

UDC 001.891.573:004.891:004.432 (045)

O. V. Zaritskyi

**MAKING-DECISION MODEL IN “CLIPS” SOFTWARE ENVIRONMENT**

Educational-Scientific Institute of Information Diagnostic Systems, National Aviation University,  
Kyiv, Ukraine  
E-mail: oleg.zaritskyi@gmail.com

**Abstract**—Theoretical basis of making-decision models analysis based on system approach has been presented. As well classification of decision-making models is been described and used in the further modeling in CLIPS software environment.

**Index Terms**—Decision making system; artificial intellect; professional activity analysis; CLIPS software environment; decision making model.

## I. INTRODUCTION

The rapid development of cybernetics and computer science, the artificial intelligence has given significant increasing of new methods and approaches in optimization of control systems. The junction of modern control theory and artificial intelligence (AI) led to the emergence of a new direction, which is called intellectual control (management) [1]. Intellectual control includes of cause expert systems based on knowledge, in particular the systems based on the rules.

Typically, decision-making information systems had been developed in several areas, the main of which is the direction of expert systems. It should be noted that the need for processing large amounts of data in the decision-making process [2], especially in the face of uncertainty, led to the emergence of a class of information systems within the methods and systems of artificial intelligence [3].

Analysis of main information system's action principles, as well as implementation of control systems in parts of algorithmically, hardware and software [4] allows us to conclude about main task of the system – synthesis of system's purposes or target solution.

Synthesis of the target solution is possible with the methods and means of obtaining information about the environment and methods for determining your own states as the control object and the control system itself.

When forming the target solution the problem of sufficiency of knowledge base, the applicability of the existing rules, possibility of their implementation, both on substance and on a constructive level has appeared. No less important is rate of incoming data and timely development of solutions templates, not only familiar with the situation, and if necessary, able to produce new knowledge.

Expert system is considered as a direction of declaration programming because information processing carried out on the level of rules instead of the level of algorithms, using programming languages like CLIPS, OPS5 etc [5], [6].

Expert systems operate under two main constraints.

1. Continuously increasing the data rate about the state of the environment, different information systems, control system and the expert system.

2. System performance, built using a declarative rule-based programming is quite limited.

There are two ways to overcome the limitations: constantly increase data processing rate in information systems or to optimize processing algorithms. Optimization algorithms suggest identification of decision-making models and the use of artificial intellect approaches only in irrational model patterns. Therefore, the objective of the article is presenting approach for identification of decision-making models types.

There are some common approaches for classification of research objects. In the research the division of the total method or hierarchical clustering is been used. The method suggests dividing a set of objects that have some similarities, and at the same time differences. Similarity could be reflected in the criteria, the difference between them – in the accessory groups.

The considered criteria are decision-making model's attributes  $C_i$ :

- $C_1$  – means of operation;
- $C_2$  – methods of operation;
- $C_3$  – level of control during the operation;
- $C_4$  – level of decisions reasoning;
- $C_5$  – type of operation performed.

It's supposed to divide types of decision-making models into three groups, according to the level of certainty of the decision [8], determined by the criteria  $C_i$ :

- classical (rational) model ( $M_1$ );
- behavioral model ( $M_2$ );

– irrational model ( $M_3$ ).

Thereby decision-making models could be described as a function of five variable  $C_i$  by common equation (1):

$$M_j = f(C_i). \tag{1}$$

The main objective of research is to clarify possible combinations of criteria's value, relationship between the criteria and using the classification methods group possible variety of decision-making models.

## II. SOLUTION OF THE PROBLEM

Described in [7] the functional model of the essence – "model solution" combines approaches of scientists M. Woodcock and Francis D. on classification levels of decision-making and F. Findler on the degree of structuring of the problem and, as a consequence necessarily level of creativity required for its solution. Level of decision by Francis D. roughly classified into ordinal scale from routine, which involves a decision in complete certainty from input and output parameters point of view to innovation, which characterized by almost complete uncertainty inherent to the development of new technologies and methodologies.

Tools and methods for performing operations been measured in ordinal scale from determined to undetermined, which is necessary for solution of innovative problems that were not been solved before, or existing methods and tools should be improved or developed.

The level of control been assessed from the constant, direct control during the operation to complete lack of control, when creative and innovative problem are been solved. Possible combinations of attributes' estimates of the essence – "model solution" presented in Table I and used as input in the classification analysis. Rating scales described in detail in the article [8].

Since the attributes evaluation of the essence are been measured by categorical values, as a function of distance in agglomerative clustering procedure were used inconsistencies percent and weighted average pairwise rules for hierarchical clustering.

Result of clustering shown in Fig. 1. Numbers of attributes estimates combinations of the essence "model solution" marked  $C_i \{1 \dots 30\}$  corresponding to the 30 experimental combinations [8].

Combinations  $C_i \{1 \dots 12\}$  correspond to the classical decision-making model, as characterized by certainty of methods and means of operation. Decision usually takes place under maximum supervision of the head or systems and its justification is been based on standardized procedures and instructions.

Combinations  $C_i \{13 \dots 18\}$  describe the behavioral decision-making model, which is characterized by some uncertainty in terms of means and methods. The person, who makes the decision, is almost within the nominal control, and the type of operation is between the process and consulting activities. It might be applied partly for researches.

Combinations of estimates  $C_i \{19 \dots 30\}$  describe irrational decision-making model, which is characterized by considerable uncertainty both in terms of methods and tools and in the implementation of the researches: applied, original, providing innovative substantiation solutions level.

As a result of the clustering attribute's set were divided into three subsets that correspond to the three defined type of decision models.

TABLE I  
COMBINATIONS OF ESSENCE "MODEL SOLUTION"  
ATTRIBUTE ESTIMATES

$C_1$	$C_2$	$C_3$	$C_4$	$C_5$
1	1	1	1	1
1	1	2	2	2
1	1	2	2	3
1	1	1	1	3
1	1	2	1	3
1	1	1	2	3
1	1	1	1	2
1	1	1	2	2
1	1	1	2	1
1	1	2	1	1
1	1	2	2	1
1	1	2	1	2
2	2	3	3	4
2	2	4	3	4
2	2	3	3	5
2	2	4	3	5
2	2	2	3	4
2	2	2	3	5
3	3	4	4	6
3	3	4	4	7
3	3	5	4	6
3	3	5	4	7
2	2	4	4	6
2	2	4	4	7
2	2	5	4	6
2	2	5	4	7
2	3	4	4	6
2	3	4	4	7
3	2	5	4	6
3	2	5	4	7

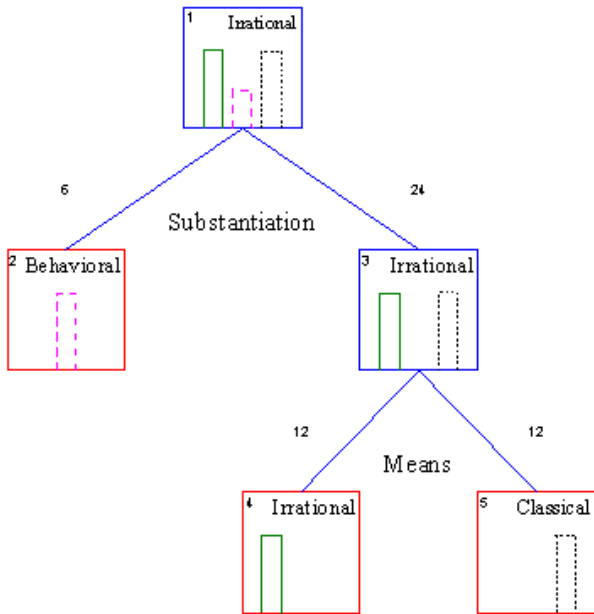


Fig. 1. Classification graph tree of decision model

Scattering diagram (Fig. 2) of canonical values for pairs of discriminant function values provides a graphical representation of the distribution (group) of models. Combinations of estimates that are the same model types are localized in certain areas of the plane.

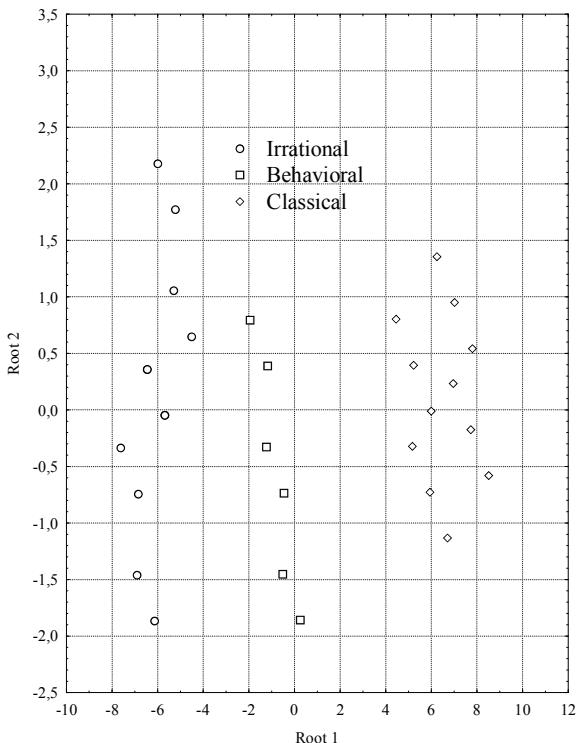


Fig. 2. Scattering diagram

The distance between centroids of irrational and behavioral decision-making model less than the between classical and behavioral models, indicating a

weak boundary between the first two models of decision.

The results of classification trees (Fig. 1) as a method of discriminates dimensional clustering for categorical predictors using the CART method correlate with the cluster analysis results (Fig. 2) in part of clear separation of possible solutions into three groups according to the attribute values.

Conceptual expert system structural model (Fig. 3) was presented in the article [9]. User's interface allows to organize data input or their loading from database into module, responsible for data calculating, and dialog with users. Method of decision interpreting allows getting reasons of the decision by the system. Working memory keeps facts, which are been creating during working of entity calculation algorithm [10]. Inference engine – program component of the system, responsible for inference, operating with rules and facts. It ranks rules and fulfill rule with the highest priority.

Working list of rules contains actual rules in order of priority, if their patterns satisfy facts or objects from working memory.

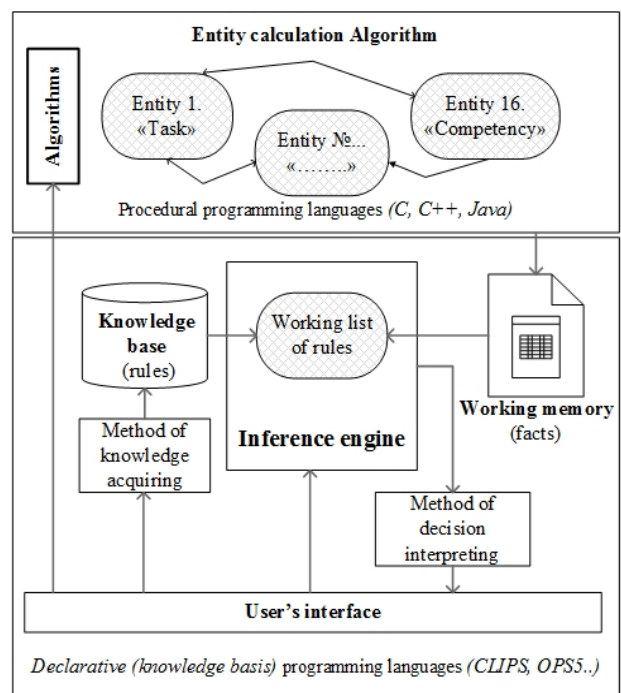


Fig. 3. Expert system structure, basis on the rules

Authors presented the results of formalizing information decision-making models by introduction and description of the entities and the attributes of the models using linguistic variables of the fuzzy sets theory in order to further use in flight control systems or other information system [10]. We'll present the criteria in terms of the linguistic variables using CLIPS language:

$C_1, C_2$  are means (methods) of operation:

```
(deftemplate Execution_methods (resources)
  0 10 points
  ((detr (z 1 4)) ; determine completely
  (detp (pi 3 5)) ; determine partly
  (udet (s 6 10))) ; undetermined
  C3 – level of control during the operation.
(deftemplate Control_level
  0 10 points
  ((ccon (z 1 4)) ; constant control
  (absc (s 6 10)) ; absence of any control
  (mang not [ ccon or absc ])) ; management
  C4– level of decisions reasoning
(deftemplate Reasoning_level
  0 10 points
  ((rout (z 1 4)) ; routine
  (sele (pi 3 5)) ; selective
  (adap (pi 2 7)) ; adaptation
  (inov (s 8 10))) ; innovation
  C5– type of operation performed
(deftemplate Operation_type
  0 10 points
  ((proc (z 1 4)) ; process
  (cons (1 0) (5 1) (6 0)) ; consultation
  (resa (pi 3 7)) ; research applied
  (resi (s 7 10))) ; research ingenious
```

Decision-making models in terms of linguistic variables using CLIPS language are presented in Fig. 4.

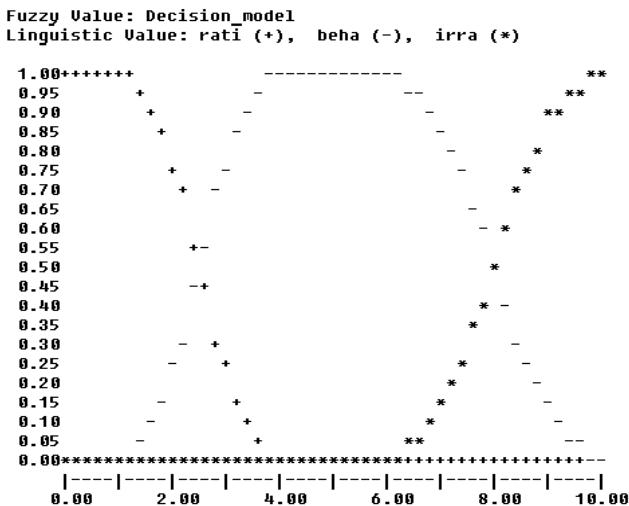


Fig. 4. Graphical presentation of linguistic variables “Decision-making models”

The expert system provides activation of appropriate knowledge base for the definition decision-making models and calculation their numerical assessments using rules.

The rules developed for the expert system are based on FUZZYClips annotation:

```
defrule Rational_model
  (Execution_methods detr)
  (Execution_resources detr)
  (Grounding_level rout or sele)
  (Control_level ccon), (Operation_type proc)
=> (assert (Decision_model rati)))
(defrule Irrational_model
  (Execution_methods detp or udet)
  (Execution_resources detp or udet)
  (Grounding_level adap or inov)
  (Control_level absc), (Operation_type resi)
=> (assert (Decision_model irra)))
(defrule Behavioral_model
  (Execution_methods detp)
  (Execution_resources detp)
  (Grounding_level sele or adap)
  (Control_level mang)
  (Operation_type cons or resa)
=> (assert (Decision_model beha)))
```

The result of decision-making models classification using developed expert system and algorithms (rules) are presented on (Fig. 5). As well, on Fig. 5 initial states of the criteria’s values are presented.

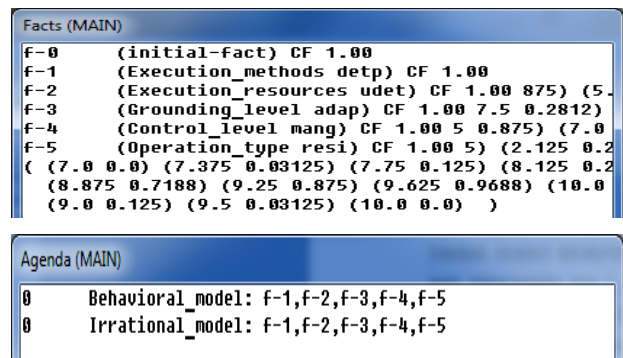


Fig. 5. Result of classification

### III. CONCLUSIONS

The analysis of possible combinations of attributes’ assessments of the essence – "model solution" and their further classification allowed to describe three types of decision-making models: classic, behavioral and irrational. On the bases of the presented criteria and types of models expert system rules were developed. The rules were implemented using CLIPS software environment.

### REFERENCES

- [1] S. N. Vasyl'ev, A. K. Zherlov, E. A. Fedosov, and B. E. Fedunov, *Intelligent control of dynamic systems*. Moscow, Fyzmatlyt, 2000, 420 p.
- [2] O. I. Larichev, *Theory and methods of decision making*. Moscow, Logos, 2000, 296 p.
- [3] S. Russel and P. Norvig, *Artificial intellect. Modern approach*. Second edition, 2006, 345 p.

- [4] J. C. Giarratano, *Expert system principles and programming*. Fourth edition. PeopleSoft, Inc., 2007, 1156 p.
- [5] B. Orchard, *FuzzyCLIPS Version 6.10d*. User's Guide Integrated Reasoning Group Institute for Information Technology National Research Council Canada. 2004. 82 p.
- [6] *CLIPS*, Reference Manual. vol. II. Advance programming guide. 2007, 293 p. [in English].
- [7] O. V. Zaritskyi, "Informational modeling of decision making process." *Software engineering*, Kyiv: NAU, no. 1(25), pp. 56–61, 2015.
- [8] O. V. Zaritskyi, "Theoretical basis of decision-making model formalizing in frame of professional activity's estimation algorithm with help of information technology." *Informatization and control questions*, Kyiv: NAU, no. 3(51). pp. 51–55, 2015.
- [9] O. V. Zaritskyi, "Theoretical basis of professional activity analysis and estimation expert systems development." *Electronics and control system*. National aviation university, Kyiv: NAU, no. 2(44). pp. 103–106, 2015.
- [10] O. V. Zaritskyi. "The formalization of decision-making models in expert information system of professional activity assessment," *Journal of Engineering Academy of Ukraine*, Kyiv: NAU, no. 1, pp. 66–71, 2016.

Received June 02, 2016.

**Zaritskyi Oleh.** Candidate of Engineering. Doctoral.

Department of information protection means, Educational-Scientific Institute of Information Diagnostic Systems, National Aviation University, Kyiv, Ukraine.

Education: Kyiv Institute of Air Forces, Kyiv, Ukraine (1996).

Research interests: mathematical modeling of processes and systems.

Publications: 25.

E-mail: olegzaritskyi@gmail.com

**О. В. Заріцький. Модель прийняття рішення у програмному середовищі CLIPS**

Наведено теоретичні основи аналізу моделі прийняття рішення на підставі системного підходу. Також описано класифікацію моделей прийняття рішення, яка в подальшому використовувалася для моделювання в програмному середовищі CLIPS.

**Ключові слова:** системи прийняття рішення; штучний інтелект; аналіз професійної діяльності, програмне середовище CLIPS, модель прийняття рішення

**Заріцький Олег Володимирович.** Кандидат технічних наук. Докторант.

Кафедра засобів захисту інформації, Навчально-науковий інститут інформаційно-діагностичних систем, Національний авіаційний університет, Київ, Україна.

Освіта : Київський інститут військово-повітряних сил, Київ, Україна (1996).

Направлення наукової діяльності: математичне моделювання процесів та систем.

Кількість публікацій: 25.

E-mail: olegzaritskyi@gmail.com

**О. В. Зарицкий. Модель принятия решения в программной среде CLIPS**

Представлены теоретические основы анализа модели принятия решения на основании системного подхода. Описана классификация моделей принятия решения, которая в последующем использовалась для моделирования в программной среде CLIPS.

**Ключевые слова:** системы принятия решения; искусственный интеллект; анализ профессиональной деятельности; среда программирования CLIPS; модель принятия решения.

**Зарицкий Олег Владимирович.** Кандидат технических наук. Докторант.

Кафедра средств защиты информации, Учебно-научный институт информационно-диагностических систем, Национальный авиационный университет, Киев, Украина.

Образование: Киевский институт Военно-Воздушных Сил, Киев, Украина (1996).

Направление научной деятельности: математическое моделирование процессов и систем.

Количество публикаций: 25.

E-mail: olegzaritskyi@gmail.com