HYBRID IBTC/DCT CODING OF DIGITAL IMAGES

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ABSTRACT

In this paper, an improved Interpolative Block Truncation Coding (IBTC) algorithm for coding the block truncated image bit plane is proposed. This algorithm is applied to the coding of grey scale images in hybrid with the DCT transform. Several test images are used to evaluate the coding efficiency and performance of this hybrid technique. It is generally shown that this IBTC/DCT algorithm gives good quality reconstructed images at reduced bit rate compared to BTC/DCT algorithm.

KEYWORDS

Image Compression, Image Processing, Image Coding,, DCT transform, Hybrid coding

1. INTRODUCTION

The performance of an image compression algorithm may be evaluated in terms of computational complexity, compression ratio, and fidelity. A good algorithm has low-computational complexity, high-compression ratio and high fidelity. Unfortunately, all three cannot be achieved simultaneously. The algorithm described in this paper combines the attributes of interpolative block truncation coding (IBTC), and discrete cosine transform (DCT) coding to achieve reasonable compression ratios while maintaining high spatial fidelity. BTC has very few computations, edge-preserving ability; but only a medium compression ratio. DCT coding has high-compression ratio, and good mean square error (MSE) performance but both encoding and decoding processes are computationally complex. The hybrid IBTC-DCT image coding algorithm presented combines the simple computation and edge preservation properties of BTC and the high fidelity and high compression ratio of DCT, and may be implemented with significantly lower coding delays than DCT alone. BTC as developed by Delp and Mitchell [1] is, essentially, a 1bit adaptive moment-preserving quantization process, which preserves certain statistical moments of small blocks of the input image. In IBTC-DCT coding the DCT coding is implemented to remove the redundancy. The overall computational complexity of IBTC-DCT coding is much less than DCT alone, while the fidelity performance is competitive. The compression ratio is about 10:1.

2. BLOCK TRUNCATION CODING BTC

In the standard Absolute Moment Block Truncation Coding BTC algorithm, the image is first divided into non-overlapping n×n blocks. Let $m=n^2$, and let $x_1, x_2,..,x_m$ be the pixel values in a given block of the original image. The quantities to be preserved are the first and second sample moments:

$$\overline{X} = \frac{1}{m}\sum_{i=1}^{m} X_i \quad (1)$$

$$\overline{X^2} = \frac{1}{m}\sum_{i=1}^{m} X_i^2 \quad (2)$$

The variance is given by

$$\sigma^2 = \overline{X^2} - \overline{X}^2 \quad (3)$$

The next step is to find a threshold X_{th} and two reconstruction levels, *a* and *b* such that

$$\hat{X} = a \quad if \quad x_i < x_{th} \ ,$$

$$\hat{X} = b \quad if \quad x_i \geq x_{th}$$

for i=1,2,3,……,m.

Where $\hat{X}$ is the value of the pixel in the reconstructed block.

To preserve the first two sample moments $\overline{X}$ and $\overline{X^2}$ the following relations must be satisfied:

$$m\,\overline{X} = (m-q)\,a + q\,b \quad (4)$$

$$m\,\overline{X^2} = (m-q)\,a^2 + q\,b^2 \quad (5)$$

Where a and b are reconstruction levels.

q- Number of pixels greater than or equal to the mean.

m- Number of total pixels.

Solving for a and b yields

$$a = \overline{X} - \sigma \sqrt{\frac{q}{m - q}} \qquad (6)$$

$$b = \overline{X} + \sigma \sqrt{\frac{m - q}{q}} \qquad (7)$$

The n×n bit map is transmitted indicating which pixels reconstruct to a and which reconstruct to b as well as information specifying a and b. It is seen that output of the BTC for each block include two numbers, a and b, which specify the high-mean, mean of pixel values greater than the block average, and low-mean ,mean of pixels less than or equal to the block average, and also a bit-map which specifies the high or low state of each output pixel. The AMBTC algorithm has the potential of low computational complexity with no multiplications involved [3].. A 4x4 block is used and each pixel is represented by an 8-bit number. The resulting bit rate is 2 bits/pixel and the compression ratio is 4:1

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3. INTERPOLATIVE BTC

Instead of transmitting all the 16 bits of the BTC bit map, only half of the bits may be chosen for transmission or storage and the others are interpolated from the values of the surrounding bits. The idea behind using bit map interpolation is to reduce the storage and transmission costs. However, the performance of this scheme is highly dependent on the block activities of image blocks. In fact, this scheme works well for smooth blocks. The proposed interpolation process is performed as follows:

Consider the *4*x*4* bit planes shown in Fig.1. The interpolation of first row of blocks is performed by using the algorithm given in[4], and the other blocks are performed according to the following logical expression:

B = 1 iff two or more of the surrounding bits, viz. N_u, A, F, and C are equal to 1.

D = 1 iff two or more of the surrounding bits, viz. P_u, C, and H are equal to 1.

E = 1 iff two or more of the surrounding bits, viz. H_s , A, F, and I are equal to 1.

G = 1 iff two or more of the surrounding bits, viz. F, K, H, and C are equal to 1.

J = 1 iff two or more of the surrounding bits, viz. F, I, N, and K are equal to 1.

L = 1 iff two or more of the surrounding bits, viz. H, K, and P are equal to 1.

M =1 iff two or more of the surrounding bits, viz. P_s, I, and N are equal to 1.

O=1 iff two or more of the surrounding bits, viz. N, K, and P are equal to 1.

The interpolation process in this case makes use of the bits in both the previous side block as well the upper block.

s - denotes side block, *u - denotes upper block*

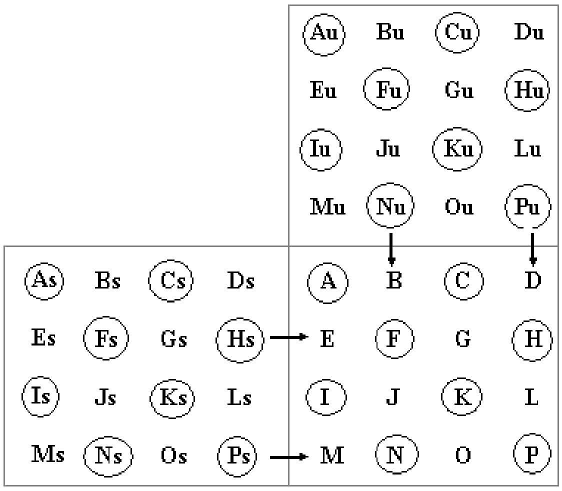


Fig. 1. IBTC bit plane- Circled- transmitted bits Uncircled- interpolated bits

4. IBTC/DCT HYBRID CODING

IBTC-DCT hybrid coding is achieved in three stages:

Stage I: BTC coding of the input image, which compresses blocks of the original N x N image into a “bit-map” and two reduced-sized gray-level images which are composed of the “high-mean” and “low-mean” pixel values of each BTC block. The primary compression ratio of stage I is 4:1 for 4x4 blocks.

Stage II: The proposed IBTC algorithm is implemented on the bit-map to reduce the nominal bit rate of 1.0 bit/pixel to 0.5bit/pixel. The compression ratio in this phase is 2:1.

Stage III: The standard JPEG coding algorithm[6] which is based on DCT is implemented to compress the N/4 by N/4 high-and low-mean subimages.

If the high-means, and the low-means, from each BTC block are grouped together as raster files, one can form two subsampled images high-mean and low-mean subimages. For a 512×512 input image with 4×4 blocks, the subsampled images are 128×128 in size. DCT is directly implemented on both the high-mean subimage, S_H , and the low-mean subimage, S_L. Since the size of the subimages is relatively small (16 times less than the original image) the computational complexity is trivial. Fig.2, shows the hybrid coding process.

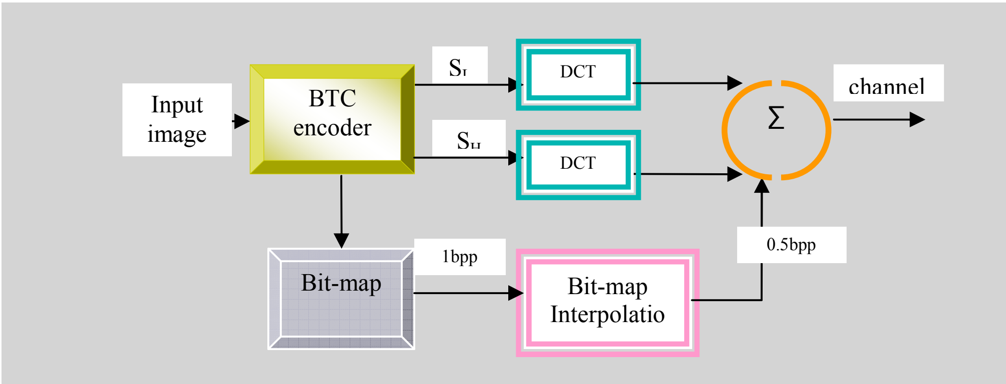


Fig.2. Hybrid IBTC/DCT coding system diagram

5. Simulation and Results

The proposed hybrid algorithm was simulated and tested using several test images. For the DCT transform different quality levels of the quantization matrix were investigated. Table 1 shows a comparison of the results obtained using the hybrid BTC/DCT coding algorithm and the proposed hybrid IBTC/DCT coding algorithm. It can be seen from this table that for the same quality of the reconstructed image the bit rate for the proposed algorithm is reduced by about 30%. In Figs..3 through 5 are shown the original and reconstructed images..

Table 1 Hybrid IBTC-DCT coding results

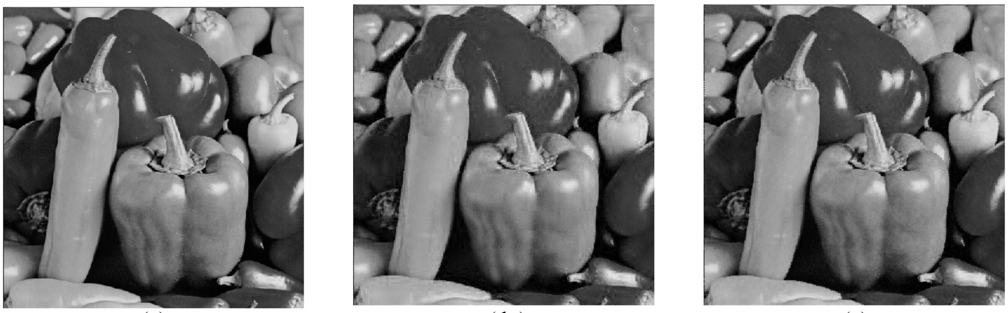
Image	BTC-DCT		IBTC-DCT	
	PSNR (dB)	Bit rate (bpp)	PSNR (dB)	Bit rate(bpp)
boat	28.50	1.20	28.50	0.86
Lena	30.25	1.18	30.50	0.82
Girl512	31.29	1.16	31.30	0.79
pepper	30.14	1.20	29.60	0.86
Couple	30.50	1.18	30.70	0.82

(a) (b) (c)

Figure 3: (a) Original "Boat" image. (b) Reconstructed image with the BTC-DCT algorithm.
(c) Reconstructed image with the IBTC-DCT proposed algorithm.

(a) (b) (c)

Figure 4: (a) Original "Lena" image. (b) Reconstructed image with the BTC-DCT algorithm. (c) Reconstructed image with the IBTC-DCT proposed algorithm.



(a) (b) (c)

Figure 5: (a) Original "pepper" image. (b) Reconstructed image with the BTC-DCT algorithm. (c) Reconstructed image with the IBTC-DCT proposed algorithm.

6. CONCLUSIONS

A hybrid image coding algorithm is presented in this paper. This algorithm combines the IBTC spatial domain technique and the DCT transform coding techniques. In the IBTC technique only half of the bits in the resulting bit plane are transmitted to the decoder. The other half is interpolated using a proposed algorithm. It has been shown that the presented hybrid IBTC/DCT coding algorithm gives good quality reconstructed images at reduced bit rate compared to the existing hybrid BTC/DCT algorithm.

References

[1] E. J. Delp and O. R. Mitchell, " Image coding using block truncation coding," *IEEE Trans. Commun.*, vol. 27, pp. 1335-1342, Sept. 1979.

[2] M. D. Lema and O. R. Mitchell, "Absolute moment block truncation coding and its application to color images," *IEEE Trans. Commun.*, vol. 32, (10), pp. 1148-1157, 1984.

[3] O. R. Mitchell and E. J. Delp, "Multilevel graphics representation using block truncation coding," *IEEE Trans. Commun*., vol. 68, pp. 868-873, July. 1980.

[4] Y. V. Rao and C. Eswaran, "A new algorithm for BTC image bit plane coding," *IEEE Trans. Commun.*, vol. 43, pp. 2010-2011, June. 1995.

[5] Wallace. G.K.' *JPEG Technical Specification, Revision 5*, JPEG Joint Photographic Experts Group *ISO/IEC JTC1/SC2/WG8 CCITT SGVIII,* JPEG-8-R5, 1990.

[6] Wallace, G. 'The JPEG still picture compression standard' , *Communications of the ACM*, 34, pp. 30-44, 1991.

[7] El ghanai Rhoma, Fituri Belgassem "Improved Algorithms For BTC Image Bit-map Coding With Reduced Rate" *SPIE Sociaty conference,* USA, 2006.