A New Approach in Fractal Image Compression with Genetic Algorithm

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Abstract: Reducing the storage cost of images in memory plays the pivotal role in the process of data transferring. Fractal image compression that uses the characteristics of existing self similarity within images for coding is a suitable method in coding an image. Although suitable mathematical construction and too much compression for coding are of its advantages, the main problem of this method is its time consuming and complexity. In this paper, it is attempt to introduce a solution for improving the subject matter i.e. preparing an image with less detail than the original one. Then the act of searching and coding is done on these images which considerably saves the time. However, to avoid the loss of quality it is necessary to increase the precision for searching the most similarities. To come to this purpose the genetic algorithm is used for coding the images. The outcome shows that by considerable reduction of necessary space for image storage as well as coding rate, the quality of image is not lessened.

Key words: Image Compression, Fractal, Genetic Algorithm

1 Introduction

Since human being can process 8 million bits at a time, for developing an image with high quality a great amount of pixels are used. For suitable storing of images as well as transferring the quality ones, grate amount of pixel is used. There are varieties of methods for compressing an image. One of the common ways is deleting signal's high frequencies and storing the low ones, which is used in JPEG, MPEG, H.261, and H.263 algorithms.

Although natural images are complex, they have similar areas. So, for developing it one may consider the characteristics of one area among the similar ones. And by using the geometric fractal, which is a new concept i.e. describing natural images, one may get any of these areas from a primary block and repetitive transformations. So an image can be considered as a series of convergent transformations and instead of image of related codes these transformations can be stored; later they can be used for image retrieval as well. [1, 6]

Different methods are introduced for fractal coding of images [1, 2, 3, 4]. In this paper we used from Barnsley method [1].

2 Fractal Compressions of Images

The basis of fractal geometric is grounded on the assumption that natural images are self similar and are formed from a systematic repetition of a primary block. For example if a process is in the form of Fig. 1 in which an image is bisect at first, and three copies are produced at the outlet, then Fig. 2 is developed as the outcome of this system with finite repeat transformations. This process that is known as a copy machine is the basis of fractal phenomena. [1, 5]

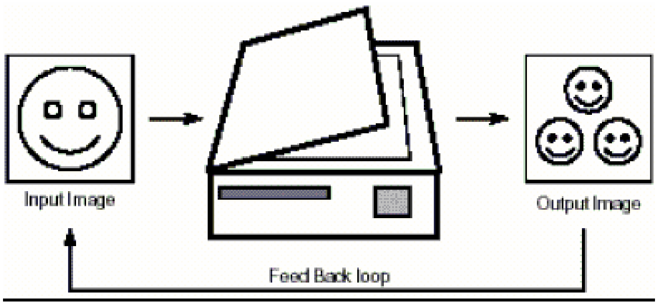


Figure 1 – Copy Machine

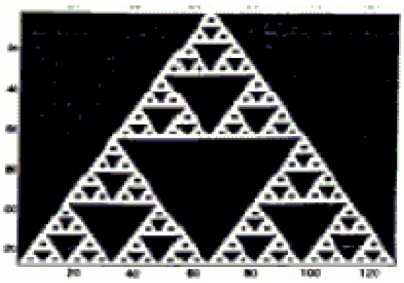


Figure 2 – Fractal Image

If we consider the operation of copy machine with the following equation,

$$w_i \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} a_i & b_i \\ c_i & d_i \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} e_i \\ f_i \end{bmatrix} \qquad (1)$$

An image can be considered as a set of transformation that can be transferred in the variety of forms such as resizing, expansion, changing the angel … on the primary images, and get the final ones. In other words coding an image with a set of transformation is similar to copy machine and called fractal phenomena. Therefore, instead of storing an image, the necessary transformations can be stored for developing it. For example instead of storing an image that needs at least 65536 bits for storing, it is sufficient to store the numbers related to four transformations which is needed for developing that image i.e. 4 × 4 × 32 = 768 bits are needed for storing it. Of course a natural image can not be produced just by one permanent point and a set of transformation, but in the form of mixing different parts each of which has fractal characteristics, and by predetermined transformations for every area and applying it to that area, the original image is produced.

3 Encoding Image

The act of coding an image is in the way that at first the original one (Range Image) is divided into a set of block with identical size (Range Block). An image with less detail (we determined it by taking the down sampling and applying low pass filter on the original image) is also divided into blocks with identical size (Domain Block). For each block it is necessary to choose a suitable block among the range blocks and transforming in the way that by applying on the range block, the produced image is to be closed to the related Domain block. For convergent transformation it is necessary that each of transformation (w_1) is to be mapping spastically that is

$$\forall p_1, p_2 \quad d_{12}(w(p_1), w(p_2)) < s * d_{12}(p_1.p_2), \quad s < 1 \qquad (2)$$

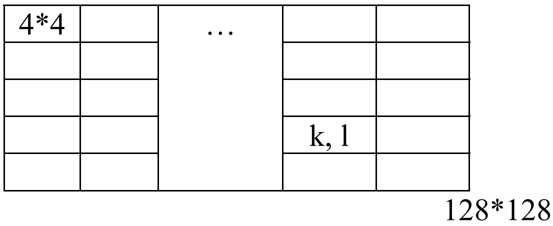
Here d_{12} metric shows the distance between two points (Norm 2) by considering the transformation spastically and applying it repetitively on image range, the result will be convergent to the original image (Board), because the aforementioned metric space is a complete one.

The process of coding is to be described by giving an example. Suppose we have 128 × 128 image as an original one that each of its pixel contains one of the 256 gray. We reduce it by taking the down sampling and applying low pass filter to develop a 64 × 64 image (image range), Then both of them are divided into 4 × 4 pixel blocks (see figure 3).

4*4			
.			
.			i, j

64*64

Domain image ($i, j \in [1,16]$)



Range image ($k,l \in [1,32]$)

Figure 3: Partition of Range and Domain

j, i block of Domain and l, k block of Range Image are considered $D_{i,j}$ and $R_{k,l}$ correspondently. Now, the necessary linear transformation for each block is defined as follow:

$$\Gamma(D_{i,j}) = \alpha D_{i,j} + t_0 \quad (3)$$
$$\alpha = [0,1], \alpha \in R$$
$$t_0 = [0,255], t_0 \in Z$$

The aim is to get the optimum linear transformation from block domain ($D_{i,j}$) to block range ($R_{k,l}$), in the way that block domain is an excellent estimate of blocks range. For this means it is necessary to determine α and t_0 parameters for every one of blocks range in a way that the objective function (4) becomes minimum.

$$\min \sum_{m,n} (R_{k,l} - \Gamma(D_{i,j})) \quad (4)$$
$$d_{12}(\Gamma(D_{i,j}), R_{k,l}) = \sum_{m,n} (R_{k,l} - \Gamma(D_{i,j}))^2 \quad (5)$$
$$i, j = 1:16$$
$$k, l = 1:32$$

In determining α, and t_0 parameters based on equation (5), the error of Euclidean norm is considered. Then by determining α and t_0 parameters related to each block of original image, they are to be stored in a file. Thus instead of storing original image it is sufficient to store the image range and obtained parameters. The process of retrieving the original image is to apply the stored transformations upon image range (Ω_{init}) till original image is developed.

$$\Omega_1 = \Psi(\Omega_{init}) \quad (6)$$
$$\Omega_2 = \Psi(\Omega_1)$$
$$\ldots$$
$$\Omega_n = \Psi(\Omega_{n-1})$$
$$\Psi = \Phi(\Omega)$$

Φ contains the set of transformations used in transferring blocks range into blocks board.

4 Genetic Algorithm

Genetic algorithm is considered as a strong method in optimizing parameters since the search is not begun from a point but a population, therefore; it has a better chance to get a global response in problem which have a number of optimum local responses. [1], because in considered problem the aim is to find the most similarities, applying this algorithm in getting the global response is discussed. For this purpose and for meeting the best estimate, the fitness function of each block board is considered in the form of equation 5. And then c and to parameters for each board block is acquired.

In this method, at first primary population (with among 20 to 100) is determined random. Here again its various conditions were studied. This algorithm contains three operator selection, crossover and mutation. Selective operator chooses members from the existing population to produce new population based on the fitness function of every member. Then with other two operators, i.e. crossover operator (with P_c probability) and mutation operator (with P_m probability) the creation of new generation is formed. The sequence of selection, crossover and mutation functions in the genetic population is done based on the algorithm of Fig. 4.

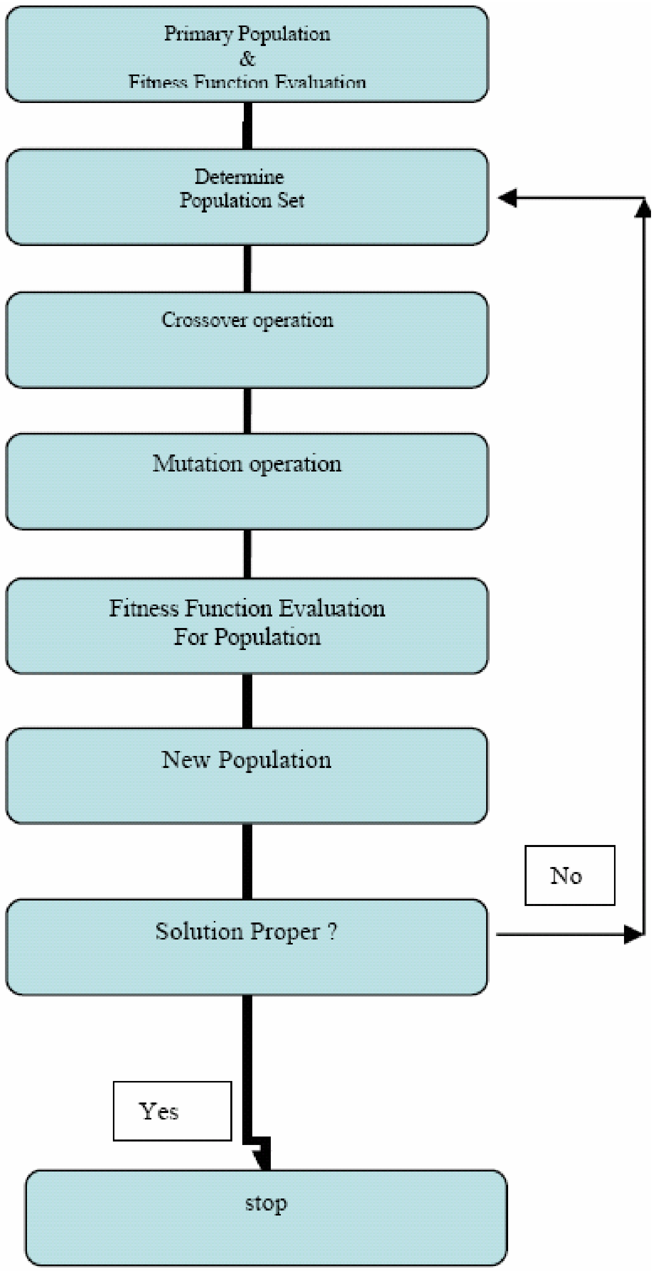


Figure 4 – Genetic Algorithm

5 Conclusions

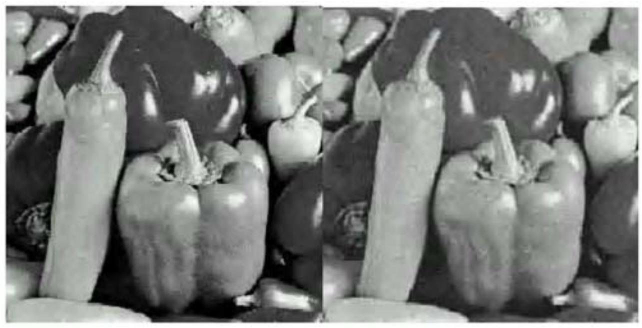
This method was studied in three conditions where comparative blocks are 2 * 2, 4 * 4 and 8 * 8. The results are shown in table 1. It was observed that increasing the dimensions of comparative blocks result the considerable reduction of coding time as well as high percentage of compression, but the quality of retrieval image is reduced. Based on this process the importance of image quality as well as coding rate and needed capacity for its storage can be determinant for block size. In employing this method it was noticed that increasing population, reducing Pm and increasing P causes the high quality of retrieval image and reduction of errors in the act of coding.

It is necessary to mention that this method cannot be used in On-Line process because of lengthening coding operation.

Block size	P_c	P_m	Compression percentage	Used memory
2 * 2	0.85	0.0015	0.20%	98304 Bit
4 * 4	0.85	0.0015	62.5%	49152 Bit
8 * 8	0.85	0.0015	71.875%	36864 Bit

Memory used for storing original image = 131077 bits

Table 1.The result of running algorithm



(a) (b)

Figure 5 – (a) main image (b) retrieval image

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