Expert Systems with Applications 41 (2014) 3409–3417

Contents lists available at ScienceDirect

Expert Systems with Applications

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

A real-time personalized route recommendation system for self-drive tourists based on vehicle to vehicle communication

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ARTICLE INFO

Keywords:
Route recommendation system
Personalization
Real-time traffic information
Vehicle to vehicle communication system (V2VCS)
Genetic algorithm (GA)

ABSTRACT

Recently, traffic jams and long queuing problems in tourist hot spots is growing with the increasing number of self-drive tourists. Some recommendation systems have been developed in attempt to relieve these problems. However, all these systems lack information pertaining to real-time traffic as well as the ability of personalization. In this research, we have developed a novel route recommendation system to provide self-drive tourists with real-time personalized route recommendations. This will help to reduce the traffic jams and queuing time in tourist hot spots. It will also help to personalize visiting routes based on the user's specific preferences. Ultimately, based on the evaluation results given by experienced self-drive tourists, we have shown that the proposed system not only saves total visiting time, but also meets their specific visiting preferences.

1. Introduction

Recently, following the sudden increase of vehicles around the world, the number of self-drive tourists have followed suit. Self-drive tourism, an emerging application of tourism industry, is developing rapidly with the widespread of vehicles (Lane & Waitt, 2007; Liu, Zhang, & Nie, 2012). However, these tourists often encounter difficulties when visiting famous tourist hot spots or scenic spots, especially on public holidays. Possible problems include that they may be congested on the main road of a tourist hotspot, they may miss their favorite point of interest (POI), or they may queue up for a long time to visit a famous POI. As they know very little about the traffic condition around POIs and the queuing time of the POIs, they often cannot stick to their schedule or have a solid, reliable visiting plan. These increasing problems of self-drive tourists may affect their satisfaction and loyalty toward the POIs and tourist hot spots (Denstadli & Jacobsen, 2011).

Although increasing research and their applications in the tourism industry can provide personalized recommendation services for tourists (Gavalas, Konstantopoulos, Mastakas, & Pantziou, 2013; Kabassi, 2010), it is hard for them to address the congestion and the long queuing problem in resorts. On top of this, only few researchers in the tourism industry have tried to address the self-drive tourism, never mind providing the personalization recommendation services for them. Therefore, a novel real-time personalized route recommendation system, like the one presented in this research, is needed to alleviate these problems and to provide route recommendation services for the growing number of self-drive tourists in the tourist hot spots.

Three main techniques are adopted to meet the requirements of self-drive tourists. Firstly, a vehicle to vehicle communication system (V2VCS) (Sichitiu & Kihl, 2008; Toor, Muhlethaler, & Laouiti, 2008), an emerging technology of the intelligent transportation system (ITS), is adopted to share real-time traffic information to recommend services to self-drive tourists. Instead of a large infrastructure investment for a communication system, the proposed V2VCS can gather information regarding the visiting behaviors of the self-drive tourists and the real-time traffic information. It can then share real-time traffic information with each other within a short distance without the need of a road infrastructure support. Secondly, instead of asking users to rate a large number of candidate routes, a fuzzy set theory based approach and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods are employed to score all the candidate routes according to the visiting preferences of self-drive tourists and the real-time value of five main route attributes. Thirdly, instead of only handling the real-time queuing information for personalization route recommendation, a genetic algorithm (GA) method is adopted to explore an appropriate route from all the candidate routes by considering the personalities of the self-drive tourists, the real time traffic information and the route score.

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http://dx.doi.org/10.1016/j.eswa.2013.11.035

Since the V2VCS has not been deployed in most tourist hot spots and self-drive tourists' vehicles right now, a web prototype system was developed to simulate the self-drive tourists in order to evaluate the proposed system. Experienced self-drive tourists were invited to conduct a simulation of one day self-drive tour around a city. The routes chosen by experienced self-drive tourists were compared with the routes generated by the proposed recommendation system. The simulation results demonstrated that the proposed system not only reduces the total visiting time, but it also meets the interests and preferences of self-drive tourists.

The remainder of the paper is organized as follows: the related work is illustrated in Section 2, and the personalized route recommendation system is represented in Section 3. In Section 4, the system evaluation and discussions are described. Finally, the conclusion and future research aims are discussed in Section 5.

2. Related works

In this research, we propose a novel personalized recommendation system to provide real time personalized route recommendation service for self-drive tourists. The proposed work is relevant to personalized route recommendation system for self-drive tourists, vehicle to vehicle communication systems and real time traffic information. In this section we illustrate the related work.

2.1. Personalized route recommendation

To satisfy the requirement of tourists, personalization cannot be neglected when it comes to the research and application of recommendation systems in the tourism industry. The concept of personalization can be generally defined as the capability to provide services to customers based on their preferences and behaviors (Adomavicius & Tuzhilin, 2005; Liang, Yang, Chen, & Ku, 2008). Personalization recommendation services can increase the user satisfaction by reducing the information overload problem (Liang, Lai, & Ku, 2007). For example, personalized recommendation systems can be employed to recommend hotels, flight, restaurants, attractions and general information regarding the tourism industry (Kabassi, 2010). They have also been adopted universally into reduce information overload and provide tourists with recommendations (Gavalas et al., 2013). In many cases of research, user profiles are obtained by the direct extraction approach (Liang et al., 2008). Although the indirect extraction approach is less intrusiveness, their accuracy may not be guaranteed. On the other hand, the direct extraction will increase the efforts of the user and cause some level of intrusiveness, but a more accurate rating from user can be obtained. Therefore, the direction extraction method has been chosen to guarantee the preciseness in this research. In addition, since the interests and preferences of self-drive tourists include both the quality and the quantity attributes of the candidate route, an online questionnaire and a fuzzy set theory based approach are employed to transfer these personalization preferences into weight on route attributes of candidate routes (Deng & Chan, 2011; Ding & Liang, 2005; Önüt, Kara, & Işik, 2009).

Recently, some research in the tourism industry has come up with method in providing personalized route recommendation service for tourists. For example, a mathematical model in combination with interactive multi-criteria methods are adopted to recommend route for tourists based on their personal requirements (Rodríguez, Molina, Pérez, & Caballero, 2012). In addition, Tsai and Lo have come up with a route recommendation system to generate museum visiting routes based on previous popular visiting behavior (Tsai & Lo, 2010). A personalization route recommendation service was also used to guide the visitor in theme parks by using a radio frequency identification (RFID) system (Tsai & Chung, 2012). In these two cases, the RFID systems were exploited to collect real-time queuing information of POIs and the visiting behavior of tourists in museums and theme parks. Then a clustering method was employed to classify the tourists into different groups based on the collected information. Finally, the recommendation route was generated according to the interests and preferences of similar tourists in the same group with the real-time queuing information.

However, there are two main problems that prevent deploying a similar route recommendation system in a broad tourist hotspot area. First, the RFID systems may not be readily available in many tourist hotspots. Additionally, this kind of RFID system needs a huge infrastructure investment on road network in the hotspot district. Second, only real-time queuing information is not enough for recommending routes. Instead, many aspects can affect the route choices of self-drive tourists (Hadjali, Mokhtari, & Pivert, 2012; Niaraki & Kim, 2009), such as the interest of POI, fee, distance, traffic conditions and road conditions of the route. These five main route attributes are the ones which are considered in our research. Therefore, based on the feature of self-drive tourism, V2VCS is adopted to collect and share related information for personalized route recommendation.

2.2. Vehicle to vehicle communication system

Recently, increasing modern vehicles are equipped with the V2VCS devices that contain GPS, GIS and wireless communication modules which can enable direct communication with other V2VCS devices within a short distance (Chiara, Deflorio, & Diwan, 2009; Sichitiu & Kihl, 2008; Toor et al., 2008). Unlike conventional communication systems, the V2VCS can transmit and share real-time traffic information among equipped vehicles without any field infrastructures (Huang, Chen, Chen, & Wu, 2009). Recently, there is growing research that adopts the V2VCS to collect and share real-time traffic information between equipped vehicles in a short distance. For example, the V2VCS can be adopted in traffic information systems (Tsao & Cheng, 2011), traffic congestion detection (Bauza & Gozalvez, 2013; Zhang, Gao, Zhao, & Chao, 2011; Zhang, Xu, & Liao, 2012) and vehicle route guidance (Ding, Wang, Meng, & Wu, 2010).

2.3. Real time traffic information

In the near future, along with the increasing numbers of self-drive tourists, the congestion and queuing problem cannot be neglected in tourism industry. However, without understanding the real time traffic information around POIs, many self-drive tourists usually cannot finish their visiting plan or stick to their original schedule.

Recently, real time traffic information has already been applied to address these problems in tourism industry. For example, the historical visiting time and real time queue information is collected by RFID system to provide personalized route recommendation service for tourists in a theme park or museum (Tsai & Chung, 2012; Tsai & Lo, 2010). In addition, real time traffic information can be used to provide vehicle guide services (Ding et al., 2010). Hence, real time traffic information collected by V2VCS is adopted in this research to address the congestion and queuing problem in self-drive tourism.

3. The personalized route recommendation system

In this research, the POIs and vehicles of self-drive tourists are assumed to be equipped with the V2VCS devices in a tourist hot spot area. When a vehicle enters or leaves a POI, the equipped