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Image Compression Using Block Truncation Coding

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Abstract: The block truncation coding (BTC) algorithm uses a two-levels (one-bit) nonparametric quantizes that adapts to local properties of the image. The quantize that shows great promise is one which preserves the local sample moments. This quantizes produces good quality images that appear to be enhanced at data rates of 1.5 bits/pictures element. No large data storage is required. And the computation is small. The quantize is compared with standard (minimum mean-square error and mean absolute error) one-bit quantizares.

Keywords: *BTC, IBTC, MIBTC, Image, Coding.*

1. Introduction

With the continuing growth of modern communication technology, demand for image transmission and storage is increasing rapidly. Advanced in computer technology for mass storage and digital processing have paved the way for implementing advanced data compression techniques to improve the efficiency of transmission and storage of images. Applications of data compression are primarily in transmission and storage of information. Typically, a compressed image when decoded to reconstruct its original form will be accompanied by some distortion. The efficiency of a compression algorithm is measured by its data compression ability, the resulting distortion and as well by its implementation complexity. The complexity of data compression algorithms is a particularly important consideration in their hardware implementation

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image transmission application are in broadcast television, remote sensing via satellite, aircraft, radar, sonar, teleconferencing, computer communication, facsimile transmission.....etc. image storage is required most commonly for education, and business document, medical image used in-patient monitoring system....etc. because of their wide application, data compression and coding schemes have been of great importance in digital image processing application of data compression is also possible in the development of fast algorithms where the number of operation required to implement an algorithm is reduced by working with the compressed data.

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 change in the data statistics and to the cannel error effects which degrade have been investigated such as differential pulse code modulation (DPCM), and binary image compression..

2. Block Truncation Coding

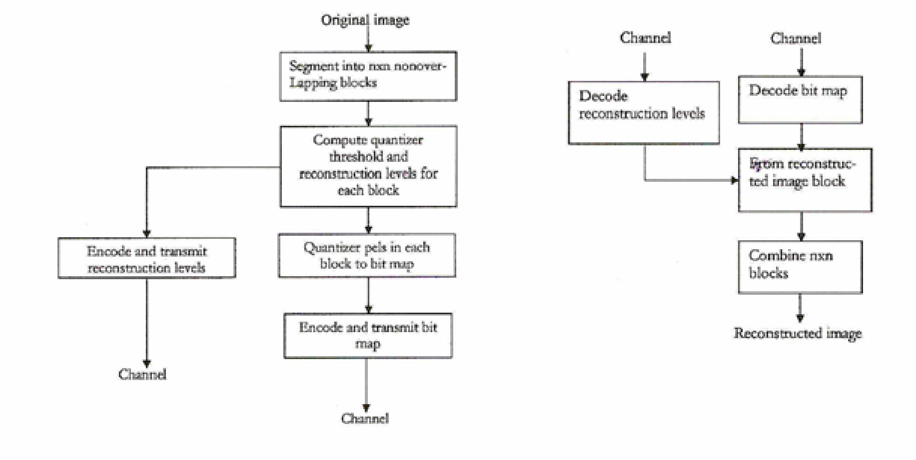
Most image data compression techniques achieve high data compression ratio. The trade off between data compression remains one of the difficult problems. Maintaining high compression ratios with good image quality is possible at a more or less high computational cost. One of the main goals for image data compression is to reduce redundancy in the image block a much as possible. That is, it is very important to represent an image with as few bits as possible while maintaining good image quality. Both compression and decompression algorithms should be simple and efficient. (BTC) is one of the simple and easy to implement image compression algorithms. This part introduces the BTC coding algorithm and modified version called interpolative the block truncation coding (IBTC).

In BTC an image is segmented into n×n (typically,4×4) non –over lapping blocks of pixels, and a two-level (one-bit) quantize is independently designed for each block. Both the quantize threshold and the two reconstruction levels are varied in response to the local statistics of a block. A diagram of the basic BTC scheme is shown in Fig. 1.

The level of each block is chosen such that the first two sample moment is preserved.

Let m = n×n, and let $X_1, X_2, X_3 \ldots\ldots X_m$ be the pixel value in a given block of the original image. The quantities we wish to preserve are the first and second sample moments:

$$\bar{X} = \frac{1}{m}\sum_{i=1}^{m} X_i \qquad (1)$$



(a) (b)

Fig. 1. Block truncation coding diagram
(a) Transmitter (b) Receiver

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

The variance is given by:

$$\sigma^2 = \overline{X^2} - \bar{X}^2 \tag{3}$$

And thus if $\overline{X}$ and $\overline{X^2}$ are preserved, the variance is also preserved. It is now necessary to find a threshold X_{th} and two reconstruction levels, a and b, such that

$$\hat{X}_i = \begin{cases} a, & X_i < X_{th} \\ b, & X_i \geq X_{th} \end{cases} \tag{4}$$
$$\text{for } i = 1,2,\ldots m$$

The reconstruction level a and b given by:

$$A = \overline{X} - \sigma\sqrt{\frac{q}{m-q}} \tag{5}$$

and

$$B = \overline{X} - \sigma \sqrt{\frac{m-q}{q}} \tag{6}$$

Where q is the number of pixels greater than or equal to the threshold $\overline{X}$.

We transmit the n×n bit map indicating which pixels reconstruct to a and which reconstruct to b as well as information specifying a and b. it is possible to transmit a and b directly (typically using 8 bit for each) or to send $\overline{X}$ and σ instead. (Note that q is known from the bit map). Assigning 8 bits each to $\overline{X}$ and σ results in a data rate of 2 bits pixels. The receiver reconstructs the image block by calculating a and b from Equ's. (5) and (6). Assigning these values to pixels in accordance with the code in the bit plane.

.***<u>As an example</u>*** of block truncation coding, consider the following 4×4 block of pixels:

$$X = \begin{bmatrix} 146 & 149 & 152 & 156 \\ 97 & 122 & 144 & 147 \\ 89 & 90 & 135 & 145 \\ 85 & 92 & 99 & 120 \end{bmatrix}$$

In this example, we designed the quantize so that the threshold is the mean, $\overline{X}$, of the entire block, and the two reconstruction levels; a and b, are the mean of the segment determined by the threshold. For this block of pixels, $\overline{X}$ = 123.0, and *q*=8 using as

The threshold, the bit map is:

$$B = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Where ‘1’ indicates that the actual pixel value is greater than the threshold and ‘0’ indicates that it is below the threshold. Computing the mean of each segment and rounding to the nearest integer, we find that the two reconstruction values are a=99 and b=147. These values are transmitted along with the bit map, and the reconstructed block is:

$$X = \begin{bmatrix} 147 & 147 & 147 & 147 \\ 99 & 99 & 147 & 147 \\ 99 & 99 & 147 & 147 \\ 99 & 99 & 99 & 99 \end{bmatrix}$$

If we assume that the reconstruction levels are represented by 8 bits each and no additional source coding is used on the bit map, the total bit rate is (8+8+16)/16=2.0 bits/pixel.

3. Interpolative BTC Image Coding

Some modified BTC algorithms have been proposed to improve the quality of coded image or further reduced the bit rate.

Fig. 2 interpolative BTC filled circles denoted pixels, and unfilled circles denote the reconstructed pixels. In this section, we represent an interpolative BTC coding algorithm based on sub sampling the truncated bit plane. As the size of bit planes will be reduced by sub sampling, the bit rate compression achieved in this way is significant. It will be demonstrated that, this coding schemes lead to small performance degradation. In the interpolate BTC coding scheme only 8 of the pixels and each block will be coded using BTC as described in previous section. The coded pixels are first decoded. The missing pixels are then reconstructed by interpolation utilizing the four surrounding pixels, which form a cross as shown in Fig. 2 . This implies that, on the one hand, the interpolation is carried out in the pixel (multilevel) domain; and on the other hand, pixels of adjacent blocks will also be used to reconstruct the missing border –pixels of a specific block. Thus, there is no need to distinguish one block from the other during the interpolation. While many interpolators may be used, we use here median filters to perform the interpolation. For interpolative BTC a five-point cross-window median filter is used.

$$y = Med\left[x_1, x_2, x_3, x_4, \frac{1}{4}\left(x_1 + x_2 + x_3 + x_4\right)\right] \tag{7}$$

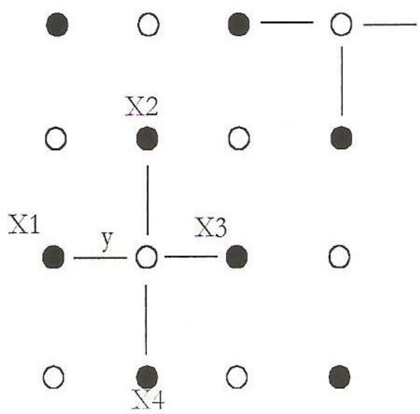


Fig. 2. Interpolative block truncation coding

The advantage of using the median filter as interpolators lies in its ease of implementation and its ability to give good results around sharp edges. In interpolative BTC, only 8 bits of each 4×4 bit plane are transmitted. If we assume that 16 bits are used to code the upper and lower means (8 bits for each), it is easy to see that the resulting bit rate is 1.5 for interpolative BTC. This implies a 25% reduction in bit rate, compared to the standard BTC method described in section (1).

4. Modify Interpolative BTC Image Coding

In this modify we use same IBTC, but, we use here median filters to perform the interpolation. For interpolative BTC a four-point cross-window median filter is used.

$$y = \mathrm{Med}\left[x_1, x_2, x_3, x_4\right] \qquad \textbf{(8)}$$

The results obtained by applying ***Block Truncation Coding (BTC), Interpolative BTC and Modify IBTC*** in image data compression.

The original image used in our investigation contains 64×64 pixels with 8-bit resolution per pixel (256 Grey levels).

Result of applying the image compression using BTC compared with original image is given in fig (3.A). The results obtained from applying IBTC and MIBTC compared with original image are shown in fig (3.B and C).

The above figure of BTC shows the reconstructed images with compression of 75%, and the figures of interpolative BTC and modifies IBTC show the reconstructed image with a compression of about 81.25%. Table (1) summarizes the results obtained by applying the three methods of compression. From this table, it can be seen that the BTC method gives better results than the IBTC and MIBTC method.

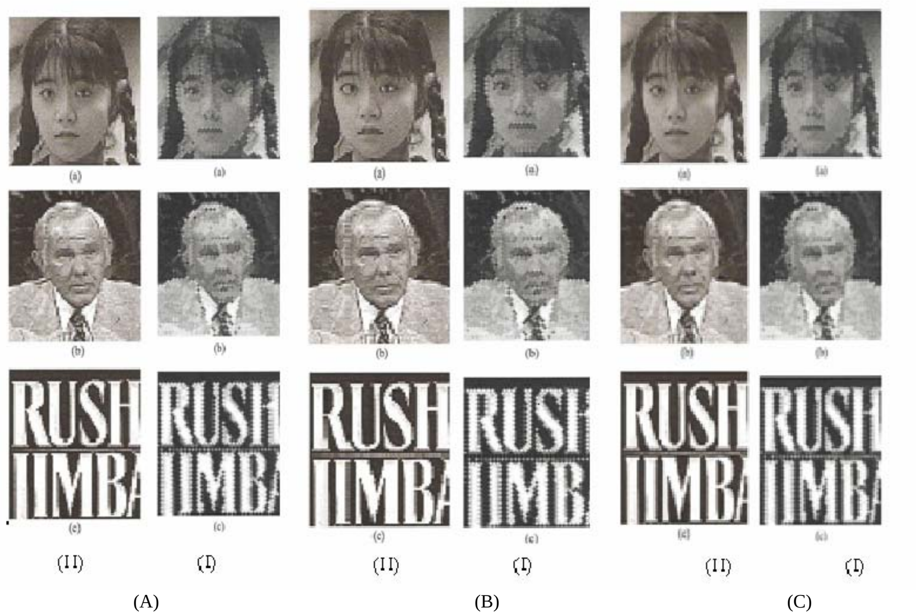


Fig. 3. Image Compressed

(A) Image compressed using BTC (I) compared with original image (II)
(B) image compressed using IBTC (II) compared with original image (I).
(C) Image compressed using MIBTC (II) compared with original image (I)

Table 1. Summarizes the results obtained by applying the three methods of compression.

		girl	man	letter
Technique	Bit rate	PSNR(dB)	PSNR(dB)	PSNR(dB)
BTC	2bit/pixel	28.35	26.69%	20.86
IBTC	1.5bit/pixel	27.796	25.478	19.138
MIBTC	1.5bit/pixel	21.6	20.26	15.35

5. *C*onclusion

In this paper a spatial domain technique for image data compression, namely, the block truncation coding (BTC) has been considered. This technique is based on dividing the image into (4×4) non overlapping blocks and uses a two-level quantize. The BTC technique has been applied to different grey level test image each contains 64×64 pixels with 8 bits/pixel (256 grey levels). The reconstructed images obtained from applying this technique have a bit rate of 2 bit/pixel. This corresponds to 75% compression. The peak signal-to-noise ratio is used as a measure of the reconstructed image quality comparison of the original and reconstructed image shows that this method provides a good compression without seriously degrading the reconstructed image. A modified BTC coding technique is investigated. This technique is the interpolative block truncation coding (IBTC) and modifies IBTC. The IBTC and MIBTC algorithm is based on sub sampling. The coded pixels are first decoded and then used to reconstruct the missing pixels using median filters interpolators, which makes the interpolation process very simple. The IBTC was applied to the same test images. The resulting bit rate of the reconstructed image is 1.5 bits/pixel, without a noticeable serious degradation compared with the BTC results. But in the MIBTC the calculation and quality are less than IBTC.

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