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Validation of a Relocation Strategy for Munich's Bike Sharing System

Svenja Reiss *, Klaus Bogenberger

University of the Federal Armed Forces, Munich, Germany

Abstract

Public Bike Sharing Systems (BSS) provide a progressive option for urban mobility, not only for commuters but also for spontaneous users and tourists. Such systems are only reasonable, if the bikes are available where the users need them at a certain time though.

Based on a detailed GPS-Data Analysis for the free-floating bike sharing system "Call a Bike" in Munich, mobility patterns of the bike usage were identified spatially and temporally. Depending on different factors like seasons, weather conditions, time of the day and holidays/weekends, a demand model was built up in order to forecast the upcoming demand at certain time and place. This model reveals optimal fleet distributions for different zones in the operating area and for different time slots. To redistribute the fleet a reasonable relocation strategy was created in order to obtain an optimal distribution of bikes within the operating area. To evaluate and proof the benefit of a potential relocation, a validation method shows what kind of effects rebalancing the BSS fleet could bear: an optimal and cost-efficient relocation scheme can generate more trips and guarantee a sufficiently well balanced fleet to satisfy the upcoming demand.

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Keywords: Bicycle; Bike Sharing Systems; Data Analysis; Relocation Method; Demand Modelling

* *Corresponding author. Tel.: +49-89-60042529; fax: +49-89-60042501*
E-mail address: svenja.reiss@unibw.de

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1. Data analysis of bike sharing trips

This work is based on the "Call a Bike" booking data of the operating period from March 2014 to December 2014, which provides the time of each trip as well as the GPS-coordinates of the start and end position of each trip. "Call a Bike" is a free-floating BSS, see also Call a Bike (2014), i.e. there are no stations like in ordinary systems but a predefined operating area. In this area users can find and rent rental bikes via GPS on their smartphone app and have to return them within the operating area again.

At first, we conducted a temporal analysis of the booking data and captured the trip numbers in the entire operating period 2014, see figure 1. The trend curve seems quite unstable: there are many ups and downs and some steep outliers are visible. In most of the cases, good respectively bad weather conditions were the reason. In our analysis, we compared the daily booking numbers to the weather (temperature and precipitation) based on data provided by Deutscher Wetterdienst (2014). The main impact has precipitation whereas only temperature (too high or low) does not prevent many cyclists from renting a bike. In case of rainfalls, booking numbers drop suddenly and even after it has stopped raining, there are far less trips.

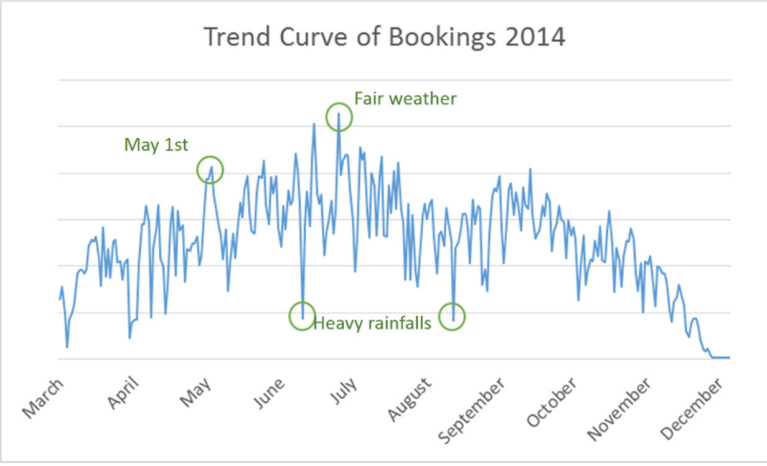

Fig. 1. Trend curve of annual bookings from March to December 2014

The temporal analysis considered not only the booking trend over the entire operating period 2014, but also daily booking patterns. There is a huge discrepancy between workdays and weekends concerning trip number distribution and trip durations. For a detailed spatial analysis, we divided the operating area into 40 zones, which may represent fictive stations. Based on that, we investigated areas, where the demand is rather high in the morning, i.e. residential areas and detected areas with a high demand in the evening, for example in the city center.

At first, we investigated diurnal plots on workdays and on weekdays, as depicted in figure 2: There is steep peak in the morning rush hour and an even broader and higher peak in the evening on weekdays (blue curve). This behavior entirely changes on weekends (red curve): there are no commuter peaks, and leisure trips seem to be prevalent, which is also proved by longer trip durations, see also Reiss et al. (2015).

For the spatial analysis, we checked rentals and returns in the five different time slots and detected spatial imbalances as well. Figure 3 shows the different rental behavior in the morning (left) - when most of the users rent bikes at the edge of the operating area, where residential areas are located – and in the evening (right) when most people pick bikes in the city center.

The idle times of the fleet provide another indication, if some part of the fleet is parked in the wrong spots and therefore certain bikes are not used. Figure 4 displays the idle times in 2014: on the one hand, around 25% of the fleet is idling less than one hour, but on the other hand, around 40% idles longer than 6 hours. Hence, by fleet relocations the idle times could be diminished.