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Analysis of the Performance of Fractal Image Compression on Different Imaging Modalities: A Review

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Abstract— In this paper, we have reviewed the performance of different types of fractal image compression techniques that are used to compress and decompress images. These techniques work using different algorithms. The quality of a particular image compression technique depends on many factors like image compression and decompression time, how much does the decompressed image match with the original image etc. To check the quality of the image we used only objective measurements. After checking the performance of different techniques, some techniques were found fast and better than the others.

Keywords- *Fractal image compression, compression and decompression techniques*

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I. INTRODUCTION

In today's world, time is one of the biggest assets. In transmission and reception of data, time plays a vital role. With the development of several new technologies based on multimedia in medical, the database and size of the images is increasing at a very fast pace, which has increased the transmission time and it also takes a lot of storage space. Thus, we need to reduce the transmission time and the storage space. The best way to achieve this is by compression. With the compression techniques we can severely reduce the storage space and increase the transmission time and that too with very little compromise in the quality of the compressed image. There are several methods to compress images and a lot of new researches have appeared in this direction [3].

In compressing and decompressing images, one of the best techniques that are used nowadays is Fractal Image Compression (FIC). FIC is a lossy compression method. FIC is based on iterated function system through which good quality reconstructed images can be obtained. Mainly, FIC technique is used on medical images like MRI, CT SCAN, X-rays, Ultrasound etc. because in these images one part of an image resembles with other parts of the same image or can also resemble with other images. In this technique, we transform the image into fractals which has two advantages. The first one is that the fractal data occupies less memory size than the original image. The second benefit is that, as the data is mathematical, the image can be easily zoomed in or zoomed out without altering any details of the image. [1],[5].There is only one disadvantage of FIC also which is that it takes a lot of time for the compression and decompression process[7]. Therefore an improvement in FIC is required, so as to make it less time consuming and more accurate so that it can prove to be a revolution in data transmission speed and storage of medical and other images.

1. REVIEW ON FRACTAL IMAGE COMPRESSION

A. *Parallel based FIC on multicore systems:*

The main idea of this model is to start more than one FIC process at the same time. Each one is responsible for a subset of the original image. Figure 1 illustrates the proposed model when 4 threads are employed. The first step of this model is to split the original image inn equal subsets of ranges. The value of n indicates the number of threads that will be employed on compression coding. Each thread works with whole set of domains and must test all element of this set against each range element received previously. The final step concerns the appending of all blocks for generating the final compresses image. This task is done after a synchronization point that waits for the ending of all threads. Fractal image compression applies transformations, which approximate smaller parts of the image by larger ones. The smaller parts are called ranges and the larger ones domains. All ranges together form the image. A complete domain-poll of an image of size txt with square domains of size d x d consists of $(t – d + 1)^2$ domains [2].

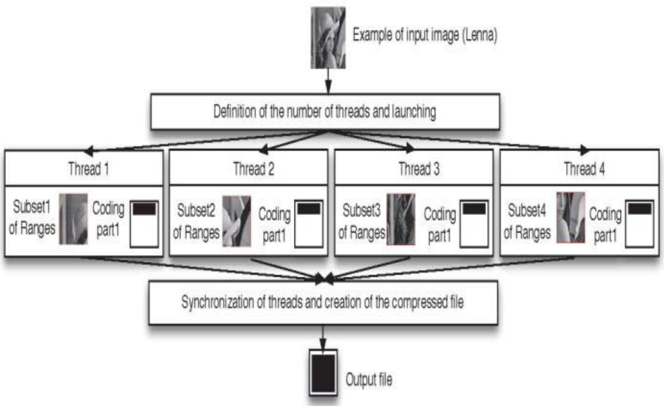

Figure 1.Parallel Model for the FIC problem with 4 threads

An application written in C Language was developed for this model that used the routines of the threads library for threads facilities. The main program took time for calculating the FIC problem i.e. (t2 –t1) where time t1 is the time before launching the threads and time t2 after the synchronization directive. As the parallel application was to be evaluated with 2, 4, 8, 16 and 32 threads, this idea consists of observing the speedup and the efficiency on different configuration machines. The best results of this algorithm appeared with 2 or 4 threads. The results showed up to 48% reduction in the image compression time[4].

B. Fractal Image Compression by Domain Classification Using Fractal Dimension of Block Complexity Approach:

According to this model, the image fidelity can be improved by considering the local image complexity for domain blocks classification by applying the constant contractive factor. Fractal Dimensions (FD) are to be processed to characterize roughness in images. The FD could be used to obtain shape information and to distinguish between smooth (small FD) and sharp (large FD) regions of the image. In other words, pre-processing local FD of the image makes it possible to generate separate sets of domain pools depending on the image complexity [6].

In this model, a space S of function f: A → G has been considered, where the set A is taken as the set of spatial coordinates of the image while G represents the set of intensity values of the image. A metric d is used such that (S, d) is a complete metric space. The fractal coding of an image F(N x N), finds a contractive mapping T on (S, d) whose fixed point F = T(F) exists and is unique (by the contractive mapping fixed point theorem). The fractal encoding process consists of the construction of the operator T, which is defined by matching the better range and domain couple of the original image.

For this model two subsets Ri and Di were supposed on F where Riis the Range formed from partitioning (n x n) non-overlapping region on A and Di (2n x 2n) is formed, also by subset of A but which may overlap. Let ti: Di → Ri be a contraction defined by matching the better ti (Di) for each Ri, which means that ti is chosen such that the distance d(Ri, ti (Di)) is as small as possible [8].

Local FD has been used in this model to subdivide the domain blocks into classes of complexity. Some methods on FD estimation do not give satisfactory result in all range of FD for images. For fast FD evaluation a simple and efficient algorithm has been used in this model by using four levels of complexity, based on the DF of each image part which is shown in Figure 2.

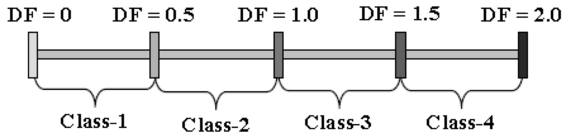

Figure 2

With this model, the domain pool used in the encoding processes has significantly reduced the encoding time. The results showed that with suitable classification on range blocks, we can speed up the encoding by about 47% and also the images encoded by the proposed approach are better than FIC [3].

C. A Novel Algorithm for Image Compression Based On Fractal and Neural Networks:

This algorithm is proposed mainly for MRI images. According to this algorithm, we can utilize the self-similarity property of an image. This algorithm comprises of three phases namely Training, Encoding and Decoding.

I. Training Phase

In the training phase, similar images high in number are taken as input images and each image is partitioned into range blocks and domain blocks individually. At the initial stage, the range block of one image is compared with the domain blocks of the same image to select the best matched domain block for that particular range block in an image and the fractal codes are given as output. During the encoding phase, the expert system takes the index of the range block of the image one by one as its input and it produces a set of domain blocks for the parallel range block. Then the search will be done only in the resulted set of domain blocks. Hence the search space is reduced and speed of the encoding time is increased. The figure 3 shown below represents the block diagram of training process [9].

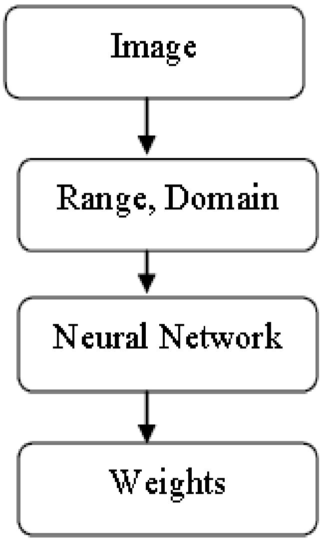

Figure 3.Training Process

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II. ***Encoding Phase***

The steps involved in encoding phase are listed as follows.

a) Divide the input MRI image (m x n) into blocks of fixed size, (Rx R). The resulting blocks are called range blocks which are then converted into a vector RB.

b) Every (k) is given to the trained expert system which results reduced set of domain blocks indices as output vector.

c) The best matched domain block from the reduced set of domain blocks is found. Then, the index of best matched domain block, the scaling parameter and the offset values are appended in the vectors [10].

d) Repeat steps 2 and 3 to find the best matched domain block for all the range blocks in the image. After executing all the above steps, encoding phase results three vectors as output which are index of the best matched domain block. It produces fractal codes or compressed codes of image and these codes are used during decoding process to reconstruct the image.

III. Decoding Phase

Decoding is the reverse process of encoding is done in which the transformation parameters are applied recursively to an initial image with mean value and it will then converge to the fractal image after fewer than ten iterations. Initially, the input image is partitioned into fixed blocks of size(R x R) are called range blocks RB and the block process operation is executed to reduce the newly formed image by averaging the intensities of four neighboring pixels and the resulted three vectors of encoding phase are considered. A single block is extracted from the reduced image first. Then its corresponding best matched domain block index, scaling parameter and its offset values are retrieved from the vectors. The pixel values of the reduced domain block are then placed in the location in the range obtained by the orientation information after scaling and offsetting. All the range blocks constitute a single iteration. The decompressed image will be constructed after one to ten iterations [11].

D. A Novel Initialization for Quantum EvolutionaryAlgorithms(QEA) Based on Spatial Correlation inImages for Fractal Image Compression:

This algorithm uses the information gathered from the previous searches for the neighbor blocks in the initialization step of search process of range blocks. Then QEA starts searching the search space to find the best matching domain block. The QEA searches around the best matched domain blocks of neighbor range blocks. If the result is not satisfying, the search process starts to find a good domain block. This algorithm proposes a novel method which uses the information from previous searches to help the evolutionary algorithm finding better solutions. In this method, based on the information gathered from the previous searches for neighbor range blocks, the q-individuals are initialized to represent the better parts of the search space with higher probability [12].

In the proposed algorithm for each range block, QEA searches among all the domain pool to find the best match domain block. The domain blocks are coded by their horizontal and vertical address in the image. Therefore a solution is a binary string having 3 parts, px; py; pT representing the horizontal and vertical location of domain block in the image and the transformation respectively. The length of the possible solution for M*N image is calculated as follows:

$$m = [\log2(M)] + [\log2(N)] + 3$$

Where m is the size of the possible solutions. This proposed algorithm has shown a lot of improvement in the performance of fractal image compression[13].

CONCLUSION

The investigations have shown that by using different proposed models and algorithms we can bring a lot of improvement in image compression and decompressions techniques. Different algorithms showed improvement in different parameters. Thus by selecting appropriate techniques for different purposes we can really improve the data compression and decompression time, reduce storage space and save a lot of transmission time.

Table 1.Comparison of different techniques discussed.

S. No.	Technique	Process or method that is used	Advantages	Disadvantages
1	Parallel based FIC on multicore systems.	Multi threads were used on a single machine.	Good speed.	Less efficiency.
2	FIC by Domain Classification.	Stored image blocks as a set of transformations.	Improved Image fidelity, Reduced transformation time.	Less compression ratio.
3	FIC Based On Fractal and Neural Networks.	Back propagation neural network algorithm is used.	Less encoding time, High quality of output image.	High Computational Complexity.
4	QEA Based on Spatial Correlation in images for FIC.	Spatial correlation between the neighbouring blocks is used.	Less Computational Complexity.	Can't be used on every image.

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