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Adaptive Processing of Signals on a Background of Clutter and Noise

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Abstract—Suppression of clutter and noise is one of the most important problems of radio location signals processing. It is shown proposed algorithm of division of processing vector into sub-vectors of non-recursive noise suppression filter allows to increase average by signals Doppler velocities probability of correct detection on 6–28% in compare to known non-adaptive whitening filter. Proposed algorithm does not require the noise correlation matrix inversion in case of modification of power of clutter noise that reduces computational burden 1.8–7 times on its realization in compare to optimal adaptive algorithm.

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For operation of radio engineering systems it is typical the influence of combined interferences (both correlated and uncorrelated ones), appearing at the receiver input together with useful signals, complicating their detection. For example, for air traffic control at the airports and aerodromes it is typical simultaneous appear of radar clutter from underlying surface and active noise interferences (ANI) from different sources (ground and on-board radio equipment, industrial noise, etc.) at the reception devices. Suppression of such clutter noise lies in their whitening of correlation component to noise level. The problem lies in its level can be modified essentially due to variations of antenna gain factor on ANI source during scanning process.

Optimal solution assumes recalculation of the coefficients of inverse noise correlation matrix for estimation of the parameters of noise whitening filter in case of modification of noise component power level. Known solution lies in preserve of previous processing vector values, i.e. it is not adaptive to ANI power modification that is typical for rejector filter [1].

Optimal solution supposes essential computational burden (amount of arithmetic operations) and known non-adaptive one leads to underuse of potential possibilities for the signals detection on a background of combined interferences.

We represent correlation matrix $\mathbf{R}$ of the clutter process as a sum of correlated $\mathbf{R}_c$ and non-correlated $P_n\mathbf{I}$ components, correspondingly:

$$\mathbf{R} = \mathbf{R}_c + P_n \mathbf{I}, \tag{1}$$

where $\mathbf{R}_c$ is $(q\times q)$ dimension correlated component (clutter) of the process, q is a filter order, $\mathbf{I}$ is $(q\times q)$-dimension identity matrix, P_n is relative power of noise component of the process.

Computational burden, required for matrix inversion is proportional to q^3, and in case of application of fast procedures it is proportional to q^2 [2]. It is supposed to obtain two-dimension correction vector $\boldsymbol{\chi}^T = [\chi_1; \chi_2]$ [3], whose multiplying by known diagonal matrix diag($\mathbf{a}$) and additional matrix $\mathbf{M}$ is approximately equal to a vector $\mathbf{a}_{opt}$ of optimal processing: $\mathrm{diag}(\mathbf{a})\mathbf{M}\boldsymbol{\chi} \approx \mathbf{a}_{opt}$ or

$$\mathrm{diag}(\mathbf{a})\mathbf{M}\boldsymbol{\chi} = \mathbf{a}_{opt} + \boldsymbol{\varepsilon}, \tag{2}$$

where $\boldsymbol{\varepsilon}$ is column vector of residual, $\mathbf{M}$ is $(q\times 2)$-dimension additional matrix, which is following: