Fast Fractal Image Compression using Statistical Self-Similarities Mechanism

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ABSTRACT
Fractal image compression is a technique used for encoding images compactly based on fractals. This method is best suited for textures and natural images, relying on the fact that parts of an image often resemble other parts of the same image. But fractal Image compression (FIC) consumes most of the time during encoding to find the best matching pair of range-domain blocks. Different techniques have been analyzed to reach shorter encoding time. This paper proposes a mechanism of Statistical Self-Similarity to achieve image compression. Unlike the other approaches no need of two partitions of same image into range and domain blocks. Instead a single partition can serve. The Statistical Self-Similarity is based on the mean value found among various blocks of subsets. The overhead of Image is halved. This makes the approach faster than other traditional approaches**.**

Keywords
Fractal Image Compression, Statistical Self-Similarity, Range Blocks and Domain Blocks, Encoding time.

1 INTRODUCTION

1.1 Image Compression
Image compression is the process of reducing the size of a file or media such as high tech images, audio and video files by encoding its data more efficiently. This is done in order to achieve a faster transmission of electronic files or digital images and a smaller space required for downloading. The goal of image compression technique is to remove redundancy present in images in-order to enable acceptable reconstruction of images. Statistical properties of images are used to design an appropriate compression technique.

1.2 Image Compression Techniques
Generally image compression techniques are divided into two categories: Lossy image compression and lossless image compression.

Lossy image compression: Lossy is a term applied to data compression technique in which some amount of original data is lost during the compression process. Lossy compression attempt to eliminate redundant information .As the amount of data is reduced in compressed image, the file size is smaller than original. This can be used in internet for faster transmission.

Lossless image compression: Lossless is a term applied to image compression where only little of original data is lost. Many audio and video compression methods are lossless compression.

2 FRACTAL IMAGE COMPRESSION

2.1 Brief Review
Fractal Image Compression (FIC) is one of the widely used image processing application in image retrievals, image signature, texture segmentation, feature extraction. The overhead expense in fractal encoding is due to huge number of Range -domain compression required to find best matching pair.

Michael Barnsley was the first to suggest the use of transformations to store images compactly [1]. The Self Similarities contained in images are represented by Iterated Function System (IFS). Later Jacquin proposed to partition the image into square blocks, search for regions of the image that are self-similar according to a certain criterion and once a match is found, compute transformations [2]. A special type of IFS, called partitioned iterated function system (PIFS), is used to represent image blocks. In Fractal encoding, the image is divided into range blocks and domain blocks. The smaller non overlapping range blocks, R, cover the entire image, whereas larger domain block, D are constructed from a subset of original image.

For every range block, the set of domain block is searched for best match. A contractive transformation is used to map each range block to its matched domain block [3]. This transformation aims to reduce the distortion measure during search process. Similarity transformation parameters between range block and domain block are used to encode the range block. The encoding time can be reduced by minimizing the number of domains required to match with each range block. Domain classification schemes based on various parameters have been investigated by researchers. [5, 6, 7]. This methods generally focus on selecting a subset from the set of domains, as the candidates for each range block. Reducing the number of domain blocks to be matched based on their local fractal dimension is one among such attempts [8]

The Two Advantage of changing images to Fractal data are: the memory required to store fractal codes is smaller than that of original image, the image can be scaled up or down to a size early without disrupting image details.

2.2 Basic Fractal Image Encoding Algorithm
Fractal coding is basically a search process and consists of following steps: Partitioning the image into sub-images or blocks, search for parts of images which are self similar in statistical sense, compute the transformations [6, 10]. The partition of range block and domain block is shown in Fig.1. Basic compression procedure is:

i. Partition the original image to get the non-overlapping range blocks, R_i.

- **ii.** Partition the original image to get overlapping domain blocks, Di.
- **iii.** The domain blocks are filtered and sub-sampled so that it match the size of range blocks, i.e., DD_i
- **iv.** For every block of DD_i, find the values of by referring R_i, D_i and using least square regression method.
- **v.** Compute the error $E(R_i, DD_i)$
- **vi.** Among all blocks DDi find the bock DDi with minimal error E(Ri,DDi)=min E(Ri, DDi)

3 THE PROPOSED MECHANISM

3.1 Self-Similarities

Self-Similarity is usually the major identifying feature of a fractal. Mandelbrot originally defined fractals using the “Fractal Dimension”. The self-similarity in a seirpinski triangle is shown in Fig.1. The self-similarity of a Sierpinski triangle is Exact. It contains many copies of itself.

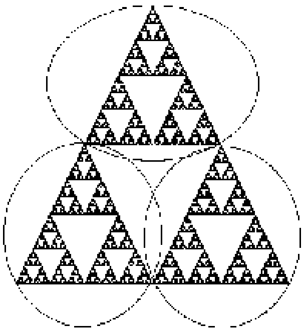

Fig.1: Self-Similarity in a seirpinski triangle

See the Figure 1 shown above. That is to say, if the image is magnified into any of the 3 pieces of **S** shown in Figure by a factor of 2, the result obtained is an exact replica of **S**. That is, **S** consists of 3 self-similar copies of itself, each with magnification factor 2.This type of self-similarity at all scales is a hallmark of the images known as fractals.

Fig.2: Example of Lena as a fractal

3.2 The proposed approach based on self-similarities

Fractals can also be classified according to their self-similarity. There are three types of self-similarities found in fractals: First type is exact self-similarity, second is quasi self-similarity, third is statistical self-similarity. This paper makes use of statistical self-similarity to achieve image compression. Traditional approaches for fractal image compression divides the image into range blocks and domain blocks. Two partitions on the same image is required. While the proposed approaches does not need two partitions instead single partition serves the purpose.

3.2.1 Basic Idea

The input image of size N×N is considered as a 2D array of pixels where each location (i,j); 1≤i,j≤N represents a pixel. The input image is then partitioned into fixed square sized blocks of size M×M. Now the image is considered as a 2D array of size N/M×N/M where each location (i,j); 1≤i,j≤N/M represents a block of size M×M.

The key concept is to search such blocks of size M×M in which the values of each pixel is not much different. The proposed technique uses a variable T for threshold, which will give maximum permissible difference between each pair in that block.

3.2.2 Proposed Mechanism

The proposed approach stores the image in the form of two block pools, as ‘block pool0’ and ‘block pool1’. ‘Block pool1’ contains the blocks for which pixel values are not close to each other. ‘Block pool1’ contains the blocks whose pixel values are closer. Therefore this work focus on the ‘block pool1’ for the compression. The mean value of all pixel values for each block of ‘block pool1’ is calculated. Instead of storing the complete block, only this mean value is stored for each block. If there exist more than one block with same mean value in the ‘block pool1’, the mean value is stored once along with all the locations of the block having same mean value.

3.2.3 Classification with variance and mean

In this paper, the block variance and mean are the methods to classify and achieve statistical self-similarity. Blocks variance is usually used to classify the simplicity or complexity for each block. The variance of block is defined as

$$\text{Var }(1)=\sqrt{1/n\times n\left[\sum_{i=1}^{n\times n} Xi^2\right]-\left(1/n\times n\sum_{i=1}^{n\times n} Xi\right)^2}$$

Where n is the size of the block and x_i is the pixel value of range and domain blocks. Range blocks are classified according to variance difference between Var(R) and var (D’). Then both range and domain blocks are classified into number of classes according to mean value. The proposed method search only domain blocks whose mean value classes are same or adjacent as the range block that can meet the criterion of

$$|\text{Var}(R) - \text{Var }(D')| \leq \text{Threshold}$$

3.2.4 The Compression Procedure

The compression procedure takes following as input: N×N Image, Block size M, Threshold T

Step1: Partition the image into blocks of M×M, (M<N) and set the status of each block as ‘Zero’ initially.

Step2: For each block Bi with status ‘Zero’, calculate the pixel values difference between each pair of elements.

Step3: If Bi≤T, then Calculate the mean of all the elements of the block and set the status of block as ‘One’

Step4: if Bi>T, then Add the block to ‘block pool 0’ along with the respective location and set the status of each block as ‘Two’

Step5: For each block Bi with status ‘One’, Set the status of block Bi as ‘Two’;

Step6: Add the mean value of the block along with the coordinate of the upper left corner of the block to 'block pool 1'

Step 7: Now at block Bj with status 'One', compare the mean value of block Bi and Bj.

Step8: if (mean (Bi) ==mean (Bj)), then set the status of block Bj as 'Two'

Step9: if the mean value of Bj is not found in the 'domain pool 1', then add the mean value of the block Bj along with the coordinate of the upper left corner of the block to 'block pool 1'.otherwise, Find the value same as that of mean (Bj) in the 'block pool 1', and attach the coordinate of the upper left corner of the block Bj with that value.

3.2.5 The Decompression Procedure

The original image is reconstructed using decompression procedure. For this 'block pool0' and 'block pool1' both has to be considered.

Step1: In the 'block pool0', place every block Bi to the appropriate position stored with Bi in the reconstructed final image.

Step2: In the 'block pool1', for each mean value of block Bi in 'block pool1' repeat the mean value to form a block Bi of size M×M.

Step3: Place the block Bi to the appropriate position(s) in the reconstructed final image.

4 EXPERIMENT AND RESULTS

This section of paper describes the analysis of the results obtained for our research findings. There are many ways to measure the quality of reconstructed image, obtained with a given compression method. Probably the two most popular measures used are mean square error(MSE) and peak signal to noise ratio(PSNR) The MSE is the cumulative squared error between the compressed image and original image, whereas PSNR is a measure of the peak error. A lower value for MSE means lesser error. Logically a higher value of PSNR is good because it means that the ratio of signal to Noise is higher. The proposed algorithm has been implemented successfully using Mat lab and evaluated their performance with different images.

Error estimates like PSNR and RMS with the reconstructed images has been found out. Results for different types for basic FIC method are listed in Table 1.

Table 1 Result of basic method

Image	PSNR	RMS
lena	28.3241	9.7791
camera man	27.2497	12.3396
car	30.9867	7.1978

The images were tested for the proposed method. The results are shown in Table 2.

Table 2.Result with proposed method

Image	PSNR	RMS
lena	27.82	11.7166
camera man	27.08	13.1643
car	26.52	9.1911

A comparison of compression ratio with proposed method is given in Table 3.

Table 3 comparison of compression time

Image	Average time	
	Basic method	Proposed method
lena	34	15
camera man	18	17
car	27	21

Different images and the reconstructed ones are shown in the **Figure 3.** The difference between the original image and the reconstructed one is also shown.

a) Lena image

b) Camera man

c) Car

e) Camera man image encoded

d) Lena image encoded

f) Encoded image of car

Fig 3 Images of original in a) Lena, b) Camera man and c) Car and Reconstructed images respectively in d), e), f)

5 CONCLUSION

In this paper, a mechanism based on statistical self-similarities is presented to improve FIC in the first part. Experimental results show the performance obtained for the test of images without remarkable deterioration of image quality. The work can be generalized to any arbitrary chosen block size and threshold value as required by different types of images. Moreover this approach can be further improved by using Exact Self-similarity mechanism on 'block pool0' to achieve higher compression.

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