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Identifying conflict patterns to reach a consensus – A novel group decision approach

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ABSTRACT

In recent years, the group ranking problem has become an important subject of study. In most group ranking problems, the focus is on identifying consensuses. No previous research has involved identifying conflicting opinions, called conflict patterns in this paper, among decision-makers. We define conflict patterns as orderings of alternatives that have roughly the same numbers of advantages and disadvantages. Conflict patterns can reveal the ranking of which alternatives are the most controversial among decision-makers and who the supporters and opponents are. Using conflict pattern data, decision-makers can communicate with people with differing opinions and attempt to resolve the differences.

In this study, an algorithm, Mining Conflict Patterns, was developed to identify conflict patterns from users' partial ranking data. Extensive experiments were conducted using synthetic and real data sets. The results indicate that the proposed method is computationally efficient and can effectively identify conflict patterns among all users.

1. Introduction

In organizations, numerous complexities or emergencies must be resolved by experts. Experts' opinions may be diverse, and therefore, conflicts may develop among experts. In this situation, majority rule does not seem to be an appropriate approach to obtaining a result. The conflict-elimination process is vital in obtaining a consensus from experts with diverse backgrounds with little resulting conflict. Consequently, developing a methodology for facilitating the understanding and analysis of conflict is a crucial research objective.

Consensus decision-making, when participants make decisions using consensuses rather than a majority vote, has become a major area of study. Generally, consensus decision-making entails conducting two processes before obtaining a final solution (Wu & Xu, 2012). First, the maximum degree of consensus between sets of experts is obtained. Next, a mechanism for generating advice on whether experts should change or maintain their preferences in order to reach a solution with a high degree of consensus and consistency is proposed. However, the process of generating a consensus from a great diversity of opinions leads to conflict. Therefore, identifying a method for resolving conflicts to gain a consensus in a group is the core of the group ranking problem (Huang, Chang, Li, & Lin, 2013). Discovering conflict patterns is the most efficient method for assisting decision-makers.

In recent years, the group ranking problem has become a vital subject of study. This technique has been applied widely in numerous contexts, such as decision-making, machine learning (Cook, Golany, Kress, Penn, & Raviv, 2005; Cook, Golany, Penn, & Raviv, 2007), web search strategies (Manning, Raghavan, & Schütze, 2008; Su & Khoshgoftaar, 2009), and group recommender systems (Adomavicius & Tuzhilin, 2005; Chen & Cheng, 2008; Lee, Cho, & Kim, 2010). The task of the problem is to obtain a group ranking that can represent the involved individuals' opinions. In general, the problem is solved by aggregating different users' opinions and identify a consensus pattern that can represent the group ranking. Decision-makers can then reference this ordered aggregate to make their decisions.

Research on group ranking problems usually emphasizes the identification of consensus patterns. However, it is also important to note the differing opinions, called conflict patterns. The utility of team decision-making is not simply a function of the quality of the decision made. Effective team decision-making also requires member commitment to the decision. Therefore, it is imperative for a manager to identify conflict patterns and, accordingly, solve the problem and avoid discordance in the organization.

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Our research aimed to develop a method and an algorithm for identifying conflict patterns. The proposed algorithm can help decision-makers identify differing opinions and thus make decisions more carefully and consider them more comprehensively.

In our research, we assumed that the input data sequence of each user is a partial ranking list of items. Specifically, to express preferences, the user ranks only items that he or she can rank rather than ranks all items. The advantage of this approach is that the user has the freedom to omit the rankings of items that he or she is unfamiliar with. Subsequently, we use partial ranking lists as the input data. On the basis of the aforementioned input format, this paper proposes an algorithm, Mining Conflict Patterns (MCP), for identifying conflict patterns in users' partial ranking lists.

This paper is divided into six sections. Our motivations are discussed in Section 1. In Section 2, we review related work. We then define the problem of Mining Conflict Patterns in Section 3. In Section 4, we discuss the development of the algorithm. Experimental results are presented in Section 5. Finally, we draw conclusions.

2. Related work

The group ranking problem can be classified into three dimensions: the completeness of preference information provided by users, the type of input format, and the compromised output format. According to the completeness of preference information provided by decision-makers (Hochbaum & Levin, 2006), approaches can be divided into two types: the total ranking approach (Chen & Cheng, 2009; Cook, Kress, & Seiford, 1997; Noguchi, Ogawa, & Ishii, 2002; Saaty, 1994) and the partial ranking approach (Chen & Cheng, 2010; Cook et al., 2007; Greco, Mousseau, & Słowiński, 2008; Hochbaum & Levin, 2006). The total ranking approach requires users to order all alternatives, whereas the partial ranking approach only requires ordering a subset of alternatives (Ma, 2010). The disadvantage of the total ranking approach is that users must rank all items even if they are not familiar with some of them. This may generate deviations and affect the results. Another disadvantage is that it is tedious for users to provide all input preference information. An excessively high number of items that must be ordered impose a heavy burden on users.

In contrast to total ranking, partial ranking is a more flexible and user-friendly method. Users must only rank a subset of items when providing input preference information, reducing the users' workload. The goal of most partial ranking approaches is to obtain a full ranking from user input data. However, Cook proved that the aggregated results do not provide a full ranking in some cases (Cook et al., 2005). In our research, we used the partial ranking method to reduce the load and increase the flexibility of the order.

There are three input formats used for group ranking problems: weighting models, pairwise comparisons, and ranking lists. For weighting models, users can use weights, or scores, to order the items. It is easy for users to express their preferences by using this format. However, users sometimes experience difficulty in expressing their preferences as precise numerical values (Damart, Dias, & Mousseau, 2007). This format is also prone to biases because of different evaluation standards among group members (Hochbaum & Levin, 2006). The pairwise comparison format is an intuitive and simple method for users to express their preferences among different items (Cook et al., 2007; Hochbaum & Levin, 2006). Nevertheless, using this format may become tedious if there are large numbers of alternatives. Most ordinal ranking problems use distance measures. To minimize the number of disagreements, Cohen developed a greedy-like algorithm to combine multiple rankings (Cook et al., 2005). Saaty (1994) developed the analytical hierarchical process (AHP) to facilitate solving multicriteria decision-making problems. The pairwise comparison method is used in the AHP to identify the relative importance of different criteria (Dong, Zhang, Hong, & Xu, 2010; Dyer & Forman, 1992; Saaty, 1994). The output is ranking lists. The AHP is more general and flexible and can be applied to total rankings and partial rankings. However, it has shortcomings: a user may be unfamiliar with some of the items, and it also requires substantial effort from users in preparing (ranking) the input data. In our research, after considering the flexibility and load, we used the ranking list method for our input data.

Table 1
A sample of five users' database.

u_i	s_i
1	$i_1 > i_2 > i_4 > i_3 = i_5$
2	$i_4 > i_1 = i_2 > i_3 = i_5$
3	$i_3 = i_5 > i_4 > i_1 > i_2$
4	$i_2 > i_1 > i_4 > i_3 = i_5$
5	$i_2 = i_4 > i_1 > i_3 > i_5$

The enforced approach involves enforcing rules to obtain a complete result or partial results. Hence, the approach always obtains consensus results even if there is no, or only a slight, consensus on rankings. In general, because of their different designs, different algorithms yield different ranking results. The results of a consensus approach indicate only what the consensuses of users are. Maximum consensus lists refer to the fact that every consensus list is constructed on the basis of users' consensuses (Chen & Cheng, 2009, 2010). However, a maximum consensus list may have numerous consensus sequences that must be inspected, and the results appear fragmented and are difficult to understand and analyze. A consensus graph can remedy the problem of maximum consensus lists (Chen, Cheng, & Huang, 2013). To the best of our knowledge, there is no research on conflict patterns. Therefore, it does not belong to a consensus list or a preference graph. In this work, we generate conflict patterns from the partial ranking lists of users.

3. Problem definition

In this section, we formally define the problem of identifying conflict patterns from users' partial ranking data. Let $U=\{u_1, u_2, \ldots, u_n\}$ denote all users and $I=\{i_1, i_2, \ldots, i_m\}$ denote the sets of all distinct items. Each user u_i has a sequence of items for expressing his or her preference. However, some items may be missing in the list because it is not necessary that all items appear in the list. The user sequence of user u_i can then be represented as a user sequence $S_i=\{a_1 \oplus a_2 \oplus \cdots \oplus a_m\}$, where (1) $a_r \neq a_s$ if $r \neq s$, (2) $a_r \in I$ if $1 \leq k \leq m$, and (3) $\oplus \in \{>, \geq, =\}$. (4) Note that not all items appear in S_i.

If the comparator is "$>$," the preceding item is more preferable than the succeeding item. If the comparator is "$\geq$," the preceding item is more or equally preferred to the succeeding item. Otherwise, u_i has the same preference for both items. The number of items in a sequence is the length of the sequence. A sequence whose length is k is referred to as a *k-sequence*.

For example, if there are five items, $I=\{i_1, i_2, i_3, i_4, i_5\}$, and the user u_1's sequence S_1 is a four-item sequence, $S_1=\{i_2 \geq i_3 = i_5 > i_4\}$, then u_1 has a stronger or equal preference for i_2 relative to i_3. In addition, u_1 has an equal preference for i_3 and i_5. Finally, i_4 is the least preferred item in u_1's list. Regarding i_1, u_1 may have no opinion.

Consider the five ranking lists in Table 1. Using our approach, if a parameter r is set to detect that conflict patterns are $i_1 > i_2$ and $i_2 > i_1$, then decision-makers can determine a complete solution based on conflict patterns. However, the proposed algorithm relaxes the consensus constraint to identify that the longest maximum consensus sequences are $\{i_1 > i_4 > i_3 = i_5\}$ and