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The Assessment of Information Model Adequacy, Realized at the Simulation Aid of Information Model in the Real Poli-Ergatic System

Urgency

In the tasks, relating to the aspects of organization decision making, using the set of possible options, we can often meet the situations, according to which the entry parameters are not enough or strictly defined, to allow us to find a unique solution.

The information interpretation, on the basis of which the solution have to be found, by different specialists can be rather subjective, and the information itself can have a great number of ambiguities, such as „excellent", „very good", „not bad", „not exactly that was expected", etc. The tasks of such kind are very often appear when there is a need in assessment of real system or process imitation model adequacy degree.

The description of main research material

In order to formalize the ambiguities of such kind we suggest to use the theory of fuzzy sets, created by L. Zade. It will allow to realize the model expert assessment on the basis of fuzzy logic.

The imitation models, to which we can relate the simulation aids with different degrees of real objects (systems) imitations, are the most important part of human – operator training [Баклашов 1982].

The degree of simulation aids compliance with the real objects (systems) will define the fullness of their usage in the practical training. Especially during the process of complex poli-ergatic systems operators training.

The more imitation model adequate (similar to), according to its visual – and – information content, to the real dynamic processes – the more degree of similarity can be provided by the simulator in the process of technological operations imitation in order to receive and work out the necessary skills and habits.

We suggest to realize the adequacy assessment by the means of acceptable divergence definition $\mathbf{Q}_{\mathbf{acc.div.}}$ between the information model, realized at simulation aid ($\boldsymbol{IM}_{\boldsymbol{SA}}$) information model, which is reproduced in the active (real) poli-ergatic system ($\boldsymbol{IM}_{\boldsymbol{AC}}$). The comparison of $\mathbf{Q}_{\mathbf{acc.div}}$. with its given limit and – acceptable meaning (norm) $\mathbf{Q}_{\mathbf{norm.}}$ will allow decision making, relating to the pos-

sibility of simulation aid usage in operators practical training at specific stages of learning.

Each ***IM*** consists of the great number of elements (the points of services area, the structure of routes in horizontal and vertical planes, dynamic environment, which can include the great number of object with different technical characteristics, for example, their speeds and maneuverability etc.). Having marked the great number of elements $\boldsymbol{IM_{SA}}$) as $\boldsymbol{M_{SA}}$, and the great number of information model elements of active poli-ergatic system – as $\boldsymbol{M_{AS}}$, we can write the conditions of similarity $\boldsymbol{IM_{SA}}$ in a following way:

$$\boldsymbol{M_{SA}} - \boldsymbol{M_{AS}} \leq \mathbf{Q_{acc.div.}}, \quad (1)$$

where, $\mathbf{Q_{acc.div.}}$ – the acceptable meaning of divergence (difference) between multitudes or the acceptable standard of divergence between information systems, which are reconstructed at simulation aid and in active system.

Ideally the mass of elements $\boldsymbol{M_{SA}} - \boldsymbol{M_{AS}} = \mathbf{0}$, but really the meaning of acceptable divergence is situated: $\mathbf{0} \leq \mathbf{Q_{acc.div.}} \leq \mathbf{1}$.

One of the variants of the information model assessment, realized at the simulation aid (IM_{SA}), relating to the degree of its conformity to the information model in the real poli-ergatic system (IM_{AS}) can be the usage of the theory of fuzzy sets and linguistic variables. Let's show at the example, how it works. Let us suppose that 36 branch experts were involved in the assessment of conformity.

Notation: taking into account that the aspects of experts selection is fully described in the great number of literature sources, we wouldn't define it in this article.

In order to build, according to experts marks, the membership function let's use the direct method [Борисов *et al.* 1980; Камышин, Рева 2012].

We suppose the experts to assess the degree of information model (realized at simulation aid) in dynamic environment, which includes moving objects, needing the services of operator ($\boldsymbol{IM_{SA}}$), conformance with the information model of real dynamic environment, reconstructing by active poli-ergatic system, using the fuzzy (odd) assessment scale of linguistic variable 'similarity' with gradation from 1 to 7 points (linguistic terms):

7 – full similarity, no differences;
6 – great similarity, minor differences;
5 – the number of similarities is more than the number of differences;
4 – the number of similarities is equal to the number of differences; (the difficulties of choice);
3 – there is a similarity, but the number of differences is bigger;
2 – there is some similarity, but the number of differences is much bigger;
1 – the similarity between information models is absent.

At the same time, according to the tasks, the experts assessed the specific possibilities of linguistic variable 'Similarity' (from 0 to 100%, with gradation 10%).

Taking account that this or other linguistic variable ‘Similarity’ will be analyzed by concrete expert as a possibility of its realization (appearance), the quantitative mark of its appearance have to be in the interval from 0 to 1.

Let’s divide the chosen interval at 10 parts. The degree of linguistic variable concrete meaning belonging will be defined as a reference of the number of experts answers, whose meanings of c belong to the concrete interval, to the maximum meaning of this number at all intervals.

The received results were defined in the table of empiric distribution (watch Table 1), which describes the frequency of linguistic variable ‘Similarity’ usage.

Table 1

The frequency of linguistic variable ‘Similarity’ usage

Mark scale	**Interval (units)** The universal multitude ***U*** – is in the interval from 0 to 1									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	0–0,1	**0,1–0,2**	**0,2–0,3**	**0,3–0,4**	**0,4–0,5**	**0,5–0,6**	**0,6–0,7**	**0,7–0,8**	**0,8–0,9**	**0,9–1**
7	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	**4**	**5**	**5**	**2**	0
5	0	0	0	0	0	**4**	**5**	**5**	**4**	0
4	0	0	0	**0**	**1**	**1**	**2**	0	0	0
3	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
j	**0**	**0**	**0**	**0**	**1**	**9**	**12**	**10**	**6**	**0**

The numbers in table are the quantity of expert voices for the belonging of linguistic variable ‘Similarity’ of the proper element ***u*** to the multitude ***U***.

So the degree of concrete meaning belonging will be defined as a reference of the number of experts voices, relating to the belonging to the concrete interval, to the maximum number of all voices.

The function of belonging $\mu_a(U)$ correlate the each element from ***u*** ϵ ***U*** with the proper meaning of interval [0; 1], which characterizes the degree of element’s belonging to multitude ***A*.**

If it is necessary, in order to minimize the number of mistakes, which can be done by experts, we have to analyze the data of table 1. In order to analyze the statistic data we can use the so-called matrix of hints, beforehand deleting the clear mistake elements ***u*** of multitude ***U*** from table 1**.** The criteria of deleting will be some zero meanings at the row near these elements, for example:

u_i	0	0	0	1	0	0	0	0	0

In further we will build the matrix of hints [Харченко *et al.* 2012], the elements of which, in our case, can be calculated according to the formula:

$$K_j = \sum_{i=1}^{7} bij, \qquad j=1,10, \tag{2}$$

where, 7 – is a number o f linguistic variables ‘Similarity’ (watch. Table 1).

The matrix of hints is the following row of elements (the sum of meanings according to the columns of proper intervals):

M=//0 0 0 0 1 9 12 10 6 0//

Let’s choose from the matrix of hints the maximum quantitative meaning:

$k_{max} = max\ k_j$ ={**0 0 0 0 1 12 9 10 6 0**}= **12** and, on the basis of the data of matrix of hints, transform the quantitative meanings of the Table 1. (we create so-called ***C-matrix***), according to the formula:

$$Cij = \frac{bij * Kmax}{Kj}, \; i=\overline{1,7}, \quad j=\overline{1,10}. \tag{3}$$

The results of calculations will be put into Table 2, on the basis of which the function of belonging will be formed:

Table 2

C-matrix **(the experts quiz results processing**

Meaning, *i*	Interval (units), *j*									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	0–0,1	**0,1–0,2**	**0,2–0,3**	**0,3–0,4**	**0,4–0,5**	**0,5–0,6**	**0,6–0,7**	**0,7–0,8**	**0,8–0,9**	**0,9–1**
7	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
6	0	0	0	0		**5,33**	**5**	**6**	**4**	0
5	0	0	0	0	0	**5,33**	**5**	**6**	**8**	0
4	0	0	0	0	**12**	**1,33**	**2**	0	0	0
3	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0

In order to build the function of belonging μa(U) let’s find the maximum meanings in the rows (1, 2, 3 … 7) of ***C-matrix*** of Table 1:

$$C_{imax} = max\ C_{ij}, \qquad i=\overline{1,7}, \quad j=\overline{1,10}, \tag{4}$$

C_{7max} = 0; C_{6max} = 6; C_{5max} = 8; C_{4max} = 12; C_{3max} = 0; C_{2max} = 0; C_{1max} = 0.

And the function of belonging can be calculated according to the formula:

$$\mu_i = \frac{??ij}{??i\,max}\ , \qquad [5]$$

The results of function's of belonging calculations are shown in Table 3.

Table 3

The meanings of linguistic variable's function of belonging

μ_i	Interval (units), j									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
	0–0,1	**0,1–0,2**	**0,2–0,3**	**0,3–0,4**	**0,4–0,5**	**0,5–0,6**	**0,6–0,7**	**0,7–0,8**	**0,8–0,9**	**0,9–1**
μ_7	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
μ_6	0	0	0	0	0	**0,89**	**0,83**	**1**	**0,67**	0
μ_5	0	0	0	0	0	**0,67**	**0,63**	**0,75**	**1**	0
μ_4	0	0	0	0	**1**	**0,11**	**0,17**	0	0	0
μ_3	0	0	0	0	0	0	0	0	0	0
μ_2	0	0	0	0	0	0	0	0	0	0
μ_1	0	0	0	0	0	0	0	0	0	0

The functions of belonging of linguistic variable 'Similarity' calculated meanings are shown on Fig. 1.

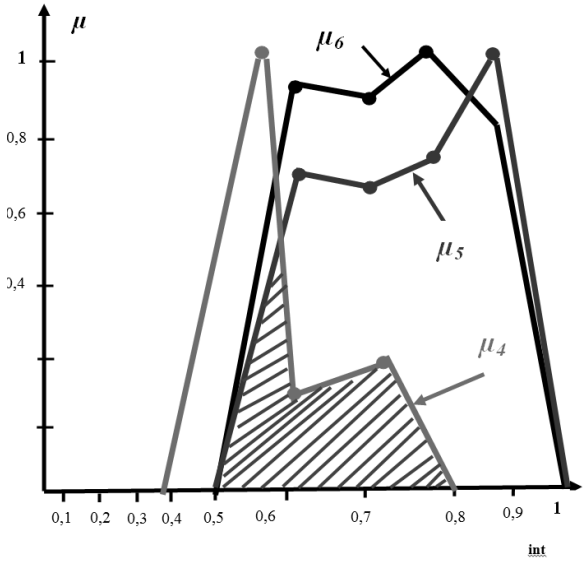

Fig. 1. The function of belonging μ_i for the calculated meanings of linguistic variable 'Similarity'

Conclusions

On the picture 1 we can see that the area, belonging to all three functions of belonging, is situated in the interval from 0,5 to 0,8, that is equivalent to the degree of similarity from 50 to 80%. It witnesses about the experts' high enough positive mark of the simulation aid information model conformity with the information model of active (real) system.

The high degree of simulation aid information model conformity can be proved by the fact that the experts didn't use the linguistic variables 'Similarity, relating to the low conformity, such as:

3 – there is a similarity, but the number of differences is bigger;
2 – there is some similarity, but the number of differences is much bigger;
1 – the similarity between information models is absent.

Literature

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Abstract

The attempt of the assessment of information model adequacy, realized at the simulation aid of information model in the real poli-ergatic system is described in this article.

The theories of fuzzy sets and linguistic variables were used. Its necessary to mention that this article is a realization oa author's personal professional opinion.

Keywords: poli-ergatic system, information model, simulation aid, theory of fuzzy sets, linguistic variables, imitation models, real objects, function of belonging, C-matrix.