Digital Image Compression using Block Truncation Coding and Discrete cosine Transform, Hybrid Technique

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Abstract—With the continuous growth of modern communication technologies, demand for data compression is increasing rapidly. Techniques for achieving image data compression can be divided into two basic approaches: spatial coding and Transform coding. This research paper presents a proposed method for the compression of digital images using hybrid compression method based on Block Truncation Coding (BTC) and discrete cosine Transform (DCT). The objective of this hybrid approach is to achieve higher compression ratio by applying BTC and DCT. Several gray scale test images are used to evaluate the coding efficiency and performance of the hybrid method and compared with the BTC and DCT respectively. It is generally shown that the proposed method gives better results.

Keywords- Image compression, hybrid technique , BTC, DCT, lossy and lossless compression, digital image.

INTRODUCTION:

With the development of the internet and multimedia technology digital image compression has attracted a great deal of research interest in the recent few years. Image compression is one of the most important factors which have a direct effect on the quality of any communication media. Compression makes it possible for generating file volume can be efficiently managed, stored and transmitted. A 16 MB image requires more than four minutes to be downloaded using a 64kbps channel, whereas, if the same image is compressed with a rate of 20:1, its size will be reduced to 800KB and will require about 12 seconds to download. Therefore demand for efficient techniques for image compression has become quite necessary [1].

Image data compression techniques can be divided into two basic approaches: Transform coding and spatial coding. It is also possible to combine the two approaches in a technique called Hybrid coding [2].

Coding in the spatial domain involves the direct manipulation of the sample image data to remove existing redundancies. This type of coding is usually simple to implement both in terms of memory requirement and number of operations. It is quite sensitive to changes in the data statistics and to the channel error effects which degrade image quality. Various coding techniques in the spatial domain have been investigated such as Block Truncation coding (BTC), and Binary Image Compression (BIC) [3].

In transform coding, the aim is to transform the original image to a new space where most of energy will be concentrated in only a few coefficients, thus data compression can be achieved by coding only those coefficients that have high energy [4].

Transform coding achieves relatively large compression ratios compared to spatial coding. A large number of transforms have been applied for image compression. These transforms include Walsh-Hadamared Transform (WHT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) ...etc [4].

Hybrid coding refers the techniques which combines transform coding and spatial coding techniques. This technique combines the advantage of hardware simplicity of spatial coding and the good performance of transform coding with respect to it is low sensitivity to channel error [2]

METHOD:

In this paper three compression methods have been applied which are BTC, DCT and a hybrid method in which both techniques are used together. A sample of standard digital images is used and indicated in figure 2. These images are used to evaluate the performance of the proposed hybrid method which is explained below:

1. The image is broken into non-overlapping blocks of size nxn where (n=4).
2. Working from left to right, top to bottom, the BTC is applied to each block.
3. Calculate the first and second sample moments and the variance of the block.
4. Find a threshold value and two reconstruction levels which are used to reconstruct the original blocks.
5. Repeat the above steps for all blocks.
6. Calculate the quality of the overall reconstructed image using the PSNR and MSE.
7. Use the obtained reconstructed image as an input image to the DCT method.
8. Calculate the quality of the reconstructed image using the PSNR and MSE.

A. Block Truncation Coding (BTC):

Block truncation coding (BTC) is a simple, fast, lossy and fixed length compression technique for gray scale images. BTC is a block-adaptive binary encoding method based on moment preserving quantization. The concept of BTC is introduced by Delp and Mitchell [18].

In BTC method, an image is first divided into n×n identical blocks (in general n=4) and each block is coded separately. Gray levels of each image block is quantized by Q level quantizer and these quantizer levels are chosen such that a few low order moments are preserved in the quantized output. In the simplest form of BTC, the first two moments are preserved and each block is represented by two quantization levels. By incorporating additional constraints, higher order moments can be preserved. Suppose k (=n2) be the number of pixels in a block and also suppose f(xi), xi ∈ C are the gray values of the pixels in a block of the original image where C represents the set of coordinates of pixels in the block, i.e., $C = \{x_1, x_2, x_3 \dots \dots \dots \dots . . x_k\}$ the first two sample moments are given by

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

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

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

$$\sigma^2 = m_2 - m_1{}^2 \qquad (3)$$

If the pixel value of each block is greater than or equal to mean, it is represented by 1 and if less than the mean, it is represented by 0. The collection of 1s or 0s for each block is called a bit plane.

In BTC, two statistical moments ***a*** and ***b*** are computed using the equations (4) and (5) and are preserved along with the bit plane for reconstructing the image. The compressed image is transmitted or stored as a set *{B, a, b}*

$$a = \bar{x} - \sigma \sqrt{\frac{q}{m-q}} \qquad (4)$$

$$b = \bar{x} + \sigma \sqrt{\frac{m-q}{q}} \qquad (5)$$

Where, ***q*** is the number of pixel values greater than or equal to *X*, and ***(m-q)*** is the number of pixels whose gray levels are less than *X*. While reconstructing the image, the ***0*** in the bit plane is replaced by **a** and the 1 in the bit plane is replaced by **b**.

B. Discrete Cosine Transform (DCT):

The Discrete Cosine Transform (DCT) has been applied extensively to the area of image compression. It has excellent energy-compaction properties and as a result has been chosen as the basis for the Joint Photography Experts Group (JPEG) still picture compression standard. DCT is an example of transform coding. The DCT coefficients are all real numbers and Inverse Discrete Cosine Transform (IDCT) can be used to retrieve the image from its transform representation. DCT is simple when JPEG used for higher compression ratio the noticeable blocking artifacts across the block boundaries cannot be neglected. The DCT can be quickly calculated and is best for images with smooth edges. The coefficients of DCT transform are computed using

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} D(x,y) \times \cos\left(\frac{(2x+1)i\pi}{2N}\right) \cos\left(\frac{(2y+1)j\pi}{2N}\right) \quad (6)$$

Where, P(x, y) is an input matrix image NxN, (x, y) are the coordinate of matrix elements and (i, j) are the coordinate of coefficients, and

$$C(u) = \begin{cases} \frac{1}{\sqrt{2}} & if\ u = 0 \\ 1 & if\ \ u > 0 \end{cases} \quad (7)$$

The reconstructed image is computed by using the inverse DCT (IDCT) according to

$$P(x,y) = \frac{1}{\sqrt{2N}} \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} C(i)C(j)D(i,j) \times \cos\left(\frac{(2x+1)i\pi}{2N}\right) \cos\left(\frac{(2y+1)j\pi}{2N}\right) \quad (8)$$

The pixels of black and white image are ranged from 0 to 255, where 0 corresponds to a pure black and 255 corresponds to a pure white. As DCT is designed to work on pixel values ranging from -128 to 127, the original block is levelled off by 128 from every entry [11]. Step by step procedure of getting compressed image using DCT and getting reconstructed image from compressed image. Since human eyes are sensible to low frequency therefore, high frequency information is usually removed in compression through quantization.

DCT could be accomplished by D = TMT^t, where M is the original matrix and T^t denotes the transpose of t matrix. T with elements T (i, j) is a DCT matrix, which is computed according to

$$T(i,j) = \begin{cases} \frac{1}{\sqrt{N}} & if\ i = 0 \\ \sqrt{\frac{2}{N}} \cos\frac{(2j+1)i\pi}{2N} & if\ i > 0 \end{cases} \quad (9)$$

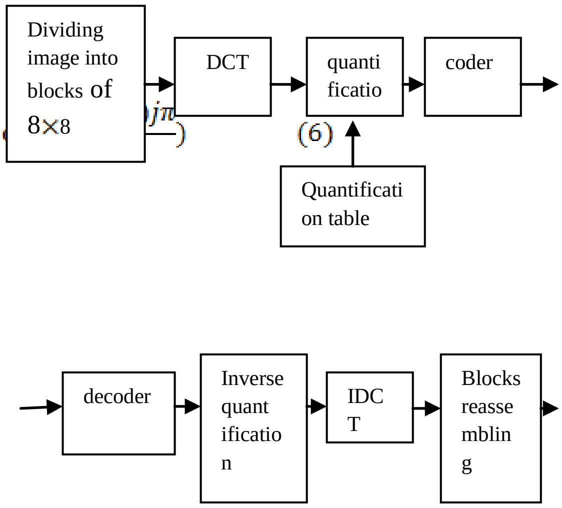


Fig.1 Block diagram of DCT and IDCT

Image Quality Measures:

There are various parameters present which are used to measure the performance of different compression algorithm. Some examples of the performance parameters of image compression are given below:

Peak signal to noise ratio (PSNR):

PSNR is an important parameter for image compression. It is measurement of the peak error present between the compressed image and original image. For better quality of image PSNR should be as high as possible.

$$PSNR = 10\log_{10}\left(\frac{MAX^2 i}{MSE}\right)$$
$$= 20\log_{10}\left(\frac{MAX\, i}{MSE}\right)$$
$$= 20\log_{10}(MAX\, i) - 10\log_{10}(MSE)$$

Compression ratio:

CR is the ratio of size of compressed image to the size of original image. Compression ratio should be as high as possible to achieve better compression.

$$\text{compression ratio} = \frac{\text{uncompressed size}}{\text{compressed size}}$$

Mean square error :

Mean Square Error (MSE) is cumulative difference between the original image and compressed image. MSE should be as minimum as possible for better quality of image.

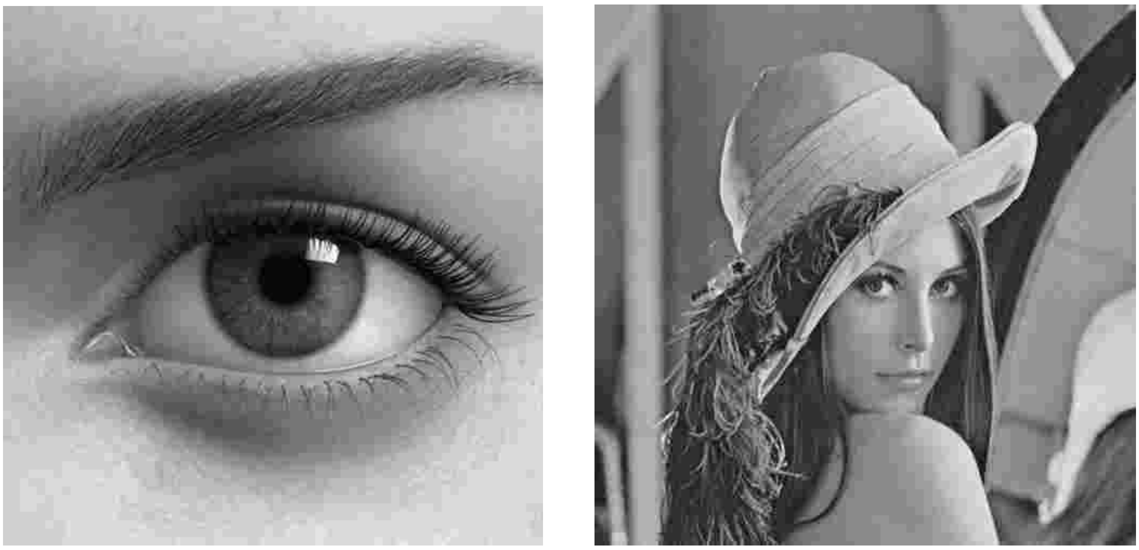
Experimental Results:

Comparative analysis of DCT, BTC and Hybrid image compression methods are shown in tabular form. Two performance parameters, peak signal to noise ratio (PSNR) and mean square error (MSE) are compared for two images. The original images which have been used in this study contain 256x256 pixels. And the resolution of each pixel was 8-bit/pixel. The images are first compressed using BTC method. The resulting images contain 2bit/pixel, which means that the achieved compression ratio using this method was 75%. These resulting images are then applied to the DCT method for further compression. The reconstructed images using DCT have a compression ratio of 50%, which means that the overall compression ratio using two methods (Hybrid Method) is around 87%. In terms of image quality, the PSNR is used as a measure of reconstructed images quality. It has been shown that the increasing compression ratio is acompained with a degradation of image quality. Despite of the high compression ratio achieved using the hybrid method, the quality of the reconstructed images still have a good and acceptable quality compared with the original images and reconstructed images using BTC and DCT respectively, as indicated in Figure 1.

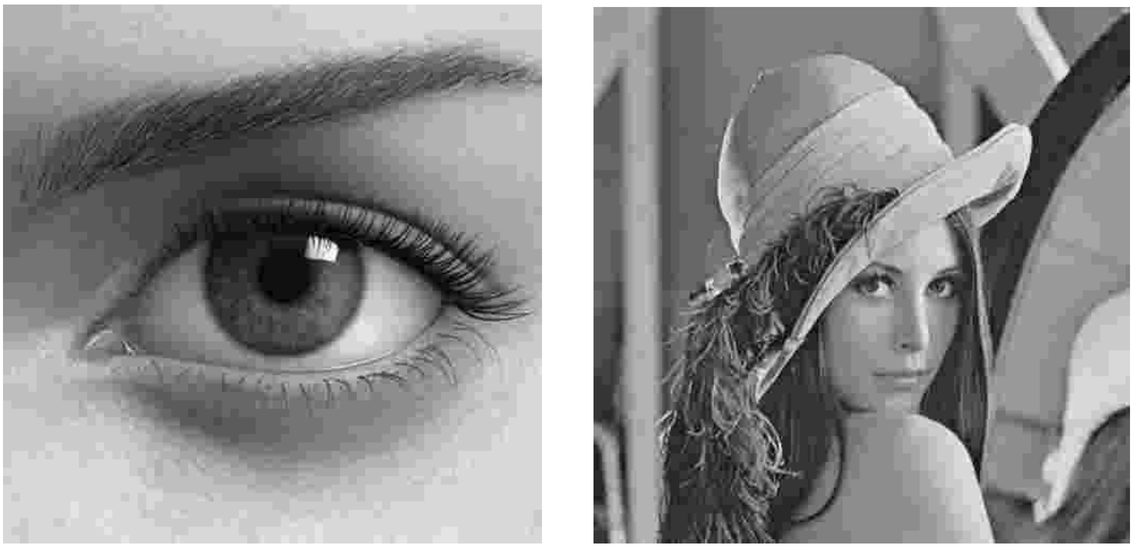
TEST IMAGE	COMPRESSION METHOD					
	BTC		DCT		HYBRID	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
EYE	33.25	29.33	30.11	27.46	39.22	27.21
LEENA	25.65	34.52	32.52	32.87	35.22	32.10


(a) Original test image


(b) reconstructed image using BTC



(c) Reconstructed image using DCT



(d) Reconstructed image using BTC/DCT hybrid method

Fig.2 Original test image and reconstructed versions of those images

REFERENCES

[1] C. Rengarajaswamy and S. Imaculate Rosaline, SPIHT Compression of Encrypted Images, IEEE, pp. 336-341,2013.
[2] Ming Yang & Nikolaos Bourbakis, "An Overview of Lossless Digital Image Compression Techniques" Circuits& Systems, 2005 48th Midwest Symposium , vol. 2 IEEE, pp 1099-1102, 7 – 10 Aug, 2005.
[3] S. Srikanth and Sukadev Meher, Compression Efficiency for Combining Different Embedded Image Compression Techniques with Huffman Encoding, IEEE, pp. 816-820, 2013.
[4] Dr. Eswara Reddy, and K Venkata narayana, "a lossless image compression using traditional and lifting based wavelet" Signal and image processing : An international Journal(SIPIJ),pp. 213 to 222, Vol 3 No 2,APRIL 2012.
[5] Subramanya A. "Image Compression Technique" potentials IEEE, Vol. 20, issue 1, pp19-23, Feb-March 2001.
[6] Marc Antonini, Michel, Member, IEEE, Pierre Mathieu and Ingrid Daubechies, Member, IEEE" image coding using wevlet transform" IEEE transactions on image processing, pp.205 to 220,Vol.1. No 2. April 1992.
[7] Doaa Mohammed, Fatma Abou-Chadi, Image Compression Using Block Truncation Coding, Journal of Selected Areas in Telecommunications (JSAT), February, 2011.
[8] Jau-Ji Shen and Hsiu-Chuan Huang, An Adaptive Image Compression Method Based on Vector Quantization, IEEE, pp. 377-381, 2010.

[9] Yi-Fei Tan and Wooi-Nee Tan, Image Compression Technique Utilizing Reference Points Coding with Threshold Values,IEEE, pp. 74-77, 2012.
[10] S. A. Mohamed; Dept. of Electr. Eng., Queen'' S Univ., Kingston, Ont., Canada ; M. M. Fahmy, Image compression using VQBTC, IEEE Transactions on Communications.
[11] Suresh Yerva, Smita Nair and Krishnan Kutty, Lossless Image Compression based on Data Folding,IEEE, pp. 999-1004, 2011.
[12] Ahmed, N., Natarajan, T., Rao, K. R., "Discrete Cosine Transform", IEEE Trans. Computers, vol. C-23, Jan. 1974, pp. 90-93.