A Context-Aware Recommender System Using Ontology Based Approach for Travel Applications

Preeti R. Dodwad, L. M. R. J. Lobo

Abstract— the purpose of tourism is to travel for relaxation and enjoyment. However, when tourists use internet to search for data about travel spots, events and relevant services they experience a data overload. It is also difficult for them to select what is truly interesting from sheer amount of available information. For a tourist guide system, it is still a tough task to provide proper travel information for tourists who posses different personal interests. Therefore, our aim is to develop a recommender system which considers tourists' personal interests and related context, so that tourists can get relevant travel information with least amount of effort. This recommender system uses an ontology based approach. Ontology consists of a set of concepts relevant to a specific domain and the relationships between them. Such an ontology structure can reason depending on the choices of a user. The user profile keeps the degrees of interest of the user on many concepts by making use of a membership function. Each concept of ontology is a fuzzy set and any user can fit into this fuzzy set to a definite degree. When preliminary assignment of user choices is done, we performed an upward and downward propagation of user's interest degrees which utilizes the taxonomical information of the ontology. The information about the user's choices is propagated throughout the complete set of concepts. This developed system has been successfully applied for a Tourism scenario and is based on user context. This system is built on an Android platform and has generated successful results.

Keywords —Context-aware recommendations, user interests, ontology, recommender systems.

I. INTRODUCTION

Nowadays, tourists use internet to search for travel relevant information. However, they experience an information overload. It is also a difficult job for them to select relevant and appropriate travel data according to their interests. In these situations, Recommender systems can be extremely useful, as they can automatically analyze the information obtainable on likely alternatives, this system can compare user interests, can allot ratings to alternatives and provide to a user suitable ones. Thus, a fundamental part of a Recommender system is the user profile, which is storing the data of the domain preferences. Currently research is going on semantic recommender systems. In these systems ontology [1]

[2] is used for representing semantic information of the domain, which is used to represent the user profile as well as the recommendable things. As mentioned in [3], semantic recommender system offer the benefits of semantic richness as preferences are more detailed and richer than the standard ones dependent only on keywords. A hierarchical structure allows one to analyze the preferences at diverse abstraction levels and ontology structures which may be used for reasoning on the preferences over all the domain concepts. The Goal of the work presented in this paper is built on a context-aware recommender system which [4] does not consider for giving recommendations.

As stated in the following section, some authors have already proposed working with user profiles based on ontology, where the concepts of ontology and the taxonomic relationships among them are exploited to propagate the preference related information throughout the ontology. In those semantic recommender systems, a user profile is prepared and maintained with the help of explicit user information (form filling, rating interested items) as well as implicit information (user interaction with recommender system). However, it is identified that they have not considered dynamic variations in the user preferences due to user actions, which affects recommendable items. The basic aim of this work presented in this paper is to fill up the above mentioned gap.

II. RELATED WORK

Semantic Recommender systems consider a user's preference and uses ontology which represents semantic information. Guson Prasamuarso Kuntarto, Dennis Gunawan (2012) [5] used ontology as a knowledge foundation and implemented a search engine application for e-tourism, for a place named Bali. Dr. M. Indra Devi, K.Palaniammal Dr.S.Vijayalakshmi (2012) [6] presented an approach which is semantic search and result . This approach considers user's priority while searching for the tourism information. Jorge Cardoso (2006) [7] took into consideration new technologies related to semantics , such as knowledge bases, ontologies, and semantic Web to create Dynamic Packaging Systems for e-tourism. Innar Liiv,Tanel Tammet, Tuukka Ruotsalo, Alar Kuusik (2009)[8] developed the SMARTMUSEUM platform with adaptive and privacy preserving user profiling. This recommender system uses combination of ontology based approach and statistics based approach.Tuan-Dung CAO,

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Thanh-Hien PHAN, Anh-Duc NGUYEN (2011) [4] build up(STAAR system) Semantic Tourist Information Access and Recommending system .This system does not consider user context for recommendations. We are expanding STAAR system with the provision of context -aware recommendations. User's context may have division as static context (user profile, interests) and dynamic context (weather information). For Semantic Recommender System one way is to represent a user's preference as well as the domain things by means of ontology concepts. This is followed by using the relationships among them for evaluation of the similarities among the user interests and the recommendable objects. For instance, in [9] the user profile consists of the items purchased by the user, together with an interest among 0 and 1. This data is propagated towards the concepts that represent leaves of domain ontology. It is noted that in this work for giving recommendations, there is a lack of initial information .Also the work does not consider dynamic changes in the user profile coming from the user's actions. The Novel part of our system is carefully considering implicit as well as explicit user preferences so that we can store and infer about the preferences related to every domain concept and their reliability.

III. SYSTEM ARCHITECTURE

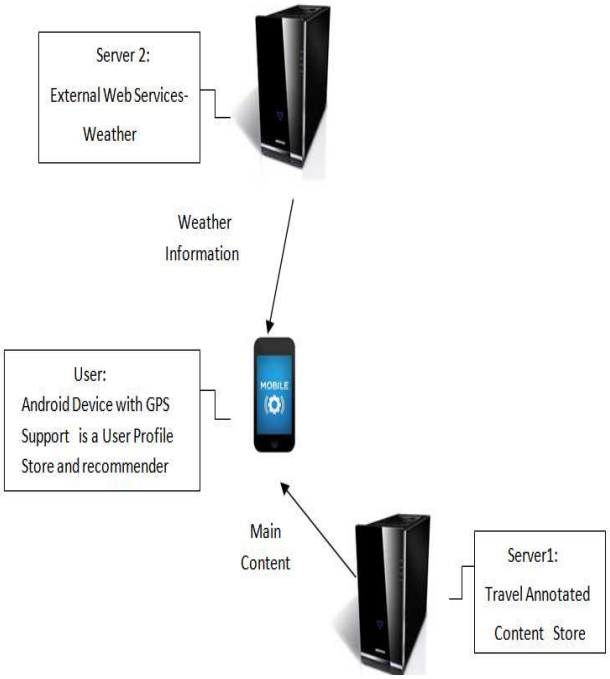

Fig. 1 System Architecture

As shown in Figure1. Our context-aware recommender system is for users, who have android device with GPS Support. The components of the system are as follows:

i) Android Device with GPS Support:

When a user accesses our application on his android device, our application provides a form to him. This form is for taking user static information and interests like his family, religion, drinking habit, eating habit, favorite kind of food. This information of the user profile is stored permanently on user's android device. The user profile also keeps the degrees of interest of the user on many concepts by making use of membership functions. This device also consists of recommender system which captures user profile. After that recommender system works as follows. It considers each concept of ontology as a fuzzy set and any user fit into this fuzzy set to a definite degree. When preliminary assignment of user choices is done, it performs upward and downward propagation of user interest degrees, which utilizes the taxonomical information of the ontology. The information about the user's choices is propagated throughout the complete set of concepts.

For giving recommendations it takes main content from server1: travel annotated content store and also considers weather for giving dynamic recommendations.

ii) Server1

It is a travel annotated content store, which is ontology. It provides main content related to travel domain.

iii) Server2

This server contains web services like weather. It provides current weather information relevant to travel place.

IV. METHODOLOGY

We have developed a context-aware recommender system in travel application. For giving recommendations we have used fuzzy approach for storage of user related data in ontology.

A recommender system considers a user profile and interests and provides recommendable objects to the user. These objects are nothing but the instances of one of the leaves of the ontology. We are using the domain ontology for representation of the user preferences. The concepts of the ontology are inferred as domain subsets in which the user can have interest. As degree of interest can vary from one to another concept, we represent the preferences using fuzzy sets.

Every concept of the ontology has a fuzzy set. So, we can give membership degree to the concept for each user. This membership degree is for user's degree of interest in a specific concept and also it is personal. If the user has complete interest in concept, then the membership degree is 1. Thinking conversely, when membership degree is 0, we consider that the user has not at all any interest in the concept .Whenever user requests a recommendation, we discover the values of membership degree for all the concepts in the ontology. After totally labeling ontology with membership degree, the recommender system can find the most suitable items for this user, considering that every object is nothing but an instance of the concepts. The values of membership degree will be calculated by making use of implicit information obtained from the interaction of the user with the system. For giving recommendations according to user profile we have used ranking based on object properties and user profile.

Summing up, the user's personal profile has the ontology copy that keeps the interest degree of this user for every concept. For instance, our recommender system is for travel to Solapur city, in Maharashtra State of India. Figure.2 shows our domain ontology, which is used for recommendation various travel spots like accommodation, attractions, food, fun spots, sports, utility spots interest to the user. These travel

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spots are concepts (classes) of domain ontology. As stated before, it is considered that all the items which our system recommends are instances of the last level concepts (classes) (Hotel, Lodge, ReligiousPlace, ScenicLandmark, FastFood, etc.).

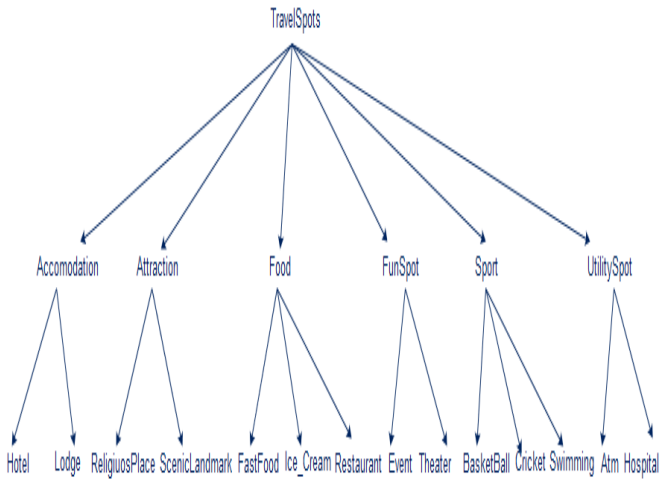

Fig. 2 Travel domain Ontology

A. USER PROFILE INITIALIZATION

Each concept of the ontology has degree of interest (i.e. membership degree), for which the calculation is made from the gathered user information, which is taken from explicit or implicit user interaction with the system. For user interest initialization, in our application user can give degree of interest on some general domain part , correspond to the first-level ontology concepts (as shown in Figure.2 above, Accommodation, Attraction, Food, FunSpot, UtilitySpot are those general concepts). Range of Rating values are from 0.0 (indicates no interest) to 1.0 (indicates highest interest). For user profile initialization, the application asks him to fill a form, where user's static information and interests like his family, religion, drinking habit, eating habit, favorite kind of food is taken. Then we use ranking based on object (instances of last level concepts in ontology) properties and user profile.

B. DYNAMIC MODIFICATION OF USER PROFILE

For the period of the execution of the recommender system, we can capture the proofs from the different kinds of actions performed on the objects. This method is used to alter the degrees of membership of the user in relation with the concepts. The information gathered about an object has affect on the instances of object (instances are the leaves in the domain ontology). We distinguish two main types of information that can be obtained from the interaction of the user with the recommender system Implicit and Explicit.

Table 1 mentions the scores *s* (range from -1 and 1) and the weights *w* (range from 0 and 0.2) in relation with teach user action.

Table1. Collection of User actions by the system

User Actions	Implicit	Explicit	S	W
Rate an item		●	[0,1]	1
Bounced back	●		-1	0.1
Stays	●		1	0.2

Weight W used in upward and downward propagation is calculated by:

$$W_N = s_N * w_N \quad (N - \text{node of domain ontology})$$

C. DOWNWARD PROPAGATION

The preference for a concept in the ontology is calculated by assigning weight to it. This weight is nothing but the value of the membership degree. Now, the next step is the propagation of the preferences towards the descendents of fist level concepts. For this we have used following formula:

$$W_N = W_{P(N)}$$

(Where N –node and P(N)- parent of the node in domain ontology)

D. UPWARD PROPAGATION

After collecting preferences for various concepts, our recommender system provides recommendable items (instances of last level concepts in the domain ontology) to the user. User can now select a certain item, now based on the bounce rate we calculate weights by using upward propagation of preferences. For this we have used following formula:

$$W_N = \sum_{CN \in C(N)} \frac{W_{CN}}{CN}$$

Where (C (N) - children of N, N- node of the domain ontology)

V.EXPERIMENTAL RESULTS

A Context-aware recommender system has been successfully built on an android platform. This system is developed for Solapur city, in Maharashtra State of India. We have manually developed travel domain ontology. It covers various travel spots, which are classified into 6 main concepts representing first level of travel domain ontology. For tourism data we have allotted a travel annotated content store (Sever1), which maintains information for tour spots such as textual description, images, location co-ordinates etc. This tourism data belongs to the instances of last level concepts in the travel domain ontology. User profile initialization is made by collecting information from the form shown in figure 3. The filled information gets permanently stored in the device of the user. After form filling, user can set his interest degree for travel spots which are concepts in first level of ontology as shown in figure 4.

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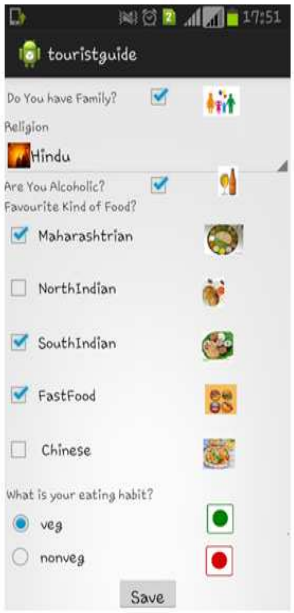

Fig. 3 User Profile Initialization

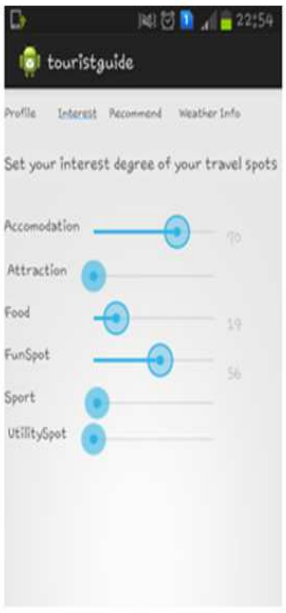

Fig. 4 User Interest Indications

After setting up interest degree user can click on recommend option. These values are transferred in travel

domain ontology using downward propagation as explained in section 4.C .Now according to his profile and preferences about travel spots, the recommendable items are displayed as shown in figures 5, 5.1, 5.2, 5.3, 5.4.

Now suppose user selects hotel 'Surya international' as shown in figure 5. He will get complete information about it, with Google map showing user's current location and destination as shown in figure 6 .If user stays on this information and then comes back , he can observes that hotel instances are above lodge instances as shown in figure 7. This is done using upward propagation as explained in section 4.D. Figure 8 shows current weather report of Solapur.

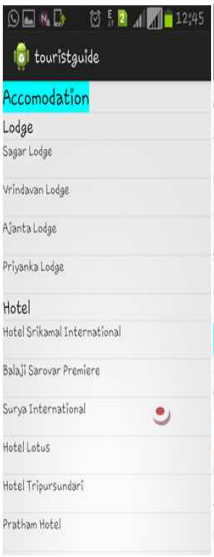

Fig. 5 Recommendations

Fig. 5.1 Recommendations Continued

Fig. 5.2 Recommendations Continued

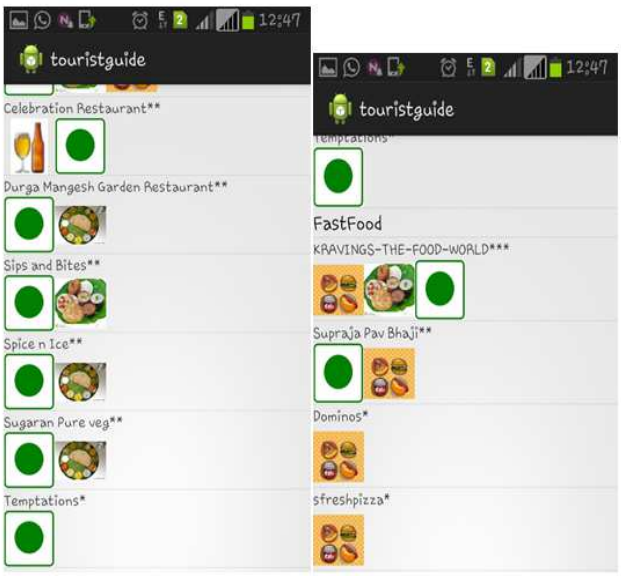

Fig. 5.3 Recommendations Continued

Fig. 5.4 Recommendations Continued

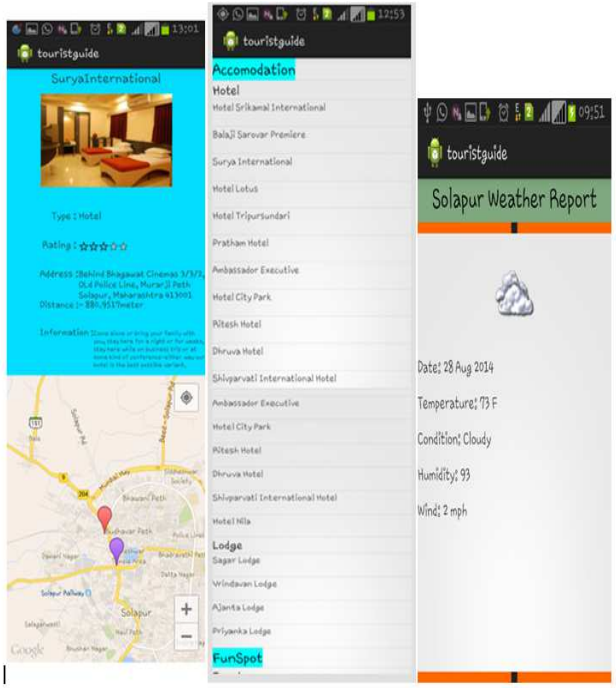

Fig. 6 Hotel Surya Information

Fig.7Upward Propagation due to User Action

Fig. 8 Current Weather Report of Solapur

VI.CONCLUSION AND FUTURE WORK

Our recommender system is based on use of ontology, which represents user profile and recommendable items. There is some work that has been carried out in this area which has suggested the usage of ontology for representing both user profile and the recommendable items [9].This system lacks initial information and is not considering the dynamic variations in the user preferences due to user actions, which affects recommendations. Our work is the first step in this direction, taking into account the maintenance of both user profile and preferences for each ontology concept. We have successfully built context-aware recommender system in travel application which considers user's static context (User profile and interests) and dynamic context (Weather

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information) for recommendations. For evaluation of a user's fulfillment with provided context-aware recommendations, we conducted a survey. Our recommender system was experimentally evaluated with the set of 100 users belonging to different categories such as engineers, doctors, students, travel agents, shopkeepers. They were asked to rate our recommender system based on features like personalization quality, context-awareness of system for recommendations, suitability of access, utility.

From the answer's responses the statistics obtained is: For personalization quality 82% of users rated positive and 18% rated very positive. 64% users rated Context-awareness feature as very positive and 36% users rated it positive. For suitability of access 75% of users rated positive and 25% of users rated very positive. Utility feature was rated as positive by 58% of users and very positive by 42% of users.

Our future work includes consideration of user's social context (friend, family, group...) for giving recommendations; the reason is tourists wish to visit places where people they know are there, integration of our system with social network.

REFERENCES

[1] Natalya F. Noy, "Semantic Integration: A Survey of Ontology-Based Approaches", ACM 2004.
[2] Asunción Gómez-Pérez and Oscar Corcho,"Ontology Languages for the Semantic Web", IEEE, 2002.
[3] Cantador, I., Castells, P. "Extracting multilayered Communities of Interest from semantic user profiles: Application to group modeling and hybrid recommendations", Computers in Human Behavior 27(4), 1321–1336 (2011).
[4] Tuan-Dung CAO, Thanh-Hien PHAN, Anh-Duc NGUYEN, "An ontology based approach to data representation and information search in Smart Tourist Guide System", IEEE, 2011.
[5] Guson Prasamuarso Kuntarto, Dennis Gunawan, "Dwipa Search Engine: When E-Tourism Meets The Semantic Web", ICACSIS, 2012.
[6] K.Palaniammal, Dr. M. Indra Devi, Dr.S.Vijayalakshmi, "An Unfangled Approach to Semantic Search for E-TourismDomain", IEEE, 2012.
[7] Jorge Cardoso,"Developing Dynamic packaging Systems using Semantic Web Technologies", Transactions on Infromation Sceince and Applications, Vol. 3(4), April 2006.
[8] Innar Liiv, Tanel Tammet, Tuukka Ruotsalo, Alar Kuusik, Personalized Context-aware recommendations in SMARTMUSEUM: Combining Semantics with statistics",In: 2009 Third International Conference on Advances in Semantic Processing, Malta 2009.
[9] Blanco-Fernández, Y., López-Nores, M., Pazos-Arias, J.J., García-Duque, J. "An improvement for semantics-based recommender systems grounded on attaching temporal information to ontologies and user profiles", Eng. Appl. Art. Intell. 24(8), 1385–1397 (2011).

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