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Traffic Safety Analysis of Overtaking Behaviour in the Rural Domain: A Case Study at a Village Entrance

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In 2021, 14.5% of all road casualties in Germany were cyclists. More than the half of the accidents (53.3%) occurred in urban areas, while 46.7% occurred outside of towns and villages. The majority of accidents involve other road users, such as cars, lorries, and other cyclists. This is particularly problematic in rural areas, where the road transport infrastructure tends to be underdeveloped and lacks dedicated space for vulnerable road users (VRUs), such as cyclists and pedestrians. The use of shared infrastructure increases the potential for conflicts among all traffic participants. As the rural domain has received less attention in research, there is a pressing need to study real-world traffic in these areas for a thorough understanding of traffic. This knowledge enables to develop infrastructural measures to improve traffic safety and to support the development of automated vehicles before their release into the public domain.

The aim of this study is to analyse traffic in the rural area using real-world traffic data acquired at a village entrance. Specifically, this work focuses on the driving behaviour during overtaking manoeuvres, which is a common and relevant manoeuvre in terms of traffic safety. The speed difference and lateral distance between motorised road users (MRUs) and VRUs are investigated, among other factors, as they affect the risk perceived by the VRUs. To achieve this, a two-week measurement campaign was conducted. The results of this campaign also supported a traffic safety audit by the German Road Safety Council e. V. (DVR). The measurement location (see Figure 1) was a village entrance on the federal road B179 in Brandenburg, Germany. The speed limit in the out of town area is 70 km/h and 50 km/h in the in-town area. Pedestrians and cyclists have to use the federal road due to the lack of traffic infrastructure for VRUs. There is a low-traffic side road in the measurement area. During the measurement campaign, traffic information is collected, including the trajectory as a time-series of absolute positions in UTM, velocity, and dimensions of road users. Additionally, anonymised video material was collected. For this purpose, a mobile measurement station was installed near and towards the village entrance. The measurement station is equipped with two stereo-camera based systems and active infrared flashes. The data is continuously acquired throughout the two-week campaign and transferred to a database afterwards. The database is then used to semi-automatically extract and categorize overtaking

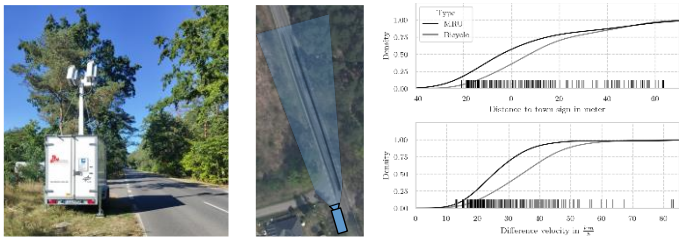

Figure 1: The measurement station (left) collects traffic information including trajectory data (middle) that allows the analysis of traffic participants behaviour in overtaking scenarios (right).

scenarios based on the traffic participants involved. The lateral distance between both involved traffic participants is estimated by projecting the trajectories onto two manually designed polygons that represent the two directions of the federal road. This projection is also utilized to relate the positions of traffic participants relative to the town sign. The overtaking scenario are categorised according to the heading direction of traffic participants and analysed according to the lateral overtaking distance, the manoeuvre's start location and the velocity difference between traffic participants involved in a scenario.

During the measurement campaign, 399 overtaking scenarios were observed. All scenarios occurred during the daytime between 4 a.m. and 9 p.m. Of these scenarios, 329 involve motorised vehicles and cyclists, while 70 scenarios involve only motorised vehicles. Of the 329 scenarios, in 200 cases the traffic participants head into the village, and in 129 cases out of the village. The average lateral distance between the overtaking motorised vehicle and the cyclists was 2.36 ± 0.51 metres for the scenarios heading out of the village and 2.59 ± 0.52 metres heading into the village. In Germany, the minimum safety distance for overtaking cyclists in the out of town area is two meters. However, 27% of all overtaking vehicles entering the village and 14.74% leaving the village did not maintain this minimum safety distance. Of the 70 scenarios involving only motorised vehicles, in 15 cases, the traffic participants head into the village and 55 out of village. In the majority of overtaking scenarios heading into the village, turning vehicles were overtaken by vehicles on the federal road. The mean lateral distance is 2.59 ± 0.57 metres for the scenarios heading into the village and 2.09 ± 0.45 meter out of the village. In the majority of the scenarios involving two vehicles heading out of the town (59.6%), the overtaking vehicle initiates the manoeuvre within the village. The velocity difference between the vehicles in these overtaking scenarios is 27.29 ± 12.71 km/h. Vehicles tend to overtake cyclists nearly evenly throughout the measurement area, with 35.38% of scenarios occurring in the village at a velocity difference of 36.84 ± 12.88 km/h.

The study found that, in most cases, overtaking vehicles maintain the minimum safety distance to cyclists. The video material showed that in some cases, the minimum safety distance was not established by the overtaking vehicle, despite there being no oncoming traffic. In one scenario the cyclist was overtaken by a bus in the out of town area. Furthermore, when cyclists use the federal roads, they are often overtaken by multiple vehicles, each maintaining different safety distances. This may be because the overtaking vehicle was unable to see the oncoming vehicle as it was hidden by the vehicle in front. This has potential of conflict because vehicles may need to abort the overtaking manoeuvre to prevent a critical situation with an oncoming vehicle by decreasing the distance to the cyclists, thus increasing the cyclists' perceived risk. During the measurement campaign, no critical overtaking manoeuvres between vehicles occurred, as vehicles tend to overtake with a reasonable lateral distance. However, the study found that the majority of vehicles initiate the manoeuvre in town and are significantly faster than the overtaken vehicle. In fact, the overtaking vehicles mostly exceed the maximum speed limit allowed within the village. This motivates the reduction of traffic speed with countermeasures such traffic islands. Traffic within the village could only be partly observed due to the measurement station's perceiving area. Further work could be done to observe traffic in a larger measurement area, and in other rural areas. Moreover, the results of this work could be used to design virtual reality-based studies to investigate subjective perceptions of traffic safety, and to support the development of automated vehicles.