Problems of using neural networks

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Abstract. Currently, the urgent task is to develop new algorithms for identifying and diagnosing technical objects. Often artificial neural networks are used in solving such problems. In these tasks, most often, there is no setting the task in an explicit formal form to describe objects and phenomena, and neural networks do well in this case to solve them. The article considers various existing approaches of identification of objects based on neural networks, as well as diagnostics of technical objects based on artificial neural networks. A vision of the prospects for further development of such tasks is offered. Various methods for training the network in the case of problems of identification and diagnosis of faults are described. The task of identifying technical objects is reduced to the task of approximating data, and the task of diagnosing the state of the system to the task of recognizing images. The algorithms for selecting the optimal network structure are investigated. The advantage of using software and hardware technologies in the construction of neural network algorithms has been evaluated. The results of the article can be used in constructing a scheme of actions of identification and diagnostics of technical objects using artificial neural networks.

1. Introduction

Neural networks are a section of artificial intelligence based on the following: principles of organization and functioning of biological neural networks are used for signal processing [1]. Many of the domestic and foreign authors, such as Tereshov V.A., Gorban A.N., Lazarev V.M., Sviridov A.P., Anil K. Jane, Osovsky S., Wosserman F., etc., worked in the field of research of artificial neural networks.

The functions of artificial neural networks include:

- approximation function, allowing to replace processes with simpler ones, for example, when solving problems of object identification;
- feature of classification and recognition of images, which is relevant in solving problems of diagnostics of technical objects state;
- prediction function, which takes into account previous states of the system when building the following, is relevant when solving problems of image recognition;
- identification and evaluation function, which is used in solving process control tasks;
- is an associative management function.

Having analyzed domestic and foreign works on artificial neural networks and neurocomputers, the following promising directions of their modern development can be identified [2]:

- neuropackages;
- digital economy;
- digital medicine;
- signal and image recognition
- virtual reality.

2. Materials and methods
The analysis of scientific works in recent years on the topic of artificial neural networks has been carried out in order to describe the problem of their use in identification, diagnosis and recognition of technical objects.

At present, more than three hundred foreign firms are engaged in research in this field, and the number of them is constantly increasing. Among them are mainly companies engaged in digital development. There are more and more developments of SBIS-neurochips, as well as a pattern of transition from software to software-hardware implementation of neural network algorithms is revealed. The number of military studies in the field of superfast supercomputers is growing [3].

In processes and phenomena where there is no formal task setting, especially in digital economics and medicine, artificial neural networks are particularly in demand.

At the same time, in processes and phenomena built with the help of a developed mathematical apparatus, and accordingly having a large number of methods of solving, the use of artificial neural networks is clearly insufficient. This concerns many technical problems, such as identification of control objects, synthesis of regulators, diagnosis of faults, etc.

3. Diagnostics of technical objects using neural networks
Having studied the works of authors who have studied artificial neural networks, it can be concluded that this topic remains quite demanded and relevant today. Of particular interest are the problems of identifying and identifying failures of control systems. Let's look at one of these systems. Figure 1 shows a diagram of possible troubleshooting paths.

![Figure 1. Chart of search of ways of decision of task.](image-url)
The structure of artificial neural networks is considerably simplified, if to delete the so-called "hot backuping" from the built charts. The use of artificial neural networks significantly reduces the cost of operating and repairing equipment.

At development with the use of artificial neural networks of algorithms of recognition, authentication and diagnostics of the systems of automatic control there is a row of problems from that basic are the following [1]:

- absence of conformities to law at the choice of type of artificial neural networks for the decision of certain type of tasks;
- absence of conformities to law at the choice of methods of educating of neural networks, that conduces to the increase of time of educating of networks and errors in the prognosis of work of networks;
- impossibility of development of digital technologies on the basis of artificial neural networks with minimum difficulties from enhanceable complication of decision of problems on the construction of continuous artificial neural networks.

On a figure 2 we will consider the flow-chart of algorithm of decision of tasks of approximation and classification with the use of artificial neural networks [4].

![Algorithm of decision of tasks with the use of neural networks.](image)

**Figure 2.** Algorithm of decision of tasks with the use of neural networks.
When using the concepts of artificial neural network, fault recognition is a group of tasks of specification and pattern recognition, therefore, after determining the goal of the task and analyzing the input data, it is necessary to carry out initial data processing, their extraction. This is motivated by the fact that the investigated image (its description) must satisfy the independence properties from possible rotation and changes in current sizes. At the same time, you can specify the characteristics of the image at the input of the neural network by such methods as the Fourier spectral transform, RSA transform, Karunen-Loève transform, wavelet transform, the more narrow application of which depends on the nature of the issue under study.

The next step in the solution is a preliminary selection of the network architecture, which may consist of:

- allocation of the number of network layers;
- selection of the required binding components between layers;
- setting the magnitude of neurons in each of the layers.

The final network diagram can be approved only after the full training of various schemes for constructing its structure in compliance with a satisfactory level of error. The next important steps will be the formation of training samples and adding noise to them. Here it is possible to determine the limit values of the noise level in order to obtain algorithms for generating the output signals of insensitivity to variations in the noise level of the input quantities.

At the stage of network training, in the case of defining the problem of diagnosing faults - problems of specification and pattern recognition - the methods of back propagation are most often used using one of the types of training algorithms on a set of training data that can represent all classes of patterns to be recognized. At the input of the network, in playback mode, is passed, passed through all phases of extraction, a classified image, exciting that output neuron that corresponds to the required class.

The ability to generalize information is a paramount indicator of the choice of one or another architecture of a built network. This shows how a trained network can perceive input from a training set that did not take place during the training process and at the same time generate predetermined results. The required network structure can be achieved both by reducing the number of hidden neurons and synaptic connections, and by increasing them. Reduction of the created network can be carried out, for example, by the method based on sensitivity, or by the method of the objective function, in which there are penalty components. It is possible to increase the number of hidden neurons using the widely known S. Falman cascade correlation algorithm [5].

4. Artificial neural networks for the identification of technical objects

Another promising area of application of artificial neural networks, as noted earlier, is the recognition of objects of technical systems and the management of various dynamic processes [1]. The problem of the practical use of artificial neural networks in automatic control systems is currently only partially resolved. The issues of using neuro-controllers in automatic control systems are not adequately covered, and there are no formal methods for constructing neural network models of control objects (CO) of varying complexity. The literature provides a limited number of solutions to problems using recurrent and non-recurrent artificial neural networks for the problem under consideration.

That is why, with the development of the theory of application of artificial neural networks, interest in recognizing technical objects with the help of new tools and methods increases every year.

The identification of technical objects using the theory of artificial neural networks, as these sources show, has the following advantages:

- with successful training, the CO neural network model is more accurate than the model formed using the transfer function, this difference is all the more noticeable as the higher order and complex mathematical description has an identifiable object;
- it is not always possible in a laboratory to simulate the dynamics of control objects in various modes, and especially extreme ones;
• synthesis by neuro-controllers makes it possible to use high-quality systems for automated control of objects with distributed parameters and non-stationary structure.

Figure 3 shows the most often cited in various sources diagram of an automatic control system with a neural network model of a control object and a neuro-controller. But you can notice that the disadvantage of this scheme is that it requires a more detailed study of the synthesis algorithm of the neuro-controller based on the inversion of the neural network model of the control object [2]. In addition, the relationship between the selection of the weight coefficients of the object’s neural network model and the neuro-controller is not quite clearly defined. In addition, additional study of the issue of the possibility of combining the neural network model and the neuro-controller into one artificial neural network is required.

![Figure 3. Structural diagram of ACS with a neural network model of a control object and a neuro-controller: NC - a neuro-controller; CO - control object; NM - a neural network model of a control object; \( q(t) \) - the signal from the setter; \( r(t) \) - the signal at the input of the neuro-controller; \( u(t) \) - the control action generated by the neuro-controller; \( f(t) \) - the disturbing effect; \( y(t) \) - the signal at the output of the control object; \( y'(t) \) - the signal at the output of the neural network model; \( e(t) \) - the error signal.]

An important part of solving the problem under consideration is the training of the neural network model. In this regard, the question arises of using identification methods that most fully provide the required information. These may be the most applied algorithms using experimentally recorded acceleration curves of the control object \( y(t) \) for various combinations of control \( u(t) \) and disturbing \( f(t) \) actions, coast curves, or innovative, taking into account the specifics of artificial neural network learning processes [4].

Issues of using astatic neuro-controllers in automatic control systems are practically not covered in scientific papers. If we consider the synthesis of neuro-controllers, then the task of obtaining a zero control error when using astatic state controllers, neural network analogues of the PID controller in automatic control systems is quite relevant.

5. Conclusion
In modern conditions, to solve research and forecasting problems, especially in industries that do not use a formal description of diagnosed objects or phenomena, the most developing area is the use of artificial neural network.

It requires the development of a formalized approach to the selection of an initial description of an object, such as an artificial neural network, a reasonable choice of an artificial neural network training
algorithm and optimization methods in a training procedure to solve a wide class of diagnostic problems using artificial neural networks.

The considered task of identifying an object of a technical structure belongs to the category of approximation problems, and the problem of diagnosing faults belongs to the spectrum of problems of classification and pattern recognition.

Every year, the tendency for the transition of neural network algorithms from software to hardware-software implementation in the artificial neural network environment is increasing.

Currently, computer hardware has great computing power, so the degree of complexity of the executable methods may be the highest. But regardless of this, it is necessary to deal with the methodological side of the issue, developing algorithms for the widespread use of artificial neural networks in the construction of control systems based on them.

The results of the above analysis of the theory of neural network analyzers can be used to develop new methods and algorithms for identifying and diagnosing technical objects.

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