COMPLEX WAVELET TRANSFORM IN BIOMEDICAL IMAGE DENOISING

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The discrete wavelet transform (DWT) has proved very valuable in a large scope of signal processing problems. However, in many applications, it reaches the following limitations. First, *oscillations* of the coefficients at a singularity, second, *shift variance*, third, *aliasing* due to downsampling, non-ideal filters and altering of the coefficients, and finally, *lack of directional selectivity* in higher dimensions.

To overcome these problems, the complex wavelet transform (CWT) employs analytic filters, i.e. their real and imaginary parts form the Hilbert transform (HT) pair, ensuring magnitude and phase shift invariance and no aliasing. The CWT strategy, that we focus on in this paper, is Kingsbury's and Selesnick's dual tree CWT (DTCWT). This moderately redundant multiresolution transform with decimated subbands runs in two DWT trees (real and imaginary) of real filters producing the real and the imaginary parts of the coefficients. The wavelet functions and the scaling function form an approximate HT pair. The analysis and the corresponding synthesis filters of each tree form orthogonal or biorthogonal bases. The 2D DTCWT produces six directional subbands per level instead of usual three to reveal the details of an image in ±15, ±45 and ±75 directions.

Due to its shift invariance and improved directional selectivity, the DTCWT outpreformes the critically decimated DWT in a range of applications, such as, motion estimation, edge detection, texture discrimination and denoising. In this paper, we exhibit biomedical MR image denoising by the means of thresholding magnitude of the wavelet coefficients.

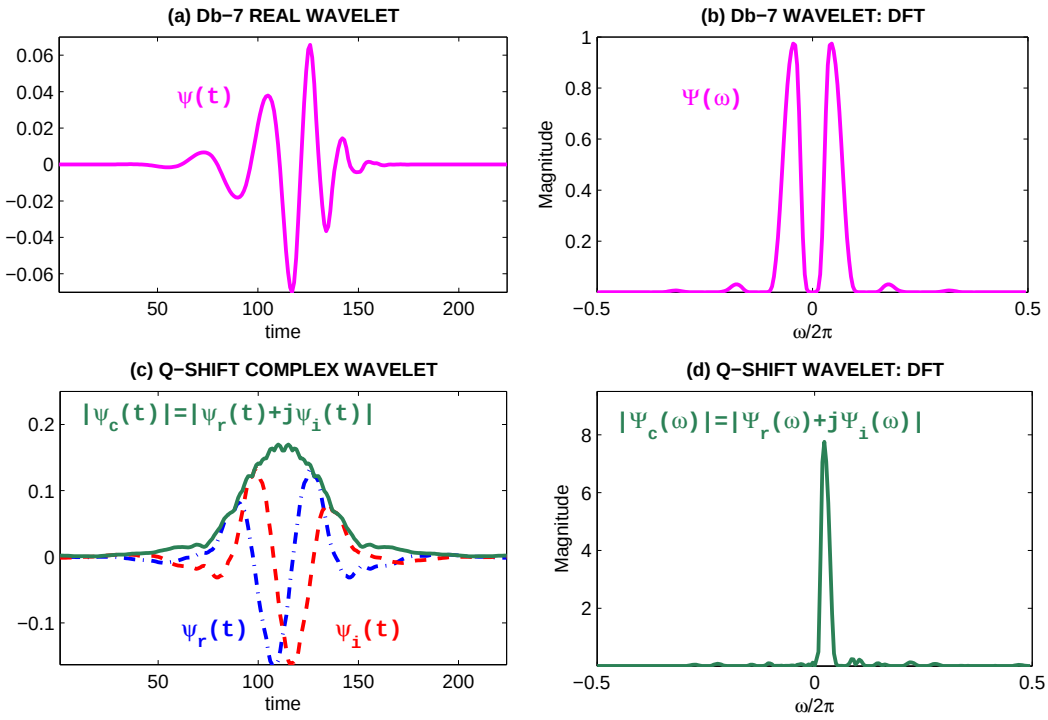

Figure 1: Comparison of the frequency spectra of a real and an analytic wavelet at level 4 both based on 14-tap filters presenting **(a)** Daubechies wavelet curve, **(b)** its magnitude Fourier transform, **(c)** a q-shift complex wavelet composed of a real and an imaginary wavelet forming an approximate Hilbert pair, and **(d)** its almost single-sided spectrum suppressing negative frequencies.