Chapter 21
Fuzzy Methods of Multiple-Criteria Evaluation and Their Software Implementation

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ABSTRACT

This chapter describes a system of fuzzy methods designed to solve a broad range of problems in multiple-criteria evaluation, and also their software implementation, FuzzME. A feature common to all the presented methods is the type of evaluation, well suited to the paradigm of fuzzy set theory. All evaluations take on the form of fuzzy numbers, expressing the extent to which goals of evaluation are fulfilled. The system of fuzzy methods is conceived to allow for different types of interaction among criteria of evaluation. Under no interaction, the fuzzy weighted average, fuzzy OWA operator, or WOWA operator are used to aggregate partial evaluations (depending on the evaluator's requirements regarding type of evaluation). If interactions appear as redundancy or complementarity, the fuzzified discrete Choquet integral is the appropriate aggregation operator. Under more complex interactions, the aggregation function is defined through an expertly set base of fuzzy rules.

INTRODUCTION

This chapter intends, in an easy-to-read style, to introduce a broad reading public (experts on theory and practice of multiple-criteria evaluation and decision making, readers interested in applications of the fuzzy set theory, and students) to a system of fuzzy methods for multiple-criteria evaluation which can be used to solve a wide range of real-life problems. Within an allotted space, we will try to comprehensively cover this topic. The theoretical approach to evaluation is common to all the presented methods, with the leading idea that the evaluation of an alternative can be viewed as a (fuzzy) degree of fulfillment of a pursued

DOI: 10.4018/978-1-61350-429-1.ch021

goal. We will explain how this evaluation is carried out in case of both quantitative and qualitative criteria. The basic hierarchical structure of evaluation model can comprise various methods for consecutive aggregation of partial evaluations into an overall evaluation. Next, we will turn our attention to a detailed analysis of particular aggregation methods. We specify the conditions under which a given aggregation method is appropriate, and give illustrative examples. We will describe the FuzzME tool, which is a software implementation of the presented methods. A reader can use the demo version of FuzzME, freely available at www, to experiment with these methods on his/her own, thus reaching deeper appreciation of their behavior. Real-world applications of using FuzzME will be described. They are from banking industry (soft-fact rating of bank clients) and from the area of human resource management.

BACKGROUND

Worldwide, one can witness an ever-increasing interest in high-quality mathematical models of multiple-criteria evaluation (e.g. rating of clients in banks, assessment of universities, comparison of alternative solutions to ecological problems). For the tasks of building evaluation models, setting some of their inputs, and interpreting their outputs, expert knowledge is needed (e.g. evaluations of alternatives according to qualitative criteria, partial evaluating functions for quantitative criteria, choice of a suitable aggregation operator, weights of partial evaluations, rule bases describing multiple-criteria evaluating functions, verbal interpretation of obtained results). With uncertainty being a characteristic feature of any expert information, a suitable mathematical tool for creating such models is the fuzzy set theory (Zadeh, 1965; Dubois & Prade 2000). For practical use of the fuzzy models of multiple-criteria evaluation, their user-friendly software implementation is necessary.

Out of numerous papers and books covering the theory and methods of multiple-criteria evaluation, a large number make use of fuzzy approach (e.g. Bellman & Zadeh, 1970; Yager, 1988; Rommelfanger, 1988; Lai & Hwang, 1994; Carlsson & Fullér, 1996; Talašová, 2003; Ramík & Perzina, 2010). Multiple-criteria evaluation (as a basis for decision making) was even one of the earliest applications of fuzzy sets (Bellman & Zadeh, 1970). In more than 40 years of existence of the fuzzy set theory, several software products for multiple-criteria decision making have been developed that utilize fuzzy modeling principles to different degrees and in different ways, e.g. FuzzyTECH (Von Altrock 1995, 1996; http://www.fuzzytech.com/) and NEFRIT (Talašová, 2000).

The fuzzy methods of multiple-criteria evaluation and the FuzzME software (Fuzzy models of Multiple-criteria Evaluation), presented in this chapter, are based primarily on the theory and methods of multiple-criteria evaluation that were published in Talašová (2000) and Talašová (2003). The theory of normalized fuzzy weights, the definition of fuzzy weighted average, and the algorithm for its calculation were taken from Pavlačka & Talašová (2006, 2007) and Pavlačka (2007). The fuzzified OWA operator and the algorithm for its calculation were published in Talašová & Bebčáková (2008). The theory of fuzzy Choquet integral and the method of its computation were taken from Bebčáková, Talašová & Pavlačka (2010). This chapter also focuses on the relationship between the nature of a problem to be solved (interaction among criteria, evaluator's requirements on the behavior of evaluating function) and the choice of appropriate mathematical model (type of aggregation operator, or perhaps an expert system). As of yet, these results have not been published in such a comprehensive form.

Related Content