Intelligent DSS Under Verbal Decision Analysis

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INTRODUCTION

Verbal decision analysis (VDA) is a relatively new term introduced in Larichev and Moshkovich (1997) for a methodological approach to discrete multi-criteria decision making (MCDM) problems that was under elaboration by Russian researchers since the 1970s. Its main ideas, principles, and strength in comparison with other approaches to MCDM problems are summarized in Moshkovich, Mechitov, and Olson (2005) and in posthumous book (Larichev, 2006) as follows: problem description (alternatives, criteria, and alternatives' estimates upon criteria) with natural language without any conversion to numerical form; usage of only those operations of eliciting information from a decision maker (DM) that deems to be psychologically reliable; control of DM's judgments consistency, and traceability of results, that is, the intermediate and final results of a problem solution have to be explainable to DM.

The main objective of this chapter is to provide an analysis of the methods and models of VDA for implementing them in intellectual decision support systems. We start with an overview of existing approaches to VDA methods and model representation. In the next three sections we present examples of implementing the methods and models of VDA for intellectual decision support systems designed for such problems solving as discrete multi-criteria choice, construction of expert knowledge base, and multi-criteria assignment problem. Finally, we analyze some perspective of VDA-based methods to implement them for intellectual decision support systems.

BACKGROUND

VDA-based methods are intended for ill-structured and unstructured discrete MCDM problems (Simon, 1960), the most typical of which are the problems of multi-criteria choice and classification. The main feature of such problems is the source of information for their solving, namely the human beings (DM and/or expert). Usually, alternatives are described with the values upon multiple criteria with ordinal scales. The DM expresses his/her preferences verbally as pairwise comparisons of alternatives in the form "one alternative is more (or less, or equally) preferable than the other." In the case of ordinal classification (Larichev, Moshkovich, & Furems, 1986), the DM indicates for each alternative one of the ordered classes on the basis of his/her preferences. However, it should be noted, that multi-criteria (or, more precisely in this case, multi-attribute), VDA-based approaches use not only a DM's preferences but his/her knowledge either in ordinal (Larichev, Moshkovich, Furems, Mechitov, & Morgoev, 1991) or nominal form (Furems & Gnedenko, 1996). Besides, such discrete multi-criteria problems (which are well known in their single-criterion statements) as assignment problem (Larichev & Sternin, 1992, 1998) and bin packing one (Larichev & Furems, 1987) have been solved within the VDA paradigm. The solutions of these problems must both satisfy the specific qualitative constraints and have as most preferable combinations of estimates upon qualitative criteria as possible.

Individual rationality of DM is the main strength of VDA. Limitations on human beings abilities to deal with multi-criteria/multi-attribute alternatives are based on the results of psychological experiments. For example, according to Larichev (1992) and Korhonen, Larichev, Moshkovich, Mechitov, and Wallenius (1997), it is relatively easy for individuals to carry out the pairwise qualitative comparison of alternatives that differ in estimates upon not more than two criteria.

Such limitations are taken into account in the ZAPROS family methods (Larichev, 2001, 2006; Larichev & Moshkovich, 1995, 1997) developed within the VDA paradigm. Preference elicitation in ZAPROS is limited to pairwise comparisons of alternatives that differ in performance on two criteria only, provided that each alternative in the pair has the best performance on all the criteria but one. In the method of dyad comparison of criteria estimates (Moshkovich, Mechitov, & Olson, 2002) admissible comparisons also involve some pairs of different performances on two criteria as well, but it is not required, that one of the performances in each pair is the best.

Recent psychological experiments (Furems, Larichev, Roizenson, Lotov, & Miettinen, 2003) have shown that an individual is capable of making reliable pairwise comparisons of alternatives that differ in estimates upon three and four criteria, using special graphical aids. However, individual abilities vary and while a test task may be too difficult for some subjects it will be easy for others. Thus, a procedure supported the multi-attribute decision making has to be adapt to the individual capability of DM with a specific consistency control of DM preferences and determination of her/his own threshold with respect to the complexity of question they are able to handle.

METHOD UNICOMBOS AND DECISION SUPPORT SYSTEM FOR MULTI-CRITERIA COMPARISON AND CHOICE

Intelligent decision support system (IDSS) UniComBOS (Ashikhmin & Furems, 2005) is designed to assist a DM in choosing the best alternative from the finite set given their qualitative performance estimates upon multiple criteria.

The DM has to describe his/her problem environment in terms of alternatives to be compared and to specify a list of criteria with a view to subsequent estimation of the alternatives' performance. In doing so, he/she may use natural language and terms of the relevant application domain.

Let us define the set of alternatives as A, the set of criteria as $C=\{C^1,\ldots,C^k\}$, where $K=\{1,\ldots,k\}$ is the set of criteria' numbers. Further, it is necessary to specify verbal estimates of all alternatives upon all criteria. In general, such estimates exist in original descriptions of alternatives, or may be obtained from experts, catalogues, and so forth.

Let us denote the estimate of alternative $x\in A$ upon criterion C^j as $C^j(x)$. Thus each alternative $x\in A$ is presented as k-tuple of estimates upon criteria from C: $\mathbf{x} = C(x)$, where $C(x) = (C^1(x), C^2(x),\ldots,C^k(x))$

$X=C(A) = \{\mathbf{x}\,|\,\mathbf{x}=C(x),\ x\in A\}$ - the set of k-tuples, which describes the real alternatives.

The scales $S^j=\left\{s_1^j, s_2^j,\ldots,s_{m_j}^j\right\}$ of estimates for criteria $C^j, j\in K$ are not defined in advance but are constructed from estimates of real alternatives upon every criterion

$$C^j : S^j = \bigcup_{x\in A} C^j(x). \quad C^j, j\in K$$

An ordering of estimates is not specified on the stage of estimating alternatives and constructing criteria scales and should be elicited later as part of DM preferences. All possible combinations of estimates form k-dimensional space $S=\prod_{j=1}^{k} S^j$.

The set of all tuples for real alternatives A form the set $\mathbf{A}=\{C(x)\,|\,x\in A\}$ and $\mathbf{A}\subseteq S$.

As a result we have the set of alternatives A, the set of criteria C, the set of scales S^j and set of multi-criteria descriptions of alternatives A.

The task is to choose the subset $X^*\subseteq X$ such that for any alternative $\mathbf{x}\in X^*$ there is no alternative $\mathbf{y}\in X$ that is preferable to $\mathbf{x}$. Besides, we would like to minimize the number of non-comparable alternatives in X^*, and, ideally, to find the only best alternative.

DM's Preferences

To solve the problem we need to take into account preferences of the DM. We try eliciting simple and reliable preferences first and only if those preferences are not enough to solve the problem we elicit more complex and less reliable preferences. In the UniComBOS approach, the complexity and reliability of preferences is associated with number of criteria involved in pairwise comparisons. We avoid asking the DM to solve