UDC 622.647

V. Diachenko[1], student
[1]**National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"**

MANAGING THE TECHNOLOGICAL PROCESS USING A NEURAL NETWORK

Abstract. *Management of adjustable parameters of technological processes is associated with the arbitrary use of information line nodes of multidimensional lattice structures of technological information signals using neural networks.*
Keywords: *information lines, technological process, neural network*

The purpose and objectives of the research. The purpose of the work is to study the possibility of using neural networks to increase the quality of technological process control by applying to its inputs values from the most informative points of lattice structures of technological information signals. The method can be used for automatic control of the technological process, for example, the performance of processes depending on the physical and mechanical properties of materials in the construction, mining and other industries, which allows to improve the thermal regime of drive electric motors, increase their reliability, productivity and efficiency of load regulation [1].

With the help of primary information sensor signals, information points of controlled and regulated parameters are formed. Such signals can be, for example, signals of current, vibration, noise, speed of rotation of the shaft of the electric motor of the feeder. Information points mean the averaged or equivalent values of the signals received from the sensors of technological information at time intervals equal to the time of discretization of time series of controlled and regulated parameters [2].

Most signals of technological information appear in the time domain as functions of time. The time axis is taken as the independent coordinate, and the amplitude axis is the dependent one. The amplitude-time representation of signals looks like the functional dependence of a certain technological parameter on an independent variable (argument) - $x(t)$, $y(t)$, etc. If you combine the time axis t and the time axis of averaging t_{yc}, then the time series become three-dimensional: $x= f(t_{yc},t)$, $y= f(t_{yc},t)$. To align the astronomical time axis with the averaging time axis, the initial time series is formed from the partial sums of the first m values of information points, where $m = 1, 2, 3 \ldots M$, divided by the corresponding number of terms: x_1,$(x_1+ x_2)/2$, $(x_1+ x_2 +x_3)/3$, … $(x_1+ x_2 + \ldots +x_m)/ M$.

The above series is an information line of lattice structures of technological information signals. One of the nodes of this information line has the greatest informative content or value.

The lattice information field of the controlled parameter is formed using orthogonal vectors to the information line (output three-dimensional time series).

The lattice information field has the form of information nodes connected to each other by orthogonal segments of time. Information points are placed in the nodes of lattice structures. Information points at discrete moments of time are not equal to the instantaneous value of the function, but to the average or equivalent value over the time series discretization period. The possible values of the information nodes of the grid field with two-dimensional orthogonal vectors are shown below in the table 1.

Table 1

x_M	$(x_M+x_{M+1})/2$	$(x_M+ x_{M+1}+ x_{M+2})/3$	. . .	$(x_M+ x_{M+1}+ \ldots + x_{2M-1})/ M$
. .	. . .	. . .	. . .	. . .
x_3	$(x_3+ x_4)/2$	$(x_3+ x_4+ x_5)/3$	. . .	$(x_3+ x_4+ \ldots + x_{M+2})/ M$
x_2	$(x_2+ x_3)/2$	$(x_2+ x_3+ x_4)/3$	. . .	$(x_2+ x_3+ \ldots + x_{M+1})/ M$
x_1	$(x_1+ x_2)/2$	$(x_1+ x_2+ x_3)/3$	. . .	$(x_1+ x_2+ \ldots + x_M)/ M$

The process of forming a lattice information field includes the preliminary accumulation of information. Analysis of the composition of the lattice information field shows that to create a field (matrix) of size $M \bullet M$, information of size $2M - 1$ is required.

The bottom line is a three-dimensional information line. Field columns (matrices) (two-dimensional orthogonal vectors to a three-dimensional information line) are nothing but linear filters with a frequency spectrum of *1/nΔt*. Each column is a two-dimensional time series with a certain averaging time *nΔt*, which corresponds to a certain frequency of the process. Thus, the information field is a matrix with a spectral analysis of the *1/nΔt* process. The lower row is the latest information line in time, the higher rows are the previous information lines of the lattice field shifted by one step in time. One of the nodes has the greatest information content or value.

In the information line of the controlled parameter (the original three-dimensional time series) with the help of two-dimensional orthogonal vectors, the most informative node in relation to the regulated parameter is found. The node thus found on the information line is connected to the input of the artificial neural network. The degree of informative value of the node is estimated using the correlation coefficients between the time series of the regulated parameter and the time series of the orthogonal vectors of the signals of the controlled quantities.

To determine the level of the correlation coefficient, the average values of a number of controlled and regulated parameters are found:

$$\mathcal{M}_y = \frac{y_1 + y_2 + \cdots + y_n}{n}$$

$$\mathcal{M}_x = \frac{x_1 + x_2 + \cdots + x_n}{n}$$

where *x* is a controlled parameter, *y* is an adjustable parameter, and *n* is the number of series values.

Determine the root mean square values of the controlled and regulated parameters by expressions:

$$\delta_y = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(y_i - \mathcal{M}_y)^2} \quad \delta_x = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \mathcal{M}_x)^2}$$

Determine the correlation coefficients of the time series of orthogonal vectors and the time series of the regulated parameter by the expression:

$$\rho = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{x_i - \mathcal{M}_x}{\delta_x}\right)\left(\frac{y_i - \mathcal{M}_y}{\delta_y}\right).$$

The time series of orthogonal vectors with the highest correlation coefficient corresponds to the most informative node of the information line of the controlled parameter.

The most informative nodes of the information lines of the controlled parameters are connected to the inputs of the artificial neural network. Its training is carried out during process regulation with the help of the most experienced operators. The trained neural network provides control of the technological process in sequence with the information received from the most experienced operators.

Conclusion. The supply of parameter values from the most informative points of the lattice structures of technological information signals to the inputs of the artificial neural network allows to improve the thermal regime of drive electric motors, increase the reliability of operation, productivity and efficiency of load regulation during the execution of the technological process.

References

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Academic supervisors: Dubovyk Volodymyr, senior lecturer,
Gorodetskyi Viktor, assoc. prof.

В. Дяченко[1], студент
[1]Національний технічний університет України
«Київський політехнічний інститут імені Ігоря Сікорського»

КЕРУВАННЯ ТЕХНОЛОГІЧНИМ ПРОЦЕСОМ З ВИКОРИСТАННЯМ НЕЙРОННОЇ МЕРЕЖІ

Анотація. *Керування регульованими параметрами технологічних процесів пов'язано з довільним використанням вузлів інформаційної лінії багатовимірних решітчастих структур сигналів технологічної інформації з використанням нейронних мереж.*

Ключові слова: *інформаційні лінії, технологічний процес, нейронна мережа.*