IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Vol. 9, Issue 6, June 2020

Evaluation and Comparison of DDBTC using HVPSNR

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Abstract: Image compression is the technique used to reduce irrelevance and redundancy of the image data in order to be able to store as well as transmit data in an efficient form. Image compression techniques may be lossy or lossless. Among the various image compression techniques, BTC [Block Truncation Coding] belongs to lossy type of image compression technique especially for greyscale images. The procedure consists of steps which divides the original image into various blocks and then uses quantizers to reduce the number of grey levels in each block while maintaining the same mean and standard deviation. BTC technique is a quite old technique but a highly efficient compression technique. BTC suffers from certain key problems such as inherent artifacts, blocking effect and false contour. Through the proposed DDBTC method, namely Dot-Diffused BTC (DDBTC), we try to deal with those problems. The parallelism process of the dot diffusion is properly exploited to provide excellent processing efficiency. Similarly, excellent image quality is assured through co-optimizing the class matrix and diffused matrix of the dot diffusion. According to the experimental results using HVPSNR [Human-Visual Peak Signal-To-Noise Ratio], the proposed DDBTC is found to be superior to the original BTC techniques.

Keywords: Image Compression, DDBTC, HVPSNR, Dot Diffused, False contour.

I. INTRODUCTION

Block Truncation Coding (BTC), which was proposed by Delp and Mitchell in 1979, is a technique for image compression. The basic concept involved is to divide the original image into many non-overlapped blocks. Each block is then denoted using two distinct values. These two values preserve the first and second moment characteristics of the original block. During the transmission of the compressed image a pair of values (2 × 8 bits/block) and the corresponding bitmap which addresses the arrangement of the two values in each block (1 bit/pixel) are transmitted. Although coding gain of BTC cannot provide a comparable coding gain to other modern compression techniques, such as JPEG or JPEG2000, the coding complexity of the BTC is much lower than the modern compression techniques.

The dot diffusion method enjoys the advantage of parallelism for digital halftoning unlike the error diffusion method. Still image quality presented by error diffusion method is still regarded as superior to other existing methods. It is shown how the dot diffusion method can be improved by optimization of the so called class matrix. By comparing the human visual characteristics, it is clear that optimization consistently results in images comparable to error diffusion, without giving up the advantage of parallelism.

II. PROBLEM DEFINITION

Two key problems addressed in this paper include blocking effect and false contour of the existing technique. The dot diffusion, employed is to cooperate with BTC and to yield the proposed dot-diffused BTC (DDBTC) image compression technique.

III. LITERATURE SURVEY

In this section I have tried to explain various existing image compression techniques and their comparisons with the proposed technique. The two values preserve the first and second moment characteristics of the original block in traditional BTC. When a BTC image is transmitted, a pair of values (2 × 8 bits/block) and the corresponding bitmap which addresses the arrangement of the two values in each block (1 bit/pixel) are required. In the previous studies, many approaches have endeavored to improve BTC.[2]
The first category of such approaches involves preserving the moment characteristic of the original image. Blocking effect and false contour are the key problems of such a method.

Now for the next method where a modified error diffusion is incorporated. The technique diffuses error into its neighboring pixels. Image quality is much better than BTC. Error diffusion (EDF) enjoys the benefit of diffusing the quantized error into neighboring pixels but suffers from prolonged processing time. [3]

Some famous halftoning-based BTC techniques have been proposed, for instance Guo[4] exploited the error value of the image thereby known as error-diffused BTC (EDBTC). In EDBTC, it uses look-up-table dither arrays to improve the processing efficiency.

Udpikar and Raina proposed a modified BTC algorithm, which preserves only the first-order moment. Moment values were given higher values than three, inorder to preserve quantizers and to get a family of moment. The second category involves improving image quality and reducing blocking effect. Kanafani et al. decomposed images into homogeneous and non-homogeneous blocks and then compressed them using BTC or vector quantization (VQ). Block classification was achieved by image segmentation using the expectation-maximization (EM) algorithm.

In order to effectively improve image quality some special BTC based halftoning techniques were developed. When the human visual system is involved, the halftoning-based BTC schemes can effectively ease the inherent annoying blocking effect and the false contour artifacts of the traditional BTC. The difference between the halftoning-based BTC and traditional BTC is similar to the halftoning and coarse quantization with a fixed threshold value.

IV. PROPOSED SYSTEM

Traditional BTC undergoes certain improvements to reach out to the proposed DDBTC. The new technique achieves image compression by exploiting the dot diffusion, and excellent image quality through the class matrix and diffused matrix of the dot diffusion. In order to have a clear picture traditional algorithm will be firstly introduced.

Given an original image of size P × Q, and which is divided into many non-overlapped blocks of size M × N, then each block can be processed independently and eventually represented by two values. The additional excellent parallelism advantage is yielded through the independent processing property.

To begin with, divide the image into blocks. Then the corresponding moment values (first-moment, second-moment, and the corresponding variance) are obtained as follows:

$$\overline{x} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} x_{i,j}$$

$$\overline{x^2} = \frac{1}{M \times N} \sum_{i=1}^{M} \sum_{j=1}^{N} x_{i,j}^2$$

$$\sigma^2 = \overline{x^2} - (\overline{x})^2$$

The grayscale pixel value in a block are denoted using the variables Xi,j . BTC being one-bit quantizer with a threshold x to binarize the block, the block is then replaced by bitmap.

$$h_{i,j} = \begin{cases} 1, & \text{if } x_{i,j} \geq \overline{x} \\ 0, & \text{if } x_{i,j} < \overline{x} \end{cases} \qquad y_{i,j} = \begin{cases} b, & \text{if } h_{i,j} = 1 \\ a, & \text{if } h_{i,j} = 0' \end{cases}$$

In order to preserve the first and second-moments of a block, the original value is substituted by its high or low mean values, the following two equations should be maintained.

$$m\bar{h} = (m - q)a + qb$$

$$m\bar{h}^2 = (m - q)a^2 + qb^2$$

where m = $M \times N$, and q denotes the number of pixels greater than x. The high and low means can be evaluated as follows:

$$a = \overline{x} - \sigma\sqrt{\frac{q}{m-q}}$$

$$b = \overline{x} + \sigma\sqrt{\frac{m-q}{q}}$$

IJARCCE
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V. ALGORITHM OF DDBTC

STEP 1 : Divide the image X into non-overlapping blocks of equal size.

STEP 2: Calculate $\overline{X}$ of each block using the above-mentioned formula.

STEP 3: Calculate the maximum and minimum values that is high and low values, of each block. Again the same formula is used as that of BTC.

STEP 4: For each block, the processing order of pixels is defined by the following class matrix and the respective diffused matrix of the given 8x8 class matrix :

(a) 8 × 8 Class Matrix

42	47	46	45	16	13	11	2
61	57	53	8	27	22	9	50
63	58	0	15	26	31	40	30
10	4	17	21	3	44	18	6
14	24	25	7	5	48	52	39
20	28	23	32	38	51	54	60
19	33	36	37	49	43	56	55
12	62	29	35	1	59	41	34

(b) Diffused Matrix for the 8 × 8 Class Matrix

0.27163	1	0.27163
1	x	1
0.27163	1	0.27163

STEP 5: Create bit map for the image using the following formula:

$$h_{i,j} = 1, \text{ if } x_{i,j} \geq \overline{X}$$
$$\text{or } 0 \text{ if } x_{i,j} \leq \overline{X}$$

STEP 6 : Calculate threshold value as follows:

$$y_{i,j} = x_{max}, \text{ if } h_{i,j} = 1$$
$$\text{or } x_{min}, \text{ if } h_{i,j} = 0$$

STEP 7: Calculate error value as follows:

Error value = Original value – Threshold value

STEP 8: Diffused error accumulated from neighboring pixels is calculated:

$$v_{i,j} = x_{i,j} + x'_{i,j}, \quad \text{where } x'_{i,j} = \sum_{(m,n)\in R} \frac{e_{i+m,j+n} \times k_{m,n}}{sum}$$

STEP 9: Consider the next pixels in the block and repeat the above steps in a recursive manner until the last block.

STEP 10: Likewise complete the entire image and the output image will be Y.

STEP 11: Using HVPSNR quality of image is assessed.

$$\text{HPSNR} = 10\log_{10} \times \frac{P \times Q \times 255^2}{\sum_{i=1}^{P}\sum_{j=1}^{Q}\left[\sum_{(m,n)\in R} w_{m,n}\left(x_{i+m,j+n} - y_{i+m,j+n}\right)\right]^2}$$

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The above mentioned steps can be diagramatically represented as follows:

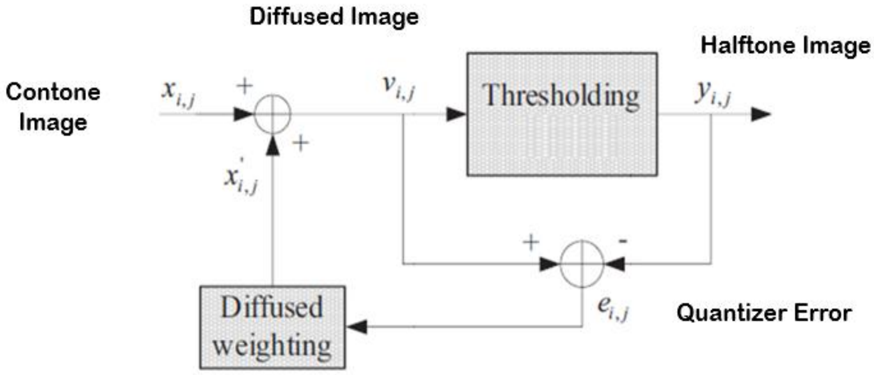

Fig 1: Diagrammatic representation of proposed DDBTC [1]

VI. IMPLEMENTATION PROCEDURE

The procedure of the co-optimization algorithm, and the detailed steps are explained below.

1. The Mese-Vaidyanathans class matrix [5] is adopted as the initial Class matrix (C) in this optimization.
2. Suppose the coefficients in the class matrix are collocated as a 1D sequence. Successively swap each member C(i) in the class matrix with one of the other 63 members C(j) (suppose the size of the class matrix is 8 × 8), where i=j
3. Generate all potential diffused weightings km, n K by adjusting 106 within a range of 0 to 1. During the generation of diffused weighting, the nearest vertical and horizontal weights are fixed as 1, and the other four diagonals are kept at the same value.
4. Evaluate the average HVPSNR with eight natural grayscale images of size 512 512, Lena, Mandrill, Peppers, Milk, Tiffany, Airplane, Lake, and Shuttle, with swapped class matrices (Step 2) and switched diffused weightings (Step
5. The highest DDBTC image quality by max HVPSNR (swapped C, switched K) is achieved with the successive combination of both swapped class matrices and switched diffused weightings is capable of achieving. These are then employed as the new class matrix and diffused matrix candidates.
6. Select another member C(i), and perform Steps 2 to 5.
7. Compare if all swapped class matrices and switched diffused weightings cannot improve HVPSNR, if so then terminate this optimization process. Otherwise, perform Steps 2 to 6.

The above-mentioned images as follows:

Fig 2: Input Images

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ISSN (Print) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

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VII. PERFORMANCE EVALUATION

A fundamental task in many image processing techniques is the visual evaluation of the processed data. For evaluating image quality mainly two methods are carried out, one is subjective and the next is objective method. Subjective evaluation is inconvenient, time-consuming and expensive. Whereas the objective evaluation uses automatic algorithms to assess the quality of the image without human interfere. Some of the objective image quality metrics include MSE, PSNR, and SSIM. In this project the metric used to evaluate the quality of compressed image is HPSNR.
Experimental results are summarized in this section. The performance of the proposed DDBTC technique is analyzed against three other BTC techniques: BTC, JEDBTC and FEDBTC. Average objective image quality comparison is performed over here. When the following image was given as input:

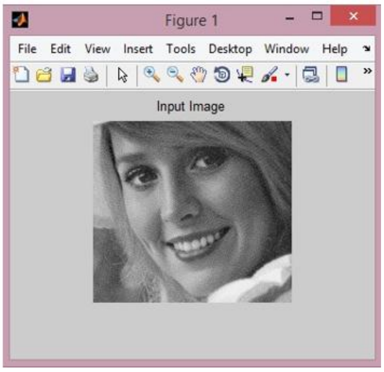

Fig 3: Input Image

Output images obtained after applying different types of compressions for the same image are as follows:

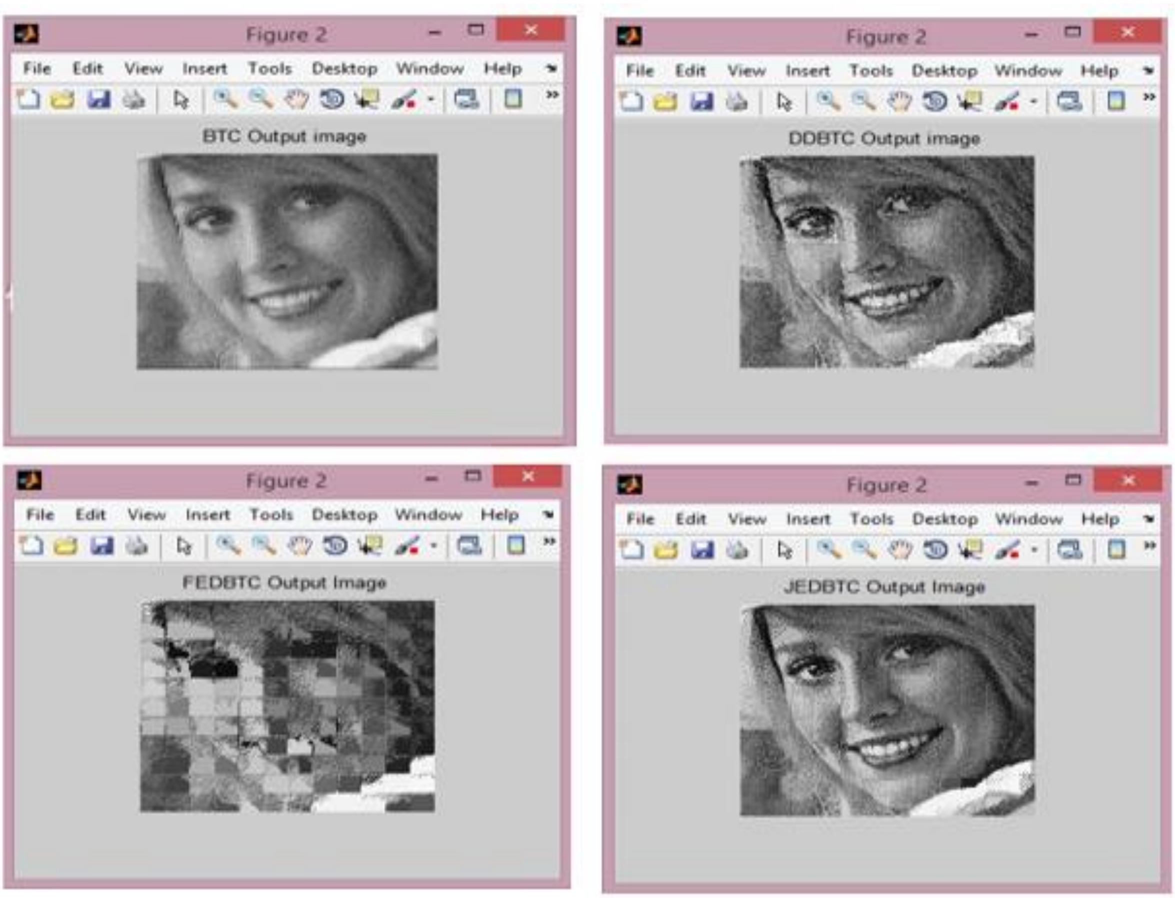

Fig 4 : Cluster of Output Images

ISSN (Online) 2278-1021
ISSN (Print) 2319-5940

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The table of performance evaluation according to HVPSNR values for every image given as input and their respective output is as follows:

Table I : Signal to Noise ratio of various images

IMAGE	BTC	JEDBTC	FEDBTC	DDBTC
ELAINE	41.24	50.74	48.77	62.86
FRUITS	48.22	50.84	41.04	55.75
LION	44.58	46.66	39.29	47.93
SQUIRREL	45.49	49.09	39.62	55.86
MANDRIL	40.18	48.83	43.61	53.99
CAR	41.46	51.04	43.17	51.32
HAND	44.30	46.91	46.29	50.02
FLOWER	37.55	45.90	34.62	47.34
DEER	43.98	43.80	38.10	45.24
SHEEP	41.50	50.63	43.93	56.38

From the above table it is very much clear that DDBTC based compression technique results in images with high HVS-PSNR values. As HVS-PSNR is inversely proportional to the noise, DDBTC is proved to be the best among the remaining three BTC techniques.

VIII. CONCLUSION

Evaluation and Comparison of DDBTC using HVPSNR was successfully carried out. The focus was on dot-diffused based BTC image compression technique which yielded an excellent image quality (even superior to that of the EDBTC) and artifact free results (inherent blocking effect and false contour artifacts of the traditional BTC) simultaneously. The performance can be attributed to the use of the inherent parallelism of the dot diffusion and the proposed co-optimization procedure over the class matrix and diffused matrix. As documented in the performance evaluation section, the proposed DDBTC is superior to EDBTC in terms of image quality and processing efficiency, and has much better image quality. Thus, the proposed DDBTC has important values and impacts in prospective highly efficient or low powerless compression communication and related application.

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BIOGRAPHY

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