Decision Support Systems and Medicine

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***Abstract* — In this article is described the structure and principle of operation of an intelligent decisions support system. System is intended to assist decision-making of processes by computer in management research in various fields, including medicine. This system is simultaneously an e-Learning system that can be applied for training and self-training the students at "Decision Support Systems" discipline.**

***Index Terms* — decision support systems, artificial intelligence, e-Learning.**

I. INTRODUCTION

Decision support systems (abbreviated DSS) are widely used in various fields such as:

- Sciences (mathematics, physics, economics);
- Humanities;
- Sport;
- Medicine.

When decisional situations appear it is necessary to make decisions.

The decision is the result of conscious activity to select directions of action and engagement in it, which usually involves the allocation of some resources. Decision resulting from the processing of information and knowledge and belongs to a person or group of persons who have the authority and responsible for the effective use of resources in certain situations [1, p. 11].

Medical institutions managers may use a DSS when have to solve a decisional problem. These problems can be modeled on the computer. Modeling is a method used in scientific research. Its essence consists in the fact of schematic reproduction investigated system in the form of another similar or of the analogous systems to study the properties and behavior of the studied system.

II. DECISION SUPPORT SYSTEM

One area of activity is considered well structured if this area can be widened into a formal system. Otherwise the field of activity is considered low structured (adapted from [2]).

Decision support systems (DSS) assist poorly structured problems - problems that relate to the low-structured domains.

Decision-making problems are problems of synthesis [3] and refers to the class of low-structured problems. Well-structured solution to a problem is obtained as a result of a dialogue between end-user, beneficiary of problem or his representative, and DSS.

DSS can be applied also for well-structured problems complexity class NP (nondeterministic polynomial). Algorithms to solve these problems require polynomial time execution can outweigh the time requested by the customer.

DSS can be applied in the management of Medical institutions to assist resolving computer using a wide range of decision-making problems, such as the purchase of medicinal equipment. Problems of equipping the medical institutions in the classification established DSS refers to monocriteriale decision problems and decision problems that can be solved by methods of decision trees. DSS can be used also in correctly diagnosing patients as results do analysis and determining appropriate treatment. An example in this context is SONARES system [4].

Intelligent Support System (abbreviated ISS) presented in this paper is intended for solving on the computer the decision problems that belong to four classes of families of decision problems.

Often beneficiary of the decision problem needs considerable time to evaluate the decision problem in all its criteria. SII can effectively assist the beneficiary to solve on the computer decision-making problems. Decision-making process consists of the elements:

1. Decider;
2. Alternative courses of action:
$$A_m = \{A_1, A_2, \dots, A_m\};$$
3. State of nature: $S_n = \{S_1, S_2, \dots, S_n\}$;
4. Probabilities of states of nature:
$$p_n = \{p_1, p_2, \dots, p_3\};$$
5. Decision matrix (see the Table 1 [5, p. 81]);
6. Criteria for the decision making based on family decision problems.

Table 1 The general structure of the decision matrix.

Stările naturii / Cursuri de acțiune alternative	S_1.....................S_j.......................S_n p_1.....................p_j.......................p_n
A_1	a_{11}..........a_{1j}..........a_{1n}
A_i	a_{i1}..........a_{ij}..........a_{im}
A_m	a_{m1}..........a_{mj}..........a_{mn}

Modeling of decision-making process is done with help of Intelligent Support System (ISS), using the following variables:

- A_m - *dependent decision variable;*

- S_n - *independent uncontrollable parameters;*
- p_n - *independent uncontrollable parameters;*
- a_{mn} - *dependent variables.*

III. STRUCTURE AND PRINCIPLE OF OPERATION SUPPORT SYSTEM INTELLIGENT

ISS can be operated in two modes a) training of students overseen by professor and b) self training students. In case b) SSI can be regarded as digital tracks students in DSS.

ISS core is developed in C#. In order to further verify the correctness of proper decision-making problem solving by the teacher (for supervised learning) or by the student (if self-training) call core mathematics package. The principle of operation of the ISS can be seen in Figure 1.

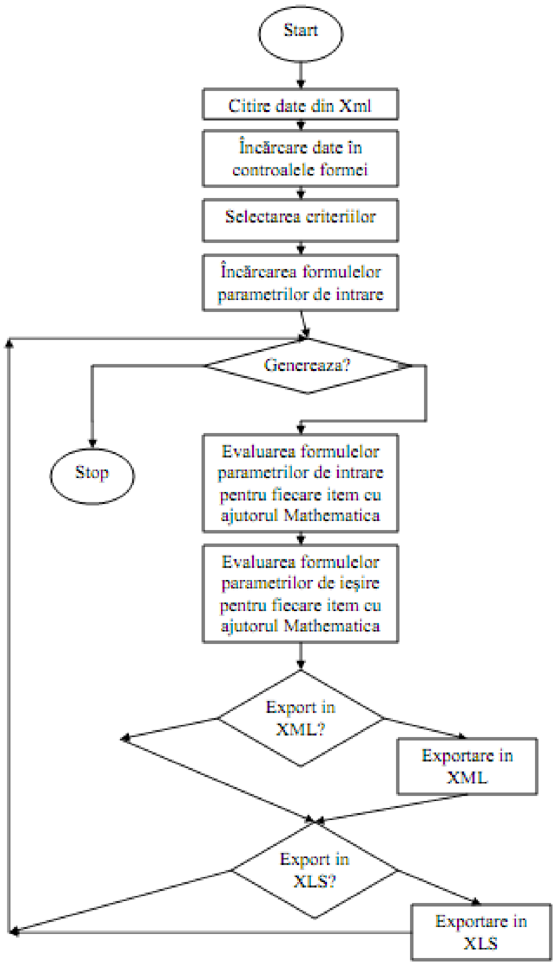


Figure 1. Structure and principle of operation of the overall ISS.

SSI was designed using the methodology oriented families decision problems.

The crowd decision problems (DP) included in course "Decision Support Systems" consists of four subsets:

$$\mathbf{PD} = \mathbf{D_1} \cup \mathbf{D_2} \cup \mathbf{D_3} \cup \mathbf{D_4},$$

where:

- $\mathbf{D_1}$ - *the family of monocriteriale decision problems* (abbreviated **FDP_Mo**)
- $\mathbf{D_2}$ - *the family of multiatribut decision problems* (abbreviated **FDP_M$_u$**);
- $\mathbf{D_3}$ - *the family of decision problems modeled by single period decision trees* (abbreviated **FDP_A**);
- $\mathbf{D_4}$ - *the family of multiatribut decision problems modeled using fuzzy sets* (abbreviated **FDP_F**).
- $D_i \cap D_j = \emptyset, \quad 1 \le i \le 4, \quad 1 \le j \le 4, \quad i \ne j.$

The set DP is meeting subsets **FDP_M$_o$**, **FDP_M$_u$**, **FDP_A**, **FDP_F**, each of the subsets are disjoint two by two.

Each issue of discipline "SSD" is treated by the authors as a *formal theory*.

Definition 1 (adapted from E. Mendelson [6]). Formal theory (axiomatized) $\Im$ is considered defined if the following conditions are met:

(1) *Is given some finite set of symbols - **alphabet** theory $\Im$. Finite strings of symbols of the alphabet are called **expressions** of theory $\Im$.*

(2) *There is a subset of expressions theory $\Im$, called **crowd theory formulas** $\Im$.*

(3) *The crowd formulas is outlined in a subset called **axioms of crowd** theory $\Im$.*

(4) *There is a finite R_1, ..., R_n relationships between formulas, called **crowd of inference rules**. For each rule R_i there is a natural number j so that for each set of j formulas and each formula A effectively determine whether these j formula and formula A relationship is R_i - and if so, A is called a **logical consequence** of these j formula by the formula R_i.*

Alphabet, the set of formulas and inference rules are crowd formal language theory (see, for example, [1]). This language is a training language - structured subset of natural language.

After building a formal model each topic shall establish the two components of intelligent e-Learning for appropriate topic: generator problems and problem solver. These two components of e-Learning is actually a virtual Tracks for training and assessing trainees' skills in knowledge DSS methods.

IV. GENERATORS THE DECISION PROBLEMS

ISS is a component of e-Learning, designed both to support the training of students as well as for:

a) students, master, doctoral students enrolled in the Faculty and for b) managers and people interested in independent study of SSD methods.

Generating tests and custom formulations laboratory problems (further - *custom problems*), represents activities that require the teacher considerable amount of time and effort. Therefore, research on automatic generation of personalized issues of computing disciplines and automatic evaluation of students' responses to these works are present.

Generator is a software problem intelligent, using random factor, every access automatically develop a personalized problem (test). Thus, for each subject can be obtained by a family of decision problems bed.

Generation of decision problems, using ISS, follows these steps:

1. End user enters dates for ISS or ISS automatically prepares input data;
2. ISS receives input from XML;
3. SSI process, analyzes, generate and transmit Mathematic software the information crowd generated for solving problems.

V. DECISION PROBLEM SOLVED

Problem solver assists the manager in decision-making and problem solving. Role of the pproblem solvers is to give an optimal response decision or assist teacher assessment tests proposed for solving students.

A problem solver is an artificial intelligence program in which:

a) program facts are axioms formal theory;
b) productions - the rules of inference;
c) questions (called and purposes) - the problems faced by managers or proposed for solving students;
d) when formulating the core purpose of an ISS the beneficiary, developed in C#, calling the Mathematics software. Mathematic software algorithms automatically prepare the test solution;
e) solutions obtained (one, several or none) can be treated as theorems proved in the formal theory corresponding theme examined and solver tests - as a system of automatic theorem proving in formal theory;
f) program in C# assisted by software running Mathematics is a problem solver.

Solving a family of decision problems using ISS following steps:

1. Mathematical software processes information received from ISS (solves the problem of modeling decision problems proposed) and returns the results ISS.
2. ISS unites (encapsulates) the problem and the results obtained from solving.
3. Output data are transmitted to the end user in XML and XLS.

VI. CASE STUDY

Whether the Ministry of Health of the Republic of Moldova wants to buy a new subordinate institutions diagnostic medical equipment A. Participating in the auction organized by the Ministry four producers of this type of equipment respectively, A_1, A_2, A_3, A_4. The organizers have chosen one of these machines.

Analyst team Health Ministry agreed on eight attributes (characteristics) that may be taken into account and can be used as criteria for evaluation of proposed equipment. The criteria are: C_1 - precision measurements; C_2 - degree of harm to the patient; C_3 - degree of environmental pollution; C_4 - efficiency measurements (minutes required for an investigation); C_5 - purchase price; C_6 - cost of operation; C_7 - term operation and C_8 - facilitate exploitation (see Table 2).

Table 2. Decision Matrix.

C_j / A_i	C_1	C_2		C_3		C_4	C_5	C_6	C_7	C_8	
A_1	0,01	M	0	M	0,33	20	10000	2500	5	D	0,66
A_2	0,001	M	0	S	0	25	20000	3500	7	B	1
A_3	0,0001	S	1	F.S	1	10	30000	500	12	F. B	0,33
A_4	0,001	M	0,5	R	0,66	30	15000	2000	9	M	0
W_j	**0,18**	**0,16**		**0,16**		**0,15**	**0,14**	**0,09**	**0,07**	**0,05**	

Legend: M - medium, S - weak, FS - very weak, D-difficult, B - good, F.B - very good FB, R – high

Demonstrates attribute value antagonism. For example, the performance attributes C_1, C_2, C_3, C_4, C_6, C_7 and C_8 necessarily lead to increased attribute C_5 - purchase price.

Under the conditions specified by the Ministry of Health has chosen an optimal way considering Moldova's needs in this type of diagnostic medical equipment and financial resources available for this purpose Ministry.

Elements of the problem are:

- ❖ list of alternatives:
  - A_1, A_2, A_3, A_4
- ❖ Evaluation Criteria:
  - $C_1, C_2, C_3, C_4, C_5\ C_6, C_7, C_8$;
- ❖ Media type decision
  - multiatribut;
- ❖ Methods decision
  - Maximin Method;
  - Maximax Method.

Below we will show the steps to solve this problem with ISS.

Step 1: Select the type of problem.

Are selected:

a) Type of problem (multiatribut problems)
b) Decision-making environment (multiatribut methods) and
c) Decision-making methods.

All these steps can be seen in Figure 2.

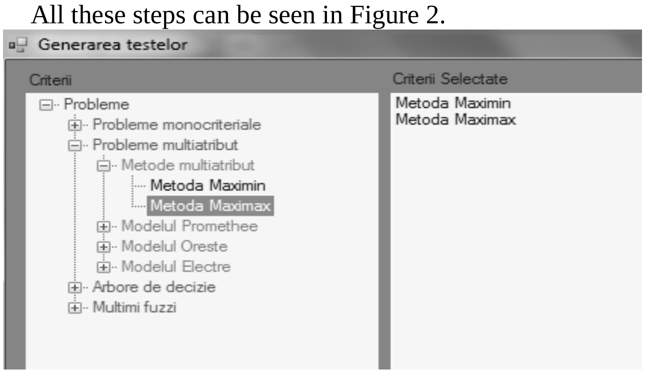


Figure 2. Select the type problem.

Step 2: Editing the decision problem can be introduced to the problem (click on the Edit button to make parameters, see Figure 3).

Figure 3. Editing the decision problem.

Step 3: Enter the parameters for the task (see Figure 4).

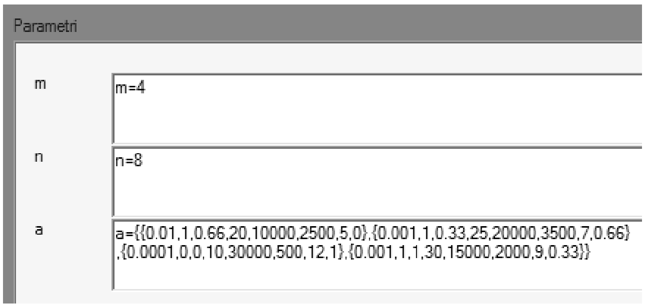


Figure 4. Entering data problem to solve.

Step 4: Saving Parameter problem and generating the problem. These buttons can be seen in Figure 3.

Step 5: Complete data visualization decision problem and problem solving outcomes (see Figure 5).

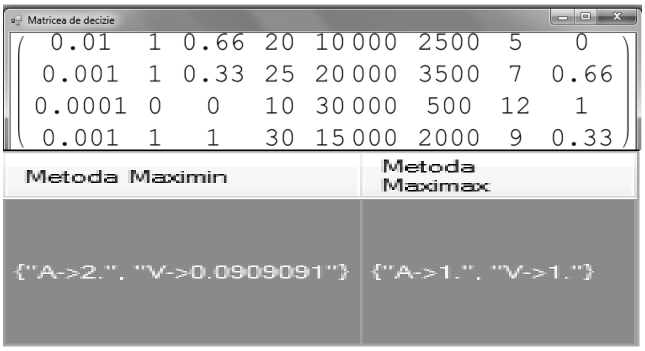


Figure 5. The problem and results.

Step 6: Export decision problem results in XLS format. Proceed to the final step when the user wishes to export your results into XLS format. is click on the Export button in XLS see Figure 6.

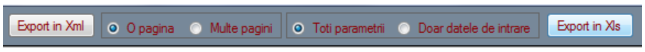
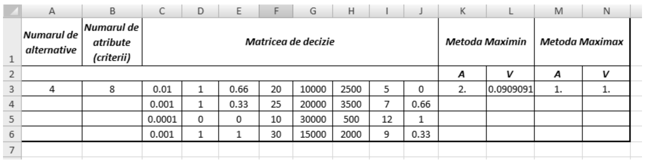


Figure 6. Exports in XLS.

Export decision problem results visualization can be seen in Figure 7.



Numarul de alternative	Numarul de atribute (criterii)	Matricea de decizie								Metoda Maximin		Metoda Maximax	
										A	V	A	V
4	8	0.01	1	0.66	20	10000	2500	5	0	2.	0.0909091	1.	1.
		0.001	1	0.33	25	20000	3500	7	0.66				
		0.0001	0	0	10	30000	500	12	1				
		0.001	1	1	30	15000	2000	9	0.33				

Fig. 7. Results issue.

After receiving the results of problem analysts' team from the Ministry of Health make an analysis of all results received under the two methods and they deem it appropriate decision.

VII. CONCLUSION

Analyst team Health Ministry decision problem analyzed results, evolved in the manner optimistic ISS (MaxiMax method) and pessimistic (maximin method) and appropriate decision.

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