Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/04/jls.htm
2015 Vol. 5 (S4), pp. 1298-1302/Zahedi and Dehghani
Research Article

A NEW METHOD TO IMPROVE THE FRACTAL IMAGE COMPRESSION USING A COMBINATION OF BLOCK CLASSIFICATION AND QUAD-TREE PARTITION

Zhaleh Molay Zahedi[1] and *Hamid Dehghani[2]
[1]Department of Electronics, Boushehr Islamic Azad University
[2]Department of Malek-Ashtar, University of Technology, Iran
**Author for Correspondence*

ABSTRACT
Here to improve the quality of the reconstructed image, a kind of fractal compression method will be discussed which is based on block classification and quad-tree partition. At first, the image will be segmented according to adaptive quad-tree partition method. Then the sub-blocks will be classified at every level. Experimental results show that reconstructed and enhanced image by this method has higher peak signal to noise ratio (PSNR) and visual effects than adaptive quad-tree partition method, while the compression ratio has also increased.

Keywords: *Block Classification – Fixed Size Block Partition - Quad-Tree Partition - Combination of Block Classification and Quad-Tree Partition*

INTRODUCTION
Fractal image compression based on fractal geometry theory is developed and its theoretical foundation is Iterated Function Systems (IFS). New Thinking of fractal image compression has completely come out of traditional (old) coding method framework. This technology officially begins a new method for fast encoding, due to the potentially high compression ratio, fast decoding, independent resolution and optimal quality of reconstructed image. Fractal image compression has also become one of the latest and popular methods in the field of image compression. But there are many unresolved issues for practical use of this technology.
In the method of fractal image compression, the smaller block size, the longer encoding time and this improves the reconstructed image and compression ratio will be low and vice versa (Zheng *et al.,* 2007; Kasaeipoor *et al.,* 2015; Ziaei and Kasaeipoor, 2015; Zhou *et al.,* 2008; Kasaeipoor *et al.,* 2014).
So based on the assumption of increasing in compression, how to reduce coding time and how to improve the quality of the reconstructed image are important goals in the development of this technology. In some cases, we make a tradeoff between them (Jacquin *et al.*, 1993; Davoodi *et al.*, 2013).

MATERIALS AND METHODS
The Method of Fixed Size Block Partition (Dimension)
Initially, the image will be divided in the form of non-overlapping blocks (Ri) and overlapping domain blocks (Di). Generally, the domain block is two times bigger than the range block in size. Then the matching process will be done on these blocks and the result of that is the creation of IFS for each range block (Ri), searching for the best matching domain block (Di) and the contraction (compressed) mapping (Wi) and then building the transformed domain block which is closer (more similar) to the range block i.e. $w_i(D_i) \asymp \mathrm{R_i}$ and ultimately saving the IFS for each range block. Contraction mapping function (Wi) includes a spatial scaling transformation, a spatial transformation and a luminescence transformation. Spatial scaling transformation is used to compress the domain block and generally is interpreted as the average of the four adjacent pixels. Spatial transformation is the same Jacobian eight affine transformation. Luminescence transformations are determined by scaling factor (S) and grayscale offset (O) which may be solved by the method of least squares.

For an image of size N × M pixels, if d_{ij} is the pixel of transformed domain block by W_i and r_{ij} is the pixel of range block, error measurement will be as follows (Belloulata and Konrad, 2009; Truong, 2010):

$$err = \sum_{i=1}^{N}\sum_{j=1}^{M}(s.d_{ij} + o - r_{ij})^2 \qquad (1)$$

By partial derivative of the above equation with respect to S and O and putting them equal to zero, the equation (2) and (3) will be obtained:

$$S = \frac{MN\sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij}r_{ij} - \sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij}\sum_{i=1}^{N}\sum_{j=1}^{M} r_{ij}}{MN\sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij}^2 - \left(\sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij}\right)^2} \qquad (2)$$

$$O = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} r_{ij} - S.\sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij}}{MN} \qquad (3)$$

If $MN\sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij}^2 - (\sum_{i=1}^{N}\sum_{j=1}^{M} d_{ij})^2 = 0$

Then $S = 0$ ، $O = \frac{1}{MN}\sum_{i=1}^{N}\sum_{j=1}^{M} r_{ij}$

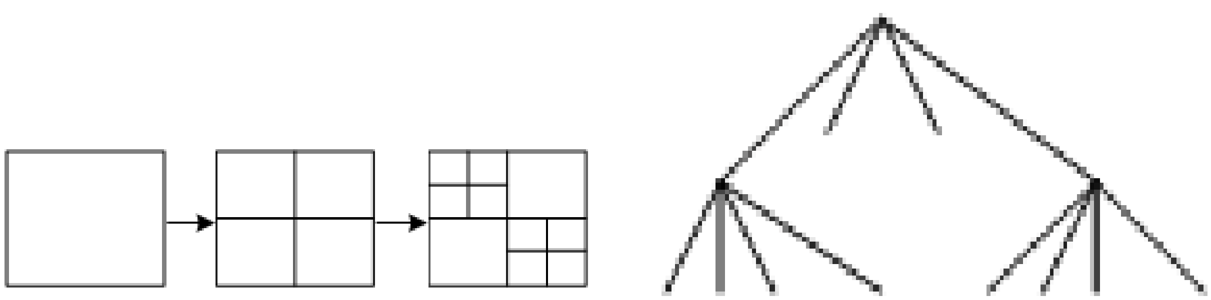
In this way, to improve the quality of the reconstructed image, the size of the block is chosen to be small, which will increase the total number of blocks and the IFS parameters. The result is increased encoding time and the compression ratio will be reduced subsequently.

Adaptive Quad-Tree Partition Method

In adaptive quad-tree partition method, the image is divided into 4 equal sized sub-blocks which are grafted together by four groups. The sub-blocks are also divided, but not based on statistical characteristics (Bani-Eqbal, 2003; Zhou *et al.*, 2007; Wohlberg and Jager, 1999; Andreopoulos *et al.*, 2000).

Figure: 1 shows a process of dividing the quad-tree.

Quad-tree partition will be done only on sub-blocks which their error is greater than a given threshold. As a result, the block for areas with rapid changes in the image is small and the blocks in large flat areas are big.



A. Image segmentation

B. Quad-tree

Figure: 1 Quad-tree partition process

Quad-tree partition will be done only on sub-blocks which their error is greater than a given threshold. As a result, the block for areas with rapid changes in the image is small and the blocks in large flat areas are big.

Block Classification and Quad-Tree Partition Method (Proposed Method)

To reduce the search time during the adaptation process of the quad-tree partition method, the sub-blocks will be classified in each level. The range block will be classified directly. The domain blocks will be transformed by spatial scaling transformation and spatial transformation before classification. As already

said, spatial scaling transformation is used in domain block compression in space spatial transformation is the same Jacobian eight affine transformation. Classification method is described as follows.
At first, each sub-block will be divided into four equal parts and then we will calculate the mean and variance for the sector. Then according to the mean values, the sub-block will be classified into three main categories.
First category: $\mu_1 \geq \mu_2 \geq \mu_3 \geq \mu_4$
Second category: $\mu_1 \geq \mu_2 \geq \mu_4 \geq \mu_3$
Third category: $\mu_1 \geq \mu_4 \geq \mu_2 \geq \mu_3$
Finally, according to the descending order of priority and posteriority of variances (∂_1‹∂_2‹∂_3‹∂_4) each main class will be divided into 24 subcategories.
In this way, each sub-block will be divided into 72 categories. The algorithm is described as follows:
Step 1: The maximum and minimum induction depth and the error threshold will be set.
Step 2: Adaptive quad-tree partition will be done on the image. Domain and range blocks will be classified at each level.
Step 3: Each range block will be compared with domain blocks which have the same class as that range block. If the error is below a given threshold, the relevant parameters are recorded otherwise it returns to step 2.

Experiments

In this case Lena's image with size of 3 × 256 × 256 × 256 pixels was chosen as the test image and fractal compression was done on the image based on these three below methods:
1. The method of fixed size block partition
2. The method of adaptive quad-tree partition
3. Block classification and quad-tree partition (proposed method in this paper)
Main Lena's image was considered as the original image with size of 3 × 256 × 256 × 256 pixels which is shown in Figure 2. In the method of fixed size block partition, the size of range and domain blocks are 8 × 8 pixels and 16 × 16 pixels, respectively. The other two methods, maximum and minimum of induction depth are considered 2 and 6. Compression ratios from these three methods are 23/63, 9/972 and 11/367, respectively. In decoding process, in the different number of repetitions, peak signal-to-noise ratio is shown in Figure 3.
This experimental result shows that the quality of reconstructed image is improved. In this case the compression ratio by the proposed method (11/367) is greater than the compression ratio by adaptive quad-tree method (9/72) and PSNR is improved 1/3 dB by the proposed method. From Figure 3, we can see that all three methods have high-speed convergence. Generally after 5 to 8 iterations, PSNR of the reconstructed image will be almost identical. When the number of iterations reaches to 10, the reconstructed image by these three methods is shown in Figure 4. The experimental results shows that the reconstructed image of the proposed method has the best visual impact.

Figure: 2 Main Lena's Image

Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2015/04/jls.htm
2015 Vol. 5 (S4), pp. 1298-1302/Zahedi and Dehghani
Research Article

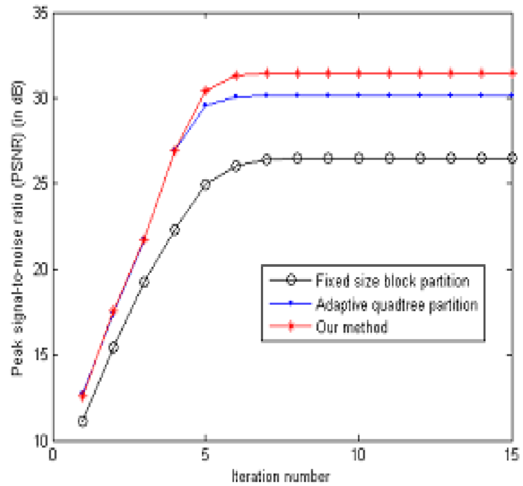


Figure: 3 PSNR of the Reconstructed Image Versus the Number of Iterations for Three Different Fractal Image Compression Methods based on
1. Fixed Size Block Partition (Black Diagram)
2. Adaptive Quad-Tree Partition (Blue Diagram)
3. Quad-Tree Partition and Block Classification - Proposed Method in this Paper (Red Diagram)

Figure: 4 A

Figure: 4 B

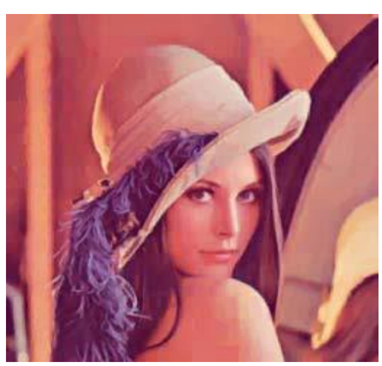


Figure: 4 C

Figure: 4 Reconstructed Images by Three Different Mentioned Methods

A) Lena's reconstructed image in the fractal compression method based on fixed size block partition
B) Lena's reconstructed image in the fractal compression method based on adaptive quad-tree partition
C) Lena's reconstructed image in the fractal compression method based on quad-tree partition and block classification (our method)

Conclusion

In traditional fractal image compression method, increasing the compression ratio and improving the quality of the reconstructed image are often inverse of each other. According to this principle that the compression ratio shouldn't be lowered and to improve the quality of the reconstructed image, in quad-tree partition method, sub-blocks are classified at every level. Even, where the compression ratio is higher than the traditional quad-tree partition method, reconstructed image has higher PSNR and better visual impact. When the iteration process converges, the value of PSNR will be improved 1/3 dB through our method.

REFERENCES

Zheng Y, Liu FR and Niu XX (2007). "An improved fractal image compression approach by using iterated function system and genetic algorithm", *Computers and Mathematics with Application* **51**1727-1740s.

Kasaeipoor A, Ghasemi B and Aminossadati SM (2015). Convection of Cu-water nanofluid in a vented T-shaped cavity in the presence of magnetic field. *International Journal of Thermal Sciences* **94**(8) 50-60.

Ziaei Rad M and Kasaeipoor A (2015). A Numerical study of similarity solution for mixed-convection copper-water Nanofluid Boundary layer flow over a horizontal plate. *Modares Mechanical Energineering* **14**(14) 190-198.

Zhou YM, Zhang C and Zhang ZK (2008). "Fast hybrid fractal image compression using an image feature and neural network", *Chaos, Solitions and Fractals* **37**(2) 623-631.

Kasaeipoor A, Ghasemi B and Raisi A (2014). Magnetic field effect on nanofluid water-cu natural convection in an inclined T shape cavity. *Modares Mechanical Engineering* **14**(12) 179-189.

Jacquin AE (1993). "Fractal image coding: *A review," Proceeding of the IEEE*, **81**(10) 1451-1465.

Davodi H, Maghsoudi T, Fami HS and Kalantari K (2013). Evaluation of strategies for developing the agriculture technology in the science and technology parks of Iran from faculty member aspect. *African Journal of Agricultural* **8**(30) 4148-56.

Belloulata K and Konrad J (2009). "Fractal image compression with region-based functionality," *IEEE Transactions on Image Processing* **11**(4) 351-362.

Truong TK, Kung CM, Jeng JH and Hsieh ML (2010). Fast fractal image compression using spatial correlation. *Chaos, Solutions and Fractals* 1071–1076 .

Bani-Eqbal B (2003). "Enhancing the speed of fractal image compression," *Optical Engineering* **34**(6) 1705–10.

Yi-Ming Zhou, Chao Zhang, Zeng-Ke Zhang (2007). An efficient fractal image coding algorithm using unified feature and DCT," Chaos, article in press doi.101016/j.chaos.

Wohlberg B and Jager G (1999). "A review of the fractal image coding literature" *IEEE Transactions on Image Processing* **8**(12) 1716-1729.

Andreopoulos I, Karayiannis YA and Stouraitis T (2000). "A hybrid image compression algorithm based on fractal coding and wavelet transform", *IEEE International Symposium on Circuit and System*, May 28-31, 37-40.