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Quantifying the Complexity of Road Intersections Using Open Data of Traffic Accidents – Insights from a Case Study in Munich

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Abstract:

Within the present work we perform a density-based cluster analysis of historical traffic accident records (of the years 2016 to 2019) with relating to previously-gained knowledge on the built infrastructure and its average geometrical values in the city center of Munich. By applying density-based clustering on locations of historical annual traffic accident records we define selected spatial polygons within our investigation area, which are subsequently set in relation to geometrical properties and spatial configuration of the present transportation infrastructure. First results show specific relationships of selected traffic accident types and classes or types of transportation infrastructural elements.

The study of Bärschmann (2011) showed that driving beginners in Munich have very specific fears when it comes to complex traffic situations or situations perceived as being dangerous. Based on selected insights from this questionnaire evaluation study Krisp and Keler (2015) designed their routing applications avoiding selected intersections within the Munich road network as they are introduced as obstacles implying a high complexity value and exceeding a manually-chosen threshold. These obstacles result from a Kernel Density Estimation (KDE) of extracted nodes of polylines representing road segments and a subsequent density threshold selection. Intersecting polylines, those with numerous curvature and nearby situated (and partially intersecting) segments of different types (such as those assigned for cyclists) usually result in higher node densities and obstacle polygons.

Sladewski et al. (2017) subsequently inspected the complexity or road intersections by defining a model of weighting every turning possibility at every road intersection independent of signalizations, intersection area sizes and resulting choices. The easiest-to-drive route is a result of computing the least-cost path from point A to point B depending on the weighting of every turning option.

Our current idea makes use of freely-accessible open data of historical German traffic accidents, which are one of the few available data sources for estimating traffic safety when not inspecting the perceived safety. We regard this data and extractable information as beneficial for validating the mentioned complexity estimation methodologies based on geometrical properties and spatial configuration of transportation infrastructural elements.

Other research focussing on perceived safety (and actual crimes) makes use of geo-coded police records, which are valuable data for researchers, administrative analysts and decision-makers as for example crime hotspots are inferable, connectable to traffic incidents and situations for inspecting potential relationships to the high-dynamic change of urban traffic situations (Kalinic and Keler, 2018) or even provide a routing application or navigation service avoiding historical hotspots of heavy crime (Keler and Mazimpaka, 2016).

In this work we focus only on the traffic accidents involving different types of conflicting road users or road users and infrastructure and try to relate extractable spatial traffic accident patterns to intersection geometries and modelled complexities as it was addressed by Sladewski et al. (2017). First, we introduce a clustering procedure for extracting historical traffic accident hotspots in Munich. These annual average areas serve for a statistical inspection of accident type frequencies and its subsequent relation to specific road intersection geometries, taking into account the type or road intersection as it is specified under German infrastructural design guidelines (Brilon, 1998). We compute polygons from the density-connected spatial traffic accident clusters and relate them to those intersections previously classified as being complex by the method of Krisp and Keler (2015). First results show selected relationships between selected locations in the city center of Munich.

We cluster geo-coded traffic accident records within the city boundaries of Munich by applying the OPTICS algorithm (Ankerst et al., 1999). In a previous step, we grouped the records into annual data sets and inspected the defined classes of traffic accident types, mainly involving varying road user types. The search distance for applying the OPTICS algorithm is 60 m and minimum number of points is set to 3 points. This results in approximate cluster numbers of 260 to 280 for the respective annual data sets. Additionally, we extracted road network information from OpenStreetMap and

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analysed the consistency of the road segment connectivity as in the north of Munich as pictured in Figure 1a. The computed clusters at the ones from the year 2016 pictured in Figure 1b.

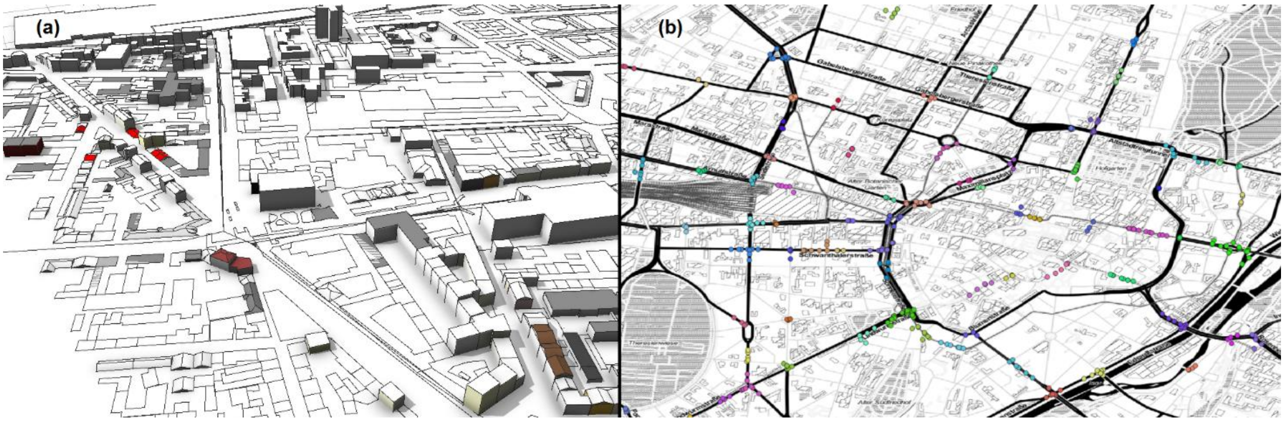

Figure 1. (a) Extracted road network information from OpenStreetMap, and (b) Computed spatial clusters of historical traffic accidents in Munich from the year 2016.

First results show a dependency of the infrastructural design complexity and the number of varying traffic accident types occurring at the respective intersecting polygons in the investigation area. Additionally, we can define classes of accident types related to specific cross-sections of selected urban road types, especially at selected intersections as pictured in Figure 1b.

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The used open data of traffic accidents in Germany in the years 2016 to 2019 is accessible via https://unfallatlas.statistikportal.de/_opendata2020.html and is provided by the Federal Statistical Office of Germany and the statistical offices of the German states and maintained by the statistical office of Baden-Württemberg.

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