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Biomedical Image Compression Using BTC Method with Rectangular Truncation Matrix

Tamanna Kapahi[1], Kamal Gupta[2]

PG Student, Dept of CSE, GNIT, Mullana, Ambala, India[1]

Assistant Professor, Dept of CSE, GNIT, Mullana, Ambala, India[2]

Abstract: Biomedical images are important factor in health care for diagnosis of disease. As medical imaging faclities are moving towards film less imaging technology, digital image processing techniques plays an important role. Image compression technique is an important multimedia application to effectively store and transmit data at lower bandwidth. BTC based algorithm is designed to compress the biomedical CT-scan image. A new application of block truncation coding (BTC) is presented to compress gray as well as rgb CT-scan images with rectangular non-overlapping truncation matrix. Experimental results are presented which demonstrate that at lower value of truncation matrix, the compression rate is low with image characteristic parameters close to the original image values.

Keywords: BTC, SNR, PSNR, RMSE, Compression.

I. INTRODUCTION

Bio medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities. Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are usually considered part of pathology instead of bio medical imaging. It includes the analysis, enhancement and display of images captured via x-ray, ultrasound, MRI, nuclear medicine and optical imaging technologies [1]. There are several methods of medical imaging – each uses different technology to create a different type of image. The types of images differ in how well they show what is happening in certain body tissues (e.g. bone, soft tissue or tumors) – this is one of the main considerations for your health professional when deciding which imaging technique to use. No single type of imaging is always better; each has different potential advantages and disadvantages, including exposure to radiation. Common types of imaging include: X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Ultrasound [2-3].

A computed tomography (CT) scan is an imaging method that uses x-rays to create pictures of cross-sections of the body. Computed tomography [4] has greatly increased the specificity and sensitivity of image information content because this approach has eliminated superposition and foreshortening of anatomic structures. CT scans can be used to diagnose and monitor a variety of different health conditions, including brain tumors, certain bone conditions, and injuries to internal organs such as the kidneys, liver or spleen.. CT scans are usually carried out on an outpatient basis, which means you'll be able to go home on the same day as the procedure. Your scan results won't be available immediately. A computer will need to process the information from your scan, which will then be analyzed by a radiologist (a specialist in interpreting images of the body). There are several advantages that CT has over traditional 2D medical radiography. First, CT completely eliminates the superimposition of images of structures outside the area of interest. Second, because of the inherent high-contrast resolution of CT, differences between tissues that differ in physical density by less than 1% can be distinguished. Finally, data from a single CT imaging procedure consisting of either multiple contiguous or one helical scan can be viewed as images in the axial, coronal, or sagittal planes, depending on the diagnostic task. This is referred to as multiplanar reformatted imaging [5-6].

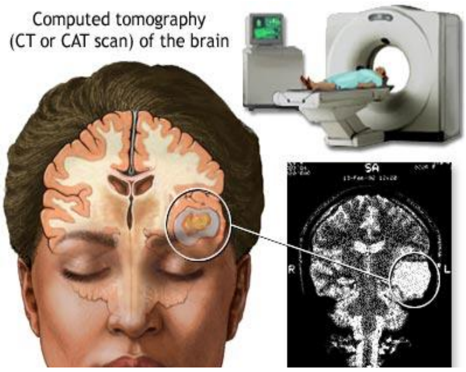

Fig. 1 CT Scan system

II. BLOCK TRUNCATION CODING

With the perpetuating magnification of modern communication technology, demand for image transmission and storage is incrementing rapidly. Advanced in computer technology for mass storage and digital processing have paved the way for implementing advanced data compression techniques to amend the efficiency of transmission and storage of images [7].

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Block Truncation Coding is a lossy image compression techniques .It is a simple technique which involves less computational complexity. BTC is a recent technique used for compression of monochrome image data. 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 original algorithm of BTC preserves the standard mean and the standard deviation [8]. The statistical overheads Mean and the Standard deviation are to be coded as part of the block. The truncated block of the BTC is the one-bit output of the quantizer for every pixel in the block .Block Truncation Coding is a well-known compression scheme proposed in 1979 for the grayscale images. It was also called the moment-preserving block truncation because it preserves the first and second moments of each image block [9].

The block truncation coding (BTC) algorithm uses a two-level (one-bit) non parametric quantizes that adapts to local properties of the image. The quantizer 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 quantizer is compared with standard (minimum mean-square error and mean absolute error) one-bit quantizer. The BTC algorithm involves the following steps:

Step1: The given image is divided into non overlapping rectangular regions. For the sake of simplicity the blocks were let to be square regions of size m x m.

Step 2: For a two level (1 bit) quantizer, the idea is to select two luminance values to represent each pixel in the block. These values are the mean x and standard deviation σ.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_i)^2}$$

where x_i represents the i^{th} pixel value of the image block, and n is the total number of pixels in that block.

Step3: The two values x and σ are termed as quantizer of BTC. Taking x as the threshold value a two-level bit plane is obtained by comparing each pixel value x_i with the threshold. A 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:

$$B = \begin{Bmatrix} 1, x_i \geq \bar{x} \\ 0, x_i < \bar{x} \end{Bmatrix}$$

By this process each block is reduced to a bit plane. For example, a block of 4 x 4 pixels will give a 32 bit compressed data, amounting to 2 bit per pixel (bpp).

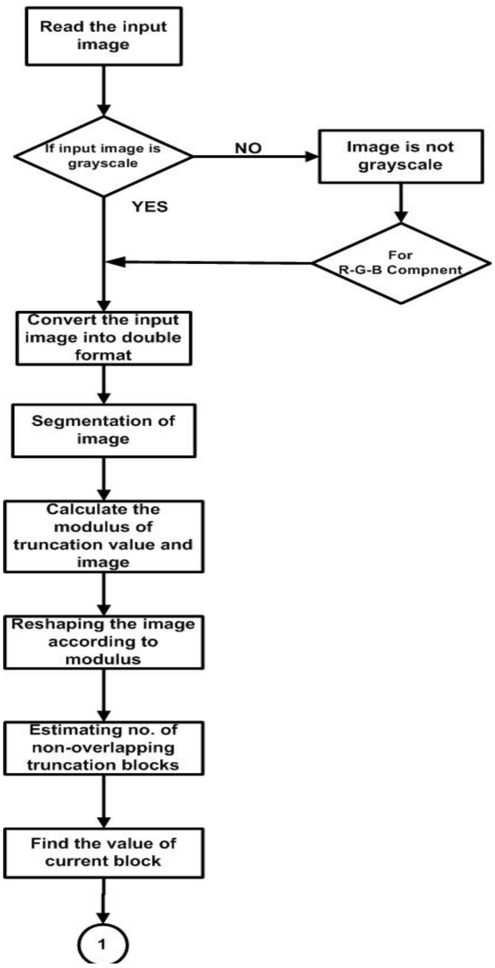
Step 4: In the decoder an image block is reconstructed by replacing '1's in the bit plane with H and the '0's with L, which are given by:

$$H = \bar{x} + \sigma\sqrt{\frac{p}{q}} \quad L = \bar{x} - \sigma\sqrt{\frac{p}{q}}$$

Where p and q are the number of 0's and 1's in the compressed bit plane respectively [7-9] [10].

III.METHODOLOGY

Research work is carried to compress biomedical RGB and gray scale image (CT-Scan images) using Block Truncation Coding (BTC) technique. The work is divided into two major parts. The main goal of image compression is to reduce redundancy in the image as much as possible. The first section of the research work comprises of compression using rectangular truncation matrix. The size of rectangular truncation matrices is $n \times 8 + n$. In second part various image characteristic parameters such as signal to noise ratio (SNR), peak signal to noise ratio (PSNR), root mean square error (RMSE), and mean absolute error (MAE) are estimated for compressed image with respect to original image. The designed algorithm is shows in Fig.1.



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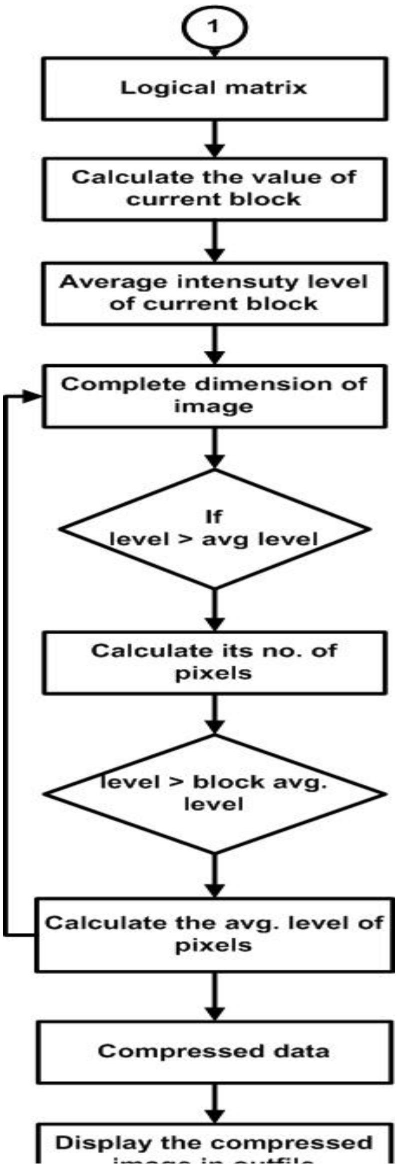

Fig. 1 Designed BTC algorithm

IV. RESULTS AND DISCUSSION

Compression of CT-scan image using rectangular truncation matrix in BTC algorithm are analysed. Table 1 and Table 2 shows the size of compressed images obtained. It can be observed that higher range of truncation matrix gives high compression ratio.

Table 1

Truncation Matrix		O/P Image Size Kb
M	N	
4	8	442
8	16	490
16	24	472
24	32	452
32	40	454
40	48	443
48	56	434
56	64	427
64	72	424
72	80	418
80	88	417
88	96	407
96	104	405
104	112	398
112	120	404
120	128	401
128	136	399

In order to monitor the information content of the image various image characteristics parameters are computed. Table 2-4 shows the PSNR, SNR, and RMSE values of the compressed image with respect to original image.

Table 2. PSNR of compressed image w.r.t original image

Truncation Matrix		PSNR (dB)
M	N	
4	8	4
8	16	8
16	24	16
24	32	24
32	40	32
40	48	40
48	56	48
56	64	56
64	72	64
72	80	72
80	88	80
88	96	88
96	104	96
104	112	104
112	120	112
120	128	120
128	136	128

Table 3 SNR of compressed image w.r.t original image

Truncation Matrix		SNR
M	N	
4	8	-0.00513dB
8	16	-0.02360dB
16	24	-0.03081dB
24	32	-0.07901dB
32	40	-0.04903dB
40	48	-0.10096dB
48	56	-0.15642dB
56	64	-0.18064dB
64	72	-0.20191dB
72	80	-0.19961dB
80	88	-0.18159dB
88	96	-0.19718dB
96	104	-0.27055dB

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104	112	-0.29515dB
112	120	-0.16807dB
120	128	-0.25245dB
128	136	-0.21308dB

Table4. RMSE of compressed image w.r.t original image

Truncation Matrix		**RMSE**
M	**N**	
4	8	12.30673
8	16	49.77749
16	24	65.20834
24	32	108.64825
32	40	73.61984
40	48	109.87663
48	56	131.94094
56	64	136.71644
64	72	142.17967
72	80	137.31762
80	88	136.01363
88	96	142.75171
96	104	156.29084
104	112	161.45942
112	120	125.32788
120	128	142.40570
128	136	136.86798

V. CONCLUSION

Block Truncation Coding (BTC) is an apparently elegant and efficient time-domain compression technique. BTC is attractive in many applications that require low complexity and moderate data rates. In this research work coding is based on dividing the image into non overlapping blocks of unequal size (rectangular). It is seen that as the block size is increased for processing, the visual quality of the image degrades rapidly with severe blocking artifacts and blurred edges.

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