STATISTICAL SYNTHESIS OF ALGORITHMS FOR THE RECEPTION OF MULTICOMPONENT DISCRETE SIGNALS

V. E. Martirosov

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Optimal algorithms have been derived for the joint nonlinear filtering of multicomponent discrete-continuous Markovian processes. Optimal reception algorithms have been synthesized for double phase-shift and frequency phase-shift telegraphy in the presence of a random initial phase of the received signal. The singularities of the resulting block diagrams have been discussed.

Let the received wave have the form

$$r(t) = s(t; \lambda, \alpha) + n(t), \tag{1}$$

where $s(t; \lambda, \alpha)$ is a signal depending on a continuous random parameter $\lambda(t)$ and on a vector of discrete parameters $\alpha = \{\alpha^{(1)}, \alpha^{(2)}, \ldots, \alpha^{(M)}\}$; $n(t)$ is normal white noise with a zero average and a correlation function $B(\tau) = (N_0/2)\delta(\tau)$; N_0 is the spectral density of the power; the processes λ, $\alpha^{(1)}$, $\alpha^{(2)}$, ..., $\alpha^{(M)}$ are statistically independent. In the general case, the parameters which are unknown and subject to extraction - $\lambda(t)$, $\alpha^{(1)}$, $\alpha^{(2)}$, ..., $\alpha^{(M)}$ - are related to the signal by nonlinear functional relationships.

Assume that $\lambda(t)$ is a normal Markovian process, while the components of the vector α are discrete Markovian processes having n possible states.

Based on the theory of conditional Markovian processes (see [1]), we write the equation for the normalized a posteriori probability density of the parameters λ, $\alpha^{(1)}$, $\alpha^{(2)}$, ... , $\alpha^{(M)}$:

$$\begin{aligned}\frac{\partial}{\partial t} W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) &= L_{pr} W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) + \\ &+ \sum_{i=1}^n a_{ij}^{(1)} W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) + \sum_{i=1}^n a_{ik}^{(2)} W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) + \ldots \\ &\ldots + \sum_{i=1}^n a_{il}^{(M)} W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) + [F(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) - \langle F \rangle] \times \\ &\times W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}),\end{aligned} \tag{2}$$

where j, k, l = 1, 2, ..., n; L_{pr} is the Fokker-Planck-Kolmogorov operator which describes the transformations of the a priori probability density; $a_{ij}^{(1)}$, $a_{ik}^{(2)}$, ... $a_{il}^{(M)}$ are coefficients which are determined by the local values of the transition probabilities of the corresponding discrete processes $\alpha^{(1)}$, $\alpha^{(2)}$, ..., $\alpha^{(M)}$;

$$\begin{aligned}F(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) &= \frac{2}{N_0} r(t)\, s(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}); \\ \langle F \rangle = \sum_{j=1}^n \sum_{k=1}^n \cdots \sum_{l=1}^n \int_\lambda & F(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)}) \times \\ &\times W(t; \lambda, \alpha_j^{(1)}, \alpha_k^{(2)}, \ldots, \alpha_l^{(M)})\, d\lambda.\end{aligned} \tag{3}$$

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