In This paper presented the design of a miniaturized dual polarized element suitable for space applications, based on flat-crossed dipoles, backed by an AMC. The success of this activity is the demonstration that VHF space applications can be accommodated on minisatellite class platform, driving the design to a further stage.

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INFORMATION COMPUTATIONAL TECHNOLOGY IN PROBLEM OF GEOPHYSICAL MONITORING

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Abstract -- Geophysical monitoring of environment covers in itself a wide range of scientific and technological problems. An overall aim of the decision of these problems is definition of spatial co-ordinates of a source of this or that nature. In work the complex of computing algorithms and computing technology in the form of the tool adequate for the decision of various problems is offered and analysed.

Keywords—geophysical monitoring, natural and technogenic event, inverse problem, estimating of parameters, identification, location, computing technology.

INTRODUCTION

Geophysical monitoring of environment covers in itself a wide range of scientific and technological problems. The decision of fundamental problems is connected with working out of methods of tracking natural geophysical processes, as for example, the continuous control of seismic processes in seismo-vulkano active areas of the Earth for the purpose of the decision of a problem of the forecast of destructive events. Methods of active [1,2] and also passive monitoring of a surrounding environment are thus used. A number of applied problems are connected with detection and identification of the technogenic explosions, the falling fulfilled steps of rockets for the purpose of their subsequent recycling [3], definition of co-ordinates of the chisel tool at deep drilling [4] etc. Overall aim of the decision of these problems is definition of spatial co-ordinates of a source of this or that nature. In work the complex of computing algorithms and computing technology for the decision of various problems is offered and analyzed.

PROBLEM STATEMENT.

The problem of estimating unknown parameters of the source is reduced to solving a nonlinear system of conditional equations [4]:

$$\vec{t} = \vec{\eta}(X,\theta) + \vec{\varepsilon} \tag{1}$$

where $\vec{t} = (t_1, t_2, \ldots, t_N)$ is the vector of travel times of seismic signals, $\vec{\eta}(X,\theta)$ is the *N*-dimensional vector of the travel times being calculated the theoretical hodograph or the regression function, $\vec{\varepsilon} = (\varepsilon_1, \ldots, \varepsilon_N)^T$ is the residual vector, $\vec{\theta} = (x, y, z, v, t)^T$ is the *m*-dimensional vector of the parameters being estimated, $X = (\vec{x}_1, \vec{x}_2, \ldots, \vec{x}_N)$ is the matrix of the coordinates of sensors (or radiation points), and *N* is the number of sensors (or radiation points). The parameters being estimated are the space coordinates of the source *x, y, z,* the velocity characteristic of the medium *v*, and the event time in the source *t.* In some cases the velocity in the medium is known. At the estimation of the parameters, information about the distribution of errors $\varepsilon_i = t_i(\vec{x}_i, \vec{\theta}) - \eta(\vec{x}_i, \vec{\theta})$ is used. It is assumed below that ε_i are mutually independent random quantities having a distribution with a zero mean and given variances: $E\varepsilon_i = 0,\ E\varepsilon_i\varepsilon_j = \sigma_i^2\delta_{ij},\ \sigma_i = \sigma(\vec{x}_i),$ where δ_{ij} is the Kronecker symbol, $i = 1,2,\ldots,N$. In cases when it is difficult to specify variances, they are taken equal, and an unbiased estimate of the observation variance with a unit weight in the process of solving the problem is obtained.

Solving equation (1) is reduced to solving the inverse problem. In this case, the accuracy of the solution depends, first of all, on errors in estimating the time vector $\vec{t} = (t_1, t_2, \ldots, t_N)$, the velocity *v*, the measurement noise $\vec{\varepsilon} = (\varepsilon_1, \ldots, \varepsilon_N)^T$, and the choice of an arrangement geometry of sensors on the Earth's daily surface. In particular, for the polar system of coordinates the error variance in determining the azimuth Az to the source and the "source-receiver" distance R by a triad of seismic stations (the case N=3) is determined by the relations

$$\sigma_{AZ}^2 = \sigma_t^2 F_1(\bar{t}, \bar{\eta}), \qquad \sigma_R^2 = \sigma_t^2 F_2(\bar{t}, \bar{\eta}), \tag{2}$$

where σ_t^2 are the estimation errors of the times $\bar{t}$ and $\bar{\eta}$ is the vector of parameters characterizing the arrangement geometry of the seismic array.

SOLUTION PROBLEM.

In full statement the decision of a problem of geophysical monitoring breaks up to following basic stages: detection and measurement of wave arrival times on the background of external noise; event type identification; calculation of the source parameters; display of the source coordinates on the digital map of a terrain.

At first stage an automated technology for solving problems in real time is required. Such a technology should help the operator is free him from numerous routine data processing operations at continuous monitoring of events recorded, as a rule, on the background of large noise. For pulse-type sources, for instance, industrial explosions, errors in determining wave travel times are determined by the variance in estimating the travel times:

$$\sigma_{\tau}^{2} = \frac{\tau_{И}}{2\Delta f(2E/N_0)} \qquad (3)$$

Here τ_u is the duration of the wave pulse, Δf is the width of its spectrum, and E/N_0 is the ratio between the pulse energy and the spectral density of external noise. It follows from (6) that the error can be decreased by increasing the ratio between the signal and noise energies, broadening the frequency spectrum Δf occupied by the pulse, and compressing the wave pulse in time by reducing it to a δ-shaped pulse. Below we consider algorithms for solving error minimization problems in the estimation of times taking into account (2).

INCREASING THE SIGNAL-TO-NOISE RATIO AND ESTIMATION OF TIMES WITH THE HELP OF WAVELET FILTRATION.

The algorithm for increasing the ratio between the levels of wave pulses and noise is most efficiently implemented with wavelet filtration. It is based on the decomposition of a 1D signal over a basis, constructed from a solution-like function (wavelet) with certain properties, by means of scale changes and shifts. The wavelet filtration is based on the integral wavelet transformation:

$$X(\tau, s) = \int_{-\infty}^{\infty} f(t)\Psi_{\tau,s}\,dt\,,$$ where $f(t)$ is a wave pulse; $\psi_{\tau,s}(t) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-\tau}{s}\right)$, $\tau, s \in R$;

$\psi \in L^2(R)$ (4).

The basis of the functional space $L^2(R)$ can be constructed with the help of continuous scaling transformations and transfers of the wavelet $\psi(t)$ with arbitrary values of basic parameters – the scale factor s and the shift parameter τ Dobeshi wavelets are most suitable for the approximation of seismic oscillations from explosions. As an example, Fig. 1 shows wavelets of the Dobeshi family of the 2^{nd}, 4^{th}, 5^{th}, 8^{th}, and 10^{th} orders. The family of such functions is used for the description of compact oscillations on time. The oscillations, generated by explosions, concern their number. The best approximation can be achieved by choosing the mother wavelet. For instance, for wave pulses, generated by industrial explosions, from Dobeshi wavelets of the 3^{rd}, 5^{th}, 8^{th}, and 12^{th} orders it was decided to choose the 8^{th} order wavelet, since a higher wavelet order does not introduce any additional information and, hence, it is redundant.

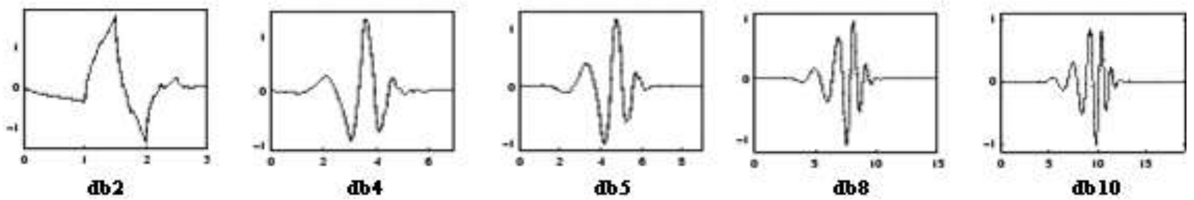


Fig. 1. Family of Dobeshi

To illustrate the quality of approximating the wave pulse by a set of wavelets, Fig.2 shows the approximation error versus the wavelet-decomposition depth. The approximation quality was estimated by using the error mean square criterion. In Fig.2, seismic signal approximation error versus wavelet-decomposition when using Dobeshi wavelets of the 4^{th}, 6^{th}, and 8^{th} orders calculated for: the model Berlage pulse (Fig.2a) used to describe the test explosion: $y(t) = (atne^{-\alpha t})^2 \sin(2\pi f_0 t)$, here a=1, n=1, α=20, f_0=42 Гц.

Other case of using- (Fig.2b) correspond to real seismic oscillation, recorded from a calibration explosion with a power of about 600 g in TNT equivalent at a distance of about 800 m.(Fig. 3a). Actually, the use of wavelets whose order is higher than the 3rd one in the first case and higher than the 4th one does not increase the approximation quality (Fig.2). In the record (Fig. 3a) the first low-amplitude wave is seismic, and the second high-amplitude wave is acoustic. To search for and calculate the arrival times of wave pulses in (1), threshold processing [5,7] according to the “three-sigma” rule was used. In stationary conditions, the seismic noise

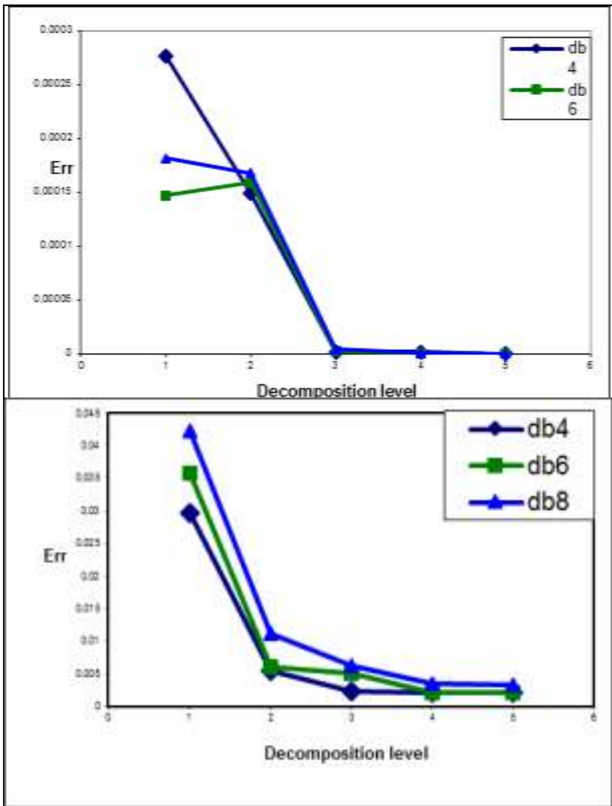


Fig 2. Seismic signal approximation error versus wavelet-decomposition depth when using Dobeshi wavelets of the 4th, 6th, and 8th orders calculated for the model (a) and real (b) seismic signals.

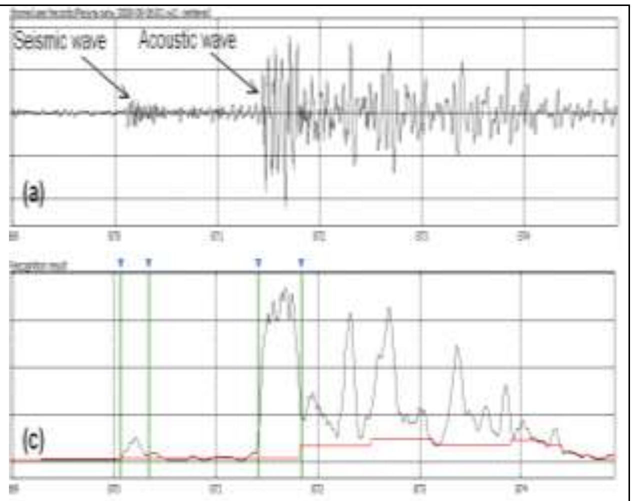


Fig 3. The example of natural field explosion filtration: (a) is the original seismic and acoustic waves, (c) is wavelet-filtered result with amplitude envelope and the result of automatic arrive times calculation by using the of Hilbert transform and thresholding. Borders of the allocated seismic and acoustic wave forms are designated by vertical lines

preceding the useful signal is described by a normal distribution with variance calculated in the continuous mode with the help of an iterative procedure of the form

$$D[N+1] = D[N] + \gamma (X[N+1] - \overline{X}[N])^2 \qquad (5)$$

where $\overline{X}[N] = \overline{X}[N-1] + \gamma (X[N] - \overline{X}[N-1])$

(6)

is the average value calculated at the step N and $\gamma = \Delta t / T$ is the convergence coefficient. Here Δt is quantization interval of analog signal, T is interval of processing. In order to calculate wave arrival times in the automatic mode, it is first necessary to find the envelope of the obtained signal $A(t)$ in form $A(t) = \sqrt{f^2(t) + f^{*2}(t)}$, where $f^*(t) = \frac{1}{\pi} \int_{-\infty}^{+\infty} \frac{f(x)}{t-x} dx$ is the Hilbert transform of signal *f(t)*. As an example of successful use of the considered computing technology, Fig.3 presents the results of detection and calculatuion of wave pulses of seismic and acoustic nature from a calibration explosion with a power of about 600 g in TNT equivalent at a distance of about 800 m. The estimation error of arrival times determined by the calibrated wave travel times for this region constituted 0.9%.

Unlike an example resulted on fig. 3, the situation when wave forms are essentially below level of noise is typical. Except the factors considered in (3), noise stability wavelet - filtrations will depend on a set coordination wavelet to a kind of initial signals. Thus it is necessary to notice, that its application is justified, first of all, under the relation to fluctuations which are described by solitono-like functions. Explosions concern their number. An example of a wavelet-filtration of a test signal of a kind on fig. 3, recorded from field explosion with the imposed noise in the ratio the signal/noise, equal 1/4, is resulted on fig. 4. In the top part of drawing record of a mix a signal with noise, more low-result of allocation of a signal from noise, even more low (fig. 4в) - result of smoothing of the received response by means of algorithm STA/LTA [6] with parametres 0.1 c/1s.

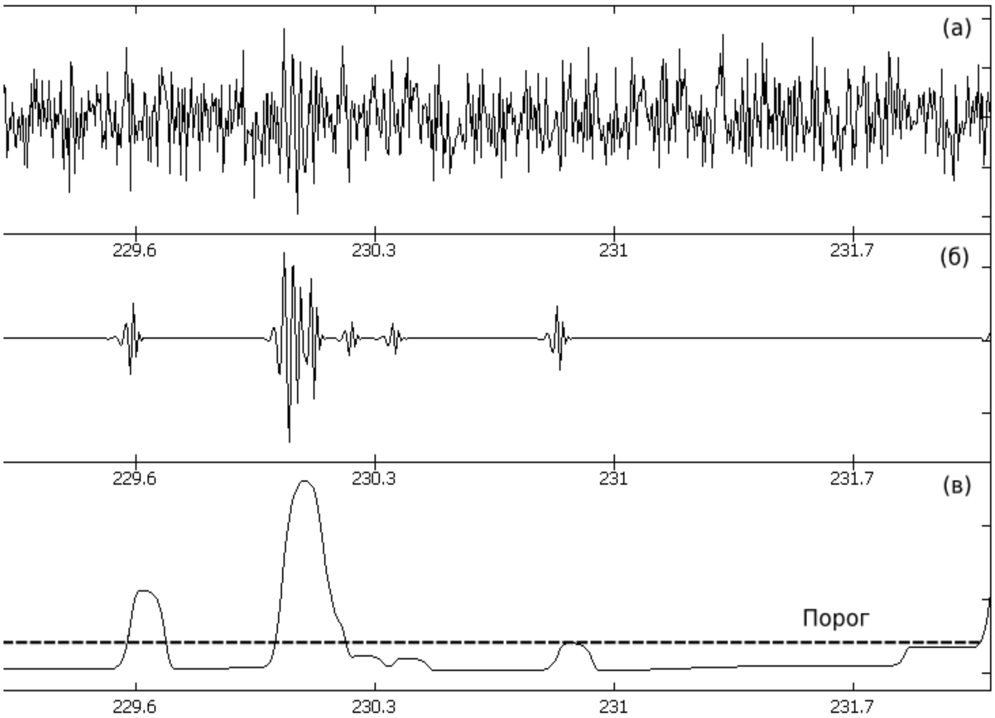


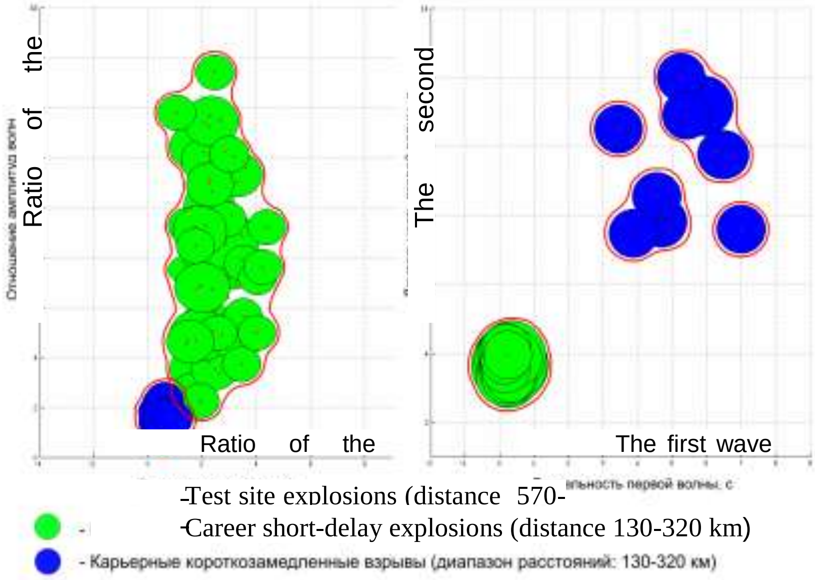
Fig. 4. Results of a wavelet-filtration of a test signal in noise: (a)- initial record (the signal/noise makes a parity 1/4), (б) - result of a wavelet-filtration, в) - result of smoothing by algorithm STA/LTA with parametres 0.1 c/1 c.

EVENT TYPE IDENTIFICATION

In a general view types of seismic events of pulse character it is characterized by the big variety (industrial and the military explosions, falling on the earth of a body of a terrestrial and unearthly origin, etc.), a priori data about which can be absent. Such events respectively are described by variety of areas (clusters) in space of informative features. It defines statement of a problem of identification of different events in the conditions of priori indeterminacy of their occurrence. One of approaches to solving of the identification problem of in such statement consists in coverage of simple by the closed dividing surfaces which are described, generally, the nonlinear equations of a high order. Complexity of realization of such surfaces leads to necessity of their approximation by a set simple, for example, hyperellipsoids, each one to be considered as separate standard:

$$\sum_{i=1}^{n}\left(\frac{x_i - m_i^{(j)}}{\sigma_i^{(j)}}\right)^2 = R_j^2,\ j = 1,2,\ldots,M \qquad (7)$$

An example approximating complex curved surface by hyperspheres set in the informative features plane , describes different types of seismic explosions-military and career-represented in Fig. 5.



a) b)

Fig. 5.

Here in quality informative features (fig. 5a) are chose frequencies of waves P and S, on an axis of ordinates are relations of their amplitudes. On fig. 5б as features are chosen duration of corresponding waves. As statistical parameters of standards is generally unknown procedure of estimating them in space of features on realizations of seismic processes according to (5), (6) necessary. Construction of a system to identify seismic events by wave records implies choosing a system of informative features on whose basis the classification will be made. As a result of studying the peculiarities of seismic records of quarry blasts, the following system of four features was chosen [7]:

- The ratio between the amplitudes of waves of different nature (seismic and acoustic ones) and the ratio between waves of the same nature (longitudinal and transverse ones). Waves of this type are generated by seismic events simultaneously. As an example, Fig.3a presents records of a high-speed low-amplitude seismic wave and of a high-amplitude acoustic wave obtained from an explosion with a power of 400g;
- The ratio between the average frequencies *Fs* / *Fa* and wave duration;
- The ratio between the arrival times of different wave types. This characteristic is stable with respect to a certain seismic event. For instance, the ratio between the arrival times of transverse and longitudinal waves is about 1.7. At the same time, the delay between the arrival times of seismic and acoustic waves *Ta-Ts* will vary, on average, according to the linear law depending on distance.

The decision on belonging to the given area is accepted at fulfillment of one of conditions:

$$g(\bar{x}) = \sum_{i=1}^{n} \left(\frac{x_i - m_i^{(j)}}{\sigma_i^{(j)}} \right)^2 \le R_j^2, \; j = 1,2,\ldots,M \qquad (8)$$

Here *M is* number of the standards approximating given area; R_j^2 - threshold value for jth standard; $m_i^{(j)}$, $\sigma_i^{(j)}$ are a mean value and standard deviation of the i^{th} feature j^{th} standard.

ESTIMATION UNKNOWN PARAMETERS OF THE SOURCE

The problem of estimating the parameters $\vec{\theta}$ in (1) is part of the so-called regression analysis, and estimates of the least-squares method are its solution:

$$\vec{\theta} = \arg\min_{\vec{\theta}\in\Omega} Q(\vec{\theta}), \qquad Q(\vec{\theta}) = \sum_{i=1}^{N} \sigma_i^{-2}(t_i - \eta(\vec{x}_i,\vec{\theta}))^2 . \qquad (9)$$

To find the minimum of the functional $Q(\vec{\theta})$, the Gauss-Newton iterative method or its modifications based on a linear approximation of the regression function in the vicinity of the point $\vec{\theta}^k$ are used:

$$J(X,\vec{\theta}^k)\Delta\vec{\theta}^k + \vec{\eta}(X,\vec{\theta}^k) - \vec{t} + \vec{\varepsilon} = 0 \qquad (10)$$

where $J(X,\vec{\theta}) = \left(\frac{\partial\eta(\vec{x}_i,\vec{\theta})}{\partial\theta_1}, \frac{\partial\eta(\vec{x}_i,\vec{\theta})}{\partial\theta_2}, \ldots, \frac{\partial\eta(\vec{x}_i,\vec{\theta})}{\partial\theta_m} \right)$, $i = 1,2,\ldots,n.$

(11)

The estimates $\vec{\theta}$ are found as a result of the iterative process $(\vec{\theta} = \lim_{k\to\infty} \vec{\theta}^k)$:

$$\vec{\theta}^{k+1} = \vec{\theta}^k + \Delta\vec{\theta}^k, \quad [J^T(X,\vec{\theta}^k)\ J(X,\vec{\theta}^k) + \alpha^2 I]\Delta\vec{\theta}^k = J^T(X,\vec{\theta}^k) y(X,\vec{\theta}^k),$$

k=0,1,2

(12)

Here $y(X,\vec{\theta}) = (\vec{t} - \eta(X,\vec{\theta}))^T$, α is the regularization parameter, and I is the unit matrix.

The other approach to solving problem (1)-(4), also used by the author, is to solve system (3) directly at each step of the iterative process. At the present time, the method of pseudoinversion (or generalized inversion) based on singular decomposition (*SVD*-decomposition) is most widely used to solve this system [8].

CONCLUSION

1.Information computational technology, based on the decision of a inverse problem of restoration of co-ordinates of different type of nature-technogenic events in interests of geophysical environment monitoring is offered and analyzed. Within the limits of technology algorithms of noiseproof allocation and measurement of parametres of wave forms on a basis вейвлет filtration of oscillations from explosive sources are analyzed. The algorithm of identification of sources with application of a method of the closed dividing surfaces is offered and analyzed. The problem of definition of sources co-ordinates as a inverse problem of a seismoacoustic location is decided.

2. The considered information computational technology has been used in the decision of problems of a seismo-acoustic location test explosions, and also definition of co-ordinates of the explosive source moved on depth of borehole. In first case the average value of the error in determination the coordinates of the separate explosions corresponds of 1.5%, in second- value the error along the coordinate z at maximal depths does not exceed 1%, and the horizontal deviation does not exceed 2 m.

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NEURAL NETWORK PROGRAMMING IS A TOOL FOR CREATING ARTIFICIAL COGNITIVE SYSTEMS

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The composition of the operations used in the models of neural network programming makes it possible to automate the creation of software with constantly growing intelligence and represents a transition to a new architectural paradigm - associative artificial cognitive systems (ICS) capable of self-learning and the synthesis of new knowledge.

Key words: neural network, cognitive system, neural network programming, associative memory, associative thinking, generation of new knowledge, neural network control structures, heuristic model, heuristic, knowledge transformation methods.

One of the directions of artificial intelligence is connected with the study of neural network problems with the help of neuropackets, for the creation of which specific models, methods and algorithms implemented by the scientific direction called "Neuroprogramming" are used.

The specific nature of the models used in neuroprogramming is related to the composition of the operations used, such as "learning by example", "creating associative memory", using "associative thinking", "acquiring new knowledge", "extracting new knowledge accumulated in teaching", "replenishing them knowledge bases ", etc.

Teaching by example can be performed with a teacher or without a teacher, with individual or group presentation of processed images; when using training, testing, examination and other samples, taking into account their division into epochs; with the use of connectivity (in which only the weights of the synaptic connections are modified and the parameters of the neurons do not change), using heterogeneous artificial neural networks (with modification of the neuron parameters with unchanged connections), changing the structure of the neural network due to a change in the number of neurons in the hidden layers, or complex approach, combining all three previous ones.

The creation of associative memory makes it possible to use databases of knowledge, not databases, and their constant checking "on inconsistency", dividing them into "facts bases", "relations base (links)", "rules base", "bases of algorithms, concepts" and others, with the