Chapter XXXII

Fuzzy Outranking Methods
Including Fuzzy PROMETHEE

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ABSTRACT

Outranking methods are a family of techniques concerned with ranking the preference for alternatives based on the criteria values that describe them. The breadth of applications taking inference from such preference ranking analysis includes the areas of business, health, environment, marketing, and public services. In the context of databases, the ranking issue is closely associated with data retrieval, including the ranking of matches to queries. This chapter describes the rudiments of fuzzy outranking methods, with particular attention to one such approach, namely fuzzy PROMETHEE, compounded further with the different structures of defined fuzziness of the criteria values also considered. Alternative fuzzy PROMETHEE approaches are described, with one used in two real-life applications. The results presented, with emphasis on their graphical representation, offer insights into the appropriate application of such fuzzy outranking methods.

INTRODUCTION

The notion of comparatively positioning objects with respect to each other is commonly called ranking. With respect to databases, the ranking issue is closely associated with data retrieval. Yu, Hwang, and Chang (2007) highlight that with the myriad of databases situated online, retrieving relevant data is problematic; in reality it becomes an online ranking problem (Chaudhuri, Das, Hristidis, & Weikum, 2001). It is noteworthy that in the year 2007, the First International Workshop on Ranking in Databases took place (DBRank, 2007). Its realisation was indicated as being due to the integral position of ranking in top-k queries, semantics like keyword search, and again the sheer explosion in the volume of data handled. In this chapter, the particular ranking performed
is constrained around the family of outranking methods available.

The philosophy of outranking methods originates from the pioneering work of Bernard Roy (Roy, 1968; Roy & Berther, 1973). As an approach for multiple criteria decision making (MCDM), it is closely concerned with the preference analysis of alternatives based on their values over a number of different criteria. There are regular applications of these methods in areas such as business (Albadvi, Chaharsooghi, & Esfahanipour, 2006), health care (Bilsel, Büyüközkân, & Ruan, 2006), and in particular the environment (Geldermann, Spengler, & Rentz, 2000; Goumas & Lygerou, 2000). Their findings show these methods offer viable approaches for decision makers to employ to achieve a preference ranking of alternatives.

A further relevant general description of the notion of outranking is given in Geldermann et al. (2000, p. 45), who state,

"The outranking methods, as a special subgroup of MCDM methods, are particularly suitable for integral decision making through the notion of weak preference and incomparability, which better represent the real decision situation."

The relevance of the outranking approach is demonstrated by it being considered one of the four general major families of methods in MCDM (see Carlsson & Fuller, 1996). In general, Radojevic and Petrovic (1997) clearly position multicriteria ranking methods as aids to a decision maker rather than as a substitute for them. This consideration is fully advocated in this chapter.

A more technical definition of outranking is through the notion of a preference relation, whereby an alternative \( a_i \) outranks \( a_j \) if and only if there is sufficient evidence to believe that \( a_i \) is better than \( a_j \), or at least \( a_i \) is as good as \( a_j \). Deriving such an outranking relation is the key in classical outranking methods (Aouam, Chang, & Lee, 2003). Methods relating to the outranking methodology are often presented as the combination of two steps (Bouyssou, 1996).

1. A construction step in which one or several outranking relations are built
2. An exploitation step in which outranking relations are used to derive a recommendation, possibly a ranking of the alternatives considered

Two of the main outranking methods are ELECTRE (élimination et choix traduisant la réalité), where information concerns the decision maker’s preferences, accounting for the two conditions concordance and nondiscordance (Mousseau & Dias, 2004; Roy, 1968), and PROMETHEE (preference ranking organization method for enrichment evaluation), which orchestrates outranking relations through comparisons of alternatives using a number of generalized preference functions (Beynon & Wells, 2008; Brans, Mareschal, & Vincke, 1984; Brans & Vincke, 1985).

These methods belong to the European school of MCDM (Roy & Vanderpooten, 1996), with ELECTRE being one of the first techniques to come out of it. Other concomitant outranking-based methods have also been presented (see, for example, Aouam et al., 2003; Gheorghe, Bufardi, & Xirouchakis, 2004; Tiryaki & Ahlatcioglu, 2005). As for these other methods, their operations have utilised an overall outranking intensity expression and the weights of the alternatives (to reflect a decision maker’s subjective preference). In this chapter, emphasis is on the investigation of PROMETHEE and its developments within a fuzzy environment.

Martín, Fajardo, Blanco, and Requena (2003) advocate the choice of PROMETHEE for reasons beyond its simple adequacy. It models preferences flexibly and simply within its procedure, and it is perfectly intelligible for decision makers because it is one of the most intuitive multicriteria decision methods. Furthermore, it is well adapted to problems where a finite number of alternative actions are to be ranked with respect to several, sometimes conflicting, criteria (Goumas & Lygerou, 2000). The addressed simplicity of PROMETHEE is also conversely viewed by Radojevic and Petrovic...
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