

Classification of Decision-Making Information Models as a Part of Aircraft Control System

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Abstract—Theoretical basis of decision-making models analysis information system as a part of aircraft flight control system from knowledge based system approach has been presented. As well classification of decision-making models is been described for the further development of artificial intellect “consulting” systems.

Keywords—*decision making system; flight control system; artificial intellect; professional activity analysis*

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. Currently, modern «consulting» information systems widely used [2, 3]. It should be noted that the need for processing large amounts of data in the decision-making process, especially in the face of uncertainty, led to the emergence of a class of information systems within the methods and systems of artificial intelligence.

Onboard expert systems have classified as advisory information systems that operate on the data about the current state of the control object, as well as simulate possible scenarios of changes in the external environment. Onboard expert systems should provide a logical conclusion to the current situation and development of hypotheses that could be used for classification of decision-making models of the aircraft’s crew.

II. PROBLEM STATEMENT

Analysis of main information system’s principles of action [3] – [5], as well as implementation of control systems in parts of algorithmically, hardware and software 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 [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 are means of operation;

C_2 are methods of operation;

C_3 is the level of control during the operation;

C_4 is the level of decisions reasoning;

C_5 is the 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

$$M_j = f(C_i). \quad (1)$$

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.

III. PROBLEM CLASSIFICATION SOLUTION OF DECISION-MAKING INFORMATION MODELS

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].

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

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 ... 30} corresponding to the 30 experimental combinations [8].

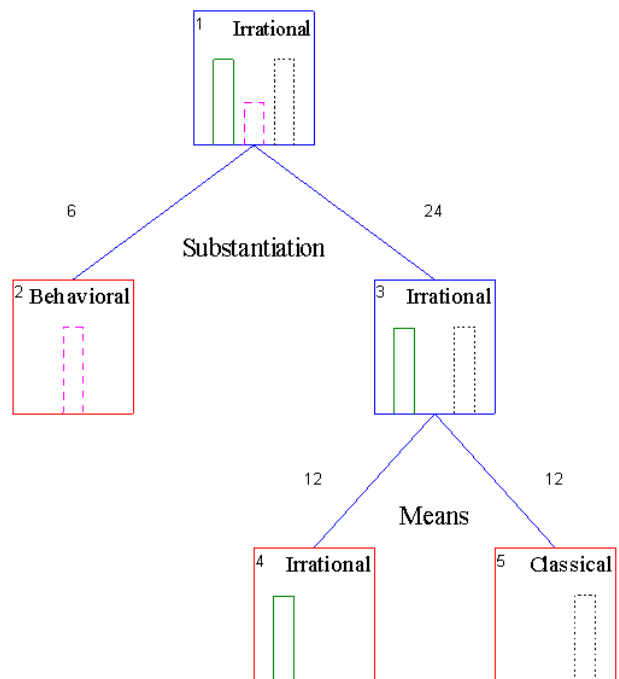


Fig. 1. Classification graph tree of decision model.

Combinations C_i {1...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 based on standardized procedures and instructions.

Combinations C_i {13...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...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.

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.

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.

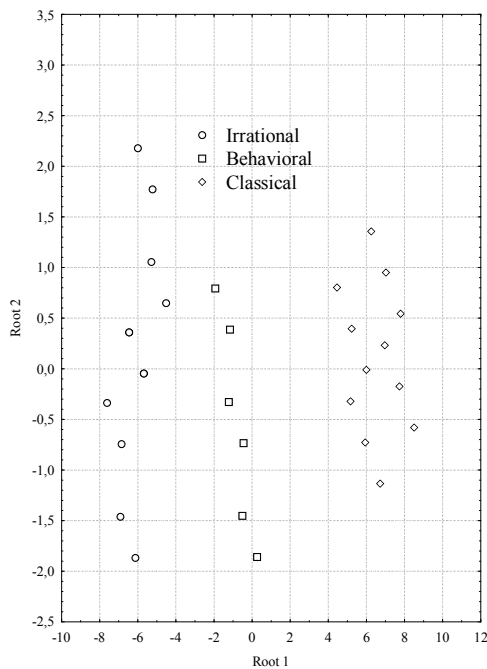


Fig. 2. Scattering diagram.

The results of classification trees (Fig. 1) as a method of discriminant 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.

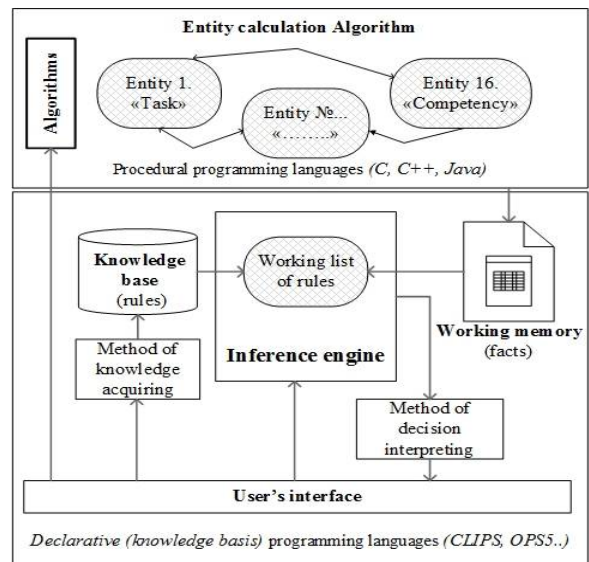


Fig. 3. Expert system structure, basis on the rules.

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:

```

C1, C2 – 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

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(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

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

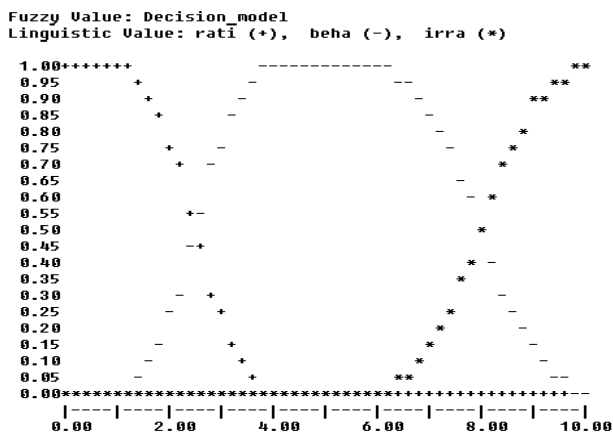


Fig. 4. Graphical presentation of linguistic variables “Decision-making models”.

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

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

```

defrule Rational_model
  (Execution_methods detp)
  (Execution_resources detp)
  (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))

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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.

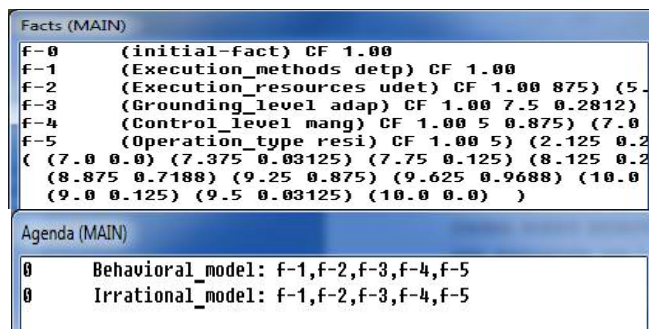


Fig. 5. Result of classification.

IV. CONCLUSION

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.

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