Evaluating bicycle traffic efficiency using bicycle traffic counts at sparse locations in cities – comparing NYC with Munich

Andreas Keler*[1], Florian Schmiedlau†[1] and Georgios Grigoropoulos ‡[1]

[1]Chair of Traffic Engineering and Control, Technical University of Munich

July 3, 2020

Summary

Cycling in urban areas has complex patterns. Depending on the qualitative conditions and the expansion of the respective bicycle infrastructure, bicycle traffic flows can develop differently. Additionally, mixed traffic participation, interaction frequencies with other road users and the spatial layout of parking facilities influence the properties of cycling trips. These factors have temporal and spatial variations and may emerge in certain periodicities. We investigate only one on these factors, namely permanent bicycle traffic count data at sparse locations and introduce an experimental methodology for delivering a first proof of concept of comparing bicycle flow in two different urban investigation areas, NYC and Munich. As the former is more complex and populated we introduce a preprocessing procedure (as an optional part of the methodology) for identifying hotspot of frequent bicycle usage via OD pairs from NYC CitiBike bike sharing service. Subsequently we extract OSM road segments for creating microscopic traffic flow simulation networks, which are then respectively calibrated based on the bicycle traffic count information at the permanent locations in both cities. First simulation results address our first research question: Is the state or quality of the present bicycle infrastructure inferable only from permanent bicycle traffic counts? The second research question addresses the possibility to infer event information, such as social or weather events from data of permanent bicycle traffic count locations. First results are discussed based on their usefulness for further studies. Bicycle traffic efficiency is compared on general level with first experiences with the two calibrated simulation networks and the detection of events with a comparison of both traffic count data sets and additional weather data.

KEYWORDS: Spatial Analysis, Bicycle Traffic Counts, Transportation Engineering, Microscopic Traffic Flow Simulation, Urban Environments.

1. Introduction

The complexity of urban traffic is often difficult to represent with massive data sets, since data are often incomplete, which arises the question of how to model unknown information. Recent data availability results in improvements in modelling and simulating urban active mode traffic (Grigoropoulos et al., 2019). Nevertheless, restrictions in space and time during observing traffic participants result in designing novel concepts of how to evaluate active mode traffic efficiencies of the real world. This work proposes one of these concepts and starts with a experimental methodology, where bicycle traffic counts at sparse locations in an urban environment are used as the input information.

Whereas trajectories of moving entities might represent a broad selection of various insights, traffic counts achieved with static sensors, mainly induction loops for cyclists, only provides information of

* andreas.keler@tum.de
† florian.schmiedlau@web.de
‡ george.grigoropoulos@tum.de

traffic efficiency, which itself might be influenced by numerous factors including weather and traffic events, traffic signal control, the design of infrastructural elements and others. Historically resulting from observations of motorized vehicle drivers, traffic count locations are usually installed in the pavements of road lanes, but since the 1990s more common also in bicycle infrastructure. Unlike observations at freeways, bicycle counts are difficult to use for defining flows of cyclists, which comes together with a higher number of possible maneuvers within optional routes resulting from the general flexibility of cyclists in using bicycle infrastructures, mixed traffic lanes or even pedestrian sidewalks. OD pairs on the other hand have the temporal information that might be beneficial when comparing to estimated routes within a known road network model. The detailed knowledge on the built infrastructure is often coming from federal guidelines, especially on estimating capacities of different types of intersections and road segments.

We focus on these factors, namely permanent bicycle traffic count data at sparse locations and introduce an experimental methodology for delivering a first proof of concept of comparing bicycle flow in two different urban investigation areas, NYC and Munich. By incorporating this data, in case of NYC with the help of additional OD pairs of the Citi Bike service for identifying bicycle traffic hotspots, into microscopic traffic flow simulations, we are able to perform simulation runs. Those address our first research question, namely the ability to estimate the present bicycle infrastructure. The second research question addresses the possibility to infer event information, such as social or weather events from data of permanent bicycle traffic count locations.

2. Methodological approach

Aware of the detailed specifications of the German HBS and the US American HCM, we first face the problem of enriching freely available geodata resulting from the OSM project initiated by Steve Coast in 2004. As the NYC network is more complex and populated we introduce a preprocessing procedure (as an optional part of the methodology) for identifying hotspot of frequent bicycle usage via OD pairs from the NYC CitiBike bike sharing service. It consists of route generations as pictured in Figure 1, which results from a previous k-means clustering step, where we focus on the polygons with higher numbers or trip destinations and starts.

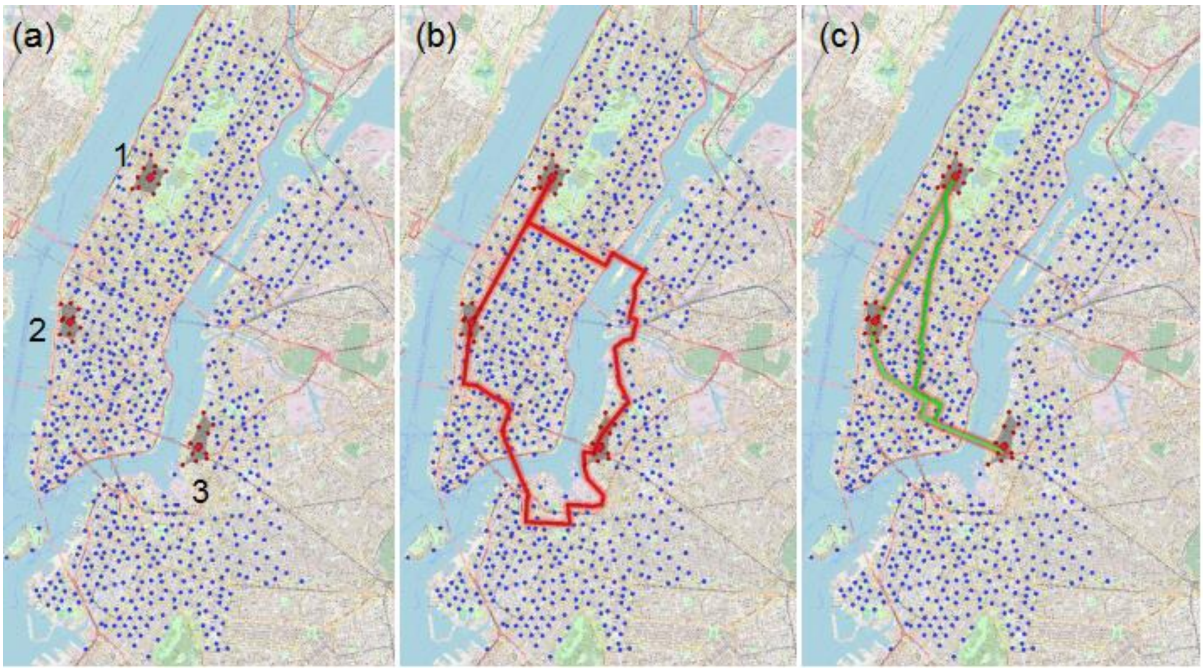

Figure 1 Bicycle flow analysis NYC, US, with (a) the locations of three selected OD pair clusters (resulting from k-means clustering), and, (b) generated routes (shortest paths) for evaluating bicycle traffic efficiency along bicycle lanes, and, (c) along mixed traffic lanes

Due to the absence of available OD pairs of bicycle trips in Munich, we generate the routes directly from the locations of bicycle traffic counts, which is pictured in Figure 2.

Afterwards, a cursive comparison of representative bicycle traffic data from the two cities of Munich and New York City concludes the analysis. April to October 2018 is chosen as the reference period, as there is the highest cycling traffic in both cities.

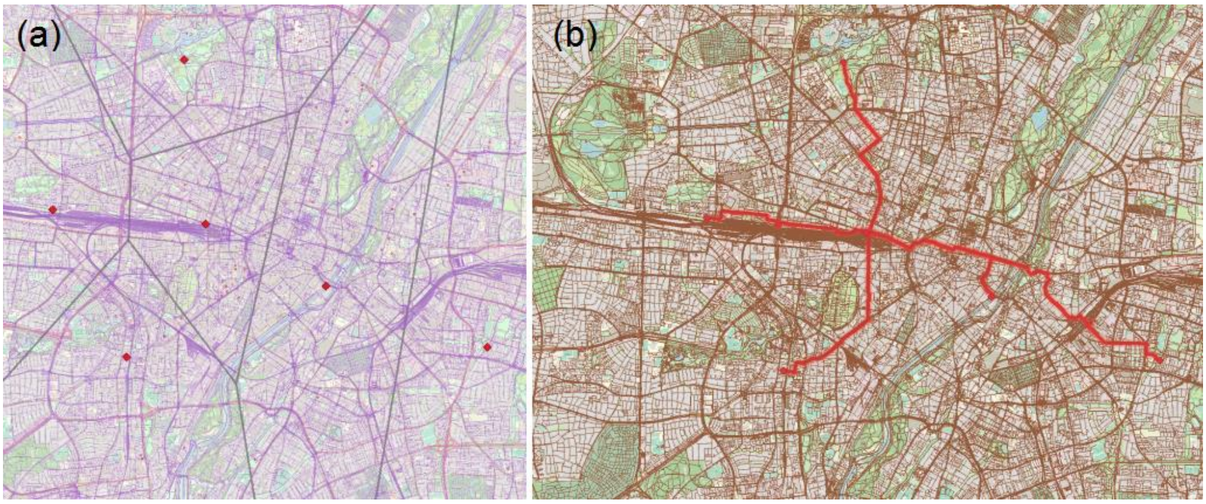

Figure 2 Bicycle flow analysis in Munich, Germany, with (a) the locations of static bicycle traffic counts, and, (b) generated routes (shortest paths) for evaluating bicycle traffic efficiency

For the subsequent traffic flow simulations at both investigation areas, we introduce a procedure, where we first construct the network from OSM extracts and then assign the type of infrastructure and if it is only available for cyclists. Data extracts from the OSM project are enriched with additional information, which allow us to estimate capacities of analyzed road segments. Segments, where mixed traffic is possible are defined as standard types. Every other road type is based on OSM attributes of every polyline element. Based on these segments, we design a microscopic traffic flow simulation network (Behrisch et al. 2011) and observe variations in average speed, delay, travel time and number of stops for selected routes within NYC, US, and Munich, Germany.

We suggest a procedure with a far simpler interpolation scheme that is not capable of reconstructing changes within lane widths (of for example cyclists) along one single link of a network, nor we are able to specify partially-static objects as delineator posts or precise spatial extents and locations of building sites.

Nevertheless, the connectivity of the links at the nodes that comply with real road intersections can be used for classifications similar to those classes defined in federal guidelines. These guidelines are essential for further insights on changing bicycle traffic efficiency.

By matching the generated routes from OD pairs with the network representation, we are able to define turning ratios and flows of cyclists, which are essential inputs for the microscopic traffic flow simulation. The main factor in this calculation for guaranteeing comparability between the bicycle flows is the graph structure comparability value, which might optionally consist of learning procedures for learning similar attributes of graphs of different networks. This is not trivial, since road networks of urban environments have various different structures.

3. Preliminary results and discussion

Both simulation networks are pictured in Figure 3 and first simulation results show that mainly at

intersection, we require more data and the relation to turning ratios of motorists.
Therefore, me can say that it is rather difficult to compare traffic efficiency solely from bicycle traffic count information.

Concerning the second research question, we are able to see a dependency on the temperature as pictured in Figure 4 and Figure 5. Nevertheless, Humidity or dependencies in weekdays are not detectable. Relations to social events require further analyses.

Figure 3 Microscopic traffic flow simulations networks in SUMO for the locations of (a) Munich, Germany, and, (b) NYC, USA

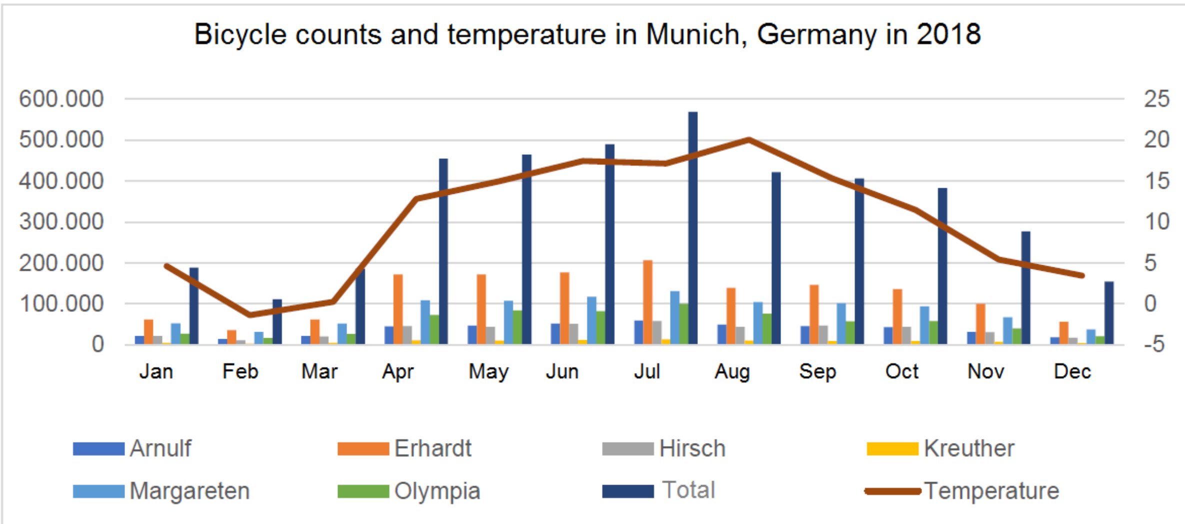

Figure 4 Distribution of the bicycle counts and temperature in Munich, Germany in 2018

Modelling the behaviour in SUMO enables to restrict or to permit simulated bicycles to take part in mixed traffic or only move along assigned bike lanes. Especially in Munich this conglomerate of different road segment types is typically diverse and different from the usually longer segments in NYC.

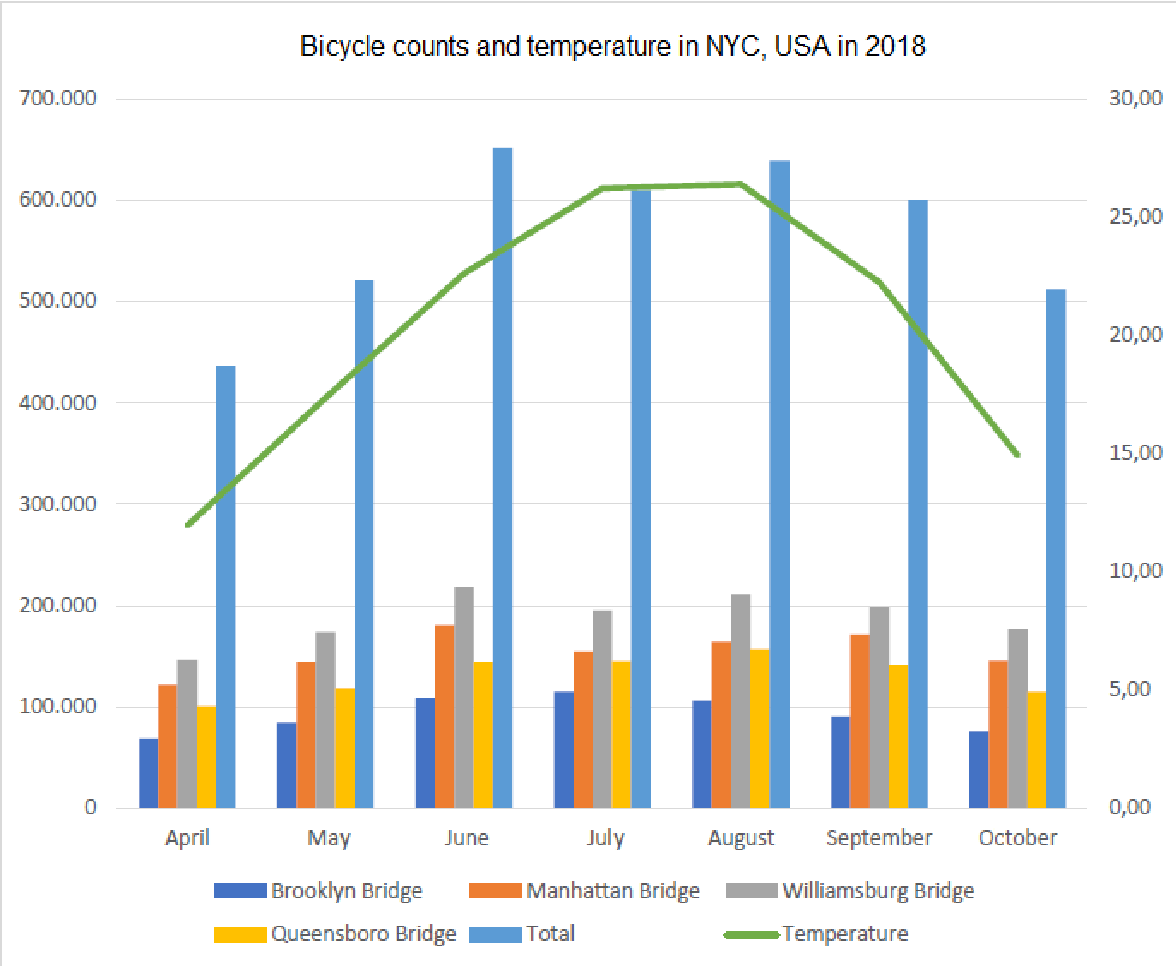

Figure 5 Distribution of the bicycle counts and temperature in NYC, USA in 2018 for the months April to October

4. Outlook

In the following steps numerous insights are inferable that picture the differences of the cities in built infrastructure. Therefore, we will point out differences in selected features of the networks for gaining further insights on bicycle traffic efficiency.

Additionally, the recent Covid-19 crisis enhanced the popularity of bicycle usage in urban environments, such as in Munich, where in the months March to May 2020 the bicycle flows increased by 20% compared to the same months of previous years. This observation is based on data coming from the described 6 bicycle traffic count locations loops for cyclists[§]. As a result of this observation the City of Munich will introduce so called pop-up bike lanes, newly established temporal bike lanes on lanes originally assigned for motorized road users for supplying these increased bicycle flows. Similar developments during the COVID-19 pandemic appear also in NYC[**]. The influence of these pop-up bikes lanes on overall traffic situations was not yet subject of ongoing research (as of July 2020).

[§] https://www.br.de/nachrichten/bayern/br24-datenanalyse-ein-fuenftel-mehr-radfahrer-in-muenchen,S2QQqc8

[**] https://www.forbes.com/sites/tanyamohn/2020/06/28/pop-up-bike-lanes-and-outdoor-dining-new-guide-helps-cities-transform-streets-during-pandemic/#71c6cfbb2ced

5. Acknowledgements

Hereby the authors acknowledge the providers of the open data platforms of NYC (NYC DOT and Citi Bike) and of Munich (Open Data Portal, OSP, City of Munich), which were essential to conduct the presented research.

6. Biography

Andreas Keler, PhD, is a postdoctoral researcher at the Technical University of Munich (TUM), Chair of Traffic Engineering and Control. His current research focus is on analysing different aspects of bicycle traffic in urban environments (bicycle highways, countdown timer displays, and, interaction with automated vehicles) via bicycle simulator studies.

Florian Schmiedlau, MSc, finished his Master's Thesis in Civil Engineering in 2019 at the Technical University of Munich (TUM), Chair of Traffic Engineering and Control. He currently works at an engineering office in the field of civil engineering.

Georgios Grigoropoulos, MSc, is a research assistant at the Technical University of Munich (TUM), Chair of Traffic Engineering and Control. He holds a master degree in Transportation Systems. As a PhD candidate his interests include the interaction and communication between bicyclists and autonomous vehicles.

References

Behrisch M, Bieker L, Erdmann J and Krajzewicz D (2011). SUMO - simulation of urban mobility: an overview. In: Proceedings of SIMUL 2011, The Third International Conference on Advances in System Simulation.

Grigoropoulos G, Keler A, Kaths H, Spangler M and Busch F (2019). Using Geodata for Simulating Urban Traffic - Current Research in the Field of Traffic Engineering and Control. *Geoinformationssysteme 2019 - Beiträge zur 6. Münchner GI-Runde*, Runder Tisch GIS e.V., 45-49.