IMAGE COMPRESSION USING PREDICTIVE EXTENDED BIT OMISSION IN INTERPOLATED ABSOLUTE MOMENT BLOCK TRUNCATION CODING

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Abstract - *The digital image processing is used for various applications. An image compression is one of the applications of the digital image processing. An image compression is a process of converting image data file into smaller files to reduce storage space and transmission time across a network without losing much quality of the image. In multimedia revolution, image compression is a key to rapid growth being made in information technology. It would be difficult to enter image on web pages without compression. Compression provides an appropriate solution to this problem. An image compression algorithms are used to reduce the number of bits required to represent an image. In image compression the reconstructed value of each sample of the image need not exactly match the original image. Depending on the required quality of the reconstructed image, varying degree of loss of information can be accepted. Such techniques are called as lossy image compression techniques. In this image compression scheme based on Interpolated Absolute moment block truncation coding by combing interpolating techniques with omitting some more bits than earlier method which been proposed. Experiment shows that the proposed image compression achieves a low bit rate with better picture quality and lower computational complexity than the similar proposed methods.*

***Key Words*: Digital image, Image compression, BTC, AMBTC, BPP, PSNR**

1. INTRODUCTION

A Digital image [1] is a simply a matrix of pixels of dimension M X N .To represent the coordinates of the image, integer values are used. Thus the values of the coordinates at the origin are (x, y) =(0,0) .The complete M x N digital image can be written in the matrix form.

A Digital image [1] is represented as a discrete two-dimensional array of numbers. Each element in the array is known as pixel (picture element).These pixels are assigned values that correspond to the relative brightness of the tiny portions of the image that they depict. These values are known as gray values.

Interest in digital image processing methods stems from two principal applications areas, improvement of pictorial information for human interpretation and processing of image data for data storage, transmission. A Digital image [1] is composed of a finite number of elements each of which has a particular location and value. These elements are referred to as picture elements or pixels.

1.1 DIGITAL IMAGE PROCESSING

The process of receiving and analyzing visual information by digital computer is called a digital image processing. A digital image [1] may be defines as two-dimensional function, f(x, y) where x and y as spatial coordinates, and the amplitude of f at any pair of coordinates (x, y) are called the intensity or gray level of the image at that point.

Digital image processing [1] is mainly used with extracting useful information from images. This is done by computers, with the little or no human intervention. Image processing algorithms may be placed at three levels. At the lowest level some techniques which deal directly with the raw noisy pixel values. Digital image processing [1] has a broad spectrum application such as space crafts, image transmission, remote sensing, finger print analyse and storage for business and medical processing. A Digital image is a discrete two dimensional (2D) array f(x, y), containing M rows and N columns where (x,y) are discrete coordinates and of dimension M X N.The number of bits b required to store a digital image is:

b=M*N*k (1.1)
Where M=N, the equation (1.2) becomes,
b=n2k (1.2)

When an image can have 2k gray levels, It is commonly referred as " k bit image". For example image with 256 possible gray levels values is called an 8 bit image.

2. IMAGE COMPRESSION

Image compression [14] is the applicable of data compression on digital images. The objective is to reduce redundancy of the image data in order to able to store or transmit data in an efficient form .Image compression may be lossy or lossless. Modern computers employ graphics extensively. Many system operations and applications provide graphical user interface (GUI) which makes it easier to use the program and to interpret the results displayed. Two dimensional intensity arrays suffer from three principal types of data redundancy that can be identified.

1. Coding Redundancy-Each piece of information or event is assigned a sequence of code symbols, called a code word. The number of symbols in each code word is its length

2. Spatial redundancy-it is the correlation between different color planes or spectral bands.

3. Temporal redundancy-it is the correlation between adjacent frames in a sequence of images (in video applications).

4. Irrelevant information-Most 2D intensity arrays contain information that is ignored by the human visual system .It is redundant in the sense that it is not used.

IMAGE TYPE	RESOLUTION PIXEL	BITS / PIXEL	UNCOMPRESSED SIZE (B for byte)	TRANSMISSION TIME (using a 28.8k modem)
Gray scale	512 x 512	8 bpp	262 KB	1 MIN 13 SEC
Color image	512 x 512	24 bpp	786 KB	3 MIN 39 SEC
Medical image	2048 x 1680	12 bpp	5.16 MB	23 MIN 54 SEC
SHD image	2048 x 2048	24 bpp	12.58 MB	58 MIN 15 SEC

Table -1 File size and Transmission time for different images.

Ideally, an image compression [14] technique removes redundant and/or irrelevant information, and efficiently encodes what remains. Practically, it is often necessary to throw away both non redundant information and relevant information to achieve the required compression. In either case, the trick is finding methods that allow important information to be efficiently extracted and represented. Lossy methods are especially suitable for natural images such as photos in application where minor loss of fidelity is acceptable to achieve a substantial reduction in bit rate. Lossless compression methods especially when used at low bit rates, introduce compression artifacts.

2.1Lossy and lossless compression

Lossy (Irreversible) Compression

The reconstructed image contains degradations with respect to the original image. Much higher compression ratios compared to lossless. The term visually lossless is often used to characterize lossy compression schemes that result in no visible degradation under a set of designated viewing conditions.

Lossless (Reversible) Compression

• The image after compression and decompression is identical to the original.

• Only the statistical redundancy is exploited to achieve compression.

• Data compression techniques such as LZW or LZ77 are used in GIF, PNG, and TIFF file Formats.

• Image compression techniques such as lossless JPEG or JPEG-LS perform slightly better.

• Compression ratios are typically ~2:1 for natural imagery but can be much larger for document images.

2.2 VARIOUS IMAGE COMPRESSION ALGORITHMS

Image compression [14] may be lossy or lossless. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics. This is because lossy compression methods, especially when used at low bit rates, introduce compression artifacts. Lossy methods are especially suitable for natural images such as photographs in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences may be called visually lossless.

Methods for lossless image compression are:

• Run-length encoding - used as default method in PCX and as one of possible in BMP, TGA, TIFF

• DPCM and Predictive Coding • Entropy encoding

• Adaptive dictionary algorithms

• Deflation - used in PNG, MNG, and TIFF • Chain codes

Methods for lossy compression:

• Lossy Predictive Coding • Transform Coding

• Zonal coding

3. EXISTING SCHEME IN COMPRESSION

3.1 ABSOLUTE MOMENT BLOCK TRUNCATION CODING

Absolute Moment BTC (AMBTC) [2] that preserves the higher mean and lower mean of a block.

AMBTC ALGORITHM

The AMBTC algorithm involves the following steps:

• Step 1: An image is divided into non-overlapping blocks .The size of a block could be
(4 x 4) or (8 x 8), etc.

• Step 2: Calculate the average gray level of the block (4x4)

• Step 3: Pixels in the image block are then classified into two ranges of values. The upper range is those gray levels which are greater than the block average gray level (x) and the remaining brought into the lower range. The mean of higher range and the lower range are calculated as: Here k is the number of pixels whose gray level is greater than.

$\bar{X}_H = \frac{1}{K}\sum_{x_i \geq \bar{x}}^{n} X_i$ (1.3)

$\bar{X}_L = \frac{1}{n-k}\sum_{x_i < \bar{x}}^{n} x_i$ (1.4)

• Step 4: Binary block, denoted by B, is also used to represent the pixels. We can use "1" to represent a pixel whose gray level is greater than or equal to x and "0" to represent a pixel whose gray level is less than x . The encoder writes XH, XL. Then the total number of bits required for a block is 8+8+16 =32 bits. Thus, the bit rate for the AMBTC algorithm is 2 bpp.

$$B=\begin{cases}1 & X_i \geq X \\ 0 & X_i < \bar{X}\end{cases} \quad (1.5)$$

• Step 5: In the decoder, an image block is reconstructed by replacing the `1' s with and the '0''s by In the AMBTC, we need 16 bits to code the bit plane which is same as in the BTC. But, AMBTC requires less computation than BTC.

$$B=\begin{cases}1 & B=0 \\ 0 & B=1\end{cases} \quad (1.6)$$

AMBTC has several advantages over BTC one advantage is in the case that the quantizer is used to transmit an image from transmitter to a receiver, it is necessary to compute at the transmitter the two quantities, the sample mean and the sample standard deviation for BTC and sample first absolute central moment for AMBTC. When we compare the necessary computation for deviation information, we will see that in case of standard BTC it is necessary to compute a sum of m values and each of them will be squared while in case of AMBTC it is only necessary to compute the sum of these m values. Since the multiplication time is several times greater than the addition time in most digital processors, thus using AMBTC the total calculation time at the transmitter is significantly reduced.

IMAGE QUALITY MEASUREMENTS

An image quality measurement [7] play important roles in various image processing applications. This evaluation should be done in such a way to be able to compare results against other image compression techniques. The image quality focused on the objective measurements such as Peak Signals to Noise Ratio (PSNR).

PEAK SIGNALS TO NOISE RATIO (PSNR)

The PSNR is mostly commonly used as measures of quality of reconstructed of lossy compression. This is a qualitative measure which is based on the Mean-Square-Error (MSE) [12] of the reconstructed image. If the reconstructed image is closer to the original image then the MSE is small. Peak signals and Noise Ratio(PSNR)[13] avoid this problems by scaling the MSE according to the image range. PSNR defined as:

$$MSE=\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[y(i,j)-x(i,j)]^2 \quad (1.7)$$

$$PSNR=20\log 10\,\frac{(255)^2}{MSE} \quad (1.8)$$

Hence represents the compressed image and represents the Original image. PSNR and BPP value for BTC and AMBTC method have been tabulated.

Images	BTC		AMBTC	
	Bpp	PSNR	Bpp	PSNR
Lena	2.0	31.46	2.0	33.25
Jet	2.0	28.86	2.0	31.42
Zelda	2.0	34.42	2.0	36.74
Pepper	2.0	30.38	2.0	33.44
Baboon	2.0	37.14	2.0	36.44
Average	2.0	32.45	2.0	34.26

Table:2 PSNR and BPP value for BTC and AMBTC method

3.2 INTERPOLATED AMBTC

In this technique [22] half (8 bits) of the number of the bits in the bit plane of extended predicted IAMBTC is dropped at the time of encoding as in Figure. In decoding phase the dropped bits recovered by taking the arithmetic mean of the adjacent pixel values as given in equation.(1.17).

X1	**X5**	X9	**X13**
X2	X6	**X10**	X14
X3	**X7**	X11	**X15**
X4	X8	**X12**	X16

Table 3: The pattern of dropping bits. The bold faced bits are dropped.

This technique requires only 8 bits to store the bit plane the steps involved in the compression scheme are as follows:

ALGORITHM

STEP 1.Divide the given image into a set of non overlapping blocks, x of size n=4*4 pixels STEP 2.Encode the blocks stating from left to right and top to bottom sequence.

STEP 3.If the block is in first row or first column then go to step5. STEP 4.Check the similarity of the neighboring blocks.

STEP 5.Compute the block mean, lower mean x and higher mean x, for the block.

STEP 6.Construct the bit plane by replacing the pixels with values greater than or equal to the mean x by '1' and the rest of the pixels by '0'

STEP 7.Drop a pattern of bits shown in the figure .Encode the block by the remaining bits along With the lower mean x and higher mean x

STEP 8.Go to step3 until all the blocks are processed.

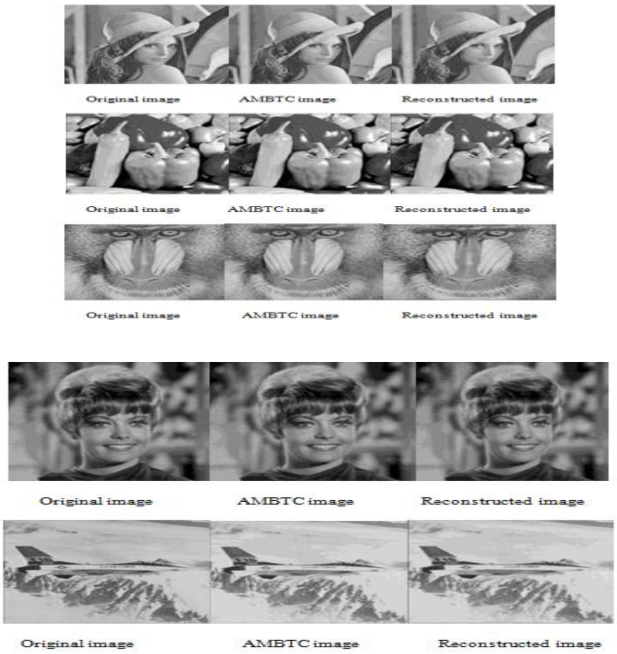

Fig -1 Standard and compressed images

4. PROPOSED METHOD

The proposed image compression scheme based on the Interpolated Absolute moment block truncation [19] coding. An AMBTC [2] is a very simple image compression coding. the basic idea of AMBTC is to divide the image into nxn (normally 4x4) non overlapping pixel block and quantize the pixel in a block to the different values of H(the higher mean) and L(lower mean).

INTERPOLATIVE TECHNIQUE

To further reduce the bits per pixels,10 bits are omitted for an single block are omitted from the 16 bit plane block as shown in the figure .In the decoding stage the omitted pixels are reconstructed through the interpolation equation as shown in the figure. In this given Figure omitted bits in specified in italic.

X1	X2	X3	X4
X5	X6	X7	X8
X9	X10	X11	X12
X13	X14	X15	X16

TABLE 3 Omitted Bits in Single Block

Proposed Equation

$X_i'=1/2(x_{i+1}+x_{i+4})$ or i=1
$X_i'=1/2(x_{i-2}+x_{i-1})$ or i=3
$X_i'=1/3(x_{i-3}+x_{i-2}+x_{i-1})$ or i=4
$X_i'=1/2(x_{i-1}+x_{i+1})$ or i=6
$X_i'=1/3(x_{i-3}+x_{i-2}+x_{i-1})$ or i=8
$X_i'=1/2(x_{i-1}+x_{i+1})$ or i=11
$X_i'=1/3(x_{i+1}+x_{i+2}+x_{i+3})$ or i=9
$X_i'=1/2(x_{i-4}+x_{i-1})$ or i=16
$X_i'=1/2(x_{i+1}+x_{i+2})$ or i=14
$X_i'=1/2(x_{i-4}+x_{i+1})$ or i=13

In the proposed method gave modification of the interpolation to reduce the bit rate to less than 1.50 bits per pixel. It requires only 6 bits to store the bit plane. The detailed steps involved in compression process are as follows:

ALGORITHM

• Step1: Divide the image into small non overlapping block size 4x4 pixels.

• Step2: Compute the mean , higher mean and lower mean for the block.

• Step3: Construct the bit plane by replacing the pixels with the value greater than or equal to the mean by '1' and the rest of the pixels by '0'.

• Step4: Continue the process until the blocks are completed.

• Step5: Drop a pattern of bits as shown in figure.

• Step6: The bit plane reconstructed through the interpolation equation.

• Step7: Continue the process until the blocks are completed.

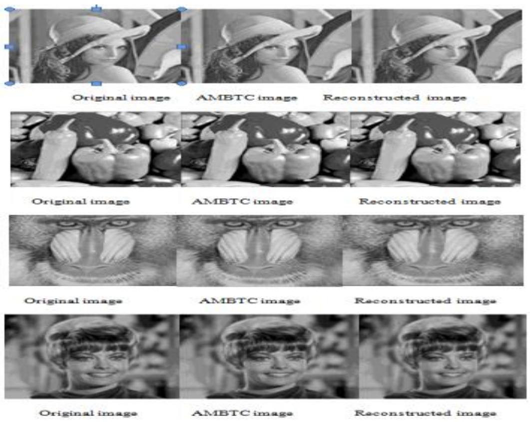

Fig -2 Compressed and Reconstructed image

PSNR and BPP value for AMBTC and Interpolative and proposed schemes are depicted below.

IMAGES	AMBTC		INTERPOLATED AMBTC		PROPOSED IAMBTC	
	BPP	PSNR	BPP	PSNR	BPP	PSNR
BABOON	2	31.33	1.5	26.88	1.375	21.53
JET	2	31.42	1.5	31.19	1.375	28.02
LENA	2	33.25	1.5	34.59	1.375	32.36
ZELDA	2	36.74	1.5	36.65	1.375	33.33
PEPPERS	2	33.44	1.5	25.16	1.375	28.61

Table -4: BPP/PSNR Values for different schemes.

5. RESULTS AND DISCUSSION

The proposed method is tested with Lena, Baboon, jet, peppers and Zelda images. The input images taken for the study are given. The results obtained in terms of PSNR and bpp with the proposed method are compared with that of the BTC [19] and AMBTC [2] methods in Table. The results are generated for different kinds of standard and other kinds of images.

Fig - 3 Input images taken for study

To evaluate the performance of the proposed image compression scheme, we use the mat lab tool [5] to exhibit the process of five standard gray scale images 512x512 pixels "Lena", "Pepper" , "Baboon", "Zelda", "jet". Which are shown in the figure. We observe that proposed scheme achieves compression with acceptable image quality .Even though it is a lossy method; it is acceptable for human visual system.

The AMBTC contains 2 bits per pixel for the standard image Lena. Whereas the PSNR is 33.25.the measures BPP and PSNR provide the adequate image quality. Likewise all the standard images contains BPP and its corresponding PSNR value ,But in our proposed method gives the BPP is 1.375 for the standard image Lena with PSNR value of 32.36 .when compared to the AMBTC the quality of an image will become very high. The standard image Baboon which takes BPP as 1.375 and the PSNR value as 21.53.It has the low computational complexity and good image quality. The image like "jet" "Lena" "Pepper", "Baboon", "Zelda" gradually increase the PSNR value such as 3,32,28,21,33, respectively. An average image quality of with PSNR value of 28.768 with the average image bits per pixel of 1.375 can be achievable using this proposed method.

IMAGES	AMBTC (16BIT)		INTERPOLATED AMBTC (8 BIT)		PROPOSED IAMBTC(6 BIT)	
	BPP	PSNR	BPP	PSNR	BPP	PSNR
BABOON	2	31.33	1.5	26.88	1.375	21.53
JET	2	31.42	1.5	31.19	1.375	28.02
LENA						
ZELDA	2	33.25	1.5	34.59	1.375	32.36
PEPPERS	2	36.74	1.5	36.65	1.375	33.33
	2	33.44	1.5	25.16	1.375	28.61
AVERAGE	2	33.236	1.5	30.894	1.375	28.768

Table -5: Average BPP and PSNR Values for various schemes

6. CONCLUSIONS

A two-stage compression is achieved with the proposed method. In the first stage, the bit rate is reduced by categorizing the blocks into high detail and low detail blocks. The interpolation technique is used in the second stage to reduce the bit-rate further. 75% of compression is achieved with the existing methods BTC and AMBTC and interpolation technique. A higher compression rate is achieved with the proposed method, which is a significant improvement. The quality of reconstructed images depends on the selection of bits to be selected for the omission. This technique is best suitable for hand-held devices and may also be extended to colour images. A low bit rate image compression scheme by combining prediction, bit plane omission, and interpolative techniques and by extending the Interpolative AMBTC has been proposed .Experimental results of our scheme on standard images show that an average bit rate of 28.768 is achievable. Our scheme gives lower bpp and little psnr values then the methods of existing ones.

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