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# Image Compression using Set of selected Bit planes using Adaptive Quantization Coding

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***Abstract*— In this paper , a new method for image compression based on adaptive quantization using set of selected bit planes is being proposed .This technique combines adaptive quantization with an additional unit, with the aim of checking the intensity variation of each image block, and selects bit planes on basis of their intensity variations as compared to predefined threshold. Block truncation method and adaptive quantization coding method for image compression are also explained. The results obtained showed a good reduction in bpp compared with the AQC algorithm, with a little loss in PSNR due to the dropping of some blocks that claimed to be low intensity variation according to a comparison with predefined thresholds for each color plane.**

**Keywords:** Block truncation coding (BTC), Color image compression, Adaptive quantization coding (AQC), bit planes.

## I. Introduction

The amount of image data grows day by day. Large storage and bandwidth are needed to store and transmit the images, which is quite costly. Hence methods to compress the image data are essential now-a-days. Image compression addresses the problem of reducing the amount of data required to represent a digital image. It is a process intended to yield a compact representation of an image, thereby reducing the image storage/transmission requirements. The image compression techniques are categorized into two main classifications namely Lossy compression techniques and Lossless compression techniques [1]. The lossy type aims to reduce the bits required for storing or transmitting an image without considering the image resolution much. The lossless type focuses on preserving the quality of the compressed image so that it is exactly the same as the original one. All the digital image compression techniques are based on the exploitation of information redundancy that exists in most digital images. The redundancy stems from the statistics of the image data that is directly related to the image data probability distribution and can be treated by information theory techniques using image entropy concepts. The objective of compression is to reduce the number of bits as much as possible, while keeping the resolution and the visual quality of the reconstructed image as close to the original image as possible. Lossless techniques like Huffman coding, Run-length coding etc. are used to remove the statistical redundancy. Also lossy techniques are designed such as transform coding, Block truncation coding, sub band coding etc. Block transforms operate on blocks of (NXN) image and have low memory requirements while processing block by block. However, block transforms suffer from artifacts at block edges. Image based transforms operate on entire image. The most popular image transform being the Discrete Wavelet Transform (DWT), but tends to have higher memory requirements.

As most of the planes as produced by quantizer that are used for representing the various blocks of image do not appear in the coding of images, hence resulting in very low contribution to the visual quality of the reconstructed image. Also, some different bit planes produce very similar visual perception result due to the properties of the human visual system. So, here we have proposed a technique which uses set of selected bit planes that are visually sensitive for coding based on certain predefined threshold using BTC and AQC technique.

Section-II summarizes methods based on Block truncation coding (BTC) technique. Section-III describes the BTC and AQC coding method .Section-IV describes the proposed method in this paper. In Section-V, Simulation results of the proposed method are explained. Section - VI gives the conclusion of this paper.

## II. RELATED WORK

Image compression is important in digital image transmission and storage. For the transformation independent types we can mention block truncation coding (BTC), which was first implemented by Delp and Mitchell in 1979 [2].This algorithm is used for grayscale image compression with a bit rate of two bpp and a good PSNR.. BTC is a recent technique used for compression of monochrome image data. The algorithm divides an image into non-overlapped blocks and represents each pixel in a block by its high mean or low mean. It is a simple and efficient image compression algorithm .It is one-bit adaptive moment-preserving quantizer that preserves certain statistical moments of small blocks of the input image in the quantized output .The bit rate of the BTC is limited, because the image quality decreases rapidly when bit rate is decreased. However, it is an attractive option due to its simplicity and involves less computational complexity. In the literature, many studies have been done to improve the computational complexity, bit rate, and visual quality of the BTC such as variable block truncation coding with optimal threshold, where the image is divided into variable size blocks rather than fixed size, and an optimal threshold is adopted to minimize the mean square error [3]; adopting universal hamming codes and a differential pulse code modulation (PCM) to the bit plane and the side information of the BTC to reduce bit rate and preserving the low computational complexity [4]; using a set of predefined bit planes to independently encode image, where the Huffman coding is also adopted to further reduce the bit rate [5]. These studies proposed good solutions in quality or coding gain improvement. However, the complexity is increased as well. In [7] the interpolative BTC coding scheme is proposed which uses only 8 of the pixels and each block will be coded using BTC . The coded pixels are first decoded. The missing pixels are then reconstructed by interpolation utilizing the four surrounding pixels, which form a cross. In the HBTC algorithm [8] to improve the compression ratio of the basic BTC, only luminance bit-map is employed to represent the edge information of the coding block. It was a combination of ordinary BTC and adaptive quantization coding AQC. Absolute Moment block truncation coding (AMBTC) in [9] preserves the higher mean and lower mean of the blocks and use this quantity to quantize output and provides better image quality than image compression using BTC.

# III. BTC and AQC Algorithm

## A. *Block Truncation Coding(BTC)*

In BTC an image is segmented into n×n (typically, 4×4) non overlapping blocks of pixels, and a two-level (one-bit) quantizer is independently designed for each block. Both the quantizer 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 $X_1, X_2, X_3 \ldots X_m$ 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:

$$\overline{X} = \frac{1}{m} \sum X_i \quad \text{for i=1 to m} \tag{1}$$

$$\overline{X^2} = \frac{1}{m} \sum X_i^2 \quad \text{for i=1 to m} \tag{2}$$

The variance is given by:

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

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

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

The reconstruction levels A and B are given by:

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

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

Where q is the number of pixels greater than or equal to the threshold *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 $X$ and σ instead. (Note that q is known from the bit map). Assigning 8 bits each to $X$ 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.

## B. *Adaptive quantization coding (AQC)*

The AQC compression algorithm was introduced in [6] for overdrive of motion blur reduction in a liquid crystal display (LCD). The algorithm was composed of the following steps:

i) Divide the image into non-overlapped blocks of (m×n) pixels

ii) Compute the quantizer step using the following relation:

$$Q_{step} = (B_{max} - B_{min})/8 \tag{7}$$

Where $Q_{step}$ is the three bits quantizer step, number 8 represents the number of quantizer levels (QL), and $B_{max}$ and $B_{min}$ are the maximum and minimum of the block, respectively.

iii) Compute the bit plane ($B_{plane}$) of each block using a three-level quantizer according to the following equation:

$$B_{plane} = (I_{in} - B_{min}) / Q_{step} \tag{8}$$

Where $I_{in}$ represents the intensity values of the input image.

The encoded bit stream includes a bit plane, quantizer step and the minimum of each block. According to the previous description, the resultant bit rate of a gray scale image compressed using this algorithm can be computed using the following equation

$$bpp = ( bit_{step}+bit_{min} )/ (m\times n) +3 \quad (9)$$

Where $bit_{step}$ is the bits required for quantizer step encoding and $bit_{min}$ is the bits used for encoding the minimum of each block (typically 8 bits). As an example, if a gray scale image having (512×512) pixels with a block of (4×4) pixels, the resultant bpp will be 3.8125 bpp.

The decoding process will go according to the following relation:

$$I_{decod}=B_{min}+ B_{plane} \times Q_{step} \quad (10)$$

Where $I_{decod}$ is the decompressed image.

This algorithm outperformed the BTC algorithm from a performance and quality point of view, but had higher bpp than the BTC algorithm.

## IV. PROPOSED ALGORITHM

In conventional methods all the bit planes so produced by quantizer are used for representing the various blocks of image. However, most of the bit planes do not appear in the coding of images resulting very low contribution to the visual quality of the reconstructed image. Also, some different bit planes produce very similar visual perception result due to the properties of the human visual system. This necessitates to focus on the design of a small set of visually sensitive bit planes. So, here we have proposed a technique which uses set of selected bit planes for coding based on certain predefined threshold based on intensity of each bit plane.

This new algorithm for image compression uses selected set of bit planes that uses intensity based versions of AQC for image compression. The proposed algorithms aim to reduce the high bpp of an original AQC whilst trying to keep the quality of the compressed image at an acceptable level. This algorithm is a combination of an original AQC and an intensity checking unit with the aim of checking the intensity variation of each image block, as shown in Fig.1.The algorithm can be said as Intensity Based Adaptive Quantization Coding.

**Steps Followed:**

1) The image was first divided into non-overlapped block (n×n) pixels
2) For each block the difference between the maximum, minimum and quantizer step was computed according to (7) (AQC algorithm-Section III)
3) The threshold was predefined for each color plane.
4) The quantization step is compared with a predefined threshold, it exploits the fact that the low variation blocks required lower quantization steps compared with the high variation or edge blocks.
5) For each of the pixel value in block, bit plane is computed on basis of intensity according to (8).
6) For the blocks where the quantization step was less than the threshold, the bit plane and quantization step bits were discarded and only the minimum value was encoded.
7) For the blocks where the quantization step was more than the threshold all the information i.e bit plane, quantization step and minimum value was encoded.
8) Only selected bit planes are encoded and compressed image is obtained.

The encoded bit stream for low and high variation blocks is shown in Table I. On the decoder side, the decoder will be sensitive to the flag bit.

If it is in high state the block is classified and decoded as a low variation block, otherwise it will be decoded as a high variation block.

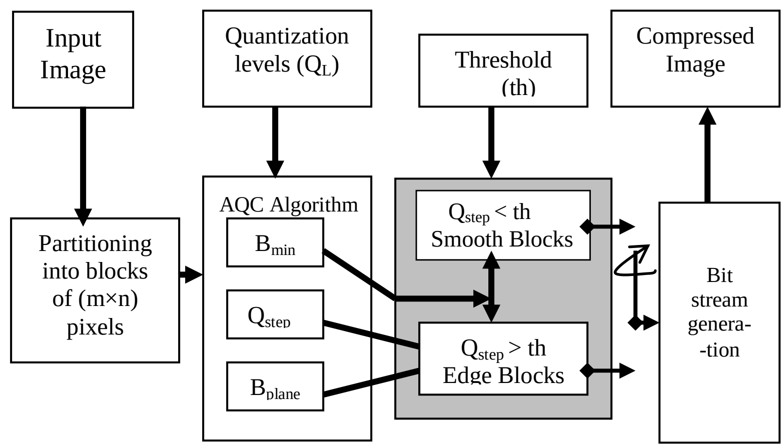


Fig. 1

Table I
Bits Required For each Block Type

| Block Type | Bits Required for each attribute for (4×4) blocks and 8 level quantizer | | | | Total bits |
|---|---|---|---|---|---|
| | Flag | Minimum | Bit plane | Quantizer step | |
| High variation | 1 | 8 | 48 | 5 | 62 |
| Low variation | 1 | 8 | 0 | 0 | 9 |

## V. Results

The performance of the discussed algorithms was assessed using objective and subjective fidelity criteria on several test images. The PSNR and bit rate was used as an objective test of the three algorithms. These tests were performed on different sample images using block size (4×4) and $Q_L$=4, where $Q_L$ represents quantizer levels.

In subjective test three images are discussed to give the reader a visual impression of the compressed image. Fig 2.a shows the original Lena image and Fig 2.b, 2.c, 2.d shows the image compressed by BTC, AQC and Proposed algorithm

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respectively. As seen from objective results shown in Table 2, the bit rate obtained is least from proposed method as compared to BTC and AQC technique. Hence we can say that compression is best obtained from proposed algorithm as compared to BTC and AQC technique. Same algorithms are applied on two other images also and Bit rate and PSNR are calculated as discussed above.

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 proposed method provides a good compression without seriously degrading the reconstructed image when compared with AQC technique.

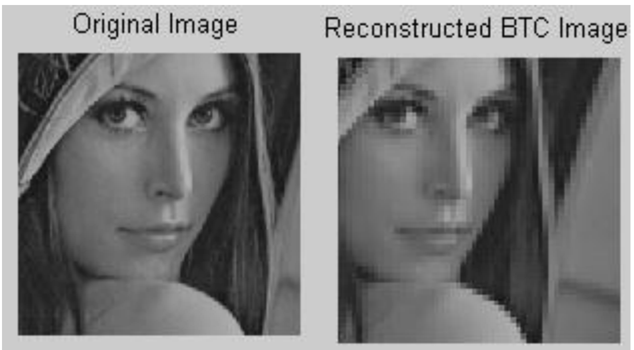


Fig 2.a Fig 2.b

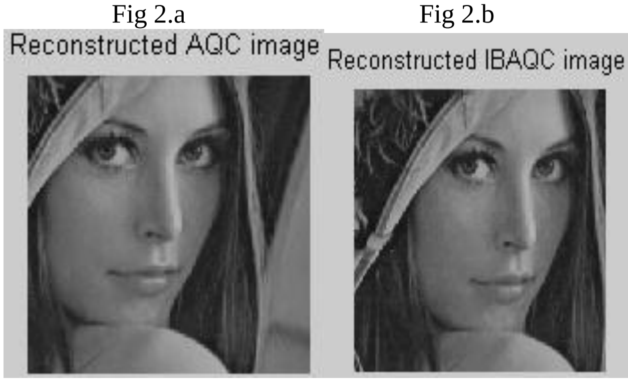


Fig2.c Fig 2.d

Fig.2 Lena Image

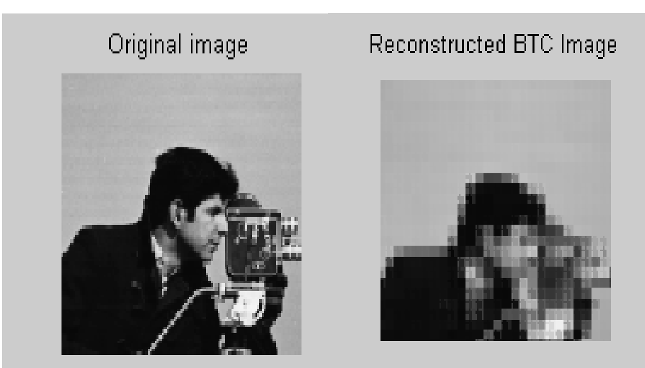


Fig 3.a Fig 3.b

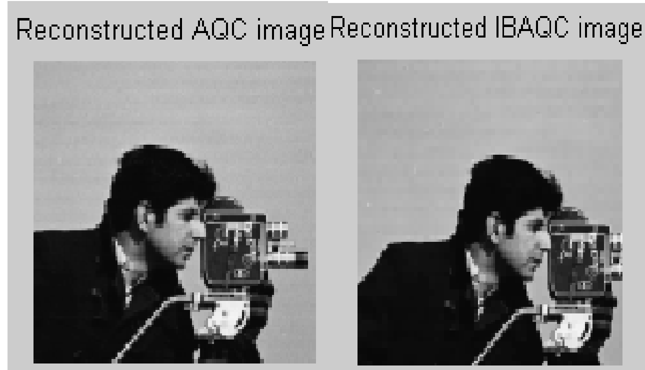


Fig 3.c Fig 3.d

Fig.3 Cameraman Image


Fig 4.a Fig 4.b


Fig 4.c Fig 4.d

Fig.4 Manu Image

TABLE 2

| Block size 4x4 and $Q_L$ =2 | Lena Image | | Cameraman Image | | Manu Image | |
|---|---|---|---|---|---|---|
| Technique | Bit rate | PSNR (dB) | Bit rate | PSNR (dB) | Bit rate | PSNR (dB) |
| BTC | 2 | 28.947 | 2 | 21.625 | 2 | 35.465 |
| AQC | 4 | 45.666 | 4 | 46.510 | 4 | 44.876 |
| Proposed Technique (selectd bit planes) | 3.7989 | 40.290 | 3.6731 | 41.422 | 3.6509 | 38.911 |

The algorithms can be tested for various quantizer levels and Block sizes. Also as observed from results in table 2, the AQC and proposed method using selected bit planes give much better compression with increasing PSNR as compared to that obtained using BTC technique.

# VI. Conclusion

In this paper the algorithms based on BTC and AQC algorithms have been introduced. The objective is to reduce bpp produced by AQC while preserving the image quality. The proposed algorithm uses only selected bit planes of those produced by encoder .The bit planes are selected by using an additional processing unit to check the intensity variation of each block according to a predefined threshold. The results obtained showed a good reduction in bpp with a little less PSNR as compared to that acquired using AQC algorithm. Also results show that much better compression is obtained by AQC and proposed technique as compared to BTC.BTC produces least PSNR of all the three techniques discussed. The compression can further be increased by combining DWT and proposed algorithm.

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