Composition of DCT and Wavelet Transform for Image Compression

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The paper reports an advanced image compression algorithm based on a newly proposed standpoint of time-frequency analysis. The advanced algorithm yields 40% improvement against JPEG2000 in compression performance, which means that it attains the same image quality with 40% less data. Compared with JPEG, the improvement may reach 50%. Especially, it makes more improvement at high quality than low quality to the same image. It doubles the coding speed of JPEG2000. But the implementation complexity is only at the level of baseline JPEG. The revolutionary enhancement is critical to high definition (HD) image and video coding technology because of the sea amount of data there. In the paper, the new standpoint of time-frequency analysis is elaborated. Based on the new standpoint, the concept of transform composition is introduced. Furthermore, the composition of DCT and wavelet transform is applied to image compression. Generally speaking, transform-based image and video compression technology is an application of the time-frequency analysis theory. In traditional standpoint of time-frequency analysis, the whole time or spatial domain of a signal is divided into intervals. In one interval, one applies FFT or DCT to calculate the local frequency spectrum in the interval and then makes analysis or process on this local spectrum. The whole analysis progress goes on with changes of interval. By contrast, from the new standpoint, the analysis or process is made on the distribution of signal frequency content locally at a certain frequency, rather than the frequency spectrum locally at time. The analysis progress goes on with changes of frequency. The distribution of frequency content at certain frequency may be better described by a further transform such as wavelet transform to exploit the statistical correlation in it. In image coding application, the image data is divided into blocks, $8 \times 8$ or $4 \times 4$. Block by block, the data are transformed by fast DCT. Then, the DCT coefficients are regrouped into frequency bands by a newly proposed frequencywise rearrangement technique. Inside each band, the DCT coefficients are further decomposed by wavelet transform. Afterward, the composite coefficients are scanned and encoded by the highly efficient guided quadtree reaching (GQR) method. The GQR method scans the coefficients in a 2-dimensional pattern, under the guidance of a value map which helps to rule out as many as possible zero coefficients from the coding procedure. Adapted to GQR method, a new quantization mechanism is designed based on contrast sensitivity function weights. The encoding/decoding is progressive, from the highest bit plane to the lowest one. In lossless compression, the DCT is replaced by a $4 \times 4$ Hadamard transform implemented in double-level lifting scheme. Both the block transform and wavelet transform are integer reversible. The lossless coding efficiency improves 25% over JPEG2000.