Dynamic Demand Estimation for Single-Ride AMoD and Fleet Size Optimization for Pooled AMoD across the globe

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1 Introduction

Automated vehicles (AVs) are rarely seen on the streets today. Even when we occasionally catch a glimpse of one, there is always a person in the driver's seat ready to take control in case of an emergency. However, plenty of research has been devoted in the last years to how automated vehicles might impact the way we travel [1, 2, 3, 4, 5, 6, 7, 8].

Elimination of the driver would bring two important changes in how we use cars. First, people that can not drive because they do not posses a driver's license or are otherwise unable to drive would gain access to the freedom that the automobile provides. Second, a substantial cost element of taxi services would be eliminated by removing the driver from the equation, which shows the potential for shared vehicle fleets to thrive and potentially reduce private vehicle ownership.

Researchers focusing on impacts of shared automated vehicle fleets are suggesting that the required number of vehicles needed to serve the demand in urban cores is about 10% of the current fleet. While this promises to reduce the necessary parking space, it creates additional vehicle miles traveled, because of the need to re-position vehicles to efficiently serve the demand. Potential induced demand from those people who currently do not use a car only worsens the picture. In order to mitigate this problem, ride-sharing is seen as a potential solution.

This work focuses on first estimating the potential demand for single-occupancy on-demand automated taxi fleets and second on estimating the potential of pooling in the world of automated taxi fleets. The goal of this work is to present results and insights for two European cities: Paris and Zurich, two North American cities: Los Angeles and San Francisco and one South American city: Sao Paulo. The diversity of these cities in size, socio-demographics, land use, and geography should shed additional light of potentials of this kind of services under different circumstances.

2 Methodology

In order to investigate the tasks as set forth in the previous section a multi-agent transport simulation (MATSim, [9]) and its derivative *eqasim* [10] have been used. A synthetic population of agents representing travel behavior of people performing activities in the study area has been generated for Zurich, Paris, Los Angeles, San Francisco, and Sao Paulo, and shall be used as an input to MATSim simulations.

Furthermore, we utilize the findings of [11] on cost estimates for future shared automated fleets for each of these cities. Finally, a mode-choice model was estimated for each of these cities based on the household travel diary surveys conducted in each city. As shared automated vehicles are a thing of the future, and as information on individual's preferences towards AVs was obtained only for Zurich [12], we have used this information to approximate mode-choice parameters for other cities in this study.

Finally, we solve the problem of minimal fleet sizing of a pooled vehicle fleet by means of a mixed integer linear programming (MILP) program [13]. We use a variant of a discrete minimum-cost flow problem. Capacity of vehicles is assumed to be two, five, and ten. Therefore, the algorithm first identifies OD pairs where a 10-seater vehicles can be used, then 5-seater, and then the rest of the demand is served by 2-seater AVs. This is followed by fleet minimization in order to serve the obtained trips. VKT is kept at minimum by allowing only configurable short-distance relocation of empty AVs. The pooling technique tries to pool rides with similar departing time, and origin and destination locations. Departure time of the pooled vehicle and acceptable distance between origins and destinations of individuals being pooled together is a configurable variable in the algorithm.

3 Results

The potential demand for shared AV fleets in Zurich and Paris can be seen in Figures 1 and 2, respectively. Blue values show the demand for fixed prices, while red one shows the demand in case of a dynamic price based on the fleet size, and fleet utilization [14]. While the city of Paris is 20% larger in size than Zurich, its population density is more than four times higher. This leads to a better fleet utilization in Paris, but not as substantial as one might expect (48 compared to 35 rides/vehicle in Zurich for maximum demand dynamic price levels).

Finally, to investigate the full potential of pooling passengers with similar ODs, vehicles with capacities of two, five and ten are used as part of a mixed vehicle fleet. Tested scenarios are with free-flow speed, but also with congestion, for the city of Zurich. In all cases the number of vehicles needed to serve the demand is reduced along with the total vehicle kilometers traveled (VKT). In the scenarios with free-flow speeds only 3.7% of the original fleet is needed to serve the demand. If we are to consider that the congestion would stay on the same level as today this share raises to 4.6%. Reduction of VKT is between 2.6% and 9.8%.

4 Conclusion

Here we briefly show the potential demand for shared automated mobility on-demand service for Zurich and Paris with both fixed and dynamic pricing structures. This is further followed by first results on potential of pooling for shared AVs for Zurich, where we show further possibilities of reducing the required fleet to serve the demand, and also VKT.

Incorporating the results from other cities mentioned in the introduction will help us to further our understanding of potentials of singe-occupancy and pooled shared AV fleets in different geographical regions, with various population densities, and socio-demographics.

5 Acknowledgments

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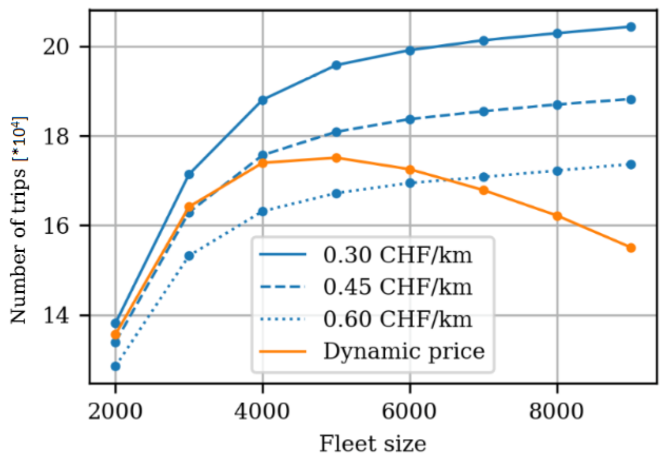

Figure 1: Dependency of the number of trips done using the AMoD service on fleet size in Zurich. In the fixed price cases (blue) low fleet sizes lead to high waiting times and low demand, in the dynamic price case (red), high prices for large fleet sizes lead to a demand maximum at around 5k vehicles.

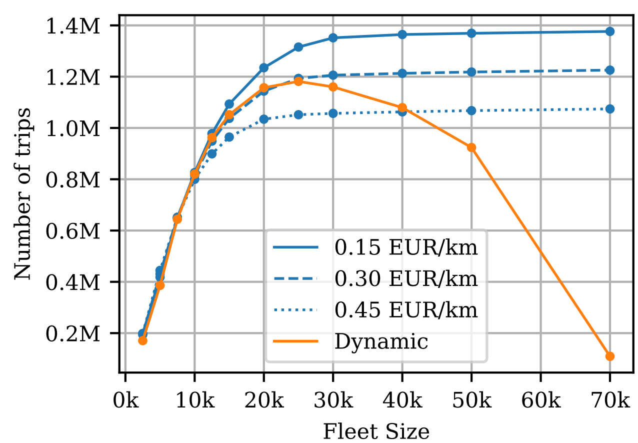

Figure 2: Dependency of the number of trips done using the AMoD service on fleet size in Paris. In the fixed price cases (blue) low fleet sizes lead to high waiting times and low demand, in the dynamic price case (red), high prices for large fleet sizes lead to a demand maximum at around 25k vehicles.

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