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Who should you follow? Combining learning to rank with social influence for informative friend recommendation

Chien Chin Chen *, Shun-Yuan Shih, Meng Lee

Department of Information Management, National Taiwan University, Taiwan

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ABSTRACT

Social network sites have gradually taken the place of traditional media for people to receive the latest information. To receive novel information, users of social network sites are encouraged to establish social relations. The updates shared by friends form social update streams that provide people with up-to-date information. However, having too many friends can lead to an information overload problem causing users to be overwhelmed by the huge number of updates shared continuously by numerous friends. This information overload problem may affect user intentions to join social network sites and thereby possibly reduce the sites' advertising earnings, which are based on the number of users. In this paper, we propose a learning-based recommendation method which suggests informative friends to users, where an informative friend is a friend whose posted updates are liked by the user. Techniques of learning to rank are designed to analyze user behavior and to model the latent preferences of users and updates. At the same time, the learning model is incorporated with social influence to enhance the learned preferences. Informative friends are recommended if the preferences of the updates that they share are highly associated with the preferences of a target user.

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1. Introduction

The prevalence of social media has advanced the way people exchange information. Nowadays, users can gather various kinds of information from social media that allow the creation and exchange of user-generated content for a variety of purposes ranging from entertainment to learning and shopping. Among all social media, social network sites such as Facebook have become increasingly popular, with estimates of over 60% of adults in the US[1] having more than one social network site account. The most popular social network site worldwide is Facebook, which as of 2014 had 1393 million active users.[2] There is a great deal of evidence showing that social network sites are ubiquitous and have become a part of our daily life.

Users on social network sites exchange information by sharing *updates* using posts, photos, or videos. These updates form *social update streams*, which are sets of chronologically ordered updates shared by users' friends [15]. When users share an update, the update will instantaneously appear in their friends' social update streams, which enable users to get the latest information. It has been asserted that Internet users heavily rely on social update streams to seek information and thus are willing to notify and be notified by their friends of important information [33]. As a result, social update streams accelerate the spread of information among social circles. By taking advantage of efficient information delivery, social update streams have successfully played a role in word-of-mouth marketing and event detection. For example, Twitter is regarded as an ideal place to provide a highly interactive one-to-many information channel, which is why organizations like Microsoft US, Coca-Cola, etc., use a combination of retweets, hashtags, and hyperlinks to promote marketing messages, and even to respond to customers' complaints either made directly to organizations or discovered by monitoring the social update streams [12]. Li et al. [24], who conducted a real-time analysis of the updates on Twitter, demonstrated that temporal and spatial patterns on social update streams generally coincide with emergent accidents (e.g., earthquake or tsunami); in this way, social update streams can be an important source information for national surveillance. Due to their varied functionalities and efficient delivery, social update streams have gradually taken the place of traditional media and are becoming an important mechanism of information dissemination [4,22].

Social network site users need to establish friendships to receive updates. However, when the quantity of friends reaches a fairly high level, users can be overwhelmed by the amount of fresh social updates. The thousands of social updates from hundreds of friends per day may be seen as a kind of spam in the social update streams. This so-called *information overload* problem [21] may subsequently lead to a degraded

* Corresponding author.
E-mail addresses: patonchen@ntu.edu.tw (C.C. Chen), r02725032@ntu.edu.tw (S.-Y. Shih), r02725014@ntu.edu.tw (M. Lee).

[1] Pew Research (2014). "Social Networking Fact Sheet." From http://www.pewinternet.org/fact-sheets/social-networking-fact-sheet/.

[2] Facebook (2015). "Facebook Q4 and Full Year 2014 Earnings." From http://investor.fb.com/eventdetail.cfm?eventid=154637.

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user experience which in turn may affect user intention to join or remain a member of social network sites. Since a major source of income for social network sites comes from advertising based on the number of site users [11], the information overload problem may affect the revenues of the sites.

From a decision support perspective, recommendation systems are supporting tools that analyze users' behavior to suggest items relevant to their preferences [17]. The personalized recommendation is essential to substantially reduce information overload and has been shown effective to increase users' satisfaction and loyalty to e-services [25]. Therefore, in order to resolve the information overload problem of social update streams and to create a win–win proposition for both social network site users and owners, effective friend recommendation methods which suggest *informative friends* to users are critical [50], where an informative friend is a friend whose posted updates are relevant to the preferences of the user. Recommending informative friends not only enriches the content of social update streams but also helps social network sites retain users to increase potential advertising revenues.

In recent years, more and more studies have started to investigate friend recommendation for social network sites. A great proportion of friend recommendation methods are comparable to the link prediction of social networks [16], which analyzes the structures of social networks (e.g., friends of friends) to predict potential links (i.e., friendships) between users. Other methods adopt recommendation system techniques to compute the similarity between users in terms of user-generated content and friend lists. Preference-similar users are recommended to a target user [44]. Although the two approaches enable expansion of users' social circles, they could intensify the information overload problem because the informativeness of the suggested friends is neglected. In this paper, we thus study the informative friend recommendation problem. We design a model-based friend recommendation method which employs *learning to rank* [29] to recommend informative friends to users. Recent recommendation studies [9,44] advocate learning to rank to incorporate users' implicit feedback with the recommendation algorithms. Instead of measuring the preference degree (e.g., rating) of an item, learning to rank utilizes the implicit feedback to train a ranking model which discriminates preferences between items. In the proposed method, we consider social updates as items and integrate techniques of matrix factorization with learning to rank in order to learn the latent preferences of users and updates. At the same time, as users are more likely to receive and respond to updates their friends are interested in, social influence (the association of friends and their preferences) is incorporated to derive representative latent preferences. Thereafter, informative friends are recommended if the preferences of the updates they share are highly associated with the preferences of a target user. To examine the proposed method, we adopted a real-world dataset consisting of thousands of updates and users. The experiment results based on this large dataset demonstrate the effectiveness of the proposed method in recommending informative friends; further, the updates shared by the recommended friends were highly associated with user preferences. The proposed method thus outperforms many well-known friend recommendation methods and learning to rank recommendation methods.

The remainder of this paper is organized as follows. The next section contains a review of related works on recommendation systems and friend recommendation. We introduce the proposed friend recommendation method in Section 3, and then evaluate it in Section 4. Section 5 provides discussions and implications, and some concluding remarks and future avenues of research are given in Section 6.

2. Related works

In this section, we first review a number of recommendation systems and their applications on learning to rank. Next, we consider social influence and introduce their techniques used in friend recommendation.

2.1. Collaborative filtering on recommendation systems

The goal of recommendation systems is to suggest items relevant to user preferences. The most widely used recommendation approach is collaborative filtering [6,40] which assumes that like-minded people prefer similar items and thus analyzes user behavior (e.g., ratings) on items to identify reference users whose preferences are similar to those of a target user. Items that interest the reference users then are recommended to the target user. Methods of collaborative filtering can be classified as either memory-based or model-based. Normally, memory-based methods record all the ratings made by users. The ratings are regarded as explicit user preferences and are analyzed by a similarity metric to find out reference users. For instance, Resnick et al. [40] employed the Pearson correlation coefficient to select positively correlated users as the reference users; and Linden et al. [28] utilized cosine similarity, which is the normalized inner product of users' rating vectors, to measure the similarity between users. However, a major concern with the memory-based methods is the sparsity of ratings [7] in that users generally rate few items. Consequently, the explicit preferences are too sparse to infer effective reference users. To remedy the sparsity problem, model-based methods analyze users' ratings to model users' latent (implicit) preferences. One of the most popular model-based methods is matrix factorization whose goal is to represent the latent preferences of users and items as Z dimensional preference vectors that approximate the user–item rating matrix. Matrix factorization maps both users and items to a joint latent factor space such that user–item behavior can be represented as inner products in the space. It is worth mentioning that model-based collaborative filtering has become a major recommendation methodology due to its superior performance in several recommendation contests, such as the Netflix Prize competition and KDDCUP [5,20]. Sarwar et al. [42] applied the singular value decomposition (SVD) [47] to the user–item rating matrix. The authors demonstrated that the decomposed singular vectors successfully represent the latent preferences of users and are capable of discovering reliable reference users for effective item recommendations. Paterek [36] developed an effective model-based recommendation method, which achieved a remarkable performance in the Netflix prize competition, by enhancing the SVD recommendation method with a memory-based technique; he also introduced bias variables to decrease the root mean square error of the predicted ratings and to increase the accuracy of item recommendations. Koren [19] merged the ratings predicted by an SVD-based method and a memory-based method, and thus formulated a neighborhood model which optimizes a cost function that integrates the latent preferences of users and their neighborhoods. As the SVD-based method and the memory-based method addressed item recommendation from different perspectives, their combination complemented each other and thus significantly improved recommendation accuracy. Recently, Koren et al. [20] conducted a thorough analysis of matrix factorization techniques and formulated matrix factorization as an optimization problem, thereby introducing a gradient descent-based learning algorithm to rapidly approximate adequate preference vectors by minimizing the root mean square error between the actual item ratings and the ratings predicted by the preference vectors. This method achieved remarkable performances on many recommendation datasets and is currently the state-of-the-art matrix factorization method.

2.2. Learning to rank on recommendation systems

Methods of matrix factorization-based collaborative filtering have normally formulated the preference approximation as an optimization problem whose goal is to predict item ratings as accurately as possible. However, it would be more appropriate to model the approximation

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