Using Wavelet Transforms to Enhance Signal-to-Noise in Capillary Electropherograms

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Every method of analysis generates some noise that may interfere with the determination of the analytical signal. It is generally accepted that a signal peak that is three times greater than the noise fluctuations is the limit of detection. One approach to improving an analytical determination is to accentuate the difference between signal and noise using mathematical methods after data collection. This may allow us to lower our limits of detection to extend our quantitative analysis range.

In this presentation we describe our use of the Wavelet Transform (WT) to improve S/N ratio by selecting most efficient coefficients and transform level. The basic concept of the WT comes from Fourier Transform (FT). Even though, they share most properties, the WT has some benefits over the FT. One of the advantages is that there are many different coefficients to use. Also, the WT gives a chance to analyze a data stream for frequency and position in time (two-dimensional frequency analysis).

In this experiment, the Haar wavelet and the Daubechies wavelet transforms were used. Both were constructed in the MATLAB environment for maximum flexibility. Sample data sets included ideal, computer-generated Gaussian peaks and actual electropherograms collected using an ultraviolet absorbance detector for the capillary electrophoresis separation of low-flow push-pull perfusion samples for the determination of nitrite (NO_2^-) and nitrate (NO_3^-). The results demonstrate that the reconstructed data sets using the WT give an increased S/N ratio generally, but the better enhancements were seen as more complicated wavelets and higher levels of transformation were used. However, this increase was determined to be nonlinear relative to the transformation level and the original peak S/N ratio. Further investigation is necessary to determine if there is a mother wavelet that maintains a linear response. With ideal, Gaussian peaks with random noise added, the S/N enhancement is quite high with a 5-fold enhancement being uncommon. Enhancements with real data produce less dramatic results. Therefore, we are planning to investigate if we can decrease the limit of detection along with the limit of quantization.

*Sample result using computer-generated Gaussian peak, using Daubechies 8 coefficients.

Original data points = 1024
Transformed level = 4

S/N (original, top) = 10.2032
S/N (reconstructed, bottom) = 48.6995
Enhancement = 4.773