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Development of location-based services for recommending departure stations to park and ride users

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ABSTRACT

More and more commuters are beginning to favour public transportation. Fast and convenient park and ride (PnR) services provided by public transportation authorities are the result of changes of household demographics and household, increasing fuel prices and a focus on environmental sustainability. However, lack of parking spaces in PnR facilities creates a major bottleneck to this service. The aim of this research is to develop a location-based service (LBS) application to help PnR users choose the best train station to use to reach their destination using a multicriteria decision making model. A fuzzy logic method is used to estimate parking availability when a user is estimated to arrive at a PnR facility. Two surveys are conducted to collect traffic flow, travel behaviour and service quality data at four selected Perth Western Australia train stations. With the proposed approach and survey data, a prototype of LBS application, Station Finder, was developed using the Android SDK 4.0 and Google API 16. This application is a useful and practical tool to save travel cost and time of PnR users'.

1. Introduction

Park-and-ride (PnR) services have been considered an important composite alternative to private car and public transport, especially for low-density areas where there is low demand for fixed route transit services (Farhan and Murray, 2008). However, parking demand at these facilities has often exceeded supply. Park and ride users face serious competition for parking spaces, particularly at peak times such as early morning, and the time ay which parking capacity is reached is trending earlier and earlier. Many solutions have been proposed to solve this problem (Litman, 2007; Victoria Transport Policy Institute, 2012), such as increasing the parking supply by enforcing minimum parking requirements (Shoup, 1999); reducing parking demand with priced parking (Ahmadi Azari et al., 2013); using the existing parking capacity more efficiently with shared parking; and addressing variable demand, such as parking brokerage services (Zhang et al., 2011b); or providing real time parking availability information, which is the subject of this paper.

The aim of this paper is to use location-based services to inform PnR users of the best departure station based on their current location and planned departure time. The best departure station is not only determined by parking availability at the train station but also by the travel time, frequency of the train, and service quality of the train station (Debrezion et al., 2009). PnR users can then make more effective travel decisions based on this real time information. An LBS is an

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information and entertainment service provided through a mobile network based on the current location of the mobile users device (Evans, 2011). The LBS for this study takes the users' current location and recommends the best departure station. The central research question of this study is to investigate whether fuzzy logic methods can capture the uncertainty of parking availability.

This paper is structured as follows: Section 2 discusses the current research related to recommending station to PnR users and parking availability measurements. In Section 3, the research methodology is described, followed by research findings in Section 4. A prototype of LBS application, Station Finder, is designed and developed in Section 5. Section 6 discusses the research findings and a short conclusion is provided in Section 7.

2. Literature review

Park and ride (PnR) , where commuters drive to a train station, park their car, and complete their journey by train, has become "the most important innovation in urban public transportation since the Second World War" (Boyce et al., 1972). It provides commuters fast and convenient transit services to research their destinations. However, the impact of PnR, especially parking availability, on mode choice and station choice is still little known. One of the earliest studies on transit station choice in relation to PnR was conducted by Boyce et al. (1972), who investigated how access cost to stations and parking availability influenced PnR users' departure station choice. A model was formulated to predict station choice, which is useful for transit planning. Kastrenakes (1988) extends this research by including more factors, such as frequency of service during the peak hours, into station choice models. Debrezion et al. (2009) categorised station choice factors into two types: factors related to accessibility of stations, such as travel time and train frequency and factors related to train services, such as service quality and availability of parking spaces, the park and ride possibility, security and bike stands and storage facilities (lock-ups). Their model proved that the service quality (the derived rail service quality index (RSQI)) and train frequency have a positive effect on the choice of departure station. Travel time or distance has a negative impact. In a recent stated choice survey for calculating the willingness-to-pay levels, travellers placed the quality of the information they receive and services available as the most valuable factors rather than transfer time, which contradicts the widely held opinion of experts in the field (dell'Olio et al., 2011).

Prior knowledge of parking availability greatly helps users to develop travel plans. Parking choice is considered to be an important factor for activity scheduling behaviour (Habib et al., 2012). Parking-assist systems, such as the parking guidance and information (PGI) system (Ji et al., 2011; Rodier et al., 2004; van der Waerden et al., 2011), were developed to help drivers find parking easily. It uses a monitor system, parking pay systems, laser scan detectors, and loop detectors to monitor available parking spaces in real time and then sends parking availability messages to drivers via Variable Message Signs (VMS) (Bannert, 2003; Manni, 2010; Orski, 2003; Srikanth et al., 2009). A system with real time information would be a great convenience to drivers, but its accuracy and reliability have been questioned in the literature (Caicedo, 2009; Mei et al., 2012).

A mobile application that provides personalised en route transit trip information, including real-time traffic and parking information, has been developed in the San Francisco Bay Area of California (Zhang et al., 2011a). Still in early development, it is presently limited in all information is in real time and it lacks future estimates, so users need to analyse and determine the best solution by themselves based on their current location and travel needs. An alternative, short-time forecasting models for parking space choice, has begun to attract the scholars' attention. Some web-based reservation parking services use time-of-arrival based location detection (Manni, 2010). Zhaosheng and Xiaodong (2003) along with neural networks to forecast the "empty/full" state of the parking lot, without accurate digital surveillance of available parking spaces. Also, phrase construction in combination with Elman neural network, and weighted Markov chain models have been proposed for parking space prediction (Chen et al., 2007; Ji et al., 2007). Fuzzy logic methods have been used extensively to solve complex traffic and transportation engineering problems (Teodorović, 1999), such as estimating excessive fuel consumption for commercial aircraft (Chang, 2014), route choice (Henn and Ottomanelli, 2006; Quattrone and Vitetta, 2011), traffic simulation (Taha and Ibrahim, 2012) and intelligent parking systems (Teodorović and Lučić, 2006). It follows that fuzzy logic is a promising method for understanding the transportation process or decision-making under uncertainty, ambiguity and imprecision (Teodorović, 1999). Very little research has been done to predict the uncertainty of parking availability during peak demand periods using fuzzy logic methods. Therefore, our study will aim to fill this in research gap.

3. Methodology

3.1. Study area and data collection methods

Four train stations with PnR facilities in Perth, Western Australia (WA) were chosen for our case study (see Fig. 1). Oats Street is a busy station near major arterial roads and bus routes and some preliminary studies have already been done here; the nearby Victoria Park, Carlisle, and Welshpool stations selected for comparison.

Two types of surveys were designed for the study. Firstly, a field survey was conducted to collect traffic flow data during weekdays from 3 to 17 August, 2012 at these four PnR parking lots. Researchers stood in the entrance of the car park lot from