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Research Article

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Research on the Application Ontology-Based Personalized Tourist Recommendation System

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ABSTRACT

In view of the defects of the traditional user modeling technology in personalized recommendation system, this paper introduces an ontology-based user modeling method. In order to retrieve the most interested goods from a large amount of information for the user, a recommendation model is designed which combines the ontology technology and tourism information. This paper mainly studies the knowledge representation in tourism field and ontology-based model building method. This paper describes the implementation procedure of how to use the ontology editor tool Protégé to construct OntoTRec, and points out the procedure and method how to realize it. The feasibility and effectiveness of recommendation algorithm proposed in this paper have been verified on real-world data sets, and it achieved higher prediction accuracy compared with existing recommendation algorithms.

Key words: Ontology; Personalized recommendation; Collaborative filtering; Web crawler; Preference prediction

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INTRODUCTION

Tourism industry is highly dependent on information, because in later stages of tourism products, just to provide the information of product without providing the product itself. At present, how to use the network to provide intelligent and personalized service has become a hot research point in computer industry and in tourism industry[1]. With the rapid development of Internet technology, travel information has exploded, so the amount of information about travel on the Internet is large and scattered. But people hope to get accurate information and help them to arrange their tourism activity reasonably through the network, Instead of being buried in a pile of network data. How to find the useful information to meet the individual tourist needs from these massive data? Personalized recommendation technology is considered an effective way to solve such problems, which has been extensively academic studied in tourism industry[2]. Based on Collaborative Filtering, the recommendation system can automatically predict the user interest and preferences by collecting the evaluation information from other similar users. The basic assumption of Collaborative Filtering is that users will be more like the goods of those similar users prefer. Collaborative Filtering has been widely used in some large and well-known business systems, such as Amazon and Alibaba[3]. Currently, algorithm of Collaborative Filtering (abbreviated CF) include memory-based, model-based and hybrid recommended techniques[4]. The most popular model used by Collaborative filtering recommendation system is k-nearest neighbor (abbreviated kNN) collaborative filtering technology[5], including two techniques, one is user-based recommendation and another is project-based recommendation.

The term Ontology is originally from the field of philosophy. Now it is used widely in other field, for example, artificial intelligence, information retrieval, semantic Web, natural language processing and so on[6]. Ontology has the property of clarity, formalization and sharing. In general, Ontology describes the relationship between one concept and the other concept in an application field, makes them have a unique meaning, obtains the relevant knowledge in the field, provides a common understanding of knowledge in this field, and makes it easy for user and

computer to communicate. Firstly, Gruber gave the definition of Ontology: Ontology is Explicit formal description of shared conceptual model[7]. After that, in 1998, Guarino gave the concise definition of the term: ontology is a logical theory, and used for explaining the predetermined meaning of a formal vocabulary[8].

In the existing recommendation algorithm, some of them are based on users' interest preferences, some of them are based on project similarity, or make a combination of both. But these algorithms are not really to expose the properties and characteristics of the product itself, and can not recommend interest products accurately for tourist. To solve this problem, this paper discusses the personalized recommendation algorithm based on ontology, and analyzes deeply the application of ontology in collaborative filtering recommendation system.

RELATED RESEARCH

The application of personalized recommendation in the field of tourism, including recommended both individual products, such as monomer attractions, hotels, restaurants, flights, etc., and integrated products, such as destinations, travel plans, travel packages. In the field of tourism, the two most successful recommendation system technology is tripmatcher of triplehop (is applied www.ski-europe.com) and expert advice platform MePrint of VacationCoach (is applied travelocity.com). These two recommendation systems are trying to simplify searching process for holiday destinations by simulating discussion between traditional travel agency and customers[9]. Existing studies include: recommending tourist routes based on the sensitive search, tourists needs, or attractions popularity[10]. In order to provide travelers satisfied personalized recommendations, scholars conducted extensive research and exploration. Most of them applied artificial intelligence techniques[11]. Zhou[12] summed up the role and connotation of travel information, which include tourist information, the awareness of tourism destination and tourist behavior relationship; Chen conducted a case study of Meizhou, wrote algorithms and achieved system integration by analyzing system demand, designing system function and system space, and successfully applied it in Tourism information system of Meizhou[13]. Luo discussed key technologies necessary in the establishment of tourism information systems in 2005, such as 3S technology, multimedia technology, and network technology, pointed out the significance of studying "digital tour". Lin [14] explored how to build tourism information system on the platform of geographic information system, based on Changle City, Fujian Province. Qun and Yuan[15] comprehensively reviewed the research progress of Tourism Information System in China, and put forward to the further development of tourism information system. Huang[16] integrated Bayesian network and semantics web and provided personalized recommendations of tourist attractions on the Internet. Xu[17] established a tag recommendation system based on user preference model; In order to adapt the characteristics of tourism and overcome limitations in traditional recommendation techniques, Wang[18] proposed a tourism recommendation system based on constraint, and designed recommendation engine in detail, which could access to all kinds of knowledge in tourism areas and recommendation rules through visualization tools. Xu[19] proposed a secondary recommended method based on ontology. This method introduced ontology to describe tourism resources, achieved the association of user-need information and filter conditions in recommendation. Users could make evaluation to recommend results. Zhang[20] proposed personalized recommendation algorithm which merged timing behavior and trusts, so improved user satisfaction. In his another literature[21], he proposed a social networking recommendation algorithm which merged a variety of context information. So improved the accuracy of recommendation. All of researchers are trying to solve the problem of how to build accurate contact between users' preferences and recommended content in personalized recommendation. Middleton[22] proposed Quickstep and Foxtrot systems, which based knowledge and made Ontology represent users' interest field. Cantador[23] proposed personalized message recommendation system --- news@hand. This system applied semantic technology to recommend online message. Burke[24] used hotel's cuisine knowledge, proposed recommended method based on the rules and examples, and recommend the hotel to customer. Noor[25] Proposed a personalized recommendation system, which combined social networking technologies and the Semantic Web, and which built a bridge between user preferences and personalized searching. Castells[26] developed aceMedia recommendation system, described the characteristics of user preference as a conceptual ontology vector. García-Crespo[27] used fuzzy logic method to find a link between user preferences and characteristics of hotel, which focused on solving personalized matching based on user preference.

Against some of the weaknesses of the traditional user modeling techniques, this paper conducts exploratory research on user modeling in personalized recommendation system based on ontology, proposes personalized recommendation models and algorithms based on ontology. After running on real data sets, the experimental results show that the algorithms proposed in this paper are superior to the traditional collaborative filtering algorithms both in running efficiency and in recommendation accuracy.

MODEL BUILDING OF PERSONALIZED RECOMMENDATION BASED ON ONTOLOGY

1. Construction of tourism ontology

This paper adopts skeleton method to build knowledge ontology in tourism field. Firstly, determines the scope and purpose of ontology, and analyzes knowledge ontology; Secondly, establishes ontology, using Protégé software express the concepts and relationships, saves as a OWL file; Finally, integrates the established ontology and travel personalized recommendations system.

After analyzing all the concepts, property or relationship involved in tourism ontology, we get the main things involved in tour recommendation. They are: traffic, attractions, accommodation, diet, shopping, tour style, weather conditions...ect. The tourism domain ontology data described in Figure 1.

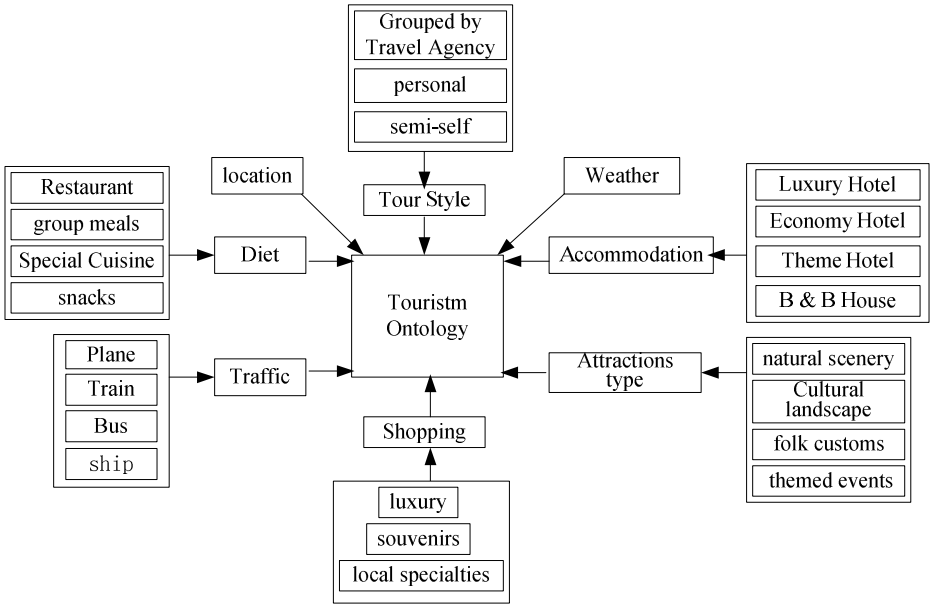

Fig. 1 Diagram of tourism ontology

After establishing tourism information ontology, the system also establishes tourists information ontology. Because tourists are main characters in various tourism transaction processes, so establishing a tourist-centered information ontology database can provide system more extensive information to facilitate intelligent query and knowledge reasoning. For more detailed information about tourists, some personal information and other important information are included in the tourists database, such as age, gender, time preference, income, occupation, hobbies, travel interests, travel style, consumption habits, and so on. Tourists information ontology is shown in Figure 2.

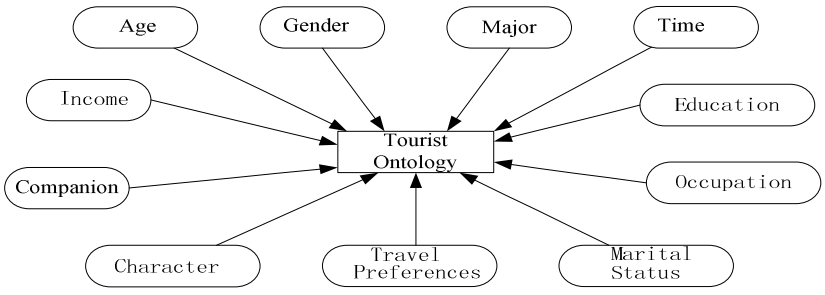

Fig. 2 Diagram of tourist ontology

2. Description tourism ontology

This paper adopts OWL to describe the tourism ontology. OWL stands for Web Ontology Language, which is a standard Semantic Web ontology language. OWL uses an object-oriented way to describe the field of knowledge. That is using class attribute to describe the object, and also using axiom to describe the characteristics and

relationships of these classes attributes. In the definition of ontology, some terms at the same level could be defined into different categories. So we use owl: disjoint class to define. Disjoint classes Defined by OWL as shown in Table 1.

Table 1: Disjoint classes defined by OWL

```
<owl:Class rdf:about="#Diet"/>
<owl:disjointWith rdf:resource="#Accommodation"/>
<owl:disjointWith rdf:resouree="#Traffic"/>
<owl:disjointWith rdf:resource="#ScenerySpot"/>
<owl:disjointWith rd:resource="#Route"/>
<rdfs:subClassOf rdf:resource="#Culture"/>
</owl：Class>
```

When establishing class attributes, we need to define some constraints of attributes according to certain fields. For example, the star of hotel should be included in hotel category. In the category defined by OWL, allValuesFrom represents the constraints relationship, as shown in Table 2.

Table 2: Constraints relationship

```
<owl:Class rdf:ID="Hotel">
<rdfs:subClassOf>
<0wl:Restriction>
<owl:allValuesFrom rdf:res0urce="#HotelStar"/>
<owl:onProperty>
<owl:ObjectProperty rdf:about="#HasStar"/>
</owl:onProperty>
</owl:Restriction>
</rdfs:subClass0f>
<rdfs:subClassOf rdf:resource="#ScenerySpot"/>
</owl:Class>
```

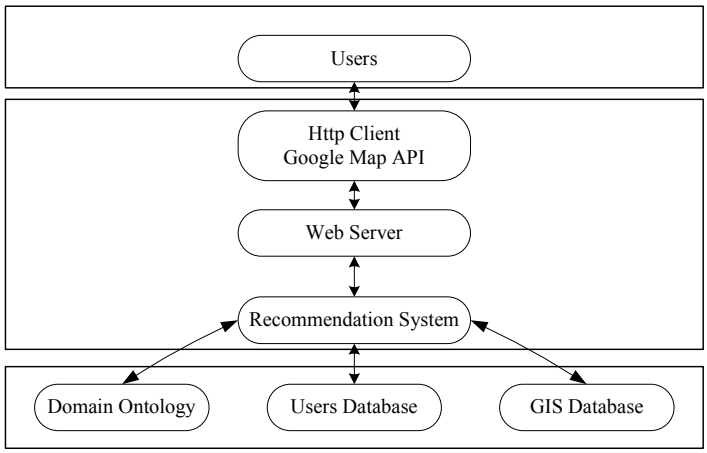

Fig. 3 personalized tourism recommendation model

3. Personalized Tourism Recommendation Model Based on Domain Ontology

This paper establishes a personalized tourism recommendation model based on ontology (referred OntoTRec). This model bases on tourism domain ontology, integrates traditional collaborative filtering algorithms, can provide tourists with more accurate tourism products. The architecture diagram of personalized tourism recommendation

model as shown in Figure 3.

As can be seen from Figure 3, the entire recommendation model can be divided into three levels. They are user layer, network service layer and data layer. User layer mainly faces for user, provides users with tourism products that personal interested; Network service layer makes the data match between user's personality characteristics and knowledge-base, under the control of a central control module, completes the relevant recommendations queries; Data layer mainly consists of ontology, using pre-build tourism commodities, improves user satisfaction of a personalized match.

Tourism recommendation is closely related with the spatial distribution of tourists. Therefore, the recommendation system combines tourism ontology with geographic information systems (GIS)[28]. On one hand, geographic information system can store a large number of tourism-related geospatial information, and provide a map interface. On the other hand, ontology can provide geospatial integrated semantics information in the recommendation systems. In the recommendation process, using this approach can appropriately handle spatial data, thus it can reduce time and make more effective tourism planning[29]. The core of the architecture is recommendation system developed in Java, which deals with the interaction between all modules. In addition, it will dynamically update and manage user profiles. Data stored in the two databases, one of which is stored in tourism resources, another store user profiles.

RESULTS

1. Introduction to Data Set

This paper using web crawlers makes an extraction for tourism information from e-commerce website, and corrects HTML document on the web pages, and then converts the information into a DOM tree, removes noise and filters out irrelevant information, matches Word Segmentation results under the rules of Ontology matching, stores the ontology concepts and their attributes in the database.

2. Methods of Comparison

To test the performance of OntoTRec recommended model proposed in this paper, This article does experiment to verify the validity of the model. We chose two recommendation algorithm as a reference model: UserCF[30]and ItemCF[31]. Wherein, UserCF is user-based CF algorithm, this algorithm mainly looking for similar users, based on users' similar preferences to recommended product; ItemCF is program-based CF algorithm, based on the similarity between items to recommend similar commodity to target user. We obtain the similarity of users or items by calculating from Pearson similarity formula (1).

$$sim(u,a)=\frac{\sum_{i\in I_{u,a}}(R_{u,i}-\overline{R}_u)(R_{a,i}-\overline{R}_a)}{\sqrt{\sum_{i\in I_{u,a}}(R_{u,i}-\overline{R}_u)^2}\sqrt{\sum_{i\in I_{u,a}}(R_{a,i}-\overline{R}_a)^2}} \quad (1)$$

Wherein, $sim(u,a)$ is the similarity of user a and u. $I_{u,a}$ represents product group scored by u and a, $R_{u,i}$ and $R_{a,i}$ represents score of commodity i from u and a, $\overline{R}_u$ and $\overline{R}_a$ represents respectively the mean value of all goods from u and a.

3. Experimental Results

In this paper, we divide the data set, training set accounted for 10%, 20% ... 90% of the data set respectively. The prediction accuracy of OntoTRec recommendation algorithm, UserCF algorithm and ItemCF algorithm as shown in Figure 4. It is easy to see, regardless how to divide the training set, the prediction accuracy of OntoTRec recommendation algorithm is higher than UserCF and ItemCF algorithm. In addition, the prediction accuracy of UserCF algorithm is higher than ItemCF algorithm.

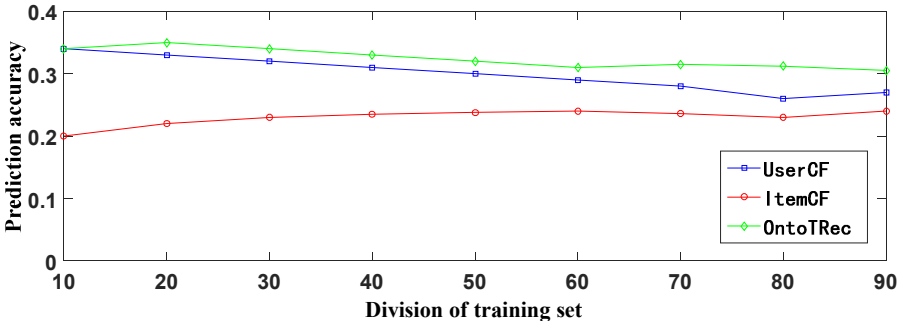

Fig. 4 Prediction accuracy comparison

CONCLUSION

This paper summarizes personalized recommendation technology and ontology technology, and makes a good combination of the two technology, expecting to improve the accuracy of recommendation system. We use the tool of ontology editor Protégé to build tourism domain ontology,and establish personalized recommendation tourism Model. The experimental results on real data sets show that the recommendation accuracy of recommended model OntoTRec proposed in this paper is higher than that of recommended model that is user-based and program-based collaborative filtering algorithm respectively. So the recommended model OntoECRec solves effectively the problem of low recommendation accuracy of the traditional collaborative filtering algorithm.

The OntoTRec algorithm is applied to travel website, the web can provide users with personalized produces and services and guide tourists get what they need rapidly. Moreover, recommendation tourism Model can help travel enterprise promote tourism products and improve tourists loyalty in the fierce competitive electronic commerce environment. To build a certain field ontology which can meet a wide range demand of users is an extremely complex task. Tourism ontology constructs in this paper is relatively simple, we will further improve it in the future in order to further improve users' satisfaction with tourism recommendation result.

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