Research on Learning Resources Personalized Recommendation Based on Knowledge Topic Ontology

Xiao Jianqiong[1]*

[1]*Experiment Center of China West Normal University, Nanchong, Sichuan Province, China*

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Abstract

At present, the connection of network course learning resources are generally formed man-made hyperlinks, which can't reflect inner semantic association of resources. How to set up dynamically and mine various semantic association among network courses resources, it is an important issue to realize network course learning resources associated evolution. Ontology of semantic web is introduced into building model of knowledge, Knowledge ontology is used as the basis of knowledge description and expression in construction of network course learning resources, to establish dynamically and mine semantic association among learning resources and domain curriculum knowledge. The research designed a network courses learning sources personalized recommendation system based on knowledge topic ontology by using the processing of personalized recommendation. Experiments show that the system can recommend dynamically suitable learning sources to learners, promote preferably construction of curriculum knowledge, to realize active recommendation of personalized learning resources recommendation service.

Keywords: Knowledge Topic Ontology; Semantic Association; Personalized Recommendation; Learning Resources

1 Problem

Numerous learning resources have been designed and developed by different network learning platform, with rapid development of all kinds of network learning platform. But by analysing and researching existing network course resources construction and using status, we found that these learning resources mainly exist the following problems: (1) Due to the large granularity of resources and coarser organization way of knowledge, these learning resources couldn’t be organize and reuse. (2) Learning sources are lack of semantic, and are short of correlation between resources and resource. (3) Presentation of learning content cannot be reflected effectively the inner link among knowledge points, there is no effective integration with the knowledge of related courses is not conducive to their logical relationship between knowledge and expansions of knowledge, cannot adapt to needs of personalized learning. Therefore, learning resources retrieval is difficulties, retrieval results have more redundant information, information overload and learning trek and so on. As the carrier of the makes the learning resources cannot meet personalized needs of different learners. In order to improve use efficiency of earning resources, and realize to recommend automatically personalized learning services, to meet different learners needs of personalized learning, related scholars pointed out that the current construction of learning sources is facing six challenges, including how to meet demands of infinite personalized learning group, how to realize dynamic generation and life evolution of learning resources, how to build ubiquitous learning resources space, how to support informal learning cognition, how to realize natural aggregate of different content based on semantic, how to share social cognitive and human network in the process of study [1].

Ontology is a conceptualization, formalized, explicit description to knowledge [2], it is composed mainly several elements: concept, the attribute of concepts, relations, functions, axiom and examples. The interaction of these elements constitute a subject knowledge representation, thus, no matter what form, what kind of learning resources can be recognized and understood by computer. Ontology is introduced into building and expressing learning sources, and set up an efficient access structure of domain knowledge, realize the resource of semantic association through mining all kinds of semantic relations among resources, so as to realize sharing and reuse of learning resources content.

The personalized recommendation system is a powerful tool to solve the problem of information overload. It can recommend information and products to users’ according to user's different needs, interests, motivation and emotion and so on Personal factors, to realize zero distance services on two-way communication between users and product [3]. The personalized recommendation system has been applied widely in many fields; one of the most typical applications is e-commerce. At the same time, academic study has been very high heat about recommendation system, formed gradually an independent disciple-ne. This research used for reference process ideology of personalized recommendation, and the core technology of semantic Web ontology was brought in designing and constructing learning resources, to establish course ontologies, Knowledge topic ontologies, learner ontologies and correlative ontologies by taking advantage of semantic

* ***Corresponding author’s*** e-mail: xjq_2005@163.com

Web, then carried through proper semantic annotation for course and its resource instances, to form courses and knowledge topic learning source repositories, we could design and develop knowledge content, structure and system that integrated subject knowledge topic ontology, built a personalized learning resource recommendation system, to recommend dynamically suitable learning resources, this promoted learners to set up domain knowledge structure system.

2 Learning resources model structure

Knowledge topic is the smallest unit of knowledge structure. Of course, knowledge topic is the basic unit of the learners' learning [4]. According to inner link among knowledge points, using ontology to build modelling of discipline knowledge, and establish a knowledge ontology repository, not only may show primly hierarchical structure of the knowledge, but also can be in the form of visual graph structure to represent kinds of relationships among knowledge points. Therefore, learning resource system was designed based on core of knowledge ontology that could realize resources sharing, interoperability and reusability and personalized recommendation well.

Learning resources include not only text, images, animation, audio and video and so on traditional resources, but also virtual reality, 3D, text messaging, twitter and propagated in the device, such as the IPHONE and IPAD media resources, etc. Resource management system needs to be done for all types of resources management function, including the preparation, review, distribution and retrieval, etc. Its system structure model is shown in figure 1 [5] [6].

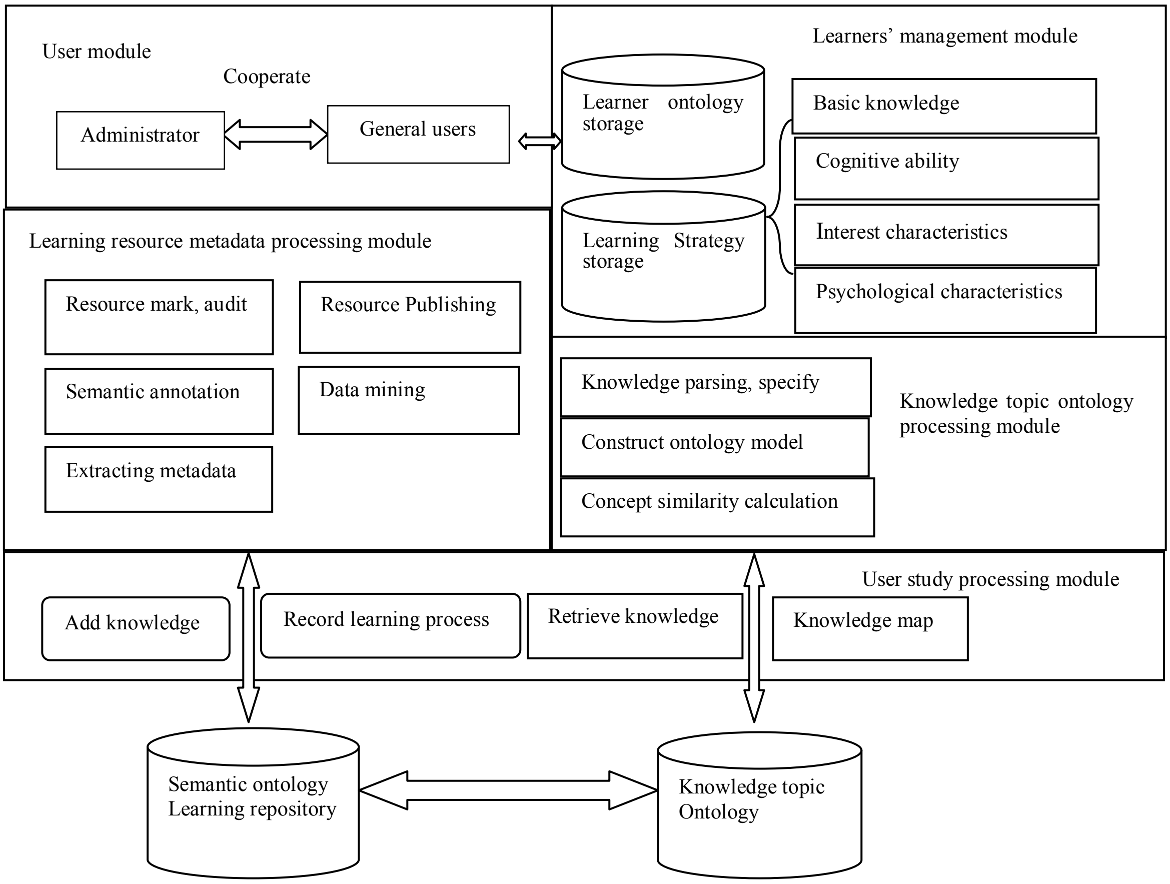

FIGURE 1 Learning resources function model structure

Among them, the administrator takes part in the whole process of construction learning resources, responsible for reviewing and releasing resources, in order to ensure the normal operation and sustainable development on learning resources. General users (include teachers and students) who can retrieve and use learning resources, can also create and release resources, in addition, this system can record on learners' learning process and add new knowledge to enrich learning repository after learners' learning.

There have be two core functions in this system: one is that mine the semantic association among resources through data mining KDD technology, and make semantic tagging, realize dynamic connection among resources; two is that domain subject knowledge will be done convention, the knowledge unit will be decomposed and combined, then analyze and research on the incidence relationship and hierarchy among knowledge, to build the domain knowledge ontology model according to the learners' cognitive characteristics and cognitive process, to realize the reconstruction and sharing of the learning resources.

This model, learning content is composed one by one, each of knowledge points is endowed different characteristic labels according to its present form. Then, they were combined learning units based on learner ontologies and inner link of knowledge.

3 Course knowledge topic ontology modules

Construction of Knowledge topic ontology must do from perspective of learning rule, learning navigation to analyze and understand, study attribute characteristics and relationship between some knowledge topic and other knowledge topic, and then show formally these knowledge topics and their relationship by using ontology technology.

Each course is composed of a series of chapters, each chapter contains one or more knowledge points, and each knowledge point corresponds to the number of specific learning resource object.

To this end, first course was broken down into chapters ontology, we used three kinds of attribute to describe Chapter ontology: (1) Basic attributes, including name of chapters, chapter ID, chapter introduction and chapter belongs; (2) Characteristic attributes, used to describe chapters personality traits, such as Difficulty Level show the difficulty level of the chapter, Consist Of KP said that chapters contains knowledge points; (3) Structural relationships, describe knowledge relations between this chapter and other chapters, such as Next Chapter and Previous Chapter said respectively its previous chapter and rear chapter, Requisite and Prerequisite For said logical relationship of knowledge level. Finally, chapter ontologies were extended into a series of knowledge topic ontologies. Knowledge topic ontologies also used three kinds of attribute to describe: (1) Basic attributes, including name of knowledge topic and knowledge topic ID; (2) Characteristic attributes, such as Concept ontology and Consist of R (Resource object ontology); (3) Structural relationships, show relations between this knowledge point and other knowledge points, such as Before-Requisite and Subsequent knowledge.

According to the rule of teaching and curriculum organization, there are four structure relationships of knowledge points mainly. (1) Parent-child relationships: parts and whole; (2) Dependencies: precursor sub-sequent relationship; (3) Brother; (4) reference; (5) other. Of course, the relationships among knowledge points are complex, the relationship among knowledge points is not completely linear, and there could be a mesh structure.

According to the rule of practical teaching and characteristics of curriculum knowledge, based on domain knowledge points above 5 kinds of basic relations, there are following 5 tuple form to describe knowledge ontology.

$O = <T, P, R, B, L>$

Among them, O show domain knowledge ontology, T show concept set of ontology, P is attribute set of ontology, R is relation set of ontology, B is constraint or axiom set that were defined on knowledge point ontology, L said instance set.

It is impossible to complete the domain knowledge ontology modeling, this needs a gradual process. First, using the theory of concept extraction and layered to build automatically knowledge points ontology conceptual framework, Secondly, using existing KDD technology and concept hierarchy principle to expand knowledge point ontology[7][8].Following is to Build subject knowledge point ontology model.

(1) First of all, Domain knowledge points were parsed, specified, knowledge units were decomposed and combined, to build hierarchical network structure of knowledge points by analysing and studying about relationship between knowledge points.

(2) Made the core concept listing T of domain course knowledge points, not to consider concepts’ attributes and repeated expression.

(3) Defined knowledge topic class and class hierarchy. Using the top-down approach to expand core concepts, these concepts were refined for each subclass knowledge point, to construct a domain knowledge tree structure diagrams, its upper knowledge points are parent classes, lower knowledge are subclasses; and the, minimum classes were concluded and combined appropriately from bottom of knowledge tree, and eliminated ambiguity, eventually, form reasonable and complete concept system and its hierarchy.

(4) Define knowledge topics related class attributes. According to the characteristics of domain content ontology concepts, attributes of domain knowledge topic ontology can be described by using a 7 tuple form [8]:

P=<ID,Keywords,Kind,Applicability,Importance,Difficulty,Master-Type>.

The ID is a unique identifier in the knowledge ontology library; Keywords describe the knowledge's key words; Kind said knowledge types, divided into four classes (1, 2, 3, 4), respectively corresponding to the facts, standardization knowledge, skill knowledge and understanding knowledge, etc. [7]; Applicability is scope of knowledge; Importance reflect the importance level of the knowledge point, values range is [0, 1],it is more important if its value is larger; Difficulty describe the easy level, values range is [0, 1], it is more difficult if its value is larger; Master-type show cognitive ability for knowledge points, divided into 7 classes (a, b, c, d, e, f, g), respectively corresponding to the understanding, familiar, memorization, comprehending, mastering, application and comprehensive.

(5) Created instance to knowledge topic classes and added class attribute value.

The established knowledge ontology model can exist independently, and can be associated with each other through semantic, because it was built based on the inherent logical structure of knowledge points.

4 Semantic similarity calculate compute based on ontology concept

4.1 ANALYSE SEMANTIC SIMILARITY CALCULATION METHODS [9] [10] [11]

Many experts and scholars have done in-depth research on concept semantic similarity calculation, obtained many pioneering achievements. The concept semantic similarity calculation method can be divided into three categories:

based on distance calculation method, based on the information content calculation method and based on attribute calculation method, etc.

(1)Based on distance calculation method

This method is the most intuitive method. Its basic principle is: in the concept ontology structure graph, the similarity is the higher; the distance path of these two concepts is the shorter. It calculated semantic distance by using the geometric distance of ontology concepts in hierarchical network, the similarity of two concepts c_1 and c_2 is the relation edge number that they are corresponding to the shortest path of nodes in the network hierarchy, its calculation model is:

$$Sim(c_1,c_2)_{dist} = \frac{2*Max(Dept) - MinDist(c_1,c_2)}{2*Max(Dept)} \tag{1}$$

Max (Dept.) is the maximum depth of network hierarchy; MinDist (c_1, c_2) is the shortest distance of c1 and c2.

This method is easy, and do not rely on additional information. But it can't reflect on the depth of location, the similarity is the smaller, the depth is the deeper by using this method.

(2) Based on information content calculation method

The similarity of two concepts is determined through sharing information between the two concepts in a given ontology, if mutual information of two concepts is the more; the similarity of these two concepts is the greater. Its calculation model is:

The Parent (c_1, c_2) represents recent common ancestor nodes of concept c_1 and c_2 in the network.

$$Sim(c_1,c_2)_{cont} = \frac{2*\log parent_{(c_1,c_2)}}{\log p_{c_i} + \log p_{c_2}} \tag{2}$$

(3) Based on attribute calculation method

The relationship of concepts was shown object properties in ontology. Therefore, in different applications, the correlation of concepts is under the influence of object properties, calculating formula is:

$$Sim(c_1,c_2)_{prop} = \sum_i p_i(c_1 \cap c_2) - \left(\exists p_i(c_1) - \nexists p_j(c_2)\right) - \left(\exists p_j(c_2) - \nexists p_i(c_1)\right) \tag{3}$$

$c_1 \cap c_2$ is public attribute set of c1 and c2, $\exists p_i(c_1) - \nexists p_j(c_2)$ said that concept c1 has the property, but concept c_2 has not, $\exists p_j(c_2) - \nexists p_i(c_1)$ show that concept c_2 has the property, but c_1 has not.

The common limitations of these methods are that they must depend on the concept complete properties set; these methods cannot be implemented for incomplete properties set.

4.2 CALCULATING SEMANTIC SIMILARITY IN THIS SYSTEM

This research came up with semantic similarity calculation method that merged together based on distance and attribute calculation method. The method embodied mainly system structure and relationships of knowledge points, while considered knowledge ontology hierarchy, repleni-shed semantic with model through ontology concept attributes, which could improve accuracy of semantic similarity calculation, good experiment results have been achieved.

(1) Relation path weights of domain knowledge point ontology

There are mainly 5 kinds of knowledge point relationship from the above analysis. Different type relationship is different influence to relation path, therefore, semantic similarity calculation model need to give different weights to different relations. The weight influence about relationship type to relationship path is defined as follows: [12].

$$\text{Weight}(c,p) = \begin{cases} 1, \text{ synonymy} \\ 0.8, \text{ is A} \\ 0.6, \text{ part of} \\ 0.4, \text{ reference} \\ 0.1, \text{ other} \end{cases}$$

P is the parent node of C in the shortest path.

(2) Calculate relation path semantic distance

Two concepts c_1 and c_2 have common jointly Parent node that is expressed as the Parent in Domain ontology hierarchical network. The relationship path semantic distance of two concept c_1 and c_2 can be expressed as:

$$Dist\left(c_1,c_2 = \sum_{c\in path(c_1,parent)} \frac{1}{Weight(c,p)} + \sum_{c\in path(c_2,parent)} \frac{1}{Weight(c,p)}\right) \tag{4}$$

So, Semantic similarity calculation model based on distance is amended as:

$$Sim(c_1,c_2)_{dist} = \frac{Dist(c_1,c_2)}{2*(Max(Dept)-1)} \tag{5}$$

(3) Semantic similarity calculation model based on distance and attribute

$$Sim(c_1,c_2)=\alpha*\mathrm{Sim}(c_1,c_2)_{dist}+\beta*\mathrm{Sim}(c_1,c_2)_{prop} \quad (6)$$

α and β is adjustable weights and $\alpha+\beta=1$.

In order to verify the validity of this algorithm, we added relevant attributes and relationships as a calculation example by using Antoniou G & Hamelin F (2008). Under the same domain ontology structure, to calculate similarity of several concepts in the ontology structure with four different similarity calculation method, the calculation results are shown in table 1. $\alpha=0.6$ and $\beta=0.4$.

TABLE 1 Comparing semantic similarity calculation algorithm results (%)

Similarity	**This system model**	**Based on distance**	**Based on information content**	**Based on attribute**	**Expert experience**
Sims(Printer,HPPrinter)	73.68	82	76	70	72
Sims(Printer,LaserPrinter)	45.35	60	50	40	43
Sims(HPPrinter,ProductType)	63.63	75	70	59	62
Sims(PrductTYpe1,Effect1)	56.55	65	60	50	52
Sims(PrductTYpe2,Effect2)	43.92	55	50	38	42
Sims(PrductTYpe3,Effect3)	63.56	76	69	57	62
Sims(PrductTYpe4,Effect4)	68.69	80	76	60	66

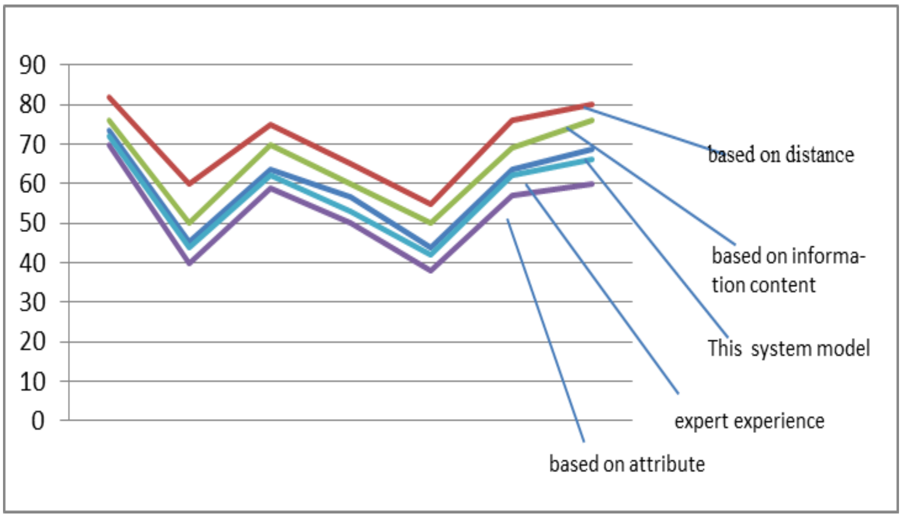

FIGURE 2 comparing semantic similarity calculation algorithms

Through the experimental results of table 1 and figure 2, we can see: experimental results of this system algorithm model are more close to expert experience, because of considering multiple factors, such as ontology network layer depth, relationship types and ontology properties and so on.

5 Learning resources personalized recommendation system structure model

5.1 PERSONALIZED RECOMMENDATION FRAME

There are user layer, recommendation engine layer, semantic layer and Learning resources function layer in this personalized recommendation system [13] [14] [15]. The structure is shown in figure 3.

Among them, the user layer offers personalized interfaces on learning resources custom-made, browse, learn and evaluate for learners.

The main functions of recommendation engine layer are that construct learner's model and resource model according to their preference, then the learners and resources were associated with semantic, to provides the recommended basis for recommendation engine.

The core functions of Semantic layer have three aspects: one is to mine semantic association between resources through the data mining KDD technology, made semantic tagging, to realize dynamic connection between resources; Second is to construct domain knowledge ontology model according to the learners' cognitive characteristics and cognitive process; Three is to build semantic association on curriculum and resource ontology.

Learning resources function layer's main function is to build kinds of necessary ontology for recommend system.

5.2 PERSONALIZED RECOMMENDATION PROCESS

The recommended process is shown in the figure 4.

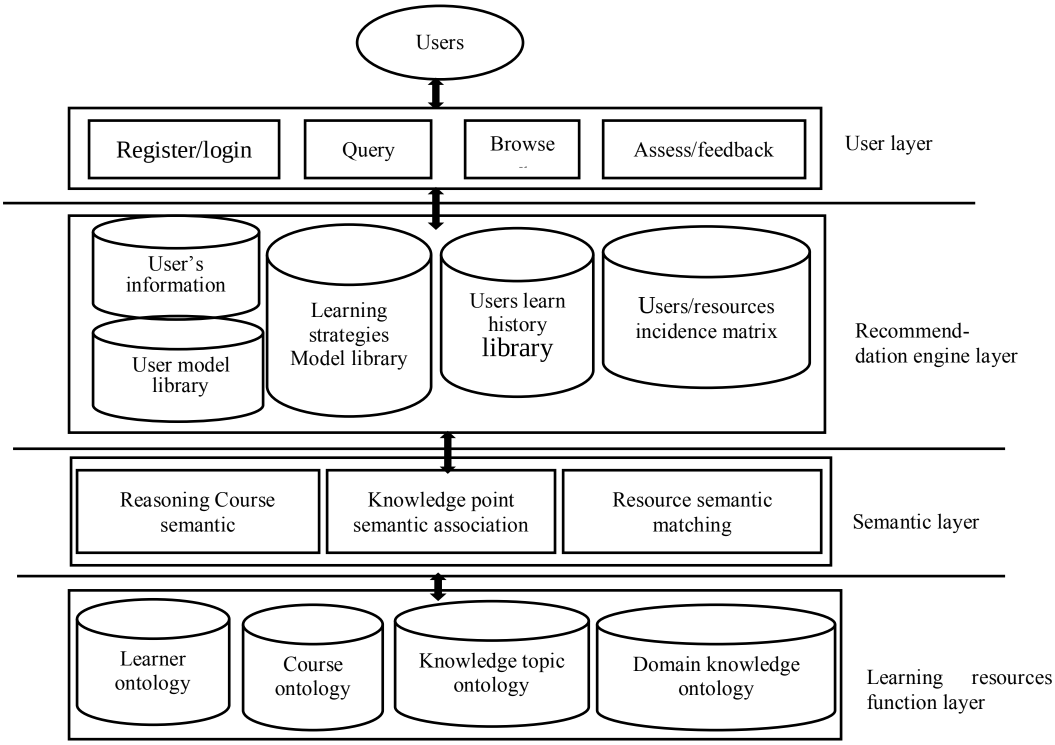

FIGURE 3 recommendation frame

The third step, the system extracted intelligently learning resource object. The system extracted intelligently associated learning resource object, and carried out semantic relation reasoning for resource object ontology, to reason multiple resource ontology instances based on given rule.

The fourth step, the system calculated learning resource object semantic value. The system calculated semantic matching value of the learning resource object according to the above formula.

Fifth, the system sorted and recommended learning resource object according to the resources object semantic matching value, The highest recommended the first three learning resource object is recommended for learners (the number can be set up).

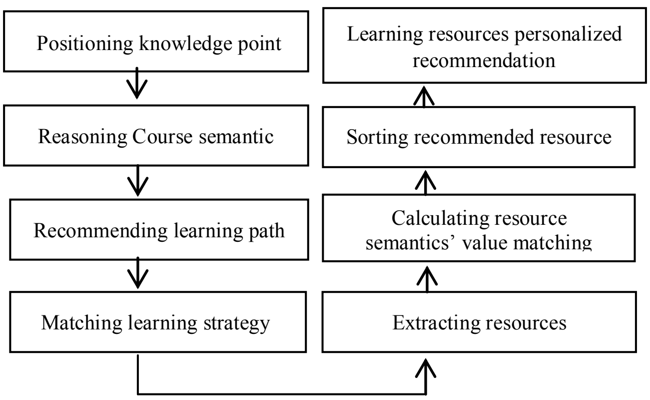

FIGURE 4 personalized recommendation process

6 Conclusions

Variety and quality of resources is the guarantee to network course learning, and the ways of presentation and the design of push strategy is an effective way to improve the learning efficiency. This paper researched on personalized service in the network course learning, knowledge units were decomposed and combined, analyzed and researched on their incidence relation and hierarchy, to build the domain knowledge ontology model based on learners' cognitive characteristics and cognitive process. This model could show clearly knowledge structure, and could reveal the inner relation among knowledge.

In addition, the learning content in the system is open, allowing learners to add and update the content, to ensure that the learning resources have a strong "vitality", can stimulate and sustain learners' learning enthusiasm and motivation, so as to improve the learning efficiency and quality.'

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Authors

<Xiao Jianqiong >, <1972.1.1>,<GuangAn, Sichuan Province, China >

Current position, grades: Master degree, associate professor
University studies: China West Normal University
Scientific interest: data mining and knowledge management
Publications: two teaching materials about University computer foundation teaching,
Experience: We should establish dynamically and mine semantic association among learning resources and domain curriculum knowledge to realize network course learning resources associated evolution.
For University computer foundation teaching, If the teacher can pay attention to arouse the enthusiasm of students, the teaching effect would be better. We can explain or decorate a challenging or applied or interesting tasks, questions or problems, and increase the rewards and incentives, integrate theory with practice, to make the class lively and interesting, which attract the attention of students