SYNTHESIS OF DIGITAL DETECTOR- METERS FOR MIXED MARKOVIAN PROCESSES

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Optimal and quasi-optimal detection-measurement algorithms for mixed Markovian processes in discrete time have been synthesized and analyzed. As an example, the problem of detecting a signal having a bi-Gaussian probability density and an exponential correlation function in a background of correlated interference having analogous statistical characteristics of the white and Gaussian noise has been considered. The method of statistical simulation has been used to compare various detection algorithms.

Under modern conditions, which are characterized by the complexity of the problems solved by radioengineering systems and the variety of the interference environment, signals having a random structure find extensive application. These may likewise include many forms of interferences of natural and artificial origin.

It is of interest to synthesize algorithms for the detection and measurement of such processes in discrete time, since they are adequate for the extensively used digital computers.

Let the useful signal x(k) and interference z(k) belong to the class of processes having a random structure in discrete time, and assume that they are described (see [1]) by the equation

$$x(k) = F_1[x(k-1), a_j(k)] + G_1[a_j(k)]\, w_1(k); \tag{1}$$

$$z(k) = F_2[z(k-1), c_\beta(k)] + G_2[c_\beta(k)]\, w_2(k), \tag{2}$$

where x(k) is the N_1-dimensional vector of state for the signal; z(k) is the N_2-dimensional vector of state for the interference; $a_j(k)$, $c_\beta(k)$ are Markov chains having the transition matrices $\Pi^a_{ij}(k, k-1)$, $\Pi^c_{\alpha\beta}(k, k-1)$ and the initial probabilities $p^a_i(0)$, $p^c_\alpha(0)$, respectively ($i, j = 1 \ldots M_1$, $\alpha, \beta = 1 \ldots M_3$); $w_1(k)$, $w_2(k)$ are uncorrelated sequences of Gaussian vectors $E[w_1(k)] = 0$, $E[w_1(k) \times w_1^T(k)] = Q_1(k)$, $E[w_2(k)] = 0$, $E[w_2(k)\, w_2^T(k)] = Q_2(k)$; $F_1[\cdot]$, $F_2[\cdot]$ are vector-valued functions; $G_1[\cdot]$, $G_2[\cdot]$ are matrices having the dimensionality $N_1 \times N_1$ and $N_2 \times N_2$, respectively. The initial a priori densities P(x(0)), P(z(0)) are Gaussian, and $E[x(0)] = \hat{x}(0)$, $E[(x(0) - \hat{x}(0))(x(0) - \hat{x}(0))^T] = \hat{P}_1(0)$, $E[z(0)] = \hat{z}(0)$, $E[(z(0) - \hat{z}(0))(z(0) - \hat{z}(0))^T] = \hat{P}_2(0)$.

Assume that the sampled process can be described by the relationships

$$y(k) = \begin{cases} h_1(x(k), z(k), b_m(k), d_\mu(k)) + C_1[b_m(k), d_\mu(k)]\, v(k) & \text{for } \Theta = 1; \quad (3) \\ h_2(z(k), d_\mu(k)) + C_2[d_\mu(k)]\, v(k) & \text{for } \Theta = 0, \quad (4) \end{cases}$$

where y(k) is the N_3-dimensional measurement vector; $b_m(k)$, $d_\mu(k)$ are Markov chains having the transition matrices $\Pi^b_{nm}(k, k-1)$, $\Pi^d_{\eta\mu}(k, k-1)$ and the initial probabilities $p^b_n(0)$, $p^d_\eta(0)$, respectively (n, m = 1 ... M_2, $\eta, \mu = 1 \ldots M_4$); v(k) is an uncorrelated sequence of Gaussian vectors; $E[v(k)] = 0$, $E[v(k)\, v^T(k)] = R(k)$; $h_1[\cdot]$, $h_2[\cdot]$ are vector-valued functions; $C_1[\cdot]$, $C_2[\cdot]$ are matrices having the dimensionality $N_3 \times N_3$; $\Theta = 1, 0$ characterizes the situations of presence and absence of the useful signal, respectively.

Assume the Markov chains $a_j(k)$, $b_m(k)$, $c_\beta(k)$, $d_\mu(k)$ are independent of one another. Under these conditions the continuous component x(k) depends solely on the discrete component $a_j(k)$, and z(k) correspondingly depends on $c_\beta(k)$.

The Bayes method of adaptive estimation, which is extensively used to synthesize algorithms for estimating processes having a random structure of the form given by Eqs. (1), (2), leads to filters having a growing memory (see [1]) and does not allow a recurrent optimal detection-measurement algorithm for such processes to be derived.

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