Performance Comparison of Texture Pattern based Image Retrieval using Haar Transform with Binary and Ternary Image Maps

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ABSTRACT
The theme of the work presented here is performance comparison of texture pattern based image retrieval techniques using Haar transform with binary image maps and ternary image maps. Different texture patterns namely '4-pattern', '16-pattern', '64-pattern' , '256-pattern' and '1024-pattern' are generated using Haar transform matrix and then compared with the two image maps binary and ternary (one a time) to generate the feature vector as the matching number of ones & minus ones (in case of binary image maps) and ones, zeros and minus ones (in case of ternary image maps) per texture pattern. The proposed content based image retrieval (CBIR) techniques are tested on a generic image database having 1000 images spread across 11 categories. For each proposed CBIR technique 55 queries (randomly selected 5 per category) are fired on the image database. To compare the performance of image retrieval techniques, crossover point of average precision and recall values of all the queries are computed per image retrieval technique. Ameliorated performance (higher precision and recall values) has been observed with the ternary image maps. Further the performance of proposed image retrieval methods is enhanced using the combination of original image and even image part. In the discussed image retrieval methods, the combination of original and even image part for 16-pattern texture with ternary image maps gives the highest crossover point of precision and recall reflecting better performance.

Categories and Subject Descriptors
1.4 Image Processing and Computer Vision
1.4.2 Compression (Coding):- Approximate methods
H.3.3 [Information Search and Retrieval]

General Terms
Algorithms, Performance

Keywords
CBIR, Haar transform, Texture, Pattern, Binary, Ternary, Image maps

1. INTRODUCTION
One of the major challenges being faced by the technicians in various disciplines of ICT is to store, transmit, index and manage image data effectively to make easy access to the image databases of humongous size being generated due to large numbers of images generated from diverse sources like 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 thirst for better 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'.

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

2. HAAR TRANSFORM

This sequence was proposed in 1909 by AlfrédHaar [21]. Haar used these functions to give an example of a countable orthonormal system for the space of square-integrable functions on the real line [9,22]. For full 2-Dimensional Haar Transform for an NxN image the number of additions required are $2N^2\log_2(N)$ and no multiplications needed. The Haar transform can be generated using the function ψ(t) can be described as:

$$\psi(t) = \begin{cases} 1 & ,0 \le t < \frac{1}{2} \\ -1 & ,\frac{1}{2} \le t < 1 \\ 0 & ,\text{otherwise} \end{cases} \qquad (2)$$

and its scaling function φ(t) can be described as:

$$\varphi(t) = \begin{cases} 1 & ,0 \le t < 1 \\ 0 & ,\text{otherwise} \end{cases} \qquad (3)$$

Using the Haar transform matrix assorted texture patterns namely 4-pattern, 16-pattern, 64-pattern, 256-pattern and 1024-pattern are generated. To generate N2 texture patterns, each row of the Haar matrix of size NxN is multiplied with every element of all possible rows of the same matrix (one row at a time to get one pattern). The texture patterns obtained are orthogonal in nature.

$$\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

1(a). 2x2 Haar transform matrix

$$\begin{array}{c} \\ 1 \\ 1 \end{array}\begin{array}{c} 1 \quad 1 \\ \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix} \end{array} \quad \begin{array}{c} 1 \quad 1 \\ \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix} \end{array}\begin{array}{c} \\ 1 \\ -1 \end{array}$$

$$\begin{array}{c} 1 \\ 1 \\ \\ \end{array}\begin{array}{c} \begin{bmatrix} 1 & -1 \\ 1 & -1 \end{bmatrix} \\ 1 \quad -1 \end{array} \quad \begin{array}{c} \begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix} \\ 1 \quad -1 \end{array}\begin{array}{c} 1 \\ -1 \\ \\ \end{array}$$

1(b). '4-pattern' texture patterns

Figure 1. Generation of '4-pattern' Haar texture patterns

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

2(a). 4x4 Haar transform matrix

$$\begin{array}{c} \\ 1 \\ 1 \\ 1 \\ 1 \end{array}\begin{array}{c} 1 \quad 1 \quad 1 \quad 1 \\ \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix} \end{array} \quad \begin{array}{c} 1 \quad -1 \quad 0 \quad 0 \\ \begin{bmatrix} 1 & -1 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 1 & -1 & 0 & 0 \\ 1 & -1 & 0 & 0 \end{bmatrix} \end{array}\begin{array}{c} \\ 1 \\ 1 \\ 1 \\ 1 \end{array}$$

$$\begin{array}{c} 1 \\ 1 \\ 1 \\ 1 \\ \\ \end{array}\begin{array}{c} \begin{bmatrix} 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & 1 & -1 & -1 \end{bmatrix} \\ 1 \quad 1 \quad -1 \quad -1 \end{array} \quad \begin{array}{c} \begin{bmatrix} 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & -1 \\ 0 & 0 & 1 & -1 \end{bmatrix} \\ 0 \quad 0 \quad 1 \quad -1 \end{array}\begin{array}{c} 1 \\ 1 \\ 1 \\ 1 \\ \\ \end{array}$$

2(b). First four of the '16-pattern' texture patterns

Figure 2. First four of the '16-pattern' Haar texture patterns

Figure 1(a) shows a 2X2 Haar transform matrix. The four texture patterns generated using this matrix are shown in figure 1(b). Similarly figure 2(b) shows first four texture patterns (out of total 16) generated using 4X4 Haar transform matrix shown in figure 2(a).

3. GENERATION OF IMAGE MAPS

Image bitmaps of colour image are generated using three independent red (R), green (G) and blue (B) components of image to calculate three different thresholds and one overall luminance threshold. 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 4, 5 & 6. Let the luminance threshold T be as given by equation 7

$$TR = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n} R(i,j) \qquad (4)$$

$$TG = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n} G(i,j) \qquad (5)$$

$$TB = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n} B(i,j) \qquad (6)$$

$$T = \frac{TR + TG + TB}{3} \qquad (7)$$

3.1 Binary Image Maps

Here three bitmaps will be computed as BMr, BMg and BMb. If a pixel in each component (R, G, and B) is greater than or equal to the respective threshold, the corresponding pixel position of the bitmap will have a value of 1 otherwise it will have a value of -1.

$$BMr(i,j) = \begin{cases} 1, & if.R(i,j) >= TR \\ -1, & if.R(i,j) < TR \end{cases} \quad (8)$$

$$BMg(i,j) = \begin{cases} 1, & if.G(i,j) >= TG \\ -1, & if.G(i,j) < TG \end{cases} \quad (9)$$

$$BMb(i,j) = \begin{cases} 1, & if.B(i,j) >= TB \\ -1, & if.B(i,j) < TB \end{cases} \quad (10)$$

3.2 Ternary Image Maps

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 11, 12and 13.

$$Tshrl = TR - |TR - T| \quad , \quad Tshrh = TR + |TR - T| \quad (11)$$

$$Tshgl = TG - |TG - T| \quad , \quad Tshgh = TG + |TG - T| \quad (12)$$

$$Tshbl = TB - |TB - T| \quad , \quad Tshbh = TB + |TB - T| \quad (13)$$

Then the individual colour plane global ternary image maps are computed (TMr, TMg and TMb) as given in equations 14, 15 and 16. If a pixel value of respective colour 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'.

$$TMr(i,j) = \begin{cases} 1, & if.R(i,j) > Tshrh \\ 0, & if.Tshrl <= R(i,j) <= Tshrh \\ -1, & if.R(i,j) < Tshrl \end{cases} \quad (14)$$

$$TMg(i,j) = \begin{cases} 1, & if.G(i,j) > Tshgh \\ 0, & if.Tshgl <= G(i,j) <= Tshgh \\ -1, & if.G(i,j) < Tshgl \end{cases} \quad (15)$$

$$TMb(i,j) = \begin{cases} 1, & if.B(i,j) > Tshbh \\ 0, & if.Tshbl <= B(i,j) <= Tshbh \\ -1, & if.B(i,j) < Tshbl \end{cases} \quad (16)$$

4. PROPOSED CBIR METHODS

The feature vector of the image is generated by comparing the image maps with the Haar texture patterns for matching number of ones & minus ones (in case of binary image maps) and ones, zeros and minus ones (in case of ternary image maps). The size of the feature vector of the image is given by equation 17.

Feature vector size= 2*3*(no. of considered texture-pattern) (17)

Five assorted texture pattern sets are used along with original and original-even image to unfold twenty novel feature vector generation methods giving rise to twenty new image retrieval techniques. In the proposed CBIR techniques the combination of original and even part of images gives better results than the original image alone [1,2]. 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. Also the feature vector size is independent of image size in proposed CBIR methods.

Table 1. Feature vector size of discussed image retrieval techniques

CBIR Technique	Feature vector size for Binary Image Maps	Feature vector size for Ternary Image Maps
4-Pattern	8	12
16-Pattern	32	48
64-Pattern	128	192
256-Pattern	512	768
1024-Pattern	2048	3072

5. 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 augmented Wang image database [18] of 1000 variable size images spread across 11 categories of human being, animals, natural scenery and manmade things. The categories and distribution of the images is shown in table 2.

To analyse the effectiveness of proposed CBIR techniques, the average precision and recall values of the 55 queries (randomly selected 5 from each image category) have been used as statistical comparison parameters [4,5]. These two parameters have been defined in the equations 11 and 12.

$$\Pr ecision = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (11)$$

$$\text{Recall} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (12)$$

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	

6. RESULTS AND DISCUSSIONS

The performance of the proposed CBIR methods is tested by firing 55 queries (randomly selected 5 from each image category) on the image database. The feature vector of query image and database image are matched using the Euclidian distance. The average precision and recall values are found for all the proposed CBIR methods. The intersection of precision and recall values gives the crossover point. The crossover point of precision and recall is computed for all the proposed CBIR methods. The CBIR technique with higher value of crossover point indicates better performance.

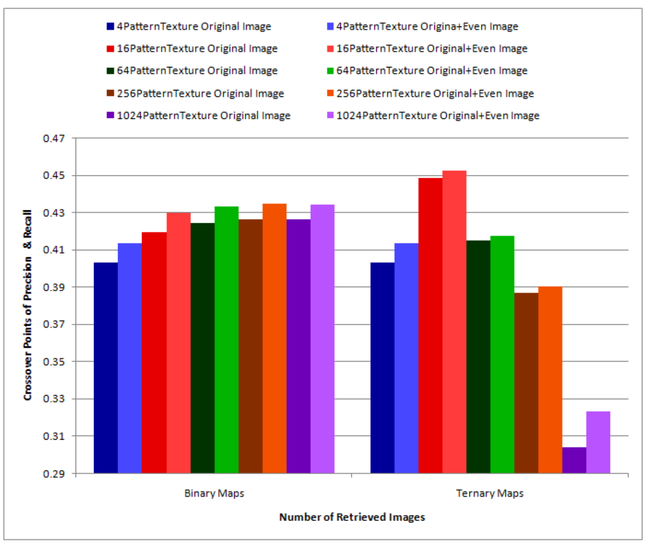

Figure 3. Performance comparison of proposed CBIR methods with binary and ternary image maps

Figure 3 shows the performance comparison of proposed CBIR methods with the binary and ternary image maps. It is observed that in case of binary image maps the performance of the texture pattern based image retrieval increases with increase in number of texture patterns generated. The crossover points of the '256-pattern' texture and '1024-pattern' texture based image retrieval are almost same indicating that the texture based image retrieval gives improved performance up to a certain level only. Moreover as the number of texture patterns generated is increased the size of the feature vector also increases thus increasing the time complexity for query execution. In case of ternary image maps '16-pattern' texture based image retrieval with combination of original and even image gives the highest precision-recall crossover point indicating better performance. Beyond this, on increasing the number of texture patterns, the results start deteriorating.

From the comparison of proposed texture based image retrieval techniques using binary and ternary image maps, it is observed that '16-pattern' texture based image retrieval using ternary image maps with the combination of original and even image gives the highest precision-recall crossover point indicating better performance. The size of the feature vector in '16-pattern' texture based method is around ten times smaller than that of '256-pattern' texture based image retrieval method using binary image maps [30]. Since the size of the feature vector is reduced so is the time complexity in query execution. Feature extraction using the combination of original image with even part of image further improves the performance of the proposed texture pattern based CBIR. Increasing the number of texture patterns helps in performance amelioration up to certain extent only beyond which the performance is degraded and the size of feature vector is also increased.

7. CONCLUSION

As compared to the texture pattern based image retrieval using Haar transform with binary image maps [30], the performance of image retrieval can be ameliorated using the ternary image maps. Among the various texture patterns used for content based image retrieval, "16-pattern" texture patterns using ternary image maps give the best result with the combination of original image and even image part. The precision-recall crossover point of this texture pattern is higher than that of texture patterns with binary image maps [30]. Moreover, it is observed that the performance of proposed CBIR method improves with increasing number of texture patterns up to a certain level. The combination of original image with even image part gives ameliorated performance than the original image alone.

8. 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] Haar, Alfred, "ZurTheorie der orthogonalenFunktionensysteme". (German), MathematischeAnnalen, volume 69, No. 3, 1910, pp. 331–371.

[22] Charles K. Chui, "An Introduction to Wavelets", Academic Press, 1992, San Diego, ISBN 0585470901.

[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, "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.