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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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SOFTWARE IMPLEMENTATION OF DECISION SUPPORT SYSTEM

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Abstract. *The paper describes decision support system (DSS) ALTERNATIVE-F developed by the authors and implemented on the personal computers. The methodology of utility theory is used for the decision analysis. The architecture of the ALTERNATIVE-F system is described. The system runs within FoxBase+ DBMS environment. Special features of the ALTERNATIVE-F system implementation are presented.*

Keywords. *DECISION SUPPORT SYSTEM, MULTIATTRIBUTE DECISION MAKING, UTILITY THEORY, ARCHITECTURE OF THE SYSTEM.*

1. Introduction

The main direction of scientific research held in computer sciences today is intellectualization of software of all the classes. Two types of software used to generate among the alternative course of actions can be distinguished. These types are:

1) expert systems which infer the appropriate decision on the basis of domain (situation, context) description and previously accumulated knowledge base,

2) systems of multiattribute choice (known also as decision making systems - DMS) which provide a choice of, in some sense, the best decision on the basis of alternatives description in the space of attributes (criteria) and specification of the user's preferences.

Expert systems (ES) require domain knowledge base thus they could be applied in comparatively narrow domains which possess domain knowledge accumulated, formalized and represented in the appropriate way. Instead, decision making systems pretend to larger universality but as neither "correct" nor generally adopted preferences exist they need presence of the decision maker and/or experts and operate, as a rule, in an interactive mode during both problem formulation

and solving (including specification of the preference system) phases.

Inspite of principal differences between expert systems and multiattribute decision making ones, we can speak today about starting the process of mergence for the software systems of these two types. Thus, utilization of multiattribute choice within expert system environment seems to be quite possible. For example, it might be used as a meta-rule for choice of the next executable production from a set of admissible ones under given context or for final choice of decision if operation of the inference block is resulted in several alternatives.

It seems even more reasonable to apply methods of knowledge engineering within DMS. Here, usage of IF-THEN rules with aim to take into account additionally user's defined constraints and desirability levels in the criteria space could serve as an example.

Note, that groundless dominating of the efforts oriented to the development of expert systems over that of the second type of decision support systems could be observed today. This discrepancy could be especially well seen at the software market, where various ES shells, instrumental and application ES number tens and hundreds but decision making systems number only few. Moreover, most of the available at the market DMS don't meet the requirements to the software operating within personal computers.

2. A Short Survey of the ALTERNATIVE-F DSS

The ALTERNATIVE-F interactive DSS /1/ is intended for running on IBM PC and compatibles. It provides solution of the problems of alternatives comparison and choice from a discrete set (with practically no limitations imposed on this set's power or number of criteria).

The DSS enables the user to set and solve decision making problem both under certainty and under risk and uncertainty. To evaluate alternatives, the user may apply attributes with relation and ordering scales as well as so called "graphical attributes". The alternatives could be associated with point and interval estimates or with distributions on attributes values. The user may define, if necessary, additional constraints in the multi-dimensional space of estimations by introducing rules of four types.

The DSS implements methods of utility theory for decision making /1,2/ and therefore maximizing of mathematical expectation of multiattribute utility function serves as a deciding rule (goal function).

Software is written in FoxBase+ (version 2.10) command language. The ALTERNATIVE-F DSS has particular modules ensuring interface with files like **.dbf* what very often allows to avoid utilization of interactive mode during input of alternatives and attributes as well as values of attributes serving as estimations of alternatives. Information concerning several DM problems can be accumulated and stored simultaneously in one user's directory. Besides, a software interface with FoxGraph business graphics package is implemented within the ALTERNATIVE-F system, what enables the user to express final as well as some intermediate results in the form of two- and three-dimensional figures and graphs.

3. General Concept of the ALTERNATIVE-F DSS

3.1. Methodological background

The ALTERNATIVE-F DSS is used to build a model, find a solution of the DM problem under uncertainty and multiple attributes as well as to make sensitivity analysis of this solution.

The DSS implements methodology of utility theory /2/ which states that a DM problem could be, in general form, defined as follows:

$$\max_{x \in X} [u(x) = \int_R u(r)\, f(r/x)\, dr] ,$$

where x is an alternative (feasible decision); X is set of discrete alternatives or a continuous set defined by inequalities and equations; $\mathbf{R}=\{\mathbf{R}_1, ..., \mathbf{R}_j, ..., \mathbf{R}_m\}$ is a set of DM attributes; $r=(r_1, ..., r_j, ..., r_m)$ is a vector in attributes space, i.e., a consequence of a certain decision; u(r) is a multiattribute utility function defined in $R=R_1 \times ... \times R_j \times ... \times R_m$ and expressing the user's preferences; f(r/x) is a density function of the joint conditional distribution F(r/x) in space of attributes values.

The analysis of DM theory methods /1, 2/ leads to the following conclusions:

1) methods of utility theory for DM are rather complicated thus one should not hope that the decision maker will be able to study and apply them without assistance and guidance of a skilled specialist - so called DM consultant. The latter significantly limits application domain of the utility theory methods because the consultant might not be always available or he might not be introduced in all the details of the problem under consideration due its confidential nature;

2) these methods require collection and processing of large amount of expert and judgemental information and, consequently, difficulties with organization of data processing and calculating arise which could be overcome by means of computers only.

Thus the main goal of development of ALTERNATIVE-F DSS was to propose sufficiently universal decision making support tool which implements a complete set of the utility theory methods and performs functions of the DM consultant both in the final stage of making calculations and in those of revealing qualitative features of the DM problem (stage of structurization) and assessing and preliminary processing of quantitative data (stage of parametrization).

During the decision making session (solution of one particular DM problem) the ALTERNATIVE-F system performs following functions:

1) revealing of goals and defining of the set **R** of DM attributes;

2) determination of set of alternatives and assessment of distribution F(r/x);

3) evaluation of preferability of the possible consequences of alternatives and assessment of unidimensional (single-attribute, scalar) utility functions (linear, piecewise linear or exponential ones) $u_j(r_j)$, j=1, 2, ..., m;

4) specification of multiattribute (m-dimensional) utility function u(r) what includes determination of its functional form (additive, multiplicative, etc.) and values of scaling constants;

5) selection of the "best" decision, i.e., alternative maximizing expected utility.

3.2. The architecture of the system

To implement the ALTERNATIVE-F system FoxBase+ DBMS environment was chosen. The logical structure of the system adequately represents a sequence of actions undertaken with aim to construct DM model and to choose the "best" decision by utility theory methods. The system under consideration contains nine basic modules meant for performing of following functions:

1) module MODEL enables the user to start solving of a new DM problem or to work with one of those being already solved;

2) module ALTER collects and processes judgemental information to determine a set of feasible alternatives (in interactive mode or by reading the corresponding fields from particular *.dbf type file);

3) module ATTRIB is used to determine goals and attributes for the DM problem under consideration either in the interactive mode or by reading the list of attributes from previously (and, may be for different purposes) created file;

4) with help of module ASSIGN possible consequences of the alternatives are estimated, appropriate attribute values are assigned to them and preferability of the consequences is evaluated;

5) module PRAVIL ensures taking into account of user's additional wishes and desires through constructing of the rules reflecting constraints and desirability levels in the attributes space;

6) module OCEN calculates expected utilities of all the alternatives and selects the "best" solution on the basis of these calculations and impacts of the rules mentioned above;

7) module PRINT1 serves for the visualization of results obtained and, if necessary, for printing different reports representing both collected judgemental data and intermediate and final results;

8) module LIBR is used to create subjective verbal scales of the qualitative attributes;

9) module THREEDIM ensures interface with FoxGraph package.

3.3. Internal data base of the system

The data base of the ALTERNATIVE-F system consists of **.dbf* type files of following kinds:

- file *models.dbf* contains names and annotations of the DM problems;
- files like *help*.dbf* contain help and explanation screens and therefore ensure availibility of context-sensitive support at any time;
- files like *r4*.dbf* are used to store user's defined verbal scales for the qualitative attributes;
- files of the **eta.dbf* subtype contain names and types of data base fields where the data obtained from the user will be put in.

Thus, at the beginning of DM process name and annotation of a new problem is stored in the file *models.dbf* and several empty files are created using information from **eta.dbf* or one of the previously solved problems is selected and corresponding data files are opened. After that these files are sequentially updated and modified according to information received from the user.

3.4. Limitations of the first version

The current version of the ALTERNATIVE-F system does not provide a possibility to solve DM problems with continuous set of alternatives. Only additive functional form is used at present to represent multiattribute utility function u(r). Values of the scaling constants are calculated in approximate way on the basis of information concerning ranges of the attributes.

To eliminate impact of these (and some other) simplifications, rules of following four types are allowed to use in the DM process:

- simple rule reflecting flexible constraint on the values of any particular attribute;
- simple rule defining "classical" (exclusive) constraint on the values of one attribute;
- IF-THEN rule describing logical connection between values of a pair of attributes and imposing flexible constraint in two-dimensional subspace of attributes values;
- IF-THEN rule defining in similar manner exclusive constraint.

4. Example

As a sample to demonstrate the ALTERNATIVE-F system very simple DM problem is used. It is supposed that the user wants to by a car and has a possibility to select one of the hypothetical types of cars. The process of this problem solving is shown briefly in the Appendix.

5. Conclusions

The analysis of the applications of this DSS in real-world problems shows that the present version of the ALTERNATIVE-F needs further improvement in order to meet requirements of real DM problems better.

With this end in view, there are outlined and already partly implemented additional extentions of the system in two directions. First of them provides for maximum comfort for the user including development of additional data protection facilities. Second direction assumes extension of number of implemented utility theory methods what will, for example, enable the user to operate with continuous (not only discrete) set of alternatives.

6. References

1. Borisov, A.N., Viļums, E.R. and Sukur, L.Ya. (1986) Interactive Decision Support Systems for Mini-Computers: Information Technology, Mathematical Methods and Software, (In Russian), Riga: Zinātne.

2. Keeney, R.L. and Raiffa, H. (1976) Decisions with Multiple Objectives: Preferences and Value Tradeoffs. New York: Wiley.

LIST OF ALTERNATIVES

No	NAME OF ALTERNATIVE
a.1	Car_1
a.2	Car_2
a.3	Car_3
a.4	Car_4
a.5	Car_5

Figure 1. List of alternative types of cars

LIST OF ATTRIBUTES

No	NAME	TYPE	WEIGHT
c.1	Price $*1000	N	0.19
c.2	Max_speed kmph	N	0.05
c.3	Comfortability	V	0.14
c.4	Mainten_exp $pmonth	N	0.24
c.5	Visual impression	V	0.10
c.6	Safety	G	0.29

Figure 2. List of attributes used to evaluate alternatives

INFORMATION CONCERNING ATTRIBUTE:
*Price $*1000*
TYPE: numeric WEIGHT: 0.190 ASSESSMENT: interval

ALTERNATIVE	LEFT MARGIN	RIGHT MARGIN
Car_1	3.0	3.5
Car_2	4.0	6.0
Car_3	3.5	5.5
Car_4	6.0	8.0
Car_5	7.0	10.0

Figure 3. Values of the attribute "Price" assigned to the alternatives

INFORMATION CONCERNING ATTRIBUTE:
Comfortability
TYPE: verbal WEIGHT: 0.143 ASSESSMENT: point

ALTERNATIVE	ESTIMATE
Car_1	low
Car_2	medium
Car_3	medium
Car_4	high
Car_5	very high

Figure 4. Verbal values of the attribute "Comfortability" assigned to the alternatives

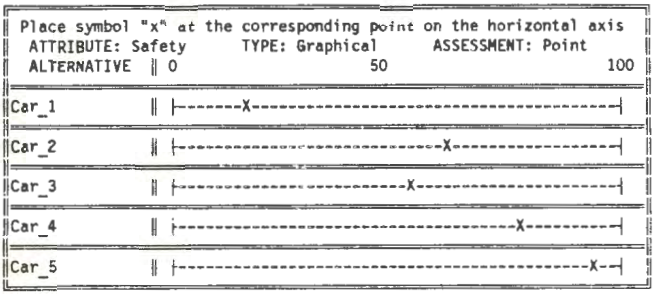

Figure 5. Screen form used to assign values of the graphical attribute to the alternatives

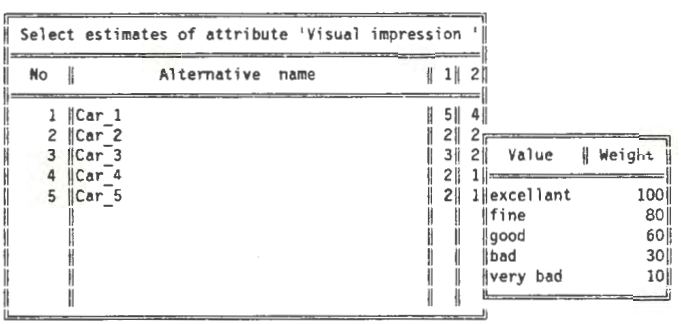

Figure 6. Screen form used to assign values of the verbal attribute to the alternatives

LIST OF RULES

NAME	RULE DEFINITION	WEIGHT
R1	Mainten_exp $pmonth WOULD BE LESS THAN 300.00	90.000
R2	IF Price $*1000 GREATER THAN 6.00, THEN Comfortability WOULD BE GREATER THAN high	80.000
R3	Price $*1000 MUST BE LESS OR EQUAL 7.00	Exclusive

Figure 7. List of the user's defined additional constraints

TABLE OF RESULTS

No	ALTERNATIVE NAME	SUM	RANGE	RULES	
				SUM	RANGE
a.1	Car_1	0.256	5	1.13	3
a.2	Car_2	0.672	2	1.34	1
a.3	Car_3	0.582	4	1.13	2
a.4	Car_4	0.658	3	1.00	4
a.5	Car_5	0.753	1	-1.00	5

Figure 8. Solution of the problem taking into account attributes and rules separately

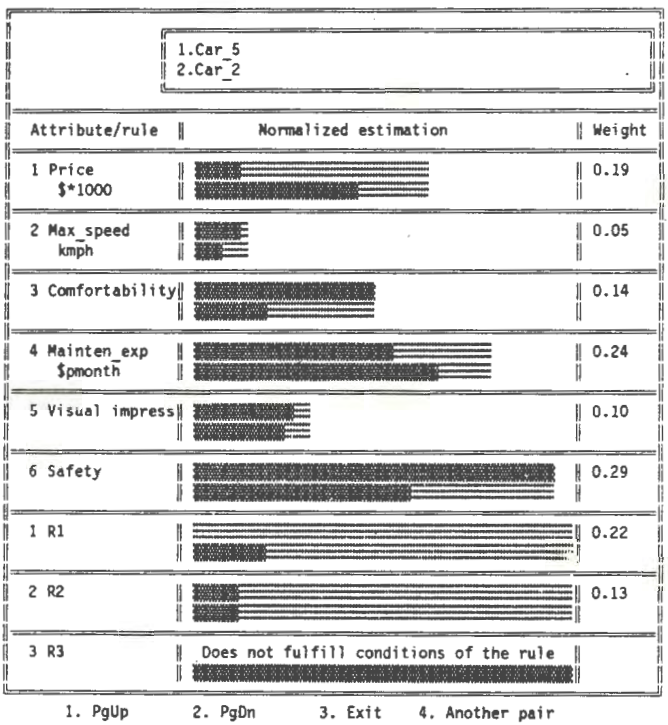

Figure 9. Comparison of the pair of alternatives