LOSSLESS REGIONS OF INTEREST AND ADAPTIVE WAVELET COMPRESSION OF BACKGROUND

Rakowski W.

Department of Informatics, Technical University of Bialystok
ul. Wiejska 45A, 15-351 Bialystok, Poland
email: waldi@ii.pb.bialystok.pl
fax: (48 85) 7423423

Abstract

A new compression scheme of images with lossless coding for Regions Of Interest (ROI) is developed. It is based on adaptive quantisation scheme in wavelet transform domain. The ROIs are encoded by the lossless JPEG-LS method. The background is encoded by embedded (SPIHT-based) wavelet method. The ROIs can have arbitrary shape. A mask indicating a set of wavelet coefficients corresponding to ROIs is obtained by adequatly defined control low pass filters. Zeroing wavelet coefficients indicating by the mask increases the number of zerotrees in SPIHT coding, and therefore one can expect higher coder's bitrate. Numerical results to illustrate the performance of the proposed algorithm are provided.

Introduction

An image can contain a specially important parts called Regions of Interest, which pixel values may not be changed, whereas an information loss outside that parts, in so called background is admissible. The important region (ROI) can occupy, for instance, several percent of pixels in the image. For that kind of images one can apply a hybrid method of compression: lossless method for ROI, lossy method for background. A suitable method for coding of ROI is JPEG-LS [4].

Compression ratios obtained using JPEG-LS method are in the range of 1.5:1 to 3:1. An important increase in compression ratio of whole image can be archieved by using a lossy method of compression for background. Lossy compression techniques are capable of archieving compression ratios on the order of 50:1 or higher. A highly effective method of lossy compression is wavelet method [2]. Bitstream of an image compressed by the hybrid scheme contains at first a lossless code of the ROI, and next a lossy embedded code of background.

Idea of the algorithm

The state-of-the-art lossy compression system as wavelet-based SPIHT [2] is prepared to work with images without holes matching the ROI. Thus we propose an adaptive modification of the wavelet image pyramid for SPIHT coding. The modification consists in filling with zeros the ROI related set of wavelet coefficients in the wavelet pyramid. Effectivity of such operation follows from the technique of quantinsation and coding based on zerotrees concept. The idea of wavelet zerotrees is as follows. The image in wavelet domain is split into subbands LL_k , LH_k, HL_k, …, LH_1, HL_1, HH_1 (Fig. 1).

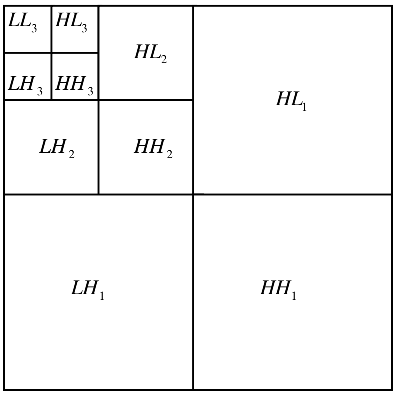

Fig. 1 Three-level wavelet image pyramid

Each wavelet coefficient $c[i,j]$ (except those in the LL_k and LH_1, HL_1, HH_1) is related to exactly four descendants in the next higher subband $c[2i,2j]$, $c[2i,2j+1]$, $c[2i+1,j]$, $c[2i+1,2i+1]$.

Each of these four is in turn related to four in the next subband and so on. It is highly probable that when a wavelet coefficient $c[i,j]$ has magnitude less than some threshold all of its descendants will also. The set of coefficients is then called a zerotree with respect to the mentioned threshold. In the methods of embedded zerotree coding such as Shapiro's embedded zerotree wavelet (EZW) algorithm [4] and set partitioning in hierarchical trees (SPIHT) of Said and Pearlman [2], the set of wavelet coefficients included in a zerotree is encoded by one symbol in the coder's alphabet. Filing with zeros wavelet coefficients corresponding to the ROI pixelsincreases the number of zerotrees, and therefore we expect higher coder's bitrate.

There is relatively easy to derive explicit formulas for indexes of zeroing wavelet coefficients in the case of rectangular shape of ROI. However at arbitrary shaped ROI such explicit formulas do not exist. Therefore instead of a formula we use control image pyramid which is obtained by adequately defined control filters. This control pyramid will be useful to determine which coefficients in the wavelet image pyramid can be safely set to zero not affecting reconstructed outside ROI pixels.

The control image pyramid is obtained analogously to wavelet image pyramid by:

1. Replacing the original image by a mask, which is a map of the ROI in image domain, so that it is 1 for pixels outside the ROI and 0 inside.
2. Replacing the analysis filters h_0, h_1 by corresponding to them control filters $\bar{h}_0, \bar{h}_1$, which have the same support but their coefficients are constant equal to inverse cardinality of the analysis filter support.

In the resulting control image pyramid coefficients with zero value create ROI related set. Places where coefficients are equal to one are outside of ROI. Intermediate values denote transition areas including ROI boundaries.

Results and conclusion

Table 1. Quality measures for wavelet compression of Barbara without modification of wavelet pyramid (upper part) and with its modification (lower part).

Compr. Ratio	$PSNR_w$ [dB]	SNR_w [dB]	MSE_w [dB]	$MaxErr_w$ [dB]
8	36,57	30,16	14,33	21
16	31,28	24,88	48,47	48
32	26,93	20,53	131,76	79
64	24,86	18,46	211,96	96
8	37,96	31,55	10,40	20
16	32,39	25,99	37,52	38
32	28,08	21,68	101,12	72
64	25,12	18,72	199,79	96

Fig. 2 includes the original image "Barbara" (512x512) that we used for testing our algoritm. Fig.3 includes our ROI shown as negative subimage.

Table 1 includes compression quality measures of image "Barbara". Comparing results in the table, we see that for instance at the compression ratio equal to 8:1, introduced modifications increase $PSNR_w$ by 1.4 dB, where index $_w$ means that the measure ignores perfectly reconstructed values in the ROI.

The image shown in Fig. 4 was reconstructed from lossless JPEG-LS code of the ROI (c. r. 1.6:1) and lossy modified wavelet code of background (c. r. 16:1). Global compression ratio equal to 6:1, $PSNR_w$ equal to 33.28 dB.

We can conclude that filing by zeros ROI related set of wavelet coefficients (determined by control image pyramid) increases significantly compression gain.

Fig. 2 Original image "Barbara"

Fig. 3 The ROI in original image

Fig. 4 shows the 5-level control image pyramid corresponding to the ROI in "Barbara" for biorthogonal CDF 9/7 analysis filter bank.

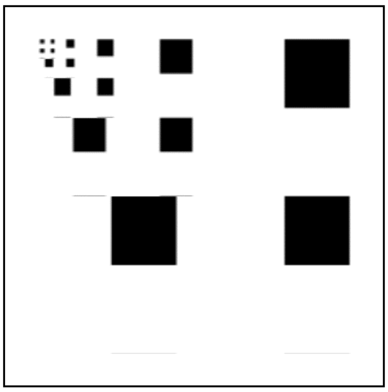

Fig. 4 5-level control image pyramid

Fig. 5 Output of our decoder

Acknowledgments

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