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Improved Fractal Based Image Compression for Grayscale Using Combined Shear and Skew Transformations

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ABSTRACT

Now a days, image compression techniques work with great efficiency to achieve higher compression. The fractal image compression is a lossy type of image compression technique. This technique provides very high compression ratios which are highly in demand in CCTV cameras and grayscale implementation. The image is broken into domain of the smaller range blocks and these range blocks are transformed according to specified criteria. The similar blocks located are then reunited to form the compressed image approximation. In the fractal approach, maximum redundant blocks are tried to be achieved which provides better compression ratios .In this paper, a combined shear and skew based transformation approach is implemented to attain better results.

KEYWORDS : Fractals, Image compression, Grayscale, Discreet Cosine Transform, affine transformations.

INTRODUCTION

Images files saved on computers are collections of bits (binary digit) representing pixels or points forming the picture elements [5]. Since the human eye can process large amounts of information, many pixels are required to store moderate quality images. These bits provide the 0 and 1 representation of the image. Mostly redundancies do not lead to high compression ratios [5]. The standard methods of image compression rely on eliminating high frequency components of the signal by storing only the low frequency components. The fractal image compression utilizes the affine transformations. These transformation preserves collinearity (i.e., all points lying on a line initially still lie on a line after transformation) and ratios of distances (e.g., the midpoint of a line segment remains the midpoint after transformation)[2]. In this sense, affine transformations depict special class of projective transformation that do not move anything from the affine space to the plane at infinity [2]. An affine transformation is also called an affinity. Geometric contraction, expansion, dilation, reflection, rotation, shear, similarity transformations, spiral similarities, and translation are all affine transformations.

Image data comprise of a significant portion of the multimedia data and they occupy the major portion of the communication bandwidth for multimedia communication. Therefore development of efficient techniques for image compression has become quite necessary. A common characteristic of most images is that the neighboring pixels are highly correlated and therefore contain highly redundant information. The basic objective of image compression is to find an image representation in which pixels are less correlated. The two fundamental principles used in image compression are redundancy and irrelevancy. Redundancy removes redundancy from the signal source and irrelevancy omits pixel values which are not noticeable by human eye [3].

2. LITERATURE SURVEY

A.Krishnamoorthy (2014). In traditional fractal image compression, the encoding procedure is time-consuming due to the full search mechanism. In order to speed up the encoder, we adopt particle swarm optimization method performed under classification and Dihedral transformation to further decrease the amount of MSE computations. The classifier partitions all of the blocks in domain pool and range pool into three classes according to the third level wavelet coefficients. Each range block searches the most similar block only from the blocks of the same class. Furthermore, according to the property of Dihedral transformation, only four transformations for each domain block are considered so as to reduce the encoding time. Experimental results show that, the encoding time of the proposed method is faster than that of the full search method. Experimental results show that the proposed method is about 181 times faster with only 1.56dB decay in image quality.

[2] A R NadiraBanu Kamal (2015). This research paper on iteration free fractal image compression for color images using the techniques Vector Quantization, Genetic Algorithm and Simulated Annealing is proposed, for lossy compression, to improve the decoded image quality , compression ratio and reduction in coding time. Fractal coding consists of the representation of image blocks through the contractive transformation coefficients, using the self-similarity concept present in the larger domain blocks. Fractal coding achieves high compression ratio but it consumes more time to compress and decompress an image. Different techniques are available to reduce the time consumption and improve the decoded image reliability. But most of them lead to a bad image quality, or a lower compression ratio. Usage of synthetic codebook for encoding using Fractal does not require iteration at decoding and the coding error is determined immediately at the encoder. The techniques Vector Quantization, Genetic Algorithm and Simulated Annealing are used to determine the best domain block that matches the range blocks. The proposed algorithm has the better performance in terms of image quality, bit rate and coding time for Color images. Only the encoding consumes more time but the decoding is very fast.

[3] Chandan Singh Rawat1 et. Al (2013). Digital images are often used in several domai8ns. Large amount of data is necessary to represent the digital images so the transmission and storage of such images are time-consuming and infeasible. Hence the information in the images is compressed by extracting only the visible elements. Normally the image compression technique can reduce the storage and transmission costs. During image compression, the size of a graphics file is reduced in bytes without disturbing the quality of the image beyond an acceptable level. Several methods such as Discrete Cosine Transform (DCT), DWT, etc. are used for compressing the images. But, these methods contain some blocking artifacts. In order to overcome this difficulty and to compress the image efficiently, a combination of DCT and fractal image compression techniques is proposed. DCT is employed to compress the color image while the fractal image compression is employed to evade the repetitive compressions of analogous blocks. Analogous blocks are found by using the Euclidean distance measure. Here, the given image is encoded by means of Huffman encoding technique. The implementation result shows the effectiveness of the proposed scheme in compressing the color image. Also, a comparative analysis is performed to prove that our system is competent to compress the images in terms of Peak Signal to Noise Ratio (PSNR), Structural Similarity Index (SSIM) and Universal Image Quality Index (UIQI) measurements.

[4] H. MiarNaimi, et. Al (2007). In this paper a new fractal image compression algorithm is proposed in which the time of encoding process is considerably reduced. The algorithm exploits a domain pool reduction approach, along with using innovative predefined values for contrast scaling factor, ***S***, instead of scanning the parameter space [0, 1]. Within this approach only domain blocks with entropies greater than a threshold are considered. As a novel point, it is assumed that in each step of the encoding process, the domain block with small enough distance shall be found only for the range blocks with low activity (equivalently low entropy). This novel point is used to find reasonable estimations of ***S,*** and use them in the encoding process as predefined values, mentioned above. The algorithm has been examined for some well-known images. This result shows that our proposed algorithm considerably reduces the encoding time producing images that are approximately the same in quality.

[5] Jianji Wang, et. Al (2013). Fractal image compression (FIC) is an image coding technology based on the local similarity of image structure. It is widely used in many fields such as image retrieval, image demising, image authentication, and encryption. FIC, however, suffers from the high computational complexity in encoding. Although many schemes are published to speed up encoding, they do not easily satisfy the encoding time or the reconstructed image quality requirements. In this paper, a new FIC scheme is proposed based on the fact that the affine similarity between two blocks in FIC is equivalent to the absolute value of Pearson's correlation coefficient (APCC) between them. First, all blocks in the range and domain pools are chosen and classified using an APCC-based block classification method to increase the matching probability. Second, by sorting the domain blocks with respect to APCCs between these domain blocks and a preset block in each class, the matching domain block for a range block can be searched in the selected domain set in which these APCCs are closer to APCC between the range block and the preset block. Experimental results show that the proposed scheme can significantly speed up the encoding process in FIC while preserving the reconstructed image quality well.

[6] **Jie He 1,et. Al(2014).** A super-sampling algorithm is presented to avoid the need for recoding when magnifying a reconstructed image after fractal image compression, thus making the fractal image compression method more practical. The sizes of and coordinates of range blocks and domain blocks in the decoder are adjusted according to the proportional relationship between the decoded initial image and the encoded image; then, the bilinear interpolation method is applied to complete the re-sampling process; and then, iterations are conducted. Thus, image magnification is directly completed in the decoding process. Image magnification with this algorithm does not lead to change in image texture or loss of image quality, and also image quality through super-sampling mainly depends on the size of sub-blocks during coding, according to experimental results. The method put forward in this paper can broaden the application scope of fractal image compression by effectively avoiding the excess time consumption resulting from re-decoding.

[7]K. Raja Kumari, et. Al (2014). Fast Fourier Transform and Discrete cosine transform (DCT) are widely used in many practical image/video compression systems because of their compression performance and computational efficiency. The proposed work in Fractal image compression using discrete wavelet transform is followed by Huffman Run length Encoding. The main idea of the proposed procedure for both Encoding process and image compression is performed. To compare the results, the mean square error, signal-to noise ratio and encoding time criteria and compression ratio (bit per pixel) were used. The simplicity to obtain compressed image and extracted contours with accepted level of the reconstruction is the main advantage of the discrete wavelength transform algorithms.

[8] M.Salarian, et. Al (2015). In this paper a new fractal image compression algorithm is proposed in which the time of encoding process is considerably reduced. The algorithm exploits a domain pool reduction approach, along with using innovative predefined values for contrast scaling factor, ***S***, instead of searching it across [0,1]. Only the domain blocks with entropy greater than a threshold are considered as domain pool. As a novel point, it is assumed that in each step of the encoding process, the domain block with small enough distance shall be found only for the range blocks with low activity (equivalently low entropy). This novel point is used to find reasonable estimations of ***S,*** and use them in the encoding process as predefined values, mentioned above, the remaining range blocks are split into four new smaller range blocks and the algorithm must be iterated for them, considered as the other step of encoding process. The algorithm has been examined for some of the well-known images and the results have been compared with the state-of-the-art algorithms. The experiments show that our proposed algorithm has considerably lower encoding time than the other where the encoded images are approximately the same in quality.

[9] Mehdi Salarian, et. Al (2008). Fractal image compression has some desirable properties like high quality at high compression ratio, fast decoding, and resolution independence. Therefore it can be used for many applications such as texture mapping and pattern recognition and image watermarking. But it suffers from long encoding time due to its need to find the best match between sub blocks. This time is related to the approach that is used. In this paper we present a fast encoding Algorithm based on no search method. Our goal is that more blocks are covered in initial step of quad tree algorithm. Experimental result has been compared with other new fast fractal coding methods, showing it is better in term of bit rate in same condition while the other parameters are fixed.

[10] Preeti Banerjee, et. Al (2014). Fractal image compression (FIC) is an image coding Technology based on the local similarity of image structure. It is broadly used in many fields such as image recovery, image denoising, image verification, and encryption. FIC, still, bear the high computational complexity in encoding. Although many schemes are available to speedup encoding, they do not easily satisfy the encoding time or the reconstructed image quality requirements. In this paper a new novel approach for efficient fuzzy logic based fractal image compression in DCT domain using quadtree algorithm is proposed. This paper deals with the fuzzy logic based method because, fuzzy logic is a strong tool to handle vagueness, and since images are vague in terms of pixel values fuzzy logic is most appropriate logic for its analysis. In the proposed technique one domain block is considered for each range block and searched only for matched contrast scaling. Hence the outcomes fractal code does not contain coordinates of the matched domain block. This leads the advantage that the Quadtree algorithm can be here applied and the size of range block can be reduce as small as 2x2 pixels. Hence the quality of decoded image can be improved while the compression ratio can be maintained. The advantage of using fuzzy based technique is that, Fuzzification of an image leads to the reduction in the contrast and brightness of input image to be compressed. The advantage of this reduction in contrast and brightness is that this reduction leads to increase the pixel redundancy and hence help to increase the compression ratio (CR) and peak signal to noise ratio (PSNR) during the image compression. The results obtained after implementation of the proposed fractal image compression technique shows that the encoding time required is very small as compare to conventional fractal image compression (CFIC) techniques. Moreover the PSNR and compression values obtained from proposed work are higher than CFIC.

[11] Priyadarshini K S, et. Al (2015).this paper presents a short survey on the parallel computing of JPEG and Fractal image compression algorithms. Image compression is a type of data compression. Data Compression generally involves encoding techniques that uses fewer bits than the original representation. Image compression uses various techniques that will remove the redundant and the irrelevant information from the image. Image compression can thus efficiently reduce the storage space required and also speed up the transmission. However, most of the image compression techniques have problems like computational complexity, load etc. Parallel computing can effectively improve the processing speed. JPEG and fractal image compressions are two of the efficient techniques available in image compression. With the availability of the high performance computing in the form of multicore processing systems and GPUs can greatly accelerate the processing of the JPEG image compression technique. Fractal image compression takes advantage of the natural affine redundancy present in the typical images to achieve a high compression ratio .To speed up the compression process the sequential fractal image compression algorithm needs to be converted into parallel fractal image compression algorithm, this translation exploits the inherently parallel nature.

[12] **Sachin Dhawan (2011).** Image compression is now essential for applications such as transmission and storage in data bases. In this paper we review and discuss about the image compression, need of compression, its principles, and classes of compression and various

algorithm of image compression. This paper attempts to give a recipe for selecting one of the popular image compression algorithms based on Wavelet, JPEG/DCT, VQ, and Fractal approaches. We review and discuss the advantages and disadvantages of these algorithms for compressing grayscale images, give an experimental comparison on 256×256 commonly used image of Lenna and one 400×400 fingerprint image.

[13] SUMATHI POOBAL, et. Al (2011). Compressing medical images becomes an important task as to reduce storage space and transmission time and use of bandwidth for voluminous medical images; to enable rapid browsing and retrieval of medical imagery from databases. The use of digital image data offers the additional advantage of a computer compatible format that can be stored and analyzed. In this paper Quad-Tree partitioning method of Fractal Image Compression (FIC), a lossy image compression method, which works on self-similarity is applied on different imaging modalities like x-ray, CT scan, angiogram, mammogram and ultrasound. The quality of the compressed images becomes an important factor along with considerable compression ratio determines effective image compression. This paper analyses the effect of various objective quality factors like Mean Square Error, Peak Signal–to–Noise-Ratio (PSNR), Average Difference, Maximum Difference, Normalized Correlation, Mean Absolute Error, Normalized absolute error, Structural Correlation/Content is studied for various imaging modalities. It is found that FIC works better on mammogram than other modalities, with highest compression ratio as 46.29 and PSNR as 32.50dB, indicating acceptable quality image as PSNR lies between 20dB – 40dB. It is also found that for mammogram other objective quality measures are also close to Optimum values.

[14] THAI NAM SON,et. Al (2015). Fractal Image Compression (FIC) method provides a color image compression solution with an extremely high compression ratio; however it requires relative large amount of operations to complete codification. It means that FIC's encoding time is so long. In this paper, we have developed an efficient FIC approach applied to color images, which utilizes a fractal coding on RGB to YUV color transformation, suitable sampling modes, and special methods to decrease encoding time. We also propose a parallel technique in order to speed up this phase, while still maintain the advantageous features of the approach. The experimental results performed by Fisher's method for color images with and without parallel processing support have verified the possibility to design a fast fractal coder for color images.

[15] Veenadevi.S.V, et. Al (2014). Fractal image compressions of Color Standard Lena and Satellite imageries have been carried out for the variable size range block method. The image is partitioned by considering maximum and minimum size of the range block and transforming the RGB color image into YUV form. Affine transformation and entropy coding are applied to achieve fractal compression. The Matlab simulation has been carried out for three different cases of variable range block sizes. The images reconstructed using iterative functions and inverse transforms. The results indicate that both color Lena and Satellite imageries with Rmax = 16 and Rmin = 8, shows higher Compression ratio (CR) and good Peak Signal to Noise Ratios (PSNR). For the color standard Lena image the achievable CR~13.9 and PSNR ~25.9 dB, for Satellite rural image of CR~ 16 and PSNR ~ 23 and satellite urban image CR~16.4 and PSNR~16.5. The results of the present analysis demonstrate that, for the fractal compression scheme with variable range method applied to both color and gray scale Lena and satellite imageries, show higher CR and PSNR values compared to fixed range block size of 4 and 4 iterations. The results are presented and discussed in the paper.

[16] Y. Chakrapaniand K. et. Al (2009). In this paper the technique of Genetic Algorithm (GA) is applied for Fractal Image Compression (FIC). With the help of this evolutionary algorithm effort is made to reduce the search complexity of matching between range block and domain block. One of the image compression techniques in the spatial domain is Fractal Image Compression but the main drawback of FIC is that it involves more computational time due to global search. In order to improve the computational time and also the acceptable quality of the decoded image, Genetic algorithm is proposed. Experimental results show that the Genetic Algorithm is a better method than the traditional exhaustive search method.

3. METHODOLOGY:

In fractal image compression, the image is divided into a number of domain blocks with arbitrary size ranging from 4x4 to 16x16, or more[1].

Figure Block Similarity[6]

Transformation W have a unique fixed position in the 3D space of all image. That is, on an image we apply W to it and we will converge to a fixed image [4]. Suppose we are given an image f that we wish to compress. This means we want to find a collection of transformations w1,w2, ...,wNand want f to be the fixed point of the map W[4]. In other words, we want to partition f into pieces to which we apply the transformations wi, and get back the original image f [4].

The following example suggests how the Fractal Encoding is done. Suppose that we are dealing with a 128 x 128 image in which each pixel can be one of 256 levels of gray. We called this picture Range Image [16]. We then reduce by averaging (down sampling and low pass-filtering) the original image to 64 x 64[10]. We called this new image Domain Image. We then partitioned both images into blocks 4 x 4 pixels.

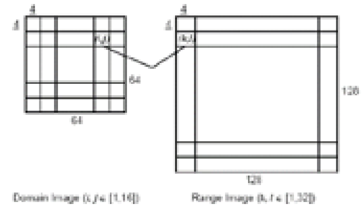

Figure Fractal Domain and Range Block [11]

$$(D_{i,j}) = \alpha D_{ij} + t_o \qquad (2)$$

where $\alpha = [0,1]$, $\alpha \in \Re$ and $t_o \in [-255, 255]$, $t_o \in Z$.

Now affine transformation of Domain Block is used to find the best approximation of a given Range Block using shear and skew transformations. Each Domain Block is transformed and then compared to each Range Block Rk,l. The exact transformation on each domain block, i.e. the determination of a and to is found minimizing

$$\min \sum_{m,n} (R_{k,l})_{m,n} - (\Gamma(D_{i,j}))_{m,n} \quad (3)$$

with respect to α and t_0

$$\alpha = \frac{N_s^2 \sum_{m,n} (D_{i,j})_{m,n} (R_{k,l})_{m,n} - (\sum_{m,n} (D_{i,j})_{m,n})(\sum_{m,n} (R_{k,l})_{m,n})}{N_s^2 \sum_{m,n} ((D_{i,j})_{m,n})^2 - (\sum_{m,n} (D_{i,j})_{m,n})^2} \quad (4)$$

$$t_0 = \frac{(\sum_{m,n} (D_{i,j})_{m,n})^2 - \sum_{m,n} (R_{k,l})_{m,n})^2}{N_s^2 \sum_{m,n} ((D_{i,j})_{m,n})^2 - (\sum_{m,n} (D_{i,j})_{m,n})^2} \quad (5)$$

wherem, n, Ns = 2 or 4 (size of blocks)

Each transformed domain block G (Di,j) is compared to each range block Rk,lin order to find the closest domain block to each range block[14]. This comparison is performed using the following distortion measure.

$$d_{l_2}(\Gamma(D_{i,j}), R_{k,l}) = \sum_{m,n} ((\Gamma(D_{i,j}) - (R_{k,l})_{m,n})^2 \quad (6)$$

Each distortion is stored and the minimum is chosen. The transformed domain block which is found to be the best approximation for the current range block is assigned to that range block, i.e. the coordinates of the domain block along with its a and to are saved into the file describing the transformation. This is what is called the Fractal Code Book [4].

$$\Gamma(D_{i,j})_{best} \Rightarrow R_{k,l} \quad (7)$$

The reconstruction process of the original image consists on the applications of the transformations describe in the fractal code book recursively to form compressed image Winit, until the encoded image is retrieved back. The transformation over the whole initial image can be described as follows:

$$\begin{aligned} \Omega 1 &= \eta(\Omega_{init}) \quad (8) \\ \Omega 2 &= \eta(\Omega 1) \\ \Omega 3 &= \eta(\Omega 2) \\ \ldots &= \ldots \\ \Omega n &= \eta(\Omega_{n-1}) \end{aligned}$$

It can be expressed as two distinct transformations:

$$\eta = \Gamma(\Omega)\Psi(\Omega) \quad (9)$$

4. DCT

A discrete cosine transform (DCT)[7] expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio and images (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations on, it turns out that cosine functions are much more efficient (as explained below, fewer are needed to approximate a typical signal, whereas for differential equations the cosines express a particular choice of boundary conditions.

In particular, a DCT is a Fourier-related transform [9] similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common [15].

The most common variant of discrete cosine transform is the type-II DCT [15], which is often called simply "the DCT"; its inverse, the type-III DCT, is correspondingly often called simply "the inverse DCT" or "the IDCT". Two related transforms are the discrete sine transform (DST), which is equivalent to a DFT of real and odd functions, and the modified discrete cosine transform (MDCT), which is based on a DCT of overlapping data.

DCT performs efficiently at medium bit rates [12]. Disadvantage with DCT is that only spatial correlation of the pixels inside the single 2-D block is considered and the correlation from the pixels of the neighbouring blocks is neglected. Blocks cannot be decorrelated at their boundaries using DCT. This is overcomed when using DCT in combination with fractal image compression as a result higher image compression is achieved for grayscale images at low quality [13].

5. ALGORITHM

The algorithm part describes the actual implementation strategy of the shear transformation. This algorithm works in the loop the first cycle implements the affine transformations and the second loop uses the combined shear ad skew approach. The steps of the algorithm can be explained as follows.

Step 1. Load the RGB or Gray scale image.
Step 2. Divide the image into row and column wise pixels representing pixel intensities using type 2 DCT.
Step 3. Create the range blocks and the domain blocks of the image.
Step 4. Low pass the redundant blocks according to the range blocks using skew and shear transformations.
Step 5. Again Low pass the redundant blocks according to the range blocks using rotation, scaling and relocation transformations.
Step 6. Reject the irrelevant blocks.
Step7. Create Collage B of the relevant blockapproximate to the original image.
Step 8. Reconstruct the image using iDCT.
Step 9. Calculate PSNR, MSE and CR.

6. RESULTS

6.1 Peak Signal to Noise Ratio (PSNR)

Generally, the image steganography system must embed the content of a hidden message in the image such that the visual quality of the image is not perceptibly changed. Thus to study the embedding perceptual effect, we have used the peak signal to noise ratio (PSNR) which is defined as [6, 12]:

$$\mathrm{PSNR} = 10\log_{10}\frac{(L-1)^2}{\mathrm{RMS}}$$

Where

$$\mathrm{RMS} = \frac{1}{m \cdot n}\sum_{i=1}^{m}\sum_{j=1}^{n}(x_{i,j} - x'_{i,j})^2$$

6.2 Mean Square Error (MSE)

In a sense, any measure of the center of a distribution should be associated with some measure of error. If we say that the number t is a good measure of center, then presumably we are saying that t represents the entire distribution better, in some way, than other numbers.

In this context, suppose that we measure the quality of t, as a measure of the center of the distribution, in terms of the mean square error

$$\mathrm{MSE}(t) = \frac{1}{n}\sum_{i=1}^{k} f_i (x_i - t)^2 = \sum_{i=1}^{k} p_i (x_i - t)^2$$

MSE (t) is a weighted average of the squares of the distances between t and the class marks with the relative frequencies as the weight factors. Thus, the best measure of the center, relative to this measure of error, is the value of t that minimizes MSE.

6.3 Compression ratio (CR)

Data compression ratio is defined as the ratio between the uncom-

$$\text{Compression Ratio} = \frac{\text{Uncompressed Size}}{\text{Compressed Size}}$$

$C_R$is compression ratio, defined as $C_R = n_1/nc$

Where n_1 is the number of information carrying units used in the uncompressed dataset and nc is the number of units in the compressed dataset. The same units should be used for n1 and nc; bits or bytes are typically used.

When nc<<n1, $C_R \rightarrow$ large value and $R_D \rightarrow 1$. Larger values of C indicate better compression.

TABLE – 1

Image	PSNR	MSE	Initial File Size (kb)	Final File Size (kb)	Compression
Pirate	26.2668	153.6031	257.05	33.84	7.596:1
Beach	27.6759	111.0431	23.81	8.91	2.6723:1
Jet plane	27.5193	115.1187	257.05	26.58	9.6708:1
House	35.4649	18.4781	257.05	18.74	13.7166:1
Lake	23.5752	285.4695	257.05	30.74	8.3621:1

7. CONCLUSION

The power of fractal encoding is shown by its ability to outperform using the DCT, which forms the basis of image compression. The shear and skew based fractal image compression is a new algorithm but is not without problems. Most critically, fast encoding is required for it to find wide use in multimedia applications. The results acquired show that the proposed approach utilizes inter-pixel redundancies to render excellent de-correlation for natural images. The higher amount of the relevant pixels is identified with the addition of the shear and skew transformations. These transformations allow to form lesser no. of the range blocks in the collage as a result the compression result is higher. Thus, all the uncorrelated transform coefficients can be encoded independently without compromising coding efficiency. Also, some of the high frequency content can be discarded without significant quality degradation. Fractal image compression provides faster compression in grey scale as compared to RGB due to single plane complexity as compared to the three plane complexity in the color image.

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