersections, we reason on the time-varying interactions between the different traffic participants. The outcomes are different interaction areas that are matter of further simulation experiments, focusing on the dynamic interactions between moving car drivers and bicyclists.

2. Methodological approach

The focus of this work is to explicitly include the geo-spatial component of movement trajectories into analysis. The goal is 1) to segment the occupied space by various methods, which may originally result from urban planning or GIScience approaches, and base on different standardized methods of the interdisciplinary field of spatial cognition, 2) to classify the occupied space by vehicle and bicycle drivers, 3) to associate dynamically changing attribute values with those visibility features (points, lines and polygons).

The results of practical tests, namely bicycle trajectory analyses, coming from real movement data acquisitions and bicycle simulator experiments, of at least two selected complicated road intersections in Germany, serve for gaining insights on estimated visibilities of spatial components and the spatial configuration of road intersections in general.

The trajectory data will be used to associate behavioral aspects of bicyclists and car drivers that lead to safe interactions. Particular importance is placed on the comparison between traffic situations, driving situation and driver situation, and the respective interaction patterns with urban space as outlined by Plavšić (2010) and Gerstenberger (2015).

3. Practical tests and first results

Practical tests include, in a first phase, the computation of isovist polygons for every spatiotemporal position of acquired bicyclist and car driver movement trajectories, and in a second phase the generation of a time series layer of timestamped isovist polygons. Resulting from these two procedures, we propose a specific isovist polygon matching procedure, where certain areas are derived that imply a proportionally high appearance of traffic participants. This step includes enriching of the computed isovist polygon series with additional attributes, including number of passing traffic participants, velocities and movement densities, which is defined via trajectory lengths and inspected time window. Areas with low movement densities are then associated with sidewalks and areas with high interaction movement densities (bicyclists and car drivers) are assigned to different levels of interaction frequencies. In general, we can say that we classify vehicle and bicycle movement by estimated qualities of visibility properties, which are represented as time series of isovist polygons. Resulting from this, the most important outcomes are the areas (polygons) with high, medium and low bicyclist car driver interactions.

4. Outlook

The future steps following the presented approach imply the adaptation of the precomputed timestamped isovist polygons into a classification scheme, that imply typical compositions of urban road intersections as proposed by the Road and Transportation Research Association (FGSV).

The first step in doing this is to inspect any correlations between the mentioned polygon matching results and specific components of the built infrastructure at selected road intersection types, consisting of both static and dynamic features. Afterwards, we relate every trajectory position of turning maneuvers and other groups of movement with visibility polygons.

The second big step is to include the adapted classification scheme together with eventually gained knowledge into a bicycle simulation software that is linked to a physical traffic simulator. This leads to the further inspections of how interactions depend on the visibilities of specific road intersections and specific properties of the latter.

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