Predictive Image Compression Using Conditional Averages[1]

Ş.D. Babacan
Department of Electronic Engineering
Boğaziçi University
Istanbul, Turkey
derin.babacan@boun.edu.tr

K. Sayood
Department of Electrical Engineering
University of Nebraska,
Lincoln, NE 68588-0511, USA
ksayood@eecomm.unl.edu

The optimal estimate (in the mean squared sense) of a pixel is the conditional expected value $E[X_{i,j}|\{X_{i-l,j-m}\}_{(l,m)=(1,1)}^{(i,j)}]$. In practice we can assume that the pixel is conditionally independent of pixels that are some distance from it and hence the conditioning variables can be limited to pixels in the causal neighborhood of $X_{i,j}$.

Consider the set of pixels in the causal context of $x_{i,j}$. For convenience we put an ordering on these pixels so we can refer to them as $x_1^{i,j}, x_2^{i,j}, \ldots, x_k^{i,j}$. Given a particular set of values $\bar{\alpha} = (\alpha_1, \alpha_2, \ldots, \alpha_k)$, define $C_k(\bar{\alpha}) = \{x_{l,m} : |x_i^{l,m} - \alpha_1| \leq T, i = 1, 2, \ldots, k\}$ where T is a user defined parameter. We estimate $E[X_{i,j}|x_i^{i,j} = \alpha_i, i = 1, 2, \ldots, k]$ by the sample mean $\hat{\mu}_{X|\bar{\alpha}} = \frac{1}{||C_k(\bar{\alpha})||} \sum_{x \in C_k(\bar{\alpha})} x$ where $||\cdot||$ denotes cardinality. If $||C_k(\bar{\alpha})||$ is small or even zero we use the MED predictor from JPEG-LS. As the set $C_k(\bar{\alpha})$ is built using the past history of the image the information about the size of the set is available to both encoder and decoder.

Similar to *ppm* we first attempt to use a larger context. If there are not sufficient matches to this context in the history we shift to a smaller context. Unlike *ppm* we do not need to send escape symbols to the signify the shift. This is because the decision on which context to use is based on the set of encoded pixels which is available to both encoder and decoder.

We compare the performance of the proposed predictor with the GAP predictor used in CALIC and the MED predictor used in JPEG-LS and LOCO-I. The comparison in terms of bits per pixel is shown below. While the amount of gain (over the CALIC

Image	Proposed predictor	GAP	MED Predictor	JPEG-LS	CALIC
Boat	4.34	4.67	4.62	4.25	4.23
Barbara	5.02	5.48	5.48	4.86	4.72
Goldhill	4.71	4.97	4.87	4.72	4.70
Lena	4.19	4.52	4.55	4.25	4.18
Mandrill	6.03	6.31	6.27	6.04	5.98
Elif	2.93	3.61	3.34	3.18	3.19
Sena	3.25	3.87	3.64	3.34	3.38

predictor) varies from a high of about 27 % for the *Elif* image to a low of 4.4% for the *Mandrill* image, the proposed predictor outperforms the GAP and MED predictor over the entire test set. Even when we compare this first stage predictor with the full blown JPEG-LS and CALIC algorithms the proposed predictor holds its own.

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