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SPEEDING UP FRACTAL IMAGE COMPRESSION

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ABSTRACT

Various compression methods have been proposed. In recent year fractal image compression gained more interest because of their capability to achieve high compression ratios while maintaining very good quality of the reconstructed image. However, this method suffers from a long encoding time arise from very large number of domain blocks that must be examined to match each range block. Our proposed technique based on Most Frequent Pixel (MFP) used to reduce the encoding time in fractal coding algorithms. In this technique, a limited number of frequently pixels ranging from (5 to10) have been adopted for a block of different sizes. The quality of the decoded image is affected by the number of pixels of gray values. When five pixels are limited, the decoded image is rather bad .Thus, when the limited numbers increase, the decoded image becomes clear more and more. In this paper we found we can reduce the encoding time to half when applying MFP technique than the traditional technique and the reconstructed image need 6 iterations to reach it attractor.

INTRODUCTION

Fractal image compression exploits redundancy given by self-similarities within an image. The image to be coded is partitioned into a set of image blocks (called range-blocks). For each range one searches for another part of the image called a domain that gives a good approximation to the range when appropriately scaled in order to match the size of the range and transformed by a luminance transformation that provides for contrast and brightness adjustment. The list of parameters specifying for each range the corresponding domain and the affine luminance transformation together with the partition information is called a fractal code. Such a fractal code defines an operator working on the space of images. When this operator is applied to an arbitrary image, it partitions the image and replaces each range by the (transformed) domain (Fisher, 1994; Jacquin, 1997). The most widely used strategies to partition the image are hierarchical methods like quad tree or horizontal/vertical partitioning. Here the coding costs for the partition are relatively low. On the other hand, more complex partitioning could lead to lower approximation errors (Ruhl et al., 1997). Fractal coding process is quite complicated but decoding process is very simple, which makes use of potentials in high compression ratio. The given image of size NxN is partitioned into overlapping domain blocks D_i (of size 2rx2r), for each quad tree partition, where rxr is the size of the range blocks R_i. The domain step size used is 2 in horizontal and vertical directions. The domains are classified based on the mean and variance of the pixels in the four quadrants of the block (Zumbakis and Valantinas, 2005). The domain pool D (search codebook) is constructed by placing the entire domain blocks D_i, corresponding to same class in individual lists. The range-domain matching process consists of contracting each domain block to the size of the range block by averaging 2x2 pixels. During encoding, a potential range R_i is also classified. The domain range matching process consists of searching the domain pool D for D_i and an affine transformation W_i, which minimizes the rms distance between the range block R_i and the transformed domain block W_i. For a range block with n pixels, each with intensity r_i and a decimated domain block with n pixels, each with intensity d_i, the objective is to minimize the quantity,

$$E(R_i, D_i) = \sum_{i=0}^{N-1} (s.d_i + o - r_i)^2 \qquad \dots(1)$$

When the partial derivatives are done by using equation (1) with respect to s and o is zero. Solving the resulting equations will give the best coefficients s and o (Zhou et al., 2003)
The minimum of E^2 occurs when:

$$\frac{dE^2}{ds} = 0 \; and \; \frac{dE^2}{do} = 0 \qquad \dots(2)$$

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$$s = \frac{n\sum_{i=0}^{n-1} r_i d_i - \sum_{i=0}^{n-1} r_i \sum_{i=0}^{n-1} d_i}{n\sum_{i=0}^{n-1} d_i^2 - (\sum_{i=0}^{n-1} d_i)^2} \quad \dots (3)$$

$$o = \frac{\sum_{i=0}^{n-1} r_i \sum_{i=0}^{n-1} d_i^2 - \sum_{i=0}^{n-1} r_i d_i \sum_{i=0}^{n-1} d_i}{n\sum_{i=0}^{n-1} d_i^2 - (\sum_{i=0}^{n-1} d_i)^2} \quad \dots (4)$$

$$E^2(R, D) = \frac{1}{n}\left[\sum_{i=0}^{n-1} r_i^2 + s\left(s\sum_{i=0}^{n-1} d_i^2 - 2\sum_{i=0}^{n-1} d_i r_i + 2o\sum_{i=0}^{n-1} d_i\right) + o\left(no - 2\sum_{i=0}^{n-1} r_i\right)\right] \dots (5)$$

At each range-domain matching instance and before the determination of E^2, some conditions should be applied on the determined values of (s) and (o), these conditions :The value of (s) must be within a bounded interval$(s_{min} \leq s \leq s_{max})$, the minimum scale s_{min} must be not less than (-1.5), while the maximum scale value s_{max} must not more than (1.5). The value of (o) must be within a limited interval $(o_{mni} \leq o \leq o_{max})$. The minimum offset (o_{min}) value must be not lessthan (-256), while the maximum offset value (o_{max}) must not more than (256).

Fractal Encoding Algorithm

Fractal Image coding attempts to find a set of contractive transformations that map (possibly overlapping) domain blocks onto a set of range blocks that tile the image. The basic algorithm for fractal encoding is as follows (Distasi et al., 2006):

1 The image is partitioned into non overlapping range blocks which may be rectangular or any other shape such as triangles. In this paper quad tree range blocks are used.
2 The image is covered with a sequence of possibly overlapping domain blocks. The domain blocks occur in variety of sizes and they may be in large number.
3 For each range block the domain block and corresponding transformation that best covers the range block is identified. The transformations are generally the affined transformations. For the best match the transformation parameters such as contrast and brightness are adjusted.
4 The code for fractal encoded image is a list consisting of information for each range block which includes the location of range block, the domain that map onto that range block and parameters that describe the transformation mapping the domain onto the range.

Speed-up Fractal Image Compression

Various techniques have been proposed to overcome the time complexity. Therefore, we proposed a new technique attempts to accelerate the searching. The proposed method takes an input image and partitioning it into non-overlapping blocks (range blocks). For the first block, it checks which gray value is the most frequent. Since each pixel is usually represented by 8 bits, the Most Frequent Pixel (MFP) must possess the maximum number of bits in the block. We simply delete all the occurrences of the most frequent pixel from the block and represent all other pixels in an array like data structure. The block to array conversion is performed according to a left-to-right-top-to-bottom manner. Now the Second Most Frequent Pixel (SMFP) and its frequency are searched. For a block, it is guaranteed that the frequency of any pixel except MFP and SMFP will be less than or equal to the frequency of the SMFP. Thus, if k bits are required to denote SMFP's frequency, any pixel frequency of the block can be denoted by k bits. Finally, these steps are to be performed for each block of the image.

Encoding Algorithm of SFICMFP Technique

Image encoding image needed to select partitioning scheme to generate the range blocks $R_i \subset I^2$.For this purpose, $R_i$is generated by a quad tree partition, and a domain pool D must also be selected .This can be chosen to be an sub squares in the image. Thus, in our work we reduced number of pixels in range blocks by a new proposed technique. The new technique is based on limited number of MFP in range blocks, and used to match these blocks with the domain blocks. This approach is outline in the following steps of encoding process.

1. Load an input image into buffer.
2. Partitioning the image into small blocks (SB) with non-overleap (i.e., range blocks).
3. Choose big blocks (BB) with overlap (i.e., domain blocks).
4. Get first small block (SB) from R-block.
5. The block is converted to an array of 16 elements. Left-to-right-top-to-bottom approach is followed for the conversion
6. Find the MFP in the array and delete all of its occurrences. The array now contains less than 16 elements.
7. Find the frequency of SMFP. If k bits are required to represent this frequency.
8. Loop on all domain blocks (BBs) for each one calculates and quantization the value of (s and o), perform all the affine transformations, $(R_i \approx s_i D_i + o_i)$ mapping.
9. Choose the block that resembles the R-block with the (RMSE), compute the encoding parameters that satisfy the mapping. Those parameters represent one fractal elements.
10. Pack the parameters into a more compact shape in order to chive more compression.

Store the compact bit stream in the output.

Decoding Algorithm of SFICMFP Technique

One of the most remarkable features of fractal image compression is the simplicity of the decoder. The decoder of adaptive encoder proceeds in the same way as in the case of the traditional encoder. 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 shrinks 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. The following steps show the decoding process of our proposed technique:

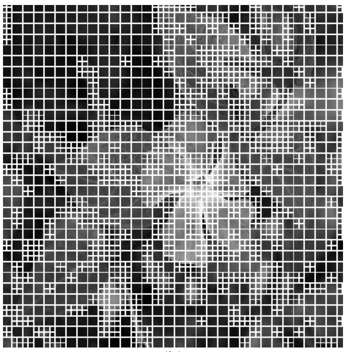
1. Generate the first reconstructed domain image plane randomly, we may initialize the domain image with 0, 1, 2,…, 128,..etc, values.
2. The values of the indices of (s_i) and (o_i) for each range block should then be mapped into the reconstructed values of (s_i) and (o_i) by using the de quantization process.
3. Each range block, in the image, is reconstructed by using equation (5), and then located in its position in the decoded image plane (i.e., range pool).
4. Down sample the decoded (reconstructed) image (range pool) into the size of domain pool by averaging or integer sampling to produce a new domain pool.

5. Repeat step 3 until we reach the at tractor state (i.e., decoded image will not be changed as we processed in the iteration).

RESULTS AND DISCUSSION

The largest time consuming part of the encoding process lays in the stage of search (matching) for an appropriate domain for each range, since for each range in the partition of the original image all elements of the domain pool are inspected. From the domains in domain pool we select the best one (i.e., the domain D_k that yields the best least square approximation of the original image in the range). Therefore, the problem arising during the encoding when a large pool of image is a subsets (i.e., the domain pool has to be searched repeatedly many times). This searching process is, in fact, dominating all the other computations in the encoding process. In this section, we shall present various results of compression ratio, quality, and encoding time which are affected by limited number of pixels. The main objective of these experimental tests is to study the effect of limit number of gray-values on the final decoded image. The experimental tests will be performed on 256×256 tiger image. Also, the experiments imply Speeding up method with the adaptive quad tree partitioning scheme. The minimum and maximum block sizes that will be chosen are 4×4, 8×8 and 16×16 respectively. Fig.1 Illustrate Compression results of SFICMFP technique applied on flower image.

(a)



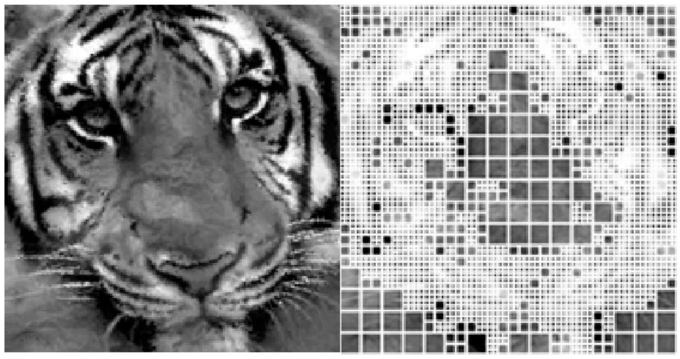
(b)

(c)

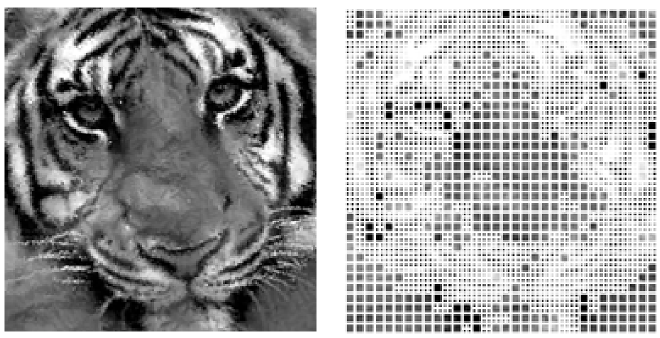
Fig.1: The results of SFICMFP technique with Varity encoding parameters: a) Original Image, b)Image Partition Maximum and Minimum block size (16&4) Standard deviation=2, Mean=0.1, And No. Pixels=7, c) Reconstructed Image compression ratio=6.32, PSNR=34.015dB, No. Bluck=2289, and Encoding time=7 Sec

Limitation the Number of Frequently Pixels

In our work, a limited number of frequently pixels ranging from (5 to10) have been adopted for a block of different sizes. The quality of the decoded image is affected by the number of pixels of gray values. When five pixels are limited, the decoded image is rather bad .Thus, when the limited numbers increase, the decoded image becomes clear more and more. Fig.2 demonstrates the efficiency of SFICMFP technique for encoding images. It is clear that a slight increase in compression ratio and PSNR values will occur when the number of Pixels increase and vice versa. From fig.2, it is obvious that there is a relationship between compression ratio and PSNR at different values of No. Pixels, Mean, standard deviation.



No. of frequent pixels=5, Min. block size=4
C.R=5.66, SNR=21.737, Max. Block size=16
PSNR=28.623 dB, Time=6.30sec



No. of frequent pixels=8, Min. block size=4
C.R=4.16, SNR=23.23, Max. Block size=8
PSNR=31.8 dB, Time=7.1sec

Fig. 2. Illustrated results of SFICMFP technique depends on limited different pixels with effect of affine transformation

The Effect of Rate Distortion on Encoding Time

Reconstructed image is influenced by rate distortion which also effects PSNR value since it is directly proportional with rate distortion on the other hand we see that compression ratio is inversely proportional with encoding time. When rate distortion value is 30%, the results of the effect of using this value is pointed out in Table1which shows the effect of the number of partitioning blocks on encoding time. In fact, encoding time usually decreases whenever there are decreasing in the number of partitioning blocks. That's the aim of the technique, i.e. decreasing in time with an accepted image, and this, in return, the aim of the work. The table also shows the effect of No. of frequent pixels when the limited number of pixels are little, then time decrease since No. of frequent pixels is directly proportional with PSNR, and the number of partitioning blocks is also directly proportional with PSNR.

Table 1. The result of SFICMFP technique depends on limited different frequent number of Pixels with affine transformation

Min. block size	Max. block Size	No. of Pixels	C.R	PSNR (dB)	Time (sec)	No. of Blocks
4	16	5	8.91	32.31	9.10	1710
4	16	8	9.02	31.97	7.30	1710
4	16	10	9.12	28.21	6.10	1710
8	16	5	12.44	27.76	5.01	699
8	16	8	12.49	27.05	4.65	699
8	16	10	12.54	26.38	3.62	699
4	8	5	7.31	33.13	10.20	2091
4	8	8	7.42	32. 57	7.10	2091
4	8	10	7.43	31.91	6.40	2091

Conclusion

Proposed technique provides noteworthy reduction in the amount of computations as well as complexity of suitable domain search. Approximation error is computed on the basis of vectors instead of images; hence the total time requirement of the desired process is reduced significantly. The time requirement is independent of complexity and depends on the size and number of range partitions.

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