A Survey on Lossy Image Compression Technique Based on Block Truncation Coding

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***Abstract*— Block Truncation Coding (BTC) technique has gain attention during the last few years as a simple coding method to get good quality image restoration by gathering the first two statistical moments of an image: the mean and the second one is variance. It reduces the amount of computation required by the traditional coding methods significantly, such as transform or hybrid coding. In this paper, review of the image compression technique has been illustrated. Here, we have described various image compression strategies which has been adopted and accepted in a large extent for lossy image compression. The basics of image processing have been reviewed here in order to provide the basic knowledge and information about image processing.**

Keywords—**Image Processing, Compression, BTC Scheme, storage, resolution, decoding, transmission, coding, mean, bit plane, pixel.**

I. INTRODUCTION

In today's electronic world, digital still pictures and video images play a significant role in multimedia based knowledge exchange applications. Such high resolution digital pictures require a lot of memory space for image storage, processing and retrieval by digital computers. Satellite and aerial images generate big data files demanding large transmission time for image transfer. In internet applications, such big data transmission slows down the net speed. Image compression techniques aim at reducing the transmission file size, by using lesser bits for the images. This is visualized by using fewer bits per pixel of the image. Normally this bit reduction will affect the quality of the image reproduced at the receiver. This process is known as 'Lossy Image Compression'. But images could also be compressed without reduction in quality of the image by employing suitable coding techniques. Inherently, such 'Lossless Image Compression' methods yield less compression, compared to 'Lossy' methods.

The 'Compression ratio (CR)', the 'Peak Signal to Noise Ratio (PSNR)' and the 'Contrast (C)' are the parameters used to measure the quality of image compression. Both time-domains (spatial) and frequency domain (spectral) image compression techniques are employed in image compression.

Block Truncation Coding (BTC) is an simple and efficient time domain compression technique, developed by Delp and Mitchell. The basic idea of BTC is to execute moment preserving quantization for blocks of pixels so that the quality of the image will still be acceptable and the need for the storage space will decrease. Even if the compression obtained by the algorithm is not up the mark to the standard JPEG compression algorithm, the BTC has gained popularity due to its practical usefulness. Several methods to get improvements of the basic method have been recently proposed in the literature.

II. ISSUES IN IMAGE COMPRESSION

Size Reduction

File size lessening remains the absolute most critical profit of picture layering. Contingent upon what document sort you're working with, you can keep on compacting the picture until it's at your craved size. This implies the picture consumes up less room on the hard drive and holds the same physical size, unless we alter the picture's physical size in a picture proof reader. This record size decrease meets expectations gloriously for the Internet, permitting website admins to make picture rich destinations without utilizing much transmission capacity or storage too.

Slow Devices

Some electronic gadgets, for example, machines or cams, may stack huge, uncompressed pictures gradually. Album drives, for instance, can just read information at a particular rate and can't show huge pictures progressively. Likewise, for a few webhosts that exchange information gradually, packed pictures stay fundamental for a completely practical site. Different types of capacity mediums, for example, hard drives, will likewise experience issues stacking uncompressed records rapidly. Picture squeezing considers the quicker stacking of information on slower gadget.

Degradation

When you clamp a picture, in some cases you will get picture debasement, importance the nature of the picture has declined. In the event that sparing a GIF or PNG document, the information stays despite the fact that the nature of the picture has declined. On the off chance that we have to demonstrate a high-determination picture to somebody, expansive or little, we will discover picture squeezing as a drawback.

Data Loss

With some regular document sorts, for example, JPEG, when a picture recoils in size the clamping system will toss a portion of the photograph's information for all time. To pack these pictures, we need to guarantee you had an uncompressed reinforcement before beginning. Else, we will lose the high caliber of the first uncompressed picture for all time.

III. LOSSY IMAGE COMPRESSION TECHNIQUE

3.1 Block Truncation Coding

Block truncation coding is one of the lossy coding techniques applicable for gray scale images. It reduces the file size but loses some extent of original information of the image [9]. The significant advantages of this coding approach are low computational complexity and high parallelism.

The basic idea of BTC is to perform moment preserving quantization for blocks of pixels. The input image is divided into non-overlapping blocks of pixels of sizes 4×4, 8×8 and so on. Mean and standard deviation of the blocks are calculated. Mean is considered as the threshold and reconstruction values are determined using mean and standard deviation. Then a bitmap of the block is derived based on the value of the threshold which is the compressed or encoded image. Using the reconstruction values and the bitmap the reconstructed image is generated by the decoder. Thus in the encoding process, BTC produces a bitmap, mean and standard deviation for each block. It gives a compression ratio of 4 and bit rate of 2 bits per pixel when a 4×4 block is considered. This method provides a good compression without much degradation on the reconstructed image. But it shows some artifacts like staircase effects or raggedness near the edges. Due to its simplicity and easy implementation, BTC has gained big interest in its further improvement and application for image compression.

The algorithm for BTC is as follows:

Step 1: Input a gray scale image of size M×N pixels and the dimension of the square block k by which the image is to be divided into non-overlapping blocks.

Step 2: Divide the image into various blocks, each of size k×k, value of k can be 4, 8, 16, and so on. Each block, W is represented as;

$$\boldsymbol{W} = \begin{bmatrix} w_1 & \cdots & w_k \\ \vdots & \ddots & \vdots \\ {w_1}^2 & \cdots & {w_k}^2 \end{bmatrix}$$

Step 3: calculate the mean and variance of gray level in block W

$$\mu = \frac{1}{p}\sum_{i=1}^{p} w_i \quad (1)$$

$$m_1 = \frac{1}{k}\sum_{i=1}^{k} f(x_i) \quad (2)$$

$$m_2 = \frac{1}{k}\sum_{i=1}^{k} f(x_i)^2 \quad (3)$$

m_1 is the sample mean and the sample variance σ^2 of image block is given by:

$$\sigma^2 = m_2 - m_1 \quad (4)$$

Step 3: Now the compressed bit map is obtained by

$$B = \begin{cases} 1, w_i > \mu \\ 0, w_i \le \mu \end{cases} \quad (5)$$

Step 4: The bit map B, μ and ı are transmitted to the decoder.

The algorithm for decoder is as follows:

Step 1: Calculate a & b

$$a = \mu + \sigma\sqrt{\frac{p}{q}} \quad (6)$$

$$b = \mu - \sigma\sqrt{\frac{q}{p}} \quad (7)$$

where p = No. of 0's in the bit map and q = No. of 1's in the bit map

Step 2: The reconstructed image Z can be obtained by replacing the element 1 in B with H and element 0 with L.

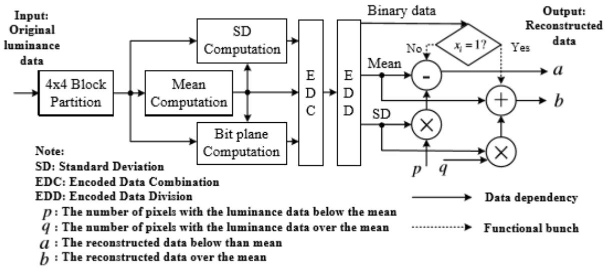

Figure 1: Block diagram of Block Truncation Coding

3.2 AMBTC Method

Absolute Moment Block Truncation Coding (AMBTC) [4] gather the higher mean and lower mean of each block and use this to quantize output. It provides much better image quality than image compression using BTC. Moreover, the AMBTC is quite faster compared to BTC. Cheng and Tsai [5] proposed an algorithm for image compression based on the moment preserving edge detection. The algorithm is computationally faster because it involves analytical formula to calculate the parameters of the edge feature in an image block. Reconstructed images are of better quality according to human perceptual experience. Desai et al. [6] proposed an edge and mean based compression algorithm that produces good quality images at very low bit rates.

The absolute moment BTC (AMBTC) [34] preserves sample mean (m1) and first order absolute central moment α, where

$$\alpha = \frac{1}{K}\sum_{i=1}^{K}|F(X_i) - m_1| \quad (8)$$

And corresponding quantization levels are

$$a = m_1 - \frac{\alpha k}{2k'} \quad (9)$$

$$b = m_1 + \frac{\alpha k}{2(k-k')} \quad (10)$$

If the quantization levels are set as m_{low} (lower mean) and m_{high} (higher mean), then MSE is reduced. The means, m_{low} and m_{high} are defined as follows.

$$m_{low} = \frac{1}{k'}\sum_{f(x_i \le m_1)} f(x_i) \quad (11)$$

$$m_{high} = \frac{1}{k-k'}\sum_{f(x_i \le m_1)} f(x_i) \quad (12)$$

AMBTC is faster than BTC, as no square root operation is required.

In the bit-stream of BTC method, bit-plane shares a significant amount of space. Such requirements can be reduced. Normally, lossless coding for bit-plane is acceptable. However, considering a lossy coding method for bit-plane a large compression is possible at the cost of the quality [13,14,15].

3.3 Enhanced Block Truncation Coding (EBTC)

Enhanced Block Truncation Coding (EBTC) [9] is an improved compression algorithm for gray scale images to reduce the correlation and spatial redundancy between pixels of an image. This method also maintains good compression ratio and quality of an image. Futuristic Algorithm for Gray Scale Image based on Enhanced Block Truncation Coding (FEBTC) [10] has greater PSNR value than AMBTC and EBTC without degradation of bit rate. Hence the improvements on BTC continue to reduce the bit rate and computational complexity by keeping the image quality to satisfactory limits.

III.IV Modified Block Truncation Coding Algorithm using max-min quantizer (MBTC)

MBTC divides the image into blocks, quantizes each block based on a threshold and the bitmap is generated, which is the compressed image. The compressed image is decoded by preserving the higher mean and lower mean of each block.

The algorithm for Encoder of this method is as follows [32].

Step 1: Input a gray scale image of size M×N pixels and the dimension of the square block k by which the image is to be divided into non-overlapping blocks.

Step 2: Divide the image into blocks, each of size k×k, value of k can be 4, 8, 16, and so on. Each block, W is represented as;

$$\mathbf{W} = \begin{bmatrix} w_1 & \cdots & w_k \\ \vdots & \ddots & \vdots \\ w_1{}^2 & \cdots & w_k{}^2 \end{bmatrix}$$

Step 3: Find the maximum (max) and minimum (min) values of gray levels in the block W. Also calculate the mean (μ) of the block using (1).

$$\mu = \frac{1}{p}\sum_{i=1}^{p} w_i$$

Where p is the total number of pixel values in each block.

Step 4: Find the threshold (T) by calculating the average value of maximum (max), minimum (min) and mean (μ) of the gray levels in the block using (2).

$$T = \frac{max+min+\mu}{3} \quad (13)$$

Step 5: Quantize the block W based on the threshold value (T) in such a way that, if a pixel value is greater than T, the value 1 is assigned and otherwise, value 0 is assigned to the bitmap. Then the compressed bitmap B obtained is,

$$\mathbf{B} = \begin{bmatrix} b_1 & \cdots & b_k \\ \vdots & \ddots & \vdots \\ b_1{}^2 & \cdots & b_k{}^2 \end{bmatrix}$$

Where, $b_j = \begin{cases} 1, w_i > T \\ 0, w_i \le T \end{cases}$

Step 6: Pixels in the image block W are then classified into two ranges of values. The upper range is those gray levels which are greater than T and lower range is those which are less than or equal to T. The mean of higher range (μ_H) and the lower range (μ_L) are calculated using (3) and (4) respectively. Then these two values are used for reconstruction of the image.

$$\mu_H = \frac{1}{p}\sum_{i=1}^{p} w_i, w_i > T \quad (14)$$

$$\mu_L = \frac{1}{q}\sum_{i=1}^{q} w_i, w_i \le T \quad (15)$$

Where, p is the number of gray values greater than T and q is the number of gray values less than or equal to T.

Step 7: Repeat the steps 3 to 6 for each block. The resultant bit map B represents the encoded image. Since the values of this bit map is either 0 or 1, only 1 bit per pixel is needed to represent each pixel. For the reconstruction of the image, the bit map B, $\boldsymbol{\mu_H}$ and $\boldsymbol{\mu_L}$ for each block is transmitted to the decoder.

The decoding procedure is as follows:

Step 1: Divide the bit map into k×k blocks.

$$\mathbf{B} = \begin{bmatrix} b_1 & \cdots & b_k \\ \vdots & \ddots & \vdots \\ b_1{}^2 & \cdots & b_k{}^2 \end{bmatrix}$$

Step 2: Decode bitmap block B with the reconstruction values μ_H and μ_L in such a way that the elements assigned 0 are replaced with μ_L and elements assigned 1 are replaced with μ_H. Then the decoded image block Z can be represented as,

$$\mathbf{Z} = \begin{bmatrix} z_1 & \cdots & z_k \\ \vdots & \ddots & \vdots \\ z_1{}^2 & \cdots & z_k{}^2 \end{bmatrix}$$

Where, $z_i = \begin{cases} \mu_L, b_j = 0 \\ \mu_L, b_j = 1 \end{cases}$

Step 3: Repeat step 2 for each block and the resultant matrix represents the reconstructed image.

This method uses the average value of maximum, minimum and mean of the pixel values as threshold for quantization. This will reduce the difference between pixel values in each segment. In the decoding process MBTC preserves the higher mean and the lower mean. A set of images with different textures and edges has been tested and found that the reconstructed images show a better visual quality than BTC and other modified BTC's.

IV. VECTOR QUANTIZATION

Vector quantization is a quantization technique that allows the modeling of probability density functions by the distribution of vectors. It was originally used for data compression. It works by dividing a large set of points into groups which having approximately the same number of points closest to them. Vector quantization is based on the competitive learning method.

A training algorithm for vector quantization can be illustrated as:

- choose a sample point randomly
- Get the nearest quantization vector centroid towards the sample point.
- And repeat the procedure.

A modified more efficient methodology adopt the following methodology:

- The centroid sensitivity is increased
- Get a sample point randomly
- calculate the quantization vector centroid with the smallest distance sensitivity
- Repeat

Use in data compression

Vector quantization is also termed as "block quantization" or "pattern matching quantization" is often applicable in lossy data compression. Compression is carried out by encoding values from a multidimensional vector space into a finite set of values from a discrete dimension. A lower space vector needs less storage space, so the data is compressed. Due to the density matching property of vector quantization the compressed data has errors that are inversely proportional to density.

V. CONCLUSION

In this paper, a review has been made on image compression methodology. In this study we found that all methods have their own features and they are improving the result. BTC provide good compression ratio. If we increase the block size then the quality of the image degraded. In vector quantization, since it follows the concept of segmentation based on different region, it returns good visual aspect of the image. From the study the future work can be to merge BTC with vector quantization to get good compression ratio with better image quality.

REFERENCE

[1] D. Salomon, Data Compression: The Complete Reference. Springer-Verlag, New York, 2000.

[2] Y. Q. Shi and H. Sun, Image and video compression for multimedia engineering: fundamentals, algorithms, and standards. CRC Press, USA, 1999.

[3] D. Huffman, A method for the construction of minimum redundancy codes. Proceeding of the IRE, 40:1098 – 1101, 1952.

[4] I. H. Witten, M. N. Radford, and J. G. Cleary, Arithmetic coding for data compression. Communications of ACM, 60:520 – 540, 1987.

[5] W. Pratt, Digital Image Processing, John Wiley and Sons, New York, 1978.

[6] K. R. Rao and P. C. Yip Eds, The Transform and Data Compression Handbook. CRC Press, Boca Raton, FL, 2001.

[7] R. C. Gonzalez and R. E. Woods, Digital Image Processing, Prentice Hall, 2002.

[8] W. B. Pennebaker and J. L. Mitchell, JPEG: still image data compression standard. New York: Van Nostrand Reinhold, 1993.

[9] G. K. Wallace, The jpeg still picture compression standard. IEEE Transactions on Consumer Electronics, 38: xviii – xxxiv, 1992.

[10] D. Tabuman and M. W. Marcelin, JPEG 2000: image compression fundamentals, standards and practices, Kluwer Academic Publishers, 2001.

[11] A. Christopoulos, A. Skodras, and T. Ebrahimi, Jpeg2000 still image coding system: an overview. IEEE Transactions on Consumer Electronics, 46:1103–1127, 2000.

[12] A. Skodras, A. Christopoulos, and T. Ebrahimi, Jpeg2000: the upcoming still image compression standard. Pattern Recognition Letters, 22:1337–1345, 2001.

[13] T. Ebrahimi, C. A. Christopoulos, and D. T. Lee, Special issue introduction, jpeg2000. Signal Processing: Image Communication, 17:1–144, 2002.

[14] J. M. Shapiro, Embedded image coding using zero trees of wavelet coefficients. IEEE Transactions on Signal Processing, 41:3445 – 3462, 1993.

[15] A. Said and W. A. Pearlman. A new, fast, and efficient image codec based on set partitioning in hierarchical trees. IEEE Transactions on Circuits and System for Video Techniques, 6:243– 250, 1996.

[16] D. Marpe and H. L. Cycon, Very low bit rate video coding using wavelet-based techniques, IEEE Transactions on Circuits and Systems for Video Technology, 9:85 – 94, 1999.

[17] D. Gleich, P. Planinsic, and Z. Cucej, Low bitrate video coding using wavelet transform, In Proc. of the EURASIP conference on Video/Image Processing and Multimedia Communications, pages 369 – 374, 2003.

[18] R. Leonardi and J. R. Ohm, Wavelet video coding - an overview (iso/iec jtc1/sc29/wg11 w7824). 2006.

[19] R. B. Arps, Binary image compression. In Image Transmission Techniques, pages 219 – 276. Academic Press, W. K. Pratt (Ed.), New York, 1979.

[20] H. Samet, Application of spatial data structures: Computer Graphics, Image

Processing and GIS. Addison Wesley, Reading , MA, 1990.

[21] J. A. Storer and H. Helfgott, Lossless image compression by block matching. The Computer Journal, 40:137 – 145, 1997.

[22] G. Langdon and J. Rissanen, Compression of black white images with arithmetic coding. IEEE Transactions on Communications, 29:858 – 867, 1981.

[23] A. Moffat. Two-level context based compression of binary images. In Proc. Of the Data Compression, pages 382 – 391. IEEE Computer Society Press, 1991.

[24] A. E. Jacquin, Image coding based on a fractal theory of iterated contractive image transformations. IEEE Transactions on Image Processing, 1:18 – 30, 1992.

[25] G. E. Oien and S. Lepsoy, Fractal-based image coding with fast decoder convergence. Signal Processing, 40:105 – 117, 1994.

[26] L. Thomas and F. Deravi, Region-based fractal image compression using heuristic search. IEEE Transactions on Image Processing, 4:832 – 838, 1995.

[27] Z. Wang and A. C. Bovik, A universal image quality index. IEEE Signal Processing Letters, 9:81 – 84, 2002.

[28] Z. Wang, A. C. Bovik, and L Lu, Why is image quality assessment so difficult? In Proc. of the IEEE international conference on Acoustic, Speech, and Signal Processing, pages 3313 – 3316, 2002.

[29] Z. Wang, A. C. Bovik, H. R. Sheikh, and E. P. Simoncelli. Image quality assessment: From error visibility to structural similarity. IEEE Transactions on Image Processing, 13:600 – 612, 2004.

[30] E. J. Delp and O. R. Mitchell, Image compression using block truncation coding. IEEE Transactions on Communications, 27:1335 – 1342, 1979.

[31] Jing-Ming Guo & Yun-Fu Liu, Improved Block Truncation Coding Using Optimized Dot Diffusion, IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 23, NO. 3, MARCH 2014

[32] Jayamol Mathews, Madhu S. Nair & Liza Jo, Modified BTC Algorithm for Gray Scale Images using max-min Quantizer, IEEE 2013.

[33] Ki-Won Oh & Kang-Sun Choi, Parallel Implementation of Hybrid Vector Quantizer based Block Truncation Coding for Mobile Display Stream Compression, IEEE ISCE 2014.

[34] Jing-Ming Guo, Heri Prasetyo, and Jen-Ho Chen, Content-Based Image Retrieval Using Error Diffusion Block Truncation Coding Features, IEEE Transactions on Circuits and Systems for Video Technology 2014.

[35] Seddeq E. Ghrare & Ahmed R. Khobaiz, Digital Image Compression using Block Truncation Coding and Walsh Hadamard Transform Hybrid Technique, IEEE conference 2014.

[36] Jing-Ming Guo & Heri Prasetyo, Content-Based Image Retrieval Using Features Extracted From Halftoning-Based Block Truncation Coding, IEEE Transactions on image processing, vol. 24, no.3, march 2015.