An Efficient Image Compression Method using DCT, Fractal and Run Length Encoding Techniques

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***Abstract*— Compression of the color images has many applications in most of the mobile technologies. Reducing the time taken for file transfer is important in digital communication fields. Image compression means reducing the graphics file size, without degrading the quality of the image. For digital images, Fractal image Compression (FIC) has been considered as an efficient method. FIC is a lossy compression method that explores the self similar property for natural image. In this paper, a combination of Discrete Cosine Transform and fractal with quadtree technique and Run Length Encoding is proposed to compress the image. Implementation result shows that the image is compressed effectively using the proposed work.**

***Keywords*— Image Compression, DCT, Quadtree, Fractal Image Compression, Run Length Encoding, Run Length Decoding**

I. INTRODUCTION

An image is a two-dimensional function, f(x, y), where x and y are spatial (plane) coordinates, and the amplitude of fat any pair of co-ordinates (x, y) is called intensity or gray level of the image at that point [1]. A color image is a digital image that includes color information for each pixel. For visually acceptable results, it is necessary to provide three color channels for each pixel that are interpreted as coordinates in some color space. It has three values per pixel and they measure the intensity and chrominance of light. The actual information stored in the digital image data is the brightness information in each spectral band.

Image compression is used to minimize the size in bytes of a graphics file without degrading the quality of the image. It allows more images to be stored in a given amount of disk more memory space. The time required for image to be sent over the internet or downloaded from web pages is reduced. The recent growth of web application based on multimedia have not only sustained the need for more efficient ways to encode signals and images but also have made compression of such signal central to storage and communication technology[2].

The Discrete Cosine Transform (DCT) is an example of transform coding. The DCT coefficients are all real numbers unlike the Fourier Transform. The Inverse Discrete Cosine Transform (IDCT) can be used to retrieve the image from its transform representation. The one-dimensional DCT is useful in processing speech waveforms. The two dimensional (2D) signals useful in processing images, for compression coding we need a 2D version of the DCT data. In DCT image data are divided up into n*m number of block. DCT converts the spatial image representation into a frequency map: the average value in the block is represented by the low-order term, strength and more rapid changes across the width or height of the block represented by high order terms. DCT is simple when JPEG used, for higher compression ratio the noticeable blocking artifacts across the block boundaries cannot be neglected. The DCT is fast [3].

Fractal Image Compression (FIC) is a lossy method to encode the image in a way that would require less storage space by using the self-similar nature of an image [4]. Michael Barnsley was the first person to use the idea of fractals in image compression. The basic idea of fractal image compression technique was introduced by Barnsley [5] in 1980 according to the contractive mapping fixed-point theorem. In Iterated Function System (IFS), the transform consisting of a sequence of affine transformations is applied to the entire image. Later Jacquin [6] proposed a partitioned IFS (PIFS) associated with a block-based automatic encoding algorithm where those affine transformations are applied to partitioned blocks [7]. By using repeated iterations of affine transformation of the plane, one could reproduce a fractal like image by storing the image as a collection of transformations rather than a collection of pixels. Fractals are complicated looking images that arise from simple algorithms. These images are generated by iterative execution of simple algorithms at different scales. This property is called self-similarity which is used to re-construct the image [8].

The rest of the paper is organized as follows: Section 2 describes some of the recent related works. Section 3 describes Fractal Image Compression and Quadtree technique. The proposed work is described in section 3. Experimental results of the proposed work are explained and discussed in section 5. Finally, conclusion is provided in section 6.

II. RELATED WORKS

Kharate and Patil [9] had proposed that the compression ratio as well as the quality had been considerably improved by appropriate selection of the mother based on the nature of images. The technique they have proposed had been based on

Threshold Entropy with enhanced run-length encoding based wavelet packet best tree. As complete tree had not been decomposed, their method had minimized the time complexity of wavelet packets decomposition. Sub bands that include significant information based on threshold entropy had been chosen by their algorithm. Anup Garg [8] had proposed a new method for image compression fractal image compression encoding algorithm is used with thresholding and fractal decoding algorithm to get decompressed image. A new developed thresholding method is applied to the whole image after taking the fractal encoding algorithm. To the obtained range blocks revised threshold is applied with hard thresholding function to get the new range blocks. Decompressed image is obtained after applying fractal decoding algorithm. The improved algorithm is tested against pure fractal encoding algorithm. The pure fractal image compression has the disadvantage of having long encoding time with some compromise with quality of image. The method improves the encoding time with higher compression ratio.

D.Venkatasekhar and P. Aruna [10] had proposed that Genetic algorithm is used to find the best block of replacement, so fractal image is done easily. Here Genetic algorithm with Huffman coding is used for fractal image compression. Intuitively, Huffman coding can offer better fast fractal compression than Arithmetic coding. When compare to Arithmetic coding, Huffman coding is best for compression, It increase the speed of compression and produces high PSNR. Totally genetic algorithm with Huffman coding increases the speed. William Robson Schwartz and Helio Pedrini [11] had proposed an encoding method for reducing computational cost to find matching blocks for range blocks. The combination of a partition-based method using quadtree decomposition with robust feature descriptors in their work allowed the search to consider only blocks sharing similar properties, providing significant speed-up.

Chakrapani and Soundera Rajan [12] had proposed a back propagation based neural network for fractal image compression. One of the image compression techniques in the spatial domain was Fractal Image Compression (FIC) but the main drawback of FIC using traditional exhaustive search was that it involves more computational time due to global search. In order to improve the computational time and compression ratio, artificial intelligence technique like neural network had been used. Feature extraction reduces the dimensionality of the problem and enables the neural network to be trained on an image separate from the test image thus reducing the computational time.

From the literature survey, it is evident that in fractal image compression, the encoding time and complexity is too high. To overcome these difficulties, an efficient image compression method using DCT, Fractal and run length encoding is proposed.

III. Fractal Image Compression

Fractal image compression is also called as fractal image programming because compressed images are represented by contractive transforms. These transforms are composed of group of a number of affine mappings on the whole image, known as Iterated Function System (IFS).Contractive transformation is applied to the IFS called Collage theorem. This theorem is the technique core of the fractal coding [13]. Fractal image compression is a modern image compression technique based on self similarity. In FIC the image is decomposed two times, into overlapping domain blocks to make a domain pool. Then the image is decomposed again into non-overlapping range blocks. After decomposition, for each range block, best matched domain block in the domain pool is searched with a contractive affine transformation. Finally the best matched domain block can be found for each range block in the original image [2].

A. Quadtree Technique

A quadtree partitioning is a representation of an image as a tree in which each node corresponding to a square portion of the image contains four sub-nodes corresponding to the four quadrants of the square, the root of the tree being the initial image [14][15]. The image is assigned to the tree and the uniformity is tested. If the uniformity is not met, then it is quartered into four sub images. The four sub images have the same size and they are associated with the four child nodes of the root. Next the uniformity of each sub image will be tested and the sub image will be divided repeatedly until the uniformity condition is met or some minimum sub image size has been reached [16].

IV. Proposed Work

An efficient image compression method using DCT and fractal with quadtree technique is proposed to compress the image effectively. Initially median filtering is applied to the input image to remove the noises in the image. Then, the preprocessed image will be segmented n*n non-overlapping blocks. DCT will be applied to each block of the image. The zero coefficients will be prevented by zigzag scanning of block values. Then the image is partitioned as fractals by quadtree technique. Using Run Length encoding technique, the image compression is performed. Following techniques are used in the proposed system.

A. Median filtering

Median filtering is applied to the input color image, to remove the noises in the image. It is often desirable to be able to perform some kind of noise reduction on an image in image compression. The median filter is a nonlinear digital filtering technique used to remove noise in image. Such noise reduction is a pre-processing step to improve the results of later processing. Median filtering is most widely used in digital image processing because it preserves edges while removing noise. The median filter runs through the image entry by entry, replacing each entry with the median of neighboring entries [17].

B. DCT

Discrete cosine transform (DCT) technique is most commonly employed in the compression of the images. It represents an image as a sum of sinusoids of varying magnitudes and frequencies. Most of the visually significant information about the image is concentrated in a few coefficients of the Discrete Cosine Transform. The DCT coefficients obtained are the cosine transformations applied to each pixel value of the images. The 2D DCT is applied to each color channel of the image. Then the coefficients of a DCT are quantized.

C. Zigzag Scanning

The obtained DCT coefficients are zigzagged in order to get the compression process more effective. The purpose of the zigzag scan is to group the low frequency coefficients of the n*n matrix. The zigzag scanning will be more efficient to exploit the number of zeros in the DCT coefficients. The entire DCT coefficients are rearranged in a zigzag manner.

D. Fractal Image Compression

The zigzagged DCT coefficients are then decomposed by quadtree technique in order to compress the images more effectively .A quad tree is a tree data structure in which each internal node has exactly four children. Quad trees are most often used to partition a two-dimensional space by recursively subdividing it into four quadrants or regions. The regions may be square or rectangular, or may have arbitrary shapes.

Fractal Image Compression (FIC) is a lossy compression technique for digital images, based on fractals. The FIC method is suited for textures and natural images based on the fact that parts of an image resemble other parts of the same image. Fractal algorithms convert these parts into mathematical data called fractal codes. These codes are used to recreate the encoded image. Similar blocks in a given input color image are identified using FIC (the matched domain blocks for each range block in an image). The Euclidean distance measure is used to calculate the similarity between the resultant images.

E. Run Length Encoding

Run-length encoding (RLE) is a simple form of compression in which sequences of data are stored as a single data value and count, rather than as the original sequence. RLE technique achieves best results with images containing large areas of contiguous color.

Run Length Encoding technique is applied to the resultant image to compress it.

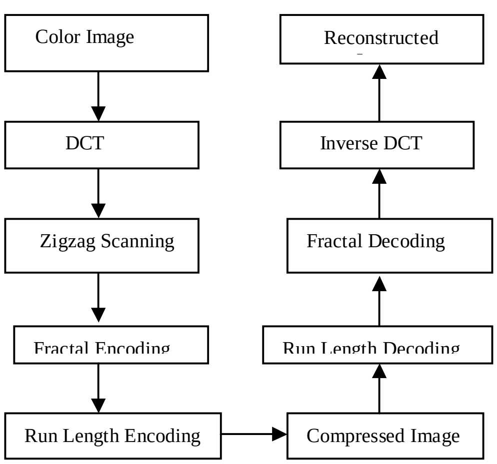

Fig 1. Structure of the proposed work

F. Proposed Algorithm

The compression algorithm is explained in the following steps:

Step 1: Divide the input image into n*n non-overlapping blocks.

Step 2: Employ DCT to each block of the image.

Step 3: Quantize the DCT coefficient of each block.

Step 4: Scan the block values in zigzag manner to exploit zero coefficients.

Step 5: The resultant image is partitioned as fractals using quadtree decomposition.

Step 6: Encode the image using Run Length Encoding to compress the image.

The decompression algorithm is explained in the following steps:

Step 7: To the compressed image, apply Run Length decoding technique and fractal decoding technique.

Step 8: Apply inverse zigzag to the image

Step 9: Then apply inverse DCT to the resultant image

V. Experimental Results and Discussion

The effectiveness of the proposed method is explained by means of the experimental results. The proposed method is implemented in Matlab 7.9. The input images used in the experiments include Boat, Flower, Scenery and Baby. Performance parameters of the images are determined by measuring the compression ratio, Peak Signal to Noise Ratio (PSNR) value and Structural Similarity (SSIM) index. In Figure 2, the input images such as Boat and Flowers are shown.

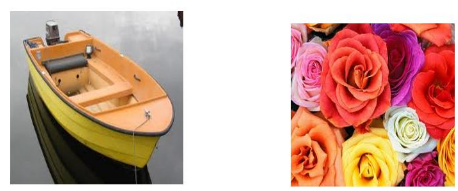

Fig. 2 Original images: i) Boat, ii) Flower

The Test images are compressed and decompressed using the proposed method and output obtained is shown in Figure 3.

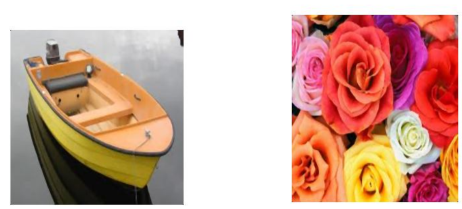

Fig. 3 Reconstructed images using proposed method

A. Comparative Analysis

Their results are evaluated in terms of various parameters such as Compression Ratio, PSNR value and SSIM index value and compared with existing techniques.

1) PSNR value

The Peak Signal to Noise Ratio (PSNR) is the ratio between a signal's maximum power and the power of the signal's noise. Figure 4 shows the comparison of compression ratio of standard algorithm of quadtree technique and proposed method.

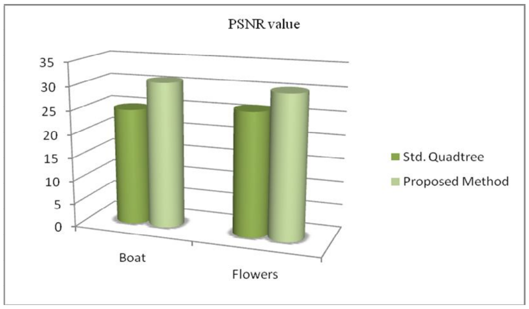

Fig. 4 Comparison of PSNR value of std.alg of quadtree technique with proposed method.

2) SSIM Index

The Structural Similarity (SSIM) index is a method for measuring the similarity between two images. Figure 5 shows the comparison of SSIM index of standard algorithm of quadtree technique and proposed method.

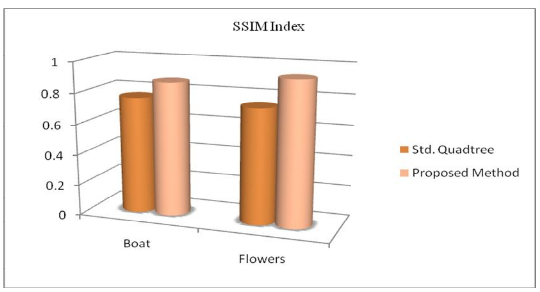

Fig. 5 Comparison of SSIM index of std.alg of quadtree technique with proposed method

3) Compression Ratio

The Compression Ratio is the ratio of original image to the compressed image. Figure 6 shows the comparison of Compression Ratio of standard algorithm of quadtree technique and proposed method.

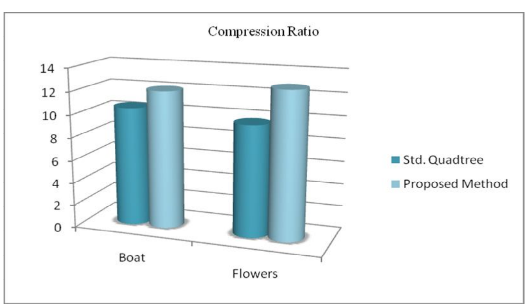

Fig. 6 Comparison of Compression Ratio of std.alg of quadtree technique with proposed method

VI. Conclusion

An Efficient Image Compression Method using DCT, Fractal and Run Length Encoding Technique compresses the input color images using different compression techniques and the color images are decompressed by reversing the compression algorithms.The combination of the different compression algorithms will make the compression more secure and the process can be employed in any of the transmission schemes.The compression ratio calculated describes that the proposed scheme compress the color image in a better way and the calculated PSNR value shows that the proposed scheme reduces the noises in the decompressed image in a better way.

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