Generalised Locally Adaptive DPCM (Abstract)

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In Differential Pulse Code Modulation (DPCM) we make a prediction $\hat{f} = \sum a(i) \cdot f(i)$ of the next pixel using a linear combination of neighbouring pixels $f(i)$. It is possible to have the coefficients $a(i)$s constant over a whole image, but better results can be obtained by adapting the $a(i)$s to the local image behaviour as the image is encoded.

An existing adaptive approach is to compute a set of gradient or edge strength measures $G(i)$ in the four directions `W`, `N`, `NW` and `NE`. The values of the four neighbours `W`, `N`, `NW` and `NE` are then *blended* together by setting $a(i) = (\sum G(i))/G(i)$. One difficulty with these schemes is that they can only produce predictors with positive $a(i)$s. This is desirable in the presence of noise, but in regions where the intensity varies smoothly, we require at least one *negative* coefficient to properly estimate a gradient.

However, if we consider the four neighbouring pixels as four local *sub-predictors* `W`, `N`, `NW` and `NE`, and the gradient measure as the *sum of absolute prediction errors* of those sub-predictors within the local neighbourhood, then we can use *any* sub-predictors we choose — even non-linear ones.

In our experiments, we chose to use three additional linear predictors suited for smooth regions, each having one negative coefficient: `Plane` ($\mathtt{N} + \mathtt{W} - \mathtt{NW}$), `Grad_W` ($2\mathtt{N} - \mathtt{NN}$) and `Grad_N` ($2\mathtt{W} - \mathtt{WW}$). We tried three sets — Blend-4 used {`W`, `N`, `NW`, `NE`}, Blend-5 used {`W`, `N`, `NW`, `NE`, `Plane`} and Blend-7 used {`W`, `N`, `NW`, `NE`, `Plane`, `Grad_W`, `Grad_N`}.

Results were computed for three versions of the standard JPEG test set and some 12 bpp medical images — the originals, smoothed versions, and versions in which controlled amounts of noise were added. We compared the zeroth order prediction error entropy with the top contenders for next lossless JPEG standard (including GAP and MED) [1], and found the best performers to be Blend-5 and Blend-7. For less noisy images they typically did up to 0.3 bpp better than GAP and MED, and with average to high noise content the gain was about 0.15 bpp.

The generalised Blend scheme [2] is a powerful technique for creating adaptive compound predictors. It works well over a large range of image types and pixel depths, contains no image-dependent thresholds, and can be easily modified for domains other than greyscale image data. Possible applications include RGB colour images, 3-D volume imaging, image sequences, and sound.

[1] N. Memon, V. Sippy, X. Wu, "A Comparison of Prediction Schemes for a New Lossless Compression Standard", *1996 International Symposium on Circuits & Systems*, Vol. II, 1996, pp309–312.

[2] T. Seemann, P. E. Tischer, "Generalised Locally Adaptive DPCM", Technical Report No. 301, Dept. Computer Science, Monash University.