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Interactive visualizations for assessing car-to-bicycle overtaking manoeuvres

Hannah Wies [a,*], Moritz Beeking [a], Karl Rehrl [a]

[a] *Salzburg Research Forschungsgesellschaft m.b.H., hannah.wies@salzburgresearch.at, moritz.beeking@salzburgresearch.at, karl.rehrl@salzburgresearch.at*

* Corresponding author

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Abstract:

Cycling has been acknowledged by the European Commission through the Declaration on Cycling as a healthy and sustainable mode of transport to be encouraged (European Commission, 2023a). However, in the past decade (2010-2020), the number of cycling fatalities in Europe did not decrease compared to other modes of transport (European Commission, 2023b) and missing bicycle infrastructure enhances accident risk (European Commission, 2022). When sharing the road, motorized vehicles pose a potential safety risk when overtaking bicyclists (Rasch et al., 2022). Numerous studies investigate overtaking manoeuvres by equipping bicycles with dedicated sensors, such as cameras, laser rangefinders, ultrasonic or LiDAR sensors (Beck et al., 2021; Dozza et al., 2016; López et al., 2020; Louro et al., 2023; Rasch et al., 2022). The predominant approach focusses on measuring the lateral clearance during the passing phase (Beck et al., 2021; López et al., 2020; Louro et al., 2023; Rasch et al., 2022). Dozza et al. (2016) propose parameters for different phases of an overtaking manoeuvre in their study, e.g. the duration of and the distance within the approaching, steering-away, passing, and returning phases of an overtaking manoeuvre. More complex sensor data, e.g. 3D LiDAR point clouds, along with derived surrogate safety measures, allow new insights on each overtake. For analysing an overtaking manoeuvre in detail, appropriate visualizations of overtaking manoeuvres are supposed to help traffic analysts and researchers. Often, both an individual overtake as well as a summary of various overtakes on the same road section are of interest to the analyst. The question arises how these analyses can be effectively supported by spatiotemporal visualizations of overtaking manoeuvres. Dodge and Noi (2021) emphasise the efficiency of interactivity and animation for visualizing objects that change their attributes and their position in space and time. Therefore, this work proposes interactive spatiotemporal visualizations to a) examine the pattern of various overtaking manoeuvres taking place at the same site and b) to visually investigate individual overtaking manoeuvres, including their measured surrogate safety measures.

The basic datasets for visualizing spatiotemporal dynamics are 3D bounding boxes of the motorized vehicle derived from 3D LIDAR point clouds and projected onto the ground plane, as well as 2D bounding boxes of the bicycle derived from its position, size, and heading. Overtaking manoeuvres for one road section are recorded with repeated test rides using an instrumented bicycle. For our study, the instrumented bicycle has been provided by BB Boreal Bikes GmbH and has been equipped with a 32-layer LiDAR sensor at the rear as well as a GNSS RTK receiver, along with other sensors not used in this work (see Figure 1). From the 2D bounding boxes, the surrogate safety measures describing the overtaking manoeuvre throughout its phases are derived.

Figure 1. Instrumented bicycle equipped with LiDAR and a GNSS RTK receiver (source: Salzburg Research).

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To visualize an individual overtaking manoeuvre, the 2D moving bounding boxes of the objects (motorized vehicle and bicycle) are transformed from a local coordinate system with the origin at the sensor's centre on the bicycle to real world coordinates. Due to the spatiotemporal dynamics of the bounding boxes, an interactive animation is used to visualize the position of both objects over time. Additionally, the surrogate safety measures of the overtake are depicted in the corresponding frame. By using the time slider, the analyst can slide back and forth to examine the spatial configuration of the bicycle and the motorized vehicle and to query a surrogate safety measure of interest at that time. The time taken for a motorized vehicle to overtake a bicyclist depends on the circumstances (oncoming traffic, visibility, etc.) and can vary substantially between individual overtakes. Hence, this work aims to develop animations suited to capture the whole overtaking manoeuvre, while still being able to analyse a certain surrogate safety measure of the overtake.

While it is of importance to investigate single overtakes, in many cases a summary of various overtaking manoeuvres per road section is of interest. In previous works (Dozza et al., 2016; Louro et al., 2023), surrogate safety measures are only represented as summarized statistics. This work tries to add a cartographic dimension to the data by suggesting an interactive map for the analysts to assess multiple overtaking manoeuvres on the same road section. The analysts can interactively choose which surrogate safety measure (e.g. minimum lateral clearance, time spent following, etc.) is visualized on the 2D map. On the one hand, this allows investigating specific patterns of the surrogate safety measures on the specific road section and on the other hand, allows identifying interesting individual overtakes to be regarded in detail.

In conclusion, this work is exploring ways to visualize spatiotemporal dynamics on an individual an on an aggregated level. Animation and interaction are used to explore various surrogate safety measures of car-to-bicycle overtaking manoeuvres. This allows in-depth analysis and additionally facilitates communication of complex measurement data.

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