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Consensus-based decision support for multicriteria group decision making ☆

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ABSTRACT

Consensus decision making is complex and challenging in multicriteria group decision making due to the involvement of several decision makers, the presence of multiple, and often conflicting criteria, and the existence of subjectiveness and imprecision in the decision making process. To ensure effective decisions being made, the interest of all the decision makers usually represented by the degree of consensus in the decision making process has to be adequately considered. This paper presents a consensus-based approach for effectively solving the multicriteria group decision making problem. The subjectiveness and imprecision of the decision making process is adequately handled by using intuitionistic fuzzy numbers. An interactive algorithm is developed for consensus building in the group decision making process. A decision support system framework is presented for improving the effectiveness of the consensus building process. An example is presented for demonstrating the applicability of the proposed approach for solving the multicriteria group decision making problem in real world situations.

1. Introduction

Decision making in real world often takes place in a group setting, in which multiple, and usually conflicting criteria are required to be considered simultaneously (Liu & Hai, 2005; Muralidharan, Anantharaman, & Deshmukh, 2002; Sreekumar & Mahapatra, 2009). To effectively solve this problem, multicriteria group decision making approaches are often used. In this context, multicriteria group decision making involves in evaluating and selecting alternatives with respect to multiple, often conflicting criteria with the participation of multiple decision makers (Muralidharan et al., 2002; Wibowo & Deng, 2009). To ensure effective decisions being made in this situation, a certain level of consensus among all the decision makers has to be reached (Sreekumar & Mahapatra, 2009; Wibowo & Deng, 2009).

Consensus decision making in a multicriteria group decision making setting is a process of seeking a reasonable agreement from all the decision makers in a given situation regarding all the alternatives for facilitating the selection of the best alternative across all the criteria (Herrera-Viedma, Martínez, Mata, & Chiclana, 2005). The process of reaching a certain level of agreement among all the decision makers usually referred to as consensus building is complex and challenging Herrera-Viedma et al., 2005; Muralidharan et al., 2002). This is because (a) individual decision makers may not share the same opinion about the alternatives, (b) they may express their opinions or assessments in a subjective and imprecise manner, and (c) the decision making process is cognitively demanding on the decision makers (Ben-Arieh & Chen, 2006; Sreekumar & Mahapatra, 2009).

Much research has been done on the development of various approaches for solving the multicriteria group decision making problem (Liu & Hai, 2005; Muralidharan et al., 2002; Sreekumar & Mahapatra, 2009). These approaches can be classified into (a) majority-based approaches, (b) ranking-based approaches, and (c) consensus-based approaches. The majority-based approach focuses on a voting process in which the decision is based on the opinion of the majority of the decision makers. This approach is popular due to its simplicity in concept and its easiness to obtain the responses from the decision makers (Herrera-Viedma et al., 2005). It is, however, often criticized due to the time consuming voting process and the inadequacy in modeling the subjectiveness and imprecision of the decision making process.

The ranking-based approach requires individual decision makers to allocate numerical scores in assessing the performance of the alternatives and the importance of the criteria in the decision making process. Those scores are then aggregated in a specific manner for producing an overall performance index for each alternative across all criteria, on which the decision is made (Chen & Hwang, 1992). This approach is effective for solving the

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multicriteria group decision making problem under specific circumstances. It is simple in concept and easy to use. It is, however, cognitively demanding on the decision makers.

The consensus-based approach recognizes the importance of reaching a certain level of agreement among the decision makers in multicriteria group decision making for facilitating the acceptance of the decision made. It usually involves in an interactive process for building the consensus among the multiple decision makers in the decision making process. This approach has proven to be practical in multicriteria group decision making. However, it usually requires tedious mathematical computation in the decision making process.

This paper presents a consensus-based approach for effectively solving the multicriteria group decision making problem. The subjectiveness and imprecision of the human decision making process is modeled by using intuitionistic fuzzy numbers. An interactive algorithm is developed for consensus building in the group decision making process. A decision support system (DSS) framework is presented for improving the effectiveness of the consensus building process. An example is presented for demonstrating the applicability of the proposed approach for effectively solving the multicriteria group decision making problem in real world situations.

In what follows, we first present a review of existing approaches for consensus-based multicriteria group decision making. We then present an interactive algorithm for facilitating consensus building in the multicriteria group decision making process. This is followed by the development of a DSS framework for improving the effectiveness of the decision making process. Finally, we present an example for demonstrating the applicability of the proposed approach for solving the real multicriteria group decision making problem.

2. Consensus-based multicriteria group decision making

Consensus-based decision making is a group decision making process that seeks a certain level of agreement from all the decision makers regarding all the possible alternatives in a given situation (Ben-Arieh & Chen, 2006). It is an iterative process in which individual decision makers are able to express their views in order to achieve a certain level of agreement for making the decision. Consensus-based decision making is popular in multicriteria group decision making due to its ability to (a) reduce the conflict among the decision makers, (b) increase the participation of the decision makers, and (c) improve the acceptance of the decision outcome (Kahraman, Engin, Kabak, & Kaya, 2009; Xu, 2009).

Consensus building is an essential part of the consensus-based decision making process. It can generally be classified into (a) hard consensus and (b) soft consensus (Herrera-Viedma et al., 2005). The hard consensus can be represented by an interval [0, 1] where 0 indicates there is no agreement and 1 indicates a full agreement among the decision makers. The soft consensus allows the decision makers to reach a consensus when most of the decision makers involved in the group decision making process agree on a specific issue. This allows the decision makers to assess their opinions in a more flexible manner (Ross & Jayaraman, 2008). Obtaining a hard consensus is almost impossible in real decision making situations (Herrera-Viedma et al., 2005; Xu, 2005). This is due to the inherent subjectiveness and imprecision in the decision making process. As a result, soft consensus building is desirable for solving the multicriteria group decision making problem in real situations.

Much research has been done on the development of numerous approaches for consensus-based multicriteria group decision making (Herrera-Viedma et al., 2005; Kahraman et al., 2009; Parreiras, Ekel, Martini, & Palhares, 2010; Xu, 2009, 2005; Zhang, Zhang, Lai, & Lu, 2009). Herrera-Viedma et al. (2005), for example, present a consensus-based approach for solving the multicriteria group decision making problem. This approach is based on a multi-granular linguistic methodology and a consensus degree and a proximity measure. The multi-granular linguistic methodology is introduced to allow the unification of the different linguistic terms used in the decision making process for facilitating the determination of the consensus degree among decision makers. The proximity measure is used to find out how far individual opinions are from the group opinion. The approach is applicable in the group decision making situation in which multi-granular linguistic preference relations are present. The consensus building process, however, may become cumbersome when the number of alternatives and criteria is large.

Xu (2005) proposes a consensus-based approach for multicriteria group decision making. With the use of this approach, each decision maker is required to provide his/her assessments over the alternatives with respect to each criterion, leading to the construction of an individual decision matrix. The developed approach then aggregates these individual decision matrices into a group decision matrix (Herrera, Herrera-Viedma, & Verdegay, 1996). An iterative algorithm is employed for consensus building through the adoption of the agreement matrix in solving the group decision making problem. The approach is practical for consensus building in solving the multicriteria group decision making problem. It, however, requires tedious mathematical computation in solving the multicriteria group decision making process.

Kahraman et al. (2009) develop a consensus-based approach for selecting and ranking information systems providers. A similarity measure is developed for measuring the consensus level among the decision makers. The technique for order preference by similarity to ideal solution (TOPSIS) (Chen & Hwang, 1992; Deng, Yeh, & Willis, 2000) is adopted for determining the weights of the evaluation criteria, leading to the finalization of the overall ranking of all the alternatives of information systems providers. The approach is capable of providing objective information in the group decision making process. It is, however, cognitively demanding on the decision makers in the decision making process.

Zhang et al. (2009) develop a novel approach for reaching consensus in solving multicriteria group decision making. Linguistic variables are used to assess the weights of all selection criteria and the performance of each alternative with respect to each criterion. A fuzzy synthetic evaluation method (Deng, 1999; Lu, Lo, & Hu, 1999) is employed to attain the consensus in the group via the agreement matrix for solving the group decision making problem. The approach is efficient for solving the multicriteria group decision making problem in a fuzzy environment. It, however, requires complicated mathematical computation, and is very demanding cognitively on the decision makers in the decision making process.

Parreiras et al. (2010) propose a consensus approach for solving the multicriteria group decision making problem using linguistic assessments in a fuzzy environment. Their approach allows the generation of a consistent group opinion based on the opinions of individual decision makers represented by multi-granular fuzzy numbers. The approach is intuitive and flexible as it allows the decision makers to change their own opinions in the decision making process. It is, however, computationally demanding on the decision makers.

The discussion above shows that there are numerous consensus-based approaches for solving the multicriteria group decision making problem. These approaches are useful in dealing with the multicriteria group decision making problem under various circumstances. Most of these approaches, however, are cognitively demanding on the decision makers in the decision making process. Furthermore, some of these approaches require tedious mathematical computation in the decision making process. To effectively