Friend Recommendation Method using Physical and Social Context

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Summary
Social network sites have attracted millions of users with the social revolution in Web 2.0. In the social network sites, a user can register other users as friends and enjoy communication. However, users of social network sites may easily get overwhelmed by the excessive volume of friend information. Recently context-aware mobile devices have been thoroughly integrated into all walks of life. The context-aware systems provide the user with adaptive recommendations from enormous information. Therefore, the essential factor of social computing is to recommend truly valuable friends using context. We propose a friend recommendation method using physical and social context. The main idea of the proposed method is consisted of the following three stages; (1) computing the friendship score using physical context; (2) computing the friendship score using social context; (3) combining all of the friendship scores and recommending friends by the scoring values.

Key words:
recommendation, social service, friend, context

1. Introduction

With the advent of Web 2.0, social computing has emerged as one of the hot research topics recently. It involves the collecting, extracting, accessing, processing, computing and visualizing of social signals and information [1].

Also, SNSs(Social Network Sites) are increasingly attracting the attention of academic and industry researchers. What makes SNSs unique is that they have a relationship with friends [2]. People tend to trust the opinions of friends they know rather than the opinions of strangers [3].

Mobile devices with context-aware sensors are becoming increasingly popular among people. The wealth of available sensor technologies creates more possibilities for context-aware systems. The context-aware systems should provide the user with adaptive recommendations for potentially relevant information. A challenging research issue in social computing is therefore the recommendation method using context.

Context has rarely been incorporated into social recommendation systems so far. But physical context and social context can be useful sources for improving recommendation [4].

In the SNSs, a user can register other users as friends and enjoy communication through a virtual message and a diary such as blog. With the rapid growth of social networks, users of SNSs may easily get overwhelmed by the excessive volume of information. The friendship can significantly affect the quality of recommendations. Therefore, the recommendation of better friend is the essential factor of social network sites to find truly valuable information.

This paper proposes a friend recommendation method using the physical and social context. The scheme considers friendship from similar physical context. Moreover, our scheme considers explicit friendship using social context such as the social network. And then, the scheme combines both the friendship using physical context and it using social context.

The main idea of the proposed method is consisted of the following three stages; Firstly, our method computes the friendship score based on similar behaviour using physical context. In the computation, we adopt the traditional information retrieval method, BM25 weighting scheme. Secondly, the method computes friendship score with friend relation in the friendship graph using social context. Finally, we combine the all of the friendship scores and then recommend friends by the scoring values.

The remainder of this paper is organized as follows. Section 2 introduces related works. Section 3 presents friend recommendation method using physical and social context. Section 4 discusses and concludes our proposed recommendation method.

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2. Related Works

2.1 Social Network Site

The evolution of the Web from Web 1.0 to Web 2.0 has brought up new platforms as SNSs that are used by users to articulate and manage their relationships. SNSs are an online phenomenon which has become extremely popular [5]. They provide social network based services to support easy message posting, information sharing and inter-friend communication [6].

SNSs are defined as web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system [2].

Relationships information obtained from a person's social network contacts can therefore be considered as one type of a person's social context, which extant literature refers to as 'who you are with' or one`s 'social situation' [7], 'identity' [8], and 'social relations' [9] or even 'who you are similar to'. Thus, information about relationships from social network can be considered as one type of a person's social context.

The SNSs are used to articulate and manage relationships to personally known people. It is expected that a recommendation sent by one of the social network contacts is perceived as highly relevant for the user. The success of SNS to bind users and their friends has initiated concepts for usage of social network data for a more precise and personalized recommendation of information to users [5].

2.2 Recommender System

Recommendation systems have received significant attention from both academia and industry since the mid-1990s when collaborative filtering was introduced. Recommendation systems are usually classified into two categories: content-based recommendations and collaborative filtering based recommendations [4,10,11,12].

Content-based filtering recommends items that are similar to ones, the active user preferred in the past [13]. Content-based recommendation systems recommend an item to a user based on item description and user's interests [12] and are useful recommending web pages, news articles, items for sale, etc.

Traditional collaborative filtering recommends items to an active that have been rated highly by users who are similar to the active user [4]. Collaborative filtering based systems recommend items that other similar users have preferred. Collaborative recommendation computes the similarity to other users rather than to other items [12]. Several hybrid recommendation systems combine both collaborative and content-based methods [12].

2.3 Social Recommender System

The social recommender systems predict the utility of items, users, or groups based on the multi-dimensional social environment of a given user. Based on this model, it introduces recommendation mechanisms for content sharing frameworks [14]. This method take into account a specialized model of dependencies between users, items, and annotations that provides a good fit for observed properties of the folksonomy. Beyond these basic structures, modern Web 2.0 folksonomys contain additional features reflecting the social nature of the content sharing framework such as contacts, personal favorites, comments, groups, etc.

SocialFusion[12] is a framework to support context-aware inference and recommendation by fusing together mobile, sensor, and social data. SocialFusion consists of 3 stages: first, a data gathering and management stage, including a novel K-anonymization algorithm; next, an inference stage that fuses together the diverse data streams using describer modules to extract contextual clues called descriptors; finally, a recommendation stage that leverages the rich assembled data and descriptors to recommend a context-aware action.

SENSE(Socially ENhanced Search and Exploration)[15,16] provides an efficient top-k algorithm that dynamically expands the search to related users and tags. It is based on principles of threshold algorithms, folding related users and tags into the search space in an incremental on-demand manner, thus visiting only a small fraction of the social network when evaluating a query. The demonstration uses three different real-world datasets: a large set of urls from del.icio.us, a large set of pictures from Flickr, and a large set of books from librarything, each together with a large fraction of the corresponding social network of these sites. The core of SENSE scoring is formed by three different quantizations for friendship strengths, corresponding to the three different searches in communities.

However, the previous approaches did not consider physical and social context for friend recommendation. The social recommender system is needed to tailor towards contexts.

3. Friend Recommendation Method

In this section, we present our method for friend recommendation using physical and social contexts. Friendships are user-user relations that come in different forms [16]. We use the concept of the spiritual friendship and the social friendship in [16]. The spiritual friendship is the relation based on similar behavior such as high overlap in tag usage. The social friendship is an explicit, user-provided relation.

We consider both the spiritual friendship and the social friendship for scoring friendship. Also, we consider context-aware computing environments. Context has rarely been considered for scoring friendship so far. However, it is important to take the current context into account.

The context is grouped into physical context such as the current user location, time, also social context such as the social network of the user [4]. The physical and social context can be useful sources for improving scoring friendship. We use physical contexts for spiritual friendship, and social contexts for social friendship.

In this paper, we propose the friendship score, *FS(u,y)* strength between user *u* and *u*'s friend *y* using physical and social contexts. The friendship score between user *u* and *u*'s friend *y*, *FS(u,y)* combines spiritual friendship score, $FS_{sp}(u,y)$ and social friendship score. $FS_{so}(u,y)$. Equation 1 shows our friendship score, *FS(u,y)*.

$$FS(u,y) = \alpha \times FS_{sp}(u,y) + (1-\alpha) \times FS_{so}(u,y) \quad (1)$$

The parameter α, 0≤α≤1, can be adjusted by the user and application characteristics. If the spiritual friendship is more important than social friendship, the parameter value of α is increased.

The spiritual friendship score, $FS_{sp}(u,y)$ is computed using physical contexts. In the previous studies, the spiritual friendship is computed using user-behaviour statistics without considering context-aware computing environment. Compared with them, our method considers physical contexts such as location, time, user profile, etc.

The spiritual friendship score is computed by a logged context score and an inputted context score. The logged context is the continually varying context such as location and time. It is computed from statistics of logged data. The inputted context is got from user's input. An example of inputted context is the user profile.

The score, $FS_{sp}(u,y)$ is computed by equation (2). The score, $FS_{sp}(u,y)$ combines both the logged context score, $FS_{splog\_norm}(u,y)$ and the inputted context score, $FS_{spinput\_norm}(u,y)$. The result of the logged context score and the inputted context score is composited using single adjustable parameter β (0≤β≤1). If the value of parameter β is increased, the logged context score is considered as more important than the inputted context score.

$$FS_{sp}(u,y) = \beta \times FS_{splog\_norm}(u,y) + (1-\beta) \times FS_{spinput\_norm}(u,y) \quad (2)$$

The logged context score, $FS_{splog\_norm}(u,y)$ is computed using the traditional information retrieval method. Specially, we adopt the BM25 weighting scheme [17].

Moreover, the result of BM25 score is normalized. The logged context score and the inputted context is computed by different mechanisms. We use a linear combination for the logged context score and the inputted context score. Therefore, the normalization is needed. The normalization makes different scores between the logged context score and the inputted context score comparable. For the BM25 formula, we used the normalization procedure presented by Song et al. [18]. The normalized formula is shown in equation 3.

$$FS(u,y)_{splog\_norm} = \frac{FS(u,y)_{splog}}{\sum_{i=1}^{n} IDF(uc_i) \times (k_1 + 1)} \quad (3)$$

Equation 4 shows out the logged context score between user *u* and *u*'s friend *y*, $FS_{splog}(u,y)$. The equation is based on the BM25 weighting scheme.

$$FS_{splog}(u,y) = \sum_{i=1}^{n} IDF(uc_i) \times \frac{f(uc_i,y) \times (k_1+1)}{f(uc_i,y) \times (1-b+b \times \frac{|y|}{avg(|Y|)})} \quad (4)$$

In equation (4), uc_i is the user *u*'s *i* th context value and the $f(uc_i,y)$ is logged uc_i 's frequency in the friend *y*. |*y*| is the total number of logged context values in the friend *y*, and *avg(|Y|)* is the average number of logged context values in the user collection from users are drawn. k_1 and *b* are free parameters, usually chosen as $k_1 = 2.0$ and $b = 0.75$.

$$IDF(uc_i) = \log \frac{N - n(uc_i) + 0.5}{n(uc_i) + 0.5} \quad (5)$$

$IDF(uc_i)$ is computed as equation (5). *N* is the total number of users in the collection, and $n(uc_i)$ is the number of users logging uc_i.

The inputted context score, $FS(u,y)_{spinput\_norm}$ is computed as equation (6). The *m* is the number of the inputted contexts, and value of *val* is 1 or 0. If the user *u*'s context

value is equals to friend *y*'s context value, then the value of *val* is 1. Otherwise, the value of *val* is 0.

$$FS_{spinput\_norm} = \frac{\sum_{i=1}^{m} val}{m} \quad (6)$$

The social friendship score, $FS_{so}(u,y)$ is computed using social contexts. The $FS_{so}(u,y)$ is computed as the inverse distance between friends in the friendship graph as in [19]. The distance is the number of edges in a shortest path connecting the two users [19]. Equation 7 shows the social friendship score, $FS_{so}(u,y)$.

$$FS_{so}(u, y) = \frac{1}{distance\ \ between\ \ u\ \ and\ \ y} \quad (7)$$

After the friendship score, $FS(u,y)$ strength between user *u* and *u*'s friend *y* is computed, our method sorts friends by scoring values. Finally, our method provides friends in ascending order.

4. Conclusion

Social network services enable a user to connect with friends. Information by friends may be more interesting, since the user trusts the friends more than others. Therefore, a friend recommendation method is one of key methods in social network services.

As compared to the traditional recommendation methods, our method finds the friends to satisfy a user's current contexts. Context has rarely been incorporated into recommender systems. The physical context and social context can be useful sources for finding good friends.

We propose a friend recommendation method using the physical and social context. Our method presents a friendship score combining both spiritual friendship and social friendship. The spiritual friendship is computed by physical contexts and social friendship is computed by social contexts. The spiritual friendship score is computed by a logged context score and an inputted context score. The logged context score is computed using the traditional information retrieval method, BM25 weighting scheme. The social friendship score is computed using distance between friends in the friendship graph.

The proposed method can be applied for context-aware applications using friend relationship in social network services. In future work, we will implement the algorithm using physical context and social context. We also will make a prototype using our method.

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