Fractal Image Compression of Satellite Color Imageries Using Variable Size of Range Block

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Abstract

Fractal image compressions of Color Standard Lena and Satellite imageries have been carried out for the variable size range block method. The image is partitioned by considering maximum and minimum size of the range block and transforming the RGB color image into YUV form. Affine transformation and entropy coding are applied to achieve fractal compression. The Matlab simulation has been carried out for three different cases of variable range block sizes. The image is reconstructed using iterative functions and inverse transforms. The results indicate that both color Lena and Satellite imageries with R_{max} = 16 and R_{min} = 8, shows higher Compression ratio (CR) and good Peak Signal to Noise Ratios (PSNR). For the color standard Lena image the achievable CR~13.9 and PSNR ~25.9 dB, for Satellite rural image of CR~ 16 and PSNR ~ 23 and satellite urban image CR~16.4 and PSNR~16.5. The results of the present analysis demonstrate that, for the fractal compression scheme with variable range method applied to both color and gray scale Lena and satellite imageries, show higher CR and PSNR values compared to fixed range block size of 4 and 4 iterations. The results are presented and discussed in the paper.

Keywords: Maximum Range Block Size (R_{max}), Minimum Range Block Size (R_{min}), Affine Transformation, Canonical Classification, PSNR (Peak Signal to Noise Ratio), CR (Compression Ratio).

1. INTRODUCTION

Fractal is a fragmented geometric shape that can be split into parts, each of which is a reduced-size copy of the whole, a property called self-similarity. Fractal image compression achieves high compression ratios in a lossy compression format uses the property of self-similarity of fractal objects. Exact self-similarity means that fractal object is composed of scaled down copies of itself that are translated, stretched and rotated according to a transformation [1]. Such a transformation is called affine transformation. In fractal image compression, the image is divided into a number of domain blocks with arbitrary size ranging from 4x4 to 16x16, or more. Then, the image is divided again into range block with size less than that of the block domain [2]. For each domain range pair two transformations is required, a geometric transformation which maps the domain to the range and an affine transformations that adjusts the intensity values in the domain to those in the range [3]. The fractal compression technique as explained in [4], [5], [6] is basically a search process consists of partitioning the image into sub images and search for parts of the images which are self similar. The various partitioning schemes are compared in [7]. The algorithm used for encoding is the Partitioned Iterated Function System [8] compared with other image compression methods. Fractal image coding based on Quadtree [9] is a novel technique for still image compression. An improved Quadtree fractal image compression Algorithm [10] produces better CR, PSNR and processing time. A new method using best polynomial [9] to decide whether a domain block is similar enough to a given range block. A domain optimization technique in fractal image compression [11] deals with reducing complexity and increasing accuracy that is range and domain block alignment and matching. The method to reduce the decompression time was proposed in [12]. Fractal image compression has high quality at high CR, but needs lot of encoding time. Using the knowledge of mean and variance to classify image blocks and combine the transformation reduction techniques to decrease the encoding time [13]. The fractal coder partitions an image into blocks that are coded via self-references to other parts of the image itself [14]. Fractal (or attractor) image compression approach relies on the assumption that image redundancy can be efficiently exploited through self-transformability. The algorithms described in this paper utilize a novel region-based partition of the image that greatly increases the compression ratios achieved over traditional block-based partitioning [15].

2. FRACTAL IMAGE COMPRESSION

Suppose a special type of photocopying machine that reduces the image to be copied by half and reproduces it three times on the copy. When the output of this machine is given back as input and several iterations of this process produces several input image. It can be observed that all the copies seem to converge to the same final image, in fact it is only the position and the orientation of the copies that determines the final image [6].The way the input image is transformed determines the final result when running the copy machine in a feedback loop. These transformations must be contractive, that is given transformation applied to any two points in the input image must bring them closer in the copy such transform called affine transformation.

An affine transformation can skew, stretch, rotate, scale, shear and translate an input image. The feature of these transformations that run in a loop back mode is that for a given initial image each image is formed from a transformed copies of itself, and hence it must have detail at every scale. These images are fractals. Storing these images as collections of transformations lead to image compression.

3. THE PROPOSED ALGORITHM

Fractal image coding is based on partitioning of the original image into non-overlapping regions called range blocks and overlapping regions called domains blocks. For each range block, the best matching domain block must be found by affine transformations w_i is of the form as follows in equation (1).

$$w_i \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_i & b_i & 0 \\ c_i & d_i & 0 \\ 0 & 0 & s_i \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \\ o_i \end{bmatrix} \qquad (1)$$

Where s_i controls the contrast and o_i controls the brightness and a_i, b_i, c_i, d_i, e_i, f_i denote the eight symmetries such as identity, rotation through +90º, rotation through +180º, rotation through -90º, reflection about mid-vertical axis, reflection about mid-horizontal axis, reflection about first diagonal and reflection about second diagonal. Fig.1. shows the proposed fractal image compression.

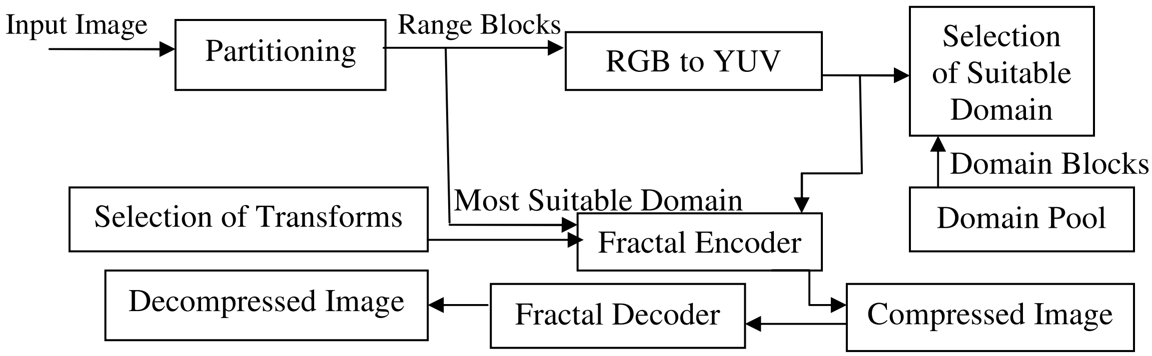

FIGURE 1: The Proposed Fractal Compression Technique.

The Fractal Encoding and Decoding Algorithm:
The algorithm steps are as follows.

- Selecting maximum Range block of size (R_{max}) of 16 or 8 and minimum Range block of size (R_{min}) of 4 or 8 are compared with domains from the domain pool, which are twice the range size.

- Convert the image RGB to YUV form.

- The domain block size of window K*K are sliding over the entire image in steps of K/2 or K/4 known as lattice. The pixels in the domain are averaged in groups so that the domain is reduced to the size of the range and applying affine transformation.

- After partitioning and transformation, the fractal encoding process is the search of suitable candidate from all available blocks to encode any particular range block.

- The attempts to improve encoding speed involves classification of sub-image into upper left, upper right, lower left and lower right quadrants shown in Fig.2. On each quadrant compute values proportional to the average intensities. They will follow one of the three ways as canonical ordering [16].

They are
(i) Major Class 1: A1>A2>A3>A4
(ii) Major Class 2: A1>A2>A4>A3
(iii) Major Class 3:A1>A4>A2>A3

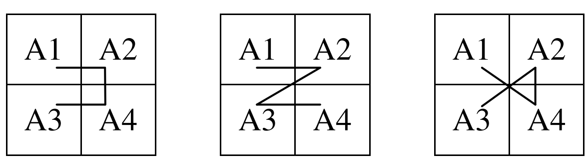

FIGURE 2: Classification Scheme of the Sub Image by Canonical Ordering.

- In addition to three major classes, there are 24 different subclasses for every major class. In this way the total domain and range blocks are represented in 72 classes. In coding process any range block is mapped to the domain blocks and using of the entropy coding to achieve fractal compression.

- Calculating the compression ratio. Record the fractal decoder to reconstruct the image and calculating PSNR.

4. RESULTS AND DISCUSSIONS

The color satellite urban image of size 2030 X 2180 and rural image of size 995 X 571 are obtained form Indian Remote Sensing IRS-II satellite. These images are taken the standard size 256 X 256. The color Standard Lena image of size 256 X 256 has been used for the fractal compression analysis. 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} = 8 (c) R_{max} = 8 and R_{min} = 4, the imageries are subjected to fractal compression scheme. The algorithm for fractal compression is realized in Matlab code and decodes the images. The Compression Ratio (CR) and Peak Signal to Noise Ratio (PSNR) values for the both gray and color of Standard Lena image, satellite rural imageries and satellite urban imageries determined for both three different variable range methods are displayed in Table 1.

Range Block Size	Parameter	Lena Image		Satellite Rural Image		Satellite Urban Image	
		Gray	Color	Gray	Color	Gray	Color
R_{max} = 16 R_{min} = 4	CR	3.2	3.1	3.8	3.6	3.9	3.7
	PSNR	29.2	28.5	26.7	25.5	20.1	18.6
R_{max} = 16 R_{min} = 8	CR	13.6	13.9	16.5	16	17.1	16.4
	PSNR	26.5	25.9	24.5	23	18.2	16.5
R_{max} = 8 R_{min} = 4	CR	3.2	3.3	3.7	3.6	3.7	3.6
	PSNR	30.7	29.9	27.7	26.4	21.8	19.5

TABLE 1: The CR and PSNR Values Derived for the Three Cases of Variable Range Block Sizes for Standard Lena and Satellite Imageries (Gray & Color).

It may be seen from Table 1 that out of the three variable range methods the Lena and Satellite Rural and Urban imageries, the variable range block size R_{max}=16 and R_{min}=8 show better performance in CR and PSNR compared to other two variable range methods. Further the Table 1 indicate that for the same variable block size both the color and grey scale Lena and satellite imageries show comparable performance in the CR and PSNR values.

The Color Lena and satellite imageries reconstructed for the variable range block size R_{max}=16 and R_{min}= 8 are shown in Fig. 3(a), 3(b) and 3(c). For comparison the original image is also displayed in the same figure. It may be seen from the figure that the variable range size the Lena and satellite imageries with significantly large CR values show very good quality for the reconstructed imageries.

FIGURE 3 (a): Reconstructed Lena Image for Variable Range Block Size of R_{max} =16 and R_{min}=8.

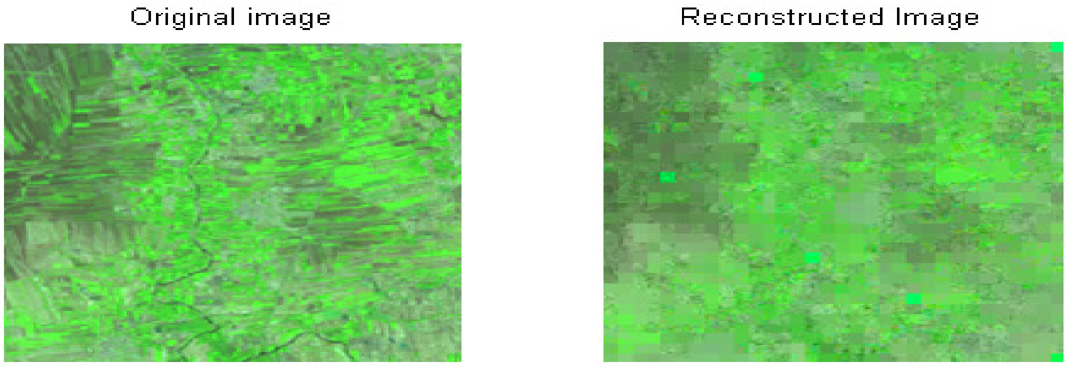

FIGURE 3 (b): Reconstructed Satellite Rural Image for Variable Range Block Size R_{max} =16 and R_{min}=8.

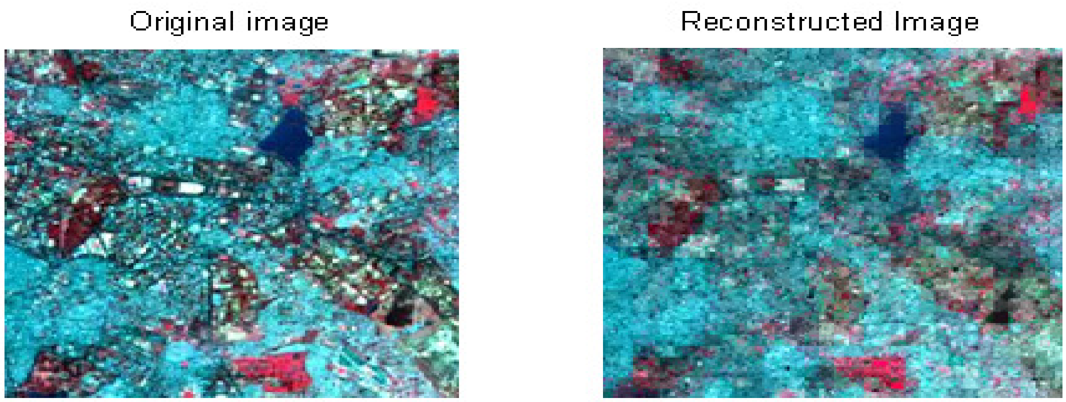

FIGURE 3 (c): Reconstructed Satellite Urban Image for Variable Range Block Size of R_{max} = 16 and R_{min}= 8.

The Color and grey scale Lena and satellite imageries reconstructed for the variable range block size R_{max}=16 and R_{min}= 8 are shown in Fig. 4(a), 4(b) and 4(c). It may be seen from the figure that for the fractal image compression both the color and gray scale Lena and satellite imageries with higher CR values show very good quality for the reconstructed imageries.

FIGURE 4 (a): Reconstructed Lena Image of Gray and Color.

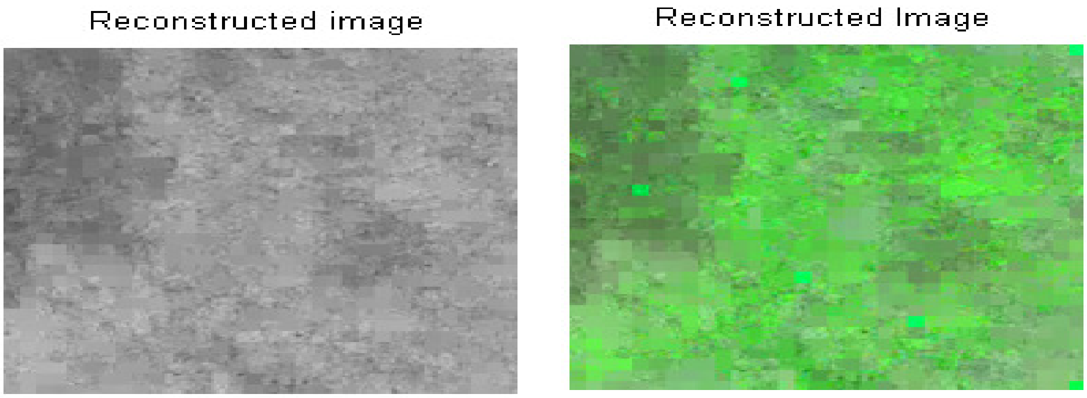

FIGURE 4 (b): Reconstructed Satellite Rural Image of Gray and Color.

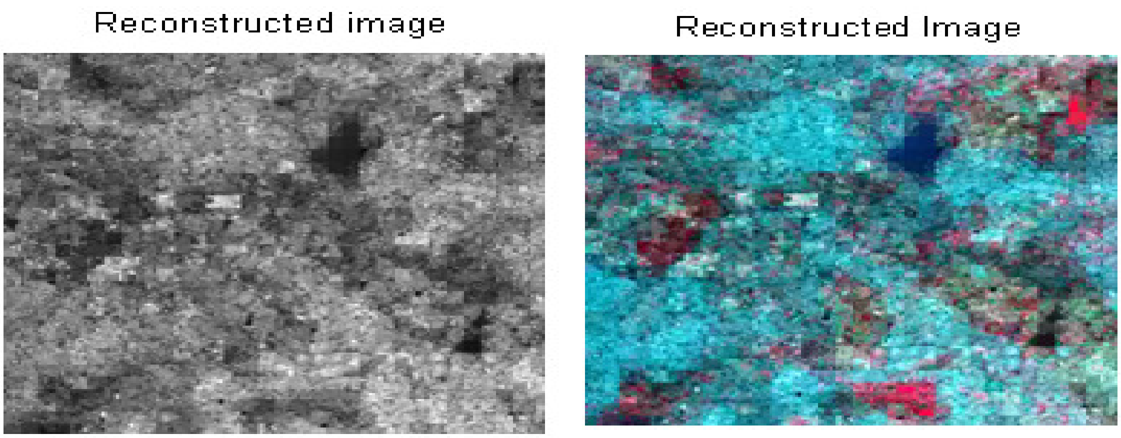

FIGURE 4 (c): Reconstructed Satellite Urban Image of Gray and Color.

The CR and PSNR values obtained from the present analysis for the variable range block size method for Lena and satellite imageries are compared with the results of same gray scale images derived from an earlier paper [17],[18] are compared and shown in the Table 2.

Range Block Size	Lena Image		Satellite Rural Image		Satellite Urban Image	
	PSNR	CR	PSNR	CR	PSNR	CR
Fixed Size $R_{max} = 4$ $R_{min} = 4$	11.9	3.2	17.1	3.2	21.8	3.2
Variable Size (Gray Image) $R_{max} = 16$ $R_{min} = 8$	26.5	13.6	24.5	16.5	21.6	16.9
Variable Size (Color Image) $R_{max} = 16$ $R_{min} = 4$	25.9	13.9	23	16	16.5	16.4

TABLE 2: Gives a Comparison of CR and PSNR Values Derived from Fixed and Variable Range Block Size Methods for Lena and Satellite Imageries (Color and Gray scale).

It is clearly evident from the Table 2 that the both color and gray scale Lena and satellite imageries shows better values for CR and PSNR values compared to fixes range block size methods. Further the Table shows that except for Satellite Urban images both the color and gray scale images shows comparable CR and PSNR values. For Urban Images the gray scale imageries show higher CR values compared to color imageries.

5. CONCLUSIONS

From the analysis carried out in the paper the following conclusions can be drawn

- The fractal encoding scheme using variable range block size R_{max}= 16 and R_{min} = 8 for color images shows superior performance by achieving higher CR ~ 13 and better PSNR values ~ 20dB for both Lena and satellite Imageries.
- For the same variable range block size both color and gray scale Lena and satellite Imageries shows similar CR and PSNR performance.
- The variable range block size method compared to fixed block size method of fractal compression scheme exhibits higher compression ratio and PSNR values for both Lena and satellite imageries.

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