Performance Comparison of Gradient Mask Texture Based Image Retrieval Techniques using Walsh, Haar and Kekre Transforms with Image Maps

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ABSTRACT
The theme of the work presented here is performance comparison of gradient mask texture based image retrieval techniques using Walsh, Haar and Kekre transforms with image maps. The shape of the image is extracted by using three different gradient operators (Prewitt, Robert and Sobel) with slope magnitude method followed by generation of image maps (binary image maps in case of Walsh transform and ternary image maps in case of Haar/Kekre transforms) of the shape feature extracted. These image maps are then compared with the different texture patterns namely '4-pattern', '16-pattern' and '64-pattern' generated using Walsh, Haar and Kekre transform matrices to produce the feature vector as the matching number of ones and minus ones (in case of Walsh transform) and matching number of ones, minus ones & zeros (in case of Haar/Kekre transforms) 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 image category) are fired on the image database. To compare the performance of image retrieval techniques average precision and recall of all the queries per image retrieval technique are computed. In the discussed image retrieval methods, the '64-pattern' shape texture generated using Kekre transform matrix with Sobel as gradient operator gives the highest crossover point of precision and recall indicating 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, Gradient operators; Walsh, Haar & Kekre Transforms; Texture Pattern; Binary Image Maps; Ternary Image Maps

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 [10,13,14]. The image indexing is studied in the perspective of image database [11,15,16,19,20] 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 [21,23], museums, archaeology [12], architecture design [17,22], geographic information systems [14], weather forecast [14,31], medical imaging [14,27], trademark databases [30,32], criminal investigations [33,34], image search on the Internet [18,28,29]. The paper attempts to provide better and faster image retrieval techniques.

1.1 Content Based Image Retrieval
For the first time Kato et.al. [13] 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 [25,26] 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 [25,26,35].

For feature extraction in CBIR there are mainly two approaches [14] feature extraction in spatial domain and feature extraction in transform domain. The feature extraction in spatial domain includes the CBIR techniques based on histograms [14], BTC [10,11,25], VQ [30,34,35]. The transform domain methods are widely used in image compression, as they give high energy compaction in transformed image [26,33]. So it is obvious to use images in transformed domain for feature extraction in CBIR [32]. But taking transform of image is time consuming. Spatial feature based CBIR methods are given in [36] as mask-shape CBIR and mask-shape BTC CBIR. The proposed CBIR methods are further attempting to improve the performance of these shape based image retrieval with help of shape texture patterns. Here the query execution time is further reduced by decreasing the feature vector size further and making it independent of image size unlike the colour averaging [7,8,9] based CBIR techniques which are dependent on the size of the image. Many current CBIR systems use the Euclidean distance [10-12,17-23] 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. EDGE DETECTION MASKS

Edge detection is a very important in image analysis. As the edges give idea about the shapes of objects present in the image so they are useful for segmentation, registration, and identification of objects in a scene. An edge is a jump in intensity. An ideal edge is a discontinuity (i.e., a ramp with an infinite slope). The first derivative assumes a local maximum at an edge. The various gradient operators [19] used for edge extraction are Prewitt, Roberts and Sobel.

3. SLOPE MAGNITUDE METHOD

The problem with edge extraction using gradient operators is detection of edges in only either horizontal or vertical directions. Shape feature extraction in image retrieval requires the extracted edges to be connected in order to reflect the boundaries of objects present in the image. Slope magnitude method is used along with the gradient operators (Prewitt, Robert and Sobel) to extract the shape features [6] in form of connected boundaries. The process of applying the slope magnitude method is given as follows. First one needs to convolve the original image with the Gx mask to get the x gradient and Gy mask to get the y gradient of the image. Then the individual squares of both are taken. Finally the two squared terms are added and square root of this sum is taken as given in equation 2.

$$G = \sqrt{G_x^2 + G_y^2} \qquad (2)$$

4. TEXTURE PATTERN GENERATION

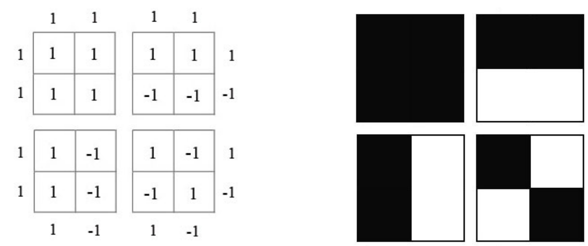
Using the non-sinusoidal transform matrices assorted texture patterns namely 4-pattern, 16-pattern and 64-pattern are generated. To generate N^2 texture patterns (N^2-pattern), NxN transform matrix is considered and the element wise multiplication of each row of the transform matrix is taken with all possible rows of the same matrix (consideration of one row at a time gives one pattern). The texture patterns obtained are orthogonal in nature. The texture pattern generation methods using Walsh transform, Haar transform and Kekre transform are elaborated respectively in sections 4.1, 4.2 and 4.3 as given below.

4.1 Walsh Texture Pattern Generation

The 4, 16 and 64 Walsh texture patterns [1,2,4,6] are generated using Walsh transform matrices [27,28,32] of size 2x2, 4x4 and 8x8 respectively. The generated four and sixteen Walsh texture patterns are shown in figure 1, 2x2 Walsh transform matrix is shown as 1(a), each row of this matrix is considered one at a time and is multiplied with all rows of the same matrix to generate Walsh texture patterns as shown in 1(b). Figure 1(c) gives the envisioned 4 Walsh texture patterns (4-pattern). The 4x4 Walsh transform matrix is given in 1(d) and visualization of 16 Walsh transform patterns generated using it is shown in 1(e), where black color represent the values '1' in the pattern and values '-1' are represented by white color. The obtained Walsh texture patterns then are resized as the size of image for which texture features have to be extracted.

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

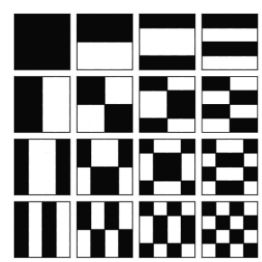
(a) 2x2 Walsh Matrix



(b) 2x2 Walsh Matrix

(c) Generated 4 Walsh Texture Patterns (4-pattern)

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



(d) 4x4 Walsh Matrix

(e) Generated 16 Walsh Texture Patterns (16-pattern)

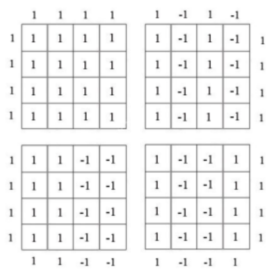
Figure 1. Walsh Texture Pattern Generation

4.2 Haar Texture Pattern Generation

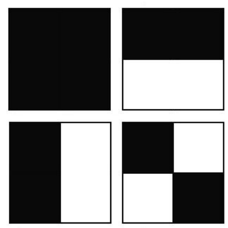
The 2x2, 4x4 and 8x8 Haar transform matrices are used to generate the 4, 16 and 64 Haar texture patterns [1,3,5] respectively. The generation of four and sixteen Haar texture patterns is shown in figure 2. 2x2 Haar transform matrix [37,38] is shown as 2(a), each row of this matrix is considered one at a time and is multiplied with all rows of the same matrix to generate Haar texture patterns as shown in 2(b). Figure 2(c) gives the visualization 4 Haar texture patterns (4-pattern). The 4x4 Haar transform matrix is given in 2(d) and 16 Haar transform patterns generated using it, are shown in 2(e), where black colour represent the values '1' in the pattern, grey colour represents values '0' and values '-1' are represented by white colour. The obtained Haar texture patterns then are resized as the size of image for which texture features have to be extracted. All the generated texture patterns are orthogonal to each other.

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

(a) 2x2 Haar Matrix



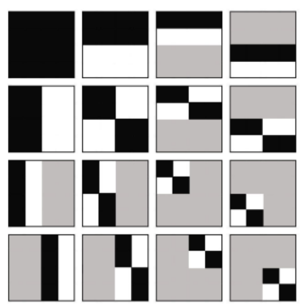
(b) 2x2 Haar Matrix



(c) Generated 4 Haar Texture Patterns (4-pattern)

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

(d) 4x4 Haar Matrix



(e) Generated 16 Haar Texture Patterns (16-pattern)

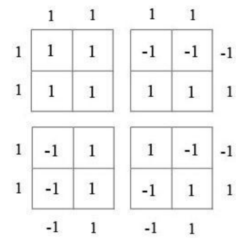
Figure 2. Haar Texture Pattern Generation

4.3 Kekre Texture Pattern Generation

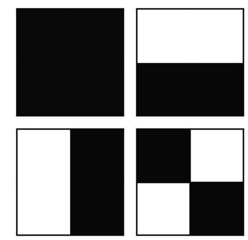
The 4, 16 and 64 Kekre texture patterns [1] are generated using Kekre transform matrices [39, 40] of size 2x2, 4x4 and 8x8 respectively. Figure 3 gives generation of four and sixteen Kekre texture patterns. 2x2 Kekre transform matrix is shown as 3(a), each row of this matrix is considered one at a time and is multiplied with all rows of the same matrix to generate Kekre texture patterns as shown in 3(b) with all the negative values are replaced by '-1'. Figure 3(c) gives visualization of the 4 Kekre texture patterns (10-pattern). The 4x4 Kekre transform matrix is given in 3(d) and visualization of 16 Kekre transform patterns generated using it is shown in 3(e), where black colour represent the values '1' in the pattern, grey colour represent the values '0' and values '-1' are represented by white colour. The obtained Kekre texture patterns then are resized as the size of image for which texture features have to be extracted.

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

(a) 2x2 Kekre Matrix



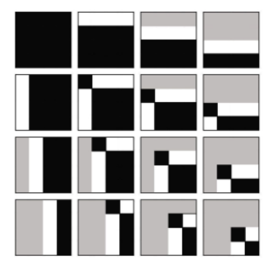
(b) 2x2 Kekre Matrix



(c) Generated 4 Kekre Texture Patterns (4-pattern)

$$\begin{bmatrix} 1 & 1 & 1 & 1 \\ -3 & 1 & 1 & 1 \\ 0 & -2 & 1 & 1 \\ 0 & 0 & -1 & 1 \end{bmatrix}$$

(d) 4x4 Kekre Matrix



(e) Generated 16 Kekre Texture Patterns (16-pattern)

Figure 3. Kekre Texture Pattern Generation

5. GENERATION OF IMAGE MAPS

Image maps of colour image are generated using three independent red (R), green (G) and blue (B) components of Prewitt/Robert/Sobel filtered image obtained using slope magnitude method. 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 slope magnitude gradient of color image in RGB space.

5.1 Binary Image Maps

Here three binary image maps [1,2,3,4,6] are computed as BMr, BMg and BMb given by equations 3, 4 and 5. If a pixel in each component (R, G, and B) is greater than or equal to 128, the corresponding pixel position of the bitmap will have a value of 1 otherwise it will have a value of -1.

$$BMr(i,j) = \begin{cases} 1, & if.R(i,j) >= 128 \\ -1, & if.R(i,j) < 128 \end{cases} \qquad (3)$$

$$BMg(i,j) = \begin{cases} 1, & if.G(i,j) >= 128 \\ -1, & if.G(i,j) < 128 \end{cases} \quad (4)$$

$$BMb(i,j) = \begin{cases} 1, & if.B(i,j) >= 128 \\ -1, & if.B(i,j) < 128 \end{cases} \quad (5)$$

5.2 Ternary Image Maps

Here for each colour plane ternary image maps [1,3] are computed (TMr, TMg and TMb) which are given by the equations 6, 7 and 8. If a pixel value of respective colour component is greater than 170, the corresponding pixel position of the image map gets a value 'one'; else if the pixel value is less than 85, the corresponding pixel position of the image map gets a value of 'minus one'; otherwise it gets a value 'zero'.

$$TMr(i,j) = \begin{cases} 1, & if..R(i,j) > 170 \\ 0, & if.85 <= R(i,j) <= 170 \\ -1, & if.R(i,j) < 85 \end{cases} \quad (6)$$

$$TMg(i,j) = \begin{cases} 1, & if.G(i,j) > 170 \\ 0, & if.85 <= G(i,j) <= 170 \\ -1, & if.G(i,j) < 85 \end{cases} \quad (7)$$

$$TMb(i,j) = \begin{cases} 1, & if.B(i,j) > 170 \\ 0, & if.85 <= B(i,j) <= 170 \\ -1, & if.B(i,j) < 85 \end{cases} \quad (8)$$

6. PROPOSED CBIR METHODS

In the proposed gradient shape texture methods, the shape feature of the image is extracted using the three gradient operators Prewitt, Robert and Sobel. Then the image map of the shape feature is generated using the modified BTC technique. The image map thus obtained is compared with the different texture patterns like '4-pattern', '16-pattern' and '64-pattern' generated using Walsh, Haar and Kekre transform matrices to produce the feature vector as the matching number of ones and minus ones (in case of Walsh transform) & ones, minus ones and zeros (in case of Haar/Kekre transforms) per texture pattern. The size of the feature vector of the image is given by equation 9.

Feature vector size= s*3*(no. of considered texture-pattern) (9)

Where, s=2 for binary maps & s=3 for ternary maps

Using three different gradient operators in association with three assorted texture pattern sets generated using Walsh, Haar and Kekre transforms, total 27 novel feature vector generation methods can be used resulting into 27 new image retrieval techniques. The main advantage of proposed CBIR methods is improved performance resulting into better image retrieval. Here also the feature vector size is independent of image size in proposed CBIR methods unlike the colour averaging based CBIR [7,8,9].

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

7. 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 [24] 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.

Table 2. Image Database: Category-wise Distribution

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

To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters [10,11] for the proposed CBIR techniques. The standard definitions for these two measures are given by the equations 10 and 11.

$$\mathrm{Pr}ecision = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (10)$$

$$\mathrm{Re}call = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (11)$$

8. 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 and plotted against number of retrieved images (from 1 to 100). The intersection of plotted precision and recall curves give 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.

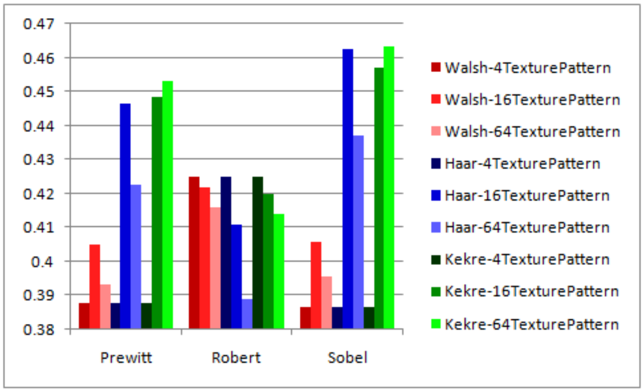


Figure 4. Performance comparison of proposed CBIR methods with different gradient operators

Figure 4 shows the performance comparison of proposed CBIR methods with different gradient operators. It is observed that in case of Prewitt and Sobel operators, the performance of proposed CBIR methods increases with increase in number of texture patterns up to a certain level ('16-pattern' texture for Wash and Haar transforms and '64-pattern' texture for Kekre transform). However in case of Robert operator, for all the three transforms the value of precision-recall crossover point decreases with increase in number of texture patterns thus indicating decrease in performance. 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.

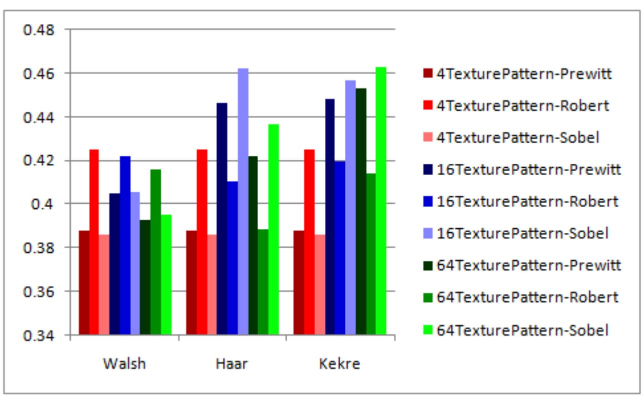


Figure 5. Performance comparison of proposed CBIR methods with Walsh, Haar and Kekre transforms

In case of Walsh transform, Robert operator gives better performance than the other two operators for all the three texture pattern set. '4-pattern' texture using Robert operator gives the best performance in case of Walsh transform. In Haar and Kekre transforms, Robert operator gives better result for '4-pattern' texture. However in case of '16-pattern' and '64-pattern' textures Sobel outperforms Robert and Prewitt operators.

In case of '4-pattern' texture all the three transforms give same performance with the three gradient operators. In '16-pattern' texture, Kekre transform gives best result for Prewitt operator while Walsh and Haar transforms give best results for Robert and Sobel operators respectively. In '64-patttern' texture, Kekre transform outperforms the other two for Prewitt and Sobel operator while Walsh transform again gives best result for Robert operator.

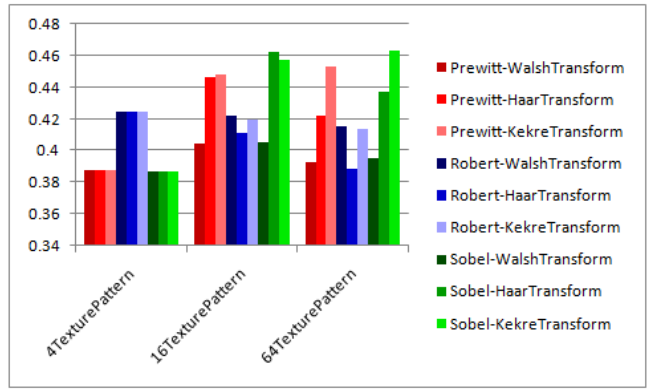


Figure 6. Performance comparison of proposed CBIR methods with different texture patterns

In all the discussed CBIR methods the '64-pattern' texture generated using Kekre transform with Sobel as gradient operator gives the best performance as indicated by higher precision-recall crossover point value.

9. PERFORMANCE COMPARISON OF VARIANTS IN GRADIENT MASK TEXTURE BASED CBIR METHODS

The novel image retrieval methods using shape texture patterns are presented in this section. Here in all 27 variations of proposed image retrieval methods with shape texture patterns are proposed using three image transforms (Walsh, Haar & Kekre), three types of texture patterns (4, 16 & 64) and three gradient operators (Prewitt, Robert and Sobel). The average of precision-recall crossover point values for respective variation is considered for the performance ranking of these variations. Three image transforms namely Walsh, Haar and Kekre are considered to generate shape texture patterns. From the results after experimentation it is found that the Kekre transform is showing best performance followed by Haar transform and then Walsh transform in proposed CBIR methods as indicated by average precision-recall crossover point values of shape texture based CBIR variants using respective image transform given in table 3. The number of texture patterns considered here are 4, 16 and 64. The 16 texture patterns have shown better performance in CBIR using texture patterns. The 64 texture patterns have given second best performance followed by 4 texture patterns with worst performance as per the average precision-recall crossover point values of shape texture based CBIR variants using respective number of texture patterns given in table 4. Among the three gradient operators used for generating the filtered image maps, Sobel gives the best performance followed by Robert and Prewitt as per the average precision-recall crossover point values of shape texture based CBIR variants using respective gradient operators given in table 5.

Table 3. Performance Comparison of Image Transforms used in image retrieval using Shape Texture Patterns

Comparative Performance	Image Transform	Average Crossover point Value
Best	**Kekre**	**0.428324**
Second Best	Haar	0.418614
Worst	Walsh	0.404003

Table 4. Performance Comparison of Number of Texture Patterns used in image retrieval using Shape Texture Patterns

Comparative Performance	Number of Texture Patterns	Average Crossover point Value
Best	**16 Pattern**	**0.430834**
Second Best	64 Pattern	0.420316
Worst	4 Pattern	0.399791

Table 5. Performance Comparison of Gradient Operators used in image retrieval using Shape Texture Patterns

Comparative Performance	Gradient Operator	Average Crossover point Value
Best	**Sobel**	**0.420054**
Second Best	Robert	0.416252
Worst	Prewitt	0.414636

10. REFERENCES

[1] 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

[2] 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

[3] 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

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

[5] 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. The paper will be uploaded online on ACM portal.

[6] 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

[7] 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

[8] 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.

[9] 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.

[10] 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

[11] 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.

[12] 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.

[13] 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

[14] 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.

[15] 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.

[16] 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.

[17] 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.

[18] 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.

[19] R.C. Gonsalez, R.E. Woods "Digital Image Processing", Second Edition, Pearson Publication

[20] 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.

[21] 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.

[22] 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.

[23] 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.

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

[25] 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.

[26] 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.

[27] 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.**

[28] 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

[29] 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.**

[30] 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).**

[31] 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..

[32] 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)

[33] 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.

[34] 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.

[35] 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.

[36] Dr. H.B.Kekre, Sudeep D. Thepade, Shobhit W., P. Mukharjee, S. Singh, Miti K., "Image Retrieval with Shape Features Extracted using Gradient Operators and Slope Magnitude Technique with BTC", International Journal of Computer Applications (IJCA), Volume 6, Number 8, pp.28-23, September 2010. Available online at http://www.ijcaonline.org/volume6/number8/pxc3871430.pdf

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

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

[39] Dr. H. B. Kekre, Sudeep D. Thepade, "Image Retrieval using Non-Involutional Orthogonal Kekre's Transform", International Journal of Multidisciplinary Research and Advances in Engineering (IJMRAE), Ascent Publication House, 2009, Volume 1, No.I, pp 189-203, 2009. Abstract available online at www.ascent-journals.com

[40] 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

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