

An introduction to nonlinear wavelet based signal processing and applications to noise removal

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While the basic principles of multiscale analysis can be traced to publications dating back to the 1960's (geophysics) the significance and implications was not fully appreciated or even understood prior to a publication by I. Daubechies in 1988. In that article Daubechies proved that there existed a family of (non-trivial, continuous and with a degree of regularity/smoothness) compactly supported orthogonal basis, the wavelet basis. In particular, Daubechies introduced a family of wavelet basis that satisfied a maximal regularity constraint. The family of maximally regular wavelets as developed by Daubechies is frequently referred to as Daubechies wavelet basis of order N , where N indicates the support or equivalently the length of the associated finite impulse response (FIR) filters. Following the publication of Daubechies key paper in 1988 wavelet theory in a more generally setting of "multiresolution analysis" has received enormous attention from a cross-section of scientific research community and the theory has a natural coupling towards signal processing in that the implementation is an iterated filter bank structure.

While the discussion of general multiresolution transforms and filter banks are beyond the scope of this talk it is our goal to introduce the general structure of scale-based decompositions enabling new ways of looking at old problems. It is often said that wavelets is a solution looking for a problem much the same, as the laser was a device looking for the right application when first developed. Significant progress has been made on wavelet-based signal processing since 1988. In 1992 Donoho and Johnstone presented a new framework for filtering using wavelets. The technique is based on "filtering" by thresholding wavelet amplitudes instead of classical frequency band filtering we are used to from classical Fourier thinking. We will try to build the intuition behind wavelet based nonlinear techniques and discuss potential applications of noise removal. We will also briefly discuss more recent results on the use of hidden Markov models for noise removal (denoising).