International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-1 Issue-1, April 2012

A Novel Idea for Further Bit Rate Reduction in BTC based Techniques for Image Compression

S.Vimala, K.Kowsalya Devi , G.S.Abinaya

Abstract*: Block Truncation Coding (BTC) is a simple and fast lossy image compression technique for digitized gray scale images. In this paper, a novel idea for further reducing the bit rate is introduced. The BTC and its two other variants, one being the Absolute Moment Block Truncation Coding (AMBTC) are discussed and the proposed idea is incorporated in all the three methods. A bitrate of 2 bpp is achieved in the existing techniques. With the proposed method, a further reduction of .25 bpp is achieved. The results of the proposed method are compared with that of the normal Block Truncation Coding methods. The proposed idea works better in terms of both the PSNR and the bpp.

Index Terms: Block Truncation Coding, PSNR, bit-rate, compression, storage, transmission

I. INTRODUCTION

This Block Truncation Coding (BTC) [l] is an efficient image coding method. Its performance, simplicity, and superior channel resisting capability make this method attractive in real-time image transmission. BTC is a recent technique used for compression of monochrome image data. It is a one-bit adaptive moment-preserving quantizer that preserves certain statistical moments for small blocks of the input image. The original algorithm of BTC preserves the standard mean and the standard deviation [2]. Various methods have been proposed during last twenty years for image compression such as BTC and Absolute Moment Block Truncation Coding AMBTC [3]. BTC has the advantage of being easy to implement when compared to Vector Quantization [4] and Transform Coding [5]. Many techniques with modifications to BTC have been proposed to reduce the bit-rate obtained with normal BTC: Gallagher [6] proposed a Median Filter Roots method; Yung-Gi Wu [7] proposed Probability based Block Truncation Image Bitplane Coding; Yu-Chen Hu [8] presented a Modified BTC with Predictive Technique and Bitplane Coding with Edge Pattern. In BTC, the input image is divided into small blocks of size 4 x 4 pixels. The elements of each block are quantized into either of the two levels (0 or1 i.e. one bit per pixel). To convert each block into a binary bit plane, the mean of the block is computed using the equation (1).

$$m = \frac{1}{16}\sum_{i=1}^{16} X_i \qquad (1)$$

Each element of the block is compared against the mean m and if it is less than the mean value, the element is quantized into 0, otherwise 1. A block of gray levels is transformed into a bit plane of 1 and 0s. Along with each bit plane, the mean $\boldsymbol{m}$ and the standard deviation σ are transmitted. The standard deviation is computed using the equation (2).

$$\sigma = \sqrt{\frac{1}{16}\sum_{i=1}^{16}(m - X_i)^2} \qquad (2)$$

The two quantizing levels g_1 and g_2 are calculated using the equations (3) and (4).

$$g_1 = m + \sigma\left(\sqrt{\frac{(16-p)}{p}}\right) \qquad (3)$$

where $\boldsymbol{p}$ is the number of pixels of a block whose values are greater than the mean value.

$$g_2 = m - \sigma\left(\sqrt{\frac{p}{(16-p)}}\right) \qquad (4)$$

While decoding the image, each bit of the bit plane is transformed into either g_1 or g_2 using the equation (5).

$$\left.\begin{array}{l}\text{if } 1,\ g_1 \\ \text{else } g_2\end{array}\right\} \qquad (5)$$

For an original image, a block of pixels requires 4 x 4 x 8 = 128 bits (8 bpp). But the same block, after compression using BTC, requires only 16 (for bit plane) + 8 (Mean) + 8 Standard deviation) = 32 bits (2 bpp).

The performance of the image compression technique is measured by computing the Mean Square Error (MSE). MSE gives the difference between the original image and the reconstructed image and is computed using the equation (6).

Revised Manuscript Received on 30 April 2013.
*** Correspondence Author**
S.Vimala*, Assistant Professor, Department of Computer Science, Mother Teresa Women's University, Kodaikanal (Tamil Nadu), India Email: vimalaharini@gmail.com
K.Kowsalya Devi M.Phil. Scholar Email: kowsalyadeepa@gmail.com
G.S.Abinaya M.Phil. Scholar Email: abisethu19@gmail.com

$$MSE = \frac{1}{M}\sum_{i=1}^{m}\left(x_i - \overline{x_i}\right)^2$$

(6)

where x_i is the pixels value of the original image and $\overline{x_i}$ is the approximated pixel value of the reconstructed image. M is the total number of pixels in the image. The Peak Signal to Noise Ratio (PSNR) is the quality of the reconstructed image and is the inverse of MSE. The PSNR is computed using the equation (7).

$$PSNR = 10Log_{10}\left[\frac{\left(2^n - 1\right)^2}{MSE}\right]$$

(7)

where ***n*** is the number of bits required to store the gray level of a pixel. For a gray scale image, ***n*** is generally 8. The BTC method tends to produce ragged edges in the reconstructed images. The MSE can be minimized by a variant of BTC (BTC2) in which, the minimal (x_{min}) and maximal (x_{max}) values are stored or transmitted along with the bit plane of the block instead of storing the Mean and the Standard deviation [9]. The mean ***m*** is calculated using the equation (8).

$$m = (x_{max} + x_{min})/2 \qquad (8)$$

Another variant of BTC called the Absolute Moment Block Truncation Coding (AMBTC) in which the high mean (hMean) and the low mean (lMean) values are stored or transmitted along with the bitplane. The hMean and lMean are computed using the equations (9) and (10) respectively.

$$hMean = \frac{1}{p}\sum_{X_i \geq m} X_i$$

(9)

$$lMean = \frac{1}{q}\sum_{X_i \geq m} X_i$$

(10)

where *p* is the number of pixels whose intensity values are greater than or equal to mean *m* and *q* is the number of pixels whose intensity values are less than mean. The MSE is further reduced and the quality of the reconstructed images is increased with the AMBTC method [10]. In all the above three methods, the bitrate obtained was 2 bpp. Mitchell and Delp [11] omit the bit plane if σ <1 to reduce the bits required to store the image. Zeng's interpolative BTC [12, 13] method is similar to the prediction technique where half of the bit plane is omitted. At the coding phase, the partial image block is reconstructed and then the missing pixel values are interpolated on the basis of the existing ones. In the proposed method, a novel idea has been incorporated to reduce the bit rate to 1.75 bpp.

The remaining paper is organized as follows: The proposed idea is explained in section 2. Results and discussion is given in section 3. Conclusion is given in section 4.

II. PROPOSED METHOD

In this method, the hMean and lMean are divided by 4 and the resulting values are stored as two quantizing levels g_1 and g_2. When the values are divided by 4, the number of bits required to store the quantizers g1 and g2 will be reduced from 8 bits to 6 bits. If *n* is the maximum gray level, then it requires $Log_2 n$ bits. 256 being the maximum gray level, it requires 8 bits. When divided by 4, the maximum value 256 will be transformed to 64. Hence it requires, $Log_2 64=6$ bits to store the transformed values. While decoding the image, the quantizers will be multiplied by 4 to get back the approximation of the original values. This will increase the distortion only by a negligible amount.

A. Algorithm for encoding the image

Step1: Input the image of size *m x m* pixels.
Step2: Divide the image into small blocks of size 4 x 4 pixels.
Step3: Compute the mean $\overline{x}$ using the equation (1).
Step4: Compute the high mean and low mean using the equations (9) and (10).
Step5: Generate the Bitplane using the pixel values and the mean value.
Step6: Divide the high mean and low mean by 4.
Step7: Store the bit plane, high mean and low mean.
Step8: Repeat the steps 3 thru. 7 for all the blocks of an input image.

B. Algorithm for decoding the image

Step1: Input the bitplanes and the corresponding quantizing values.
Step2: for i = 1 to 16
Step3: if Bitplane(i) = 1 then X_i = HighMean * 4 else X_i = LowMean * 4
Step4: Next i
Step5: Repeat the steps 2 thru. 4 for each block

III. RESULTS AND DISCUSSION

The experiments were carried over with the standard images Cameraman, Lena, Bridge, Boats, Barbara and Kush. The images are of size 256 x 256 pixels. The algorithms were implemented using Matlab 7.0 on Windows Operating System. The hardware used is the Intel Core 2 E7400@ Duo 2.8 Ghz. Processor with 2 GB RAM.

The proposed idea is incorporated in all the three methods BTC, BTC2 (a variant of BTC) and AMBTC methods. The results obtained with all the three existing methods are compared with that of the results obtained by the proposed idea. The comparisons are given in Table I, Table II and Table III.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-1 Issue-1, April 2012

TABLE I. COMPARISON OF MSE, PSNR AND BPP WITH RESPECT TO BTC AND THE PROPOSED METHODS

Image	BTC			Proposed Method		
	MSE	PSNR	bpp	MSE	PSNR	bpp
Cameraman	105.11	27.91	2.00	105.12	27.91	1.75
Lena	34.48	32.76	2.00	34.73	32.72	1.75
Bridge	150.84	26.35	2.00	151.14	26.38	1.75
Boats	123.76	27.21	2.00	123.47	27.22	1.75
Barbara	23.17	34.48	2.00	23.29	34.46	1.75
Kush	39.37	32.18	2.00	39.55	32.16	1.75
Average	79.46	**30.15**	2.00	79.55	30.14	**1.75**

TABLE II. COMPARISON OF MSE, PSNR AND BPP WITH RESPECT TO BTC2 AND THE PROPOSED METHODS

Image	BTC2			Proposed Method		
	MSE	PSNR	bpp	MSE	PSNR	bpp
Cameraman	94.61	28.37	2.00	92.45	28.47	1.75
Lena	53.71	30.83	2.00	51.55	31.09	1.75
Bridge	160.93	26.06	2.00	154.84	26.23	1.75
Boats	75.72	29.34	2.00	73.02	29.50	1.75
Barbara	40.17	32.09	2.00	38.05	32.33	1.75
Kush	60.89	30.29	2.00	59.20	30.41	1.75
Average	**81.005**	**29.50**	**2.00**	**78.19**	**29.67**	**1.75**

TABLE III. COMPARISON OF MSE, PSNR AND BPP WITH RESPECT TO AMBTC AND THE PROPOSED METHODS

Image	AMBTC			Proposed Method		
	MSE	PSNR	bpp	MSE	PSNR	bpp
Cameraman	39.44	32.17	2.00	39.88	32.12	1.75
Lena	21.02	34.90	2.00	21.53	34.80	1.75
Bridge	51.82	30.99	2.00	52.21	30.95	1.75
Boats	31.14	33.20	2.00	31.56	33.14	1.75
Barbara	13.76	36.74	2.00	14.24	36.60	1.75
Kush	18.70	35.41	2.00	16.17	36.04	1.75
Average	**29.31**	**33.90**	**2.00**	**29.27**	**33.94**	**1.75**

TABLE IV. COMPARISON OF THE AVERAGE PSNR VALUES OBTAINED WITH RESPECT TO BTC, BTC2, AMBTC AND THE PROPOSED METHODS.

Method	**Existing Method**		**Proposed Method**	
	bpp	PSNR	bpp	PSNR
BTC	2.00	30.15	1.75	30.14
BTCVariant	2.00	29.50	1.75	29.67
AMBTC	2.00	33.90	1.75	33.94

From Table IV, it is observed that there is no much difference between the PSNR values obtained with the existing methods and the proposed methods. Moreover in BTC2 and AMBTC methods, the proposed idea gives better results both in terms of the bit-rate and the PSNR Values when compared to that of the existing methods. In the other method BTC, the bit rate is reduced to 1.75 bpp with the slight degradation in PSNR (just 0.01), which is quite negligible.

The standard images Cameraman, Lena, Bridge, Boats, Barbara and Kush of size 256 x 256 pixels that were taken for the study are given in Figure 1. The visual comparison of the reconstructed images of the existing methods and the proposed method are given in Figure 2 and Figure 3.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

(a) Cameraman

(b) Lena

(c) Bridge

(d) Boats

(e) Barbara

(f) Kush

Figure1. Input images taken for the study

(a) PSNR : 32.76
bpp : 2.00

(b) PSNR : 30.83
bpp : 2.00

(c) PSNR : 34.90
bpp : 2.00

Figure 2. Comparison of the reconstructed images using existing (a) BTC, (b) BTC Variant and (c) AMBTC methods

(d) PSNR : 32.72
bpp : 1.75

(e) PSNR : 31.09
bpp : 1.75

(f) PSNR : 34.80
bpp : 1.75

Figure 3. Comparison o f the reconstructed images with the proposed idea incorporated in the existing methods (a) BTC, (b) BTC Variant and (c) AMBTC

IV. CONCLUSION

A novel idea has been described to improve the performance of the existing methods in terms of bit rate. The bit rate obtained with the proposed method is

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

reduced significantly i.e. from 2 bpp to 1.75 bpp. The proposed idea has been incorporated in three of the existing methods. In all the three methods, the reduction in the bit rate did not create much difference in the PSNR values obtained. There is only a slight degradation in the PSNR value. In one of the techniques (BTC2), the PSNR value is raised by an average of 0.2. Hence from the results obtained, it is clear that the novel idea proposed in this paper can be incorporated in any BTC based image compression method.

This method is suitable for compressing images for applications in hand-held devices.

REFERENCES

1. E.J.Delp and 0.R.Mitchell, "Image Compression Using Block Truncation Coding," IEEE Transactions on Communication, Vol. COM-27, pp. 1335-1342, Sept. 1979.
2. A.M.Eskicioglu and P.S.Fisher, "Image Quality Measures And Their Performance", IEEE Transactiona on Communications, Vol.34, pp. 2959-2965, Dec. 1995.
3. Doaa Mohammed, Fatma Abou-Chadi, "Image Compression Using Block Truncation Coding", Journal of Selected Areas in Telecommunications (JSAT), Feb. 2011.
4. N.M. Nasrabadi, R.B.King, "Image Coding Using Vector Quantization: A Review", IEEE Transactions on Communications COM-36 (1998), pp. 957-971.
5. M.Rabbani and R.Joshi, "An Overview Of The JPEG 2000 Still Image Compression Standard", signal process. Image commun. 17, pp. 3-48, 2002.
6. G.Arce and N.C.Jr.Gallagher, "BTC Image Coding Using Median Filter Roots", IEEE Transactions On Communication, Vol.31, No.6, pp. 784-793, 1983.
7. Yung-Chen Wu, "Block Truncation Image Bitplane Coding", SPOIE, Optical Engineering, Vol. 41, No. 10, pp. 2476-2478, 2002.
8. Yu-Chen Hu, "Predictive Moment Preserving Block Truncation Coding For Gray Level Image Compression", Journal of Electronic Imaging, vol. 13, No.4, pp. 871-877, 2004.
9. Pasi Franti, Olli Nevalainen and Timo Kaukoranta, "Compression Of Digital Images By Block Truncation Coding: A Survey", The Computer Journal, Vol. 37, No. 4, 1994.
10. Lucas Hui, "An Adaptive Block Truncation Coding Algorithm For Image Compression", IEEE Trans. on ASSP, Vol. 4, pp. 2233-2236, Aril 1990.
11. O.R.Mitchell and E.J.Delp, "Multilevel Graphics Representation Using Block Truncation Coding", IEEE Transactions on Communications, 868-873.
12. B.Zeng, "Two Interpolative Btc Image Coding Schemes", Electronics Letters, 27, 1126-1128.
13. B.Zeng and Y.Neuvo, "Interpolative BTC Image Coding With Vector Quantizatioon", IEEE Transactions on Communications, 41, 1436-1438, 1993.

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)