Differentiation-based Multi-resolution Approach for Lossless Image Compression

Xiaojun Qi                                           John M. Tyler
Computer Science Department           Computer Science Department
Utah State University                          Louisiana State University
Logan, UT 84322                                Baton Rouge, LA 70803
Phone: (435)797-8155                         Phone: (225)578-2198
Email: xqi@cc.usu.edu                          Email: tyler@bit.csc.lsu.edu

We design a differentiation-based multi-resolution approach for lossless image compression. The differentiation technique uses six appropriately weighted adjacent pixels (i.e., the pixels located at the west, west-west, north-west, north, north-east, and north-north of the predicted pixel) to estimate the predicted pixel intensity. This differentiation technique can also be considered as an additional rule for the seven predictors used by the lossless JPEG. The prediction error is decomposed by a (2, 2) integer wavelet transform [1] (i.e., the number of vanishing moments of the analyzing high-pass filter and the synthesizing high-pass filter is 2 and 2 respectively) to improve the prediction. The reasons to choose the (2, 2) integer wavelet transform follow [2]:

- It maintains the highly important linear phase constraint by relaxing the orthogonality constraint and associating with short length filters. Therefore, it is a suitable tool to compress images regarding minimization of computational time and maximization of compression ratios.
- It is equally as amenable to most applications as orthogonal wavelet transforms.
- It obtains exactly symmetric biorthogonal wavelet systems by keeping vanishing moments equally distributed for the analyzing and synthesizing high-pass filter.

The minimum weighted entropy determines the optimal decomposition level of the differentiation-based integer wavelet transform. Our experimental results show the one-level integer wavelet transform achieves the best optimization on the prediction error. The differentiation-based wavelet decomposition results are further coded using arithmetic coding.

The performance of the proposed approach is evaluated and compared with the lossless JPEG and lossless adaptive linear predictor schemes. Our proposed approach is compared with these two schemes because these techniques estimate the present pixel value from the previous pixel values. Our proposed scheme yields lower bits/pixel (higher compression) than the lossless JPEG. It also yields a comparable or lower bits/pixel than the lossless adaptive linear predictor scheme. However, the computational complexities are greatly reduced because the predictor coefficients are known by the encoder and the decoder.