



Recommender systems based on social networks



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ABSTRACT

The traditional recommender systems, especially the collaborative filtering recommender systems, have been studied by many researchers in the past decade. However, they ignore the social relationships among users. In fact, these relationships can improve the accuracy of recommendation. In recent years, the study of social-based recommender systems has become an active research topic. In this paper, we propose a social regularization approach that incorporates social network information to benefit recommender systems. Both users' friendships and rating records (tags) are employed to predict the missing values (tags) in the user-item matrix. Especially, we use a biclustering algorithm to identify the most suitable group of friends for generating different final recommendations. Empirical analyses on real datasets show that the proposed approach achieves superior performance to existing approaches.

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1. Introduction

Recommender systems have attracted much attention in the past decade. A recommender system is a software tool that supports users in identifying the most interesting items. There has been much work done on developing new approaches to recommender systems (Adomavicius and Tuzhilin, 2005; Brusilovsky and David, 2013). The research topic is still popular because of the abundance of practical applications that help users to deal with information overload and their great commercial value. Examples of the applications include recommending books, movies and some other commercial systems.

With the development of Web 2.0, the study of social-based recommender systems started. The traditional ones (Adomavicius and Tuzhilin, 2005; Brusilovsky and David, 2013) always ignore social interactions among users which can improve recommender systems. The fact is, when we are confused by multiple choices, we may turn to our related friends for the best recommendations, since they are those who we can reach for immediate advice. Hence, in order to provide more accuracy and personalized recommendation results, the social network information should be incorporated. Based on the above viewpoints, a few trust-based recommender systems (Jamali and Ester, 2010; Massa and Avesani,

2004; Ozsoy and Polat, 2013; Massa and Avesani, 2009; Bedi et al., 2007; Nazemian et al., 2012; Ma et al., 2008) which move an important progress forward have been proposed. The methods utilize the unilateral trust information to further improve traditional recommender systems. However, these methods have several inherent limitations and weaknesses that need to be solved. The noticeable weakness is the unilateral "trust relationship" problem. It is different from the concept "social relationship" which refers to the cooperative and mutual relationship between users. In addition, the other weaknesses are the impracticable hypothesis and the weak generalization ability. Obviously, the trust-based recommender systems may no longer be suitable. Therefore, the study of real social-based recommender systems appears on the screen. Additionally, the integration of social networks can theoretically improve the performance of traditional recommender systems. First, in terms of the prediction accuracy, the friendships among users improve the understanding of user ratings. Therefore, we can interpret user preferences more precisely. Second, as a matter of fact, the friendship between two users already indicates that they have things in common. Thus, the cold-start problem can be alleviated (Jamali and Ester, 2010; Massa and Avesani, 2004).

In order to solve the problems mentioned above, in our research, we focus on the social-based recommender system and, similar to Ma et al. (2011), propose an approach named RSBoSN (Recommender Systems based on Social Networks) that integrates social network graph and the user-item matrix to improve the prediction accuracy of the traditional recommender systems. In the process of

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recommendation, we mainly use the friendships among users and the tags labeled by the users to recommend. The user-item-tag can be considered as a two-dimensional matrix. We cluster the similar users to calculate the similarity between users and the correlation between a user and an item. The purpose in clustering is to identify the most suitable friends for realistic recommendation tasks. Based on the approach in [Ma et al. \(2011\)](#), the above two detailed aspects of social network information are employed in designing social regularization terms. We also take the situation into consideration that different friends may have dissimilar or even opposite tastes. Even if the friends of the same group focus on the same item, they may have different favorite degree. We have conducted experiments on real dataset to evaluate the performance of our approach on the prediction accuracy. The experiments show significant improvement over traditional and state-of-art social-based recommender systems in those aspects.

The remainder of the paper is organized as follows. Section 2 presents the overview of related work. Section 3 defines the problem and presents the details of the proposed approach. Section 4 presents the experiments results. Finally, we draw the conclusion in Section 5.

2. Related work

In this section, we review the approaches to recommender systems, including traditional recommender systems, trust-based recommender systems and social-based recommender systems.

2.1. Traditional recommender systems

The major traditional approaches are usually classified into three categories: collaborative filtering ([Bellogin et al., 2013](#); [Gunes et al., 2013](#); [Chang and Hsiao, 2011](#); [Bergner et al., 2012](#)), content-based filtering ([Illig et al., 2011](#); [Barragáns-Martínez et al., 2010](#)), and hybrid filtering ([Adomavicius and Tuzhilin, 2005](#)).

Collaborative filtering may be the most commonly used approach. The existing approaches can be grouped into two general classes: memory-based ([Bellogin et al., 2013](#); [Gunes et al., 2013](#)) and model-based ([Chang and Hsiao, 2011](#); [Bergner et al., 2012](#)). Memory-based approaches identify interesting items from other similar users' opinions by finding the nearest neighbor from a rating matrix. They essentially are heuristics that make rating predictions based on the entire collection of previously rated items by the users. Model-based approaches use the collection of ratings to learn a model, which is then used to make rating predictions. The cold-start and data sparsity problems are the drawbacks of collaborative filtering based approaches. Collaborative systems rely solely on users' preferences to make recommendations. Therefore, until a new item is rated by a substantial number of users, the recommender system would not be able to recommend it.

Content-based filtering approaches ([Illig et al., 2011](#); [Barragáns-Martínez et al., 2010](#)) use tags to infer recommendations. Hence, the user may be recommended items similar to the ones the user preferred in the past. The approaches are limited by the tags that are explicitly associated with the items that the systems recommend. Another limitation is that two different items are indistinguishable if they are represented by the same tags. Another problem with limited content analysis is that, if there is a new user with few ratings, it would not be able to produce accurate recommendations.

Hybrid filtering based approach ([Adomavicius and Tuzhilin, 2005](#)), on the other hand, combines both content-based filtering and collaborative filtering approaches to produce a recommendation. It can address the problems of content-based and collaborative systems. Different ways to combine collaborative and

content-based approaches into a hybrid recommender system can generate different results.

2.2. Trust-based recommender systems

The development of the traditional approaches is very mature, but they are all based on the assumption that users are independent. However, there are actually friendships among users. Based on the above assumption, many researchers have paid attention to trust-based recommender systems which combine the trust social information to further improve traditional approaches.

Many trust-based approaches have been proposed and widely applied to various areas in academia and industry ([Massa and Avesani, 2004](#); [Ozsoy and Polat, 2013](#); [Massa and Avesani, 2009](#); [Bedi et al., 2007](#); [Nazemian et al., 2012](#); [Ma et al., 2008](#)). Among these works, the model proposed in [Massa and Avesani \(2009\)](#) is the most popular one which has already been used in a practical application. [Bedi et al. \(2007\)](#) proposed one for the semantic web. The approach uses the web of trust to generate the recommendations. [Nazemian et al. \(2012\)](#) proposed a trust-aware approach which uses distrust metric to improve the accuracy of recommender systems. The relationships between users are calculated by propagating trust. Traditional approaches are used here, such as collaborative filtering. The experiments on the real datasets demonstrate that it can improve accuracy of recommender systems significantly while not reducing the coverage. [Ma et al. \(2008\)](#) proposed a factor analysis approach based on the probabilistic graphical model. It regards the user feature matrix as the link between user-item matrix and the users' trust network. The results prove that it is effective. However, the recommender progress with the real world recommendation process is inconsistent. Hence, they proposed another ensemble approach which calculates users' ratings by considering their own taste and the trusted users' favors at the same time. The experiments show that this approach can be used to develop a better recommendation model.

The trust-based recommender systems have been proved effective and achieved great progress forward. However, as analyzed in Section 1, they have several inherent limitations and weaknesses that need to be solved.

2.3. Social-based recommender systems

In this paper, the concept "social recommender systems" is defined as combining the social network information which can affect personal behaviors on the web, such as the interactive information among users and the information of tags, to improve recommender systems. With the development of social network in recent years, how to utilize social network information has become a hot issue and been studied in many applications.

[He and Chu \(2010\)](#) proposed a probabilistic model to make personalized recommendations from the social network information, especially the influence from social friends. The experiments on real dataset reveal that the friends have a similar tendency to select the same items. In addition, the approach can solve the data sparsity and cold start issues. [Domingos and Richardson \(2001\)](#), [Richardson and Domingos \(2002\)](#) proposed approaches to detect the potential customers from the social network. They calculated the conditional probability to know whether a customer would purchase a product given the adoption values of his friends. The customers have the higher values if they have more social contacts and influence them. The approach regards the probability as the combinational production of the user's internal probability of purchasing and the external effects from his friends. [Lu et al. \(2010\)](#) proposed a generic framework to improve the review quality prediction by incorporating authors' identities and social networks. In addition, they added some constraints to the text-based predictor. [Liu and Lee](#)

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