Dynamic Range Compression using the Edge-Avoiding Wavelets

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Edge-Avoiding Wavelets and their Applications

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In this short note we describe a slight modification to the dynamic-range compression scheme described in the paper [Fattal 2009] using the *same* edge-avoiding wavelet (EAW) transformation described there.

The original scheme consists of 'flattening' the approximation a^J and detail d^j, $j = 1..J$ coefficients in the following scale-dependent manner

$$\log Y \mapsto a^J, \left\{d^j\right\}_{j=1}^{J} \mapsto \beta a^J, \left\{\gamma^j d^j\right\}_{j=1}^{J} \mapsto \log Y', \qquad (1)$$

where $\beta \leq 1$ and $\gamma \leq 1$ are the parameters controlling the amount of compression and the first and last $\mapsto$ refer to the forward and backward EAW transforms respectively. This operation is performed over the luma channel, $Y(x, y)$, of the the YUV color space. The logarithm of Y makes the differences, encoded in the detail coefficients $\{d^j\}_{j=1}^{J}$, better estimators for the perceived contrasts in the image. Essentially, this scheme suppresses the contrasts at the coarser scales and preserves them at the finer scales of the image.

New Compression Scheme. We propose to view the detail coefficients $\left\{d^j\right\}_{j=1}^{J}$, computed from $\log Y$ as in (1), as the signal that needs compression. Regardless of their scale, large detail coefficients correspond to large changes in the signal that, in presence of weaker detail coefficients, create the high dynamic range of the signal. Hence, in the new scheme we make the detail coefficients more even in their magnitude as follows

$$\log Y \mapsto a^J, \left\{d^j\right\}_{j=1}^{J} \mapsto f(a^J), \left\{f(d^j)\right\}_{j=1}^{J} \mapsto \log Y', \qquad (2)$$

where

$$f(x) = \text{sign}(x)|x|^{\beta}. \qquad (3)$$

When setting $\beta < 1$ the function f defines a contractive concave mapping that increases the weak detail coefficients in relation to the larger ones, and hence this mapping compresses the dynamic range of the detail coefficients. The resulting image, which has now more even contrasts across all it scales, can be stored and displayed by lower dynamic range devices.

When testing this new scheme, we found no reason not to go all the way down in the wavelet decomposition. Hence, a^J corresponds to a *scalar* which corresponds to an overall scaling factor of Y and can hence be omitted from (2).

References

FATTAL, R. 2009. Edge-avoiding wavelets and their applications. *In Proc. ACM SIGGRAPH 23*, 3, 689–694.

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