Personalized Learning Resource Recommendation Algorithm of Mobile Learning Terminal

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***Abstract*—With the popularization of mobile devices such as the Internet and smart phones, people's learning styles are undergoing profound changes and mobile learning terminals are becoming more and more popular. In this paper, the model of personalized learning resource recommendation algorithm based on mobile learning terminal was studied, and a personalized learning model based on recommendation algorithm was designed. The algorithm can analyze the user's learning history data in the mobile learning terminal and make accurate learning resource recommendation according to the user's learning level and personal preference. Finally, the experimental results show that personalized learning resource recommendation model based on recommendation algorithm can effectively predict the direction of users' learning needs, and expand the new research directions in personalized learning resources recommendation.**

Keywords- recommendation algorithm; personalized learning; research

I. INTRODUCTION

Since the 21st Century, the rapid development of information technology has led to changes in learning mode, cognitive thinking mode, exchange and interaction mode, and the emergence of knowledge visualization, learning analysis, big data mining, e-book package and various intelligent mobile terminals have provided opportunities for large-scale personalized learning, and personalized learning has become an important feature of education in the information age (Ying Z and Zhou Z, et al. 2013) [1]. In addition, smart phones have surpassed PCs and laptops, and have become the first platform for people to access information (Yuan N, et al. 2011) [2]. The popularization rate of smart phone for college students is almost 100%, which provides students with the basic hardware conditions for mobile learning "anywhere, anytime", and makes mobile learning open and free from the limitation of time and space, and makes it possible for autonomous learning (Wang L, et al. 2013) [3]. At present, the existing mobile learning system provides a large number of learning resources. For beginners, it is difficult to select the relevant learning resources based on their own knowledge structure and understanding of the curriculum structure, and to achieve the best learning effect. Mobile learning based on personalized recommendation has just started in our country, which is still in the stage of experiment and exploration (Wang Z, et al. 2015) [4].

All Based on the students' personality traits, learning progress and learning situations, this paper constructs a mobile learning system by using personalized recommendation model to realize the individualized learning needs of students and improve their learning effectiveness.

II. STATE OF THE ART

Personalized learning is a way to learn to meet the individual needs of learners for individual differences. As of November 2017, major studies worldwide in the field of precision forecasting of personalized learning resource requirements included Personalized Learning Resource Recommendation Algorithm, Efficient Learning Algorithm for Mobile Learning Terminal, Hybrid Collaborative Filtering Algorithm and Clustering Based Recommendation Algorithm. Most of the above models and related algorithms did not study the recommendation algorithm based on the learning content, and recommend personalized learning resources to users through recommendation algorithms (Gao X, et al. 2016) [5]. On the other hand, there is no research on personalized learning resource recommendation algorithm for mobile terminal in recommendation algorithm and construction of related models. From the point of view of personalized learning resources recommendation, at present, as these researches at home and abroad (Such as PLRRA, ELAMLT, HCFA and Clustering Based Recommendation Algorithm (CBRA) and so on) have strong system D unitary (self-management and self-renewal of user learning behaviors and habits can't be realized), and do not have the unity and self-learning required by the analysis and prediction of learning resources demand for personalized learning in large-scale user groups, it is very difficult to achieve the intelligent analysis effect of mobile learning terminal based on the recommendation algorithm (Liu Y, et al. 2015) [6].

Finally, the algorithms used in the accurate prediction model of personalized learning resources both at home and abroad are not yet mature, most of them are single customized analysis systems based on specific learning users. There are many improvements in the error rate and

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the stability of the related algorithms in the market for model systems that simulate personalized learning. Therefore, it is very urgent to analyze the user requirements of individual learning by using the learning resource prediction model for mobile learning terminal based on recommendation algorithm (Zhao J C, et al. 2014) [7].

III. METHODOLOGY

A. Principle of recommendation algorithm

Until now, the most successful recommendation algorithm in the world of mobile learning terminal platform is the collaborative filtering algorithm (Lee C S, et al. 2015) [8]. In the process of personal learning resource recommendation of mobile learning terminal, this paper uses a highly stable clustering algorithm to achieve a detailed division of user groups through the user's personal information, learning interest, hobby preference and learning demand information displayed in the mobile learning terminal. Secondly, this paper uses the collaborative filtering algorithm to predict accurately the series of information presented in the user base, so as to classify users' preference of learning resources highly, and to generate highly relevant learning resources for users of mobile learning terminals (Yibo Chen, Chanle Wu, Xiaojun Guo, et al. 2012) [9].

B. Implementation steps of recommendation algorithm

The recommendation algorithm used in this paper to deal with the similar information is the K-Means clustering algorithm. The algorithm can divide the user of mobile learning terminal according to different degrees of learning preference data. The basic implementation process of the recommendation algorithm is as follows: the learning data with n users in the mobile learning terminal is aggregated, and a learning preference data set containing n user objects is generated from the learning preference data of the user group, through random process, a total of k clusters ($k \leqslant n$) are generated, and n user objects are assigned to each cluster according to the nearest neighbor principle (description of the degree of learning preference), and iterative processing is performed. When each user object belongs to the cluster corresponding to the nearest cluster center, the iteration process ends. The most prominent feature and advantage of the recommendation algorithm described in this paper lies in that the user group process of the mobile learning terminal is simple and flexible, and dynamic calculation can be realized, and the center vector of each vector group is obtained step by step and used as a reference vector, so as to achieve accurate recommendations for personalized learning resources for mobile learning terminal users.

In the process of identifying the similarity of user groups of mobile learning terminal, the recommendation algorithm takes a cluster center as the standard, and selects the most similar vector of the learning preferences as neighbors in the other vectors around the cluster center through collaborative mixing and clustering methods, which greatly reduces the time required to process vector classification and improves the efficiency of filtering and grouping clustering. Based on the basic implementation steps of the recommendation algorithm, this paper uses the cosine similarity between two vectors in the actual clustering process to describe the similarities of learning preferences among different users. The learning preference vectors of users i and j are represented by i and j, respectively. Then, the vector feature similarity sim (i, j) of the mobile learning terminal user is:

$$sim(i,j) = \cos(i,j) = \frac{i \times j}{\|i\| \times \|j\|} \qquad (1)$$

Among them, the numerator is the product of the learning preference vectors for user i and j and the denominator is the product of the module lengths of the learning preference vectors for user i and j.

According to the nearest neighbor set of mobile learning terminal users, the following formula is used for recommendation.

$$R_{i,k} = \overline{R}_i + \frac{\sum_{j \in M} sim(i,j)(R_{i,k} - R_j)}{\sum_{j \in M} (|sim(i,j)|)} \qquad (2)$$

In formula (2): M is the standard neighbor set around the mobile learning terminal user i, $R_{j,k}$ represents the prediction score of the learning resource k by the neighbor user j; and R_j is the discriminant average value of the user j for all the learning resources.

In the working process of recommendation algorithm, the reference scoring of mobile learning terminal users to unknown learning resources or known but unfamiliar learning resources is predicted by equation (2), and N learning resource points whose different learning resource scores are higher than the standard similarity are selected to recommend to the mobile learning terminal users, so as to complete the accurate personalized learning resource recommendation process, to help users to achieve an efficient learning process, to improve the learning quality of mobile learning terminal users and save the user's learning time.

C. The actual discriminant processing of recommendation algorithm

The recommendation algorithm classifies the user's learning information into the same cluster according to the similarity, when the cluster of mobile learning terminal users is not the same, and it is expressed as no similarity. When the proposed algorithm clusters different learning preference information, it will generate different learning preference similarities among members in the cluster corresponding to learning preferences, so as to realize the

clustering analysis of user groups. In the actual discriminant processing, the recommendation algorithm transforms the learning preference information of the target user group into certain language information (such as vector group) that can be recognized by the computer through a specific process. In response to this problem, in general, this article will use the vector group to handle learning preference information for mobile learning terminal users.

Firstly, according to the target user's learning preference data, the corresponding information recognition system will extract the learning preference information (such as history learning record and learning classification weight), and then perform computer vector processing to convert it into a space vector group, so that the host server where the recommendation algorithm is located stores the information vector and performs comparison processing with the existing user learning preference database information. Then, through mobile learning terminal database information of computer and the pre-set vector clustering judgment program, the preference data of some users' vector information are processed reversely, and the reduction is realized, so as to realize the discrimination of the two learning preference information. In this paper, Logistic regression is used to estimate the probability of these events, in which z is the estimated variable.

$$f(z)=\frac{1}{1+\exp(-z)} \qquad (3)$$

Secondly, some low-frequency mobile learning terminal users are individually categorized, and discriminated and verified three times, and is marked and stored by setting a new vector group to form a special vector combination cluster center information. For example, when the same type of learning preference information needs to be classified, it is possible to perform the comparison according to the vectors with the special learning preference information. When the correspondence between the cosine value and the angle of the vector satisfies the requirements of the preset minimum learning preference vector, the data of the target vector group can be processed, judged and classified. In the best case, the recommendation algorithm can realize the judgment of the learning preferences and learning resource requirements of different users under the specified similarity.

In the process, this paper carries on the linear regression verification. Assuming that the formula is $y=\omega\cdot x+b$, the unknown parameters are ω and b, the training sample set of learning preference information used in this session is{(x_i,y_i)}, i=1,2,…N, regression is to estimate ω and b according to the training sample set, to find the best value that minimizes the error in the training set.

$$P\left(Y=1\middle|x\right)=\frac{\exp\left(\omega\cdot x+b\right)}{1+\exp\left(\omega\cdot x+b\right)} \qquad (4)$$

$$P\left(Y=0\middle|x\right)=\frac{1}{1+\exp\left(\omega\cdot x+b\right)} \qquad (5)$$

Finally, due to the unique problems of hybrid collaborative filtering, the current recommendation algorithm can't reach the level of AI depth learning and depth information mining. Therefore, there are some defects and deficiencies in the information processing and the judgment of the degree of information coupling between the learning content and learning preference of mobile learning terminal users. In order to solve this problem and improve the intelligent recognition degree of recommendation algorithm to user's learning content and learning preference as much as possible, the most commonly used method is to make a precise comparison between the specific information of the mobile learning terminal and the total classification of the user in the learning process. This statistical comparative analysis is relatively mature now. Therefore, the test data for learning preference similarity of the first set of user information is shown in Table 1, the fitting image is shown in Fig.1.

TABLE.1 THE FIRST GROUP CALCULATED VALUE OF SIMILARITY

Learning content similarity	Similarities in learning preferences
0.230 234	0.349 313
0.336 371	0.441 342
0.858 479	0.819 734
0.986 523	0.917 273

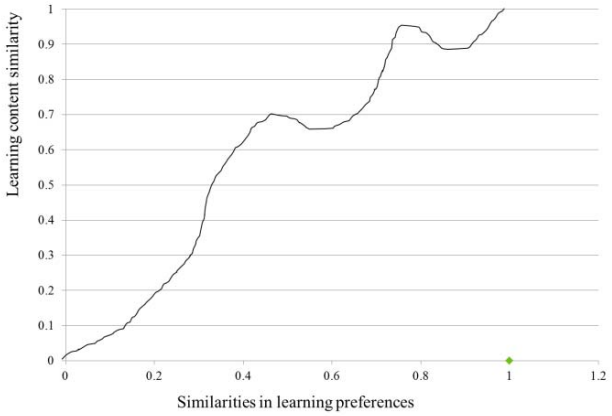

Fig.1 Fits the output image

IV. Result Analysis and Discussion

A. Establishment of personalized learning resource recommendation model based on recommendation algorithm

Personalized learning resource recommendation model based on recommendation algorithm takes curriculum resources as the center, and sets up a three information interaction platform between users and teachers, users and management. According to the learning preferences differences between different users in learning and the difference of different learning stages with the same learning preference, this recommendation model provides accurate navigation and learning resources pushing based on deep information mining for users' learning interests by using the personalized recommendation algorithm based on hybrid collaborative filtering process and information clustering.

The system consists of presentation layer, recommendation engine, business logic layer and data layer. There are 5 modules, including learner module, curriculum resource module, knowledge point module, mobile learning interface and learning behavior monitoring module. The structure is shown in Fig. 2.

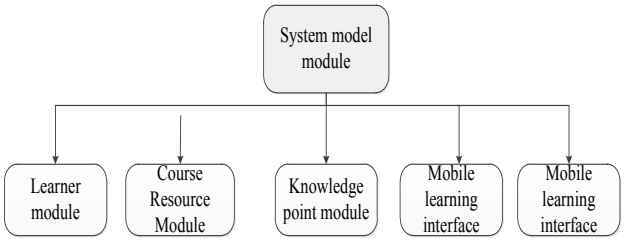

Fig.2 System model module

The model obtains the learning behavior characteristic information of the mobile learning terminal user through the following methods: obtaining the basic information (such as name, school, age, gender, mobile phone number) of the mobile learning terminal user when registering, and the purpose of this information is to extract the user's static feature information. The model further obtains user's learning behavior and duration in the learning process of mobile learning terminal through the user's daily learning log information, cumulative duration of learning, time to stay in mobile learning terminal, the number of hits of different learning content and other information, so as to achieve the user's learning behavior analysis, scientifically evaluate the learning effect of each user, and to continuously update the user's learning preference information. The data of the 5 indexes of the first group of users is shown in table 2.

TABLE.2 EXPERIMENTAL TEST DATA

Learning preference information data	Learning behavior duration relative value	Daily study log information relative value	The relative value of the time spent in the mobile learning terminal	The number of different learning content clicks
0.13	0.362	0.11	0.31	234
0.53	0.691	0.49	0.28	235
0.84	0.914	0.78	0.79	361
1.00	1.000	1.00	1.00	169

B. The result and feedback of personalized learning forecast recommendation

At present, there is not an industry standard for the accuracy evaluation of personalized learning resource recommendation for mobile learning terminals in the world. Therefore, this study takes two mobile learning terminal users with different learning preferences as subject, one of the users has a high preference for the reading of science and technology articles, but has no high interest in the history articles; the other one has a great preference for the reading of the history articles in English, but not much interest in science and technology articles. In this paper, a hybrid collaborative analysis and learning preference clustering method is proposed. By observing the model's personalized learning recommendation for two users, it can be easily seen that the two personalized learning recommendation results are totally different for two users with completely different learning preferences, and the similarity scores of the two users are quite different. This shows that this personalized learning forecasting recommendation model can distinguish the users with different learning preferences from each other and realize the recommendation of different learning resources.

In the concrete judgment process, firstly, the scientific and technological articles are used as the standard reference value, according to the results, the learning preference value of second users in science and technology articles is low (0.23511093488147), and the learning preference value of the first user in science and technology articles is very high (0.97896435881259). This shows that the model can effectively distinguish between the two, and recommend different learning resources through

differentiated results to achieve high precision mobile learning terminal resource recommendation.

In order to reduce the existence of error, this article takes the historical article as the reference, and finds that the first user has a low learning preference value in history articles (0.193 143 814 911 52), while the second user has a high learning preference value in history articles (0.969 458 741 573 85). This shows that the first discriminant is not accidental, but highly reliable. Therefore, the recommendation algorithm based on hybrid collaborative filtering and clustering can greatly improve the user's learning preferences mining and learning resource requirements mining in the process of personalized learning resource recommendation in mobile learning terminal, can more effectively provide users with more valuable learning resources, improve the learning efficiency of users, and increase the frequency of use of mobile learning terminals by users. The test of the relevant learning data of the 2 users is shown in table 3.

TABLE.3 TWO USER INFORMATION EXPERIMENTAL DATA

Two user information experimental data	Learning Preferences (Tech Articles)	Learning Preferences (History Articles)
The first user	0.235 110 934 881 47	0.193 143 814 911 52
The second user	0.978 964 358 812 59	0.969 458 741 573 85

V. CONCLUSIONS

At present, the existing mobile learning system provides a large number of learning resources. For beginners, it is difficult to select the relevant learning resources and achieve the best learning results according to their own knowledge structure and understanding of the curriculum structure. In this paper, the current research on the algorithms commonly used in personalized learning resources recommendation of mobile learning terminal industry in China was firstly reviewed, and the problems of personalized learning resource recommendation and the mining and analysis of user's learning preferences were analyzed, the recommendation algorithm models with different learning preferences for different users were proposed. Finally, two users who had great disparity in learning preferences were tested and the security analysis results of the model were validated. The experimental results show that the personalized learning resource recommendation algorithm based on recommendation algorithm can quickly determine the learning preferences of the mobile learning terminal users. Through experiments, two users with different learning preferences were compared and analyzed. It is found that the discernment error of the system architecture model used in this personalized learning resource recommendation model is within the standard reference range and can be applied to mobile learning terminal analysis push system based on personalized learning resource recommendation. In addition, the current state of development of recommended technologies in personalized learning resources in China will make the personalized learning resource recommendation model based on recommendation algorithm have more extensive application space. Although the current personalized learning resource recommendation techniques and related recommendation algorithms have certain shortcomings and other disadvantages, such as lack of accuracy and high false positive rates. However, this personalized learning resource recommendation model and recommendation algorithm technology can improve the value of personalized learning resources to users through this recommended prediction method, and can improve the learning efficiency and learning interest of mobile learning terminal users in the current process of personal learning resource prediction recommendation of mobile learning terminal in our country.

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