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Rough approximation of a preference relation by multi-decision dominance for a multi-agent conflict analysis problem

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ABSTRACT

Multi-attribute group decision-making (MAGDM) has evoked increasing attention in recent years. Meanwhile, many valuable approaches have been developed to solve various MAGDM problems. In this paper, we consider a MAGDM problem in the presence of multi-attribute and multi-decision decision making with preference, namely the MA&MD decision problem. It involves the assignment of objects (actions), evaluated based on a set of conditional attributes, to pre-defined and preference-ordered multi-decision making. The actions are described by a finite set of conditional attributes and decision attributes. Both types of attribute take the values from their domain with preference order. In order to construct a comprehensive preference evaluation model that could be used to support the optimal choice task, we define two dominance relations, one on the condition attribute set and the other on the decision attribute set. We then present the lower and upper approximations of a preference relation defined by the decision attribute set based on a multi- decision preference dominance relation. Meanwhile, we propose an approach to decision making based on the rough set model established in this paper. The approach to decision making is derived from the lower approximation of decision classes with a preference dominance relation. The idea and decision rule are applied to solving a multi-agent conflict analysis decision problem. This method addresses limitations of the Pawlak conflict analysis model and thus improves on that model. Furthermore, to give practical significance to this management decision making approach, we present two extended models of the multi-decision preference dominance-based rough set as well as the corresponding decision making method. Moreover, we compare the proposed approach to previous studies of dominance-based rough set approaches to multiple attribute (criteria) decision making. The main contribution of this paper is two-fold. One is to establish a generalization of the classical dominance-based rough set approach, i.e., the model of multi-decision preference dominance-based rough set. Another is to present a new approach to deal with the multi-agent conflict analysis decision making problem based on the proposed multi-decision rough set approach.

1. Introduction

Decision making is a procedure to find the best alternative among a set of feasible alternatives. The solution can be complex or simple. Because all decision-making problems have multiple alternatives and criteria, an increase in the number of

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alternatives and criteria makes it difficult to make decisions. Therefore, there has been extensive research on how to solve complicated decision making problems [8,18,35,39,40,49,50,54,56,57,63,73,74]. In general, the problem of multi-decision with preference (or multiple attributes and multiple decisions with preference (MA&MD)) is the most frequently considered decision problem in decision analysis [10,11,16,17,15,38,41,45,60,61]. As a generalization of traditional multiple attribute decision making (MADM) or multi-attribute group decision-making (MAGDM), it has been a hot research area. This problem is also referred to as multiple criteria sorting with preference, or group decision with monotonicity constraints. It consists of assignment of objects (or actions, schemas) evaluated based on a set of criteria (i.e., conditional attributes with a preference-ordered values set) to pre-defined and preference-ordered multi-decision making (i.e., multi-decision attributes with preference-ordered values sets, or multi-decision makers with preference-ordered values sets). It is assumed that there generally is a correlation between evaluation on conditional attributes and assignment to decision attributes with multi-decision makers, i.e., the better the evaluation of an action (object) on the conditional attributes, the better the assignment of an action (object) to the decision attributes (multi-decision makers) and vice versa.

The multiple decision with preference problem may arise in many real-world situations [21]. Let us consider, for example, the problem of the conflict analysis decision problem with multi-agents, in which objects (the favorable solution for a conflict situation) may be evaluated with regard to the disputes in a conflict situation (the conditional attribute) with "small," "medium," and "high" levels. Meanwhile, the favorable solution for a conflict situation may be evaluated for agents (the decision attribute) with preference values of "bad," "average," "good," and "excellent." That is, all agents related to a conflict situation are evaluated with regard to their individual preferences for every solution to the conflict situation. We consider the example of the Middle East conflict given in [14]. The following five issues, with slight modifications from [14], are the criteria (conditional attributes): autonomous Palestinian state in the West Bank and Gaza, Israeli military outpost along the Jordan River, Israeli retention of East Jerusalem, the Israeli military outposts on the Golan Heights, and Arab countries' granting of citizenship to Palestinians who choose to remain within their borders. The six agents, Israel, Egypt, Palestine, Jordan, Syria, and Saudi Arabia, are the decision attributes. Obviously, the Middle East conflict is a multiple attribute and multiple decision problem. Similarly, the conflict problem of labor- management negotiations also entails a multiple attribute and multiple decision problem. Many mathematical models [52] have been proposed to investigate these multi-attribute and multi- decision problems from the viewpoint of conflict. The existing approaches to these problems are the conflict analysis methods based on the classical Pawlak rough set [43,44,53]. Though the existing approaches present expected solutions for these decision making problems, there also exist some limitations, as pointed out by Deja [14].

Conflict is, no doubt, one of the most characteristic attributes of human nature, and therefore the study of conflict is of utmost importance, both practically and theoretically. Everyone encounters conflicts in everyday life. Conflict analysis and resolution play an important role in business, governmental, political and lawsuit disputes, labor-management negotiations, military operations and so on. Many mathematical models for conflict situations have been proposed and investigated [52]. Recently, rough set theory has been applied to analyze conflict situations. For example, the Pawlak conflict analysis model based on rough set has been proposed by many scholars [43,44,53]. The Pawlak conflict analysis model has proven to be an effective practical method in practice. However, some authors [12] have pointed out limitations of the Pawlak conflict analysis model: (1) What are the intrinsic reasons for the conflict? (2) How can a feasible consensus strategy be found? (3) Is it possible to satisfy all the agents? Other authors have discussed these three basic problems of the Pawlak conflict analysis model, with some important results. In this paper, we try to answer the second and third questions by a new method based on the dominance-based rough set approach proposed by Greco et al. [22–26].

As is well known, the optimal strategy which satisfies all agents in a conflict situation, i.e., the feasible consensus strategy, usually does not exist because there are different benefits and opinions. So, a sub-optimal feasible consensus strategy which satisfies the agents as much as possible is a reasonable goal. Along with this motivation, we consider the multiple agents conflict decision making problem as a kind of multiple attribute and multiple decision making problem and present a multi-decision preference dominance-based rough set model and a multi-decision $k-$ grade preference dominance-based rough set model. We also present a general approach to solve the multi-agent conflict analysis decision making problem by using the proposed rough set models.

The dominance-based rough set approach was first established by Greco et al. [22–26] in order to deal with the inconsistencies in various types of multiple criteria decision analysis using rough set methodology. The basic idea behind the dominance-based rough set approach is to replace the equivalence relation in the Pawlak rough set [42] with the dominance relation, which permits taking into account the preference order in the value set of the criteria. The dominance- based rough set approach has attracted a great deal of attention and has been used for many valuable studies. Many extended models of the dominance-based rough set approach have been proposed, such as the graded dominance interval-valued rough set model [28,68], variable-precision dominance-based rough set approach [31], dominance-based rough set model in intuitionistic fuzzy information systems [27], variable-consistency dominance-based rough set approach [2,29], stochastic dominance based rough set model [32], etc. Furthermore, several improved dominance-based rough set approaches have applied other mathematical theories to multiple criteria decision analysis [1,36,37,46,47,55,58,75]. Subsequently, Greco et al. [25] applied the dominance-based rough set approach to group decision making theory. They consider the decision of multiple decision makers by introducing specific concepts related to dominance with respect to minimal profiles of evaluations given by multiple decision makers. Their extension also provides a general methodology for rough approximations of partial preorders. Recently, Chakhar and Saad [9] study multicriteria classification problems in group decision