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Multi-role event organization in social networks

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ABSTRACT

Recently, event-based social networks (EBSNs) have become popular, hence how to organize a social event has received significant attention. Most of prior studies about social events organization usually consider the willingness of attendees and their relationships. However, they ignore the roles of attendees. In fact, many social events have requirement of attendees roles in the real world. In this paper, we propose to study the problem of Multi-Role Social Event Organization (MRSEO). Our goal is to maximize the overall harmony of the social event while considering multiple factors, such as attendees' roles, willingness and their relationships. To solve the problem, we propose two algorithms. Firstly, we propose a continuous relaxation technique based algorithm, called MRSEO-CRA. It converts the problem of MRSEO to an equivalent unconstrained continuous problem, and then employs *RatioDCA* algorithm to solve the converted one. Secondly, to better trade off between performance and running time, we further propose the other algorithm based on improved PageRank, called MRSEO-IPR. We conduct extensive experiments on real-world datasets to evaluate these two proposed algorithms and experimental results show that our algorithms outperform the state-of-the-art algorithm in terms of performance and running time.

1. Introduction

Social networks have become popular media for people of all ages to obtain and exchange information. In recent years, the emergence of event-based social networks (EBSNs) brings more and more attention to the study of social events. There are usually two important parts involved in a social event, i.e., event participants and organizers. For event participants, much effort has been done to recommend appropriate events according to their preference, location, age etc. [16,18,20,24,27]. For event organizers, how to organize a social event is more challenging, since there are many restricted conditions, such as the number of participants and event place, and manually attendees selecting process is tedious and time-consuming, especially for a large group of people. Although existing EBSNs provide a public event information sharing platform, an effective and efficient event organization strategy is absent. Therefore, it calls for an efficient automatic attendees selecting approach to organize social events.

In academia, there are a few studies focusing on how to better organize an event. Shuai et al. [29] select a set of attendees for maximizing their willingness to participate in the event. Feng et al. [7] and Yu et al. [32] search for the most influential and preferable invitee set to influence the largest number of persons to participate in the event. However, they

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assume that all of candidates are homogeneous and ignore that some events require attendees with different roles. Naturally, in real world situations, events typically come with role constraints. Here, to illustrate the point, we give two examples. The first one is most sports activities need multiple roles of participants, like forming a soccer team which needs coaches, leader, soccer players (goalkeeper and other players) and team doctor. The second one is some academic conferences need lots of scholars in different fields, such as network, language processing, artificial intelligence and data mining, where the different fields indicate the different roles.

In this paper, to bridge this gap, we formulate a new optimization problem from organizers' perspective, which considers multiple roles of attendees for organizing a social event, named *Multi-Role Social Event Organization (MRSEO)*. Specifically, given a set of persons who are socially connected and have varying roles and inherent interests in the event, we need to select a demanding sized sub-group of attendees for each role such that the overall harmony of the group is maximized. Here, the harmony of a social event, derived from the literatures, is defined as a linear combination of (i) interests of attendees and (ii) relationships between them [15,29]. Studies show that the above two factors influence not only the decision of a person joining in a social event but also the overall atmosphere of the social event. For example, Bob hesitates in making a decision to participate in an event until his friend Alice tells him her participant information on this event. Given that Bob and Alice are close friends and have the same interest, Bob finally attends the event together with Alice. Attending this event with his friends, instead of his foes, will help Bob enjoy it more, and the event will have a good and harmonizing atmosphere.

We prove that the problem of *MRSEO* is NP-hard. Specifically, it is a constrained discrete combinatorial optimization problem. Therefore, it cannot be addressed optimally in polynomial time. To address this problem, we propose two different algorithms, called *MRSEO-CRA*, based on continuous relaxation technique and heuristic parallel algorithm, called *MRSEO-IPR*, based on the improved PageRank.

The core idea of *MRSEO-CRA* is as follows. Firstly, we employ exact penalty approach to convert original constrained discrete problem to an unconstrained discrete problem for simplifying the original one. Secondly, based on the concept of *Lovasz extensions*, we convert the unconstrained discrete problem to an equivalent unconstrained continuous problem. Finally, we employ a mature algorithm for continuous optimization to find a local optimal solution.

The *MRSEO-CRA* can effectively solve the problem of *MRSEO*, however, it incurs high time complexity. To achieve a better tradeoff between performance and running time, we propose the heuristic parallel algorithm *MRSEO-IPR*. Firstly, we select important nodes as hub nodes and seed nodes based on the improved PageRank approach. Then, based on the nodes selected in above step, we design a greedy seed expansion strategy to maximize the harmony of the social event. The seed node identifying step and the second step are executed in parallel for each role to reduce running time. Finally, we propose an efficient replacement strategy to replace the nodes which violate the restricted conditions in the solution.

The key contributions of this paper are listed as follows:

- To the best of our knowledge, this is the first attempt to consider the roles of attendees in the social event organization problem.
- We propose two effective algorithms to address this problem. One is based on continuous relaxation technique, called *MRSEO-CRA*, and the other is a heuristic parallel algorithm based on improved PageRank, called *MRSEO-IPR*.
- We conduct extensive experiments on real-world datasets. The experimental results show that our algorithms outperform the state-of-the-art algorithm in terms of performance and running time.

The rest of the paper is organized as follows: in Section 2, we formally define the *MRSEO* problem. In Section 3 and Section 4, we present our proposed algorithms, i.e., *MRSEO-CRA* algorithm and *MRSEO-IPR* algorithm, respectively. In Section 5, we evaluate the proposed algorithms on real datasets. In Section 6, we review the related works. At last, we conclude the paper in Section 7.

2. Problem statement

2.1. Preliminary

A social network is represented as an undirected weighted graph $\boldsymbol{G} = (\boldsymbol{V}, \boldsymbol{E})$, where $\boldsymbol{V}$ denotes a node set and $\boldsymbol{E}$ denotes an edge set. A node $v_i \in \boldsymbol{V}$ denotes a candidate person and is associated with a role attribute r_i and an interest score b_i of the person for the social event. Regarding the role attribute, we assume that there are m roles in total and use $\boldsymbol{a} = \{a_1, a_2, ...a_u, ...a_m\}^T$ to denote the set of different roles. Regarding the interest score, a higher value of b_i indicates that the person v_i is more interested in this social event. An edge $e_{ij} \in \boldsymbol{E}$ represents the mutual familiarity between persons v_i and v_j and is associated with a social tightness score w_{ij}. A higher value of w_{ij} indicates a tighter connection between persons v_i and v_j. Refer to Table 1 for a list of the frequently used notations in this paper.

2.2. Problem definition

Given a social network $\boldsymbol{G}$, the problem of *Multi-Role Social Event Organization (MRSEO)* is to find a set $\boldsymbol{F}$ of nodes (participants) with size k and m kinds of roles so that the harmony $H(\boldsymbol{F})$ is maximized. Here, the set $\boldsymbol{F}$ needs to satisfy the following rules: i) The set $\boldsymbol{F}$ is composed of m subsets of nodes with different roles, e.g., $\boldsymbol{F} = \boldsymbol{F}_1 + \boldsymbol{F}_2 + ... + \boldsymbol{F}_u + ... + \boldsymbol{F}_m$, where $\boldsymbol{F}_u$ is