International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-2 Issue-1, March 2013

Enhanced Min-Max Procedure based on Block Truncation Coding for Image Compression

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Abstract: ***In this paper, we have proposed a method based on Block Truncation coding (BTC) for image compression. The existing Min-Max procedure based on BTC is enhanced to further improve the quality of the reconstructed images. Images are decoded using three quantization levels by extending the size of the bitplane. The three quantization levels being Minimum, Maximum and the average of both are preserved for each block. Experiments were carried over standard images like Lena, Cameraman, Boats, Bridge and Baboon. For all images, the proposed method outperforms the existing method in terms of PSNR values.***

Index Terms: ***BTC, Image Compression, MinMax, Quantization Levels, Bitplane, PSNR.***

I. INTRODUCTION

Image Data Compression is concerned with minimization of the number of information carrying units used to represent an image, perhaps the simplest and most dramatic form of data compression is the sampling of the band limited images [1]. Image Compression is of two types: Lossy and Lossless [2] & [3]. Lossless techniques are suitable for medical imaging where a small loss in data may even lead to loss of human lives. Whereas Lossy image compression techniques lead to loss of data with higher compression ratio[4] but does not make much difference between the original and the reconstructed images for the Human Visual System (HVS). Block Truncation Coding (BTC) [5], Vector Quantization (VQ) [6], Discrete Cosine Transform (DCT) [7] and Discrete Wavelet Transformation (DWT) [8] are some of the Lossy image compression methods. Of the above techniques, BTC is based on the conservation of statistical properties. Due to its simplicity, BTC is used widely. Many image compression techniques have been developed based on BTC [9]. It achieves two bits per pixel (bpp) with less number of computations.

Lema and Mitchell [10] presented a simple and fast variant of BTC called Absolute Moment Block Truncation Coding (AMBTC). It preserves the higher mean and lower mean of the blocks. However the bit rate achieved is 2 bpp, which is the same as that of the BTC. But there is improvement in the quality (PSNR) of the reconstructed images. In order to reduce the bit rate, several techniques have been used to code the statistical moments and the Bit Plane of BTC.

Revised Manuscript Received on 30 March 2013.
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[11] Min-Max is another variant of BTC to improve the quality of the reconstructed images. In our proposed method, the existing Min-Max procedure is enhanced by extending the size of the bit-plane to improve the quality of the reconstructed images at the cost of bit-rate. In this technique, the input image is split up into small blocks of size 4 x 4 pixels. The Maximum and Minimum pixel values of a block are selected initially for a block. These two values are iteratively improved in order to set the two quantization levels for each block. The performance of the image compression technique is measured by computing the Mean Square Error (MSE). MSE gives the difference between the original image and the reconstructed image and is calculated using the equation (1)

$$MSE = \frac{1}{M}\sum_{i=1}^{m}\left(x_i - \bar{x}\right)^2 \quad (1)$$

where M is the number of elements in the image. The PSNR (Peak Signal to Noise Ratio) is the quality of the reconstructed image and is the inverse of MSE. The PSNR is defined as follows:

$$PSNR = 10\log_{10}\left[(2^n - 1)^2 / MSE\right] \quad (2)$$

Where n is the number of gray levels in an image. An Enhanced min max procedure is proposed in this paper. The paper is continued as follows: In Section 2, the existing algorithms: BTC and Min-Max are explained. In Section 3, the proposed method is described. In Section 4, the results are discussed and the Conclusion is given in section 5.

II. PROCEDURE FOR PAPER SUBMISSION

A. BTC Algorithm [11]

In BTC algorithm, in the Encoding stage, the input image is divided into non-overlapping blocks of size 4*4 pixels. For each block, the mean $\bar{x}$ is computed using equation (3).

$$\bar{x} = 1/m\sum_{i=1}^{m} x_i \quad (3)$$

where xi represents the ith pixel value of the block and m is the total number of pixels in the block. The Standard deviation σ is computed using the equation (4)

$$\sigma = \sqrt{\left(\bar{x} - x_i\right)^2} / m \quad (4)$$

The Bit plane is generated using the mean value using the equation (5)

$$\text{If } x_i \geq \bar{x} \text{ then 1 else 0} \quad (5)$$

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Two quantizers q1 and q2 are computed and preserved for each block using the equations (6) and (7).

$$q_1 = \bar{x} + \sigma\left(\sqrt{p/m-p}\right) \quad \text{for } x_i \geq \bar{x} \qquad (6)$$

$$q_2 = \bar{x} - \sigma\left(\sqrt{m-p/p}\right) \quad \text{for } x_i \prec \bar{x} \qquad (7)$$

In the decoding stage, each 1 in the bit-plane is replaced with q1 and the 0 is replaced with q2.

B. *Min-Max Procedure [12]*

In Min-Max procedure, for each block, the minimum (a) and the maximum (b) pixel values are identified. The average value t is computed using the equation (8)

$$T = (a+b)/2 \qquad (8)$$

Two values a' and b' are computed using the equations (9) & (10)

$$a' = 1/(m-q) * \sum x_i \qquad (9)$$

Where all xi >= t, m is the number of pixels in the block and q is the number of pixels whose pixel value is less than t.

$$b' = 1/q \sum x_i \qquad (10)$$

Where all xi < t. Min-Max is an iterative procedure and is repeated until a' and b' become equal to a and b respectively. a' and b' become the quantizers for reconstructing the images in Min-Max procedure.

III. PROPOPSED METHOD (EMM)

In BTC and Min-Max procedures, only two quantizers are used to decode the compressed image. In the proposed method (Enhanced Min-Max), the existing, instead of two quantizers, three values are used to decode the image. This improves the quality of the reconstructed images significantly. The increase in the number of quantizers also increases the number of bits required to represent the elements of bit-plane. In BTC and Min-Max procedures, only 1 bit is required to represent the bitplane element, but in the proposed method, two bits are required. The bit-plane elements are generated using the equation (11).

$$\left.\begin{array}{l}\text{if xi is nearer to a', the element is coded as 01.}\\ \text{if xi is nearer to b', the element is coded as 10.}\\ \text{if xi is closer to the average of a' and b',}\\ \text{the element is coded as 11.}\end{array}\right\} \qquad (11)$$

In the decoding stage, all 00s are replaced with a', 01s are replaced with b' and the 10s are replaced with the average of a' and b'. As three values are used to decode the compressed block, the quality of the reconstructed block is increased by a significant level.

Encoding Algorithm

Step1: Input the image size *n x n* pixels

Step2: Divide the image into N blocks, each of size 4 x 4 pixels.

Step3: Compute the Min and Max values .

Step4: Generate the bitplane as follows:

- Compute the average of minimum and maximum values
- If the individual pixel value is closer to
  - i. Min , code it as 01
  - ii. Max , code it as 10
  - iii. Avg , code it as 11

Step5: The compressed image is transmitted in the form of bit-plane along with two quantizers : Min and Max.

Decoding Algorithm

Step1: Input the bitplane and the two quantizers : Min and Max

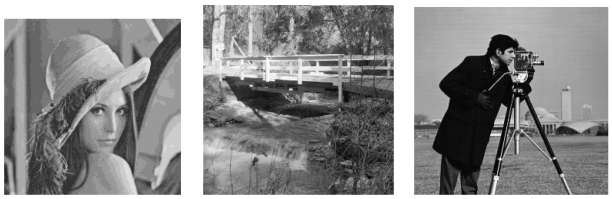
Step2: Compute the Avg (average of Min and Max)

Step3: Reconstruct the image as

- i. .If the element is 01, code it as Min
- ii.. If the element is 10,code it as Max
- iii. If the element is 11, code it as Avg

IV. RESULTS AND DISCUSSION

The experiment was done with five different standard images Lena, Cameraman, Boats, Bridge and Baboon of varying gray shades. The results obtained with the three methods: BTC, Min-Max and the proposed methods are compared in terms of bpp and PSNR. Since the size of the bit-plane is doubled, the compression achieved is less when compared to BTC and Min-Max. But the quality of the reconstructed images has been significantly raised. The images taken for the study are given in Fig.-1.



(a) Lena (b) Bridge (c) Cameraman

(d) Boats (e) Baboon

Fig.-1 Images Taken for the Study

In Table-1, the results generated in terms of bits per pixel (bpp) and PSNR are compared for the BTC, Min-Max and the proposed method (Enhanced Min-Max – EMM). For all the images, the quality of the reconstructed images is increased with the proposed (EMM) method. On an average, the PSNR is raised by 1.59.

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TABLE-1: Comparison of BTC, Min-Max and the Proposed methods with respect to bpp and PSNR.

Image	BTC		Min-Max		EMM	
	bpp	PSNR	bpp	PSNR	bpp	PSNR
Lena	2	30.05	2	34.06	3	35.58
Bridge	2	27.91	2	29.64	3	30.72
Cameraman	2	26.09	2	32.05	3	34.47
Boats	2	28.34	2	33.02	3	35.08
Baboon	2	32.91	2	35.12	3	36.00
Average	2	29.06	2	32.78	3	34.37

The images compressed and reconstructed using the BTC, Min-Max and the proposed method (EMM) are given in Figure 2 for visual comparison along with the PSNR values.

(a) BTC
PSNR: 30.05

(b) Min-Max
PSNR: 34.06

(c) EMM (Proposed)
PSNR: 35.58

Fig.2: Comparison of Reconstructed Images using BTC, Min-Max and the Proposed Methods.

V. CONCLUSION

We have presented a new algorithm for compression of gray scale images which achieves good result than the existing methods BTC and Min-Max procedures. The existing Min-Max procedure is enhanced by increasing three quantization levels. For all the images, the PSNR is raised by the proposed method (EMM). The proposed method can also be applied to color images and is suitable for hand held devices.

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