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Embedded Zerotrees of Wavelet transforms

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Embedded Zerotrees of Wavelet transforms (EZW) is a lossy [image compression algorithm](#). At low bit rates, i.e. high compression ratios, most of the coefficients produced by a [subband transform](#) (such as the [wavelet transform](#)) will be zero, or very close to zero. This occurs because "real world" images tend to contain mostly low frequency information (highly correlated). However where high frequency information does occur (such as edges in the image) this is particularly important in terms of human perception of the image quality, and thus must be represented accurately in any high quality coding scheme.

By considering the transformed coefficients as a [tree](#) (or trees) with the lowest frequency coefficients at the root node and with the children of each tree node being the spatially related coefficients in the next higher frequency subband, there is a high probability that one or more subtrees will consist entirely of coefficients which are zero or nearly zero, such subtrees are called **zerotrees**. Due to this, we use the terms node and coefficient interchangeably, and when we refer to the children of a coefficient, we mean the child coefficients of the node in the tree where that coefficient is located. We use **children** to refer to directly connected nodes lower in the tree and **descendants** to refer to all nodes which are below a particular node in the tree, even if not directly connected.

In zerotree based image compression scheme such as EZW and [SPIHT](#), the intent is to use the statistical properties of the trees in order to efficiently code the locations of the significant coefficients. Since most of the coefficients will be zero or close to zero, the spatial locations of the significant coefficients make up a large portion of the total size of a typical compressed image. A coefficient (likewise a tree) is considered **significant** if its magnitude (or magnitudes of a node and all its descendants in the case of a tree) is above a particular threshold. By starting with a threshold which is close to the maximum coefficient magnitudes and iteratively decreasing the threshold, it is possible to create a compressed representation of an image which progressively adds finer detail. Due to the structure of the trees, it is very likely that if a coefficient in a particular frequency band is insignificant, then all its descendants (the spatially related higher frequency band coefficients) will also be insignificant.

EZW uses four symbols to represent (a) a zerotree root, (b) an isolated zero (a coefficient which is insignificant, but which has significant descendants), (c) a significant positive coefficient and (d) a significant negative coefficient. The symbols may be thus represented by two binary bits. The compression algorithm consists of a number of iterations through a **dominant pass** and a **subordinate pass**, the threshold is updated (reduced by a factor of two) after each iteration. The dominant pass encodes the significance of the coefficients which have not yet been found significant in earlier iterations, by scanning the trees and emitting one of the four symbols. The children of a coefficient are only scanned if the coefficient was found to be significant, or if the coefficient was an isolated zero. The subordinate pass emits one bit (the most significant bit of each coefficient not so far emitted) for each coefficient which has been found significant in the previous significance passes. The subordinate pass is therefore similar to bit-plane coding.

There are several important features to note. Firstly, it is possible to stop the compression algorithm at any time and obtain an approximation of the original image, the greater the number of bits received, the better the image. Secondly, due to the way in which the compression algorithm is structured as a series of decisions, the same algorithm can be run at the decoder to reconstruct the coefficients, but with the decisions being taken according to the incoming bit stream. In practical implementations, it would be usual to use an entropy code such as [arithmetic code](#) to further improve the performance of the dominant pass. Bits from the subordinate pass are usually random enough that entropy coding provides no further coding gain.

The coding performance of EZW has since been exceeded by [SPIHT](#) and its many derivatives.

See also [\[edit\]](#)

- [Set partitioning in hierarchical trees](#) (SPIHT)

References [\[edit\]](#)

- Shapiro, J. M., [EMBEDDED IMAGE CODING USING ZEROTREES OF WAVELET COEFFICIENTS](#)[?]. IEEE

External links [edit]

- <http://perso.wanadoo.fr/polyvalens/clemens/ezw/ezw.html>



Wikimedia Commons has media related to **EZW**.

v · t · e		Data compression methods	[hide]
Lossless	Entropy type	Unary · Arithmetic · Golomb · Huffman (Adaptive · Canonical · Modified) · Range · Shannon · Shannon–Fano · Shannon–Fano–Elias · Tunstall · Universal (Exp-Golomb · Fibonacci · Gamma · Levenshtein)	
	Dictionary type	Byte pair encoding · DEFLATE · Lempel–Ziv (LZ77 / LZ78 (LZ1 / LZ2) · LZJB · LZMA · LZO · LZRW · LZS · LZSS · LZW · LZWL · LZX · LZ4 · Statistical)	
	Other types	BWT · CTW · Delta · DMC · MTF · PAQ · PPM · RLE	
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	Codec parts	A-law · μ-law · ACELP · ADPCM · CELP · DPCM · Fourier transform · LPC (LAR · LSP) · MDCT · Psychoacoustic model · WLPc	
Image	Concepts	Chroma subsampling · Coding tree unit · Color space · Compression artifact · Image resolution · Macroblock · Pixel · PSNR · Quantization · Standard test image	
	Methods	Chain code · DCT · EZW · Fractal · KLT · LP · RLE · SPIHT · Wavelet	
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	Codec parts	Lapped transform · DCT · Deblocking filter · Motion compensation	
Theory	Entropy · Kolmogorov complexity · Lossy · Quantization · Rate–distortion · Redundancy · Timeline of information theory		
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Categories: Image compression | Lossless compression algorithms | Trees (data structures) | Wavelets

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