Introducing Global and Local Walsh Wavelet Transform for Texture Pattern Based Image Retrieval

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Summary
The theme of the work presented in the paper is novel texture pattern based image retrieval techniques using ternary image maps and two different non-sinusoidal orthogonal Walsh wavelet transforms namely Global Walsh Wavelet Transform and Local Walsh Wavelet Transform. Different texture patterns namely '64-pattern' and '256-pattern' are generated using both the Walsh wavelet transform matrices giving rise to global and local texture patterns. The generated texture patterns are then compared with the ternary image maps to generate the feature vector based on structural matching as the matching number of ones, zeros, minus ones per Walsh wavelet texture pattern. Here total 4 variations of the proposed novel image retrieval methods using texture patterns are considered with two different texture patterns and two different ways to generate these texture patterns (Global and Local). The proposed texture content based image retrieval (CBIR) techniques are tested on the image database with help of 55 queries (randomly selected 5 from each of 11 image categories) fired on image database. The performance comparison of texture pattern based CBIR methods is done with help of precision-recall crossover points.

Key words:
CBIR; Walsh Transform; Wavelet Transform; Texture; Patterns; Ternary Image Maps; Global & Local Textures

1. Introduction

Today the information technology experts are facing technical challenges to store/transmit and index/manage image data effectively to make easy access to the image collections of tremendous size being generated due to large numbers of images generated from a variety of sources (digital camera, digital video, scanner, the internet etc.). The storage and transmission is taken care of by image compression [4,7,8]. The image indexing is studied in the perspective of image database [5,9,10,13,14] as one of the promising and important research area for researchers from disciplines like computer vision, image processing and database areas. The hunger of superior and quicker image retrieval techniques is increasing day by day. The significant applications for CBIR technology could be listed as art galleries [15,17], museums, archaeology [6], architecture design [11,16], geographic information systems [8], weather forecast [8,25], medical imaging [8,21], trademark databases [24,26], criminal investigations [27,28], image search on the Internet [12,22,23]. The paper attempts to provide better and faster image retrieval techniques.

1.1 Content Based Image Retrieval

For the first time Kato et.al. [7] described the experiments of automatic retrieval of images from a database by colour and shape feature using the terminology content based image retrieval (CBIR). The typical CBIR system performs two major tasks [19,20] as feature extraction (FE), where a set of features called feature vector is generated to accurately represent the content of each image in the database and similarity measurement (SM), where a distance between the query image and each image in the database using their feature vectors is used to retrieve the top "closest" images [19,20,29].

For feature extraction in CBIR there are mainly two approaches [8] feature extraction in spatial domain and feature extraction in transform domain. The feature extraction in spatial domain includes the CBIR techniques based on histograms [8], BTC [4,5,19], VQ [24,28,29]. The transform domain methods are widely used in image compression, as they give high energy compaction in transformed image [20,27]. So it is obvious to use images in transformed domain for feature extraction in CBIR [26]. But taking transform of image is time consuming. Reducing the size of feature vector using pure image pixel data in spatial domain and getting the improvement in performance of image retrieval is shown in [1,2,3]. But the problem of feature vector size still being dependent on image size persists in [1,2,3]. Here the query execution time is further reduced by decreasing the feature vector size further and making it independent of image size. Many current CBIR systems use the Euclidean distance [4-6,11-17] on the extracted feature set as a similarity measure. The Direct Euclidian Distance between image P and query image Q can be given as equation 1, where Vpi and Vqi are the feature vectors of image P and Query image Q respectively with size 'n'.

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$$ED = \sqrt{\sum_{i=1}^{n} (Vpi - Vqi)^2} \quad (1)$$

2. Generation of Ternary Image Maps

For generating ternary image maps, the image maps of colour image are generated using three independent red (R), green (G) and blue (B) components of image to calculate three individual colour thresholds and one overall luminance threshold [35]. Let X={R(i,j),G(i,j),B(i,j)} where i=1,2,….m and j=1,2,….,n; be an m×n color image in RGB space. Let the individual colour thresholds be TR, TG and TB which could be computed as per the equations given below as 2, 3 and 4. Let the luminance threshold T be as given by equation 5.

$$TR = \frac{1}{m*n} \sum_{i=1}^{m} \sum_{j=1}^{n} R(i, j) \quad (2)$$

$$TG = \frac{1}{m*n} \sum_{i=1}^{m} \sum_{j=1}^{n} G(i, j) \quad (3)$$

$$TB = \frac{1}{m*n} \sum_{i=1}^{m} \sum_{j=1}^{n} B(i, j) \quad (4)$$

$$T = \frac{TR + TG + TB}{3} \quad (5)$$

The ternary image maps are used for comparison with texture patterns generated using Walsh wavelet transform matrices. Here first for each component (R, G, and B), the individual colour threshold intervals (lower-Tshl, and higher-Tshh) are calculated as shown in equations 6, 7 and 8.

$$Tshrl = TR - |TR - T| \quad , \quad Tshrh = TR + |TR - T| \quad (6)$$

$$Tshgl = TG - |TG - T| \quad , \quad Tshgh = TG + |TG - T| \quad (7)$$

$$Tshbl = TB - |TB - T| \quad , \quad Tshbh = TB + |TB - T| \quad (8)$$

Then the individual color plane global ternary image maps are computed (TMr, TMg and TMb) as given in equations 9, 10 and 11. If a pixel value of respective color component is greater than the respective higher threshold interval (Tshh), the corresponding pixel position of the image map gets a value 'one'; else if the pixel value is lesser than the respective lower threshold interval (Tshl), the corresponding pixel position of the image map gets a value of 'minus one'; otherwise it gets a value 'zero'.

$$TMr(i, j) = \begin{cases} 1, & if.R(i, j) > Tshrh \\ 0, & if.Tshrl <= R(i, j) <= Tshrh \\ -1, & if.R(i, j) < Tshrl \end{cases} \quad (9)$$

$$TMg(i, j) = \begin{cases} 1, & if.G(i, j) > Tshgh \\ 0, & if.Tshgl <= G(i, j) <= Tshgh \\ -1, & if.G(i, j) < Tshgl \end{cases} \quad (10)$$

$$TMb(i, j) = \begin{cases} 1, & if.B(i, j) > Tshbh \\ 0, & if.Tshbl <= B(i, j) <= Tshbh \\ -1, & if.B(i, j) < Tshbl \end{cases} \quad (11)$$

3. Generation of Wavelet Transforms

Using the base transform matrix, two different non-sinusoidal orthogonal wavelet transforms are generated namely Global Wavelet Transform and Local Wavelet Transform. These wavelet transforms are used for generating texture patterns.

3.1 Global Wavelet Transform Generation

To generate a square Global Wavelet transform of order "2P", respective base transform matrices of size 2x2 and PxP are used. First each column of the 2x2 base transform is repeated P times. The last (P-1) rows of the PxP base transform matrix are copied into the wavelet transform starting from third row of the wavelet transform. Then the last (P-1) rows of the PxP base transform are copied into the wavelet transform starting from $(P+2)^{th}$ row and $(P+1)^{th}$ column of the wavelet transform. The remaining elements of the wavelet transform matrix are made equal to zero. The obtained matrix is normalized in order to make it an orthogonal transform matrix. Figure 1(a) shows 2x2 base transform matrix and figure 1(b) shows Global Wavelet transform of size 2Px2P.

B_{11}	B_{12}
B_{21}	B_{22}

Figure 1(a). 2x2 Base Transform

M_{11}	M_{12}	. . .	$M_{1\,(P-1)}$	M_{1P}
M_{21}	M_{22}	. . .	$M_{2\,(P-1)}$	M_{2P}
M_{31}	M_{32}	. . .	$M_{3\,(P-1)}$	M_{3P}
. .	. .	. . .	. .	. .
M_{P1}	M_{P2}	. . .	$M_{P\,(P-1)}$	M_{PP}

PxP Transform matrix

1^{st} column of B — Repeated P times; 2^{nd} column of B — Repeated P times

B_{11}	B_{11}	. . .	B_{11}	B_{12}	B_{12}	. . .	B_{12}
B_{21}	B_{21}	. . .	B_{21}	B_{22}	B_{22}	. . .	B_{22}
M_{21}	M_{22}	. . .	M_{2P}	0	0	. . .	0
M_{31}	M_{32}	. . .	M_{3P}	0	0	. . .	0
. . .	. . .	. . .	. . .	0	0	. . .	0
M_{P1}	M_{P2}	. . .	M_{PP}	0	0	. . .	0
0	0	. . .	0	M_{21}	M_{22}	. . .	M_{2P}
0	0	. . .	0	M_{31}	M_{32}	. . .	M_{3P}
0	0	. . .	0	. . .	. . .	. . .	. . .
0	0	. . .	0	M_{P1}	M_{P2}	. . .	M_{PP}

Figure 1(b). 2Px2P Global Wavelet Transform

3.2 Local Wavelet Transform Generation

To generate a square local Global Wavelet transform of order “2P”, respective base transform matrix of size PxP is used. First each column of the PxP base transform is repeated twice. In the proceeding rows, the values of the elements of wavelet transform are set as 1 and -1 diagonally as shown in figure 2(b). The remaining elements of the wavelet transform matrix are made equal to zero. The obtained matrix is normalized in order to make it an orthogonal transform matrix. Figure 2(a) shows PxP base transform matrix and figure 2(b) shows Local Wavelet transform of size 2Px2P.

M_{11}	M_{12}	. . .	$M_{1\,(P-1)}$	M_{1P}
M_{21}	M_{22}	. . .	$M_{2\,(P-1)}$	M_{2P}
. .	. .	. . .	. .	. .
M_{P1}	M_{P2}	. . .	$M_{P\,(P-1)}$	M_{PP}

Figure 2(a). PxP Base Transform

4. Texture Pattern Generation

Using the Walsh transform [21,22,26,36], two different non-sinusoidal orthogonal wavelet transforms are generated namely Global Walsh Wavelet transform and Local Walsh Wavelet Transform. With the help of these Wavelet transform matrices assorted texture patterns [30-34,37,38] namely 64-pattern and 256-pattern are generated. To generate N^2 texture patterns (N^2-pattern) texture patterns, NxN transform matrix is considered and the element wise multiplication of each row of the transform matrix is taken with all possible rows of the same matrix (consideration of one row at a time gives one pattern). The texture patterns obtained are orthogonal in nature.

4.1 Global Wavelet Transform Generation

The 64 and 256 global Walsh texture patterns are generated using Global Walsh Wavelet transform matrices of size 8x8 and 16x16 respectively. The 8x8 global Walsh wavelet transform matrix is shown as in figure 3(a), each row of this matrix is considered one at a time and is multiplied with all rows of the same matrix to generate 64 Walsh texture patterns. Figure 3(b) shows first 16 (of total 64 texture patterns) texture patterns of the 64-pattern Global Walsh texture set where black colour represent the values ‘1’ in the pattern, grey colour represents the value ‘0’ and values ‘-1’ are represented by white colour. The obtained Walsh texture patterns then are resized as the size of image for which texture features have to be extracted.

	1st column of M		2nd column of M		3rd column of M				Pth column of M	
	Repeated 2 times		Repeated 2 times		Repeated 2 times				Repeated 2 times	
	M_{11}	M_{11}	M_{12}	M_{12}	M_{13}	M_{13}	. . .	. . .	M_{1P}	M_{1P}
	M_{21}	M_{21}	M_{22}	M_{22}	M_{23}	M_{23}	. . .	. . .	M_{2P}	M_{2P}
Q/2	. .	. .	. .	. .	. .	. .	. . .	. . .	. .	. .
	M_{P1}	M_{P1}	M_{P2}	M_{P2}	M_{P3}	M_{P3}	. . .	. . .	M_{PP}	M_{PP}
	-1	-1	0	0	0	0	. . .	. . .	0	0
	0	0	-1	-1	0	0	. . .	. . .	0	0
Q/2	0	0	0	0	-1	-1	. . .	. . .	0	0
	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
	0	0	0	0	0	0			-1	-1

Figure 2(b). 2Px2P Local Wavelet Transform

1	1	1	1	1	1	1	1
1	1	1	1	-1	-1	-1	-1
1	1	-1	-1	0	0	0	0
1	-1	-1	1	0	0	0	0
1	-1	1	-1	0	0	0	0
0	0	0	0	1	1	-1	-1
0	0	0	0	1	-1	-1	1
0	0	0	0	1	-1	1	-1

Figure 3(a). 8x8 Global Walsh Wavelet Transform

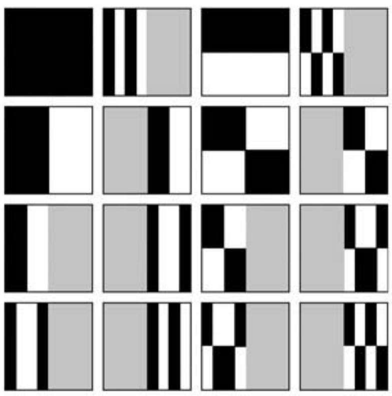

Figure 3(b). First 16 texture patterns (out of total 64) of 64-pattern Global Walsh Texture Patterns

4.2 Local Walsh Texture Pattern Generation

The 64 and 256 local Walsh texture patterns are generated using local Walsh Wavelet transform matrices of size 8x8 and 16x16 respectively. The 8x8 local Walsh wavelet transform matrix is shown as in figure 4(a), each row of this matrix is considered one at a time and is multiplied with all rows of the same matrix to generate 64 Walsh texture patterns. Figure 4(b) shows first 16 (of total 64 texture patterns) texture patterns of the 64-pattern Local Walsh texture set where black colour represent the values ‘1’ in the pattern, grey colour represents the value ‘0’ and values ‘-1’ are represented by white colour. The obtained Walsh texture patterns then are resized as the size of image for which texture features have to be extracted.

1	1	1	1	1	1	1	1
1	1	1	1	-1	-1	-1	-1
1	1	-1	-1	-1	-1	1	1
1	1	-1	-1	1	1	-1	-1
1	-1	0	0	0	0	0	0
0	0	1	-1	0	0	0	0
0	0	0	0	1	-1	0	0
0	0	0	0	0	0	1	-1

Figure 4(a). 8x8 Local Walsh Wavelet Transform

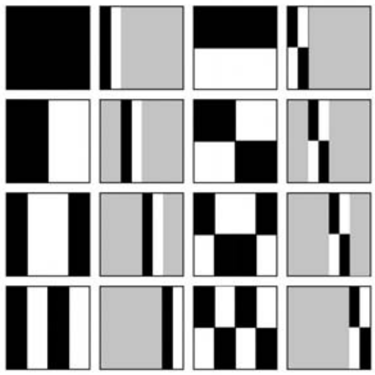

Figure 4(b). First 16 texture patterns (out of total 64) of 64-pattern Local Walsh Texture Patterns

5. CBIR Using Global and Local Texture Patterns

In all four variations of proposed CBIR method are possible using the global & local Walsh wavelet transform and the assorted texture pattern set of 64-pattern & 256-pattern. For feature extraction in CBIR using texture patterns first the ternary image map is generated and then the desired texture pattern set is generated (64-pattern or 256-pattern) using the corresponding Walsh wavelet transform.

To generate feature vectors the ternary image map of the image is compared with each pattern of the generated Walsh texture patterns (Global or Local) to find the matching number of ones, zeros & minus ones. The feature vactor will have three values (number of matching '1', '0' & '-1') per pattern per colour plane in Walsh texture patterns. The per image feature vector size for Walsh texture pattern based CBIR is given by equation 12.

$$\text{Feature vector size} = 3*3*(\text{no. of considered texture pattern}) \qquad (12)$$

Table 1. Feature vector of image retrieval using texture patterns

CBIR Technique	***64-Pattern***	***256-Pattern***
Global Walsh Texture Patterns	192	768
Local Walsh Texture Patterns Patterns	192	768

The main advantage of proposed CBIR methods is reduced time complexity for query execution due to reduced size of feature vector resulting into faster image retrieval with better performance as compared to the colour averaging [1,2,3] based image retrieval techniques. Also the feature vector size is independent of image size in proposed CBIR methods.

6. Implementation

The implementation of the discussed CBIR techniques is done in MATLAB 7.0 using a computer with Intel Core 2 Duo Processor T8100 (2.1GHz) and 2 GB RAM. The CBIR techniques are tested on the Wang image database [18] of 1000 variable size images spread across 11 categories of human being, animals, natural scenery and manmade things, etc. The categories and distribution of the images is shown in table 2.

To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters [4,5] for the proposed CBIR techniques. The standard definitions for these two measures are given by the equations 13 and 14.

$$\Pr ecision = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \qquad (13)$$

$$\mathrm{Re}\,call = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \qquad (14)$$

Table 2. Image Database: Category-wise Distribution

Category	***Tribes***	***Buses***	***Beaches***
No. of Images	85	99	99
Category	***Horses***	***Mountains***	***Airplanes***
No. of Images	99	61	100
Category	***Dinosaurs***	***Elephants***	***Roses***
No. of Images	99	99	99
Category	***Monuments***	***Sunrise***	
No. of Images	99	61	

7. Results of CBIR using Texture Patterns

The crossover point of precision-recall plays very important role in performance comparison of image retrieval methods, higher crossover point value indicates better image retrieval. The crossover point value of average precision and recall values obtained by firing 55 queries on image database are computed for proposed Walsh wavelet transform texture pattern based image retrieval methods.

Figure 5 shows the performance comparison of the proposed Walsh wavelet transform based texture pattern CBIR methods with the Walsh transform based texture pattern [34] CBIR methods. It can be observed that in case of Walsh wavelet transform based texture patterns 64-pattern based CBIR technique is better than 256-pattern based CBIR methods. Moreover it can be observed that the proposed CBIR methods are more efficient than the Walsh transform texture patterns as indicated by higher precision-recall crossover values. In the case of 64-pattern texture and 256-pattern texture, local Walsh texture patterns prove to be better than global Walsh texture patterns indicating that the local texture patterns contain more information about the image as compared to global texture patterns. Overall 64-pattern local Walsh wavelet transform based texture patterns give the best image retrieval among the discussed CBIR techniques as indicated by precision-recall crossover value.

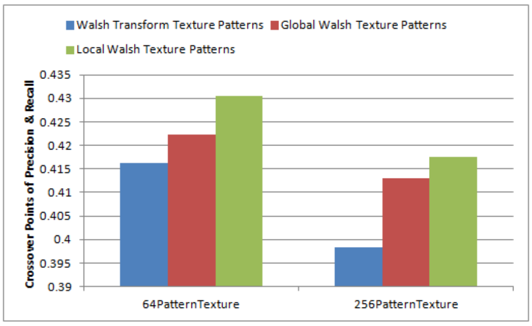

Figure 5. Performance Comparison of proposed Walsh wavelet transform based texture pattern CBIR methods with Walsh transform based texture pattern CBIR methods

8. Conclusion

The novel image retrieval methods using Walsh wavelet transform based texture patterns are presented in this paper. It has been observed that the Walsh wavelet transform based texture pattern outperform the Walsh transform based texture pattern for image retrieval. Here 64-pattern texture gives the best result beyond which the results start deteriorating indicating that texture patterns can give better results only up to a certain level. The local Walsh wavelet transform based texture patterns give better performance than the global Walsh wavelet transform based texture patterns. Among the proposed CBIR methods, 64-pattern local Walsh wavelet transform based texture patterns give better performance than other proposed methods as indicated by precision-recall crossover value.

References

[1] Dr. H.B.Kekre, Sudeep D. Thepade, Varun K. Banura, "Augmentation of Colour Averaging Based Image Retrieval Techniques using Even part of Images and Amalgamation of feature vectors", International Journal of Engineering Science and Technology (IJEST), Volume 2, Issue 10, (ISSN: 0975-5462) Available online at http://www.ijest.info

[2] Dr. H.B.Kekre, Sudeep D. Thepade, Varun K. Banura, "Amelioration of Colour Averaging Based Image Retrieval Techniques using Even and Odd parts of Images", International Journal of Engineering Science and Technology (IJEST), Volume 2, Issue 9, (ISSN: 0975-5462) Available online at http://www.ijest.info.

[3] Dr. H.B.Kekre, Sudeep D. Thepade, Akshay Maloo, "Query by Image Content Using Colour Averaging Techniques", International Journal of Engineering Science and Technology (IJEST), Volume 2, Issue 6, 2010.pp.1612-1622 (ISSN: 0975-5462) Available online at http://www.ijest.info.

[4] Dr. H.B.Kekre, Sudeep D. Thepade, "Boosting Block Truncation Coding using Kekre's LUV Color Space for Image Retrieval", WASET International Journal of Electrical, Computer and System Engineering (IJECSE), Volume 2, Number 3, pp. 172-180, Summer 2008. Available online at http://www.waset.org/ijecse/v2/v2-3-23.pdf

[5] Dr. H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Augmented Block Truncation Coding Techniques", ACM International Conference on Advances in Computing, Communication and Control (ICAC3-2009), pp. 384-390, 23-24 Jan 2009, Fr. Conceicao Rodrigous College of Engg., Mumbai. Is uploaded on online ACM portal.

[6] Dr. H.B.Kekre, Sudeep D. Thepade, "Scaling Invariant Fusion of Image Pieces in Panorama Making and Novel Image Blending Technique", International Journal on Imaging (IJI), www.ceser.res.in/iji.html, Volume 1, No. A08, pp. 31-46, Autumn 2008.

[7] Hirata K. and Kato T. "Query by visual example – content-based image retrieval", In Proc. of Third International Conference on Extending Database Technology, EDBT'92, 1992, pp 56-71

[8] Dr. H.B.Kekre, Sudeep D. Thepade, "Rendering Futuristic Image Retrieval System", National Conference on Enhancements in Computer, Communication and Information Technology, EC2IT-2009, 20-21 Mar 2009, K.J.Somaiya College of Engineering, Vidyavihar, Mumbai-77.

[9] Minh N. Do, Martin Vetterli, "Wavelet-Based Texture Retrieval Using Generalized Gaussian Density and Kullback-Leibler Distance", IEEE Transactions On Image Processing, Volume 11, Number 2, pp.146-158, February 2002.

[10] B.G.Prasad, K.K. Biswas, and S. K. Gupta, "Region –based image retrieval using integrated color, shape, and location index", International Journal on Computer Vision and Image Understanding Special Issue: Colour for Image Indexing and Retrieval, Volume 94, Issues 1-3, April-June 2004, pp.193-233.

[11] Dr. H.B.Kekre, Sudeep D. Thepade, "Creating the Color Panoramic View using Medley of Grayscale and Color

Partial Images ", WASET International Journal of Electrical, Computer and System Engineering (IJECSE), Volume 2, No. 3, Summer 2008. Available online at www.waset.org/ijecse/v2/v2-3-26.pdf.

[12] Stian Edvardsen, "Classification of Images using color, CBIR Distance Measures and Genetic Programming", Ph.D. Thesis, Master of science in Informatics, Norwegian university of science and Technology, Department of computer and Information science, June 2006.

[13] Dr. H.B.Kekre, Tanuja Sarode, Sudeep D. Thepade, "DCT Applied to Row Mean and Column Vectors in Fingerprint Identification", In Proceedings of International Conference on Computer Networks and Security (ICCNS), 27-28 Sept. 2008, VIT, Pune.

[14] Zhibin Pan, Kotani K., Ohmi T., "Enhanced fast encoding method for vector quantization by finding an optimally-ordered Walsh transform kernel**",** ICIP 2005, IEEE International Conference, Volume 1, pp I - 573-6, Sept. 2005.

[15] Dr. H.B.Kekre, Sudeep D. Thepade, "Improving 'Color to Gray and Back' using Kekre's LUV Color Space", IEEE International Advanced Computing Conference 2009 (IACC'09), Thapar University, Patiala, INDIA, 6-7 March 2009. Is uploaded at online at IEEE Xplore.

[16] Dr. H.B.Kekre, Sudeep D. Thepade, "Image Blending in Vista Creation using Kekre's LUV Color Space", SPIT-IEEE Colloquium and International Conference, Sardar Patel Institute of Technology, Andheri, Mumbai, 04-05 Feb 2008.

[17] Dr. H.B.Kekre, Sudeep D. Thepade, "Color Traits Transfer to Grayscale Images", In Proc.of IEEE First International Conference on Emerging Trends in Engg. & Technology, (ICETET-08), G.H.Raisoni COE, Nagpur, INDIA. Uploaded on online IEEE Xplore.

[18] http://wang.ist.psu.edu/docs/related/Image.orig (Last referred on 23 Sept 2008)

[19] Dr. H.B.Kekre, Sudeep D. Thepade, "Using YUV Color Space to Hoist the Performance of Block Truncation Coding for Image Retrieval", IEEE International Advanced Computing Conference 2009 (IACC'09), Thapar University, Patiala, INDIA, 6-7 March 2009.

[20] Dr. H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shah, Prathmesh Verlekar, Suraj Shirke,"Energy Compaction and Image Splitting for Image Retrieval using Kekre Transform over Row and Column Feature Vectors", International Journal of Computer Science and Network Security (IJCSNS),Volume:10, Number 1, January 2010, (ISSN: 1738-7906) Available at www.IJCSNS.org.

[21] Dr. H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shah, Prathmesh Verlekar, Suraj Shirke, "Walsh Transform over Row Mean and Column Mean using Image Fragmentation and Energy Compaction for Image Retrieval", International Journal on Computer Science and Engineering (IJCSE),Volume 2S, Issue1, January 2010, (**ISSN: 0975–3397). Available online at www.enggjournals.com/ijcse.**

[22] Dr. H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Color-Texture Features Extracted from Walshlet Pyramid", ICGST International Journal on Graphics, Vision and Image Processing (GVIP), Volume 10, Issue I, Feb.2010, pp.9-18, Available online www.icgst.com/gvip/Volume10/Issue1/P1150938876.html

[23] Dr. H.B.Kekre, Sudeep D. Thepade, "Color Based Image Retrieval using Amendment Block Truncation Coding with YCbCr Color Space", International Journal on Imaging (IJI), Volume 2, Number A09, Autumn 2009, pp. 2-14. Available online at **www.ceser.res.in/iji.html.**

[24] Dr. H.B.Kekre, Tanuja Sarode, Sudeep D. Thepade, "Color-Texture Feature based Image Retrieval using DCT applied on Kekre's Median Codebook", International Journal on Imaging (IJI), Volume 2, Number A09, Autumn 2009,pp. 55-65. Available online at **www.ceser.res.in/iji.html (ISSN: 0974-0627).**

[25] Dr. H.B.Kekre, Sudeep D. Thepade, Akshay Maloo "Performance Comparison for Face Recognition using PCA, DCT &WalshTransform of Row Mean and Column Mean", ICGST International Journal on Graphics, Vision and Image Processing (GVIP), Volume 10, Issue II, Jun.2010, pp.9-18, Available online http://209.61.248.177/gvip/Volume10/Issue2/P1181012028.pdf..

[26] Dr. H.B.Kekre, Sudeep D. Thepade, "Improving the Performance of Image Retrieval using Partial Coefficients of Transformed Image", International Journal of Information Retrieval**,** Serials Publications, Volume 2, Issue 1, 2009, pp. 72-79 (ISSN: 0974-6285)

[27] Dr. H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shah, Prathmesh Verlekar, Suraj Shirke, "Performance Evaluation of Image Retrieval using Energy Compaction and Image Tiling over DCT Row Mean and DCT Column Mean", Springer-International Conference on Contours of Computing Technology (Thinkquest-2010), Babasaheb Gawde Institute of Technology, Mumbai, 13-14 March 2010, The paper will be uploaded on online Springerlink.

[28] Dr. H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, Vaishali Suryavanshi,"Improved Texture Feature Based Image Retrieval using Kekre's Fast Codebook Generation Algorithm", Springer-International Conference on Contours of Computing Technology (Thinkquest-2010), Babasaheb Gawde Institute of Technology, Mumbai, 13-14 March 2010, The paper will be uploaded on online Springerlink.

[29] Dr. H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, "Image Retrieval by Kekre's Transform Applied on Each Row of Walsh Transformed VQ Codebook", (Invited), ACM-International Conference and Workshop on Emerging Trends in Technology (ICWET 2010),Thakur College of Engg. And Tech., Mumbai, 26-27 Feb 2010, The paper is invited at ICWET 2010. Also will be uploaded on online ACM Portal.

[30] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, "Image Retrieval using Shape Texture Patterns generated from Walsh-Hadamard Transform and Gradient Image Bitmaps", International Journal of Computer Science and Information Security (IJCSIS), Volume 8, Number 9, 2010.pp.76-82 (ISSN: 1947-5500), Available online at http://sites.google.com/site/ijcsis

[31] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, "Performance Comparison of Texture Pattern based Image Retrieval using Haar Transform with Binary and Ternary

Image Maps”, International Journal of Computer Applications (IJCA), Proceedings on International Conference and workshop on Emerging Trends in Technology (ICWET 2011), Number 3, Artilcle 5, 2011.pp.23-28 (ISBN: 978-93-80747-67-2), Available online at http://www.ijcaonline.org

[32] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, “Query by Image Texture Pattern content using Haar Transform Matrix and Image Bitmaps”, Invited at ACM International Conference and Workshop on Emerging Trends in Technology (ICWET 2011), TCET, Mumbai, 25-26 Feb 2011.

[33] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, “Amelioration of Walsh-Hadamard Texture Patterns based Image Retrieval using HSV Color Space”, International Journal of Computer Science and Information Security (IJCSIS), Volume 9, Number 3, 2011 (ISSN: 1947-5500), Available online at http://sites.google.com/site/ijcsis

[34] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, “Image Retrieval using Texture Patterns generated from Walsh-Hadamard Transform Matrix and Image Bitmaps”, (Selected) Springer International Conference on Technology Systems and Management (ICTSM 2011), MPSTME and DJSCOE, Mumbai, 25-27 Feb 2011.

[35] Dr. H.B.Kekre, Sudeep D. Thepade, Shrikant Sanas, “Improving Performance of multileveled BTC based CBIR using Sundry Color Spaces”, CSC International Journal of Image Processing (IJIP), Volume 4, Issue 6, Computer Science Journals, CSC Press, www.cscjournals.org

[36] Dr. H.B.Kekre, Sudeep D. Thepade, Akshay Maloo “Performance Comparison of Image Retrieval Using Fractional Coefficients of Transformed Image Using DCT, Walsh, Haar and Kekre’s Transform”, CSC International Journal of Image Processing (IJIP), Volume 4, Issue 2, pp 142-157, Computer Science Journals, CSC Press, www.cscjournals.org

[37] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, “Performance Comparison of Texture Pattern Based Image Retrieval Methods using Walsh, Haar and Kekre Transforms with Assorted Thresholding Methods”, International Journal of Computer Science and Information Security (IJCSIS), Volume 9, Number 3, 2011 (ISSN: 1947-5500), Available online at http://sites.google.com/site/ijcsis

[38] Dr. H. B. Kekre, Sudeep D. Thepade, Varun K. Banura, “Performance Comparison of Gradient Mask Texture Based Image Retrieval Techniques using Walsh, Haar and Kekre Transforms with Image Maps”, International Journal of Computer Applications (IJCA), Proceedings on International Conference on Technology Systems and Management (ICTSM 2011), Number 3, Artilcle 8, 2011 (ISBN: 978-93-80746-62-5), Available online at http://www.ijcaonline.org

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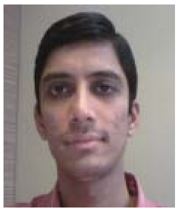

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