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Intelligent system for time series forecasting

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Abstract

The paper presents a mathematical model of processing and forecasting time series data. The mathematical model based on the methods of artificial neural networks and preliminary data processing using wavelet transforms discribed.

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Keywords: time series; forecasting; artificial neural networks; wavelet transform.

1. Introduction:

The most optimal and reliable method of forecasting is predicting at short intervals. The purpose is to optimize the activity of industrial enterprise in planning and carrying out activities aimed at minimizing the environmental, material damages and the general negative impact on the environment.

In order to predict the value of the time series is not enough just to apply these values to the neural network. Reducing the influence of parasitic noise is added to the useful signal noise component, it requires the use of low-pass filtering. Wavelet filtering (W-filter) was used for this purpose. After processing, they are fed to the neural network. The latter, in turn, must be formed and trained according to the task. Once the neural network has been initialized and is ready to fill the required number (needed for foresight) of the wavelet expansion coefficients obtained by using W-filter, connects the memory unit required for constant adjustment of the neural network coefficients. To receive as a result of the predicted values of the time series, it is required to restore the approximate coefficients. Thus, automated monitoring system includes three main phases of functioning: pre-processing at the

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wavelet W-filter forming and training the neural network and restoring the time series data of the predicted coefficients.

2. Processing and analysis of time series by wavelet transform

Consider multiresolution wavelet decomposition nonstationary signal in a time-series of samples *x(k)* to the level n. In this case, the signal *x(k)* is decomposed into two projections - projection onto the space V^n (approximating coefficients representing the low-frequency component of the signal) and the space W^n (detailing the factors responsible for the transmission of high-frequency part of the signal)[4,5].

Expressions for calculating approximate and detail coefficients of the wavelet decomposition of the first decomposition level are of the form:

$$C_1(k) = \frac{1}{p}\left(u(k) + \xi(k)\right)\varphi_1(k),$$
$$d_1 = \frac{1}{p}\left(u(k) + \xi(k)\right)\psi_1(k) \tag{1}$$

where $u(k)=x(k)-n(k)$ - the actual value of count, n(k) - noise component),$\xi(k)$ - the reference fluctuation component,$\varphi_1(k)$ - scaling function, $\psi_1(k)$- the wavelet function.

The approximation and detail coefficients of higher expansion levels are calculated by the following expressions:

$$C_{i+1}(k) = \frac{1}{p} C_i(k)\varphi_{i+1}\left(2^{i+1}t - k\right),$$
$$d_{i+1}(k) = \frac{1}{p} C_i(k)\psi_{i+1}\left(2^{i+1}t - k\right). \tag{2}$$

Recovery time series is carried out by the formula [4,5]:

$$s(k) = d_1 + d_2 + .. + d_n + C_n, \tag{3}$$

where $C_n = \frac{1}{p} C_{n-1}\varphi_n\left(2^n t - k\right)$.

Considering the (1), (2) and (3), the mathematical model of the reduced experimental time series with the wavelet decomposition to a level n is given by [6,4]

$$s(k) = \frac{1}{2}\left[\left(u(k) + \xi_k\right)\psi_1(k) + \left[\sum_{i=1}^{n-1}\left(C_i\psi_{i+1}(k)\right)\right] + C_i\psi_{i+1}(k)\right] \tag{4}$$

Fig. 1 shows the results of investigation approximate autocorrelation coefficients $C_i(k)$. As can be seen from Figure 1, graphs ACF approximating coefficients $C_i(k)$ show an increase in the correlation time with an increase in the level of wavelet decomposition[5,7].

Figure 2 shows results of studies of the time series according to the attenuation component and noise variance, respectively, reduce the error from the neural network learning level wavelet processing the input time series signals, where β(τ)=σ2n,W/σ2n,inthe variance of the noise components at the output of filter W-wavelet processing.