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The Performance Of Fractal Image Compression On Different Imaging Modalities Using Objective Quality Measures

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Abstract- In the arena of, high speed data transmission and requirement of large data to store in minimum available space, compression is very prominent aspect. There are various techniques, which have been applied for this purpose. One of most useful technique is fractal image compression. In which the main errand is to lessen the transmission time and storage capacity. In this paper, the primary objective is to determine the performance of fractal image compression using quad-tree decomposition applied on different modalities, using objective quality factors such as mean square error, Peak Signal to Noise Ratio (PSNR), average difference, max difference, normalized co-relation, mean absolute error, structural co-relation. From the repercussion we observed that, proposed method has better results than the existing technique.

Keywords— *Quad-tree Partitioning (QP), Peak Signal Noise Ratio (PSNR), Mean Square Error (MSE), Normalized Absolute Error (NAE)*

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I. INTRODUCTION

Image compression is process to remove the redundant information from the image so that only essential information can be stored to reduce the storage size, transmission bandwidth and transmission time. With the development of multimedia system and biometric security systems the image database is growing continuously and increased the necessity of efficient storage and fast retrieval of images a lot. The essential information is extracted by various transforms techniques such that it can be reconstructed without losing quality and information of the image. The development of higher quality and less expensive image acquisition devices has produced steady increases in both image size and resolution, and a greater consequent for the design of efficient compression systems [1]. Although storage capacity and transfer bandwidth has grown accordingly in recent years, many applications still require compression. The basic rule of compression is to reduce the numbers of bits needed to represent an image. In a computer an image is represented as an array of numbers, integers to be more specific, that is called a digital image. The image array is usually two dimensional (2d), if it is black and white (*bw*) and three dimensional (3d) if it is colour image [3]

Fractal image compression is a lossy image compression method. This method is best suited for textures and natural images which relies on the fact that certain parts of an image often resemble other parts of the same image. A fractal is nothing but a rough fragmented geometric shape that can be subdivided in parts, each of which is approximately a reduced size copy of the whole image. Fractals are easily found in nature like trees and ferns. 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.[1]

II. MATERIALS AND METHODS

A. FIC Encoding Algorithm

1) Tolerance T, minimum tree depth m, maximum tree-depth M, bits used for scaling factor and offset are considered as 8, 4, 6 , 5 and 7 respectively.
2) Image is partitioned into four sub-nodes and is compared with domains from the domain pool D.
3) The pixels in the domain are averaged, in groups of four so that the domain is reduced to range size.
4) The root mean square (RMS) value between the transformed domain pixel values and the range pixel values is found out.
5) If the RMS $\geq$ T and depth $\leq$ M, the image is subdivided into smaller partitions.
6) If the RMS $\geq$ T, then the partitioning is stopped and the domain is mapped as wi.

B. FIC Decoding Algorithm

Decoding an image consists of iterating W from any initial image.

1) For each range R_i, the domain Di that maps is shrunk by two averaging non-overlapping groups of 2x2 pixels.
2) The shrunken domain pixel values are then multiplied by scaling factor s_i added to offset factor o_i and placed in the location in the range determined by the orientation information,
3) This iteration is done until the fixed point is approximated by maximum number of iterations, that is, until further image does not change the image or the change is below some small threshold value.

C. Objective Measurement

A good objective quality measure should reflect the distortion on the image well, for example, blurring, noise, compression,

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and sensor inadequacy. There are different parameters that can be used for objective measurement. [3]

1) Mean Square Error: MSE is the average squared difference between a reference image and a distorted image. The large value of MSE means that image is poor quality.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(f(i,j)-(f^{'}(i,j))^2$$

2) Peak Signal Noise Ratio: PSNR defines between the maximum possible power of a signal and the power of corrupting noise the large value of Peak Signal to Noise Ratio (PSNR) means that image is of good quality.

$$PSNR = 10\log\frac{255^2}{MSE}$$

3) Maximum Difference (MD): The difference is the maximum difference of the pixels in original and compressed image among all differences. The large value of Maximum Difference (MD) means that image is poor quality.

$$MD = MAX(|x(m,n) - x'(m,n)|)$$

4) Normalized Absolute Error (NAE)-Normalized absolute error is a measure of how far is the decompressed image from the original image with the value of zero being the perfect fit. Large value of NAE indicates poor quality of the image.

$$\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}\left|[f(i,j).f^{'}(i,j)]\right|}{\sum_{i=1}^{M}\sum_{J=1}^{N}\left|f(i,j)\right|}$$

5) Normalized Correlation (NK): The closeness between two digital images can also be quantified in terms of correlation function. The large value of NK means that image is of good quality.

$$NK = \frac{\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j).f(i,j)]^{'}}{\sum_{i=1}^{M}\sum_{J=1}^{N}f(i,j)^2}$$

6) Average Difference (AD): A lower value of Average Difference (AD) gives a “cleaner” image as more noise is reduced i.e. lower the average difference better is the quality of the image.

$$AD = \frac{1}{MN}\sum_{m=1}^{M}\sum_{n=1}^{N}(x(m,n)-x^{'}(m,n))$$

7) Structural Content (SC): It is an estimate of the similarity of the structure of two signals. Large value of SC means that the image is of poor quality.

$$SC = \frac{\sum_{m=1}^{M}\sum_{n=1}^{N}(x(m,n))^2}{\sum_{m=1}^{M}\sum_{n=1}^{N}(x^{'}(m,n))^2}$$

D. Image Compression Tools and methods:

These are the tools that compress the image online. There are various image compression techniques available that compress the image. The basic advantage of online image compression tool is that there is no need to download these tools saving memory space on one’s computer and these tools also hold the advantage of directly uploading the resultant compressed image for personal or commercial use. The images compressed can also be saved for future use. The different tools can reduce the size of various images of various formats and can produce customized results on the user preference. For example image compression can be done by reducing the size of the image as specified by the user. These tools can optimize, compress and resize the image as per the need.

1) Web Resizer: Web Resizer is one of the most effective tools for resizing your images for free and edits your photos so that it can be easily attached to your emails or web pages. It allows uploading of images of size less than 5 MB.

2) Shrink Pictures: Shrink Pictures makes image optimization very simple and comprehensive. Shrink Pictures permits you to upload images at a maximum size of 6Mb. The maximum dimension of the image should be of 1000 pixel and uses JPEG compression technique to compress the image.

3) Jpeg Optimizer: JPEG Optimizer is a free online tool for resizing and compressing your digital photos and images for displaying on the web in forums or blogs, or for sending by email.

4) Dynamic Drive: Dynamic Drive is a simple tool that helps you to instantly compress images of GIF, JPG or PNG format. Moreover, it also enables to convert your images from one format to another. However, the upload limit for any image is 300 KB. [3]

III. RESULTS AND DISCUSSION

We have used MATLAB software for compression. We have used Image toolbox functions which were required for the implementation. Fractal image compression technique which we have implemented is based on the theory of fractals and quad decomposition. We have considered this algorithm for normal images as well as for normal images. In figure 1, we have considered a medical image to be considered for image compression.

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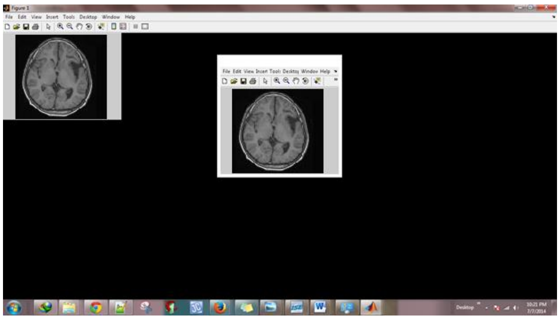

Figure 1: Medical image considered for compression

Quad-tree-based Fractal image compression means for non-deterministic nature of IFS compression techniques, though as a result the compression ratios achieved. However, quad-tree compression can be used to any kind of image and implementations deliver better compression ratios. Basic quad-tree techniques divide the target image into 4 squares, known as Domains and also divide the image into 16 squares, known as Ranges. The result after quad-tree decomposition is shown in figure 2 for medical image.

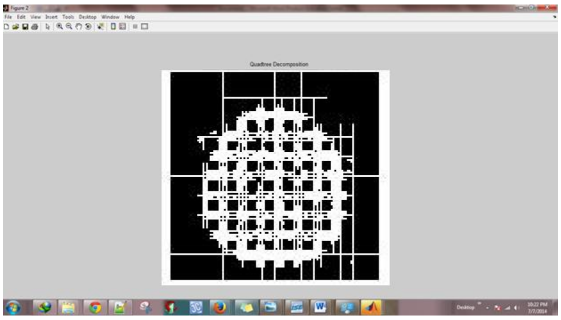

Figure 2: Result after quad tree decomposition

The fractal image compression algorithm then attempts to cover every range with a domain, using a contractive mapping, where the fitness of the range/domain map is maximized. If a range is failing to find a match, the process is repeated after partitioning that particular range block into four quadrants.

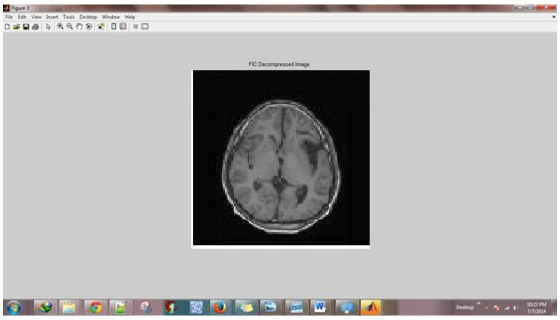

Figure 3: After Applying Fractal image compression on Medical Image

Quad-tree compressed images also estimate other fractal properties, specifically the ability to convert a stored image at a higher resolution than the original and have the rendering algorithm to 'scale' the image. The results of the images after applying the algorithm are shown in figure 3.

Table1: Results for different objective using proposed method

S no.	Objectives	Output
1	Time taken for compression	8.432695 sec
2	Time taken for decompression	54.886939 sec
3	Compression ratio	3.289382
4	PSNR	27.144326

IV. CONCLUSIONS

Analysis of various Image compression techniques for different images is done based on parameters, compression ratio(CR), mean square error (MSE), peak signal to noise ratio (PSNR). Fractal Image Compression gives a great improvement on the encoding and decoding time. A weakness of the proposed design is the use of fixed size blocks for the range and domain images. There are regions in images that are more difficult to code than others .Therefore there should be a mechanism to adapt the block size (R, D) depending on the mean and variance calculated when coding the block. This type of compression can be applied in Medical Imaging, where doctors need to focus on image details, and in Surveillance Systems, when trying to get a clear picture of the intruder or the cause of the alarm. This is a clear advantage over the Discrete Cosine Transform Algorithms such as that used in JPEG.

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