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Advanced Fractal Image Coding Based on the Quadtree

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Abstract

Fractal image coding simply based on quad tree is a unique technique for still image compression. Compared with other image compression methods, fractal image coding has the advantage of higher compression ratio, higher decoding speed and decoded image having nothing to do with the resolution of image. It spends too much time to look for the best matching R_i block on encoding. To improve the encoding speed, we must narrow the search range and improve the search skills to ensure the best match block falls within our range. In this paper, an advanced fractal image compression algorithm based on quad tree is proposed. First, we can improve the construction method of search attractor by constructing directly from the big D_i block, so it can save a lot of searching time in encoding. Second, the attractors can be self-constructed, so it is not happened that the attractor is not found in the traditional methods. Experimental result shows that the algorithm makes image coding faster and more efficiency.

Keywords: Image compression; Fractal; Quad tree; Coding

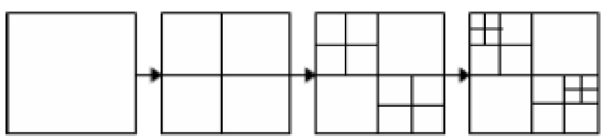
I. Introduction

Fractal image compression, is base on the IFS (iterated function system) proposed by M.F.Barnsley, (1986), "Fractal functions and interpolation", is a unique approach to image coding. Its performance relies on the presence of self-similarity between the regions of an image. Since most images process a high degree of self- similarity, fractal compression contributes an excellent tool for compressing referred by Cardinal J.(2001), "Fast Fractal Compression of Grayscale Images", Truong T K(2004),Kung C M,Jeng J H,(et a1), "Fast Fractal Image Compression Using Spatial Correlation". In order to improve the efficiency of fractal image compression, many people proposed a variety of flexible segmentation methods, such as quad tree, rectangular, triangular and region segmentation method, it has proposed in Tong Chong .(2001), " Fast Fractal Image Encoding Based on Adaptive Search", Saupe D, RuhlM.(2004) "Evolutionary Fractal Image Compression". In this paper, an advanced fractal image coding algorithm based on quad tree is proposed to improve the speed of fractal image coding.

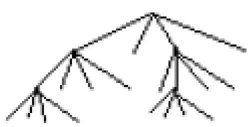
The setting of the paper is given below. Section II shall introduce the basic fractal image coding based on quad tree. Section III shall describe our improvement. Then the experimental results of the proposed method shall be shown and compared with that of the traditional one in Section IV. Finally, Section V shall serve to present the conclusions.

II. Review of the Quad tree Approach

Quad tree segmentation is a unique technique that divides a gray level image into a set of homogenous regions. The segmentation represents into a tree, and each tree node has four children. When we decompose an image following this quad tree technique, we first assign the whole image to the root of the tree and test its uniformity. If the uniformity condition is not met, it is then quartered into four sub-images. These four sub-images have the same size and are associated with the four child nodes of the root. The uniformity of each sub-image will be tested next, and the sub-image will be subdivided repeatedly until the uniformity criterion is met or some minimum sub-image size has been reached and it has been proposed in Distasi R, Nappi M,(2006). A demonstration of the process is shown in Figure 1.



(a) The segmentation process



(b) The corresponding quadtree

Figure 1: Example of quadtree segmentation

Before division, we first set maximal and minimal depth of the quad tree and maximal allowable error to decide the number of ranges. Then, we continuously split a range into four square ranges of the same size by the quad tree method until minimal depth is met. An optimum matching block will be searched for each range on the level. If it is found, it can be marked as R_i and the range corresponding with it can be marked as D_i and the split is not done again. Otherwise they are further splited into four ranges. This process continues until we get the maximal depth is met. It has been proposed in Erjun Zhao, Dan Liu, (2005), Tong Chong (2001).

III. The Proposed Method

A. The Proposed Algorithm

As mentioned above, the traditional method of fractal coding generally divides the original image into larger blocks D_i and also divides the original image into smaller blocks R_i .Then classifies the blocks D_i by the defined standard and searches the similar D_i in the divided classes. It takes too much time in searching, and it is also the main reason of the long time in fractal coding. The algorithm of the paper used is different from the traditional method. It divides the original image directly into larger blocks D_i, divides the original image into smaller blocks *Ri*, then classifies the blocks R_i by the defined standard and searches the similar R_i in the divided classes. Then it searches the attractor in the corresponding classes, if it does not find out the right R_i, searches the most similar R_i, and calculates the correctional value to construct the fictitious $\overline{R_i}$ and saves the correctional value, instead of searching the R_i from the huge database. So it boosts the speed of the encoding. And the algorithm begins searching R_i from the biggest block, and the traditional algorithm begins searching R_i from the least block. Main step of the improved encoding algorithm is as follows:

Step I. First of all, the original image is segmented to determine D_i.
Step II. Then, directly split to locks find the correct R_i for each block.
Step III. Exchange and distribute the D_i sub-blocks according to the block mean, and note the information of exchange. The block mean and exchange information are added as part of its code.
Step IV. Interchange R_i according to the same method as step 3, and the exchange information is added as part of the it's code.
Step V. Search the same block of D_i in R_i if find, continue next, if not find, look for the most similar block R_i and calculates the correctional value to construct the fictitious $\overline{R_i}$ add the correctional value as part of its code
Step VI. Repeat step 4 and 5 until it reaches the set of conditions.
Step VII. Encoding with the traditional fractal encoding method based on quad tree.
Main step of the improved decoding algorithm is as follows:
Step 1.Read the encoding file by sequences. First, read the block mean of D_i and its exchange information. According to the exchange information, we can get the sub-block mean with the original order.
Step 2.Then read the correctional value and Interchange information of R_i to calculate the mean of R_i.
Step 3.Repeat step 2 until reaching the smallest block size.
Step 4.According to exchange information and the original mean, decoding with the traditional fractal decoding method based on quad tree.

B. Encode file format

Encode file format is shown as figure 2, which consists of 5 parts

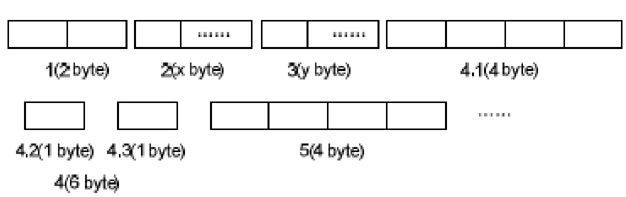


Figure 2: encode file format

Part 1 is block classification information, which occupies 2 bytes.
Part 2 is judging information of initial D_i block mean. Its each bit shows that the mean error of initial block is less than the given error or not. If 0, it is less than and indicates that the block pixel value equal the block pixel mean multiply by the size of block. If 1, it is larger than and indicates that the block

should be further splited into four small blocks. So the second part byte size is not fixed, its equal line number multiply by column number, and divided by 8.

Part 3 is judging information of square R_i block mean. Its each bit shows that the mean error of *Ri* block is less than the given error or not. Its value represents the same meaning as Part 2.Its byte size is not fixed too, which equal line number multiply by column number, and divided by 8.

Part 4 is the basic information of Original Square R_i block, occupying 6 bytes. The first 4 bytes represent the mean of initial block, and following 1 byte represents position exchange information of initial block, the last 1 byte represents judging information of quad tree mean.

Part 5 is the cycle information of quad tree, occupying 4 bytes which represent the judging, correctional and exchange information of quartered squares individually. Correctional value is computed as follows:

$$C_i = E_{Ri} - \overline{E_{Ri}} \qquad (1)$$

Where E_{Ri} is the block mean of R_i and $\overline{E_{Ri}}$ is computed as follows:

$$\overline{E_{Ri}} = 4 \times E_i \times \frac{E_i}{E_1 + E_2 + E_3 + E_4} \qquad (2)$$

Where E_1, E2, E3, E4are mean of the original four sub-blocks mean.

So when decoding, the corresponding E_{ri} can be computed as follows

$$E_{Ri} = 4 \times E_i \times \frac{E_i}{E_1 + E_2 + E_3 + E_4} + C_i \qquad (3)$$

C. Exchange information format

There are eight special classification transformation methods known as the "reflection-rotation" transformation, shown in table 1. With the transformation methods, we can classifies the blocks R_i, and reduce the searching time in encoding.

Table 1 eight "reflection- rotation" transformations

ID	transformation matrix	meaning
0	$\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$	Rotation 0^o
1	$\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$	Rotation 90^o
2	$\begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}$	Rotation 180^o
3	$\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$	Rotation 270^o

4	1 0 0 -1	X reflection
5	-1 0 0 1	Y reflection
6	0 1 1 0	Y= X reflection
7	0 -1 -1 0	Y= X reflection

But in our methods, the encoding time is mainly used in calculating the correctional value, not in searching the similar block, so we don't use the eight special classification transformation methods. To get the exchange information, first we divide the original image directly into four smaller blocks, shown in figure 3.

1	2
3	4

Figure 3 the sequence of blocks

And then we define an array named as A_1,A_2,A_3,A_4 , the value of A_1,A_2,A_3,A_4 are assigned with the corresponding mean value of block.

		6	5	4	3	2	1

Figure 4 block exchange information

As shown in figure 4, the block exchange bit value is all set "0" first. We compare the A_1 value with the A_2, A_3, A_4, *and* set the exchange information in corresponding 6th, 5th, 4th bit in figure 4. For example, if $A_1$is smaller than A_2, then exchange the mean value of $A_1$and A_2, and set "1" in the 6th bit in figure 4, if $A_1$is smaller than A_3, then exchange the mean value of A_1 and A_3,and set "1" in the 5th bit, and so on. We compare the A_2 value with the A_3 A_4, and set the exchange information in corresponding 3rd, 2nd bit in figure 4. and the exchange information of A_3 compared with A_4 is set in 1st bit.

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IV. Experimental results

We have made several experiments in MatLAB to code and to decode the original image “Lena” (256 x 256) by the traditional fractal and the advanced method on a microcomputer(PIV 2.4G,256MB). Experimental parameters and demands are listed as follows: Maximal size of a range: 32x 32; Minimal size of a range: 4x4.Under the same experimental conditions, the two methods can both reconstruct the original image well. Figure 5 is the image processing results. From Table 2, we can see that the advanced method provides significant improvement in encoding time, but the compression ratio decreased.

(a) Original image

(b) Reconstructed image with traditional method

(c)Reconstructed image with the improved method

Figure 5: Image Processing Results

Table2. Performance comparison between the traditional and improved method

Coding method	the traditional fractal coding method	Improved method
encoding time	345	227
Compression ratio(s)	13.09	10.8
PSNR/dB	29.17	30.12

V. Conclusions

In this paper, we have proposed an advanced fractal image compression algorithm based on quadtree, which construct search attractor directly from the big D_i block. And if D_i can not search the similar R_i , we searches the most similar R_i , and calculates the correctional value to construct the fictitious $\overline{R_i}$, Experimental results show that if the correctional value is reasonable, it could reduce the image distortion degree, and the algorithm makes image coding faster and more efficiency. Disadvantage of the advanced algorithm is that image compression ratio decreased Compared with the traditional method, and it is the direction of further research.

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