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A novel recommendation method based on social network using matrix factorization technique

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ABSTRACT

The rapid development of information technology and the fast growth of Internet have facilitated an explosion of information which has accentuated the information overload problem. Recommender systems have emerged in response to this problem and helped users to find their interesting contents. With increasingly complicated social context, how to fulfill personalized needs better has become a new trend in personalized recommendation service studies. In order to alleviate the sparsity problem of recommender systems meanwhile increase their accuracy and diversity in complex contexts, we propose a novel recommendation method based on social network using matrix factorization technique. In this method, we cluster users and consider a variety of complex factors. The simulation results on two benchmark data sets and a real data set show that our method achieves superior performance to existing methods.

1. Introduction

The rapid development of information technology and the fast growth of the Internet have facilitated an explosion of information which has accentuated the information overload problem. In recent years, recommender systems have proven to be an effective technique to deal with this problem and become extremely common in a variety of applications. They predict users' potential future likes and interests by using users' past preferences data. The quality of the results of a recommender system is determined mainly by the recommendation algorithms it adopts. Designing an excellent algorithm is crucial to the performance of a recommender system. Accordingly, various kinds of recommendation algorithms have been proposed, including collaborative filtering (CF) (Aligon, Gallinucci, Golfarelli, Marcel, & Rizzi, 2015; Kumar, Pujari, Sahu, Kagita, & Padmanabhan, 2017; Tsai, Steinberger, Pająk, & Pulli, 2016), content-based filtering (Khodambashi et al., 2015; Narducci et al., 2016; Puglisi, Javier, Forné, & David, 2015; Soares & Viana, 2015), K-Nearest Neighbor (K-NN) (Park, Park, Jung, & Lee, 2015; Adeniyi et al., 2016; Maillo et al., 2017; Yesilbudak, Sagiroglu, & Colak, 2017), diffusion approach (Gan, 2016; Ju & Xu, 2014; Zhou et al., 2010), and hybrid recommendation approach (Dooms, Pessemier, & Martens, 2015; Kaššák, Kompan, & Bieliková, 2016; Nilashi, Ibrahim, & Ithnin, 2014). Collaborative filtering is the most popular information filtering technique which usually works by searching a large group of users and to find a smaller set with tastes similar to target user. Content-based filtering method tries to recommend items to the active user similar to those rated positively in the past. It is based on the correlation between the content of the objects and the users' preferences. K-NN is a non-parametric method used for classification and regression. In K-NN, k is a user-defined constant, and an unlabeled vector is classified by assigning the label which is most frequent among the k training samples nearest to that query point. Diffusion approach is based on specific transformations of the input data to object-object networks. Personalized recommendations for an individual user are then obtained by using the user's past preferences as "sources" in a given network and propagating them to yet unevaluated objects. Hybrid recommendation approach is usually used to solve the cold-start problem, by combining collaborative and content data in such a way that even a new

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object that has never been rated before can be recommended. In fact, a number of studies have demonstrated that hybrid methods can provide more accurate recommendation results than independent approaches.

However, with the development of E-commerce and the increasingly complicated user context, how to fulfill personalized needs has become a new trend in personalized recommendation service studies. Psychological and sociological researches show that users' decisions in adopting information are influenced by their preferences and social relationships. Bandura (2001) gave a social cognitive theory of mass communication and argued that users' decisions were influenced by two pathways. In direct pathway, users' preferences determined their decisions. In indirect pathway, their decisions were influenced by friendship networks. Furthermore, Benjamin (1974) showed the similar opinion that factors such as cognition, feeling, taste, interest and interpersonal relationship developed the users' social behaviors. Bond and Smith (1996) found that people's decisions were easily influenced by other people's behaviors to some extent.

Therefore, scholars tend to incorporate complex context factors into the study of recommender systems. The merge of social network and E-commerce has led to enriched user information dimensions, resulting in more accurate personalized recommendation results. This paper gets its recommendation results by designing a personalized recommendation model based on social network context, combining the effect of user preference and user social relationship, and adopting matrix factorization technique. In this approach, we propose an improved clustering algorithm K-harmonic means (KHM) which has the same advantage as K-means but less sensitive to initial conditions. Then, matrix factorization technique is used to compute the similarities between clustered users. Especially in the process of similarity computation, users' preferences, social relationships and associations between users and items are considered. Detailed numerical analysis on benchmark data sets *MovieLens* and *Book-Crossing* and a real data set indicate that our algorithm outperforms other algorithms. Specifically, the recommendation results are not only accurate but also diverse.

The target of our work is to provide a recommendation method which can bring high accuracy and certain diversity under complex context. The main contributions of this paper are summarized as follows:

(1) In order to obtain accurate users classification for subsequent recommending, we propose a good performance hybrid clustering algorithm which composes of K-harmonic means (KHM) and Particle Swarm Optimization (PSO). It overcomes the sensitivity of initial conditions.
(2) In the process of similarity computation, we consider users' preferences, social relationships and associations between users and items. Especially, we use matrix factorization technique to alleviate the data sparsity and cold-start problems.

The remainder of this paper is organized as follows. Section 2 describes the relate works and Section 3 introduces some relevant methods. In Section 4, a socialized recommendation method based on matrix factorization (SRM-MF) is proposed. Section 5 provides experimental results of SRM-MF on two data sets. Finally, we draw implications and conclusions in Section 6.

2. Relate works

The problems (such as resource-overload and information-mislead) brought by big data have become increasingly serious. For individual user, how to acquire useful content from massive information quickly and accurately has become one prior issue. While for an enterprise user, how to mine customers' potential needs efficiently, enhance intelligence level of information searching and pushing, improve individualized service quality in this fierce competitive environment, has been put top in modify list in its E-commerce activities. To a certain extent, the creation of personalized recommendation technology has solved the dilemma between information diversity and customer needs specialization. Almost all the E-commerce platforms, such as Amazon, Alibaba., has applied various kinds of recommendation system more or less. However, with the development of E-commerce and the increasingly complicated user context, how to fulfill personalized needs has become a new trend in study of personalized recommendation service.

In recent years, many socialized recommendation methods have emerged. Ma, King, and Lyu (2011) proposed a novel probabilistic factor analysis framework which naturally fused the users' tastes and their trusted friends' favors together. The proposed framework was quite general, and it could also be applied to pure user-item rating matrix even if they did not have explicit social trust information among users. In this framework, they coined the term *social trust ensemble* to represent the formulation of the social trust restrictions on the recommender systems. Jiang, Cui, Wang, Zhu, and Yang (2014) investigated the social recommendation problem on the basis of psychology and sociology studies, which exhibited two important factors: individual preference and interpersonal influence. In this work, they first presented the particular importance of these two factors in online behavior prediction. Then they proposed a novel probabilistic matrix factorization method to fuse them in latent space. Sun et al. (2015) proposed a social regularization approach that incorporated social network information to benefit recommender systems. Both users's friendships and rating records (tags) were employed to predict the missing values in the user-item matrix. Han et al. (2016) proposed an easy-to-compute metric, *Community Similarity Degree* (CSD), to estimate the degree of interest similarity among multiple users in a community. They demonstrated that selecting communities with larger CSD could achieve higher recommendation precision. Li, Ma, and Shi (2016) examined the problem of social collaborative filtering to recommend items of interest to users in a social network setting. Many social networks captured the relationships among the nodes by using trust scores to label the edges. In this paper, they proposed a model-based approach for recommendation employing matrix factorization after removing the bias nodes from each link, which naturally fused the users' tastes and their trusted friends' favors together. Feng, Sharma, Srivastava, Wu, and Tang (2016) proposed a Social network regularized Sparse Linear Model (SocSLIM) with its extensions incorporating local learning (LocSocSLIM). SocSLIM learned sparse coefficient matrix for users by solving a sparse representation problem over user-item rating/purchase matrix and user–user social network's adjacency matrix at the same time by sharing coefficient matrix. The coefficient matrix was used to