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Modeling Uncertainty in Multi Criteria Decision Analysis (MCDA) Problems:

A Probabilistic TOPSIS Model using Bayesian Belief Networks (BBNs) (BBNTOPSIS)

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***Abstract*—TOPSIS (technique for order preference by similarity to ideal solution), one of the MCDA (multi-criteria decision analysis) methods, is a technique to evaluate the performance of alternatives through the similarity with the ideal solution. Despite its popularity and simplicity in concept, this technique is often criticized because of its inability to deal adequately with uncertainty and imprecision inherent in the process of mapping the perceptions of decision-makers. In order to overcome this challenge, this paper presents a probabilistic model based on Bayesian belief networks (BBNs) -a state-of-the-art technique in modeling uncertainty. BBNs provide a framework for presenting causal relationships and enables probabilistic inference among a set of variables. The new approach explicitly quantifies uncertainty in TOPSIS formulation and also provides an appropriate method for modeling experts' knowledge, and updating the outranking results with respect to new believes and evidences. The capabilities of proposed approach are explained by a project supplier selection problem.**

Keywords-MCDA; TOPSIS; Bayesian belief networks (BBNs); uncertainty; outranking

I. INTRODUCTION

The practice of multi-criteria decision analysis (MCDA) is concerned with the evaluation of a set of possible courses of action or alternatives generally characterized by multiple conflicting criteria. One of these techniques known as technique for order preference by similarity to ideal solution (TOPSIS) is a technique to evaluate the performance of alternatives through the similarity with the ideal solution [١]. TOPSIS is based on a simple and intuitive concept; it enables consistent and systematic criteria, which is based on choosing the best alternative having the shortest distance from the ideal solution and the farthest distance from the anti-ideal solution. The ideal solution is one that maximizes the benefit criteria and minimizes the cost criteria. The anti-ideal solution maximizes the cost criteria and minimizes the benefit criteria. In summary, the ideal solution is composed of all best values attainable of criteria, and the anti-ideal solution consists of all the worst values attainable of criteria.

In many practical cases, it is difficult to treat uncertain data and human opinions using conventional multi-criteria analysis. Despite the popularity and simplicity in concept of TOPSIS, this technique is often criticized because of its inability to deal adequately with uncertainty and imprecision inherent in the process of mapping the perceptions of decision-makers. In the traditional formulation of TOPSIS, the personal judgments are represented by numerical values. However, in many real world cases the human preference model is uncertain and the decision-makers might be unable to assign single numerical values to the judgments of comparison. Anyway, TOPSIS has been extended to deal MCDA with an uncertain decision matrix resulting in fuzzy TOPSIS, which has widely been applied to solve various MCDA problems [٢-١٤]. But the fuzzy MCDA methods do not take into account the causality of performance rating of the alternatives according to criteria. Moreover, in the cases with lack of previous experience that data are incomplete or imprecise, these methods cannot learn from the actual evidences to update the outranking. In this situation, i.e. lack of objective data, more advanced techniques are required to:

- Capture uncertainty of performance rating of the alternatives with respect to criteria,