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Conflict resolution in a knowledge-based system using multiple attribute decision-making

Byeong Seok Ahn [a], Sang Hyun Choi [b,*]

[a] College of Business Administration, Chung-Ang University, 221 Heukseok, Dongjak, Seoul 156-756, South Korea
[b] Department of Industrial and Systems Engineering, Engineering Research Institute, Gyeongsang National University, 900 Gazwadong, Jinju Gyeongnam 660-701, South Korea

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ABSTRACT

The metarules useful in the conflict resolution are often directly related to the multiple, conflicting, and non-commensurate objectives associated with the problem domain. However, in its current form, the use of metarules for conflict resolution has some drawbacks. Above all, the metarule use in rule selection is not tailored to the current situation or the specific user; it is tailored to the domain expert, whose domain expertise and preferences were used to construct a knowledge-based system. In this paper, we presents a new method for resolving the conflicts of rules in the knowledge-based system, using decision analysis techniques that explicitly incorporate a user's preference judgments about the rules. To this end, we consider a conflict resolution problem as a multiple attribute decision-making problem. Further, the proposed method allows for user's preference judgments that are specified not by rigid format but by user-friendly format for the purpose of reducing burden of information specification.

We have applied the proposed methodology to an organizational information-oriented service and resource planning, in which there exist multiple conflicting objectives to be considered.

1. Introduction

Techniques from the disciplines of artificial intelligence (AI) and decision analysis (DA) have both been used extensively in the development of computerized decision aids. The expert system (ES), one of several methods for emulating human decision-making, is a computer program for solving decision problems that requires significant human expertise by using explicitly represented domain knowledge and computational decision procedures (Kastner & Hong, 1984). In normative DA, decision models have been developed to represent complicated real-world decision problems. Both ES and DA, though rooted in different fields, have basic conceptual similarities in terms of objectives (decision-aiding), delivery vehicle (the computer), and conceptual basis (graphs and networks).

Unfortunately, from the perspective of many types of practical decision-aiding applications, both normative decision aids and expert system technology have significant limitations. Particularly, in the expert system development, there is a lack of established techniques for problem structuring and knowledge engineering. This usually leads to time consuming rule-based development efforts with limited success in domains where the knowledge required to solve problems is not already well established (Davis, 1982). Further, current expert systems do not explicitly consider preferences, which play a key role in DA; when preferences are (indirectly) addressed, they are the preferences of the expert, rather than the user's preferences adjusted to the current problem solving environment (White, 1990). Normative decision analysis, on the other hand, is usually built around a prescriptive and rigid problem structure called a decision analysis model. This model, in turn, may not be compatible with the evolutionary approach to system development which is characteristic of AI (Lehner, Mattew, & Donnell, 1985).

In this paper, we focus on the DA's prescriptive methodology (prioritizing or ranking alternatives or options in a prescriptive manner), which incorporates a user's preference judgments, for conflict resolution in a knowledge-based system. The process of using a knowledge-based system consists of a cycle having three phases: matching, conflict resolution, and action. Using inference, it is possible to identify a set of rules that matches the context. If this occurs during the matching process in a production system, some approaches should be applied to resolve possible conflicts (Barr & Feigenbaum, 1981; Davis & King, 1977; Hayes-Roth, Waterman, & Lenat, 1983).

Metarules useful in conflict resolution are often directly related to the multiple, conflicting, and non-commensurate objectives associated with the problem domain. However, in its current form, the use of metarules for conflict resolution has three key drawbacks:

* Corresponding author. Tel.: +82 55 751 6215; fax: +82 55 762 6599.
E-mail address: chois@gnu.ac.kr (S.H. Choi).

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1. Use of metarules in rule selection is not tailored to the current situation or the specific user; it is tailored to the domain expert, whose domain expertise, preferences, etc. were used to construct the system.
2. Use of metarules in rule selection does not take into account objectives tradeoffs.
3. Metarules do not permit efficient representations of expert knowledge when many objectives or decision contexts must be taken into account.

We propose DA-based methodology that integrates the two disciplines synergistically and further considers a group of individuals in a situation where multiple experts take part in. Finally, we have applied the proposed method to a real-world problem, information-oriented service and resource planning of a company where there exist multiple conflicting objectives under consideration.

The rest of this paper is organized as follows. Section 2 reviews a number of approaches towards decision theoretic expert systems. Section 3 suggests the use of decision analysis techniques for conflict resolution in expert systems, and application are discussed in Section 4.

2. Research background

In view of the ES applications, the ESs can largely be divided into two categories: analytic and synthetic. An analytic ES deals with the valuation of the alternatives, e.g., prediction, classification, and diagnosis. On the other hand, a synthetic ES focuses on constructing one or more feasible options, e.g., generation of alternatives, design, configuration, and planning. Early ES researchers were more concerned with automated probabilistic reasoning for diagnosis under uncertainty. For a reduction of probability calculation, two simplifying assumptions (mutual exclusiveness and conditional independence on the probabilities) are adopted for tractability. A large number of medical diagnostic problems have been dealt with successfully using these methods (Szolovits & Pauker, 1978). However, due to the unwarranted simplifying assumptions and intrinsically restricted problem domain, the Bayesian reasoning method lost its standing basis. Concern with the restrictive assumptions of the simplified probabilistic scheme coupled with the perception that a combinatory explosion would threaten any attempt to move beyond these assumptions or to larger domains led to disenchantment with the approach (Horvitz, Breece, & Henrion, 1988).

From the viewpoint of conflict resolution, Huang and Cheng (2008) proposed the conditional probability knowledge similarity algorithm and calculation system. Zadeh (1992) and Negnevitsky (2002) used rule-based knowledge to represent knowledge. There are a number of studies related to knowledge matching (Chen, 2004; Liu & Wang, 2005; Yang & Wu, 2004; Zhang & Rasmussen, 2001).

Apart from likelihood knowledge-based ES, there have been other approaches that use ESs for constructing utility functions in DA applications (we call an ES embedding a user's preferential knowledge a *preferential knowledge-based ES*). Farquhar (1987) examines applications in the construction of evaluation functions for intelligent computer systems with the intent of demonstrating the usefulness of utility theory for these AI-based research activities. He reports on three basic multiattribute utility theory (MAUT) approaches for modifying evaluation functions in intelligent systems. Lehner et al. (1985) outline an approach that systematically exploits both the problem structuring techniques of DA and the incrementally modifiable software architectures found in AI. Keeney (1988) notes that many AI-based decision aids treat preferences implicitly and heuristically and hence violate the premise that preferences should be prominent in decision aid development, since preferences are the driving force for making decisions. He remarks that implicit representation of preference does not permit an investigation of how preference can affect changes in suggested actions. He then provides suggestions for knowledge engineers to explicitly structure preferences in ESs and, hence, to integrate DA into ESs. As a method for incorporating DA's prescriptive technique in the ES conflict resolution process, White and Syskes (1986) suggest the possibility of utilizing a user preference-guided approach to conflict resolution; in design problem such as fossil fuel boiler design and computer aided design, alternative designs created by production rules should be evaluated by employing user preferences to personalize the search for improved design (Brown & White, 1987; Syskes & White, 1991). The prescriptive DA method, which takes into account a user's preferences, will be described in the next section.

3. Transforming a conflict resolution problem into multiattribute decision-making

3.1. A single user case in conflict resolution

In this part, we briefly introduce DA's key concepts and techniques that will be used as a conflict resolution method in a rule-based system. In multicriteria single decision-making, one usually considers a set of alternatives (options or candidates), which is valued by a family of criteria (objectives). When any two of three types of inputs such as ranking of alternatives, attributes weights, and utility scores are given from a decision maker (DM) as shown in Fig. 1, many studies have been conducted to infer the remaining parameter (most of studies deals with the identification of rank of alternatives when the attribute weights and utility scores are provided or evaluated from the DM).

Assuming additive independence, the expect utility of an alternative, $a \in A$ can be denoted by

$$EU(a) = \sum_{i=1}^{n} w_i u_i(a) = wu(a)$$

where w is a tradeoff weight among attributes, usually assumed to be summed to one (Keeney & Raiffa, 1976). By comparing the magnitude of each alternative's expected utility, the most preferred alternative is identified. As mentioned in the literature (Kahneman, Slovic, & Tversky, 1983; Weber, 1987; White, Sage, & Dozono, 1984), the assessment of precise utility scores and tradeoff weights can be time-consuming and stressful, and can thereby represent a significant barrier to the acceptability of any MAUT-based decision-making procedure. Therefore, natural language statements about the attribute weights (e.g., attribute i is twice as important as attribute j) and utility scores are more appropriate assessments of preferences, although these do not always provide sufficient information for precise determination of alternatives ranking. The types of natural language statements for preferential knowledge in-

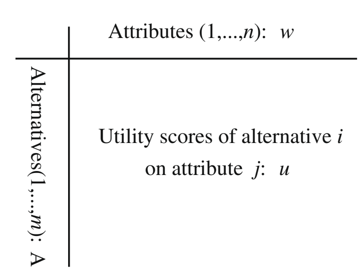

Fig. 1. Components of a multiattribute decision-making problem.