Image Compression Using Balanced Multiwavelets

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(ABSTRACT)

The success of any transform coding technique depends on how well the basis functions represent the signal features. The discrete wavelet transform (DWT) performs a multiresolution analysis of a signal; this enables an efficient representation of smooth and detailed signal regions. Furthermore, computationally efficient algorithms exist for computing the DWT. For these reasons, recent image compression standards such as JPEG2000 use the wavelet transform.

It is well known that orthogonality and symmetry are desirable transform properties in image compression applications. It is also known that the scalar wavelet transform does not possess both properties simultaneously. Multiwavelets overcome this limitation; the multiwavelet transform allows orthogonality and symmetry to co-exist. However recently reported image compression results indicate that the scalar wavelets still outperform the multiwavelets in terms of peak signal-to-noise ratio (PSNR).

In a multiwavelet transform, the balancing order of the multiwavelet is indicative of its energy compaction efficiency (usually a higher balancing order implies lower mean-squared-error, MSE, in the compressed image). But a high balancing order alone does not ensure good image compression performance. Filter bank characteristics such as shift-variance, magnitude response, symmetry and phase response are important factors that also influence the MSE and perceived image quality.

This thesis analyzes the impact of these multiwavelet characteristics on image compression performance. Our analysis allows us to explain—for the first time—reasons for the small performance gap between the scalar wavelets and multiwavelets.

We study the characteristics of five balanced multiwavelets (and 2 unbalanced multiwavelets) and compare their image compression performance for grayscale images with the popular

(9,7)-tap and (22,14)-tap biorthogonal scalar wavelets. We use the well-known SPIHT quantizer in our compression scheme and utilize PSNR and subjective quality measures to assess performance. We also study the effect of incorporating a human visual system (HVS)-based transform model in our multiwavelet compression scheme.

Our results indicate those multiwavelet properties that are most important to image compression. Moreover, the PSNR and subjective quality results depict similar performance for the best scalar wavelets and multiwavelets. Our analysis also shows that the HVS-based multiwavelet transform coder considerably improves perceived image quality at low bit rates.