Transportation Research Part C 44 (2014) 299–317

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

A study on smart parking guidance algorithm

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ARTICLE INFO

Article history:
Received 10 January 2014
Received in revised form 18 April 2014
Accepted 18 April 2014

Keywords:
Smart parking guidance
Parking guidance algorithm
City transportation management
Parking facility

ABSTRACT

Parking problem becomes one of major issues in the city transportation management since the spatial resource of a city is limited and the parking cost is expensive. Lots of cars on the road should spend unnecessary time and consume energy during searching for parking due to limited parking space. To cope with these limitations and give more intelligent solutions to drivers in the selection of parking facility, this study proposes a smart parking guidance algorithm. The proposed algorithm supports drivers to find the most appropriate parking facility considering real-time status of parking facilities in a city. To suggest the most suitable parking facility, several factors such as driving distance to the guided parking facility, walking distance from the guided parking facility to destination, expected parking cost, and traffic congestion due to parking guidance, are considered in the proposed algorithm. To evaluate the effectiveness of the proposed algorithm, simulation tests have been carried out. The proposed algorithm helps to maximize the utilization of space resources of a city, and reduce unnecessary energy consumption and CO_2 emission of wandering cars since it is designed to control the utilization of parking facility efficiently and reduce traffic congestion due to parking space search.

1. Introduction

Originally, an automobile (hereafter a car) was invented to increase convenience and comfort in everyday life. However, the car congestion in a big city causes undesirable problems such as environmental issues, energy consumption, parking space shortage, traffic jams, noise, air pollution, and even minor psychological damage to some people. Among them, the parking space shortage is regarded as one of major issues in the city transportation management since the spatial resource of a city is limited and the construction cost of new parking is expensive. As a result, many cars on the road should spend unnecessary time and consume extraneous energy during searching for parking spaces. According to the recent research work (Giuffrè et al., 2012) dealing with the significance of parking problem, the traffic flow peak caused by searching parking facilities can increase as much as about 25–40%. Arnott et al. (2005) mentioned that about 30% of cars on the road in the downtown area of major cities seemed to be cruising for parking spots, which took an average of 7.8 min. The other study (Soup, 2007) found that the wandering of cars in order to find a parking facility is responsible for about 30% of the entire traffic in a city. Soup (2007) summarized the annual waste of resources to find a parking lot in a city of LA, USA, as shown in Table 1. Furthermore, Caliskan et al. (2007) cited from a study of parking situation in Schwabing (a district of Germany) that an annual total economy damage had been estimated as 20 million euro, caused only by the traffic searching for free parking lots.

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http://dx.doi.org/10.1016/j.trc.2014.04.010
0968-090X/

Table 1
Annual waste of resources to find a parking lot in Westwood Village, LA 2007 (Soup, 2007).

Item	Figure	Remarks
Cruising distance	950,000 miles	38 trips around the earth or four trips to the moon
Waste of time	95,000 h	11 years
Waste of gasoline	47,000 gallons	177,660 l
CO_2 production	730 tons	

Due to the significance of parking problem, various technical developments to resolve it have been introduced and implemented until so far. For example, the parking guidance and information system (PGIS) is the most frequently adopted solution in many cities. Generally, the PGIS has a form of message board which is installed on the road to help wandering drivers who try to find parking facilities. The rough direction and number of free parking lots at each parking facility are provided to drivers by the message board. Based on the PGIS message board, drivers can decide which parking facility they will use. However, the provided information by the message board may be not valuable when drivers actually arrive at the parking facility since the number of free parking lots on the sign may be changed during driving. Furthermore, the form of message board is inappropriate to provide drivers with detailed direction to each parking facility. The information delivered by PGIS message board is limited so that it is impossible to provide personalized information such as which parking facility is the closest from a driver to destination, which parking facility is cheaper than others, and how a driver can avoid traffic jam while heading to the guided parking facility. In summary, the PGIS as a form of message board is not suitable for providing the smart parking guidance considering dynamic situations of both parking facilities and traffic conditions. Due to these shortcomings, the impact of PGIS system as a form of message board may be relatively limited from the viewpoint of reducing the car wandering time for searching parking space (Thompson and Bonsall, 1997; Waterson et al., 2001).

To cope with these limitations and give more intelligent solution to drivers in the selection of parking facility and direction guidance, this study introduces the concept of smart parking guidance system and proposes a parking guidance algorithm to assign the car requesting parking space to the most appropriate parking facility considering driving duration and distance to parking facility, walking distance from parking facility to destination, expected parking cost, and traffic congestion due to parking guidance itself. According to Caicedo's work (2010), the real-time parking information management could improve 10% of traffic in efficiency. Based on this result, the considering smart parking guidance system is designed to be operated in the real-time environment. In the proposed system, the real-time monitoring of parking lot status is performed by sensors, and the monitored status data are collected and transferred through wire/wireless telecommunication network. All data collected from both parking facilities and cruising cars are integrated and managed by the central server for smart parking guidance. The proposed parking guidance algorithm is designed to maximize the utilization of spatial parking resource of a city, to reduce unnecessary energy consumption and CO_2 emission of wandering cars, to improve drivers' satisfaction, and to alleviate traffic congestion due to parking guidance itself.

This study is organized as follows. The following section introduces previous research works related to parking management systems. The detailed procedure of the parking guidance algorithm to assign the car requesting parking space to the most suitable parking facility is explained in Section 3. Section 4 validates the proposed algorithm with simulation tests. Finally, it ends with conclusion and discusses on the development for smart parking guidance system.

2. Previous works

The application of various information and communication technologies (ICTs) in everyday urban life makes it possible to realize the concept of smart city. In general, the smart city is identified as the following characteristics: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living (The Centre of Regional Science, 2007). Among them, the smart mobility is one of the most fast-growing areas using various ICTs actively, and a well-known example for smart mobility is the intelligent transport system (ITS). The ITS collects real-time information of road status and controls traffic adaptively. According to the traffic status, traffic lights are changed automatically so that the overall traffic can be adjusted so as not to be congested. Smart parking combined with ITS can play an important role in achieving the concept of smart mobility. The smart parking guidance based on the real-time information of parking lot in the city can be available within the smart city. However, the current status of smart parking guidance is still in its infancy. The integration of ICTs and efficient information management to enhance parking guidance still remains as challenging issues. Considering that parking problem is one of the complicated issues in a big city and its limited availability can cause the quality deterioration of urban mobility, it is important to improve the current parking guidance approach in an intelligent way. This section will review the previous research efforts to provide parking guidance and discuss about pros and cons of their works.

2.1. ICTs for smart parking

To monitor the availability of parking lots, various kinds of sensors and sensor network technologies have been developed, and some of them are already available as commercial products in the market. Most of them are designed and used