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Improving personalized recommendations using community membership information



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ABSTRACT

While early recommender systems have mostly focused on numeric ratings to model their interests, recent research in this area has explored a range of other sources that can provide information about user interests, such as their bookmarks, tags, social links, or reviews. One source of information that has received little attention so far is users' membership in online communities. Online communities frequently evolve around specific topics. Therefore, user membership in a community could be interpreted as a sign of user interests in the topics of a particular community, and furthermore, could apply to personalized recommendations as a source of information. This paper explores the feasibility and the value of using users' community membership as a source of personalized recommendations for individual users. The first part of the paper focuses on feasibility. It attempts to assess to what extent the interests of users within the same community are truly similar. The second part focuses on the value of this information to personalized recommendations. It suggests several recommendation approaches that use community membership information. It also assesses the comparative quality of recommendations that are generated by these approaches. In particular, we substantiate our approach with one typical social bookmarking system, CiteULike. The results of our study demonstrate that the interests of members of the same communities are significantly closer than the interests of non-connected users. Moreover, we found that recommendation approaches based on community membership produce recommendations that are as accurate as those produced through a collaborative filtering approach, but with better efficiency. The recommendations are also more complete than those produced by a collaborative filtering approach. In addition, for cold-start users who have insufficient bookmarking information to reliably represent their interests, recommendations based on community membership are the most valuable.

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1. Introduction

The ability to create and join online communities has emerged as one of the most popular features in many types of social systems. Online communities usually form around recognizable topics, such as a fan club of a musician, a community of Hadoop programmers, an online forum for students taking the same class, or an online space for members of the same project. In this context, a user's membership in a community might indicate his or her interests in the topic of the

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http://dx.doi.org/10.1016/j.ipm.2017.05.005 0306-4573/© 2017 Elsevier Ltd. All rights reserved. community. Social dynamics in online communities extensively focus on contributing and distributing topic-relevant information (Lou, Fang, Lim, & Peng, 2013). Information shared by one community member frequently attracts the attention of other members (Faraj, Kudaravalli, & Wasko, 2015). Therefore, the social associations formed between members of the same community could be used as an information source to open up new possibilities to improve the information access of online users, and particularly to enhance personalized recommendations for users who are engaged in various communities.

To put this idea into the context of modern research about online sociality, we could consider membership in the same community as a social link between users. The pervasiveness of online sociality has brought scholarly attention to the use of online social networks as a valuable source of information for personalized recommendations. The direction of research is collectively referred to as 'social recommendations'. Social recommendations usually leverage users' online social networks by augmenting or replacing anonymous 'peers' used in collaborative filtering approaches with users' social connections. However, existing social recommendation approaches have predominantly¹ focused on just a few types of online social connections, such as friendship and trust (Lee and Brusilovsky; Lee, 2013). Despite the growing popularity of online communities (see Section 2.2), the social networks established by users' memberships in the same community have not been truly explored for generating social recommendations. This paper attempts to bridge this gap by examining the feasibility and value of community-based social networks as a useful information source for personalized recommendations.

The first part of this paper focuses on the feasibility of community membership as a useful information source. In specific, the parts attempts to uncover the presence of shared interests among the members of the same community. The presence of shared interests is a critical condition for using community membership information as a source of personalized recommendations. We examine the presence of shared interests by assessing the following hypothesis:

H.1 Information similarity between two members of the same community is higher than information similarity between two users who are not socially associated.

The second part focuses in the value of community membership information. The part investigates a range of approaches to generate personalized recommendations for individual users using their community membership. To assess the value of these approaches, we compare them to collaborative filtering (CF) by assessing the following hypothesis:

H.2 Recommendations based on users' self-defined community membership are better than collaborative filtering recommendations based on anonymous peers.

In this paper, both hypotheses are examined in the context of a popular social bookmarking system, *CiteULike*, where users actively participate in both communities and bookmarking activities.

The remainder of this article is structured as follows. Section 2 surveys existing literature on various problems of CF recommendation technology, online community membership, and other recommendation technologies based on online communities. Section 3 introduces the data set used in our study. The analysis of the shared interests among community comembers follows in Section 4. Section 5 introduces recommendation approaches based on community membership and assesses these approaches from several prospects. The article ends with a conclusion and discussion of possible areas of future work.

2. Related work

2.1. Collaborative filtering recommendation technology and its problems

Personalized recommendations have emerged as a solution to problems of information glut, which is caused by the overwhelming amount of information available on the web. Among various recommendation technologies (such as, contentbased, case-based, demographic-based, hybrid recommendations, and so forth), the most popular is collaborative filtering (CF). A number of well-known companies, such as Amazon, Netflix, Last.fm, and YouTube have adopted and demonstrated the effectiveness of the technology (Zhang et al., 2016, Zhou, Wilkinson, Schreiber, & Pan, 2008). The CF systematically employs a process of 'word of mouth' to produce personalized suggestions based on preferences of like-minded anonymous 'peers' in a fully automated way. In spite of the strengths and big success of this approach, the use of a fully automated black-box process has called the quality of CF recommendations into question. There are several studies that have shown that CF technologies are vulnerable to attacks from malicious users (Gunes, Kaleli, Bilge, & Polat, 2014). For instance, a group of ad-hoc users are able to copy other users' rating profiles and shift the recommendation predictions to the desired directions to make profits (Zhang & Zhou, 2014). Even if well-intended users have eccentric preferences (so-called "gray/black sheep users"), their small overlap of ratings with other users makes it difficult for a recommender system to find their peer cohorts and recommend relevant items (Gras, Brun, & Boyer, 2016). CF recommendations also suffer from such problems as data sparsity, cold-start users, and computational overload (Sedhain, Sanner, Braziunas, Xie, & Christensen, 2014). The problems of CF technology have occurred in part because of a lack of user involvement in the recommendation processes. Although users are the recipients of CF recommendations, the recommender systems do not allow users to get involved

¹ According to our survey of the field, among the 40 existing studies of social recommendation approaches published through April 2016, 46% focus on friendship links and 39% focus on trust links between users (Lee and Brusilovsky, Forthcoming).

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