# THE ON-BOARD OPERATIVE ADVISORY EXPERT SYSTEMS FOR ANTHROPOCENTRIC OBJECT

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*Abstract: A class of intelligent systems located on anthropocentric objects that provide a crew with recommendations on the anthropocentric object's rational behavior in typical situations of operation is considered. We refer to this class of intelligent systems as onboard real-time advisory expert systems. Here, we present a formal model of the object domain, procedures for obtaining knowledge about the object domain, and a semantic structure of basic functional units of the onboard real-time advisory expert systems of typical situations. The stages of the development and improvement of knowledge bases for onboard real-time advisory expert systems of typical situations that are important in practice are considered.*

*Keywords: expert systems, AI architectures, inference technique.*

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## Introduction

In up-to-date complex engineering of man-machine objects, the problems of setting the goals of object operation (general and current) are always solved by a crew (an operator or a group of operators governing the man-machine object). Such objects are called anthropocentric. An anthropocentric object is a functionally consistent set of onboard measuring and executive devices (OM&ED), an onboard digital computing system (ODCS) with implemented algorithms for the anthropocentric object system-forming kernel (onboard digital computer (ODC) algorithms), and a crew with algorithms of its activity (CAA) supported by the information-control field (ICF) of a crew compartment, which is the carrier of everything listed above.

The anthropocentric object operation is naturally divided into operation sessions for which the anthropocentric object and its crew is prepared in advance. As a result of this preparation, prior information and the main (general) goal of the forthcoming operation session are transmitted aboard the anthropocentric object (inserted into the ODCS algorithms and into the crew activity algorithms).

## 1. Onboard Real-Time Advisory Expert Systems of Typical Situations for an Anthropocentric Object

The external world in which a TS ORTAES operates is the information medium of an anthropocentric object (Fig. 1) formed by the output information of onboard measuring devices, the standard (not included in the TS ORTAES) onboard digital computer algorithms, and the crew compartment information-control field signals. Before starting a forthcoming operation session [Fedunov,1998], *a priori* information about this session is loaded into the TS ORTAES. This information is transmitted from the intellectual system, preparing the anthropocentric object for the operation session [Vasil'ev and others, 2000].

For every problem sub-situation significant for a TS, the ORTAES generates solution recommendations for the crew with brief explanatory notes. The recommendations and explanatory notes for them come to the crew compartment information-control field (the information part). The crew can disregard the ORTAES recommendation and resolve the problem sub-situation by other methods without reporting about this to the ORTAES. In this case, the ORTAES must develop the next recommendation taking into account the method implemented by the crew. Any disregard by the crew toward ORTAES recommendations is registered by the onboard objective control system, and when the operation session is completed, this information is submitted to the intelligent system analyzing the completion of the operation session.

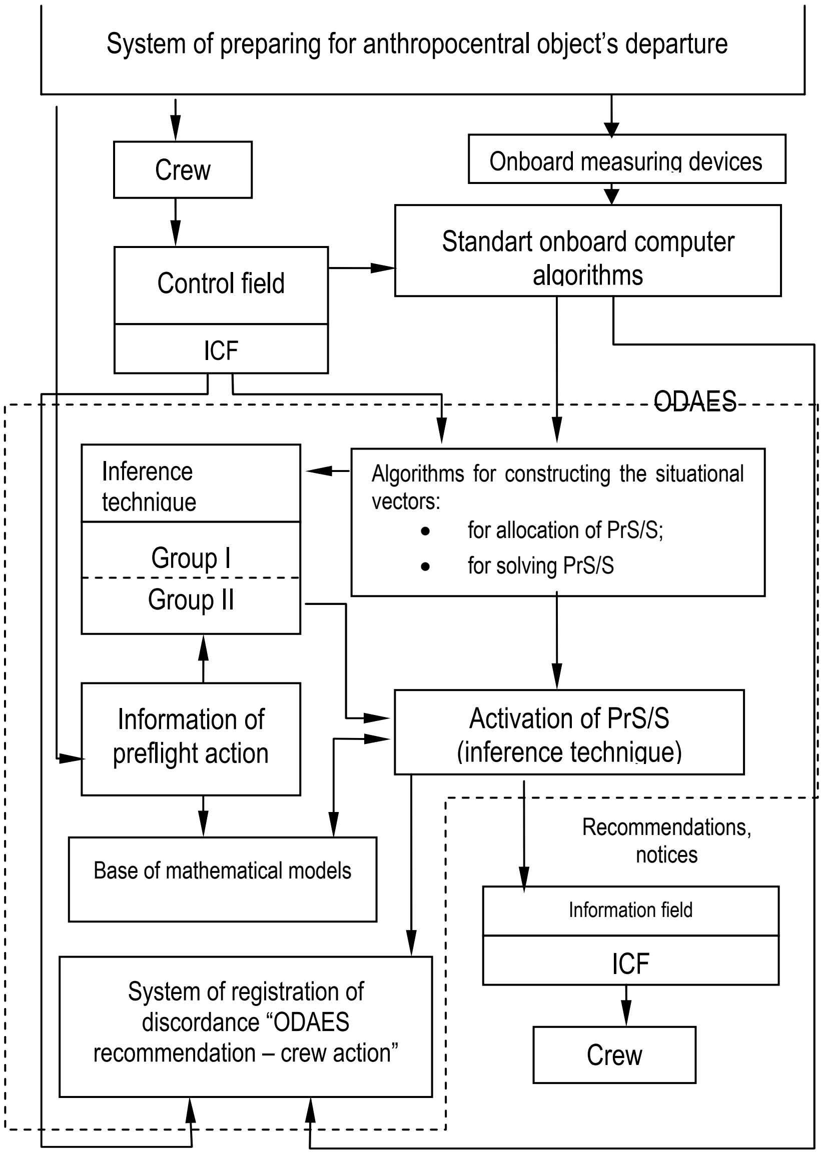


Fig. 1. The ORTAES of typical situation. Function units.

The ORTAES recommendations must be in constant agreement with the activated model of the crew behavior at the conceptual and operative levels. The crew perceives the external world where the anthropocentric object operates, and the object technical state itself (the inboard world) through the sense organs and through the crew compartment information model of the outboard and inboard situation in the information-control field (the observable external world). With professional skills and prior information (the most general information about the external world and specific information about the anthropocentric object operation session), the crew (within its activated model of behavior in this TS) each time selects the current problem sub-situation (PSS) without reporting about this to the TS ORTAES. Precisely with respect to this PSS, the TS ORTAES must immediately elaborate a reasonable and efficient recommendation for solving it.

Let us enumerate the main features of a TS ORTAES:

- it must solve all the problems of its own typical situation;
- it must have a restricted dialogue with the crew (restrictions on the time interval allowed by the external situation and on the information input through the information-control field of the anthropocentric object crew compartment performed by an operator);

- as for algorithms and rules, it must be oriented to the situational control structures;
- it must be in constant agreement with the activated conceptual model of operator behavior by generating recommendations for solving the current problem at the level of a professional operator with a significance that is sufficient for him (so as not to convey information the operator already probably knows);
- it must have a delayed self-education component.

## 2. Structure of The Knowledge Base of The TS ORTAES

The TS ORTAES always operates (in the real-time mode) in cooperation with an operator [Fedunov, 1996]. It constantly produces and presents recommendations for the operator about a rational method for solving the current problem (PrS/S). In this context, the operator within the activated TS does not report to the ORTAES about the problem that has occurred and about the necessity to present recommendations for its solution to him. Furthermore, the operator can disregard (without reporting to the ORTAES) the recommendation elaborated by the ORTAES, and the ORTAES has to operate further by taking into account the operator's decision (made contrary to its recommendation).

We briefly dwell on the description of the destination and the form of the inference technique in the knowledge base of an ORTAES (Fig. 1).

Using the current information from onboard measuring devices, standard algorithms in onboard computer, signals from the information-control field (ICF) of the crew compartment, a situation vector SV(TS-PrS/S) is formed in the knowledge base of the ORTAES. This vector describes the state of the outboard and onboard environment for assigning (or identifying) current PrS/S. We call the technique of such an assignment the inference technique on the set of PrS/S. It is constructed on the basis of results of cooperating with experts who are specialists in the object domain considered. These mechanisms are implemented in the ORTAES in the form of the rules "if ..., then ..., else...". Their completeness and consistency is achieved by finalizing the ORTAES on systems of imitational modeling (SIM) [Fedunov, 1996] together with experts.

The inference technique used for (determining) a rational solution to the current PrS/S is represented by three types of mechanisms.

### 2.1. Inference Technique Taking into Account the Current Preferences of the Crew.

Let a problem and some alternatives for its resolution be given. Suppose that, in each alternative, we are interested in some of its properties, which we will use for comparing the alternatives while choosing the most preferable one. We shall call these properties the comparison criteria. Suppose that we have several criteria which we use for comparing the alternatives. Also sup: that there is an expert (or experts) who has a suffitly definite opinion about the problem and the alternatives for solving this problem, which allows him to pairwise compare the alternatives according to each criterion.

The method of multicriteria choice of an alternative is a systematic procedure for hierarchical ordering of the elements of the problem. This method allows one to arrange the alternative according to their preferences with respect to a totality of specified comparison criteria. In order to constructively use this method in the inference technique, we present its justification based on studies by Saaty [Saaty,1991].

#### *2.1.1. A Method of Pairwise Comparison of Alternatives with one Preference Criterion.*

Let us distinguish one of the comparison criteria and pairwise compare the alternatives with respect to this criterion.

To formalize the procedure for choosing a preferable alternative, first, we consider the simplest example, namely, the problem of choosing the heaviest object (the comparison criterion) in a given set of objects $A_1$,..., $A_i$ ..., $A_n$ (alternatives) whose absolute weights (physical) are known. The weight of the object $A_1$ is $w_1$, the weight of the object $A_2$ is $w_2$, and the weight of the object $A_n$ is $w_n$. Since the object weights are known, to range them by weight, it is sufficient to arrange their weights in ascending order (to sort $n$ numbers) and to choose the object with the greatest weight. Let us see in what ways one can choose the heaviest object.

We shall pairwise compare the weights of the objects $A_i$; i = 1 - n, recording the comparison results in the form of a table (matrix).

The properties of an ideal matrix of pairwise comparisons can also be used for experimental matrices.

Let a researcher have a sufficient amount of qualitative information about some instances $A_1,..., A_n$ compared by a certain criterion. Suppose that the matrix of pairwise comparisons of order *n* (experimental matrix) is composed for these instances. Naturally, it differs from the ideal matrix (calculated for this case). To estimate this difference, Saaty proposes the following procedure [Saaty,1991].

Calculate the consistency index (CI) of the experimental matrix CI = $\frac{\lambda_{max} - n}{n-1}$, where $\lambda_{max}$ is the maximal eigenvalue of the experimental matrix of pairwise comparisons and и is the order of this matrix.

One can immediately see that, if the experimental matrix is ideal, then CI = 0.

In [Saaty,1991], an estimate (the random consistency index) is introduced for an arbitrary square matrix of order *n,* which is positive, inversely symmetric, and has a unit principal diagonal. In the same paper, a table of the random consistency indices (RCI) of such matrices is given. A fragment of the table from [Saaty,1991] is presented in Table 1.

Finally, Saaty proposes to calculate the consistency ratio (CR): CR = $\frac{CI}{RCI}$, where RCI is founded from table 1. For $0 \le CR \le 0.10$-$0.15$, he proposes to consider the experimental matrix as close to the ideal one and to use all useful properties of the latter for the experimental matrix. The main point of these properties is that, by the eigenvector of the experimental matrix corresponding to its maximal eigenvalue $\lambda_{max}$, one can judge the priorities of the instances compared according to the criterion considered.

Table 1

| Order of the matrix, n | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|
| RCI | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 | 1.49 |

It is known that the determination of the eigenvalues and the corresponding eigenvectors for matrices of a high order n is a fairly complicated problem. We propose an approximate method for determining them. This method is based on the properties of the ideal matrix of pairwise comparisons.

Let us use these properties of the ideal matrix of pairwise comparisons for arranging the arbitrary alternatives (instances) $A_1, ...,A_i, ...,A_n$ according to a certain criterion. Suppose that the matrix of pairwise comparisons of these alternatives is composed, and suppose that, checking its consistency, we find that this matrix is reasonably consistent; i.e., $0 \le CR < 0.10$-$0.15$ for this matrix.

Then, the following Rule 1 is valid.

Rule 1. For a reasonably consistent experimental matrix of pairwise comparisons of the alternatives $A_1, ...,A_i, ...,A_n$ with respect to the criterion *Kj,* the vector of priorities is determined in the an approximate method.

Rule 2. The vector of priorities can be used if the experimental matrix of pairwise comparisons is reasonably consistent.

### *2.1.2. Constructing the Matrices of Pairwise Comparisons (Experimental Matrices) in Practical Problems.*

We have considered the case where the "exact" weight ratios are presented in the matrix of pairwise comparisons.

However, in practical problems, it is often impossible to exactly measure the results of pairwise comparisons. One of the methods for quantitatively estimating the ratio of alternatives (for the ideal matrix, this is the ratio of the object weights) is the use of a numeral scale.

The method used most often is the Saaty 9-mark scale. If one uses the Saaty scale, then the matrix of pairwise comparisons is inversely symmetric.

It is convenient to represent the results of pairwise comparisons in the form of matrix. In the upper left corner of the matrix, we write the name of the criterion, according to which the objects are pairwise compared.

In the example considered above, it is the weight. The rows and columns of the matrix correspond to the names of alternatives. The vertical ordering of the names (the first column of the matrix) and the horizontal one (the first row of the matrix) are the same. Any cell of the matrix contains the result of the pairwise comparison of the alternative in the row with the alternative in the column. This result is estimated according to the Saaty scale.

#### *2.1.3. Multicriteria Choice of an Alternative.*

Let there be several alternatives $A_1,..., A_i,.... A_n$ for the solution to a problem. These alternatives should be ordered according to criteria $K_t,..., Kj,..., K_s$.

For any criterion $K_j$, we estimate the weights of the alternatives $A_1,..., A_i,.... A_n$

$$S (Kj) = \{S_1 (Kj),…, Si (Kj),…, Sn (Kj)\}$$

Using the method of pairwise comparisons and estimating the results by the Saaty scale, we determine the weights of the criterion significances $S = \{S_{lt} ...,Sj,...,S_s\}$ for the researcher.

Then, for any $A_i$, it is natural that its weight according to a criterion $S_i(K_j)$ is taken into account in the resulting weight for all criteria with the coefficient equal to the weight of this criterion's significance. The total weight (priority, rating) of the *i*-th object is determined by the formula

$$R_i = S_i (K_1) S_1 + … + S_i (K_j) S_j + … + S_i (K_s) S_s = \sum_{j=1}^{S} S_i (K_j) S_j$$

Finally, the alternatives $A_1,..., A_i,.... A_n$ in the problem of multicriteria choice are arranged in accordance with the total weights. The alternative with the greatest total weight is the most preferable according to the whole set of comparison criteria.

#### *2.1.4. The Structure of the Inference Technique in ORTAES Constructed on the Basis of the Algorithm of Multicriteria Choice.*

The knowledge base of ORTAES contains a mathematical model for generating alternative versions for resolving problem sub-situations of admissible types which are fed into ORTAES at the stage of preparation for the operation session of the anthropocentric object (for piloted aircraft, when preparing for departure). The MM contains algorithms for determining the criterion values $K_j \in \{K_j)$ for any alternative generated.

Current information characterizing the problem sub-situation and admissible types of alternatives for resolving this PrS/S is supplied at the input of the MM. On the basis of admissible types of alternatives and the existing conditions for the occurrence of the PrS/S, in the MM, a complete set of alternatives $\{A_i\}$ of admissible types is generated, and, for any alternative $A_i \in \{A_i\}$, the numerical value of each criterion $K_j \in \{K_j\}$ is calculated. Moreover, an operative correction (by the crew or onboard computer) of the values of some coordinates of the vector SV(PrS/S-solution) characterizing the PrS/S is possible.

Thus, any alternative (from the set generated by the MM) is characterized by a vector whose coordinates are the numerical values of the criteria Kj.

On the basis of these vectors, the matrices of pairwise comparisons of the alternatives are constructed for each criterion.

We separately dwell on the matrix of pairwise comparisons of criteria. When constructing this matrix, one should maximally take into account the crew preferences formed by analyzing the existing current (for the operation session) situation. Taking into account that the crew's possibility of inputting this information is unlikely, one should maximally use the transitivity property of the matrix of pairwise comparisons when constructing this matrix.

After this, the vector of total weights of alternatives is calculated by the algorithm presented in Subsection 2.1.4. An example of implementing the inference technique described is given in [Musarev and others,2001].

### 2.2. Inference Technique Based on Precedents.

Such inference methods are used in problem subsituations, whose complexity does not allow one to constructively formalize them, but for which there is some experience (precedents) of their successful resolution.

One of difficulties of this approach is the correct choice of the coordinates $(x_1,...,x_i,..., x_n)$ of the situational vector SV(PrS/S-solution), both in their number and in the form of representation of each coordinate. The completeness of the description of the situational vector and the connection of a particular vector with a particular precedent is established by long-term cooperation with experts, who are actual bearers of this knowledge.

As a rule, the coordinates of the situational vector are linguistic variables.

*2.2.1. Linguistic Variable as a Coordinate of the Situational Vector.*

A linguistic variable is defined by Zadeh in [Zadeh,1976] as a variable whose values belong to a specified set of terms or expressions of a natural language. The latter were also called terms.

To work with linguistic variables, one should represent each term via an appropriate fuzzy set [Zadeh,1976, Rotshtein,1999]. The latter, in turn, is represented via a universal set (universe) and the membership function of the elements of the universal set to the considered fuzzy set. The membership function takes the values in the interval [0, 1]. It quantitatively estimates the grade of membership of an element in a fuzzy set.

Note that both the universal sets and the membership functions on the set are specified on the basis of investigation results (together with experts) of the corresponding object domain.

For a large number of terms, their membership functions are usually specified in a unified form. Most often, this is a piecewise linear function.

*2.2.2. Knowledge Matrices by Precedents.*

Let a state of a problem sub-situation be described by a situational vector with coordinates ($x_{1,\dots,}$ $x_i$, .., $x_n$) and each coordinate $x_i$ be a linguistic variable with a set of terms $A_i$ = $\{a_i^1,\dots,a_i^j,\dots,a_i^{K_i}\}$. For certain realizations of the situational vector, where each linguistic variable takes one of its possible values (a concrete term), there is a precedent of successful resolution of this PrS/S.

Suppose that a set *$d_j$, j* = 1, ..., *p,* of precedents is accumulated and each precedent is associated with a set of particular situational vectors, for which this precedent has been selected.

Table 2

| Nos. | Coordinates of situational vector | | | | | Precedent |
|---|---|---|---|---|---|---|
| | $x_1$ | … | $x_i$ | … | $x_n$ | |
| 1.1<br>:<br>$1\kappa_1$ | $a_1^{11}$<br>:<br>$a_1^{1K_1}$ | .......<br>:<br>....... | $a_i^{11}$<br>:<br>$a_i^{1K_1}$ | .......<br>:<br>....... | $a_n^{11}$<br>:<br>$a_n^{1K_1}$ | $d_1$ |
| | | | | | | |
| : | : | : | : | : | : | : |
| p1<br>:<br>$p\kappa_p$ | $a_1^{p1}$<br>:<br>$a_1^{pK_p}$ | .......<br>:<br>....... | $a_i^{p1}$<br>:<br>$a_{1i}^{pK_p}$ | .......<br>:<br>....... | $a_n^{p1}$<br>:<br>$a_{1n}^{pK_p}$ | $d_p$ |

Let us construct the matrix of this correspondence (Table 2). We select the rows of the matrix corresponding to a precedent (the block of the precedent). Any row of the matrix is a concrete situational vector for which the corresponding precedent has been successfully realized in the past.

We enumerate the rows of the block of precedent *$d_j$*, with two indices: the first index is the number of the precedent (here, it is the number of the block), and the second index is the serial number of the situational vector in this block.

This matrix determines a system of logical propositions of the form *"if..., then..., else..."* For instance, the row $j_1$ of the matrix encodes the following proposition:

if $x_1 = a_1^{j1}$ and $x_2 = a_2^{j1}$ and … and $x_i$ = $a_i^{j1}$ and … and $x_n$ = $a_n^{j1}$, then $d_j$ , (2.1) *else* a similar proposition for the next row, etc. The obtained system of logical propositions ordered in this way is called a fuzzy knowledge matrix or, simply, a knowledge matrix.

*2.2.3. Algorithm for Calculating the Membership Function of Precedent $d_t$.*

First of all, we present an algorithm [Zadeh,1976] for determining the membership function $\mu_{dj}(x_1, .. x_i, .. x_n)$ of the precedent $d_j$ interpreted as a fuzzy set on a universal set $Ud = Ux_1 \times \ldots \times Ux_i \times \ldots \times Ux_n$, where $Ux_i$ is a universal set on which the terms of the linguist variable $x_i$ are defined, and $U_d$ is the Cartesian product of the universal sets $Ux_i$ .

Any logical proposition of the type (2.1) or, equivalently, any row of the knowledge matrix is a fuzzy relation of the corresponding fuzzy sets. For instance, for (2.1), this is $a_1^{j1} \times a_2^{j2} \times \ldots \times a_n^{jn}$ .

In accordance with [6, 7], the membership function of a fuzzy set generated by this fuzzy relation is $\mu_{a_1^{j1}}(x_1) \wedge \ldots \wedge \mu_{a_i^{j1}}(x_i) \wedge \ldots \wedge \mu_{a_n^{j1}}(x_n)$, where "$\wedge$" we denote the "min" operation.

Analyzing the whole block of logical propositions related with precedent $d_j$ (the block of the corresponding rows of the knowledge matrix), note that they form the union of the corresponding fuzzy sets generated while considering the rows of the selected block. In accordance with [6, 7], the membership function of this union, which is identified with the membership function of the precedent *dj,* is

$$\mu_{d_j}(x_1,\ldots,x_i,\ldots,x_n) = (\mu_{a_1^{j1}}(x_1) \wedge \ldots \wedge \mu_{a_i^{j1}}(x_i) \wedge \ldots \wedge \mu_{a_n^{j1}}(x_n)) \vee$$

$$\ldots \vee (\mu_{a_1^{jK_j}}(x_1) \wedge \ldots \wedge \mu_{a_i^{jK_j}}(x_i) \wedge \ldots \wedge \mu_{a_n^{jK_j}}(x_n))$$

where by «$\vee$» we denote the "max" operation.

Table 3.

| Nos. | Coordinates of the situational vector | | | | | min | max | d |
|---|---|---|---|---|---|---|---|---|
| | $x_1$ | | $x_i$ | | $x_n$ | | | |
| : | : | : | : | : | : | : | : | : |
| $j_1$<br>:<br>$j_s$<br>:<br>$j_{K_j}$ | $(a_1^{j1})^*$<br>:<br>$(a_1^{js})^*$<br>:<br>$(a_1^{jK_j})^*$ | .......<br>:<br>.......<br>:<br>....... | $(a_i^{j1})^*$<br>:<br>$(a_i^{js})^*$<br>:<br>$(a_i^{jK_j})^*$ | .......<br>:<br>.......<br>:<br>....... | $(a_n^{j1})^*$<br>:<br>$(a_n^{js})^*$<br>:<br>$(a_n^{jK_j})^*$ | $\min_i (a_i^{j1})^*$<br>... ...<br>$\min_i (a_i^{is})^*$<br>... ...<br>$\min_i (a_n^{jK_j})^*$ | $\max_{js} \min_i (a_i^{js})^*$ | $\mu_{d_j}$ |
| | | | | | | | | |

Formally, this algorithm for determining the membership function of the precedent *dj* can be written in the following form:

(a). fix an arbitrary point $(x_1^*,\ldots,x_i^*,\ldots,x_n^*) \in U_{x_1} \times \ldots \times U_{x_i} \times \ldots \times U_{x_n}$ ;

(b). for any block of the knowledge matrix corresponding to $d_j$ determine $\mu_{dj}(x_1, .. x_i, .. x_n)$ at this point according to the scheme of Table 3.

Note that, for any fixed point $(x_1^*, x_i^*,\ldots, x_n^*)$, the block of the matrix presented in Table 3 is numerical, because each term $a_i^{js}$ from this block is replaced with the value of its membership function $(a_i^{js})^*$ calculated at the corresponding $x_i^*$. The operation $\min_i a_i^{js}$ is performed with the numbers located in rows "i" 1≤ i≤ n, and the minimal number in the corresponding row is placed in the column "min." The operation $\max_{jS} \min_{i} a_i^{js}$ selects the greatest of the row minima obtained for $1 \le j_s \le K_J$. This number is the value of the membership function $\mu_{dj}$ $(x_1 \ldots x_i, \ldots, x_n)$ at the fixed point $(x_1^*, \ldots, x_i^*, \ldots, x_n^*)$. Performing this calculation for every point of the universal set, we obtain the membership functions that interest us.

### *2.2.4. Algorithm for Choosing a Precedent when Observing a Situational Vector with Quantitative Coordinates.*

When observing a situational vector [Rotshtein,1999] with quantitative coordinates (all coordinates of the vector are measured by numerical scales), in order to select the most preferable precedent, it is not necessary to completely determine the membership functions $\mu_{dj}(x_1, .. x_i, .. x_n)$ on the whole set of points of the universal set. It is sufficient to calculate their values only for fixed numerical values of the coordinates of the vector, which is obtained by us as a result of the observation. For this purpose, we should use the algorithm from Subsection 3.3 once, taking the coordinates of the observed situational vector as $(x_1^*, \ldots, x_i^*, \ldots, x_n^*)$.

As a result, for any precedent *dj,* we obtain a number $d_j(x_1^*, \ldots, x_i^*, \ldots, x_n^*)$, which is the grade of membership of $d_j$ to the point $(x_1^*, \ldots, x_i^*, \ldots, x_n^*)$.

Starting from this interpretation, the most preferable precedent for resolving the observed PrS/S is the precedent $d_j^*$ such that

$$d_j^*(x_1^*, \ldots, x_i^*, \ldots, x_n^*) = \max_{1 \le j \le p} d_j(x_1^*, \ldots, x_i^*, \ldots, x_n^*).$$

### 2.3. Three types of inference techniques are presented.

They are constructive for resolving problem substitutions of typical situations of anthropocentric object functioning (for instance, flights of piloted aircraft).

The first type of inference technique (on product rules) is based on results of the mathematical investigation of the PrS/S and, to a certain degree, on the knowledge of experts in the object domain under consideration. This technique is widely used by designers of the knowledge bases of the first Russian and foreign ORTAES.

The second type of inference technique is based on the use of the algorithm for multicriteria choice of an alternative. The technique is directed to the substantial use of the results of the preparation for the operation session of the anthropocentric object (prior information) and crew preferences formed while operatively analyzing the situation existing in the current operation session. The considered example of the use of this technique allows one to hope that it can be successfully employed in practice when designing the real knowledge bases of ORTAES.

The third type of inference technique has been studied only theoretically and has not been tested on practical examples. It is directed to be used in the inference technique of precedents and is based on the algorithms for choosing a solution on the basis of the knowledge matrix. These algorithms are successfully applied in diagnostic problems.

The choice of the type of inference technique for constructing in ORTAES a recommendation for resolving a problem sub-situation of a concrete type depends on its complexity and on the possibility of adequately formalizing it mathematically.

## Conclusion

(1) The TS ORTAES of anthropocentric objects is a class of dynamic intelligent systems presenting, in the real-time mode, to the crew of an anthropocentric object the complete recommendations on its rational behavior under current operation conditions.

The TS ORTAES has the following specific features:

- working in the real-time mode of operation of the anthropocentric object that carries the TS ORTAES with the restricted dialogue "TS ORTAES-crew" under continuous coordination of ORTAES recommendations and activated (at the current instant) conceptual model of the crew behavior;
- solving all problems of the TS for which the TS ORTAES is developed;
- the procedure of the recommendation inference in the TS ORTAES is based on the principles of situational control;
- the delayed component of the TS ORTAES self-education.

(2) The semantic structure of the TS ORTAES knowledge base consists of the following:

- a two-level (with respect to semantics) rule base identifying, at the upper hierarchy level, the problem sub-situation (PSS) that occurred and determining methods for its solution at the lower hierarchy level;
- mathematical model (MM) bases consisting of MMs of tree types (the MMs predicting space-time occurrence of significant events, the MMs generating admissible solutions and their ranking, and the MMs for estimating unobservable phase coordinates;
- three types of inference techniques are presented. They are constructive for resolving problem sub situations of typical situations of anthropocentric object functioning.

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