Personalized Recommendation Method for E-commerce Platform based on Data Mining Technology

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***Abstract*—In recent years, E-Commerce has been widely utilized and attracted more and more attention. Therefore, in this paper, we propose a novel collaborative filtering based personalized recommendation method for E-commerce platform. Firstly, we illustrate the proposed personalization recommendation system contains three modules: 1) Behavior record module, 2) Model analysis module, and 3) Recommendation algorithm module. In our proposed personalized recommendation algorithm, recommendation results are gained according to users' rating score on various products. Moreover, users rating scores are represented as a user rating data matrix. Secondly, in our proposed recommendation algorithm, maximum margin matrix factorization is used to obtain personalized recommendation results by semi-definite programming solvers. Finally, experimental results demonstrate that our proposed algorithm can achieve higher accuracy than other methods, and can provide more suitable products for E-commerce users.**

Keywords- Personalized recommendation, E-commerce platform, Data mining, Matrix factorization, Collaborative filtering.

I. INTRODUCTION

With the rapid development of Internet and intelligent computing technology, E-Commerce has been widely used and attracted more and more attention [1]. However, structure of E-Commerce website has become more and more complex. Then, it is very difficult for users to find products they want in E-Commerce website [2,3]. Therefore, to deal with this problem, personalized recommendation systems are developed to provide suitable products to target consumers in terms of user requirements [4]. Recommendation systems are able to promote E-Commerce sales via analyzing user buying requirements and estimating similarity between various users [5,6].

The key problem in personalized recommendation is to design an effective recommendation algorithm, which can fully mining users' real requirements to suggest suitable products for customers [7]. Personalized recommendation system collects and models information resources according to potential demands, interests, hobby, and history behaviors of users, and then recommend user to purchase specific goods or services [8]. However, with the unprecedented development of E-commerce scale, personalized recommendation system needs to deal with massive data with a lot of features. Compared with traditional recommendation systems, the recommendation system in the big data environment has its own unique characteristics [9][10].

In this paper, we introduce collaborative filtering technique in personalized recommendation method for E-commerce platform. collaborative filtering technique has been widely in data mining and other areas, such as predicting user preferences [11], Mitigating the Sparsity Problem [12], clinical prediction [13], multimedia recommendation in a mobile environment [14], Measure prediction capability of data [15], Web Service Recommendation [16], music recommendation [17].

The rest of the paper is organized as follows. We describe the personalization recommendation system in section 2. In Section 3, we provide a novel personalized recommendation algorithm for E-commerce platform. Section 4 conducts experiments to test the effectiveness of the proposed method. Finally, we conclude the whole paper in section 5.

II. DESCRIPTION OF THE PERSONALIZATION RECOMMENDATION SYSTEM

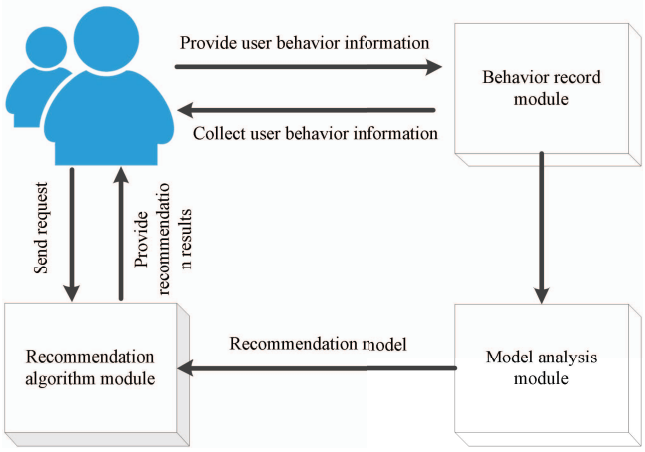

Figure 1. Structure of the personalization recommendation system

A personalization recommendation system is made up of three modules: 1) Behavior record module, 2) Model analysis module, and 3) Recommendation algorithm module. Behavior record module is used to save different types of user behaviors, such as browsing and rating. Model analysis module analyzes potential user interest and its degree based on user behavior records. Afterwards, based on the above

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steps, recommendation algorithm can find the products which users are interested, and then recommend them to target user. Inspired from the above analysis, structure of the personalization recommendation system is illustrated in Fig. 1

In the collaborative filtering based personalized recommendation algorithm, recommendation results rely on users' rating score on different products. Users rating scores are represented as a $m \times n$ matrix (denoted as $A(m,n)$), where m denotes the number of users, and n refers to the number of products. Element R_{ij} of matrix $A(m,n)$ refer to the rating score by user U_i for product P_j. User rating data matrix is shown in Table. 1.

Table. 1 User rating data matrix

	P_1	P_2	……	P_n
U_1	R_{11}	R_{12}	……	R_{1n}
U_2	R_{21}	R_{22}	……	R_{2n}
……	……	……	……	……
U_n	R_{n1}	R_{n2}	……	R_{nn}

Afterwards, we use cosine similarity to estimate user similarity as follows.

$$sim(i,j) = \cos\left(\vec{i},\vec{j}\right) = \frac{\vec{i}\cdot\vec{j}}{\left\|\vec{i}\right\|\cdot\left\|\vec{j}\right\|} \tag{1}$$

III. THE PROPOSED ALGORITHM

The innovation of this paper is to utilize the matrix factorization to solve the proposed problem. Suppose that H refers to a $n \times m$ user/item rating matrix, in which each element H_{ij} refers to the element which is located at the i^{th} row and the j^{th} column. H_{ij} is equal to zero, if the preference of the i^{th} user for the j^{th} item is unavailable.

The proposed personalized recommendation method for E-commerce platform can be represented as the following optimization problem.

$$\min_{U,V} \pi(H,U,V) + \delta R(U,V) \tag{2}$$

where H denotes the data matrix, $X = UV^T$ means the low-rank approximation, $\pi(\ )$ refers to a loss function which is defined to estimate the degree that X approximates H, $R(\ )$ denotes the regularization function to enhance different properties for X. In addition, parameter δ is used to control the degree of regularization. Symbol U and V refer to the factor matrix of users and items respectively.

If matrix completion issue is regarded as supervised learning with Φ as the training, the following loss function is defined through minimizing regularized squared errors:

$$\min_{U,V} \sum_{(i,j\in\Phi)} \left(h_{ij} - U_i V_j^t\right)^2 + \delta\left(\left\|U_i\right\|^2 + \left\|V_j\right\|^2\right) \tag{3}$$

where Φ denotes index matrix to illustrate non-zeros in H. To predict $x_{ij} = U_i V_j^T$ of the discrete h_{ij} with R labels. Based on the above definitions, maximum margin matrix factorization is exploited to achieve personalized recommendation results through the following optimization objectives:

$$F(U,V,\mu) = \sum_{(i,j)\in\Phi} \sum_{r=1}^{R-1} Z\left(\begin{array}{l} T_{ij}^r\left(\sigma_{i,r} - UiV_j^T\right) \\ +\dfrac{\delta}{2}\left(\left\|U\right\|_F^2 + \left\|V\right\|_F^2\right) \end{array}\right) \tag{4}$$

$$\text{s.t. } T_{ij}^r = \begin{cases} 1, if\ r \geq h_{ij} \\ -1, otherwise \end{cases}$$

where symbol $\left\|\ \right\|_F$ denotes the Frobenius norm, $\sigma_{i,r}$ refers to the threshold or rank r of the i^{th} user. In particular, function $Z(\ )$ is defined as follows.

$$Z(t) = \begin{cases} 0, & if\ t \geq 1 \\ \dfrac{(1-t)^2}{2}, & if\ t \in (0,1) \\ \dfrac{1}{2} - t, & otherwise \end{cases} \tag{5}$$

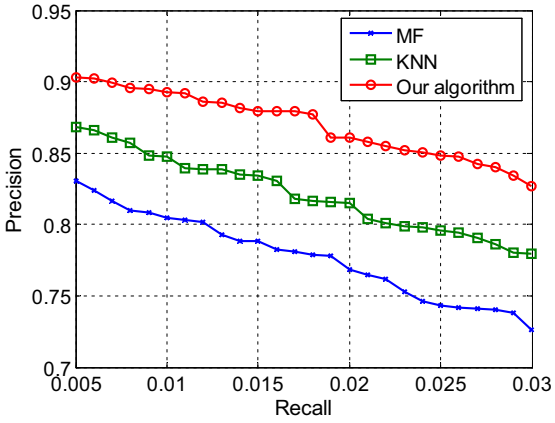
Particularly, we solve the optimization problem of Eq.4 by semi-definite programming solvers.

IV. EXPERIMENT

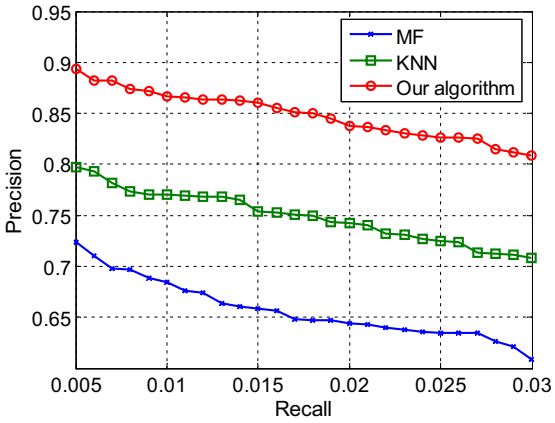
In this section, we conduct an experiment based on

two standard dataset: 1) MovieLens and 2) Netflix datasets. The MovieLens dataset is made up of 1,000,209 anonymous ratings of 3706 movies generated by 6040 users, and the Netflix dataset includes 100,480,507 anonymous ratings of 17,770 movies provided by 480,189 users. Particularly, in this experiment, we divide all users to several groups, and each group contains 2 to 12 users. In addition, users who have more training ratings are possible to be clustered in one group. We test the performance of our proposed algorithm by three types of user groups: 1) small group (2 to 4 users), 2) medium group (5 to 8 users) and 3) large groups (9 to 12 users). To test the performance of our algorithm, MF [18] and KNN [19] based collaborative filtering technique are compared with ours.

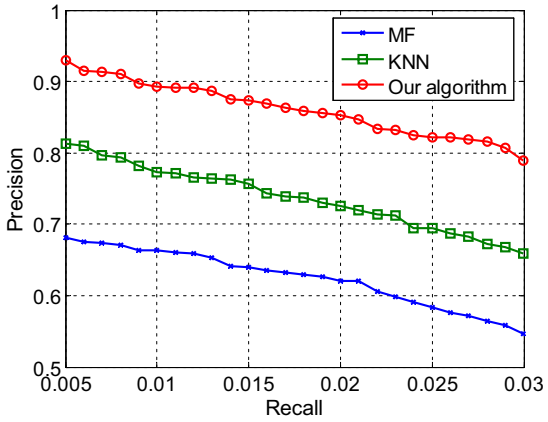
Firstly, we make performance evaluation using MovieLens dataset, and experimental results for small group, medium group, and large group are shown in Fig. 2 respectively.



(a) small group



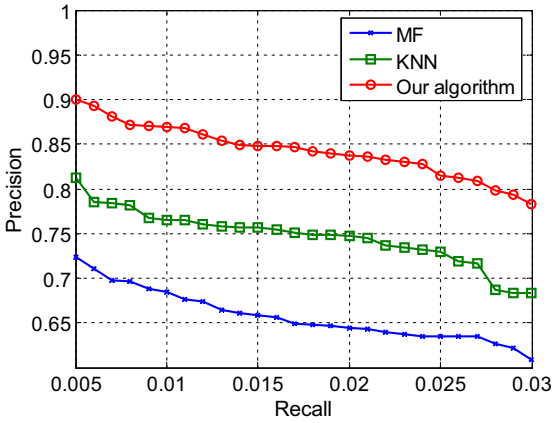
(b) medium group



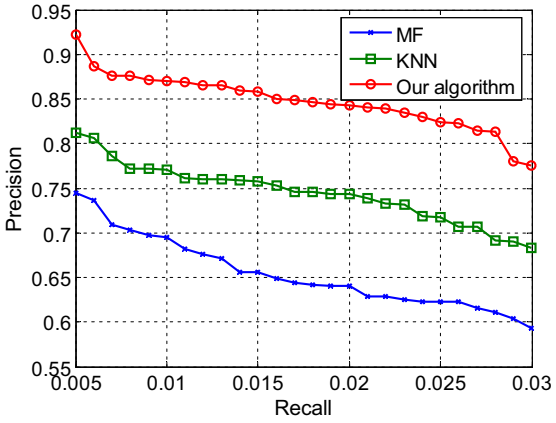
(c) large group

Figure 2. Performance evaluation using MovieLens dataset

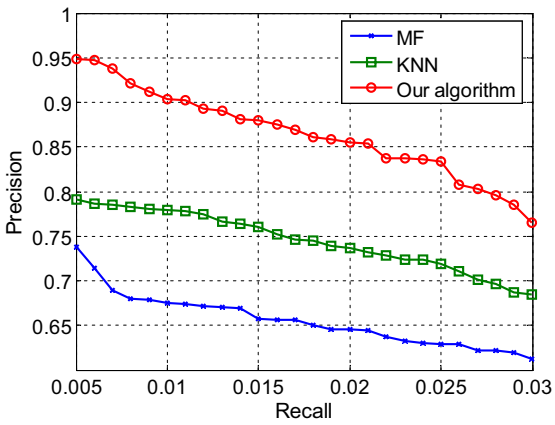
Secondly, we make performance evaluation using Netflix dataset, and experimental results for small group, medium group, and large group are shown in Fig. 3 respectively.



(a) small group



(b) medium group



(c) large group

Figure 3. Performance evaluation using Netflix dataset

Integrating all experimental results above, it can be seen that our proposed algorithm can achieve higher precision than other methods in personalized recommendation. Therefore, we also can conclude that apart from movies, our algorithm can also be used for personalized recommendation in other types of products in E-commerce.

V. CONCLUSION

This paper proposes a collaborative filtering based personalized recommendation method for E-commerce. Our personalization recommendation system is made up of Behavior record module, Model analysis module, and Recommendation algorithm module. In addition, personalized recommendation results are calculated in terms of users' rating scores on different products. Furthermore, we exploit maximum margin matrix factorization to gain personalized recommendation results by semi-definite programming solvers. Experimental results demonstrate the effectiveness of our proposed algorithm.

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