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HYBRID IMAGE COMPRESSION TECHNIQUE

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ABSTRACT— With the continuing growth of modern communication technologies, demand for image data compression is increasing rapidly. Techniques for achieving data compression can be divided into two basic approaches: spatial coding and Transform coding. This report presents a method for the compression of digital images using hybrid compression method based on Block Truncation Coding (BTC) and Walsh Hadamard Transform (WHT).The objective of this hybrid approach is to achieve higher compression ratio by applying BTC and WHT. Several gray-scale test images are used to evaluate the coding efficiency and performance of the hybrid method and compared with the BTC and WHT respectively. The hybrid method yields better results.

Keywords— Image compression, BTC, WHT, CR, Hybrid method, MSE, PSNR.

1, 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.

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. Coding in the spatial domain involves the direct manipulation of the sample image data to remove existing redundancies. Spatial 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). 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.

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-Hadamard Transform (WHT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) etc. 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, METHODS

In this report three compression methods have been applied which are BTC, WHT and a hybrid method in which both techniques are used together. A sample of standard digital images is used and indicated in Figure 3.1. These images are used to evaluate the performance of the hybrid method as shown below:

1. The image is broken into non-overlapping blocks of size (n x n) 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 WHT method.
8. Calculate the quality of the reconstructs image using the PSNR and MSE.

2.1 BLOCK TRUNCATION CODING

Block Truncation Coding (BTC) works by dividing the image into small sub blocks of size 4 x 4 pixels and then reducing the number of gray levels within each block. This red ction is performed by a quantizer that adapts to the local image statistics. The basic form of BTC divides the whole image into N blocks and codes each block using a two-level quantizer. The two levels, a and b are selected using the mean (X) and standard deviation (¬) of the gray levels within the block and are preserved. Each pixel value within the block is then compared with the mean and then is assigned to one of the two levels. The X and (¬) are calculated using the equations (2.1) and (2.2). Where m is the total number of pixels in each block, q is the number of pixels greater than or equal to X. The sample mean X and standard deviation (¬) are defined as

$$\bar{X} = \frac{1}{m}\sum_{i=1}^{m} x_i \tag{2.1}$$

$$\bar{X^2} = \frac{1}{m}\sum_{i=1}^{m} x_i^2 \tag{2.2}$$

$$\sigma = \sqrt{\bar{X^2} - \bar{X}^2} \tag{2.3}$$

Where, m is the number of pixels in each block, and xi is the original pixel value of the block. 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

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is called a bit plane, B. In BTC, two statistical moments a and b are computed using the equations (2.3) and (2.4) 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}

$$a = \bar{X} - \sigma\sqrt{\frac{q}{m-q}} \qquad (2.4)$$

$$b = \bar{X} + \sigma\sqrt{\frac{m-q}{q}} \qquad (2.5)$$

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

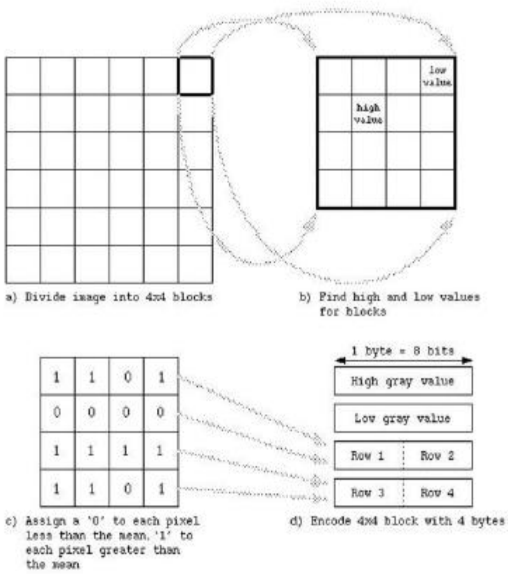
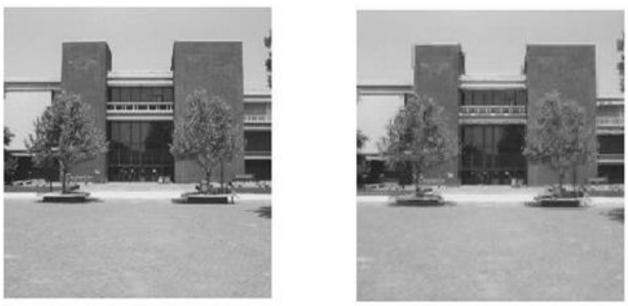


Figure 2.1: Basic Block Truncation Coding



(a) (b)

Figure 2.2: (a)Original image. (b) BTC image

2.2 WALSH HADAMARD TRANSFORM (WHT)

The system of Walsh functions is the basis for Walsh transform. Walsh functions are orthogonal and have only +1 and -1 values . In general, the Walsh transform can be generated by the Hadamard matrix as follows:

$$H_{2^k} = \begin{bmatrix} H_{2^{k-1}} & H_{2^{k-1}} \\ H_{2^{k-1}} & -H_{2^{k-1}} \end{bmatrix} \tag{2.6}$$

For k=1,2,3,....

H1 =1 for k=0

For k = 1, the 2X2 Hadamard matrix H_2 is defined by:

$$H_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{2.7}$$

For k = 2, the 4X4 Hadamard matrix H_4 can be easily obtained using the formula:

$$H_4 = \begin{bmatrix} H_2 & H_2 \\ H_2 & -H_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \tag{2.8}$$

The sequence ordered Hadamard matrix is constructed by changing the row ordering of the above matrix, based on the number of sign changes in each row. The natural ordering is transformed into sequence order by reversing the bit order for the binary code (BC) of row index and then finding the Gray code (GC). An example of such transformation is given next:

BC (110) → Bit reversal (011) → (010)

In Walsh-Hadamard, the basis functions are based on square or rectangular waves with peaks of +1 and -1. One main advantage of rectangular basis functions is that the computations are very simple. When the image is projected onto the basis functions, each pixel should be multiplied with +1 or -1. In order to perform the transform operation to convert an image from the spatial domain to the frequency domain, the right size of image basis function should be used.

	Matrix							Row	Sign Changes
1	1	1	1	1	1	1	1	0	0
1	1	1	1	-1	-1	-1	-1	4	1
1	1	-1	-1	-1	-1	1	1	6	2
1	1	-1	-1	1	-1	-1	1	2	3
1	-1	-1	1	1	-1	-1	1	3	4
1	-1	-1	1	-1	1	1	-1	7	5
1	-1	1	-1	-1	1	-1	1	5	6
1	-1	1	-1	1	-1	1	-1	1	7

$$H_8 = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & -1 & -1 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & 1 & -1 & -1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & -1 & 1 & -1 & 1 & 1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & -1 & 1 & -1 & 1 & -1 & 1 & -1 \end{bmatrix} \quad (2.10)$$

In our case the original image is divided into 8x8 blocks, so the H_8 matrix represented above is used in order to get the transformed image.

3, IMAGE QUALITY MEASURES

The standard methods of assessing the quality of digital image compression objectively are Mean Square Error (MSE), Signal-to-Noise Ratio (SNR) or Peak Signal-to Noise Ratio (PSNR). These measures are calculated as follows.

$$MSE = \frac{1}{NM}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left[|f(i,j) - f^*(i,j)|^2\right] \quad (2.11)$$

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(y_i - x_i)^2 \quad (2.12)$$

$$PSNR = 10\ log\left(\frac{2^B - 1}{MSE}\right)^2 \quad (2.13)$$

$$PSNR = 20\ \log\left(\frac{255}{MSE}\right) \quad (2.14)$$

where, y_i is the reconstructed pixel value, x_i is the original pixel value and N is the number of pixels in an image. B represents the number of bits per pixel. Another important objective used for image evaluation is the compression ratio which is calculated as:

$$CompressionRatio(CR) = \frac{Original\ Image\ Size}{Compression\ Image\ Size} \quad (2.15)$$

Compression ratio in terms of number of pixels which can be expressed as:

$$CR(Bits/Pixel) = \frac{Number\ of\ bits\ in\ compressed\ image}{Number\ of\ pixels\ in\ original\ image} \quad (2.16)$$

VIII. RESULTS AND CONCLUSIONS

RESULTS:

The original images used in this study contain 256x256 pixels with a resolution of 8-bit per 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 WHT method for further compression. The reconstructed images using WHT 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 accompanied with a degradation of image quality. The PSNR results are shown on Table 3.1. 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 WHT respectively, as indicated in Figure 3.1.

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CONCLUSIONS:

In this report a hybrid image compression method based on BTC and WHT is shown. The evaluation of performance using objective criteria including MSE and PSNR show that the hybrid method achieves a good compression ratio while keeping a good quality of the reconstructed images. a comparative investigation between the hybrid method and the BTC and WHT proves that the hybrid method performs better than the BTC and WHT.

Table 3.1: The PSNR and MSE measurments of the test images [1].

Test Image	Compression Method					
	BTC		WHT		Hybrid	
	MSE	PSNR	MSE	PSNR	MSE	PSNR
Lena	69.02	29.74	110.89	27.68	119.24	25.31
Camera Man	84.73	25.85	183.75	25.5	196.7	25.2
Bird	22.17	34.67	29.04	33.48	31.96	33.1
CR	**75%**		**50%**		**87%**	

a) Original Test Images

b) Reconstructed Images using BTC

c) Reconstructed Images using WHT

d) Reconstructed Images using BTC/WHT Hybrid Method

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