Recommender System with Composite Social Trust Networks

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ABSTRACT

The development of online social networks has increased the importance of social recommendations. Social recommender systems are based on the idea that users who are linked in a social trust network tend to share similar interests. Thus, how to build an accurate social trust network will greatly affect recommendation performance. However, existing trust-based recommender approaches do not fully utilize social information to build rational trust networks and thus have low prediction accuracy and slow convergence speed. In this paper, the authors propose a composite trust-based probabilistic matrix factorization model, which is mainly composed of two steps: In step 1, the existing explicit trust network and the inferred implicit trust network are used to build a composite trust network. In step 2, the composite trust network is used to minimize both the rating difference and the trust difference between the true value and the inferred value. Experiments based on an Epinions dataset show that the authors’ approach has significantly higher prediction accuracy and convergence speed than traditional collaborative filtering technology and the state-of-the-art trust-based recommendation approaches.

KEYWORDS

Collaborative Filtering, Composite Trust, Matrix Factorization, Recommender Systems, Social Network

INTRODUCTION

In an era of social connectedness, people are becoming increasingly enthusiastic about interacting, sharing, and collaborating through social networks, online communities, blogs, wikis, and other online collaborative medias (Cambria, Rajagopal, Olsher, & Das, 2013). Big social data has driven researchers to pay more and more attention to the improvement of recommender algorithms in order to provide an intelligent mechanism for filtering the excess information available to users (Park & Chang, 2009; Choi, Yoo, Kim, & Suh, 2012). As an efficiency way to information filtering, recommender systems have been studied and deployed extensively over the last decade in various application areas, including e-commerce, social networks, and advertisements.

Collaborative filtering (CF) (Breese, Heckerman, & Kadie, 1998) is the most popular recommender system, which is based on the simple assumption that similar users tend to share similar interests. CF has attracted considerable attention since its effectiveness, and has been developed and adopted by large, successful commercial systems, including Amazon1 (Linden, Smith, & York, 2003) and Netflix2.

However, traditional CF technology suffers from several inherent weaknesses, such as data sparsity, imbalance of rating data, and shilling attacks (Su & Khoshgoftaar, 2009). Recently, online social networks such as Epinions, Twitter, and Lastfm, where users can link with each other

DOI: 10.4018/IJWSR.2016040104

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and share content (such as comments, messages, and music), have become popular platforms. To overcome the above mentioned problems, trust-based recommender systems have been studied in social recommendations. Trust-based recommender systems incorporate social trust information to do recommendation, and thus can mitigate the data sparsity problem by capturing social trust relationships that are stored outside each user’s local similarity neighborhood (Lathia, Hailes, & Capra, 2009). Social trust information also makes recommender systems resistant to shilling attacks to some extent, by preventing malicious community members from abusing the system. Previous studies (Bedi & Sharma, 2012; Chen, Zeng, Zheng, & Chen, 2013; Yan, Zheng, Chen, & Wang, 2013) have shown that trust-based recommendations always outperform traditional CF algorithms in terms of prediction accuracy and decision-support accuracy.

Researchers generally adopt two approaches when establishing trust networks: explicit methods that draw explicit social trust networks from pre-established (or manually input) social links among users, and implicit methods that infer implicit social trust among users on the basis of their buying, rating, or other interaction histories (Lathia, Hailes, & Capra, 2009). Both methods assume that underlying relationships (either pre-existing or inferred) can be described and rationalized as a web of trust. Webs of trust are conceptualized as graphs in which users are nodes and edges are weighted according to the extent that users trust each other (Lathia, Hailes, & Capra, 2009).

However, most existing research focuses either on explicit social trust (Jamali & Ester, 2010) or simply using implicit social trust (Ma, Zhou, Liu, Lyu, & King, 2011; Liu & Aberer, 2013). None of the approaches builds a rational social trust network based on both users’ explicit trust and implicit trust, thus causes information lose and defects recommendation performance. Moreover, most existing work either minimizes the difference between the true ratings and the inferred ratings (Ma, King, & Lyu, 2009), or minimizes the difference between the real trust values and the inferred trust values (Ma, Yang, Lyu, & King, 2008). Chen et al. (2013) minimize both the rating difference and the trust difference between the true values and the inferred values, but use only users’ explicit social trust networks, ignoring users’ implicit social trust networks.

To overcome the above problems, in this paper, we propose to combine the user–item rating matrix with the composite social trust network to improve the accuracy of recommender systems. First, we apply linear regression to build a composite social trust network using both the explicit and implicit methods, since we can get an explicit trust value and an implicit trust value using explicit method and implicit method, respectively. Next, we incorporate the composite trust network into probabilistic matrix factorization (Mnih & Salakhutdinov, 2007) to simultaneously minimize both the rating difference between the true value and the inferred value (calculated by merging the preferences of the user with those of the user’s trusted friends), and the trust difference between the true value and the inferred value. Finally, we perform gradient descent on the objective function and determine the latent user-specific matrices and item-specific matrices to predict the ratings that users will give to different items. Experiments based on Epinions dataset show that our approach has significantly higher prediction accuracy and faster convergence speed than traditional CF-based approaches and the state-of-the-art trust-based recommendation approaches.

The rest of the paper is organized as follows. We first review related works on traditional CF-based and trust-based recommender systems. We then present our proposed composite trust-based social matrix factorization method. Next, we present the results of our conducted experiments to demonstrate the effectiveness of our proposed approach. Finally, we draw conclusions and propose future work.
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