RESEARCH ARTICLE OPEN ACCESS

Fractal Compression of Colored Satellite Stereo Images Based on HV Partitioning Method

Heba Hatem [1], Mariam Saii [2], Al Samoual Saleh [3]
PhD student [1], Assistant Professor [2], Professor [3]
Dept. of Mechanical and Electronic Engineering
Tishreen University
Syria

ABSTRACT

In this research, a stereo image compression method based on fractal encoding was proposed to overcome the problems related to other image compression methods. The reference image, which is the left one in our research and the disparity map, were compressed using fractal compression based on Horizontal and Vertical partitioning technique. We used semi global stereo matching algorithm to calculate the disparity map between left and right stereo image scenes. We compared our proposed method to the symmetric stereo image compression method. We used Peak Signal to Noise Ratio PSNR as a quality measure and Compression Ratio CR as an efficiency measure. The results of our proposed algorithm were compared to the results of the state of art compression algorithms, which are JPEG based on Discrete Cosine Transform DCT and JPEG2000 based on DWT Discrete Wavelet Transform.

Keywords:- Fractal compression, Stereo image, disparity map, HV partitioning , Semi Global method.

I. INTRODUCTION

3D imaging is a wide research area driven both by the entertainment industry and by scientific applications [1].A stereo pair consists of two images of the same scene recorded from two slightly different perspectives. The two images are distinguished as the Left and the Right image and from the data of this pair, the information in the depth-dimension of the shot scene can be calculated [2]. Representing a 3-D scene requires twice as much bandwidth as the corresponding 2-D scene, since a separate view is presented to each eye. This increase in data rate poses one of the most imposing challenges for stereoscopic media transmission and consumption, and thus compression of 3-D content has received a lot of research attention [2]. Figure(1) shows a stereo image pair. Stereo image compression methods can be classified in two categories which are symmetric and asymmetric methods[3]. Symmetric encoding of the image pair is when the left and right images are compressed by equal amounts resulting in equal degradation. Asymmetric encoding is when the compression and therefore degradation of the left and right images is unequal [3]. The basic strategy is to encode one of the image scenes as a reference image ,then estimate the disparity between blocks in the right and left images[4] .

In this paper , we used the last method to compress a set of satellite colored stereo images provided by website [5]. We applied fractal compression on both the left image scene and the disparity map. The disparity map where calculated using semi global stereo matching method. The reconstructed left image and the disparity map were used to reconstruct the right image.

II. RGB COLOR SPACE VS YCBCR COLOR SPACE

RGB color space consists of the three main colors: red, green, and blue. Combining the luma and chromatic components in this color space make it more sensitive to noise than other color spaces[6]. In YCbCR color space, the luminance channel (Y) is separated from the chromatic channels (Cb, Cr). The conversion of the RGB color model to YCbCr color model is achieved using the equations[6]

$$Y = 0.299R + 0.587G + 0.114B \quad (1)$$
$$Cb = (B - Y) * 0.564 + 128 \quad (2)$$
$$Cr = (R - Y) * 0.712 + 128 \quad (3)$$

Fig. 1 Teddy stereo image pair

III. STEREO CORRESPONDENCE AND THE DISPARITY MAP

The goal of the stereo correspondence problem is to find matching pixels in the left and right view images of a stereo image pair. The result from finding matching pixels is normally saved in a disparity map. The term disparity refers to the horizontal distance between two matching pixels and the disparity map defines a value of this horizontal pixel distance for each image pixel coordinate. Hence, it may be seen as a function of image pixel coordinates[7].There are different matching costs. In this paper we used Sum of Absolute Difference SAD , which is given in equation (4) considering that the scan line is in the u direction

$$C_{SAD}(x,y,d) = \sum_{(u,v)} |I_L(u,v) - I_R(u-d,v)| \quad (4)$$

Where I_L is the left image and I_R is the right image and d is the disparity

A. *Semi Global Matching Method*

This method relies on the minimization of an energy function. This energy function is usually defined as the combination of a data energy and a smoothness energy. The data energy is often based upon matching metrics like NCC, SSD, or SAD. In this paper we used SAD .The smoothness energy is there to penalize disparity solutions that are not smooth. The energy function adds smoothness terms to the cost function. The first term of the energy function is the pixel cost function. The second term adds a penalty P1 for all pixels q in the neighbourhood Np, for which the disparity changes a little bit (that is, for one 1 pixel). The third term adds a larger adaptive penalty P2, for all bigger disparity changes. Using a low penalty P1 for small changes permits an adaptation to slanted or curved surfaces. The penalty P2 for larger changes preserves discontinuities. The T stands for an indicator function, which is one when the condition is true, and zero if the condition is wrong[8].

$$E(d) = \sum_p (C(p,dp) + \sum_{q\in N_p} P1T[|dp-dq| = 1] + \sum_{q\in N_p} P2T[|dp-dq| > 1]) \quad (5)$$

IV. FRACTAL IMAGE COMPRESSION

Image compression is the process of reducing the amount of data required to represent given quantity of information in image to reduce storage requirement and transmission cost [9]. Fractal image compression is one of the lossy compression methods based on the concept of fractals. It exploits similarities in different parts of the image based on the theory of affine transformation and partitioned iterative function system (PIFS). The advantage offered by fractal image compression are high decoding speed, resolution independent and high bit rate. But due the computational cost and computational time in the coding phase, fractal coding is incompetent against other techniques[10].Baseline algorithm for partitioned Iterated function System based fractal encoding is [11]. **Step 1**. Read input image. **Step 2.**Partition image into non overlapping range blocks of size n*n. **Step 3.**Partition image into overlapping domain blocks of size 2n*2n.

Step 4. For every range block find domain block which minimizes equation (6)

$$E = min(\|r_i - (s_k d_k + o_k\|) \quad 1 \leq k \leq range\_size \quad (6)$$

Where s_k is the scaling parameter and o_k is the offset parameter which are given in the following equations

$$s_k = \frac{n\sum_{i=0}^{n} d_i r_i - \sum_{i=0}^{n} d_i \sum_{i=0}^{n} r_i}{n\sum_{i=0}^{n} d_i^2 - (\sum_{i=0}^{n} a_i)^2} \quad (7)$$

$$o_k = \frac{1}{n}[\sum_{i=0}^{n} r_i - s_k \sum_{i=0}^{n} d_i] \quad (8)$$

Before comparing, domain blocks are down sampled by taking average of four neighbouring pixels so as to make domain blocks equal to size of range blocks. After this each domain block is compared with range block by applying eight different affine transformations.

Step 5.Store transformation parameters to encode file.

A- Fractal Image Compression using HV portioning method

The Horizontal-Vertical (HV) partition like the quadtree, produces a tree-structured partition of the image. Instead of recursively splitting quadrants, each image block is split into two by a horizontal or vertical line. Splitting positions may be constructed so that boundaries tend to fall along prominent edges, or based on the accuracy of approximation by constant pixel values in each of the new blocks created by a particular split[12] .Figure(2) shows the HV partition of an image

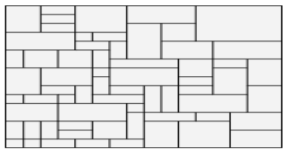

Fig. 2 HV partitioning method

V. RESULTS AND DISCUSSION

We applied fractal image compression based on HV partitioning on colored satellite stereo images using the method of compression the reference image and the disparity map . The block diagram of the proposed method is presented in figure(3) At first we calculated the disparity map between left and right views of each stereo image using semi global matching method. Figure (4) shows left and right image scenes and the calculated disparity map.

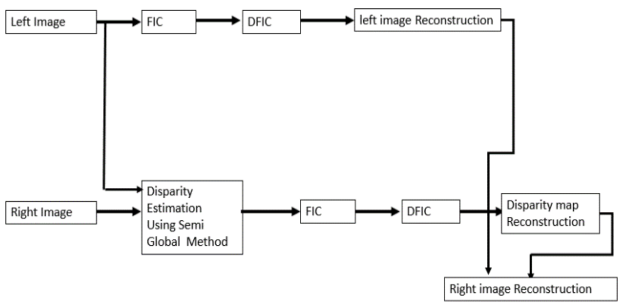

Fig. 3 The proposed method

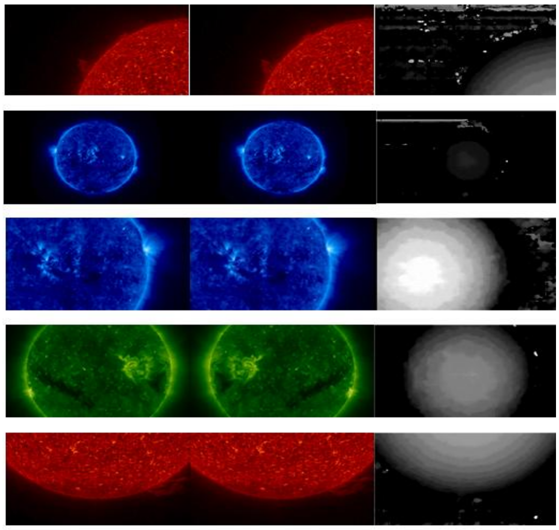

Fig. 4 satellite stereo image pairs used in the paper and the corresponding disparity maps

In this paper ,we considered that the left image scene is the reference image .We applied fractal image compression using HV partioining on the left image and the disparity map .We used two methods to deal with the colored left image .The first was to separte the color image in RGB color space into three separated channels red ,green and blue.And then compress each one of them as a gray image. The second method was to convert the image first into the ycbcr color space to exploit the frequency corelation in order to gain more compression .And then compress each one as a gray image. We used Peak Signal to Noise Ratio PSNR and Mean Square Error MSE as quality measures .And used Compression Ratio CR, compression precentage and Compression Time as efficiency measures.

$$MSE = \frac{1}{M.N}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[f(x,y) - f(x,y)']^2 \qquad (8)$$

Where $f(x,y)$ is the original image,$f(x,y)'$ is the decompressed image and M.N is the size of the image

$$PSNR = 10\log_{10}\frac{255^2}{MSE} \qquad (9)$$

$$CR = {B_{org}}/{B_{comp}} \qquad (10)$$

$$CP = \left(1 - \frac{1}{CR}\right).100\% \qquad (11)$$

Where B_{org} is the total number of bits in the original image and B_{comp} is the total number of bits in the compressed image. To calculate the objective measures for the color image we should calculate these measures for each channel and then calculate the average as follow

$$PSNR_R = 10\log_{10}\frac{255*255}{MSE_R} \qquad (12)$$

$$PSNR_G = 10\log_{10}\frac{255*255}{MSE_G} \qquad (13)$$

$$PSNR_B = 10\log_{10}\frac{255*255}{MSE_B} \qquad (14)$$

So the total PSNR for the color image is

$$PSNR_{rgb} = \frac{PSNR_R + PSNR_G + PSNR_B}{3} \qquad (15)$$

And in the same manner the CR for the color image became

$$CR_{rgb} = \frac{CR_R + CR_G + CR_B}{3} \qquad (16)$$

$$CP_{rgb} = \left(1 - \frac{1}{CR_{rgb}}\right).100\% \qquad (17)$$

So the objective meausre for the stereo image is

$$PSNR_{stereo} = \frac{PSNR_{rgb\_left} + PSNR_{disparity}}{2} \qquad (18)$$

$$CR_{stereo} = \frac{CR_{rgb\_left} + CR_{disparity}}{2} \qquad (19)$$

$$CP_{stereo} = \frac{CP_{rgb\_left} + CP_{disparity}}{2} \qquad (20)$$

The same equations are applicable on the YCbCr components. Table (1) contains the objective quality and efficiency measures for the fractal compression of left scenes of the stereo images in both RGB and YCbCr color space

TABLE(1)

OBJECTIVE QUALITY AND EFFICIENCY MEASURES FOR FRACTAL COMPRESSION OF COLORED LEFT SCENES

left		**CR**	**CP**	**MSE**	**PSNR**	**CT(hh: mm:ss)**
Image 1	RGB	6.97	85.65	6.65	40.65	00:20:29
	YCbCr	6.68	85.03	5.55	40.81	00:13:18
Image 2	RGB	7.54	86.73	16.87	38.92	00:14:11
	YCbCr	8.2	87.8	20.89	39.32	00:12:08
Image 3	RGB	6.34	84.22	2.73	43.93	00:09:05
	YCbCr	5.53	81.91	9.42	39.82	00:05:54
Image 4	RGB	5.98	83.27	12.29	39.51	00:06:29
	YCbCr	5.73	82.54	4.29	41.9	00:05:35
Image 5	RGB	4.38	77.16	3.52	43.26	00:08:23
	YCbCr	8.29	87.93	2.45	44.55	00:04:46

Table (2) contains the objective quality and efficiency measures for the fractal compression of the disparity maps for each of the previous stereo images

TABLE(2)

OBJECTIVE QUALITY AND EFFICIENCY MEASURES FOR FRACTAL COMPRESSION OF THE DISPARITY MAPS

	CR	CP	MSE	PSNR	CT(hh:mm:ss)
Disparity1	10.13	90.13	7.5	39.37	00:02:39
Disparity2	49.05	97.96	2.94	43.43	00:01:34
Disparity3	11.6	91.38	4.35	41.73	00:01:08
Disparity4	12.72	92.14	4.38	41.71	00:01:46
Disparity5	9.16	89.1	4.32	41.77	00:01:40

Table (3) contains the objective quality and efficiency measures for the stereo image as whole in RGB color space after applying equations(18) ,(19) and (20)

TABLE(3)
OBJECTIVE QUALITY AND EFFICIENCY MEASURES FOR FRACTAL COMPRESSION OF THE STEREO IMAGES IN RGB COLOR SPACE

	Cr	CP	MSE	PSNR	CT(hh:mm:ss)
Stereo1	8.4	88.3	7.07	40.01	00:22:40
Stereo 2	28.3	96.46	9.9	41.17	00:15:27
Stereo 3	8.97	11.14	3.54	42.83	00:10:07
Stereo 4	9.35	10.69	8.33	40.61	00:07:45
Stereo 5	6.77	85.223	3.92	42.52	00:09:37

Table (4) contains the objective quality and efficiency measures for the stereo image as whole in YCbCr space

TABLE(4)
OBJECTIVE QUALITY AND EFFICIENCY MEASURES FOR FRACTAL COMPRESSION OF THE STEREO IMAGES IN YCBCR COLOR SPACE

	CR	CP	MSE	PSNR	CT(hh:mm:ss)
Stereo1	8.4	88.09	6.525	40.09	00:15:57
Stereo2	28.63	96.5	11.91	41.37	00:13:42
Stereo3	8.57	88.33	6.88	40.7750	00:06:37
Stereo4	9.23	89.16	4.33	41.81	00:06:48
Stereo5	8.725	88.53	3.38	43.16	00:05:49

Figure(5) shows a comparison between compression ratio obtained in RGB and YCbCr color spaces

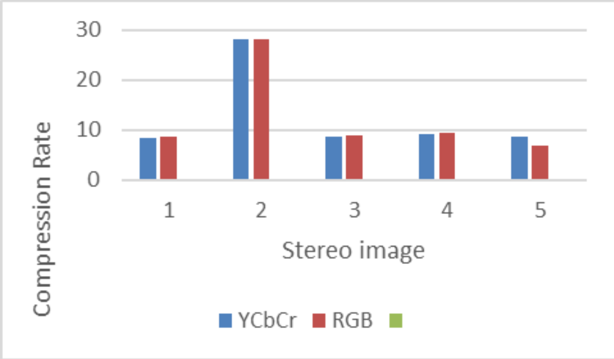

Fig. 5 Compression ratio of fractal stereo image compression

We notice that the fractal compression of the colored stereo images used in this paper was better when the image was converted first to YCbCr color space .We obtained an average value of compression ratio parameter of 12.711 in YCbCr color space and 12.388 in RGB color space
Figure(6) shows a comparison between PSNR obtained for RGB and YCbCr color spaces

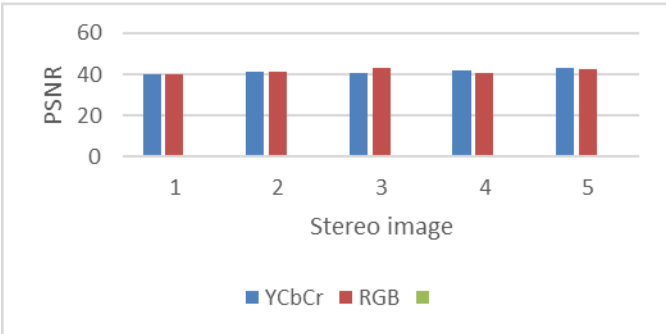

Fig.6 Peak Signal to Noise Ratio of fractal stereo image compression

The quality of the compression was also better in YCbCr color space .We received an average value of PSNR parameter of 41.441db in YCbCr and 41.428 db in RGB .
Figure(7) shows a comparison between encoding time for stereo images in RGB and YCbCr color spaces

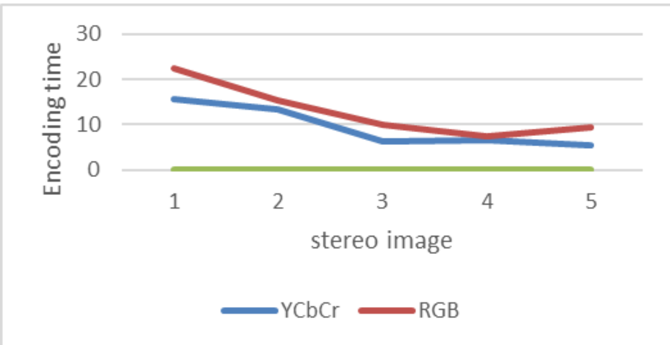

Fig.7 Encoding time for stereo images

The efficiency of the fractal compression was also better in YCbCr color space as we can see in figure(8) . The improvement of the time parameter is a very important factor in fractal image compression.

Fig(8-a) shows the left scene of stereo image1 after decompression when using RGB color space ,while fig(8-b) shows the error image between the original and the reconstructed left image

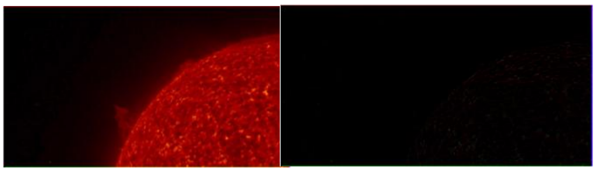

Fig. (8-a) Reconstructed left image scene ,(8-b) Error image

Now for the reconstruction of the right image scene we should use the disparity compensation using the following method :

If d(x,y) is the disparity map where x and y are the indices of the row and the column in the disparity map. And as the disparity map contains the horizontal spatial shifts between the corresponding pixels in the stereo image pair ,then the final reconstruction of the right image would be according to equation (21)

$$f_{RR}(x, y - d(x, y)) = f_L(x, y) \quad (21)$$

Where f_{RR} is the reconstructed right image and f_L is the left

left		CR	CP	MSE	PSNR	CT(hh: mm:ss)
Im1	**RGB**	6.97	85.7	6.65	40.65	00:40:58
	YCbCr	6.68	85	5.55	40.81	00:26:32
Im2	**RGB**	7.54	86.7	16.87	38.92	00:28:22
	YCbCr	8.2	87.8	20.89	39.32	00:24:16
Im3	**RGB**	6.34	84.2	2.73	43.93	00:18:10
	YCbCr	5.53	81.9	9.42	39.82	00:11:48
Im4	**RGB**	5.98	83.3	12.29	39.51	00:12:58
	YCbCr	5.73	82.5	4.29	41.9	00:11:10
Im5	**RGB**	4.38	77.2	3.52	43.26	00:16:46
	YCbCr	8.29	87.9	2.45	44.55	00:09:26

image and d(x,y) is the disparity map .

We compared the results of our proposed algorithm with symmetric compression of stereo images. Where we applied fractal image compression using HV partitioning method on both left and right image scenes with equal amount of compression. Thus the quality and efficiency objective measures for the stereo image compression will be calculated using the following equations

$$PSNR_{stereo} = \frac{PSNR_{rgb\_left} + PSNR_{right}}{2} \quad (22)$$

$$CR_{stereo} = \frac{CR_{rgb\_left} + CR_{right}}{2} \quad (23)$$

$$CP_{stereo} = \frac{CP_{rgb\_left} + CP_{right}}{2} \quad (24)$$

Table(5) shows PSNR obtained when applying symmetric compression of stereo images

TABLE(5)

PSNR OBTAINED BY SYMMETRIC COMPRESSION METHOD

Figure (9) shows a comparison between compression ratios obtained by our proposed algorithm and symmetric compression of stereo images, and we can notice the improvement we got using our proposed algorithm

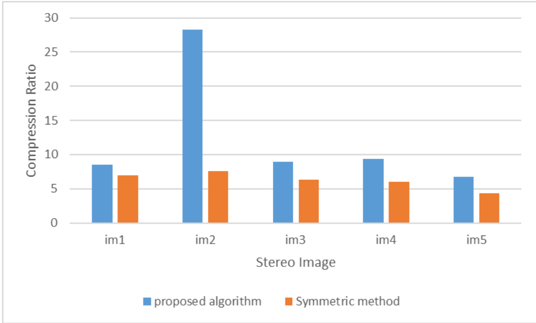

Fig. 9 Compression ratios obtained by our proposed algorithm and Symmetric algorithm

Figure(10) shows a comparison of encoding time obtained by our algorithm and symmetric algorithm

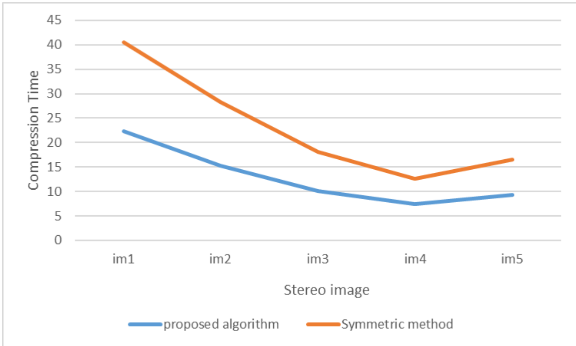

Fig.10 Encoding time of our proposed algorithm and symmetric algorithm

Table(6) shows PSNR obtained in when applying JPEG and JPEG2000 methods on the satellite stereo images

TABLE(6)

PEAK SIGNAL TO NOISE RATIO OBTAINED BY JPEG AND JPEG2000

	JPEG	JPEG2000
Stereo1	34.5	33.15
Stereo2	39	44.6
Stereo3	41.5	46.28
Stereo4	38.5	42
stereo5	38.43	41.48

Figure(11) shows the difference between PSNR obtained for the three method

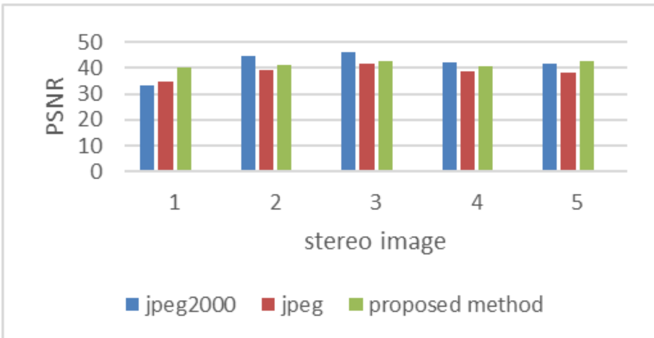

Fig.11 Comparison between Peak Signal to Noise Ratio obtained by JPEG ,JPEG2000 and fractal image compression

The average value of the PSNR was 41.428 for fractal image compression and 38.386 for jpeg method and 41.502 for jpeg2000 .

VI. CONCLUSION

In this paper, we applied fractal image compression using HV partitioning method on colored satellite stereo images. We used asymmetric stereo image compression method. We chose the left image to be the reference image and calculated the disparity map between the left and the right image using semi global stereo matching method. The right image was reconstructed using the reconstructed left image and the information of the disparity map. Fractal compression achieved very good compression rates and kept the PSNR in high levels.

REFERENCES

[1] A. Benoit,P.L. Callet ,P. Campisi , and R.Cousseau, Quality Assessment of Stereoscopic Images, EURASIP Journal on Image and Video Processing, Volume 2008, Article ID 659024, 13 pages

[2] J. N. Ellinas, M. S. Sangriotis, A novel stereo image coder based on quad-tree analysis and morphological representation of wavelet coefficients, Department of Informatics and Telecommunications, National and Kapodistrian, University of Athens, Panepistimiopolis, Ilissia, 157 84 Athens, Greece

[3] Paul W. Gorley, Nicolas S. Holliman, Investigating Symmetric and Asymmetric Stereoscopic Compression using the PSNR Image Quality Metric, ©2010 IEEE

[4] W.Woo and A.Ortega , Stereo image vompression with disparity compensation using the MRF Model , Signal and Image Processing Institute , Department of Electrical Engineering System , University of Southern California , Los Angeles

[5] https://www.nasa.gov/mission_pages/stereo/multimedia/LeftRightImages.html

[6] [6] Z. H. Al-Tairi, R.W.Rahmat, M. I. Saripan, and P.S. Sulaiman, Skin Segmentation Using YUV and RGB Color Spaces, J Inf Process Syst, Vol.10, No.2, pp.283~299, June 2014

[7] J.N. Ellinas, M.S. Sangriotis2, Stereo image compression using wavelet coefficients morphology, Image and Vision Computing, 2003 Elsevier B.V

[8] Heiko Hirschmu¨ller, Stereo Processing by Semi-Global Matching and Mutual Information, IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE,2007

[9] Er. Chetan , Er. Deepak Sharma, Fractal Image Compression Using Quad Tree Decomposition & DWT, International Journal of Scientific Engineering and Research (IJSER),2014

[10] 1Yashavanth E, 2Vijay Kumar L.J, 3K.V Suresh., HYBRID FRACTAL IMAGE COMPRESSION FOR SATELLITE IMAGES, INTERNATIONAL JOURNAL OF ADVANCES IN ELECTRICAL POWER SYSTEM AND INFORMATION TECHNOLOGY (IJAEPSIT) ISSN (ONLINE): 2395-6151, VOLUME-1, ISSUE-2, 2015

[11] Umesh B. Kodgule,B.A.Sonkamble , Discrete Wavelet Transform based Fractal Image Compression using Parallel Approach, International Journal of Computer Applications (0975 – 8887) Volume 122 – No.16, July 2015

[12] Brendt Wohlberg and Gerhard de Jager, A Review of the Fractal Image Coding Literature, IEEE Transactions on Image Processing, vol. 8, no. 12, pp. 1716-1729, December 1999.