Research on Personalized Recommendation System in E-Learning Based on Semantic Web

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Abstract. The semantic web is the future of web, which gives the network information with well-structured semantic meaning. Aiming at the need for characteristic learning, this paper analyzes the development of the personalized recommendation system, puts forward a personalized recommendation system in the E-Learning based on the semantic web, and analyzes the link between them. The proposed system adopts the principle and technology of the semantic web, discusses the construction and storage of the domain ontology, values the semantic modeling of the learner and the learning resources as the basis, combines the learner's model with the domain knowledge ontology of the learning resources for matching, and realizes the personalized recommendation through the semantic recommendation algorithm. Finally the paper design and realizes the prototype of this system.

Keywords: personalized recommendation-semantic web-Ontology-E-Learning

1 Introduction

E-Learning is the learning and teaching activities through the network, which changes the relationship between teachers and students from the traditional role of teachers to the role of students. E-Learning brings us abundant learning resources. However, at the same time it also brings a series of very serious problems such as getting-lost, learning isolation, and so on. The main reason is that currently E-Learning system only describes some of the basic information of the learning resources, but rarely describes the complex relationship between resources, teachers and students and their respective properties, so that students in their learning process can't fully have a comprehension of the resources, leading to the one-sidedness, passivity and blindness in their use.

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The semantic web is a new internet technology which gives information with well-structured semantic meaning, so it makes it possible that computer and people can work together in mutual understanding circumstance to provide personalized, active learning with strong technical support[1]. And the e-learning system established by semantic web and personality recommendation service technology can truly realize the personalized network education by providing personalized and timely teaching strategy.

2 Personalized Recommendation and Semantic Web

2.1 Personalized Recommendation System

In 1990s the recommendation system was put forward as an independent concept. With the development and mature of the web technology, the application of the recommendation system in the network also has gotten vigorous development. There have been many related researches on these topics in the domestic and foreign academic circles. Hailing Xu gave comprehensive, comparative study on web recommendation system[2]. Guoxia Wang carried out the comprehensive discussion on the definition and the key technology of the personalized recommendation system, and analyzed the hot spot in future[3].

Generally, personalized recommendation system has three important modules: user module, recommended object module and recommendation service module. General recommendation system model process is shown in Fig. 1.

From Fig. 1, we can see that through matching of the interest demanding information in the user model and the feature information in the recommended object model, the recommendation system uses the corresponding recommendation algorithm to calculate and select, and finds an object which user might be interested in, then recommends to the user. Among them, the recommendation service modeling is the most core and key parts, and to a great extent it determines the quality of the recommendation system's performance. The

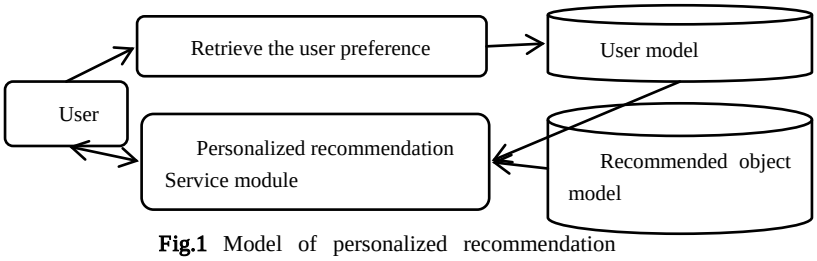

Fig.1 Model of personalized recommendation

research on recommendation service is the most prosperous part. At present, the recommendation service's strategy has appeared a lot, while the criteria for the classification also has no unified standards. But in general the basic recommended strategy includes several: recommendations based on the contents, collaborative filtering recommendation, recommendation based on the knowledge , recommendation based on the network structure, combined recommendation, etc[3-5].

2.2 Personalized Recommendation System Based on Semantic Web

Berners-Lee proposed the concept of semantic web. The semantic web is the extension of existing web, in which information is given well-defined meaning, easier to computer and synergy. The most important key in the realization of semantic web is the construction and storage of ontology library. The ontology library for the semantic web provides a set of shared terms and information's structure. The difficulty of the data retrieval realized in the semantic web is the ontology similarity's matching.

Yan Chen etc carried out the research into personalized recommendation system under the semantic environment, specially the establishment of a semantic recommendation system model(SRS) [6]. The SRS model is a six-dimension group, just as ASRS = < U, I, R, P_{UI}, P_{IR}, F >, which includes: U is the user concept set; I was the interest concept set; R is the recommendation resources concept set; P_{UI} is the semantic relation between the concepts of U and I, $P_{UI} \in$ UI, as can be represented by binary group p_{UI} (u,i); PIR is the semantic relationship between I and R, $P_{IR} \in$ IR, as can be represented by binary group p_{IR} (i,r); F is the sets of the operation relationship between concepts. The SRS model can be realized by the description logic which is a gens of language for knowledge representation and presents the domain knowledge with structured and easily understood form.The description logic based on the semantic technology can be converted into the first-order predicate logic, which can realize the semantic reasoning.

3 Design of Personalized Recommendation System Based on Semantic Web in E-Learning

The general idea is this: firstly, we should use the semantic web technology to establish the ontology of the learners, the learning courses and the learning resources; Then we should make an appropriate semantic tagging for the learning resources; The semantic tagging mainly is the process to establish the semantic relation between the ontology and its related examples, in which we can link the

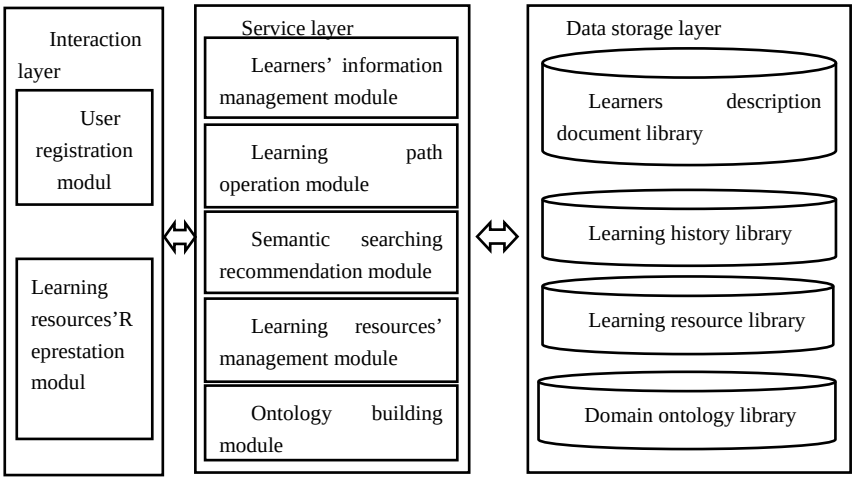

Fig.2 System architecture

created ontology with the practical courses and learning resources so as to establish the description file of them; Finally, through the semantic matching and sorting of the ontology of the learners, the courses and the learning resources, which is realized by the semantic reasoning and the semantic searching engine, the sorted and sequenced result will be submitted to recommended mechanism, and then the learning needs such as personalized learning path and resources can be dynamically recommended to learners.

The overall system architecture is designed in the Fig. 2.In this figure, the data storage layer includes the learners' ontology library, learners' description file library, the courses' ontology library, the learning resources' object database and the learning history library. The learners' ontology library includes the learners' basic type, level, learning ability and the ontology to describe the preference of user, etc.; The learners' description document library contains a learner's personal information, personal learning preferences and the current state of study, etc.; The courses' description ontology library contains the courses' ontology and the knowledge structure and its internal relations, etc.; The library of learning resources' object is used for the storage of learning resources, including ontology and its examples. The library of learning history records every learner's learning behavior and related properties, including the currently learning knowledge ID, learning level and learning time, etc.

The management module of users' information in service layer mainly realizes the learners' registration to fill out the personal information and preference information, etc.; The learners' modeling module is mainly responsible for the semantic representation of the learners' personalized description; The management module of the courses and the learning resources is mainly responsible for the modeling of the learning courses' ontology and the learning resources' object, and the semantic tagging of examples and storage of them; According to the learners'

model and learning history, the personalized recommendation module put forward personalized learning path and learning objects.

The interaction layer mainly provides the dynamic or static interface between the system and the user, the user and the user's interactive tools. Generally, it is a network teaching platform. Through this layer the learners can realize systematic study, personalized learning and communicating study.

4 Analysis of System Implementation

4.1 Users' Semantic Modeling

The establishment of users' model to obtain their demanding information is the key to realize the personalized service. The users' model can realize dynamic acquisition and representation, storage and modification of an user's interest, preference, classification and identification, so it can help system to understand the characteristics and categories and needs of users better.

In the system, the users' model mainly includes the learners' cognitive model and the learners' interest model. The learners' cognitive model can refer to the research of Richerd Riding and his colleagues in Birmingham university[7]. They said that cognitive style model can be reduced to two basic cognitive style dimensions: Wholist-Analytic, Verbal-Imagery. They also put forward their own evaluation method of cognitive style, the cognitive style analysis, referred to as the CSA.

There are two ways to get input data of a learner's interest. They are explicit acquisition method and implicit acquisition method. Explicit acquisition method is simple and direct. At the same time, the results are more specific, comprehensive, objective, and reliable. It's defect is with low agility. Implicit acquisition method analyses from the learners' learning behavior. That is to say the system get the user's interest preference through tracking and reasoning the user's behavior, such as his browsed course site in the learning process, his questions put forward and answered, his participation in the discussion of course and so on. Therefore, before the analysis of learners' learning behavior we must firstly make cleaning, extraction and analysis of the learners' log file to get their related important information. The defect of this method is that tracking results may not correctly reflect the user's interest and preference.

4.2 Learning Resources' Semantic Modeling

The semantic web construct ontology mainly uses the following four aspects of technology: URI, XML and XML Schema, RDF and RDF Schema, OWL. Noy put forward a method called knowledge engineering to develop ontology. This method completed the ontology development through seven steps[8].

According to the construction steps of the semantic web ontology, we introduce the process of the construction of the resources' ontology library in E-Learning. The learning object is the course, so the resources' ontology specifically is the course ontology. An ontology mainly includes the field concept, the structure and relations of the field concept, the concept of attributes and some inference rules. In order to construct the course ontology, we need to introduce the concept of knowledge point. The so-called knowledge point[9] refers to the basic organization and transfer unit of information in the process of teaching activities, and it is the basic logic unit of learning resources' structure. The relationship between the knowledge points is similar to the network. As nodes in a knowledge network, the association between each other also is very complicated. To master a knowledge point, one may want to learn some other knowledge points, which may also cite other knowledge point. Between the knowledge points there are mainly the following several kinds of contact: the precursor or successor relation, the inclusion relation, the relevant relation, the reference relation, etc. We can use the ontology description language (OWL) to describe the contact of knowledge points. And the relations between the learning objects constitute the basic framework of itself, such relation operators as: RDFS:subClassOf (or superClassOf) which represents the class hierarchy; owl:equivalentClass which represents the equivalence relation; owl:disjointWith which represents exclusive relationship between class and class and there is no common example between them.

The following is a part code of a domain ontology of teaching resources. This part code says that the concept of teaching system includes two son concept: network teaching system and multimedia teaching system and there is exclusive relationship between the two son concept.

```
<owl:Class RDF:ID =" network teaching system ">
< RDFS:subClassOf >
<owl:Class RDF:ID =" teaching system ">
< /RDFS:subClassOf >
<owl:disjointWith ><owl:Class RDF:ID =" multimedia teaching system "/ >
</owl:disjointWith >
</owl:Class >
<owl:Class RDF:ID =" multimedia teaching system ">
< RDFS:subClassOf ><owl:Class RDF:ID =" teaching system "/ >
</RDFS:subClassOf >
<owl:disjointWith ><owl:Class RDF:ID ="network teaching system "/ >
</owl:disjointWith ></owl:Class >
```

The construction of domain ontology library is a huge project, which needs a lot of experts in the field and often is done in semi-automatic manner. Nowadays with the rapid growth of the resources it obviously can't meet the demand that we depend only on the domain expert to construct the domain ontology manually. We must research further on the automatic domain ontology construction. And it is obviously not possible and also not realistic to construct an ontology library covering all areas, so it requires us to consider more on the transfer and sharing of an ontology library. This also needs our further research.

4.3 Semantic Recommendation Algorithm

We have introduced and completed the construction of the users' semantic modeling and resources' ontology before. The following process we need to do is to connect the users and resources, to understand the users' needs and to provide users with the resources they need. This is the engine of personalized service. Because our users' model and learning resources' model is based on the semantic web, we can realize our personalized service engine based on the semantic web information filtering technology[10].

This article put forward a kind of commonly used information filtering technology based on semantic web - the calculation method and formula based on the correlation properties of the concept[11]. In the calculation model of the correlation degree, it is through the same attributes and the different attributes of two concepts to calculate the semantic correlation between them. This method also has the following definition:

Public attribute: ($C_1 \cap C_2$) for common attributes of concept C_1 and C_2.

Different attributes: (C_1 - C_2) for attributes which concept C_1 has but C_2 do not.

So, concept C_1 and C_2 semantic correlation calculation formula is shown below:

$$Sim(C1, C2) = \theta f(C1 \cap C2) - \alpha f(C1 - C2) - \beta f(C1 - C2) \quad (1)$$

Among (1), α , β , θ are more than and equal to zero. Their values are given different weights in order to distinct the different attribute or the same attribute of the C_1 and C_2 concept.

Based on the semantic correlation calculation method to compare the concepts of users' model ontology and the concepts of the learning resources' ontology library, if many attributes of two concepts are the same, these two concepts are very similar, or are very relevant. And then through the calculated results personalized recommendation is realized.

5 Epilogue

The semantic web is the future of Internet. Firstly, in this paper we carry out the analysis of the personalized recommendation system and the semantic web technology. Then we integrate the semantic web technology and the personalized service together, and apply them in E-Learning to form the personalized recommendation system based on semantic web, and then establish a student-centered learning mode in E-Learning which has a better way to realize the personalized service. Finally, we design and realize the system prototype.

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