Evaluation of the Traffic Efficiency of Bicycle Highways: A Microscopic Traffic Simulation Study

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Introduction

The project RASCH analyzes the traffic characteristics of bicycle traffic in bicycle highways and their intersections with the rest of the road and bicycle network. The examination and evaluation is based on microscopic traffic flow simulation and examines the effects of a bicycle highway on traffic participants. This microscopic traffic simulation study considers a possible inner-city pilot route of the city of Munich, where the present bicycle infrastructure may be upgraded to a bicycle highway. Through microscopic traffic simulation studies the potential improvements of traffic efficiency and safety for bicyclists can be determined. Specifically, it is examined to what extent traffic control measures specifically adapted to bicycle traffic can fulfill the criteria for fast bicycle connections specified in [1]. Furthermore, the influence of the heterogeneous composition of bicycle traffic on traffic flow along bicycle highways is evaluated, as compared to motorized private transport, there is a much wider diversification regarding the driving behavior of different user groups, which is reinforced by the different bicycle types such as pedelecs, cargo bikes and bicycles with trailers.

Literature Review

Bicycle Traffic Composition

The bicycle traffic composition is of key importance for the microscopic traffic simulation of a bicycle highway traffic flow. Also, the consideration of different types of bicycles is important for the modeling and simulation of bicycle traffic flow. Reasons for this are the different dimensions of bicycle length and width, which fundamentally influences the traffic flow, overtaking maneuvers, estimated speeds or acceleration and deceleration profiles. Cargo bikes generally occupy a larger area of space, which strongly influences the interaction with other cyclists. At the same time, in the case of bicycle with child transport, due to the increased responsibility for safety, lower speeds are expected.

Grabke (2017) investigated the bicycle composition at selected locations in Munich. Cycling surveys were carried out at six different locations in Munich during peak periods. The results of the survey show that in most cases the group of 18- to 40-year-olds are traveling on a trekking or city bike. Pedelec riders take only a share of 0.6% to 5% [2].

Traffic Control Measures for Bicycle Traffic

The application of traffic-adaptive control strategies at the intersections between bicycle highways and the road network has the potential to increase the traffic efficiency and safety for bicycle traffic. The specific requirements of bicycle traffic are taken into account for the design of traffic signal plans in the German guidelines for the design of traffic facilities [3]–[6]. Different traffic control methods for bicycle traffic are proposed. These methods usually aim at increasing the safety for bicycle traffic in the intersection space. This includes traffic measures such as the offset of the green time, the reduction of the cycle time to a maximum value of 90 seconds and the design of signal coordination for bicycles. A detailed description and evaluation of such traffic-related measures for bicycle traffic is given in [7].

In recent years, various traffic control measures, which take into account the requirements of bicycle traffic are deployed in European cities. These measures aim at accelerating bicycle traffic along signalized corridors through the implementation of bicycle-friendly signal coordination measures and the prioritization of bicyclists at intersection approaches. Examples

include European cities with high traffic volumes, such as Copenhagen [8], Amsterdam [9], Rotterdam [10] Vienna [11], Bern [12] and Munich [13].

It is also possible to consider bicycle traffic in the urban traffic management system and thus at network level. In York (United Kingdom), the tail-end biasing method was developed, which uses an optimization technique for the offset of green times. The goal of the optimization is to offset the final part of the green times. This method was initially developed to optimize bus traffic but also improved the traffic flow of all road users moving at a slower speed. In Nijmegen (Netherlands) the adaptive network control method SCOOT is applied [7].

Newly developed innovative traffic control applications either assist the bicyclists along the coordinated route or consider the bicycle traffic state. Such a technique is used in Rotterdam in the Netherlands to support coordination of bicycles through structural measures. The system named Evergreen consists of LED lights, starting a few hundred meters in front of the considered traffic signal system. The LEDs show green blocks and thus signal cyclists the correct progression speed to allow a stop-free passage [10].

Sitraffic SiBike [14] is a mobile application developed by Siemens that prioritizes bicyclists at signalized intersections. SiBike has the potential to increase traffic efficiency and traffic safety for bicyclists. The advantage of Sitraffic SiBike over a fixed signal coordination is that Sitraffic SiBike prioritizes the bicycle traffic taking into account the actual state of traffic control at an intersection as soon as a bicycle has driven through a predefined position upstream. Thus, the traffic light control is adapted to the bicycle traffic state. At the same time, no structural measures are necessary - only the signal program is changed.

Methodology

For the microscopic traffic flow simulation studies, the existing traffic network is introduced in the microscopic traffic flow simulation software SUMO [15]. The dimensions of the traffic infrastructure in the simulation network is adjusted according to the real infrastructure elements. The simulation model is calibrated and validated using traffic volumes provided by the city of Munich.

In order to assess the potential effects of bicycle traffic flow on future bicycle highways, the effects of different volumes and different bicycle traffic compositions are examined through microscopic traffic simulation studies. Through these studies, dimensioning limitations for bicycle highways are defined. In addition, different signal control strategies at the intersections with the urban road network are implemented in order to assess their effect on bicycle traffic efficiency. These include the design of a signal coordination along the study corridor and the implementation of prioritization measures at the signalized intersection approaches aiming to improve bicycle traffic efficiency and traffic safety.

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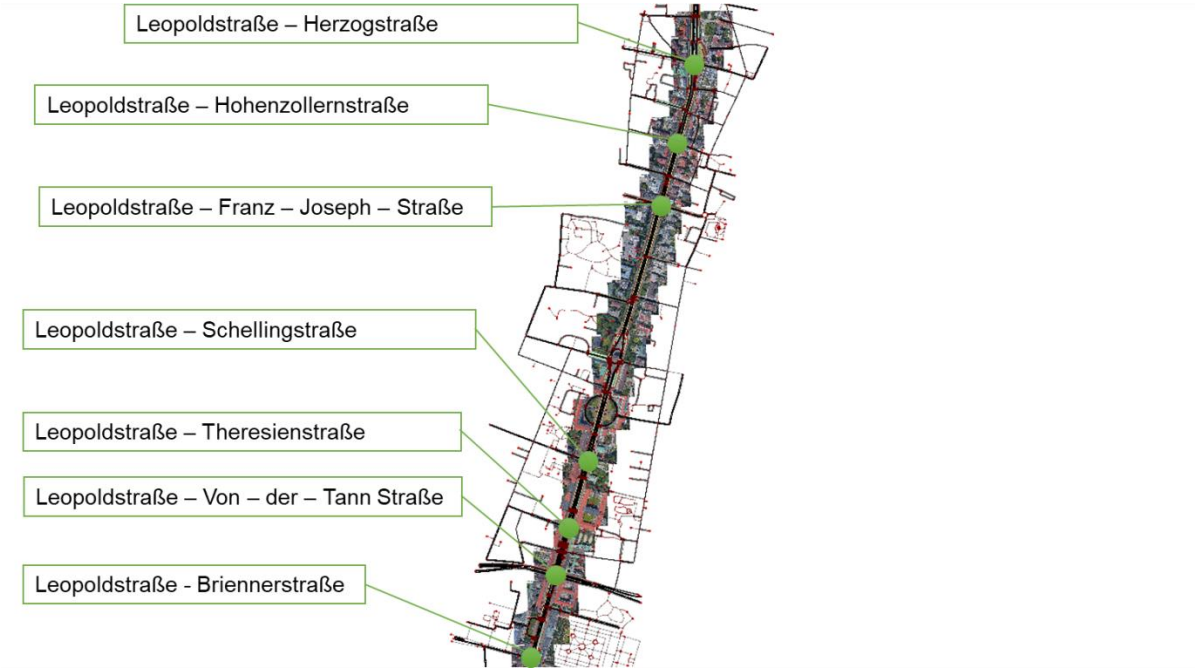

Figure 1: Simulation Network of the bicycle highway in SUMO

Expected Results

Through this study, the potential of bicycle highways in the improvement of bicycle traffic efficiency and safety is determined. It is also examined to what extent traffic control measures can contribute to increasing the bicycle traffic flow efficiency. Furthermore, the influence of the heterogeneous composition of bicycle traffic is evaluated. Finally, limitations in the dimensioning of bicycle highway infrastructure are identified.

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