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A novel method that recommends friends to users based on their life styles instead of social graphs

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ABSTRACT

Existing social networking services recommend friends to users based on their social graphs, which may not be the most appropriate to reflect a user's preferences on friend selection in real life. In this paper, we present Friendbook, a novel semantic-based friend recommendation system for social networks, which recommends friends to users based on their life styles instead of social graphs. By taking advantage of sensor-rich smartphones, Friendbook discovers life styles of users from user-centric sensor data, measures the similarity of life styles between users, and recommends friends to users if their life styles have high similarity. Inspired by text mining, we model a user's daily life as life documents, from which his/her life styles are extracted by using the Latent Dirichlet Allocation algorithm. We further propose a similarity metric to measure the similarity of life styles between users, and calculate users' impact in terms of life styles with a friend-matching graph. Upon receiving a request, Friendbook returns a list of people with highest recommendation scores to the query user. Finally, Friendbook integrates a feedback mechanism to further improve the recommendation accuracy. We have implemented Friendbook on the Android-based smartphones, and evaluated its performance on both small-scale experiments and large-scale simulations. The results show that the recommendations accurately reflect the preferences of users in choosing friends.

Keywords*—Friend recommendation, mobile sensing, social networks, life style, Facebook, Potential Friends.

1 INTRODUCTION

Twenty years ago, people typically made friends with others who live or work close to themselves, such as neighbors or colleagues. We call friends made through this traditional fashion as G-friends, which stands for geographical location-based friends because they are influenced by the geographical distances between each other.

With the rapid advances in social networks, services such as Facebook, Twitter and Google+ have provided us revolutionary ways of making friends. According to Facebook statistics, a user has an average of 130 friends, perhaps larger than any other time in history [2].

One challenge with existing social networking services is how to recommend a good friend to a user. Most of them rely on pre-existing user relationships to pick friend candidates. For example, Facebook relies on a social link analysis among those who already share common friends and recommends symmetrical users as potential friends. Unfortunately, this approach may not be the most appropriate based on recent sociology findings [16], [27], [29], [30]. According to these studies, the rules to group people together include: 1) habits or life style; 2) attitudes; 3) tastes; 4) moral standards; 5) economic level; and 6) people they already know Apparently, rule #3 and rule #6 are the mainstream factors considered by existing recommendation systems. Rule #1, although probably the most intuitive, is not widely used because users' life styles are difficult, if not impossible, to capture

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through web actions. Rather, life styles are usually closely correlated with daily routines and activities.

Therefore, if we could gather information on users' daily routines and activities, we can exploit rule #1 and recommend friends to people based on their similar life styles. This recommendation mechanism can be deployed as a standalone app on smartphones or as an add-on to existing social network frameworks. In both cases, Friendbook can help mobile phone users find friends either among strangers or within a certain group as long as they share similar life styles. In our everyday lives, we may have hundreds of activities, which form meaningful sequences that shape our lives. In this paper, we use the word activity to specifically refer to the actions taken in the order of seconds, such as "sitting", "walking", or "typing", while we use the phrase life style to refer to higher-level abstractions of daily lives, such as "office work" or "shopping". For instance, the "shopping" life style mostly consists of the "walking" activity, but may also contain the "standing" or the "sitting" activities. To model daily lives properly, we draw an analogy between people's daily lives and documents, as shown in Figure 1. Previous research on probabilistic topic models in text mining has treated documents as mixtures of topics, and topics as mixtures of words [10]. Inspired by this, similarly, we can treat our daily lives (or life documents) as a mixture of life styles (or topics), and each life style as a mixture of activities (or words).

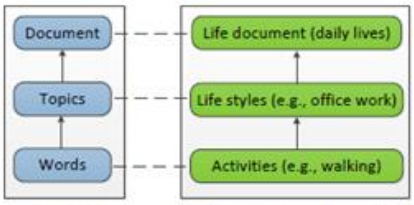

Fig. 1: An analogy between word documents and people's daily lives.

Observe here, essentially, we represent daily lives with "life documents", whose semantic meanings are reflected through their topics, which are life styles in our study. Just like words serve as the basis of documents, people's activities naturally serve as the primitive vocabulary of these life documents. Our proposed solution is also motivated by the recent advances in smartphones, which have become more and more popular in people's lives. These smartphones (e.g., iPhone or Android-based smartphones) are equipped with a rich set of embedded sensors, such as GPS, accelerometer, microphone, gyroscope, and camera. Thus, a smartphone is no longer simply a communication device, but also a powerful and environmental reality sensing platform from which we can extract rich context and content-aware information. From this perspective, smartphones serve as the ideal platform for sensing daily routines from which people's life styles could be discovered. In spite of the powerful sensing capabilities of smartphones, there are still multiple challenges for extracting users' life styles and recommending potential friends based on their similarities. First, how to automatically and accurately discover life styles from noisy and heterogeneous sensor data? Second, how to measure the similarity of users in terms of life styles? Third, who should be recommended to the user among all the friend candidates? To address these challenges, in this paper, we present Friendbook, a semantic-based friend recommendation system based on sensor-rich smartphones. The contributions of this work are summarized as follows:

To the best of our knowledge, Friendbook is the first friend recommendation system exploiting a user's life style information discovered from smartphone sensors. _ Inspired by achievements in the field of text mining, we model the daily lives of users as life documents and use the probabilistic topic model to extract life style information of users. _ We propose a unique similarity metric to characterize the similarity of users in terms of life styles and then construct a friend-matching graph to recommend friends to users based on their life styles.

We integrate a linear feedback mechanism that exploits the user's feedback to improve recommendation accuracy. _ We conduct both small-scale experiments and largescale simulations to evaluate the performance of our system. Experimental

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results demonstrate the effectiveness of our system. The rest of the paper is organized as follows. Section 2 discusses related work. Section 3 provides the highlevel overview of Friendbook. Section 4 presents activity recognition and life style modeling and extraction. In Section 5, we describe the social graph construction and user impact estimation. We elaborate on the user query and friend recommendation in Section 6. We describe the feedback mechanism in Section 7. In Section 8, we evaluate the performance of Friendbook intensively with both simulations and real experiments. Finally, we conclude the paper and present the future work in Section 9.

Existing System:

Recommendation systems that try to suggest items (e.g., music, movie, and books) to users have become more and more popular in recent years. For instance, Amazon recommends items to a user based on items the user previously visited, and items that other users are looking at. Netflix and Rotten Tomatoes recommend movies to a user based on the user's previous ratings and watching habits. Recently, with the advance of social networking systems, friend recommendation has received a lot of attention. Generally speaking, existing friend recommendation in social networking systems, e.g., Facebook, LinkedIn and Twitter, recommend friends to users if, according to their social relations, they share common friends. Meanwhile, other recommendation mechanisms havealso been proposed by researchers. For example, Bian and Holtzman [8] presented MatchMaker, a collaborative filtering friend recommendation system based on personality matching. Kwon and Kim proposed a friend recommendation method using physical and social context. However, the authors did not explain what the physical and social context is and how to obtain the information.

Proposed System:

In this section, we give a high-level overview of the Friendbook system. Figure 2 shows the system architecture of Friendbook which adopts a client-server mode where each client is a smart phone carried by a user and the servers are data centers or clouds On the client side, each smart phone can record data of its user, perform real-time activity recognition and report the generated life documents to the servers. It is worth noting that an offline data collection and training phase is needed to build an appropriate activity classifier for real-time activity recognition on smartphones. We spent three months on collecting raw data of 8 volunteers for building a large training data set. As each user typically generates around 50MB of raw data each day, we choose MySQL as our low level data storage platform and Hadoop Map Reduce as our computation infrastructure. After the activity classifier is built, it will be distributed to each user's smart phone and then activity recognition can be performed in real-time manner. As a user continually uses Friendbook, he/she will accumulate more and more activities in his/her life documents, based on which, we can discover his/her life styles using probabilistic topic model.

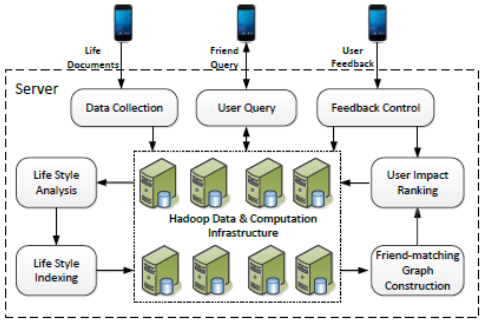

Fig. 2: System architecture of Friendbook.

LIFE STYLE EXTRACTION USING TOPIC MODEL

Life Style Modeling

As stated in Section 1, life styles and activities are reflections of daily lives at two different levels where daily lives can be treated as a mixture of life styles and life styles as a mixture of activities. This is analogous to the treatment of documents as ensemble of topics and topics as ensemble of words. By taking advantage of recent developments in the field of text mining, we model the daily lives of users as life documents, the life styles as topics, and the activities as words.

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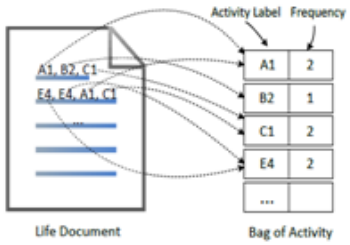


Fig. 3: Bag-of-Activity modeling for life document.

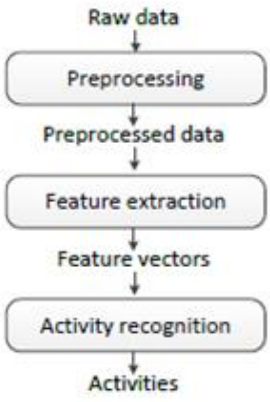


Fig. 4: The flowchart of activity recognition

FRIEND-MATCHING GRAPH AND USER IMPACT

To characterize relations among users, in this section, we propose the friend-matching graph to represent the similarity between their life styles and how they influence other people in the graph. In particular, we use the link weight between two users to represent the similarity of their life styles. Based on the friend-matching graph, we can obtain a user's affinity reflecting how likely this user will be chosen as another user's friend in the network.

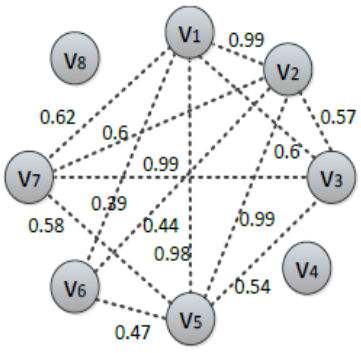


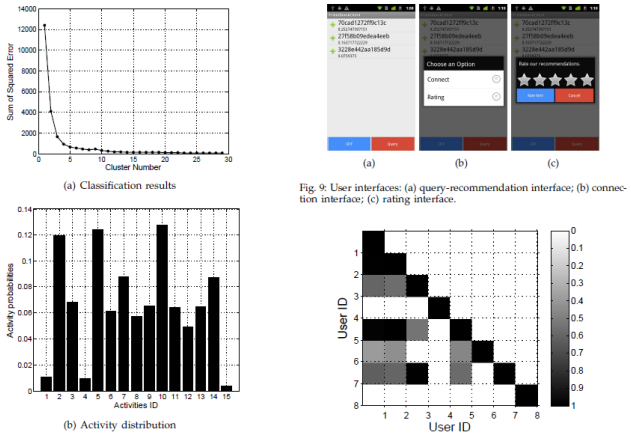
Fig. 6: An example of Friend-matching Graph for 8 users.

EVALUATION

In this section, we present the performance evaluation of Friendbook on both small-scale field experiments and large-scale simulations.

Evaluation using Real Data

We first evaluate the performance of Friendbook on small-scale experiments. Eight volunteers help contribute data and evaluate our system. Table 1 demonstrates the profession of these users. Most of them are students, while the rest include a businessman, an office worker, and a waitress. Each volunteer carries a Nexus smart phone with Friendbook application installed in advance.



(a) Classification results

(b) Activity distribution

8: Classification performance using the K-means clustering.

Fig. 9: User interfaces: (a) query-recommendation interface; (b) connection interface; (c) rating interface.

Fig. 10: The gray image representation of the eight users' similarity.

CONCLUSION

In this paper, we presented the design and implementation of Friendbook, a semantic-based friend recommendation system for social networks. Different from the Friend recommendation mechanisms relying on social graphs in existing social networking services, Friendbook extracted life styles from user-centric data collected from sensors on the smart phone and recommended potential friends to users if they share similar life styles. We implemented Friendbook on the Android-based smart phones, and evaluated its performance on both small scale experiments and large-scale simulations. The results showed that the recommendations accurately reflect the preferences of users in choosing friends

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