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Event recommendation in social networks based on reverse random walk and participant scale control

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HIGHLIGHTS

- Construct a heterogeneous graph for an event based social network.
- Propose a reverse random walk with restart to compute node proximity on the graph.
- Propose two algorithms to implement event participant scale control.
- Conduct experiments to confirm the superiority of the proposed scheme.

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ABSTRACT

With the merging of cyber world and physical world, event-based social networks have been playing an important role in promoting the spread of offline social events through online channels. Event recommendation in social networks, which is to recommend a list of upcoming events to a user according to his preference, has attracted a lot of research interests recently. In this paper, we study the event recommendation problem based on the graph theory. We first construct a heterogeneous graph to represent the interactions among different types of entities in an event-based social network. Based on the constructed graph, we propose a novel event scoring algorithm called reverse random walk with restart to obtain the user–event recommendation matrix. In practice, the participant capacity of an event may be constrained to a limited number of users. Then based on the user–event recommendation matrix, we further propose two participant scale control algorithms to coordinate unbalanced user arrangements among events. After the rearrangement, each user will be assigned a list of recommended events, which considers both local user preference and global event capacity. Experiment results on Meetup dataset show that the proposed method outperforms the state-of-art algorithms in terms of higher recommendation precision and larger recommendation coverage.

1. Introduction

Recent years have witnessed the popularity of *event-based social networks* (EBSNs), such as Meetup,[1] Plancast[2] and Tencent Event, acting as a bridge between the cyber world and the physical world. These EBSNs offer a convenient platform for users to establish and share various social events, including cocktail parties, concerts, outdoor hiking and etc. Furthermore, these EBSNs also apply some event detection techniques to discover upcoming events from the internet. For example, a real time event detection method based on social streams has been introduced in [1]. How to mine the variety internet data and discover new events remains the research interest of the Social Event Detection (SED) task of MediaEval.[3]

With the help of EBSN platforms, users could be easily informed about upcoming events from the cyber space and decide to attend

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1 http://www.meetup.com/.

2 http://www.plancast.com/.

3 http://www.multimediaeval.org/.

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offline events in the physical world according to his preferences. However, the number of upcoming events is often very huge, which makes searching interested events an cumbersome task for EBSN users. For example, Meetup currently has 16 million users with more than 300,000 monthly events [2]. Although some of the existing EBSNs provide users with the interface to retrieve, classify, and rank the events by manually setting some search conditions, it is still very difficult for users to express their preferences and locate interested events from the mass of resources, let alone expanding his preferences to some novel events. In order to help a user to quickly obtain his interested events, a good social event recommendation system is in demand according to his preference.

Event recommendation can be simply formulated as the following scoring problem. Let $U = \{u_1, u_2, \ldots, u_M\}$ and $E = \{e_1, e_2, \ldots, e_N\}$ denote the set of M users and N events, respectively. For a given user u_i, event recommendation is to rank the upcoming events in his preference order. Let $s_i(e_j)$ denote the preference score of user u_i to attend the event e_j. Let $L_i^K = \langle e_i^{(1)}, e_i^{(2)}, \ldots, e_i^{(K)} \rangle$ (normally, $K \ll N$) denote the list of recommended K events for user u_i, and in the order of preference score from large to small. For each user, the challenging work of event recommendation is to predict the preference score $s_i(\cdot)$ of each upcoming event. The basic objective is to improve the recommendation accuracy. Besides, recommendation diversity is also an important metric, which indicates the serendipity capability of finding novel yet interesting events for catering to users [3].

Unlike general item recommendation, such as recommending books, films and etc., a social event has its unique temporal and spatial characteristics. Before an event takes place, no one could have '*consumed*' it and offered a valid evaluation about the event [4], which raises the issue of new item cold-start problem. In practice, a common approach to alleviate this problem is to adopt the registration or RSVP mechanism. After an event is announced, a user can register this event, which reveals his intention of participation [5]. The location of a social event also plays a role in event recommendation [6]. Some users like to attend events near their homes; While some other users tend to participate in events in their favorite regions [7]. These two specific dimensions of social events determine that event recommendation would be much different from general item recommendation.

Event recommendation has more interesting characteristics in terms of heterogeneous social relations among users [8]. In Meetup, users form various online groups, and a user often joins multiple groups. Generally, users of a same online group share some similar interests. On the other hand, users share offline social interactions by co-attending offline social events, and those who have attended a same event are likely to show some similar preferences. People who share close connections in both the online and offline social networks are likely to have similar preferences towards future events. Thus capturing such characteristics of both online and offline social networks can help to predict a user's decision more effectively [9].

Since the emergence of collaborative filtering technology, the recommender system has been extensively researched in the last decade. This method is based on the past item evaluations from a large group of users. For each user, the system will firstly find its taste mates by computing similarity of the past evaluation vectors, and predict his preference to an unvisited item with the weighted average value of his fellows towards this item [10]. Another mainstream of research focus is the content-based recommendation, which recommends items that are similar to the content of previously preferred items of a target user [11]. However, the collaborative filtering approaches often encounter the data sparsity and cold-start problem [12]; While the content-based methods also have the technical bottleneck of content abstraction and preference localization. Furthermore, the two classic approaches have not fully explored the unique characteristics for event recommendation and all the possible connections in an event-based social network.

In this paper, we study the event recommendation from a graph-based approach with further considerations of event participant capacity. We first identify the factors that could represent a user's preference, including his geographic location, his online and offline social network connections, as well as his interests expressed by tags. To relieve the data sparsity problem, we conduct dimension reduction to abstract latent entities upon locations and tags. We then construct a heterogeneous graph model to express the interactions of multiple entities and convert the recommendation problem into a node-dependent proximity calculation problem on the heterogeneous graph. We propose a novel Reverse Random walk with Restart (RRWR) method to obtain the user–event recommendation matrix. Then based on this matrix, we further propose two participant scale control algorithms to coordinate unbalanced user arrangements among events. After the rearrangement, each user will be assigned a list of recommended events, which considers both local user preference and global event capacity. Experiment results on Meetup data show that our algorithm can outperform the state-of-the-art methods in terms of higher recommendation precision and larger recommendation coverage.

The rest of paper is organized as follows: Section 2 reviews the related work. Section 3 abstracts latent entities and constructs the heterogeneous graph. Section 4 proposes the reverse random walk with restart algorithms, and two participant scale control algorithms are presented in Section 5. Section 6 provides our experiment results, and the paper is concluded in Section 7.

2. Related work

We briefly review the related work on event recommendation from two aspects: factor-based and graph-based recommendation. We also review some recent efforts on event recommendation that incorporates some practical constraints.

2.1. Factor-based recommendation

In the factor-based recommendation, some latent factors that could impact on event recommendation are firstly extracted and then used as inputs for some score computation model [5,7,13–15]. For example, Guo et al. [14] construct two kinds of networks, and define three variations of relations between users in their work. In [15], Chen et al. propose to exploit a user's social interaction relations and collaborative friendships for event recommendation. The geographic location also influence a user's choice by either distance factor or his regional preference [7,16–19]. However some observations in [20] show that the distance factor is not a pivotal factor within the domain of a city. Tag-aware recommendation systems consider a user's interest expressed by tags [21]. As tags are not predefined by administrators, the number of tags is always very large and hard to interpret. Many approaches have been proposed to analyze tags, including topic-based models [22–24], network-based models [25] and tensor-based models [26,27]. In our work, we comprehensively consider the geographic locations, social interactions as well as the interest subjects to predict users' preferences to upcoming events.

2.2. Graph-based recommendation

In graph-based event recommendation, a graph is constructed to express the interactions of entities in a recommender system, where entities are represented as nodes and interactions between them are represented as edges [28–31]. Based on the graph model, the recommendation task is then converted into a node

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