Comparing the Effects of Ride-Hailing and Ride-Pooling on Urban Network Capacities Using Microsimulation Tools

Master‘s Thesis of Griffin Hanekamp

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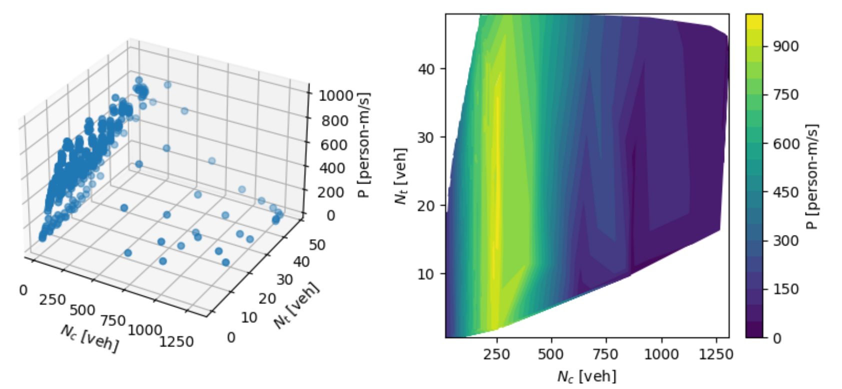
During the past decade, ride-hailing and ride-pooling services have established themselves as integral parts of the urban transportation network by providing a convenient and accessible mobility offering to city residents. While ride-hailing and ride-pooling primarily utilize traditional vehicle technologies, the introduction of autonomous vehicles to the marketplace may lead to performance changes for these ride-sharing services. Understanding the dynamics of autonomous ride-sharing fleets and their interaction with other travel modes in intermodal networks is essential for traffic planning going forward. Using the three-dimensional passenger Macroscopic Fundamental Diagram (3D-pMFD), this thesis evaluates the impact of ride-hailing and ride-pooling on the passenger production of a bi-modal network given certain interactions. The goal of this thesis is to develop an optimized traffic system utilizing two travel modes, private cars and one of ride-hailing and ride-pooling, to maximize network capacity using the microsimulation tool SUMO.

Independent Variables	Values
Number of passenger car trips (*P* Value)	1.3, 1.2, 1.1, 1.0, 0.9, 0.8, 0.7, 0.6
Number of ride-sharing trips (vol-ume % added)	1 %, 5 %, 10 %, 15 %, 20 %
Type of ride-sharing service	Ride-hailing, Ride-pooling
Stop process	All junctions, mid-edge, mid-edge with parking

Description of test network microsimulation scenarios executed in this thesis

In total, 540 simulation trials are conducted covering six traffic scenarios on two types of road networks (a test network and a real-world network). All scenarios feature private cars and a type of ride-sharing fleet. The vehicles in the ride-sharing fleet are permitted to stop at either all junctions, a designated mid-edge stop, or a designated off-street mid-edge parking area to pick-up and drop-off passengers. The SUMO data output for each scenario is used to estimate the 3D-pMFD. The results reveal that bi-modal network capacity is maximized in the test network in Scenario 5: ride-hailing + mid-edge parking. Bi-modal network capacity is maximized in the real-world network in Scenario 6: ride-pooling + mid-edge parking. These results reveal the benefit of implementing an off-street parking location for ride-sharing pick-up and drop-off maneuvers, as this feature predominantly prevents traffic buildup on the roadway. Additionally, all junction stops are shown to largely perform worse than mid-edge stops in terms of maximizing network capacity. Furthermore, ride-pooling vehicles are not shown to perform distinctly better than ride-hailing vehicles in any metric related to passenger production. This may be due to the absolute and relative time loss allowed by SUMO’s ride-pooling dispatch algorithm in its default setting.



Test Network Scenario 5: (left) 3D-pMFD plot and (right) 2D contour plot of the 3D-pMFD after Delaunay Triangulation

Scenario #	Scenario	Test P_{max}	Real-World P_{max}
1	Ride-hailing all junction stops	957	2546
2	Ride-pooling all junction stops	929	2516
3	Ride-hailing mid-edge stops	952	2553
4	Ride-pooling mid-edge stops	955	2572
5	Ride-hailing mid-edge stops with parking	1000	2589
6	Ride-pooling mid-edge stops with parking	993	2641

Summary of the maximum passenger production values P_{max} (pers-m/s) found in both networks

This thesis’ results support the use of the methodology to estimate well-defined 3D-pMFDs. Additionally, the network capacity benefits of implementing an off-street stop process for ride-sharing vehicles are clear. When applying these results in a real-world setting, one must consider, however, the negative externalities resulting from an off-street stop location: the disruption of bicycle and pedestrian space. Few conclusions can be drawn from this thesis’ results regarding the performance of ride-hailing versus ride-pooling services. Possible reasons for the substandard performance of the ride-pooling fleets include an inadequate time loss threshold employed by SUMO’s ride-pooling dispatch algorithm and a suboptimal ratio of fleet size to trip demand. Future studies can go further in this subject by manipulating the size and average occupancy of ride-pooling vehicles, examining dynamic stop processes based on local traffic conditions, and analyzing the impact of varying fleet sizes. Above all, this study has revealed the potential benefits associated with implementing a ride-sharing service in an urban traffic network and can act as a steppingstone for future research on intermodal urban networks.