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Matched Normalized Signal Filtering

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Abstract—A new matched filtering method, which is based on normalization of discrete orthogonal transformations "in terms of step" and normalization of tested signals "in terms of level" by the minimum of transform coefficient criterion, is suggested.

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Analysis of similarity or inequality between signals is usually performed by means of classical matched filters. Construction of line-matched filters is based on some restrictions of tested signals (stationary of a signal and white noise with zero mean, differentiability of a signal, etc.). In this case, the optimal detection is provided by the correlation between tested signal $s(t)$ and signal $x(t)$ with additive white noise [1]. However, if the sequence of determine signals with difference form is presented, then the detection of a signal, matched with a reference signal, is difficult [2]. It is possible, that the maximum of correlation function could be significantly lower than convolution of pulse response of a line-matched filter with totally different signal having big amplitude. Therefore, the likelihood criterion, based on the coincidence of N-dimensional signal vector in a sequence with N-dimensional reference vector (the scalars of these vectors are different), is used frequently [2]. However, these nonlinear matched filters have some disadvantages. On the one side, the rearrangement of components of N-dimensional vector does not change the sum, on the other side, it corresponds to the rearrangement of samples of a tested signal. Thereby, signals with different form but having the same set of samples will be obtain the equal representative vector in the N-dimensional space.

A new matched filtering method, based on using of orthogonal transformation normalized "in terms of step" [3] or "in terms of level" [4] during calculation of signal's spectrum, is suggested.

"IN TERMS OF STEP" NORMALIZATION

It means normalization of a reference signal, so that its maximum and minimum values are equal +1 and –1 respectively, and projection of discrete samples of a "smooth" transform of orthogonal transformations (parallel to argument's axis) on a normalized reference signal. The reference points of a reference signal are corresponded to nonequidistant steps along argument's axis (the periods of a reference signal and a matched transform are equal). If necessary, we should renumber the transform samples with respect to their reference numbers (i.e. the corresponding columns of a matrix of discrete orthogonal transformation are rearranged).

As result, if we take the samples of a tested signal with nonequidistant step (tested signal differ from a reference signal by scale and dc component only), then the spectrum of a signal, normalized as described above, will have the dc component and transform only. The number of this transform is equal to the number of the one, with respect to which the normalization is performed.

"In terms of level" normalization

The such correct coefficients of a reference signal are introduced (after subtraction of a dc component from it for example) that the division by them of this reference signal makes it identical to the transform of discrete orthogonal transformation (accurate within arbitrary scale factor).

In this case, the tested signal after subtraction of a dc component and division by correct coefficients coincides with appropriate transform of transformation. The spectrum of a corrected signal will contain one transform if tested and reference signals differ by scale factor and dc component only.

Both normalization methods lead to "enrichment" of spectrum when the difference between form of a tested and reference signal is small or additive noise is present. If these difference are significant, then the transform will not be the dominant of a calculated spectrum.

To obtain the quantitative estimation of degree of similarity and inequality in both cases the transform coefficient [4]