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Image Compression By Using Enhanced Fractal Methods

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Abstract

Fractal image compression give some advantage in compression ratio, resolution independence and fast decompression but it still suffer from encoding time, In this paper an enhanced to traditional algorithm based on using zero-mean method is applied, where a mean of range block is used instead of offset parameter which simplify and speeding up encoding time, also a domain pool is reduction by filtration a domain pool from those block with high entropy value. In addition to discard domain blocks which have some distance ratio from matching process ,An another speeding up technique where proposed in this paper based on suggest simple symmetry predictor to reduce isometric trails from 8 to 1 trail. In this project the RGB image is transformed to YIQ color space and then the I&Q band have been down sampled in order to get effective compression, after that the encoding algorithm is applied separately on each band.

1. Introduction

With the ever increasing demand for images, sound, video sequences, computer animations and volume visualization, data compression remains a critical issue regarding the cost of data storage and transmission times. While JPEG currently provides the industry standard for still image compression there is ongoing research in alternative methods. Fractal image compression is one of them [7].

In Fractal compression, the exhaustive search algorithm can obtain the optimal domain block to represent the range block by searching exhaustively all the blocks within the domain pool, but this process suffers from long encoding time and limits its practical applications. To solve this problem, extensive research on fast fractal image encoding algorithms has been came out. However, these techniques reduce the required computation at the expense of additional memory and degradation of the reconstructed image quality [3].

2. Fractal Compression

In the encoding phase of fractal image compression, the image of size N x N is first partitioned into nonoverlapping range blocks R_i , { R_1 , R_2 ,...R_p} of a predefined size BxB. Then, a search codebook (domain pool) is created from the image taking all the square blocks (domain blocks) *Dj* , { *D1* ,*D2* ,...*Dj* } of size 2Bx2B, with integer step L in horizontal or vertical directions. For a given range R*i* , the encoder must search the domain pool for best affine transformation w*i* , which minimizes the distance between the image R *i* and the image w*i* (D*i*). The distance is taken in the luminance dimension not the spatial dimensions. Such a distance can be defined in various ways, but to simplify the computations it is convenient to use the Root Mean Square (RMS) metric. For a range block with n pixels, each with intensity *ri* and a decimated domain block with n pixels, each with intensity *di* the objective is to minimize the quality

$$E(R_i, D_i) = \sum_{i=1}^{n} (sd_i + o - r_i)^2$$

(1)

Which occurs when the partial derivatives with respect to s and o are zero. Solving the resulting equations will give the best coefficients s and o [8].

$$s = \frac{n\sum_{i=1}^{n} d_i r_i - \sum_{i=1}^{n} d_i \sum_{i=1}^{n} r_i}{n\sum_{i=1}^{n} d_i^2 - (\sum_{i=1}^{n} d_i)^2}$$

(2)

$$o = \frac{1}{n}(\sum_{i=1}^{n} r_i - s\sum_{i=1}^{n} d_i)$$

(3)

With s and o given the square error is

$$E(R_i, D_i)^2 = \frac{1}{n}\left[\sum_{i=1}^{n} r_i^2 + s(s\sum_{i=1}^{n} d_i^2 - 2\sum_{i=1}^{n} d_i r_i + 2o\sum_{i=1}^{n} d_i) + o(on - 2\sum_{i=1}^{n} r_i)\right]$$

(4)

3. Zero-Mean Fractal Compression Method

In Zero-Mean method the offset parameters is replaced by the mean of rand block because of it has wide dynamic range (i.e., [-255,510]), this may cause large errors in some image regions especially those which belong to high contrast area and require an additional bit (i.e., sign-bit) [1].

The contractive affine transform in zero-mean become in the form:

$$r_i' = s(d_i - \bar{d}) + \bar{r}$$
(5)

Where

$$\bar{r} = \frac{1}{m}\sum_{i=0}^{m-1} r_i$$
(6)

$$\bar{d} = \frac{1}{m}\sum_{i=0}^{m-1} d_i$$
(7)

And the parameter S calculated by :

$$s = \begin{cases} \dfrac{\frac{1}{m}\sum_{i=0}^{m-1} d_i r_i - \bar{r}\bar{d}}{\sigma_d^2} & \text{if } \sigma_d^2 > 0 \\ 0 & \text{if } \sigma_d^2 = 0 \end{cases}$$
(8)

The approximated square of error calculated by :

$$\chi^2 = \sigma_r^2 + s\left[s\sigma_d^2 + 2\bar{d}\bar{r} - \frac{2}{m}\sum_{i=0}^{m-1} d_i r_i\right]$$
(9)

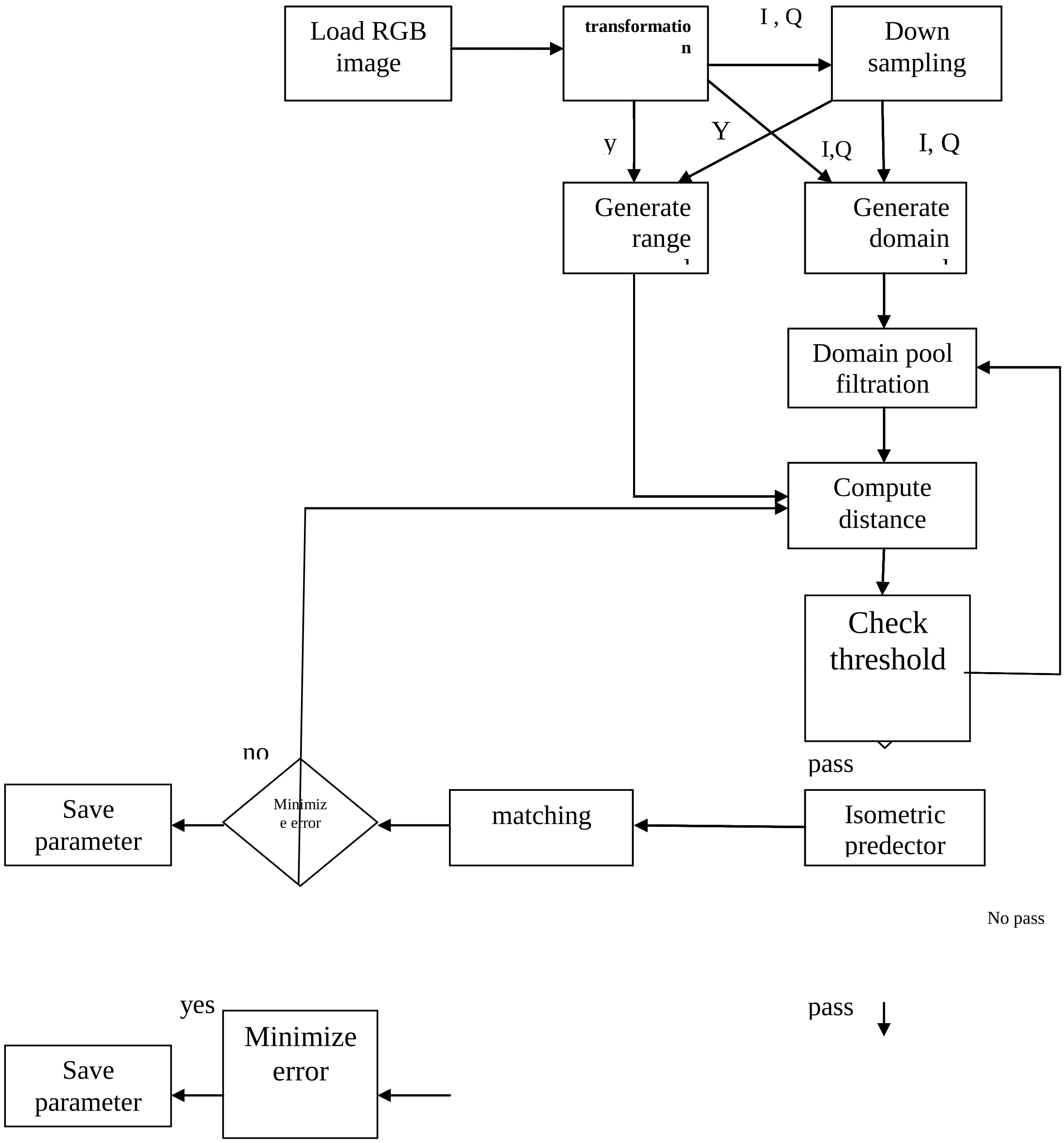
Where

$$\sigma_d{}^2 = \frac{1}{m}\sum_{i=0}^{m-1} d_i{}^2 - \bar{d}^2$$
(10)

$$\sigma_r^2 = \frac{1}{m}\sum_{i=0}^{m-1} r_i^2$$
(11)

4. Proposed System Model

In this paper the RGB image is transformed to YIQ color space and then the I&Q band have been down sampled in order to get effective compression because most of the data energy is concentrated in Y component, while the components I, Q convey little part of the image information energy, beside to that the Human Vision System (HVS) doesn't show high spatial discrimination for the chrominance components (I, Q), while it has high discrimination power against the contents of Y-component [6], after down sampling the encoding algorithm is applied separately on each band. Then YIQ reconstruct image transform to RGB image after up sampling I,Q reconstruct band .



Figure(1) block diagram of proposed system model

We can describe each step in the above figure as:

Filtration

The observation that many domains are never used in a typical fractal encoding, and only a fraction of this large domain pool is actually used in the fractal coding. The collection of used domains is localized in regions with high degree of structure. As expected the indicated domains are located mostly along edges and in the regions of high contrast of the image.

Analyzing the domain pool, there is a very large set of domain blocks in the pool with high entropy, which are not used in the fractal code. Thus, it is possible to reduce the search time by discarding a large fraction of high entropy blocks [4].

By calculate a histogram of each domain block we can calculate an entropy value associated with this block by [5]:

$$H(p_1, p_2, \ldots p_n) = H(s) = -\sum_{i=1}^{n} p_i \log p_i$$
(12)

Distance Calculation

A few numbers of features that characterize the domain and range images [8].Then the comparison of range blocks and domain blocks is based on these features rather than on individual pixels.

By using histogram for each domain and range block we can calculation some features such as standard deviation (v), Skewness(s) and Kurtosis (ku) [2,5] :

$$v = \sqrt{\sum_{k=1}^{K} (k-m)^2 p_k}$$
(14)

$$s = \frac{1}{v^3} \sum_{k=1}^{K} (k-m)^3 p_k$$
(13)

$$ku = \frac{1}{v^4} \sum_{k=1}^{K} (k-m)^4 p_k - 3$$
(16)

$$p_k = \frac{h_k}{\sum_{k=1}^{K} h_k}$$
(15)

Where K is the number of element in histogram vector.
m is the mean of block.

From these features find distance of each range/domain block and calculate the ratio

Ratio=$distance(domain\ block)/distance(range\ block)$ (17)

and discard those domain blocks with ratio great than some predefine threshold.

Isometric Predictor

To find a determinate in both X,Y direction of each block ,we multiply each pixel position by its weight and finally summating all result of such block

$$Dx = \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} W(i,j) * i \quad (18)$$

$$Dy = \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} w(i,j) * j$$

(19)

Where

$$W(i,j) = pixel(i,j) - mean(block)$$

(20)

m: width of block , n : height of block

The table below show the X,Y determinate of 3 random selected block and their 7-trail

Table (1) X,Y determinate of 3 random block

Block ID/transformation	Block -1-		Block -2-		Block -3-	
	Dx	Dy	Dx	Dy	Dx	Dy
0: Identity	89.5	6.5	130.5	112.5	28	3
1: Rotation 90	-6.5	89.5	-112.5	130.5	-3	28
2 : Rotation 180	-89.5	-6.5	-130.5	-112.5	-28	-3
3: Rotation 270	6.5	-89.5	112.5	-130.5	3	-28
4: Reflection case	-89.5	6.5	-130.5	112.5	-28	3
5: Reflection and Rotation 90	-6.5	-89.5	-112.5	-130.5	-3	-28
6: Reflection and Rotation 180	89.5	-6.5	130.5	-112.5	28	-3
7: Reflection and Rotation 270	6.5	89.5	112.5	130.5	3	28

It obvious that, the Id(Identifier) of block determine by values of Dx,Dy and their sign .

After apply these criteria on group of domain blocks and their 7-transformaion we get this table:

Table (2) Id of domain block and its 7-transformation

Id of original domain block	Id of transformed block							
	0	1	2	3	4	5	6	7
0	0	3	2	1	4	5	6	7
1	1	0	3	2	5	6	7	4
2	2	1	0	3	6	7	4	5
3	3	2	1	0	7	4	5	6
4	4	5	6	7	0	3	2	1
5	5	6	7	4	1	0	3	2
6	6	7	4	5	2	1	0	3
7	7	4	5	6	3	2	1	0

After we get this table we can now determine the id of range block and domain block (original domain block) we use its id to find the desired row and use id of range block to find desired column which represent the transformation must be applied on domain block.

5. Experimental Results

The proposed system was established using visual basic (ver.6) and test on laptop Intel® core Duo, centrino, 2 GHz processor, testing on image with size 256X256, 24 bit per pixel

Table (3) the results on 2 images

IMAGE	BLOCKSIZE	C.R.(Compression Ratio)	ET(second)	PSNR(dB)
LENA	4X4	9.721	8.35	30.149
LENA	8X8	40.421	5.07	23.307
LENA	16X16	161.684	0.701	21.199
BABOON	4X4	9.721	5.937	31.5
BABOON	8X8	40.421	1.543	22.14
BABOON	16X16	161.684	0.723	20.341

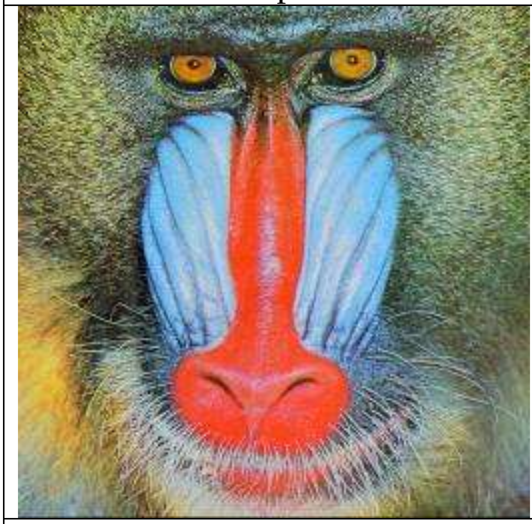
	
Lena Before compression	Lena After decompression
	
Baboon Before compression	Baboon After decompression

Figure (2) the images of testing system

6-Conclusion

By filtering a domain block using entropy and taking only those domain blocks which pass distance threshold, less no of domain block will enter matching process, so encoding time will decrease.

Also by using Isometric predictor the encoding time will decrease around (70%) and the PSNR will decrease around (2%).

When increasing the size of block, the encoding time and PSNR will be decrease and C.R. will be increase.

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ضغط الصور الملونه باستخدام طرق الضغط الكسوري المحسنه

الخلاصة

ضغط الصور الكسوري يعطي نتائج ايجابيه تتمثل بنسبة الضغط العالية وسهولة وسرعة اجراء عملية فك الضغط إلا إنها تعاني من بطيء عملية الضعط ، في هذا البحث تم اقتراح عدة طرق بهدف تسريع عملية الضط عن طريق اعتماد zero–mean والتي تمتاز بتبسيط و تسريع عملية الضغط عن طريق استبدال معامل ال offset بقيمة معدل البلوك بالاضافة الى عملية تقليل بلوكات المنطلق عن طريق استبعاد البلوكات ذات الطاقه العالية والبلوكات التي تملك نسبة بين المسافة الاقليدية لذلك البلوك الى المسافة الاقليدية لبلوك المدى تفوق عتبة معينة هذا بالاضافة الى بناء متنبئ للتحويل التناظري ليقلل من عدد عمليات التناظر الثمان لعملية تناظر واحدة.

لقد تم في هذا البحث تحويل الصوره من نظام RGB الى نظام YIQ ومن ثم تصغير كل من I و Q الى الربع من حجمه الاصلي ليتم تطبيق الخوارزمية على كل نطاق على حده.