



Visual Communications and Image Processing '94

Aggelos K. Katsaggelos
Chair/Editor

25–29 September
Chicago, Illinois



Volume 2308
Part Three of Three Parts

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Wavelet Transforms in a JPEG-like Image Coder

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Abstract

The discrete wavelet transform is incorporated into the JPEG baseline coder for image coding. The discrete cosine transform is replaced by an association of two-channel filter banks connected hierarchically. The scanning and quantization schemes are devised and the entropy coder used is exactly the same as used in JPEG. The result is a still image coder that outperforms JPEG while retaining its simplicity and most of its existing building blocks. Objective results and reconstructed images are presented.

Keywords: image coding, wavelet transform, JPEG.

1 Introduction

The discrete cosine transform (DCT) [1] plays a major role in the popular image data compressors and DCT based algorithms are widely available nowadays. In still image compression, the JPEG baseline coder (JPEG) [2] is a "de facto" standard and there are several chips and programs available to perform JPEG compression and decompression. JPEG is based on the DCT, because of the DCT's fast implementation algorithm allied with good performance. Recently, much attention has been devoted to the dyadic discrete wavelet transforms (DWT) [3], which has a versatile time-frequency localization due to a pyramid-like multiresolution decomposition. Several authors have studied the DWT in image coding, obtaining performances superior to JPEG or most of other DCT-based coders [4]–[7]. However, many times, most of the advantages come at the cost of an increase in complexity, and by the use of more sophisticated encoding algorithms. In this work we explore a JPEG-like coder which uses the main building blocks of JPEG (sometimes with minor changes) and the DWT to achieve a versatile system that outperforms JPEG, with small complexity penalty.

2 Transforming the image

As in any transform coder, the image is transformed and the resulting transform coefficients are, then, quantized and encoded. The DWT is known to be generated by a cascade of filter banks and the DWT is essentially the well-known subband decomposition [3], [8]–[12]. However, in its most popular form, the dyadic DWT, the input spectrum is partitioned into octave-width subbands. The advantage of the DWT comes from the trade-off between spatial and frequency resolutions, as the DWT has shorter basis functions (filters) for higher frequencies, and longer basis functions (filters) for lower frequencies. Also, there are more samples to represent the higher frequency subbands, than the lower frequency ones. Therefore, the combination of more samples and shorter basis functions will attain a better spatial localization for higher frequencies. On the other hand, the low-frequency basis functions (filters) are longer and the low-frequency subbands have less samples, attaining a better subband selectivity with less spatial resolution. As low frequency components lack details, spatial resolution is not so important in this case.

Fig. 1(a) shows the analysis section of a two-dimensional (2D) separable filter bank, where first the image rows are passed through the 2-channel filter bank, and, then, the columns are processed. Fig. 1(b) shows the synthesis section to reconstruct the signal from the subband signals. The analysis section can be viewed as a 2×2 transform applied to the image (note that each subband has one fourth of the samples in the original signal). Also, the synthesis section can be viewed as a 2×2 inverse transform. Fig. 1(c) shows the connection of the transforms to construct the forward DWT. Note that only the low-pass subband is connected to another transform. The DWT is composed by a

¹This work was supported in part by CNPq, Brazil, under Grant 260.804/90-1.



Figure 8: Zoom of image "Lena" coded at 0.5 bpp. Top left: original; top right: C0 (JPEG); bottom left: C2; bottom right C3.