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Combining fuzzy iteration model with dynamic programming to solve multiobjective multistage decision making problems

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Abstract

This paper aims to develop a fuzzy dynamic programming approach for multiobjective multistage decision making problems. Fuzzy dynamic programming usually convert the problems into corresponding single objective problems by an aggregate of hybrid objective values that expresses the performance of the particular stage decision. Weight-assessment is an important problem arising from the evaluation of multiple objectives. Therefore, a fuzzy iteration model is first developed to simultaneously provide the objective weights and the evaluation of alternatives with multiple objectives. Then a fuzzy dynamic programming is derived by applying the fuzzy iteration model to classic dynamic programming to evaluate the decisions at each stage in the dynamic process of decision makings, where the objective weights are initially elicited from the information implicit in alternatives and can be interactively adjusted to reflect the changes of decision situations by using a non-structured decision making analysis method if necessary. Finally, the fuzzy dynamic programming is validated through a problem of water resource allocation.

Keywords: Decision analysis; Multiple criteria evaluation; Aggregation operator; Fuzzy dynamic programming

1. Introduction

Fuzzy dynamic programming [1] is a powerful technique to solve multiobjective multistage decision making problems. The essentials of the approaches in the literature [14–19] are usually converting the multiobjective problem into a single-objective problem, by an aggregate of hybrid objective values that

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expresses the performance of the particular stage decision. This aggregation may take on various forms from a pessimistic minimum to an optimistic maximum, through all intermediate cases exemplified by an average, for example, appropriate aggregation operators in [17,19] were developed to aggregate objective and subjective aspects for solving a socioeconomic regional planning problem. At each stage, multiobjective multistage decision making essentially is a problem of multiobjective decision making (MODM), so it is a natural consideration of incorporating the methods of MODM into dynamic programming techniques to solve this kind of problems. For example, simple additive weighting (SAW) method is frequently employed into fuzzy dynamic programming, and surrogate worth tradeoff (SWT) method was integrated with a single-objective dynamic programming to solve multi-objective capacity expansion problems [2].

A novel fuzzy recognition model for multicriteria classification and sorting, firstly proposed by Chen and Zhao [12], has received a variety of applications [8,11,20]. By incorporating the model with conventional dynamic programming, two approaches, *Maximum Membership Approach* [3] and *Stage Optimization Approach* [4,6], were proposed to solve multiobjective dynamic programming problems. Cui et al. [13] developed the former to its multi-dimensional form and applied it to solve the problems in water resources systems. And the latter was applied to solve the flood control problem of the upper and middle reaches of the Yangtze River [9]. Furthermore, the two methods were extended to their multi-level versions to more precisely recognize the differences between alternatives [10]. However, in practice, it is difficult for decision maker to provide the objective weights in each stage especially when the decision maker is not expert at the specific problem.

Human factors play a very important part in virtually all real-life problems, so the weight of objective is one of the primary components and a significant parameter to express decision maker's knowledge, experience and judgment preference in MODM. From a structural viewpoint, the weight-assessing methods can be categorized into two types: subjective methods, such as, AHP and Delphi, and objective methods, such as the extreme weight approach, random weight approach and entropy method. For the first, the value of weight is highly dependent on decision-maker' experience and judgments, so the methods are with strong subjectivity; for the second, the weight is computed from the outcomes without asking the perceptions of the decision makers. For multiobjective multistage decision making problems, the weight assessment is more complicated due to the changing situations at each stage. It is difficult, even impossible, for decision makers to immediately provide precise values for objective weights, especially for some real time decision problems, for example, real time flood control operation problems. To overcome the above weaknesses, the weights for multistage decision problems can be initially provided by an objective method and then adjusted according to decision situation changes at different stages. A convenient weight-assessing approach should be developed to obtain the initial weights in the dynamic process of decision makings.

This paper aims to extend the previous research works [3,10] to evaluate multiple hybrid objectives of the alternatives and provide the initial objective weights at the same time in the dynamic decision making process. In the next section, a fuzzy iteration aggregation method for MODM is developed after performing a fuzzy optimization process, in which the initial objective weights are elicited through iteration from the information implicit in the relative membership degrees of alternatives. Section 3 briefly introduces the non-structured decision making analysis method, which is used in this paper to quantify the relative membership degrees of the alternatives regarding qualitative objectives or further adjust the objective weights in light of decision maker's knowledge, experience and judgment preference if necessary. In Section 4, a backward recurrence equation for multistage multiobjective decision makings is derived by