Improving Wavelet Compression with Neural Networks

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We add a neural network predictor to the PWC image codec [1] to predict wavelet coefficients, thereby reducing the variance of the residuals with consequently reduced bit rate of the encoded data. The part of the codec in which the predictor is inserted is shown in Figs. 1 and 2. The 2-layer, 20-hidden node, fully connected network was trained offline on box-shaped causal contexts of 24 coefficients (other architectures were also examined). Training on static wavelet coefficients resulted in unwanted output oscillations; this was corrected by training dynamically on the \( \hat{C}_{j<i} \). The net was trained on the first 16 images in the Kodak database and tested on images 18-24 (image 17 was used for validation; the images are \( 512 \times 768 \)). Adding the network predictor for wavelet levels 0-2 and subbands LH, HL and HH reduced the bit rate (at fixed PSNR) by approximately 5% across the test set. We found that the reduction in variance did not always result in a reduction of the first order empirical entropy of the wavelet coefficients; we showed that this was a binning artefact whose effect is reduced as the quantization level increases. The additional computational complexity required was 500 multiply-adds per coefficient; some simple methods to significantly reduce this load are currently under investigation. Figure 3 shows how the nonlinear prediction reduces variance by predicting edges.

Figure 1: The proposed encoder.  
Figure 2: The corresponding decoder.

Figure 3: Left: Example subimage under test. Center: Corresponding LH0 wavelet coefficients before prediction, with amplitudes represented by gray level, mid-gray=0. Right: After prediction – note how the network predicts edges.