3. Automation and computer technology

NEURO-MECHANICAL PROCESSING MEASUREMENT INFORMATION ABOUT MECHANICAL QUANTITIES

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The control over the course of technological processes in production and the improvement of the quality of industrial products requires an increase in the accuracy of the measurement of geometric parameters and parameters of the movement of objects. These are the elements of production equipment and manufactured goods. Such measurements are proposed to be carried out on the basis of digital video objects of objects. In the conditions of production, there are a large number of adverse and non-stationary factors that negatively affect the means of measuring mechanical quantities with digital video.

When measuring geometrical parameters under the influence of adverse and non-stationary factors, there are additional errors in measuring video information. The indicated errors are caused by the deviation of the current properties of the measuring information, the current parameters of the measuring channel, the current parameters of random and dynamic errors from the values used in the previous calculations of measuring instruments. Therefore, in order to increase the accuracy of the measurement of geometric parameters and parameters of the object movement, it is necessary to compensate for the specified additional errors. Such compensation can be realized on the basis of improvement of procedures of computerized processing of measuring video information.

When measuring geometric parameters and parameters of motion of objects using artificial neural networks, the following tasks of computerized processing of measuring video information can be solved:

1. Algorithmic compensation of random and dynamic errors of video images with measuring information.

2. Search and selection of industrial products and elements of production equipment on video images, determination of their current coordinates and other geometric parameters.

3. Determination of parameters of motion of industrial equipment and industrial products made of natural stone on the basis of time sequences of video images.

Artificial neural networks in the computerized processing of video images with metering information provide the following advantages compared with other digital computing devices [1]:

1. The presence of built-in training procedures for networks that provide adaptation of measurement tools to the influence of adverse and non-stationary factors and reduce their additional error.

2. High-precise computerized processing of measuring video information about geometric parameters and parameters of object movement in working conditions.

3. Increase of speed of means of measurements provided the use of specialized neuroprocessor in the computer. The neuroprocessor carries out computerized processing of video images in the parallel mode of computing.

Thus, it is necessary to perform algorithmic compensation for additional errors of measurement of geometric parameters and parameters of motion of objects. This compensation is implemented in adaptation and training procedures for an artificial neural network that contains adaptive linear neurons.

In order to optimally adjust the parameters of the computerized processing of video images, it is necessary to identify the parameters of the device for the formation of video images (video camera). The camcorder is part of the measuring system for determining the mechanical quantities with digital video. Since the computerized processing of video information is carried out, it is expedient to present the results of the identification in the form of a discrete transfer function $H_{\mathrm{V}}(z)$. Correspondingly, the computer implements a transfer function $H_C(z)=1/H_{\mathrm{V}}(z)$ to recover video images and compensate for errors. To improve the speed of the measuring system it is possible to carry out computerized processing of video images in the form of two one-dimensional procedures. These procedures are applied separately to the rows and columns of the digital video [2]. If necessary, two-dimensional algorithmic processing is realized by transformation $H_{\mathrm{C}}(z)$ into a two-dimensional discrete transfer function $H_{\mathrm{C}}(z_1,z_2)$ by one of the known methods [2, 3].

It is proposed to identify the parameters of the camcorder using an adaptive auto regression model [4] implemented by an artificial neural network. The training procedure for such a network results in the weighting coefficients corresponding to the values of the coefficients of the discrete transfer function $H_{\mathrm{V}}(z)$ at the current time.

We write the difference equation and the discrete transfer function for the auto-regression model of the camcorder with an external input $f_0(n)$ [2, 3]:

$$f_{\mathrm{D}}(n)+\sum_{i=1}^{s}c_i f_{\mathrm{D}}(n-i)=\sum_{j=0}^{r}b_j f_0(n-j),\ H_{\mathrm{V}}(z)=\frac{b_0+b_1z^{-1}+b_2z^{-2}+...+b_rz^{-r}}{1+c_1z^{-1}+c_2z^{-2}+...+c_sz^{-s}}, \quad (1)$$

where $f_{\mathrm{D}}(n)$ - line of video with dynamic errors at the output of the camcorder, c_i, b_j - parameters of the auto-regression model, which are identified.

The results of identifying these parameters provide a minimumthe mean value of the error of the measurement information about the geometric parameters and parameters of the object movement (the objective function when designing the measuring system)

$$\overline{\varepsilon^2} = \frac{1}{N}\sum_{n=0}^{N-1}\varepsilon^2(n) \to \min_{c_i, b_j}, \tag{2}$$

$$\varepsilon(n) = f_{\text{M}}(n) - f_{\text{D}}(n) = f_{\text{M}}(n) - \sum_{j=0}^{r} b_j^* f_0(n-j) + \sum_{i=1}^{s} c_i^* f_D^*(n-i),$$

where N - the number of discrete video signal amplitudes in the lines of the digital video image, $f_{\text{M}}(n) = f_{\text{D}}(n) + \xi(n)$ - the measured value of discrete counters $f_{\text{D}}(n)$ in a row or a column of the video at the output of the PFVZ, $\xi(n)$ - random errors of video images caused by noise in the PFVZ,

$$f_D^*(n) = \sum_{j=0}^{r} b_j^* f_0(n-j) - \sum_{i=1}^{s} c_i^* f_D^*(n-i) = f_{\text{D}}(n) + \Delta_{\text{AR}}(n) \; -$$

- estimation of discrete counters $f_{\text{D}}(n)$ in a row or a column of a video based on the autoregressive model, c_i^*, b_j^* - current estimations of the parameters of the autoregressive model, $\Delta_{\text{AR}}(n)$ - the error of the autoregressive model with the current parameters c_i^*, b_j^*.

Equation (2) includes both measured values $f_{\text{M}}(n)$ of discrete counters in a row or column of video images at the output of the camcorder, and their estimates $f_D^*(n)$ for the current parameter values c_i^*, b_j^*. Therefore, it is expedient to minimize the average value of the quadratic error based on the recurrence procedure.

An example of estimating the accuracy of the results of identifying parameters of an auto-regression model of a video camera according to formulas (2) is shown in Fig. 1. The autoregressive model of the third order according to formulas (1) ($r = 2, s = 3$) provides the accuracy of the identification of the parameters of the video camera (0,3 ... 0,8)% and is used to compensate for the errors of measurement of mechanical quantities.

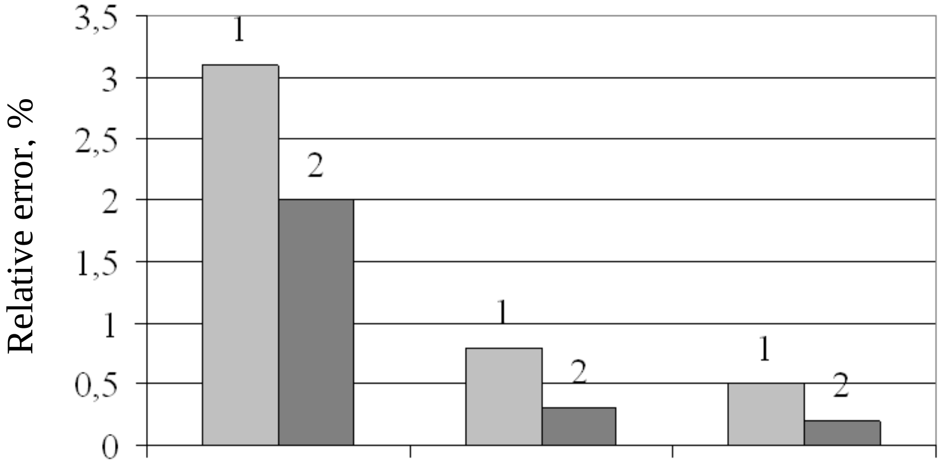

Fig. 1. Relative error of approximation of parameters of devices for the formation of video images based on the autoregressive model:
1 - digital camera; 2 - digital video camera

Thus, a method for identifying the parameters of devices for the formation of video images on the basis of an adaptive linear artificial neural network is developed. Identification results are used to optimally adjust the parameters of procedures for algorithmic compensation of the dynamic errors of video images in working conditions for measuring mechanical quantities.

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