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Short Communication

Analysis of Smooth and Complex Domain Blocks Classification for Fractal Image Compression

Amit Kumar Biswas[1*] and Sanjay Sharma[2]
[1]Department of Computer Applications, Bhilai Institute of Technology, Durg, Chhattisgarh, India
[2]Depatment of Mathematics, Bhilai Institute of Technology, Durg, Chhattisgarh, India
akbiswasbit@gmail.com

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Abstract

Fractal Image Compression has been an old and high compression method of still image compression, but it is being a slow method due to a computation complexity for searching the matching block from large domain. This paper proposed an analysis of domain blocks classification for speeding up the encoding time. For the analysis, three methods: fractal dimension (FD), linear interpolation (LI) and discrete cosine transform (DCT), are used for block complexity measure. The Experiments compares the methods with smooth and complex domain blocks classification.

Keywords: Fractal Image Compression, Fractal Dimension, Linear Interpolation, Discrete Cosine Transform.

Introduction

Image compression is a great interest in applications area where efficiency to store the data or online transmission through internet is applicable. Fractal based real world images have the built-in property of high visual complexity and similarity while the information content is very low and by simple recursive process they can be generated easily. Barnsley proposed an interesting application about fractal image compression is that any real world image would be represented by fractal image-attractor sets of two dimensional affine transformations[1]. Mathematically this transformation is called Iterated Function System (FIS). However, Barnsley has not proposed the automated method to coding gray scale image. A new compression has been proposed by Jacquin and a block based coding approach to compress gray level image automatically[2,3].

Two main problems, when an image is compress without losing image quality are: encoding time and compression ratio. The linear search coding method is a efficient technique for high compression, while take a long time to search the matching domain block. To decrease the encoding time for the above method, it is required to classify the blocks with respect to block complexity i.e. smoothed blocks and complex blocks and apply the linear search only for the complex block. In this paper we analysis the three blocks complexity measure approaches: FD, LI and DCT to classify the blocks.

The description about FD, LI and DCT is explained in section 2. The experiments and results are explained in section 3. The last section, discuss the conclusion.

Complexity Measure Methods

Fractal Dimension: Fractal Dimension is a method for block complexity measure and it is being calculated by box-counting method. There are a number of methods to calculate FD. For fast FD calculation, a simple and efficient algorithm has been used which calculate the dimension values between 1 to 2[1,4,5]. The classification condition which is given in equation (1) to classify the image block as:

$$FD = \begin{cases} < 1, & Smooth\ image\ block \\ \geq 1, & Complex\ image\ block \end{cases} \quad (1)$$

Linear Interpolation: Linear interpolation is a simple method to estimated some unknown values in a range of continuous function according to both the given end values. Linear interpolation obtain the other unknown values based on the known values without any error by using linear function. For smooth or linear blocks, use the two dimensional linear interpolation given in equation (2), (3), (4) and separate the complex blocks from smooth blocks.

Suppose G_k is the gray function of block b_k and (x_i, y_i) are co-ordinates of a pixel in b_k. For a block $b_k, k = 1, 2, \dots\dots, N$, consider four arbitrary pixel positions in square block as (x_1, y_1), (x_2, y_2), (x_3, y_3), and (x_4, y_4) and the corresponding gray values of that pixels are g_1, g_2, g_3, and $g_4$respectively. The two dimensional interpolation of b_k can be represented as

$$G_k^{'}(x_k, y_k) = A_k * x_k + B_k * y_k + C_k * x_k * y_k + D_k \quad (2)$$

Substituting the gray values $g_1,\ g_2,\ g_3,\ g_4$ and the co-ordinates $x_1,\ y_1,\ x_2,\ y_2,\ x_3,\ y_3, x_4, y_4$ in the equation (1) and obtained the parameters $A_k, B_k, C_k, and\ D_k$ uniquely. After that gray values of other pixels in block b_k can be obtained by equation (1) and calculate the Error as

$$E_{lin}^{k} = \left\| G_k - G_k^{'} \right\| \tag{3}$$

then,

$$E_{lin}^{k} = \begin{cases} < T_{lin},\ Smooth\ image\ block \\ \geq T_{lin},\ Complex\ image\ block \end{cases} \tag{4}$$

where T_{lin} is a threshold value.

Discrete Cosine Transform: The discrete cosine transform (DCT) widely used in the area of image compression for the excellent energy compaction properties. For the image blocks, calculate the DCT coefficients denoted by $F(x, y)$. To classify the image blocks according to AC coefficients of $F(x, y)$ as:

$$|F(0,1)| + |F(1,0)| + |F(1,1)| = \begin{cases} < T_{DCT},\ \ Smooth\ Image\ Block \\ \geq T_{DCT},\ \ Complex\ Image\ Block \end{cases} \tag{5}$$

where T_{DCT} is a threshold value.

Methodology

Experiment is done according to above mentioned method. The methods are tested on six standard grayscale 256×256 pixel images: Lena, Baboon, Cameraman, F16, Goldhill and Pepper. An 8x8 non-overlapping block is used to obtain the complexity values of all the three methods.

Results

Table-1 is experimental results on 256×256 images on laptop (IBM R52 with 2GB RAM). Comparing among the methods to present that number of smooth block and number of complex blocks are almost same except some images.

Conclusion

This paper analysis the three blocks complexity measure methods: Fractal Dimension, Linear Interpolation and DCT. The above result will help to choose the domain blocks classification approach for Fractal Image Compression in the context of encoding time.

Table-1
Experimental Result

	No. of Smooth Blocks			No. of Complex Blocks		
	FD	**LI**	**DCT**	**FD**	**LI**	**DCT**
Lena	441	330	318	583	694	706
Baboon	54	28	153	970	996	871
Cameraman	571	510	623	453	514	401
F16	538	481	472	486	543	552
Goldhill	134	115	265	890	909	759
Pepper	328	327	320	626	697	704

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