Improving Personalized Services in Mobile Commerce by a Novel Multicriteria Rating Approach

Qiudan Li, Chunheng Wang, Guanggang Geng
Key Laboratory of Complex Systems and Intelligence Science,
Institute of Automation, Chinese Academy of Sciences, Beijing
{qiudan.li, chunheng.wang, guanggang.geng}@ia.ac.cn

ABSTRACT
With the rapid growth of wireless technologies and mobile devices, there is a great demand for personalized services in m-commerce. Collaborative filtering (CF) is one of successful techniques to produce personalized recommendations for users. This paper proposes a novel approach to improve CF algorithms, where the contextual information of a user and the multicriteria ratings of an item are considered besides the typical information on users and items. The multilinear singular value decomposition (MSVD) technique is utilized to explore both explicit relations and implicit relations among user, item and criterion. We implement the approach in an existing m-commerce platform, and encouraging experimental results demonstrate its effectiveness.

Categories and Subject Descriptors
H.2.8 [**Database Applications**]: Data mining; H.3.5 [**Online Information Services**]: Web-based services.

General Terms
Algorithms, Experimentation, Human Factors.

Keywords
Personalized service, collaborative filtering, m-commerce.

1. INTRODUCTION
With the rapid growth of wireless technologies and mobile devices, there is a great demand for personalized services in m-commerce. Providing personalized services is about a process of matching users and merchants based on their profiles and preferences in conjunction with a changing environment constituting several context factors such as time, location and weather. In our previous work [1], we have demonstrated that effective representations of information relationships among user, content and context can enhance the personalized services of the system. However, we only adopted a single criterion to rate the extent to which a user is interested in an item in a standard 2D $User \times Item$ space. But multicriteria ratings have an important impact on many applications. For example, in a food industry for m-commerce, service, cuisine, and distance are three significant criteria for restaurant ratings. In fact, multicriteria ratings for an item can provide us more precise approximations to the similarity between two users than the overall rating since they give a good insight into why users like the item whereas the latter can only tell us how much users like it [5].

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Inspired by the technique of multi-dimensional collaborative filtering in e-commerce [4], we propose a novel MSVD-based CF approach to personalized services in m-commerce, which incorporates contextual information and multicriteria ratings into the recommendation process and enriches our previous work [1]. The basic idea of this paper is to first identify similar contextual information to that of the active mobile user, and then recognize the nearest neighbors of the user based on the MSVD technique under some relevant context information, and at last perform personalized services based on those found similar neighbors. Within this framework, a 3-order tensor is used to represent the 3D $User \times Item \times Criterion$ data, and the truncated MSVD technique is utilized to explore the underlying relations among user, item and criterion. The framework can take full advantages of the multi-dimensional representation capability of a higher-order tensor, the approximation capability of the MSVD, and the function of collaborative filtering.

2. A NOVEL COLLABORATIVE FILTERING-BASED FRAMEWORK
Figure 1 shows the flow chart of the proposed method which consists of three components.

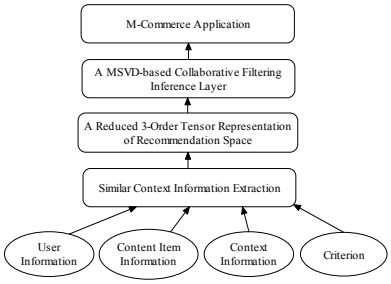

Figure 1: Flow chart of the proposed method

2.1 The Tensor-based Recommendation Space
Inspired by the ideas of the papers [2][3][4], we define the new recommendation space of m-commerce by a 4-order tensor as follows, where the contextual information of a user and the multicriteria ratings of an item are added to the traditional space:

Definition1 Recommendation Space: The matrix representation of recommendation space is a 4-order tensor $A \in R^{U \times I \times O \times C}$, where U, I, O and C are sets of users, content items, contexts and criteria.

In our system, contextual information includes mobile user's location, time, weather and user activity. Both context and content informaiton is obtained by the similar process of our previous

work [1]. Multicriteria of an item are presented in terms of practical scenarios. We reduce the 4-order tensor of recommendation space to the 3-order tensor by utilizing the context pertinent to that of active user. The data are much sparser since fewer data points having similar contexts to active user are used for rating. The truncated MSVD technique is proposed in the following part to analyze the underlying relations among user, item and criterion.

2.2 The MSVD-based Collaborative Filtering

Each element of the above reduced 3-order tensor represents the rating of $< User \times Item >$ pair on a criterion under a specific context. The multilinear SVD of an N-order tensor is defined as follows:

Definition 2 MSVD: Every $(I_1 \times I_2 \times \cdots \times I_N)$ -tensor A can be written as the product [6]:

$$A = S \times_1 U^{(1)} \times_2 U^{(2)} \cdots \times_N U^{(N)},$$

Where $U^{(N)}$ is a unitary $(I_n \times I_n)$ -matrix, S is a $(I_1 \times I_2 \times \cdots \times I_N)$ -tensor with the property of all-orthogonality, and n-mode singular values of A are ordered decreasingly in S.

The details on MSVD is explained in [6]. An approximation tensor $\hat{A}$ to A can be obtained by discarding the smallest n-mode singular values for given values of $I_n'(1 \leqslant n \leqslant N)$, Figure 2 gives an illustration for $N = 3$.

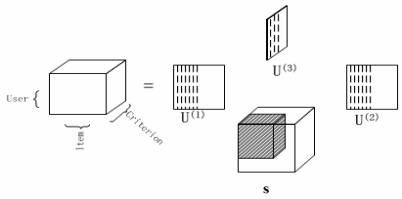

Figure 2: The truncated 3-order SVD

Based on the works in [1][2][4], we perform the inference by the truncated MSVD technique for m-commerce as follows:

Step1: For an active mobile user, identify his/her context information; **Step2**: Based on the context information, and the 3-order tensor representation of recommendation space, we perform the tensor approximation based on the truncated MSVD technique, which reveals both explicit relations and implicit relations among user, item and criterion; **Step3**: Find active user's nearest neighborhoods according to the approximated tensor and then perform top-N recommendations based on the rating information of the found neighbors.

3. EXPERIMENTAL RESULT

We implement the proposed method in an existing m-commerce platform of food industry to provide Top-N recommendation, and compare its recommendation quality against that of our previous method [1]. The previous method provides recommendation by a multi-dimensional collaborative filtering, and does not consider multicriteria ratings. The cosine-based similarity metric and the maximum recommendation number of items are used in our experiment. We explore the survey to gather the user preference information, namely, each user is asked to give multicriteria ratings (10 criteria considered: cuisine, ambience, service, etc.) for a restaurant item under a specific context. All the above data are stored in Data Service Layer of the m-commerce platform. The resulting data set includes 200 users and 30 restaurants items. The data set is divided into 80% training set and 20% test set. The quality of recommendation is measured by precision, which is widely used in information retrieval area. We compute the average precisions on test set. The comparison result of our method and previous one (without considering multicriteria ratings) is shown in Figure 3.

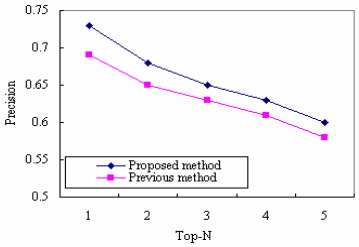

Figure 3: Average precision comparisons of two methods

From the results, we can find that the precision of the newly proposed method is higher than that of previous one. The results show that the new method can identify the similarity relations among user efficiently, and therefore improves the quality of recommender system.

4. CONCLUSIONS and FUTURE WORK

In this paper, we presented a novel multicriteria rating approach to improve personalized services in m-commerce, which utilized the MSVD technique to explore the underlying relations among user, item and criterion. Experimental results demonstrated the effectiveness of our method. Choosing the rank of truncated MSVD to get the optimal approximation in m-commerce application is still difficult and remains the subject of ongoing research.

5. ACKNOWLEDGMENTS

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