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MODAL SYNTHESIS OF COMPENSATED OPTIMAL SYSTEMS WITH DELAY

Annotation. *This article proposes modal synthesis for linear stationary closed loop systems with the lag using optimal control law in the form of a linear combination of the state variables to ensure the specified dynamic characteristics. Procedure of modal synthesis of the optimal control law is performedbased onundefined coefficients method. The delay compensation method is proposed to use in order to eliminate the stable self-oscillations occurrence at the stabilization process near given trajectory.*

Keywords: *linear stationary system, stabilization mode, transport lag, modal synthesis, optimal law.*

Introduction

Systems synthesis task is one of the key tasks of both automatic control theory and practice. Its solution results in definition of the structure of the automatic control system and its parameters of the condition of the system sustainability and quality of transient processes (achieving the required performance, the inadmissibility of the considerable overshoot) improving control accuracy in steady-state conditions etc.Linear controllers are an effective way to ensure dynamic performance not only linear control objects of arbitrarily high order, but also objects that contain non-linear and discrete units which have a significant, but not a determining influence on dynamic processes.There are two main deterministic approaches to create the control system for the object's state vector - analytical design of optimal controllers and modal control.

Professor A.M. Letov [1,3] published his work in 1960, in which was obtained the analytical solution of the problem of linear stationary object's optimal stabilization with a quadratic quality functional, it was later called "analytic construction of regulators" (ACOR). Problem of linear non-stationary objects optimization was solved in Kalman's work [2] published in 1960.ACOR has the ultimate goal of obtaining control law purely analytically, based on the requirements for management quality [2]. Synthesis of the desired optimal closed loop control system using ACOR depends on the designer choice of suitable penalty matrix coefficient values to obtain a minimum of quality criterion is not quite convenient because of absence of obvious relationship between selected

coefficients and transients in a closed-loop system.In addition, the application of the ACOR method leads to the necessity of solving nonlinear matrix Riccati equation, which is a non-trivial task and requires the use of special numerical procedures.

The essence of the modal synthesis of optimal control is to determine the numerical values of the delayless feedback transmission coefficients in all the variables of the object state in order to ensure a predetermined distribution of the characteristic equation roots (eigenvalues) in the closed-loop control system. The majority of industrial objects have delays. The delay may occur due to time spent on signal transmission or, as happens more often can be caused by the phenomenon of simplifying assumptions, by virtue of which it is considered that action of intermediate and reinforcing links in the controlled object is reduced to a signal transmission with delay [5,6]. Of particular interest is the training of remote control operators for various types of technical objects. Inertia of the operator himself has a significant impact on the management quality in addition to the delay in the signal transmission. Therefore, it's imperative to have the best (reference) dynamic realization (control laws) in preparation of the operator considering the inertia and delay in the control loop. In thisarticle authors proposed a procedure for the synthesis of the optimal modal stabilization of linear stationary systems with delay based on the method of undetermined coefficients with the simultaneous compensation of the delay to eliminate self-oscillations. This article is an extension of the work of the authors [4].

Method of undetermined coefficients

It is known [3] that for completely measurable systems of the form:

$$\begin{aligned} \dot{\bar{x}} &= A\bar{x} + B\bar{u}, \\ \bar{y} &= C\bar{x}. \end{aligned} \tag{1}$$

In the case of a quadratic quality criterion, extreme control is a linear function of state variables:

$$\bar{u} = \bar{p}^T \bar{x}. \tag{2}$$

Moreover, if the vector of feedback coefficients$\bar{p}$is chosen in such a way that the poles of the closed system (1) are located at preassigned arbitrary points, then the required dynamic properties will be provided in the closed system [4]. Thus, this problem is reduced to the choice of the optimal location of the poles and determination of the feedback coefficients.

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We show that the unknown coefficients $\overline{p_i}(i=\overline{1,n})$ of the characteristic determinant of a closed optimal system [7]:

$$det(\lambda)=|A+Bp^{-T}-I|\lambda=$$
$$\begin{vmatrix} a_{11}+\mathrm{b_1p_1}-\lambda & \dots & a_{1j}p_j & \dots & a_{1n}+\mathrm{b_1p_n} \\ a_{j1}+\mathrm{b_jp_1} & \dots & a_{jj}+\mathrm{b_jp_j}-\lambda & \dots & a_{jn}+\mathrm{b_jp_n} \\ a_{n1}+\mathrm{b_np_1} & \dots & a_{nj}+\mathrm{b_np_j} & \dots & a_{nn}+\mathrm{b_np_n}-\lambda \end{vmatrix},$$

linearly enter into the expression for the coefficients of the characteristic polynomial of a closed system.

Indeed, let $\exists b_k/b_k \neq 0$. Then, subtracting the kth ($j \neq k$) line from the jth line, multiplied byb_j/b_k, we get a determinant equal to the original, in which the feedback coefficients $\overline{p_i}(i=\overline{1,n})$ enter the kth line. Expanding it along this line and grouping the terms with the corresponding λ powers, we finally arrive at the following expression of the characteristic polynomial of the closed system (3) or (4):

$$H(\lambda)=\lambda^n+\left(\sum_{i=1}^{n}\mathrm{c_{n\text{-}1,i}p_i}+\mathrm{d_{n\text{-}1}}\right)\lambda^{n-1}+\dots+\left(\sum_{i=1}^{n}\mathrm{c_{0,i}p_i}+\mathrm{d_0}\right), \quad (3)$$

$$H(\lambda)=\lambda^n+\left(\mathrm{\overline{c}_{n-1}^{-T}\overline{p}}+\mathrm{d_{n\text{-}1}}\right)\lambda^{n-1}+\dots+\left(\mathrm{\overline{c}_0^{-T}\overline{p}}+\mathrm{d_0}\right). \quad (4)$$

We define the unknown parameters c_{ji},d_j ($j=\overline{0,n-1}; i=\overline{1,n}$) in $n+1$ step using the undetermined coefficients method. To do this, we put $p_i=0$ ($i=\overline{1,n}$) in the characteristic determinant at the first step and reveal it by one of the known numerical methods and find that the coefficients found for different powers of λ determine the unknown coefficients $d_j(j=\overline{0,n-1})$ in the expressions for the characteristic polynomial of the closed system for the corresponding powers of λ. In the next n steps, setting sequentially one of the coefficients $p_i(i=\overline{1,n})$ equal to one while others remain zero and revealing the characteristic determinant, we obtain expressions for the unknown parameter c_{ji} for the corresponding power $\lambda^j(j=\overline{0,n-1})$ in the characteristic polynomial of the closed system.

$$c_{ji}=f_i-d_i, \quad (5)$$

where f_i is the coefficient of the ith open characteristic determinant. On the other hand, the characteristic polynomial of a closed system with the desired roots $\lambda_1,\lambda_2,\dots,\lambda_n$ has the form [4]

$$F(\lambda)=\prod_{i=1}^{n}(\lambda-\lambda_i)=\sum_{j=0}^{n-1} l_j\lambda^j+\lambda^n. \quad (6)$$

As a result, to determine the feedback coefficients $\bar{p}$ in expression (2), we equate the expressions for the coefficients for the same powers in (4) and (6) and obtain a system of linear algebraic equations:

$$\mathrm{col}\left(\bar{c}^T,\bar{c}^T,\ldots,\bar{c}^T\right)\bar{p}=\bar{l}-\bar{d}, \quad (7)$$

where $\bar{l}=(l_{n-1},l_{n-1},\ldots,l_0),\bar{d}=(d_{n-1},d_{n-2},\ldots,d_0).$

Now consider the procedure for modal synthesis based on the undefined coefficients method proposed for linear dynamical systems with transport delay[5,6].

Formulation of the problem

The dynamics model of the object is described as

$$\dot{\bar{x}}=A\bar{x}+By, \quad (8)$$

where $\bar{x}=(x_1,x_2,\ldots,x_n)^T$ is fully measured vector of system states deviation from a predetermined trajectory of movement; A,B - coefficient matrix with dimension $n\times n$, $n\times l$; y - a scalar, characterized by deviation of controls, taking into account the reaction of the operator, the dynamic model has the form

$$\dot{y}=\lambda_y y+d_u u(t-\theta), \quad (9)$$

where λ_y,d_u,θ- constants determined by psychophysical features of operators(and besides $\lambda_y=-\frac{1}{T};d_u=\frac{k}{T}$); $u(t)$ − scalar control action, which will be sought in the form (2). The objective is to determine the coefficients $\bar{p}=(p_1,p_2,\ldots p_n)^T$, providing some predetermined dynamic characteristics of the stabilization process and achieving sustainable programmed movement of the system (8).

Resolving stabilization problem

As the operator delayθ is sufficiently small value, we'll write the equation (9) as a

$$\dot{y}(t)=\lambda_y y(t)+d_u u(t)-d_u\theta\dot{u}(t). \quad (10)$$

In that case, if in some way estimate or measure the condition of the operator $y(t)$, the system (8), (10) is fully observed and the problem is solved as follows.

We introduce into consideration the advanced phase vector. Then the closing equation has the form $\tilde{x} = (x_1, x_2, \dots, x_n, x_{n+1} = y)^T$.

$$u = p^T \tilde{x} \tag{11}$$

and the characteristic polynomial of the closed-loop system (8), (10) takes the form:

$$\det\left(A^* - I\lambda\right) = \begin{vmatrix} A - I\lambda & B \\ -\dfrac{d_u\left(\overline{p}^T - \theta\overline{p}^T A\right)}{1 + d_u\theta p_{n+1}} & \dfrac{\lambda_y + d_u p_{n+1} - \theta\overline{p}^T B}{1 + d_n\theta p_{n+1}} - \lambda \end{vmatrix} = 0, \tag{12}$$

where A^* is a matrix $(n+1)\times(n+1)$, $\bar{p} = (p_1, p_2, \dots p_n)^T$.

It is known that the multiplication of all the elements of a row or column by the factor λ is equivalent to multiplying the determinant on λ[7]. Hence, the determinant (12) can be written

$$\det\left(A^* - I\lambda\right) = \frac{1}{1 + d_u\theta p_{n+1}} \begin{vmatrix} A - I\lambda & B \\ \overline{p}^T - \theta\overline{p}^T A & \lambda_y + d_u p_{n+1} - d_u\overline{p}^T\theta B - \lambda(1 + d_u\theta p_{n+1}) \end{vmatrix}$$

and therefore assuming that the $(1 + d_u\theta p_{n+1})^{-1} \neq 0$,

we'll put

$$\begin{vmatrix} A - I\lambda & B \\ \overline{p}^T - \theta\overline{p}^T A & \lambda_y + d_u p_{n+1} - d_u\theta\overline{p}^T B - \lambda(1 + d_u\theta p_{n+1}) \end{vmatrix} = 0. \tag{13}$$

It is easy to show that the determinant (13) is a polynomial of degree $(n+1)$ on λ, and its coefficients are linearly dependent on $\overline{p} = (p_1, p_2, \dots p_n, p_{n+1})^T$, i.e.

$$\det\left(A^* - I\lambda\right) = H\left(\lambda, \tilde{p}\right) = \lambda^{n+1} + \left(\tilde{d}_n^T\tilde{p} + d_n^0\right)\lambda^n + \dots + \left(\tilde{d}_n^T\tilde{p} + d_n^0\right) = 0 \tag{14}$$

.

Indeed, when uncovering the determinant (13) in the last line, in which each element is a linear combination of the coefficients p, we're getting the expression (14).

Determination of unknown coefficients $d_i, d_i^0 (i = \overline{0,n})is$ made similarly to the procedure cited in this paper above.When equating between the coefficients of the polynomial powers (14) and the polynomial with spectrum $\{\lambda_i\}(i = \overline{1, n+1})$ selected to provide specified quality parameters of transient processes

$$L(\lambda)=\prod_{i+1}^{k+1}(\lambda-\lambda_i)=\sum_{k=0}^{n+1}\mathrm{l_k}\lambda^{\mathrm{k}}, \tag{15}$$

where $l_{n+1}=1$, we get the joint system of linear algebraic equations

$$D_{n+1}p=\tilde{l}, \tag{16}$$

where $D_{n+1}$is matrix with $(n+1)\times(n+1)$coefficients and $p\tilde{l}$ are column vectors with dimension $(n+1)$. The solution of system (16) provides the defined spectrum $\{\lambda_i\}(i=\overline{1,n+1})$ to closed-loop system. Frequently it is not possible to evaluate or measure the state of the operator $y(t)$ in real conditions. Then it is necessary to put $p_n+1\equiv 0$ in the closing equation (11). As a result, the characteristic determinant of a closed-loop system has the form

$$\det\left(A^*-I\lambda\right)=\left|\frac{A-I\lambda}{d_u(\overline{p}^T-\theta\overline{p}^T A)}\right|\frac{B}{\lambda_y-d_u\theta\overline{p}^T B-\lambda}\Bigg|. \tag{17}$$

Desired characteristic polynomial is determined, as in the previous case, bythe expression (15). When equating the coefficients of the polynomials (17) and (15) with the same powers λ we obtain incompatible systems of linear algebraic equations in contrast to (16)

$$D_n\bar{p}=\tilde{l}, \tag{18}$$

where D_n is matrix of $(n\times n)$ coefficients and $\bar{p}$is n-dimensional column vector. It is possible to use the least squares method [8], for solving such a system, according to which the vector of unknown coefficients $\bar{p}$ is approximately defined as

$$\bar{p}=(D_n^T D_n)^{-1}D_n\tilde{l}. \tag{19}$$

Ensuring the absence of auto-oscillations near a given trajectory of the system

The optimal stabilization law (11) of the system (8), synthesized, proposed by the method of indefinite coefficients, provides the given dynamic properties of the process of stabilization of the system in the event of deviations from the given (software) trajectory of motion. However, this law does not eliminate the occurrence due to the presence of a lag of stable self-oscillations at the end point of the stabilization process near the given trajectory of motion. To compensate for the delay, a modified Bess's method [8] is proposed, the essence of which is as follows.

Let the equation of optimal (on an arbitrary criterion) switching surface in the absence of lag in the system is known and has the form

$$\Phi(x_1, x_2, ..., x_n) = 0, \ \bar{x} \subset X^n. \tag{20}$$

Assuming that the function F is solved for one of n of its arguments, for example, x_1, we write (29) in the

$$x_1 + \varphi(x_2, x_3, ..., x_n) = 0; \ \bar{x} \subset X^n. \tag{21}$$

It should be noted that the condition of solvability is not necessarily taken for clarity. The surface of the switching (21) is shown in Fig.1, where ABC is some optimal trajectory of the forced motion of the system to the switching surface (21).Let for simplicity in the control circuit there is a scalar control influence with delay θ. In order that the trajectory of the ABC in this case remains, as in the system without delay, it is obvious that the optimum surface is the geometric point of the points from which, after a while time θ, under the forced motion of the system, the point depicting moves to the surface (21).The equation of the optimum surface of the switching of the compensated system in this case has the form

$$\Phi^*(x_1, x_2, ..., x_n) = 0, \ \bar{x} \subset X^n$$

or

$$x_1 + \varphi^*(x_2, x_3, ..., x_n) = 0, \ \bar{x} \subset X^n. \tag{22}$$

Denote the distance between the projections of the points B and C on the $x_1 \dots x_n$ axes $\Delta_{x_1} \dots \Delta_{x_n}$ respectively. Obviously, $\Delta_{x_i}(i = \overline{1,n})$ there are functions of the delay time θ, and the values $x_i = x_i + \Delta_{x_i}(i = \overline{1,n})$ are the current values of the coordinates, which represent the value of the coordinates of the system through the delay time θ.

For geometric reasons we have

$$x_1 + \varphi^*(x_2, ..., x_n, \theta) = \Delta_{x_1} - \varphi(x_2 + \Delta_{x_2}, ..., x_n + \Delta_{x_n})$$

or

$$\Phi^*(x_1, ..., x_n) = \Phi(x_1 + \Delta_{x_1}, ..., x_n + \Delta_{x_n}). \tag{23}$$

E*quation* (23) is a general equation for determining the function Φ^* of a given function Φ. To do this, according to Bess's method, it is enough to determine the values $\Delta_{x_i}(\theta)(i = \overline{1,n})$, and then substitute the future

values of the system's coordinates $x_i + \Delta_{x_i}$. In the system equation of the system's switching without delay. However, the definition of these quantities is substantially related to the time interval between two sequential control switchings that is specific to the class of tasks considered and absent in the Bess [8] method, which is general in nature. To determine these values, we write the general solution for coordinates of the vector $\bar{x}$ in the "reverse" time $z = t_k - t$

$$x_i(z) = f_i(\bar{x}^0, u, z); \bar{x}^0 = (x_1(t_0), x_2(t_0), ..., x_n(t_0)), \quad (24)$$

where u - controlling influence; $\bar{x}^0$ - vector of initial values of corresponding coordinates lying on the optimal surface of switching system without delay.

In the general case, when solving the optimal control tasks for the speed and fuel consumption, the system usually takes several switching operations. In this case, the importance between the values of $\Delta z_п$ and θ.

If $\Delta z_n < \theta$ for obtaining future values of the i −th coordinate is sufficient to find the value of optimal control, which corresponds to the trajectory of the SBA (Fig. 1). Then for value $z = \theta$ to get $x_i = x_i + \Delta x_i = f_i(x_i, ..., u, z)$ from (33) and put them in equation (23).

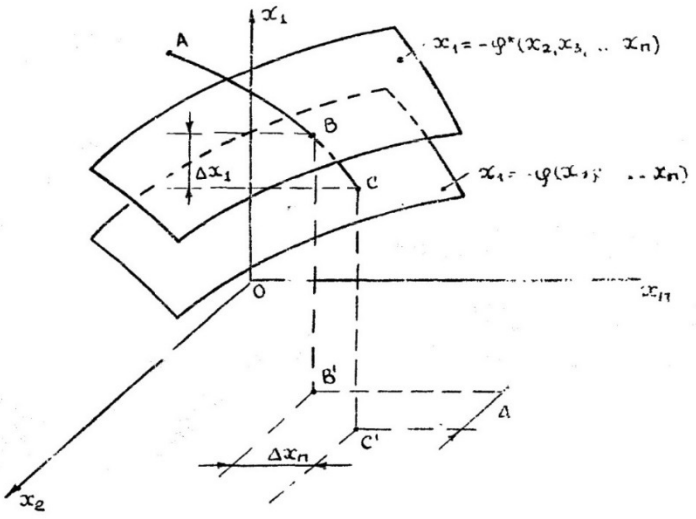

Fig.1 Geometric interpretation of Bess's method

If $\Delta z_n \geq \theta$ it is necessary to put $z = \theta - z_n$ in the equation (24). In this case the initial values $x_i^0 (i = \overline{1,n})$ lying on the new optimal switching surface, the next directly behind the original surface, and U is the new value of the control corresponding to the forced optimal motion after the new switching surface and founded x_i from (24) put in the equation (23).

Our task corresponds to the first case. Then, in order to maintain a stable motion of the system under $t \geq t_k$ the condition of the equilibrium of the control system, it will be determined as $u(t) = 0$ on the finite interval $[t_k - \theta, t_k]$.

In fact, in our case, this control disconnection surface is a tube inside which there is a software path

Conclusions

The modal synthesis of linear closed loop stationary systems with transport delay and with the optimal control law (11) in accordance with the shown procedure can provide the required dynamic properties in them as proposed in the article. The procedure for modal synthesis of an optimal control law is carried outbased on the undefined coefficients method proposed in this article.Delay compensation method [8] is proposed to use in order to eliminate the stable self-oscillations occurrence (due to the delay) at the stabilization process end point near given trajectory.

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EVALUATIONS OF DIAGNOSTIC EFFICIENCY OF THE STATE OF TECHNICAL SYSTEMS

Abstract: *The purpose of this paper is to study a possibility of increasing effectiveness of diagnosing the state of technical objects by constructing algorithms for processing input data and optimizing the selection of model parameters using genetic algorithms.*

Keywords: *genetic algorithm, absorbent, interface, data mining, ART-networks, neural network.*

Introduction

The process of analyzing information, namely data from a large number of sensors and devices during the diagnostics of the state of technical systems, which involves processing of a large stream of information by an engineer, is a very complicated task. Owing to the rapid development of information technologies, which enables automatic processing of information obtained from a variety of sensors, the work of the engineer becomes easier. New approaches to the automatic analysis and processing of input data for monitoring technical systems help to reduce the time of processing diagnostic information and provide decision support to the engineer carrying out the diagnosis of the technical state of the system.

Formulation of the Problem

Under the diagnostics of a technical system, we consider receiving signals from a gas sensor, on the basis of which an analysis of temporal and temperature dependencies of electrical conductivity of the absorbent in different gaseous environments and different partial pressures is carried out [1]. Sensors measuring such signals are new modern devices. As of today, automatic information processing systems for this type of sensors do not exist [2]. Therefore, there is an urgent task in developing a modern information technology for collecting, classifying, processing and analyzing data from sensors of this type. A special task of IT development lies in creation of a modern software complex, which will address the following problems: classification of input data, optimization of IT learning parameters, processing and analysis of data with the help

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of a genetic algorithm, convenient and intuitive interface, visualization of obtained results and convenience of settings.

Main Section

Consider the mathematical apparatus used to process data in order to implement control functions in technical monitoring systems. The main function of most information systems is recording of statistical data [3]. Large volumes of data stored in the technical monitoring databases require statistical processing. Preliminary data analysis involves assessment of the center of distribution, variance and the shape of the distribution function. The statistical methods of processing of information include such types of analysis as: variance, factor, cluster, regression and correlation analyses. Data mining [4] is used to identify hidden knowledge stored in large volumes of information. Data Mining methods include: basic iterative methods, fuzzy logic, genetic algorithms and neural networks. Thus, the mathematical apparatus of decision support systems (DSS) is represented by a sufficiently developed range of methods and approaches for collecting, processing and storing data. The hardware and software of engineering DSS are often considered separately, which does not allow one to systematically solve the tasks of technical diagnostics. This determines the direction of research on the development of an integrated system of technical monitoring, which will enable improvement of the assessment of the state of the systems.

For improvement of the diagnostic efficiency of technical systems, Adaptive Resonance Theory (ART) networks [5] have been used for processing input data. ART-networks implement a single-type clustering strategy based on self-learning, the main advantage of which is the ability to work in real time with an apriori unknown number of classes. The input data for a neural network implementing the adaptive resonance theory for the real vectors is a set L, which consists of pairs of vectors $\{x_i, y_i\}$ and has a matrix form. The peculiarity of such an approach is the arbitrary dimension of the input data, which complicates the processing of data in diagnostics in real time.

$$L = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} & y_{11} & y_{12} & \cdots & y_{1m} \\ x_{21} & x_{22} & \cdots & x_{2n} & y_{21} & y_{22} & \cdots & y_{2m} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ x_{k1} & x_{k2} & \cdots & x_{kn} & y_{k1} & y_{k2} & \cdots & y_{km} \end{pmatrix}.$$

For data clustering it is necessary: To feed the entry of such a network with a similarity coefficient – ρ, where ($0 < \rho < 1$), a set of training pairs$\{X_i, Y_i\}$, an input vector of the parameters of the *i*-th object $X_i = \{x_{ij} | j = 1, 2, .., n\}$, a vector of belonging of the *i*-th object to the *j*-th class, *n*– the number of values of the object parameters (dimension of the problem) $Y_i = \{y_{ij} | j = 1, 2, .., m\}$, the number of the to-be-distinguished classesm and the number of training pairsk.

Let us form the algorithm of data processing:

1. A neural network implementingthe of adaptive resonance theory is created for vectors of real values with a similarity coefficient ρ. To the entrance of this network, a sequence of X_i is fed. In the beginning, the network contains: n neurons in the input layer andm′ neurons in the output layer ($m' = 0$). When a new vector $X_i = (x_{i1}, x_{i2} \ldots, x_{in})$ is fed to the network input, the normalization is performed:

$$x_j = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}}, \qquad j = \overline{1..n}$$

after which, all the neurons of the output layer become active.

2. For all active neurons, the value of the activation function is calculated as the distance between the vector of weights and the input vector in the Euclidean metric.

$$f_j(X) = \sqrt{\sum_{i=1}^{n} \left(w_{ji} - x_i\right)^2}, i = \overline{1..m'}$$

3. Among the active neurons, the most active neuron is selected:

$$M' = \arg[\min_{j=\overline{1..m'}}\{f_j(X)\}]$$

If there are no more active neurons, then a new output neuron with the number $m' + 1$ is generated, with bonds:

$$w_{i\,m'+1} = x_i,\ C_{m'+1} = 1,\ i = \overline{1..n},$$

where C is a counter of vectors assigned to a given neuron. This step is performed until the active neuron is determined.

4. The active neuron passes the proximity check: $f_i \le (1 - \rho)$. If the condition is fulfilled, then we proceed to step 5, otherwise the active neuron becomes inactive, and we jump to step 6.

5. Correction of the connections of the winner neuron.

$$w_{ij} = w_{ij} + \frac{x_i - w_{ij}}{C_j}, \quad i = \overline{1..n}, C_j = C_j + 1,$$

where C_j is the number of vectors assigned to the j-th neuron.

6. Work with the current vector is complete.

An adaptive resonance theory network for the real vectors, to each input vector X_i, assingns a certain classC_j. After the adaptive resonance theory network for the real vectors has processed all the vectors X_i, each classC_j is converted into a vector

$$D_i = \{d_{ij} | j = \overline{1..r}\}, d_{ij} = \begin{cases} 1, & j = C_i \\ 0, \text{else} & j \neq C_i \end{cases}$$

whereris the number of classes.

The resulting clustered input vector is the initial input vector X_i with the cluster-related information added to it, which is encoded by the vector D_i. Thus, we obtain clustered vectors of the following form: $X_i^* = (x_{i,1}, x_{i,2}, \ldots, x_{i,n}, d_{i,1}, d_{i,2}, \ldots, d_{i,r})$.

Further on, the research data consist of a set of training pairs; each *i*-thtraining pair is a pair of vectors $\{x_i, y_i\}$, where $x_i = \{x_{ij} | j = 1, 2, .., n + r\}$ is the input vector; $y_i = \{y_{ij} | j = 1, 2, .., m\}$ is the expected output vector.

Letk be the number of training pairs, thenwe can denote all the input data by a matrix of the following form:

$$L^* = \begin{pmatrix} x_{11} & x_{12} & \ldots & x_{1n} & d_{11} d_{12} \ldots d_{1r} & y_{11} & y_{12} & \ldots & y_{1m} \\ x_{21} & x_{22} & \ldots & x_{2n} & d_{21} d_{22} \ldots d_{2r} & y_{21} & y_{22} & \ldots & y_{2m} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ x_{k1} & x_{k2} & \ldots & x_{kn} & d_{k1} d_{k2} \ldots d_{kr} & y_{k1} & y_{k2} & \ldots & y_{km} \end{pmatrix}.$$

Training pairs are located in the rows of this matrix. In the course of repeated experiments on the learning of the neural network, the theory of adaptive resonance for the real vectors on the test samples demonstrated the correctness of the presented algorithm. The experiment also showed that this learning method has the advantages of simplicity of settings and the possibility to additionally train the adaptive resonance networks, with only one similarity parameter ρ to be chosen.

To improve the assessment of the effectiveness of diagnosing the state of technical systems, it is necessary to optimize the process of selecting a model. The process of optimizing the parameters of the

algorithm can be completely automated. Optimization of the process of selection of the model is implemented with the use of the genetic algorithm [5].

On the basis of algorithms of processing of input data and optimization of the process of selection of the model, an information technology of decision support was developed.

Experimental Research

Using the information technology of decision support [7], an analysis of the of the operability of the algorithm for automated selection of input parameters and its effectiveness in general was carried out. Consider, for example, the size of the population being 40, the number of epochs – 15, the time of one epoch – 1000 and the mutation rate – 0.2. The optimal parameters obtained as the results of the work of the automated information technology have appeared to be similar to those selected by an expert in the field. An increase of the number of epochs to 200 in the experiments showed a better result than the one provided by an expert in the industry. The outcomes of the experiments showed that the information technology developed using the above algorithms works faster and provided a higher quality than the network, the parameters for which were selected manually, for example: training the system takes 17 seconds versus 30 seconds of manual selection; the error in training data was 0.62 vs. 0.77.

Conclusions

According to the results of experimental research, it is proved that the information technology developed for evaluation of the efficiency of diagnosing the state of technical systems is operational. But the developed algorithm for the classification of alcohols in the gaseous environment of sensors with the help of clustering did not provide more efficient and qualitative results, though most likely, this is a feature of diagnostics of the state of this technical system.

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UDK 574:004.2

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APPROXIMATE SPATIAL MODEL BASED ON INTERVAL FUZZY ROUGH SOFT SETS

Annotation. *This work presents a spatial model for the real-time GIS-based decision support systems based on the interval fuzzy rough soft sets. A dynamic fuzzy rough soft topology represents a structure of a geoecotechnical system that contains a multitude of interacting processes, which evolve in space and time. In disaster conditions, some of the interacting processes can be destructive. Their dynamics are modeled using the spread model. The area of interest is represented as an approximation by a grid of cubic cells. This allows taking into account the peculiarities of the initial information obtained from drones using remote sensing techniques and having a significant uncertainty. As a result, boundaries of contours of spreading destructive processes are blurred using fuzzy rough soft topology. The proposed model reduces the computational complexity and provides the acceptable performance of real-time DSS.*

Keywords: *destructive processes, spatial model, fuzzy rough soft set, fuzzy-rough soft topology, grid of cells, blurred boundaries*

1 Introduction

Complex systems containing territories with natural and artificial objects as well as a multitude of interacting processes, which evolve in space and time, can be considered as geoecotechnogenic systems (GETS). Some processes arising within GETS are destructive because they give rise to a danger and risk to the certain valuable objects causing their destructions and can often lead to critical situations or emergencies.

Solving decision support problems in disaster situation requires real-time geographic information systems (GIS) containing a spatial model of confined space (area of interest, AOI), where the destructive processes take place, as well as adequate models of the destructive processes exposed onto the spatial model. However, the most of the destructive processes are poorly observed and their spreading over the AOI is weakly modeled, so developing decision support systems (DSS) is a complex and non-trivial task, which becomes more complicated due to uncertainty of information, a wide geographically distribution of events and, as usual, a lack of time [1]. The efficiency of decision-making strongly depends on the availability of online disaster monitoring tools aimed at the real-time computation of the most important parameters related to the spreading of the destructive processes.

Today, a suite of the most modern methods and techniques, such as remote sensing, GIS, geospatial analysis, unmanned aerial vehicles (UAV), can be synergistically used to build GIS-based DSS. Remote sensing techniques allow generating a full range of data for disaster monitoring [2], which have a form of streams of great volumes that come from sensors on a continuous basis at a high rate and should be analyzed in a real-time [3]. UAVs can effectively perform long-time missions to obtain remote sensing data [4]. However, due to the instrumental inaccuracy and distortions caused by vibrations, remote sensing information obtained from UAVs is incomplete, imprecise, vague, and often blurred [5]. The dynamics of the spreading destructive process depends on the accuracy of determining the boundaries of its dynamic contour. However, the uncertainty of observations significantly reduces the accuracy of determining the boundaries of such contours [6]. Obtained remote sensing data should be correctly transferred to the disaster spread model, geolocated and mapped to the AOI.

Using the well-established approaches for the spatial modeling do not provide the required performance and acceptable efficiency of GIS-based real-time DSS in disaster conditions [7]. A key aspect to achieve the desired performance is to build an approximate spatial model of spreading destructive processes, taking into account their partial observability and uncertainty of observations. Thus, we need to soften the requirements for the accuracy of remote sensing data representation, which will give an opportunity to improve DSS performance. In this case, boundaries of the dynamic contours of the spreading processes can be vague and blurred.

There are several well-known approaches to deal with the uncertainty and vagueness in the spatial models, such as fuzzy set theory [8], rough set theory [9] and soft set theory [10]. Each of these approaches has its inherent difficulties as pointed out in [10]. It should be noted that due to the absence of some important information a priori, such as membership functions for fuzzy sets, equivalence relations for rough sets, or parameterizations for soft sets, these approaches cannot ensure the adequacy of the spatial model of the destructive process independently. Therefore, many researchers combine some of these approaches. Some authors proposed to use for spatial modeling the combinations of rough and fuzzy sets [1], rough and soft sets [11], fuzzy and rough sets [12]. In [13], the authors proposed the concepts of rough fuzzy soft sets and fuzzy

rough soft sets, which have a number of advantages to build a blurred spatial model. Based on this, we can use soft topological spaces to build a spatial model of the destructive process, as well as the fuzzy rough method for its blurring.

The aim of this work is to develop the approximate spatial model of the destructive process within GETS in disaster conditions [14]. To overcome the computational complexity problem, we build a topological spatial model and soften the effects of discretization using the fuzzy rough sets. The developed model allow analyzing big data streams coming from the remote sensors and representing them in a user-friendly style.

2 Modeling dynamics of GETS in disaster conditions

Let us consider the AOI as an open connected subspace X of two-dimensional Euclidean space endowed with the topological properties [15]. To build a topological space on X we use an equivalence relation $\Re_X \subseteq X \times X$ (reflexive, symmetric, and transitive) [1]. Then the pair $apr_X = (X, \Re_X)$ is called the approximation space. The family of all composite sets is denoted by $Def(apr_X)$ and uniquely determines the topological space $T = (X, Def(apr_X))$.

Suppose that each point $x \in X$ has a non-empty finite set of attributes A, V_a is a domain of $a \in A$ and f is a function such that $f : X \times A \to V$. Let's impose a metrical grid of coordinate lines with $\delta = \Delta\alpha_1 = \Delta\alpha_2 = \Delta\alpha_3$ within X, which form a set C of square cells with the size being $\delta \times \delta \times \delta$. Thus, space X is discretized by a grid C of isometric square cells $c \in C$. Assume that a cell $c \in C$ is a spatial homogeneous object of a minimal size. Each cell $c \in C$ is associated with a set of attribute values, which is called the cell state, via the value function $f(c, A)$. The proposed discretization assigns equal values of the attributes to each point belonging to a certain cell c, therefore each cell $c \in C$ represents a homogeneous area of the AOI in terms of attribute values A, so it can be reduced to a point of X. It's suggested to model disaster dynamics in GETS by means of a change of states of the cells covered by the disaster.

Suppose the set of attributes A can be divided into subsets: not changing over time (static) attributes A_S, time-varying (dynamic) attributes A_D, slowly changing (environmental) attributes A_E,

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$A = A_S \cup A_D \cup A_E$. Suppose $W = \{w_0, ...w_i, ...w_F\}$ is an ordered set of the cell state categories (phases), where w_0 is the initial phase, w_F is the final phase, and each w_i is the transitional phase. We consider each significant change of the cell attribute's value, which forces the cell to change its state, as an event. Assume, during the destructive process, the cell moves through a sequence of qualitatively different categories of states, which should be evaluated during continuous remote sensing. It is clear that the model of the destructive process can be represented as a model of dynamic change of states of a subset of cells covered by the process within the spatial model. Thus, the GETS structure can be represented as a topology space, which includes subspaces of cells of the same phase and makes it possible to assess the position and boundaries of the dynamic contour of the process. Since the belonging of each cell to a certain phase is determined approximately due to the uncertainty of remote sensing, the topological space describing the structure of GETS as well as the boundaries of the contour of the spreading process are blurred.

3 Representing GETS structure using the spatial model

GETS structure at each time moment t can be represented as a set of subsets of cells with the states being in one or another phase.

3.1 Representing GETS structure using soft sets

It's suggested to represent GETS structure at each moment t in the form of a soft set [10] $\Upsilon_{W_D}(t) = \left\{\left(w, \Upsilon_{W_D}(w,t)\right) : w \in 2^W, \Upsilon_{W_D}(w,t) \in 2^C\right\}$, where $\Upsilon_{W_D}(w,t)$ is w-element of the soft set, namely a set of cells with the states belonging to the phase $w \in W_D$ at time moment t. Fig.1 shows a structure of GETS in the form of the soft set, which breaks down the set of cells into three subsets such as w_0-, w_1-, and w_2-elements.

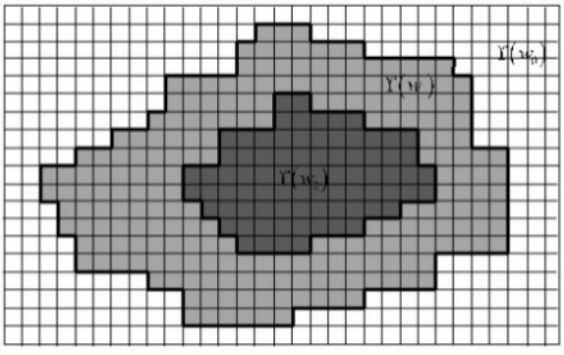

Fig. 1. GETS structure in the form of the soft set

Let $Def\left(\Upsilon_{W_D}\right)$ be a set of all compositional sets of the soft set $\Upsilon_{W_D}(t)$. Then GETS structure can be represented in the form of topological space $T_C^{W_D} = \left(C, Def\left(\Upsilon_{W_D}\right)\right)$.

3.2 Representing the GETS structure using fuzzy soft sets

By applying different ways of blurring to the soft set, we can obtain blurred GETS structures, which can be represented in the form of blurred topological spaces.

The most general way of blurring is using fuzzy sets. Let L be the interval [0,1], 2^C be a family of all strict subsets of the set of cells C, and L^C be a family of all fuzzy subsets of the set of cells C. Each fuzzy set is a mapping $\tilde{C}^w(t): C \to L$. Then at each time moment, the blurred GETS structure can be represented as fuzzy soft set [20].

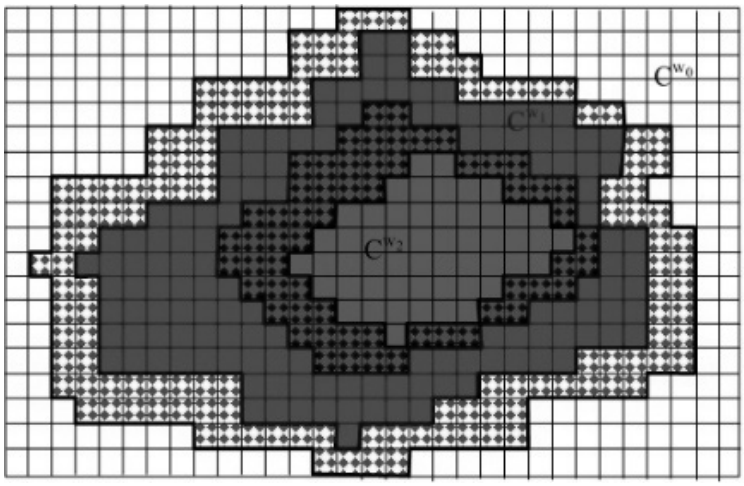

Fig. 2. Blurring soft set using fuzzy set

It subdivides the set of cells C into the phases (Fig.2): $\tilde{\Upsilon}_{W_D}(t) = \left\{\left(w, \tilde{\Upsilon}_{W_D}(w,t)\right): w \in 2^{W_D}, \tilde{\Upsilon}_{W_D}(w,t) \in L^C\right\}$, where $\tilde{\Upsilon}_{W_D}(w,t) = \left\{\left(c, \tilde{\Upsilon}_{W_D}(w,t)(c)\right): c \in C\right\} = \tilde{C}^w(t)$, $\tilde{C}^w(t) = \left\{\left(c, \tilde{C}^w(c)(t)\right): c \in C\right\}$ is a fuzzy set of cells with the state (phase) $w \in W_D$ at the time moment t, $\tilde{\Upsilon}_{W_D}(w,t)(c) = \tilde{C}^w(c)(t)$ is a degree of membership of the cell c to the fuzzy set $\tilde{C}^w$ of cells with the states belonging the phase $w \in W_D$ (w-element of the soft set $\tilde{\Upsilon}_{W_D}$) at the time moment t.

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Definition. $\forall t \in T$ a set $\tilde{\tau}(t) = Def\left(\tilde{\Upsilon}_{W_D}(t)\right) \subseteq L^C$ is a fuzzy topology $\tilde{\tau}(t)$ in the set C, which meets the following conditions **[16]:**

a) $(\forall t \in T), \left(\bar{0}, \bar{1} \in \tilde{\tau}(t)\right)$ or $(\forall t \in T), \left(\Phi, \tilde{C} \in \tilde{\tau}(t)\right)$;

b) $(\forall t \in T), \left(\tilde{C}^{w_i}(t), \tilde{C}^{w_j}(t) \in \tilde{\tau}(t)\right) \Rightarrow \left(\tilde{C}^{w_i}(t) \cap \tilde{C}^{w_j}(t) \in \tilde{\tau}(t)\right)$;

c) $(\forall t \in T), \left(\left\{\tilde{C}^{w_j}(t), j \in J\right\} \subseteq \tilde{\tau}(t)\right) \Rightarrow \left(\cup_{j \in J} \tilde{C}^{w_j}(t) \in \tilde{\tau}(t)\right)$.

A pair $\tilde{T}_C^{w_D}(t) = \left(C, \tilde{\tau}(t)\right)$ is called Chang topological space.

3.3 Representing the GETS structure using rough soft sets

The fuzzy soft set is the most detailed description of blurred GETS structure, but in practice, determining the degrees of membership of cells to the phases can be impossible. If such degrees are unknown, the simplest way of blurring soft topology is using rough sets **[9]**, which are built on the basis of determining the lower approximation (subset of cells belonging to the rough set unambiguously), upper set (subset of cells, which possibly belong to the rough set), and boundary set (subset of cells with the degrees of membership in the rough set being unknown).

Let $\Re_C^{w_D}$ be indiscernibility relation in the set of cells C such as $\Re_C^{w_D} = \left\{(\mathrm{c}_i, \mathrm{c}_i) \in C \times C \middle| f(\mathrm{c}_i, w_D) = f\left(\mathrm{c}_j, w_D\right)\right\}$, where $f(\mathrm{c}_i, w_D)$ is the phase, which corresponds to the state cell c_i. Then $apr_C^{w_D} = \left(C, \Re_C^{w_D}\right)$ is Pawlak approximation space **[9]**.

Definition. Let $\Upsilon_{W_D} = (\Upsilon, W_D)$ be a soft set in the set of cells C. Then $\underline{\Upsilon_{W_D}} = (\underline{\Upsilon}, W_D)$ is a lower rough approximation, and $\overline{\Upsilon_{W_D}} = \left(\overline{\Upsilon}, W_D\right)$ is an upper rough approximation of the soft set Υ_{W_D}.

They constitute soft sets **[18]**, such that $\underline{\Upsilon_{W_D}}(w) = \left\{c \in C \middle| \Re_C^{w_D}(c) \subseteq \Upsilon_{W_D}(w)\right\}$ and $\overline{\Upsilon_{W_D}}(w) = \left\{c \in C \middle| \Re_C^{w_D}(c) \cap \Upsilon_{W_D}(w) \neq \varnothing\right\}$, for all $w \in W_D$. If $\underline{\Upsilon_{W_D}}(w) = \overline{\Upsilon_{W_D}}(w)$, w-element of the soft set Υ_{W_D} is a strict set, in other cases it is a rough set **(Fig.3)**.

Definition. A rough set of cells with the states being in the phase w, at the time moment t is determined by two approximations:

$$\hat{\Upsilon}_{W_D}(w,t)=\left\{\underline{\Upsilon_{W_D}}(w,t),\overline{\Upsilon_{W_D}}(w,t)\right\}$$

where $\underline{\Upsilon_{W_D}}(w,t)$ is a lower approximation containing the cells, which definitely belong to the set $\hat{\Upsilon}_{W_D}(w,t)$; $\overline{\Upsilon_{W_D}}(w,t)$ is an upper approximation containing the cells, which possibly belong to the set $\hat{\Upsilon}_{W_D}(w,t)$.

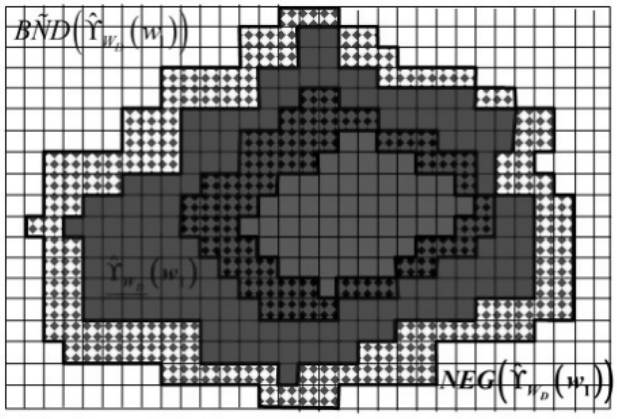

Fig. 3. Blurring soft set using rough set

Definition. Negative area of the rough set $\hat{\Upsilon}_{W_D}(w,t)$ is a subset of cells C, which definitely don't belong to the set of cells with the states being in the phase w: $NEG\left(\hat{\Upsilon}_{W_D}(w,t)\right)=C-\overline{\Upsilon_{W_D}}(w,t)$.

Definition. Boundary area of the soft set $\hat{\Upsilon}_{W_D}(w,t)$ is a subset of the set of cells C, which belong to the upper approximation $\overline{\Upsilon_{W_D}}(w,t)$, but don't belong to the lower approximation $\underline{\Upsilon_{W_D}}(w,t)$: $BND\left(\hat{\Upsilon}_{W_D}(w,t)\right)=\overline{\Upsilon_{W_D}}(w,t)-\underline{\Upsilon_{W_D}}(w,t)$.

Let $Def\left(\hat{\Upsilon}_{W_D}\right)$ be a family of all fuzzy rough sets, which represent the sets of cells belonging to one or another phase.

Definition. A set $\hat{\tau}(t)=Def\left(\hat{\Upsilon}_{W_D}(t)\right)$ is a rough topology in C. At each time moment, the pair $\hat{T}_C^{w_D}(t)=\left(C,\hat{\tau}(t)\right)$ is the rough topological space.

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The rough set is a convenient tool to represent obtained data, which describe the subsets of cells belonging or non-belonging to a definite phase when we can see the areas of territory belonging to the phase w, not belonging to the phase w, and the boundary areas of cells with unknown degrees of belonging to the phase w.

3.4 Representing the GETS structure using fuzzy rough soft sets

Using remote sensing techniques during monitoring often allows assessing gradations of belonging the cells from rough sets boundary area to a certain rough set of cells. It is possible by means of visual information describing different gradations of gray or brightness. Such information allows representing GETS structure in the form of the fuzzy rough soft set **[19].**

The fuzzy rough soft set of cells, which subdivides the set of cells into phases at each time moment t is represented as the set of three elements consisting of upper and lower approximation of the rough set **(Fig.4),** as well as the boundary area of the rough set in the form of the fuzzy set: $\tilde{\hat{\Upsilon}}_{W_D}(t)=\left\langle \underline{\hat{\Upsilon}_{W_D}}(t), \overline{\hat{\Upsilon}_{W_D}}(t), B\tilde{N}D\left(\hat{\Upsilon}_{W_D}(t)\right)\right\rangle$.

The fuzzy rough soft set subdivides the set of cells into w-elements, each of which is a rough set of cells belonging to a certain phase $w\in W_D$: $\tilde{\hat{\Upsilon}}_{W_D}(w,t)=\left\langle \underline{\hat{\Upsilon}_{W_D}}(w,t), \overline{\hat{\Upsilon}_{W_D}}(w,t), B\tilde{N}D\left(\hat{\Upsilon}_{W_D}(w,t)\right)\right\rangle$, where $B\tilde{N}D\left(\hat{\Upsilon}(w,c,t)\right)$ is a degree of belonging the cell c, which is included in the boundary area $c\in B\tilde{N}D\left(\hat{\Upsilon}_{W_D}(w,t)\right)$ of the rough set $\hat{\Upsilon}_{W_D}(t)$, to the fuzzy set $B\tilde{N}D\left(\hat{\Upsilon}_{W_D}(w,t)\right)$ at time moment t.

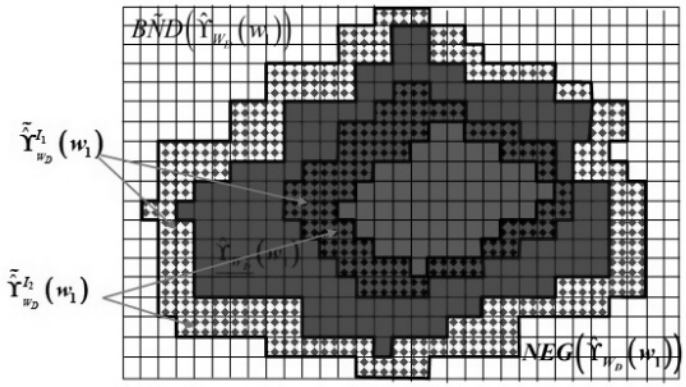

Fig. 4. Blurring topology using fuzzy rough soft set

Definition. The GETS structure at time moment t can be represented as a fuzzy rough soft set of cells: $\hat{\Upsilon}_{W_D}(t)=\left\{\left(w,\hat{\Upsilon}_{W_D}(w,t)\right):w\in W_D\right\}$, where each rough set of cells $\tilde{\hat{\Upsilon}}(w,t)$ is w-element of the fuzzy rough set $\tilde{\hat{\Upsilon}}_{W_D}(t)$.

Let $Def\left(\hat{\Upsilon}_{W_D}\right)$ is a family of all fuzzy rough sets, which represent the sets of cells belonging to one or another phase.

Definition. The set $\hat{\tau}(t)=Def\left(\hat{\Upsilon}_{W_D}(t)\right)$ is fuzzy rough topology in C. At time moment t, the pair $\hat{T}_C^{w_D}(t)=\left(C,\hat{\tau}(t)\right)$ is the fuzzy-rough topological space.

3.5 Representing the GETS structure using interval fuzzy rough soft sets

Each w-element of the fuzzy-rough set contains a fuzzy set of cells belonging to the boundary area of a rough set and setting the degree of membership of each cell of the boundary region to the phase w. In practice, setting the exact value of membership degree is impossible, but it is possible to assess the intervals to which such values can belong. In this regard, the authors have been suggested to model boundary area in the form of an interval fuzzy set [20].

Let us consider a set of intervals $L^I=\left\{[a,b]:0\le a\le b\le 1\right\}$ and a partial order relation $\le_{L^I}$, such that $[a_1,b_1]\le_{L^I}[a_2,b_2]\Leftrightarrow a_1\le a_2,\mathrm{b}_1\le b_2,\forall[a_1,b_1],[a_2,b_2]\in L^I$.

The interval fuzzy set on the set C is a mapping [20] $\tilde{C}^I:C\to L^I$, where $\tilde{C}^I(c)=\left[\tilde{C}_*^I(c),\tilde{C}^{I*}(c)\right],\forall c\in C$, $\tilde{C}_*^I(c)$, and $\tilde{C}^{I*}(c)$ are lower and upper degrees of membership of the cell c to the fuzzy set $\tilde{C}^I(c)$. The interval fuzzy set of cells belonging to the boundary area of the soft set $\hat{\Upsilon}_{W_D}(w,t)$ corresponding to the phase w at the time moment t, can be defined in the following way: $B\tilde{N}D^I\left(\hat{\Upsilon}_{W_D}(w,t)\right)=\left\{c,\left(B\tilde{N}D_*^I\left(\hat{\Upsilon}_{W_D}(w,\mathrm{c},t)\right),B\tilde{N}D^{I*}\left(\hat{\Upsilon}_{W_D}(w,\mathrm{c},t)\right)\right)\right\}$, $c\in BND\left(\hat{\Upsilon}_{W_D}(w,t)\right)$, where $B\tilde{N}D_*^I\left(\hat{\Upsilon}(w,\mathrm{c},t)\right)$ and $B\tilde{N}D^{I*}\left(\hat{\Upsilon}(w,\mathrm{c},t)\right)$ are lower and upper degrees of membership of the cell c to the fuzzy set

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$B\tilde{N}D\left(\hat{\Upsilon}(w,t)\right)$, which represents the boundary area of the soft set $\hat{\Upsilon}(w,t)$ of cells whose states belong to the phase w at time moment t.

The interval fuzzy rough soft set of cells, which subdivides the set of cells into the phases, at each time moment t is represented as the set: $\tilde{\hat{\Upsilon}}^{I}_{W_D}(w,t)=\left\langle \underline{\hat{\Upsilon}_{W_D}}(w,t), \overline{\hat{\Upsilon}_{W_D}}(w,t), B\tilde{N}D^{I}\left(\hat{\Upsilon}_{W_D}(w,t)\right)\right\rangle$ **(Fig. 5).**

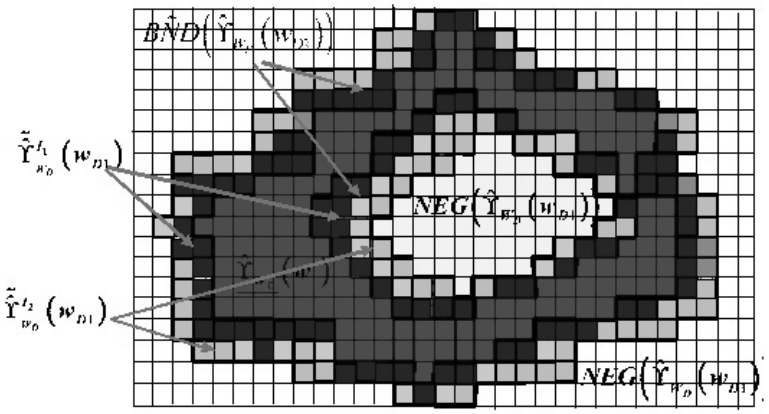

Fig. 5. Blurring topology using interval fuzzy rough soft set

Definition. The GETS structure at time moment t can be represented as interval fuzzy rough soft set of cells: $\bar{\tilde{\Upsilon}}^{I}_{W_D}(t)=\left\{\left(w,\bar{\tilde{\Upsilon}}^{I}_{W_D}(w,t)\right): w\in W_D\right\}$.

Let $Def\left(\bar{\tilde{\Upsilon}}^{I}_{W_D}\right)$ be a family of all interval fuzzy rough sets, which represent the sets of cells belonging to one or another phase.

Definition. The set $\bar{\tilde{\tau}}^{I}(t)=Def\left(\bar{\tilde{\Upsilon}}^{I}_{W_D}(t)\right)$ is an interval fuzzy rough topology in C. At time t, the pair $\bar{\tilde{T}}^{w_D I}_{C}(t)=\left(C,\bar{\tilde{\tau}}^{I}(t)\right)$ is the interval fuzzy rough topological space.

4 Experiment Results

The developed spatial model of the spreading destructive processes was used in the GIS-based real-time DSS providing the geospatial analysis of emergencies in real time disaster situations.

The real DSS performance mainly depends on the sampling of the spatial model and the kind of used soft topology. We have performed an experiment with DSS in the form of simulation of the disaster situations based on the proposed spatial model with the variable cell size.

The simulation has been aimed at examination of a validity and an efficiency of the proposed spatial model as well as evaluation of influences of the cell size and the kind of soft topology on DSS reaction time.

The results of the experiment are depicted in Fig. 6, 7.

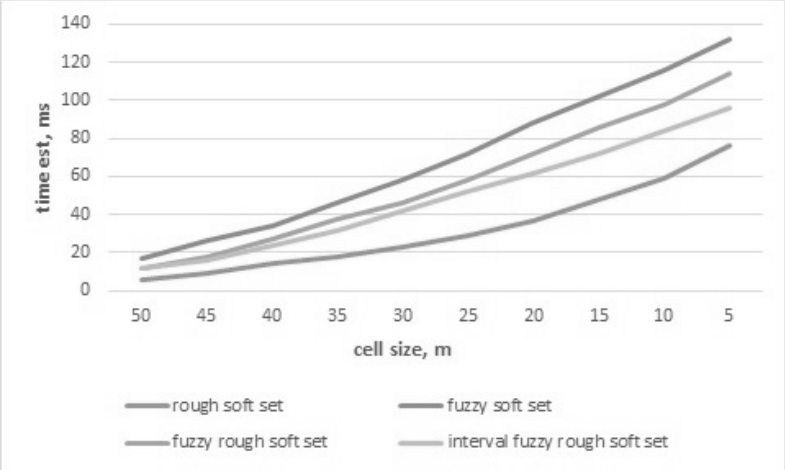

Fig. 6. Total time of decision making vs. cell size

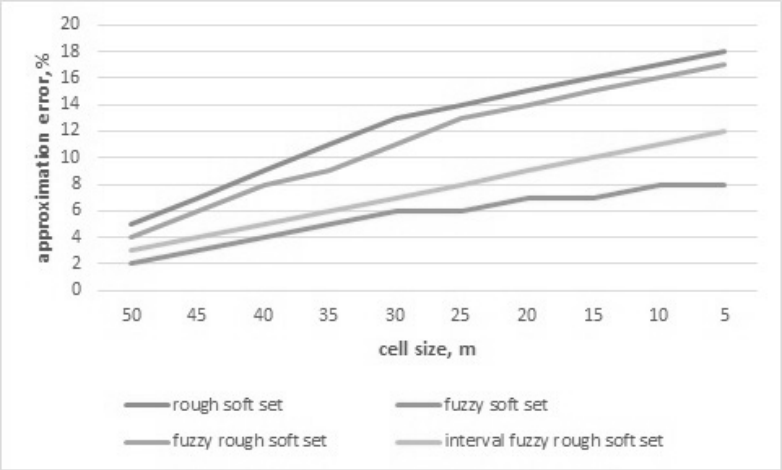

Fig. 7. Approximation error vs. cell size

The results of the experiment show that the proposed model provides acceptable performance in terms of accuracy and speed for all kind of topology. The fastest performance is demonstrated by the rough soft topology; however, it does not provide acceptable accuracy. The fuzzy topology significantly loses in terms of speed. The interval fuzzy rough topology shows sufficient results on the speed with enough accuracy.

5 Conclusions

The approximate spatial model for the real-time GIS-based DSS based on the interval fuzzy-rough soft sets is proposed. The model of the destructive process is represented as the model of dynamic change of states of the subset of cells covered by the process within the spatial

model. As a result, the structure of GETS is represented as a topology space, which includes subspaces of cells that are in the same phase. The soft topological spaces are used to build a spatial model, as well as the fuzzy-rough method is used for its blurring. Since the belonging of each cell to the certain phase is approximately determined due to the uncertainty of remote sensing, the topological space describing the structure of GETS is blurred, and the boundaries of the dynamic contour are also blurred. The proposed spatial model representing uncertain information about the disaster reduces the computational complexity and provides flexible and timely decision-making in real time.

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SOME ASPECTS OF NONLINEAR NON-STATIONARY PROCESSES FORECASTING

The mathematical tools set forth implemented in data mining problems of different nature for forecasting of nonlinear non-stationary processes. Results of its implementation for forecasting of nonlinear non-stationary processes is provided.

Keywords: *Nonlinear Non-Stationary Processes, Forecasting, Ecological Processes, Economical Processes*

Introduction

Intensive development of science has led to the emergence of a large quantity of methods for forcasting the behavior of processes of different nature that is received in the form of time series [1,2]. Note that almost all of them are nonlinear and non-stationary (one can only say piecewise linearity and piecewise stationary).

But all this amount of available methods of forecasting does not guarantee that they cover all possible variants of the situation's development. However, the vast majority of methods are two-staged. In the first stage, the parameters of the predicted series are analyzed, in the second stage the appropriate forecasting method is selected and, finally, the forecast is obtained. But what to do when series parameters are varying? One method can no longer be used, since series parameters have already changed, and the choice of another is impossible, because the process of changing of parameters has not yet been completed.

Therefore, it is necessary to develop a mathematical apparatus for the purpose of creating new methods for analysis and forecasting of nonlinear non-stationary processes of different nature in order to increase the adequacy of mathematical models of nonlinear non-stationary processes and improving the quality of prediction estimates, which are calculated by using building models. The development will be carried out with using of data mining.

Data mining by the definition is the process to find in the raw data unknown non-trivial practically useful and accessible knowledge interpretations, necessary for decision making in different spheres of human activity [3]. Data Mining (DM) is the term which is used for description of knowledge representation in databases, data research, data

samples processing, data clearing and collection. It is the process of identifying correlations, trends, patterns, links, and categories [4] Data mining is developed on the basis of such branches of science as applied statistics, artificial intelligence, database theory etc.

The process of automatic search of hidden patterns or interconnections between variables in the data mining is divided into the task of classification, modeling and forecasting using statistical and mathematical methods.

Complex problems at the macro level, such as problems of predicting the quality of life, are characterized by analysis and forecasting of nonlinear non-stationary processes. In this connection, it is proposed to consider some of the methods that can be used for using in the similar problems. These include the following methods:

- hidden Markov models;
- the method of similar trajectories;
- linguistic modeling.

The Main

The method of hidden Markov models.

Traditionally, hidden Markov models are defined as triplet,

$$\lambda = (A, B, \Pi)$$

where 1) $A = \{a_{ij}\}$ - matrix of probabilities/probability matrix of transitions from a state into the state S_j, $a_{ij} = P[q_{i+1} = S_j \mid q_i = S_i], 1 \le i, j \le N$;

2) $B - \{b_j(k)\}$ - distribution of probabilities/ probability distribution of observed characters in the state ^{j}? where $b_j(k) = P[v_k \mid q_i = S_j], \quad 1 \le j \le N, \quad 1 \le k \le M$ (for / in a continuous case $b_j(k)$ is given as the probability density distribution function).

3) $\Pi = \{\Pi_i\}$ - probability of each initial state,

The main tasks during applying HMM to determine process parameters. It is necessary to resolve three tasks in order to apply HMM in speech recognition [5].

Task 1: If sequence of observations sequence and model $\lambda = (A, B, \Pi)$ are given, then how to effectively compute $P(O \mid \lambda)$ -

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reliability/probability of such sequence with given parameters of the model?

Task 2: If sequence of observations sequence and model $\lambda = (A, B, \Pi)$ are given, then how to determine the corresponding sequence of internal states?

Task 3: If sequence of observations sequence is given then how to determine parameters of the model $\lambda = (A, B, \Pi)$, based on maximization criterion $P(O \mid \lambda)$

Here are approaches to solving the first HMM task.

To calculate effectively the probability of generation of given sequence $P(O_j)$.

As already is indicated, this task is with the necesity to calculate the probability of sequence of observations sequence with given parameters of model λ, that is $P(O \mid \lambda)$. The direct method of calculation of this probability is to calculate of the sum of all possible state sequences. Consider one of these possible sequences $O_t;\ t = 1, T$.

The Probability of observation sequence $P(O \mid Q, \lambda)$ in given state sequence is calculated as

$$P(O \mid Q, \lambda) = \prod_{i=q}^{N} P(O_i \mid q_i, \lambda)$$

or

$$P(O \mid Q, \lambda) = b_{q_1}(O_1) * b_{q_2}(O_2) * \ldots * b_{q_T}(O_T).$$

The probability of such a state sequence can be written as

$P(Q \mid \lambda) = \Pi_{q_1} * a_{q_1 q_2} a_{q_2 q_3} \ldots * a_{q_{T-1} q_T}$

Compatible probability $P(O \mid \lambda)$ is calculated as a product of above indicated probability:

$$P(O \mid Q, \lambda) = P(O \mid Q, \lambda) P(Q \mid \lambda).$$

Thus the probability $P(O \mid Q, \lambda)$ is calculated as the sum of the compatible probability of all possible state sequences q

$$P(O \mid \lambda) = \sum_{aiiQ} P(O \mid Q, \lambda) P(Q \mid \lambda) =$$

$$= \sum_{q_1, q_2, \ldots, q_T} \Pi_{q_1} * b_{q_1}(O_1) * a_{q_1 q_2} b_{q_2}(O_2) * \ldots * a_{q_{T-1} q_T} b_{q_T}(Q_T).$$

It is easy to calculate that the number of multiplications required for calculation of this sum is $(2T - 1)N^T$. That is, if the model has five states (N=5) and observation sequence has the length one hundred (T=100), then the number of arithmetic operations is $2 \cdot 100 \cdot 5^{100} \approx 10^{72}$.

However there is the more effective method of probability calculation P. It is called the Forward-Backward procedure and consists of the following: a variable is introduced that is defined as

$$\alpha_i(i) = P(O_1 O_2 \ldots O_i, q_i = S_i \mid \lambda).$$

Let's it the "direct" variable which is the probability of appearance of a partial observation sequence for this model, $O_1 O_2 \ldots O_i$. We can define inductively this "direct" variable as

- initialization:

$$\alpha_1(i) = \prod b_i(O_1),$$

$$1 \le i \le N;$$

- induction:

$$\alpha_{t+1}(j) = \left[\sum_{i=1}^{N} \alpha_1(i) a_{ij} \right] b_i(O_{t+1})$$

$$1 \le t \le T - 1$$

$$1 \le j \le N$$

completion:

$$P(O \mid \lambda) = \sum_{i=1}^{N} \alpha_T(i).$$

Herewith step 1) has initialized the direct variables with the compatible probability of states and initial observations. Inductive step 2) is the heart of the procedure. It is illustrated in the Fig. 1.

At the completion step 3) wanted probability as sum by i of final values of direct variables is calculated, herewith

$$\alpha_T(i) = P(O_1 O_2 \ldots O_T, q_T = S_i \mid \lambda).$$

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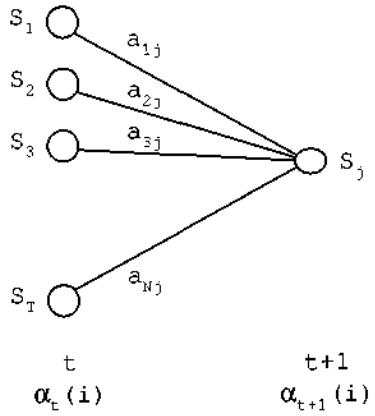

Fig. 1 - Inductive step of Forward-Backward procedure

Thus to calculate probability $P(O \mid \lambda)$ it is already necessary about N^2T calculated operations, instead of $2TN^T$ for direct method, so that this is the (more) faster method. In our example for $N = 5$ and $T = 100$ it requires in all about 3000 arithmetic operations, instead of 10^{72} operations for direct calculation.

Then we introduce “inverse/reverse” variable and define it as

$$\beta_t(i) = P(O_1 O_2 \ldots O_T, q_t = S_i \mid \lambda)$$

that is $\beta_t(i)$ - is the probability of partial observation sequence from the (moment of) time t till the end of sequence of the given state S_i at the (moment of) time t and with parameters of model λ.

Also exactly we can calculate $\beta_t(i)$ inductively by/according the following procedure:

1) Initialization

$\beta_T(i) = 1$

$1 \le i \le N$

2) Induction

$$\beta_T(i) = \left[\sum_{j=1}^{N} a_{ij} b_j(O_{t+1})\right] \beta_{t+1}(j)$$

$t = T-1, T-2, \ldots, 1, 1 \le i \le N$

For solving the first PMM task it’s sufficient to calculate only the "direct" or only the "inverse" variable.

The method of "similar trajectories".

$$d(Y_k, Y_n) = (Y_k - Y_n)^T (Y_k - Y_n)$$

Method of Linguistic Modeling

Building a Linguistic Model. To achieve the goal, task of finding a linguistic pattern of the time series should be solved, which includes:

1) calculation of the difference series of the output time series;

2) choice of intervaling criterion of difference series;

3) intervaling of a certain difference series in accordance with the chosen criterion;

4) finding a linguistic chain for a certain difference series;

5) finding a transition matrix for each possible pair of symbols in the linguistic chain of the certain difference series;

An input data for this task is the time series.

An output data for this task is a linguistic pattern of the time series (dynamic process), which is:

– set of intervals, obtained as a result of intervaling of the difference series of a certain order from the time series;

– a transition (precedency) matrix, based on the set of intervals (described above) and on the time series.

A specified linguistic pattern is built separately for difference series, input time series, different orders [7-9]. Thus we obtain a set of linguistic patterns, which is an intermediate result of the forecasting problem using linguistic modeling.

Approach of linguistic modeling to construct a linguistic pattern of the input time series will be considered further.

One of the approaches is an using (of) pattern recognition methods to implement of forecasting procedures. So let's stop just at the of pattern recognition. Most of various mathematical methods for solving pattern recognition tasks can be divided into two main classes.

The first class can be positioned in relation with decision theory, (or as) it is also called (as) a discriminant approach. In this case, the objects are characterized by sets of numbers – the results of a certain set of measurements, which are called features. Pattern recognition with using of this approach is usually done by (means of) partitioning of sets of measurements into the regions. [10].

The second class develops within the syntactic (or structural) approach. Among the features of this approach is pattern recognition in

which an information about pattern structure is important, and from the very recognition procedure it is required that it enables not only to refer the object to a certain class (that is, define its classification), but also to give a description of those parts of an object that excludes the possibility of its classification into another class.

Syntactic approach to pattern recognition makes it possible to describe a sufficiently large set of complex objects by using a small set of elements and grammatical rules. And in this the recursive nature of apparatus of grammar (will) help.

The grammatical rule (or substitution rule) can be applied any (number of) times, so it is possible to provide some of the structural characterize some structures of infinite set of sentences in a sufficiently compact (enough) way.

Various relationships defined between partial patterns can traditionally be represented by logical and mathematical operations.

Processing of symbol sequences puts some problems. Symbols are grouped into words, words form sentences, but not in a free way, but in accordance with certain rules. To identify regularity patterns in the location in sentence, it is necessary to determine the representation, within which these laws could not only be described, but also be found in symbolic sequences.

These questions are basic for studying (of) the character sequences. Just as for linguistic requirements at one time by Noam Chomsky in the middle of the last century the theory of formal grammar was proposed, which became one of the main sections of mathematical linguistics.

According to the stages of constructing a linguistic model, the initial task will be divided into the following subtasks:

- subtask of obtaining of difference series;
- intervaling subtask;
- linguistization subtask;
- subtask of construction of transition matrix.

Subtask of obtaining of difference series. The purpose of this subtask is to obtain of series that characterize the dynamics of changing of movement of mouse cursor: the speed (the difference series of the 1st order), the acceleration (the difference series of the 2nd order), etc. Thus, the difference series are derivatives of the initial series.

Given: Vector of integers $\bar{X}$ with power (of) $n = |\overline{X}|$.

Results: Vector of integers $\overline{D}$ with power (of) $k = |\overline{D}|$.

Limitations:

$$\forall d_i \in \overline{D} : d_i = x_{i+1} - x_i$$

where $i \in [0; n-1)$; $x_{i+1}, x_i \in \overline{X}$

$$k = n - 1$$

Intervaling subtask. The purpose of this subtask is construction of a user alphabet by splitting (of) a sorted difference series into a set of intervals, each element of which characterizes a certain alphabet letter.

Given:

– hypothetical power of alphabet a;

– Vector of integers $\overline{D}$ power (of) $k = |\overline{D}|$.

Results:

Vector of integer pairs with power (of) $n = |\overline{I}|$.

Limitations:

$$\forall x \in \overline{I} : x^1 \leq x^2$$

$$\forall x_i , x_{i+1} \in \overline{I} : x_i^2 < x_{i+1}^1,$$

where $i \in [0; n-1)$

$$n \leq a$$

$$a \ll k$$

$$\exists x \in \overline{I} : \forall d \in \overline{D}, d \in [x^1; x^2]$$

$$\forall d_i, d_{i+1} \in \overline{D} : d_i \leq d_{i+1},$$

where $i \in [0; k-1)$

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$$x_0 \in \bar{I} : x_0 = (-\infty; x_1^1)$$

$$x_n \in \bar{I} : x_n = (x_{n-1}^2; +\infty)$$

Linguistization subtask. The purpose of this subtask is to obtain of a linguistic chain by (means of) finding the corresponding alphabet letter for each value of the difference series. The alphabet letter uniquely corresponds to a certain interval from the set of intervals obtained as a result of solution of the previous problem.

Given:

– Vector of integers with power (of) $k = |\overline{D}|$ which corresponds to the limitation represented in previous formulas;

– Vector of integer pairs $\bar{I}$ with power (of) $n = |\bar{I}|$ with the limitations represented in previous formulas.

Results:

Vector of integers $\overline{A}$ with power (of) k .

Limitation:

$$\forall x_i \in \overline{A} : \exists d_i \in \overline{D}, \exists y_j \in \bar{I}, d_i \in [y_j^1; y_j^2], x_i = j, \quad (1.1)$$

where $i \in [0; k), j \in [0; n)$

Subtask of construction of transition matrix The purpose of this subtask is to construct of a transition matrix between two alphabet letters in a sentence. The alphabet and its letters are defined / determined in the intervaling subtask, and sentences are (defined) in the linguistization subtask.

Given:

– vector of integers $\overline{A}$ that corresponds to limitation 1.1 with power (of) $k = |\overline{A}|$;

– the power of set of intervals n , obtained as a result of solving the intervaling subtask.

Results: square matrix with rational numbers $\overline{P}$ by dimension .

Limitation:

$$\forall x_{ij} \in \overline{P} : \; x_{ij} \in [0.0; 1.0],$$

where $i, j \in [0; n)$

In the case if there is information obtained in the form of a graphic image, we have the following. Using the Freeman Chain Code, we proceed to the symbolic entry of the data sequence

Resulting sequence is analyzed for the presence of grammatical constructions. At the output we obtain a list of grammatical constructions with probabilities of their presence in the process, as well as a matrix of probability from one symbol to another. This stage is closely correlated with modeling of hidden Markov processes, as well as the method of similar trajectories.

By means of the above describing mathematical tools and developed algorithms several time series (Swiss International Air Lines stock, Dow Jones Industrial Average value of gold) were analyzed.

For maximum file size 4000 timeslots were taken with a gradual reduction of series size of the up to 200 with steps (of) 200.

The results of calculations are illustrated in fig. 2,3.

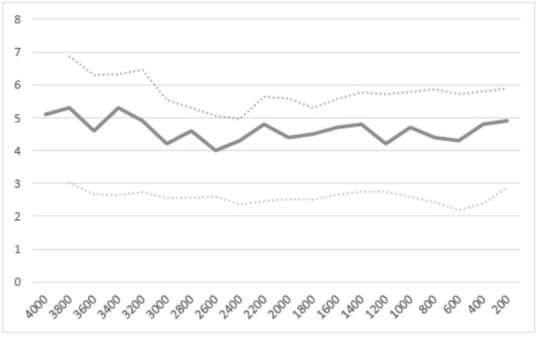

Fig. 2 - Change of the number of successful trend forecasting for different dimensionality of the input time series.

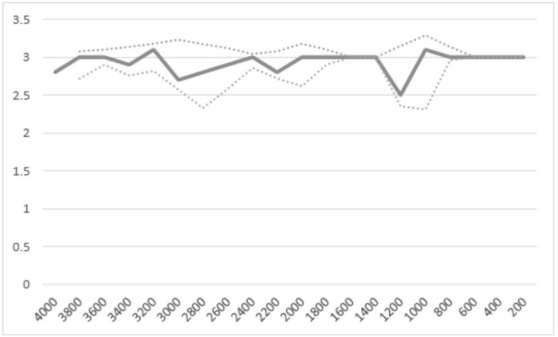

Fig. 3 – Change of the number of successful forecasting of time series values for different dimensionality of the input time series.

The calculations were repeated at different dimensionality values of input series for the obtained series without a trend difference series. Obtained results are shown in fig. 4, 5.

Depending on the power of alphabet, corresponding character encodes one or another range of values, therefore, a study was done on the dependence of forecasting quality from number of symbols in the

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alphabet. Dimensionality of input series was 400 values. Results of experiments are illustrated in pictures fig. 6, 7.

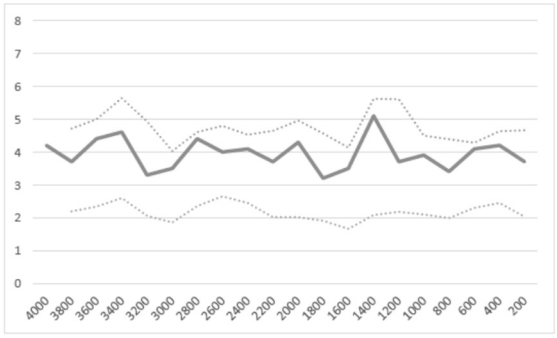

Fig. 4. Change of the number of successful trend forecasting for initial series without trend difference series.

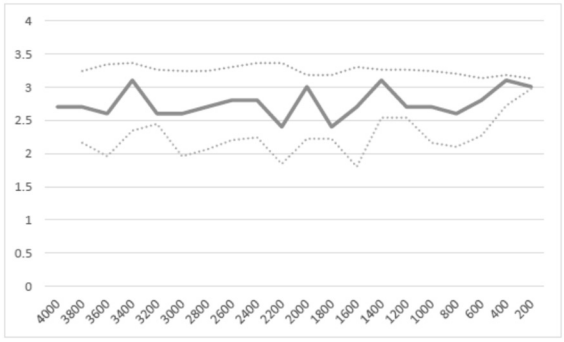

Fig. 5. – Change of the number of successful forecasting of time series values for initial series without trend difference series.

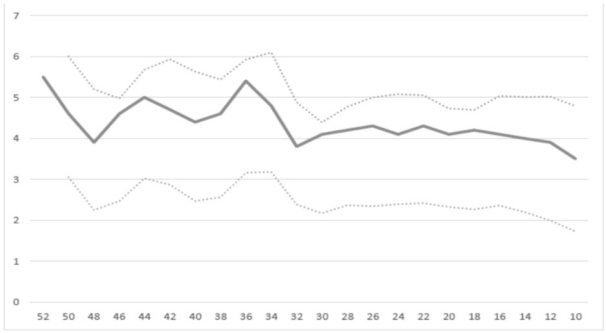

Fig 6 - Change of the number of successful trend forecasting for different alphabet dimensionality.

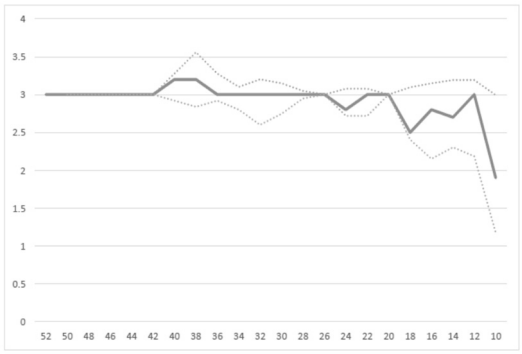

Fig.7 - Change of the number of successful forecasting for different alphabet dimensionality.

Conclusion and future research directions

Thus, a mathematical tools was developed to calculate quantitative and qualitative marks of time series of economical and ecological by using of hidden Markov models and linguistic modeling, which is distinguished by the stability of the obtained results and provides (for) improvement of the quality of forecasts of the corresponding marks.

The structures of new mathematical models of nonlinear non-stationary processes, which differ in simplification of constructing the model, and provide a description of the high level of adequacy for investigated processes, are formed.

The presented methods are universal both from the kind of obtained information and from the presence of nonlinearities and non-stationary

information in this information. But there is a general lack of all statistical methods - the lack of historical information.

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FEATURES OF IMPLEMENTATION OF THE INFORMATION SECURITY POLICY IN THE CREATION OF THE RATIONAL SYSTEM OF ELECTRONIC DOCUMENTARY COOPERATION FOR PUBLIC AND COMMERCIAL STRUCTURES OF UKRAINE

Annotation. *The article presents an algorithm for a reasonable choice of a rational electronic document management system from an existing set of analogues. The main selection criteria are due to the functionality of the software and hardware architectures of the system, as well as the limited number of financial resources. The article substantiates that the information security policy of such a system: first, it will guarantee the adequacy of the level of information protection to the level of its criticality and profitability of implementing information protection measures; secondly, it will allow to evaluate and check the security of information; thirdly, it will ensure the personification of the provisions of the security policy (in relation to the subjects of the EDS) and the reporting (registration, audit) for all critical resources from the security point of view; Fourthly, it will provide visibility of measures to protect information, continuity of the operation of such a system and its restoration in case of unforeseen situations, and so on. Models of threats and the infringer of the chosen CSA will allow to determine the necessary levels of the functioning of the information security subsystem, namely the level of organizational and technical measures, the level of current control and the level of elimination of the consequences of the realized threats.*

Keywords: *algorithm, analog, security, choice, document, threat, protection, information, criterion, model, policy, intruder.*

Introduction

Under the conditions of modern market economy an important component of the development of high-tech industries is their comprehensive information support [1, 2]. Some information requirements are put forward to the information supply, namely: in quality (shortness and precision of formulations, timeliness of receipt); on purposefulness (satisfaction of specific needs); accuracy and probability (correct selection of source materials and information, continuity of their collection, accumulation and processing, optimality of systematization of information and its proofing / transmission). In the activity of state and commercial structures such as the Kyiv City State Administration (KSDA) and, for example, the State Enterprise "Antonov" of Ukraine, which are complexes with a large number of everyday

connected and interacting units, preciseness and reliability of information support are primary and indispensable factors of their reliable and efficient functioning.

These requirements can be met by introducing modern electronic computers and technical means of telecommunications in the process of recording material media - documents that pass through the stages of their creation, issuing (approval), signing (approving), registering, reviewing, executing, writing off into the archives, storage and destruction. Taking into account that today's documents today, unfortunately, are not subject to the ever-increasing vital needs and strict rules of life rhythm, which accelerates significantly from year to year, one of the obvious ways to make them "go the right direction", while minimizing the human factor , is the automation of motion and processes of document processing by creating such systems as electronic document flow systems (EDS).

Analysis of recent research and publications

The mentioned problem is highlighted in many publications of foreign and domestic authors. The most famous among them is the work of G.Yu. Maximovich, SL Kuznetsova, A.K. Rogova, O.A. Efimova, V.P. Berestova M.Yu. Krukovsky and other scholars. Nevertheless, the analysis of publications in the subject area under consideration suggests that a comprehensive study of the problem of creating a promising EER, their implementation in the main phases of the life cycle of paper documents and the formation by their participation of authentic electronic images of the latter to date is absent. Therefore, it requires additional and more in-depth study.

The purpose of the article

Proceeding from this, the relevance of the article is due to the actual increase in the requirements for prospective EADs due to the continuous growth of volumes of information that has recently been processed in information systems, as well as the need to ensure the authenticity of the electronic image of the document to its paper original. One possible solution to this problem is the introduction of some unified one within an organization, for example, KSCA SED, which will facilitate such processes as: creation, management of access, use and distribution of electronic documents in computer networks with the use of electronic

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communications; control over the flow of documents in the institution. Therefore, the purpose of the paper and its main content is precisely the introduction of a valid choice algorithm among the set of existing rational EED, the software and hardware architecture of which is conditioned by the requirements of functionality, and the actual selection procedure is objectively limited to available financial resources.

Main part

In providing modern document circulation, the SED plays, as a rule, a decisive role. To the extent of their functional tasks, for the most part, are: maintenance of office functions functions (creation and registration of documents, collective work with documents, work with libraries); conducting electronic storage of documents (archival storage of documents; entering them into a repository; organization of attributive and full-text search of documents, as well as access to them via the web); automation of business processes (description of workflow-processes and their implementation); Providing administration and security measures (defining access rights and user roles, implementing cryptography and data integrity tools). According to experts from the international expert company GartnerGroup [3], due to the rapid development of the ERA market, the main suppliers of which are IBM (Lotus) - 49.0%, Microsoft - 39.4%, Nowell - 6.2%, and a number of other companies - 5.4%, the most common today are the following systems: systems that are oriented on business processes or otherwise flow of work (business-process EDM or otherwise EDMS-systems); corporate systems (enterprise-centric EDM); content management systems; information management systems; image / imaging systems (imaging systems).

In the post-Soviet market, the most well-known among them is recognized:

a) Western Development SED:

Russified: DocsOpen (Hummingbird), PC DOCS (Hummingbird), LinkWorks (DEC), Staffware (Workware PLS), Lotus Notes (Lotus-IBM);

non-corrosive: Directum (EMC), Documentum, DocuLive;

b) SET of Russian development:

based on Western systems: Office Media company InterTrust Moscow (Lotus Notes), Irida company IBS Moscow (Lotus Notes), Clerical work of the firm InTorKon, Chelyabinsk (Lotus Notes), Optima-WorkFlow of the Optimo company (MS Exchange, MS SQL), Lotus Notes Bios Reporter;

own: LanDocs, Effect Office, Document 2000 (TelcomService), Eutrophication Documentation (Sognitive Technologies), DILO (EOS), N.System (Computer Technology Center), LS Flow Software), ESCADO (Interprocomloman), 1C: Documentation and 1C: Archive (1C), Document 2000 (TelcomService), DocsVision (Digital Design) and others;

c) ERA of the Ukrainian development: DOKA PROF.STEEP 2.0 (Kvazar-Micro), ISoperator (System Plus), InTEAM-Workflow (pool.kiev.ua), etc.

Western software development tools are mainly aimed at maximizing the full use of electronic documents and tools for collective work of users, as well as the absence of intermediate links. This, in turn, determines the change of existing processes in the office and the need for its optimization, as well as regulates the development of new technologies for working with documents. The main feature of these EDSs is the simulation of specific actual workflow processes and settings for these models of other software systems.

Traditional Russian technology of the processes of record keeping from the west is different, first, with a clearly defined vertical character of the document movement (leader - executor - leader) in the middle of the institution; and secondly, the registration, control and reporting forms and magazines; thirdly, tracking the whole complex of work with documents in registration journals or typewriters, where all information about documents, their movement, resolutions, control over the timing, etc. are entered. In this case, this technology is regulated both by state standards, as well as sectoral instructions and guidelines for office work.

Software tools that implement the Russian ERAs are primarily aimed at using in public institutions and preserve all the traditions and standards of office work adopted in each particular of them. The task of such systems is to provide support for paper workflow, reduce the complexity of routine operations on document processing. In addition, they are able to significantly expand the boundaries of traditional processes of record keeping and document circulation through the processing of documents using computer networks. Systems in this direction are a kind of "overpass" for the gradual transition from paper to paperless documents. Unlike the Russian systems known today, the SED of Ukrainian development, unfortunately, performs purely specialized functions.

Given the above and over-saturation of the domestic market alternatives, differing from each other in terms of functional capabilities and technological solutions, the choice of the most efficient EER, that is, that satisfies the needs of a particular institution (enterprise) - the problem is quite relevant. His solution is considered in the works SL Kuznetsova, OA Efimova, G.Yu. Maximovich and other authors [4-8]. At the initial stage, they propose to do some preparatory work, namely:

to formulate a list of tasks that should help to solve this problem;

to develop a detailed organizational plan for the implementation of the SED;

take into account the reliability of the supplier company of the EER and its proposed terms of delivery, implementation and support;

to determine eligibility for the price at delivery, introduction and maintenance;

take into account the possibility of updating the EDS in a reasonable time (with reasonable price conditions) under the specifics of the establishment (enterprise).

In the process of further work on the comparison of different systems, these authors suggest to focus on the model shown in Figure 1.

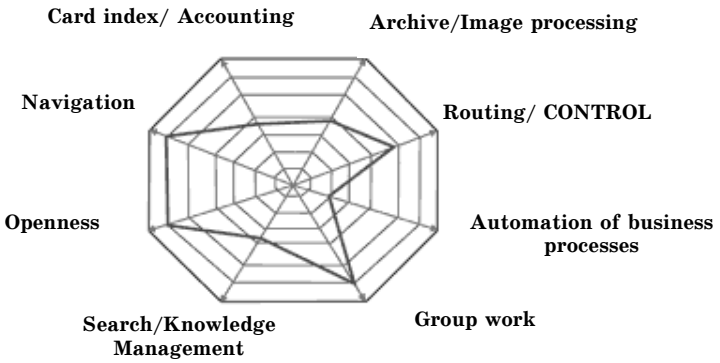

Fig. 1. Model of analysis of functionality of automation systems

At the same time, they believe that the chosen SET must support the Russian-speaking interface, be simple and flexible when installing and configuring, be reliable in operation, and, in addition, meet the criteria of scalability, distribution, openness, modularity, controllability, processability, security, efficiency, etc. Taking into account the above, and considering that the organization and maintenance of document circulation in Ukraine are fundamentally different from Russian - the basis for choosing the EER, which would satisfy the requirements, for

example, KSCA will choose the most popular in our country, the system of both Russian and western production (Table 1) [4-13].

Table 1

List of SADs to be surveyed and their brief description

SED	Company	Brief description
Foreign systems		
Directum	Directum www.directum.ru	A complete ECM system that ensures the transparency of management of the organization and improves the efficiency of all its employees. It maintains a complete lifecycle of document management, with the traditional "paper" clerical work logically integrates into electronic document management.
Russian systems created with the use of foreign products		
Boss-referent	IT, www.it.ru	Electronic document management and office automation system for large geographically distributed enterprises and for medium-sized businesses. The main results of the implementation of the system are increasing the manageability of the organization and the speed of decision-making, the formation of a fundamentally new level of performance discipline, the creation of conditions for the exchange of knowledge and information.
Russian systems created without the use of foreign products		
DocsVision	Digital Design, www.digdes.ru, www.docsvision.com	A system for automating office and office work, creating electronic archives, managing design and project documentation. Provides synchronization of business processes and workflow, supports modern methods of managing quality, processes and knowledge.
LanDocs	LANIT, www.landocs.ru	A program for complex automation of processes of record keeping and creation of electronic archives in organizations of different sizes. Maximizes the accumulated staff skills and the existing

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SED	Company	Brief description
		communication and network infrastructure of the organization.
OPTiMA-WorkFlow	OPTIMA, www.optima.ru	Software platform for creation of complex automated control systems of documents used for automation: document management support; control of executive discipline; management of processes of processing and transformation of paper documents into electronic form; archival storage and exchange of paper and electronic documents; formation of regulatory reporting and support of processes of making managerial decisions; protecting information from unauthorized access, etc.
Dilo	Electronic office systems, www.eos.ru	A comprehensive solution that implements mixed, paper-electronic document flow and automates all aspects of documentary provision of management activities of enterprises and organizations. Easily deployed to the existing IT infrastructure of the organization. Has a simple and intuitive interface.
Euphrates-document circulation	Cognitive Technologies, www.cognitive.ru	A universal system for organizing storage, accounting and maintenance of any type of electronic and paper documents, designed for work in a small department, and in general in an organization with a complex scheme of information flows. Provides the entire lifecycle of electronic documents within key business processes of the organization: introduction and registration of documents; work with electronic documents; control of execution, movement, distribution and storage of documents; preparation of reports, etc.

In order to obtain information about the possibilities of the systems selected for comparison, we will compile a table with the functions which are characteristic of it (Table 2), using the following factors: the opportunity is realized; incomplete realization of the opportunity (improvement is possible due to the use of third-party or additional software, defined in the notes); the opportunity is not realized. The next step, which will somehow affect the choice of a rational EDS, will analyze the relevance of the selected functional for comparing systems to the technical requirements (TB) to them. To do this, considering that the EDS is a software that supports multistage document processing under the scheme "input - check - execution - generation (and possibly print) the report," TV will split into groups, firstly, the so - called business - requirements and, secondly, software requirements. Under business requirements, in this case, we will understand: requirements for the identification of users (authorization, authentication and delineation of user access rights to documents); Requirements for document repositories (data warehouse performance, database resilience, document search and archiving, replication of data, etc.); requirements for the so-called business logic (document flow paths, tasks for users, work with user scripts), etc.

In solving this problem, it is advisable to pay attention to the so-called "pitfalls" that may arise during the introduction and subsequent industrial exploitation of the selected EED and which:

- can be related, for example, with the lack of standard or additional tools necessary to set up the system for the needs of the institution on its own;
- can lead to the recognition of the system unreliable, dangerous or generally unproductive;
- can significantly affect the total cost of the system.

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Table 2.

Functions of electronic document management systems

System / Function	Boss-referent	Dilo	Euphrates-document circulation	Directum	DocsVision	LanDocs	Optima-Workflow
АВТОМАТИЗАЦІЯ РОБОТИ КАНЦЕЛЯРІЇ							
Create documents	1	1	1	1	1	1	1
Maintaining a registration card	1	1	1	1	1	1	1
Conducting the nomenclature of cases	1	1	1	1	1	1	1
Scanning documents	0,5[1,2]	0,5[1,5]	1	0,5	0,5	1	0,5[1]
Compatibility with software that provides recognition of document images	0,5[1,2]	0,5[1,5]	0,5	0,5	0,5[1]	0,5[1]	0,5[1]
Registration of documents from e-mail	1	1	1	1	1	1	1
Registration based on an existing document	0	0,5	1	0	0	0	0
Supporting paper and electronic documents	1	1	1	1	0,5	1	0,5
Control over filling required fields	1	1	1	1	1	1	1
Check for duplication at registration	0	1	1	0	0	0	0
Using directories	1	1	1	1	1	1	1
Adding new directories	1	0,5	1	1	1	1	1
Support for hierarchical directories	1	1	1	1	1	1	1
Processing documents with cross references	1	1	1	1	1	1	1
Presence of templates of created documents	1	1	1	1	1	1	1
Maintaining the history of working with documents	1	1	1	1	1	1	1
The presence of replication means	1	0	0	1	0	0	1
GPA	**0,74**	**0,74**	**0,82**	**0,74**	**0,66**	**0,71**	**0,71**
AUTOMATION OF ROUTE PROCESSES AND CONTROL OF EXECUTION							
Support for sequential and parallel routing of documents and tasks	1	1	1	1	1	1	1
Work with typical routes	1	1	1	1	1	1	1
Work with free routes	1	0,5	1	1	1	1	1
Ability to change routes	1	0,5	1	1	1	1	1
Auto-lock document for editing	0,5	1	1	1	1	0	1
Notification of employees about the receipt of documents and tasks at their addresses	1	1	1	1	1	1	1
Automation of the process of acceptance / refusal of orders for execution	0	1	0,5	0	1	0	0
Control over examination of documents	1	1	1	1	1	1	1
Control over the execution of documents	1	1	1	1	1	0	1
GPA	**0,83**	**0,88**	**0,94**	**0,88**	**1,00**	**0,66**	**0,88**
AUTOMATIZATION OF ANALYST AND MANAGEMENT ACTIONS							
Search by attributes	1	1	1	1	1	1	1

Logical search	1	0,5	1	1	1	0	1
Full-text search	1	1	1	1	1	0,5	1
Support for the morphology of the Russian language	0	1	1	1	0,5	1	0,5
Availability of hierarchical search templates	1	1	0,5	1	0,5	0,5	0,5
Operational modification of search templates	1	1	1	1	1	1	1
Availability in the system of the report generator	0,5[3]	0,5	1	1	0,5	1	0,5[4]
Obtaining certificates of executive discipline	1	1	1	1	1	1	1
GPA	**0,81**	**0,88**	**0,94**	**1,00**	**0,81**	**0,75**	**0,81**
AUTOMATIZATION OF THE ARCHIVAL PROCEDURE							
Write-off to archive	1	1	1	1	1	1	1
Maintaining archives of electronic documents	0,5	0,5[6]	0,5[7]	0,5	0,5	0,5[8]	0,5
Search by archive	1	1	1	1	1	1	1
Maintenance of archival repositories of electronic documents of documents	1	1	0,5	0,5	1	1	1
Maintaining a separate archival base of documents	0	1	1	0,5	0,5	0,5	0,5
Providing accounting and traffic control and timing for keeping files and documents in the archive	0	1	1	0,5	0	0	0
Ensuring optimization of data storage	1	1	0,5	1	1	1	1
GPA	**0,64**	**0,93**	**0,79**	**0,71**	**0,71**	**0,71**	**0,71**
IN GENERAL	**3,02**	**3,43**	**3,49**	**3,33**	**3,18**	**2,83**	**3,11**

Note:

1 - with the use of external OCR

2 - integration with CuneForm

3 - by using *Report'sMen*

4 - by using *Crystal Reports*

5 - optional "streaming scan"

6 - Optional subsystem "Archive Case"

7 - Optional module "Archivarius"

8 - optionally LanDocs system: Archive

Another, not less important step in choosing a rational EDS in the aggregate of alternatives existing on the world market is to determine their cost component in which, besides the actual cost of licensed software, should be laid down (Table 3), firstly, the cost of measures from a permanent operational- technical support of the system (introduction, training of personnel, updating and ordered deliveries); and secondly, the cost of additional system modules and third-party software, such as the DBMS used, etc.

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Table 3.

The cost of the used DBMS and the EDS as a whole

Name of the SED	Cost, $							Competitiveness of licenses		DBMS
	Licenses for simultaneous work of 50 users	Introduction, $/год	Teaching, $/год	Technical support for 1 year, $ (від)	System updates, $	Ordered work, $/год.	Total, $		Version	Cost, $
Boss-referent	42 000,00[1]	0,00	0,00	8 400,00	0,00	0,00	50 400,00	ні	Lotus Notes / Domino	Від 3964
Dilo	10 245,16	37,06	26,48	2 049,03	0,00	50,00	12 407,73	ні	MS SQL Server	Від 900[3]
Euphrates-document circulation	27 400,00	0,00	15,00	5 480,00	0,00	0,00	32 895,00	так	MS SQL Server[4], Oracle[4]	0[5]
Directum	38 885,00	20,00	12,00	7 771,00	0,00	20,00	46 678,00	так	MS SQL Server,	Від 900[2]
Docs Vision	9 200,00	30,00	20,00	1 800,00	2 800,00	40,00	13 890,00	так	MS SQL Server	Від 900[2]
LanDocs	33 735,00[6]	50,00	0,00	6 675,00	0,00	40,00	40 500,00	так	MS SQL Server, Oracle	Від 900[2]
Optima-Workflow	18 200,00	0,00	15,00	2 400,00	5 460,00	30,00	26 105,00	так	MS SQL Server, Oracle, IBM DB2, DataBase	Від 900[2]

Note:

1 - without discount

2 - *SQL Server Standart Edition 2005 Win32 English OLP NL*

3 - under *MS SQL Server*

4 - design solution

5 - Built-in database "NIKA". As part of the project decision

6 - LanDocs: Workflow + LanDocs: Document Server + can be implemented by Oracle Database or Microsoft SQL Server + LanDocs: Routing

Taking into account the outcomes of the final evaluation of the EER functionality that were to be investigated, is defined as the average of all the above-mentioned components (Table 4).

Table 4.

Final evaluation of functionality

System		Boss-referent	DILO	Euphrates-document circulation	Directum	DocsVision	LanDocs	Optima-Workflow
Average rating point	functionality of the document circulation system	3,02	3,43	3,49	3,33	3,18	2,83	3,11
	quality standard tools for setting up a document management system	0,88	0,25	1,00	0,50	0,88	0,88	0,75
	quality additional tools for customizing the document flow system	1,00	0,60	0,92	0,75	0,83	0,67	1,00
	reliability, security and productivity of the document management system	0,81	0,88	0,94	0,94	0,94	0,94	1,00
In general		5,71	5,16	6,35	5,52	5,83	5,32	5,86
Interest, %		81,6	73,7	90,7	78,9	83,8	76,0	83,7

The closer the result of the evaluation of each of the systems will be close to 100%, the more balanced it will be considered functional, and the more likely this system can be attributed to the so-called "rational" EDS in this approach to comparison (Figure 2).

Based on the results of the example given in the article (Table 2, 3 and 4, Figure 3), it can be argued that practically all systems that were selected for comparison:

have almost identical functionality. At the same time, the typical tasks of electronic document circulation among them are still carried out by the system DILO, Euphrates-document circulation, DocsVision and Optima-Workflow;

can be adapted to meet the needs of their institutions by means of availability without the participation of the developer or his partners and without incurring additional costs. At the same time, the owners of the

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Euphrates-Document Management systems and DocsVision will handle this task best;

have more or less full complementary functionality due to flexible user interface configurations. In this case, the best positions in this aspect are the Boss-Referent and Optima-Workflow systems. By other parameters, the positions taken are Directum, DocsVision and Euphrates documents;

provide the necessary level of reliability and security of electronic document circulation in the institution. At the same time, Directum, DocsVision, LanDocs, Optima-Workflow and Eutrophication are the best suited for these tasks. The BOS-Referral system, implemented on the Lotus Notes / Domino platform, offers, in contrast, the most advanced administration tools for distributed work due to the specific capabilities of the platform mentioned above;

are in different price categories. With the total cost of server and user licenses, as well as the cost of the DBMS used, the Dilo and DocsVision systems are the most acceptable ones for the results obtained.

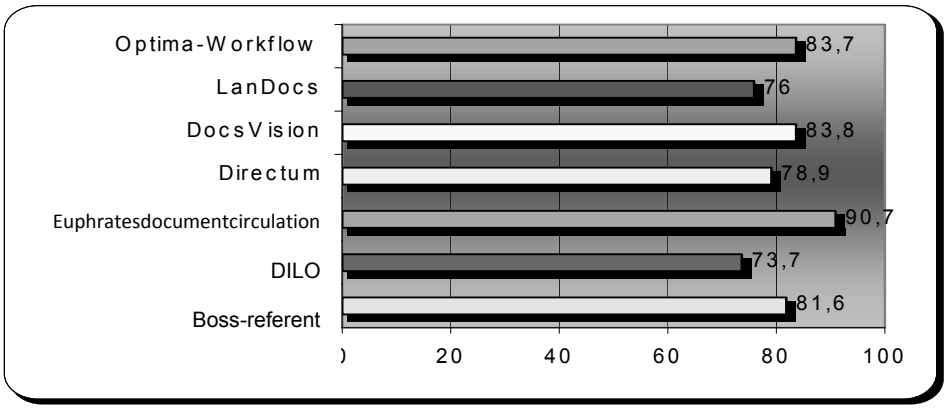

Fig. 2. EDS comparison results

These conclusions provide the opportunity, in turn, to combine the selected systems to be compared in a group of highly functional EDS, to which experts include Euphrates-Documentation, Directum, DocsVision and Optima-Workflow, as well as SEDs of average functionality, to which experts refer to DILO systems , Boss-Referent and LanDocs. The most developed functionality among them, as evidenced by the results of the research, has been shown by the Euphrates-Documentation System of the Cognitive Technologies company. Unlike other systems, it consistently gained a large number of points in each of the areas of work with documents. The leading positions of the Euphrates-Documentation system

are also confirmed by an assessment of the number of its implementation (Fig. 3). Thus, according to experts from the international expert company GartnerGroup [2], today it occupies about 34% of the world market for the implementation of these systems. This is explained by: the flexible pricing policy of the company-developer; the universality of this EDS - the presence in it of its own NIKA database, built-in scanning and text recognition tools, a simple and intuitive interface; the ability to configure and modify the system when implementing it as a developer and / or its partners, and directly by customers. These facts, as a result, in turn, increase the possibilities of this EDS in terms of maintenance and scalability, as well as the ease of its integration into the corporate IT infrastructure of any institution in Ukraine.

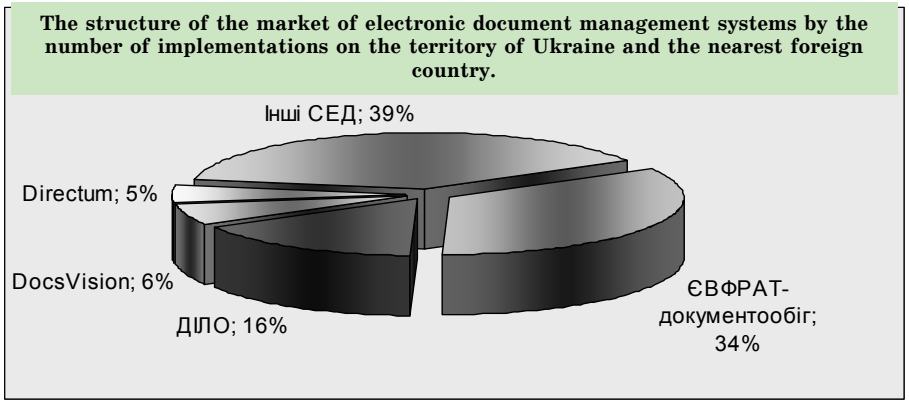

Fig. 3. Percentage of implementation of electronic document management systems

In addition, other high-and mid-range EDSs, including DILO, Directum and DocsVision, are also significant in the market. For example, today, according to the available estimates, the DIAL system occupies about 16% of the world market of implementation. It is most popular in public institutions. This is primarily due to the orientation of this system to automate the procedures of traditional office work. The exception is the Optima-Workflow system, which developers did not initially consider it as a mass solution for small and medium-sized businesses.

After the choice of the state / commercial structure of the rational EHS, the question arises as to the definition of such a set of requirements, rules, restrictions, recommendations, etc., which would contribute to the regulation of the order of information processing in the organization and were aimed at protecting information from threats primarily anthropogenic - that is, the formation information security policy (Fig.

4). When designing a security policy, information processing technology, offender patterns and threats, operating system features, physical environment, and other factors must be taken into account. As part of a common security policy, there may be policies to ensure the confidentiality, integrity, availability of processed information, etc. Security policy should relate to: information (level of criticality of resources of the EER); interaction of objects (rules, responsibility for the protection of information, guarantees of protection); areas of application (which components of the LOM security policy apply, and which ones are not).

Security policy should be designed in such a way that it does not require frequent modifications (the need for frequent changes indicates excessive specification, for example, it is not always appropriate to specify a specific name or version of a software product). The security policy should include the use of all possible measures for the protection of information: legal and moral and ethical norms, organizational (administrative) measures, physical, technical (hardware and software) measures, and determine the rules and procedures for the use of each of these types in the LOM.

Security policy should be based on the following basic principles of system integrity, integrity, continuity of protection, adequacy of mechanisms and measures of protection and their adequacy to threats, flexibility of management of the system of protection, simplicity and convenience of its use, openness of algorithms and mechanisms of protection, unless otherwise provided separately. Security policy should provide guarantees that the SED provides:

1) the adequacy of the level of information security to its critical level;

2) profitability of measures to protect information;

3) assessment and verification of information security;

4) personalization of the provisions of the security policy (regarding the subjects of the EER), reporting (registration, audit) for all critical resources from the point of view of safety;

5) visibility about the procedure for providing information security;

6) continuous work and its restoration in case of unforeseen situations, etc.

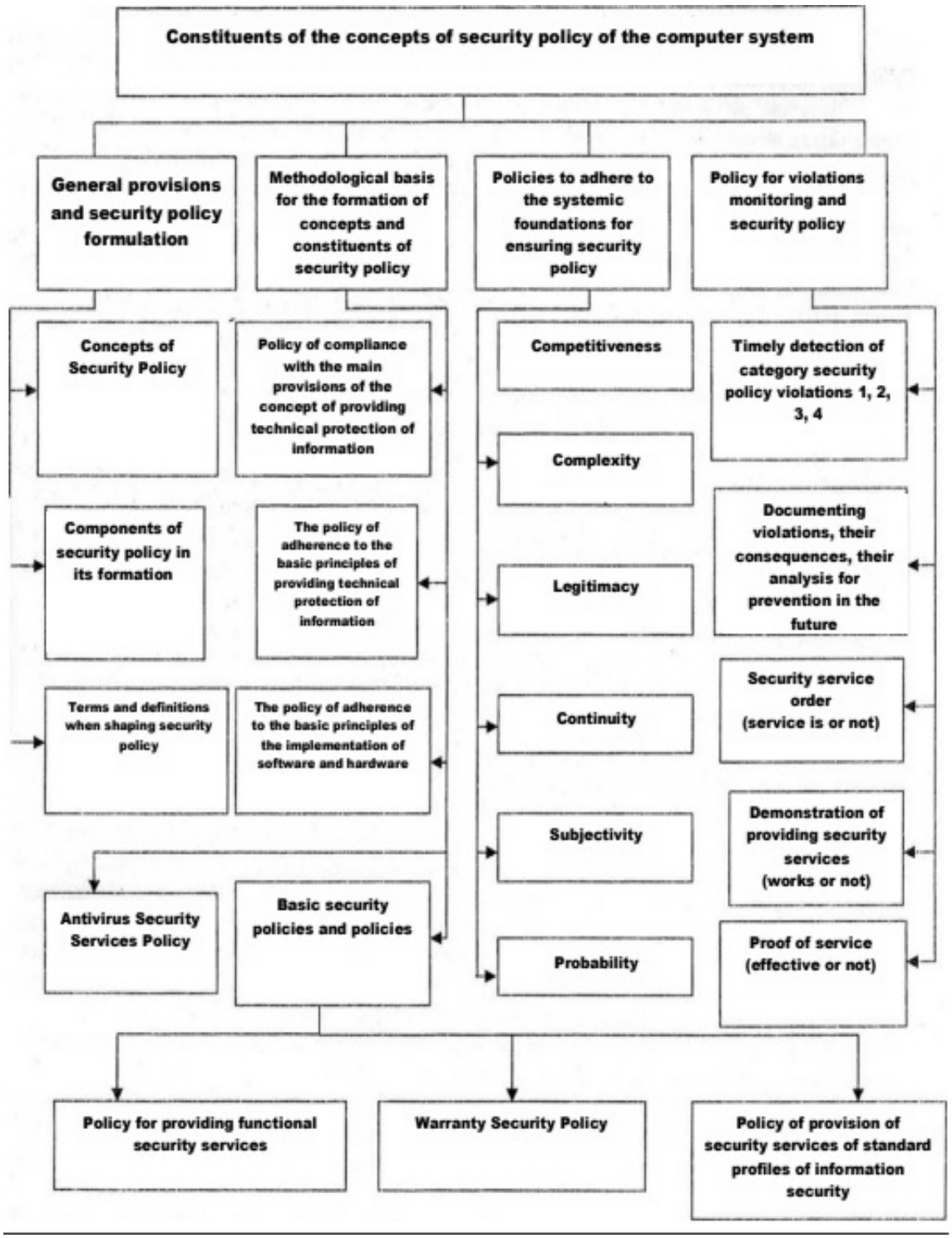

Fig.4. Basic EMS Security Policy Model

Security policy is being developed at the preparatory stage (SD TZI 3.7-001-99) for the creation of a CSCI. This should take into account the requirements of all documents that regulate the protection of information in the LAN and ensure their strict observance. The methodology for developing a security policy should include the following: development of the concept of information security in the LOM (outlining the system of

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views, the main principles, revealing the main areas of information security); risk analysis (allows us to formulate general security provisions related to the technology of information processing in the EDS); definition of requirements for measures, methods and means of protection; selection of basic decisions on security of information; the organization of the renovation work and ensuring the continuous functioning of the EHEA; documenting security policy.

Conclusions and perspectives for further research

Recently traditional paper workflow is giving way to a more modern electronic device. Which not only significantly reduces the time to work with documents, but also helps to optimize management processes in the organization (institution).

The Ukrainian SET market, represented by software solutions from both domestic and Russian and several transnational suppliers, remains, unfortunately, still as informally closed and little-learned as before. This is explained by the fact that: until now, the segmentation of the Ukrainian EER market has not been carried out; volumes and capacity of the market are determined fairly roughly, mainly on the basis of assessments of market participants themselves; the systematization of both the actual systems and the companies working in this area in general is absent. However, the positive factor in the development of ERA in Ukraine is the existence of a fairly clear regulatory framework in the area of electronic document management and electronic digital signature (EDS), as well as guidance documents that require and regulate the implementation of EHS in government institutions. Negative - the lack of state technical specifications regulating, for example, the formats of secure exchange of such documents, etc.

The decision to solve the problem of choosing among the selected systems a rational variant of the EDS and avoiding a number of hidden problems should contribute to the use of the analytical material provided in the article. According to his results, it is also possible to conclude that the complex automation of processes of information activity of state and commercial structures of Ukraine will provide a combination of methods and tools of office automation, database management systems (input, storage and search of structured information), workflow systems (management, routing and coordination of travel documents, control over the timeliness of their processing) and electronic document management

systems (input, storage and retrieval), as well as integration of software productive that implement these techniques.

The main prerequisite for a positive solution to this problem is, according to the authors' opinion, a substantiated choice of the base platform, on the basis of which certain solutions will be implemented for integrated automation of information activities, as well as a system integrator - that is, a company that will provide the full range of necessary services and offer the client a comprehensive solution that will satisfy as much as possible. all its needs. The most qualified representatives in the field of development and introduction of advanced IT technologies that operate in the Ukrainian market and can act as a system integrator for the implementation of a comprehensive program for automating the processes of information activities of state and commercial structures of Ukraine, in our opinion, are Incom, Quasar-Micro, Soft -Laine and a number of others. At the same time, for the base platform, the client can be selected software applications from corporations IBM, OpenText and EMC (Enterprise Content Management), which according to reports of the International expert company GartnerGroup [2] are among the three leaders of the world market ECM systems or companies Oracle and Microsoft, which steadily hold the line following the leaders.

The main objective of the implementation of the EDS protection system is to create an advanced system for managing flow of work, control over executive discipline, in particular mechanisms for performing technological processes for processing documents and organizing control over these processes. The key requirement put forward to modern EDS is to provide legitimate users with access to legally significant electronic documents and their processing facilities. The models of threats and the infringer of the protected EDS should determine the necessary levels of functioning of the subsystem of information security, namely the level of organizational and technical measures, the level of current control and the level of elimination of the consequences of realized threats.

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УДК 004:94

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THE USE OF ONTOLOGIES FOR SOLVING INFORMATION SECURITY TASKS

Annotation. *The basic information security issues and solutions through the use of ontologies and ontology systems are described.*

Keywords: *ontology, ontology systems, informational security, consolidated information.*

Introduction

Today, information regarded as one of the main resources of the social development, and information systems and technologies as a means of increasing productivity and efficiency of people's work. Therefore, information is the most valuable and expensive resource. The problem of information security from the moment of its appearance and to the present state has been a long and largely contradictory path in its development.

Presentation of the main material

Since the process of providing information security is a continuous process, the existing methodology for designing a secure system is an iterative process eliminating the drawbacks found.

In 1996, the classical work of Grusho A.A. and Timonin E.E. "Theoretical fundamentals of information security "expressed and substantiated the thesis that the guaranteed security in the automated system should be understood as a guaranteed performance of a priori specified security policy [1].

Previously, security policy guarantee conditions were formulated in the form of standards. This is the approach used by American computer security experts, having published since 1983 several books of the so-called "rainbow series" standard. In Ukraine, similar documents were adopted by the State Technical Commission [4].

The main problems of information security in computer systems arise because information is not rigidly associated with the carrier. The main factors that make it difficult to solve the problem of information security in PC are as follows:

mass application;

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constantly increasing complexity of functioning;

variety of software for personal computers, architectural solutions and easy adaptation to solve various tasks of users [2].

We can highlight the main types of information security issues:

interception of information (violation of the confidentiality of certain information);

modification of information (editing of the original text of the message and / or its replacement with other information);

substitution of authorship (copyright infringement).

At present, the issue of ensuring the security of consolidated information resources is becoming more and more urgent.

The term "consolidated information" covers various sources of information obtained from several sources and integrated in a consistent manner, that are collectively endowed with signs of completeness, integrity, and consistency, and constitute an adequate information model of the problem area in order to analyze, elaborate and effectively use it in decision making support processes. Therefore, the concept of "competitive intelligence", which is used on parity by some researchers, is still one aspect of holistic processes and information consolidation procedures, namely as a process of formation of an information resource for decision making support [5].

At the same time, consolidated information, with the use of all possibilities, actively operating information resources, is called to develop the technological basis for the creation of an information product, to carry out a qualitative and content-related transformation of information, functionally intersecting in this context with the scientific (production of new knowledge) and management (development of solutions, scenarios) activities.

The protection of consolidated information can be provided in various ways, which include modeling the necessary components of information security, namely:

determining of information resources to be protected;

monitoring of a complete set of potentially possible threats and channels of information leakage;

analysis of vulnerability and risks related to the collection of information and leakage channels;

determining of the requirements for protection system;

selection of means of information security and their implementation;

control of protection system [6].

Thus, consolidated information technologies require information security within a particular institution or organization.

Also, at present, there is a fairly active use of ontological models in various aspects of information security.

Ontology is the presentation in a certain language of knowledge about a certain subject area (environment, world). Ontology is necessarily accompanied by some concept of this area of interest. Often this concept is expressed by identifying the basic objects (individuals, attributes, and processes) and the relationships between them. The determination of these objects and the relationships between them is usually called conceptualization.

The following definition of ontology is generalizing: Ontology is a generally accepted and generally accessible conceptualization of a certain area of knowledge (world, environment) that contains a basis for modeling this area of knowledge and defines protocols for interaction between agents that use knowledge in this area and finally includes agreements on the presentation of the theoretical fundamentals of this area of knowledge [7].

The use of ontological models allows the application of a unified knowledge base that holds the conceptual access control system for information resources, as well as the formal semantics of a modeled system. In this case, due to the combination of such a model with the ontological model of the subject area, it will be possible to determine the rules of access in terms of the domain, taking into account their semantics, and also to make decisions on granting or refusing access on the basis of the results of logical conclusion, which cannot be done using databases.

In general, it is possible to distinguish the following areas of research in this area:

formalization of the subsets of XACML language and use of the logical output to validate the security policies formulated by administrator [8];

use of logical output in existing access control models, such as RBAC (Role Based Access Control) and ABAC (Attributes Based Access Control) [9];

creation of an ontology that defines the conceptual system of the subject area of information security General Privacy Ontology[10], Security Ontology [11], NRL Security Ontology [12].

Conclusion

In the course of the conducted analysis, a generalized description of current problems in the field of information security was made, as well as a classification of types of security threats. It was revealed that one of the most important mechanisms of modern means of providing comprehensive information security is the system of control and differentiation of access to resources, for the implementation of which it is expedient to use ontological models and methods of ontological engineering, which will allow determining access rights based on the logical conclusion.

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M.A. Doronina

ASSESSMENT OF DISTRIBUTED DELAY TIME OF INPUT SIGNAL BY STATIONARY OBJECTS

Annotation. *The article proposes a new method for estimating the distributed delay time of a signal by a stationary linear object whose transfer function is normalized and does not contain zeros. It is shown that the required time is determined by the coordinate of the intersection graph of forced component of the reaction of the object on a linearly increasing input signal from the x-axis. Analytical studies are confirmed by the results of mathematical modeling of the work of the proposed algorithm on a computer.*

Key words: *density function of random values, time constant, distributed time of signal delay by the object.*

Articulation of issue

Every dynamic object is inertial in its substance. This feature belongs to it because any transfer of energetic or material resources can`t immediately be carried out. Time delay of signal transfer from input to output of the object may be transportation (pure) or distributed (capacitive) (in the econometrics it is known as «distributed lag») [1-4].

If transport delay of signal for time τ in continuous object is described by unit with transfer function $\exp(-s\tau)$, where s - Laplace operator, distributed delay is a result of the influence on input signal of transfer function without pure delay element.

Review of recent investigations and publications

The following algorithm of time assessment of distributed delay is given in the study [3]:

a) transfer function $W(s) = \int_0^\infty \exp(-st)k(t)dt$ by representationof $\exp(-s\tau)$ in the form of range $1 - s + s^2/2! - s^3/3! + \ldots$ is written down as follows

$$W(s) = H_0 - H_1 s + H_2 s^2/2! - H_3 s^3/3! + \ldots$$

Where $H_i = \int_0^\infty t^i k(t)dt$ - moment i – in the order of impulsive transition function $k(t)$;

b) time of distributed delay is determined with using a formula

$$T = H_1 / H_0 . \quad (1)$$

The last expression shows that it is necessary to find an impulsive transition function and calculate its momentsfor determine of distributed time of signal delay. It is a very complex procedure.

Therefore an actual task is finding of simple and descriptive algorithm of temporal value assessment of distributed delay, which linear continuous object makes.

Objective of the study

The objective of the study is a development and analysis of time assessment signal delay algorithm in the continuous object without using of impulsive transition function and its moments.

Presentation of basic material of the research

Transfer function written above $W(s)$ can be presented in the form:

$$W(s) = (W(s) / W(0)) \cdot W(0) . \quad (2)$$

In the expression (2) a multiplier $W(0) = H_0$ is an amplification coefficient. It doesn`t have inertial properties and doesn`t delay a signal, which passes through it.

According to normalized transfer function $W(s)/W(0)$, it has an amplification coefficient, equal to one. In other words

$$\int_{-\infty}^{+\infty} k(t)dt = 1 . \quad (3)$$

If $k(t)$ corresponds also to condition

$$k(t) \geq 0 , \quad (4)$$

it can be considered as probability density function of distributed delay time T. Using impulsive transition function with such properties, we can calculate distributed delay time

$$T = \int_{-\infty}^{+\infty} tk(t)dt . \quad (5)$$

If transfer function of aperiodic unit takes the form

$$W(s) = \frac{1}{Ts + 1} ,$$

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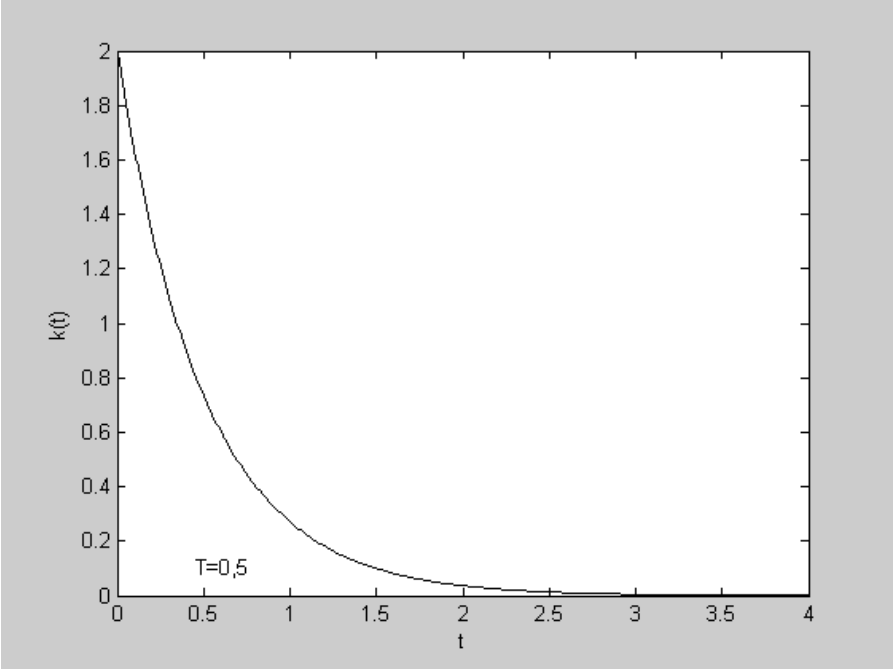
its impulsive transition function is described by the expression

$$k(t) = \begin{cases} 0 & npu\ t < 0 \\ \dfrac{1}{T} e^{-\frac{t}{T}} & npu\ t \geq 0 \end{cases}.$$

Due to the fact, that $k(t)$ meet conditions (3) and (4), in this case the distributed delay time T coincides with the constant time of the aperiodic object. (Pic. 1).



Pic. 1. Impulsive transition function of aperiodic unit under *T=0,5*

Now send a signal to the input of this aperiodic unit $u(t) = t$ and \we`ll find its reaction force through Duhamel integral (Pic. 2):

$$y(t) = \int_0^t u(\vartheta)k(t-\vartheta)d\vartheta = t - T + Te^{-\frac{t}{T}}. \qquad (6)$$

During analyzing the expression (6) of output signal $y(t)$ we can see, that its forced component $t - T$ falls behind time from input signal $u(t)$ also on T value.

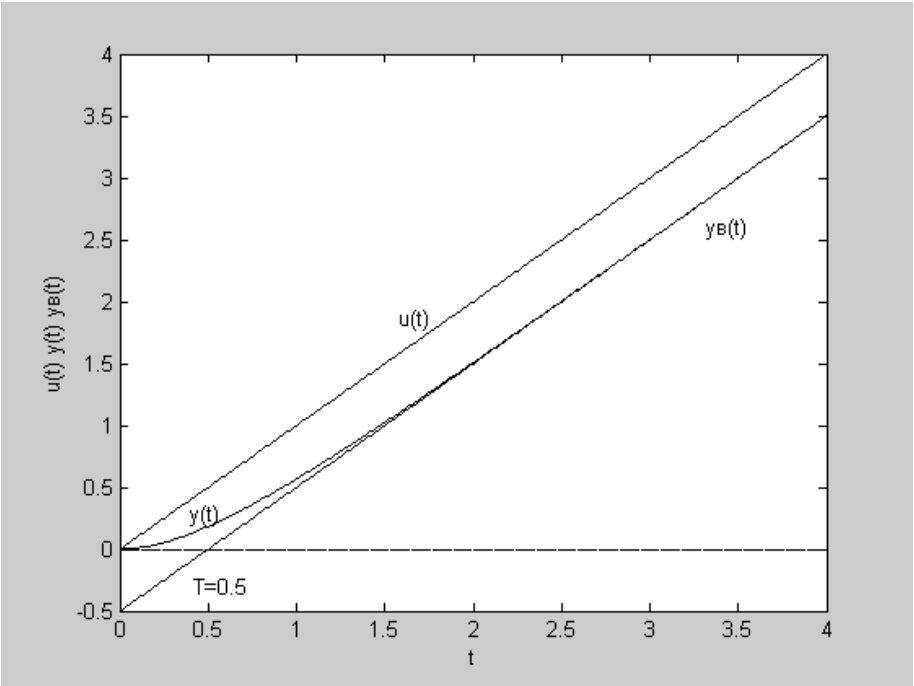
In case, when the object has a transfer function

$$W(s) = \frac{1}{T_1 T_2 s^2 + (T_1 + T_2)s + 1},$$

its impulsive transition function

$$k(t) = \frac{1}{T_1 - T_2}(e^{-\frac{t}{T_1}} - e^{-\frac{t}{T_2}})$$

meets conditions (3) and (4).



Pic. 2. Aperiodic unit reaction under *T=0,5* on the linearly increasing input signal

While sending a linearly increasing signal to the input of this object $u(t) = t$ an output signal will be the following

$$y(t) = t - (T_1 + T_2) + (T_1^2 e^{-\frac{t}{T_1}} - T_2^2 e^{-\frac{t}{T_2}}) \frac{1}{T_1 - T_2}.$$

Its forced component $t - (T_1 + T_2)$ is behind from the input signal $u(t) = t$ on value $T_1 + T_2$, which corresponds with value T for $k(t)$ (Pic. 3 and 4):

Using mathematical induction method we can prove, that aperiodic units n with transfer functions, turning on consequently

$$W_i(s) = \frac{1}{T_i s + 1}$$

$(i = \overline{1, n})$, realize a distributed delay, which value is

$$T = T_1 + T_2 + \ldots + T_n.$$

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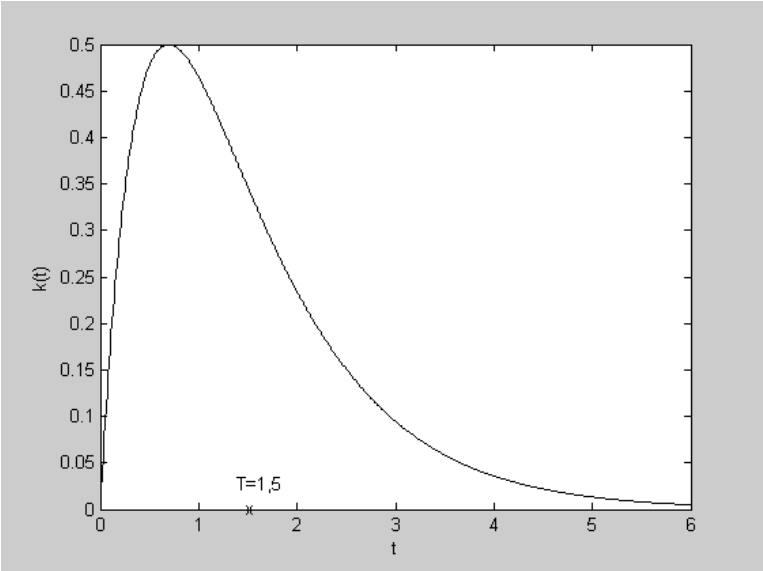
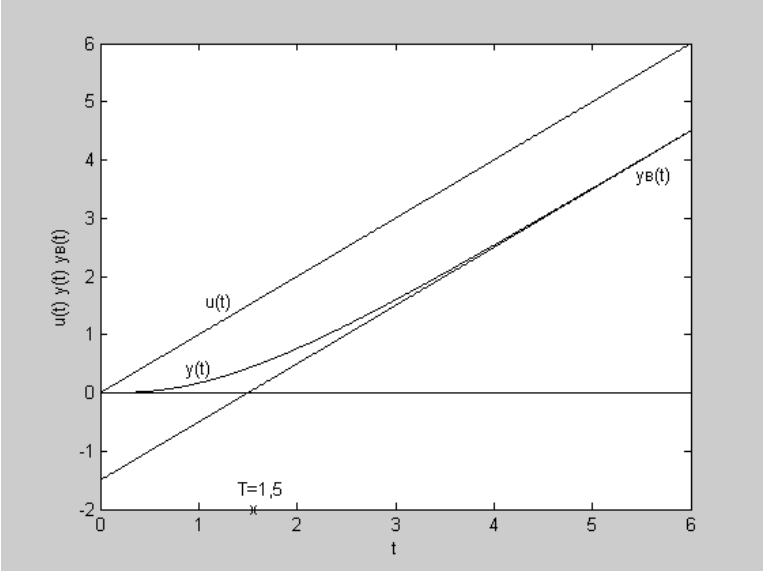


Pic. 3. Impulsive transition function of two connected in sequence aperiodic units



Pic. 4. Reaction of two connected in sequence aperiodic units on the linearly increasing input signal

Now we consider a distributed delay, which is made by oscillatory link with transfer function (a condition is not meet here (4))

$$W(s) = \frac{a^2 + b^2}{s^2 + 2as + (a^2 + b^2)}. \qquad (7)$$

The last we can write in such matter:

$$W(s) = \frac{1}{(\frac{1}{a + jb}s + 1)(\frac{1}{a - jb}s + 1)}.$$

Taking into attention complex values

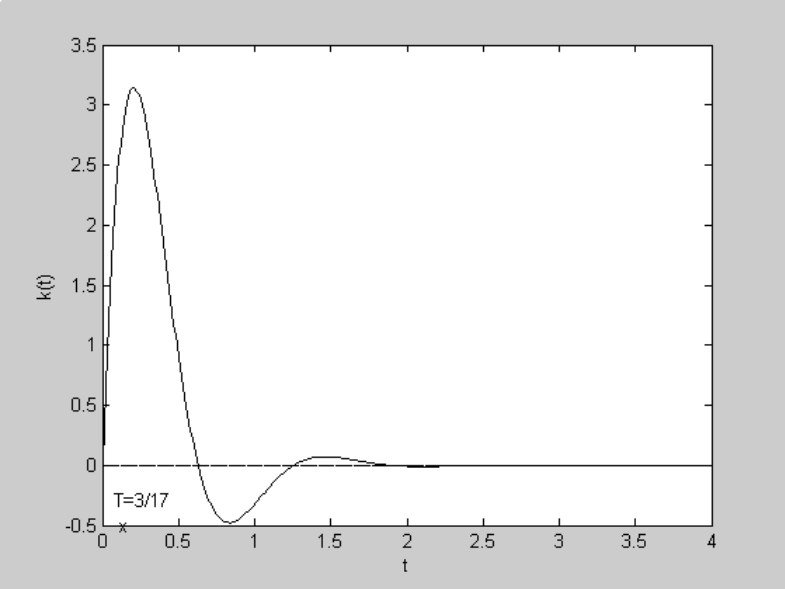
$$\frac{1}{a+jb} \text{ and } \frac{1}{a-jb}.$$

as «time constants», we`ll find their amount.

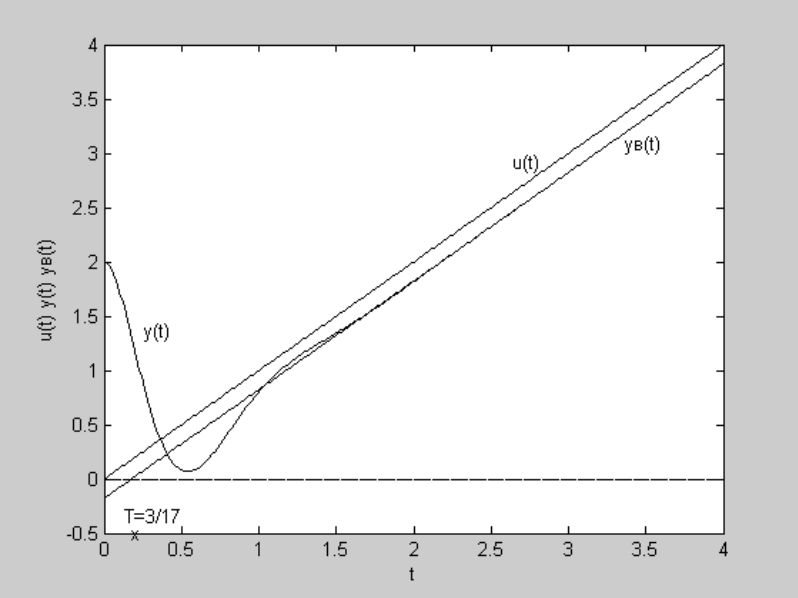
It will be equal to value

$$\frac{2a}{a^2+b^2}.$$

It will be just the time of distributed delay, which is made by oscillatory link for linearly increasing input signal.



Pic. 5. Impulsive transitiona function of the oscillatory link



Pic. 6. Reaction of the oscillatory link on the linearly increasing input signal

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On pic. 5 and 6 it is shown results of finding a input signal distributed delay value by oscillatory link with parameters $a = 3$, $b = 5$ through first (H1) and zero (H0) moments and using the input signal $u(t) = t$.

Conclusions

When performing this study the effective methodology of determination of the distributed time of signal delay has been developed by continuous stationary object with transfer function without zeros.

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REVERSE ENGINEERING OF THE GENE REGULATORY NETWORK WITH COMBINED USE OF THE CLONAL SELECTION ALGORITHM AND DIFFERENTIAL EVOLUTION

Abstract. *The development of methods for reverse engineering of gene regulatory networks is one of the important tasks in the post-genomic era. The algorithm of clonal selection is one of the popular approaches for the reconstruction of gene networks based on microchip data.*

Keywords: *Reverse engineering system reconstruction, population, gene regulatory networks, clonal selection algorithm, differential evolution algorithm, DNA microarrays.*

I. Introduction

Reverse engineering or system reconstruction is the process of deriving the structural and dynamic system characteristics under study on the observations basis of its behavior and certain knowledge in the relevant subject area.

Today, reconstruction plays an important role in biology as one of the main tools for modeling biological systems and their interactions, which is key to understanding the mechanisms of their functioning [1]. One of the most widely used applications of the methodology of reconstruction in biology is the identification of gene regulatory networks (GRN) [2]. Detection of the presence and nature of interactions between GRN genes is essential for the creation of new drugs. Reconstruction helps researchers find answers to a number of questions, among which we can distinguish the following: what processes in the body regulate the gene being studied; which genes affect the test gene; how genes interact; what genes are responsible for a particular type of disease; which drugs will have an effect in case of a disease, etc. The technology of DNA microarrays [3] facilitates the study of the behavior of GRN greatly, but the task of reconstruction remains difficult, since it contains a large number of unknowns.

A number of mathematical models are used to describe the structure and dynamics of GRS, among which the most widespread are Boolean

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networks [4], linear models [5], differential equations [6], associative networks [7], Bayesian networks [8], neural networks [9, 10], the model of the state space [11]. In this paper, the classical system of ordinary differential equations (ODE) in the form of an S-system was chosen as the GRN model, for the identification of which a hybrid algorithm for clonal selection and differential evolution was proposed.

II. Formulation of the problem

For a regulatory network consisting of N genes, the S-system is represented by the ODE system of the following kind [7]:

$$\frac{dx_i}{dt} = \alpha_i \prod_{j=1}^{N} x_j^{g_{ij}} - \beta_i \prod_{j=1}^{N} x_j^{h_{ij}}, i = 1 \dots N, \quad (1)$$

where $x_i(t)$ – expression's level of i-th gene at the time point t; α_i, β_i – non-negative numbers, called rate constants; g_{ij}, h_{ij} – kinetic orders that determine the direction and level of regulatory impact, that is, stimulation or inhibition.

Reconstruction of the regulatory network involves not only choosing a mathematical model, but also developing a method for identifying it. Identification of the S-system consists in finding optimal values of parameters from the set $v = \{\alpha, \beta, g, h\}$. The complexity of the task's solution is due to its high dimensionality. The number of parameters to be found is determined by the expression $2N(N + 1)$. That is, for GRN consisting of only four genes, the search space dimension is 40. For this reason, the task of reconstructing the S-system can't be solved analytically. It is known that population methods such as genetic algorithms or artificial immune systems have proved to be successful in solving such problems. But at large dimensions, the convergence rate of population methods can be very low. Thus, the aim of this study is to develop a new, fast and accurate method for optimizing the S-system's parameters, taking advantage of the population approach and hybridization technology.

III. The algorithm of clonal selection

In the research [15] immune system is considered from the view point of the mechanism of clonal selection. On the basis of clonal selection principle, an optimization algorithm CLONALG was proposed in [16], which is widely used at present as one of the varieties of IIS. In clonal algorithm, the affinity values express the proximity measure of the

individual to the optimal solution and are calculated on the basis of the objective task's function. Step-by-step algorithm description is presented below.

Step 1. $Population = 0$.

Step 2. Create an initial population of solutions randomly (Ab^0).

Step 3. Estimate populations Ab^0 based on the objective function f.

Cycle until the condition of shutdown $e = false$.

Step 4. Save the best solution in the current generation.

Step 5. Select antibodies from Ab^0 with the greatest affinity.

Step 6. Create clones Ab^c of selected antibodies in an amount $n \sim f$.

Step 7. To make a mutation of clones with intensity $p_m! \sim f$.

Step 8. Estimate populations Ab^c based on the objective function f.

Step 9. Select clones with the greatest affinity from Ab^c and transfer them to Ab^0.

Step 10. Replace the d worst antibody in Ab^0 new antibodies generated randomly.

Step 11. Estimate new antibodies in Ab^0.

Step 12. $Population = Population + 1$.

Cycle until end

Step 13. Conclusion: the best solution in the current generation.

In CLONALG you can use different ways of presenting solutions, depending on the type of task. The binary and real representations are most often used. Also, the conditions and objectives of the problem are decisive when choosing a method for representing immune operators, the affinity function form , and algorithm parameters values.

When calculating the main population affinity, conditions are created for the selection of cells, that are complete (at this stage) enter into interaction with the antigen maximally, that is, they form the minimum of the objective function. During the activation process, the selected antibodies increase their representation in the solution space due to cloning. Cells, whose affinity is higher, create more clones, but this cells are less susceptible to mutation. The mutation in CLONALG is of high intensity, since it is the main driving force of evolution. In the process of replacement, cells with low affinity are removed from the main population, and new generated randomly individuals come in their place. This avoids local extremes, and explores the entire target surface.

Individuals of the population are coded by real numbers rows in the range from 0.0 to 1.0. Each line contains a complete set of parameters of the S-system (Fig. 1).

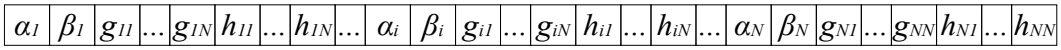

Fig. 1. Encoding of antibodies of the hybrid clonal algorithm

When evaluating the next solution variant, the values of the individual string are recalculated into new ranges, in accordance with the allowable intervals of the change of one or another S-system's parameter, which are set before the algorithm start.

The affinity measure or objective function of the task is left the same as in work [11]:

$$f = MIN \sum_{i=1}^{N} \sum_{j=1}^{T} \left(\frac{x_i^M(t_0 + j\Delta t) - x_i(t_0 + j\Delta t)}{x_i(t_0 + j\Delta t)} \right)^2, \quad (3)$$

where t_0 – time to start measuring the gene expression level; Δt – time step between successive measurements; T – number of measurements; $x_i^M(t_0 + j\Delta t)$ – values of the i-th gene expression level, obtained by means of the model, i.e., by the decision of SODU (1) (in this case by the Runge-Kutta method of the fourth order); $x_i(t_0 + j\Delta t)$ – measured values of the i-th gene expression level.

IV. Differential evolution algorithm

The differential evolution algorithm (DE) is one of the evolutionary algorithms varieties [18, 19]. With its high efficiency, DE has found application in many subject areas, as a global optimization method. There are several variants of DE, differing in details of the evolutionary operators implementation. In this paper we use the version presented in [18]. A brief description of DE method is given below.

The task of objective function minimization is considered:

$$f(\boldsymbol{x}) \to min, \boldsymbol{x} = (x_1, \ldots, x_n), \quad (3)$$

where $\boldsymbol{x}$ – the vector of task's parameters, on the basis of which the individuals of the solutions populations are built $\boldsymbol{x}_i^G, i = 1, \ldots, P$; P – размер популяции решений; G – текущее поколение.

The main difference between DE algorithm and other evolutionary algorithms is the implementation of the mutation operator. The DE mutation is as follows:

$$\boldsymbol{v}_i^{G+1} = \boldsymbol{x}_{r3}^G + F(\boldsymbol{x}_{r1}^G - \boldsymbol{x}_{r2}^G), \quad (4)$$

where $\boldsymbol{v}_i^{G+1}, i = 1,\dots,P$ – an individual, that is the result of a mutation; $r1, r2, r3 \in \{1,\dots,P\}$ – indexes of individuals, that are chosen from the population of solutions randomly in the current generation, such that $r1 \neq r2 \neq r3 \neq i$; F – scale coefficient ($F \geqslant 0$).

Components of individuals $\boldsymbol{x}_i^G$ are replaced by the corresponding components of the vectors partially $\boldsymbol{v}_i^{G+1}$ with the formation of candidates population $\boldsymbol{u}_i^{G+1} = (u_{i1}^{G+1},\dots,u_{in}^{G+1})$. Formation of a vector $\boldsymbol{u}_i^{G+1}$ occurs according to the following expression:

$$u_{ij}^{G+1} = \begin{cases} v_{ij}^{G+1}, if\ randEvent(p_{DE}) = 1 \vee j = k \\ x_{ij}^G, otherwise \end{cases}, j = 1,2,\dots,n, \quad (5)$$

where $k \in \{1,\dots,n\}$ random parameter index, chosen once for each individual, the sense of which is to ensure the transition of at least one vector component $\boldsymbol{v}_i^{G+1}$ to vector $\boldsymbol{u}_i^{G+1}$; p_{DE} – the transition probability of the j-th component of the vector $\boldsymbol{v}_i^{G+1}$ to vector $\boldsymbol{u}_i^{G+1}$. Since expression (5) is associated with the crossover operator in evolutionary algorithms, p_{DE} called the crossing-over probability. It is not difficult to see that expression (5) is very similar to expression (2), therefore in this work p_{DE} is called the intensity of DE mutation.

The next generation population is formed from the current generation population and the candidates population by means of DE-selection:

$$\boldsymbol{x}_i^{G+1} = \begin{cases} \boldsymbol{u}_i^{G+1}, if\ f(\boldsymbol{u}_i^{G+1}) \leq f(\boldsymbol{x}_i^G) \\ \boldsymbol{x}_i^G, otherwise \end{cases}, \quad (6)$$

i.e. each individual from the candidate population is compared with the corresponding individual from the current population. If the candidate has a smaller value of the objective function, he passes into a new generation. Otherwise, the current individual passes into the new generation.

V. The proposed hybrid algorithm

The idea of combining different computational methods and the formation of hybrids is based on the assumption that the new computational method obtained as a result of combining should have a

higher productivity than the constituent components. Being embodied in life, this idea led to the creation of hybridization technology, which allows synthesizing whole algorithms classes capable of solving complex tasks at a qualitatively new level. According to this technology, the strengths of the methods involved in hybridization form a combined result that characterizes the main advantages of the hybrid approach, such as: obtaining better solutions; getting solutions in less time; solving problems of large dimension.

In this paper, a hybrid clonal algorithm is proposed in which the mutation phase is extended by operators taken from the algorithm of differential evolution. A step-by-step description of the algorithm is presented below.

Step 1. $Population = 0$.

Step 2. Create an initial population of solutions randomly (Ab^0).

Step 3. Estimate populations Ab^0 based on the objective function f.

Cycle until the condition of shutdown $e = false$.

Step 4. Save the best solution in the current generation.

Step 5. Select antibodies from Ab^0 with the greatest affinity.

Step 6. Create clones Ab^c of selected antibodies in an amount $n \sim f$.

Step 7. To make a mutation of clones with probability $p_c! \sim f$ and intensity $p_m! \sim f$ according to the formula (2).

Step 8. To make DE-mutation of clones with intensity $p_{DE}! \sim f$ according to the formula (4) и (5) and place the results into the population of candidates Ab^t.

Step 9. Estimate populations Ab^t based on the objective function f.

Step 10. To carry out DE-selection of candidates according to the formula (6).

Step 11. Select the candidates with the highest affinity from Ab^t and transfer them to Ab^0.

Step 12. Replace the d worst antibody in Ab^0 new generated randomly antibodies.

Step 13. Estimate new antibodies into Ab^0.

Step 14. $Population = Population + 1$.

Cycle until end

Step 15. Conclusion: the best solution in the current generation.

Step 7 is left to prevent premature convergence of the algorithm. Unlike the classical CLONALG, in this case, mutations are not all clones, but only a part of them, which is controlled by the parameter p_c. In this case, the probability values p_c and intensity p_m are subject to investigation. In addition, the authors studied the effect of the intensity of the DE-mutation p_{DE}, the scale factor F and DE-selection on the quality of the algorithm. The results of the research are presented in the next section.

VI. Experimental research

In this research work, the efficiency of the algorithm was evaluated both on artificial and on real gene networks, and the experimental results were compared with other existing methods found in the modern literature. Now the performance of the S-system model was measured in terms of its sensitivity (Sn) and specificity (Sp), which were defined as follows:

$$S_n = \frac{TP}{TP + FN}, \tag{4}$$

$$S_p = \frac{TN}{TN + FP}, \tag{5}$$

where True Positive (TP) denotes the number of correctly predicted rules, and True Negative (TN) is the number of correctly predicted uncontrollable output algorithms. False Positive (FP) indicates the number of incorrectly predicted rules, and False Negative (FN) represents the number of false-predicted uncontrollable output algorithms.

To test the effectiveness of modeling the S-system, a reference small artificial network was chosen. It contains five genes with simple regulatory dynamics. In the studies of other authors this network was already used to test the effectiveness of the proposed algorithms. Therefore, in this article, the same network was used to test our methodology, and also to compare its effectiveness with earlier work.

The proposed methodology was applied to synthetic noiseless data having the parameters shown in Table 1.

Time series data were obtained by solving the system of differential equations (1). For training, we used datasets containing only positive values. In our work, only 70 data points were used for each of the genes. Twelve identifiable parameters were also used. The search interval is

selected in the range [-3; 3] for kinetic orders $g_{i,j}$ и $h_{i,j}$ in the range [0,12] for rate constants, α_i и β_i.

Table 1.

The actual parameters of the S-system for an artificial gene network.

	$g_{i,1}$	$g_{i,2}$	$g_{i,3}$	$g_{i,4}$	$g_{i,5}$	$h_{i,1}$	$h_{i,2}$	$h_{i,3}$	$h_{i,4}$	$h_{i,5}$	α_i	β_i
1	0	0.0	1.0	0.0	-1.0	2.0	0.0	0.0	0.0	0.0	5.0	10.0
2	2	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	10.0	10.0
3	0.0	-1.0	0.0	0.0	0.0	0.0	-1.0	2.0	0.0	0.0	10.0	10.0
4	0.0	0.0	2.0	0.0	-1.0	0.0	0.0	0.0	2.0	0.0	8.0	10.0
5	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0	10.0	10.0

For the hybrid clonal selection algorithm (HACS), 8000 iterations were used. The number of the maximum iteration and the initial population remains high for solving the nonlinearity of the S-system. Initial parameter values α_i and β_i were established in 0,95. The choice of parameters requires certain experiments. The frequency boundary and the step size were initialized to [0,1], while the random movement was fixed to 0.001.

Table 2 shows the expected parameters for the experiment. The values of kinetic orders less than 0.1 were ignored. The S-system model based on the hybrid clonal algorithm produced satisfactory results for silent data, since almost all the parameters were predicted to be correct. In addition, HACS also accurately determined the correct sign and position of the rules (regulated and unregulated). However, the predicted parameter values for gene No. 3 were somewhat less accurate, but still quite satisfactory in terms of predicting TP and FP and the nature of their regulation.

Table 2.

Calculated values of parameters of the S-system for an artificial network

	$g_{i,1}$	$g_{i,2}$	$g_{i,3}$	$g_{i,4}$	$g_{i,5}$	$h_{i,1}$	$h_{i,2}$	$h_{i,3}$	$h_{i,4}$	$h_{i,5}$	α_i	β_i
1	0.2	0.0	1.2	0.0	-1.0	2.1	0.0	0.0	0.0	0.2	5.0	10.0
2	2.4	0.2	0.0	0.2	0.0	0.2	2.0	0.2	0.0	0.0	9.0	9.0
3	0.0	-1.1	-0.2	-0.2	-0.2	0.0	-1.1	0.0	0.0	0.0	7.0	8.0
4	0.3	0.0	2.1	0.0	-1.1	0.0	0.0	0.0	2.0	0.0	7.6	9.5
5	0.2	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	2.1	9.5	9.4

To fully evaluate the proposed HACS algorithm, it was tested on noisy artificial data. The approach proposed in [19] was used, where 5%, 15% and 25% were added to the data.

Table 3 presents comparative studies of the effectiveness of various reverse engineering algorithms. It can be noted that in the presence of different noise levels, the HACS-based S-system model is better than the algorithms based on differential evolution (DE) and the algorithm for clonal selection.

Table 3.

Comparative study of HACS-based S-system with the other techniques for noisy artificial data

Methods	HACS		ACS		DE	
Noise(%)	S_n	S_p	S_n	S_p	S_n	S_p
5	1.0	0.96	1.0	087	1.0	0.75
15	1.0	0.79	0.81	0.71	0.93	0.73
25	1.0	0.68	0.65	0.68	0.89	0.74

VII. Conclusions

The report describes the application of the S-system to search for gene networks from microchip's data using the combined algorithms of clonal selection and differential evolution. The algorithm is implemented on the microchip data which, as shown, is able to determine and predict the dynamics of the studied data on which the training was conducted. The obtained results show the high accuracy of the algorithm. One of the problems with the reconstruction of gene networks from real data is the lack of final network models to compare the methods being developed.

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Z. Holub

THE ALGORITHM FOR DETECTING ONLINE DISCUSSION FRAGMENTS CONTAINING INFORMATION AND PSYCHOLOGICAL MANIPULATION

Annotation. *The paper scrutinizes the algorithm for detecting suspicious fragments of online community discussions that potentially contain information and psychological manipulation precedents. The classes of criteria for detecting suspicious discussion fragments are presented; the system of filters for detecting the fragments is described. The stages of the algorithms for detecting suspicious fragments are detailed.*

Keywords: *information and psychological manipulation, suspicious discussion fragment, online community*

Introduction

The internet means of communication are the most common and widely spread way of communication nowadays. Information transmission speed, vast audience, source diversity, the possibility of overcoming territorial limits make the internet means of communication attractive for informing and information search.

Due to the little number of requirements for publishing information (e.g. registration) and a great number of informers and recipients, the significant deal of internet-communication takes place on online community platforms. However, online community members could be exposed to the harmful effect of information and psychological manipulation. Information and psychological manipulation (IPM) is a deliberate influence on the subconsciousness of online community members by means of information and utilizing psychological mechanisms with the aim to affect thought process and reach one party vested goal.

Formulation of problem

The high speed of information sharing is typical for online communities. Therefore the prerequisite of IPM prevention is the timely detection of IPM precedents. The last requires the large unit of people with specific qualifications or application of automated methods and means.

The aim of the paper is to develop the algorithm for detecting discussion fragments that potentially contain IPM. The algorithm foresees

application of the system of filters for detecting suspicious discussion fragments [1]. This process takes place at the second stage of the algorithm for monitoring online community with the aim of IPM detection [2]. The output of the considered in the paper algorithm is a set of suspicious discussion fragments, which are sent to the next stage of the algorithm for monitoring online communities with the aim of detecting IPM in order to identify IPM precedents.

Analysis of recent research and publication

Research in different fields and areas is aimed at increasing effectiveness of internet communication [3], in particular, increasing and using advantages and preventing negative phenomena of internet communication. Numerous studies are devoted to linguistic [4], intentional [7], behavioral [5, 6] and psychological mechanisms and means of communicative acts realization in internet media.

The basic material

The detection of suspicious discussion fragments is one of the two interim tasks fulfilled at the second stage of the algorithm of monitoring online communities with the aim of detecting IPM. The two interim tasks of the stage are detecting suspicious discussion fragments and detecting of precedents of IPM in online discussions.

Suspicious discussion fragments are the sets of logically connected messages, which quantitative and qualitative features as well as quantitative and qualitative characteristics of the profiles of their authors are characteristic to messages containing IPM.

Criteria for detection of a suspicious discussion fragment

The system of filters and means for detecting IPM tactics are based on different criteria. The system of filters base on static criteria that are utilized for suspicious profiles detection and dynamic criteria of the surface level that are used for detecting clusters of suspicious messages [9]. Meanwhile, means for detecting IPM tactics are based only on dynamic criteria.

Criteria that signal the potential existence of IPM are classified into two temporal classes, namely dynamic and static. The feature of the classification is a time period required for gathering and processing information necessary for computing the criterion.

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• Static criteria are computed on the basis of members activities during the set period of time.

• Dynamic criteria do not require gathering data over the set time period, the presence of IPM can be stated right after determining them.

By means of static criteria information activity of a member is considered in relation to three structural and organizational levels of the content of an online community. According to the formal model of an online community, these three levels are community level, discussion levels, and message level. [1, 9]. Criteria of these three organizational and structural levels differ from one another in the computation mechanism and importance.

The values of criteria of the discussion and community levels are considered in relation to a community member. By means of these criteria, suspicious community members are detected. The activity of the latter is to be analyzed for IPM precedents.

Static criteria of the messages level point at elements of the content of the discussion that are to be analyzed for IPM presence.

Dynamic criteria are used for analysis of the particular act of information activity. They contain no generalized information about the role and behavior of the member of an online community.

The algorithm for detecting a suspicious discussion fragment

The analysis of an online community with the aim of detecting suspicious fragments of a discussion starts with processing discussion by filters of the highest level, namely community level. The criteria of community level do not demand complicated calculations, therefore these criteria make it possible to analyse the bulk of information without significant time and resource spending. If the fragment of a discussion is identified as manipulative by the present number of filters of the level N^{Filter}, it is not send to the filters of next levels, but saved in database as a suspicious discussion fragment.

At the next level, namely discussion level, at first are analysed the fragments which were trapped by the number of filters closest to N^{Filter}. If the sum total of all filters they were trapped by at all levels equals, N^{Filter}, then fragments are marked in database as the one's that contain IPM. For instance the number of filters that trapped a discussion fragment at the community level and at the discussion level equals the

predefined by expects threshold value, then the fragment is considered to be suspicious and is sent to the next level for detecting IPM precedents by applying deep analysis.

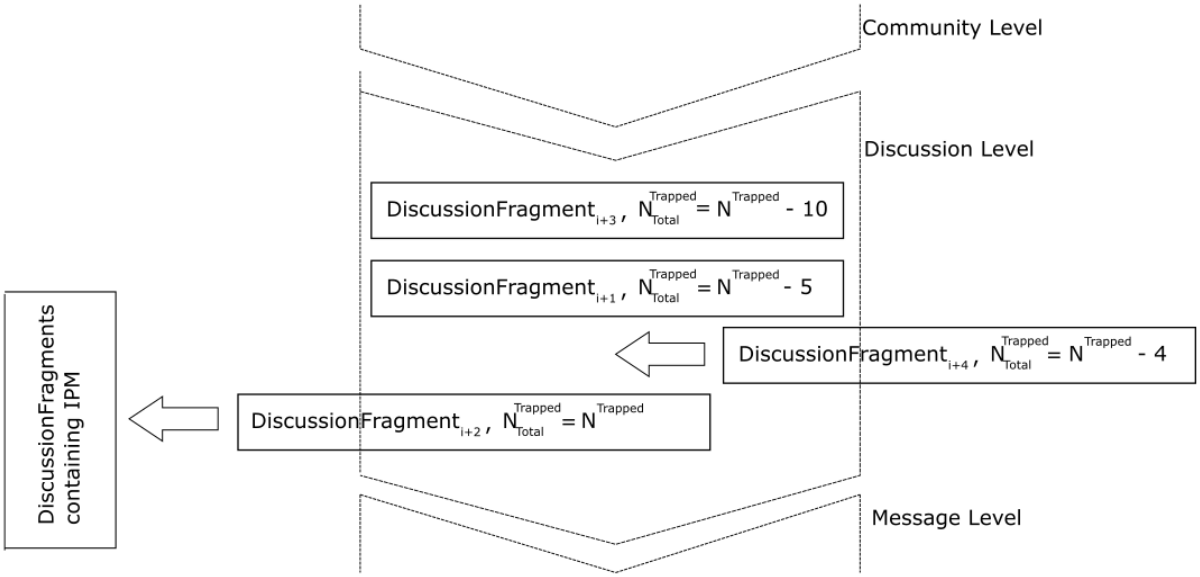

Figure 1. Sorting discussion fragments

Every criterion used by the filter for detecting specious precedents has different value in light of IPM detection process. Therefore a filter is assigned a value, predefined by experts.

The filters of each succeeding level require more data for calculations than of the preceding level, therefore it is reasonable to apply them to discussion fragments that were checked, but not trapped by the filters of other previous levels.

The subsequent application of criteria of the next levels only to the discussion fragments that were not suspected in presence of IPM, decreases the volume of information queuing to be checked for containing IPM. Furthermore, within each level simple filters that do not require complicated calculations are exploit first. In case of not detecting enough indications of IPM, they are subjected to further check by more sophisticated compound filters. This is done in order to increase the efficiency of the performance of the system of filters.

The number of community discussions a member posts in is an example of a compound filter. If a member takes an active part in numerous discussions, but his posts are relevant only to a small number of the discussions, then the member is considered to be a manipulator.

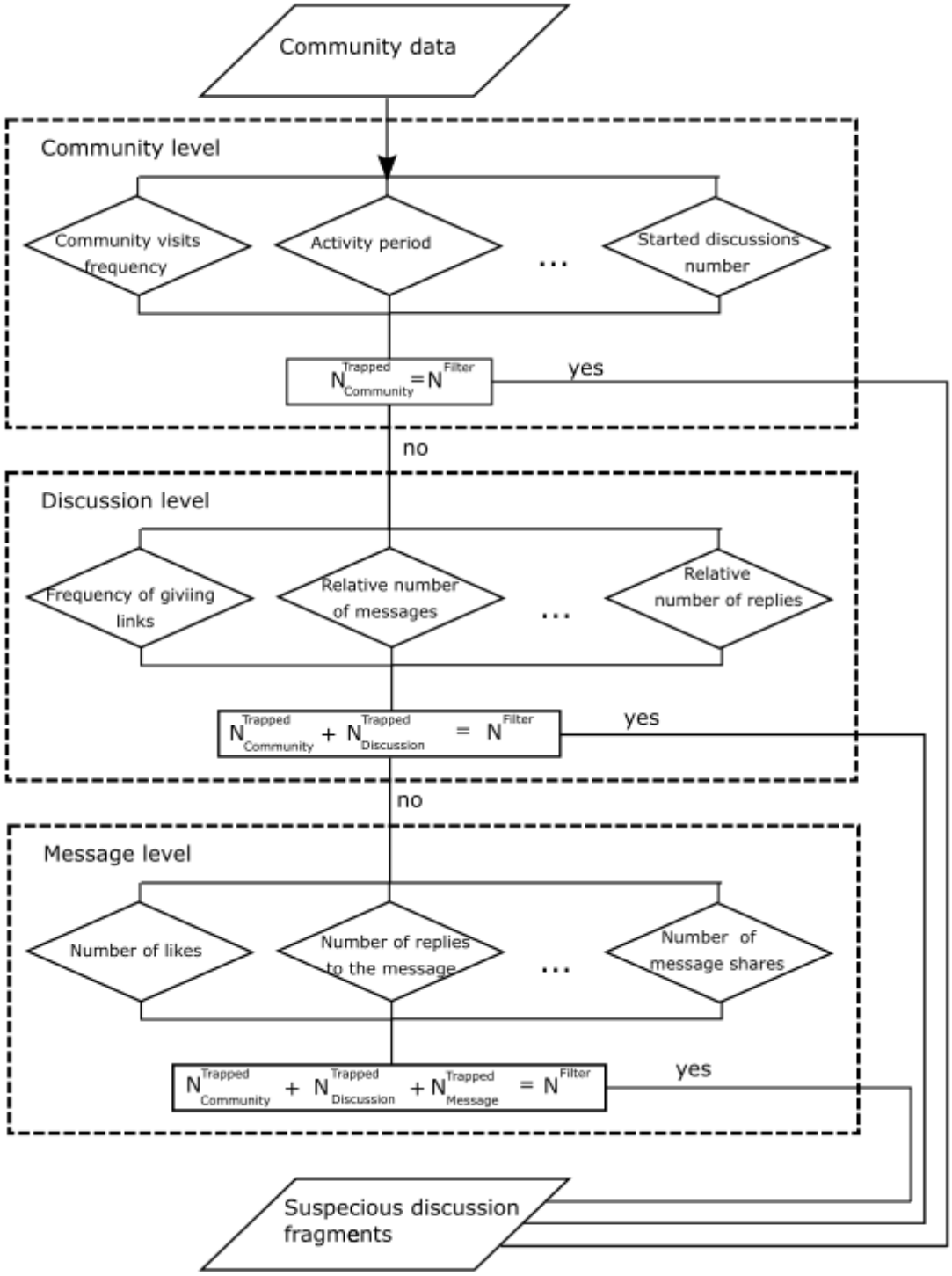

Figure 1. Filtering discussion fragments according to the organization and structural levels

The number of IPM markers identified at the preceding interim stage defines the order of processing the discussion fragments on the next interim stage. For instance, if a suspicious discussion fragment was detected by filters of the community level, this fragment is analysed before the fragment that was detected by filters of community and

discussion levels. The sequence of fragments according to which they are going to be analysed for the presence of IPM precedents, depends on the relation of the quantity of filters, which trapped the discussion fragment to the number of filters the fragment was processed by. The smaller the value of the relation is the sooner the fragment is check for presence of IPM precedents.

The output of the system of filters is the list of discussions that potentially contain IPM. The discussion fragments in the list are arranged according to the urgency of their check for IPM precedents presence.

Conclusion

The key prerequisite of an effective functioning of an online community is detection and neutralization of harmful information activities, that are beneficial only to their stakeholders. Existence of IPM precedents in an online community causes the decrease in content quality, member's credit and as a result leads to the member's quitting the community and the end of active functioning of the community.

Owing to the criteria devised on the basis of different user's profile characteristics and applying the system of filters the system for detecting suspicious discussion fragments is developed and the algorithm for accomplishment of the interim stage is suggested. The system of filters and the algorithm for detection suspicious discussion fragments enables the monitoring of online communities with the aim of IPM detection. The drawbacks like time spending and human resources required to check a huge bulk of information are excluded. The results of the system of filters are sent to the succeeding stage of the algorithm for monitoring online community, which foresees the deep analysis of content with the aim to detect IPM precedents and further identification of the IPM tactic.

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UDC 004

V. Hrytsyk, M. Petryk

IMAGE SEGMENTATION IN COMPUTER VISION DIAGNOSTIC SYSTEMS

Annotation. *Applicability image segmentation approaches for image segmentation for actual diagnostic task are studied in the work. Abnormal patient's neurotic-tremor moves analysis and identification hybrid model is described in article.*

Keywords: *segmentation, identification, diagnostic IT model*

1. Introduction

The last 50 years in our technology-oriented society has become such a situation in which more and more people and organizations are engaged in processing information and less – in the processing of material objects. There are tendencies that by the year 2030 the machines will disappear dozens of professions that serve data input. Computer technology is so firmly rooted in our society that today it is impossible to imagine any kind of activity is not connected, one way or another, with a computer [3].

Summarizing the survey of researches and implementation of intellectual IT in the EU and the US: Through FP7 and Horizon 2020, the EU funded the development of sophisticated techniques for understanding audiovisual projections throughout life for typical and non-typical populations. It is believed that robotic input systems that are integrated into the body with the hands and feet are the near future of computer vision. And this will require the development of models and methods for the synthesis of methods for the reception of visual spectrum data, obtained in real time [2,4]. Thus, the actual problem of the development of artificial intelligence is the development of the principles of computer perception of the outside world through the understanding of video data [1,5].

Industry 4.0 leads us to another informational explosion. And the human brain and society itself can not control this information explosion - we need more advanced information systems that will carry out the lion's share of information processing. Because information it is a key element of the decision-making process. In addition, quantity of varied and different levels of complexity of information that our world generates is spin-off, so we need adaptive information input systems. That is, such

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that humans will not to interfere with their work when changing external conditions - the systems themselves must be re-configured.

In particular, the development of Cyber-Physical Systems perception of the external world by people with disabilities in the visual spectrum is relevant today. This applies to both congenital (eg, congenital blindness) and acquired conditions (for example, with age or as a result of an accident). Today, implant technologies allow sensors to transmit information to the retina of the eye, so researching the methods and ideas of allocating a useful signal in real time is extremely relevant.

2. Formulation of the problem

Main task it is primary automatic diagnosis by information analytic system (IAS). The IAS needs to recognize abnormal, untypical patient condition. Method bases on recognizing week control of writing (fig 1).

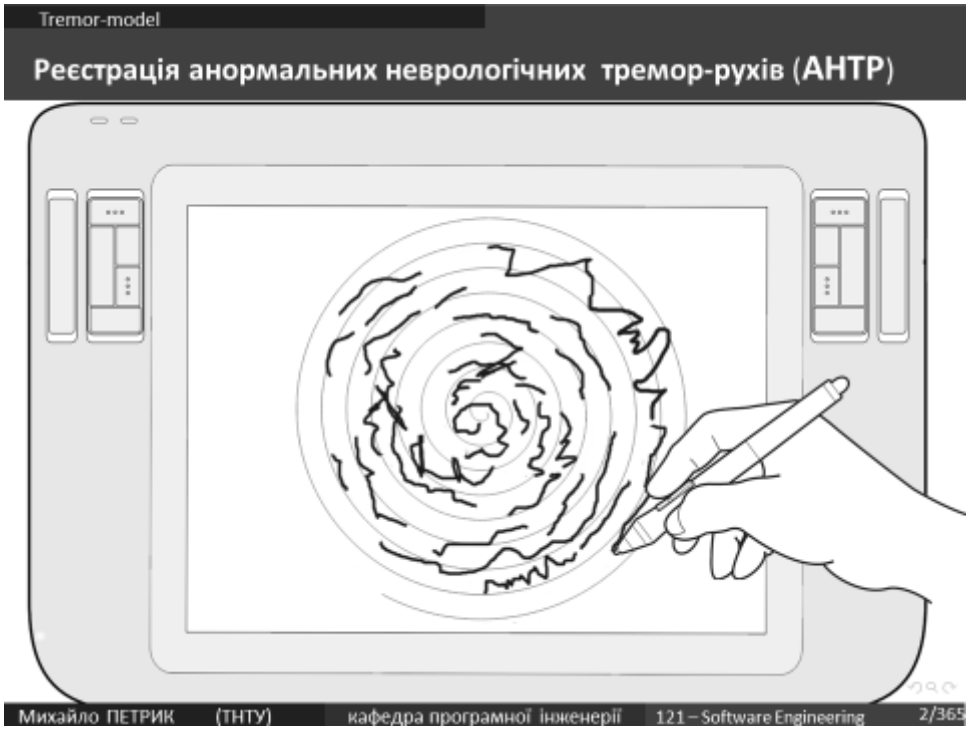

Fig. 1. Visualization of Idea of week write control.

Therefore, we describe separate our problem on some tasks: segmentation and recognition.

3. Main approaches to objects selection on task area

For our problem (Computer vision systems in real-time), we will investigate several main groups of threshold approaches that work effectively in real time.

3.1. Binarization methods with global threshold

1. *Binaryization with lower threshold.*

Binaryization with a lower threshold method refers to a group of image segmentation methods based on global thresholds.

The essence of the method is that the global brightness threshold is selected as a certain constant, and, depending on the ratio of this constant to the local brightness values for each pixel, the binary value of this pixel. This method is the most simple and widespread. The method is effective for standard conditions. We describe it as follows:

$$a_{xy}^{new} = \begin{cases} 0, if\ \frac{r+g+b}{3}(a_{xy}) \le L \\ 1, if\ \frac{r+g+b}{3}(a_{xy}) > L \end{cases}, \quad (3.1)$$

here a_{xy}^{new} – the resulting value of the brightness of the pixel;

a_{xy} – input value of pixel brightness;

$L(const) \in [0, 255]$ – global lighting level;

r, g, b – The original values of the red, green, and blue component of the a_{xy} pixel color.

3.2. Binarization methods with local threshold

3.2.1. Niblak method

The method is based on the calculation of the local threshold of illumination.

The idea is to align the threshold of brightness of binaryization from point to point based on the deviation of the local mean brightness value (the value calculated for each pixel based on the brightness values of itself and its neighbors), from the local (calculated for only one pixel) in the given mask [6].

That is, the binary representation of the pixel is computed as follows:

$$a_{xy}^{new} = \begin{cases} 0, \ if\ B(x,y) \le L \\ 1, \ if\ B(x,y) > L \end{cases}, \quad (3.2)$$

here $B(x,y) \in [0{,}255] = \frac{r+g+b}{3}(a_{xy}),$ – local pixel brightness value a_{xy};

$L \in [0{,}255] = m_{w\times w}(x,y) + k * s_{w\times w}(x,y)$ – local brightness threshold for pixel a_{xy} in the $w \times w$ district;

$m_{w\times w}(x,y) \in [0{,}255] = \frac{\sum_1^{w\times w} B(x,y)}{w\times w}$ – the average brightness value in the $w \times w$ district of the pixel (x,y);

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$s_{w\times w}(x,y) = \sqrt{\frac{1}{w\times w}\sum_1^{w\times w}(B(x,y) - m_{w\times w}(x,y))^2}$ – Mean square deviation of the sample in the district of the pixel;

$k(const) = -0{,}2$ for objects that are more likely to be represented in black (namely if $B(x,y) \le 127$), and $k = 0{,}2$ For objects that are more likely to be white $B(x,y) > 127$;

$w(const)$ – mask size of district, for example, 15[6].

3.4. Methods with perticial thresholds preprocessing

This method exeprs background pixel britness values:

$$a_{xy}^{new} = \begin{cases} 0, & if\ B_{x,y} > L \\ f(y,x), f(x,y), & if\ B_{x,y} \le L \end{cases}, \quad (3.4)$$

3.6.3. Otsu method.

The method uses a histogram of the distribution of the brightness values of the pixels of the image

The essence of the Otsu method is to set the threshold between classes on a histogram in such a way that each of them is as "dense" as possible. If expressed in a mathematical language, then this is reduced to minimizing the intra-class variance, which is defined as the weighted sum of dispersions of the two classes:

$$\sigma_w^2(L) = w_1(L)\sigma_1^2(L) + w_2(L)\sigma_2^2(L), \quad (3.6.3.1)$$

де weight w_i – this is the probability of two classes separated by the threshold L;

σ_i^2 – dispersion of these classes.

Otsu proved that minimizing the dispersion inside the class is equivalent to maximizing the dispersion between classes, which can be expressed through the probability w_i and the arithmetic mean μ_i:

$$\sigma_b^2(L) = \sigma^2 - \sigma_w^2(L) = w_1(L)w_2(L)[\mu_1(L) - \mu_2(L)]^2. \quad (3.6.3.2)$$

At first we need to build histogram $p(l)$ of image and determine the entries rate $N(l)$ of every brightness level at image $G(x,y)$. We are looking for total brightness N_T of image pixels:

$$N_T = \sum_{i=0}^{\max(G)} p(i) \quad (3.6.3.3)$$

Then for each value of the half-ton (threshold) $L = \overline{1, max(G)}$ we perform the following:

$$\omega_1(L) = \frac{\sum_{i=0}^{L-1} p(i)}{N_T} = \sum_{i=0}^{L-1} N(i), \qquad \omega_2(L) = 1 - \omega_1(L) \quad (3.6.3.4)$$

$$\mu_T = \frac{\sum_{i=0}^{\max(G)} i*p(i)}{N_T} = \sum_{i=0}^{\max(G)} i \times N(i) \quad (3.6.3.5)$$

$$\mu_1(L) = \frac{\sum_{i=0}^{L-1} i*p(i)}{N_T*w_1(L)} = \frac{\sum_{i=0}^{L-1} i \times N(i)}{w_1(L)}, \quad \mu_2(L) = \frac{\mu_T - \mu_1(L) \times w_1(L)}{w_2(L)} \quad (3.6.3.6)$$

$$\sigma_b^2(L) = \sigma^2 - \sigma_w^2(L) = w_1(L)w_2(L)[\mu_1(L) - \mu_2(L)]^2. \quad (3.6.3.7)$$

The wanted threshold is equal to L, at which $\sigma_b^2(L)$ is equal to maximum:

$$L = argmax_L\, \sigma_b^2(L) \quad (3.6.3.8)$$

Binary pixel representation is calculated as:

$$a_{xy}^{new} = \begin{cases} 0, \ if\ B(x,y) \le L \\ 1, \ if\ B(x,y) > L \end{cases}. \quad (3.6.3.9)$$

3.6.4. *Triangle method*

The method uses a histogram of the distribution of brightness values in the image (graphically shown in Figure 2).

We build line s on the histogram from minimal brightness value b_{min} to maximum brightness value b_{max}. The threshold will be defined the element of the histogram, the distance from which to s is greatest [9]:

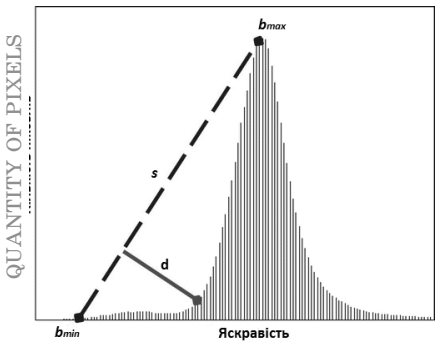

Fig.2. Triangle method

$$L = argmax_{b(i)} d, \quad (3.6.4.1)$$

where

L – threshold value;

d – distance from histogram value$b(i)$ to line s.

Binarization we realize by standard formula:

$$a_{xy}^{new} = \begin{cases} 0, if\ B(x,y) \le L \\ 1, if\ B(x,y) > L \end{cases} \quad (3.6.4.2)$$

3.6.5. The threshold based on the gradient of brightness determining method

Let pixels of the image can be divided into two sets (two classes) – pixels belonging to the set of objects and pixels belonging to the set of background. Then, the algorithm for calculating the threshold is the following two steps:

1) The brightness gradient module for each pixel is determined:

$$G(m,n) = \max\{|G_m(m,n)|, |G_n(m,n)|\} \quad (3.6.5.1)$$

here $G_m(m,n) = f(m+1,n) - f(m-1,n)$;

$$G_n(m,n) = f(m,n+1) - f(m,n-1).$$

2) Threshold is calculated as:

$$t = \frac{\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} f(m,n)G(m,n)}{\sum_{m=0}^{M-1}\sum_{n=0}^{N-1} G(m,n)} \quad (3.6.5.2)$$

here t –threshold value.

3.7. Methods of binarization using color brightness entropy

3.7.1. Yen's method

This method refers to methods that use the entropy of the distribution of the brightness of colors in the image. Yen's method looks at the object on the images and the background on which this object is located, as two different sources of visual information. And the value of brightness, in which the sum of these two entropies reaches their maximum, is considered the optimum threshold for image segmentation [8].

To begin, we need to calculate the histogram $p(l)$ of the image and the input frequency $N(l)$ of each brightness level of the image $G(x,y)$. We also look for the total brightness of N_T image pixels:

$$N_T = \sum_{i=0}^{\max(G)} p(i) \quad (3.7.1)$$

We are building auxiliary normalized histograms:

$$p_{norm}(i) = \frac{p(i)}{N_T}, \quad (3.7.2)$$

$$p_{normC}(i) = p_{normC}(i-1) + p_{norm}(i), \quad (3.7.3)$$

$$p'_{norm}(i) = p'_{norm}(i-1) + p_{norm}(i)^2, \quad (3.7.4)$$

$$p''_{norm}(i) = p''_{norm}(i+1) + p_{norm}(i+1)^2, \quad (3.7.5)$$

We find the entropy of the object and its background:

$$C_f(T) = -\log\{p_{normC}(i) \times (1 - p_{normC}(i))\}. \quad (3.7.6)$$

$$C_b(T) = -\log\{p'_{norm}(i) \times p''_{norm}(i)\}. \quad (3.7.7)$$

Determine the value of i, when the sum of these entropies is maximal:

$$L = argmax_i \{C_b(T) + C_f(T)\}. \quad (3.7.8)$$

We use this value as the threshold of brightness and binaryize the image:

$$a_{xy}^{new} = \begin{cases} 0, if\ B(x,y) \le L \\ 1, if\ B(x,y) > L \end{cases} \quad (3.7.9)$$

4. Model

On the next step, input vector is presented in 3D visualization (fig.3).

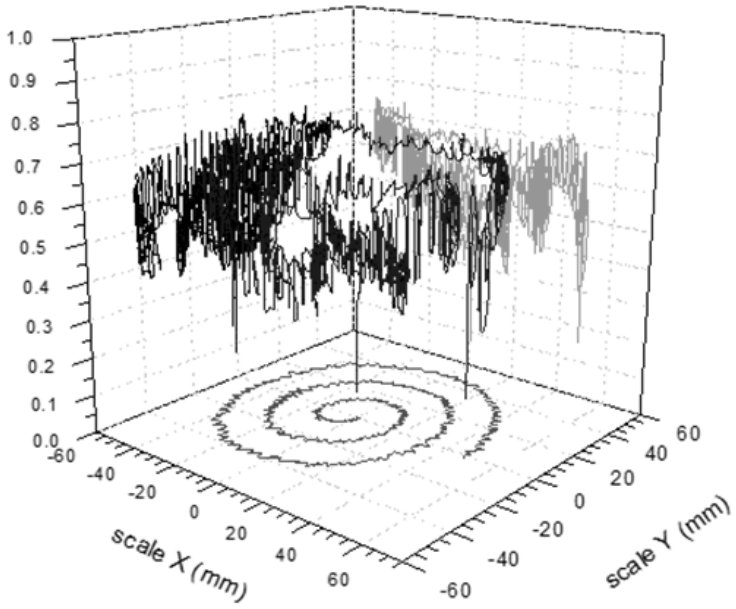

Fig.3. 3D visualization.

We describe trajectory as Set of digital elements:

$$I_{n_1} = \left\{ z \in \bigcup_{k=1}^{n_1+1} (l_{k-1}, l_k),\ 0 \le l_0 < l_{n_1+1} < \infty \right\}$$

$$u_j(t,z) = \int_0^t \sum_{k=1}^{n_1+1} \int_{l_{k-1}}^{l_k} \mathcal{H}_{jk}(t-\tau, z, \xi) \left[\sum_{i=1}^{n_2+1} \sigma_{ij} S_i(\tau, \xi) \right] d\xi d\tau, \quad j=\overline{1,n_1+1}$$

The recall matrix of system: for the any *j*-th element of the working trajectory at time *t* when the *k*-th impulse is signaled from the sensors of the *i*-th set of neural nodes of the cerebral cortex:

$$\mathcal{H}_{jk}\left(t,z,\xi\right)=\sum_{m=1}^{\infty}\frac{\sin q_m t}{q_m}\frac{V_j\left(z,\beta_m\right)V_k\left(\xi,\beta_m\right)}{\left\|V\left(z,\beta_m\right)\right\|^2};\ {}_{j,k=\overline{1,n+1}}$$

where

$\mathrm{P}=\left[\sigma_{ij}\right],\ {}_{i=\overline{1,n_2},\ j=\overline{1,n_1}}$ - it is interface matrix of connection between $\mathcal{H}_{jk}$ elements and neural networks impulses from sensors S_i of neural nodes of the brine.

The hybrid spectral vector-function components $V(z,\beta_m)$ are:

$$\begin{bmatrix} V_1(z,\beta_m) \\ \dots \\ V_k(z,\beta_m) \\ \dots \\ V_{n_1+1}(z,\beta_m) \end{bmatrix}=\begin{bmatrix} \left(\prod_{i=1}^{n_1}\xi_{i+1}\frac{\beta_m}{b_{i+1}}\right)\omega_0^2(\beta_m)\vartheta_1^{11}\left(\frac{\beta_m}{b_1}z\right)-\omega_0^1(\beta_m)\vartheta_1^{21}\left(\frac{\beta_m}{b_1}z\right) \\ \dots \\ \left(\prod_{i=k}^{n_1}\xi_{i+1}\frac{\beta_m}{b_{i+1}}\right)\omega_{k-1}^2(\beta_m)\vartheta_k^{11}\left(\frac{\beta_m}{b_k}z\right)-\omega_{k-1}^1(\beta_m)\vartheta_k^{21}\left(\frac{\beta_m}{b_k}z\right),\ {}_{k=\overline{2,n}} \\ \dots \\ \omega_{n_1}^2(\beta_m)\vartheta_{n_1+1}^{11}\left(\frac{\beta_m}{b_{n_1+1}}z\right)-\omega_{n_1}^1(\beta_m)\vartheta_{n_1+1}^{21}\left(\frac{\beta_m}{b_{n_1+1}}z\right) \end{bmatrix}$$

here

$\{\beta_m\}_{m=1}^{\infty}$ - it is set of hybrid vector-function components spectral values

$\left\{\vartheta_k^{11}\left(\frac{\beta_m}{b_k}z\right),\ \vartheta_k^{21}\left(\frac{\beta_m}{b_k}z\right)\right\},\ k=\overline{1,n_1+1}$ - it is basis function set of hybrid vector-function components.

The model of abnormal neurotic-tremor moves is shown by transcendental equation of spectral values β_m jf vector function $V(z,\beta_m)$:

$$\omega_{n_1}^2\left(\beta\right)\vartheta_{n_1+1}^{11}\left(\frac{\beta}{b_{n_1+1}}l_{n_1+1}\right)-\omega_{n_1}^1\left(\beta\right)\vartheta_{n_1+1}^{21}\left(\frac{\beta}{b_{n_1+1}}l_{n_1+1}\right)=0$$

here

$$\omega_k^j(\beta)=\omega_{k-1}^2(\beta)\psi_{1j}^k\left(\frac{\beta}{b_k}l_k,\frac{\beta}{b_{k+1}}l_k\right)-\omega_{k-1}^1(\beta)\psi_{2j}^k\left(\frac{\beta}{b_k}l_k,\frac{\beta}{b_{k+1}}l_k\right)$$

$$\psi_{ij}^{k}\left(\frac{\beta}{b_k}l_k,\frac{\beta}{b_{k+1}}l_k\right)=\vartheta_k^{i1}\left(\frac{\beta}{b_k}l_k\right)\vartheta_k^{j2}\left(\frac{\beta}{b_{k+1}}l_k\right)-\vartheta_k^{i2}\left(\frac{\beta}{b_k}l_k\right)\vartheta_k^{j1}\left(\frac{\beta}{b_{k+1}}l_k\right),\quad i,j=\overline{1,2},\ k=\overline{1,n}$$

$$\vartheta_k^{12}\left(\frac{\beta}{b_s}l_k\right)=-\xi_s\frac{\beta}{b_s}\vartheta_k^{21}\left(\frac{\beta}{b_s}l_k\right),\qquad \vartheta_k^{22}\left(\frac{\beta}{b_s}l_k\right)=\xi_s\frac{\beta}{b_s}\vartheta_k^{11}\left(\frac{\beta}{b_s}l_k\right),\quad s\in\{k,k+1\}$$

$$\omega_0^1(\beta)=-\vartheta_0^{11}\left(\frac{\beta}{b_1}l_0\right);\qquad \omega_0^2(\beta)=-\vartheta_0^{21}\left(\frac{\beta}{b_1}l_0\right),$$

Conclusions

Applicability image segmentation approaches for image segmentation for actual diagnostic task are studied. In addition, the recognition procedure is optimized. Abnormal patient's neurotic-tremor moves analysis and identification hybrid model is described in article.

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UDC 681.2

Y.N. Kharlamova

ESTIMATION OF PARAMETERS OF THE QUASI STABLE OBJECT USING A SYMMETRIC INTERACTION OF CHANNELS OF INFORMATION AND MEASUREMENT SYSTEM WHICH STRUCTURE ARE REBUILT

Annotation. *The algorithm for obtaining the estimates of unknown parameters of the quasi-stationary control target using an information and measurement system with two adaptive channels, which structure are rebuilt and parameters are changed intentionally developed by the author is shown. The considered adaptive algorithm operates on a sequential estimation procedures of unknown parameters object. At each stage of estimating unknown parameters structures of channels are rebuilt, which allows them to get as close to the properties of the object under study. The basis of this change is the principle of duality models of system and signal. Purposeful variation of parameters the channels of information-measuring system is in accordance with an algorithm that realizes the energy interaction between the two heavy balls. The influence of error of the previous estimation of parameter on the accuracy estimation of the following parameter is studied.*

Keywords: *quasi stable object, symmetric interaction of channels, information-measuring system, heavy ball method, energy interaction between the two balls.*

Problem statement

Getting characteristics managed controlled process for solving tasks of optimal control/monitoring carried out through the use of adaptive information-measuring systems (IMS). In the process of estimating the parameter values of real technical objects established that the difference in energies of channels IMS causes undesirable changes in their parameters. Undesirable oscillations of variable parameters of IMS channels using energy exchange between them can be eliminate.

Analysis of recent research and publications

Decrease in work efficiency of IMS is mainly caused by power fluctuations of variable parameters IMS channels. In [1], in order to improve the quality a characteristic of the identification process, the problem of stored energy redistribution between two identical in structure, but with different energy characteristics of adaptive models was solved. During the work described algorithm for finding the values of the parameters of the object the process of parameter settings of the adaptive model is carried out by gradient methods. On the basis of this algorithm in [2] it has been described and analyzed for efficiency

algorithm in which the parameters of channel IMS purposefully changed realizing the principle of symmetric energy interaction between the two heavy balls [3-5].

The purpose of the article

The aim is to demonstrate the algorithm of estimate the parameters of the quasi-stationary object using the interaction parameters of two structurally equivalent channel IMS that purposefully changed that developed by the authors. At the core of these changes is the duality principle of the system and signal.

Main part

As a control object will be considered an RLC electrical circuit with a series connection of elements whose parameters L, R and C are unknown and shall be evaluation. The dynamics of the circuit is described by the differential equation:

$$L \cdot i^{(2)}(t) + R \cdot i^{(1)}(t) + \frac{1}{C}\int_0^t i(\tau)d\tau = Q \cdot t, \quad i(0) = 0, \tag{1}$$

where $i(t)$ - he current flowing in the circuit; Q - known parameter [6].

After differentiating equation (1) and assuming that $x(t) = i(t)$, $a_0 = 1/\tilde{N}$, $a_1 = R$, $a_2 = L$, we get the differential equation:

$$a_2 x^{(2)}(t) + a_1 x^{(1)}(t) + a_0 x(t) = Q, \tag{2}$$

Evaluation of parameter a_0 of the object (2) will carry out by using IMS with two interacting with each other channels, whose dynamics is described by the differential equations:

$$\begin{cases} y^{(2)}(t) = -\dfrac{b_1}{b_2} \cdot y^{(1)}(t) - \dfrac{b_0}{b_2} \cdot y(t) + \dfrac{q_0(t)}{b_2} \\ z^{(2)}(t) = -\dfrac{c_1}{c_2} \cdot z^{(1)}(t) - \dfrac{c_0}{c_2} \cdot z(t) + \dfrac{q_0(t)}{c_2} \\ b_0(t) = \xi_{01}(t), \;\; \xi_{01}{}^{(1)}(t) = \xi_{02}(t), \;\; \xi_{01}(0) = b_{00}, \;\; \xi_{02}(0) = 0 \\ \xi_{02}{}^{(1)}(t) = -\alpha_0 x(t)\left[\left(2x(t) - y(t)\right)\xi_{01}(t) - z(t)\zeta_{01}(t)\right] - \beta_0 \cdot \xi_{02}(t) \\ c_0(t) = \zeta_{01}(t), \;\; \zeta_{01}{}^{(1)}(t) = \zeta_{02}(t), \;\; \zeta_{01}(0) = c_{00}, \;\; \zeta_{02}(0) = 0 \\ \zeta_{02}{}^{(1)}(t) = -\alpha_0 x(t)\left[\left(2x(t) - z(t)\right)\zeta_{01}(t) - y(t)\xi_{01}(t)\right] - \beta_0 \cdot \zeta_{02}(t) \end{cases} \tag{3}$$

$$q_0(t) = Q(t).$$

If the evaluation a_0^* of value of the parameter a_0 was made with an uncertainty Δ_0, than instead of the input signal $q_1(t) = \int_0^t Q dt - a_0^* \int_0^t x(t)dt$, $a_0^* = a_0 = \frac{1}{C}$, $q_1^{(1)}(t) = q_0(t) - a_0^* x(t)$, $q_0(t) = Q$ at an estimation value of the next model parameter a_1 of the object (2) input signal will be:

$$\overline{q_1(t)} = \int_0^t Q dt - a_0^* \int_0^t x(t)dt \pm \Delta_0 \int_0^t x(t)dt = q_1(t) \pm \Delta_0(t),\ a_0^* = a_0 \pm \Delta_0,\quad \Delta_0(t) = \Delta_0 \int_0^t x(t)dt,$$

$$\overline{q_1^{(1)}(t)} = q_0(t) - a_0^* x(t),\quad q_0(t) = Q.$$

Then, at estimation the parameter a_1 the structure channels of IMS will be reconstructed as follows:

$$\begin{cases} y^{(1)}(t) = -\frac{b_1}{b_2} \cdot y(t) + \frac{\overline{q_1(t)}}{b_2} \\ z^{(1)}(t) = -\frac{c_1}{c_2} \cdot z(t) + \frac{\overline{q_1(t)}}{c_2} \\ \overline{q_1^{(1)}(t)} = q_0(t) - a_0^* \cdot x(t) \\ a_0^* = a_0 \pm \Delta_0 \\ b_1(t) = \xi_{11}(t),\ \xi_{11}^{(1)}(t) = \xi_{12}(t),\ \xi_{11}(0) = b_{10},\ \xi_{12}(0) = 0 \\ \xi_{12}^{(1)}(t) = -\alpha_1 x(t)\left[\left(2x(t) - y(t)\right)\xi_{11}(t) - z(t)\zeta_{11}(t)\right] - \beta_1 \cdot \xi_{12}(t) \\ c_1(t) = \zeta_{11}(t),\ \zeta_{11}^{(1)}(t) = \zeta_{12}(t),\ \zeta_{11}(0) = c_{10},\ \zeta_{12}(0) = 0 \\ \zeta_{12}^{(1)}(t) = -\alpha_1 x(t)\left[\left(2x(t) - z(t)\right)\zeta_{11}(t) - y(t)\xi_{11}(t)\right] - \beta_1 \cdot \zeta_{12}(t) \end{cases} \quad (4)$$

In the case when the parameter a0 was found accurately as evaluation a1* of parameter values a1 was made with an uncertainty Δ_1, instead of the input signal:

$$q_2(t) = \int_0^t \int_0^t Q dt^2 - a_0^* \int_0^t \int_0^t x(t)dt^2 - a_1^* \int_0^t x(t)dt,$$

$$q_0(t) = Q,\quad a_1^* = a_1 = R,$$

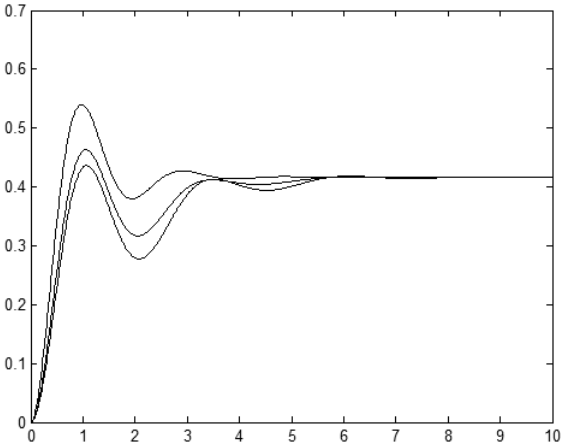
$$q_2^{(1)}(t) = q_1(t) - a_1^* x(t),$$

at an estimation value of the next model parameter a_2 of the object (2) input signal will be:

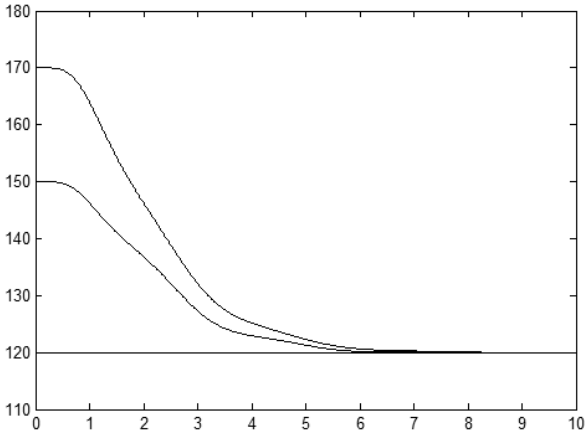
$$\overline{q_2(t)} = \int_T^t \int_T^t Q dt^2 - a_0^* \int_T^t \int_T^t x(t) dt^2 - a_1^* \int_T^t x(t) dt \pm \Delta_1 \int_T^t x(t) dt = q_2(t) \pm \Delta_1(t)$$

$$a_0^* = a_0, \quad a_1^* = a_1 \pm \Delta_1,$$

$$\Delta_1(t) = \pm \Delta_1 \int_T^t x(t) dt, \quad \overline{q_2^{(1)}(t)} = q_1(t) - a_1^* x(t).$$



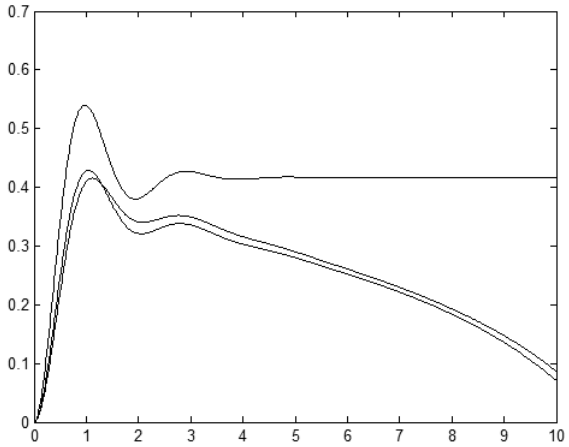
a) transient processes of object and IMS channels



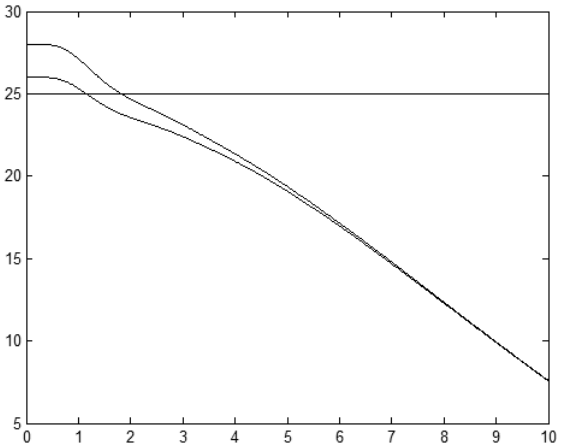
b) processes of the variation of parameters of IMS channels

Fig. 1. Graphs of simulation results of parameter estimation process a_0

$\left(\alpha_0 = 2.4,\ \beta_0 = 1.8,\ b_{00} = 150,\ c_{00} = 170\right)$.



a) transient processes of object and IMS channels



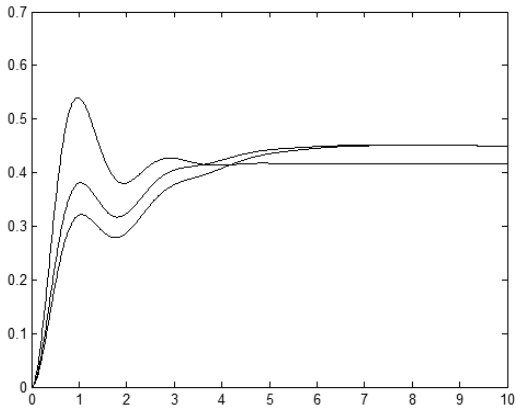
b) processes of the variation of parameters of IMS channels

Fig. 2. Graphs of process simulation results of parameter estimation a_1, with an uncertainty in the evaluation of the parameter a_0

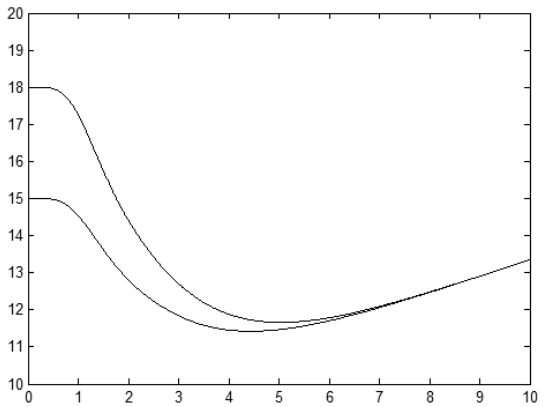
$\left(\alpha_1 = 2.05,\ \beta_1 = 1.99,\ b_{10} = 28,\ c_{10} = 26\right)$.

The structures of two interacting IMS channels in the evaluation of the parameter a2 described by differential equations:

$$\begin{cases} y(t) = \dfrac{\overline{q_2(t)}}{b_2} \\ z(t) = \dfrac{\overline{q_2(t)}}{c_2} \\ \overline{q_2{}^{(1)}(t)} = q_1(t) - a_1{}^* \cdot x(t) \\ a_1{}^* = a_1 \pm \Delta \\ b_2(t) = \xi_{21}(t),\ \ \xi_{21}{}^{(1)}(t) = \xi_{22}(t),\ \ \xi_{21}(0) = b_{20},\ \ \xi_{22}(0) = 0 \\ \xi_{22}{}^{(1)}(t) = -2 \cdot \alpha_2 x(t)\left[x(t) \cdot \xi_{21}(t) - q_2(t)\right] - \beta_2 \cdot \xi_{22}(t) \\ c_2(t) = \zeta_{21}(t),\ \ \zeta_{21}{}^{(1)}(t) = \zeta_{22}(t),\ \ \zeta_{21}(0) = c_{20},\ \ \zeta_{22}(0) = 0 \\ \zeta_{22}{}^{(1)}(t) = -2 \cdot \alpha_2 x(t)\left[x(t) \cdot \zeta_{21}(t) - q_2(t)\right] - \beta_2 \cdot \zeta_{22}(t) \end{cases} \quad (5)$$



a) transient processes of object and IMS channels



b) processes of the variation of parameters of IMS channels

Fig. 3. Graphs of process simulation results of parameter estimation a_2, with an uncertainty in the evaluation of the parameter a_1 and correct evaluation of parameter a_0 $\left(\alpha_2 = 1.84,\ \beta_2 = 1.5,\ b_{20} = 15,\ c_{20} = 18\right)$.

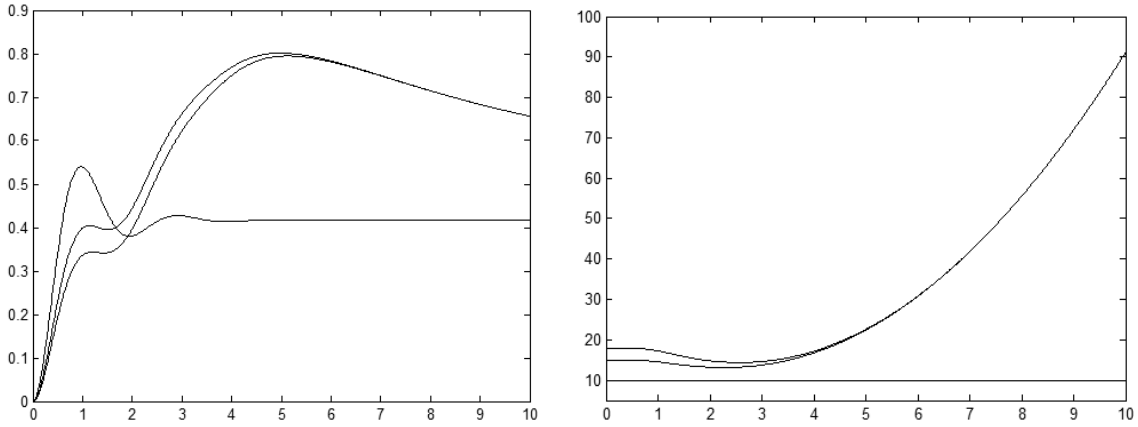
If the estimate of the parameter a_0 also was done with an uncertainty, the input signal will contain an uncertainty in the evaluation of the previous parameters:

$$\overline{q_2(t)} = \int_T^t \int_T^t Q dt^2 - a_0{}^* \int_T^t \int_T^t x(t) dt^2 \pm \Delta_0 \int_T^t \int_T^t x(t) dt^2 - a_1{}^* \int_T^t x(t) dt \pm \Delta_1 \int_T^t x(t) dt = q_2(t) \pm \Delta_{01}(t),$$

$$a_0{}^* = a_0 \pm \Delta_0, \quad a_1{}^* = a_1 \pm \Delta_1$$

$$\Delta_{01}(t) = \pm\Delta_0 \int_T^t \int_T^t x(t)dt^2 \pm \Delta_1 \int_T^t x(t)dt,$$

$$\overline{q_2^{(1)}(t)} = \overline{q_1(t)} - a_1^* x(t).$$



a) transient processes of object and IMS channels

b) processes of the variation of parameters of IMS channels

Fig. 4. Graphs of process simulation results of parameter estimation a_2, with an uncertainty in the evaluation of the parameters a_0 and a_1

$$\left(\alpha_2 = 1.84,\ \beta_2 = 1.5,\ b_{20} = 15,\ c_{20} = 18\right).$$

In this case the patterns of two interacting channel IMS in the evaluation of parameter a_2 will be described in according to differential equations (5), with the substitution of $q_1(t)$ for $\overline{q_1(t)}$ (figure 4).

The results of mathematical modeling parameter estimation process according to algorithms (3) - (5) are shown in Figure 1 - Figure 3, respectively. Convergence time of parameters $b_i(t)$ and $\tilde{n}_i(t)$ to each other and to the estimated parameter a_i depends on the value of the coefficients α_i and β_i.

Conclusions and perspectives for further research

The paper investigated the behavior of adaptive channels of IMS with an uncertainty in the evaluation of the previous parameter. The study results showed that, in evaluation of next parameter the presence of uncertainty in the evaluation of the previous parameter is adversely affect the IMS efficiency - with time parameters $b_i(t)$, $c_i(t)$ of models whose structures are rebuilt not converge towards each other and the a_i, $\left(i = \overline{0,2}\right)$ object parameters. Uncertainties of evaluating subsequent parameters

a_i, $\left(i=\overline{0,2}\right)$ can be decreased by a more accurate estimate of the previous parameters of IMS channels. This can be achieved by selecting appropriate values α_i, β_i $(i=\overline{0,2})$ and increasing the observation time t.

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UDK 621.391.3

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THE FORMALIZED CORRELATIONS AND INTERCONNECTIONS OF TELECOMMUNICATION SYSTEMS AND TELECOMMUNICATION ROUTES FROM THE STANDPOINT OF SYSTEM THEORY

Problem Statement

The nowadays stage of development of world civilization is characterized by the transition from the industrial to the information type society, which involves new forms of social and economic activity based on the widespread use of information and telecommunication technologies. The technological basis of such a society is the Global Information Infrastructure (GII) that should provide every inhabitant of the planet with a free access to the information resources.

In its turn, the tangible and at the same time the system-forming basis of such an infrastructure are telecommunication systems. The major national problem is a creation of a highly efficient telecommunication environment. Without solving it, the building of an information society and the application of information technology achievements to the fields of production, business, science, education, medicine and culture will turn out to be problematic [1].

In the process of formation and development of computerized systems, the term “telemechanics system” was indicated as a set of technical means for a distance transmitting of commands from the operator or controlling computer to the control objects by radio channels or wire lines, as well as control information in the feedback [1]. So, telemechanics was meant to be the management at a distance.

In the process of developing digital data transmission systems the standardization of devices, processes, information flows, processing and presentation procedures became relevant. This gave impetus to the development and implementation of telecommunication systems (TCS) in practice.

Telecommunication systems are the systems of communication of the corresponding level of management. Telecommunication routes (TCR) and data channels are the constituent parts of TCS. TCS and data channels implement data support of computerized systems.

Today, the theory of systems satisfies the needs of sociology, ecology, biology, military science, groups of interacting computers, radio equipment, and others. The system theory studies the formal interrelationships between the constituent parts of the material world phenomena abstracting from their specific nature.

In general terms, the system is a set of interconnected elements that form a corresponding integrity, unity.

Telecommunication systems and telecommunication routes are integral parts of computerized systems and therefore it is appropriate to consider the correlation between TCS and TCR.

Initially in the process of formation and development of computerized system the term "telemechanics system" indicated a set of technical means for a distance transmitting by radio channels or wire lines of commands from the operator or controlling computer to the control objects, as well as control information in the feedback [1].

In the process of developing digital data transmission systems the standardization of devices, processes, information flows, processing and presentation procedures became relevant. This gave impetus to the development and implementation of telecommunication systems (TCS) in practice.

Analysis of publications, the purpose of elaboration

The general definition of TCS literally coincides with the definition in the case of macroapproach to the classification of TCS, i.e. to the classification and study of communication systems. In the case of macroapproach, TCS is the communication system itself of the corresponding level of management, and all the lines and communication means are the elements of this system. So TCS is a communication system. The distance between subscribers does not matter. The lines and communication means are telecommunication routes. They are implemented for the exchange of information between the control object and the processing system, which characterizes the state of the object.

Telecommunication route is a communication path, a transmission path, a complex of technical equipment and communication lines intended to form specialized channels for information transmission [2]. The notion of "route" is broader than the channel. The communication route is characterized by certain standard indicators: the frequency band, the information transmission rate, etc.

Consequently, the optimization of parameters and characteristics of the electronic TCR circuit devices is a priority task. To do this, it is necessary to clearly identify the correlations and interconnections of the concepts of telecommunication systems and telecommunication routes from the standpoint of the theory of systems.

Subject of elaboration

The focus of the theory of systems lies in the study of cause-and-effect relationships.

The most general definition of the theory of systems [1] is the analytic one according to which the system is called the reflection on abstract sets

$$S \subset \cdot * \{V_i : i \in I\}, \quad (1)$$

where * is the symbol of the direct (Cartesian) product;

V_i is the system element with index i;

I is the set of indexes.

For a finite set of element the mapping (1) can be rewritten in the form

$$S \subset V_1 *_2 * V_n. \quad (2)$$

The expression (2) emphasizes the fact that the system is a set of elements V_i that interact with each another.

One and the same object at different stages can be considered in various aspects. In some cases, it can act as a system. In others, the same object can be regarded as an element of a more general system – the metasystem. The relations or links between certain objects can also be the elements of the system.

Thus, the level of consideration of being a system can be varied.

When describing a system, one can proceed from two basic assumptions:

– the system's behavior is purposeful, its function is subordinated to certain formal rules of decision-making and management (purposeful, controlling or controlled systems);

– there are cause-and-effect relationships in the system, they are characterized by the dependence of its response on the corresponding

outputs from the influences on the inputs ('input – output" or "black box" systems).

There are open and closed systems. Open systems are those connected with the environment by incoming and outgoing channels. Closed systems do not have such channels.

Open systems have inputs

$$X = x\{V_i : i \in I_x\}. \quad (3)$$

The influences come through them. Their outputs

$$Y = x\{V_i : i \in I_y\}. \quad (4)$$

At the outputs the reactions to incoming influences are observed. For the open systems, the more specific definition is as follows

$$S = \subset X * Y. \quad (5)$$

System (5) is called the "input – output" or "black box" system. The system element (V_i, $i \in I$) is understood as the simplest undivided part of the system. Indivisibility means that the further division is inappropriate because it destroys the properties of the element, or does not provide any additional information when studying the specific system properties and structure which should be considered.

The general definition of TCS literally coincides with the definition in the case of macroapproach to the classification of TCS, i.e., to the classification and study of communication systems [4].

Macroapproach, microapproach and mesaapproach are classified to the study of communication systems, i.e., to the classification of TCS.

In the case of macroapproach, TCS is the communication system of the corresponding control unit itself, and all lines and communication means are system elements.

In the case of a microapproach TCS is considered as a separate device or junction that consists of elements (such as radio components) which interact with each other.

Mesapproach is applied at the level of interacting means and communication systems.

Also, when studying TCS it is necessary to consider it in the process of interaction with other systems, or with the environment. TCS elements

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can be independent of each other. In this case, their entropy, that is their common uncertainty, is the sum of separate uncertainties:

$$H_{V_1V_2} = H_{V_1} + H_{V_2}, \quad (6)$$

where H_{V_i} – the uncertainty of one system element. The general system uncertainty with n independent elements

$$H_{\Sigma} = \sum_{i=1}^{n} H_{V_i}. \quad (7)$$

In case the elements v_1 and v_2 are dependent then

$$H_{V_1V_2} = H_{V_1} + H_{V_2/V_1}, \quad (8)$$

or

$$H_{V_1V_2} = H_{V_1/V_2} + H_{V_2}, \quad (9)$$

where H_{V_1/V_2} and H_{V_2/V_1} are the conditional entropies.

The mutual uncertainty of the dependent elements is smaller compared to the independent, i.e.

$$H_{V_2} \geq H_{V_2/V_1}. \quad (10)$$

TCS has its own functional and structural characteristics and properties.

The functional characteristic of TCS is its behavior characteristic in time. It can be represented by a mathematical description of the system reaction to some influences. The functional properties of TCS include:

– current traffic parameters;

– loading of resources;

– the size of the reserves;

– deviation of working parameters of network elements.

The structural characteristic of TCS is a conditional display of a set of its elements and interconnections between these elements. An adequate mathematical model of this structure is mathematical graphs, matrices, incidents, complexities, compatibilities.

The structural properties of the TCS include the existing configuration of the TCS network, which should be restructured in accordance with the change of functional capabilities state.

It is appropriate to draw attention to the following definitions: telecommunication systems and telecommunication routes.

In the case of a macroapproach to the classification of TCS above it was noted the following. TCS is the system of communication of the corresponding control unit, and all lines and means of communication are the system elements. The lines and communication means are called telecommunication routes. They are used to exchange information between the object of management and the data processing system.

The following definition is given in [5]. The telecommunication route is a communication path, a transmission path, a complex of technical equipment and communication lines for the formation of specialized channels for information transmission. Consequently, the concept of a "route" is broader than of a "channel". The routes are usually multichannel. The term "tone frequency channel" is used as a standard channel. The frequency clarity band width in it is within 300Hz – 3400Hz. The main characteristics of the channels are the clarity band and the kind of signals in them.

When defining the notion of "route", the main thing is its functional purpose. For example, the routes of reception – transmission of telemetry signals (TM), telesignaling (TS), telecontrol (TC), telegraphy (TG), alphanumeric arrays (ANA), radio link communication path, a group path of pulse-code modulation equipment, line channel of the compression system (organizing a large number of channels).

To organize the automatic control of the object nowadays the information management systems (IMS) are widely used. There the object of management is connected with the devices for processing information (including computers) with the help of lines and means of communication. Lines and communications are telecommunication routes. They transmit information of telemetry (TM), telesignaling (TS), telecontrol (TC), alphanumeric arrays (ANA).

In the case of a macroapproach to the classification of telecommunication systems, the information-control system is a telecommunication system itself. That is, the communication system of the corresponding control unit itself, and all the lines and means of communication are elements of this system.

In the case of a microapproach to the classification of TCS, i.e. with a more detailed consideration of its constituent parts, telecommunication routes can also be called telecommunication systems.

Taking into account that the mesoapproach is used at the level of interacting means and communication complexes, we can say that one of the possible variants of TCS is a certain number of IMSs, which are united in one whole. The information in them is transmitted in the form of numeral arrays and circulates in accordance with the protocols of exchange. And the tasks to be solved are:

– changes in the topology of TCS (tree-like, star-shaped, circular, general "tire", annular, multi-link);

– routing;

– defining and providing current traffic parameters;

– loading of resources;

– providing acceptable working parameters of the network elements, etc.

Telecommunication systems can be called weakly structured. The relationships between the elements in them are quite general and can be set, for example, by graphs, tables, logical connections. These relationships cannot be functionals or analytic functions.

A weakly structured system can be conditionally divided into a certain number of levels [6]. System levels can be considered as its elements, among which are communications, interfaces (real channels, electrical or logical connections). Seven-level models of TCS are also known. The list of levels of such a TCS is: applied, representative, sessional, transport, network, channel, physical.

The physical level is the physical environment (ether, fiber optic, wire, etc.), through which the signals are distributed from one consumer to another.

The channel level is providing of the interference protection, synchronization, signal coding.

The network level provides switching, routing the information packets. At this level, packet forwarding through the network as well as routing are implemented in accordance with the protocols.

The transport level serves to communicate with the upper levels that are responsible for organizing the information exchange.

The sessional level provides identification of connections, management of the dialogue between the applied processes of information processing.

The applied level is the upper level. It provides the quality of service, the availability of a partner to the transmission environment, the management of applied processes, terminals, network in general.

The representative level provides the choice of forms, the language of the alphabet and the format of presenting the information to the user, and in the opposite direction the transformation of information from the form of the upper level into the one that is required for its further transmission by the transport network takes place.

The seven-level model of the interaction of open TCS provides communication between TCS in accordance with interactions protocols.

The channel, physical, network and transport levels of the TCS combine the traditional notion of communication.

Three-level model of TCS is also known, according it the system performs three main functions: subscriber access, distribution of information flows and their transmission through the highways. This TKC model is quite constructive in the stages of studying or designing a particular system.

Most technical objects simulation can be fulfilled on the micro, macro and metalevels, which differ in the grain size of the considered processes in the object. Level methods differ from each other in type and dimensionality of the obtained system of equations. For the complex technical objects the dimensionality of a mathematical model (MM) becomes extremely high and it is efficient to proceed to the metalevel for simulation. At the meta-level, two categories of technical objects are mainly modeled: the objects that are the subject of the study of the theory of computerized control and the objects that is the subject of the theory of mass service. The objects that are the subject of the study of the theory of computerized control can be represented as a set of blocks, performing augment, integration, transmission of a signal with a given coefficient. We can say that these objects also include telecommunication channels of computerized information processing and management systems. For the first category of objects it is possible to use the mathematical apparatus of the macrolevel. Enough large elements can be distinguished when modeling at the macrolevel in the technical system, which are further considered as an indivisible unit. On the macrolevel the elements are an amplifier, modulator, etc. At the meta-level structural object schemas are used, which include the elements selected at the macrolevel. For each

structural element the transmitting functions are defined. The transmitting function of the whole topological model of a complex technical object, in this case of a telecommunication path, is determined with taking into account the functions of the transmission of separate constituent parts – structural elements. It is a mathematical model of a complex technical object itself. Therefore, due to the nature of the research and taking into account the requirements for the simplicity and reliability of the set problem solution, it is most appropriate to select and use mathematical models in the form of transmitting functions of telecommunication paths elements.

The receiving-transmitting path of informational sending of telecontrol and telesignaling has the following generalized mathematical model:

$$Y = F(X, Q), \tag{11}$$

where Y, X, Q are the vectors of output, internal and external parameters, F is the operator of the object. We can record

$$\begin{aligned} Y &= (y_1, y_2, \ldots, y_m), \\ X &= (x_1, x_2, \ldots, x_n), \\ Q &= (q_1, q_2, \ldots\ldots, q_l), \end{aligned} \tag{12}$$

where m, n and l are the number of output, internal and external parameters.

By the nature of the operator, the object of the model can be in the form of: a linear differential equation of the nth degree, a differential equation in separate derivatives, systems of linear differential equations, finite-difference equations, a system of regressive equations, transfer functions, weight functions.

An alternative to mathematical modeling is a physical breadboarding, but mathematical modeling has a number of advantages: less time to prepare an analysis, a possibility to perform experiments on critical behaviours that would lead to the destruction of the physical prototype and others. Most technical objects simulation can be fulfilled on the micro, macro and metalevels, which differ in the grain size of the considered processes in the object. Level methods differ from each other in type and dimensionality of the obtained system of equations by sampling the components of the equations of reactive branches, by the permissible types of interconnected branches. For the complex technical

objects the dimensionality of a mathematical model (MM) becomes extremely high and it is efficient to proceed to the metalevel for simulation. At the meta-level, two categories of technical objects are mainly modeled: the objects that are the subject of the study of the theory of computerized control and the objects that is the subject of the theory of mass service. The basic provisions for obtaining mathematical models of technical objects at the macrolevel are as follows. When modeling at the macrolevel rather large elements are singled out in the technical system, they are further considered as an indivisible unit. For each element of a simulated technical object the component equations must be obtained. The systems obtain MM by combining component and topological equations. Component equations can be linear, nonlinear, algebraic, ordinary differential or integral. The analogy of the component equations is as follows.

In most technical systems and telecommunication tracts, in particular, three types of elementary elements can be distinguished.

1. The element of R-type. This element transforms energy into heat energy.

2. Elements C and L (accumulation of kinetic and potential energy).

The mathematical models of almost any complexity technical objects can be received by combining these elementary elements, as well as the sources of phase variables. The phase variables of the electrical subsystem are the currents I and the voltages U. The resistance equation: $I = U/R$. Capacity equation: $I = C(dU/dt)$. Inductance equation: $I = L(dI/dt)$. The analogies of the topological equations are as follows. The topological equations in most physical subsystems are based on the equilibrium equation and the continuity equation. In electrical subsystems the connections between separate elements are established on the basis of Kirchhoff's law. The topological equations of subsystems are written down for junctions and contours of the equivalent circuit. The objects that are the subject of the study of the theory of computerized control can be represented as a set of blocks, performing addition, integration, transmission of a signal with a given coefficient. The connection between separate phase variables (currents and voltages) related to different subsystem elements is given by the topological equations derived from the information about the subsystem structure (L, R, C, active elements). The procedure for obtaining topological equations is fulfilled for each

modulated object (amplifier, modulator, digital analog converter, quasi-optimal receiver, etc.) because the object structures are different. At the macrolevel the objects are an amplifier, a modulator, etc. At the metalevel structural schemas of an object are used instead of topological equations of the whole structure. The transfer function is determined for each structural element.

We consider it most efficient to choose and use the mathematical models in the form of transmitting functions. That is, they must be theoretical by the way of obtaining models, analytical – by way of displaying the object properties, belonging to the meta hierarchical level, complete – by the nature of the detailed description within a single level, functional – by the nature of the object mapping properties.

Taking into account all the given above, we can say that the variety of models confirms that TCS belongs to complex organizational-technical systems.

Conclusions

It is shown in which relations the notions of telecommunication systems, information-control systems, telecommunication paths, communication channels stand. A clear understanding of this becomes the basis for:

– ensuring the correspondence of the national information infrastructure to the international standards and recommendations of the International Telecommunication Union (MCE), the European Conference of Postal and Telecommunication Administrations (CEPT) and the International Organization of Standardization/International Electrotechnical Commission (ISO/IEC), which will promote the interaction of its technical means, information devices and services with those operating in the global information space within the European and Global information infrastructure;

– creating a single national integrated multiservice broadband communication network;

– TV and radio networks optimization and distribution of information and channels flows, increasing the efficiency of these networks usage, their modernization and development with providing the necessary level of functioning quality;

– creating and implementing domestic secure information technologies and systems for protecting information from unauthorized access and unauthorized distribution.

The following definition is given: “Telecommunication system is a communication system of the corresponding control level”.

Telecommunication path is a complex of technical equipment and communication lines intended to form specialized channels for information transmission. In defining the concept of a path the main thing is its functional purpose (for example, “the compression system path”, etc.).

The main characteristics of the channels are the frequency clarity band width and the type of signals in them (for example, the “tone frequency channel” with a frequency band width of 300 Hz - 3400 Hz).

Information-control systems in some cases can be considered telecommunication systems, and in other cases they can be considered as the elements of telecommunication systems. It all depends on the macro, micro and mesaapproach to the classification of TCS.

Telecommunication systems can be called weakly structured.

The multitude of the models confirms that TCS belongs to complex organizational-technical systems. That is, the main technological tasks of the information society development strategy are the development of modern telecommunication infrastructure, since the creation of a highly efficient telecommunication environment is a major national problem [2]. Without solving it, the building of an information society and the application of information technology achievements to the fields of production, business, science, education, medicine and culture will turn out to be problematic. The amounts of data flows transmitted by the modern telecommunication systems grow in geometric progression within the simultaneous acceleration of the process of combining heterogeneous information flows. Therefore, as a part of creating and developing the national information infrastructure for the building an integrated telecommunication environment of the information sphere it is necessary to provide:

– a balanced development of all types of telecommunications with the priority use of digital technologies;

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– a preference for telecommunication provision of national, sectoral and regional information poles and their association with interregional communication channels;

– a creation of telecommunication systems supporting the information interaction of the person with the state and public structures of all levels.

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S.V. Olszewski, Yu.Yu. Med, V.O. Nosenko

FEATURES OF ELECTRORADIOLYTIC DESTRUCTION OF PERSISTENT ORGANOCHLORINE TOXICANTS

Annotation. *The unsatisfactory state of the specialized storage facilities of persistent organochlorine toxicants of agricultural use on the territory of Ukraine indicates the urgency of the creation of mobile systems for the destruction of mixtures of toxicants or toxicants of undetermined chemical composition. Perspective in terms of universality may be the method of electroradiolytic destruction of hazardous substances in the liquid phase. However, the expected energy consumption of the electroradiolysis method calls into question the profitability of its industrial use. The paper presents a methodology for estimating the minimum possible energy consumption during electroradiolytic decomposition of persistent organochlorine toxicants into individual atoms and it is shown that due to the structural transformations of parent molecules whithout change of their atomic composition, energy costs exceed the total dissociation energy of toxicants and of their fragments.*

Keywords: *high-energy particles, electroradiolytic destruction, persistent organochlorine toxicants.*

Introduction

Article 6.1.d of the Stockholm Convention on Persistent Organic Pollutants, to that Ukraine is a party, notes that waste such as organochlorine toxicants should be "disposed of in such a way that the content of a persistent organic pollutant is destroyed or irreversibly transformed ...". At the same time, reliable engineering and technical methods embodied in mobile systems, that are aimed to the destruction of mixtures of toxicants or toxicants of an indefinite chemical composition have not been created. The unsatisfactory state of practically all specialized storage facilities of agricultural toxicants on the territory of Ukraine unambiguously indicates both the high actualyti of the needs for these mobile systems and the state level of these needs.

A promising in this aspect is a number of plasma-chemical technologies for the distruction of toxic organe compounds in aqueous solutions based on the use of high-energy flows of plasma particles bombarding the liquid surface [1]. This influence on the processes of molecules decomposition in a liquid phase called elektroradiolytic destruction. For the design of industrial samples of plasma-liquid reactors, that use the electroradiolytic mechanism of destruction, it is important to have methods for quantifying the required power consumption for the destruction of specific toxic compounds with defined

molecular structure [2]. Particularly, that assessments are important for neutralization of mixtures of toxicants, since universal environmentally admissible methods of utilyzation of toxic mixtures are not created currently [3]. The paper considers the method of estimating energy costs for the destruction of persistent organochlorine molecules by simulating the quantum-mechanical properties of the shock dissociation reactions of the dichlorodiphenyltrichloroethane (DDT) molecule and its dissociation products.

Energy content of electroradiolytic destruction of molecules

The total energy that needs to be spent on the destruction of a complex molecule can be defined as the multiply of the destroyed molecules number by the sum of the dissociation energies of the target molecule and its fragments. For its calculation it is necessary to consider a totality of dissociation chains that include the molecule itself and all the products of the subsequent decomposition acts, except individual atoms. The dissociation energy of the *j*-th bond can be calculated as the difference in energy between the main and dissociated states of the molecule:

$$W_j = E_F - E_0 \quad (1)$$

in here E_0 – is the energy of the parent molecule in the ground state, E_F – is the energy of the dissociation state.

In fact, the task of evaluating the energy required for the complete destruction of a organochlorine stable molecule under the influence of a stream of high-energy particles is reduced to enumeration of all possible channels of dissociation of the molecule and its fragments, obtaining an array of dissociation energies and dissociation rate constants for each destruction channel and their summation taking into account the probability of the corresponding destruction channel. For reactions of order 1, that include shock dissociation, the count of destroyed molecules per unit time in volume unit is equal to the multiply of the constant of the reaction rate by the total number of primary molecules in volume unit. By definition, the probability of the j-th destruction channel will be the ratio of the number of destroyed molecules in the j-th channel to the total number of destroyed molecules by all possible channels:

$$p_j = \frac{\Delta N_j}{\sum_j \Delta N_j} = \frac{k_j N}{\sum_j k_j N} = \frac{k_j}{\sum_j k_j} \quad (2)$$

Consequently, the minimum required energy of complete destruction of complex molecules can be estimated as:

$$E_{total} = \sum_j p_j W_j \quad (3)$$

However, for polyatomic molecules, that are quantum mechanical systems, this estimate is strongly understated, since their transformation can be quite elaborate and require much greater activation energy for dissociation reactions.

Any chemical transformation of the molecular system, associated with a change in the mutual arrangement of its constituent atoms, can be considered as its phase motion along the coordinate of the reaction to the hypersurface of potential energy $E\left(\vec{\xi}\right)$. Here and thereafter E – is the potential energy of the system, $\vec{\xi} = \left(r_1, \varphi_1, \vartheta_1, r_2, \ldots r_N, \varphi_N, \vartheta_N\right)$ – is the vector of the internal coordinates of the *N*-atomic molecule. As the reaction coordinate, it is understanded the trajectory of motion on the hypersurface of potential energy, along which the energy has a minimal value. In order to predict the direction and rate of conversion of the molecular system, one must know the dependence of the energy of the system *E* on the relative position of the atoms. Depending on the distance between the atoms, the value of *E* corresponds either to non-interacting atoms **X** and **Y** (region $U = 0$) or to a stable **XY** molecule ($U = U_{\min}$), or to intermediate formations that are realized in the process of recombination of **X** and **Y** atoms or to the excitement of internal states of the **XY** molecule in dissociation. All elementary chemical reactions can be divided into two groups. The first group is the reaction for which the maximum on the hypersurface of the potential energy along the coordinate of the reaction is absent. This case is characteristic for many processes of homolytic destruction of a chemical bond with the formation of two radicals. For this reactionary group, the bursting energy of **XY**

bonds can be calculated as the difference between the sum of the energies of individual fragments **X**, **Y** and the energy of the molecule **XY**.

The second group is the reactions for which the hypersurface of potential energy pass through maximum during motion along the coordinate of reaction. The location of this maximum are accepted as the transition state of the reaction.

For a radical decay, the activation energy coincides with the enthalpy of the reaction, which, in turn, can be calculated in accordance to the expression:

$$\Delta_r H^0\left(R_1 - R_2\right) = \left(\Delta_f H_{opt}\left(R_1\right) + \Delta_f H_{opt}\left(R_2\right)\right) - \Delta_f H_{opt}\left(R_1 - R_2\right) \qquad (4)$$

here $\Delta_f H_{opt}\left(R_1 - R_2\right)$, $\Delta_f H_{opt}\left(R_1\right)$ and $\Delta_f H_{opt}\left(R_2\right)$ – the enthalpy of the formation of the parent compound and the corresponding radical fragments, that born during the breakdown of the chemical bond. The criterion for the rightfulness of the use of expression (4) is the absence of transitional states of the initial molecule in the process of its dissociation. The absence of such transitional states can be established in the absence of a clearly expressed maximum on the dependence curve of the potential energy of the molecule on the coordinate of reaction. For reactions of non-radical transformation of molecules instead of enthalpies of the final and initial states it is necessary to use the enthalpies of the transitional and initial states.

The calculation of the main kinetic and thermodynamic parameters of chemical reactions that must occur in the liquid phase can be carried out under the conditions of the Arrhenius law. Using the basic ideas of the theory of transition state (activated complex) and quantum-mechanical methods, one can calculate the constant of the speed k_t of an elementary chemical reaction. An important role in these calculations is played by the Eyring equation that binds the constant of the reaction rate and the equilibrium constant of the formation of the activated complex [4], expressed through the concentration $k_t = \frac{ek_B T}{h} K_c^{\neq}$, where k_B is the Boltzmann constant, h is Planck's constant.

Results of simulation and discussion

The potential energy of the system was found from the solution of the Schredinger equation for the wave function of the polyatomic molecule in the *n*-th state $\Phi_n\left(\vec{\xi}\right)$, also called the molecular orbital.

$$\hat{\boldsymbol{H}}\left\{\Phi_n\right\} = E_n \Phi_n\left(\vec{\xi}\right) \tag{5}$$

here $\hat{\boldsymbol{H}}\left\{\cdots\right\}$ – Hamilton's operator, E_n is the energy of the molecule in the *n*-th state.

According to the LCAO method, the molecular orbitals $\Phi_n\left(\vec{\xi}\right)$ were represented by a linear combination of atomic orbitals:

$$\Phi_n\left(\vec{\xi}\right) = \sum_{i=0}^{M} c_{n,i}\varphi_i\left(\vec{\xi}\right) \tag{6}$$

where M is the number of functions that is determined by the necessary accuracy and was a free parameter of the task. The explicit form of atomic orbitals $\varphi_i\left(\vec{\xi}\right)$ was approximated by a linear combination of basic functions from the standard Pople basis sets:

$$\varphi_i\left(\vec{\xi}\right) = \sum_{j=0}^{J} b_{i,j} G_j\left(\vec{\xi}\right) \tag{7}$$

Here $G_k\left(\vec{\xi}\right)$, in explicit form, there are functions from the Pople basis set: $G_{nlm}(\boldsymbol{r},\theta,\varphi) = N_n(\alpha)\boldsymbol{r}^{n\text{-}1}e^{-\alpha \boldsymbol{r}^2}Y_{lm}(\theta,\varphi)$, where $Y_{lm}(\theta,\varphi)$ – are spherical functions.

Substituting (7) into (6) received:

$$\Phi_n(\xi) = \sum_{i=0}^{M} c_{n,i} \sum_{j=0}^{J} b_{i,j} G_j(\xi) = \sum_{i=0}^{M}\sum_{j=0}^{J} c_{n,i} b_{i,j} G_j(\xi) = \sum_{j=0}^{J} a_{n,j} G_j(\xi) \tag{8}$$

where $a_{n,j} = \sum_{i=0}^{M} c_{n,i} b_{i,j}$.

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That is, the problem of the synthesis of wave functions was reduced to the problem of finding the coefficients $a_{n,j}$.

The coefficients $a_{n,j}$ were found by solving the optimization problem for the target function that assumed the value of the potential energy $E(\vec{x})$ in the J-dimensional space of the coefficients by the Marquardt method, where $\vec{x} = \left(a_{n,1}, a_{n,2}, \ldots, a_{n,j}, \ldots, a_{n,J}\right)^{T}$.

As a result of the calculations, it was shown that the activation energy of the radical decomposition of the DDT molecule lies within the range from 6.0 to 8.7 eV. The least energy of radical dissociation corresponds to the separation of the chlorine atom from the CCl_3 group. The greatest energy of radical dissociation corresponds to the separation of the hydrogen atom from the benzene ring. The constants of the velocity of radical dissociation lie within the limits from $3.3809 \cdot 10^{4}$ to $8.1736 \cdot 10^{-6}$ c^{-1}.

More interesting from the viewpoint of estimating the energy of DDT destruction are the channels of non-radical decay. As the simulation showed, there are channels of molecule transformation that don't change its elemental composition, but need energy expenditure for activation, which, after transformation of the molecule, dissipates to heat. We call these reactions invariant transformations (Fig. 1).

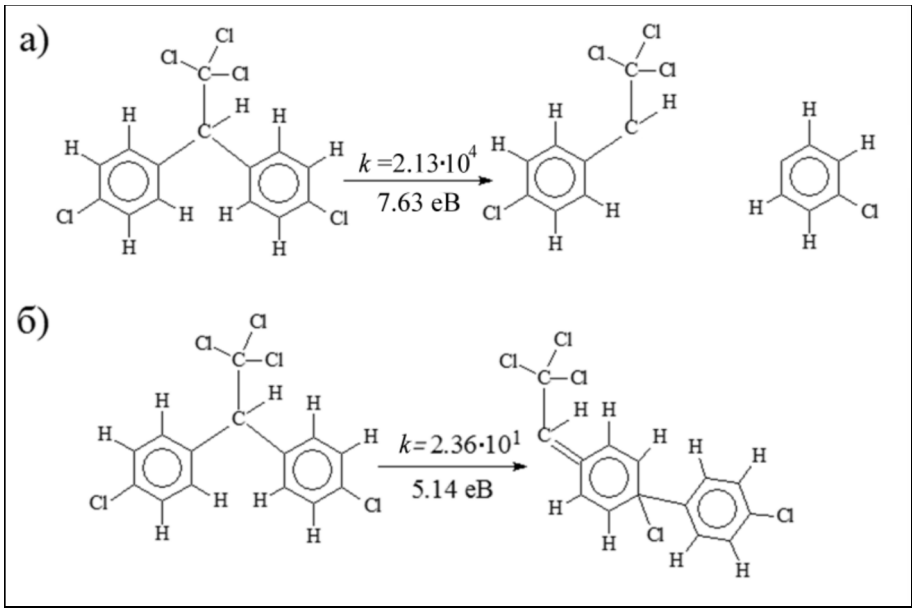

Figure 1 – Channels of radical destruction – a) and invariant transformation – b) of DDT molecules.

The calculations have shown that the activation energy of the radical decay is 7.63 eV, with the constant of the reaction rate $2.13 \cdot 10^4$ s^{-1}. At the same time, the energy of the invariant transformation is 5.14 eV, that is, it has the same order of magnitude. The rate constant of the invariant transformation is $2.36 \cdot 10^1$ s^{-1}.

The dependence of the potential energy of a DDT molecule on the reaction coordinate under radical decay and invariant transformation is shown in Fig. 2

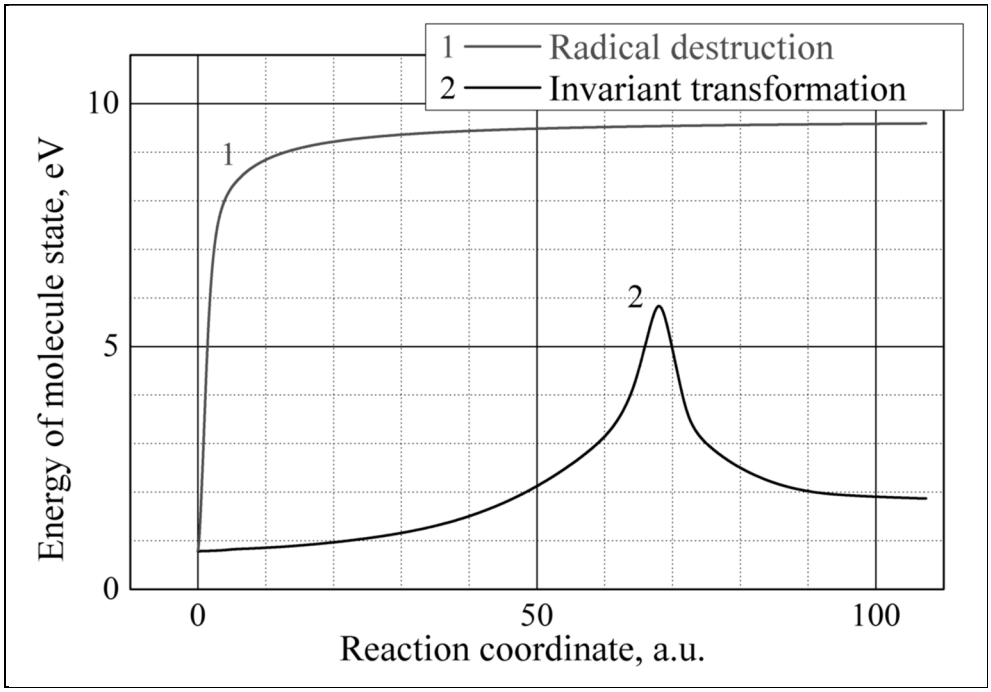

Figure 2 – Dependences of the potential energy of a DDT molecule on the reaction coordinate under radical decay – curve 1 and invariant transformation – curve 2.

Curve 1 corresponds to the trajectory of the radical decay reaction, curve 2 - the trajectory of the reaction of the invariant transformation. As can be seen from the obtained dependencies, in the case of radical dissociation, the energy of the high-energy particle is spent on the destruction of the target, and formula (1) for estimating energy costs for destruction is valid. Conversely, for an invariant transformation, the energy of the initial and final states varies little, and the energy of the high-energy particle is spent on the excitation of the transition state, and in the future, when the target passes to the final state, it dissipates in the form of heat. In this case, the elemental composition of the molecule does not change, which causes a high probability of reverse transformation into the parent toxicant.

In fact, the presence of channels of invariant transformation of target molecules and their fragments causes a significant increase in the energy that must be introduced into the solution of persistent toxicants by the flow of high-energy particles. Despite the fact that the rate constant of such reactions is much less than for radical dissociation reactions, their influence may be significant, since target molecules don't escape from the reaction zone. Thus, the method of estimation of actual energy consumption for the destruction of persistent organochlorine toxicants can not be reduced to direct summation of the activation energies of the dissociation of parent molecules and their fragments. This estimation requires the solution of the kinetic problem of scattering the flow of high-energy particles in solutions of the toxic chlororganics in the conditions of competition of invariant transformations and impact dissociation.

Conclusions

- Electroradiolytic mechanism of DDT molecules destruction includes both radical and non-radical dissociation and transformation, that invariant with respect to the molecule atomic composition. The activation energy of invariant transformations is small different from the dissociation energy.
- Despite the fact that the rate constants of invariant transformations are usually three orders less than the dissociation rate constants, it is impossible to exclude the contribution of these transformations from the total energy consumption, since the concentration of toxic reagents due to such reactions practically does not change.
- The presence of invariant transformations is a source of unproductive dissipation of the energy of the high-energy particles stream, that causes an increase in the minimum required power of plasmochemical reactors for the neutralization of persistent organochlorine toxicants by the electroradiolytic mechanism.

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S.V. Olszewski, Ya.V. Tanasiichuk

MODELING OF FREQUENTIS CHARACTERISTICS OF RESONATOR SYSTEM OF POWERFUL KLYSTRON WITH THE MELTING OF THE TRANSIENT CHANNELS

Annotation. *The idea of regeneration of powerful microwave devices arose in the 50's of the last century. As the experience of profile enterprises of Ukraine shows, in most cases only the replacement of a cathode unit is performed during regeneration. However, in order to decide on the suitability of the device for regeneration, it is necessary to make a defect of the structure to match the TC. The paper presents the results of modeling the influence of mechanical defects on the state of the resonator system of a powerful klystron and their numerical impact assessment. The principal possibility of performing the diagnostics of the construction of microwave devices on the subject of its suitability for regeneration by non-destructive methods with localization of the defect in the constructionis shown.*

Keywords: *klystron, construction's defect, diagosmic microwave devices.*

Introduction

The analysis of works devoted to the regeneration of high-power microwave devices [1,2] shows that the constructive and technological complexity of such devices led to the establishment of the concept of restoration, which reduces to the dismantling of the device that has refused, on separate гтшees, while deflecting defective, are suitable for reuse in other devices of the same type.As shown by the analysis of the data of the defect of devices made on the State Enterprise plant "Generator", suitable for regeneration, there are about 55% of the devices provided by the customer.With such a high percentage of defective devices and the use of manual disassembly of elements, the process of defect becomes a source of non-productive technological costs.In this connection, the task of optimizing the process of defect in terms of exclusion from the technological cycle of the defect of unprofitable operations and increasing the accuracy and speed of diagnosis.One of the possible solutions may be the creation and use of diagnostic methods that would not require manual disclosure of the device.Such methods can be, for example, cold measurements of electrodynamic parameters of resonator units or the method of scanning probe microscopy for surface control.In the analysis of the main reasons for the device to be regenerated, it was discovered that the main reasons are: melting of transmitted channels; flow of liquid from the cooling system; sputtering

at the cathode pole in the vicinity of transmitted channels; scale on the internal surfaces of the resonator system, etc. One of the common defects ofunits (about 25%) in the interior vacuum cavity is the melting of transmitted channels of resonators. Therefore, it is expedient to start work on simplifying the process of defect, namely, on the development of methods for detecting this defect by non-destructive methods.

Experiment technique

As can be seen from Figure 1, the electronic stream must pass from the cathode through the lattice, the flowing channels of the resonators and settled on the anode. Whether its deviation is inadmissible and entails a number of negative consequences such as changing the output parameters, melting in the construction, and others.

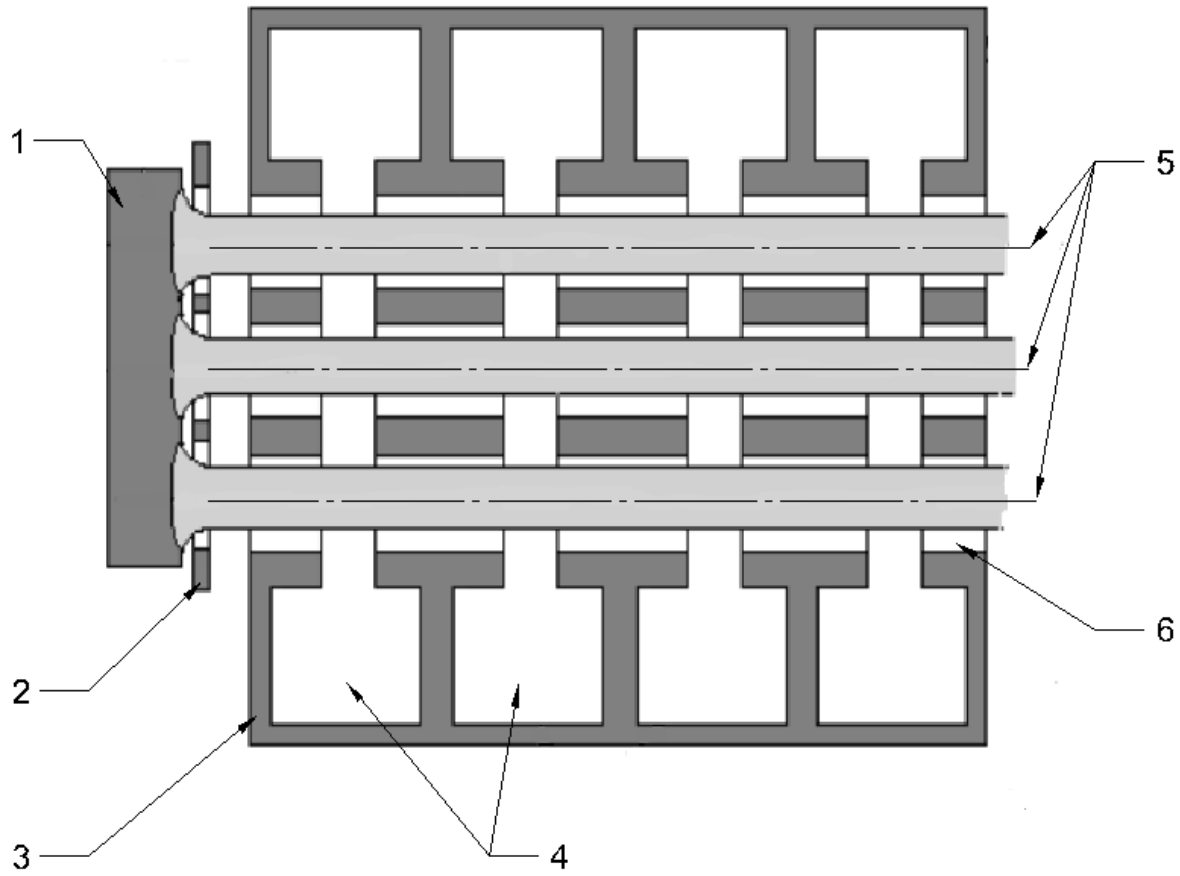

Figure 1 – Idealized klystron scheme. 1 - cathode, 2 - lattice, 3 - anode, 4 - resonators, 5 - electronic bundles, 6 - transmitted channels..

Since the acquisition of real devices for research is associated with a number of difficulties, then for the study of the effect described above defects, the resonator system of klystron (Figure 1) built its simulation model in an HFSS Ansoft [3] environment with characteristics Q_0= 133,

fрез =0,915 ГГц. . The walls of the resonator were considered to be perfectly conducting surfaces. Its frequency is shown in Figure 2.

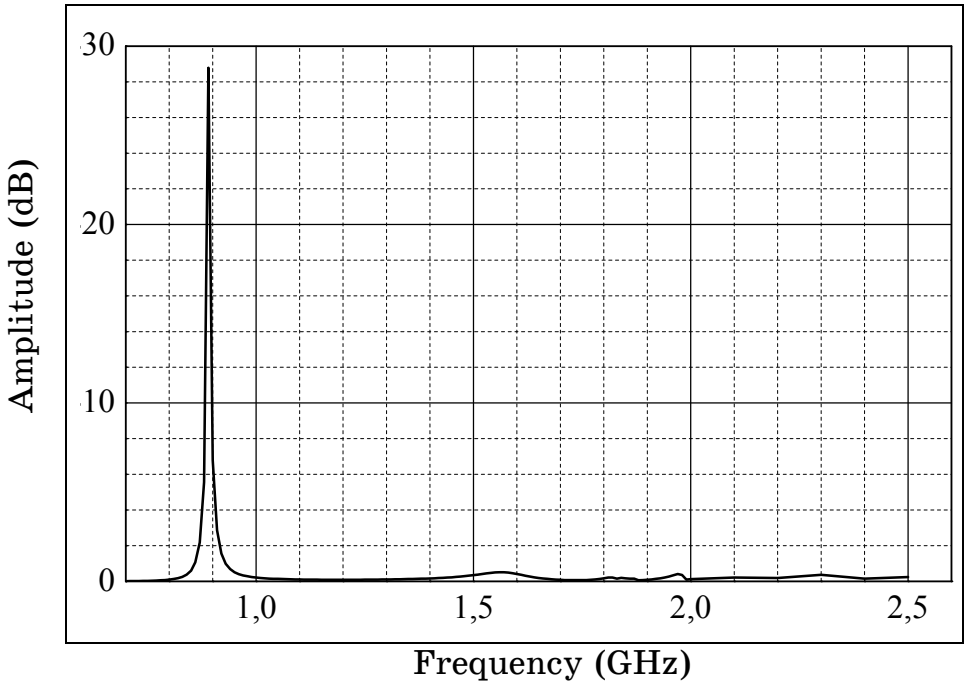

Figure2 – AFCmodels of the resonator systemof a powerful klystron.

Effect of melting on the frequency response of the resonant system

Melting in the resonator system leads to a change in its geometry. They have a cylindrical shape. As is known, [4] the resonator is part of the space bounded by a metal wall. Since the form of the defect is close to the cylindrical one, the defect itself can be regarded as a cylindrical cavity resonator attachedto the resonator system of the microwave device.For resonances of E-waves in a cylindrical resonator there is [5]:

$$(\lambda_0)_{\mathrm{E}} = \frac{1}{\sqrt{\left(\frac{\nu_{ni}}{2\pi R}\right)^2 + \frac{p^2}{4l^2}}} \quad (1);$$

Where$R$ – inner cylinder radius and$l$ – its height.he numbers n, i, p, determine respectively the field variation along the azimuth, radius and height of the resonator.By$\nu_{ni}$the$i$-throot of the bessel function of the first kind of the n-th order is indicated.

Resonances of type H waves in a cylindrical resonator are determined by the relation:

$$(\lambda_0)_H = \frac{1}{\sqrt{\left(\frac{\mu_{ni}}{2\pi R}\right)^2 + \frac{p^2}{4l^2}}} \quad (2);$$

Byμ_{ni} the$i$-throot of the bessel function of the first kind of the n-th order is indicated

Since R i l parameters of the resonator defect are much smaller than the characteristic dimensions of the resonance system, then its resonant wavelength will also be much smaller. At the frequency response of the resonator system this will be manifested in the form of harmonicappearance.

Results of modeling

In order to generate an electromagnetic field solution, HFSS employs the finite element method[6]. In general, the finite element method divides the full problem space into thousands of smaller regions and represents the field in each sub-region (element) with a local function.

In HFSS, the geometric model is automatically divided into a large number of tetrahedra, where a single tetrahedron is a four-sided pyramid. This collection of tetrahedra is referred to as the finite element mesh. For the model, the following parameters were set: band frequency 0,7..2,5GHz, step 10 MHz, maximum number of passes 10.

The results of the analysis of modelconstructionare shown in Figure 2. The next step was to attached changes to the constructionof the resonator model to simulate the melting of the transmitted channels. For this purpose, a cylinder was placed on the resonator wall and its radius R, length l and location in the structure of the resonator were varied and fixed as the frequency response of the system.

As you can see from Figure 3,for$R_1$the average harmonics ranges from 2.5 to 5dB. However, it is clearly visible that the peak reaches 10 dB and corresponds to the resonance frequency of the defect.

With an increase in R_1toR_2 , as expected, the resonance frequency of the defect began to decrease and the division of harmonics into groups around two peaks at 15 dB.

Finally with R_3, which was the maximum value of the radius of the defect, formed three groups of harmonics around clearly defined peaks.

As can be seen from Figures 3.4, 5, the attached of a defect has little effect on the resonance frequency of the system, but causes the appearance of harmonics $f_h$and a decrease in the amplitude at the resonant frequency.As we see in the vicinity of the same frequencies there are harmonics families of different amplitudes, which depends on the position of the defect in the construction. Thus we can talk about the possibility

of defect localization in the construction by analyzing the frequency response of the system.

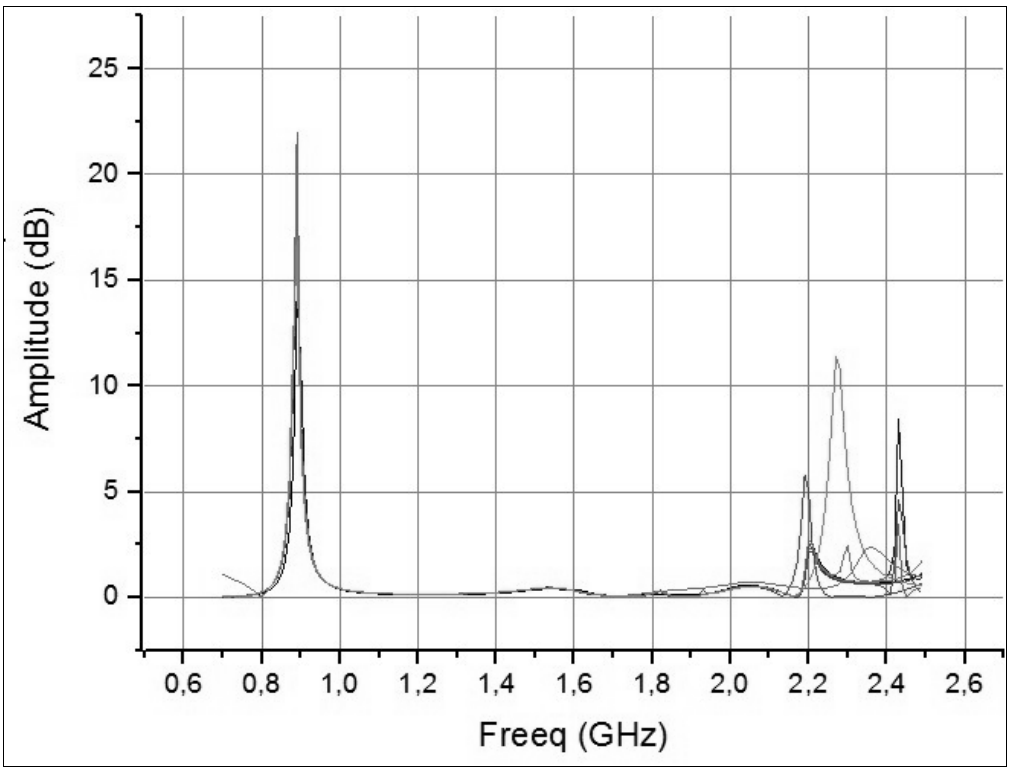

Figure 3 – AFC model of a resonator system of a powerful klystron with a defect's volume of 1% of the volume of the resonator.

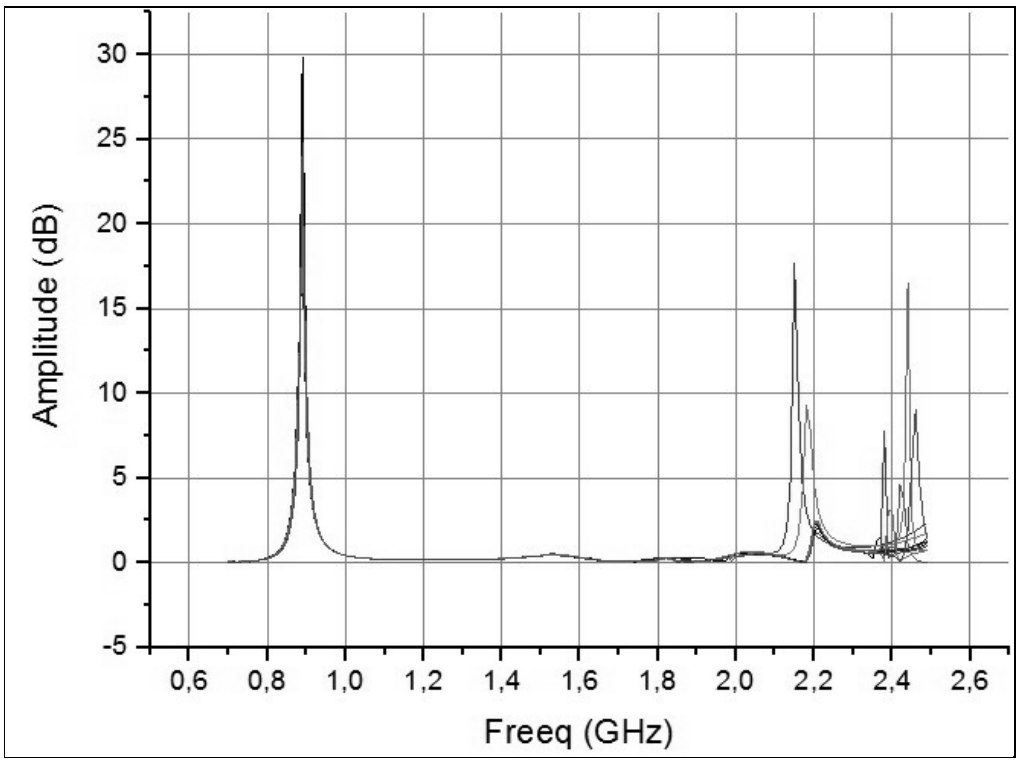

Figure 4 – AFC model of a resonator system of a powerful klystron with a defect's volume of 3% of the volume of the resonator.

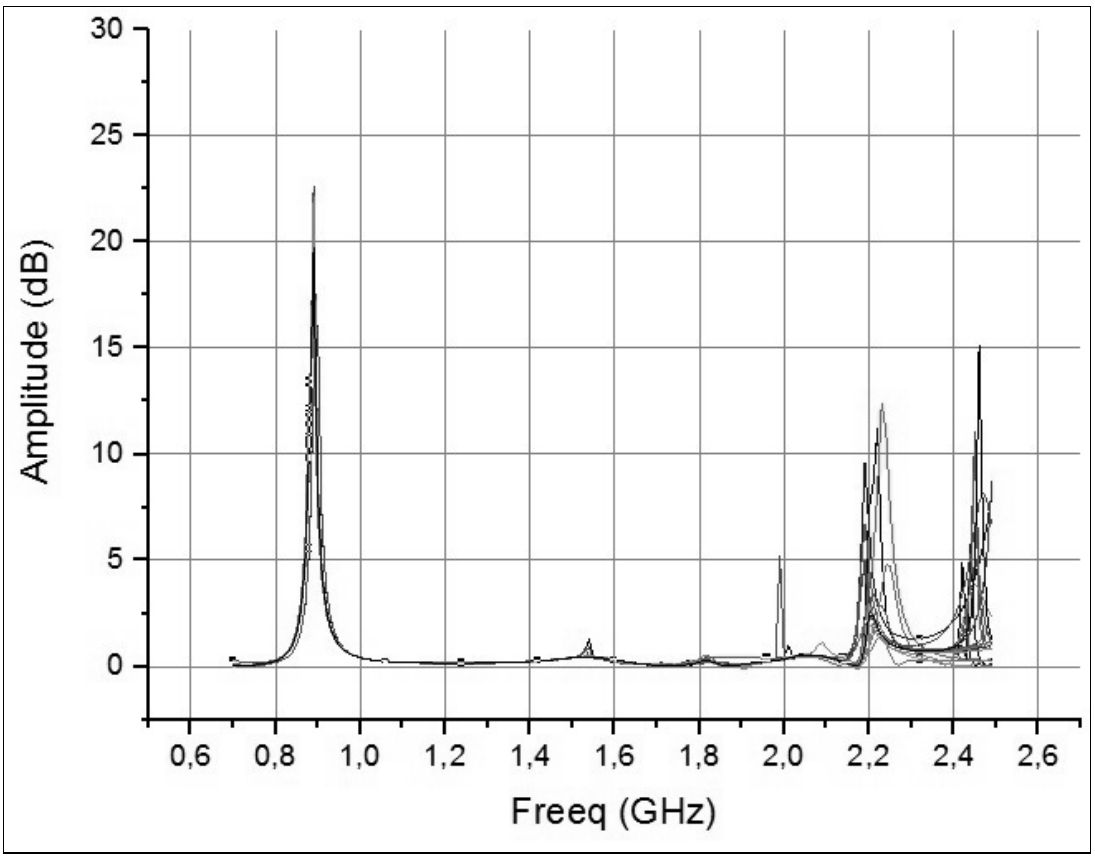

Figure 5 – AFC model of a resonator system of a powerful klystron with a defect's volume of 5% of the volume of the resonator.

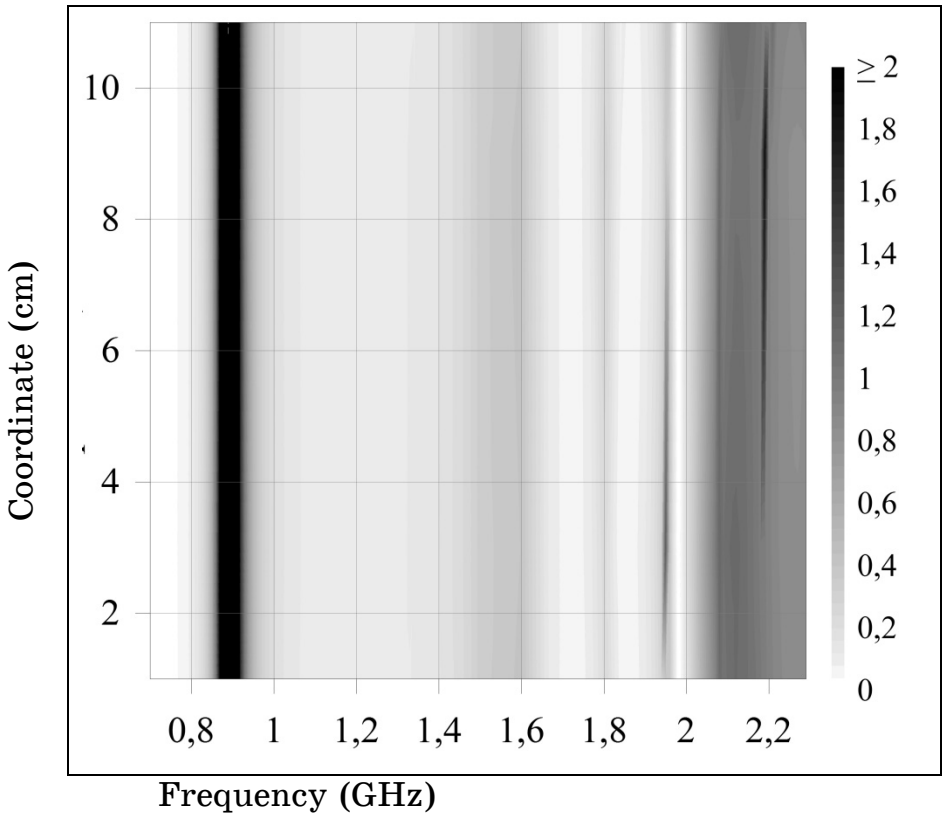

Figure6 – An example of defect localization in a construction.

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As we can see from Figure 6, the attached of a defect causes the expansion of the spectrum line in the range of 0.8-1 GHz, indicating a small displacement of the resonant frequency of the model. Lines at frequencies close to 1.95 GHz and 2.2 GHz reflect harmonics caused by a defect. As you can see, the gradation of the color of these lines depends on the position of the defect in the construction, which makes it possible to localize it.

Returning to formulas 1 and 2, knowing harmonics frequencies becomes an interesting inverse problem - finding the parameters R and l of a cylindrical resonator, which will allow us to estimate the magnitude of the defect and obtain more data for making a decision about the state of the system in general.

Conclusions

• A hypothesis was made about the possibility of detecting the melting of transmitted channels in the resonator system of the klystron by measuring the frequency response of normal and defective devices. To test the hypothesis, an imitation model of the resonator system was constructed. It is now possible to identify and locate the structural defect in the resonator system of the klystron in the form of melting.

• A set of AFCs for systems with defects with volume from 1 to 5% of the resonator volume is obtained, and the numerical values of the harmonics amplitudes when variations in the size of the defect and its position in the structure.

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UDK 004:93

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INFORMATION TECHNOLOGY OF UPDATING OF DECISION SUPPORT ALTERNATIVES IN THE DISTRIBUTED DATABASE OF CRITICAL APPLICATION SYSTEMS

Annotation. *Information technology of generating and evaluating of relevant alternatives for making decisions for the distributed database upgrading in ergatic systems of critical application is proposed. Using the method of fuzzy classification for generating and evaluating of relevant alternatives for making decisions in conditions of inconclusive, inaccurate and contradictory information in real time is considered.*

Key words: *decision – making relevance, ergatic systems of critical application, real time mode, informational needs.*

Actuality of the research

This paper aims at improving information technology of decision support in complex ergatic systems of critical application.

Using the given information technology will allow to generate and evaluate relevant alternatives for decision – making made by a human operator in conditions of inconclusive, inaccurate and contradictory information in real time with the following upgrading of the distributed database. Due to this the paper is considered to be of great importance.

Analysis of publications on the problem

Supporting the relevance of the knowledge base (KB) operation is a difficult and time-consuming process. Proposed ways of the KB updating and its support [1-3] suggest professional technical knowledge, moreover, they presuppose the existence of large arrays of address databases received from various sources. In papers [4-6] methods of examination and diagnosis in order to maintain the KB relevance are considered. There are some disadvantages of the KB upgrading in using expert methods [3] connected with the customer's inability to define needs exactly to the system being developed. Also, physiological problems may appear. Developing the KB system, the expert can prevent the transfer of his knowledge, fearing of being replaced with the machine after a little while [7]. Considered ways of the KB upgrading, in our opinion, are the complex procedure and they take much time.

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This paper presents information technology of the KB upgrading by means of preformatting, with using fuzzy classification, relevant alternatives for decision making, with the further their expert evaluation, which in turn will allow to boost operativeness of the KB upgrading process in critical application systems in managing of complex technological facilities in real time.

The purpose of the paper

Improving information technology allowing in real time to generate and evaluate relevant alternatives for decision support made by a human – operator with the further upgrading of the distributed database (DB).

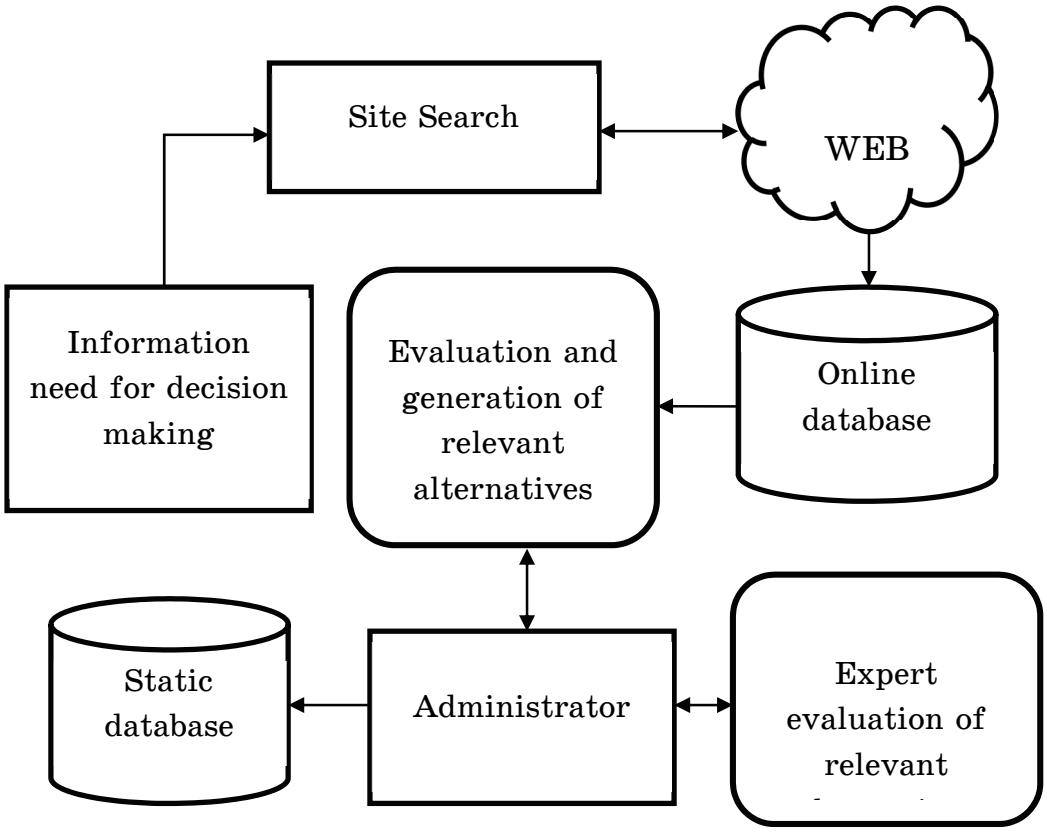

Figure 1 – Information technology of generating, evaluating and upgrading of decision making alternatives in the distributed DB

First of all, it is necessary to divide lots of documents D into two groups (classes): C_1 - relevant and C_2 - irrelevant documents. The following factors affect the document relevance [8]:

F_1 - number of repetitions of keyword query in full scale in the document;

F_2 - number of repetitions of search request in document subtitles;

F_3 - number of repetitions of synonyms of key words.

To solve this problem, we use the method of fuzzy classification [9]. Introduce fuzzy variables V_1, V_2, V_3, which we call as well as informative signs F_1, F_2, F_3. Let all the variables have two single therms: “low number”, “high number”. Then we will label therms V_1 by ″sign1″, ″nosign1″; therms V_2 by ″sign2″, ″nosign2″; therms V_3 by ″sign3″, ″nosign3″. Quantitative informative signs F_1, F_2, F_3 are labeled by x_1, x_2, x_3. Where $x_1, x_2, x_3 \in N$, that is a set of natural numbers.

Membership functions $\mu_{11}(x_1)$ and $\mu_{12}(x_1)$ the therms ″nosign1″ and ″sign1″ respectively from the input variable x_1 are shown in fig.2.

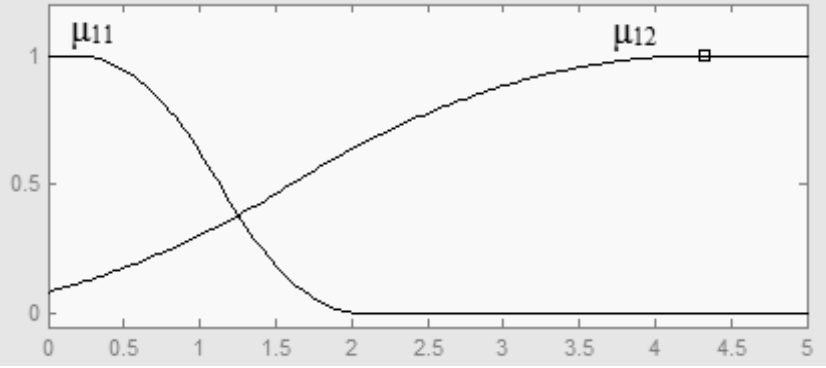

Figure 2. Membership functions

They represent standard polynomial functions of Fuzzy Logic Toolbox package, each of which is characterized by two parameters, that is $\mu_{11}(x_1) = zmf(x_1, [a_1\ b_1])$, $\mu_{12}(x_1) = smf(x_1, [e_1\ d_1])$. Similarly, functions $\mu_{21}(x_2) = zmf(x_2, [a_2\ b_2])$, $\mu_{22}(x_2) = smf(x_2, [e_2\ d_2])$, $\mu_{31}(x_3) = zmf(x_3, [a_3\ b_3])$, $\mu_{32}(x_3) = smf(x_3, [e_3\ d_3])$ $\mu_{32}(x_3) = smf(x_3, [e_3\ d_3])$ are membership functions of therms ″nosign2″, ″sign2″, ″nosign3″, ″sign3″ correspondently. Here $a_1, b_1, e_1, d_1, a_2, b_2, e_2, d_2, a_3, b_3, e_3, d_3$ - are real parameters. Because of informative signs $x_1, x_2, x_3 \geq 2$ the probability of having the document relevant increases significantly [8], let us take into account membership functions in the

scope $0 \le x_i \le b \quad (i = \overline{1, 3})$, $b \ge 5$. The value b one can define in the optimization process during the training sample.

Classification problem consists of assigning an object, specified by the vector of informative signs $V = (x_1, x_2, x_3)$, to one of advance certain classes $\{C_1, C_2\}$, that is, consists of performing of mapping the form:: $V = (x_1, x_2, x_3) \to u \in \{C_1, C_2\}$.

Classification based on fuzzy inference is made on the knowledge base in the form:

IF $x_1 = \text{sign1}$ and $x_2 = \text{sign2}$ and $x_3 = \text{sign3}$

OR $x_1 = \text{sign1}$ and $x_2 = \text{sign2}$ and $x_3 = no\text{sign3}$

OR $x_1 = \text{sign1}$ and $x_2 = no\text{sign2}$ and $x_3 = \text{sign3}$

OR $x_1 = no\text{sign1}$ and $x_2 = \text{sign2}$ and $x_3 = \text{sign3}$

OR $x_1 = no\text{sign1}$ and $x_2 = no\text{sign2}$ and $x_3 = \text{sign3}$

OR $x_1 = no\text{sign1}$ and $x_2 = \text{sign2}$ and $x_3 = no\text{sign3}$

THEN $u = C_1$ (1)

IF $x_1 = \text{sign1}$ and $x_2 = no\text{sign2}$ and $x_3 = no\text{sign3}$

OR $x_1 = no\text{sign1}$ and $x_2 = no\text{sign2}$ and $x_3 = no\text{sign3}$

THEN $u = C_2$.

Then membership degrees of an object , informative signs are given by a vector $V^* = (x_1^*, x_2^*, x_3^*)$, to classes C_1, C_2 from knowledge base (1), are calculated as:

$$\mu_{C_1}(V^*) = (\mu_{12}(x_1^*) \wedge \mu_{22}(x_2^*) \wedge \mu_{32}(x_3^*)) \vee (\mu_{12}(x_1^*) \wedge \mu_{22}(x_2^*) \wedge \mu_{31}(x_3^*)) \vee$$

$$\vee (\mu_{12}(x_1^*) \wedge \mu_{21}(x_2^*) \wedge \mu_{32}(x_3^*)) \vee (\mu_{11}(x_1^*) \wedge \mu_{22}(x_2^*) \wedge \mu_{32}(x_3^*)) \vee$$

$$\vee (\mu_{11}(x_1^*) \wedge \mu_{21}(x_2^*) \wedge \mu_{32}(x_3^*)) \vee (\mu_{11}(x_1^*) \wedge \mu_{22}(x_2^*) \wedge \mu_{31}(x_3^*)) \quad (2)$$

$$\mu_{C_2}(V^*) = (\mu_{12}(x_1^*) \wedge \mu_{21}(x_2^*) \wedge \mu_{31}(x_3^*)) \vee (\mu_{11}(x_1^*) \wedge \mu_{21}(x_2^*) \wedge \mu_{31}(x_3^*)).$$

Here $\wedge$ and $\vee$ mean operation of finding the minimum and maximum correspondently.

As a solution, there is selected class with a maximum degree of membership:

$$u^* = \underset{\{C_1,C_2\}}{\arg} \max(\mu_{C_1}(V^*), \mu_{C_2}(V^*)) \tag{3}$$

As a criterion of training fuzzy classifier [2] let us choose the simplest criterion [9] - a criterion of error rates minimization of classification during the training sample:

$$\frac{100\%}{N} \sum_{k=1}^{N} \Delta_k(P) \to \min, \tag{4}$$

where $\Delta_k(P) = \begin{cases} 1, & if \quad u_k \neq F(P, V_k) \\ 0, & if \quad u_k = F(P, V_k) \end{cases}$ - an error of classification of the *k-th* object, specified by the vector of informative signs V_k; N – the number of objects in the training sample (or - the number of pairs of "input-output) (V_k, u_k), $k = \overline{1, N}$ classifier (2));

$P(a_1, b_1, e_1, d_1, a_2, b_2, a_3, b_3, e_3, d_3)$ – is the vector of the parameters of the membership function of the fuzzy therms x_1, x_2, x_3 from knowledge base (1); $F(P, V_k)$ – is the result of the classification on the fuzzy basis (1) with parameters P if the input value is V_k.

Training fuzzy classifier, therefore, is finding the vector P that minimizes the distance between the results of the logical inference and experimental data from the sample (V_K, u_K).

As the minimized function (4) is an integer, the most appropriate tool is the genetic algorithm for finding extremum. For its realization we use gatool MatLAB function

Considered above the classification process (2), (3) on knowledge base (1) not only divides documents into two groups: relevant and irrelevant, but also it allows to array relevant documents in order of relevance. In fact, the more the variable $\mu_{C_1}(V^*)$, the more relevant the document, specified by the vector of informative signs $V^*(x_1^*, x_2^*, x_3^*)$.

After preliminary evaluation, formed relevant alternatives are sent by the administrator on the e – mail to the experts for evaluating. For

solving similar problems, Delphi approach is used the most commonly, which is the complex logical and mathematical procedures, directed to getting information from professionals, its analysis and generalization aimed at preparing and making rational decisions.

Let us suppose there are n documents, which each of *m* experts has in order of decreasing (or increasing) of privacy strength of some feature. Label by x_{ij} the rank (location number) of *j-th* object (j = 1,2, …, n) in ranking *i-th* expert (i = 1,2, …, m). Sum of ranks in ranking of *i-th* expert [2]:

$$\sum_{j=1}^{n} x_{ij} = 0{,}5n(n+1) \tag{5}$$

If it is difficult for experts to rank objects, they can give the same ranks to two or more objects. In this case the total number of different ranks in ranking will be less than *n*. It is necessary to put in order such ranking when the condition is realized (5). For this object with similar ranks the rank is given which equals to average value of location numbers which these objects share between them.

Information received from *m* experts is generalized by calculating of the sum of ranks x_i, given by all the experts to each of *n* object. The result of generalization is locating objects in order of increasing of the sum of ranks.

Expert's coordination in objects ranking is worth evaluating by the concordance coefficient.

$$K_0 = \frac{12s}{m^2(n^3 - n) - m\sum_{i=1}^{m} T_i}, \tag{6}$$

where

$$s = \sum_{j=1}^{n} dj^2;$$

$$T_i = \sum_{\mu=1}^{n} (t_{\mu i}^3 - t_{\mu i});$$

$$d_j = x_j - 0{,}5m(n+1)$$

Variables d_j define deviation of sums of ranks of *j-th* object from the average value of sums of ranks across all objects. Variables $t_{\mu i}$ – are numbers of μ*-th* ranks repetition in ranking of *j-th* expert (number of tied ranks in ranking of *i-th* expert). Coefficient K_0 equals to one when all the experts ranked objects identically and it equals to zero at uniform sums of ranks of all the objects.

For definition and estimation automation of main aspects of expert evaluation coordination, the administrator interface was developed (fig.3), which will allow to define the degree of memberships of relevant alternatives quickly and their significance for KB updating (fig.4).

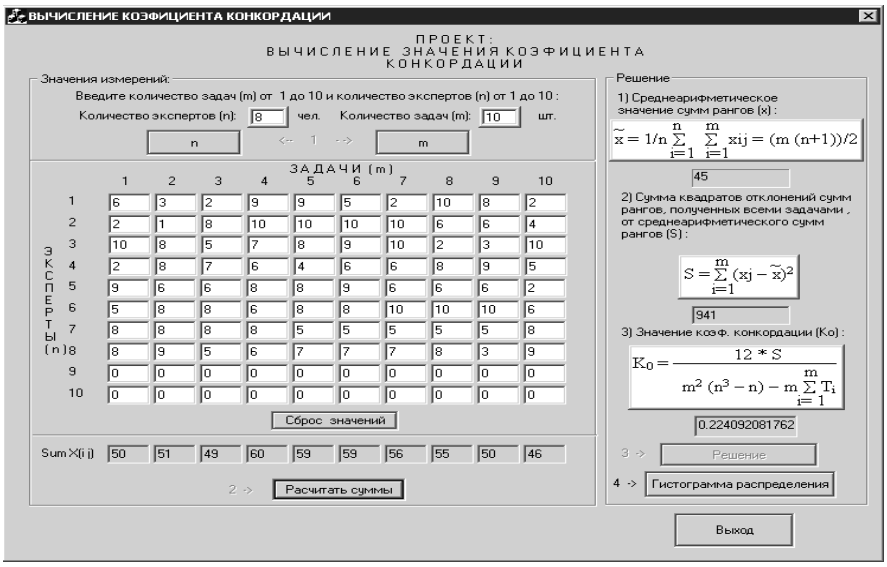

Figure 3- Expert's coordination calculation interface

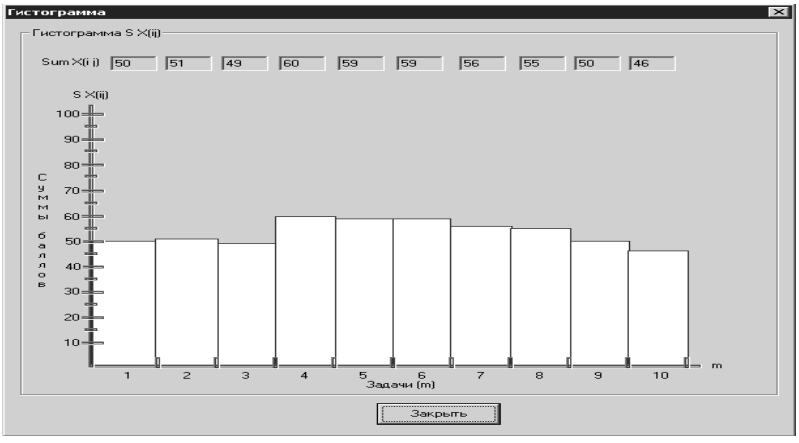

Figure 4- Bar chart of degree division of alternatives value for making decision

Conclusion

Using the given information technology will allow to generate and evaluate relevant alternatives for decision – making according to

information request of a human – operator in conditions of inconclusive, inaccurate and contradictory information in real time with the following upgrading of the distributed database.

Supposed technology will allow to increase the efficiency of the KB upgrading process and can be used in critical application systems in managing of complex technological facilities in real time.

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O.I. Savytskyi, M.A. Tymoshenko

AGENT CONTROL OF THE PROCESSES OF THE THREE-STAGED IRON ORE ENRICHMENT

Annotation. *The processes of iron ore enrichment from the point of view of automated control are considered. Complexity of measurement, non-stationary and inertia of processes require the use of combinations of methods of modern intellectual means of automated control. The efficiency of multi-agent control in complex with intelligent controls in comparison with the methods used today is established. The expediency of using intelligent controls, in particular fuzzy logic devices for controlling technological equipment, has been proved. The method of control of three-stage enrichment, taking into account the relationships between agents and application of methods of fuzzy logic, is proposed.*

Keywords: *Automation, enrichment, multi-agent control, fuzzy logic, system approach.*

The problem and its relation to scientific and practical tasks

Taking into account the directions of development of the modern world market, the main goal of production is to reduce the cost and improve the quality of the product. This goal is achieved through the integrated optimization of production processes based on the introduction of modern technologies. Improvement of the quality of automation of industrial technological processes is the main way in addressing the issue of production efficiency.

The enrichment complex includes various technological mechanisms, which carry out various operations and are different in design, and therefore require different approaches in the construction of control systems. In addition, they are interconnected and directly affect each other's work; require the use of many measuring devices that capture the values of different physical nature. This leads to an increase in the required design capacity [1-4].

Analysis of research and publications

The specified complexities can be avoided by using distributed control. Considering the complex of enrichment of iron ore as one large decentralized system of distributed mechanisms, it is possible to synthesize control systems of each mechanism of each stage separately, which are in constant interconnection. This approach provides an opportunity to increase the speed and reduce the load on the general

system and reduce the requirements for the calculated capacities of the executive system [5].

However, distributed control has its own disadvantages, the most important of which is the presence of a certain "command center". Although the mechanisms operate independently of each other under distributed control, there is still an existing center that processes all the data that is needed to regulate the interaction between controlled mechanisms and it has significant accounting resources. In the event of a failure of the control center, the system objects will not be able to interact.

Multi-agent control (MAC) avoids specified disadvantage. Multi-agent control is one of the leading concepts of the fourth scientific and technological revolution, informational (Industry 4.0). It implies complete decentralization of control, the absence of some of the main system and the free work of each control system (agent) by the technological mechanisms of each other. However, while the agents interact with each other and exchange information with each other. The main difference in the approach based on the principles of collective multi-agent control is the relatively low calculated complexity of implementing its algorithms, which allows you to quickly take solutions, that are if not optimal, but close to them in a dynamically changing situation.

Problem statement

A general description of the multi-agent system (MAS) can be shown in the form of an algebraic [6] system:

$$MAS = (A, E, R, ORG) \tag{1}$$

where A - set of agents, ie a set of creators; E - set of MAS, ie the communication environment in which MAS interacts with other MAS; R - set of interactions between agents, ie an array of configurations; ORG - represents the current MAS as an image.

In this model, the i-th agent (creator) in terms of organizing its interface with other elements of the system can be written as a triple:

$$A_i = (E_i, R_i, ORG_i) \tag{2}$$

where E_i – MAS of the communicating environment, in which agents interacts with each other ($E_i \in E$); R_i – a subset of agent bonds with other agents ($R_i \in R$); ORG_i - representing of the current MAS as an image.

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The connection between the technological mechanisms of the enrichment factory is very important as it allows to consider the entire enrichment process in aggregate and to control it according to the general picture.

Material presentation and research results

According to the proposed scheme (Fig. 1), four operations are carried out in the section of the enrichment plant - grinding, classification, desliming and wet separating of iron ore. Accordingly, there are such technological mechanisms as mills, magnetic separators, desilmers and classificating mechanisms. For the first stage it is a spiral classifier, for the following - a hydrocyclone. Also shown are the parameters of the enrichment operations necessary for monitoring the process and calculations of control effects, namely pulp consumption and density. Parameters have been calculated taking into account the presence in the section of recycles and sumps between some mechanisms. Also measured is the amount of iron in the final product, which in this case is 64.23%.

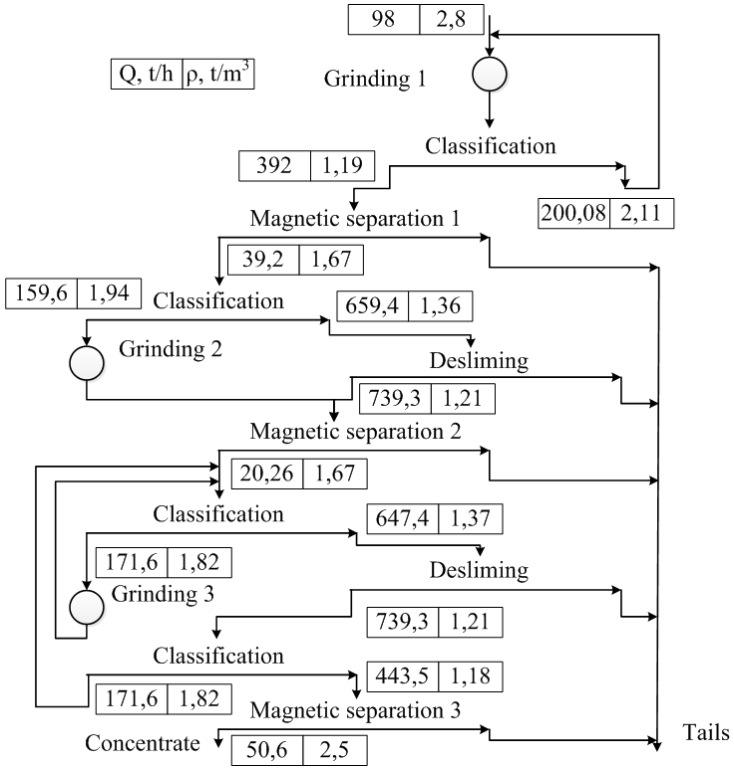

Fig. 1 Technological scheme of the process of three-stage iron ore enrichment

The scheme depicted in Figure 1 is represented by the interaction of the agents in Figure 2. It shows the multi-agent control system of the three stages of enrichment taking into account the connection between

them and the transmission of information signals from sensors to the PAC (programmable automation controller). To the mill in the first stage, iron ore falls from the feeder. The regulation of the amount of ore is controlled by the drive feeder by the drive mechanism of the feeder (Af) based on information from the performance sensor (Qo). After the first and second grinding stages, intermediate density measurements are performed between the stages using a densitymeter (ρ). In addition to the density in the final product, after the third stage, many more parameters are required, such as the size of the grinded material with use of a granulometer (GM), the content of the useful component (magnetic iron), fixed by the sensor indicated in the figure as (%), and the productivity for water and for pulp in general (respectively Qw and Qp flow meters). Each stage has its own PAC that collects data and processes it. On the basis of the data obtained, the algorithm calculates the controlling impact and presents it to the executive mechanisms (A1, A2 and A3), which, in turn, regulate the supply of additional water into the mill. Taking into account that the optimum levels of hydrocyclones are constantly maintained, we can control not only the supply of additional water, but also control the supply of pulp. Therefore, three more control impacts are applied to the pumps of the hydrocyclones (P1, P2 and P3). Also, the separators and deslimers are controlled on the basis of the mechanisms Rs and Rd. At the same time, the first stage is visualized in the SCADA system on the basis of the data calculated in the first stage PAC. The parameters of the regulators shown in Figure 2 depend on the input ore parameters. That is, the structure of the stage remains unchanged with variable parameters of control objects, links between stages and regulators.

Let's consider the difference between the classical measurements of the parameters of the mechanism’s work and its work in the agent form, in which case parameters are mostly calculated. The supply of hydrocyclone comes from a sump, to which the pulp under industrial conditions comes directly from several mechanisms and mixes. In this case, fluctuations of the values of the pulp’s parameters - such as its density, the amount of solid, etc., occur. For example, in order to calculate the average content of the solid phase in the mixture of pulp, which arrives to a sump with known costs (measured by flow meters),

solid content and iron content in the solid phase, appropriate calculations should be taken [7].

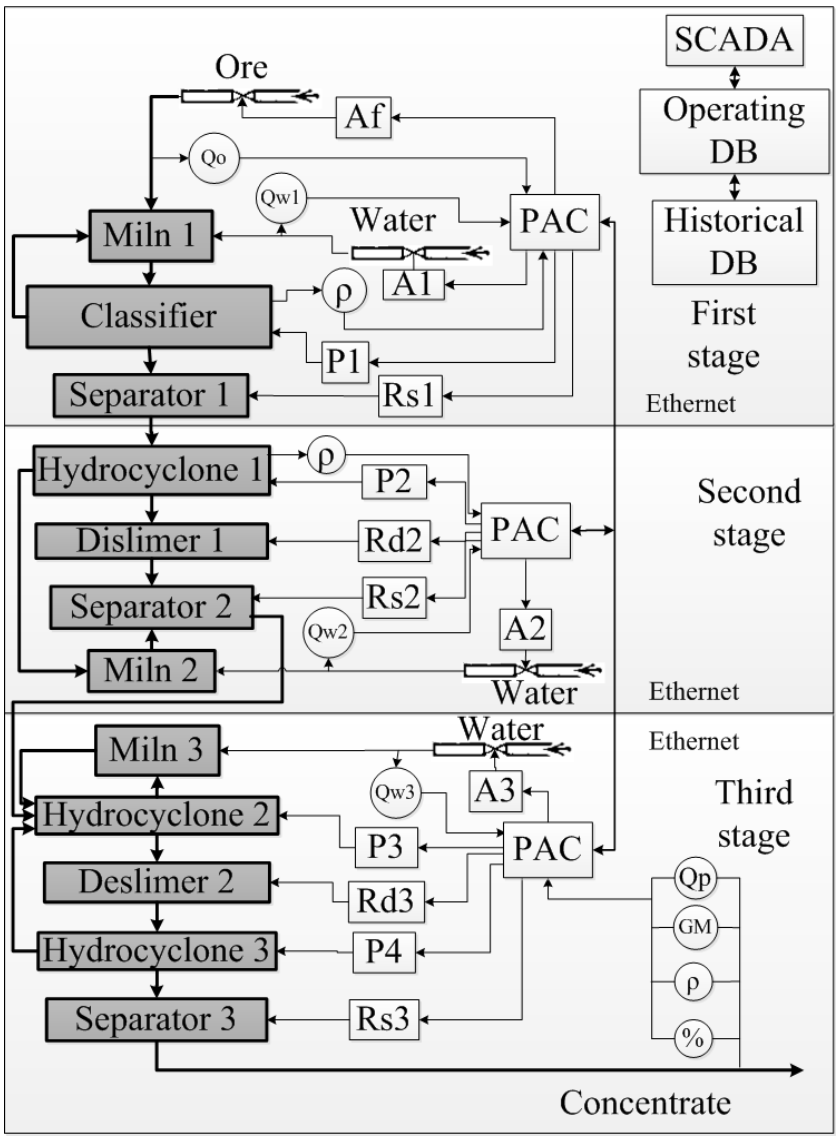

Fig. 2 A three-stage enrichment control scheme, with taking into account the relationships between agents

$$\delta_0 = \frac{1}{a - b\alpha},\ a = \frac{1 - \frac{\delta_0^* \alpha_0^*}{\delta_м \alpha_м}}{\alpha_0^* (1 - \frac{\alpha_0^*}{\alpha_м})},\ b = -\frac{(a - \frac{1}{\delta_м})}{\alpha_м} \quad (3)$$

where $\alpha, \alpha_м, \alpha_0^*$ - the iron content in the enriched pulp, in the original ore and the estimated content of iron in the enriched pulp; $\delta_м, \delta_0^*$ - magnetite density and initial ore density.

$$T_0 = \frac{\sum \frac{\hat{c}_i' \delta_i T_i}{T_i + (1 - T_i)\delta_i}}{\sum \frac{\hat{c}_i' \delta_i}{T_i + (1 - T_i)\delta_i}} \quad (4)$$

where T_i – the content of solid phase by mass in the i-th stream of pulp (i=1, 2, ..., n); δ_i – density of solid phase of the i-th stream; $\hat{c}_i'$ - the relative fraction of solid and liquid phases in volume in the i-th stream.

$$\delta_0 = \frac{\sum \hat{Q}_i' \frac{\delta_i T_i}{T_i + (1 - T_i)\delta_i}}{\sum \hat{Q}_i'} \quad (5)$$

where $\hat{Q}_i'$ - volume flow rate of the i-th flow of pulp.

$$T' = \frac{T}{T + (1 - T)\delta} \quad (6)$$

First, according to the formula (3), the densities of the solid phases of the pulp's streams entering the sump are determined, then the average content of the solid in the mixture by mass is calculated according to formula (4). After calculating the density of the solid phase in the mixture by the formula (5), the mass content of the solid in the pulp mixture is converted to volume content by formula (6).

In this case, the above-mentioned operations are used to calculate only one characteristic of the pulp from the many required for the calculations. They can be greatly simplified, by presenting the basic parameters of the functioning of the technological mechanism in the form of parameters of the control agent, and by modeling less important parameters on the basis of already measured information. The system is much simpler and faster in agent representation.

Measurement of a large number of characteristics of the processed product is very valuable in terms of the use of numerous measuring and converting devices, loading I/O modules on programmable automation controllers (PACs), and the whole load of the system. The application of fuzzy logic, and in this particular case of fuzzy controllers, will avoid the majority of emerging problems. For example, in case of stabilization of the hydrocyclone overflow, the fuzzy controller will contain the following rule base.

Table 1

Fuzzy rules for regulating the overflow of hydrocyclone

№	Name	Description	Action
1	Measuring the density and productivity of overflow and comparison with the given values	ρ LESS ρз & Q LESS Qз	W:=W-w & P:=P+p
2		ρ LESS ρз & Q EQUALS Qз	W:=W-w
3		ρ LESS ρз & Q MORE Qз	W:=W-w & P:=P-p
4		ρ EQUALS ρз & Q LESS Qз	P:=P+p
5		ρ EQUALS ρз & Q EQUALS Qз	-
6		ρ EQUALS ρз & Q MORE Qз	P:=P-p
7		ρ MORE ρз & Q LESS Qз	W:=W+w & P:=P-p
8		ρ MORE ρз & Q EQUALS Qз	W:=W+w
9		ρ MORE ρз & Q MORE Qз	W:=W+w & P:=P-p

In this case ρ, ρз – measured (average) and nominal density of overflow; Q, Qз – measured (average) and actual productivity of hydrocyclone's overflow; W, w – actual (average) the value of the amount of water supplied to the hydrocyclone and the predetermined value of the quantity of regulating water; P, p – the current value of the pump's feed and the preset value of the pump's regulating feed. Thus, the first entry in the table in the syntax of fuzzy logic is understood as "if the overflow's density (average) and the productivity of the hydrocyclone's overflow (average) are less than specified, then it is necessary to reduce the flow of water into the sump and increase the pump's feed". This approach allows reducing the number of used measuring devices in general and using more simple sensors, in this case, a density meter and flow meter. If this does not help to get the given density, then it is necessary to form a signal on the first agent to increase the supply of ore.

In order to control the quality of the output products of the mill, the magnetic separator and the deslimers, the fuzzy rules will look like respectively in tables 2, 3 and 4.

Table 2

Fuzzy regulator rules for controlling miln's work

№	Name	Description	Action
1	Measuring of density and productivity of miln's final product and comparsion with given values	ρ1 LESS ρ1з & Q1 LESS Q1з	V:=V+v & A:=A+α
2		ρ1 LESS ρ1з & Q1 EQUALS Q1з	V:=V+v
3		ρ1 LESS ρ1з & Q1 MORE Q1з	V:=V+v & A:=A-α
4		ρ1 EQUALS ρ1з & Q1 LESS Q1з	V:=V+v & A:=A+α
5		ρ1 EQUALS ρ1з & Q1 EQUALS Q1з	-
6		ρ1 EQUALS ρ1з & Q1 MORE Q1з	V:=V-v & A:=A-α
7		ρ1 MORE ρ1з & Q1 LESS Q1з	V:=V-v & A:=A+α
8		ρ1 MORE ρ1з & Q1 EQUALS Q1з	V:=V-v & A:=A+α
9		ρ1 MORE ρ1з & Q1 MORE Q1з	V:=V-v & A:=A-α

Table 3

Fuzzy regulator rules for stabilizing of magnetic separator's overflow

№	Name	Description	Action
1	Measuring of density and productivity of overflow and comparsion with given values	ρ2 LESS ρ2з & Q2 LESS Q2з	P:=P+p
2		ρ2 LESS ρ2з & Q2 EQUALS Q2з	K:=K-k
3		ρ2 LESS ρ2з & Q2 MORE Q2з	K:=K-k & P:=P-p
4		ρ2 EQUALS ρ2з & Q2 LESS Q2з	K:=K+k & P:=P+p
5		ρ2 EQUALS ρ2з & Q2 EQUALS Q2з	-
6		ρ2 EQUALS ρ2з & Q2 MORE Q2з	-
7		ρ2 MORE ρ2з & Q2 LESS Q2з	P:=P+p
8		ρ2 MORE ρ2з & Q2 EQUALS Q2з	-
9		ρ2 MORE ρ2з & Q2 MORE Q2з	-

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Table 4

Fuzzy regulator rules for stabilizing of magnetic deslimer's overflow

№	Name	Description	Action
1	Measuring of density and productivity of overflow and comparsion with given values	ρ3 LESS ρ3з & Q3 LESS Q3з	D:=D+d & P:=P+p
2		ρ3 LESS ρ3з & Q3 EQUALS Q3з	P:=P-p
3		ρ3 LESS ρ3з & Q3 MORE Q3з	D:=D-d
4		ρ3 EQUALS ρ3з & Q3 LESS Q3з	D:=D+d
5		ρ3 EQUALS ρ3з & Q3 EQUALS Q3з	-
6		ρ3 EQUALS ρ3з & Q3 MORE Q3з	P:=P-p
7		ρ3 MORE ρ3з & Q3 LESS Q3з	D:=D+d
8		ρ3 MORE ρ3з & Q3 EQUALS Q3з	D:=D+d
9		ρ3 MORE ρ3з & Q3 MORE Q3з	D:=D+d & P:=P-p

Here ρ1, ρ1з – measured (average) and nominal density of product, grinded in miln,; Q1, Q1з – measured (average) and actual productivity of miln; ρ2, ρ2з – measured (average) and nominal density of magnetic separator's final product; Q2, Q2з – measured (average) and actual productivity of magnetic separator; ρ3, ρ3з – measured (average) and nominal density of magnetic deslimer's final product; Q3, Q3з – measured (average) and actual productivity of magnetic deslimer; V, v – actual value of productivity of feeder, which supplies the ore to the mill, and the predetermined value of the regulating power supply value; A, α – the actual value of the water flow after the valve supplying the process water to the mill and the predetermined value of the regulating value of the water flow; K, k – the current value of the number of magnetic separators in the battery and a predetermined value of the regulating quantity of the number of switched-on separators; D, d – current value of the diameter of the discharge nozzle of the deslimer and the preset value of the regulating diameter of the deslimers nozzle of the discharger.

When controlling magnetic separation it is quite difficult to pick up a controlling influence that would not violate the physical nature of the process and would not be too expensive, therefore, magnetic separation control is usually carried out indirectly. In this case, through the control of the number of separators simultaneously working in the

stage of and through the control of the previous mechanism in the stage - setting the supply of the hydrocyclone's pump.

Application of the agency structure requires the use of PACs, which allows the following benefits:

- Using of Data Science platform;
- Providing agent clients with cost-effective and convenient forecasting analytics tools that improve application performance, increase the level of intellectual data analysis, productivity of the decision-making process.
- Application of custom code in several languages, such as SAS, R, SQL and Python, controllers language.
- Optimization of complex control problems by choosing the best solution with the most efficient use of limited resources.
- Minimize training time and increase the effectiveness of cooperation between agents of all levels in transferring skills.
- Reduce costs, resources, and maintenance by performing all of the analytics tasks on a single platform.
- Improved data preparation.
- Advanced predictive modeling techniques and algorithms for supporting applications.
- Advanced visual analyzers available through a series of graphs and reports.
- Easily connect to many data formats and databases from virtually any data source.
- Improved productivity and automation of the decision making process.
- Analyzers allow agents to analyze data directly in their database without having to export them in order to quickly and effectively apply analytics to themselves and all agents.
- The function of automatic code generation, which reduces the amount of programming time by more than 30%.
- An intuitive graphical user interface that reduces manual interference and allows users of all levels of skill to easily navigate through software [8, 9].

Conclusions and directions of further research.

The analysis makes it possible to argue that the use of multi-agent control will greatly increase the accuracy of control of the technological

mechanisms of the ore mining complex and, in general, will make control more adapted to real conditions and requirements related to the quality and quantity of concentrate. The use of modern control means, such as fuzzy logic, artificial intelligence, in general, will improve the quality and accuracy of control.

The direction of further research is a more detailed study of the links between the technological mechanisms of different stages of enrichment and their impact on the parameters of the final product.

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UDK 005

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PROCESS OF RESTRUCTURING AS INNOVATIVE IS MECHANISMS OF UPDATING OF INFRASTRUCTURAL ENTERPRISES

Annotation: In the article expediency of application of processes of restructuring is grounded as an innovative mechanism of updating of building enterprises of infrastructural type.

Keywords: *building enterprises of infrastructural type, building, restructuring, analysis, management.*

Introduction

Building has the characteristic features that distinguish him from other industries and dictate the necessity of specific forms of organization and management of building operations. Complication and variety of production of goods of building industry embrace different objects - from onedomestic dwelling-houses to the large industrial enterprises and engineering building. Technology of construction-works improves constantly.

Uniqueness of building objects. Every building object after the essence is unique, as he is constrained taking into account certain physical terms, functional setting, individual requirements of customer, financial possibilities and many other factors. Stationary character of building products. The created object cannot be moved. Products are produced for a consumer and consumed in the same place. Thus, a building market is essentially the market of construction-works.

Variety of participants of building process. To the building process project, building, engineering firms, customers of objects, producers and suppliers of building materials and equipment, financial institutions and public organs, are brought over. Thus noticeable variety of building firms after their sizes and specialization - from shallow handicraft and domestic firms to the giants of building industry with milliards cycle.

Formulation the problem

To groun d the process of restructuring of building enterprises as innovative mechanism of development of competitiveness of building complex in modern terms, that will allow to provide mobility of organizational and technological constituent of enterprise.

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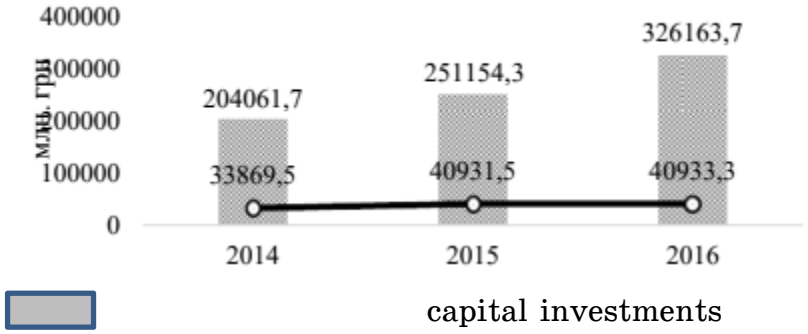
The basic material

Development of building industry closely constrained with other industries of national economy and building plays an important role, so as due to building the infrastructure of economy of country is created and improves. It is Therefore expedient to analyse the volumes of capital investments in all spheres of activity, in particular in building. The volumes of capital investments with every year grow and the main source of their financing is remained by the personal funds of enterprises and organizations. In the first half-year of 2017 of enterprise and organization due to all sourcings mastered 155,1 milliards of hrn. of capital investments, that on 22,5% more volume of capital investments for corresponding period of 2016 [3]. On a chart evidently, that among all investments, building occupies 16,6% in 2014, 16,3% in 2015 and 12,6 in 2016. In machines, equipments, inventory and transport vehicles it is inlaid 50,8% of all investments, in building and building - 41,1% [3]. The most increase of capital investments comparatively with the analogical period of 2016 p is fixed in the Zaporizhzhya (65%), Ternopil (64%) and Zakarpattia (46,4%) areas. The slump of capital investments is marked in the Kyiv (-7,4%), Mykolaiv (-2,5%) and Volyn (-1,2%) areas [1]. The prospects of development of building industry in Ukraine remain unchanging as yet, to what the indicator of business confidence testifies in building.

Table 1

Comparison of volumes of capital charges and investments in building



By basic factors that restrain building activity there are financial limitations and insufficient demand. However, changes that take place lately abandon the best hopes. Among most active after the rates of building became Kyiv, Dnipro of area and Western Ukraine.

As experience testifies in relation to an acceptance and ground of any level of administrative decisions, in that clean and in relation to tacking / or including to every sort of alliances, unstate associations or economic concord, the decision of the scientifically-applied and organizationally-economic task becomes urgent from determination of expediency of incorporation of the national economic system and, accordingly, Ukrainian enterprises to the new format of functioning. And, also, it follows to admit and carry out authentication of the real terms/ of pre-conditions and limitations on results realization of integration choice of the state [6,9]. It is marked, as known, largely, it must be based on the dominants of providing of sufficient economic strength security, and not only for Ukraine but also for any state of the world.

Thus, it follows to bring arguments over in relation to [6; 9; 16;]: first, to expediency of realization of corresponding type of politics with working out in detail of results on results the deep and complex analysis of factors, that can predict the origin of that or other sort of calls, risks or threats to national economic interests; second, existence of corresponding technology of authentication and objective system of evaluation of adequacy of the existent system of adjusting of economy to the requirements to relevation of infobase and requirements in realization of system research of modern problems and obstacles on the way of forming, increase and use of potential of steady development of Ukraine.

Organizationally-economic pre-conditions are indicated higher of providing of effectiveness of strategic management restructuring of enterprises of base for Ukraine industries and productions that can barrier an acceptance and realization of objective administrative decisions in the field of the management of steady development of regions of Ukraine potential, authors [6; 9; 16] offer divided into three groups: And - external character of "soft hegemony" of international management; II - internal nature, that conditioned by the scales of development of the potential of steady development already formed on the walks of life of Ukraine; III are factors, that determine the necessity of the cardinal updating of different spheres of activity of national industry, the list of that is exposed by research authors in intercommunication from, : formed by branch and regional copulas; balance of interests purchased in the last time; intensifying of differentiation of economic and social development of regions.

And will mark that is why, that most actual, on this stage of development of national economy, before the enterprises of industrial and communal thermal energy and, accordingly, power and scientifically complete an engineer, a task stands in relation to providing, activation and stimulation in the contiguous spheres of activity of politics of the prudent and effective use of different types of energy, that and such direction of restructuring as updating and reformation of industrial and economic activity, improvement of organizational and of communication structures of management requires confession priority and others like that. As, now, consumed by thermal energy's objects, in majority to it, anything on quality and technical descriptions the imported fuel, and enterprises from the contiguous types of economic activity (but communal energy also) have features of functioning and specific terms of development within the limits of certain region (and, accordingly, excellent requirements to quality of products).

Will mark also, that cost of building, restructuring, modernisation, reformation and, accordingly, service of the Ukrainian termal- generating equipment depend on charges on [7; 16; 17]: table of contents of auxiliary personnel of the systems of the central and sectional heating; removal of extraordinarily high level of hierarchicalness and complication of the checking, account and allocation of charges system used in the state comparatively with without by expense exploitation of the systems of the individual heating (however, now, it arises up, simultaneously with these objective processes, and problem in relation of account of thermal energy, as, in Ukraine, as yet, the volumes of charges of natural gas are taken into account only); acquisition and completing of thermal energy equipment by an automatic tool and starting vehicles (mechanical part of equipment that is produced on the Ukrainian enterprises has a high level of quality and sufficient warranty term of exploitation, and automatic

Consequently, working out in detail of pre-conditions in relation to providing of effectiveness of strategic management restructuring of enterprises envisages a requirement in realization of complex energyeconomic inspection of the industrial and economic systems of industrial thermal energy in the regions of Ukraine. In this accordance, will mark that, as known (it is presented in [5; 8]), on results the complex power inspection of enterprises : from 35 424 the heating Ukrainian boiler rooms (total power 117,8 thousand Gkал provides generating 104,3

million Gkал) that operate (from them, 9800 work on a hard fuel and 24565 on gaseous, and on liquid - only 333 boiler rooms [133; 142; 189]) need urgent modernization 15 871 (term exploitation is 20 to). If and was possible in their limits for a year simultaneously to carry out updating of and productive, and technological cycles (for producing with new descriptions of progressive thermal energy equipment), then other (19 553) generating industrial and economic complexes, needing permanent service, will "break ranks" (proceeding in their powers it will be not maybe on all parameters).

However, as known, during one year to carry out restructuring and updating of productive facilities of 15 871 enterprises, simultaneously, is an impracticable task, as, modernization 1 it takes place 3 to (minimum term). Consequently: industrial and housing complexes of our state will not be provided a heat (for a year can lose 46,7 million Gkал of heat).

Marked higher interpretation and present probability of origin of further destructive (where evolutional) structure of i dynamic processes within the limits of the real to the sector of economy of Ukraine and, consequently, substantial decline of power strength of the state security as a result of: violation thermal of generating and supply (an extent of networks is 32,5 thousand - 5,9 thousand a kilometer kilometers from them an emergency); origin of emergencies; material losses and, that it practically maybe, human also. Lately on the thermo generating enterprises of Ukraine 80,1 thousand of standard type of caldrons is set. From here: introduction of renewal cycle of to teach again of personnel (sufficient high level of qualification) and passing to maintenance of new equipment not only are complicated and needs set time, and will leave without warranty service control the operating heating system and generate stations that and so have the substantial spending (16,2 million т in. п.) - in т. ч., and in connection with, so names, by "reformation" and privatizing of unprofitable industrial objects (well-known facts of raider attacks are on state and non-state enterprises).

Besides, necessity of sectorial redistribution of labor resources [11; 16] will require considerable financial charges and efforts of regional and local correlations [10; 13].

Conclusion

Reasonably, that development of building industry closely constrained with other industries of national economy and building plays

an important role, so as due to building the infrastructure of economy of country is created and improves. In particular, the volumes of capital investments with every year grow and the main source of their financing is remained by the personal funds of enterprises and organizations. A historical analysis shows an unevenness to the process of forming of present housing fund, the cycle of spades of that will recur in case of occurring of requirement under major repairs and after completion tenure of employment of houses, reconstruction or at new building, - obviously, if to envisage maintenance or increase of the attained level of the housing providing.

On the basis of results deep economically-statistical analysis and system-universal analyses and comparative estimation of terms and limitations that exist in the field of the cardinal restructuring of production on the way of realization of integration choice of the state to the incorporation to the countries of europations concord a necessity to envisage the real levels of correlativeness of national technical descriptions of the specialized enterprises real to the sector of economy from administrative politics of adaptively of the Ukrainian industrial and economic cycles to the technical requirements of functioning only network concord and industrial and economic function real sector country ЄС is certain.

It is confirmed, that withstand and legalized, now, within the limits of national production, it is taken into account normatively-legal options and regulations and envisaged objectively present requirements to the level and qualification of personnel; to balance and measuring of thermal economy of options, adapted output-input ratios; to the feasability study already of put into an operation, however, with the threadbare fixed productive assets and modern requirements; quality and maintenance of current documentation; code system; table of contents of new power passports of RPC and passports of exploitation of the heating systems and others like that.

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UDC 004.432.4

V.G. Vasilenko, I.V. Baklan, V.V. Shyrii

ABSTRACT DATA TYPES IN PROBABILISTIC PROGRAMMING LANGUAGES

Annotation. *Today, there are quite a few different probabilistic programming languages that to some extent use the concepts of probability theory for their calculations. But we wanted to know what data types exist for solving probabilistic tasks. In the present paper we present a system analysis of abstract data types in selected languages of probabilistic programming.*

Keywords: *Probabilistic programming, Abstract data types, Probabilistic programming languages, Programming languages.*

Formulation of problem

Probabilistic programming languages, in their simple form, extend the well-known deterministic programming language with primitive constructions for random choice [17]. However, over time, there was a creation of new tools for probabilistic inference and the emergence of new complex probabilistic simulation programs. The presence of a large number of probabilistic programming languages led to the idea that there is a certain programming paradigm, the so-called probabilistic programming.

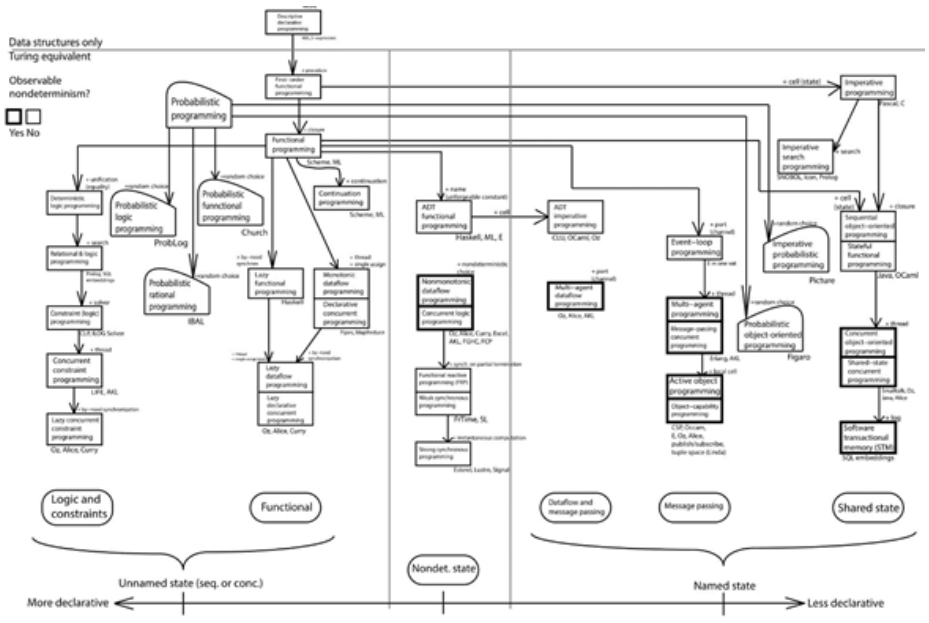

Figure 1 - Classification of programming paradigms [17]

Basic principles language design and probabilistic programming were given in [8]. Also in this article describes the differences between Probabilistic Programming and Probabilistic Model Checking.

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Literature review

About each of probabilistic programming languages there are relevant article or the corresponding page on the Internet from their authors. Therefore we will list those languages about which we will speak. Namely: Church (MIT BCS/CSAIL) [5, 13], Anglican (MIT, Oxford University and DARPA PPAML) [2-4, 15], Venture (MIT BCS/CSAIL) [9, 11, 18], Infer.Net (Microsoft Research) [12], TensorFlow [6, 13] (Google) with libraries TensorFlow Distributions (Google, Columbia University) [1] and Edward (Columbia University) [7, 8, 16].

The purpose and objectives of Article

In each of the languages of probabilistic programming with the help of abstract types, the basic concepts of probability theory are realized: probability space set, random variable, probability, probability distribution. These concepts, in our opinion, must necessarily be implemented in languages of probabilistic programming.

In this article, we will analyze the implementation of the basic concepts of probability theory with abstract data types in probabilistic programming languages. Namely: Church, Anglican, Venture, Infer.Net, TensorFlow with libraries TensorFlow Distributions and Edward.

Main part

Church (MIT BCS/CSAIL).

Let's start our analysis with the Church. Church - a universal language for describing stochastic generative processes. Church is based on the Lisp model of lambda calculus, containing a pure Lisp as its deterministic subset.

We will provide the partial description of language with [5]: «Church language is based upon a pure subset of functional language Scheme, a Lisp dialect». What we can understand from the reading: Church uses the same abstract types as Scheme. Feature of Church is the fact that expressions are values and these expressions describe generative processes.

In Church there is one interesting feature – all computation returns to Church in the form of random variable [12].

To specify sets, you can use built-in commands, such as list, vector and map. Using the built-in Scheme types to represent probabilities,

Church uses the type number. And it can be like integer or, if it is necessary to calculate probability, rational.

For calculation of probability a distribution function is used. It returns value from evaluating the body given env and values of formal parameters.

Anglican (MIT, Oxford University and DARPA PPAML).

Because Anglican is like the Clojure programming language, it uses the same data types. Here are just Clojure data types are Java data types, which also means that all values in Clojure are regular Java reference objects.

For representation of sets, Anglican, as well as Church, uses the list, vector or hashmap types. Sample method returns a random sample and roughly corresponds to the default implementation of the sample checkpoint.

For storage and work with probability, Anglican uses library java.lang.BigDecimal – decimal values or other classes, because Java primitives are usually boxed in Clojure functions. The observe method returns the log probability of the value, which roughly corresponds to the default implementation of the observe checkpoint.

To determine the distribution used macro defdist. It takes care of defining a separate type for every distribution so that Clojure multimethods (or overloaded methods) can be dispatched on distribution types when needed.

Venture (MIT BCS/CSAIL).

Venture is essentially a Lisp-like higher-order language augmented with two novel abstractions:

Probabilistic execution traces (PETs or abbreviated as “traces”) are a first-class object that represents the sequence of random choices that a probabilistic program makes. Each program subcomputation that yields a result corresponds to a random variable.PETs serve as the only native form of mutable storage in Venture, and map dynamic “addresses” assigned over the course of program execution to the manifest values taken by the program at those addresses;

Stochastic procedures (SPs). SPs are used to encapsulate simple probability distributions, as well as user-space VentureScript programs and foreign probabilistic objects. An SP consists of a linked collection of programs and meta-programs that collectively describe aspects of a

probabilistic program that are important for its use in modeling and inference. SPs are designed to allow simple probability distributions, user-space VentureScript, and foreign probabilistic programs to be treated uniformly as building blocks of complex probabilistic computations;

The authors state that Venture uses the usual scalar and symbolic data types from the programming language Scheme. Also in Venture there is support for collections and additional datatypes corresponding to a primitive object from the probability theory and statistics. There is support for the stochastic procedure datatype for using compound procedures returned by lambda.

Here is a list of the most important values:

- Atoms – discrete items with no internal structure or ordering;
- Numbers – data types like as integer, rational, real, and complex;
- Collections – vectors, which map numbers to values and support O(1) random access, and maps (map values to values) with support O(1) amortized random access;
- Stochastics procedures – standard library components and can also be created by Lambda and others stochastic procedures.

Infer.NET (Microsoft Research).

Infer.NET framework for running Bayesian inference in graphical models. Infer.NET provides the state-of-the-art message-passing algorithms and statistical routines needed to perform inference for a wide variety of applications.

In Infer.NET it is possible to create three types of variables: random (values are unknown and whose posterior distributions can be calculated during inference), constant (fixed values), observed (values not specified when the model is constructed, but are given before performing inference).

Infer.NET is used to create variables other than simple data types, such as bool, double, int, enum, string, char. Vector and PositiveDefiniteMatrix are used as vector and matrix types for creation of probabilistic sets. In addition, all of them and also TDomain [], ISparseList <>, IList <> can be used for discrete, continuous, multivariate and sequence distributions.

For greater convenience and possible simplicity, the developers provided methods for creating random variables with various distribution factors. It can pass in random variables as arguments e.g. Variable <bool>

instead of int. In [11] you can see examples of such usage, as well as with the description and syntax on Infer.NET. Built-in functionality allows you to use different types of data parameters. For example, with discrete distribution.

TensorFlow (Google), library TensorFlow Distributions (Google, Columbia University) and Edward (Columbia University).

TensorFlow is based on use of so-called tensors. We will give small definition about tensors. Tensors are simply mathematical objects that can be used to describe physical properties, just like scalars and vectors. In fact tensors are merely a generalization of scalars and vectors; a scalar is a zero rank tensor, and a vector is a first rank tensor [18].

The rank (or order) of a tensor is defined by the number of directions (and hence the dimensionality of the array) required to describe it. For example, properties that require one direction (first rank) can be fully described by a 3Ч1 column vector, and properties that require two directions (second rank tensors), can be described by 9 numbers, as a 3Ч3 matrix. As such, in general an nth rank tensor can be described by 3n coefficients.

Tensors are used to represent the data structure in programs written in TensorFlow. Using tensors, TensorFlow represents the probability space is an N-dimensional array or list. The tensor has a static type and a dynamic dimension.

TensorFlow provides several possibilities for creating so-called random tensors with different distributions. In this case, after each call and calculation, new random values are created.

Tensors can be of such data types: bool, half, float, float64, uint8, int8, int16, int32, int64, complex64, complex128, string. But you can also use standard data types with Python. For example, as bool, str, list or tuple.

More recently, for TensorFlow, another library of adaptation of the vision of probability theory to the modern deep-learning paradigm of end-to-end differentiable computation. It is called TensorFlow Distributions [1]. It is constructed on such two abstractions: Distributions and Bijectors. The first provides a collection of approximately 60 distributions with fast, numerically stable methods for sampling, log density, and many statistics. The second one allows composable volumetracking transformations with automatic caching. Together these enable modular

construction of high dimensional distributions and transformations not possible with previous libraries.

Also, this year was presented Edward [15] – deep probabilistic programming library, which expands deep-learning research by enabling new forms of experimentation, faster iteration cycles, and improved reproducibility. Edward provides a language of random variables to construct a broad class of models: directed graphical models, stochastic neural networks, and programs with stochastic control flow. In Edward, random variable is an object parameterized by tensors. For Edward, the TensorFlow Distributions library has a backend.

Conclusion and future research directions

We will write short outputs about each of the probable languages selected by us. We will select several highlights. The first is that all the languages we choose use the data types of their "parent" programming languages. The second is that for the use of distributions and random variables, the built-in functions or methods in each of the languages are used. And the list of these distributions can be different. Depending on various factors (development experience, knowledge in the field of probability theory, etc.), the development of own probabilistic concepts can cause confusion.

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UDC 681.5

M.A. Voronenko

INFORMATIZATION OF THE PROCESSES OF DECISION-MAKING IN EMERGENCY SITUATIONS

Annotation. *The processes of optimization of making managerial decisions in emergency situations taking into account the risk are considered. It is substantiated that an analysis of the risk of making erroneous decisions in management is a complex of actions that unites the identification, study and analysis of the mechanisms of possible undesirable consequences that have an impact on people's health, as well as the effective functioning of the health protection system at all.*

Keywords: *optimization, emergency situations, health protection system.*

Introduction

Today the number of anthropogenic emergency situations (accidents at nuclear power plants, fires and explosions at industrial facilities, transport accidents) constitute 75-80% of the total number of emergencies. 39% of all natural emergencies occur in Asia, 26% - in America, 13% in Africa, 13% in Europe, 9% in Australia and 9% also in Oceania. According to the information from International Red Cross organization, natural emergencies deprived the lives of more than 11 million people in the XX century. Annually, the number of people affected by natural disasters increases by an average of 6%. Many sufferings inflict on humanity outbreaks of infectious diseases, due to which at least 1.3 million people die each year.

Effective decision-making aimed at eliminating the emerging problem situations is impossible without information about the risk of the situation and its development. Therefore, in the management of the emergency situation, an information system must function, which will provide the structural units with the necessary operational and statistical information, and will facilitate the adoption of group decisions at various levels of government. For this, it is necessary to develop algorithms, programs and information technologies based on the achievements of modern mathematical science and computer facilities.

The purpose

Emergency management systems are developed in different countries (USA, FRG, Japan, Russia, etc.). At the same time, automated information systems are created. Examples of these are the GISNH

Information System of Natural Disasters, established by the United Nations in Geneva, RODOS (the development of European institutions for monitoring radiation risks in Europe), the PPS decision support system implemented in a number of Scandinavian countries. RISK WIT, ATMOSPHERE, CARIS systems are designed for information support for decision making in chemical contamination, DSS / IPC - to assist managers in industrial pollution of the environment. In the United States, the Federal Emergency Management Agency has established a national network and emergency management system for NEMS, consisting of communication networks, information systems and various facilities. National systems of IRIS (Germany), RIMNET (Great Britain), ARAC (USA), RAS GO and "Center" (Ukraine) [1,4,5] are also established in some countries.

Therefore, it becomes urgent to unite the efforts of all interested parties and institutions in the preparation and adoption of justified decisions in the sphere of ensuring the security of the population, the state, territories, and the natural environment. This is also the work to raise the level of awareness of society, management bodies and organizations on issues of analysis, risk control, risk acceptability. This is an independent examination and development of programs, projects, promising ideas, technical solutions, regulatory documents and also scientific research activities.

The main material

The health of people occupies a special place in the system of values held by any civilized nation. As from the point of view of a single human biography formation, and at the level of the society development, it is difficult to find another phenomenon that would have more bigger importance than health, a deep inner meaning and influence on different aspects of activity.

To improve the effectiveness of the management system, its functioning at all levels should be organized in accordance with the principles of accountability, transparency, predictability and provision of social guarantees to employees.

Flexibility of management (at any level) is a constant balance between risk and possible achievements. Constant balancing is risk management, that is, risk is a component of the management entity. Figure 1 shows the structure of the natural and man-made risk management system [2].

The analysis of the literature sources indicates that the content and nature of public management of national health systems in Eastern Europe are closely related to the risk of making wrong decisions in planning and implementation.

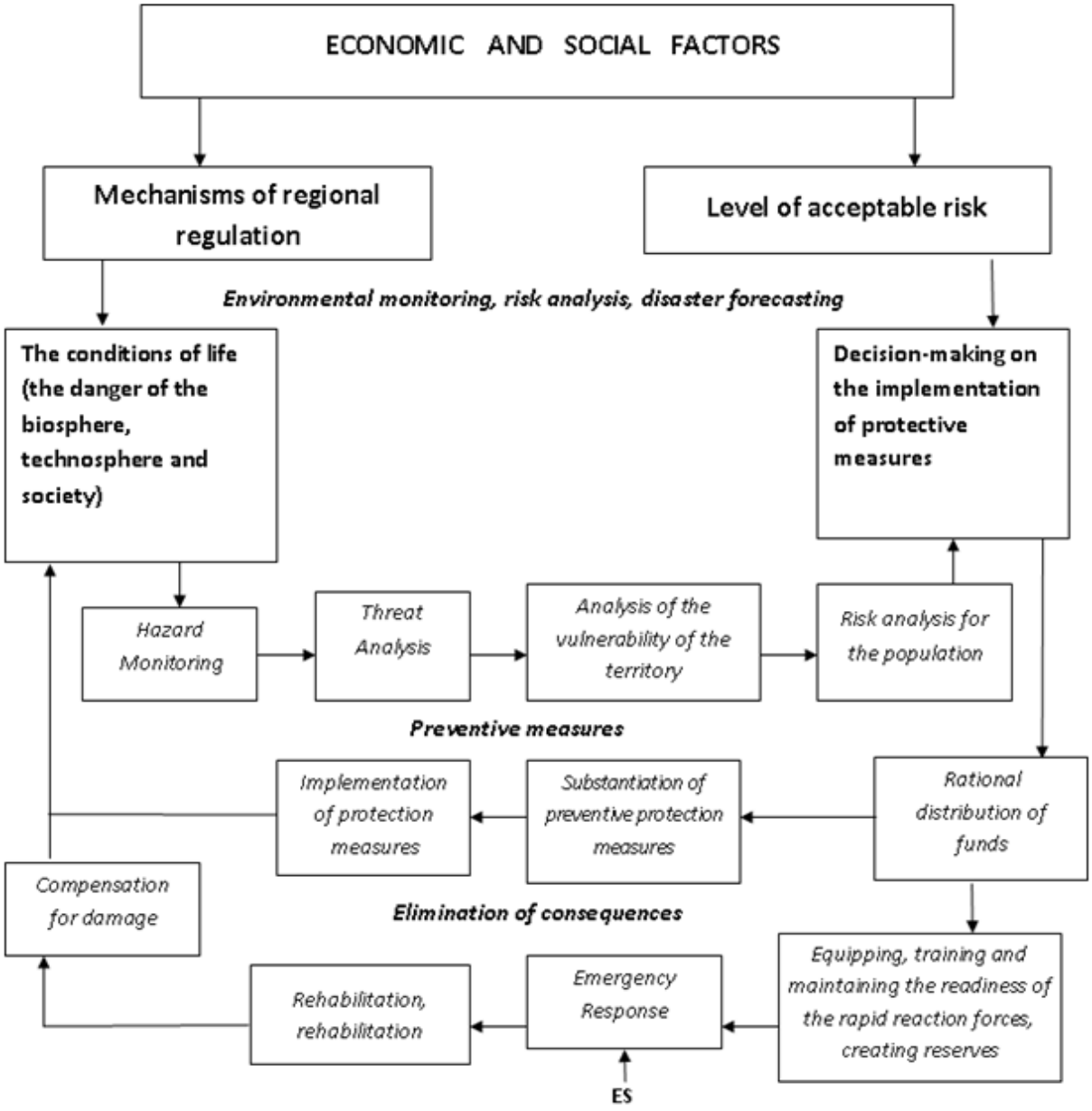

Fig. 1. Structure of the management system for natural and man-made risks

Schematically, the relationship between the main components of the risk of making erroneous decisions in management, including health management, is shown in Fig. 2.

Based on the above and taking into account the research of V. Kuzmenko [2] and A. Terentyeva [5], it can be concluded that the risk analysis of making erroneous decisions in the management of the health care system is a complex of actions that unites the identification, study

and analysis of the mechanisms of possible undesirable consequences affecting people health, effective functioning of the health care system and its management bodies in order to prevent or counter the effects.

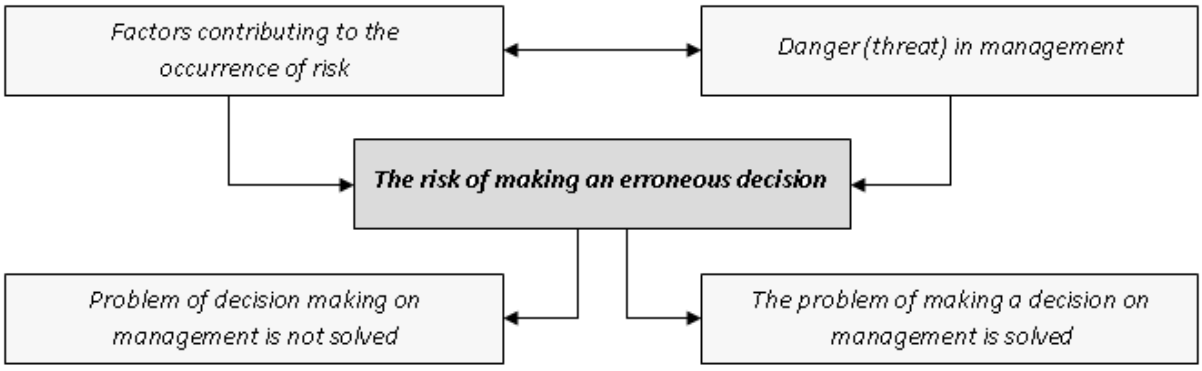

Fig. 2. The relationship between the components of the risk of making an erroneous decision

The aforementioned predetermines the need to apply a system approach to the study of public health management process in order to improve the effectiveness of management itself. System analysis is, in fact, a methodology for studying objects by mapping them as a data system. An analysis of such a system can be a really effective means of solving complex, often vaguely formulated problems. In this case, any object is considered not as a single, indivisible whole, but as a system of interrelated constituent elements, their properties and qualities. System analysis can be reduced to clarifying the complex problem of its structuring into a series of tasks that are solved with the help of different modeling methods, searching for criteria and their solution, detailing the goal, creating an effective organization to achieve it [3].

In the context of system analysis, the emergency situations management can be displayed as a large complex system combining a significant number of particular nature interrelated components, ordered by attributes. Effective activity of such a complex management system provides certain prerequisites and properties, such as hierarchy, structure, integrity, functionality, manageability, direction to the goal, self-organization and the like [5].

One of the main tasks of system analysis is the creation of an information base. Work on information support provides for two phases. First, the collection, analysis and processing of information, and, secondly, the formation of a database that is used at different stages (generating an information model, obtaining many predictable solutions,

estimating the model's accuracy, analyzing received forecasts, and so on). When forming the information base, the following requirements for the initial information should be taken into account [4]:

–filling statistical data in order to obtain reliable information and to reveal the degree of inertia of various performance indicators of the system;

–providing the most complete system performance, which is modeled on the basis of output data;

–comparison of statistical indicators;

–the uniformity of the methods for calculating the values of each indicator.

One of the tools for implementing the principles of system analysis in public health management is the application of the method of strategic planning. The main goal of strategic planning is regular assessment of the operating conditions, development of appropriate strategies to ensure a strong balanced position, which plays an invaluable role in long-term success. In determining the strategic course, an integral component is the conduct of internal and external system analysis.

External system analysis determines the threats and opportunities for program development. Evaluation of the results obtained as a result of the external system analysis is necessary in the dynamics (past - present - future), which allows to predict and develop a program of actions, determine the feasibility of implementing those or other directions and identify the most important of them, to investigate the probability of achieving the goal.

Internal system analysis provides a choice between qualitative and quantitative methods of data accumulation. Quantitative methods, first of all, provide the ability to compare data and represent them in numerical form. They make it possible to assess the confidence interval relative to the size and structure of the phenomenon, and also contribute to increasing the credibility of research in the eyes of society. In turn, qualitative methods have a wide range of varieties and provide for a wealth of details, details, fragments that reflect the features and high flexibility of research, increased attention to the essence of phenomena and views, dynamic tracking of changes in time. It is often necessary to combine quantitative and qualitative methods within a single study.

To implement strategic planning, it is necessary to evaluate the alternatives, which is related to SWOT analysis (Figure 3) [7].

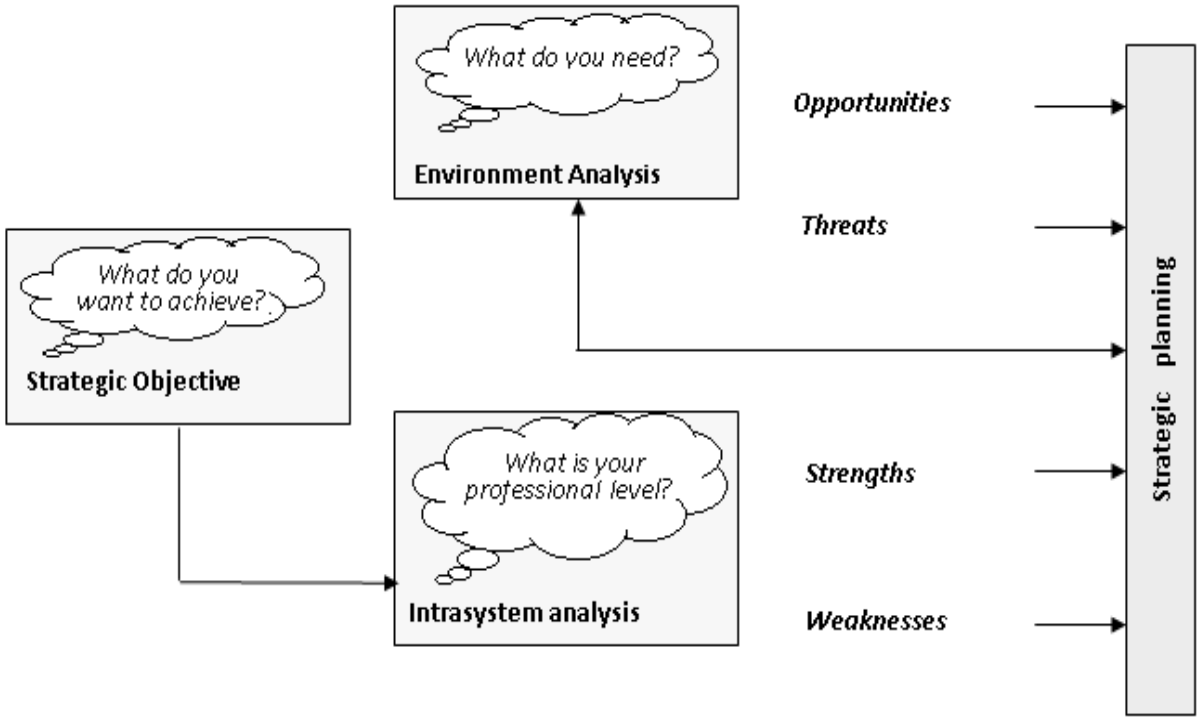

Fig.3. SWOT analysis in strategic planning

In this case, it is necessary to take into account possible options for interaction of factors, where S – strengths, W - weaknesses, O - opportunities, T - threats:

- OS (+ +) - maximum opportunities, maximum strengths;
- OW (+ -) - maximum of opportunities, minimum of weaknesses;
- TW (- -) - minimum of threats, minimum of weaknesses;
- TS (- +) - minimum of threats, maximum of strengths.

It is known that with system analysis there are many threats to the reliability of the findings: the "aging" of the samples, extraneous events, the impact of retesting, the modification of instruments and methods of research, and the like. Data on which variables affect the desired results should be taken into account from existing studies. Based on this analysis, you can better understand which methods are effective, and which require further development.

System analysis at the level of regional management is traditionally associated with the adoption of management decisions and their formulation in the form of regulatory legal acts [3]. One should be prepared for the fact that, at least in some cases, the use of analysis results is negative and obvious, often the system analysis can be

conceptual and it is difficult to see "with the naked eye". Representatives of the authorities and organizations do not always use the results of the research directly to make immediate decisions. However, with the help of system analysis, decision makers supplement their knowledge, so the impact of research results on approved solutions is stretched over time [4,5].

Significant changes in the organization of management that occurred at the turn of the 20th and 21st centuries have acquired an irreversible nature and are associated mainly with the scientific justification of modern trends in social and cultural development, the processes of globalization, informatization and the internationalization of management systems and management practices.

The basis for effective management of collective activities of people are objective processes of social development, knowledge of which significantly affects the interpretation of the relevant concepts, approaches to clarifying their content and patterns of development.

That is why, at the forefront of scientific research on the regularities and trends that occur in the sphere of management organization at the moment and are of great practical importance, there have appeared various directions and processes that are most reflective of the changing conditions of the global market environment for the functioning of modern organizational structures. These complex external conditions led to the reorientation of the management systems of organizational formations to the widespread introduction of the latest technologies and methods of highly productive monitoring, forecasting, justification of risk operations and the dominants of a strategic approach in management.

Conclusion

1. The analysis of the literary sources of ukrainian and foreign authors indicates that the content and nature of decision support systems regional management in the context of sanitary and epidemiological situations are closely related to the risk of making erroneous decisions in the planning and implementation phase.

2. The processes of making managerial decisions optimization in emergency situations taking into account the risk are considered. It is substantiated that an analysis of making erroneous decisions risk in management is a complex of actions that unites the identification, study and analysis of possible undesirable consequences mechanisms that have

an impact on people's health, as well as the effective functioning of the health protection system.

3. It has been found that one of the effective ways to optimize the activity of the health protection system can be considered the modeling of emergency situations management process.

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THE RESEARCH OF WATER SUPPORT QUALITY IN KHERSON REGION

Annotation. *A study of water supply sources in the Kherson region has been carried out. It is substantiated that the state of health of the population of the region depends, among other things, on the quality of drinking water. Since at present most of the samples show no compliance with the standard and a significant excess of the norm, it is necessary to carry out studies on modeling and forecasting the processes of deterioration of the quality of drinking water.*

Keywords: *correlation sequence, population, groundwater quality.*

Introduction

Water is 60 percent of the body weight of a person. The most intelligent part of our body - the brain - consists of water by 84 percent, kidneys consists of water by 83, heart and lungs consists of water by 7 percent, and so on. Even with the loss of one to two percent of the water available in the body, a person experiences thirst, a loss of 10 percent of moisture leads to a disorder of the mental apparatus, and a loss of 14 to 15 percent of water leads to the death of the body. On average, a healthy person is drinking to 2.5 liters of moisture per day, therefore, in order to maintain the water balance in the body, he must consume the same amount of water [1].

The purpose

For 60 years of life, a person drinks a whole cistern - 50 tons. It is estimated that the world's population consumes 7 billion cubic meters of water per day. The water cycle in nature provides a sufficient amount of water for the present population of the globe, but in the process of circulation the water becomes more and more polluted. In other words: there is no water problem on the Earth, there is a problem of clean water. It is believed that more than two billion people on Earth are practically unable to use clean drinking water. According to the World Health Organization, almost 80 percent of all diseases are caused by poor quality drinking water. Hence it is clear that the problem of water purification will be one of the main problems of mankind in the XXI century [2].

In our work, we investigate the quality of water supply sources, in particul ar, the quality of drinking water in the Kherson region.

The main material

Caring for obtaining a sufficient amount of water, suitable for drinking and to meet the cultural and everyday needs of the population in water, accompanies humanity throughout all periods of its existence. At the same time, the nature and forms of water supply of the population changed along with socio-economic conditions. At present, the satisfaction of the needs of populated areas in the water is carried out mainly by centralized water supply systems, i.e. household and drinking water pipelines, the main source of which in Kherson and Kherson region are groundwater. In total, there are more than 2.500 wells in the region and only 55% of them supply water in accordance with the requirements, which was approved in 1982 and has not been changed since then, despite a significant deterioration in the ecological situation in Ukraine [3,4].

On the territory of the Kherson region there are 9 cities, 30 urban-type settlements and 675 rural settlements (Figure 1). Centralized water supply is provided to all cities and towns of urban type and 611 rural settlements. Water supply to the settlements of the region is carried out from 58 communal, 362 departmental and 792 rural water pipelines. All in all, 1213 water pipes are used for water supply of the population, which is 3 more than last year due to open two water pipes in Kherson (bakery, CJSC "Micon") and one on bunkering ships in Kherson port.

The main sources of water supply for water pipes are more than 2.5 thousand artesian wells. 88 wells, 4 facilities for the use of groundwater and 13 artesian wells, and 105 sources of decentralized water supply are additionally used for water supply to the rural population [3,4].

Fig.1 The map of the Kherson region

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Over the past 20 years, the city has almost no new sources of water supply [5]. The situation with water supply and sanitation in the city is critical (Table 1).

Table 1

Status of water supply sources

Districts and cities	**Number of water pipes that do not meet sanitary standards**	**Total number of wells**	**Total number of wells with a broken fence**	%
Ivanivka district	20	75	20	26,7
Bilozerka district	-	141	3	2,1
Beryslav district	3	187	76	40,6
Velyka Oleksandrivka district	19	93	19	20,4
Velyka Lepetykha District	9	113	9	7,9
Verkhniy Rohachyk District	10	65	29	44,6
Vysokopillia district	11	48	15	31,2
Henichesk district	3	230	3	31,2
Hola Prystan district	-	195	-	-
Hornostaivka district	6	118	6	5,1
Kalanchak district	6	64	6	5,1
Kakhovka district	4	89	8	9,0
Nyzhni Sirohozy District	4	129	16	12,4
Nova Kakhovka	2	100	2	2,0
Novovorontsovka District	2	62	25	72
Novotroitske district	16	143	16	11,2
Skadovsk district	10	188	10	5,3
Oleshky district	10	124	10	8,1
Chaplynka district	3	183	60	42,3
Kherson	11	234	-	-

The construction of the Podstepne's water intake that was started is suspended due to design deficiencies, and the construction of a water intake from the Dnipro river due to a shortage of funds in the budget of

the city and the region. From year to year, it was planned to continue the construction of the second stage of the Antonovka's water intake with a capacity of 8-10 thousand m^3 of high-quality drinking water per day, but again because of lack of funds in the local budget construction was not conducted. For this reason, there is a constant shortage of drinking water in Kherson in 30-40 thousand m^3 per day especially in the summer, hot period.

A special situation is observed at the first site of the water pipeline, where the ammonium and nitrate contamination of groundwater has assumed alarming proportions: the nitrate content of the exploited wells is 72.9 -248 mg/dm^3. Pollution of this area with nitrogen compounds is associated with the activities of the Kherson seaport. In the observed well № 982, located five meters from the seaport area towards the water intake facilities, the mineralization increased 18 times (up to 9.22 g/dm^3) after corrosion, the sulfate content increased by 284 times (up to 5105 mg/dm^3), which indicates the presence of nearby halo of groundwater pollution.

The ecological condition of the territory of the region is affected by a huge number of abandoned wells, the presence of which is the result of the reorganization of enterprises and farms in the region. Even in the worst condition are the sewer networks and facilities of the city. Out of a total of 282 km, 49% are completely worn out. Particular danger is created by emergency pressure and gravity sewage pipelines of large diameter from 300 to 1200 mm, accidents leading to the discharge of untreated sewage into the environment and the Dnipro river basin. In total, in 2009, 1646 minor accidents and 38 major accidents were eliminated on the sewerage networks of Kherson [4,5]. More than 300 km of emergency sewer networks are operated. Thus, the main pressure collector, which takes waste water from the city of Skadovsk and the entire health zone, is completely worn out. Particularly alarming are the rural water pipelines with an underdeveloped street network, as well as a low level of technical and preventive maintenance. Every year, the length of depreciated networks increases, the number of accidents and breakthroughs that are not eliminated for 2-3 weeks [4,5].

The work of household and drinking water pipelines and sources of decentralized water supply is under the control of the sanitary epidemiological service of the region. In the current survey of water pipes,

16066 drinking samples were taken for microbiological testing, 9487 samples were taken for sanitary-epidemiological indicators. 482 samples from the total number of samples that were examined for microbiological indicators did not meet the requirements of the state standard. This amounted to 2.6%. 1849 samples from the total number of samples that were examined for chemical indicators did not meet the requirements of the state standard. This amounted to 15.2% [5].

Intensive use of groundwater in the past (excess of predicted operational reserves) has become one of the causes of chemical contamination of groundwater in the main Neogene aquifer complex in the south-eastern region of the region. Long-term use of underground sources of water supply leads to their contamination by more mineralized waters below the located underground aquifers, so 45% of artesian wells supply water that does not meet the sanitary requirements for indicators: mineralization, dry residue, stiffness, nitrates, sulfates, chlorides (Figure 2).

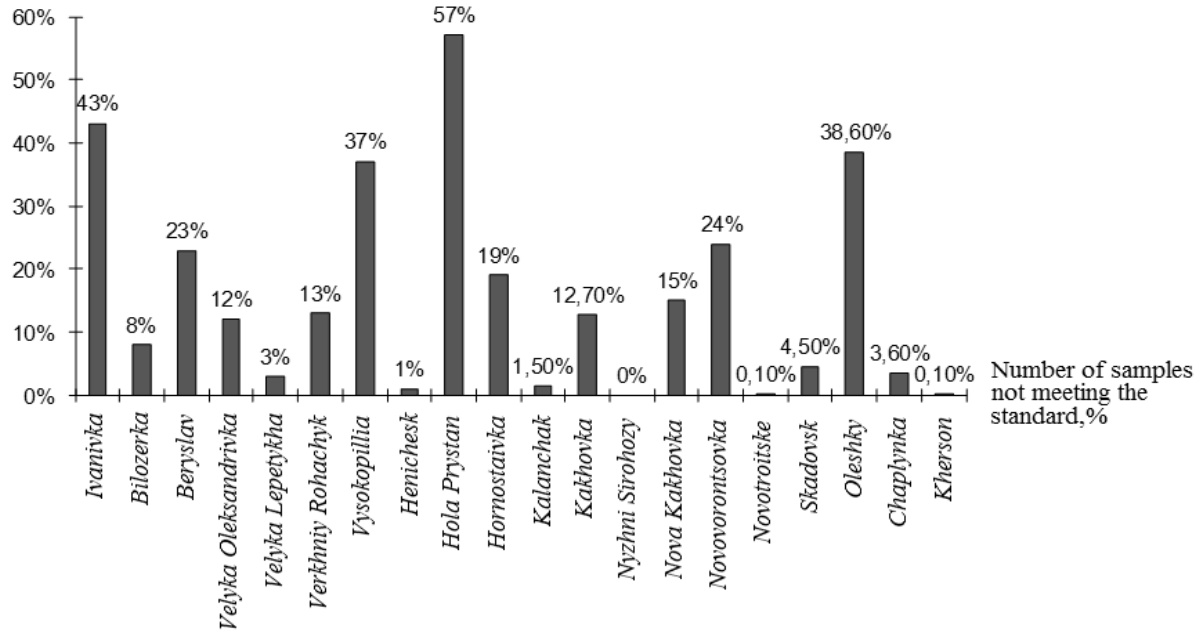

Fig. 2. The number of drinking water samples that do not comply with the state standard, out of the total number of samples in percentage

In spring and summer, a large part of the population of Belozerka, Berislav, Vysokopilla, B.Aleksandrovka, Genichesk, Kakhovka and Chaplynka districts remains without water.

Figure 3 shows the dynamics of deterioration of water quality in the region on a dry residue for the period 2000-2017. As we can see, with the

norm of the dry residue of 1000 units, at the present time the overwhelming majority of samples show an excess of this indicator.

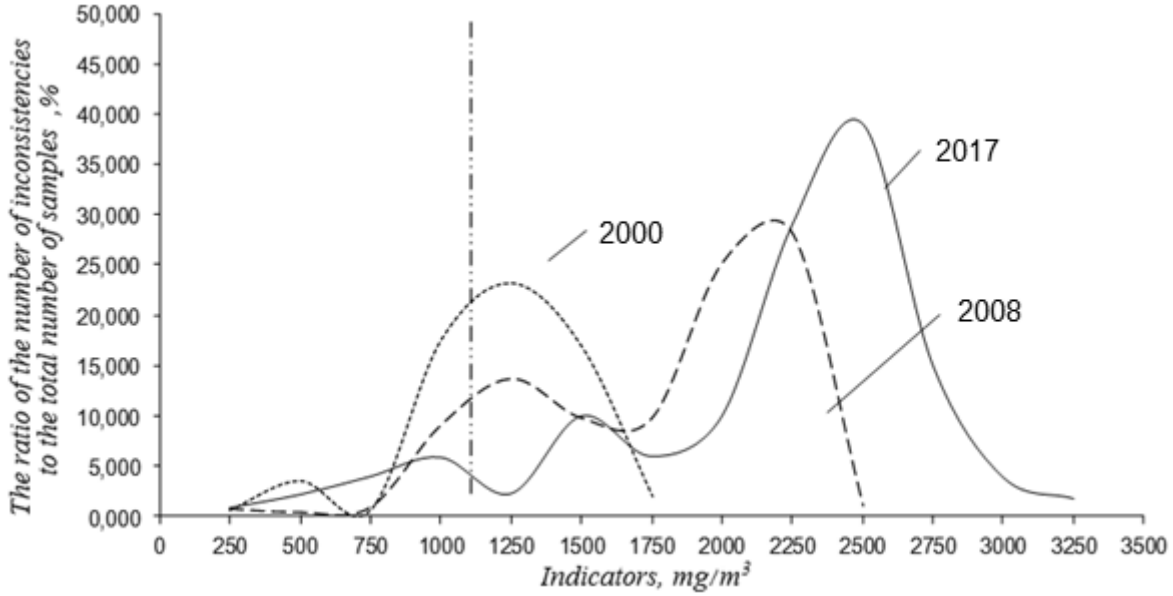

Fig.3. Dynamics of water quality deterioration on dry residue

According to the Berislav district, a correlative dependence was constructed showing that the cardiovascular system in this region is 84% determined by the quality of drinking water [3]. In addition, the effect of a temporary lag was noticed: the incidence in the current year is determined by the quality of water two years later. This indicates that the disease develops gradually: a year later the disease develops, and two years later the patient turns to the doctor.

Next, we performed the following experiment: to the deviation in the chemical composition of water this year added 15% of the value of the previous year. On the example of statistics of diseases of the Henichesk district (Fig. 4) we showed how the residual phenomena of previous years affect the incidence of today (cumulation effect). The correlation sequence in the original case is described by equation:

$$Ys = 422{,}9 + 3{,}69x. \quad (1)$$

Correlation sequence in the case of adding 15% of the values of the previous year is described by equation:

$$Ys = 328{,}41 + 6{,}59x. \quad (2)$$

The coefficient of multiple determination $\mathbf{R^2}$ in this case increased from 4% to 59%, and the standard error $\boldsymbol{\sigma}$ decreased from 87.5 to 38.4.

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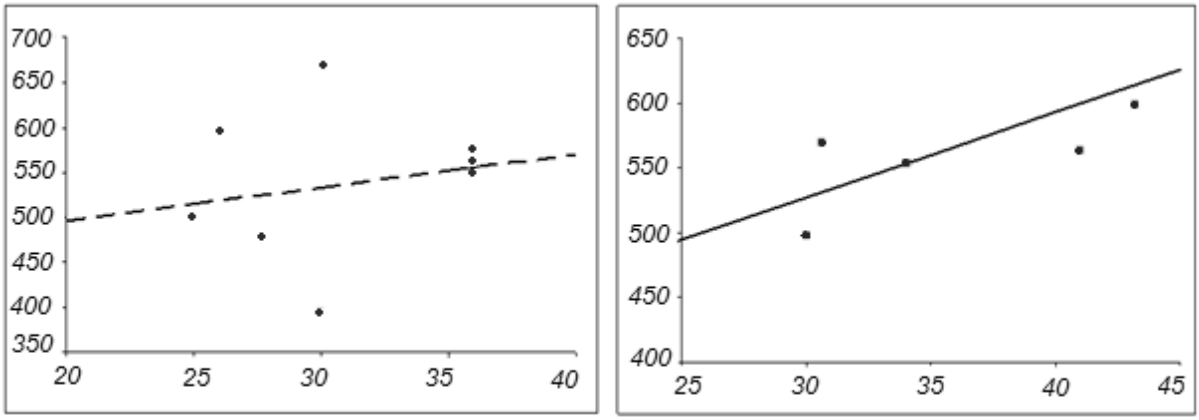

a) b)

Fig.4. Dependence of diseases of the cardiovascular system of a person on the water quality of the Henichesk district: a) with the initial regression; b) with a shift of two years + **15**% from the previous year

Among the total number of samples that do not comply with the standard, two most significant parameters (chlorides and total hardness) were identified, which determine the main percentage of nonconformities. On these two indicators, a two - factor model of the dependence of diseases of the gastrointestinal tract on the number of drinking water samples that do not correspond to the norm on chlorides and the general rigidity is constructed. Based on the statistics of the Berislav district. It is linear in rigidity and non-linear in chloride, that is, the incidence increases with decreasing water hardness and increases square with increasing chloride content in water. The same studies were conducted in Belozerka, Genichesk, Vysokopilla, Gornostaevka, Novotroitsk and Chaplynka districts, where the growth of diseases is confirmed against the background of deteriorating water quality.

The incidence in many cases depends solely on the sanitary condition of settlements, the hygienic living conditions of the population, the state of the environment. One possible solution is to predict this problematic situation. Studies are needed to model these processes, as well as their consequences, namely, the health status of the population; modeling situations, thanks to the current state of affairs with water supply; the modeling of the way out of the situation at the moment of its transformation into a critical one.

Conclusion

A study of water supply sources in the Kherson region has been carried out. It is substantiated that the state of health of the population

of the region depends, among other things, on the quality of drinking water. Since at present most of the samples show no compliance with the standard and a significant excess of the norm, it is necessary to carry out studies on modeling and forecasting the processes of deterioration of the quality of drinking water.

For this, it is necessary to develop algorithms, programs and information technologies based on the achievements of modern mathematical science and computer facilities.

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УДК 004.9/004.6:004

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WEB-APPLICATIONS PROTECTION ESTABLISHMENT

Annotation. *The modern world carries thousands of threats and potential dangers literally at every step and every moment of time. The World Wide Web, which has become an integral part of our lives, is no exception.*

Keywords: *information protection, SQL injection, cross-directory attack.*

Introduction

Insecure software undermines our finances, health, defense, energy and other important infrastructures. As software becomes more and more complex and related, the complexity of achieving application security grows exponentially. The rapid pace of modern software development processes makes the most common risks needed to identify and resolve, with what's fast and accurate. [1]

Google reported the safety of websites in 2016, announcing an increase in the number of broken sites by 32% in 2016 compared to 2015. Also, the trend is not expected to decline soon. [2]

The OWASP (Open Web Application Security Project) community is involved in the classification of Web application attacks and vulnerabilities. This is an international nonprofit organization focused on analyzing and improving software.

OWASP has created a list of the 10 most dangerous attack vectors on the web application, the list being called OWASP TOP-10, and it focuses on the most dangerous vulnerabilities. This project, first published in 2003 and regularly updated. It aims to increase awareness of application security by identifying some of the most critical risks to organizations

Technique of illegal extraction of confidential information and protection mathods

SQL injection is one of the most common methods of hacking applications running on databases, based on the implementation of an arbitrary SQL code request. Thus, changing the input parameters by adding in them the structures of the SQL language causes a change in the logic of executing the SQL query (in this example, instead of the news with the given identifier, all available news in the database will be

selected, since the expression 1 = 1 is always true).

A Simple SQL Injection Example:

*String stmt = "SELECT * FROM users " +"WHERE username='" + username + "' " + "AND password='" + password + "';";.*

Intruder input:

"jakob" + "' OR 1=1;-- "WHERE username='jakob' AND password='' OR 1=1;-- ';

To protect against SQL injections use:

- shielding single and double quotes;
- checking of type or data type typization;
- checking of the structure of input data using regular expressions.

Cross Site Scripting is a type of vulnerability in interactive information systems. XSS occurs when the page that was generated by the server for some reason fall into user scripts. The specific of these attacks is that instead of direct attacking the server, malicious users use a vulnerable server to attack the user.

As browsers do not allow interaction between sites (cross-site access), intruders use different techniques to implement cross-site scripting:

1) Saved intersite scripting matches the entry of a malicious script by a web application to steal temporary files that contain the session ID. Such a script redirects the web application to a web page hidden from the user, the URL request will contain temporary victim browser files as a query parameter. Once an attacker receives a temporary cookie URL, unauthorized access to the user session may occur.

2) Reflected cross-site scripting matches the reflection of an infected script from a web server, such as an error message, a search result, or any other response that includes a portion or all of the data sent to the server as part of the request. Reflected attacks are delivered to the victim (user) in another way, in the form of an email or as a link to another website. When a user clicks on such a malicious link, fills in a special form on the website, or even simply browses the malicious web resource, the affected code gets to the vulnerable website, which reflects the attack back to the user's browser. Then, the victim's browser executes this code because it came from a "trusted" server. Reflected cross-site scripting is also known as unstable.

3) Cross-site scripting based on an object model of a document (OML)

is a type of attack, when attacking actions are performed as a result of modifying the ODM environment in a victim's browser using a client-side script, that is, in this case, the user code executed in an unexpected manner . In this case, the web page remains unchanged, but the code stored on the victim page is executed according to the malicious modification of the OMD environment.

Example: Submit the form using invalid data. It is redirecting to http://acme.com/login.php?msg=Invalid%20login%20data.

The msg parameter is enabled in HTML. The attacker uses the msg parameter to add a malicious script:

```
window.onload = function( )
{
  document.forms[0].action= 'http://evil.com/steal_data.php';
};
```

http://acme.com/login.php?msg=%3Cscript%3Ewindow.onload%20%3D%20function%28%29%20%7Bdocument.forms%5B0%5D.action%3D%27http%3A%2f%2fevil.com%2fsteal_data.php%27%3B%7D%3B%3C%2fscript%3E

To protect use:

- encryption of each variable that is part of the HTML;
- checking the user's input, creating whitelists.

The **Counter Site Request Forgery (CSRF** also known as **XSRF)** is a kind of attack on website visitors that uses the disadvantages of the HTTP protocol. If a victim enters a site created by an attacker, a person is secretly sent a request to another server (for example, to a payment system server) that performs some harmful operation (for example, money transfer to the account of the attacker).

Most **CSRF** prevention methods work by embedding additional authentication data in queries that allows the web application to detect requests from unauthorized locations.

Cross-directory attack. An attacker's access to files and folders stored outside the root directory. Possible manipulation of variables that refer to files using "dot-dot-slash" (../) sequences. Web application that shows the user's home directory files:

http://acme.com/list_user_files.php test.txt

hello_world.txt http://acme.com/show_file.php?file=test.txt

The vulnerability lies in this case:

http://acme.com/show_file.php?file=../../../../etc/passwd

To protect using: "whitelisted" user input, identifying files for temporary access.

Incorrect session management includes cryptographically weak session identifiers (Session ID's), Sotsitelnaya engineering, etc. Possible methods of prevention:

- attaching the session identifier to the IP address;
- cryptographically persistent session identifiers (using proven encryption algorithms).

Conclusions

Web resource security is a process that combines a certain set of actions. The developed system is first investigated for safety purposes, then a series of measures and works being done to achieve it are determined.

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СОДЕРЖАНИЕ

МАТЕМАТИЧНЕ ТА ПРОГРАМНЕ ЗАБЕЗПЕЧЕННЯ ІНТЕЛЕКТУАЛЬНИХ СИСТЕМ

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РЕФЕРАТИ

УДК 681.51

Михальов О.І., Мелкумян Е.Ю., Солдатова М.О., Волкова О.А. **Модальний синтез компенсованих оптимальних систем із запізнюванням** / О.І. Михальов., Е.Ю. Мелкумян, М.О. Солдатова, О.А. Волкова // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 3–11.

У цій статті пропонується модальний синтез для лінійних стаціонарних замкнутих систем з запізненням з використанням оптимального закону керування у вигляді лінійної комбінації змінних стану для забезпечення заданих динамічних характеристик. Процедура модального синтезу закону оптимального управління виконується на основі методу невизначених коефіцієнтів. Для компенсації запізнювання пропонується використовувати для усунення виникнення стійких автоколивань в процесі стабілізації поблизу даної траєкторії пропонується використовувати метод компенсації запізнювання Бесса.

Бібл. 8.

УДК 004.654: 004.852

Булана Т.М. **Оцінки ефективності діагностування стану технічних систем** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 12–17.

Метою статті є підвищення ефективності діагностування стану технічних об’єктів шляхом побудови алгоритмів обробки вхідних даних та оптимізації підбору параметрів моделей за допомогою генетичних алгоритмів.

Бібл. 6.

УДК 574:004.2

Бардачов Ю.М. **Наближена просторова модель на основі інтервальних нечітко-наближених м’яких множин** / Ю.М. Бардачов, М.В. Жарікова, В.Г. Шерстюк // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 18–30.

У статті описується просторова модель для систем підтримки прийняття рішень на базі геоінформаційної системи реального часу на основі інтервальних нечітко-наближених м'яких множин. Динамічна нечітко-наближена м'яка топологія є структурою геоекотехнічної системи, яка містить множину взаємодіючих процесів, що розвиваються в просторі та часі. В умовах небзпечного природного явища деякі взаємодіючі процеси можуть бути деструктивними. Їх динаміка описується моделлю розповсюдження. Місцевість апроксимується сіткою кубічних комірок. Це дозволяє враховувати невизначеність вхідної інформації, що отримується за допомогою безпілотників, з використанням методів дистанційного зондування. Межі контурів розповсюдження руйнівних процесів розмиваються з використанням нечітко-наближеної м'якої топології. Запропонована модель дозволяє зменшити обчислювальну складність та забезпечує прийнятну ефективність системи підтримки прийняття рішень в режимі реального часу.

Бібл. 20, іл. 7.

УДК 004.942

Баклан І.В. **Деякі аспекти прогнозування нелінійних нестаціонарних процесів** / І.В. Баклан, В.В. Савченко, Ю.М. Селін, Т.В. Шулькевич // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 31–42.

Викладено математичний апарат, що можна застосовувати в задачах аналізу даних різної природи задля прогнозування нелінійних нестаціонарних процесів. Наведено результати його застосування для прогнозування таких процесів. Зазначимо, що майже всі вони є нелінійними та нестаціонарними (можна казати виключно про кусочну лінійність та кусочну стаціонарність).

Але вся ця кількість наявних методів прогнозування не дають гарантію що вони покривають вся можливі варіанти розвитку ситуації. Разом з тим, переважна більшість методів є двохетапними. На першому етапі аналізуються параметри раду, що прогнозується, на другому етапі обирається відповідний метод прогнозування і, нарешті, отримується прогноз. Але що робити, коли параметри ряду змінюються? Один метод вже неможна використовувати, бо параметри ряду вже змінилися, а обрати інший ще неможна, бо процес зміни параметрів ще не завершився.

Бібл. 10, іл. 7.

УДК 681.513.5: 623.4

Бурячок В.Л. **Особливості реалізації політики інформаційної безпеки у створенні раціональної системи електронного документального співробітництва для державних та комерційних структур України** / В.Л. Бурячок, Л.В. Кузьменко, О.В. Кононенко, О.О. Боскин // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 43–61.

У статті викладено алгоритм обґрунтованого вибору раціональної системи електронного документообігу з існуючої множини аналогів. Основні критерії вибору обумовлені функціональністю програмної і апаратної архітектури системи, а також обмеженою кількістю фінансових ресурсів. У статті обґрунтовано, що політика безпеки інформації такої системи: по-перше, дасть гарантії адекватності рівня захисту інформації рівню її критичності і рентабельності реалізації заходів щодо захисту інформації; по-друге, дозволить оцінити і перевірити захищеність інформації; по-третє, забезпечить персонофікацію положень політики безпеки (щодо суб'єктів СЕД) та звітності (реєстрації, аудиту) для всіх критичних з точки зору безпеки ресурсів; по-четверте, забезпечить наочність заходів по захисту інформації, безперервність роботи такої системи і її відновлення в разі виникнення непередбачених ситуацій, і так далі. Моделі загроз і порушника обраної СЕД дозволять визначити необхідні рівні функціонування підсистеми забезпечення безпеки інформації, а саме рівень організаційно-технічних заходів, рівень поточного контролю і рівень усунення наслідків реалізованих загроз.

Бібл. 13, іл. 4., табл. 4.

УДК 004:94

Дідик О.О. **Використання онтологій для розв'язання завдань інформаційної безпеки** / О.О. Дідик, О.Є. Огнєва // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 62–66.

Розглянуто основні проблеми інформаційної безпеки та їх вирішення за допомогою використання онтологій та онтологічних систем.

Бібл. 12.

УДК 621.396.96

Доронина М.А. **Оцінка розподіленого часу затримки вхідного сигналу стаціонарними об'єктами** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 67–73.

В статті запропонована нова методика оцінки розподіленого часу затримки сигналу стаціонарним лінійним об'єктом, передаточна функція якого нормована і не містить нулів. Показано, що шуканий час визначається координатою перетину графіка вимушеної складової реакції об'єкта на лінійно зростаючий вхідний сигнал з віссю абсцис. Аналітичні дослідження підтверджені результатами математичного моделювання роботи запропонованого алгоритму на ЕВМ.

Бібл. 5, іл. 6.

УДК 519.716.39: 519.6: 57.017

Фефелов А.А. **Реверсна інженерія генної регуляторної мережі з комбінованим використанням алгоритму клонального відбору та диференціальної еволюції** / А.А. Фефелов, М.А. Таїф, В.І. Литвиненко, М.А. Вороненко, О.М. Степанченко, І.В. Сокур, І.А. Лур'є // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 74–84.

Розробка методів реверсної інженерії генних регуляторних мереж є одним із важливих завдань в постгеномную епоху. Алгоритм клонального відбору є одним з популярних підходів при реконструкції генних мереж на основі даних мікрочіпів.

Бібл. 24, іл. 1, табл. 3.

УДК 004.773.2

Голуб З.Д. **Алгоритм виявлення фрагментів онлайн–дискусії, що містять інформацію та психологічні маніпуляції** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 85–91.

У статті представлено алгоритм виявлення підозрілих фрагментів онлайн-дискусій, які потенційно містять прецеденти інформаційно-психологічної маніпуляції. Запропоновано класифікацію критеріїв виявлення підозрілих фрагментів дискусії. Описано систему фільтрів для затримання підозрілих фрагментів. Розглянуто дії на етапах алгоритму виявлення інформаційно-психологічної маніпуляції.

Бібл. 9, іл. 2

УДК 004

Грицик В.В. **Сегментація зображень у системах комп'ютерного зору для задач медичної діагностики** / В.В. Грицик, М.Р. Петрик // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 92–101.

У цій статті описано методи, що застосовувались для систем сегментації та модель що представляє динаміку елементів, що описують стан пацієнта. Візуалізовано 3D модель нетипової поведінки системи (невротично-треморних рухів). Візуалізовано залежності, отримані з обробки поля ували. Обґрунтовано потребу розробки таких систем (актуальність задачі). Робота є результатом досліджень з розробки систем ранньої діагностики.

Бібл. 13, іл. 3.

УДК 681.2

Харламова Ю.М. **Оцінка параметрів квазістійкого об'єкта за допомогою симетричної взаємодії каналів інформаційно-вимірювальної системи, структура якої перебудована** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 102–108.

Показано алгоритм отримання оцінок невідомих параметрів квазістаціонарного об’єкту керування, використовуючи інформаційно-вимірювальну систему з двома адаптивними каналами, структури яких перебудовуються, та параметри яких навмисно змінюються. Розглянутий адаптивний алгоритм використовує процедуру послідовних оцінок невідомих параметрів об'єктів. На кожному етапі оцінки невідомих параметрів структури каналів перебудовуються, що дозволяє їм наблизитись до властивостей досліджуваного об'єкта. Основою цієї зміни є принцип подвійності моделей системи та сигналу. Цілеспрямована зміна параметрів каналів інформаційно-вимірювальної системи відповідає алгоритму, який реалізує енергетичну взаємодію між двома важкими кулями. Вивчено вплив похибки попередньої оцінки параметра на оцінку точності наступного параметра.

Бібл. 6, іл. 4.

УДК 621.391.3

Корніловська Н.В. **Формалізовані співвідношення та взаємозв’язки телекомунікаційних систем та телекомунікаційних трактів з позиції теорії систем** / Н.В. Корніловська, С.В. Вишемирська, І.А. Лур’є, О. Годлевський / Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 109–122.

Розглянуто сучасний стан телекомунікаційних систем і телекомунікаційних трактів. Узагальнені їх функціональні та структурні характеристики та властивості. Наведено визначення телекомунікаційних систем з позиції мікропідходу, макропідходу та мезопідходу. Описані рівні телекомунікаційних систем. Визначені співвідношення та взаємозв’язки понять телекомунікаційні системи та телекомунікаційні тракти з позиції теорії систем. Показано в яких співвідношеннях стоять поняття телекомунікаційні системи, інформаційно – управляючі системи, телекомунікаційні тракти, канали зв’язку.

Бібл. 7

УДК 502/504:544.558

Ольшевський С.В. **Особливості електрорадіолізної деструкції стійких хлорорганічних токсикантів** / С.В. Ольшевський, Ю.Ю. Мед, В.О. Носенко // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 123–130.

В роботі розглянуті результати моделювання ланцюжків електрорадіолізної деструкції стійких хлорорганічних токсикантів у водних розчинах. Показано, що як для молекул вихідного токсиканта, так і для продуктів їх дисоціації мають місце інваріантні щодо елементного складу молекул перетворення, енергія активації яких мало відрізняється від енергії дисоціації. Наявність таких перетворень спричиняє непродуктивну трансформацію єнергії потоку частинок в тепло, внаслідок чого має зростати споживна потужність реактора при незмінних цільових витратах.

Бібл. 4, іл. 2.

УДК 519.6/621.373.423

Ольшевський С.В. **Моделювання частотних характеристик резонаторної системи потужного клістрона при проплавленні пролітних каналів** / С. В. Ольшевський, Я.В. Танасійчук // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 131–137.

В роботі розглянуті результати експериментальних та теоретичних досліджень впливу механічних дефектів на стан резонаторної системи потужного клістрона. Дана числова оцінка впливу дефектів об'ємом 1.. 5% від об'єму резонатора на його АЧХ.

Бібл. 6, іл. 6.

УДК 004:93

Передерій В.І. **Інформаційна технологія актуалізації альтернатив підтримки прийняття рішень у розподіленій базі даних систем критичного застосування** / В.І. Передерій, Є.Ю. Борчік, О.Є. Огнєва // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 138–146.

Запропоновано інформаційну технологію формування та оцінки релевантних альтернатив прийняття рішень для актуалізації розподіленої бази даних в ергатичніх системах критичногоного застосування. Запропоновано використовувати метод нечіткої класифікації для формування і оцінки релевантих альтернатив прийняття рішень в умовах невизначеної, неточної і суперечливої інформації, в реальному часі.

Бібл. 9, іл. 4.

УДК 622.7: 658.562

Савицький О.І. **Агентне керування процесами трьохстадійного збагачення залізної руди** / О.І. Савицький, М.А. Тимошенко // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 147–157.

Розглянуто процеси збагачення залізної руди з точки зору автоматизованого керування. Обгрунтовано використання засобів мультиагентного керування у комплексі з інтелектуальними засобами керування, зокрема апарату нечіткої логіки. Сформульовано напрямки подальших досліджень. Вони передбачають більш глибоке дослідження зв'язку між механізмами різних стадій збагачення залізної руди та розробку відповідної автоматизованої системи керування.

Бібл. 9, іл. 2, табл. 4.

УДК 005

Тонкачеєв Г.М. **Процес реструктуризації як інноваційний механізми оновлення інфраструктурних підприємств** / Г.М. Тонкачеєв, В.Є. Кістіон // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 147–157.

В статті обґрунтовується доцільність застосування процесів реструктуризації як інноваційного механізму оновлення будівельних підприємств інфраструктурного типу.

Бібл. 18, табл. 1.

УДК 004.432.4

Василенко В.Г. **Абстрактні типи даних в ймовірнісних мовах програмування** / В.Г. Василенко, І.В. Баклан, В.В. Ширій // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 166–172.

Сьогодні існує безліч різних імовірнісних мов програмування, які певною мірою використовують поняття теорії ймовірностей для розрахунків. Але ми хотіли б знати, які типи даних існують для вирішення ймовірнісних завдань. У даній роботі ми представляємо системний аналіз абстрактних типів даних на вибраних мовах імовірнісного програмування. Ми виявили кілька моментів. Перший момент полягає в тому, що всі вибрані нами мови, використовують типи даних своїх "батьківських" мов програмування. Другий полягає в тому, що для використання дистрибутивів та випадкових величин використовуються вбудовані функції або методи кожної з мов. Ми спробували зобразити основні сфери використання сучасних ймовірнісних абстрактних типів даних у ймовірнісних мовах програмування.

Бібл. 10, іл. 1.

УДК 681.5

Вороненко М.О. **Інформатизація процесів приняття рішень в надзвичайних ситуаціях** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 173–180.

Розглянуто процеси оптимізації прийняття управлінських рішень в умовах надзвичайних ситуацій з урахуванням ризику. Обґрунтовано, що аналіз ризику прийняття помилкових рішень в управлінні - це комплекс дій, що об'єднує ідентифікацію, вивчення і здійснення аналізу механізмів ймовірних небажаних наслідків, які мають вплив на здоров'я людей, а також ефективне функціонування системи охорони здоров'я в цілому.

Бібл.5, іл. 3.

УДК 681.3

Вороненко М.О. **Дослідження якості водозабезпечення в Херсонській області** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 181–188.

Проведене дослідження джерел водопостачання в Херсонській області. Обґрунтовано, що стан здоров'я населення регіону залежить в тому числі і від якості питної води. Так як в даний час більшість проб демонструють невідповідність стандарту і значне перевищення норми, необхідно проводити дослідження з моделювання та прогнозування процесів погіршення якості питної води.

Бібл.5, іл. 4, табл.1.

УДК 004.9/004.6:004

Ольшевський С.В. **Забезпечення безпеки у веб-застосувань** / С.В. Ольшевський, Д.І. Тарнавський, Ю.С. Івженко // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6(113). – Дніпро, 2017. – С. 189–192.

У роботі розглянуті результати теоретичних досліджень з безпеки веб-застосувань. Показано що розроблена система спочатку має бути проаналізована на предмет безпеки, потім визначається низка заходів і робота, що виконуються для її досягнення.

Бібл.5.

УДК 681.51

Михалёв А.И. **Модальный синтез компенсированных оптимальных систем с запаздыванием** / А.И. Михалёв, Е.Ю. Мелкумян, М.А. Солдатова, А.А. Волкова // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 3–11.

В этой статье предлагается модальный синтез для линейных стационарных замкнутых систем с запаздыванием с использованием оптимального закона управления в виде линейной комбинации переменных состояния для обеспечения заданных динамических характеристик. Процедура модального синтеза закона оптимального управления выполняется на основе метода неопределенных коэффициентов. Для компенсации запаздывания предлагается использовать для устранения возникновения устойчивых автоколебаний в процессе стабилизации вблизи данной траектории предлагается использовать метод компенсации запаздывания Бэсса.

Библ. 8.

УДК 004.654: 004.852

Буланая Т.М. **Оценки эффективности диагностики состояния технических систем** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 12–17.

Целью статьи является повышение эффективности диагностики состояния технических объектов путем построения алгоритмов обработки входных данных и оптимизации подбора параметров моделей с помощью генетических алгоритмов.

Библ. 6.

УДК 574:004.2

Бардачев Ю.Н. **Приближенная пространственная модель на основе интервальных нечетко-приближенных мягких множеств** / Ю.Н. Бардачев, М.В. Жарикова, В.Г. Шерстюк // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 18–30.

В статье описывается пространственная модель для систем поддержки принятия решений на базе геоинформационной системы реального времени на основе интервальных нечетко-приближенных мягких множеств. Динамическая нечетко-приближенная мягкая топология является структурой геоекотехнической системы, содержит множество взаимодействующих процессов, развивающихся в пространстве и времени. В условиях опасного природного явления некоторые взаимодействующие процессы могут быть деструктивными. Их динамика описывается моделью распространения. Местность аппроксимируется сеткой кубических ячеек. Это позволяет учитывать неопределенность исходной информации, получаемой с помощью беспилотников, с использованием методов дистанционного зондирования. Границы контуров распространения разрушительных процессов размываются с использованием нечетко-приближенной мягкой топологии. Предложенная модель позволяет уменьшить вычислительную сложность и обес-печивает приемлемую эффективность системы поддержки принятия решений в режиме реального времени.

Библ. 20, ил. 7.

УДК 004.942

Баклан И.В. **Некоторые аспекты прогнозирования нелинейных нестационарных процессов** / И.В. Баклан, В.В. Савченко, Ю.М. Селин, Т.В. Шулькевич // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 31–42.

Изложено математический аппарат, можно применять в задачах анализа данных различной природы для прогнозирования нелинейных нестационарных процессов. Приведены результаты его применения для прогнозирования таких процессов. Отметим, что почти все они являются нелинейными и нестационарными (можно говорить исключительно о кусочной линейности и кусочной стационарности).

Но все это количество имеющихся методов прогнозирования не дают гарантию что они покрывают все возможные варианты развития ситуации. Вместе с тем, подавляющее большинство методов являются двухэтапными. На первом этапе анализируются параметры ряда, что прогнозируется, на втором этапе выбирается соответствующий метод прогнозирования и, наконец, получается прогноз. Но что делать, когда параметры ряда меняются? Один метод уже нельзя использовать, потому что параметры ряда уже изменились, а выбрать другой еще нельзя, потому что процесс изменения параметров еще не завершился.

Библ. 10, ил. 7.

УДК 681.513.5: 623.4

Бурячок В.Л. **Особенности реализации политики информационной безопасности в создании рациональной системы электронного документального сотрудничества для государственных и коммерческих структур Украины** / В.Л. Бурячок, Л.В. Кузьменко О.В. Кононенко, О.О. Боскин // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 43–61.

В статье изложен алгоритм обоснованного выбора рациональной системы электронного документооборота из существующего множества аналогов. Основные критерии выбора обусловлены функциональностью программной и аппаратной архитектур системы, а также ограниченным колличеством финансовых ресурсов. В статье обосновано, что политика безопасности информации такой системы: во-первых, даст гарантии адекватности уровня защиты информации уровню ее критичности и рентабельности реализации мероприятий по защите информации; во-вторых, позволит оценить и проверить защищенность информации; в-третьих, обеспечит персонификацию положений политики безопасности (в отношении субъектов СЭД) и отчетности (регистрации, аудита) для всех критических с точки зрения безопасности ресурсов; в-четвертых, обеспечит наглядность мероприятий по защиты информации, непрерывность работы такой системы и ее восстановление в случае возникновения непредвиденных ситуаций, и так далее. Модели угроз и нарушителя выбранной СЭД позволят определить необходимые уровни функционирования подсистемы обеспечения безопасности информации, а именно уровень организационно-технических мероприятий, уровень текущего контроля и уровень устранения последствий реализованных угроз.

Библ. 13, ил. 4., табл. 4.

УДК 004:94

Дидык А.А. **Использование онтологий для решения задач информационной безопасности** / А.А. Дидык, О.Е. Огнєва // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 62–66.

Рассмотрено основные проблемы информационной безопасности и их решение с помощью использования онтологий и онтологических систем.

Библ. 12.

УДК 621.396.96

Доронина М.А. **Оценка распределенного времени задержки входящего сигнала стационарными объектами** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 67–73.

В статье предложена новая методика оценки стационарным линейным объектом, передаточная функция которого является нормированной и не содержит нулей. Показано, что искомое время определяется координатой пересечения графика вынужденной составляющей реакции объекта на линейно возрастающий входной сигнал с осью абсцисс. Аналитические исследования подтверждены результатами математического моделирования работы предложенного алгоритма на ЭВМ.

Библ. 5, ил. 6.

УДК 519.716.39: 519.6: 57.017

Фефелов А.А. **Реверсная инженерия генной регуляторной сети с комбинированным использованием алгоритма клонального отбора и дифференциальной эволюции** / А.А. Фефелов, М.А. Таиф, В.И. Литвиненко, М.А. Вороненко, О.Н. Степанченко, И.В. Сокур, И.А. Лурье // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 74–84.

Разработка методов реверсеной инженерии генных регуляторных сетей является одной из важных задач в постгеномную эпоху. Алгоритм клонального отбора является одним из популярных подходов при реконструкции генных сетей на основе данных микрочипов.

Библ. 24, ил. 1, табл.3.

УДК 004.773.2

Голуб З.Д. **Алгоритм обнаружения фрагментов онлайн-дискуссии, содержащих информацию и психологические манипуляции** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 85–91.

В статье представлен алгоритм обнаружения подозрительных фрагментов онлайн-дискуссий, которые потенциально содержат прецеденты информационно-психологической манипуляции. Предложена классификация критериев выявления подозрительных фрагментов дискуссии. Описана система фильтров для задержания подозрительных фрагментов. Рассмотрены действия на этапах алгоритма обнаружения информационно-психологической манипуляции.

Библ. 9, ил. 2

УДК 004

Грицик В.В. **Сегментация изображений в системах компьютерного зрения для медицинской диагностики** / В.В. Грицик, М.Р. Петрик // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 92–101.

В работе описано методы сегментации, которые были использованы при создании методики и исследовании модели которая описывает состояние пациента. Показано модель 3D диагностики ненормального поведения последовательности, которая представляет невротически-триморные движения пациента. Обосновано актуальность работ. Работа является результатом исследований в направлении разработки систем ранней диагностики.

Библ. 13, ил. 3.

УДК 681.2

Харламова Ю.Н. **Оценка параметров квазиустойчивого объекта с помощью симметричного взаимодействия каналов информационно-измерительной системы, структура которой перестроена** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 102–108.

Показан алгоритм получения оценок неизвестных параметров квазистационарного объекта управления, используя информационно-измерительную систему с двумя адаптивными каналами, структуры которых перестраиваются, и параметры которых намеренно изменяются. Рассмотренный адаптивный алгоритм использует процедуру последовательных оценок неизвестных параметров объектов. На каждом этапе оценки неизвестных параметров структуры каналов перестраиваются, что позволяет им приблизиться к свойствам исследуемого объекта. Основой этого изменения является принцип двойственности моделей системы и сигнала. Целенаправленное изменение параметров каналов информационно-измерительной системы соответствует алгоритму, который реализует энергетическую взаимодействие между двумя тяжелыми пулями. Изучено влияние погрешности предварительной оценки параметра на оценку точности следующего параметра.

Библ. 6, ил. 4.

УДК 621.391.3

Корниловская Н.В. **Формализованные соотношеня и взаимосвязи телекоммуникационных систем и телекоммуникационных трактов с позиции теории систем** / Н.В. Корниловская, С.В. Вышемирская, И.А. Лурье, А. Годлевский // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 109–122.

Рассмотрено современное состояние телекоммуникационных систем и телекоммуникационных трактов. Обобщенны их функциональные и структурные характеристики и свойства. Приведены определения телекоммуникационных систем с позиции микроподхода, макроподхода и мезоподхода. Описаны уровни телекоммуникационных систем. Определены соотношения и взаимосвязи понятий телекоммуникационные системы и телекоммуникационные тракты с позиции теории систем. Показано в каких соотношениях состоят понятия телекоммуникационные системы, информационно - управляющие системы, телекоммуникационные тракты, каналы связи.

Библ. 7.

УДК 502/504:544.558

Ольшевский С.В. **Особенности электрорадиолизной деструкции стойких хлорорганических токсикантов** / С.В. Ольшевский, Ю.Ю. Мед, В.О. Носенко // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 123–130.

В работе рассмотрены результаты моделирования цепочек електрорадиолизной деструкции стойких хлорорганических токсикантов в водных растворах. Показано, что как для молекул исходного токсиканта, так и для продуктов их диссоциации имеют место инвариантные относительно элементного состава молекул превращения, энергия активации которых мало отличается от энергии диссоциации. Наличие таких превращений приводит к непроизводительной трансформации энергии потока частиц в тепло, в результате чего должна расти потребляемая мощность реактора при неизменных целевых затратах.

Библ. 4, ил. 2.

УДК 519.6/621.373.423

Ольшевский С.В. **Моделирование частотных характеристик резонаторной системы мощного клистрона при проплавлении пролётных каналов** / С.В. Ольшевский, Я.В. Танасийчук // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 131–137.

В работе рассмотрены результаты экспериментальных и теоретических исследований влияния механических дефектов на состояние резонаторной системы мощного клистрон. Дана численная оценка влияния дефектов обьемом 1..5 % от обьема резонатора наего АЧХ.

Библ. 6, ил. 6.

УДК 004:93

Передерий В.И. **Информационная технология актуализации альтернатив поддержки принятия решений в распределенной базе данных систем критического использования** / В.И. Передерий, Е.Ю. Борчик, О.Е. Огнева // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 138–146.

Предложена информационная технология формирования и оценки релевантных альтернатив принятия решений для актуализации распределенной базы данных в эргатичных системах критического использования. Предложено использовать метод нечёткой классификации для формирования и оценки релевантных альтернатив принятия решений в условиях неопределенной, неточной и противоречивой информации, в реальном времени.

Библ. 9, рис. 4.

УДК 622.7: 658.562

Савицкий А.И. **Агентное управление процессами трехстадийного обогащения железной руды** / А.И. Савицкий, М.А. Тимошенко // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 147–157.

Рассмотрено процессы обогащения железной руды с тчоки зрения автоматизированного управления. Обосновано использование средств мультиагентного управления в комплексе с интеллектуальными средствами управления, в особенности аппарата нечеткой логики. Сформулировано направления дальнейших исследований. Они предполагают более глубокое исследование связи между механизмами разных стадий обгащения железной руды и разработку соответствующей автоматизированной системы управления.

Библ. 9, ил. 2, табл. 4.

УДК 005

Тонкачеев Г.Н. **Процесс реструктуризации как инновационный механизмы обновления инфраструктурных предприятий** / Г.Н. Тонкачеев, В.Е. Кистион // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 158–165.

В статье обосновывается целесообразность применения процессов реструктуризации как инновационного механизма обновления строительных предприятий инфраструктурного типа.

Библ. 18, табл. 1.

УДК 004.432.4

Василенко В.Г. **Абстрактные типы данных в вероятностных языках программирования** / В.Г. Василенко, І.В. Баклан, В.В. Ширий // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 166–172.

Сегодня существует множество различных вероятностных языков программирования, которые в определенной степени используют понятия теории вероятностей для расчетов. Но мы хотели бы знать, какие типы данных существуют для решения вероятностных задач. В данной работе мы представляем системный анализ абстрактных типов данных на выбранных языках вероятностного программирования. Мы обнаружили несколько моментов. Первый момент заключается в том, что все выбранные нами языки, используют типы данных своих "родительских" языков программирования. Второй заключается в том, что для использования дистрибутивов и случайных величин используются встроенные функции или методы каждого из языков. Мы попытались изобразить основные сферы использования современных вероятностных абстрактных типов данных в вероятностных языках программирования.

Библ. 19, ил. 1.

УДК 681.5

Вороненко М.А. **Информатизация процессов принятия решений в чрезвычайных ситуациях** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 173–180.

Рассмотрены процессы оптимизации принятия управленческих решений в условиях чрезвычайных ситуаций с учетом риска. Обосновано, что анализ риска принятия ошибочных решений в управлении - это комплекс действий, который объединяет идентификацию, изучение и осуществление анализа механизмов вероятных нежелательных последствий, которые имеют влияние на здоровье людей, а также эффективное функционирование системы здравоохранения в целом.

Библ.5, ил. 3.

УДК 681.3

Вороненко М.А. **Исследование качества водообеспечения в Херсонской области** // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 181–188.

Проведено исследование источников водоснабжения в Херсонской области. Обосновано, что состояние здоровья населения региона зависит в том числе и от качества питьевой воды. Так как в настоящее время большинство проб показывают не соответствие стандарту и значительное превышение нормы, необходимо проводить исследования по моделированию и прогнозированию процессов ухудшения качества питьевой воды.

Библ. 5, ил. 4, табл. 1.

УДК 004.9/004.6:004

Ольшевский С.В. **Обеспечение безопасности в веб-приложениях** / С.В. Ольшевский, Д.И. Тарнавский, Ю.С. Ивженко // Системні технології. Регіональний міжвузівський збірник наукових праць. – Випуск 6 (113). – Дніпро, 2017. – С. 189–192.

В работе рассмотрены результаты теоретических исследований по безопасности веб-приложений. Показано, что разработанная система сначала должна бать проанализирована на предмет безопасности, затем определяется ряд мероприятий и работа, выполняемых для ее достижения.

Библ. 5.

UDC 681.51

Mikhalyov A. **Modal synthesis of compensated optimal systems with delay** / A. Mikhalyov, E. Melkumyan, M. Soldatova, A. Volkova // System tecnologies. №6 (113). – Dnipro, 2017. – P. 3–11.

Systems synthesis task is one of the key tasks of both automatic control theory and practice. Its solution results in definition of the structure of the automatic control system (ACS) and its parameters of the condition of the system sustainability and quality of transient processes (achieving the required performance, the inadmissibility of the considerable overshoot) improving control accuracy in steady-state conditions etc.

The majority of industrial controlled objects have delays. The presence of the delay is due to the final velocity of information flows propagation in the technological objects. The delay may also occur due to time spent on signal transmission or, as happens more often can be caused by the phenomenon of simplifying assumptions, by virtue of which it is considered that action of intermediate and reinforcing links in the controlled object is reduced to a signal transmission with delay. Of particular interest is the training of remote control operators for various types of technical objects (for example, management of the lunar rovers, walking robot, and others.). Inertia of the operator himself has a significant impact on the management quality in addition to the delay in the signal transmission. Therefore, it's imperative to have the best (reference) dynamic realization (control laws) in preparation of the operator considering the inertia and delay in the control loop.

In this article authors proposed a procedure for the synthesis of the optimal modal stabilization of linear stationary systems with delay based on the method of undetermined coefficients. Bess'sdelay compensation method is proposed to use in order to eliminate the stable self-oscillations occurrence (due to the delay) at the stabilization process end point near given trajectory.

Ref. 8.

UDC 004.654: 004.852

Bulana T.M. **Evaluations of diagnostic efficiency of the state of technical systems** // System tecnologies. №6 (113). – Dnipro, 2017. – P. 12–17.

The purpose of this paper is to study a possibility of increasing effectiveness of diagnosing the state of technical objects by constructing algorithms for processing input data and optimizing the selection of model parameters using genetic algorithms.

Ref. 6.

UDK 574:004.2

Bardachov Yu. **Approximate spatial model based on interval fuzzy rough soft sets** / Yu. Bardachov, M. Zharikova, V. Sherstjuk // System tecnologies. №6 (113). – Dnipro, 2017. – P. 18–30.

The article deals with complex systems containing territories with natural and artificial objects as well as a multitude of interacting processes, which evolve in space and time, which are considered as geoecotechnogenic systems. Some processes arising within geoecotechnogenic systems are destructive because they give rise to a danger and risk to the certain valuable objects causing their destructions and can often lead to critical situations or emergencies

This work presents a spatial model for the real-time GIS-based decision support systems in geoecotechnogenic systems in destructive process conditions based on the interval fuzzy rough soft sets. A dynamic fuzzy rough soft topology represents a structure of a geoecotechnical system that contains a multitude of interacting processes, which evolve in

space and time. In disaster conditions, some of the interacting processes can be destructive. Their dynamics are modeled using the spread model. The area of interest is represented as an approximation by a grid of cubic cells. This allows taking into account the peculiarities of the initial information obtained from drones using remote sensing techniques and having a significant uncertainty. As a result, boundaries of contours of spreading destructive processes are blurred using fuzzy rough soft topology.

The experiment with DSS in the form of simulation of the disaster situations using the proposed spatial model with the variable cell size is described. The results of the experiment show that the proposed model provides acceptable performance in terms of accuracy and speed for all kind of topology. The fastest performance is demonstrated by the rough soft topology; however, it does not provide acceptable accuracy. The fuzzy topology significantly loses in terms of speed. The interval fuzzy rough topology shows sufficient results on the speed with enough accuracy.

The proposed model reduces the computational complexity and provides the acceptable performance of real-time DSS.

Ref. 20, il. 7.

UDC 004.942

Baklan I.V. **Some aspects of nonlinear non-stationary processes forecasting** / I.V. Baklan, V.V. Savchenko, Y.M. Selin, T.V. Shulkevych // System tecnologies. №6 (113). – Dnipro, 2017. – P. 31–42.

The mathematical tools set forth implemented in data mining problems of different nature for forecasting of nonlinear non-stationary processes. Results of its implementation for forecasting of nonlinear non-stationary processes is provided. Note that almost all of them are nonlinear and non-stationary (one can only say piecewise linearity and piecewise stationary).

But all this amount of available methods of forecasting does not guarantee that they cover all possible options for the development of the situation. However, the vast majority of methods are two-stage. In the first stage, the parameters of the predicted council are analyzed, in the second stage the appropriate forecasting method is selected and, finally, the forecast is obtained. But what to do when the parameters of the row vary? One method can no longer be used, since the parameters of the row have already changed, but the choice of another is not possible, because the process of changing the parameters has not yet been completed.

Ref. 10, il. 7.

UDC 681.513.5: 623.4

Buriachok V.L. **Features of implementation of the information security policy in the creation of the rational system of electronic documentary cooperation for public and commercial structures of Ukraine** / V.L. Buriachok, L.V. Kuzmenko, O.V. Kononenko, O.O. Boskin // System tecnologies. №6 (113). – Dnipro, 2017. – P. 43–61.

The article presents an algorithm for a reasonable choice of a rational electronic document management system from an existing set of analogues. The main selection criteria are due to the functionality of the software and hardware architectures of the system, as well as the limited number of financial resources. The article substantiates that the information security policy of such a system: first, it will guarantee the adequacy of the level of information protection to the level of its criticality and profitability of implementing information protection measures; secondly, it will allow to evaluate and check the security of information; thirdly, it will ensure the personification of the provisions of the security policy (in relation to the subjects of the EDS) and the reporting (registration, audit) for all critical resources from the security point of view; Fourthly, it will provide visibility of measures to protect information,

continuity of the operation of such a system and its restoration in case of unforeseen situations, and so on. Models of threats and the infringer of the chosen CSA will allow to determine the necessary levels of the functioning of the information security subsystem, namely the level of organizational and technical measures, the level of current control and the level of elimination of the consequences of the realized threats.

Bibl. 13, il. 4., tabl. 4.

UDK 004:94

Didyk O. **The use of ontologies for solving information security tasks** / O. Didyk, O. Ohnieva // System tecnologies. №6 (113). – Dnipro, 2017. – P. 62–66.

The basic information security issues and solutions through the use of ontologies and ontology systems are described.

Bibl. 12.

UDC 621.396.96

Doronina M.A. **Assessment of distributed delay time of input signal by stationary objects** // System tecnologies. №6 (113). – Dnipro, 2017. – P. 67–73.

The article proposes a new method for estimating the distributed delay time of a signal by a stationary linear object whose transfer function is normalized and does not contain zeros. It is shown that the required time is determined by the coordinate of the intersection graph of forced component of the reaction of the object on a linearly increasing input signal from the x-axis. Analytical studies are confirmed by the results of mathematical modeling of the work of the proposed algorithm on a computer.

Ref. 5, il. 6.

UDC 519.716.39: 519.6: 57.017

Fefelov A.A. **Reverse engineering of the gene regulatory network with combined use of the clonal selection algorithm and differential evolution** / A.A. Fefelov, M.A. Taif, V.I. Lytvynenko, M.A. Voronenko, O.M. Stepanchenko, I.V. Sokur, I.A. Lurie // System tecnologies. №6 (113). – Dnipro, 2017. – P. 74–84.

The development of methods for reverse engineering of gene regulatory networks is one of the important tasks in the post-genomic era. The algorithm of clonal selection is one of the popular approaches for the reconstruction of gene networks based on microchip data.

Ref. 24, il. 1, tabl. 3.

UDK 004.773.2

Holub Z. **The algorithm for detecting online discussion fragments containing information and psychological manipulation** // System tecnologies. №6 (113). – Dnipro, 2017. – P. 85–91.

The paper scrutinizes the algorithm for detecting suspicious fragments of online community discussions that potentially contain information and psychological manipulation precedents. The classes of criteria for detecting suspicious discussion fragments are presented; the system of filters for detecting the fragments is described. The stages of the algorithms for detecting suspicious fragments are detailed.

Bibl. 9, il. 2

UDC 004

Hrytsyk V.V. **Image segmentation in computer vision diagnostic systems** / V.V. Hrytsyk, M.R. Petryk // System tecnologies. №6 (113). – Dnipro, 2017. – P. 92–101.

Segmentation methods, abnormal patient's neurotic-tremor moves analysis and identification hybrid model are described in the paper. 3D model of untypical behavior of set digitals of values is shown. The necessity of developing such systems (actuality of the problem) is substantiated. The work is the result of research on the development of early diagnostic systems.

Ref. 13, il. 3.

UDC 681.2

Kharlamova Y.N. **Estimation of parameters of the quasi stable object using a symmetric interaction of channels of information and measurement system which structure are rebuilt** // System tecnologies. №6 (113). – Dnipro, 2017. – P. 102–108.

The algorithm for obtaining the estimates of unknown parameters of the quasi-stationary control target using an information and measurement system with two adaptive channels, which structure are rebuilt and parameters are changed intentionally developed by the author is shown. The considered adaptive algorithm operates on a sequential estimation procedures of unknown parameters object. At each stage of estimating unknown parameters structures of channels are rebuilt, which allows them to get as close to the properties of the object under study. The basis of this change is the principle of duality models of system and signal. Purposeful variation of parameters the channels of information-measuring system is in accordance with an algorithm that realizes the energy interaction between the two heavy balls. The influence of error of the previous estimation of parameter on the accuracy estimation of the following parameter is studied.

Bibl. 6, il. 4.

UDC 621.391.3

Kornilovska N.V. **The formalized correlations and interconnections of telecommunication systems and telecommunication routes from the standpoint of system theory** / N.V. Kornilovska, S.V. Vyshemyrska, I.A. Lurie, O. Hodlievskyi // System tecnologies. №6 (113). – Dnipro, 2017. – P. 109–122.

The modern state of telecommunication systems and telecommunication routes is considered. Their functional and structural characteristics and properties are generalized. The definitions of telecommunication systems from the position of the micro approach, macro approach and meso approach are given. The levels of telecommunication systems are described. Relationships and interrelations of the concepts of telecommunication systems and telecommunication routes from the standpoint of system theory are determined. It is shown in what relations the concepts of telecommunication systems, information management systems, telecommunication routes, communication channels consist.

Bibl. 7

UDC 502/504:544.558

Olszewski S. V. **Features of electroradiolytic destruction of persistent organochlorine toxicants** / S.V. Olszewski, Yu.Yu. Med, V.O. Nosenko // System tecnologies. №6 (113). – Dnipro, 2017. – P. 123–130.

The results of modeling the chains of electro-radiolytic destruction of persistent organochlorine toxicants in aqueous solutions are considered. It is shown that both for the initial toxicant molecules and for the products of their dissociation, there are invariant transformations that save the atomic composition of parent molecules, the activation energy of which differs little from the dissociation energy. The presence of such transformations leads

to an unproductive transformation of the energy of the particle flow into heat, as a result of which the reactor power consumption must increase at constant target costs.

Ref. 4, il. 2.

UDC 519.6/621.373.423

Olszewski S.V. **Modelling of kinetics plasma-chemical disposal of persistent organic pollutants in water solutions by high-voltage pulsed discharge** / S.V. Olszewski, Ya.V. Tanasiichuk // System tecnologies. №6 (113). – Dnipro, 2017. – P. 131–137.

The paper considers the results of experimental and theoretical studies of the influence of mechanical defects on the state of the resonator system of a powerful klystron. This numerical estimate of the influence of defects in the volume of 1 ..5% of the volume of the resonator on its AFC.

Ref. 6, il. 6.

UDK 004:93

Peredery V. **Information technology of updating of decision support alternatives in the distributed database of critical application systems** / V. Peredery, E. Borchik, O. Ohnieva // System tecnologies. №6 (113). – Dnipro, 2017. – P. 138–146.

Information technology of generating and evaluating of relevant alternatives for making decisions for the distributed database upgrading in ergatic systems of critical application is proposed. Using the method of fuzzy classification for generating and evaluating of relevant alternatives for making decisions in conditions of inconclusive, inaccurate and contradictory information in real time is considered.

Ref. 9, il. 4.

UDC 622.7: 658.562

Savytskyi O.I. **Agent control of the processes of the three-staged iron ore enrichment** / O.I. Savytskyi, M.A. Tymoshenko // System tecnologies. №6 (113). – Dnipro, 2017. – P. 147–157.

Iron ore enrichment processes are considered in terms of automated control. Using tools of multi-agent control in combination with intelligent control means, in particular the apparatus of fuzzy logic is substantiated. Directions for further research are formulated. They suggest a deeper study of relationships between the mechanisms of different stages of iron ore enrichment and the development of appropriate automated control system.

Ref. 9, il. 2, tabl. 4.

UDK 005

Tonkacheev G.N. **Process of restructuring as innovative is mechanisms of updating of infrastructural enterprises** / G.N. Tonkacheev, V.E. Kistion // System tecnologies. №6 (113). – Dnipro, 2017. – P. 158–165.

In the article expediency of application of processes of restructuring is grounded as an innovative mechanism of updating of building enterprises of infrastructural type.

Ref. 18, tabl. 1.

UDC 004.432.4

Vasilenko V.G. **Abstract data types in probabilistic programming languages** / V.G. Vasilenko, I.V. Baklan, V.V. Shyrii // System tecnologies. №6 (113). – Dnipro, 2017. – P. 166–172.

Today, there are quite a few different probabilistic programming languages that to some extent use the concepts of probability theory for their calculations. But we wanted to know what data types exist for solving probabilistic tasks. In the present paper we present a system analysis of abstract data types in selected languages of probabilistic programming. We revealed several moments. The first is that all the languages we choose use the data types of their "parent" programming languages. The second is that for the use of distributions and random variables, the built-in functions or methods in each of the languages are used. We tried to depict the main areas of use of modern probabilistic abstract data types in probabilistic programming languages.

Ref. 19, il. 1.

UDC 681.5

Voronenko M.A. **Informatization of decision-making processes in emergency situations** // System tecnologies. №6 (113). – Dnipro, 2017. – P. 173–180.

The processes of optimization of making managerial decisions in emergency situations taking into account the risk are considered. It is substantiated that an analysis of the risk of making erroneous decisions in management is a complex of actions that unites the identification, study and analysis of the mechanisms of possible undesirable consequences that have an impact on people's health, as well as the effective functioning of the health protection system at all.

Ref. 5, il. 1.

UDC 681.3

Voronenko M.A. **The research of water support quality in Kherson region** // System tecnologies. №6 (113). – Dnipro, 2017. – P. 181–188.

A study of water supply sources in the Kherson region has been carried out. It is substantiated that the state of health of the population of the region depends, among other things, on the quality of drinking water. Since at present most of the samples show no compliance with the standard and a significant excess of the norm, it is necessary to carry out studies on modeling and forecasting the processes of deterioration of the quality of drinking water.

Ref. 5, il. 1, tabl. 1.

UDC 004.9/004.6:004

Olszewski S.V. **Web-applications protection establishment** / S.V. Olszewski, D.I. Tarnavskyi, Y.S. Ivzhenko // System tecnologies. №6 (113). – Dnipro, 2017. – P. 189–192.

The paper considers the results of theoretical studies on the web application security. Web resource security is a process that combines a certain set of actions. The developed system in first must be analysed for safety purposes, then a series of measures and work being done to achieve it are determined.

Ref. 5.

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