

Colour Image Compression Method Based On Fractal Block Coding Technique

Dibyendu Ghoshal, Shimal Das

Abstract—Image compression based on fractal coding is a lossy compression method and normally used for gray level images range and domain blocks in rectangular shape. Fractal based digital image compression technique provide a large compression ratio and in this paper, it is proposed using YUV colour space and the fractal theory which is based on iterated transformation. Fractal geometry is mainly applied in the current study towards colour image compression coding. These colour images possesses correlations among the colour components and hence high compression ratio can be achieved by exploiting all these redundancies. The proposed method utilises the self-similarity in the colour image as well as the cross-correlations between them. Experimental results show that the greater compression ratio can be achieved with large domain blocks but more trade off in image quality is good to acceptable at less than 1 bit per pixel.

Keywords—Fractal coding, Iterated Function System (IFS), Image compression, YUV colour space.

I. INTRODUCTION

WITH the ever increasing demand for images, sound, video sequences, computer animations and volume visualization, data compression is found to be a critical issue regarding the cost of data storage and transmission time. JPEG currently provides the industry standard for still image compression, there is ongoing research in alternative methods. Fractal based image compression is one of them. Fractal-based techniques have been applied in several areas of digital image processing, such as image segmentation [1], image analysis [2], [3], image synthesis and computer graphics [4]. It has generated much interest due to its ability to provide high compression ratios with good decompression quality and it enjoys the advantage of very fast decompression. The lossy coding techniques like DCT (Discrete Cosine Transform), JPEG, MPEG-1 and MPEG-2 stand for video and still image compression and these are based on the DCT which provides good performance in terms of compression ratio. For high compression ratio, DCT based algorithms suffer from blocking effects. YUV colour scheme or space has been used in television broadcasting system owing to its properties of having lower band width, faster transmission time compared with those of RGB system. In the latter, each component i.e. red, green and blue occupy equal band width and in this case luminance and chrominance parts of RGB signal are inter-

mingled. Thus RGB system poses problem to the user of black and white (BW) television system. In YUV system, as luminance part (Y) is separated from the coloured portion i.e. U and V components, BW television system can tune any channel carrying video signal in YUV format. Moreover, as U and V components stand for the colour difference signal with respect to the intensity part, both of them occupy small band widths and that has made them popular in colour television transmission. For high compression ratios wavelet transform and fractal coding are the most appropriate applications [6]. The fractal geometry was first introduced by Mandelbrot [9] in the late seventies and is being used in a number of domains. Later on, the mathematical theory of fractals was studied and well presented by [4]. Fractal block coding reported by [5], [6] is an important land mark in applying fractals to images required compression. Although a large number of research works on the compression of digital image signal are reported, no study on fractal based compression of coloured digital image signal using YUV colour format is seen in published or on-line literature. In this paper a fractal block coding technique for digital color images in YUV space is proposed. The proposed technique provides the high compression ratio compared to other techniques.

The rest of the paper is arranged as follows: Section II presents overview of the fractal block coding technique, Section III describes the fractal coding for color images, Section IV provide the experimental results, Section V and VI presents the conclusion and references respectively.

II. MATHEMATICAL BACKGROUND OF FRACTAL BLOCK CODING TECHNIQUES

Image compression based on the fractal coding makes fruitful uses of image self-similarity in spatial domain by ablating image geometric redundancies [7].

Fractal image coding is based on the theory of iterated function systems (IFS) [4]. This process is quite complicated but decoding process is comparatively its simple, which makes use of its potentials in high compression ratio. Basically there are mainly four steps for fractal block coding of digital images. First step is image partitioning, second step is selection of a discrete contractive image transform class, third step relates to reduction of distortion based on constructing codebook and Last step deals with the quantization of the parameters related to entire fractal compression process. All these steps are depicted in Fig. 1 in a flow-chart form.

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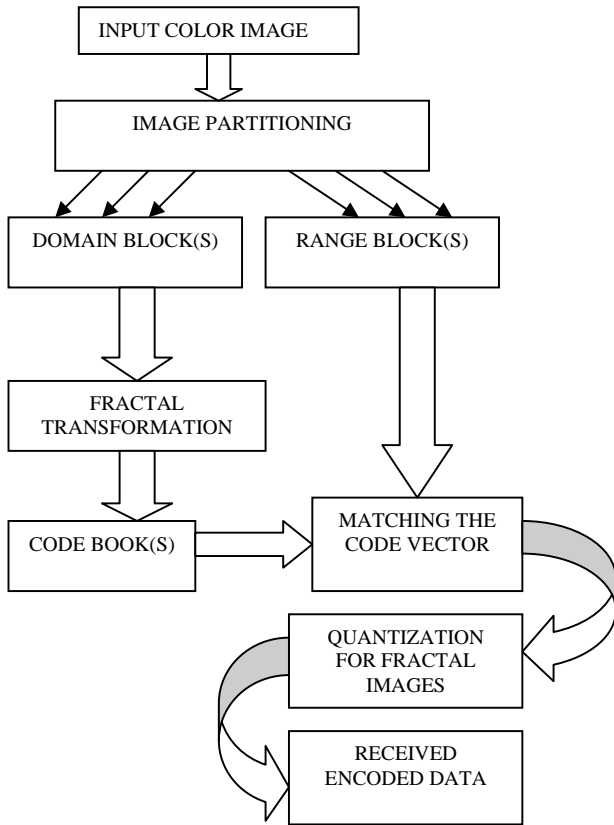


Fig. 1 Sequence of the fractal blocks coding technique in flow-chart form

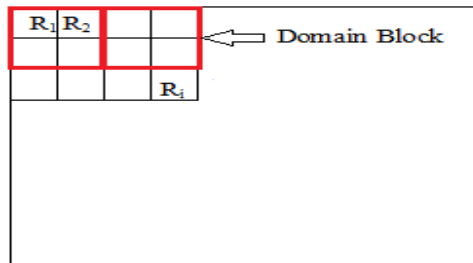


Fig. 2 (a) Schematic presentation of Range and domain blocks in the context of fractal coding



Fig. 2 (b) Lena image partitioned into range and domain blocks

Image can be partitioned into non-overlapping several square blocks called range blocks. Similarly image can be partitioned into overlapping several square blocks called domain blocks. The size of the domain blocks is larger than

the range blocks. It is customary that the domain blocks size are double of the range blocks (i.e. Domain blocks = 2 x Range blocks). Fig. 2 (b) shows the partitioned range and domain blocks of Lena image and Fig. 2 (a) Range and domain blocks.

Fractal based image transformations are mainly divided into two parts viz. geometric and mosaic. In geometric contraction, operator maps the domain block (D_i) to a range block (R_i). In the present study the size of the domain block is taken to be the twice of that of the range block. The geometric part of the transformation can be processed by averaging over non-overlapping 2x2 or 4x4 size sub-blocks within the input domain block. So the size of the range block obtained from image blocks formed by such averages will be of the same but the mosaic part will be one out of the few pre-decided ones and it exploit the redundancies present in the image in the form of mirror symmetry, self-similarity and different orientations of the same image block etc. This operation may comprise various processes such as averaging the contrast scaling, color reversal, luminance shift and the mid-vertical axis reflection or horizontal axis or first diagonal or second diagonal reflection or 90 degree or 180 degree or 270 degree rotation around the centre of the block. But the mosaic part of the fractal transformation consists of scaling by a chosen constant, isometric and luminance shift and other minor factors.

Domain blocks are transformed based on fractal coding and produce code vectors. Code book is constructed with the help of code vectors and Fig. 3 shows the architectural view of coding of range blocks with the help of code book and finally formed by domain blocks.

The size of the code book depends on the size of domain blocks available and the number of fractal transformations used. Finally the range blocks are produced with the help of code vector matching.

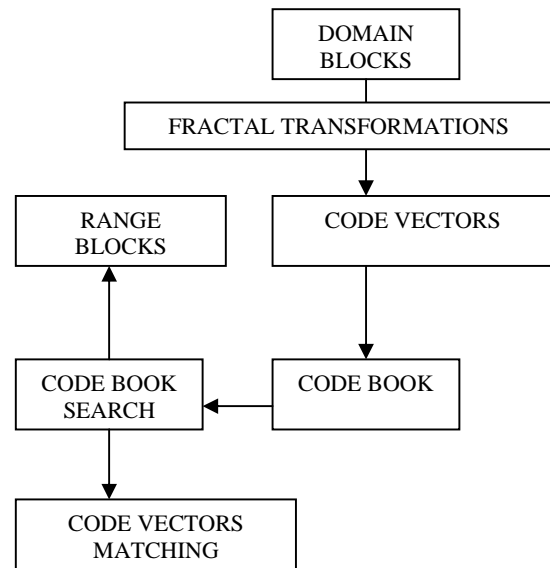


Fig. 3 Range blocks coding with the help of code book formed by domain blocks

For distortion measure in this coding system the normalized mean square error (NMSE) is used and this is defined as

$$NMSE = \frac{1}{N^2} \sum_{i=1}^N \sum_{j=1}^N (I_{i,j} - T_{i,j})^2$$

Here $I_{i,j}$ and $T_{i,j}$ are $(i,j)^{th}$ pixel intensities of original image and encoded $N \times N$ size image, respectively. At the final stage the transformed images are quantized with less quantization error and it is transformed into the encoded receiver.

$$PNSR = \frac{(255)^2}{NMSE}$$

where PNSR= peak signal to noise ratio.

Simultaneously the encoded receivers transmit these transformations for iteration to fulfill the purpose. Then the constructed images are called fractal images. The iteration free fractal encoding method [11] greatly reduces the decoding time, but does not reduce the encoding time much. Similar ideas are explored in some of the recent works to reduce the encoding time [10]-[12].

III. PROPOSED FRACTAL CODING FOR COLOR IMAGES IN YUV SPACE

For colour image compression, there exists some correlation between the color components and greater compression is achieved by exploiting those correlation and redundancies. It is known have that a fractal compression of color images of 24 bit/pixel with the dimension of 512x512 of pixels. These images are split into YUV planes and these YUV planes are transformed and produce components of fractal coder i.e. range blocks and domain blocks. Fig. 4 shows the YUV components for fractal coding.

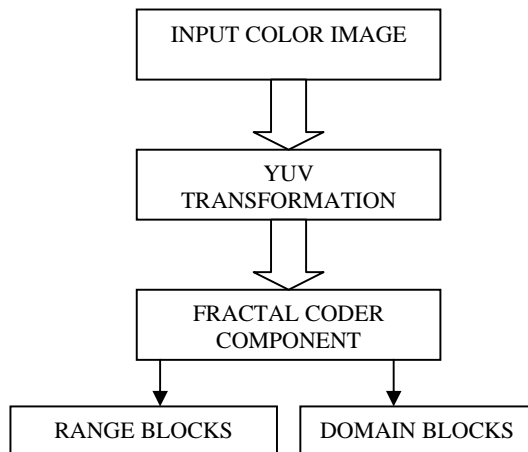


Fig. 4 Block wise presentation of YUV component for fractal coding scheme

The sizes of the domain blocks are always double that of the range blocks. In the present study the size of range block is varied into three slabs e.g. 4x4, 8x8, and 16x16. This will yield maximum 16388 domain blocks for each color plane.

There are three colour planes in YUV space for the design of code book and the same is used to code non-overlapping range blocks obtained from these three colour planes.

To get the codebook design carried out, the fractal transformation with domain blocks from all three colour planes. This code book is used to construct the range blocks. Every range block coded send the positions of the domain block to avoid the requirement of code book and fractal transformation is used. To reduce the bit rate required, variable bit allocation depending on the type of the image block coded [8] is used. If the image block having a significant gradient, needs quantize all the parameters using fractal transformation for achieving good image quality.

IV. EXPERIMENTAL RESULTS AND DISCUSSIONS

The present study has been carried out using Matlab software (version 2009a).The necessary programs have been done in simple manners to implement the interactive contraction process to two test images viz. Lena and Baboon of size 512x512 pixels each have been adopted from database.

The fractal coding is basically a lossy-compression technique and the compression is carried out domain wise and with gradual decrease of the area. The partition of the digital image in space domain is done on the basic of self-similarity i.e., the similarity among the intensity level of the pixels. The range blocks are the ultimate aim and these are reached through the domain blocks. For the simplest case and with a view to avail mathematical ease, the domain blocks are gradually divided by two but in steps. In the subsequent stage the range blocks are made to have very small size. In one present study there range block size viz. 4x4, 8x8 and 16x16 and the range block dimensions are the ultimate parameters which determines the attribute of the compressed image. It has been found out that when range block dimension is made higher, the entropy of the images decreases up to a certain limit (where range block is 8x8), beyond which it increases again which implies that lower compressing capability. The variation of entropy with the range block size attains an optimized value beyond which the scaling of compression becomes lower that is the bit/pixel become lower. The optimize condition provides a balance between the self-similarity of the pixel number and the pixel depth.

On the other hand peak signal noise ratio; decreases with the increase of range block size. These indicate that the resultant images by fractal compression are more prone to be affected by noise when the range blocks attain higher dimension. Obviously, it reflects the undesired situation. The same type of graphics has been observed for Lena and Baboon images.

Furthermore the recent study aims at to provide better compression ratio by using YUV colour format. Here from the inherent property of the YUV format, pixel depth becomes less than 24 which holds good for most common RGB colour format. Besides, as the chrominance components that is U and V stand for the colour difference and the difference is made with respect to the luminance part the ratio between U and V

component can be adjusted so that it can lead to better compression of digital images using fractal coding.

Using the peak signal to noise ratio (PNSR) the coding performance can be defined as

$$PNSR = \frac{(255)^2}{NMSE}$$

The experimental result shows that good quality images are obtained at about 1bit/pixel in Fig. 5. The experimental results are summarized in Table I and these are shown in Figs. 5 (a)-(d) and Figs. 6 (a)-(d). Here it is consider the size of 4x4 images for obtaining good quality of the reconstructed images. From the experimental result we have learned that if we increased the size of range blocks from the size 4x4 to 16x16, the compression ratio increases rapidly without disturbing the images quality and the respective graph shown in Figs. 7 (a)-(d).

TABLE I
 EXPERIMENTAL RESULT

Test images	Range block size		
	4x4	8x8	16x16
Baboon Entropy (bits/pixel)	3.0301	1.0198	0.2199
PNSR (dB)	27.78	24.07	22.58
Lena Entropy (bits/pixel)	2.6207	1.009	0.2029
PNSR (dB)	36.09	32.52	28.63



Fig. 5 (a) The original color (RGB) image of Baboon



Fig. 5 (b) The reconstructed fractal image using 4x4 range block size (PNSR= 27.78dB and bpp= 3.0301)



Fig. 5 (c) The 8x8 reconstructed fractal image of 0198bpp and 24.07 dB. (The size of Baboon 512x512)



Fig. 5 (d) The 16x16 reconstructed fractal image of 0.2199 bpp, 22.58 dB



Fig. 6 (a) Original color Lena image (512x512 size)



Fig. 6 (b) The 4x4 reconstructed fractal image of 2.6207 bpp, 36.09 dB



Fig. 6 (c) The 8x8 reconstructed fractal image of 1.009 bpp, 32.52 dB



Fig. 6 (d) The 16x16 reconstructed fractal image of 0.2029 bpp, 28.63 dB

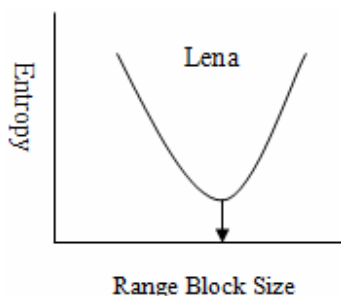


Fig. 7 (a) The increasing of compression ratio of Lena image

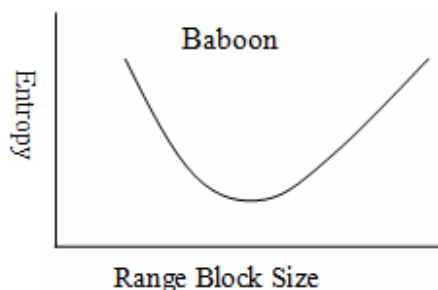


Fig. 7 (b) The increasing of compression ratio of Baboon image

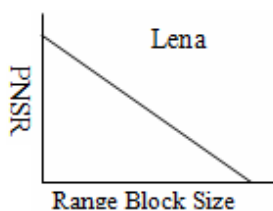


Fig. 7 (c) The increasing of compression ratio of Lena image

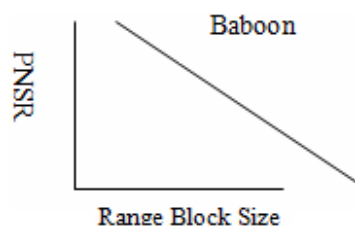


Fig. 7 (d) The increasing of compression ratio of Baboon image

V. CONCLUSIONS

The present study has been carried out to get greater compression ratio using fractal coding on colour digital images in YUV format the division of the image plan by domain blocks followed by range blocks are made by a factor of two. But the affine mapping and self-similarity are always maintained in fractal compression one and above the entropy (in bit/pixel) has been found to be lower than unity in the present study and this reflects the efficacy of fractal coding. With the help of this type of compression the memory space occupied with in the memory of the computer would become much less compared to any other compression method. These would also help in reducing either the transmission time when the channel bandwidth remains the same as, by keeping the transmission time constant, lower bit rate channel can be used to transmit image signal mainly for television signal.

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