Analysis of Fractal Image compression Technique in Neural Networks

Anshu Agarwal*, Dr. Smita Shandilya** and Dr. Shishir K. Shandilya***
*-***Bansal Institute of Research and Technology, Bhopal

Abstract: This Research work particularly deals with fractal image compression with an idea to minimize the computational requirements to achieve enhanced reproduction of image quality. Problems such as use of fractal geometry for image compression, extension of this concept for color image compression, encoding of video sequences in compression, application of the concept of compression for remote-sensed images, use of wavelets in fractal compression algorithm for enhanced performance, and extension of wavelet-based fractal concept for compression of textured images have been discussed in this study. The concept of wavelet is combined with this to enhance the performance. Fractal image compression is desirable because of its resolution independence, faster decoding and competitive rate distortion curves. However, the main drawbacks in the Fractal Image compression method, such as longer computation time for encoding and heavy computation for full and exhaustive search, have been alleviated using Partitioned Iterated Function Systems in this study.

Keywords: Fractal Image Compression, wavelet Transform, MATLAB.

Introduction

The increasing demand for multimedia content such as digital images and video has led to great interest in research into compression techniques. 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. In general, this thesis investigates still image compression in the transform domain. Multidimensional, multispectral and volumetric digital images are the main topics for analysis. The main objective is to design a compression system suitable for processing, storage and transmission, as well asproviding acceptable computational complexity suitablefor practical implementation. 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 color image [3]. Digital image compression algorithms exploit the redundancy in an image so that it can be represented using a smaller number of bits while still maintaining acceptable visual quality. Factors related to the need for image compression include.
The large storage requirements for multimedia data

- Low power devices such as handheld phones have small storage capacity
- Network bandwidths currently available for transmission
- The effect of computational complexity on practical implementation

In the array each number represents an intensity value at a particular location in the image and is called as a picture element or pixel. Pixel values are usually positive integers and can range between 0 to 255. This means that each pixel of a BW image occupies 1byte in a computer memory. In other words, we say that the image has a grayscale resolution of 8 bits per pixel (bpp). On the other hand, a colour image has a triplet of values for each pixel one each for the red, green and blue primary colours. Hence, it will need 3 bytes of storage space for each pixel. The captured images are rectangular in shape [2].

Literature Review

DCT: This achieves data compression by concentrating most of the signal in the lower spatial frequencies. DCT introduces no loss to the source image samples. It merely transforms them to a domain in which they can be more efficiently encoded. DCT based image coders perform well at moderate bit rates, but at higher compression ratios the image quality degrades because of blocking artifacts (Subhasis Saha 2000). JPEG: JPEG is established by ISO (International Standards Organisation) and IEC (International Electro technical Commission). It generally degrades at low bit rates i.e., high

compression ratio due to the block based DCT scheme, it uses. JPEG with DCT is simple and gives satisfactory performance at lower compression rates. It has noticeable and annoying blocking artifacts at low bit rates (high compression rates). At compression rates less than 25:1 or so, the JPEG performs better than simple wavelet coders. Beyond this the performance of JPEG degrades drastically. It gives better compression with arithmetic coding than Huffman Coding. JPEG 2000 is with wavelet based compression and wavelet provides substantial improvements in picture quality at higher comp ratios (Subhasis saha 2000). There are various methods by 11 which the decomposition takes place. Wavelets avoid blocking artifacts at higher compression ratio since the image is not split into 8□8 blocks as in JPEG or DCT. It is robust (Subhasis Saha 2000).
Fractal image compression: The property of self-similarity or scaling is one of the main concepts of fractal geometry. This is an asymmetrical compression. The encoding time is longer and decoding time is less.

In mid-1980's, IFS's became very popular. It was Barnsley (1988) and his co-workers at Georgia Institute of Technology who first noticed the potential of IFS applications in computer graphics. Initially their research focused on modelling natural shapes such as leaves and clouds, but then Barnsley and Sloan advertised in popular science magazines the incredible power of IFS and also for compressing colour images at a compression ratio of 10000:1 (Barnsley and Sloan 1998, Barnsley et al. 2002, Ali and Clarkson 1991, Florin Pop 2003). It was also supported by the decoded images. First the image was segmented into smaller blocks, as self -similar as possible. Then each part was coded as IFS with probabilities. The collage theorem provides a criterion for the choice of the transformations in the IFS code, thereby optimizing the overall result. For the decoding, the chaos game then produced a large number of points, the histogram served as approximation of the corresponding part of the image.

Forte and Vrscay studied the moment method (Vrscay 1991, Forte and Vrscay 1994a, 1994b). Bedford et al. (1992) had tried the simulated annealing method, studied the general IFS approach theoretically and came to a conclusion that there were considerable mathematical obstacles in approximating images in this way. A fully automated fractal based image compression technique for digital image was first described by Jacquin (1989, 1990, and 1992). Since then, fractal image compression received considerable attention and most of the fractal compression schemes were based on Jacquin's type of compression work. The simplest range partition consists of the fixed square blocks. This type of block partition was successful in transform coding of individual 13 image blocks since an adaptive quantization mechanism was able to compensate for the varying activity levels of different blocks, allocating few bits to blocks with less detail and many bits to more detailed blocks (Monro 1993). The transform given by Jacquin (1989) was extended by including fixed blocks with constant gradient in the vertical and horizontal directions respectively. It was further extended to 2nd order polynomials by including blocks with quadratic form (Monro and Dudbridge 1992, Monro and Wolley 1994a, 1994b). When cubic forms were considered, 3rd polynomials were also considered. In a limited domain search 2nd order polynomials gave good results in rate distortion sense (Wolley and Monro 1995). Several algorithms with different motivations were tried to obtain Partitioned iterated function systems (PIFS) or fractal code of a given image. For images, piecewise similarities were implemented by Jacquin (1990). The approach using linear fractal interpolation as well as the piecewise self-affine fractal model with algorithms that were adaptive in the choice of sizes of the ranges and domains were tried (Kaouri 1991, Mazel and Hayes 1992, Mantica and Sloan 1989, Withers 1989, Miroslav Galabov 2003, Erjun Zhao and Dan Liu 2005).

Image Compression

Image compression is applied to obtain an image representation while reducing the amount of memory needed as much as possible to encode the image (Gomes and Velho
1997). Image compression is possible because images, in general, are highly coherent (non-random), which means that there is repetitive information. Compression methods try to eliminate repetitiveness, thus producing a more compact code that preserves the essential and accurate information contained in the original image.

Irrelevancy reduction omits parts of the signal that are not noticed by the signal receiver, namely the Human Visual System (HVS). In general, three types of redundancy can be identified: □ Spatial Redundancy or correlation between neighboring pixel values.

- Spectral Redundancy or correlation between different color planes or spectral bands
- Temporal Redundancy or correlation between adjacent frames in a sequence of images (in video applications)

Image compression aims at reducing the number of bits needed to represent an image by removing the spatial and spectral redundancies as much as possible. For still image compression, temporal redundancy need not be considered (Subhasis Saha 2000). Image compression techniques are classified as either lossless (reversible) or lossy (irreversible) compression methods.

In lossless compression schemes, the reconstructed image, after compression, is numerically identical to the original image. This method is invertible. However lossless compression can only achieve a modest amount of compression. For this kind of compression to be effective, there must be some redundancy in the original data. This is used to optimize disk space on office computer such as spreadsheets, text file or program without the introduction of errors, but only up to a certain extent. In text and program files, it is crucial that compression be lossless because a single error can seriously damage the meaning of a text file, or cause a program not to run. A few types of lossless compression methods are Huffman coding, Arithmetic coding, Run length coding (Crane 1997).

Lossy Compression method offers a trade-off between compression speed, compressed data size and quality loss. This method is not invertible. When there is some tolerance for loss, the compression factor can be greater. For this reason, graphic images can be compressed more than text files or 7 programs. Lossy compression is used in digital cameras, DVDs, Internet telephony and in MP3 players. Block diagram of a lossy compression method is shown in Figure 1.

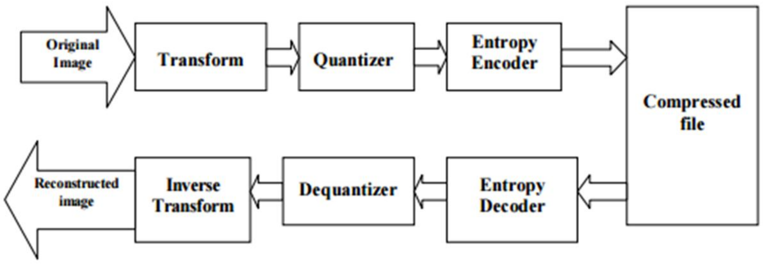
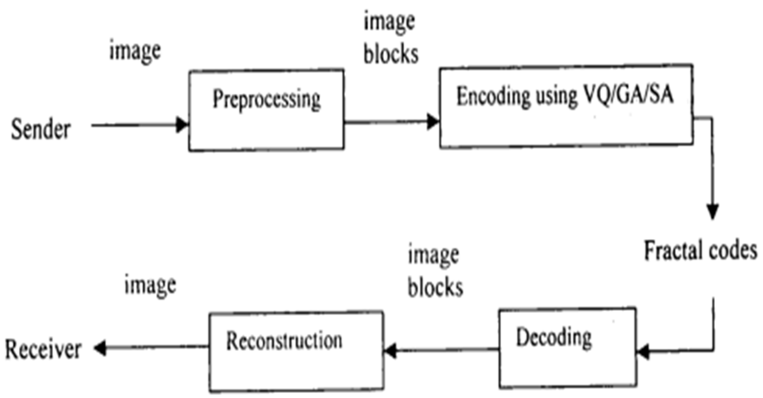


Figure 1: Lossy Image Compression System

Fractal Image Compression

The task of compressing an image includes three important parts:

- Partitioning the image and finding the transformations for each partitioned part
- Encoding (compressing) the image
- Decoding (decompressing) the image



Architecture of The Iteration-Free Fractal Image Coding Method

Partitioning the image

Quad-tree is an image structure, which appeared at the end of the 1970's, and was developed and applied in the 1980's and the 1990's. The basic idea of this partition is to decompose images by region, rather than by rows or columns, with the intention that the structural information of images can be better reflected. If an image is decomposed into quadrants continuously, the result will be a quad-tree. A quad-tree is a finite set consisting of several nodes which are either empty or consist of a root and almost four non-overlapping quad-trees. The process of image compression starts with image partitioning, based on the basic concepts and theoretical foundation that were discussed above. As the first step, the image is partitioned by some collection of ranges 'Ri'. Then for each 'Ri', a domain 'Di', which has a low rms error, is found from some collection of image pieces. Quad-tree method is used for partitioning the image into domains and ranges. The sets 'Ri' and 'Di', determine 'si' and 'oi' as well as ai ,bi , ci ,di , ei , and fi . Then a transformation W =U wi, which encodes the original image, is obtained.

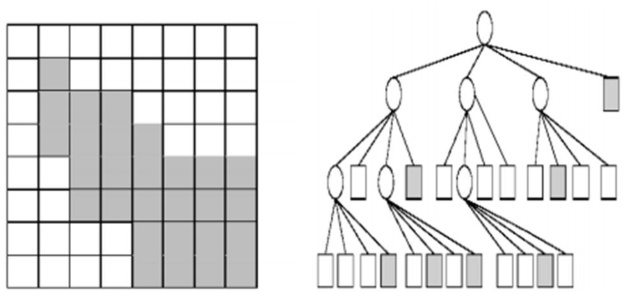


Figure 2: A Black-White Image and its Quad-tree

Determining Parameters

Given two squares containing n pixel intensities, a_1 ....a_n quantity

$$R = \sum_{i=1}^{n} (s.a_i + o - b_i)^2 \qquad (1)$$

$$s = [n^2(\sum_{i=1}^{n} a_i b_i) - (\sum_{i=1}^{n} a_i)(\sum_{i=1}^{n} b_i)] \qquad (2)$$

Available patterns are, say, P_1 , P_2 ...., of size P_M

n □ n and the levels present in a pattern are represented by t where 1 □ t □ Q . Thus, any pattern is represented as

$$km_1 = k'(A-d) + (k-k')(A+d) \qquad (3)$$

$$km_2 = k'(A-d)^2 + (k-k')(A+d)^2 \qquad (4)$$

Solving for A and d we get

$$A = m_1 + \frac{\sigma(2k'-k)}{2\sqrt{k'(k-k')}} \qquad (5)$$

$$d = m_1 + \frac{\sigma k}{2\sqrt{k'(k-k')}} \qquad (6)$$

Hence, intensity $\hat{f}(x)$ of the pixels of the corresponding block in the reconstructed image is given by

$$\hat{f}(x_i) = \begin{cases} A+d & if\ x_i \in C_1 \\ A-d & if\ x_i \in C_1 \end{cases} \qquad (7)$$

Encoding (Compressing) Algorithm

The steps of the encoding (compressing) procedure are as follows:

1) Determination of the parameters for compressing: Image name, image size, minimum partition exponent, maximum partition exponent both of which determine the size of domains and ranges, tolerance for fidelity.

2) Reading the image to be compressed and the image is partitioned into domains and ranges.

3) The steps to be followed in the Processing of domains are given below:

- The image is scaled by calculating the average values of each four- pixel group and the calculated values are saved into an array called ‘domain’.
- The image is divided into overlapping domains (16x16 or 8x8).
- Each domain block is divided into four quadrants and the variance is calculated for each quadrant.
- The domains are classified into 24 classes according to the order of each variance of the quadrants of the domain blocks. The position, the size and the class of the domain blocks are recorded in the corresponding class chain.
- After processing the 16x16 domains, the procedure is repeated until the smallest domains (4 x 4) are reached as specified by the maximum partition exponent.

The steps of the decoding (decompressing or restoring) procedure is as follows:
Determining the parameters of the restoring procedure:

- Hypothetical image (the “initial image”) name
- Compressed file name
- Number of iteration.

2) Reading the input file (the compressed file).
3) Reading the hypothetical image into an array ‘image’, which will be used as the Domains. The hypothetical image can have any values (e.g. all 0’s, or all 1’s, etc.).
4) Getting the parameters of the compressed image from the input file:

- Image size
- Maximum partition
- Minimum partition exponents
- Maximum and minimum values of the original image.

5) Preparing a blank image ‘image1’ for the restored image.
6) Reading the transformations from the input file:

Neural Network

Artificial Neural Network

Neural networks were first introduced by Mc Culloch Pitts in 1943 and Artificial Neural Networks (ANN) is inspired from biological neurons. An ANN consists of small computing units, called neurons, arranged in different layers and interconnected with each other with some nerves called synapses. These neurons calculate the results from the inputs which are derived from the network e.g. if a network topology is to be setup, all available inputs specific to topology are given into the neurons. The Processing of Information take place at many simple processing elements called nodes (also known as cells, units or neurons). Each link between nodes is associated with a weight, which controls the behavior of the trained ANN. The main advantages of ANN are distributed memory, parallelism, generalization capability, learning and redundancy. However, ANNs have some drawbacks that need to be complemented by other techniques. Neural networks are "black box" in nature; they do not provide the meaning of weight changes that gives a particular input-output, relationship. Additionally, it is challenging to determine the proper size and structure of an ANN to solve a particular problem.

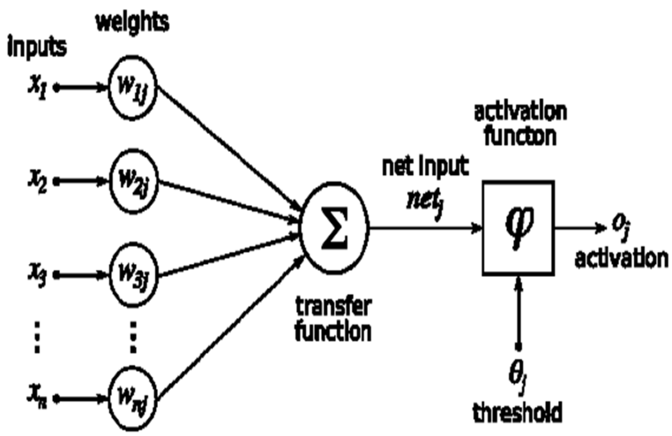


Fig 5: Structure of an artificial neuron network

Conclusion

In this thesis 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). Our simulation results from chapter 4 shows that we can achieve higher compression ratio using Hybrid technique but loss of information is more. DWT gives better compression ratio without losing more information of image. Pitfall of DWT is, it requires more processing power. 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.

References

[1] G.V.Maha Lakshmi, "Implementation of Image Compression Using Fractal Image Compression and Neural Networks for MRI Images", 978-1-5090-1987-8/16/$31.00 ©2016 IEEE
[2] Prashanth N and Arun Vikas Singh, "Fractal Image Compression for HD image with noise using Wavelet Transform", 978-1-4799-8792-4/15@2015IEEE.
[3] Aanestad A., Edwin B. and Marvick R. (2003) 'Medical image quality as socio -technical phenomenon', Journal of Methods Information in Medicine, Vol. 4, pp. 302-306. 2.
[4] Abdou Youssef, 'Medical Image Compression and Quality Testing', http://hissa.nist.gov/rbac/proj/abdou.html
[5] Adrian Munteanu, Jan Cornelis and Paul Cristea (1998) 'Wavelet lossy and lossless image compression techniques -use of the lifting scheme', International Workshop on Systems, Signals and Image Processing IWSSIP'98, pp. 12-19.
[6] Adrian Vanzyl (1995) 'Increasing Web Bandwidth through Image Compression: An overview of GIF, KPEG and Fractal Compression Techniques', Proc.AusWeb95.
[7] Ahmed N., Natarajan T. and Rao K.R. (1974) 'Discrete Cosine Transform', IEEE Transactions on Computers, Vol.23, pp. 90-93.
[8] Ahmet Eskicioglu M., Fisher and Paul S. (1993) 'A Survey of Quality measures for Gray Scale Image Compression', Space and Earth Science Data Compression Workshop, NASA CP-3191, pp. 49-61.
[9] Ahumada A.J. Jr. and Rensheng Horng (1994) 'De-blocking DCT Compressed Images' Human Vision, Visual Processing, and Digital Display V, SPIE Proc. Vol. 2179, pp.109-116.
[10] Ahumada A.J. Jr. and Rensheng Horng (1995) 'Smoothing DCT Compression Artifacts', SID Digest, Vol. 25, pp. 708-711.
[11] Alexandre Krivoulets (2003) 'Design of Efficient Algorithms for Image Compression with Application to Medical Images', Ph.D. dissertation, The IT University of Copenhagen, Denmark .
[12] Ali M. and Clarkson T.G. (1991) 'Fractal Image Compression', Information Technology and its Applications (ITA 1991), pp. 1-12. 173.