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An Efficient Compression Technique for Color Images

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ABSTRACT

With the access of the information age the need for mass information storage and rapid communication links grows. Storing images in less memory leads to a direct reduction in storage cost and faster data transmissions. These facts justify the efforts, for development of new image compression algorithms. Research regarding is to improve the execution of Fractal image compression as far as accelerating the encoding process and increasing the compression ratio while keeping a high reconstructed image quality.

This paper proposes an Fractal image compression (FIC) method for Color images fetched out for variable block size. The image here is partitioned in to block by considering maximum and minimum size of the range. The proposed method divides color image into three RGB planes and employs fractal transformation with entropy coding. By applying the inverse transforms and iterative functions, the image is reconstructed at end. The outcomes of the planned method shows improvement in fractal compression scheme applied to both color and gray scale images. Here high CR and PSNR values are acquired compared to fixed range block size of 4 by 4 iterations and other subsisting methods. This algorithm achieves a compression ratio of up to 20 with a peak signal to noise ratio (PSNR) as high as 30dB.

Keywords— Fractal Image Compression, variable block size, inverse transform, iterative functions, CR, PSNR

I. INTRODUCTION

Images are stored on computers as accumulation of bits (a bit is a binary unit of information) defining pixels or points forming the picture elements. Considering the human eye can progress large amounts of information (some 8 million bits), profuse pixels are required to store reasonable quality images. These bits support the “yes” and “no” answers to the 8 million questions that decide the image. Best data contains some amount of redundancy, which can frequently be removed for storage and restored for recovery, but this redundancy does not advantage to high compression ratios. An image can be alternated in many ways that are either not noticble by the human eye or do not contribute to the degradation of the image. The regular methods of image compression come in various varieties. The current most famous method depend on deleting high frequency components of the signal by storing only the low frequency components. The Fractal Image Compression (FIC) was planned by Jacquin. Fractal is a separated geometric shape that can be a part of parts, each of which is made smaller in size duplicate of the entire, a property called self-similarity. Fractal image compression produce high compression ratios in a lossy compression format make use of the property of self-similarity in fractal articles. Actual self-similarity means that fractal picture is collection of scaled down duplicates of itself that are interpreted, continued and pivoted as indicated by a change [1]. Similarly a transformation is called relative transformation. In fractal image compression, the image is partitioned into various domain blocks with subjective size ranging from 4×4 to 16×16. Before, the picture is divided again into range block with size short that of the block domain [2]. For each domain range match, two transformations are required. One geometric change which maps the domain to the extent and other a relative transformation that modifies the intensity values in the domain to those in the extent [3]. The fractal compression techniques as explained in [4], [5], [6] is basically a search technique consisting of partitioning the image into sub images and search for self-similar parts within the image.The various separating methods are distinguished in literature review [7] .Partitioned Iterated Function System based algorithm is used for encoding, analyzing with other image compression methods [8].Douda et al.[9] suggested another system focused around the DCT coefficients. In this plan of action, the domain blocks with a movement are given from the domain pool. The action of blocks is concentrated around least horizontal and vertical DCT coefficients. Vahdati et al.[10] suggested a fractal image compression system concentrated around spatial relationship and hybrid molecule swarm improvement with genetic algorithm. There are two stages for this algorithm. The first stage misuses neighborhood height by making utilization of the spatial relationship between neighboring blocks. In the event that the neighborhood heights are not fulfilled, the second phase of the calculation is completed keeping in mind the end goal to investigate further likenesses from the complete picture. Kharate and Patil [11] suggested that the compression ratio and also the quality had been considerably enhanced by proper determination of the mother focused around the way of pictures. The procedure they have proposed had been focused around Threshold Entropy with improved run-length encoding based wavelet packet best tree. As complete tree had not been deteriorated, their technique had minimized the time complexity of wavelet packets decay. Sub groups that incorporate important information focused around threshold entropy had been picked up by their methodology. D. Venkatasekhar and P. Aruna [12] recommended that Genetic algorithm is utilized to discover the best block of substitution, so fractal image is carried out effectively. Here Genetic algorithm with Huffman coding is utilized for fractal image compression. Khalil [13] executed a Run Length coder that had been made straightforward and more powerful. M.Ismail and S.M.Basha [14] has recommended the IFIC using range block size.Veena Devi and A.G.Ananth [15]has recommended FIC of satellite imageries using variable size of range block.

II. FRACTAL COMPRESSION

Consider an original image, say B (here we assume B is nonempty, otherwise there is nothing to be compressed), with a resolution of a by b pixels, the image file consists of a header followed by a b cells of intensity data, one for each pixel. Given the resolution, the spatial coordinates of each pixel are implied (eg. the first b cells represent the top most row of pixels, starting from left, etc.). The size of the cell united with each pixel varies, depending on the type of the image as explained below.

The simplest case is a strictly black-and-white image (such as a weekday newspaper comic strip). From each pixel will have only one bit of data - 0 for white and 1 for black, say. Thus it is a orderly two-dimensional set, as the part we are observing in is just the addition of pixels whose bit contains 1, so we only need to keep track of their two reffered spatial coordinates. Therefore the image can be considered as a (compact) subset of R2. If B is a grey- scale image, it can be considered as a (compact) subset of R3 - the two spatial dimensions and a third one for the intensity of the grey-scale (which is usually between 0 and 255, so each pixel has one byte of allied data). As might be imminent, color images require more effort. If B is a color image, then its bit-mapped file can be considered as a (compact) subset of R5. In addition to the two spatial dimensions, there are three dimensions for the three RGB color parameters. Here we shall take a short look at how the color image is observable on a TV or monitor screen.

The RGB (Red, Green, Blue) system is aimed on the fact that red, green, and blue form a set of (additive) primary colors for light. By adjusting the intensity of each of the three colors, one can equivalent any color observable by the eyes. For computer applications, each light's intensity is commonly divided into 256 discrete levels, numbered 0 to 255. Hence for each parameter for RGB is kept in one byte of memory. This gives 2563 (over 16 million) different available composite colors, from total black (RGB=[0,0,0], i.e. no light at all) to bright white (RGB=[255,255,255], intensity of all three colored light). A to the point discussion of the RGB system can be found in [16].

In his work, Barnsley observed that real-world images often are rich in affine redundancy. This means that, with a suitable IFS, large parts of an image are similar to finer parts of the same image. This determination and the Collage Theorem were the benefits of the fractal image compression algorithm.

This process is self-sustained of the resolution of the original image. The output graphic will look like the unique at any resolution, since the compressor has found an IFS whose attractor duplicates the original one (i.e. a set of equations describing the original image). Of course, this method takes a lot of work, especially during the search for the suitable range regions. But once the compression is completed, the FIF file can be decompressed very immediately. Thus, fractal image compression is asymmetrical. The practical carry out of a fractal compressor offer different levels of compression. The lower levels have more composed search criteria to cut down processing time, but with the loss of more detail. The higher levels give very good detail, but take a long time to process each image. [17]

III. PROPOSED ALGORITHM

Basic fractal image encoding and decoding

The essential scheme of fractal image compression is as per the following steps:

Step 1: Divide original image into non-overlapped sub windows. Each sub window block is called Range block or R- block.

Step 2: For each R-block, find an overlapped image block i.e. Domain block, which most likely represents current R-block after a certain change or transform.

Step 3: For every R-block, find suitable D-block from D-pool which is most likely parallel to it.

Some of the certain steps for finding the suitable D-block from D-pool which is most parallel to corresponding R-block will be as follows

Crop the D-block size to the size of R-block by Shrink operation and, mark the D-block as D'-block after Shrink operation is applied.

Transpose the D'-block by using the following eight relative transformation equation matrices proposed by Jacquin. The eight relative transformations matrices are represented in the equations as follows

Consider T= $[a_{ij}]_n$ with n=2 where1≤(i,j) ≤ 2, $\begin{bmatrix} a11 & a12 \\ a21 & a22 \end{bmatrix}$

Relative transformations matrices can be represented with the following 1 to 8 equations

$$T_0 \text{ is } a_{ij} = \begin{cases} 1, if i = j \\ 0, else \end{cases} \quad (1)$$

$$T_1 \text{ is } a_{ij} = \begin{cases} (-1)^{2i+j}, if i \neq j \\ 0, else \end{cases} \quad (2)$$

$$T_2 \text{ is } a_{ij} = \begin{cases} -1, if i = j \\ 0, otherwise \end{cases} \quad (3)$$

$$T_3 \text{ is } a_{ij} = \begin{cases} (-1)^{i+2j}, if i \neq j \\ 0, else \end{cases} \quad (4)$$

$$T_4 \text{ is } a_{ij} = \begin{cases} (-1)^{ij}, if i = j \\ 0, else \end{cases} \quad (5)$$

$$T_5 \text{ is } a_{ij} = \begin{cases} (-1)^{ii+1}, if i = j \\ 0, else \end{cases} \quad (6)$$

$$T_6 \text{ is } a_{ij} = \begin{cases} (-1)^{i+j}, if i \neq j \\ 0, else \end{cases} \quad (7)$$

$$T_7 \text{ is } a_{ij} = \begin{cases} 1, if\ i \pm j \\ 0, else \end{cases} \quad (8)$$

Above eight relative transformation blocks are generated for each D'-block and these blocks are composite new D-pool.

Compare each R-block with the blocks which are in D'- pool and obtain nearly all like block. The parallelism can be measured with normal conflict MSE using the equation 9.

$$MSE = \|(X_k * D_k + Y_k * I - R_k)\| \quad (9)$$

Where X and Y are the coefficients and should have the values for making the MSE minimum. The X_k and Y_k are represented in equation 10 and 11 respictively

$$X_k = \frac{B^2 <D_k, R_k> - <D_k, I><R_k, I>}{B^2 <D_k, D_k> - <D_k, I>^2} \quad (10)$$

$$Y_k = \frac{<R_k, I> - <D_k, I>}{B^2} \quad (11)$$

$$W = \{D_k(x,y), T_k, X_k, Y_k\} \quad (12)$$

R_k represents the relative transformation W for each R-block.

Fractal image coding, the original image is segmented into non-collaborating regions called range block s and collaborating regions called domains block s. For each range block affine transformations given in the equation given below is used to match as best d o m a i n block.

$$Wi \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} ai\,bi & 0 \\ ci\,di & 0 \\ 0 \quad 0 & si \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} ei \\ fi \\ oi \end{bmatrix} \quad (13)$$

Where Si controls the contrast and 0i controls the brightness and ai, bi, Ci, di, ei, fi denote the eight symmetries such as identity, reflection about mid-vertical and horizontal axis, first and second diagonal.

Figure 1 shows the proposed fractal image compression.

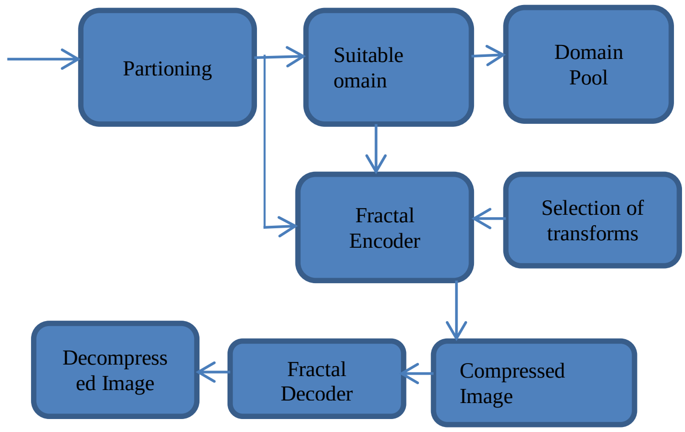


Fig.1. The Proposed Fractal Compression Technique.

1. Partition each plane image into non-overlapping blocks, called Range or R-block. Select the maximum Range block of size (Rmax) as 16 or 8 and minimum block of size (Rmin) of 4 or 8. R-blocks are compared with domains from the domain pool, which are double the range size.
2. The D block with the size of window K×K are slided over the entire 3 separated images in steps of K/2 or K/4 called as lattice. The pixels in the domain are averaged in groups to reduce to the size and apply transformation
3. After partitioning and transformation, fractal encoding searches suitable candidate from all blocks to encode any particular R block.
4. To improve encoding speed classification of sub-image into upper right, upper left, lower right and lower left quadrants is done as shown in Fig.2. These will follow one of the three ways as canonical ordering [18].

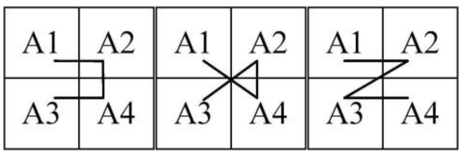


Fig 2: Classification Scheme of the Sub Image by Canonical Ordering

Classification Schemes are
(i) Major Class 1: A1>A2>A3>A4
(ii) Major Class 1: A1>A4>A2>A3
(iii) Major Class 1: A1>A2>A4>A3

In coding process any range block is mapped to the domain block s and using of the entropy coding to achieve fractal compression.

Calculating the compression ratio.

R ecord the fractal decoder to reconstruct the image and calculating PSNR.

IV. RESULTS AND DISCUSSION

The proposed method is evaluated on both gray and color images applied on a set of five color images of standard size 512×512. The test images used in the experiments are Bird image with the resolution 512×512, the color satellite urban image of size 2030×2180 from Indian Remote Sensing IRS-II satellite, The color Standard Lena image of size 512×512, the color satellite rural image of size 995×571 and Roses image with the resolution 512×512. The Quality of the re-constructed images is determined by measuring the Peak Signal to Noise Ratio (PSNR) value and the Compression Ratio (CR) for both color and grey level images.

By using the variable range block size for three cases namely (a) R_{max}= 16 and R_{min} = 4 (b) R_{max} = 16 and R_{min} = 8R_{max} = 8 and R_{min} = 4, the imageries are subjected to fractal compression scheme. The Compression Ratio (CR) and Peak Signal to Noise Ratio (PSNR) values for the both color and gray of Standard Lena image, satellite rural imageries, roses image, satellite urban imageries and Bird image determined for both three different variable range methods are displayed in Table 1 and 2 respectively. The novelty of the proposed method is, the proposed method is applied on both grey level and color images. The proposed method gives the comparable results when applied on both color and grey images.

Table 1.CR and PSNR of Test Color Images

S No	TEST IMAGES	R_{max}=16 & R_{min} = 4		R_{max}=16 & R_{min} = 8		R_{max}=8 & R_{min} = 4	
		CR	PSNR	CR	PSNR	CR	PSNR
1	Lena Image	2.99	27.88	15.45	20.16	3.16	30.15
2	Satellite Rural Image	3.87	19.75	18.08	17.88	3.33	35.65
3	Rose Image	4.44	27.01	17.85	20.11	4.02	35.66
4	Satellite Urban Image	3.55	24.55	18.90	22.89	3.37	32.59
5	Bird Image	3.68	18.88	17.45	24.95	3.11	31.79

Table 2.CR and PSNR of Test Gray Images

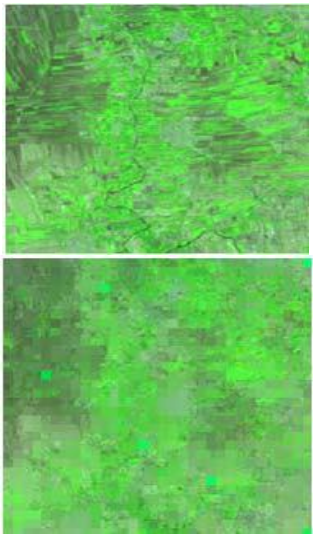
SNo	TEST IMAGES	R_{max}=16 & R_{min} = 4		R_{max}=16 & R_{min} = 8		R_{max}=8 & R_{min} = 4	
		CR	PSNR	CR	PSNR	CR	PSNR
1	Lena Image	2.99	27.88	15.45	20.16	3.16	30.15
2	Satellite Rural Image	3.87	19.75	18.08	17.88	3.33	35.65
3	Rose Image	4.44	27.01	17.85	20.11	4.02	35.66
4	Satellite Urban Image	3.55	24.55	18.90	22.89	3.37	32.59
5	Bird Image	3.68	18.88	17.45	24.95	3.11	31.79

The Color & Grey Lena, Rose, urban satellite, bird and rural satellite imageries reconstructed for the variable range block size R_{max}=16 and R_{min}= 8 are shown in Fig. 3(a)3(b) ,4(a)4(b) ,5(a) 5(b) ,6(a) 6(b), 7(a), 7(b)and 8(a) 8(b) . It may be seen from the figures and tables that the proposed IFIC method for the images of Lena, Bird, Satellite Rural, Rose and urban satellite gives significantly large CR values and shows a very good quality of the reconstructed imageries.

(a)

(b)

Figure 3: Results of Lena color image a) Lena Image b) re-constructed lena image



(a) (b)

Figure 4: Results of Satellite Urban colour image a) original satellite urban Image b) re-constructed satellite image

(a)

(b)

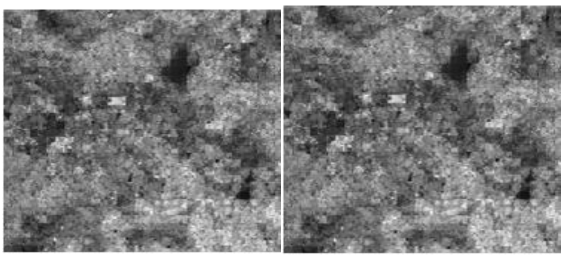
Figure 5: Results of Lena gray image a) original lena gray Image b) re constructed lena image

(a) (b)

Figure 6: Results of Rose gray image a) original rose gray Image b) re constructed rose image

(a) (b)

Figure 7: Results of Bird gray image a) original gray bird Image b) re constructed bird image



(a) (b)

Figure 8: Results of satellite rural gray image a) original gray satellite Image b) re constructed satellite image

A. Comparision with other existing methods

The present Fractal Image Compression [FIC] is compared with the other existing methods, like standard algorithm of quadtree technique [19], fractal with quadtree and DCT technique [20], and Fractal image compressions based on variable size range block method [21]. The CR and PSNR values obtained from the present method of variable range block size for test imageries are compared with the results of existing methods [19,20,21] .Standard algorithm of quadtree technique (SAQT), fractal with quadtree and DST technique (FQ&DST), FIC based on variable size range block method (FICVRB),Proposed IFIC(IFIC) in both color and gray level image with range block size Rmax=16 and Rmin= 8 are comparatively shown in the Tables 3, 4, 5 and 6.

Table 3: Comparison of CR with other available methods for color images

S. No.	Test Images	SAQT	FQ&DST	FIC VRB	FIC
1	Lena Image	10.01	14.44	13.0	17.53
2	Satellite Rural Image	8.68	13.35	15.5	18.99
3	Rose Image	8.32	12.56	15.4	18.13
4	Satellite Urban Image	10.66	13.87	13.87	17.78
5	Bird Image	9.99	14.98	16.56	16.55

The comparison chart of CR and PSNR values for the proposed method and other existing methods in both case .i.e. color and grey image when applied on test images i.e Lena, Satellite rural image, Satellite urban image, Bird and Rose images are shown in Figures 10,11 and 12 .

Table 4: Comparison of CR with other available methods for grey images

S. No.	Test Images	SAQT	FQ&DST	FIC VRB	FIC
1	Lena Image	8.78	13.55	16.87	19.99
2	Satellite Rural Image	9.77	13.33	15.75	18.89
3	Rose Image	9.85	12.15	15.75	19.9
4	Satellite Urban Image	9.15	13.03	17.71	18.53
5	Bird Image	8.98	13.01	15.99	19.54

Table 5: PSNR of the proposed method and other available methods of color images

S. No.	Test Images	SAQT	FQ&DST	FIC VRB	FIC
1	Lena Image	24.89	29.45	18.55	30.33
2	Satellite Rural Image	26.33	30.98	23.01	33.55
3	Rose Image	26.08	32.01	21.50	35.55
4	Satellite Urban Image	25	30	16	32
5	Bird Image	26.45	31.67	23.80	33.11

Table 6: PSNR of the proposed method and other available methods of gray level images

S. No.	Test Images	SAQT	FQ&DST	FIC VRB	FIC
1	Lena Image	23.13	29.88	26.5	32.25
2	Satellite Rural Image	25.15	31.19	24.55	31.15
3	Rose Image	24.33	29.10	18.55	32.01
4	Satellite Urban Image	25.36	31.87	25.55	31.95
5	Bird Image	25.15	30.48	23.76	32.78

Fig 9: Comparison chart of CR of the proposed method with other existing methods when applied on color test images

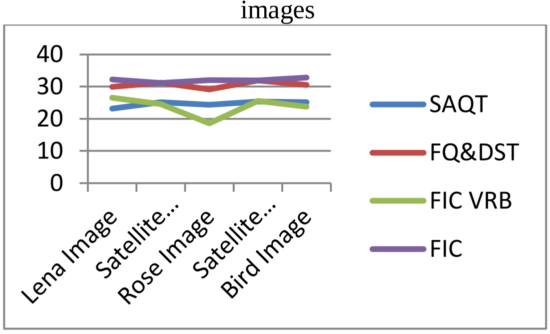


Fig 10: Comparison chart of CR of the proposed method with other existing methods when applied on gray test images

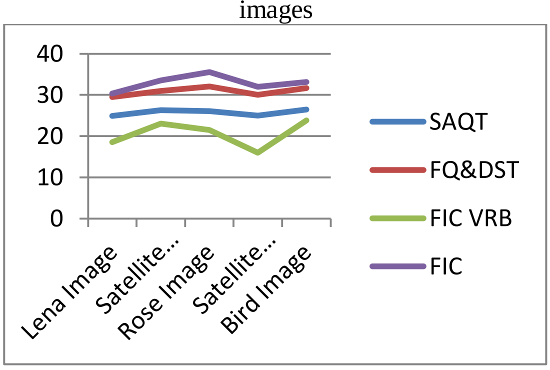


Fig 11: Comparison chart of PSNR of the proposed method with other existing methods when applied on color test images

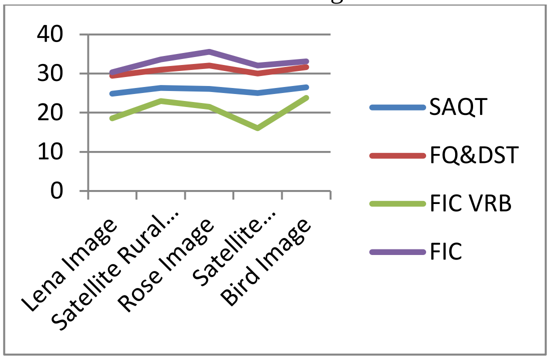
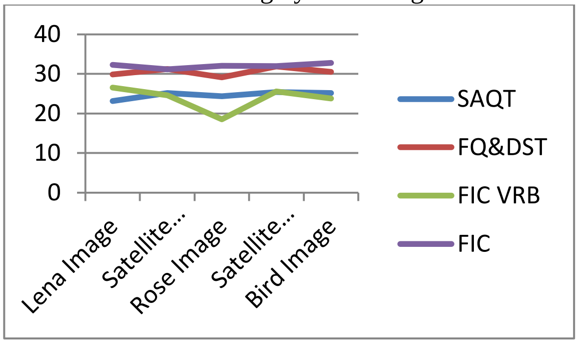


Fig 12: PSNR of the proposed method and other available methods of gray level images



V. CONCLUSION

In the present paper, an experimental work is done to get a Improved fractal image compression. The experimental results clearly depict that for the variable range block size of R_{max}=16 and R_{min}=8 a better result is obtained with good image quality and low computational cost. The uniqueness of the proposed method is, the RGB image is divided into three planes and using range block fractal concept it is compressed with reduced computational cost. When compare with the fixed block size method of fractal compression schemes, the present method exhibits higher compression ratio and PSNR values for all types of imageries. When the proposed method is applied on both color and gray scale images it gives approximately same CR and PSNR values. The proposed method when applied on different types of images like satellite image, standard color images and natural image, gives comparatively good results. The PSNR values obtained in this approach is always nearer to 30

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