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A RECURSIVE ADAPTIVE ALGORITHM OF MULTIDIMENSIONAL NONLINEAR FILTERING — BI-INDEPENDENT TRANSFORM OF SIGNALS

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New algorithms of multidimensional adaptive nonlinear filtration are suggested. The algorithms are based on generating a nonlinear estimate of the signal component and subtracting it from the realization of the input random process. The paper considers the rate of convergence of these algorithms and the possibility of their realization based on filters with finite and infinite memory, and with adjustment of weight coefficients by the direct calculation method.

The state of the art and prospects for development and application of multidimensional adaptive linear filters are described in [1, 2]. Filtering of signals can be performed both in the time and frequency domains. Adjustment of the weight coefficients in the filters may be carried out by stochastic gradient methods and by the methods of direct computations. A disadvantage of such filters is that they are intended for treatment of the second-order random processes (RP) including the linear (Gaussian in particular) processes. At input RP of higher orders these filters perform the processing with considerable errors. Thus, in order to realize asymptotically optimal algorithms of processing, we are led to development of multidimensional nonlinear algorithms of filtration and adaptive correction of their weight coefficients.

The adaptive algorithms of multidimensional nonlinear filtering suggested in [3] are based on representing the output RP filter by a specially introduced generalized Kolmogorov-Gabor matrix polynomial. Moreover, adjustment of weight coefficients has required development of adaptive algorithms of stochastic approximation (SA) realized by direct calculation methods. Also, the signal-to-noise ratio obtained at the outputs of such devices has been analyzed.

In this work we investigate new algorithms of multidimensional adaptive nonlinear recursive filtration based on representing an input vector-like RP in the form of the generalized Kolmogorov-Gabor matrix polynomial proposed by the author. For adjustment of the weight coefficients the direct computation methods and stochastic approximation algorithms are employed.

The multivariate linear adaptive filters for "whitening" the second order RP have been described in [1]. The whitening in such filters is equivalent to a well-known mathematical procedure of biorthogonalization of a system of vectors $\{\xi\}$, $i \in [1, N]$, in the Hilbert space H. Let us show it. In conformity with [4], in the Hilbert space H with the scalar product $(\xi_i, \overline{\eta}_j) = M[\xi_i \overline{\eta}_j]$, where $M[\cdot]$ denotes mean value, and $\overline{\eta}_j$ is the complex-conjugate random value (RV), a totality of vectors $\{\eta_j\}$, $j \in [1, N]$, satisfying the conditions

$$\left(\xi_i, \overline{\eta}_j\right) = M\left[\xi_i \overline{\eta}_j\right] = \delta_{ij}, \tag{1}$$

where δ_{ij} is the Kronecker delta, forms a basis usually called dual to ξ_i and, since $H = H^*$, these totalities comprise a biorthogonal system.

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