RESEARCHERID
THOMSON REUTERS

[ICRTCET-2018]

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

FRACTAL VIDEO COMPRESSION WITH NCC BASED WALSH TRANSFORM

Maclena Gomes[*1] & Ravindra Chaudhari[2]
[*1&2]St. Francis Institute of Technology, Mumbai, INDIA

ABSTRACT

Fractal video compression has an advantage of resolution independency, fast decoding and higher compression ratio. Fractal video compression provides benefit of finding uniformity between consecutive frames and within frame. A frequency domain based fractal video compression is proposed to accomplish high processing speed and good visional aspect. The searching speed is increase by using normalized cross correlation based walsh transform of overlapped domain block either calculating single block and further time is reduced by getting geometric operation of specific block directly instead of find each opeartion separately. The advantage of using Walsh transform over FFT is only addition and subtraction is required instead of complex multipilcation which ultimately reduce complexity of encoding system. The experimental results shows that encoding time require forexperimental results shows that encoding time require for walsh based transform is much less than FFT based, with good PSNR and compression ratio as well as same quality of decoded video sequence.

Keywords: *Fractal video compression; Walsh Transform; Normalized Cross Correlation; Geometric Operations*.

I. INTRODUCTION

Nowadays with increase in technology, multimedia application such as transmission of video, images, video conference and wireless communication requires good quality with lower bit rate. Also all multimedia data requires large storage space, due to which compression is necessary. Compression is a process which remove redundancy from the data. In video coding redundancy is two types, temporal redundancy and spatial redundancy [22]. A good video coding can be defined by having high compression ratio, good decoded visual quality and encoding time required. Fractal based video compression [1] has advantage of high compression ratio with adequate visual condition of decode video than other compression techniques. But fractal coding is not accepted in day to day life due to computational involvement and time absorbing for finding self similarity correlation of domain blocks, to curb this problem a normalized cross correlation using walsh transform is tender to improve encoding speed with good performance in fractal video compression.

Mostly in fractal video compression two method are used which is cube based [5,6] and frame based [5,6,2]. In cube based series of image is split into frame and the into non ovelapping block cubes of domain and range blocks. It has high decompressed quality of image but computational complexity is more with increase in image frames. In frame based it finds self similarity between frames or within frames, so in this method domain block of previous frame is used to find self similarity of range block in current frame, it has intensifying compression ratio. As per Wang's proposal the fixed partition [8] and adaptive partition [5] considering benefit of both cube based and frame based techniques.

In CPM [9] proposed by wang where the range block is mapped to domain block in previous frame circularly. In this method domain block is consider similar as that of range block of disposal of temporal correlation between frames. But during decoding of frame the compuataional complexity increases and also temporal correlational between frames are not effectively explioted. A hybrid method [10] was proposed which is combination of CPM and NCIM. The difference between both is CPM is contractive and iterative during decrypting process whereas NCIM is non contractive and non iterative as decrypting depend on decrypted frame. Using hybrid method the temporal correlation between frame is highly exploited. In CPM/NCIM the both domain and range blocks are same size, individual range block is motion compensated by domain block of past frame.

This article presents NCC which is used in fractal video compression with fixed block partition in frequency domain using walsh transform. The computational complexity is reduced due walsh kernel coefficient has binary value +1 and -1. Also walsh transform of overlapped domain blocks are calculated using tree structure in single computation which further reduces the complexity. Self equivalence into range block and the pool overlapped domain blocks are computed using NCC. Simultaneously eight isometry geometric opertion for certain block is found out directly instead of individual operation. Using this concept the computational complexity is reduce with good quality of result. Within this paper, we aim to find effective performance by increasing speed of encoder, high compression ratio and good result quality.

The paper consists of various algorithms of fractal video compressions in section 2, section 3 describes basic fractal image coding. The section 4 present proposed work based on fractal video compression. The fact finding and relative study of initiated algorithm with existing algorithms
are defined in section 5. The interpretation is outline in section 6.

II. RELATED WORK

To reduce encoding time in fractal video compression many researcher has proposed various algorithms, Wang [8] in his fixed partition algorithm using hybrid methods which is cube based and frame based has observed that the compression is low using fixed partition. So in adaptive partition [5] he says that larger cubes can be used in the region where intensity of pixels changes slowly whereas tiny cubes are used where intensity changes quickly to improve the compression quality.

S. Zhu [18] introduce the compression algorithm with cross hexagonal search for fast block matching which has two methods cross based and hexagonal based. The encoding time require using this method is less with good compression ratio but again quality degrade with increase in searching point. So hybrid block matching motion estimation [6] is proposed with three steps search and cross hexagonal search method [18]. The main advantage is searching points decreases due to that computational complexity is reduced with good compression ratio.

In [4] fractal video compression is done on region based in which prior segmentation is done and then encoded independently of each other. Using this method, the performance parameters of the compression technique is improved. Further to improve quality with less encoding time with low bit rate the automatic region based algorithm

[5] was introduces by S. Zhu. In this region is divided into two parts which is foreground and background and then only foreground is transmitted to reduce bit rate. The disadvantage of region based approach is range blocks may hold pixels from an object or else from background or additional object which makes coding difficult. To overcome this problem K. Belloulata , introduced new algorithm with use of shape-adaptive DCT [7] in region based. The advantage of this method is it improves visual quality with less encoding time with good compression ratio.

III. BASIC FRACTAL IMAGE CODING

The partitioned iterated function system (PIFS) [1,14-17] is theory used in Fractal image compression, which has bunch of contractive conversion, to an arbitrary image if contractive conversion is applied iteratively to an image then it will be close to an basic image. The images are stored in form of conversion which will be result in image compression.
The size is the basic image should be split into non overlapping block which are said as range block

(of each size n ā ā g ā T . Also

overlapping block called domain blocks of original image, each block of size ' ' as a domain pool

with 'j' pixel shift in vertical and horizontal direction ā ā g ' . The contractive mapping is applied to the best match block between range and domain pool, from the mapping the minimum MSE into range and

ISSN 2348 – 8034
Impact Factor- 5.070

domain block is considered. Sequentially three operation are taken place into range and each domain block of size ' ' .1) Averaging neighboring four pixels which form a block size in spatial shrinkage. 2) 8 geometrical operation are performed which comprises 4 reflections and 4 rotations accompanied 90 degrees and on all blocks. 3) Contractive conversion is carrying out for each geometric operation to get minimum MSE. The Eq. (1) shows error within range and domain block and brightness factor 'o' and scaling factor's' of an affine transformation are given Eq. (2) and (3) commonly.

$$MSE = \frac{1}{n}\sum_{i=0}^{n}(s\,d_i + o - r_i)^2 \qquad (1)$$

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

$$o = \frac{1}{n}\left[\sum_{i=1}^{n} r_i - s\sum_{i=1}^{n} d_i\right] \qquad (3)$$

Where the pixels values of the range block is given by , are pixels values of the domain block and n is the number of pixels. For fractal image encoding the parameter of each range block need to be stored along with coordinates of domain block, s, o and the range of conversion index of s should be within -1 to 1 to ascertain that conversion is contractive.

IV. PROPOSED WORK

In proposed approach, Walsh transform of overlapping blocks are found using tree structure which reduce the computational complexity also self-similarity is found using NCC with mean subtraction and geometric operation of the blocks. The proposed approach is applied on sequence of video to reduce computational complexity and get better encoding result with less coding time. The details are explained as follows.

A Walsh Transform

The Walsh transform [25] is used because it has many functions; the kernel factor of the basis vector is orthogonal and contains only binary value + 1 and – 1. For given block *f (u, v)* of size N x N the Walsh transforms is given by

$$F(p,q) = \frac{1}{N}\sum_{u=0}^{N-1}\sum_{v=0}^{N-1} f(u,v)\prod_{i=0}^{n-1}(-1)^{b_i(u)\,b_{n-1-i}(p) + b_i(v)\,b_{n-1-i}(q)}$$

Where $b_i^{(u)}$ is the i^{th} bit of u in the binary form.

So while computation of transform only addition and subtraction is performed other than multiplication and division operation like other transforms. Due to this Walsh transform is used which reduce the computational time. In order to get the Walsh transform of overlapping block, the idea of tree structure [13] is used where only addition and subtraction is performed at a time to get Walsh transform of overlapping block. The example of 1-D is shown below in fig. 1 in which root node is considered to be original signal vector. The value of each node is calculated with reference to basic node. The symbol + and – represent each operation executed at each tree node. A symbol + and – on an end connecting nodes at level i and level i+1 which signify the computational done at signal level i, to whole entry of x of the signal.

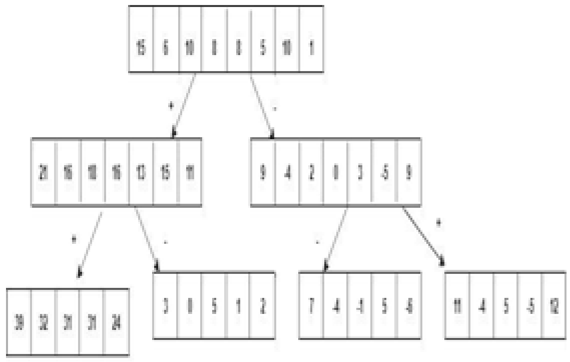

Figure.1 Tree Structure for 1-D

B. Normalized Cross Correlation

Using affine transformation the best matched domain block is achievable in fractal video coding but to get structural identical into range and domain block it's better to use NCC for similarity check. It upgrades coding skill and abstract visual quality in video compression. Hence to get optimize calculation; NCC is calculated using Walsh transform. Considering the blocks as a vector, the NCC between two block is $V=(V0,V1,......,VN-1)^T$ and $U=(U0,U1,......,UN-1)^T$,where N is the number of pixels in the block, is given by

$$\frac{1}{\sigma_V \sigma_U}(V-\underline{V})\cdot(U-\underline{U}) \qquad (5)$$

Where are the standard deviations and □ , □ are the vectors consisting of the means.

$$\sigma_V = \sqrt{(V-\bar{V})\cdot(V-\bar{V})} \qquad (6)$$

$$\bar{V} = \frac{1}{N}\sum_{i=0}^{N-1} V_i$$

$$=(\ ,\ ,\dots\dots,\ )^T$$

If orthogonal basis of block is written in such a way {Wk ; k= 0.........N-1} we get

$$V = \sum_{k=0}^{N-1} w_{v,k} W_k \qquad (7)$$

Where the ā are V's coefficient in the new basic. Rewriting Eq. (6) and (7) in this basis gives us

$$\frac{1}{\sigma_V \sigma_U}\sum_{k=0}^{N-1} w_{v,k}\,(W_k - \overline{W_k}) \cdot \sum_{k=0}^{N-1} w_{u,k}\,(W_k - \overline{W_k}) \qquad (8)$$

$$\frac{1}{\sigma_V \sigma_U}\sum_{i=0}^{N-1}\sum_{k=0}^{N-1} w_{v,i}\, w_{u,k}\,(W_i - \overline{W_i})\cdot(W_k - \overline{W_k}) \qquad (9)$$

$$\sigma_v = \sqrt{\sum_{k=0}^{N-1} w_{v,k}^2\, \sigma_{W_k}^2}$$

The expression for the NCC has now expanded to a double sum. However if the basis vector Wk were constructed such

ISSN 2348 – 8034
Impact Factor- 5.070

‹ ˆ

‹

that

'- Š‡''™‹ ‡

Then all terms outside the diagonal of the double sum would be zero. Such a basis can be created as follows set W0= ξ (1, 1... 1)^T and the other basis vectors we get from this complete orthonormal basis. Then the mean of W0 will be

i=
.
e
ξ
G
expressed as the dot product between W0 and the vectors Wi times a scalar. Due to orthogonally towards W0 those means

. The means of the other basis vectors can be

will be zero i.e. for i=1.....N-1 we get

‹ ˆ

‹

‘– Š‡”™‹ ‡

This is what we want all products outside the diagonal and the first product in the diagonal of the double sum are zero. The NCC expression will be turn outs to

$$\frac{1}{\sigma_V \sigma_U} \sum_{k=1}^{N-1} W_{V_k} W_{U_k} \qquad (10)$$

$$\sigma_V = \sqrt{\sum_{k=1}^{N-1} W_{V_k}^2}$$

An orthonormal basis that meets these requirements is the Walsh basis.

ISSN 2348 – 8034
Impact Factor- 5.070

Thus self-similarities between blocks are achieved using Eq. 10 of NCC which is simplified equation. In case if block had been performed any of the 8 geometric operation, 2 x 2 sub matrices are used to represent as follows [11],

$$T_1 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, T_2 = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$T_3 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, T_4 = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix} \quad (11)$$

$$T_5 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, T_6 = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$$

$$T_7 = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}, T_8 = \begin{bmatrix} 0 & -1 \\ -1 & 0 \end{bmatrix}$$

Where T1, T7, T6 and T4 are used to obtain clock wise rotation of original block with 0°, 90°, 180° and 270° also T3, T2, T8 and T5 are reflection over the axis's and 45° rotation. Taking second orientation of m is m 2 which can be obtained by reflecting m about the line y = (N-1)/2, where N x N is block size. The matrix T2 is given in eq. 11 and the advance coordinate is given by (u, v). This coordinates are indicated as

$$\begin{bmatrix} u - \frac{N-1}{2} \\ v \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x - \frac{N-1}{2} \\ y \end{bmatrix} \quad (12)$$

The solution turnouts to be u = -x+N-1 and v = y. Hence Walsh transform of m2 is obtain by

$$M_2(p,q) = \frac{1}{N} \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} m_2(u,v) \prod_{i=0}^{n-1} (-1)^{b_i(u) b_{n-1-i}(p) + b_i(v) b_{n-1-i}(q)}$$

$$= \frac{1}{N} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} m_1(x,y) \prod_{i=0}^{n-1} (-1)^{b_i(-x+N-1) b_{n-1-i}(p) + b_i(y) b_{n-1-i}(q)}$$

$$= \frac{1}{N} \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} \prod_{i=0}^{n-1} \text{[illegible]}$$

Hence further rearranging the terms we get

$$= \prod_{i=0}^{n-1} (-1)^{b_i(p)} M_1(x,y) \quad (13)$$

As M1=M, the eq.13 can be written,

$$M_2(p,q) = \prod_{i=0}^{n-1} (-1)^{b_i(p)} M(x,y)$$

The m3 is obtained from m reflecting about line x = (N-1)/2 and m4 is acquired by reflecting m on both the line x as well as thus same computation is been applied to get terms M1, M2, M3 and M4

ISSN 2348 – 8034
Impact Factor- 5.070

$$M_1(p,q) = M(x,y)$$
$$M_2(p,q) = \prod_{i=0}^{n-1}(-1)^{b_i(p)} M(x,y)$$
$$M_3(p,q) = \prod_{i=0}^{n-1}(-1)^{b_i(q)} M(x,y) \qquad (14)$$

$$M_4(p,q) = \prod_{i=0}^{n-1}(-1)^{b_i(p)+b_i(q)} M(x,y)$$

To solve m5, equation of change of coordinates be given as

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Solving above equation, u = y and v = x hence M5 is obtain as

$$M_5(p,q) = \frac{1}{N}\sum_{u=0}^{N-1}\sum_{v=0}^{N-1} m_5(u,v)\prod_{i=0}^{n-1}(-1)^{b_i(p)b_{n-1-i}(u)+b_i(q)b_{n-1-i}(v)}$$
$$M_5(p,q) = \frac{1}{N}\sum_{x=0}^{N-1}\sum_{y=0}^{N-1} m_5(x,y)\prod_{i=0}^{n-1}(-1)^{b_i(p)b_{n-1-i}(y)+b_i(q)b_{n-1-i}(x)}$$
$$M_5(p,q) = M(q,p)$$

Using similar concept of eq. 13 to get other orientations, hence to express M5, M6, M7 and M8 in terms of M as

$$M_5(p,q) = M_1(q,p) = M(q,p)$$
$$M_6(p,q) = M_2(q,p) = \prod_{i=0}^{n-1}(-1)^{b_i(p)} M(q,p)$$
$$M_7(p,q) = M_3(q,p) = \prod_{i=0}^{n-1}(-1)^{b_i(q)} M(q,p) \qquad (15)$$
$$M_8(p,q) = M_4(q,p) = \prod_{i=0}^{n-1}(-1)^{b_i(p)+b_i(q)} M(q,p)$$

Similarly if we consider z(i, j) = M(i, j).O(i, j) and y(i, j) = M(j, i).O(i ,j) hence considering eq.15 then

$$T_1 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} z(i,j)$$
$$T_2 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} z(i,j)\prod_{l=0}^{n-1}(-1)^{b_l(i)}$$
$$T_3 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} z(i,j)\prod_{l=0}^{n-1}(-1)^{b_l(j)} \qquad (16)$$
$$T_4 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} z(i,j)\prod_{l=0}^{n-1}(-1)^{b_l(i)+b_l(j)}$$

And for the other orientation similarly

 ISSN 2348 – 8034
Impact Factor- 5.070

$$T_5 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} y(i,j)$$

$$T_6 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} y(i,j)\prod_{l=0}^{n-1}(-1)^{b_l(i)} \qquad (18)$$

$$T_7 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} y(i,j)\prod_{l=0}^{n-1}(-1)^{b_l(j)}$$

$$T_8 = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} y(i,j)\prod_{l=0}^{n-1}(-1)^{b_l(i)+b_l(j)}$$

Hence to get geometric operation eq.16 and 17 are used. Fig.2 indicates the flow diagram of the proposed fractal video coding scheme, for resulting similarity into macro block (MB) of current frame in the likely search window (SW) of the reference frame with various geometric transformations (t).

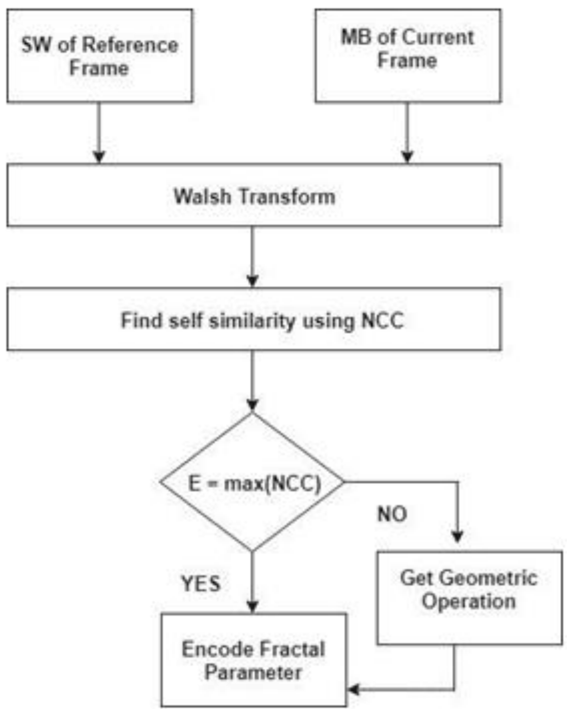

Figure.2 Flow Diagram of proposed work

V. EXPERIMENTAL RESULTS

The proposed Fractal video compression scheme using Walsh transform is performed on MATLAB R2008a with Intel core2Do CPU, 2 GB RAM is used. Experimentation is performed on typical standard video sequence i.e. Tennis, Garden of size (240 x 352), Coastguard, Foreman and Bus of size (288 x 352) and carphone size is (256 x 352). The current frame is divided into macroblocks of size 8 x 8 pixels and search window in reference frame with ± 8 pixels displacement in both horizontal and vertical direction. The Table.1 shows average comparative study of proposed based fractal video compression scheme with FFT based in which average of average of 60 frames is taken with first 12 frames as GOP (group of picture) for decoding purpose, also three parameters are compared they are peak signal to noise ratio (PSNR), compression ratio (CR) and lastly encoding time (T) in sec. The proposed

ISSN 2348 – 8034
Impact Factor- 5.070

scheme hikes speed up to factor about 4 to 5 times than other algorithm with same decrypt video quality and good compression ratio.

Table.1 AVERAGE COMPARISON OF PROPOSED SCHEME AND FFT BASED.

Video Sequence	Proposed Work			FFT Based Compression		
	PSNR	CR	T (S)	PSNR	CR	T (S)
Foreman	31.94	53.43	7.66	31.10	28.57	11.72
Car phone	33.21	63.55	5.03	33.17	28.43	10.50
Tennis	28.19	76.27	5.91	26.92	30.64	9.19
Garden	23.41	57.06	6.83	20.60	30.17	9.30
Coastguard	29.15	49.62	7.41	27.99	34.30	12.52
Bus	25.38	43.71	7.73	24.17	32.07	12.94

VI. CONCLUSION

The Walsh transform based NCC method is used for checking self-similarity between range and domain blocks with eight geometric operations are proposed in this paper. The approach scheme gives better compression ratio as well as good PSNR, also encoding time require is less than FFT based approach. The encoding times require is 4 to 5 factor less than FFT based. The quality of decompressed video of proposed scheme is same as that of FFT based. Further video quality can be increase by reducing size of range block.

REFERENCES

1. *M. Barnsely ,"Fractal Everywhere", Academic Press, San Diego, 1988.*
2. *Kulkarni M.V and Kulkarni D.B," Analysis of Fractal Video Coding using Partitioning Scheme", Journal of Signal and Image Processing ISSN:0976-8882 & E-ISSN:0976-8890, Vol. 3, Issue 4, pp. 126-129,2012.*
3. *S. Zhu, Y. Hou, Z. Wang and K. Belloulate,"Fractal Video Sequence Coding with Region Based Functionality", Applied Mathematical Modelling, Vol. 36,Issue 11, pp. 5633-5641 Elsevier, Nov 2012.*
4. *S. Zhu, Y. Hou, Z. Wang and K. Belloulate,"An Automatic Region Based Video Sequence Codec Based on Fractal Compression," AEU International Journal of Electronics and Communication, Vol. 68, Issue 8, pp .795-805 Elsevier, Aug 2014.*
5. *M. Wang and C-L.Cai,"A Hybrid Fractal Video Compression Method", An International Journal Computers and Mathematics with Applications, Vol.50, Issue 3-4, pp.611- 620 Elsevier, Aug 2005.*
6. *S. G. Farkade and S.D. Kamble," A Hybrid Block Matching Motion Estimation Approach for Fractal Video Compression," IEEE International Conference on Circuits, Power and Computing Technologies [ICCPCT-2013], 2013.*
7. *K. Belloulataa, A. Belaliaa and S .Zhu," Object-based stereo video compression using fractals and shape-adaptive DCT ," AEU An International Journal of Electronics and Communications ,Vol. 68, Issue 7,pp. 687-697 Elsevier, July 2014.*
8. *M. Wang, R. Liu and C-L. Cai,"Adaptive Partition and Hybrid Method in Fractal Video Compression", Journal Computers and Mathematics with Applications, Vol. 51, Issue 51, pp .1715-1726, Elsevier, June 2006.*
9. *C.S .Kim and S.U. Lee," Fractal Coding of Video Sequence by Circular Prediction Mapping".*
10. *C.S. Kim, R-C. Kim and S.U. Lee," Fractal Coding of Video Sequence using Circular Prediction Mapping and Non Contractive Inter frame Mapping," IEEE Trans. On Image Processing, Vol.77, No.4, April 1998.*
11. *J.H. Jeng, T.K. Truong and J.R. Shev,"Fast Fractal Image Compression using the Hadamard Transform," IEE proceeding, VIS Image Signal Process, Vol.147, No.6, Dec 2000.*

ISSN 2348 – 8034
Impact Factor- 5.070

12. *P. Nillius and J-O.T.K. Lundh," Fast Block Matching with NCC using Walsh Transform," Department of Numerical Analysis and Computer Science, TRTTA-NA-P02/11, ISSN 1101-2250, ISRN/KTH/NA/P-02/11-SE, CVAP-268, Sep2002.*
13. *Y.H .Or and H.H. Or," Real Time Pattern Matching using Projection Kernels," Department of Statistics, Stanford University, Stanford CA, Dec 21, 2004.*
14. *Y. Fisher," Fractal Image Compression," Siggraph,'92, Course notes, 1992.*
15. *M. Barnsely," Fractal Image Compression," AMS, Volume 43, No. 6, June 1996.*
16. *"An Introduction To FIC", Literature No. BPRA 065, Texas Instrument Europe, October 1992.*
17. *M. Galabov," Fractal Image Compression," ICCST, CompSysTech, 2003.*
18. *S. Zhu, Y .Hou, Z. Wang and K. Belloulata," A Novel Fractal Video Coding Algorithm using Fast Block Matching Motion Estimation Technology," ICCASM, IEEE, V8-361-364, 2010.*
19. *S. Zhu, L. Zhang," A Review of Fractal Video Coding," International Conference* on Industrial Control *and Electronics Engineering, IEEE, 951-953, Vol.252, 2012.*
20. *M.M. Dayanand, M. Kulkarni," Parallel Hybrid Fractal Video Coding Technique," IJARCSSE, Vol.4, Issue 8, Aug 2014.*
21. *Y. Fisher,T.P. Shen and D. Rogovian,"Fractal Encoding of Video Sequences," in Proc SPIE: VCIP, 1994, Vol.2308, pp. 1359-1370.*
22. *"History of Fractal", Google, Wikipedia.*
23. *R.E. Chaudhari and S.B. Dhok," Fast Quad tree Based Normalized Cross Correlation Method for Fractal Video Compression using FFT", J Electr Eng Technol; 11(2): 519-528, 2016.*
24. *R.E. Chaudhari and S.B. Dhok," Fractal Video Coding Using Fast Normalized Covariance Based Similarity Measure," Hindawi Publishing Corporation, Mathematical Problems in Engineering, Article ID 1725051, 11 pages,2016.*
25. *S. Jayaraman, S. Esakkirajan and T.Veerakumar,"Digital Image Processing,"Tata McGraw Hill Education Private Limited, ISBN 10 & 13, 2009.*
26. *R.E. Chaudhari and S.B. Dhok,"Acceleration of Fractal Video Compression using FFT," 15th International Conference on Advanced Computing Technologies (ICACT), 2013.*