ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 9, September 2015

Fractal Image Compression Based on Pearson's Correlation Coefficient Using Block Classification and Sorting Method: Review

Ms.Yojana Bagal, Mr. Shingate V. S.

#Electronics Department,
Karmaveer Bhaurao Patil College of Engineering
Satara(MH)

Abstract-A drastic increase in demand for images,videos, computer animation has seen over the years.However an image needs a huge amount of data to store it,so there is a need to limit image data volume for fast transport along communication links.As a result there is renewed interest in compression of image data. Image compression is a process of reducing or eliminating redundant or irrelevant data.The objective of compression is to reduce the number of bits as much as possible, while keeping the resolution and the visual quality of the reconstructed image as close as possible to the original image. Fractal image compression (FIC) is one such emerged coding technology which is focused by researchers now-a-days. Fractal image compression is one of the most promising techniques for image compression due to advantages such as resolution independence and fast decompression. In this paper a review of different compression techniques is discussed.

***Keywords*:** compression, demand, eliminating, emerged coding, fractal, huge data, quality.

I. INTRODUCTION

Digital images are now covering larger portion of the information world. Continuous advances in the technology of digital cameras, scanners and printers have led to widespread use of digital images. So there is growing interest in compression of data to fit required expectations. Compression has to reduce storage bits while at same time maintain quality of retrieved image [1].For this purpose statistical properties of image are used in design of an appropriate compression technique. The strong correlation between image data items enables reduction in the data contents without significant quality degradation. There are numerous lossy and lossless image compression techniques that have been explored. However some factors such as spatial resolution, bit depth, noise, spectral response, scene contents including noise, image size, viewing distance etc are found affecting achievable compression and also reconstructed image [1].

Major research work based on image coding technologies has been reported earlier. Among them traditional coding technologies encoded an image by pixel-based and statistical methods [2]. Now, a newly emerged technology is fractal image compression (FIC), which is an alternative to issues found in traditional methods. Fractal image compression is an image coding technology based on local similarity of image structure. It attempts at structure based image coding and widely used in many fields such as image retrieval, image authentication, and encryption[2].In general the methodology used for fractal image compression is as shown in fig.

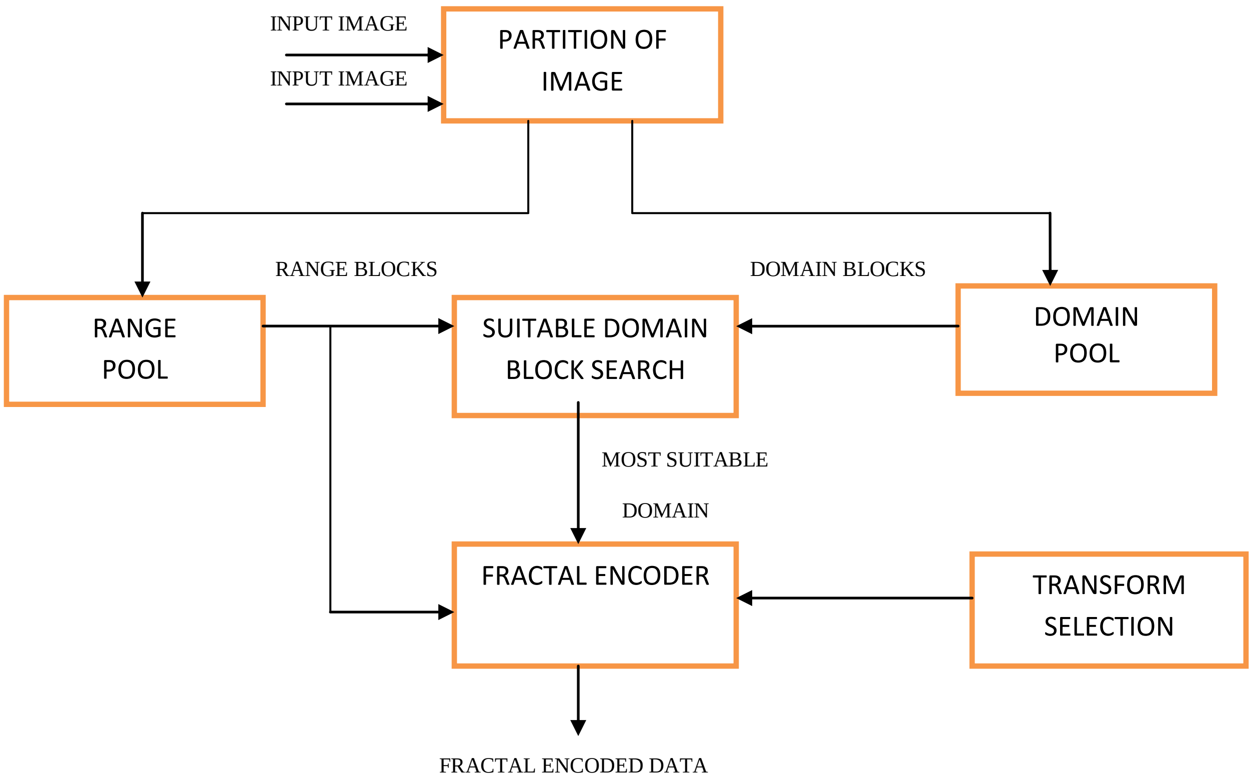

Fig1. Block diagram of FIC Scheme [1].

As shown in figure 1. APCC (Absolute value of Pearson's correlation coefficient) based FIC scheme, an image is firstly partitioned into some square blocks and then these square blocks compose a set called as pool. According to two kinds of size an image is partitioned into two different pools called as range & domain pool. Range pool is filled with non-overlapping blocks with size n*n and domain pool with blocks of size2n*2n.Domain blocks are then contracted into size n*n. Then search for a best matching domain block from domain pool with range block is made. Finally by applying a suitable transform encoding is done. In our proposed method after partitioning domain blocks are classified into 3 classes based on Fisher's 3 classes' method. To further reduce computation, sorting of domain blocks with respect to APCC (Absolute value of Pearson's correlation coefficient) is carried out. Here a preset block is used to sort domain blocks by APCCs computed between each domain block and preset block. Then for a range block, its corresponding block can be searched in a set of domain blocks in which APCCs of these domain blocks are close to APCC between range block & preset block. Range cells are encoded using domain pool as virtual codebook.

So fractal image coding is essentially block-based, wherein the image domain is decomposed into square range and domain blocks and a contraction mapping is found that best maps domain blocks into range blocks. This contraction mapping defines a fractal code of the image. Similar principle can be applied in the spectral domain,for example by means of the Discrete Cosine Transform (DCT) applied to each range and domain block prior to finding of contraction mapping. However compared to traditional methods FIC suffers from high computational complexity in encoding. In next section various fractal based compression techniques are discussed.

II.FRACTAL COMPRESSION TECHNIQUES

Fractal image compression is an image coding technology based on local similarity of image structure. It was proposed by Michael F. Barnsley in 1988 and further improved by Arnaud E. Jacquin in 1992. FIC scheme is called the baseline fractal image compression (BFIC), which uses the partitioned iterated function system (PIFS) to search the matching block pairs [3]. Since then FIC has undergone a quick development and now numerous FIC schemes have been published.In these schemes a lot of work has been conducted earlier by various authors based on searching matching pairs so as to speed up encoding process.Here we discuss a few as follows.

A) Baseline fractal image compression

In Jacquin's FIC scheme [3] regarded as baseline fractal image compression, self-similarity of an image is measured by the affine similarity in the partitioned iterated function system (PIFS). Here for an arbitrary range block R, a domain block D is searched so that affine transformation sD+o1 exists to minimize the squared distance with R, where s and o are the affine scalar parameters and 1 is a block with size n x n in which all pixels equal to 1.

B) FIC Using Spatial Correlation

This scheme used a new searching strategy based on image correlation which helped to improve encoding speed and reduce storage space, while at the same time maintains retrieved image quality.It is based on the fact that the characteristics of the spatial correlation depend on the orientations of the edge and shade wherein neighbor blocks are seen to have similar properties such as edge and shade[4]. For example consider any arbitrary block having 8 nearest neighbor blocks. If the arbitraryblock possesses a horizontal edge then its left and right neighbors are also seen to possess similar horizontal edges excluding the remaining 6 neighbors. Otherwise if block possesses diagonal edge, then only it's left up and right down neighbors possesses diagonal edge. So it is quite obvious that search of matching domain blocks gets automatically limited,thus requiring fewer bits to record the offset of domain block instead of absolute position , alternately increasing compression ratio and speed.

C) Classification based methods

Classification is generally a pre-process that is carried out before search of matching domain block.Here sets of domain and range blocks are divided into subsets with help of a hashing parameter[5].It is assumed that hashing parameter value for an arbitrary range block and its best matching domain block are equal. So given range block and its corresponding domain block are seen to be located in same class or subset.This greatly helps to minimize the extensive search process. In this method parameters used for classification vary.Wang et al. and Duh et al. grouped blocks into 3-4 classes using edge properties.On other hand Fisher divided domain pool into 72 classes, and then matching block for a range was searched from several classes closely associated with the range block. Fisher fast FIC scheme is a typical classification scheme.Tong et al. and Wu et al. used standard deviation to classify blocks given as,

$$STD_i=\sqrt{\frac{\| Di-\bar{d}iI \|}{B^2}}$$

D) Using unified feature and DCT

DCT (Discrete cosine transform) coding is another popular technique which is widely used in various fields due to its fast encoding speed and lesser computational complexity. Herein two version of fractal image compression algorithms are available namely FIC using special unified feature (UFC) and FIC using unified feature and DCT (DUFC), referred as hybrid FIC. Here the unified feature is a real number which is defines as follows:

$$M(R)=\left(\sum_{k=1}^{n}|\hat{r}_i|^{\frac{\gamma}{\gamma-1}}\right)^{\frac{2(\gamma-1)}{\gamma}}$$

$$M(D)=\left(\sum_{m=1}^{n}|\hat{d}_i|^{\gamma}\right)^{\frac{2}{\gamma}}$$

It gives a necessary condition for searching best matching pair of domain block given as:

If 1-M(*R*).M (*D*)) is small E(*R*,*D*) may be small and if 1-M(*R*).M(*D*)) is large E(*R*,*D*) must be large, where E(*R*,*D*) is matching error which is required to be minimized[6]. Also it gives rotation invariant performance with eight symmetrical transformations. Thus matching pair search is restricted to small selected domain pool and not the whole domain pool, increasing encoding speed. In UFC method matching error E(R,D) between range and domain block is tried to be minimized using above mentioned condition for unified feature. In DUFC a combination of unified feature and DCT is used. Moreover a threshold Є is set which calculates which coding to be used. In regions where E(*R*, *D*)>ε DCT coding is preferred while fractal coding is used for E(*R*, *D*) <ε .

E) DRDC (Range/Domain Approximation Error based Approach)

In DRDC scheme proposed by Richard Distasi complexity of the image coding phase is reduced by classifying blocks according to an approximation error measure. It is formally shown that postponing range domain comparisons with respect to a preset block, it is possible to reduce drastically the amount of operations needed to encode each range[7]. In DRDC scheme a preset block $\bar{\mathbf{d}}$ given as,

$$\bar{\mathbf{d}}=\frac{1}{|R|}\sum_{r\in R} r$$

Is used temporarily with which range and domain blocks are compared. The process is carried in two phases where

1) In first phase all domains are compared with preset block and approximation error is calculated and stored in tree type data structure format.
2) In second phase all range blocks are compared with preset block and approximation error is calculated. It is used as feature vector to search best matching domain for given range block.
Encoding time measured for 512*512 images with 4*4 range blocks was about 20 seconds.

F) Using SSIM (Structural Similarity)
Traditionally MSE (Mean square error) is used to evaluate similarity in image blocks. However it is found to differ from HVS (Human visual system). So a new method SSIM based on structural similarity is used. SSIM is an image quality measurement which considers HVS characteristics:

$$\text{SSIM}(x.\ y) = \frac{4\sigma_x\mu_x\mu_y}{(\sigma_x^2 + \sigma_y^2)(\mu_x^2 + \mu_y^2)}$$

SSIM between two images is calculated from mean of SSIM's between local corresponding blocks .For two images SSIM(x, y) Є [-1, 1] i.e. its value lies between -1 to 1.Larger the value of SSIM more similar are the images found. Images of SSIM are better than images of MSE schemes, since they are much clearer and have higher contrast than MSE [8].
G) Normalized one-norm and kick-out condition

Many previous methods help to reduce computational complexity, however reconstructed image quality is found to degrade considerably. As an alternative to overcome degradation a scheme is proposed based on a special measure called as one-norm of normalized block. Here in encoding process's error term calculation, computations that are redundant are found and discarded. So domain blocks that are impossible to match in best domain search process get removed earlier, thus reducing encoding time [9].
Here for an image block X, its normalized block is denoted as $\widehat{X} = \frac{(X - \bar{\mathbf{x}}I)}{\|X - \bar{\mathbf{x}}I\|}$ and the one-norm of normalized range block $\widehat{R}$ is denoted as $\|\widehat{R}\|_1 = \sum_{i=1}^{n}\sum_{j=1}^{n}|\widehat{r}_{i,j}| = \sum_{i=1}^{N}|\widehat{r}_i|$, where $\widehat{r}_i$ denotes ith element of $\widehat{R}$. The normalized one -norm of domain block is denoted by $\|\widehat{D}\|_1$ .If $\|\widehat{R}\|_1 \geq \|\widehat{D}\|_1$ and inequality $E_{L1}(R,D) \geq D_{\min}$ is held ,then it implies that $E(R,D) \geq D_{\min}$ which helps to discard unmatched domain blocks thus finding best match.
H) Huber fractal image compression (HFIC)

It is a new similarity measure for fractal image compression, where linear Huber regression technique from robust statistics is used in compression. It is generally preferred for suppressing outliers such as noises corrupting the images. Here particle swarm optimization (PSO) technique is used for searching best match. PSO is a population based algorithm for searching optimum block [10].

III. CONCLUSION

Major issues related to compression are compression efficiency, resolution, bit depth etc. which affects achievable compression. An alternative to it is use of fractal image compression. However over long encoding time in fractal image compression is one of the major difficulties for its applications. In this paper many schemes to speed up encoding have been proposed but they do not satisfy the encoding time or reconstructed image quality requirements. So we propose an APCC (Absolute value of Pearson's correlation coefficient) based scheme might help us to speed up encoding efficiently and also help to preserve reconstructed image quality better. It is based on the fact that similarity between two blocks is equivalent to absolute value of Pearson's correlation coefficient between them. For this firstly Fisher's 3 classes method is used to greatly reduce the number of blocks in the domain pool and classify the remaining domain blocks into 3 classes. Secondly the domain blocks are sorted by APCC's between each domain block and the preset block in each class, and then matching block for a range block is searched in a domain set selected by APCC with preset block.

ACKNOWLEDGMENT

The author is grateful to Mr. Shingate V.S
for his help.

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Yojana Bagal has obtained her B.E (Electronics and Telecommunication Engineering) degree from Pune University, Baramati,2008 and presently she is doing M.E (Electronics Engineering) from Shivaji University. Her area of interest is image processing.