The Compression of Fractal Color Image by YP_bP_r Color Space Using Zero-Mean Method

Eman A. Al-Hilo and Abbas F. Al-Rufaee

***Abstract*—This paper introduces an improvement on zero-mean fractal color image compression techniques, using the YP_bP_r color space. The twocolor images (Lena and Parrot) were used to test the best PSNR, CR, ET, by fractal image coding by Zero-Mean method. In Lena image the calculated results were found to be (PSNR=30.99), (CR=10.52), (ET=63.68), while in Parrot image is (PSNR=29.59), (CR=10.52), (ET=47.44).**

***Index Terms*—Component, YP_bP_r color space, TV color space, zero-mean method, image compression.**

I. Introduction

Modern society has become more and more dependent on image communication in various forms [1]. The study of image compression becomes more essential because image communication requires large memories for storage and bandwidth-consuming channels for transmission even for moderate resolution. In this research using the (YP_bP_r) TV color space, to measure efficiency transport of the image using Zero–Mean method, where we will examine the parameters (PSNR, CR, ET) by introduce different values of parameters (MinScale & MaxScale, Step Size, Block Size, Dom Size and permissible error value ($\mathcal{E}_O$)).

Different techniques have been introduced in fractal compression to overcome the large time consumed during the search process (i.e. matching between the domain-range pairs) or to obtain better quality and compression ratios [2], [3]. The researchers studied the fractal color image compression using different methods [4], [5]. In this study, an improvement has been done on zero-mean fractal color images compression techniques. Most image compression systems compress color images as several independently decomposed grayscale images. The most popular way to decompose a color image is to split this image into a primary luminance monochrome image and several secondary chrominance monochrome image. The equations 1,2 have been used to transform between YP_bP_r and RGB color space [6].

$$\begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix} = \begin{bmatrix} 0.213 & 0.715 & 0.072 \\ -0.115 & -0.385 & 0.500 \\ 0.500 & -0.454 & -0.046 \end{bmatrix} . \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.000 & 1.575 \\ 1.000 & -0.187 & -0.468 \\ 1.000 & 1.856 & 0.000 \end{bmatrix} . \begin{bmatrix} Y \\ Pb \\ Pr \end{bmatrix} \tag{2}$$

In 1997, Huawu Lin, studied several techniques introduced to improve the compression performance [7]. While Kasambe and Patel in 2007 studied the color image in color space RGB,YIQ and YUV [8]. In 2009 L. E. George studied moment feature and its effect on speeding Fractal image coding based on the Zero-Mean [9], [10]. In 2012 Kawther H. AL-Khafaji study the fractal compression by Traditional and Zero-Mean methods [11]. Al-Laythawe (2014) studied Gray Level of FIC using Zero-Mean Method [12]. Al-Hilo and R. Zehwar (2015) have studied the effect of YUV and YIQ color space on fractal color image compression [13], [14].

II. IFS Coding for Zero-Mean Blocks

The traditional affain mapping described by equation (3)

$$r_{i'} = sd_i + o \tag{3}$$

where,
$r_{i'}$: is the ith pixel value in the range block.
d_i : is the pixel value in the domain block.
s,o: represent the scaling and offset coefficients.
Taking the average of both sides in equation (3) gets [9]:

$$\bar{r} = s\bar{d} + o, \tag{4}$$

where,

$$\bar{r} = \frac{1}{m}\sum_{i=0}^{m-1} r_i, \tag{5}$$

$$\bar{d} = \frac{1}{m}\sum_{i=0}^{m-1} d_i \tag{6}$$

Subtract equation (4) from equation (3) get:

$$\acute{r}_i - \bar{r} = sd_i - s\bar{d}, \tag{7}$$

Equation (7) could be rewritten as

$$\acute{r}_i = s\left(d_i - \bar{d}\right) + \bar{r}, \tag{8}$$

The coefficients (o) in classical IFS mapping equation replaced by new parameters ($\bar{r}$)in equation (8). The scale (s) parameter could be determined by applying the least mean square difference (ϵ^2) between the approximated ($\acute{r}_i$) and actual (r_i)values [4]:

$$\epsilon^2 = \frac{1}{m}\sum_{i=0}^{m-1}(\acute{r}_i - r_i)^2, \tag{9}$$

$$\frac{\partial \epsilon^2}{\partial s} = 0, \tag{10}$$

Manuscript received November 11, 2020; revised February 23, 2021.
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DOI: 10.7763/IJCTE.2021.V13.1286

Combine equations (9) with (10) gets:

$$s = \begin{cases} \frac{\frac{1}{m}\sum_{i=0}^{m-1} d_i r_i - \bar{r}\bar{d}}{\sigma_d^2} & if\, \sigma_d^2 > 0 \\ 0 & if\, \sigma_d^2 = 0 \end{cases}, \quad (11)$$

$$\epsilon^2 = \sigma_r^2 + s\left[s\sigma_d^2 + 2\bar{d}\bar{r} - \frac{2}{m}\sum_{i=0}^{m-1} d_i r_i\right] \quad (12)$$

$$\sigma_d^2 = \frac{1}{m}\sum_{i=0}^{m-1} d_i^2 - \bar{d}^2, \quad (13)$$

$$\sigma_r^2 = \frac{1}{m}\sum_{i=0}^{m-1} r_i^2, \quad (14)$$

III. Zero-Mean Encoding Method

Theencodingprocess could be written as in Fig. 1 [15]:

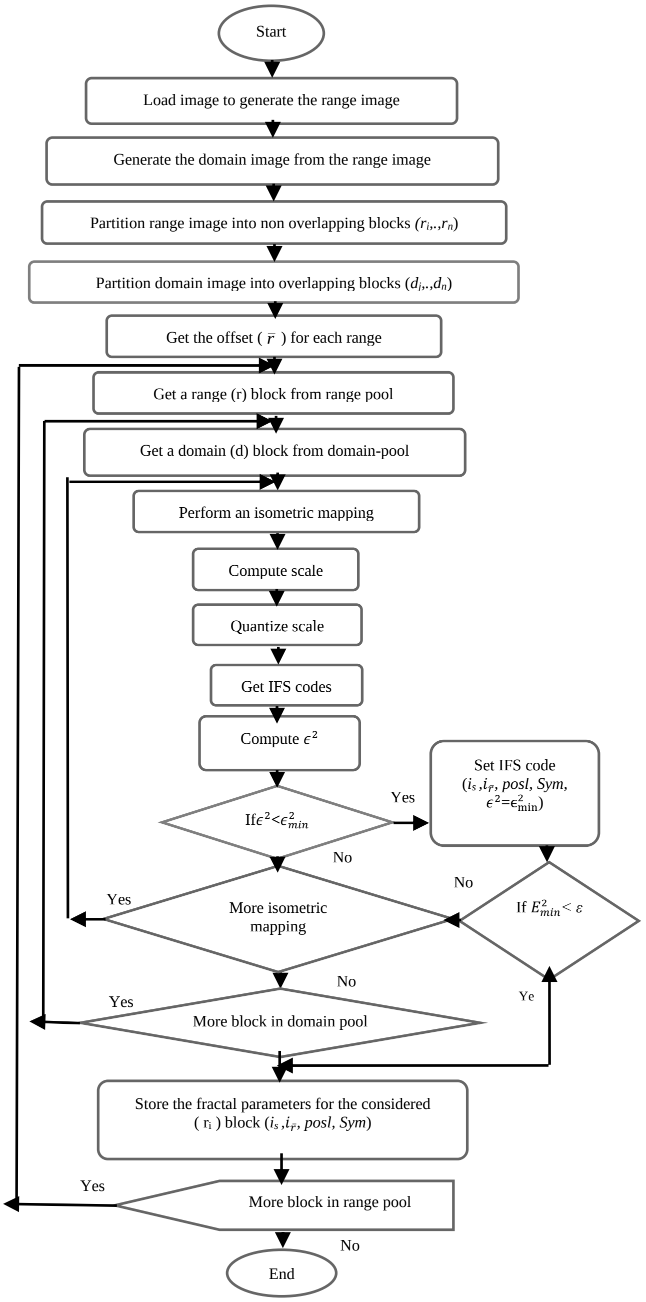


Fig. 1. Flowchart of the Zero-Mean encoding.

IV. Zero-Mean Decoding Process

The decoding process show in the Fig. 2 [15]:

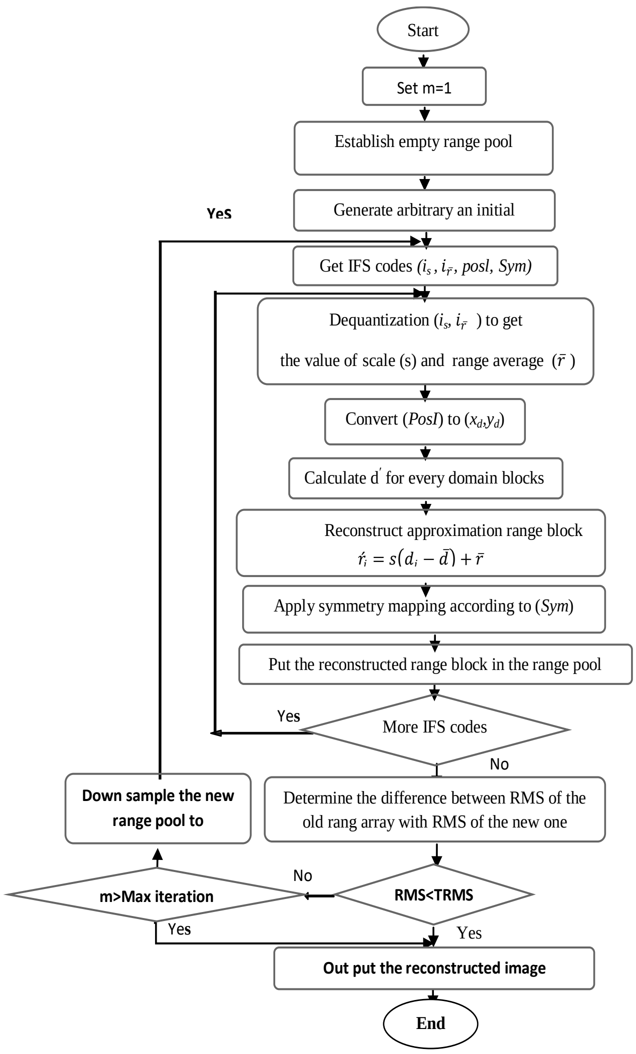


Fig. 2. Flowchart of the Zero-Mean decoding.

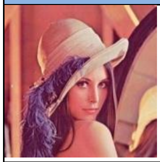
V. Tests Results

Many tests were perform to exam color (Fractal Image Compression) system by Zero-Mean technique. These tests used Lena and parrot image (256×256, 24 bit per pixel) as a testing object. The parameters Min Offset take value (0) and Max Offset take value (255) in all tests. Also, the values of other parameters were fixed when exam the effect of each parameter.

A. Max and Min Scale Tests

This set of tests was applied to study the effect of Min Scale and Max Scale parameters on the compression performance. The values of coding parameters were taken asScale Bits=2 and Offset Bits=8 Dom Size=(128×128), Block Size=(4×4), Step Size=2, $\mathcal{E}_0$=0.8, TMSE=6. Table I showthe reconstructed images for the best MaxScale and Min Scale values for Lena and Parrot images. Table II show the effect of Max Scale and Min Scale parameters on the compression performance parameters for Lena and Parrot images. Fig. 3, Fig. 4, Fig. 5 show the effects of Min Scale on PSNR, CR, and ET respectively.

TABLE I: THE RECONSTRUCTED IMAGES FOR THE BEST MAXIMUM AND MINIMUM SCALE TESTS

Original Image	MaxScale = 1 MinScale = -1	Original Image	MaxScale = 1 MinScale = -1
			
(24 bits/pixel)	PSNR=30.99 CR= 10.52 ET=63.68	(24 bits/pixel)	PSNR= 29.59 CR= 10.52 ET= 47.44

The results indicate that PSNR is inversely proportional to the values of both Min Scale and Max Scale and in the case of Min Scale (-1) and Max Scale (1) leads to high PSNR. Also, CR is not affected by the variation of Max Scale and Min Scale values and ET increase with the increases of Min Scale values.

TABLE II: MAXIMUM AND MINIMUM SCALE TESTS

Max	Min	Lena Image			Parrot Image		
		PSNR	CR	ET sec	PSNR	CR	ET sec
0.5	-0.5	29.69	10.52	61.02	27.96	10.52	46.33
	-1	30.92	10.52	61.79	29.33	10.52	46.33
	-1.5	30.87	10.52	62.45	29.57	10.52	47.47
	-2	30.79	10.52	62.18	29.52	10.52	47.11
1	-0.5	30.89	10.52	61.98	29.29	10.52	46.46
	-1	30.99	10.52	63.68	29.59	10.52	47.44
	-1.5	30.92	10.52	65.22	29.72	10.52	48.61
	-2	30.88	10.52	65.21	29.63	10.52	48.32
1.5	-0.5	30.89	10.52	62.68	29.41	10.52	47.63
	-1	30.98	10.52	65.37	29.56	10.52	48.70
	-1.5	30.76	10.52	67.33	29.60	10.52	50.89
	-2	30.68	10.52	67.48	29.62	10.52	51.09

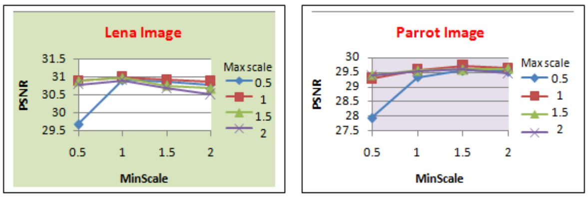


Fig. 3. The Min scale effect on PSNR of Lena and Parrot.

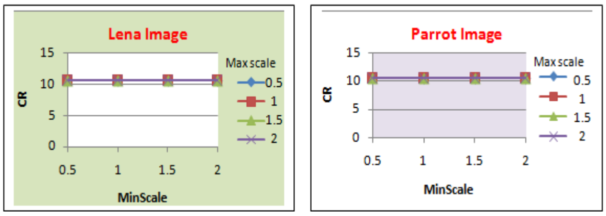


Fig. 4. The Min scale effect on CR of Lena and Parrot.

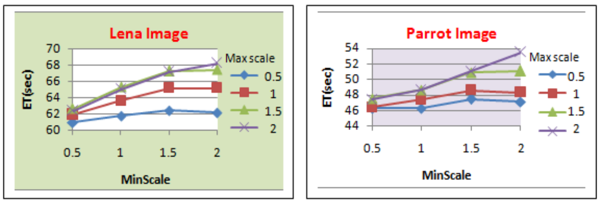


Fig. 5. The Min scale effect on ET of Lena and Parrot.

B. Domain Size Tests

The test of Domain Size parameter done to study their effects on the compression performance. The values of coding parameters were taken as Scale Bits=2 and Offset Bits=8, Block Size=(4×4), Step Size=2, $\mathcal{E}_0$=0.8, TMSE=6. Table III show the effect of Dom Size parameters on the PSNR, CR, ET. Fig. 6, Fig. 7, Fig. 8 show the effects of Dom Size on the compression performance parameters PSNR, CR, and ET respectively.

The results indicate that The Domain Size value (128×128) leads to best PSNR. Also, PSNR inversely proportional to the Dom Size value, CR is not affected by Domain Size variation, But ET decreases rapidly with the increase in Domain Size.

TABLE III: DOMAIN SIZE TESTS

Original image	Dom Size 128x128	Dom Size 64x64	Dom Size 32x32	Dom Size 16x16
				
PSNR	30.99	30.00	28.69	26.66
CR	10.52	10.52	10.52	10.52
ET	63.68	17.37	04.71	01.61
				
PSNR	29.59	29.03	28.34	26.56
CR	10.52	10.52	10.52	10.52
ET	46.93	14.65	04.49	01.55

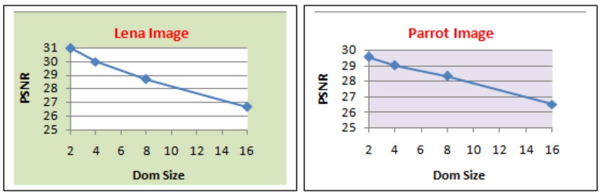


Fig. 6. The Dom Size effect on PSNR of Lena and Parrot.

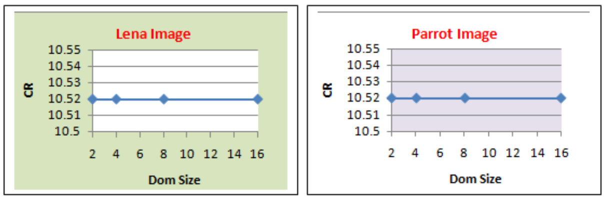


Fig. 7. The Dom Size effect on CR of Lena and Parrot.

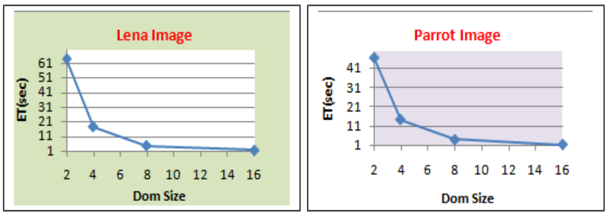


Fig. 8. The Dom Size effect on ET of Lena and Parrot.

C. Block Size Tests

This tests designed to investigate the effect of the Block Size parameter on the compression performance parameter. Table IV shows the effect of Block Size parameters on the compression performance on Lena and Parrot image. Fig. 9,

Fig. 10, Fig. 11 show theeffects of Block Size parameter on PSNR, CR, and ET respectively.

TABLE IV: BLOCK SIZE TESTS

Original image	BlockSize (2x2)	BlockSize (4x4)	BlockSize (8x8)	BlockSize (16x16)
				
PSNR	34.59	30.99	26.53	22.87
CR	02.43	10.52	45.85	201.4
ET	26.48	63.68	52.96	42.57
				
PSNR	33.23	29.59	26.29	23.04
CR	02.43	10.52	45.85	201.4
ET	17.76	46.93	51.70	42.46

The results indicate that Block Size value (2×2) shows highest value of PSNR with less CR than the case (4×4). But with value (4×4) leads to appropriate PSNR and CR than other sizes. Also, CR increases with the increase of Block Size.

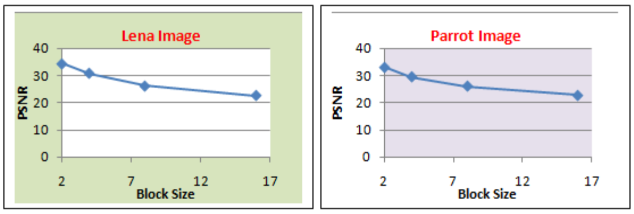


Fig. 9. The Block Size effect on PSNR of Lena and Parrot.

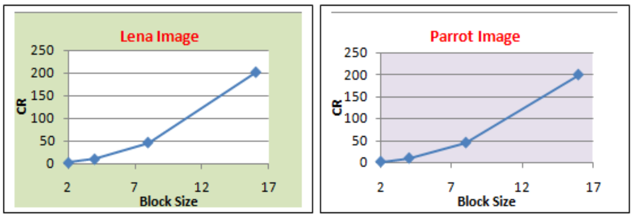


Fig. 10. The Block Size effect on CR of Lena and Parrot.

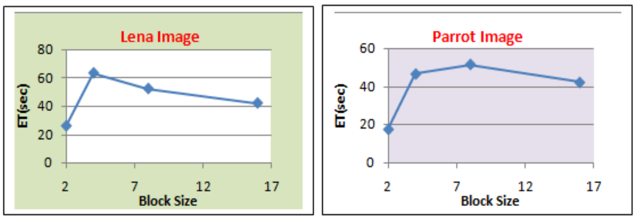


Fig. 11. The Block Size effect on ET of Lena and Parrot.

D. Step Size Tests

This test design to study the shift Step Size coefficient on the compression factor of reconstructed image. The Block Size was taken as (4×4); the values of other coefficients were taken similar to those mentioned in the previous test set. Table V presents the effects of Step Size on the compression performance parameters for both image for Lena and Parrot. Fig. 12, Fig. 13, Fig. 14 to show the the effects of Step Size on the compression performance parameters PSNR, CR, and ET respectively for both image for Lena and Parrot.

TABLE V: STEP SIZE TESTS

Original image	StepSize(1)	StepSize(2)	StepSize(3)	StepSize(4)
				
PSNR	31.41	30.99	30.50	30.33
CR	10.52	10.52	10.52	10.52
ET	240.8	63.68	29.64	17.21
				
PSNR	29.91	29.59	29.18	29.05
CR	10.52	10.52	10.52	10.52
ET	176.6	46.93	22.46	13.21

The results indicate that Step Size value 2 leads to appropriate CR and PSNR than other Step Size values. Also, The CR does not effected with Step Size variations but PSNR and ET decreases rapidly with the increase in Step Size.

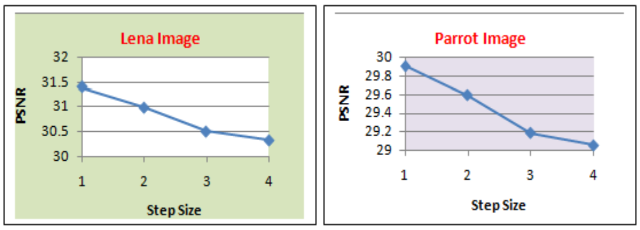


Fig. 12. The Step Size on PSNR of Lena and Parrot.

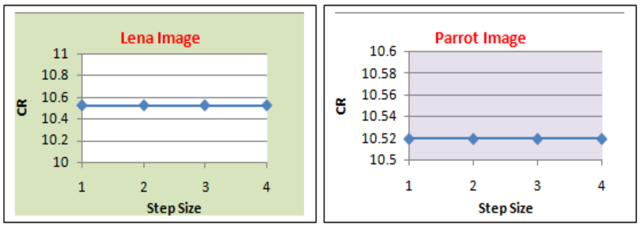


Fig. 13. The Step Size effect on CR of Lena and Parrot.

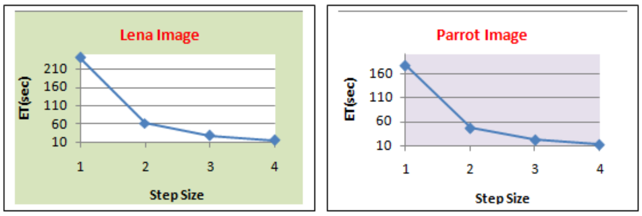


Fig. 14. The Step Size effect on ET of Lena and Parrot.

E. Permissible Error Levels ($\mathcal{E}o$) Tests

This factor ($\mathcal{E}_o$) was studied during this test to find their effect on the compression coefficient of reconstructed image. The purpose of using the conditional parameters is to reduce the computational load of the searching process within the domain pool, i.e. when the matching process reaches an error (χ^2_{min}) less than the value of ($\mathcal{E}_o$) then the searching process within domain pool is stopped. So, this conditional stopping helps in reducing the search mapping instance, and consequently decreases the computation cost of the search process. See Table VI and Fig. 15, Fig. 16, Fig. 17 to show the results. The results indicate that the permissible error value (0.8) leads to best PSNR with ET. PSNR is inversely affected by permissible error level, CR remain constant, But the encoding time decreases rapidly with the increase of permissible error value ($\mathcal{E}o$).

TABLE VI: PERMISSIBLE ERROR LEVELS ($\mathcal{E}O$) TESTS

$\mathcal{E}_o$	Lena Image			Parrot Image		
	PSNR	CR	ET (sec)	PSNR	CR	ET (sec)
0.1	30.99	10.52	74.01	29.61	10.52	72.62
0.2	30.99	10.52	74.05	29.61	10.52	72.59
0.3	30.99	10.52	73.77	29.61	10.52	71.91
0.4	30.99	10.52	74.64	29.61	10.52	69.58
0.5	31.00	10.52	72.25	29.60	10.52	64.94
0.6	30.99	10.52	70.29	29.60	10.52	57.61
0.7	31.00	10.52	67.41	29.60	10.52	51.89
0.8	30.99	10.52	63.68	29.59	10.52	47.44
0.9	30.98	10.52	60.90	29.59	10.52	46.27
1	30.96	10.52	57.85	29.58	10.52	41.76
2	30.64	10.52	36.21	29.35	10.52	25.91

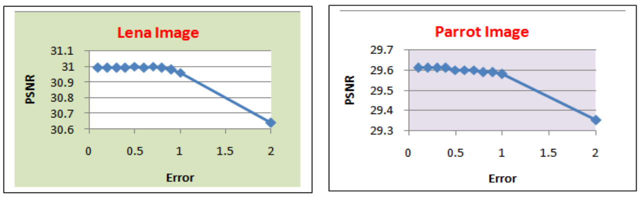


Fig. 15. The ($\mathcal{E}o$) effect on PSNR of Lena and Parrot.

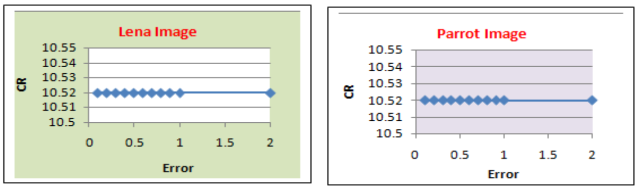


Fig. 16. The CR effect of Lena and Parrot.

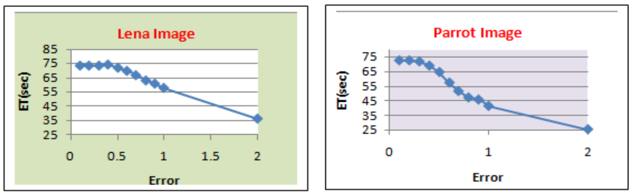


Fig. 17. The ET effect of Lena and Parrot.

VI. CONCLUSION

This search use the YP_bP_r color space which is important in Broadcast television systems for the transmission and reception of terrestrial television signals using an improvement zero-mean fractal color image compression techniques. The two color images (Lena and Parrot) were used to test the best PSNR, CR, ET by testing different compression parameter. It is found that when Min Scale value (-1), Max Scale value (1), Domain Size value (128×128), Step Size value (2), and Permissible Error Levels ($\mathcal{E}o$) value (0.8) leads to best PSNR, for two images. In Lena image the calculated results were found to be (PSNR=30.99), (CR=10.52), (ET=63.68). This indicate the encoding time very short in comparison with other methods that studied previously and this zero-mean techniques is a promise method in coding color image.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

This work is a part of M.Sc thesis titled (FRACTAL COLOR IMAGE COMPRESSION USING TV COLOR SPACE) for the researcher Abbas F. Al-Rufaee and supervisor Dr. Eman A. Al-Hilo. The idea of this project put by the supervisor. Both were contributed with program design and writing the paper. The researcher record all the results. Both the supervisor and researcher discussed the results and put the last conclusions. Also, all the figures and tables were done by researcher. The supervisor chose the journal to publish this paper but all the corrections of this paper that sent by the reviewers and editor were done by both supervisor and the researcher.

REFERENCES

[1] A. Jacquin, "Fractal image coding based on a theory of iterated contractive image transformations," *SPIE: Visual Communication and Image Processing*, vol. 1360, pp. 227-239, 1990.

[2] E. A. Al-Hilo, L. E. George, and Ali A. Al-Zuky, "Fractal color image compression," in *Proc. 4th International Information Technology and Multimedia*, Nov. 2008, pp. 637-642.

[3] C. S. Tong, "Fast fractal image encoding based on adaptive search," *IEEE Transaction on Image Processing*, vol. 10, no. 9, 2001.

[4] B. Urtgen, P. Mols, and S. Simon, "Fractal transforms coding of color images," *Visual Communications and Image Processing*, 1994.

[5] Z. Li, Z. Liang, and N. Y. Soma, "Fractal color image compression," in *Proc. 13th Brazilian Symposium on Computer Graphics and Image Processing*, 2000.

[6] M. Andreen, "Camera ISP applied on a programmable GPU," Theses, Lund University, 2008.

[7] H. Lin, "Fractal image compression using pyramids," PhD theses, Graduate Department of Electrical and Computer Engineering University of Toronto, 1997.

[8] P. Kasambe and M. Patel, "Modified fractal image compression using genetic algorithms," in *Proc. SPIT- IEEE Colloquium and International Conference*, 2007, p. 134.

[9] L. E. George and E. A. Al-Hilo, "Fractal color image compression by adaptive zero-mean method," in *Proc. International Conference on Computer Technology and Development (ICCTD)*, 2009.

[10] E. Al-Hilo and L. E. George, "Speeding-up fractal colored image compression using moments features," *Digital Image Computing: Techniques and Applications*, pp. 486-490, 2008.

[11] E. A. Al-Hilo and K. H. Al-Khafaji, "Study of symmetry process behavior in fractal gray image compression by traditional method," *Journal of Signal and Information Processing*, vol 4, pp. 176-181, 2013.

[12] E. A. Al-Hilo and H. H. Al-Laythawe, "Gray level of fic using zero-mean method," *International Journal of Electronics Communication and Computer Engineering*, vol. 5, issue 5, pp. 1064-1069, 2014.

[13] E. A. Al-Hilo and R. T. Zehwar, "Comparison fractal color image compression using YIQ and YUV color model," *International Journal of Advanced Computer Science and Applications*, vol. 6, issue 5, pp. 112-116, May 2015.

[14] E. A. Al-Hilo and R. T. Zehwar, "Fractal image compression by YIQ color space," in *Proc. the International Conference on Computational Science and Computational Intelligence*, March 10-13, 2014.

[15] E. A. Al-Hilo and L. E. George, "Study of fractal color image compression using YUV components," in *Proc. COMPSAC 36th Annual IEEE Computer Software and Applications Conference*, 2012, pp. 596-601.

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