

Design of personalized recommendation system for online learning resources based on improved collaborative filtering algorithm

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Abstract—In recent years, under the guidance of the educational concept of equality and sharing, universities at home and abroad have increased the development and application of online course learning resources. In China, online open courses are open to all learners on the platform of major portals. Due to the increasing number of online courses, it is increasingly difficult for learners to find the content they are interested in on the website. In addition, the traditional collaborative filtering has the problems of sparse data, cold start, and low accuracy of recommendation results, etc. Therefore, the personalized recommendation system studied in this paper adds the collaborative filtering recommendation technology of user and project attributes. The recommendation system can actively discover the interest of learners according to their behavior characteristics, and provide them with online learning resources of interest, and improve the accuracy of the recommendation results by improving the collaborative filtering algorithm. In this paper, personalized recommendation technology is applied to online course website, aiming at providing personalized, automated and intelligent recommendation system for online learners.

1 INTRODUCTION

With the development of online education, there are more and more online learning resources. Under the influence of the "open courseware project" launched by MIT in 2001, famous universities around the world have launched their own video open courseware one after another. In 2011, MIT has released 2080 online courses. In 2011, the ministry of education issued the "notice on starting the construction of 2011 boutique video public courses" to build 200 video public courses, and in 2012 the ministry of education issued the "notice on carrying out the recommendation work of annual boutique video public courses", which pointed out the construction of 1100 boutique video public courses. The ministry of education plans to build 5000 online open courseware courses in 2018, and 20000 online open courseware courses in 2020. Since online courses are shared with learners through websites, it will become increasingly difficult for learners to find online learning resources they are interested in as the number of courses increases. With the rapid development of personalized education, websites need to provide online learning resources needed by learners to meet the needs of different learners for different resources. Based on the above reasons, this paper proposes to integrate the personalized recommendation technology into the online open course learning website to make the website provide online learning resources of interest to

learners more automatically, intelligently and accurately, on the one hand to meet the personalized needs of online learners, on the other hand to improve learners' adhesion to the website and increase the utilization rate of online learning resources.

2 BASIC THEORIES

In 1997, Resnick P and Varian HR [1] proposed the theory of personalized recommendation system. Personalized recommendation system is a software system that uses e-commerce websites to provide customers with commodity information and suggestions, help users decide what products to buy, and simulate sales staff to help customers complete the purchase process. Specifically, personalized recommendation system is a computer system based on the interaction between users and websites, which can automatically mine, represent and maintain the interest information of individual users by analyzing the historical access data of users, and provide personalized recommendation service for each user according to the acquired interest information. In 2009, Liu Jianguo [2] pointed out that personalized recommendation system is to use the existing selection process or similarity relationship to mine the potential objects of interest of each user by establishing the binary relationship between users and information products, so as to realize personalized recommendation, whose essence is

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information filtering. In short, personalized recommendation system is a system that first obtains the user's personal interest, and then according to the personalized recommendation algorithm, recommends the product to the user.

According to the theory of personalized learning [3], the learning process is the process of personality development and cultivation, as well as the process of self-realization and pursuit of individuality. Personalized learning emphasizes that the learning process needs to adopt appropriate methods, means, contents, starting point, process and evaluation methods according to the characteristics and development potential of students, so as to promote the full, free and harmonious development of students in all aspects. Personalized learning has the characteristics of multi-dimensional learning resources, multi-dimensional learning value pursuit, unique learning style, lifelong learning process and independent learning style. Online learning resources are open resources for learners in the whole society. Different learners have different needs for course resources. Therefore, as a website equipped with online open courses, it is necessary to provide personalized video resources for learners according to their characteristic attributes and behavioral characteristics, so as to meet their personalized learning needs.

3 RECOMMENDATION ALGORITHM IMPROVEMENT

A. Personalized recommendation system model

The personalized recommendation system of online learning resources based on improved collaborative filtering algorithm has three important modules [4], which are user interest module, recommendation algorithm module and recommendation object module. The user interest module obtains the user's interest information to establish the user's interest model, the recommendation object module is used to describe and model the resource, and the recommendation algorithm module is used to recommend the resource to the user by building the appropriate personalized recommendation technology. Therefore, the recommendation system matches the characteristic information of the resource with the information of the user's interest and demand, and at the same time, calculates and filters the corresponding algorithm to recommend the resource that the user is interested in, as shown in Figure 1.

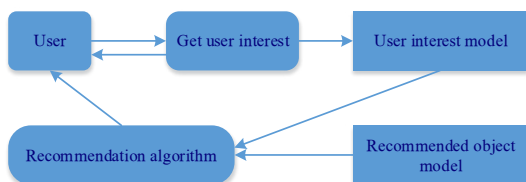


Figure 1. Personalized recommendation system model.

User interest information is the key to user modeling, in order to ensure the accuracy of user interest model and recommendation system needs to collect user interest preference from various angles, the user's interest information mainly through the user attribute information,

the user active passive information, user information, history is recommended to obtain the characteristics of the object attribute. The user attribute information is the most basic information of the user, including the user's natural attributes and social attributes, such as name, gender, age, occupation, education, etc. Different recommendation systems require different user attribute information, which should be determined according to the system's function in practical application. The information voluntarily provided by the user refers to the information that the user voluntarily provides to the recommendation system, such as the text that the user initiatively enters in the search box and the way that the user expresses his interest and preference by scoring, choosing mood, voting and questionnaire survey. The information passively provided by the user means that the user does not need to manually express their interest, but the recommendation system judges the user's preference according to the user's behavior of browsing websites and resources, such as the number of times the user clicks on the resource, browsing path, and residence time. The feature attribute of the recommendation object is to obtain the information of the user's preference through the feature information of the historical resources that the user browses and watches, as shown in Figure 2.

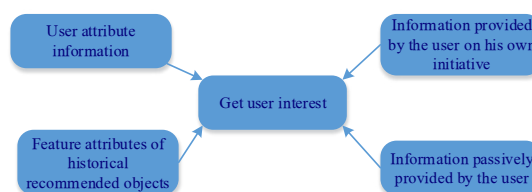


Figure 2. User interest information category.

The recommendation object model is modeled according to the characteristic properties of the object. As the objects recommended by the recommendation system include many fields, different recommendation objects have different properties. Generally, there are two methods based on content and classification. For example, web pages, newspapers and news are mainly based on content to extract features, while multimedia resources such as music and movies are based on classification to extract features.

B. Collaborative filtering recommendation technology

Collaborative filtering recommendation algorithm [5] does not need to pay attention to the content characteristics of the recommendation object, only needs to pay attention to the user's evaluation of the recommendation object. Collaborative filtering recommendation technology mainly consists of two different algorithms: user-based collaborative filtering and project-based collaborative filtering. The core of user-based collaborative filtering is that users select each recommendation object based on the recommendation of friends, which refers to users with similar interests. Recommended process of it is the user evaluation of project resource block synthesis score vector matrix and the user rating scores of vector for the project, through the appropriate similarity algorithm to compute the similarity scores of individual users, and finally to score for sorting, using reasonable low threshold filter out the similarity of users, and then find out the most similar users, and

calculate the most similar users all the average value of video resources for recommendation.

Project-based collaborative filtering is based on the user-project matrix, which calculates the similarity of projects. Collaborative filtering algorithm based on the project of the recommended process is through a user the project of project evaluation matrix vector to compute the similarity of the target project, and then through the reasonable threshold filter out low similarity projects, formation of backup resources list, finally choose the highest score from the backup resource list multiple target objects as recommended results presented to the current user, as shown in Figure 3.

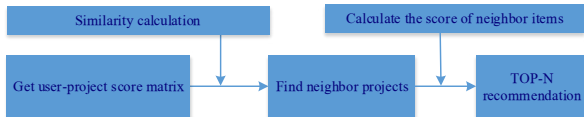


Figure 3. Collaborative filtering algorithm based on project.

C. Improved collaborative filtering algorithm

The traditional user-based collaborative filtering algorithm is to obtain the user's evaluation of resources to form a user-item rating matrix. The content of this paper is online open course resources, so the main task is to obtain a user-video rating matrix, according to the rating matrix to calculate the similar users, and then from the similar users to obtain a higher rating of the video to recommend to the current users. Traditionally, the score of users is mainly obtained by the methods of user rating, selection of mood, voting, and questionnaire survey. In this paper, an implicit method will be adopted to obtain users' interest in videos. In the implementation process of the improved collaborative filtering algorithm, the effective length (L) of the current video watched by the user is first obtained, and the video efficiency (P) is calculated according to formula $P = L/S$. L is the length of

the video watched by the user, and S is the total length of the video. Then the video efficiency is mapped to the interval of $[0,10]$. The video efficiency needs to be accurate to the integer when calculating. If the video is 50% efficient, then the user's interest in the video is 5.0, indicating that the user neither likes nor dislikes the video. To prevent the rating matrix from being too sparse, the rating of the videos not watched by the user was also set to 5.0. Through experiments on the improved algorithm, the results show that adding default score can effectively improve the accuracy of recommendation results, and the test results of the relationship between video efficiency and score, as shown in Table I. According to the user's rating of online course video resources, a user-video rating matrix is constructed, where $R_{j,k}$ is the rating value of the j user to the k video, as shown in Table II.

The similarity degree is calculated according to user-video rating matrix. The users with high similarity degree from the nearest neighbor, and then the average score of the video is calculated based on all the scores of the videos in the nearest neighbor. Finally, it is recommended to the users according to the result of $Top-N$. The similarity between user a and user b is defined as $Sim(a,b)$, each user's rating of all video resources can

constitute an n -dimensional vector, and the similarity between two users can be calculated according to the similarity between two n -dimensional vectors. In formula (1), \vec{m}, \vec{n} and m are the rating vectors of user n to the video, $R_{a,c}$ and $R_{b,c}$ are the ratings of user a and b to the video c .

$$Sim(a,b) = \cos(a,b) = \frac{\vec{m} \cdot \vec{n}}{|\vec{m}| \cdot |\vec{n}|} = \frac{\sum_{c=1}^n R_{a,c} \cdot R_{b,c}}{\sqrt{\sum_{c=1}^n R_{a,c}^2} \sqrt{\sum_{c=1}^n R_{b,c}^2}} \quad (1)$$

In order to effectively solve the problem of cold start in collaborative filtering algorithm, this paper adds user attribute and course attribute recommendation to the improved algorithm, so as to further solve the problem of cold start of recommendation system. Add user attributes of collaborative filtering for registered users, their courses can also recommend results fusion user attribute information to improve the accuracy, can also mix the user attribute information to get the nearest neighbors, increase the weight of the user, the use of the user of course video integrated scoring average as the final recommendation results. By adding course attributes to improve the accuracy of personalized recommendation, the core of the algorithm in this paper is to find videos with the same attributes as those watched by users as the recommendation result, as shown in Figure 4.

TABLE I. TEST RESULT

P/%	0	10	25	50	75	90	100
Score	0.0	1.0	2.5	5.0	7.5	9.0	10.0

TABLE II. USER-VIDEO RATING MATRIX

Matrix	Project 1	.....	Project k	.....	Project n
User 1	R _{1,1}	.....	R _{1,k}	.....	R _{1,n}
.....
User j	R _{j,1}	.....	R _{j,k}	.....	R _{j,n}
.....
User m	R _{m,1}	.....	R _{m,k}	.....	R _{m,n}

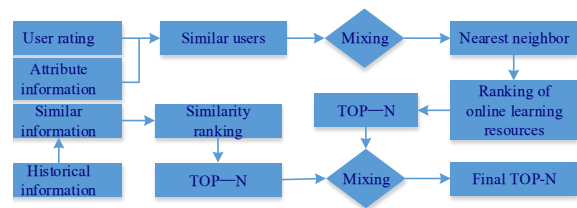


Figure 4. Collaborative filtering algorithm with course attributes added.

4 DESIGN OF PERSONALIZED RECOMMENDATION SYSTEM

A. Architecture design of personalized recommendation system

Personalized recommendation system is based on online course learning platform, actively perceives users' interest, and then recommends to users the course resources similar to their interest. The focus of this system is how to implement the recommendation system, so the course resource information comes from the online teaching platform of super star, and no local streaming

media server is built. Personalized recommendation system architecture adopts B/S structure [6], the user through the browser, click on the video to watch, a WEB server through the acquisition of super star online teaching platform of video resources, display to the user, and store the user to watch video information, collect the user's behavior data, and then to deal with data, using the corresponding recommendation algorithm recommended to the user, as shown in Figure 5.

B. Function design of personalized recommendation system

Personalized recommendation system function is to meet the personalized needs of users, it includes user registration module, user login module, user data collection module, data processing module, recommendation algorithm module and page display module. The user registration module is to provide the registration function for new users in order to obtain the user's attribute characteristics. User login module is to provide login service for registered users to facilitate users to save their interest records. The user data collection module is to collect the information of watching videos and obtain video resource information from super star online teaching platform. Data processing module is to process the collected data and filter out some useless information to form the user interest model. The recommendation algorithm module processes the collected user data and behavior data to find out the videos that users are interested in. Page display module is to show the user the recommended results, as shown in Figure 6.

C. Process design of personalized recommendation system

Personalized recommendation system is mainly for three types of users to recommend, because the information collected by different users is not the same, so the choice of recommendation algorithm is also different. For an old user not logged in, the system selection recommendation algorithm based on the project properties feature, and for a new user login, because could see their interested in video, system selection recommendation algorithm based on user attributes feature to recommend, for old user login, provides the user attributes, and the user is evaluated on some online learning resources, so the system choice based on the user, project characteristic attribute, and a video of the user rating matrix of hybrid recommendation, satisfy the accuracy of recommendation results and diversity.

D. Core function design of personalized recommendation system

The personalized recommendation system mainly obtains the user's attribute information and behavior information, establishes the user interest model, and then selects different recommendation algorithms for different user types. Therefore, the core function of the recommendation system, as shown in Table III.

TABLE III. CORE FUNCTIONS OF PERSONALIZED RECOMMENDATION SYSTEM

The name of the function	The functionality
FetchUserData()	Get user registration information
FetchVideoData()	Gets project attribute information
FetchUserVideoData()	Get the user's viewing video information
FetchWeightVector()	Get user rating information for all videos
UserAttributeRecommendation (userid)	Rough recommendations based on user attributes
CF(SimUserid)	Collaborative filtering recommendation algorithm
VideoAttributeRecommendation (videoid)	Rough recommendations based on project attributes
MixRecommendation (userid)	Hybrid recommendation

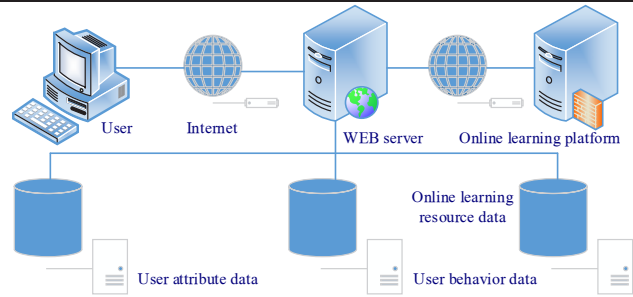


Figure 5. Architecture design of personalized recommendation system.

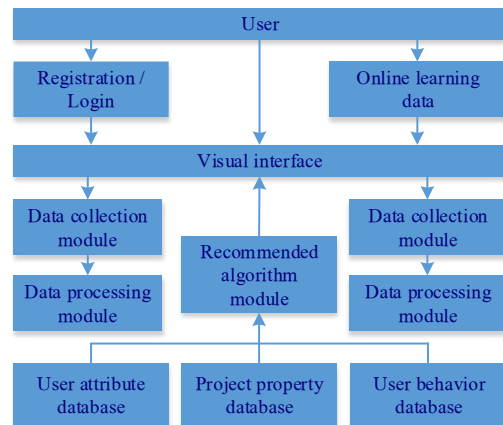


Figure 6. Collaborative filtering algorithm with course attributes added.

5 CONCLUSION

In order to help learners match the curriculum resources that meet their own interests in a large number of online learning resources, this paper designs and develops a personalized recommendation system for online development of curriculum resources through the research of personalized recommendation technology and the combination of online open curriculum learning resources, aiming to provide learners with personalized video learning resources proactively. Based on the improved collaborative filtering algorithm, online learning resource personalized recommendation system can actively find interest according to the behavior characteristics of learners, and provide interested online learning resources for learners, which to a certain extent improves the loyalty

and adhesion of users to the website, promotes the wide use of online courses, and provides reference for the application of personalized recommendation system.

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