Information Sciences 334–335 (2016) 338–353

Contents lists available at ScienceDirect

Information Sciences

journal homepage: www.elsevier.com/locate/ins

An outranking sorting method for multi-criteria group decision making using intuitionistic fuzzy sets

Feng Shen [a], Jiuping Xu [b,*], Zeshui Xu [b]

[a] School of Finance, Southwestern University of Finance and Economics, Chengdu 611130, China
[b] Uncertainty Decision-Making Laboratory, Sichuan University, Chengdu 610064, China

ARTICLE INFO

Article history:
Received 12 February 2015
Revised 21 October 2015
Accepted 8 December 2015
Available online 12 December 2015

Keywords:
Multi-criteria group decision making
Intuitionistic fuzzy sets
Outranking relations
Sorting method
Bridge risk assessment

ABSTRACT

In real world multi-criteria group decision making (MCGDM) problems, the decision making information provided by the decision makers is often imprecise or uncertain because of a lack of data, time pressure, or the decision makers' limited information-processing capabilities. Intuitionistic fuzzy sets, however, have been shown to have greater imprecision and an increased ambiguity than ordinary fuzzy sets. For these reasons, this paper proposes a new outranking sorting method for group decision making using intuitionistic fuzzy sets. Based on a proposed intuitionistic fuzzy support function, risk function and credibility function, we first propose a new method for the construction of an intuitionistic fuzzy outranking relation to exploit the sorting problems. Then we extend the proposed intuitionistic fuzzy sorting method to take account of group decision techniques and to develop an adaptive search and adjustment approach for the group consensus. Finally, a numerical example for a bridge risk assessment is provided to elucidate the details of the proposed method, and then this method is compared with other current methods to further demonstrate its flexibility.

1. Introduction

Multi-criteria decision making (MCDM) provides a systematic quantitative approach for decision making problems involving multiple criteria and actions and can assist decision makers in rationally considering all the important objective and subjective criteria for a problem [10]. Over the past few decades, many MCDM methods have been developed to solve the real-life problems in the fields of management science and operations research [3,12,14,15]. However, with the increasing complexity of the social-economic environment, many organizations have moved from a single decision maker to a group of experts to successfully accomplish this task [16]. Accordingly, multi-criteria group decision making (MCGDM) problems, where a group of decision-makers express their opinions or preferences on multiple criteria and attempt to find a common solution, have been widely discussed in recent years [5,13,20,24,27].

During the MCGDM process, decision makers usually use qualitative and/or quantitative measures to evaluate the performance of each alternative with respect to each criterion and consider the relative importance of each criterion with regard to the overall goal. How these individual decision makers express their judgments depends on both the nature of the features describing the alternatives and their own knowledge. However, under many practical decision situations, it is difficult, if not impossible, to obtain exact assessment values because of the inherent vagueness and uncertainty of human judgments [26]. Fuzzy set the-

* Corresponding author. Tel.: +86 28 85418191; fax: +86 28 85415143.
E-mail address: xujiuping@scu.edu.cn (J. Xu).

http://dx.doi.org/10.1016/j.ins.2015.12.003
0020-0255/

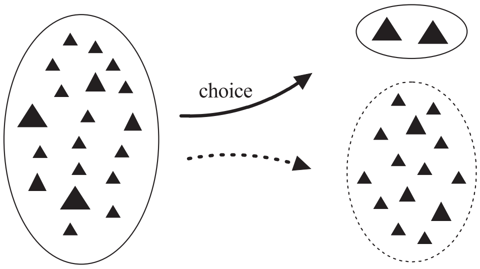

Fig. 1. The choice problematic.

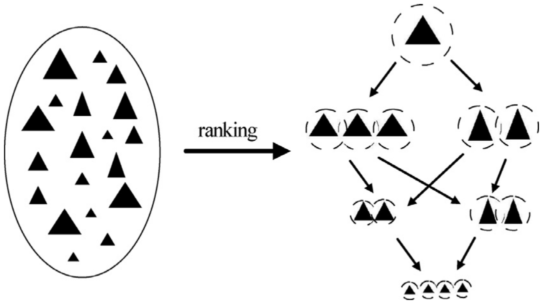

Fig. 2. The ranking problematic.

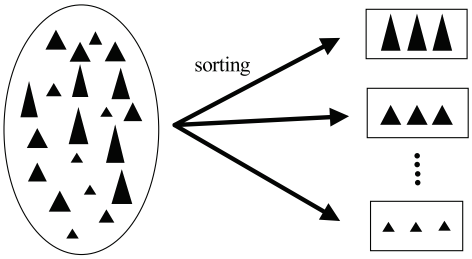

Fig. 3. The sorting problematic.

ory by Zadeh [32] has been used as an effective tool when seeking to deal with this uncertainty and vagueness, and has had great success in various fields. Specifically, as an extension of Zadeh's fuzzy set, Atanassov [1] introduces the intuitionistic fuzzy set (IFS), which was characterized by a membership function and a non-membership function. IFS has been widely applied to decision making [6,18,22,23,25,27,29]. Specially, many researchers have applied the IFS to real complex MCGDM problems in recent years. Xu et al. [27] developed a new Atanassov's interval-valued intuitionistic fuzzy outranking choice method to solve MCGDM supplier selection problems. Chen [6] developed an extended TOPSIS method with an inclusion comparison approach to address multiple criteria group decision-making medical problems in the interval-valued intuitionistic fuzzy set framework. Xu [29] developed an interactive approach to handle MCGDM problems with one or some different incomplete preference information structures on the attributes, in which the attribute values were represented as intuitionistic fuzzy numbers. Park et al. [18] extended the group decision making VIKOR method for an interval-valued intuitionistic fuzzy environment, in which the attribute weights information was partially known.

When modeling real world decision problems using MCDM, several problematics (or problem formulations) can be considered [17]. Roy distinguished three basic problematics: choice, ranking and sorting [19]. The objective of the choice problematic (see Fig. 1) is to assist the decision maker to select a small as possible subset of actions composed of the most satisfactory alternative(s). The ranking problematic (see Fig. 2) consists of establishing a preference pre-order (either partial or complete) for the set of alternatives, and is concerned with the ranking of all alternatives from the best to the worst. The sorting problematic (see Fig. 3) formulates the decision problem in terms of a classification so as to assign each alternative from the set of alternatives to one of the predefined categories defined by norms or typical elements. The assignment of an alternative to the appropriate category relies on its intrinsic value and not on a comparison with other alternatives.

In this paper, we are interested in the multiple criteria sorting problematic. Indeed, the need to sort alternatives into ordered categories is a problem in many real-world situations. ELECTRE-TRI, a well-known sorting method, was first introduced by Yu [30] and was detailed in Roy [19]. The main objective of ELECTRE-TRI is the proper utilization of the binary outranking relations, S, the meaning for which is "at least as good as". The original ELECTRE-TRI model involved several parameters and included