Limiting Distortion of A Wavelet Image Codec

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An important feature of the *embedded zerotree wavelet* image coding algorithm (EZW) introduced by J. M. Shapiro is the progressivity of coding: the bits of the wavelet coefficients are sent in the order of importance in terms of *mean square error* (MSE). This enables the coder to stop when a predefined output size limit is reached. There are applications where certain level of image quality must be guaranteed. This can be achieved by overestimating the size of the output, but a more intuitive technique would be to *calculate the MSE while coding* and to output only the information that is needed to reach acceptable image quality.

In this paper a *new EZW based wavelet coding scheme is introduced*. Here we refer to the new coding scheme with name *Distortion Limited Wavelet Image Codec* (DLWIC). The codec is designed to be *simple to implement*, *fast* and have *modest memory requirements*. It is also shown, how the distortion of the result can be calculated while progressively coding a transformed image, if the transform is unitary.

EZW exploits spatial inter-band correlations of the wavelet coefficient magnitudes by coding the bit-planes of the coefficient matrix in a hierarchical order. The order is defined by a quad-tree structure where the completely zero subtrees (zerotrees) can be represented by only one symbol. In DLWIC the correlations between different orientations are also taken into account by binding together the coefficients on three different orientation bands in the same spatial locations. The maximum absolute values of the coefficients in all subtrees are stored in two-dimensional heap structure. This allows the coder to test the zerotree property of a subtree with only one comparison. A binary arithmetic coder with multiple separate probability distributions (states) is used to reach compression performance that is similar to the previously known EZW variants.

A biorthogonal wavelet transform is used to construct an *octave band composition*. Because biorthogonal wavelet transforms are unitary, the MSE of an image is equal in spatial and wavelet domains. The value of the square error (SE) is updated in the compression process. We start by calculating the initial SE as the total energy of the image and decrease it while bits are sent according the information content of the bits. For every bit sent, the change in SE of the image is defined by the difference of coefficients predicted values before and after the bit is sent. Calculations can be implemented efficiently with table lookups. This has the advantage that we know the MSE of the final decompressed image already in the coding phase and we can stop the transmission of bits when an acceptable distortion level is reached.

The efficiency of the DLWIC is compared to an advanced EZW variant and the industry standard JPEG using a set of test images. An estimation on speed and memory requirements of the DLWIC algorithm is made.