Fractal Image Compression using Soft Computing

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Abstract: **Image compression is a method through which we can reduce the storage space of images, videos which will helpful to increase storage and transmission process's performance, Images are compressed using lossy and Lossless compression schemes. In this paper Fractal image compression is discussed .Fractal image compression is a lossy compression method for digital images, based on fractals. The 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. Fractal Encoding involves partitioning the images into Range Blocks and Domain. Blocks and each Range Block is mapped onto the Domain Blocks by using contractive transforms called the Affine Transforms. The Fractal encoding technique takes a longer encoding time and less decoding time.We are going to analyze soft computing techniques for fractal image compression.**

Keywords:**Fractals, Iterated Function systems, Quad-tree, Affine transformations, Soft computing .**

I. INTRODUCTION

Fractal Compression was first developed by Michael Barnsley in 1987, who introduced the fundamental principle of fractal image compression. Barnsley's graduate student Arnaud Jacquin implemented the first automatic algorithm in software in 1992[2]. All methods are based on the fractal transform using iterated function system. Fractal image compression is also called fractal image encoding as the compressed image is represented by contractive transforms and mathematical functions which are required for reconstruction of the image. Contractive transforms ensures that the distance between any two points on the transformed image will be less than the distance between the same points on the original image. Collage Theorem States that if the error difference between the target image and the transformation of that image is less than a certain value the transforms are an equivalent representation of the image.

Large amount of data can't be stored if there is low storage capacity present. The compression offers a means to reduce the cost of storage and increase the speed of transmission. Image compression is used to minimize the size in bytes of a graphics file without degrading the quality of the image. There are two types of image compression is present. They are lossy and lossless . In lossless compression, the reconstructed image after compression is numerically identical to the original image. In lossy compression scheme, the reconstructed image contains degradation relative to the original. Lossy technique causes image quality degradation in each compression or decompression step. In general, lossy techniques provide for greater compression ratios than lossless techniques i.e. Lossless compression gives good quality of compressed images, but yields only less compression where as the lossy compression techniques lead to loss of data with higher compression ratio[3].

The basic idea of fractal compression is to find similarities between larger and smaller portions of an image. This is accomplished partitioning the original attractor after few iterations. The mathematical theory about these principles can be found on .Related works. Fractal compression allows fast decompression but has long encoding times. The most time consuming part is the domain blocks searching from each range. In order to reduce the number of computations required, some authors have proposed to restrict the set of domain blocks[4].

II. FRACTAL IMAGE COMPRESSION

Fractal compression is a lossy compression method for digital images, based on fractals .The fractal compression technique relies on the fact that in certain images, parts of the image resemble other parts of the same image. Fractal algorithms convert these parts, or more precisely, geometric shapes into mathematical data called "fractal codes" which are used to recreate the encoded image. Once an image has been converted into fractal code its relationship to a specific resolution has been lost; it becomes resolution independent.The image can be recreated to fill any screen size without the loss of sharpness that occurs in other compression schemes.

Fractal-based techniques produce outstanding results in terms of compression in images, retaining a high degree of self-similarity. Another interesting feature of fractal-based techniques is their ability to produce a good-quality rendered image for an arbitrary scaling factor.

Image compression methods can also be classified as either symmetrical or asymmetrical. For symmetrical methods, the compression and the decompression processes take roughly the same amount of time/effort. JPEG is one example of such methods. Fractal image compression, on the other hand, is an example of asymmetrical methods. Asymmetric methods take more time/effort compressing an image than decompressing it. The idea is to do most of the

work during the compression, thus creating an output file that can be decompressed very quickly.

A.Why Fractal Image Compression

- Takes advantage of similarities within an image
- Advanced detail interpolation
- High theoretical compression rates
- Fast decompression times

B.Resolution independence and fractal scaling

An inherent feature of fractal compression is that images become resolution independent after being converted to fractal code. This is because the iterated function systems in the compressed file scale indefinitely. This indefinite scaling property of a fractal is known as "fractal scaling".

C.Fractal interpolation

The resolution independence of a fractal-encoded image can be used to increase the display resolution of an image. This process is also known as "fractal interpolation". In fractal interpolation, an image is encoded into fractal codes via fractal compression, and subsequently decompressed at a higher resolution.

D.Self Similarity

Example

One can see the self similar regions in the image above. Fractal compression stores this type of information to achieve compression. To do fractal compression , the image is divided into sub-blocks. Then for each block , the most similar block if found in a half size version of the image and stored. This is done for each block.Then during decompression, the opposite is done iteratively to recover the original image. The quality in Fractal Image Compression is affected by the panel size. Smaller the panel size , more accurate will be the encoding of the image and better will be the quality of the decoded image.

Advantages and disadvantages of fractal image compression:

When the fractal image compression is compared to other methods used to compress different images, some of the main advantages and disadvantages can be summarized.

Advantages:

- Good mathematical encoding frame.
- Resolution-free decoding.
- High compression ratio
- Quick decompression.

Disadvantages:

- Slow encoding.

III ITERATED FUNCTION SYSTEMS

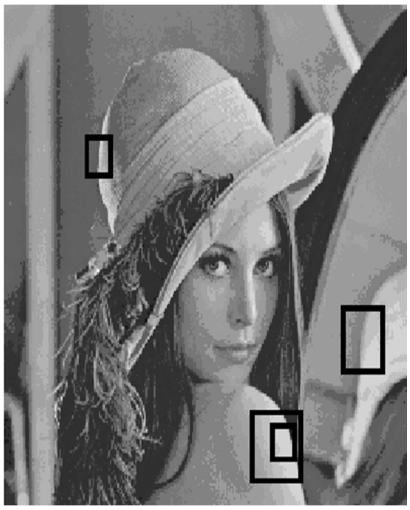
FIC technique represents images in terms of iterated function systems (IFS) that can be used to generate the original image FIC uses a special type of IFS called Partitioned IFS A PIFS consist of complete metric space X, a collection of sub domain Di ,I=1,…..,n and a collection of contractive mappings wi:Di → X ,I =1,…,n.The primary tool for describing images with Iterated function systems is the affine transformation. Affine transformation can be combination of rotations, scaling and translations of coordinate axes in n-dimensional space. Let wi be the affine transformation on $I \rightarrow I^2$ that

$W1(x)= w1\begin{pmatrix} x \\ y \end{pmatrix}=\begin{pmatrix} a & b \\ c & d \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix}+\begin{pmatrix} e \\ f \end{pmatrix}$

Where a, b, c, d, e are the coefficients used to shrink, rotate,translate and shear the image.

IV SELF-SIMILARITY PROPERTY

A typical image does not contain the type of self-similarity found in fractals.But, it contains a different sort of self-similarity. The figure shows regions of Lenna that are self-similar at different scales. A portion of her shoulder overlaps a smaller region that is almost identical, and a portion of the reflection of the hat in the mirror is similar to a smaller part of her hat.



The difference here is that the entire image is not self-similar, but parts of the image is self-similar with properly transformed parts of itself. It is this restricted redundancy that fractal image compression schemes attempt to eliminate.

V. COMPRESSION PROCEDURE

- Input Image is loaded into the buffer
- The Image is partitioned into non overlapping square blocks called the Range blocks
- The Initial size of the domain blocks is chosen to be twice the size of the range block
- The domain blocks is down sampled to the size of range blocks and the eight possible affine transformations is computed for each Range block
- The domain block chosen, shall resemble the range block with respect to some metric and accordingly encoding parameters are computed .The decoding time generally depends on the number of Iterations and here it takes only few iterations ranging from 4-8 to reach the fixed point.

The reconstruction process of the original image consists of the applications of the transformations described in the fractal code book iteratively to some initial image until the encoded image is retrieved back.

VI. QUADTREE PARTITIONING

The most popular partitioning mechanism in fractal Image compression (FIC) is obtained by partitioning the image in a tree structure called quad-tree partitioning method. A quad-tree partitioning [8-9] 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 as in figure shown below[5].

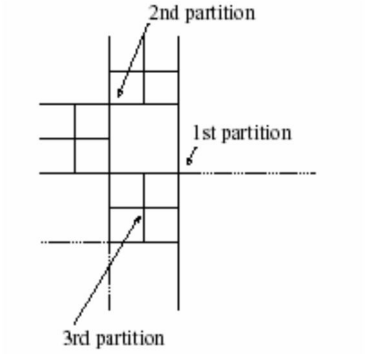


Figure: Quadtree partitioning

VII. FRACTAL IMAGE COMPRESSION USING SOFT COMPUTING

There are many optimization techniques which are used to improve efficiency of fractal image compression. Some of these are –

a)Pollination based optimization
b)Genetic Algorithm
c) Ant Colony Optimization
d) Particle Swarm Optimization
e) Biogeography Based Optimization

a)Pollination Based Optimization: Optimization is a natural process embedded in the living beings .Pollination is a process of transfer of pollen from male parts of flower called anther to the female part called stigma of a flower. Some flowers will develop seeds as a result of self-pollination, when pollen and pistil are from the same plant, often (but not always) from the same flower. Other plants require cross-pollination: pollen and pistil must be from different plants. Plants benefit from pollinators because the movement of pollen allows them to reproduce by setting seeds. However, pollinators don't know or care that the plant benefits. They pollinate to get nectar and/or pollen from flowers to meet their energy requirements and to produce offspring. In the economy of nature, the pollinators provide an important service to flowering plants, while the plants pay with food for the pollinators and their offspring. The floral display, fragrance and nectar lure pollinators and leads to pollination. Some species of plants optimize their nectar, display and fragrance producing resources. If pollination process is proceeding smoothly the plants spend average resources. If pollination process is above normal the plants reduce expenditure on resources for producing nectar,floral display and fragrance in the flowers. If the pollination success goes below normal, plants increase the resource expenditure such that more floral display, fragrance and nectar to attract pollinator. As more pollinators and their number of visits increase the pollination success rate increases .

b) *Genetic Algorithm*: Genetic Algorithm (GA) is a stochastic algorithm simulating the process of natural evolution, which is usually applied to optimize controlled parameters and constrained functions. Especially GA is efficient to solve nonlinear multiple-extreme problems. An improved genetic algorithm proposed for obtaining matching domain blocks of fractal partition in image compression, which uses the partition iterated function system and fractal image compression. Genetic algorithms (GA's) are mathematically motivated search techniques that try to emulate biological evolutionary processes to solve optimization problems. Instead of searching one point at a time, GA's use multiple search points. GA's attempt to find near-optimal solutions without going through an exhaustive search mechanism. Thus, GA's can claim significant advantage of large reduction in search space and time.

c) *Ant Colony Optimization*: A fractal encoding algorithm based on ant Colony algorithm is proposed to reduce encoding time. The ACO algorithm produces a completely identical fractal encoding to that of the conventional full search in reduced time. The algorithm can realize fractal image coding very well and also it has better PSNR, and it gets more compress ratio than traditional block-based

partition. Ant colony algorithms are a novel category of evolutionary computing methods for optimization problems. Ant Colony Optimization (ACO) is a paradigm for designing meta-heuristic algorithms for combinatorial optimization problems. The essential trait of ACO algorithms is the combination of a priori information about the structure of a promising solution with a posteriori information about the structure of previously obtained good solutions.

d) *Particle Swarm Optimization*: Particle swarm optimization (PSO) as an alternative searching method. Originated from the evolutionary computation together with the social psychology principle, PSO is a general-purpose optimization algorithm which also uses the concept of fitness. It provides a mechanism such that individuals in the swarm communicate and exchange information, which is similar to the social behavior of insects and human beings. PSO directs particles to search the solution more efficiently. Since the paradigm of PSO requires only primitive mathematical operations, this computationally inexpensive algorithm can be implemented in a few lines of computer code. Full search FIC can exactly find the best domain block corresponding to each range block, but it is very time-consuming. PSO can provide a faster way to encode the range blocks. PSO is a population-based algorithm for searching global optimum. The original idea of PSO is the simulation of a simplified social behavior. It ties to artificial life, like bird flocking or fish schooling, and has some common features of evolutionary computation. Such as fitness evaluation.

e) *Biogeography Based Optimization*: BBO is a population-based optimization algorithm it does not involve reproduction or the generation of "children." This clearly distinguishes it from reproductive strategies such as GAs and evolutionary strategies.BBO maintains its set of solutions from one iteration to the next, relying on migration to probabilistically settle in those solutions. BBO solutions are changed directly via migration from other solutions (islands). That is, BBO solutions directly share their attributes (SIVs) with other solutions.

VIII. CONCLUSION

In this study the basics of fractal coding are discussed. In addition the advantages and disadvantages in the fractal coding are summarized through the discussion of the exiting work. The field of fractal compression is relatively new, as is the study of fractals, and as such there is no standardized approach to this technique. The fractal method has the benefit of faster decompression speed, having done most of the computation during the compression step, while giving equal or better compression ratio. These advantages mean that fractal image compression is well suited for applications requiring fast access to high-quality images. Fractal Image Compression is a much promising and still young technology that can fit well in many areas of the multimedia systems' world. Despite the great compression time, the benefits of compression and resolution independence are much broader. The main concept in this compression scheme is to use Iterated Function Systems (IFS) to reproduce images. With the help of quad-tree Partitioning technique we can present a variable block size that can provide higher compression performance than the fixed-size partitioning technique. An important property of fractals is that they exhibit self similarity. Soft Computing techniques are used to decrease the encode time, and increase the visual quality of the images.

REFERENCES

[1] A.E. Jacquin., "Image coding based on a fractal theory of iterated contractive image transformation", *IEEE Trans. On Image Processing, **1**(1): (1992)* .

[2] Arnaud E. Jacquin, (1993)., "Fractal image coding", *Proceedings of IEEE VOL.81, pp. 1451-1465.*

[3] Hitashi., et.al., "Fractal image compression- a review," *International Journal of Advanced Research in Computer Science and Software Engineering*, Volume 2, Issue 2, February 2012.

[4]Madaliya, et.al., "Fractal Image Compression Using Graphics Hardware," *International Journal Of Advanced Engineering Research And Studies.*

[5]Padmashree .S,et.al., "Comparative Analysis of Quad-tree Partitioned Iterated Function Systems for Medical Images" *International Journal of Computer Applications (0975 – 8887)*,Volume 59– No.14, December 2012.

[6] Soyjaudah M.S., "Fractal image compression using quad-tree partitioning" *International Journal of Electrical Engineering Education 39/1*.

[7] Distasi.R., "A range/domain approximation error- based approach for fractal image compression", *IEEE Trans. Image processing*, vol. 15, no. 1, pp. 89-97, Jan. 2006.

[8] Lu ,Jing Yi., "Research of Image Compression Based on Fractal Coding," *Applied Mechanics and Materials*,pages 418-422, December, 2012.

[9] M. Ghazel, g. H. Freeman, and e. R. Vrscay,"fractal image denoising," *IEEE trans. Image process*, vol. 12, no. 12, pp. 1560–1578, dec.2003.

[10] Hu, L., Chen, Q. and qing, Z. "An image compression method based on fractal theory," *The 8th international conference on computer supported cooperative work in design proceedings*, 546 – 550. 2003.

[11]Kaouri, A. H. . Fractal coding of still images. *Queen's university of Belfast*, UK. 2002.

[12] Yancong, Y. and Ruidong, P. Fast Fractal Coding Based on Dividing of Image, 2010.

[13]Gaganpreet et.al., "Implementation of fractal image compression using BBO," *Presented at 6th International Multi Conference on Intelligent Systems, Sustainable, New and Renewable Energy Technology and Nanotechnology (IISN2012)*, March 16-18,2012,pp. 269-273.

[14]Gaganpreet et.al., "Pollination Based Optimization For Color Image Segmentation,"*International Engineering & Journal of Computer engineering & Technology (IJCET)*, Volume 3, Issue 2, July- September (2012), pp. 407-414.

[15] Hitashi el.al., "Fractal Image Compression Scheme Using Biogeography Based Optimization On Color Images," *International Engineering & Journal of Computer engineering & Technology (IJCET)*, Volume 3, Issue 2, July- September (2012), pp. 35-46