Group Verbal Decision Analysis

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INTRODUCTION

Ordering and classification of objects by their properties are among the typical problems in multiple criteria decision aiding (MCDA). The difficulties of choice problems increase when the same object may exist in several copies with different attributes' values, and values of different attributes may be repeated within the object description. For example, such situation arises when several experts estimate alternatives upon multiple criteria. In this case, individual expert assessments may be similar, diverse, or contradictory. Various techniques for classification of alternatives or their ranking have been developed. But most of the methods do not pay a serious consideration to contradictions and inconsistencies in decision makers' (DM) preferences and a problem description.

Group verbal decision analysis (GroupVDA) is a new methodological approach in the MCDA area, which enlarges verbal decision analysis (VDA) approach to a group decision. GroupVDA deals with choice problems where preferences of several decision makers may be discordant, and alternatives are described with manifold repeating quantitative and qualitative attributes. New GroupVDA methods are based on the theory of multisets or sets with repeating elements, and represent multi-attribute objects as points in multiset metric spaces.

The main goal of this article is to consider the state-of-the-art methods and models for collective choice of several independent actors. We start with an overview of existing MCDA approaches to collective choice. Then we motivate our respect of group decision method under VDA. In next section we describe a multiset model for representation of multi-attribute objects. It is shown that the theoretical model of multisets is well appropriated for representing and analyzing a collection of objects that are described with many inconsistent quantitative and qualitative attributes and may exist in several copies. Then we introduce GroupVDA methods for searching solution of ordering and classification problems of multi-attribute objects as points in multiset metric spaces. Objects are arranged by closeness with regard to any "ideal" object in any multiset metric space. An objects' classification is built in any multiset metric space in accordance with the generalized classification rule that approximates diverse (and may be contradictory) individual sorting rules of several actors. Finally, we give the short examples of case studies and analyze some perspective of GroupVDA methods.

BACKGROUND

A DM's preference is one of the milestones in the MCDA area. The person expresses his/her preferences when he/she describes properties and characteristics of a problem under analysis, compares decision alternatives, and estimates the quality of choice. Preferences may be represented as decision rules of a mathematical, logical, and/or verbal nature and explained with any language. While solving the problem, a person may behave inconsistently, make errors and contradictions. In the case of individual choice, the consistency of subjective preferences is postulated.

A collective choice of several independent actors is more complicated and principally different due to variety and inconsistency of many subjective preferences. Each of the DMs has his/her own personal goals, interests, valuations, and information sources. As a result, individual subjective judgments of several persons may be similar, concordant, or discordant. Usually, in MCDA techniques, one tries to avoid possible inconsistencies and contradictions between judgments of several persons and replace a number of opposite opinions with a single so-called common preference that is the mostly agreed with all points of view. Nevertheless, individual preferences may be coordinated not always.

Let us discuss some ranking and classifying methods. Direct sorting objects is very popular due to its simplicity for a person. Every object, which is estimated under a numerical criterion, is assigned to one of the given classes immediately. In the case of several persons, the final ordering of objects may be constructed, for instance, as weighted averages or as the Kemeny median, if a concordance of estimates is acceptable (Kemeny & Snell, 1972).

In the pairwise comparisons, the final ordering objects will be complete if all pairs of objects are comparable, and DMs' preferences are transitive. If objects are incomparable, then ordering will be partial. In the case of multiple criteria and/or several persons, for example, in MAUT (multi-attribute utility theory) and TOPSIS (technique for order preference by similarity to ideal solution) (Hwang & Lin, 1987), the final arrangement of objects by comparing many matrixes is cumbrous. Objects may be arranged also by their ranks, which are calculated or evaluated by a decision maker.

In AHP (analytic hierarchy process) techniques (Saaty, 1990), priorities for the alternatives and criteria are derived by hierarchical paired comparisons with respect to a contribution to the problem goal. In ELECTRE methods (Roy, 1996, Vincke, 1992), multicriterial alternatives are compared and arranged by the outranking relation based on the special indexes of concordance and discordance. In ZAPROS methods (Larichev & Moshkovich, 1997; Moshkovich, Mechitov, & Olson, 2002), the so-called joint ordinal scales are to be constructed for ranking multicriteria alternatives. (Note that rearrangement of rank vectors in an ascending order, which is used in ZAPROS methods for alternatives comparison, generally, is mathematical incorrect.) In all of the mentioned techniques, the final results imply any coordination of individual judgments.

In the case of one criterion and a small collection of objects, an arrangement/classification of objects is not so difficult for a DM. The more number of objects, criteria, and/or actors, the more complicated and difficult a procedure is due to persons' errors, inconsistencies, and contradictions. Multiplicity and redundancy of attributes, which describe the choice problem, produce an additional difficulty of problem solving because manifold data are to be processed simultaneously without non-numerical transformations such as data "averaging," "mixing," "weighting," and so on. So, new methods are needed, which do not exclude discordant information and provide for a reasonable decision.

VDA emphasizes ill-structured discrete choice problems represented with quantitative and qualitative attributes. The most important features of VDA are as follows: (1) the problem description with a professional language, which is natural and habitual for a decision maker; (2) a usage of verbal (nominative, ordinal) data on all stages of the problem analysis and solution without transformation into a numerical form; (3) an examination of the DM's judgments consistency; (4) a logical and psychological validity of decision rules; and (5) an explanation of intermediate and final results. These VDA peculiarities are almost the same as mentioned (Larichev & Moshkovich, 1997).

In the case of individual rational choice, when decision rules are based on judgments of the only DM, the consistency of DM's subjective preferences is postulated as preference transitivity in many MCDA techniques. So, special facilities for discovering and removing possible inconsistencies and contradictions within single DM's judgments are included in VDA-based methods. A situation, where decision rules are based on judgments of several independent DMs, is principally different due to variety and inconsistency of DM's subjective preferences. As a result, individual decision rules may be similar, diverse, or contradictory. Such kinds of peculiarities would not be agreed or excluded but have to be included into GroupVDA procedures.

MULTISET MODEL FOR REPRESENTATION OF MULTI-ATTRIBUTE OBJECTS

Let $A=\{A_1,...,A_n\}$ be a collection of n objects evaluated upon m criteria $Q_1,Q_2,...,Q_m$. A criteria list depends on the aim of analysis. Different criteria may have a different relative importance (weight) for various cases. Each criterion has a nominal or ordinal scale of verbal estimates $Q_s=\{q_s^{e_s}\}, e_s=1,\ldots,h_s, s=1,\ldots,m$. Ordinal estimates are ordered from the best to the worst as $q_s^1 \succ q_s^2 \succ \ldots \succ q_s^{hs}$. Criterion estimates q_s^{es} may be either quantitative or qualitative. Sometimes it is useful to transform a quantitative continuous scale into a qualitative discrete scale with a reasonably small number of grades. For instance, scales of criteria Q_1-Q_7 may be the following: q_s^1 – very large; q_s^2 – large; q_s^3 – medium; q_s^4 – small. On the other hand, verbal estimates are never converted into numerical ones.

Usually a multi-attribute object A_i is represented as a vector or cortege $q_i=(q_{i1}^{e1},\ldots,q_{im}^{em})$ in the Cartesian m-space of attributes $Q=Q_1\times\ldots\times Q_m$. When an object A_i is evaluated by k several individuals upon m criteria independently, multi-attribute description of

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