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An algorithmic approach to group decision making problems under fuzzy and dynamic environment

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ABSTRACT

Our paper introduces a new methodology to solve group decision-making problems under fuzzy and dynamic environment. The methodology takes group members' linguistically defined pair wise preferences of alternatives in different time intervals and aggregates them across the intervals to obtain each member's net preference levels. Each member's net preference levels are again aggregated across the members to obtain the group's preference. Our paper attaches higher importance to the members whose involvement in the decision process is more recent than the members who opined their views in the past. The fuzzy aggregation operator, IOWA (Induced Ordered Weighted Average) is used to aggregate their views in accordance to their importance in the group. The Ranked_List algorithm, introduced in our paper, inputs the aggregated views of the members in pair wise form and produces the set of sequences of ranked list of alternatives representing the group's consensus view as output. The Ranked_List algorithm is validated and analyzed through a series of synthetic data sets and its results are compared with a movie selection case study. The methodology is illustrated with a numerical example.

1. Introduction

In any group decision-making (GDM) problem, a decision maker (DM) considers the group members' views to select the best alternative(s) from the available alternatives or rank them according to their preferences (Hochbaum & Levin, 2006). The members, in general, give their preferences in linguistic terms by comparing a pair of alternatives. The members may give different views about the same set of alternatives over a time-period due to changing environmental situations such as addition /deletion of new/old information, members' lack of knowledge, impreciseness in preference relations etc. For example, views on product's popularity, marketing campaigns, stock valuations, brand value of a corporate or personality do vary from time to time in a given time period. The changing preferences indicate the members varying perceptions and the mindset in the decision making process. Further, as their opinions are fuzzy and vague and do vary over the time, it is difficult to judge their exact preference at any point of time. Thus it would be unrealistic for DM to take the last preference as the final choice as the preferences are dynamic and change depending on the context and the environment. Our paper attempts to capture the members' mindset by taking his/her opinions in the recent past (not the opinions which were given long-ago). Methodologies given in Xu and Yager (2008), Tsai, Yang, Leu, Lee, and Yang (2013) are based on members' multi-period views concerning investment decisions, medical diagnosis, military system efficiency etc. It becomes important not to ignore the members' variant views as it only masks the reality and gives an unwarranted veil of pseudo accuracy to the preference analysis. Furthermore, when there is a significant variation in the member's opinions, taking a member's singular view may often distort the analysis, and lead to wrong decisions.

Our paper incorporates member's variant opinions in GDM and obtains a methodology to solve GDM in a dynamic environment. The members' linguistic preferences are represented as fuzzy numbers and measured through a basic linguistic term set S defined in our paper. The number of basic linguistic terms in S depends on the level of granularity of uncertainty in the members' opinions. Initially, each member's pair wise preference statements in different time intervals are collected and matched to a linguistic term in S. Then these preferences are aggregated across the time intervals to obtain the net view of the members. In order to have a consensus amongst the members, one can select the process of negotiation (Wachowicz & Blaszczyk, 2013) (Pérez, Wikström, Mezei, Carlsson, & Herrera-Viedma, 2013) or aggregation (Herrera, Herrera-Viedma, & Verdegay, 1997),

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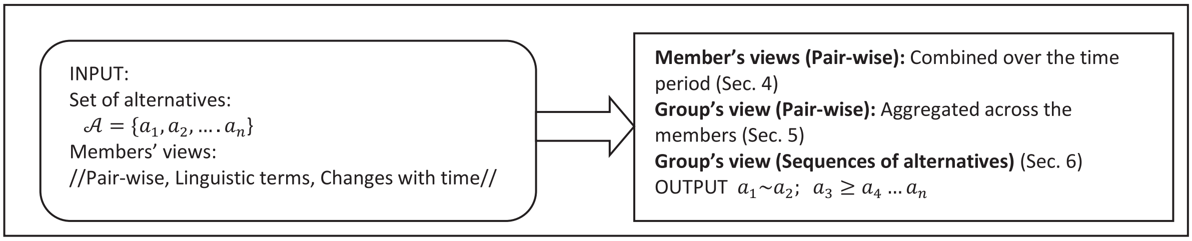

Fig. 1. Schematic view of GDM in fuzzy and dynamic environment.

(Cabrerizo, Moreno, Pérez, & Herrera-Viedma, 2010). In the method of negotiation, the members are asked to reassess their views continually until the consensus is reached. On the other hand, the aggregation process takes the members' opinions and analytically aggregates to obtain a consensus agreement. Our paper focuses on the methodology of aggregation. The aggregation operator IOWA (Yager 2003) is used to aggregate the members' preferences in accordance to their importance in the group. The members' importance is derived through a new concept "member's recentness" which is defined in our paper. The operator IOWA uses members' importance as it orders parameters to aggregate the members' views as per their importance and obtains the group view in pair-wise form. The other contribution of our work is to convert the group's pair-wise preference of alternatives into several ranked lists of alternatives (not pair-wise) in the form of sequences to represent the group's views. The alternatives that are placed in different sequences are not comparable. The algorithm Ranked_List, introduced in our paper, obtains the above results as the outputs after taking the members' pair-wise preferences of alternatives as inputs.

The schematic view of our procedure is shown in Fig. 1.

The proposed methodology has wide applications in today's internet era. Members or consumers express their views on sites such as Yahoo, blogs, Face-book, Twitter etc. very frequently. These linguistically defined views may vary from time to time depending on the needs and the trend in the market. For instance, information may be about tourist destinations (good, enjoyable, pleasant etc), music (interesting, enjoyable,) shares in the stock markets (little risk, good return, good resale value), product reviews in the market (good, less maintenance, good experience) etc. Application of our methodology will suggest a good tourist destination or a suitable product, after combining the available dynamic information from the social network sites. Other possible applications of our methodology may be in the supply chain management. In this case, different departments may have their own preferences in supplier selections, which may vary from time to time depending on their requirements. Our methodology can be used to select the suppliers, under multiple preferences of the departments that vary over a time. The variances in the departments' preferences are mainly caused by market situations, logistic constraints, and retailer demands. Another potential application could be in any organization. In general, a committee of in-house members decides an employee's promotion based on the qualities like (1) emotional steadiness (2) oral and written communication skill (3) personality (4) relevant experience and (5) self -confidence. It is expected that the committee members should have the stable opinion about the person on the above attributes. However, in reality, the members do change their views from time to time about the same person on the above qualities depending on the various environmental factors and the needs of the organization. Our work can accommodate these changes and suggest a suitable solution for the above problem.

In Section 2, literature related to our work is given. In Section 3, we provide a brief description of the linguistic concepts. In Section 4, we give a methodology to aggregate the member's view over the time-intervals. Section 5 describes the procedure to obtain the aggregated view of the members as group's pair-wise preference. Ranked_List algorithm is given in Section 6. In Section 7, the methodology is illustrated with a numerical example and the experimental results of Ranked_List algorithm are discussed. Finally, in Section 8, some concluding remarks are made.

2. Related work

Many works are available in the literature (Kacprzyk & Fedrizzi, 1990), (Morais & Almeida, 2011), (Yu & Lai, 2011), (Bouzarour-Amokranea, Tchangania, Ayeley, & Peresa, 2015), (Mohanty, 1998) for the resolution of GDM problems. Some recent interesting development has been for resolution of GDM through visual procedures (Palomares, Liébana, López, & Herrera, 2014), (Palomares, López, & Herrera, 2014), (Palomares, López, & Herrera, 2014). The graphical representation of GDM resolution aids in understanding of evolution of consensus in the group and are especially helpful in case of large number of alternatives. Most of them are in static environment and a few of them are in a dynamic environment. To our knowledge, no methodology is available in the literature, where all the features of group decision making such as fuzziness and incompleteness in the members' statements, member's divergent views in time intervals and their importance based on their timings of involvement are simultaneously considered. In Morais and Almeida (2011),Yu and Lai (2011), Yager (2001), the members are asked to evaluate a complete set of alternatives either by giving their attribute wise utility values or comparing them pair wise in numeric, linguistic or in ordinal scales. In Bouzarour-Amokranea et al. (2015), the members are required to provide the degree of supportability and rejectability of all the alternatives. This is deviant from real life situations where the members do not have knowledge or interest to evaluate the entire set of alternatives. In Chen and Cheng (2009), Chen and Cheng (2010), Cook, Golany, Penn, and Raviv (2007), the group members are asked to submit a partial preference list of the alternatives. The methodologies (Chen & Cheng, 2009), (Chen & Cheng, 2010), (Cook et al., 2007) consider partial preference information in precise form. Their approach is not applicable for situations with vague information (Mardani, Jusoh, & Zavadskas, 2015). There are some other works where the members' imprecise information in GDM is incorporated using fuzzy sets (Guha & Chakraborty, 2011), (Chen & Lee, 2010), (Parreiras, Ekel, & Morais, 2012), (Zhang, Ma, Liu, & Liu, 2012), (Garcıa, Moral, Martínez, & Viedma, 2012), (Lee, 2012) in static environment. Based on additive and order consistency the paper by Lee (2012) has solved GDM having incomplete fuzzy preference relations. In Herrera, Herrera-Viedema, and Verdegay (1996), a direct approach of solving a GDM problem with linguistic inputs of the members is given. Using the concepts of dominance and strict dominance, then alternatives are ordered as the consensus decision. In Rodríguez, Martinez, and Herrera (2013), an algorithm is given for linguistic group decision model that facilitates the elicitation of flexible and rich linguistic expressions using