Quasimatched Wavelet Filtration

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Abstract—The wavelet analysis theory is considered as a state-of-the-art frequency-time method of signal processing for signals containing jumps, bursts and surges. A new method has been proposed for estimating the wavelet spectra of pulsed signals using the normalized correlation coefficient and a technique for matching the wavelet filters has been developed on the basis of the proposed method making it possible to enhance the quality and speed of digital signal processing.

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INTRODUCTION

Signal transformation is required for obtaining the signal information inaccessible in the initial form. The integral Laplace and Fourier transforms are most frequently used in engineering problems for signal analysis. The transition to more complex signals and, especially to those containing surges or parameter jumps, in the modern radio electronics and telecommunications systems predetermined further development of the theory of integral transforms, since the classical transforms are ineffective in this case.

Hence, for the purpose of enhancing the speed of systems for digital signal processing (DSP) the fast Fourier transform (FFT) was developed [1]. During the signal analysis and synthesis FFT makes it possible to reduce the number of multiplication operations by several orders and thereby to essentially enhance the speed of DSP. The cosine transform [1], same as the Hartley transform [2] and unlike the Fourier transform with a complex basis function consisting of the real and imaginary parts have the real basis function making it possible to double the speed of the FFT algorithm. The Haar transform [3] is performed faster than any other transform with harmonic basis function due to a simple form of the transform kernel. However, such transform is effective only in processing the signals with amplitude jumps.

The Gabor transforms and window Fourier transforms [3] were among the first proposed for the analysis of nonstationary signals. The use of window function in such transforms, unlike the stationary Fourier transform, allows us both to separate the spectral composition of signal and to obtain the time distribution of frequency components. A disadvantage of any window transform is a constant width of the window function that determines the width of separated frequency components and the width of time intervals where these components are located, i.e., the entire time-frequency plane is analyzed with the same resolution. The use of such transform for a complex signal containing the useful information only in a specific region of spectrum is not rational.

The up-to-date mathematical tool, free from the above mentioned disadvantages and specifically developed for supplementing the theory of signal analysis, is the wavelet transform [4]. The peculiarities of the specified transform include a dynamic kernel and multibasisness. Due to the flexible kernel of transform the time-frequency wavelet spectrum has a good frequency resolution in the region of low frequencies and the good time resolution in the region of high frequencies. In addition, for one and the same signal it is possible to construct different spectra depending on the selected kernel of wavelet transform and thereby select the best processing algorithm.

Up to date, however, the wavelet theory has not got a proper impetus for the development of its practical applications. Hence, only statistical parameters were developed for estimating wavelet spectra [4]. Moreover, calculations of such parameters are difficult and they can be used only for the analysis of random signals. Engineers generally choose wavelets by intuition, based on their similarity to signals under investigation [5].

That is why the purpose of the present study is the development of parameters for estimating the wavelet spectra of pulsed signals and the development of new algorithms of wavelet filter matching for enhancing the speed and effectiveness of DSP.