Neurocomputing ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Neurocomputing

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

Attraction recommendation: Towards personalized tourism via collective intelligence

Junge Shen, Cheng Deng, Xinbo Gao*

Department of Electronic and Engineering, Xidian University, Xi'an 710071, China

ARTICLE INFO

Article history:
Received 31 March 2015
Received in revised form
31 July 2015
Accepted 9 August 2015
Communicated by L. Shao

Keywords:
Heterogeneous information
Collective intelligence
Attraction recommendation
Personalization

ABSTRACT

Travel recommendation systems can tackle the problem of information overload and recommend proper attractions on the basis of users' preferences. Most existing travel recommendation systems utilized travel history, yet neglected the low frequency of tourism and the flexible styles of attractions in different cities, which will cause the inaccuracy in both collaborative filtering recommendation and content-based recommendation. To deal with this issue, we propose a novel personalized travel recommendation framework by leveraging explicit user interaction and multi-modality travel information. As far as we known, it is the first time that attractions are recommended by user interaction and collective intelligence in a unified framework. Specifically, we first collect heterogeneous travel information by multi-user sharing, which is regarded as collective intelligence to provide reliable references by other travelers. Second, valuable knowledge is mined from collective intelligence in order to filter out the noisy data and make travel information structured. Then, personalized attraction similarity (PAS) model is designed to suggest attractions through fusing heterogeneous information with weighted adaptation and simultaneously considering explicit user interaction. Finally, context information such as the user's location is well adopted to refine the recommendation that may influence the user's choice at a particular moment. Experimental results on pseudo-relevance data and real-world data demonstrate that our method gains promising performance in terms of effectiveness as well as efficiency.

1. Introduction

With attraction the improvement of people's daily life, tourism has become more and more popular. Moreover, with the rapid development of Internet technology and the rise of social media, the users' requirements for the quality of travel service have become more and more high. However, it is challenging that valuable information can be quickly and correctly picked out from massive travel information. For generic, most existing commercial tourism websites show the must-see attractions in the location city on the basis of user ratings to travelers. When travelers wish to explore the places where they have not previously been to, it is rather difficult for them to schedule a perfect trip in view of personal interests and characteristic tourism. Consequently, in order to satisfy users' personal requirements and content-based recommendation can be introduced for personalized attraction recommendation. Meanwhile, when the attractions are so appealing, travelers will take souvenir photos, write comments and make scores. Thus, the heterogeneous information uploaded by travelers can be considered as their travel preferences and experiences, namely *collective intelligence*. Moreover, considering massive travel information, an intelligent website or system should take advantage of collective intelligence for content-based personalized attraction recommendation. Therefore, it is more desirable to mine knowledge from heterogeneous collective intelligence and combine personalization in the coming intelligent travel recommendation system.

The traditional dominant travel recommendation approaches are roughly divided into two categories: collaborative filtering recommendation [1,2] and content-based recommendation [3,4]. Travelers may travel once or twice a year even less on average, so travel-based user data is very sparse. Although collaborative filtering recommendation is much easier to implement than content-based recommendation, it will cause cold-start problem which depends on productive users' behaviors and profiles. Consequently, collaborative filtering approaches [5,6] are not appropriate for sparse data in travel situation. By comparison, content-based approaches can handle the sparse user data but only can cope with single-modality information instead of heterogeneous information. And some works [7,8] focus on visual information classification and the visual-based classification problem is well-suited for the attraction recommendation, because visual information can vividly

* Corresponding author.
E-mail address: xbgao@mail.xidian.edu.cn (X. Gao).

http://dx.doi.org/10.1016/j.neucom.2015.08.030
0925-2312/

represent the attractions. In reality, travel information contains massive heterogeneous information [9], including text, image and numerical value. In the case of travel recommendation, the content-based recommendation should be adopted in order to solve the problem with heterogeneous information from social media. Aiming to make full use of abundant heterogeneous resources in social media, the knowledge of collective intelligence will be explored to address the cold-start problem.

To further establish the personalized recommendation, the user information is collected either explicitly or implicitly. Explicit collection [10] means that user providing information actively, where the users should answer the questions provided by the interface for interaction. Implicit collection [11] is a passive way to mine users' interests from user historical behavior and context information. However, implicit way is not available for travel recommendation, because different cities have a diversity of architectural styles so that travel histories are not the best way as prior knowledge. For example, there are many different styles of parks around the world. The visual characteristics are not uniform in parks in different cities or even in the same city. Obviously, implicit information, such as user history, is not suitable for travel recommendation.

According to above analysis, due to the intrinsic characteristics of tourism, content-based recommendation with user explicit feedback, inevitably, is more suitable for travel personalized attraction recommendation. Therefore, we formulate a novel framework of travel attraction recommendation with personalization which consists of four principal modules, such as collective intelligence collection, knowledge extraction, PAS-model and user interaction. As shown in Fig. 1, in order to learn experiences of other travelers, we first collect travel heterogeneous information as collective intelligence from various travel-related websites on the Internet. Photos with metadata are crawled from Flickr [12] which are searched by the GPS location of each attraction. Meanwhile, official travelogues from Wikitravel and comments from Tripadvisor [13] are searched by the name of the attraction. In the same manner, ratings by travelers from Tripadvisor are tailed up. Then, knowledge is multi-modality descriptions of attractions, which is extracted from collective intelligence in different aspects, i.e., content-based, semantic-based and social-based. And then, given user interaction to avoid data sparsity and cold-start problem, the personalized attraction similarity model (PAS-model) is established with a combination of knowledge fusion to recommend attraction in a comprehensive view. In the model, each aspect of knowledge can construct graph-links between attractions with appropriate similarity measure. To realize personal recommendation, the user can choose favorite and unfavorite attractions as positive and negative labels in an explicit way, and the recommendation problem is considered as graph-based classification. Candidate recommended attractions are classified by graph-based multi-modality attraction information fusion in the way of weighted adaptation. Finally, users' current situation is utilized properly as context information to optimize the candidate attractions that can influence the user's choice under a particular condition. To give an intuitive way, personalized attraction recommendation is shown as an attraction ranking list in our system.

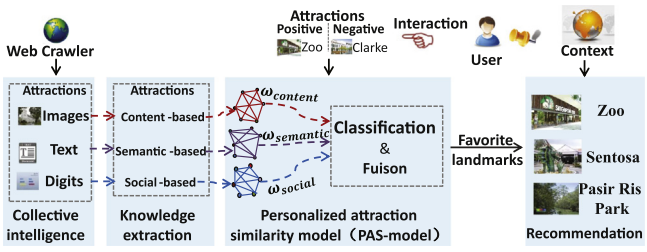

Fig. 1. The flowchart of the personalized recommendation framework.

Our contributions are summarized as: (a) personalized attraction recommendation with explicit interaction is first composed in the personalized travel recommendation by analyzing collective intelligence from social media; (b) PAS-model is designed in a unified way to solve the recommendation problem which can mine the intrinsic links between modalities of heterogeneous information and fuse heterogeneous collective intelligence with weight adaptation; (c) context information are considered to refine the recommended attractions to simulate the particular situation to predict user's favors. The rest of the paper is organized as follows. Section 2 briefs related work. Then, in Section 3, we introduce our personalized attraction recommendation framework. The details of our framework are introduced in Section 3. Experiments and discussions are presented in Section 4. The final is conclusion in Section 5.

2. Related work

In an unfamiliar city, travelers want to visit both popular and favorite attractions. Travel attraction recommendation infers what the users' preferences and shows interesting and popular attractions for users to plan trips for them. Intelligent attraction recommendation on the basis of travel information and user's information is a hot topic. In general, dominant methods are classified as collaborative-filter (CF)-based, content-based methods.

On one hand, users' traveling histories, groups of users and user-location relationships are used by collaborative-filter-based methods. In [9], Markov model and topic model are combined to predict preference attractions based on user's traveling history. Based on collaborative filtering, [14] mined knowledge from GPS data to discover locations, and activities and a collective matrix factorization is utilized to recommendation. Cost-aware collaborative filtering [15] crawls travel logs from a travel company, and then represents cost factors associated with different travel packages. A latent factor model can join the cost factors together for recommendation.

On the other hand, content-based recommendations are produced by mining the travel information. In content-based methods, some works of travel recommendation utilized geo-tagged photos in social websites. Ref. [16] clustered a large amount of geotagged photos based on geo-location. Then, query provided by users can match the similar attractions based on text or images with the assumption that users will like similar attractions. Ref. [17] exploited the context information of photos, including textual tags, geolocation, images and the similarity of users. Similarities of users are calculated to predict user's favorite attractions. Then, a ranking algorithm is employed to show ranking attractions to users. When visiting to a city, the work of [9] proposed personalized recommend attractions with the Bayesian network techniques on the basis of users behavior and users' relationships. An expert tourist guide is presented by [18], which adapts not only user's travel history, but also considers travel time and users' preferences. In [19], based on locations traveling history and geotagged contributed images, user profiles and attributes are taken into account in personalized travel recommendation by a probabilistic Bayesian learning framework. Then, demographics are mined for personalized attraction and route recommendation.

It is observed that each category has its merits in recommendation. However, travel data has its special characteristic, such as sparsity and variety. In other words, when thinking about all the hassles of traveling, most people has been travelled once or twice in their whole lives. Thus, few travel histories can be obtained and collaborative filtering may be not easy to implement. As

Please cite this article as: J. Shen, et al., Attraction recommendation: Towards personalized tourism via collective intelligence, Neurocomputing (2015), http://dx.doi.org/10.1016/j.neucom.2015.08.030