Analyzing the Effects of Transfer Constraints on a Ride-pooling Service

Master‘s Thesis of Rutvik Mulani

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Introduction: Increased mobility-on-demand (MOD) service in the city, due to its door-to-door nature, increases traffic congestion and reduces the efficiency of public transport. Therefore, the MOD feeder service is the best option to improve public transport efficiency. Many factors affect the efficiency of the MOD feeder services. The study analyzes the parameters that affect efficiency and identifies potential locations for implementing the MOD feeder service in Munich.

Methodology:

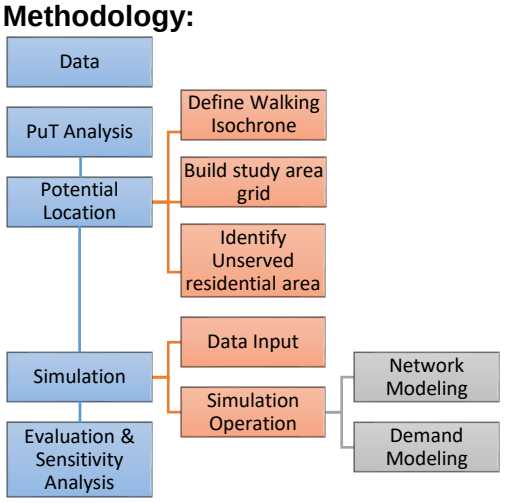

Figure 1: Overall Methodology

A synthetically generated demand model was used in simulation. Demand is generated during morning and evening peaks, in different directions, and with different adoption rates. FleetPy, a Python tool used for the simulation. Different parameters are used in the simulation, as shown in Figure 2. To combine all values to design scenarios.

Three different methods used for sensitivity analysis: 1) ANOVA, 2) Regression & 3) Random forest method. These methods are used to identify which factor most influences the efficiency of the MOD feeder service.

Parameters	Values(Morning)	Values(Evening)
Adoption Rate	(0.5, 1, 2, 5)min	(0.5, 1, 2, 5)min
Fleet Size	(12, 24, 60)vehicle	(12, 24, 60) vehicle
Detour Factor	(30, 50, 80)%	(30%, 50%, 80%)
Max. Waiting Time	(300, 480, 600)sec	(480, 600, 900) sec
Headway	(10, 15, 20)min	(10, 15, 20) min
Delta (two-directional coordination time)	(0, 20, 50)%	(0, 20, 50)%
Walking Time(drop-off point to Platform)	(2, 3, 5)min	(2, 3, 5)min

Figure 2: Simulation parameters and values

Result: Using the geographical filter and grid-based method, the top potential locations for the MOD feeder service are found in Figure 3. All locations are outside of the city. Locations are served by the S-Bahn. One of the potential locations used for analysis.

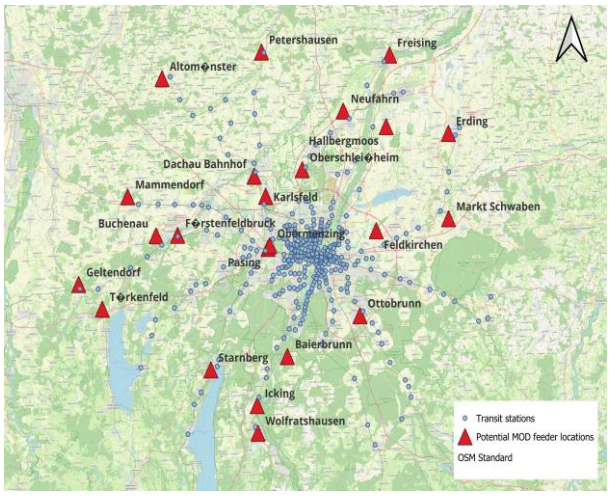

Figure 3: Potential locations for MOD feeder service

Extract different KPIs from the simulation result as listed below. **User Experience KPIs:** 1) Transfer waiting time, 2) In-vehicle time, 3) Detour time, 4) Rejection rate. **Operational KPIs:** 1) Fleet utilization, 2) Empty VKT, 3) Average occupancy. **Financial KPI:** Cost per served request.

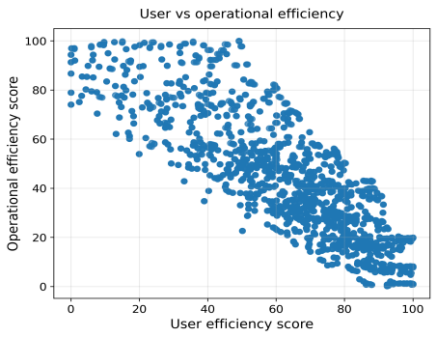

Figure 4: Fundamental trade-off (Morning)

The result shows a fundamental trade-off between user efficiency and operational efficiency. Figure 4 shows that while operational KPIs increase, user KPIs decrease. For example, increasing the detour factor parameter it decrease the empty VKT, but on the other hand, in-vehicle travel time and detour - time increase. This decreases the user efficiency. The same trade-off shows in the evening peak period in Figure 5. Due to this trade-off, which narrows the set of feasible scenarios, a threshold is needed to balance overall efficiency and exclude the worst-performing scenarios.

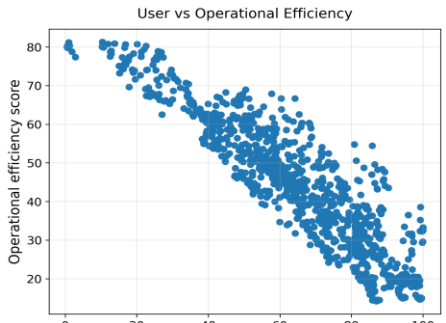

Figure 5: Fundamental trade-off (Evening)

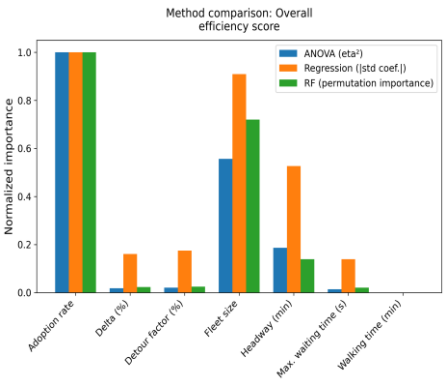

Figure 6: Method comparison(Morning peak)

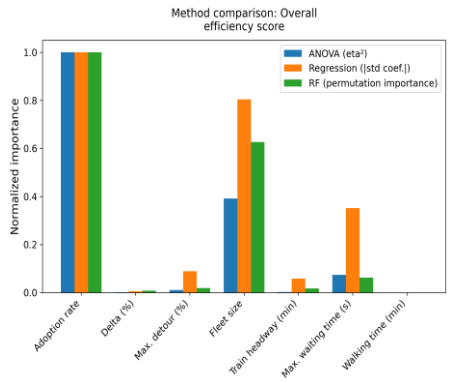

Figure 7: Method comparison(Evening peak)

Comparing all three methods, ANOVA, Regression, and the random forest method, adoption rate and fleet size are the most influential on overall efficiency. The transfer from the MOD feeder service to the Public transport (PT) headway is more important during the morning peak. In contrast, in the evening peak, the maximum waiting time for the PT to the MOD feeder service has a greater influence on the transfer waiting time.

Conclusion: Geographical filtering and a grid-based method are used to identify potential locations for the MOD feeder service. Careful parameter balancing is required in the design of the MOD feeder system. Strong synchronization is required to reduce the transfer waiting time. Operational parameters are important while demand is opposite in the evening peak period. Due to a fundamental trade-off between user efficiency and operation efficiency, the implementation of MOD feeder services must be assessed from different perspectives, such as government and business.