FUZZY MODEL OF COMPLIANCE WITH HYDRO-UNIT DEFECTION

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Annotation. *The requirement of reliability and safety of hydraulic systems is always relevant: both in the design process, and in the operation, repair and monitoring processes. Currently, systems designed to support decision-making processes, in particular situational-advising systems, as a type of expert systems, are becoming particularly relevant. The main components of the formalization and construction of fuzzy situational models of correspondences of the type "situation - causes - actions" (S-C-A) for the processes of defect detection of a hydraulic unit are described.*

Key words. *Monitoring, hydraulic unit, repair, fault detection, situational model, fuzzy compliance, decision making (conclusion).*

Formulation of the problem. When creating fuzzy models of complex situations, the construction of correspondence functions in the conditions of deterministic, probabilistic, or fuzzy initial information plays an important role. Many approaches to the construction of these functions are known, the most commonly used of which are the following [1,2]:

1) the construction of functions based on pairwise comparisons. This approach is based on the processing of a matrix of estimates reflecting the opinion of experts on the relative belonging of elements to the set or the degree of importance of the property formalized by the set;

2) constructing a function using statistical data using tooltip matrices;

3) the construction of a function based on expert estimates: to construct a function of correspondence of probabilistic or fuzzy numbers, approximately equal to a certain clear number, and approximate intervals of estimates. The task is reduced to finding the parameters of a predetermined function, the solution of which uses the results of an expert survey;

4) construction of a function based on interval estimates: it is intended to solve selection problems in which there is no clear line between the ideal and unsatisfactory state (in the criteria space).

Based on the analysis of correspondences and constructed information models, we set the task of sequential analysis and conformity assessment as an approach to improving (training) of decisions made at the stage of hydraulic unit troubleshooting. The approach is to extract patterns IF < input > - THEN < out > from possible knowledge. The essence of the proposed approach is to select such functions of correspondence of possible terms and such weights of rules that minimize the difference between the results of inference and possible data. In terms of mathematical programming, this problem can be formulated as follows.

Find a correspondence matrix that satisfies the restrictions on the range of variation of the group of parameters V, B, A; here A- is the vector of parameters found by visual inspection of the hydraulic unit, B - is the parameter factor formed according to the requirements of the client,

V- is the parameter vector determined by complex chemical-technological and / or electronic-mechanical studies:

$$\begin{gathered} A=(a1,\ a2,\ \ldots,\ ah). \\ B=(b1,\ b2,\ \ldots,\ bq) \\ V=(v1,\ v2,\ \ldots,\ vn) \end{gathered} \tag{1}$$

The solution of the problem. The formation of such a knowledge base requires a lot of static material in three areas of the analysis of signs: A, B, and V.

Based on the foregoing, we give a formal form of the task. Consider an object of the form

$$y = f(x_1, x_2, \ldots, x_n) \tag{2}$$

with n inputs and m outputs, for which are known:

a) the interval of change of inputs and outputs:

$$x_j E[\underline{x_j}, \overline{x_j}], \quad j = \overline{1n}, \quad y = [\underline{y}, \overline{y}];$$

b) classes of decisions (actions) $d_i(i=1,\overline{m})$ in case of discrete output:

$$[\underline{y}, \overline{y}] = \underbrace{(y, y_j)}_{d_1} \cup \underbrace{(y_j, y_2)}_{d_2} \cup ... \cup \underbrace{(y_{i-1}, y_i)}_{d_i} \cup ..\underbrace{(y_{m-1}, \overline{y})}_{d_m};$$

c) a training sample in the form of M data pairs “inputs and outputs” $\{x_\rho, d_\rho\}$,

where $x_\rho = \{x_1^\rho, x_2^\rho, ..., x_{n1}^\rho\}$ - input vector in ρ -pair, $\rho = 1\overline{M}$.

It is required to synthesize knowledge about the object (2) in the form of a system of logical statements reflecting the expert's experience in typical situations:

IF $[(x_j = \alpha_1^{i1}) and (x_2 = \alpha_2^{i1}) and ..., and (x_n = \alpha_n^{i1})]$ (with weight w_{i1})

OR $[(x_1 = \alpha_1^{i2}) and (x_2 = \alpha_1^{i2}) and ..., and (x_n = \alpha_n^{i2})]$ (with weight w_{i2}) …, (3)

OR $[(x_1 = \alpha_1^{iki}) and (x_2 = \alpha_2^{iki}) and ..., and (x_n = \alpha_n^{iki})]$ (with weight w_{iki});

$Thany E \alpha_i = [y_{i-1}, y_i]$ for all $i = 1, \overline{m}$.

Here $\alpha_j^{i\rho}$ is the set by which the variable is evaluated x_j in line with number $\rho = \overline{1, K\rho}$; K_i - the number of lines - conjunctions corresponding to the class $d_i, i = 1, \overline{m}$; w_{ip} – number in the range [0,1] which characterizes the weight of the statement with the number $i\rho$. In terms of mathematical programming, the defect problem can be formulated as follows: find a minimized matrix from the knowledge base that satisfies the restrictions on the range of parameters W, (A, B, V.) And the number of rows provides

$$\sum_{\rho=1}^{M} \{\sum_{i-1}^{m} [\varphi^{d_i}[X_\rho, W, V, B, AE \varphi_\rho^{d_i}(y)]\} = \min \quad W, V, B, A, \quad (4)$$

Where $\varphi_\rho^{di} = \begin{cases} 1, & if \quad d_i = d_\rho \\ 0, & if \quad d_i \neq d_\rho \end{cases}$ Knowledge Base Parameter Matrix

Table 1.

Situation	IF			Weight	THAT
	X1	… Xj …	Xn		Y
I1	a(i1/1)	a(i1/j)	a(i1/n)	w(i1)	d(i/1)
I2	a(i2/2)	a(i2/j)	a(i2/n)	w(i2)	d(i/2)
…	…	…	…	…	…
ik	a(ik/1)	a(ik/j)	a(ik/n)	w(ik)	d(i/k)
ρ1	b(ρ1/1)	b(ρ1/j)	b(ρ1/n)	w(ρ1)	d(ρ/1)
ρ2	b(ρ2/1)	b(ρ2/j)	b(ρ2/n)	w(ρ2)	d(ρ/3)
…	…	…	…	…	…
ρl	b(ρl/1)	b(ρl/j)	b(ρl/n)	w(ρl)	d(ρ/l)
r1	v(r1/1)	v(r1/j)	v(r1/n)	w(r1)	d(r/1)
r2	v(r2/1)	v(r2/j)	v(r2/n)	w(r2)	d(r/2)
…	…	…	…	…	…
rh	v(rh/1)	v(rh/j)	v(rh/n)	w(rh)	d(rh/1)

The specifics of the decision-making method designed to determine the causes of operational situations is as follows. For each input situation, first of all, it is necessary to systematize the values obtained from experts in accordance with [2]. As a result, for each typical situation, it is possible to construct situational (dynamic) correspondence models (SCM) in the form of graph diagrams of algorithms or a tree of scenarios. Here, the situation C_l is understood as a certain set of signs of the state of control objects that will satisfy a specific state of the object. The reason is understood as a fuzzy (associative) set of parameters $P = <p_1, p_2, ..., p_n>$, whose values characterize the causes that led to the emergence of a particular situation C_k. A decision is a combination of actions *D=<d₁, d₂, ...dₗ,>*, the implementation of which affects the situation. The action can be clear, probabilistic or fuzzy, serving as advice or recommendation for LPR.

Each cause C_j is described by a corresponding fuzzy variable

$$\langle P_z, T_i, Mj \rangle,$$

Where $T_i = \{T_i^1, T_i^2, ..., T_i\}$ term –many fuzzy variable C_j (a set of fuzzy terms, the number of terms); M_i - basic set of reasons C_j . To every action S_1 corresponds to a set of fuzzy values of terms:

$T_1 = \{T_s^1, T_s^2, ..., T_s^z\}$, z - is the number of fuzzy terms.

The process of forming a fuzzy model of correspondences of the form "S - C - A" (situation - cause-action) is carried out in four stages. At the first stage, each expert forms verbal associations “object - signs - fuzzy signs”. The process of assessing a fuzzy situation is carried out by experts (a group of experts to assess the state of a hydraulic unit). The expert’s loyalty (competency) is evaluated on a scale from the interval [0,1].

The process of forming a fuzzy model of correspondence (FMC) is carried out as follows: all possible causes of defects are highlighted, all possible ways to eliminate them are identified, a tabular form of the Knowledge Base Parameter Matrix is formed, each expert assesses the situation using the appropriate terms or real numbers from the interval [0,1]. At the second stage, the resulting (summary) Knowledge Base Parameter Matrix is formed on the basis of the component model for each expert individually. Thus, the correspondence function of the resulting model is determined by the algorithm

$$m\langle dj, T_j^t \rangle = \min_{m_k} \langle d_j, T_j^t \rangle, k = \overline{1, N},$$

Where **N-** number of experts. At the third stage, based on the resulting model, the FMC is formed in the following sequence.

1. FMC breaks up depending on the cause into «m» many fuzzy matches:

$$\tilde{L}_1, \tilde{L}_2, ...\tilde{L}_j, ...\tilde{L}_m, \quad \tilde{I}_1, \tilde{I}_2, ..., \tilde{I}_j, ...\tilde{I}_m,$$

Where $\tilde{L}_j = (D, T_j, \tilde{A}_j)$, D - fuzzy match origin $\tilde{L}_j$, $T_j -$ term sets of a fuzzy variable C_j **(**area of arrival of fuzzy matching $\tilde{L}_j$**)**, $\tilde{A}_j$ - fuzzy match graph; $\tilde{L}_j; \tilde{I}_j = (T_j, T_{s1}, B_J), T_{s1} -$ term set of fuzzy variable $\boldsymbol{S_t}$ (area of arrival of fuzzy matching $\tilde{I}_j$);

2. For each type of defect d_j on the fuzzy match graph $\tilde{L}_j$ the maximum value of the correspondence function is determined *(m<dᵢ , Pⱼ >).*

3. For each term value T_j fuzzy variable C_j the maximally corresponding term value of the fuzzy variable is determined - S_t :

$$m_B^k < P_j, S_I >=> \max m_B < T_j^k, T_{s1}^q >, q = \overline{1, t} \; .$$

4. Based on the values of the matching functions $m_a^k < d_i, P_j >$ и $m_s < P_j, S_j >$ formed SCM kind of « S - C - A ».

At the fourth stage, a control solution is formed on the basis of fuzzy correspondences $\tilde{L}$ и $\tilde{I}$. The process of forming a control solution in the VMS becomes iterative in nature and is carried out on the basis of a composition of fuzzy sets. “Defect-action” situations can be represented as fuzzy matching $\tilde{M} = (D, S, \tilde{C})$, where $\tilde{C}$ - fuzzy match graph $\tilde{M}$, which is determined based on the composition of the graphs $\tilde{A}$ и $\tilde{B}$. Measures of similarity of situations are defined as equalities of fuzzy sets. The threshold value of the similarity measure assumes a value from the interval [0,1].

The statement of the problem of constructing a situational (fuzzy) model of correspondence is reduced to the following:

A.1. Optimality conditions (optimization criterion):

$$\forall_{x_1}\ E\ X_1 <X_1\ E\ X>.\ X\rightarrow Y < \forall_{y_{j1}}\ E\ Z_{i\ E\ y}>;$$
$$Y\rightarrow Z<z_k\ E\ Z_1 E\ Z>:\ S\ \{z\}:\ f\rightarrow extr,$$

those. for all $x_1\ E\ X_1$ signs of a situation where X_1 - a subset characterizing a specific situation, there is a correspondence $X\rightarrow Y$ subset of reasons Y, at the same time there is a correspondence $Y\rightarrow Z$ subset of actions. Need to define a strategy $S\ \{z\}$ (sequence of actions), in which some weight function f strives for its extreme value. Function f takes a maximum or minimum value depending on the specific task being solved on the basis of the VMS. For example, f may be the number of defects tending to a minimum value when using a certain strategy $S\ \{z\}$ action.

B . 2. Boundary conditions (area of possible solutions):

$$G=G_x\ f\ G_y\ ;\quad G_y=\{X,\ Y,\ F_1\};\ \ G_y=\{Y,\ Z,\ F_2\};$$
$$X_1=u<x_i,\ y_j>;\quad g_1\ E\ F_1;$$
$$x_2=u<y_j,\ z_k>;\quad g_2\ E\ F_2.$$

C. 3. Limiting conditions (area of feasible solutions):

$$G=G_c\ o\ G_D;$$
$$G_D\ E\ G_n,\quad G_n\ Eo\ G_s.$$

In the end, it should be noted that the signs of situations, causes and actions can be deterministic, probabilistic or fuzzy. Moreover, each sign of the situation can have a significant impact on other signs, i.e. have a weight coefficient that determines the relative importance in front of other signs.

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IMITATION MODELING THE DISCRETE COMMUNICATION CHANEL IN MATLAB STATEFLOW ON BASIS OF PETROVICH MODEL

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Abstract: *The article defines the study of a discrete communication channel based on the Petrovich model, amending the faults and its simulation model using MATLAB software. In addition, to reduce the probability of multiple errors in data transmission, coding the discrete channel up to a fault tolerance level, to investigate the distribution of error-free transmission intervals in the discrete channel based on the Petrovich model, to construct the Petrovich model for the discrete channel, The State-flow diagram of Petrovich model is presented for the under research discrete channel. The processes meant by the article save real-time mode of technical engineers in the field of communication services. The research investigation have been carried out on the improvement of the created simulation model which enables the programmers to control the object remotely, to detect errors and shortcomings early, and to take corrective measures.*

Keywords: *network, model, simulation model, discrete channel, transmission, reception, coding, control area, data area.*

Introduction

Currently, the processes in the field of increasing the capacity of discrete communication channels, improving the quality of communication systems are inextricably linked with the development