International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-7, Issue-6, June 2019 E-ISSN: 2347-2693

High Quality Color Image Compression using DWT and Multi-level Block Partition Encoding-Decoding Technique

Manjusha Gulabrao Kulthe[1*], Priyanka Jaiswal[2], Bharti Chourasia[3]

[1,2,3]Department of Electronics and Communication, RKDF Institute of Science & Technology, SRK University, Bhopal

Corresponding Author: morey0209@gmail.com

DOI: https://doi.org/10.26438/ijcse/v7i6.225229 | Available online at: www.ijcseonline.org

Accepted: 11/Jun/2019, Published: 30/Jun/2019

***Abstract*—** Text and image data are important elements for information processing almost in all the computer applications. Uncompressed image or text data require high transmission bandwidth and significant storage capacity. Designing and compression scheme is more critical with the recent growth of computer applications. Among the various spatial domain image compression techniques, multi-level Block partition Coding (ML-BTC) is one of the best methods which has the least computational complexity. The parameters such as Peak Signal to Noise Ratio (PSNR) and Mean Square Error (MSE) are measured and it is found that the implemented methods of BTC are superior to the traditional BTC. This paves the way for a nearly error free and compressed transmission of the images through the communication channel.

Keywords:- Multi-level Block Truncation Code (ML-BTC), Bit Map, Multi-level Quantization (MLQ), Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE)

I. INTRODUCTION

In today's electronic world, digital still pictures and video images play a significant role in multimedia based knowledge exchange applications. Such high resolution digital pictures require a lot of memory space for image storage, processing and retrieval by digital computers. Satellite and aerial images generate big data files demanding large transmission time for image transfer. In internet applications, such big data transmission slows down the net speed. Image compression techniques [1] aim at reducing the transmission file size, by using lesser bits for the images. This is realized by using fewer bits per pixel of the image. Normally this bit reduction will affect the quality of the image reproduced at the receiver. This process is known as 'Lossy Image Compression' [2]. But images could also be compressed without reduction in quality by employing suitable coding techniques. Inherently, such 'Lossless Image Compression' methods [3] yield less compression, compared to 'Lossy' methods [4]. The 'Compression ratio (CR)', the 'Peak Signal to Noise Ratio (PSNR)' and the 'Contrast (C)' are the parameters used to measure the quality of image compression.

Most compression algorithms are based on the assumption that there exists redundancy in the original data. Redundancy means that some symbols (characters or pixels) are more likely to occur than others, i.e. there is some unbalanced probability distribution of symbols in the possible input data.

Text compression algorithms work based on the assumption that there are some characters that are often occurring than others in the input data. Compressing text data is achieved by exploiting two types of redundancies, called alphabetic redundancy and contextual redundancy, in the input text data. Often occurrence of characters and combination of characters (patterns) in the input data are called as alphabetic redundancy and contextual redundancy respectively.

Lossy compression algorithms are based on the principle of removal of subjective redundancy and are extremely important in applications such as transmission of still images over the internet where certain amount of distortion may be tolerated. Traditional image compression techniques such as run length coding, arithmetic coding and Huffman code are lossless coding schemes. Statistical redundancy present in the image can be effectively compressed using such lossless compression but the compression gain achieved is low [5]. The best compression ratio that can be achieved with current lossless compression standards such as Joint Photographic Experts Group (JPEG) is around 3 to 4. Transform coding is a widely applied method for lossy image compression. Image transforms effectively de-correlate the pixels so that pixels representing similar events in the image are grouped together according to their spatial or spectral properties. After transformation, the useful information is concentrated into a few of the low-frequency coefficients and the Human Visual System is more sensitive to such low spatial frequency information than to high spatial frequency [6].

II. LOSSY AND LOSSLESS IMAGE COMPRESSION SYSTEM

In transform based image compression, the image is subjected to transformation and then the transformed data are encoded to produce the compressed bit stream.
An image reconstructed following lossy compression contains degradation relative to the original. Often this is because the compression scheme completely discards redundant information. However, lossy schemes are capable of achieving much higher compression. Lossy methods are especially suitable for natural images such as photos in applications where minor (sometimes imperceptible) loss of fidelity is acceptable to achieve a substantial reduction in bit rate. The lossy compression that produces imperceptible differences can be called visually lossless.

In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. However lossless compression can only achieve a modest amount of compression. Lossless compression is preferred for archival purposes and often medical imaging, technical drawings, clip arts etc. whereas lossy compression methods, especially when used at low bit rates, introduce compression artifacts.

Lossy and lossless transform based image compression system is shown in figure 1. In figure 1, the original image X is passed through the partition block then partition method divide the original image into X_0, X_1,………..X_{n-1} sub part. All sub part is passed through the transform block then transform block change the X_0, X_1,………..X_{n-1} to Y_0, Y_1,………..Y_{n-1} domain.

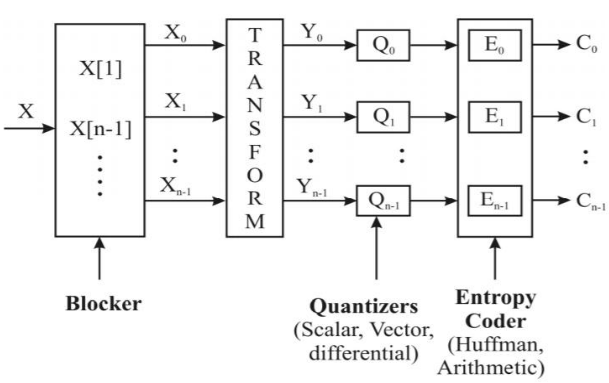

Figure 1: Transform-based image compression system

Finally, the quantized coefficients are coded to produce the compressed bit stream. The coding process typically exploits a statistical model in order to code symbols with fewer bits for symbols that has higher probability of occurrence. In doing so, the size of the compressed bit stream is reduced. Assuming that the transform employed is truly invertible, the only potential cause for information loss is in the coefficient quantization, as the quantized coefficients are coded in a lossless manner [9]. The decompression process simply mirrors the process used for compression. The compressed bit stream is decoded to obtain the quantized transform coefficients. Then, the inverse of the transform used during compression is employed to obtain the reconstructed image.

III. METHODOLOGY

- **Discrete Wavelet Transform**

Wavelets are signals which are nearby in time and scale and for the most part have a sporadic shape. A wavelet is a waveform of successfully restricted span that has a normal estimation of zero. The term 'wavelet' originates from the way that they incorporate to zero; they wave all over the pivot. Numerous wavelets likewise show a property perfect for smaller flag portrayal: symmetry. This property guarantees that information isn't over spoken to. A flag can be disintegrated into many moved and scaled portrayals of the first mother wavelet. A wavelet change can be utilized to break down a flag into part wavelets. When this is done the coefficients of the wavelets can be pulverized to evacuate a portion of the subtleties. Wavelets have the extraordinary favorable position of having the capacity to isolate the fine subtleties in a flag. Small wavelets can be utilized to separate fine subtleties in a flag, while expansive wavelets can distinguish coarse subtleties. Also, there are a wide range of wavelets to browse. Various types of wavelets are: Morlet, Daubechies, etc. [6].

This technique first decomposes an image into coefficients called sub-bands and then the resulting coefficients are compared with a threshold. Coefficients below the threshold are set to zero. At last, the coefficients over the limit esteem are encoded with a misfortune less pressure system. The pressure highlights of a given wavelet premise are principally connected to the overall scarceness of the wavelet area portrayal for the flag.

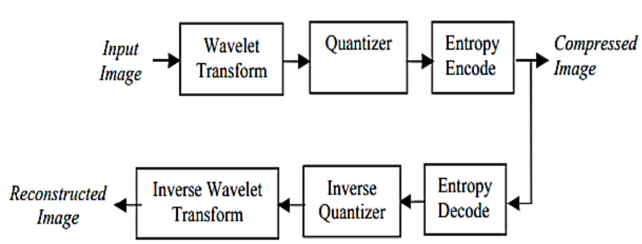

Fig. 2: The structure of the wavelet transform based compression.

The thought behind pressure depends on the idea that the normal flag part can be precisely approximated utilizing the accompanying components: few estimation coefficients (at an appropriately picked dimension) and a portion of the detail coefficients.The steps of compression algorithm based on DWT are described below:

I. Decompose Choose a wavelet; choose a level N. Compute the wavelet. Decompose the signals at level N.
II. Threshold detail coefficients For each level from 1 to N, a threshold is selected and hard thresholding is applied to the detail coefficients.
III. Reconstruct Compute wavelet reconstruction using the original approximation coefficients of level N and the modified detail coefficients of levels from 1 to N.

IV. PROPOSED METHODOLOGY

Transmission and capacity of crude pictures require enormous amount of circle space. Henceforth, there is an earnest need to decrease the extent of picture before sending or putting away. The most ideal answer for the issue is to utilize pressure techniques where the pressure of information on advanced pictures are made to diminish insignificance and repetition of the picture information to have the capacity to proficiently store or transmit information. A large portion of the current pressure systems utilized have their negatives and an improved method which is quicker, successful and memory productive can fulfill the prerequisites of the client.

Picture pressure flourishes to store or transmit the information in a capable mode just as to offer a best picture quality at a predetermined piece rate. Picture pressure should be possible in lossy or lossless mode. Lossless pressure is favored for recorded targets and principally utilized in therapeutic imaging, specialized illustrations, cut craftsmanship, or funnies. This is because of the presentation of pressure ancient rarities, low piece rates and furthermore in light of the fact that the assets can't be impressively spared by utilizing picture pressure technique. Lossy techniques are particularly appropriate for characteristic pictures, for example, photos in applications where unimportant loss of loyalty is middle of the road to achieve an impressive decrease in bit rate. Here assuaged resulting picture quality without much observation by the watcher is accomplished.

ML-BTC

Encoder part of the proposed technique shows that the original image is divided into three parts i.e. R component, G component and B component. Each R, G, B component of the image is divided into non overlapping block of equal size and threshold value for each block size is being calculated.

Threshold value means the average of the maximum value (max) of ‘k × k’ pixels block, minimum value (min) of ‘k × k’ pixels block and m_1 is the mean value of ‘k × k’ pixels block. Where k represents block size of the color image. So threshold value is:

$$T = \frac{\max + \min + m_1}{3} \quad (1)$$

Each threshold value is passing through the quantization block. Quantization is the process of mapping a set of input fractional values to a whole number. Suppose the fractional value is less than 0.5, then the quantization is replaced by previous whole number and if the fractional value is greater than 0.5, then the quantization is replaced by next whole number. Each quantization value is passing through the bit map block. Bit map means each block is represented by ‘0’ and ‘1’ bit map. If the Threshold value is less than or equal to the input image value then the pixel value of the image is represent by ‘0’ and if the threshold value is greater than the input image value then the pixel value of the image is represented by ‘1’.
Bit map is directly connected to the high and low component of the proposed decoder multi-level BTC algorithm. High (H) and low (L) component is directly connected to the bit map, bitmap converted the ‘1’ and ‘0’ pixel value to high and low pixel value and arrange the entire block.

$$L = \frac{1}{q}\sum_{i=1}^{p} W_i \quad W_i \le T \quad (2)$$

$$H = \frac{1}{p}\sum_{i=1}^{p} W_i \quad W_i > T \quad (3)$$

W_i represent the input color image block, q is the number of zeros in the bit plane, p is the number of ones in the bit plane. In the combine block of decoder, the values obtained from the pattern fitting block of individual R, G,B components are combined after that all the individual combined block are merged into a single block . Finally compressed image and all the parameter relative to that image will be obtained.

- **Error-compensated scalar quantization**

The application of ICDF in the TDDC-based coding aims at a better interpolation and a lower compression cost. However, when the compression happens, the interpolation efficiency as well as the coding efficiency will be limited by the distortion occurring on those filtered pixels (denoted as ~x) that will be used for interpolation. To solve this problem, we purpose to reduce the sum of square error (SSE) distortion of ~x as much as possible via controlling the quantization error of the transformed macro-block based on an error-compensated scalar quantization (ECSQ).

V. IMAGE QUALITY MEASURES

It is a noteworthy assignment in assessing the picture nature of a picture pressure framework to portray the measure of debasement in the remade picture. On account of lossy pressure, the recreated picture is just estimation to the first. The difference between the original and reconstructed signal is referred to as approximation error or distortion. Generally, the performance is evaluated in terms of compression ratio and image fidelity [10]. A good image compression algorithm results in a high compression ratio and high fidelity. Unfortunately, both requirements cannot be achieved simultaneously. Albeit numerous measurements exist for evaluating contortion, it is most generally communicated as far as means squared mistake (MSE) or pinnacle motion to-clamor proportion (PSNR). The execution of picture pressure frameworks is estimated by the metric characterized in conditions (1) and (2). It is based on the assumption that the digital image is represented as $N_1 \times N_2$ matrix, where N_1 and N_2 denote the number of rows and columns of the image respectively. Also, $f(i,j)$ and $g(i,j)$ denote pixel values of the original image before compression and degraded image after compression respectively.

Mean Square Error (MSE)

$$= \frac{1}{N_1 N_2} \sum_{j=1}^{N_2} \sum_{i=1}^{N_1} (f(i,j) - g(i,j))^2 \quad (4)$$

N_1 = Row Dimension of Image
N_2 = Column Dimension of Image
f(i, j) = Original Image
g(i,j) = De-noising Image

Peak Signal to Noise Ratio (PSNR) in dB

$$= 10 \times \log_{10}\left(\frac{M \times N}{MSE}\right) \quad (5)$$

Evidently, smaller MSE and larger PSNR values correspond to lower levels of distortion. Although these metrics are frequently employed, it can be observed that the MSE and PSNR metrics do not always correlate well with image quality as perceived by the human visual system. For this reason, it is preferable to supplement any objective lossy compression performance measurement by subjective tests such as the Mean Opinion Score (MOS) to ensure that the objective results are not misleading [11].

VI. SIMULATION RESULT

Shows the building, buildings, sailing, ocean and light house images are implemented MATLAB tool. All the images are divided into three part i.e. original image, resize image and compressed image.

Table 1: Experimental MSE Results for Different Types of Image

Image of Size 512×512	**4×4 Block Pixel**	**8×8 Block Pixel**	**16×16 Block Pixel**	**32×32 Block Pixel**
Airplane Image	9.431	17.338	29.672	44.543
House Image	4.929	6.136	15.342	23.953
Peppers Image	8.753	18.543	28.553	42.107
Flower Image	4.657	14.556	22.554	37.834
Parrot Image	10.257	21.001	33.512	47.353
Butterfly Image	26.914	33.882	45.771	57.441

Table 2: Experimental PSNR Results for Different Types of Image

Image of Size 512×512	**4×4 Block Pixel**	**8×8 Block Pixel**	**16×16 Block Pixel**	**32×32 Block Pixel**
Airplane Image	44.44 dB	41.79 dB	38.25 dB	36.50 dB
House Image	50.96 dB	46.32 dB	38.57 dB	40.42 dB
Peppers Image	44.82 dB	42.10 dB	39.86 dB	37.96 dB
Flower Image	47.51 dB	44.56 dB	41.43 dB	38.41 dB
Parrot Image	44.08 dB	42.05 dB	38.89 dB	37.44 dB
Butterfly Image	39.89 dB	38.79 dB	37.95 dB	36.62 dB

VII. CONCLUSION

In this paper a spatial domain technique for image data compression, namely, the multi-level block truncation coding (ML-BTC) has been considered. This technique is based on dividing the image into non overlapping blocks and uses a two-level quantize. The ML-BTC technique has been applied to different grey level test image each contains.

The multi-level block partition encoder and decoder technique is presented. Such method is suitable in situations where image or image is compressed once but decoded frequently. It is clear that the decoding time due to spatial domain based compression is much less than that of the sub-band compression techniques.

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