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Quantification of potential cruising time savings through intelligent parking services

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ABSTRACT

Intelligent parking services (IPS) use modern technology to help travelers find parking. Local authorities also recognize IPS as the new solution to reduce cruising-for-parking in urban areas. While many cities are considering to invest in the system, the potential of IPS in reducing cruising is often unknown. This makes it very difficult to assess the investment and evaluate the performance of IPS.

This paper provides a generalized methodology to evaluate the potential cruising time savings generated by using IPS. Based on probability theory and a macroscopic parking model, the cruising conditions with and without IPS are emulated. By comparing these two sets of conditions, the total cruising time savings can then be estimated. The model requires very few data inputs; the main inputs being the parking occupancy and the number of cruising vehicles over time. To illustrate the methodology, an application example based on an area within the city of Zurich, Switzerland, is provided. It is shown that, in this small downtown area (0.28 km^2), IPS can save up to 15.6 h of cruising time (17%) in a typical working day.

The authors hope that this study can be used to establish a systematic tool for IPS evaluation. The use of such a tool could further support practitioners' decisions on parking management.

1. Introduction

To reduce cruising-for-parking in urban areas, intelligent parking services (IPS) are often promoted. IPS, based on real-time data collection, provide parking guidance and/or reservation systems to help travelers find available parking spaces in a shorter time (Mahmud et al., 2013; Wang and He, 2011; Nawaz et al., 2013; Chinrungrueng et al., 2007). However, since the potential reduction in cruising time due to IPS often remains unknown, it is difficult for some municipalities to push forward such a project, and devote the required resources for testing, implementing, and maintaining the system. The fact is that, even though the local authorities are aware of the advantages of IPS, they lack a methodology to quantitatively assess its potential performance.

In this paper, we aim to fill this gap by proposing a generalized methodology to quantify the potential cruising time savings that can be achieved with IPS. We estimate the normal searching conditions (without any assistance from IPS) and the searching conditions with IPS under the best case scenario. By comparing these two sets of conditions, we can find the potential cruising time savings that could be generated by IPS. In the best case scenario (with IPS), we assume all the available parking spaces are perfectly assigned to the parking searchers. Practical issues regarding the implementation of IPS are out of the scope of this paper, i.e., we assume all users deploy IPS and the system operates smoothly, etc.

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Using the proposed methodology, it is possible to assess the potential of IPS by simply estimating the parking demand and recording the parking occupancy. This is valuable because the model can be easily applied under various background conditions (e.g., different network layouts and levels of parking supply). A large portion of data collection is saved since the model is macroscopically built. That means that the investigation of the parking experience of individual travelers can be avoided. Instead, the probability of them finding parking is estimated directly based on the searching conditions (e.g., the searched time, the number of searchers, the number of available parking spaces). Due to its simplicity, the model also leads to significant savings in computational costs as well as labor costs, releasing some resources that could then be used for other parking or transportation management improvements. Notice that the IPS considered here does not incorporate a parking reservation system. If a parking reservation system is enabled, the demand/supply pattern may change significantly as the spaces are preassigned. Then, the situation becomes completely different and cannot be directly compared to the scenarios without IPS. Additionally, IPS cannot address the traffic delay caused by the parking maneuvers themselves (Cao et al., 2016; Cao and Menendez, 2015).

It is important to point out that IPS are not always the solution for all urban areas, and should be explicitly evaluated before their implementation to avoid any misuse of resources. In some situations, IPS do not bring benefits at all since cruising is caused by reasons other than lack of information. These reasons could be the mismatch between parking demand and supply, or special personal preferences on parking spaces. If that is the case, then the local authorities should pay more attention to parking policies aiming to adjust the demand pattern instead of investing in building a parking guidance system.

For local authorities, this study helps to evaluate the benefits that can be brought by IPS. For service providers, this study helps to find potential markets where IPS can significantly enhance the parking experience. It also helps them in the estimation of the time that travelers could expect to save by using their services.

The remainder of this paper is organized as follows. Section 2 describes the existing literature on this topic. Section 3 shows the assumptions and the framework of the model. Section 4 presents the methodology to quantify the cruising time savings generated by using IPS. Section 5 provides a case study based on real data from the city of Zurich, Switzerland, to illustrate the proposed methodology. Section 6 presents a new general indicator that can be used to easily and rapidly assess the potential of IPS for cruising time reduction. Section 7 summarizes this study.

2. Literature review

Literature on estimation of cruising-for-parking traffic can be found in (Arnott and Inci, 2006; Shoup, 2006; Geroliminis, 2015; Cao and Menendez, 2015; Horni et al., 2013b; Boyles et al., 2015; Benenson et al., 2008; Mingardo et al., 2015; Van Ommeren et al., 2012; Guo et al., 2013; Millard-Ball et al., 2014; Van Nieuwkoop et al., 2016). Since the focus of this paper is only on the reduction of cruising time, those studies are not described in detail here.

In the early stages of the technology, the effects of parking information services were mostly qualitatively analyzed using empirical data. Later on, either based on survey data or simulation tools, researchers were able to provide more explicit results on the reduction of cruising time or the number of cruising vehicles. Interestingly, the results from different studies are not always aligned. Many of the studies show positive effects of IPS. In Aachen, Germany, Spencer and West (2004) found that the number of motorists searching for parking was reduced from 30% to 20% after 3 years of implementation of the parking guidance system. Another study, Caicedo (2010), showed that a 10% efficiency improvement in parking search time could be achieved with real-time information. Additional studies have found a rather high reduction in cruising time, including, for example, a 22% reduction in Eindhoven, Netherlands, estimated using a micro simulator (Jonkers et al., 2011); and a 14%-34% reduction in Tel-Aviv, Israel, for a bike parking reservation system (Kaspi et al., 2014). On the other hand, there are some studies pointing out the inefficiency of IPS. Based on survey data from Southampton, UK, and a traffic simulation model, it was argued that the effectiveness in reducing cruising at the network level is rather limited (Waterson et al., 2001). Similarly, Tasseron et al. found with the PARKAGENT simulator (Tasseron et al., 2015) that “the search time can barely be decreased” on a grid network.

The authors found two studies (Mei et al., 2012; Hill et al., 2013a) that provide generalized guidelines to evaluate the potential of IPS (parking guidance variable message signs in this case). They both suggest, based on microscopic models, that IPS only achieve high benefits when the parking supply is close to or less than the parking demand. Our paper will use a macroscopic model to mathematically prove whether this is a reasonable rule of thumb or not.

Summarizing all the studies shown above, the effects of IPS on urban parking management and cruising reduction can be rather controversial. There are different causes for cruising-for-parking and even in the best scenario of IPS usage, the cruising cannot be completely eliminated. As illustrated in the literature review, the potential of IPS differs from one city to another. Here we provide a generalized methodology to quantify the potential cruising time reduction due to IPS under different scenarios, so that the proposed methodology could be applied easily to different network layouts and parking conditions.

3. Model framework

3.1. Framework and assumptions

Consider a homogeneous network where cruising-for-parking typically occurs, such as a small network with on-street parking supply, or inside a large parking garage. In this network, the number of cruising vehicles and the number of available parking spaces change over time. In our model, these changes occur based on thin time slices (e.g., 1 min). In other words, the number of cruising vehicles and available parking spaces are updated from one time slice to another, i.e., within each time slice, the conditions are