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A Review on Different Fractal Compression Techniques

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Abstract: With the increasing popularity of digital image processing researchers are still looking to maximize transmission efficiency and reduce the storage required for a particular image. An uncompressed grey scale image of 512x512 pixel requires 260,000 bytes for storage and a huge bandwidth for transmission which is not very efficient. That is why researches are coming up with different image compression techniques. One such technique is fractal compression which provides us with higher compression ratios so that it can be transmitted over a smaller bandwidth. This paper gives a brief introduction to fractal compression. In this paper, we also study different algorithms for fractal compression, their merits and demerits.

Keywords: Image Compression, Fractal Compression, Huffman Coding, Iterated Function System, DBSCAN

I. INTRODUCTION

The main aim for an efficient multimedia data transfer is to retrieve almost the same quality of the data at the receiver-end that was originally transmitted. The current algorithms which are in use are not very efficient since they lead to loss of data and do not retain the original quality. Michael Barnsley first introduced the idea of fractal image compression in 1857. Apart from images, fractal compression can also be used for audio and video compression. Microsoft once compressed a 10hr HD video into a 700 megabytes cd. The fractal image compression algorithm is based on the fractal theory of self-similar and self-affine transformations. Fractal algorithms convert these parts into mathematical data called "fractal codes" which are used to recreate the encoded image. Fractal image representation may be described mathematically as an iterated function system.

II. DIFFERENT CLASSES OF IMAGE COMPRESSION

A. Lossless VS Lossy Compression

LOSSY compression refers to the compression techniques in which the redundant information is discarded. These compression techniques help in achieving high compression ratios, even though the images may look visually lossless but there is considerable loss of information. Lossless compression techniques involve negligible loss of information but the compression ratios achieved are moderate using this technique.

B. Predictive VS Transform Coding

In the predictive coding technique, the available values are used to extrapolate the future values and are coded. This technique is faster to implement, requires fewer computations and is adapted to local image characteristics. On the other hand, transform coding requires longer time and more number of computations since the process involves converting an image in spatial domain into some other form using transformation methods like (discrete cosine transform), and then these coefficients are coded.

III. ITERATED FUNCTION SYSTEM

Generally, an image is divided into pixel, but in fractal compression, the image is divided into fractals. Iterated function system is a method of fractal construction which exhibit the property of self- similarity and affine transformation forms the basis of IFS. Self-similarity means that small parts of images appear similar to large parts of the same image. To find self-similarity between the various parts of the image the entire image is divided into different parts. For eg when we consider a primary Leena image it can be seen that the reflection of the hat in the mirror is quite similar to the original image hence this reflected portion can be acquired using transformations and also the parts of the shoulder also exhibit similarity.so this proves that it is not necessary for the entire image to exhibit self-similarity but it is ok even if small parts of the image appear similar to the larger parts. The pseudo code for the algorithm is as follows:

1) Set x=O and y=O,
2) Select transformation wi depending on its probability pi
3) Apply transformation wi to the point (x, y) to obtain (xn, yn)
4) Set x=xn, y=yn and plot (x, y), (5) go to step (2) and repeat as many times as required.

Fractal has the following properties:

a) It has a fine structure, i.e., details on arbitrarily small scales.
b) It is too irregular to be described in a traditional geometrical language, both locally and globally.
c) It exhibits has some form of self-similarity, perhaps approximate or statistical.
d) Its fractal dimension is usually higher than its Euclidean dimension.
e) A fractal is defined in a very simple way, perhaps, recursively. Segmentation is required for most fractal compression algorithms

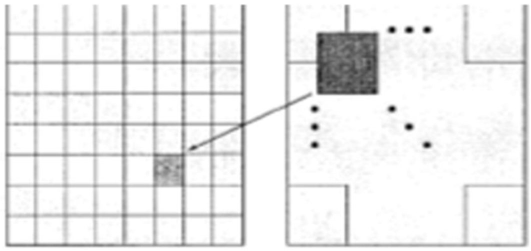

Fig. 1 Block mappings in PIFS representation

IV. FRACTAL COMPRESSION USING AFFINE TRANSFORMATION

In IFS compression algorithm starts a target image T which lies in a subset S belongs to R2 is taken. The target image T is rendered on a computer graphics monitor. To begin fractal image compression, an affine transformation is introduced having coefficients that produce a new image with dimensions smaller than that of T to ensure contraction mapping.

$$w_i(\mathbf{x}) = w_i\begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} a & b \\ c & d \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} e \\ f \end{pmatrix} \qquad (1)$$

The user can vary the coefficients a,b, c,d,e, and f to shrink, translate and rotate the image T to get a new image w1(t). Once w1(t) is obtained the coefficients of affine transformations are recorded, and a new affine transformation w2(x) is introduced along with its sub-copy w2(T). The same process is carried out with this new image as was done with w1(T). It is essential to avoid any overlapping to avoid complications. In this manner, a set of affine transformations w1, w2, w3 ,w 4....wn is obtained such that where N is as small as possible.

$$\tilde{T} = \bigcup_{n=1}^{N} w_n(T) \qquad (2)$$

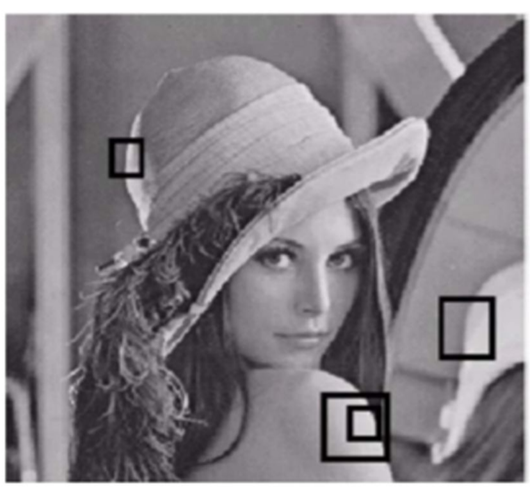

Fig 2 : Displaying Self- Similarity Different Location

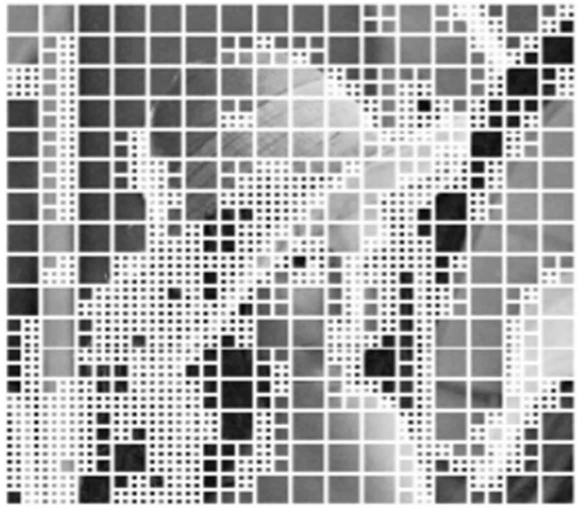

Fig 3: Reconstructed image displaying different fractals

V. DIFFERENT ALGORITHMS TO IMPLEMENT FRACTAL COMPRESSION

A. Using DBSCAN Algorithm

Density based spatial clustering consists of two important parameters, maximum radius of the neighborhood and minimum number of neighbors in the neighborhood of that pixel. In this compression scheme the image is divided into non-overlapping BxB block which are known as the range blocks. The size of this block can be varied. Then pixels in the color image is grouped into different clusters [15]. Each range block is compared with the center of the corresponding domain block. Total 9 range blocks are considered in the process of forming a cluster. Here we use a threshold value, t. The difference between the corresponding R component, G component and B component of each range block and the center of the domain block is compared with this t. If this difference value is below t, a matching is found. This procedure is separately done for the three components in the RGB color scheme. The decompression is just the reverse of compression. The DBSCAN algorithm leads to decline in the encoding time by reducing successive pursuits through the entire picture to its neighbors. The size of the image is reduced during compression and is approximately 20% of the input image. The size is further reduced during decompression and is approximately 10% of the original image.

B. Using Huffman Coding and Quadtree Decomposition

In this method the original image divided using a quadtree decomposition using a certain threshold and x and y coordinates are recorded along with mean value and block size. The image is encoded using Huffman encoding and later reconstructed using Huffman decoding. Veenadevi. S.V. and A.G. Ananth in his paper titled " Fractal Image Compression Using Quadtree Decomposition And Huffman Coding apply the algorithm on three different types of images. The test results for the three kinds of images:- Leena image, Satellite Rural image and satellite urban image shows that Huffman coding and quadtree decomposition can be used to achieve high compression ratios and good PSNR values especially for satellite urban images and satellite rural images. The time taken for encoding and decoding process is also more for satellite urban images.

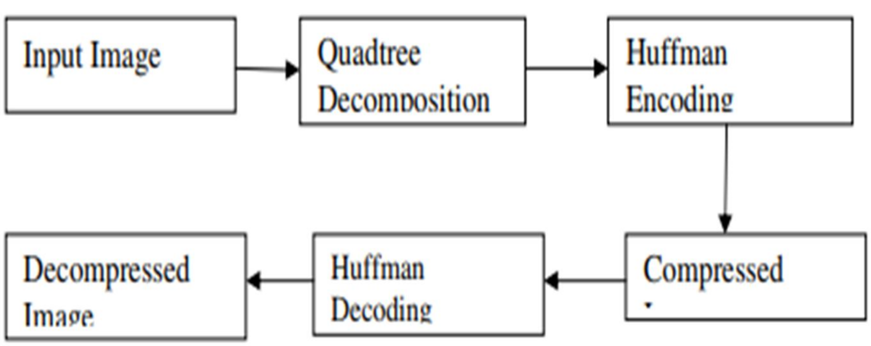

Fig 4: Block Diagram of Huffman coding and quadtree decomposition

C. Iteration Free Fractal Image Compression For Color Images Using Vector Quantization, Genetic Algorithm And Simulated Annealing

Fractal compression uses self -similarity property of image domains. This proposed technique has the advantage that it consumes less time for decoding process and the storage space required is also less which meets the modern day requirements. This technique unlike most techniques is an iteration-free fractal image encoding for color images. It combines three different algorithms Vector Quantization (VQ), Genetic Algorithm (GA) and Simulated Annealing (SA). The proposed method using the VQ aims to design an efficient domain block for the fractal encoding, it also uses global optimization techniques like GA and SA to improve decoded images quality and it also helps in speeding the encoding process. these techniques combined reduces the computational complexity since it is iteration free method thus it reduces the cost of coding, it also improves the image quality and reduces the coding time. To start off the rocess the domain block of each and every RGB component was classified before comparing it for a better domain block in order to reduce computational time. GA method for iteration free fractal encoding is best suited for better picture quality, VQ is favored for decreased coding time and SA is ideal for ideal picture quality and time. The proposed techniques utilizing VQ, GA and SA gives computational productivity, thus lessening the expense of coding. The execution time can further be lessened by realizing the proposed methods in parallel for encoding.

VI. CONCLUSIONS

The fractal image compression technique is mainly based on iterated function system. Self -similarity is a crucial property exhibited by fractals. After studying various algorithms for fractal compression we come to a conclusion that DBSACN Algorithm provides the optimal results when compared to other fractal compression algorithms. The fractal compression technique helps in achieving high compression ratio but the encoding time in this technique is much more when compared to other image compression techniques.

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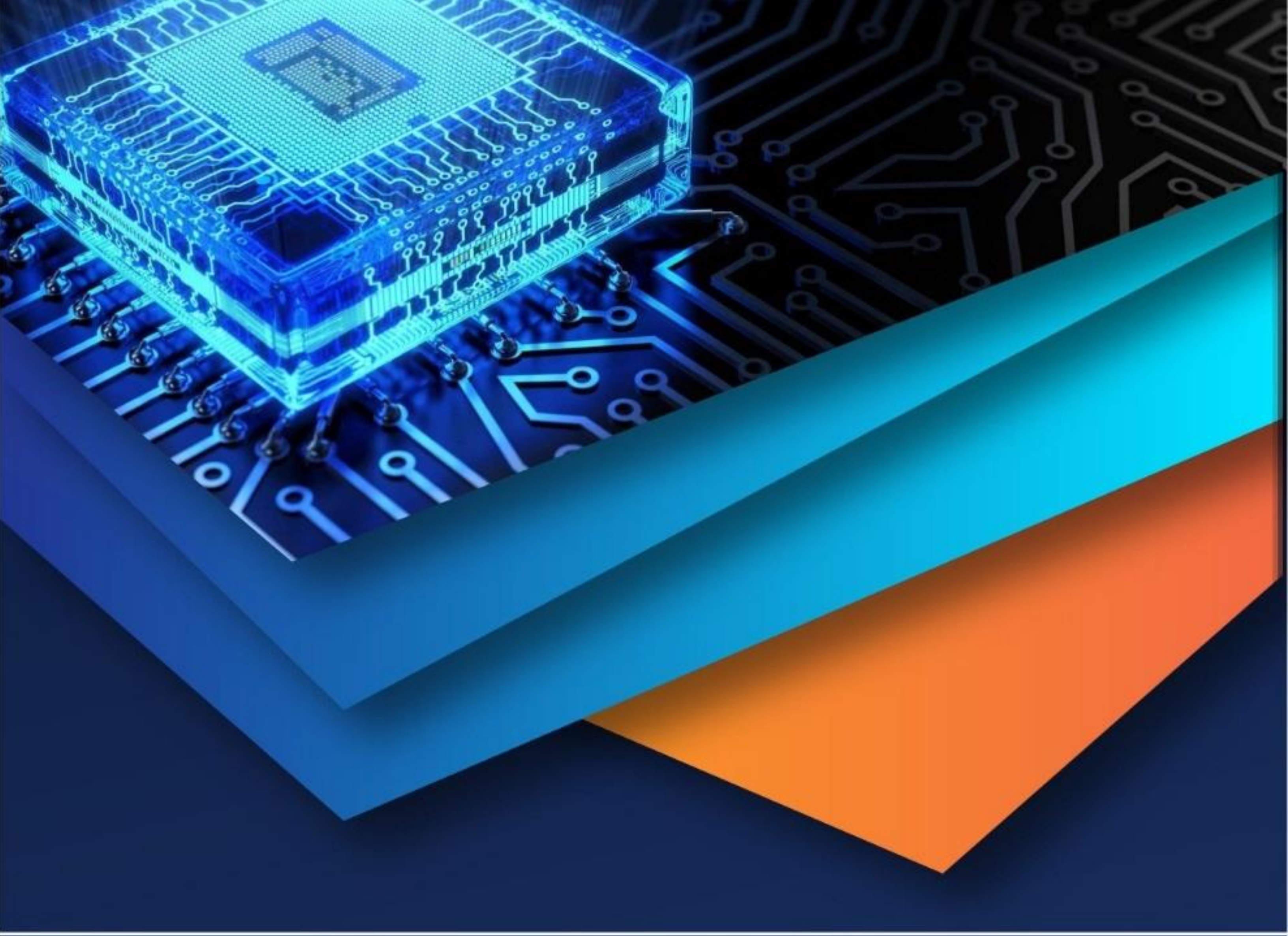

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