Elements of Adaptive Wavelet Image Compression

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The Adaptive Wavelet Image Compression (AWIC) algorithm is a fast, simple wavelet-based image compression technique that follows the classical paradigm of image transformation, quantization, and entropy encoding. A key component of AWIC is a technique of channel symbol definition that provides greatly reduced Huffman table encoding costs, allowing optimal Huffman codewords to be generated and used for each level of the wavelet transformed image. Further optimizations for compression performance were achieved through empirical studies.

The entropy encoder used in AWIC adapts to the statistics of each transform level to take advantage of the fact that the source statistics of the subbands in a wavelet-transformed image differ among the levels. This approach requires that a Huffman table be provided for each level in the compressed data stream for the decoder. Huffman tables representing the broad range of values contained in the subbands can be quite large. In many cases, there may be several hundred possible basic channel symbols to be represented and using the standard techniques for encoding a Huffman table will yield a large number of bits. However, wavelet transform coefficient distributions suggest a method that uses escape codes to reduce this limitation. Treating the transform coefficient magnitude and zero run-length distributions for each level separately, the knee of each distribution determines where escape code usage begins. Because of the slight taper to the flat tails of the distributions, escape codes that organize channel symbols into groups containing an increasing power of two (2, 4, 8, 16, ...) elements are used. Each group requires an additional fixed-length code using the number of bits needed to uniquely identify between the symbols in the group. For example, an escape code group containing four consecutive symbols requires only two additional bits to select the proper basic symbol within that group. By gathering the remaining channel symbols into groups of increasing powers of two, the smaller escaped values, which are more likely than the larger values, enjoy the benefit of using fewer bits for their encoded values. Also, symbols that are grouped into the same escape code have nearly equal probabilities, which is optimal for fixed-length encoding. The set of basic channel symbols and escape codes that adapt to source statistics define the final set of channel symbols to be Huffman encoded.

The success of the AWIC algorithm is measured in terms of compression performance, computational complexity, and retention of application-specific features. The image quality measured at a large number of compression rates is competitive with values given in the literature for other algorithms. Measurements comparing the entropy of the redefined channel symbols to the efficiency of their encoding suggests that AWIC is nearly optimal for its paradigm. The implementation of the algorithm is straightforward and retains the capability to perform progressive and selective transmission. The current implementations for image compression and decompression using AWIC are fast and nearly balanced.