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Speeding Fractal Medical Image Compression by using Highest Gray Value of Pixels Technique

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Abstract

In this research, we concerned with speeding up fractal image compression by using a new adapted method based on computing the highest value of the pixel of the image to reduce the computational complexity in the encoder stage *and which are led to decreasing the encoding time while the reconstructed image from the work as good as we want. For increasing the effectiveness of search stage we used another type of partitioning method* that led to increase the flexibility of range partition, this method is HV-partition. *We applied this method on medical images and also present a comparison of this method against other method which used to speed the fractal compression. The application of fractal images compression presented in this research is based on decreasing of the computational complexity in the searching stage that performing by selecting the blocks which has highest gray value of pixels which make high efficiency on encoding time that make another way to speeding up fractal medical images compression .*

Key word: fractal image compression, HV-partition, number of pixels in each block, range ,domain.

الخلاصة

في هذا البحث نهتم بتسريع الضغط ألكسوري للصور بواسطة استخدام طريقة جديدة تعتمد على حساب أعلى قيمة لبكسل الصورة لتقليل التعقيد في الحسابات في مرحلة الضغط والذي سوف يقود إلى تقليل وقت الضغط إثناء أعادة تركيب الصورة بالوضع الجيد والمطلوب ولغرض زيادة فعالية مرحلة البحث استخدمنا نوع أخر من طرق التقطيع والتي تقود إلى زيادة المرونة في تقطيع المدى، هذه الطريقة هي التقطيع الأفقي العمودي. نحن نطبق هذه الطريقة على الصور الطبية و أيضا يقدم مقارنة هذه الطريقة مع الطريقة الأخرى المستخدمة في تسريع الضغط ألكسوري. التطبيق لضغط الصور ألكسوري المقدم في هذا البحث يبنى على تقليل التعقيد في مرحلة البحث وذلك عن طريق اختيار الكتل التي فيها قيم البكسل عالية الذي يؤدي إلى تقليل وقت هذه المرحلة مما يؤدي إلى فعاليه عالية في وقت التنفيذ هذا يعطي طريقه أخرى لتسريع الضغط ألكسوري للصور الطبية.

1. Introduction

Fractal image encoding is attractive due to its potential high compression ratio, fast decompression and multi-resolution properties. However, the key problem is the long encoding time consuming of existing methods. The main reason is that the similarity matching computation between range and domain blocks is complex. In response to this problem, an effective method is to perform image blocks classification before blocks matching. After classification, exhausting searching is replaced by partial searching, and the similarity matching computation is done only during the blocks in the same class[*HAN Jin-shu*, 2007].The encoding process fractal image compression involves very high time complexity. This weak aspect makes the fractal compression, although it achieves high compression performance. Determining a good set of affine transformations that perfectly encodes image content is time consuming. This is because all image blocks have to be compared with a large codebook of blocks, similar to the vector quantization encoding method and Fisher's Method. A typical codebook consist of many thousands of blocks and consequently, cause the encoding process to suffer from long matching time. Most of the speeding techniques cause degradation in image quality; this is due to the fact that the speeding up(reduction in the encoding time) should be on the account of image fidelity[Fisher, 1992]. An image may be described in terms of a set of mathematical rules (Iteration Function System(IFS)) which can be represented using relatively much less number of bits. As a result, large amount of data reduction can be achieved. The value of compression ratio in this case may go up to 1000:1depending on the image to be coded. However, computational cost of encoding process is usually very high, because a large number of iterations is needed by IFS to converge. To reduce the computational cost, image is partitioned to small blocks and then fractal coding procedure is applied [Bhabatosh Chanda, 2009].

2.Introduction of Medical Image Compression

Medical images used at medical facilities are now commonly digitalized due to corresponding advances in information technology. CT(Computed Tomography) or MRI(Magnetic Resonance Image) generates digitalized signals by its own, and diagnostic images from legacy devices can be digitalized by film scanner and such. The size of digitalized images is varied by the image devices. CT images are mostly in resolution and RI and Ultrasonic images are usually NMI(Nuclear Medicine Imaging) is usually at low resolution, to images are commonly used. Fields utilizing digitalized medical images such as PACS(Picture Archiving and Communication System) require an economical compression technique without diminishing diagnostic values. There are two types of image compression technique depending on whether there is information loss in the decompressed images. Well known JPEG(Joint Photographic Experts Group) based on DCT(Discrete Cosine Transform) is loss compression techniques with relatively high compression ratio which is done by exploiting human eye perception. However under a special circumstance such as disease diagnostic requires medical images to be at high-resolution as possible with minimized data decompression time. Thus, rather than loss compression with relatively high compression ratio, mathematical lossless compression techniques are favored in this fields[Se-Kee Kil, *et al.,* 2006].

3. Fractal Image Coding

'Fractal' images are often geometrically complex and yet have low-information content.

Fractal are scale invariant, self-similar patterns to be generated using simple mathematical relations. If a similar process might be used to generate images, then the process can be used in image compression. Statistically, self-similarity can be described as a general impression of big or small objects remains the same. It does not imply exactly magnified or reduced copies of each other.

Barnsly developed an iterative contractive transformations for fractal image coding. The constituent parts of the representation can be formed by geometric transformations of the object itself. To ensure stability single transformations should be contractive. They should also consist of translations, rotations and scaling according to parameters which somehow need to be determined. Once found, the transformations themselves are sufficient to reproduce the complete image[Madhuri, 2009].

The first stage in the process (generation fractal fixed points and contractive mappings) is to consider how the original image might be represented by some collection of self-transformations, such that together they represent approximately the image itself. To do this, it is not possible to employ transformations of an arbitrary nature. For coding they need to be contractive overall and result in a unique sub image which consists of the original suitably shifted and distorted geometrically according to the coefficients of the transformation. This fixed point or attractor turns out to be independent of the original starting image and to be the limiting value of successive iterations of the transformation[Al-A'mri, , 2001 ; La Torre, *et al.,* 2006].

4. H-V Partitioning of Image .

A weakness of the quadtree based partitioning is that it makes no attempt to select the domain pool(D) in the content dependent way. The collection must be chosen to be very large so that a good fit to a given range can be found. A way to remedy this, while increasing the flexibility of range partition, is to use HV-partition. In an HV-partitioning , a rectangular image recursively partitioned either horizontally or vertically to form two new rectangular as shown in fig.(1). The partitioning repeats recursively until a covering tolerance is satisfied, as in the quadtree scheme [Fisher, 1992]. In an HV partition a rectangular range block can be split either horizontally or vertically into two smaller rectangles. A decision about the split location has to be made. While adopts a criterion based on edge location we follow and propose to split a rectangle such that an approximation by its DC component1 in each part gives a minimal total square error. We expect fractal coding to produce relatively small collage errors with this choice because

- approximation by the DC component alone (which is part of the fractal encoding) will already give small sums of squared errors by design of the splitting scheme, and
- for the approximation of the dynamic part of the range blocks we have a larger part of the domain available, if the range block variances are low. This comes from the limitations of the scaling factor, $|s| \leq s_{max}$

The DC component of a block is defined here as the block whose pixel values are equal to the average intensity of the block[Dietmar, *et al.,* 1999]. A rectangular image is recursively partitioned either horizontally or vertically to form two new uniformity and also incorporates a rectangle degeneration prevention mechanism as in figure (2). [Madhuri , 2009; Wohlberg and de Jager, 1999] .

if the examined block is too big to be a domain block, it is split either horizontally or vertically, according to the split which makes the biggest difference between pixels either side of the split (giving slightly more weight to splits nearer the middle of the block). The function find Transform'' is the same as before, except that a different suitability predicate is needed, to check that the dimensions of a domain block are multiples of the dimensions of the range block it is being compared with[Curtis and Martin, 2000].

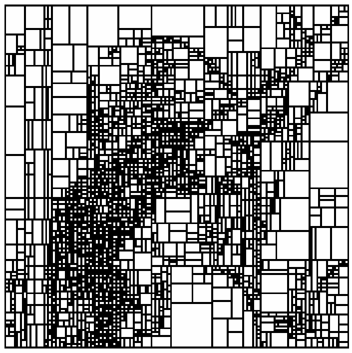


Fig. (1): HV-partition (Horizontal –vertical partitioning)

5. Error Metrics

Two types of the error metrics used to compare the various image compression techniques are the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR). The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. The mathematical formulae for the two types are [Madhuri, 2009]:

$$MSE = \frac{1}{N\times N}\sum_{X=0}^{N-1}\sum_{Y=0}^{N-1}\left[f'(x,y)-f(x,y)\right]^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$PSNR\,(dB) = 10 * \log_{10}(255^2 / MSE) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$SNR = 10\log_{10}\left[\frac{\max f(x,y) - \min f(x,y)}{MSE}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where f (x, y) is the original image, f' (x, y) is the approximated version (which is actually the decompressed image) and M,N are the dimensions of the images. A lower value for MSE means lesser error, and as seen
from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of signal to noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction. So ,if you find a compression scheme having a lower MSE (and a high PSNR) ,it can be recognized that it is better one [Satish , 2001].

6. Speeding up Fractal Encoding based on Highest Gray Value of Pixels Technique.

Image encoding techniques based on IFS are very effective as far as image quality is concerned In the last few years there have been a vast interest on this topic. The basic idea of IFS-based encoding lays in exploiting the similarity among different sized image blocks. Bigger blocks (domain) are mapped onto smaller blocks (ranges) that must be tile the original image. So that, a large number of sequential search through a list for rang must be performed. The new proposed fractal compression methods are based on reducing the computation requirements of the blocks matching process[Madhuri, 2009]. A central concept in fractal modelling schemes is a mapping that transformations. One piece of an image to another (usually of a smaller size). We will call such transformed the domain block and the result of the transformation the rang block. In our setting a piecewise mapping may be defined as a function T_n:R^2 R^2 .

7. Fractal Encoding based on Highest Gray Value of Pixels (HGVP) Technique.

Fractal image encoding is capable of yielding competitive rate distortion ;however; it suffers from long time, come from search all ranges through all D to find D_i which minimize:

$$\left\| R-\left[s_i sym(D_{i,j})-o\right]\right\| < \left\| R-\left[s_k sym(D_{k,m})-o_k\right]\right\| \; for \quad \forall i\neq k \quad or \quad j\neq m \; ....(4)$$

Where (s_i ,o_i) are the corresponding affine transform coefficients which map the domain block (D_i) to match the range block (D_i) to match the range block (R). The sym (D_{kj}) refers to he output obtained by applying symmetry operation (k) upon block (D_i), the scaling coefficient(s) is clamped to [-1,1] to ensure the convergence of the decoding process. In fact both (s) and (o) should uniformly quantized to yield $\bar{s}$ and $\bar{o}$. The collage error for range (R) can be compute from:

$$E(R,D)=\left\|R-(\bar{s}D+\bar{o})\right\|^2 \quad ....(5)$$

From eq.(6) there are eight ways to map one selective point to another. So for each R_i many of domains have to be compared, i.e., eq.(7) involve the full search of domain pool.

Various techniques have been proposed to overcome the time complexity. Therefore, we proposed a new technique attempt to accelerate the searching. This technique based on limit number of gray-value of pixels. In our new technique we used a very simple bit allocation scheme from a given range block. We have partition an image, such that each range is a flat partition of contour, then re arrangement of pixels depend on the gray-values. pixels arranged in a ascending arrangement, starting from the minimum value and jump, uniformity to till the maximum one . we chose fixed number of pixels(which they have the maximum values) depend on block size. Usually fixed number equal to:

Threshold condition = Min BLK Size of range block-1....................................(6)

Each block satisfy this threshold are used to match the domain blocks in the collage image. Next step, we used threshold condition. This condition chose fixed number of pixels.

8. Transformations

Two basic transformations exist in fractal image coding. The first, the geometric transformation, maps from the larger domain block to the range block. If no other operations occur, this transformation results in the range block pixels being the average of the

4 corresponding pixels in the domain block. In addition to the geometric transformation performed for every range block, affine transformations may be employed transformations include transformations that either change pixel values or pixel locations as listed below:

1. Change of Pixel Values
   (a) Absorption to gray level
   (b) DC gray level shift
   (c) Contrast scaling
2. Change of Pixel Locations
   (a) Identity
   (b) Reflection about vertical axis
   (c) Reflection about horizontal axis
   (d) Reflection about first diagonal
   (e) Reflection about second diagonal
   (f) 90° rotation around center
   (g) 180° rotation around center
   (h) -90° rotation around center

The algorithm searches for the transformations that produce the lowest distortion measure of root mean square error between the transformed domain block and the target range block.

9.Adaptive (HGVP) Technique.

The aim of fractal encoder is to minimize the Root-Mean-Square (RMS) error between the original and transformed image. For this aim, the natural way of driving the partitioning process is that adopting RMS error as the splitting threshold. The classical split threshold computes the RMS error between the range R and the optimal transformed domain D according this equation

$$E(R,D)\left\| R-(\bar{s}D+\bar{o}) \right\|^2 \qquad \text{...(7)}$$

In fact both (s) and (o) should uniformly quantized to yield $\bar{s}$ and $\bar{o}$. Before doing this computation we need to make sure which range blocks of the searching is used. In HGVP technique we select the number of highest gray-values in the range block, to speed up this technique we attempt to encode the bigger ranges, thus leading to optimal rate distortion. When range of mean values are increased from 30% to 50% for all levels of HV-partition, then the subdivision of bigger blocks is favored over that smaller ranges. Then overall effect abutter rate-distortion, improve image quality and faster search. we compute scaling factor (s) and offset factor for all range and domain in searching process according the following equation[Madhuri, 2009]

$$s=\frac{n\sum_{i=1}^{n} d_i r_i - \sum_{i=1}^{n} d_i \sum_{i=1}^{n} r_i}{n\sum_{i=1}^{n} d_i^2 - \left(\sum_{i=1}^{n} d_i\right)^2} \quad \text{.........(8)}$$

And

$$o=\frac{1}{n}\left(\sum_{i=1}^{n} r_i - s\sum_{i=1}^{n} d_i\right) \quad \text{.........(9)}$$

10. Materials and Methods:

10.1 Encoding algorithm

To encoding an image, we need to select an image partitioning scheme to generate the range blocks $R_i \subset I^2$. In this work, we will be assume that the R_i are generate by a HV- partition and we must also select a domain pool D. Before we used R_i to search, must be reduction number of range blocks.

for the range $R=(r^{ij})$ $0 \leq i < N, 0 \leq j < M$, the biased differences of vertical and horizontal pixel intensity sums ,respectively, are computed:

$$h_j = \frac{\min(j, M-j-1)}{M-1}\left(\sum_i r_{i,j} - \sum_i r_{i,j+1}\right) \quad \text{.........(10)}$$

$$v_i = \frac{\min(i, N-i-1)}{N-1}\left(\sum_j r_{i,j} - \sum_j r_{i+1,j}\right) \quad \text{.........(11)}$$

In our work we reduced number of range blocks by proposed new technique. New technique based on select the limit number of highest Gray level in range blocks, and used these blocks to match the domain blocks, This approach is outlined in the following algorithm:

1. Load an input image in to buffer. Partition the image into small blocks (SB) with non-overleap (i.e., range blocks).
2. Choose big blocks (BB) with overlap(i.e., domains blocks).
3. Get first SB from R-block.
4. Arrange the pixel values of the SB ascending.
5. Choose the highest values of the pixel values.
6. Determine number (n) out of (the highest values of the pixels).
7. Loop on all BBs for each one calculates and quantization the value of contrast (s) and brightness (o) by perform all the affine transformations,($R_i \approx s_i D_i + o_i$) mapping.
8. Choose the block that resembles the R-block with (RMSE), compute the encoding parameters that satisfy the mapping. Those parameters represents fractal element.

10.2 Decoding Process

One of the most remarkable features of fractal image compression is the simplicity of the decoder. The decoder in this work proceeds in the same way as in the case of the traditional encoder (i.e., fixed block size encoding).We can summarize the decoding process by the following steps.

Starting from any initial image, we repeatedly apply the W_i until we approximate the fixed point. This means that for each W_i we find the domain D_i shrink it to the size of its range R_i multiply the pixel values by s_i and add o_i and put the resulting pixel values in position of R_i.

10.3 Results and Discussion

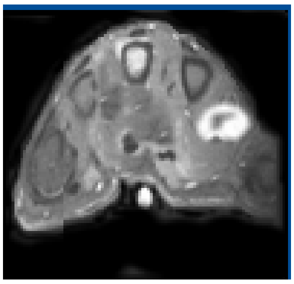
Reconstructed image is influenced by Rate Distortion which also effects PSNR value since it is directly proportional with Rate Distortion on one hand, on the other hand we see that Rate Distortion is inversely proportional with encoding time. In this research used the two types images to explain HGVP technique effectives on the quality of the reconstruction image and effect it on compression values and speeding up of the encoding operation which are refer by the encoding time. A problem with the traditional search method is that more D-block is examined then actually necessary. Many of them are totally different from the R-block and it is not suitable to sent to the affine transform to match them with the considered range block. Thus only suitable, similar domain blocks (i.e., have similar characteristics) should be send for affine matching. According to this work we need to improve the values of encoding time to make the encoding time as acceptable as quality of reconstructed image. in this work used three medical Gray scale images with size 256× 256 and used the HV_ partitioning techniques with minimum block size 4 and maximum block size 8. In the following experiment results we used different values of standard deviation (std) and Mean (M) to find the best values of each one which led to improve the values of encoding time to make the encoding time as acceptable as quality of reconstructed image. The best value of Mean(M) is 0.1 and the best value of standard deviation is 0.7 which are using in this work to make the encoding time as acceptable and high quality of reconstructed image. The minimum value an maximum value of the scaling which are used in this results (from -1.5 to 1.5) and the minimum value and maximum value of the offset (from -200 to 500) and the Qntscl =100.00 and Qntofs=1.000 and the number of iterations are used in decompression process for extracting the reconstruction image are 5 iterations.

Table(1):shows The result of medical Gray Image (A) with size 256× 256 and of minblsz =4 and maxblsz=8.

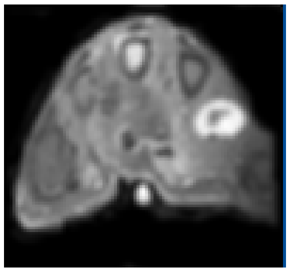
Number of pixels	C.R	SNR	PSNR (dB)	Time (sec)
3	8.9	28.239	25.311	22.218
4	9.01	26.804	26.989	41.329
5	9.05	26.057	27.001	55.248
6	9.11	25.054	28.666	64.231
7	9.16	24.043	29.761	72.876

Table(2):shows The result of medical Gray Image (B) with size 256× 256 and of minblsz =4 and maxblsz=8.

Number of pixels	C.R	SNR	PSNR (dB)	Time (sec)
3	9.19	28.121	26.356	21.218
4	9.21	27.804	27.589	43.329
5	9.44	26.325	28.781	58.248
6	9.98	25.023	29.416	69.231
7	10.01	24.345	30.761	75.876

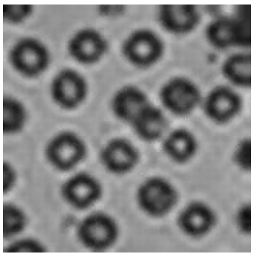


A1 image with No. pixel=7
Std=0.7
M=0.1
PSNR=29.761
Time=72.876

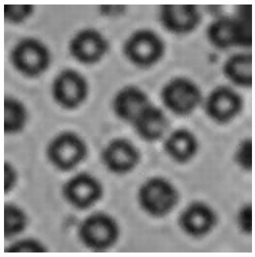


A1 image with No. pixel=3
Std= 0.7
M= 0.1
PSNR=25.311
Time=22.21

Fig(2): (Reconstruction image of encoding process of HGVP technique with Gray medical image (Bone) with size 256× 256 and 5 iteration of decoding process and minblsz=4 and maxblsz=8 No.Blk=1710) .



No. pixel=3
Std=0.7
M=0.1
PSNR=26.356
Time=21.218



No. pixel=7
Std= 0.7
M= 0.1
PSNR=30.761
Time=75.876

Fig(3): (Reconstruction image of encoding process of HGVP technique with Gray medical image (cell) with size 256× 256 and 5 iteration of decoding process and minblsz=4 and maxblsz=8 and No.Blk=1317) .

Table (3): Comparison between the results of traditional method and HGVP technique with mimblksz= 4, maxblsz= 8).

Image	Traditional Technique				A New HGVP Technique			
	C.R	SNR	PSNR (dB)	Time (second)	C.R	SNR	PSNR (dB)	Time (second)
Bone	9.25	32.933	30.596	244.272	8.9	28.239	25.311	22.218
	10.44	32.451	29.115	222.69	9.01	26.804	26.989	41.329
	11.67	32.154	28.817	183.103	9.05	26.057	27.001	55.248
	12.32	31.432	26.981	121.234	9.11	25.054	28.666	64.231
	12.97	30.541	26.421	98.651	9.16	24.043	29.761	72.876
Cell	5.45	33.933	32.596	221.272	9.19	28.121	26.356	21.218
	7.65	32.211	31.115	192.69	9.21	27.804	27.589	43.329
	9.67	31.554	29.817	183.103	9.44	26.325	28.781	58.248
	11.54	30.932	28.981	121.234	9.98	25.023	29.416	69.231
	12.59	29.341	27.213	103.498	10.01	24.345	30.761	75.876

11.Conclusions and discussion.

In this work, a new approach suggested for speeding up the operations in the encoding process, which leads to reduce that time. Many tests were performed on different medical images to study the behaviour of normal and speeded FIC method. From the results of these tests , the following conclusions could be summarized:

- Reconstructed image is influenced by Rate Distortion which also effects PSNR value since it is directly proportional with Rate Distortion on one hand, on the other hand we see that Rate Distortion is inversely proportional with encoding time.
- PSNR is directly proportional with number of pixel.
- The encoding time is directly proportional with number of pixel.
- Compression ratio is directly proportional with number of pixel.
- The encoding time is inversely proportional with each of :Mean (M) and Standard deviation (Std).
- PSNR is inversely proportional with each of (M) And (Std).
- Compression ratio is directly proportional with each of (M) And (Std) .

In order to keep the quality of the reconstructed image, it is not recommended to increase the block size more than 16×16 although this operation will increase the compression ratio. The encoding time is inversely proportional with number of blocks, also the PSNR is inversely proportional with number of blocks , while the compression ratio C.R is proportional with number of blocks. The encoding time is inversely proportional with block size, also the PSNR is inversely proportional with block size ,while the compression ratio C.R is proportional with block size. In case of the suggested approach for the encoding time reduction, the testing results showed that this approach achieve a relatively very short encoding time compared with the classical implementation of FIC method.

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