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Large-scale microscopic simulation of taxi services

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Abstract

The paper presents research on large-scale microscopic simulation of taxi services in Berlin based on floating car data collected by the Taxi Berlin fleet, the largest taxi association in Germany's capital. Firstly, Berlin's taxi market is shortly described and the demand and supply data obtained from FCD analysed. Secondly, the online taxi dispatching problem formulation for this specific case is given, followed by the definition of two real-time rule-based heuristics used to dispatch taxis dynamically within the simulation. Finally, the simulation setup in MATSim is described, and the results obtained with both heuristics are analysed and compared in terms of dispatching performance, proving the effectiveness of the second strategy at different demand scales.

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Keywords: online taxi dispatching, dynamic vehicle routing, floating car data, Berlin, MATSim, microscopic simulation

1. Introduction

Simulation is an indispensable tool in order to analyse and optimize complex services with dynamically changing demand and supply, all embedded into a dynamic environment. In the case of taxi services in large cities, a reliable simulation approach must model all these elements both at the microscopic level of detail and in the large-scale (regional, or at least city-wide) scope. The high dynamism of taxi demand is a result of almost all requests being immediate trips with an unspecified destination. For example, partially independent taxi drivers who can choose which rank to wait at, reject serving a request, or decide upon their working hours, account for the limited control over the stochastic supply side. Finally, urban traffic, being the environment for taxi services, implies stochastic time-dependent travel times.

Once the simulation model is ready, analysis and optimization may begin, for instance, by changing the dispatching algorithm, scaling demand and supply, or relocating taxi ranks. As far as the authors know, out of many taxi simulation models [1,2,3,4,5], the microscopic ones, though limited in scope, were created for Singapore [1,4] and Mielec, Poland [6,7] only. This paper presents a wide-range microscopic model covering the city of Berlin and the neighbour-

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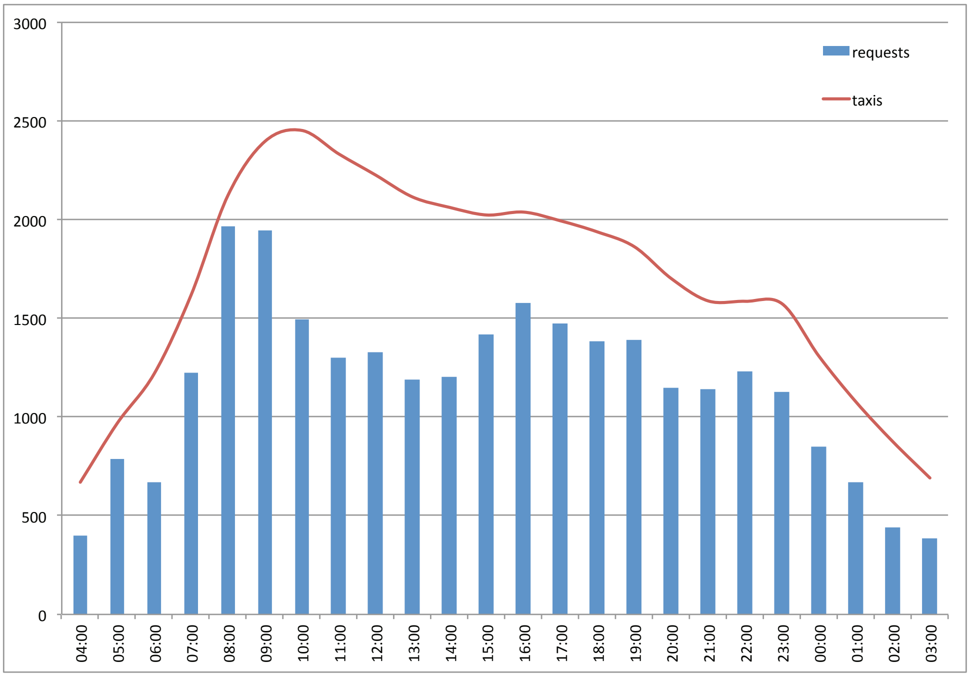

Fig. 1: Hourly request submissions and active taxicabs

ing Brandenburg region, which is then used to assess the performance of two real-time rule-based taxi dispatching strategies.

2. Taxi supply and demand in Berlin

Currently, the Berlin taxi market consists of some 7,600 vehicles licensed to operate in the city. They are organised in 3000 taxi companies employing roughly 18,000 taxi drivers. To model Berlin's taxi supply and demand, in this paper, trajectories of Berlin's biggest radio taxi operator, Taxi Berlin, are used. Overall, they have some 5,700 vehicles working within their range, most of them equipped with GPS trackers that submit their current location and occupation status in a flexible interval (depending on the vehicle's occupation status, but at least once every 60 seconds). These data are, among others, mainly used for travel time prediction in Berlin[8]. With the current occupation status of the vehicle also being submitted, a zone-based matrix of demand for each hour can be generated and used for the demand side of the simulation. On the supply side only the amount of vehicles logged into the system at each second is known, not the actual length of each vehicle or driver shift. This is due to data anonymization by regular reassignment of IDs to vehicles. Furthermore, the amount of vehicles per zone in each occupation status is known in intervals of five minutes.

For the simulation purposes, the supply and demand data of one week (15 April - 22 April 2014) were provided, of which the timeframe between Tuesday 4:00 am and Wednesday 4:00 am has been picked for simulation[1]. Figure 1 shows the amount of taxis and requests served during the timeframe investigated. Overall, 27,376 trips were registered. The vehicle supply adjusts to the demand for taxi trips. There is a strong morning peak followed by two somewhat smaller peaks in the afternoon and evening.

The extracted taxi demand is aggregated into 518 zones. Within the city boundaries, these zones correspond to the city quarters defined by the city administration as *Lebensweltlich orientierte Räume (LOR)*[9]. In the outskirts, community boundaries are used instead. The zone with the highest amount of trips starting or ending is the one

[1] Around 4am, taxi supply and demand is the lowest, making it an intuitive breakpoint between days