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Conclusion Precedent Vectors for the Introduction of Situational

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ABSTRACT

The purpose of the study is to elaborate and substantiate the algorithms of solving problems with the software implementation of algorithmic shell prompt withdrawal of precedent. Using the methods of literature's theoretical analysis and mathematical modeling the authors determine mechanisms of withdrawal, based on precedents and examine matrix knowledge precedents. Furthermore, the research reveals the selection algorithm precedent under the supervision of situational vector quantitative coordinates. The practical value is that the submissions can be useful for solving the current problems with the functioning of the session of the general objectives anthropocentric object.

KEYWORDS
İntelligent systems; anthropocentric object; operational output of precedent; improvement of on-board computers; software implementation of algorithmic shell

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Introduction

Modern technical anthropocentric facilities operating in complex domains (aircraft, particularly military aircraft, vehicles, operators of complex stationary objects) do not think without intellectual support their crews (Roudavski & McCormack, 2016). Importantly, these intelligent systems have to work in concert with the crew activated the conceptual model, helping him solve current problems with the functioning of the session of the general objectives anthropocentric object. A number of on-board intelligent systems cannot do without the operational output of precedent.

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Nowadays anthropocentric object (Anthr / object) is defined as its shell and realized it the sum of its macro components (board Anthr / object) consisting of:

- On-board measurement devices (and sometimes on-board systems of measuring devices), receives information about the outside world and within the on-board;
- Backbone core Anthr / object, which (kernel) the leading role belongs to the team of operators (the crew);
- Board actuators (actuators onboard complexes) acting on the outside and inside world trip (Fedunov, 2005; Roudavski & McCormack, 2016; Zheltov & Fedunov, 2016).

Currently, it realized that improving "the hardware component" anthropocentric developed objects (Anthr / object) is not enough for the desired sharp increase efficiency of their use (Fedunov, 2011). Achieving this is possible by directing the efforts of engineers and scientists to improve the intellectual component of the "system-core" board complex Anthr / object – combined algorithms onboard digital computers (digital computer algorithms) and algorithms crew activities, which is now called the "on-board intelligence" and that of a set of disparate systems on-board equipment to create a functional integrated complex, aimed at implementation of the given tasks sessions functioning (Fedunov, 2010).

In today's Anthr / object algorithmic support onboard computer solved the problem of information processing, management, use of the means to the external environment. Objectives of operational use of the current session the functioning of the target (goal-setting objectives) and the choice of rational ways (tactics) to achieve this goal (tactical objectives) can only be solved by the crew.

The results of scientific research, improvement of on-board computers, measuring and executive devices Anthr / facilities allow developing and implementing on board developed Anthr / objects algorithms and a new type of system that will be able to provide a solution to mentioned tactical problems (Fedosov, 2005; Fedunov, 1996).

Scholars determine two classes of onboard intelligent systems:

– Intelligent system "Situational awareness crew" that places the crew of the ongoing external environment and within the board (the information model within the board and the external conditions) sufficient to adequately assigning them the current phase (target) flight (solution of the problem of goal-setting) (Gribkov & Fedunov, 2010);

– On-Board promptly councils expert systems typical situations (Bpcests) operation Anthr / object quickly ramp adjustment requirements crew a way to achieve the intended purpose stage, with the depth of his study sufficient to implement it after the consent of the crew (Fedunov, 1998).

In these intelligent systems use different mechanisms of output (Fedunov, 2002), operatively solve arising from Anthr / object problem. One of them – an operational conclusion based on precedents.

It is pertinent to point out that P.P. Groumpos (2013) gives a review of modern intelligent decision support systems. It considers only the systems supporting the 2GCL and 3GCL tasks. The author did not find systems designed to deal with 1GCLs.

Methods

The method of mathematical modeling was used in the study. The authors analyzed terms of linguistic variable in order to present the examples of solving problems with the software implementation of algorithmic shell prompt withdrawal of precedent. The analysis of the existing research allowed determining the ways of solving problems with the software implementation of algorithmic shell prompt withdrawal of precedent.

Data, Analysis, and Results

Mechanisms of withdrawal, based on precedents

These mechanisms are applied output in the problematic sub situations (PrS/S), the complexity of which does not allow for their constructive formalization, but who has experience (precedents) for their successful resolution.

One of the difficulties of this approach is the right choice of coordinates ($x_{1,...,}$ x_i, .., x_n) situational selection SV (PrS/S-decision), which describes the PrS/S, both in their number and shape of each submission coordinates. The completeness of the description of the vector situation and the particular relationship of the vector with a specific precedent set during prolonged work with the experts – real carriers of knowledge.

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

Linguistic variable - coordinate situational vector

Lotfi Zadeh (1976) linguistic variable defined as a variable that takes its values in a given set of terms or sentences of a natural language. The latter were called terms.

Here is an example of linguistic variable:

"Height" = {super, low, low, medium, large}.

Here, the "height" – the name of the linguistic variable (LP). In parentheses there are a lot of its terms.

To work with the linguistic variables each term should be related to the corresponding fuzzy sets (Kofman, 1982; Rothstein, 1999), which in turn is represented by a universal set (universe) and the membership function of the elements of the universal set of fuzzy sets under consideration.

The membership function takes values from the interval [0,1]. It quantifies the degree of membership of the element of fuzzy sets.

Example. We define the term "super" (C / N) of the linguistic variable "height".

Universal set U = [h = 0,…,100].

The membership function of a fuzzy set "super low" is shown in Figure 1.

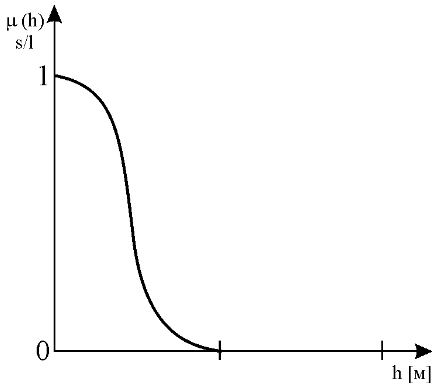

Figure 1. The membership function of a fuzzy set "super low"

Note that both universal sets and membership functions are assigned to it by the results (together with experts) study the subject field.

With a large number of terms of membership functions are usually set in a uniform manner. Most of all – it is a piecewise linear function.

Matrix Knowledge precedents

Let the state of PrS/S describes the situational vector with coordinates ($x_{1,...,}$ x_i, .., x_n), and each coordinate x_i – linguistic variable with the set terms A_i = $\left\{a_i^1,...,a_i^j,...,a_i^{K_i}\right\}$. For some specific implementations of the vector situation, where each linguistic variable is one of its possible values (specific term), there is precedent for a successful resolution of this PrS/S.

Let accumulated a lot of d_j, j = 1,...,p precedents and each of them is associated with a variety of case-specific vectors in which he (precedent) was elected.

Matrix composition such compliance (see Table 1). Group the rows of precedents for (block precedent). Each row of the matrix represents a specific situational vector, in which in the past has successfully implemented a precedent.

We enumerate the line block precedent d_j two indices: the first index – the number of precedent (here it is the block number), the second index – a serial number of the vector situation in this block.

The introduced matrix defines a system of logical statements of the form "if ... then ... else ...". For example, a row of j_1 encrypts saying:

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, (1)

otherwise a similar expression for the next line, and so on.

The resulting orderly way system called fuzzy logic statements matrix of knowledge or just – knowledge matrix.

Table 1. Matrix composition

№	*Coordinates situation vector*					*precedent*
	x_1	…	x_i	…	x_n	
1.1	a_1^{11}	…….	a_i^{11}	…….	a_n^{11}	
:	:	:	:	:	:	d_1
$1\kappa_1$	$a_1^{1K_1}$	…….	$a_i^{1K_1}$	…….	$a_n^{1K_1}$	
:	:	:	:	:	:	:
j1	a_1^{j1}	…….	a_i^{j1}	…….	a_n^{j1}	
:	:	:	:	:	:	d_j
$j\kappa_j$	$a_1^{jK_j}$	…….	$a_i^{jK_j}$	…….	$a_n^{jK_j}$	
:	:	:	:	:	:	:
p1	a_1^{p1}	…….	‥	…….	a_n^{p1}	
:	:	:		:	:	d_p
$p\kappa_p$	$a_1^{pK_p}$	…….		…….	$a_{1n}^{pK_p}$	

The algorithm for computing the membership function precedent d_j

First of all, an algorithm of the definition of membership functions $\mu_{dj}(x_1, .. x_i, .. x_n)$ precedent d_j, treating it as a fuzzy set on the universal set. $Ud = Ux_1 \times \ldots \times Ux_i \times \ldots \times Ux_n$, where Ux_i – universal set, which set the terms of the linguistic variable x_i, and Ud – Cartesian product of universal sets Ux_i.

Each logical statement of the type (1) or, also, each row of the matrix of knowledge is an odd ratio of the corresponding fuzzy sets. Thus, for (1) it will $a_1^{j1} \times a_2^{j2} \times \ldots \times a_n^{jn}$

The membership function of a fuzzy set, fuzzy relations that formed in accordance with A. Kofman (1982) and A. P. Rothstein (1999) will

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

where by "$\wedge$" designated operation "min".

Analyzing the entire block of logic statements relating to the precedent d_j (unit corresponding rows of knowledge), we see that they are combining respective fuzzy sets generated when considering the selected block of lines. The membership function of the association, identified with the membership function precedent d_j, according to A. Kofman (1982) and A. P. Rothstein (1999) to be

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

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

where through «$\vee$» denotes the operation "max".

Formally presented an algorithm for determining membership functions precedent d_j can be written as:

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

b) for each block knowledge matrix corresponding d_j, designation $\mu\mu_{dj}$ (x_1, .. x_i, .. x_n) at this point according to the scheme in Table 2.

Table 2. Fixed point unit matrix

№	Coordinates situation vector					min	max	d
	x_1		x_i		x_n			
:	:	:	:	:	:	:	:	:
j_1	$(a_1^{j1})^*$	....	$(a_i^{j1})^*$	....	$(a_n^{j1})^*$	$\min_i (a_i^{j1})^*$		
:	:	:	:	:	:	... ...	$\max_{js}$	μ_{d_j}
j_s	$(a_1^{js})^*$	....	$(a_i^{js})^*$	....	$(a_n^{js})^*$	$\min_i (a_i^{js})^*$	$\min_i (a_i^{js})^*$	
:	:	:	:	:	:	... ...		
j_{K_j}	$(a_1^{jK_j})^*$	....	$(a_i^{jK_j})^*$	....	$(a_n^{jK_j})^*$	$\min_i (a_n^{jK_j})^*$		
:	:	....	:	....	:	....	....	:

Note that for a fixed point (x_1^*, ..., x_i^*, ..., x_n^*) unit matrix shown in table 2 is numeric, as instead of each term a_i^{js} this unit delivered the value of its membership function $(a_i^{js})^*$ calculated in the respective x_i^*. Operation $\min_i a_i^{js}$ performed on numbers, standing in a row "i", 1≤ i ≤ n in column "min" the minimum number entered on the appropriate line. Operation $\max_{jS} \min_i a_i^{js}$ allocates among the received lower-lows $1 \le j_s \le K_j$ greatest. This number is the value of the membership function μ_{dj} (x_1, .. x_i, .. x_n) in this fixed point $\left(x_1^*,...,x_i^*,...,x_n^*\right)$.

After such calculations for each point of the universal set, we get interested in the membership function.

The selection algorithm precedent under the supervision of situational vector quantitative coordinates

The on-board intelligent systems posted on Anthr/object, based on the current measurements of airborne measuring devices (point $\left(x_1^*,...,x_i^*,...,x_n^*\right)$, Measurements), formed by SV (PrS/S – solution) with quantitative values of its coordinates. Only in this fixed point $\left(x_1^*,...,x_i^*,...,x_n^*\right)$ at the moment of measurement and the need to determine the value of the membership function μ_{dj} (x_1, .. x_i, .. x_n).

In the observation of situational vector (Rothstein, 1999) with the quantitative coordinates (coordinates of all measured on a numerical scale) to select the most appropriate precedent there is no need to fully define the membership function $\mu_{dj}(x_1, .. x_i, .. x_n)$ the whole set of points of the universal set. It is enough to calculate their value only for fixed numerical values of the coordinates of which we received as a result of monitoring. It will have to use the algorithm once Sect. 1.3, taking as $\left(x_1^*,...,x_i^*,...,x_n^*\right)$ coordinates of observed situation vector.

As a result, for each use case d_j we get the number $d_j\left(x_1^*,...,x_i^*,...,x_n^*\right)$ which is the degree of membership d_j point $\left(x_1^*,...,x_i^*,...,x_n^*\right)$.

Based on this interpretation, the most preferred as a precedent for the resolution of the observed PrS/S will be a precedent d_j^*, for which

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

An illustrative example

Let some PrS/S describes situational vector SV (PrS/S -decision) with coordinates $\{x_1, x_2, x_3, x_4\}$, represented by linguistic variables:

x_1 – the specific energy of the aircraft;

x_2 – increasing the length of the motion trajectory of the aircraft in the horizontal plane;

x_3 –increasing the length of the motion trajectory of the aircraft in a vertical plane;

x_4 – the degree of achievement of the final result.

Let this class PrS/S observed two successful precedent d_1, d_2, each of which was applied in two (different) cases.

Linguistic variables are the following standardized values (terms):

x_i ={small, medium, high }, i = 1, …, 4. (see. figure 3 and table 4).

Let each term linguistic variables presented a unified universal set (ten-point scale) and unified piecewise linear (triangular) membership functions (Figure 2).

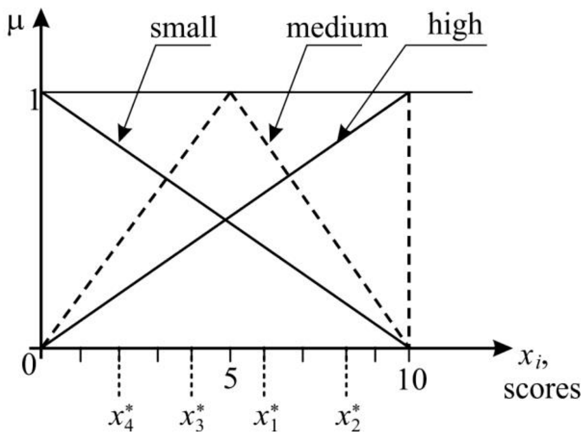

Figure 2. Graphical representation of term of linguistic variables

Matrix for this knowledge PrS /S is presented in Table 3.

Table 3. PrS/S matrix

№	Coordinates situation vector				Precedents
	x_1	x_2	x_3	x_4	
1.1	high	high	high	high	
1.2	high	medium	medium	high	d_1
2.1	high	medium	high	small	
2.2	medium	high	medium	medium	d_2

Let there PrS /S, described by coordinates $x_1^* = 6, \quad x_2^* = 8, \quad x_3^* = 4, \quad x_4^* = 2$.

Then, according to the choice of algorithm preferred precedent we obtain the solution in Table 4.

Table 4. The solution of PrS/S

№	Coordinates situation vector				min	max
	x_1	x_2	x_3	x_4		
1.1	0.6	0.8	0.4	0.2	0.2	0.2
1.2	0.6	0.4	0.6	0.2	0.2	
2.1	0.6	0.4	0.4	0.8	0.4	0.4
2.1	0.8	0.8	0.6	0.4	0.4	

Conclusion: The most preferred precedent for the resolution of PrS/S ($x_1^* = 6, \ x_2^* = 8, \ x_3^* = 4, \ x_4^* = 2$) a precedent d_2.

Algorithmic shell prompt withdrawal of precedent

The shell is implemented in C++ environment Microsoft Visual Studio 2008 using the QT library for the operating system Windows.

The resulting software allows you to simulate an arbitrary problem situation (problem sub situation), asking her situational vector SV (PrS/S – solution) with a full description of its origin (for each set of coordinates is entered relating to the terms and each term trapezoidal membership function and universal set on where it is defined) and the matrix of knowledge.

Any specific implementation seems problematic situation is the same situational vector SV (PrS/S – solution) with current quantitative coordinates.

Examples of solving problems with the software implementation of algorithmic shell prompt withdrawal of precedent

Example 1. Let us considered problematic situation described by the following situational vector:

(PrS/S – solution) = {LV1, LV2, LV3, LV4, LV5}

where LV1....LV5 – vector coordinates situational (linguistic variables). The range of values of linguistic variables defined terms:

LV1 = {T1Lv1, T2Lv1, T3Lv1, T4Lv1, T5Lv1}

LV2 = {T1Lv2, T2Lv2}

LV3 = {T1Lv3, T2Lv3, T3Lv3}

LV4 = {T1Lv4, T2Lv4, T3Lv4, T4Lv4, T5Lv4, T6Lv4, T7Lv4}

LV5 = {T1Lv5, T2Lv5, T3Lv5}

Each linguistic variable, an ensemble of trapezoidal membership functions defined in the relevant universal set.

For LV4 they will look as follows (Figure 3):

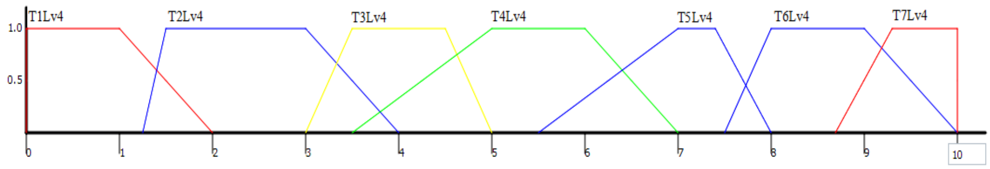

Figure 3. Trapezoidal membership functions for LV4

For other linguistic variables – similar.

Formed vector of possible outcomes

Let the matrix of knowledge introduced four precedent (outcome):

O = { O 1, O 2, O 3, O 4}

Let the experts formed by a matrix of knowledge (Table 5).

Table 5. Matrix of knowledge

	Getting results						
	LV1	LV2	LV3	LV4	LV5	Outcomes	Value
1	T3Lv1	T1Lv2	T1Lv3	T5Lv4	T1Lv5	O1	0.125
2	T2Lv1	T2Lv2	T3Lv3	T4Lv4	T2Lv5	O1	0.333333
3	T1Lv2	T4Lv3	T5Lv4	T2Lv5	T2Lv5	O2	0
4	T4Lv1	T1Lv2	T3Lv3	T4Lv4	T1Lv5	O2	0
5	T2Lv1	T2Lv2	T1Lv3	T5Lv4	T2Lv5	O2	0.125
6	T3Lv1	T1Lv2	T1Lv3	T6Lv4	T1Lv5	O3	0
7	T3Lv1	T2Lv2	T3Lv3	T5Lv4	T3Lv5	O3	0
8	T2Lv1	T1Lv2	T4Lv3	T1Lv4	T1Lv5	O3	0

Let the input of the operational output of precedent is applied the current SV (PrS/S – the solution), the coordinates of which are given in Table 6

Table 6. The coordinates of SV matrix

	Current SV	
LV1	3	3
LV2	5	5
LV3	6.5	6.5
LV4	6	6
LV5	4	4

For this value SV (PrS/S – solution) matrix is transformed into a quantitative knowledge matrix (Table 7).

Table 7. Quantitative knowledge matrix

	Getting results						
	LV1	LV2	LV3	LV4	LV5	Outcomes	Value
1	0.6	1	0.125	0.333333	0.5	O1	0.125
2	1	0.5	0.333333	1	1	O1	0.333333
3	0.6	1	0	0.333333	1	O2	0
4	0	1	0.333333	1	0.5	O2	0
5	1	0.5	0.125	0.333333	1	O2	0.125
6	0.6	1	0.125	0	0.5	O3	0
7	0.6	0.5	0.333333	0.333333	0	O3	0
8	1	1	0	0	0.5	O3	0

As a result of the matrix of knowledge inference algorithms get recommendations on preferred precedent (the outcome). To quantify this situation is precedent vector O1.

The calculations determine the preferred O1 precedent for the resolution of specific implementation PrS/S, determined SV (PrS/S – solution), which is shown in Table 6.

Discussion

Can note, in contrast to P.R. Warsaw, and A.P. Eremeev, (2009), in rapid implementation of mechanism for the withdrawal of precedent it is not necessary to force to introduce the metric algorithm preference precedents.

It is pertinent to point out that S.Y. Zheltov, and B.E. Fedunov, (2015, 2016) have presented a similar investigation on structures of algorithms for the support of crew decision-making and operation modes of the on-board real-time advisory expert system and its dialog with the crew.

The proposed operational goal setting algorithm uses a priori information (a specified sequence of typical situations that ensures the accomplishment of the current session of the object operation, a priori specified set of threats that can emerge in the course of the operation session, a knowledge matrix with the terms of linguistic variables for each pair typical situation–threat) and the current data (obtained from the object's crew and onboard measurement system). For the description of the operational goal setting task, the following concepts are used: the crew circumspection, the crew situational awareness, and the crew situational confidence (Zheltov & Fedunov, 2016).

B.E. Fedunov, (2011) also confirms our thesis about creation of intelligent systems of two classes of their system-generating core.

Conclusion

Operational conclusion on precedent and software-based algorithmic shell prompt conclusion are described. Software implementation of algorithmic shell is focused both on a stand-alone its use, and the incorporation of its knowledge base board promptly advising expert systems (Fedunov & Shestopalov, 2010). Illustrative examples of the application of the operational output of precedent are presented.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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