Friend Recommendation based on Location Based Multiple Network Co-relation

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Abstract

With the rapid development of computer science and internet technologies, social media and social network has experienced explosive growth over the last decades. Social websites, such as Flickr, YouTube, and Twitter, have billions of users who share photos, videos and opinions, they also make friends on these websites. On-line friendship is an emerging topic that attracts the attentions from both economists and sociologists. The study of the on-line friendship, on one hand, can help the on-line merchants to find their potential customers, and thus make more precise recommendations; on the other hand, it helps to get a deep understanding of the relationships among different people. However, individuals' on-line friend making behavior is relatively complex and may be affected by many different factors. For example, an individual might make on-line friends with others because they discuss a hard-mathematical problem, or it is possible that he/she makes a friend because they both enjoy a film. The reasons for friend making behaviors are likely to be diverse In this , with my collaborators, try to give some solutions of on-line social friend recommendation from several aspects. One problem for social friend recommendation is that how shall we find the important social features that would highly influence individuals' friend making behaviors. Usually, the reason an individual A would make friends with another person B is not that A is satisfied with all the characteristics of B, but that he/she has interest in some factors that B has illustrated. These factors can be viewed as instructive social features for friend recommendation tasks. So, in this thesis paper, we first discuss the important social features for friend recommendation.

Introduction

The online social relationship is a recently emerging topic with the rapid development of the social media. Online social communication platform such as Facebook1, Twitter2, and Wechat3 give good support for individuals to share experiences, images and videos as well as to communicate with friends. Multimedia platform such as Youtube4, Flickr5, and Instagram6 are also providing more convenient methods for the interactions between users. There are plenty of commercial opportunities when taking the online friendships into consideration: an individual might recommend some good products to his/her friend circle, and it is relatively easier for an individual to try some new products, with his/her friends' recommendations. So it is quite meaningful to study further the friendship in the online social platform.

Though the online friendships have few limitations compared with traditional friendship, the online individuals do follow some rules to find a friend (Carullo, Castiglione & Santis 2014)(Ghorbani & Ganjali 2012). Similar with the traditional friendships, some kinds of physical constrains also exist for online friendship. A simple example is that it is quite meaningless to recommend a young French student to a Korean old man, because they do not understand each other's language. For some time-sensitive situations (for example, online game), it is also not wise to recommend a man who lives in China to one who locates in America, because of the 12-hour time gap. In our opinion, one of the important social reasons for individuals to surf the internet is that they want to find online friends that share similar personal interests, no matter who they are and where they are (Jebabli, Cherifi, Cherifi & Hamouda 2015)(Ahmed, Rashid, Hasan & Mahmud 2015). People want to find someone to make discussions about certain topics, to bring new ideas about these topics, and to learn something from other parts of the world (Yin, Zhou, Cui, Wang, Zheng & Nguyen 2016)(Pipanmekaporn & kamolsantiroj 2016). For example, a man who has an interest in delicious food, no matter where he is, might make online friends with those who share many photos and comments about the menus and tasting experiences in restaurants from different areas of the world. As a consequence, we think the online friend recommendation should be based on individuals' interests. Individuals' interests are related deeply to their social environments, social status and social behaviors, etc. (Zhao, Wang, Yu, Liu & Zhang 2013), which we summarize as "social role". Taking social environment for example, a man in mainland China seldom has an interest in horse-riding since it is very expensive there are no places for this activity. But a man in

Hongkong might take care of such activity since horse race betting is legal in Hongkong. A man in Australia is possible to have a great interest in horse-riding, because in Australia there are plenty of land for horse and the price is relatively cheap.

Related Works

A. Friend/Link Prediction in LBSNs

Brown et al. [6] study the influence of spatial proximity on users' social relationships, that is the correlation of the geographical closeness of users' check-ins and social relationships. Scellato et al. [1] study the link prediction space of two users to check whether they will become friends or not, and use a semi-supervised framework to predict new links among friends-of-friends and place-friends. Pham et al. [2] introduce an entropy-based model to first measure the diversity of co-occurrences and then utilize location entropy to weigh each co-occurrence differently, depending on the popularity of each location. Cheng et al. [7] formulate the friend prediction problem as a binary classification problem. They introduce two models, the first model focuses on predicting friendship of two individuals with only one of their co-occurred places' information. The second model proposes a solution for predicting friendship of two individuals based on all their co-occurred places. Bayrak et al. [8] study the influence of place categories on friend prediction, assuming that friends might visit locations that belong to the same type of location categories e.g., museums, cinemas and so on. Instead of the top-k friend recommendation task, all the aforementioned methods focus on the link prediction task in LBSNs, that is a binary classification task trying to determine whether two users might become friends or not. Recently, there has been a surge of interest in representation learning for social networks. For example, DeepWalk [18] learns representations of nodes using a sequence of truncated random walks. The learned representations capture a linear combination of community membership at multiple scales. Gover et al. [19] introduce the node2vec model, to learn a mapping of nodes to a low-dimensional space of features that maximizes the likelihood of preserving network neighborhoods of nodes. They define a flexible notion of a node's network neighborhood and design a biased random walk procedure, which efficiently explores diverse neighborhoods. However, both DeepWalk and node2vec try to learn non-linear representations of social networks for the multi-label network classification and link predictions tasks and do not produce top-k friend recommendations.

B. Top-k Friend Recommendation in LBSNs

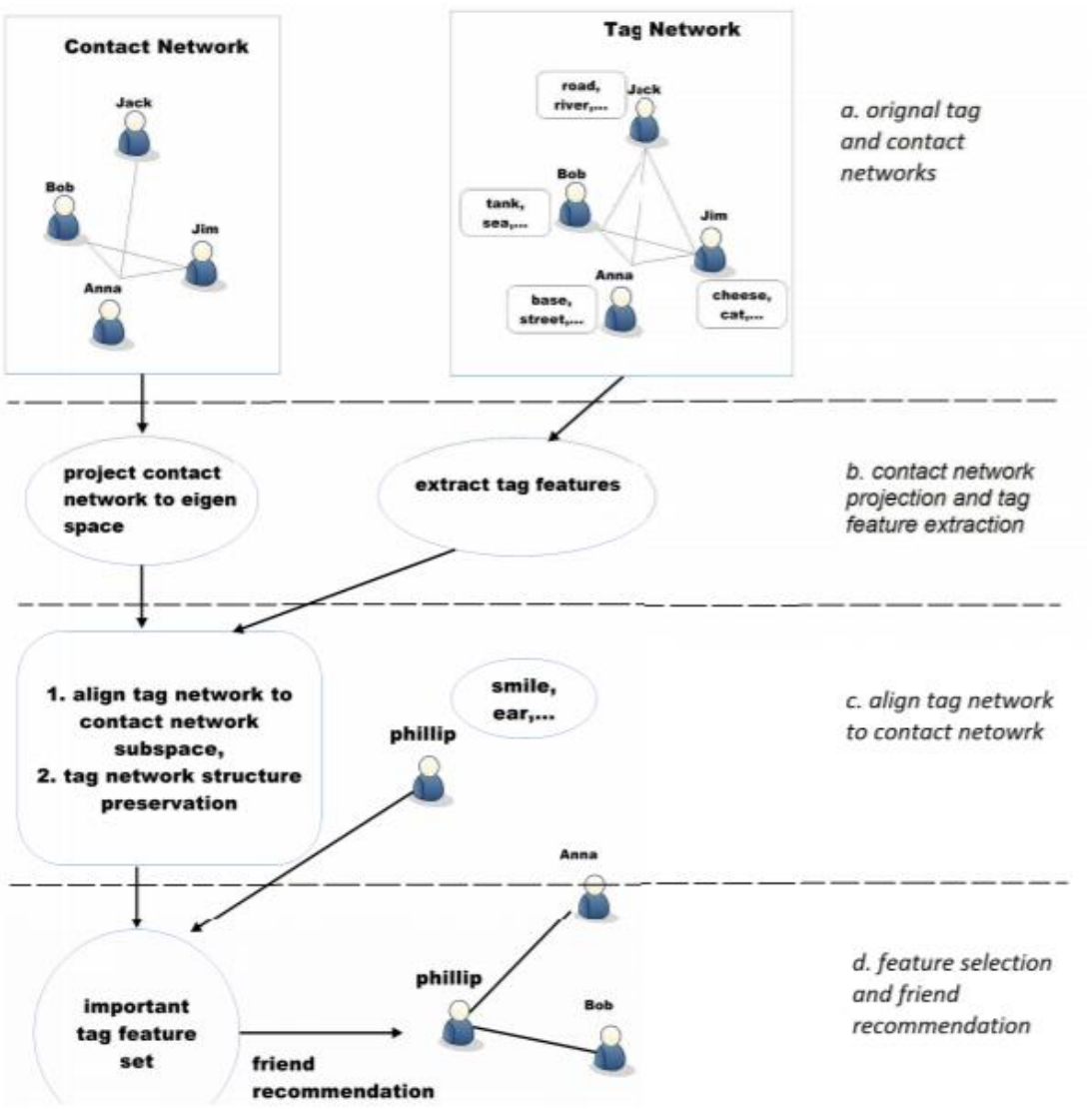
The BPR model is a baseline model that considers a pairwise ranking loss function to generate top-k recommendations [17]. Ding et al. [15] extend the BPR model by first extracting deep features based on a convolutional neural network, and then using a deep neural network to produce friend recommendations. However, the available contextual information at LBSNs is ignored in both studies. Yu et al. [9] introduce a random walk process to find geographically related friends. Raw GPS data are analyzed to extract discriminate GPS patterns. Then, the extracted geographical information and the social network of friends are combined in a heterogeneous information network, performing random walks to provide friend recommendations. Yu et al. [10] infer social relations based on users' preferences on POIs' categories, by evaluating the degree to the preference coverage. Lu et al. [11] present the GIB-FR model, a Bayesian latent model that combines geographical information and user behaviour for friend recommendation. In particular, they investigate whether users who share common areas when they participate in social events will have a tendency to associate with each other. Finally, they formulate the recommendation task as a pairwise ranking problem, using the BPR framework. Bagci et al. [12] build a graph based on users' context, that is social relation, personal preferences and current location. To rank the recommendation scores of friends, a random walk with restart approach is employed. User's visited locations in recommendation region are also considered to identify places related to friends, that is potential friends that have check-ins at common locations. In addition, local experts and popular locations are employed in populating the context of the user. To identify the local experts and popular locations in a certain region, a HITS-based algorithm is introduced.

Proposed Work

The entire proposed work is being divided into following subsections:

1. Original Tags and Contact Networks

We first project the contact network to its eigen-space and extract tag features(Fig 4.2b)– in our case, features are the tag words provided by the photo uploaders. Then we align the tag network T to the eigen-representation of the contact network C(Fig 4.2c) by considering network correlation and structure preservation. In the last step we select some important word features from the whole feature set (which is composed of all the tag words). These important tag features illustrate the correlations between tag and contact network. These features make the tag network more similar to the contact network. So when a new user with some tags comes into the network, based on how his/her tag features matches to the pool of those important features that have been selected previously, we can map him/her to the existing contact network to see which users are closer to the new one, these closer users are more likely to be his/her potential friends.



2. Feature Extraction

In the alignment of tag and contact network, we treat tag words as features. The tag data crawled from social website such as Flickr usually contains much noise and thus data refinement is required for a better recommendation result. After removing some explicit stop features such “a”,“the”, as well as features that too often or too seldom appear in Flickr tags. After this we build the vocabulary of tags.

3. Friend Recommendation

For a new user with some tag words coming into the network, we select these features based on the alignment from tag network to contact network, and these important features illustrate the correlations of contact and tag networks. So, we calculate the similarities between tag features of the new user and those important features of the existing

users. Because the important features pool reflects each existing user tag's contribution and the correlation between tag and contact networks, therefore, this similarity indicates the distance of the new user to those existing ones in the contact network. The more similar on the important tag set, the more closer the two uses should be. So by ranking the tag similarity of the new user and the members that already in the networks, we choose top K as recommending friends.

Conclusions

In this work, we study the friend recommendation problem from the view of network correlation. A person has many different social roles on-line. For each social role, he/she makes different friends, and these different social roles form different social networks. To consider the effect of different social roles, we propose a network alignment method to find the correlations among different networks. The second aspect we take into account is the pairwise user similarity preservation to maintain the original data structure. Experimental results by aligning tag and contact networks have shown that the proposed NC-based SFR outperforms other methods in friend recommendation: we achieve the highest precision in friend prediction. We found that a small number of features can align the tag network to contact network well and provide sufficient information for friend recommendation. Both network alignment and social network structure preservation play an important role in our task.

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