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Artificial Neural Network-based Technique for Operation Process Control of a Technical Object

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ABSTRACT

This paper presents a method to control an operation process of a complex technical object, a radr system, using trivalent diagnostic information. Also, a general diagram of the complex technical object has been presented, and its internal structure has been described. A diagnostic analysis has been conducted, as a result of which, sets of the functional elements of the object and its diagnostic signals have been determined. Also, the methodology for the diagnostic examination of the technical system has been presented. The result is a functional and diagnostic model, which constituted the basis for initial diagnostic information, which is provided by the sets of information concerning the elements of the basic modules and their output signals. The theoretical results obtained in the present study have been verified in practice on a radar system. The radar system in question is a complex and reparable technical object. It belongs to the group of technical equipment for which a short time of shutdowns is required (an ineffective use of the object). A DIAG computer program was used in the diagnosis process of the radar system. The final results obtained through computations conducted by the DIAG software have been presented in the Table 1.

Keywords: Technical operation, control systems, technical diagnostics, neural networks, knowledge bases, ANN, artificial neural network, radr system

1. INTRODUCTION

Technical objects used in the operation process were exposed to external reactions, and to energy changes (ageing processes, etc). The state of a technical object used in the process of operation is different, after a certain period of time, from the nominal state for which the said object was designed. The effect of this unfavourable process is the diminishing functional properties. For this reason, the quality of the use of the object is subject to change; it usually deteriorates. For description of the quality of the use of an object, the quality which best reflects the functional properties is the functional quality function ($F_C(t)$) and the coefficient of the quality of the use of the object (F_C), which is calculated for the boundary value of the function ($F_C(t)$). The index of the attributes of the functional quality function can therefore constitute a current assessment of the state of the object, and owing to it, can be recognised as its measure.

The technical state of the object in a given time of the use determines the possibilities of the realisation of its required functions. It is determined by a subset of its physical properties[2-4], which describe a given object. For practical reasons, to the states of the object in the diagnosis process, numerical values are assigned, which depend on the logic of the classification of the states applied. For divalent logic, these are states from set {1, 0}, where: 1 is the operational state, and 0 is the non-operational state. For the trivalent assessment of the classification of states[4,5] to the states of the object, states marked with the values from set {2, 1, 0}, were assigned, where 2 is the state of full operation; 1 is the state of incomplete usability; 0 is the state of non-operation (defect).

In the process of the use of the object, the values of elementary functions $F_c(e_{i,j})$ presented in Fig. 1 depend on the divergence between the actual state of the object described with vector õ($e_{i,j}$), which determines plane (ù) of the real properties of the functionality function, and the nominal vector described with $F_C(e_{i,j})$, which determines nominal plane (M_E) of the properties of the functionality function. Where, ω is the surface of actual functionality features of the object, M_E the surface of the nominal functionality features of the object, $F_c(e_{i,j})$ the value of functionality function, õ($e_{i,j}$) vector of actual diagnostic signal, $H(e_{i,j})$ vector of differential metric of diagnostic signal.

A new technical object introduced to operation, or an object after regeneration in an operation system, realise its function required on level $F_c(e_{i,j}) = 1$, while determining plane (M_E) of the properties of the nominal operation of the object. It is evident from the analysis (Fig. 1) that an object operated for a longer period of time is subject to a reduction of its functional properties. Then, the technical object realises only in part, and not completely, its function, required on level $F_c(e_{i,j}) \leq 1$ while determining plane (ω) of the properties of the current operation of the object

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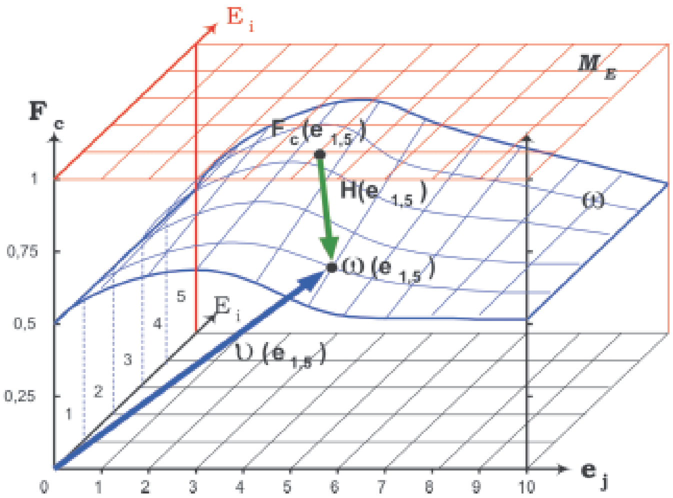


Figure 1. Distribution of changes of object's states during operating time (example)

(Fig. 1). For this event, the object is in the state of an incomplete usability: value of state 1. If the object stops to realise its required function, then it will be in the state of non-usability: value of the state: 0. When the object is in the states of incomplete usability or in the state of non-usability, then such an operational situation of the object is known as the shutdown state (Fig. 2). Where, $X(e_{i,j})$ diagnostic signal in jth element of ith set, $X_{(w)}(e_{i,j})$ model signal for $X(e_{i,j})$ signal, F_C function of the use of the object. For the state of the object's shutdown {1, 0}, a process should be organised to reconstruct the functional properties in the maintenance system of the object.

Repairable technical objects requiring a short time of shutdown (radar systems, airplanes, etc), are frequently equipped with specialist adjustment systems which reconstruct their functional functions to the nominal level. An adjustment system of the object's functionality functions (Fig. 2) is a sophisticated system of regeneration of the object, which include the sub-systems: diagnosis and maintenance. The purpose of the diagnostic system is current and constant recognition (monitoring) of the state of the object. The maintenance sub-system regenerates an object in the states of shutdown through a reconstruction of its functionality properties to the nominal level. An adjustment system presented in this manner (Fig. 2) can perform its function if such a diagnostic system can be developed which will recognise the object's states in the values of trivalent logics {2, 1, 0}. A diagram of the above mentioned process of control of the operation process by the system of adjustment of the object's functionality function is presented in Fig. 2.

A functional and diagnostic analysis constitutes the basis for the designing of every maintenance system of any technical object. The result is information obtained about the object, including usability, diagnostic, functional, maintenance-specialist and any other data.

2. MODEL OF THE TECHNICAL OBJECT

The technical object {O} used for tests in the present study is a reparable complex technical object of an analogue class. While preparing a diagnostic model of this class of an object, its internal structure was divided into four levels of the maintenance structure (Fig. 3) level 1: object {*O*} level 2: assemblies (in object {*O*}), level 3: subassemblies (in each assembly $\{E_i\}$), level 4: modules-basic elements (in each subassembly, of each assembly of the object).

The first level of the maintenance structure of the object is constituted by the object itself. It is a set of functional assemblies $\{E_i\}$. The assemblies of the object constitute the second level of the object's maintenance structure, while each of these is a set of operation sub-assemblies. Subassemblies in assemblies constitute the third level of the object's maintenance structure. The lowest level, i.e., the fourth level of the structure, is constituted by the basic elements: modules.

As the basic element – modules, the smallest distinguished (as a result of the division) functional element in the object on the output where there occurs at least one diagnostic signal, is defined. If there are a larger number of signals on the output of a given element, then one generalised signal is determined. There is a rule in the present study that to each element of the object, only one diagnostic

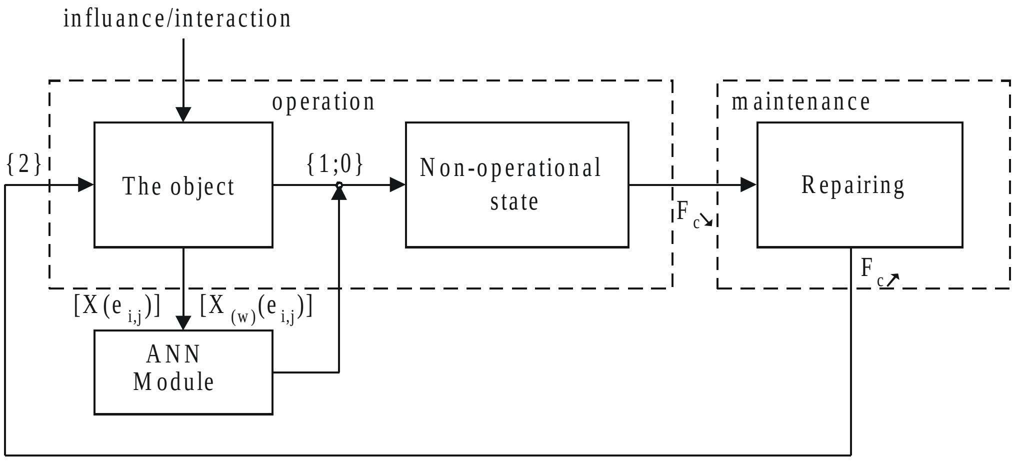
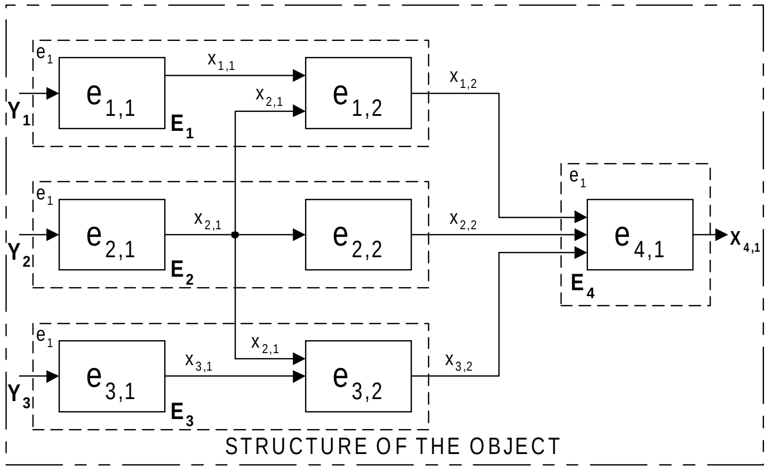


Figure 2. Diagram of operation process for technical object utilising artificial neural network



E_i ij[th] functional assembly in the object,
e_i j j[th] subassembly or functional element in a given assembly,
$Y_{1,2,3}$ input signals in the object.

Figure 3. Functional and diagnostic model of the object.

signal is assigned.

Each functional sub-assembly of the object consists of basic elements, which are the smallest and indivisible functional elements in the object. It was assumed that such an element is understood as a basic element in the object where there is an output (diagnostic) signal on its output.

If object $\{O\}$ has been divided into i structural levels, and in each of these, there are j basic elements, then each of the object's structural levels constitutes a set of operating elements $\{e_{i,j}\}$, which is presented in the form of the following dependence:

$$\{O\} \Rightarrow \left(\{E_i\} \Rightarrow \{e_j\}\right) = \{e_{i,j}\} \tag{1}$$

where: $\{O\}$ – object's internal structure, $\Rightarrow$ – relation of result (division), E_i – i^{th} functional assembly of the object, e_j – j^{th} subassembly in i^{th} assembly of the object, $\{e_{i,j}\}$ – set of basic elements in the object (structure of the object).

The division of the object's internal structure $\{e_{i,j}\}$ accepted in the paper defines explicitly the depth of penetration into this structure. The accepted division is considered sufficient if one distinguish the basic module-element in the structure of the object. One of the purposes of the functional-diagnostic analysis is the determination of the object's state. The object's state is determined on the basis of an examination of the set of output (diagnostic) signals $\{X(e_{i,j})\}$(Table 1)[1,2,5]. The set of its functional elements $\{e_{i,j}\}$ determined during a diagnostic study of the object constitutes the basis for the list included in the table of a set of diagnostic signals (Table 1).

The issue of the recognition of the object's states (Table 2) for the regeneration of usable properties in the operating system (Fig. 2) is constantly developing. More and more effective (modern) diagnostic systems of technical objects are being sought, also using artificial neural networks (Fig. 4).

3. STRUCTURE OF DIAGNOSTIC PROGRAMME DIAG WITH ANN

The ANN network developed is presented in Figure 3. It consists of three layers: F_1–input layer, F_2–output layer and intermediate layer[5]. The input cells of layer F_1 process the initial diagnostic information according to the algorithm presented in Fig.5. The whole of the issue of information processing by ANN neurons (Fig.5) takes place in D-dimension diagnostic space (ω) (Fig.1) determined by the elementary signal vectors (X_i). The input signal in the form of $X_i = [x_1, x_2, ..., x_n]^T$ is being passed to all neurons of ANN's input layer.

The input cells memorise the vectors of signal standards $\{X_i\}$. Basing upon that, the neurons from the input layer determine the measures of similarity between the input signal vector and its standard and the length of the input signal $\{X_i\}$ to all vectors of weights $w_{i,j} = [w_1, w_2, ..., w_n]^T$, where i =1,…,N.

Table. 1. Table of object's input diagnostic signals

Object	Level of Object e_i	Vector of initial diagnostic signals $\{X(e_{i,j})\}$				
		$X(e_{1,1})$	...	$X(e_{i,j})$	...	$X(e_{i,J})$
	E_1	$X(e_{1,1})$	...	$X(e_{1,j})$	...	$X(e_{1,J})$
	⋮	⋮	...	⋮	...	⋮
O	E_i	$X(e_{i,1})$	...	$X(e_{i,j})$	...	$X(e_{i,J})$
	⋮	⋮	...	⋮	...	⋮
	E_I	$X(e_{I,1})$	...	$X(e_{I,j})$	...	$X(e_{I,J})$

$X(e_{i,j})$ diagnostic signal of j^{th} element in i^{th} assembly.

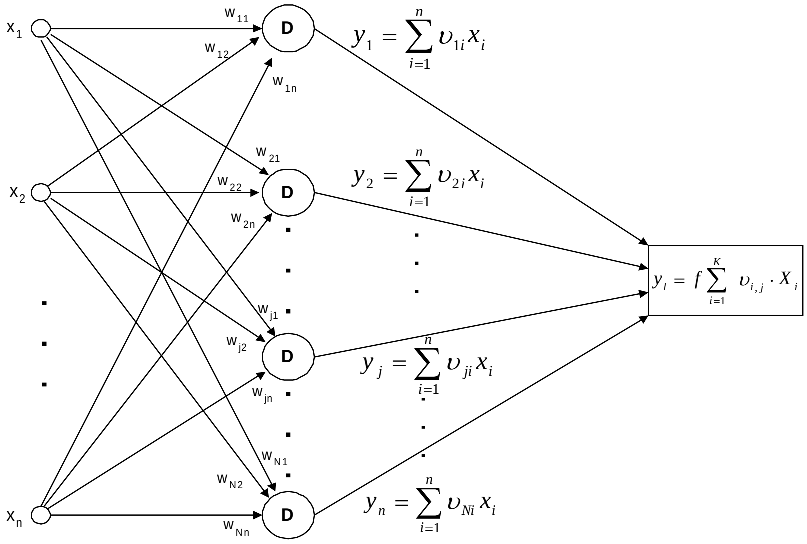


Figure 4. Diagram of neural networks.

In the ANN network presented in Fig. 4, the neuron i placed in layer F_1 is connected to neuron j placed in layer F_2, where: j = 1,2,…N. Neuron i sends the signal of value x_i with the connecting strength $w_{i,j}$ of the activation function. Following the literature of the subject[5,8,10,11,13,] the Minkowski's measure is used for the analysis of the measures of signal vectors. The Minkowski's measure can be expressed by Eqn (2) as

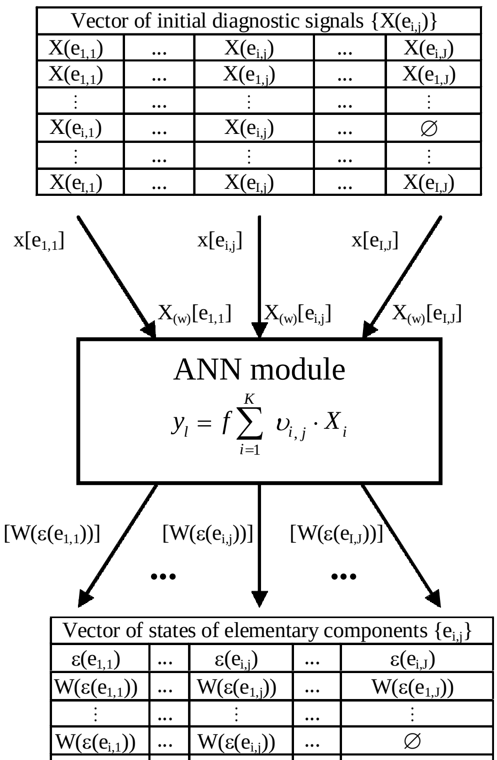


Figure 5. Scheme of diagnostic program DIAG

$$D_M\left(X_i, X_{(w)i}, \alpha\right) = \left(\sum_{i=1}^{N}\left|X_i - X_{(w)i}\right|^{\alpha}\right)^{1/\alpha} \quad (2)$$

where D_M is the standard deviation of the signal measure vector.

In the comparative analysis of diagnostic signals, a special case of Minkowski's measure was applied, with parameter α=2. Then, the Eqn (2) becomes the Euclidean measure and can be used with the ANN network[7,8,10,12,15]. For this reason, in the process of input data processing, a transformation of input data was performed to reduce too high initial disproportions between the initial values in particular dimensions. One of certain input data transformation methods, which is at the same time quite effective, is the normalisation of input data which transforms the values into range of (0, 1).

The standardisation of the measures of signal vectors was performed according to the Eqn (3) as:

$$\Delta X_{(n)i} = \frac{X_i - X_{(w)i}}{D_i} \quad (3)$$

where, $\Delta X_{(n)i}$ normalised vector of measure of length of j^{th} signal

The input cells of the ANN determine the values of weight coefficients ($w_{i,j}$) basing upon the Eqn (4):

$$w_{i,j} = \left|F(\Delta X_{(n)i}) - F(\Delta X_i)_G\right| \quad (4)$$

where, $F(\Delta X_{(n)i})$ is the determined value of the distribution function of a normalized vector of the measure of signal properties length; $F(\Delta X_i)_G$ is the border value of the distribution function of a normalized measure vector of signal properties length.

For the ANN presented in Fig. 4, neuron i is connected with neuron j, so it transmits a signal of value (X_i) with weight coefficient ($w_{i,j}$) and the activation function, represented by the Eqn (5):

$$f_l\left(x,w\right)=\sum_{i=1}^{K} w_{i,j}\cdot X_i \tag{5}$$

If in the network, the j^{th} neuron is characterised by the minimal length between the vector of weight coefficients and the input signal vector, then it adopts the value of 1 on its output, while the other neurons adopt the value of 0. For this reason, such a model is known as "the winner takes it all". Therefore, for the input signal neuron which is known as the winner, it can be stated that the activation of this neuron can be expressed as

$$d\left(x,w_j\right)=\min_{1\le i\le N} d\left(x,w_i\right) \tag{6}$$

where, d is the measure is the signal similarity.

The program of searching for the wining neuron is realised basing upon the Eqn (6). It compares the values of each neuron's output. Alternatively, during a normalisation of the vector of signals and weights, the winner can be found by deriving for each j^{th} neuron the length between the vector of its weights ($w_{i,j}$) and the vector of excitations (x_i). On this basis, in the output surface of the network, the weight coefficients ($\nu_{i,j}$) are determined according to Eqn (7):

$$d\left(x,w_{i,j}\right)=\upsilon_{i,j}=\left|1-w_{i,j}\right|=\sqrt{\sum_{i=1}^{N}\left(x_i-w_{i,j}\right)} \tag{7}$$

where $d(x, w_{i,j})$ is the distance of j^{th} vector of weight from the input signal.

When the activity (value of potential) of j^{th} neuron decreases below ($w_{i,j}$) = (w_{min}), then j^{th} neuron does not take part in 'looking for a winner' competition, so the winner is sought among the other neurons for which the weights fulfill the condition ($w_{i,j}$) ≥ (w_{min}). It was assumed that the maximum value of the potential can reach the value of 1, while for (w_{min}) = 0, all of the neurons take part in the competition, yet for ($w_{i,j}$) = 1, only one. The value of its output function is s derived from the Eqn (8)

$$y_l = f\sum_{i=1}^{K} \upsilon_{i,j}\cdot X_i \tag{8}$$

where $\nu_{i,j}$ is the weight coefficient.

The determination of the value of the network's output function $\{y_l\}$ made possible to explicitly determine the set of elementary vectors of signals which describe the diagnostic space of object (ω) (Fig.1). In view of the fact that the purpose of a diagnosis of the object[2,3,5] is the recognition of its state in the values of the accepted logic of states' assessment, the results obtained in the form of Eqn (8) were subject to the classification process according to the diagram presented in Fig. 6. Where, (y_1^1, y_1^2) is the range of non-significant changes of the outputs; ($y_1^{1'--}$, y_1^1) and (y_1^2, $y_1^{2'}$)) are the range of significant changes of the outputs, and ((-∞, $y_1^{1'}$) and ($y_1^{2'}$,+ ∞)) are the range of inadmissible changes of the outputs.

On the final stage of the work of a neural network, a classification process of the object's states is realised according to the algorithm (Fig. 5). For this purpose, to the values of the output function as determined by the network, proper classes of the object's states in the values of the three-value logic[4] {2, 1, 0} were assigned according to the classification diagram (Fig. 6). The classes of states are defined as following:

- The state of full operation–the value bound is 2. In this state, the changes of the output function values (y_l) are within the range of non-significant changes.

$$\left(W\left(\varepsilon\left(e_{i,j}\right)\right)\Rightarrow 2\right)\Leftrightarrow\left\{y_l\in\left(y_l^1,y_l^2\right)\right\} \tag{9}$$

where: (y_l^1, y_l^2) – the range of non-significant changes of the output function values (y_l).

- The state of incomplete usability–the value bound is 1. In this state, the change of the output function values (y_l) are within the range of significant changes.

$$\left(W\left(\varepsilon\left(e_{i,j}\right)\right)\Rightarrow 1\right)\Leftrightarrow\left\{y_l\in\left(y_l^{1'},y_l^1\right)\cup\left(y_l^2,y_l^{2'}\right)\right\} \tag{10}$$

where: ($y_1^{1'--}$, y_1^1) and (y_1^2, $y_1^{2'}$)) – the range of significant changes of the output function values (y_l).

- The state of non-operation (defect)–the value bound is 0. In this state, the changes of the output function values (y_l) are in the range of non-admissible changes.

$$\left(W\left(\varepsilon\left(e_{i,j}\right)\right)\Rightarrow 0\right)\Leftrightarrow\left\{y_l\in\left(-\infty,y_l^{1'}\right)\cup\left(y_l^{2'},+\infty\right)\right\} \tag{11}$$

where: ((-∞, $y_l^{1'}$) and ($y_l^{2'}$,+∞)) – the range of non-admissible changes of the output function values (y_l).

The results of the object's diagnosis obtained from the Eqns (9) to (11) are presented in Table 2.

4. RESEARCH RESULTS OF DETERMINATION OF A DIAGNOSTIC INFORMATION WHICH CONTROLS THE OPERATING PROCESS OF A RADAR SYSTEM

The rocket homing station (NEWA SC) is presented in Fig. 7 and scheme is presented in Fig. 8 is part of an anti-aircraft rocket set (SA-3 SC). The purpose of the set (NEWA SC) is to fight air targets (aircraft, helicopters, rockets, drone vehicles), as well as ground and water targets

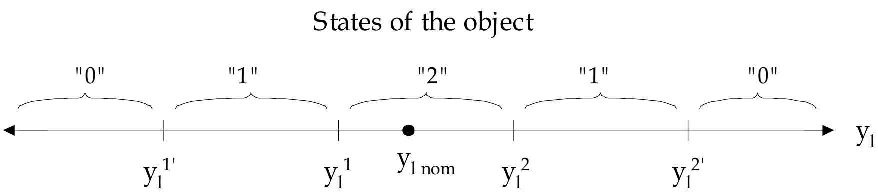


Figure 6. Range of variability of diagnostic signal features.

Table 2. Table of object's states

State of object	State of module	Vector of states of elementary components $\{e_{i,j}\}$				
		$\varepsilon(e_{1,1})$	...	$\varepsilon(e_{i,j})$	...	$\varepsilon(e_{i,J})$
	$W(\varepsilon(E_1))$	$W(\varepsilon(e_{1,1}))$	...	$W(\varepsilon(e_{1,j}))$	...	$W(\varepsilon(e_{1,J}))$
	⋮	⋮	...	⋮	...	⋮
$W(\varepsilon(O))$	$W(\varepsilon(E_i))$	$W(\varepsilon(e_{i,1}))$	...	$W(\varepsilon(e_{i,j}))$	...	∅
	⋮	⋮	...	⋮	...	⋮
	$W(\varepsilon(E_I))$	$W(\varepsilon(e_{I,1}))$	...	$W(\varepsilon(e_{I,j}))$	...	$W(\varepsilon(e_{I,J}))$

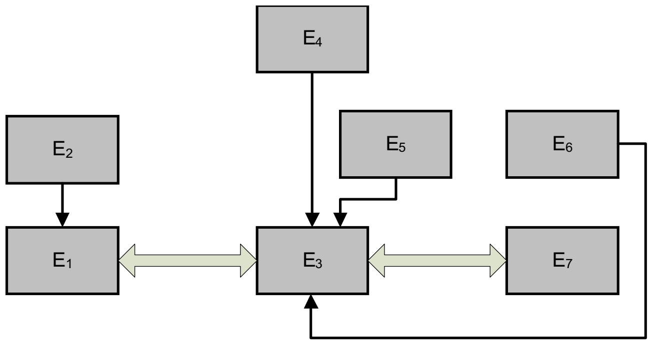
$W(\varepsilon(e_{i,j}))$ value of state assessment logics for j^{th} element within i^{th} module (from the set of the accepted three-value logic of states' assessment) -{2,1,0})
∅ symbol complementing the size of table.

within the range of the missiles. The radar system detects (determines the azimuth, distance, and height) and controls the air fight. The anti-aircraft set is adapted to work regardless of time of the year and the day, in temperatures ranging from – 40°C to + 50°C, with a relative humidity of 90 per cent and the wind speed up to 20 m/s. The method presented is about the control of the exploitation of a technical object on the basis of its state and verified on the example of a reparable technical object, which is a radar system. A functional and diagnostic analysis of the object was carried out for this purpose. A functional model was prepared which described the object: a missile homing station of an anti-aircraft missile set, presented in Fig. 7.

Figure 7. (WZE S.A. photo) Rocket homing station (NEWA SC) of (SA-3 SC) system.

As a result of the described manner of the division of the object's internal structure, the object was subject to a three-level division of its structure. As a consequence of this division of the internal structure (Fig. 7), seven functional assemblies were distinguished (E_1, E_2,…, E_7), and up to five basic elements-modules[1,4-6] were distinguished in each one of these. As a result of the analysis carried out, a functional and diagnostic diagram was developed, on the basis of which a set of operational elements and a set of output (diagnostic) signals were established.

The modern diagnostic system (Fig. 9) with measurement module utilising not only measurement A/D converter card with appropriate signal interfaces but also some computer



E_1 commanding block;
E_2 assembly of identification "our own–stranger";
E_3 homing block;
E_4 receiver;
E_5 transmitter;
E_6 radio transmitter of commands;
E_7 drive control block.

Figure 8. Functional model of missile homing station (NEWA SC).

tool used for proper signal registration as well as for acquiring and processing registered data. The purpose of such a process is to build diagnostic knowledge base upon the analysis of both the object and the results of measurement stored.

The diagnostic system with measurement module was implemented and used within the diagnostic module which recognises the states of theobject. The system has the following elements:

- Measurement structure of investigated object received from the functional analysis. In effect of such are analysis it is possible to establish the set of object's elements (modules) $\{e_{i,j}\}$ with adequate output signal

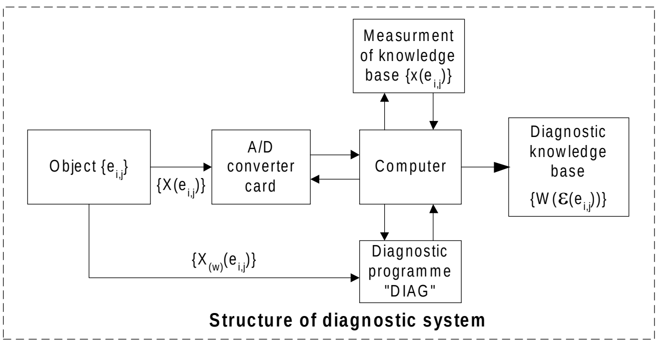


Figure 9. Scheme of diagnostic system with measurement module.

along with the set of diagnostic signals necessary to measure $\{X(e_{i,j})\}$.

- Signal track assuring that the levels of measured signals match the range of A/D converter inputs.
- A/D converter to measure and acquire the values of diagnostic signals $\{X(e_{i,j})\}$,
- PC application (software) to control the operating of A/D converter and register measurement data. PC application task is also to prepare the matrix base $\{X(e_{i,j})\}$ in the form of matrix (Fig. 10).
- Diagnostic module the use of DIAG software requires preparation of input diagnostic information. PC application task is also to prepare the diagnostic knowledge base $\{W(å(e_{i,j}))\}$ in the form of a table of states of the object (Fig. 10).

For diagnosing process, a measuring track was designed for the diagnostic system. A properly designed measuring system for the diagnostic system enables one to obtain a reliable measuring knowledge base for the diagnostic system $\{X(e_{i,j})\}$(Table 1). The measurement module registration and visualisation of measured signals was realised using NI M-series USB-6221 A/D converter card. It allows performing up to 16 measurements at once. USB-6221 device (NI M-series family) contains 16 differential analog input (16-bit, 250 kS/s), two analog outputs (16-bit, 833 kS/s), 24 digital I/O with 1MHz timer plus two 32-bit fast counters. M-series devices are equipped with NI-STC 2 module, NI-PGIA 2 amplifier, and NI-MCal calibration technology that assures higher number of highly efficient I/O channels plus better resolution and higher speed.

The use of DIAG software requires preparation of input diagnostic information on the basis of a functional and diagnostic analyses of a given object. A functional and diagnostic model of an object needs to be made. On the basis of this, the following was determined: a set of basic elements, a set of diagnostic signals $\{X(e_{i,j})\}$ (Fig. 10) and a set of their model (standard) signals $\{X_{(w)}(e_{i,j})\}$. The object's measuring information created in this manner constitutes the input information in the diagnosing system

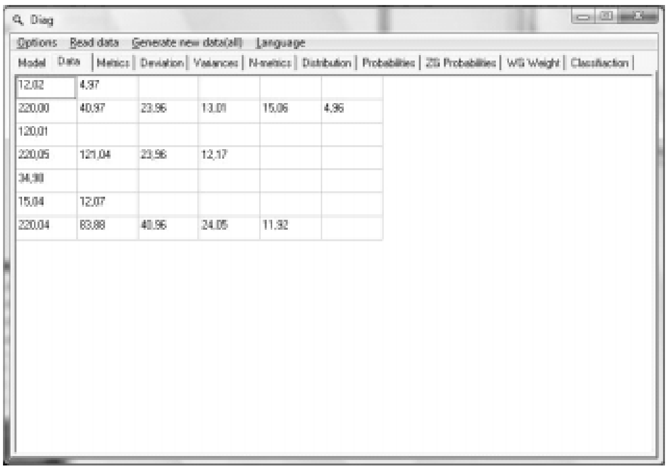


Figure 10. Matrix of measures of diagnostic signals from the object.

with a neural network. The results of measurements for chosen elements of object are presented in Fig. 10.

The test of the state of the object using DIAG software was conducted according to the algorithm. On the basis of the measurements made of the properties of the distinguished diagnostic signals, tests and an analysis by DIAG software with an artificial neural network (ANN), which belongs to the group of self-organizing networks, were made of these. The neural system does not require any strenuous training because the weight coefficients of the networks are determined during calculations (these are simply known).

The diagnostic information is developed in a diagnostic system of recognition of the states of a reparable technical object, using ANN. The accepted method of diagnosing by a neural network consists the image of vectors of diagnostic signals with the images of their models.

The operation of DIAG software by the user is done using dialogue windows of the programme located on the menu bar: Options – Read data – Generate new data. After starting of the programme, the menu bar is displayed: "Options", "Read data" and "Generate new data" (Fig. 10). Loading of input data to the programme can be done manually from the keyboard or automatically: directly from the measuring system (the measuring card). The programme has been developed in such a way so that one could at any time make correction of the sizes of the structure of the object tested, including the number of the assemblies, or the number of the basic elements-modules in a given assembly.

DIAG software is started by placing the cursor in the "Options" window, and after pressing the cursor, we obtained the final result of the programme in the form of the "Table of the object's states". The table obtained has the size of the internal structure of the object-table of input data, where: i^{th} line applies to i^{th} assembly, and j^{th} element of the table applies to the j^{th} basic element of the object.

In DIAG software, depending on the user's needs, one can use stage results of calculations being the result of the realisation of the algorithm of DIAG software. The sets of quantities calculated in DIAG programme are placed on the toolbar (Fig. 10), where: 1–Model; 2– Input data; 3–Metrics; 4–Deviations of metric vector; 5–Variances; 6–Norm of distance metric; 7–Distribution function; 8–Probabilities; 9–ZG Probabilities; 10–WG Weight coefficients; 11–Classification of states.

Placing the cursor in any of the menu windows results in a given quantity being automatically displayed on the screen (Fig. 11).

The elements from this set were grouped into subsets of classes using the classification method proposed. The state of the object was determined on the basis of the measurements of the diagnostic signal features processed. These were processed and analysed by an ANN. The final results obtained of DIAG software were presented in the form of a table of states (Fig. 12).

For the method presented, an effective diagnostic system was built whose task is to recognise (classify) the object's states in trivalent logics {2, 1, 0}. The diagnostic system

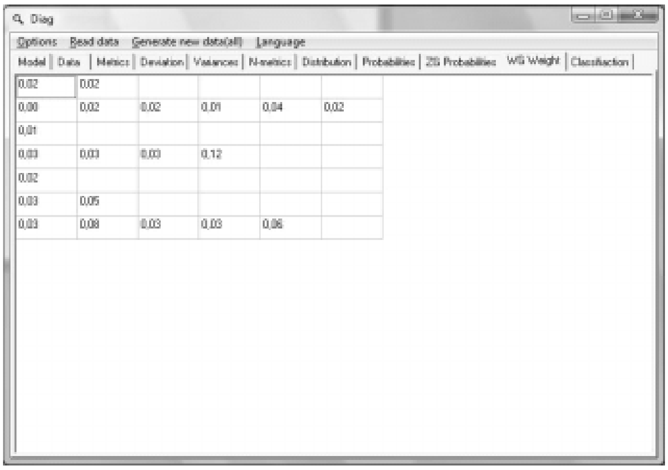


Figure 11. Result form of DIAG software for the type of work of "WG Weight coefficients".

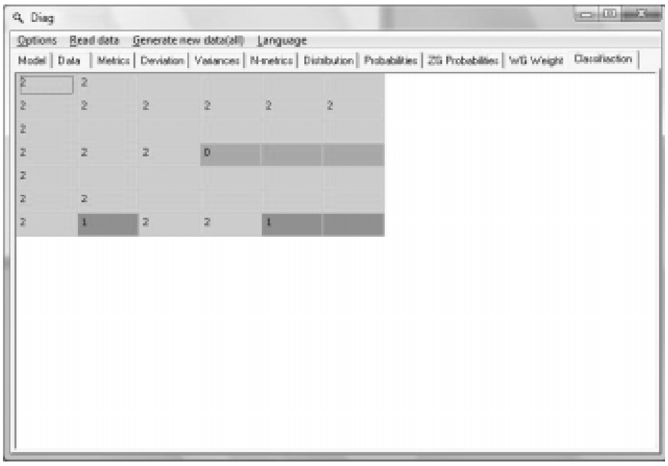


Figure 12. Final results obtained from DIAG software presented in the form of a table of states of the object.

used in the tests was constructed on the basis of the measuring information obtained and DIAG diagnosing software. DIAG software is a specialist computer program developed for the method presented. The diagnostic information obtained during diagnosing in the form of the diagnostic knowledge base $\{W(\varepsilon(e_{i,j}))\}$ constitutes the input information in the process of obtaining of the expert knowledge base which assists the maintenance of the technical object tested.

The issues presented in the article of the determination of a set of diagnostic information concerns various fields of knowledge, including technical diagnostics, the theory of operation, information technology, artificial neural networks etc. Each of these fields is well and broadly worked out in the literature. It is the author's opinion that one can claim with full responsibility that even the basic problem, that is the use of diagnostic information obtained in the diagnosing process of a technical object in the designing and organisation of the operation process, is being constantly developed in various aspects (directions). At present, the direction of the applications of neural networks, among others in the diagnostics of technical objects, is being intensively developed. However, new solutions and possibilities are constantly being sought, hence the author's papers and studies are presented concerning a practical application of a trivalent evaluation (classification) of the object's states[4-7]. However, there is no full description in the literature of methods to develop ways and algorithms for the processing of diagnostic information obtained by diagnostic systems: an artificial neural network etc. to the form of an expert knowledge base of a maintenance system, presented in a computer programming language. A new problem, which in the author's opinion requires a solution, is the use of information developed in the trivalent evaluation of information states by the artificial neural network of information (knowledge) for the development of the method to control the prevention of technical objects, referred to in the literature as operation according to the object's state.

The method of prevention of objects according to the state requires that two problems be solved; in the literature, they are being developed independently. The first one of these is concerned with the development of a method to determine the date of the execution of maintenance (i.e. when the regeneration of the object should begin). This issue is the domain of the theory of forecasting of the object's states in time and is continuously being developed. The second issue is the construction (designing) of an effective system for the maintenance of a technical object. In the author's opinion, the method presented in the article serves as an answer to the first issue.

The authors explicitly state that the research results presented are unique and innovative in the light of the existing literature.

5. CONCLUSION

The paper presents a method to control the operational process of a technical object on the example of a radar system (NEWA SC). The basis of the presented system of regulation of the object's function of use (F_c) is constituted by diagnostic information which concerns the object's states. The diagnostic information is developed in a diagnostic system of recognition of the states of a reparable technical object, using an ANN. The accepted method of diagnosing by a neural network comparing the image of vectors of diagnostic signals with the images of their models. For this purpose, the technical object examined was subject to a diagnostic study. An important stage of the work is a functional and diagnostic analyses of the object.

The paper presents an algorithm of processing of information by an ANN. The diagnostic information developed by the ANN in a trivalent evaluation of the states constitutes the basis for the realisation of the proposed method to control the prophylactics of technical objects according to their state. A technical object, which is normally used, and which realises its required function, is subject to a continuous examination of its state (diagnosing) by a neural network. When the neural network recognises a state of an incomplete usability {1}, or the state of non-operation {0} of the object, this means that the time has been determined when the regeneration of the object should begin. The strategy of prophylactics of technical objects according to the object's state (testing of the quality level of its function of use) is being constantly developed and improved.

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