Performance Comparison of Gradient Mask Texture based Image Retrieval Techniques using Global and Local Hybrid Wavelet Transforms with Ternary 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 global and local hybrid wavelet transforms generated from the combination of Walsh, Haar and Kekre transforms. Ternary image maps of Prewitt/Robert/Sobel filtered images are compared with '64-pattern' texture set generated using local and global hybrid wavelet transforms for matching number of ones, minus ones & zeros 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 Haar-Walsh (HW) global hybrid wavelet transform matrix with Sobel as gradient operator gives the highest crossover point of precision and recall indicating better performance.

Keywords
CBIR, Walsh, Haar, Kekre, Hybrid Wavelet Transforms, Texture Patterns, Shape, 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].

1.1 Content Based Image Retrieval
For the first time Kato et all [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'.

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

2. EGDE 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. Sobel Operator is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. The Sobel mask can be depicted as shown in equation 2 and 3.

$$G_x = \begin{bmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \quad (2)$$

$$G_y = \begin{bmatrix} +1 & 0 & -1 \\ +2 & 0 & -2 \\ +1 & 0 & -1 \end{bmatrix} \quad (3)$$

Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. The Prewitt mask can be defined as given in equations 4 and 5.

$$G_x = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & +1 & +1 \end{bmatrix} \quad (4)$$

$$G_y = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ -1 & 0 & +1 \end{bmatrix} \quad (5)$$

Equations 6 and 7 show the Roberts gradient operators. It is used to detect edges applying a horizontal and vertical filter in sequence.

$$G_x = \begin{bmatrix} +1 & 0 \\ 0 & -1 \end{bmatrix} \quad (6)$$

$$G_y = \begin{bmatrix} 0 & +1 \\ -1 & 0 \end{bmatrix} \quad (7)$$

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 & 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 8.

$$G = \sqrt{G_x^2 + G_y^2} \quad (8)$$

For the sample image shown in Figure 1(a), the shape features extracted using the gradient operators Prewitt, Robert and Sobel are respectively shown in Figures 1(b), 1(c) and 1(d).

Figure 1(a): Input Image for Slope Magnitude Technique

Figure 1(b): Shape extracted using Slope Magnitude Technique with Prewitt Operator

Figure 1(c): Shape extracted using Slope Magnitude Technique with Robert Operator

Figure 1(d): Shape extracted using Slope Magnitude Technique with Sobel Operator

Figure 1: Slope Magnitude Method

4. GENERATION OF HYBRID WAVELET TRANSFORM

The hybrid wavelet transform [42] matrix of size NxN (say 'T_{AB}') can be generated from two orthogonal transform matrices [38,42] (say A and B respectively with sizes pxp and qxq, where N=p*q=pq) as given by Figures 2 and 3. Here first 'q' number of rows of the hybrid wavelet transform matrix are calculated as the product of each element of first row of the orthogonal transform A with each of the columns of the orthogonal transform B. For next 'q' number of rows of hybrid wavelet transform matrix the second row of the orthogonal transform matrix A is shift rotated after being appended with zeros as shown in Figure 3. Similarly the other rows of hybrid wavelet transform matrix are generated (as set of q rows each time for each of the 'p-1' rows of orthogonal transform matrix A starting from second row up to last row).

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1p} \\ a_{21} & a_{22} & \cdots & a_{2p} \\ \vdots & \vdots & \vdots & \vdots \\ a_{p1} & a_{p2} & \cdots & a_{pp} \end{bmatrix} \qquad B = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1q} \\ b_{21} & b_{22} & \cdots & b_{2q} \\ \vdots & \vdots & \vdots & \vdots \\ b_{q1} & b_{q2} & \cdots & b_{qq} \end{bmatrix}$$

Figure 2: Orthogonal Transform Matrices

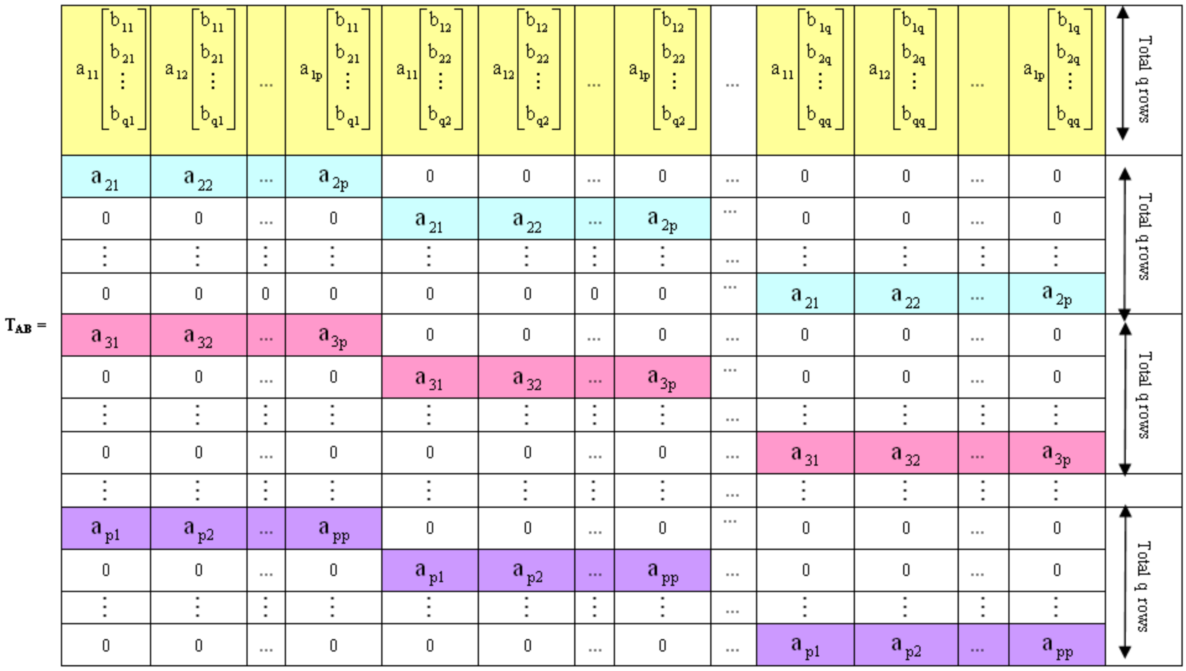

Figure 3: Generation of Hybrid Wavelet Transform

4.1 Generation of Global Hybrid Wavelet Transform

To generate '64-pattern' texture set, 8x8 hybrid wavelet transform is required. To generate a global hybrid wavelet transform of size 8x8, two orthogonal transform matrices A of size 2x2 and B of size 4x4 are required i.e. p=2, q=4 thus N=p*q=8. In this paper we have considered the combinations of Walsh, Haar and Kekre transform [1,37] matrices to generate 9 global hybrid transforms as Haar-Haar, Haar-Kekre, Haar-Walsh, Kekre-Haar, Kekre-Kekre and so on. However, since the 2x2 matrix is same for Haar and Walsh is same, the global hybrid wavelet transforms Haar-Haar & Walsh-Haar, Haar-Kekre & Walsh-Kekre and Haar-Walsh & Walsh-Walsh turn out to be same. Thus we consider only six global hybrid wavelet transforms as Haar-Haar (HH-Global), Haar-Kekre (HK-Global), Haar-Walsh (HW-Global), Kekre-Haar (KH-Global), Kekre-Kekre (KK-Global) and Kekre-Walsh (KW-Global). Figures 4(a), 4(b) and 4(c) show 2x2 Haar transform, 4x4 Walsh transform and 4x4 Kekre transform respectively. HW-Global and HK-Global hybrid wavelet transforms are shown in Figures 5(a) and 5(b) respectively.

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

Figure 4(a): 2x2 Haar Transform

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

Figure 4(b): 4x4 Walsh Transform

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

Figure 4(c): 4x4 Kekre Transform

Figure 4: Orthogonal Transform Matrices

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

Figure 5(a): 8x8 HW-Global

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

Figure 5(b): 8x8 HK-Global

Figure 5: Global Hybrid Wavelet Transforms

4.2 Generation of Local Hybrid Wavelet Transform

To generate '64-pattern' texture set, 8x8 hybrid wavelet transform is required. To generate a local hybrid wavelet transform of size 8x8, two orthogonal transform matrices A of size 4x4 and B of size 2x2 are required i.e. p=4, q=2 thus N=p*q=8. In this paper we have considered the combinations of Walsh, Haar and Kekre transform [1,37] matrices to generate 9 local hybrid transforms as Haar-Haar, Haar-Kekre, Haar-Walsh, Kekre-Haar, Kekre-Kekre and so on. However, since the 2x2 matrix is same for Haar and Walsh is same, the local hybrid wavelet transforms Haar-Haar & Haar-Walsh, Kekre-Haar & Kekre-Walsh and Walsh-Haar & Walsh-Walsh turn out to be same. Thus we consider only six local hybrid wavelet transforms as Haar-Kekre (HK-Local), Haar-Walsh (HW-Local), Kekre-Kekre (KK-Local), Kekre-Walsh (KW-Local), Walsh-Kekre (WK-Local) and Walsh-Walsh (WW-Local). Figures 6(a), 6(b) and 6(c) show 2x2 Walsh transform, 2x2 Kekre transform and 4x4 Haar transform respectively. HW-Local and HK-Local hybrid wavelet transforms are shown in Figures 7(a) and 7(b) respectively.

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

Figure 6(a): 2x2 Walsh Transform   Figure 6(b): 2x2 Kekre Transform   Figure 6(c): 4x4 Haar Transform

Figure 6: Orthogonal Transform Matrices

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

Figure 7(a): 8x8 HW-Local   Figure 7(b): 8x8 HK-Local

Figure 7: Local Hybrid Wavelet Transforms

5. TEXTURE PATTERN GENERATION

To generate N^2 texture patterns [1-6,37,39] (N^2-pattern), NxN hybrid wavelet 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). If a pixel value of a texture pattern is greater than zero then corresponding pixel value of the texture pattern is considered equal to ‘one’, the values that are less than zero are considered equal to ‘minus one’ and the remaining values are considered equal to ‘zero’. The texture patterns obtained are orthogonal in nature. The first sixteen texture patterns of the ‘64-pattern’ texture set generated using global and local hybrid wavelet transforms above are shown in Figures 8 and 9 respectively. Here black represents ‘1’, gray represents ‘0’ and white represents ‘-1’.

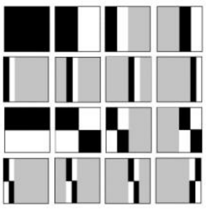

Figure 8(a): HH-Global

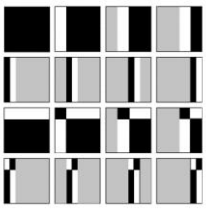

Figure 8(b): HK-Global

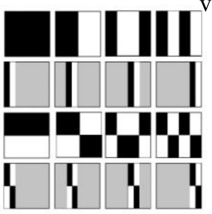

Figure 8(c): HW-Global

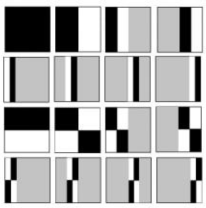

Figure 8(d): KH-Global

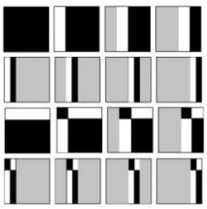

Figure 8(e): KK-Global

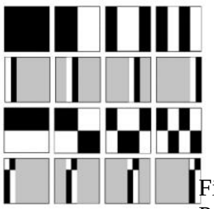

Figure 8(f): KW-Global

Figure 8: First sixteen texture patterns (out of total 64) generated using 8x8 Global Hybrid Wavelet Transforms

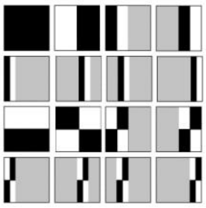

Figure 9(a): HK-Local

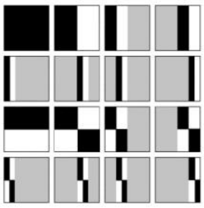

Figure 9(a): HW-Local

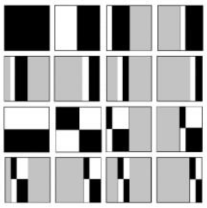

Figure 9(a): KK-Local

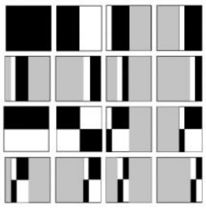

Figure 9(a): KW-Local

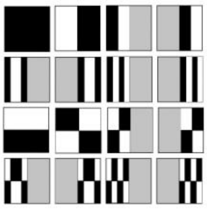

Figure 9(a): WK-Local

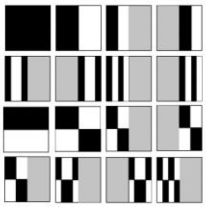

Figure 9(a): WW-Local

Figure 9: First sixteen texture patterns (out of total 64) generated using 8x8 Local Hybrid Wavelet Transforms

6. GENERATION OF TERNARY IMAGE MAPS

Image maps [1,2,3,4,6] of color 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. Here for each color plane ternary image maps [1,3] are computed (TMr, TMg and TMb) which are given by the equations 9, 10 and 11. If a pixel value of respective color 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’.

$$TMr(i,j) = \begin{cases} 1, & if..R(i,j) > 170 \\ 0, & if.85 <= R(i,j) <= 170 \\ -1, & if.R(i,j) < 85 \end{cases} \tag{9}$$

$$TMg(i,j) = \begin{cases} 1, & if.G(i,j) > 170 \\ 0, & if.85 <= G(i,j) <= 170 \\ -1, & if.G(i,j) < 85 \end{cases} \tag{10}$$

$$TMb(i,j) = \begin{cases} 1, & if.B(i,j) > 170 \\ 0, & if.85 <= B(i,j) <= 170 \\ -1, & if.B(i,j) < 85 \end{cases} \tag{11}$$

Figures 11, 12 and 13 show ternary image maps generated from Prewitt, Robert and Sobel filtered images respectively. The sample image from the database used to generate ternary image maps is shown in Figure 10.

Figure 10: Sample Input Image from the database for generating Ternary Image Maps

Figure 11(a): Ternary Image Map of R-Plane

Figure 11(b): Ternary Image Map of G-Plane

Figure 11(c): Ternary Image Map of B-Plane

Figure 11: Ternary Image Map of Prewitt filtered Image

Figure 12(a): Ternary Image Map of R-Plane

Figure 12(b): Ternary Image Map of G-Plane

Figure 12(c): Ternary Image Map of B-Plane

Figure 12: Ternary Image Map of Robert filtered Image

Figure 13(a): Ternary Image Map of R-Plane

Figure 13(b): Ternary Image Map of G-Plane

Figure 13(c): Ternary Image Map of B-Plane

Figure 13: Ternary Image Map of Sobel filtered Image

7. PROPOSED CBIR METHODS

In the proposed gradient shape texture based CBIR methods, the shape feature of the image is extracted using the three gradient mask operators Prewitt, Robert and Sobel. Then the ternary image map of the shape feature is generated using the modified BTC technique as described above. The ternary image map thus obtained is compared with the '64-pattern' texture set generated using global and local hybrid wavelet transforms to produce the feature vector as the matching number of ones, minus ones and zeros per texture pattern. The size of the feature vector (FV) of the image is given by equation 12.

FV size = s*p*(no. of considered texture-pattern)

Where, s=3 for ternary maps & p=3 for no. of color planes (12)

In all total thirty six variations of proposed CBIR method are possible using three different gradient operators in association with six global and six local hybrid wavelet transforms for '64-pattern' texture set. The main advantage of proposed CBIR methods is that the feature vector size is independent of image size unlike the color averaging [7,8,9,40] and vector quantization [41] based CBIR. Moreover the time complexity for query execution in the proposed CBIR methods is reduced due to reduction in size of feature vector resulting into faster image retrieval with better performance.

8. IMPLEMENATATION

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 1.

Table 1: Image Database Category-wise Distribution

Category	Tribes	Buses	Beaches
Number of Images	85	99	99
Category	**Horses**	**Mountains**	**Airplanes**
Number of Images	99	61	100
Category	**Dinosaurs**	**Elephants**	**Roses**
Number of Images	99	99	99
Category	**Monuments**	**Sunrise**	
Number of Images	99	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 13 and 14.

$$\text{Precision} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (13)$$

$$\text{Recall} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (14)$$

9. RESULTS AND DISCUSSION

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. The crossover points of average precision–recall values of proposed shape texture pattern based image retrieval methods are shown in Figures 14 and 15.

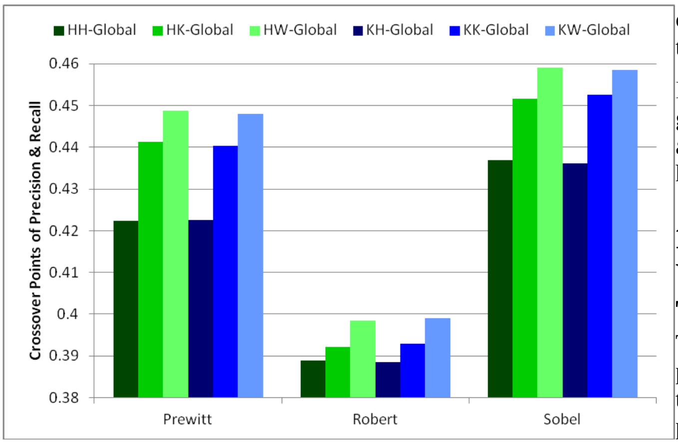

Figure 14: Performance comparison of proposed CBIR methods with different gradient operators for global hybrid wavelet transforms

Figure 14 shows the performance comparison of proposed CBIR methods with different gradient operators for global hybrid wavelet transforms. Here in case of global hybrid wavelets, it is observed from the graph that the gradient operator Sobel outperforms the gradient operators Prewitt and Robert in all the proposed CBIR methods. However gradient operator Robert gives the worst performance. In all the three gradient operators, it is observed from the precision-recall crossover points that HW-Global hybrid wavelet transform performs the best followed by KW-Global hybrid wavelet transform. Moreover it is observed that in the combination of global hybrid wavelet transform if the second transform matrix is Walsh then the performance is ameliorated and the performance is deteriorated if the second transform matrix is Haar.

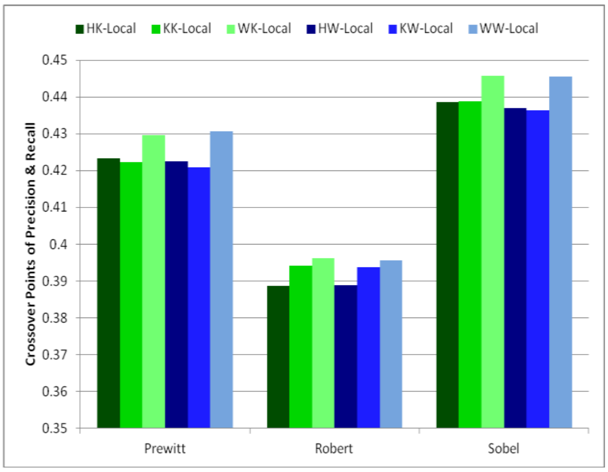

Figure 15: Performance comparison of proposed CBIR methods with different gradient operators for local hybrid wavelet transforms

Figure 15 shows the performance comparison of proposed CBIR methods with different gradient operators for local hybrid wavelet transforms. It can be observed from the graph that in local hybrid wavelet transform also gradient operator Sobel gives the best performance followed by Prewitt and Robert. In Robert and Sobel gradient operators WK-Local hybrid wavelet transform performs the best followed by WW-Local hybrid wavelet transform as indicated by precision-recall crossover point value. However in case of Prewitt operator, WW-Local outperforms other local hybrid wavelet transforms followed by WK-Local hybrid wavelet transform. Moreover it is observed that in the combination of local hybrid wavelet transforms if the first transform matrix is Walsh then the performance is best.

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

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

The novel image retrieval methods using gradient mask texture patterns are presented in this section. Here in all 36 variations of the proposed image retrieval methods with gradient mask texture patterns are proposed using six global (HH-Global, HK-Global, HW-Global, KH-Global, KK-Global & KW-Global) & six local (HK-Local, KK-Local, WK-Local, HW-Local, KW-Local & WW-Local) hybrid wavelet transform 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. Twelve hybrid wavelet transforms (6 global and 6 local) are considered to generate shape texture patterns. From the results after experimentation it is found that the HW-Global hybrid wavelet transform is showing the best performance and KH-Global hybrid wavelet transform is showing the worst performance in proposed CBIR methods as indicated by average precision-recall crossover point values of shape texture based CBIR variants using respective hybrid wavelet transform given in Table 2. The '64-pattern' texture set has given better performance with global hybrid wavelet transforms than local hybrid wavelet transforms as per the average precision-recall crossover point values of shape texture based CBIR variants using respective scope of hybrid wavelet transforms given in Table 3. Among the three gradient operators used for generating the filtered image maps, Sobel gives the best performance followed by Prewitt and Robert as per the average precision-recall crossover point values of shape texture based CBIR variants using respective gradient operators given in Table 4.

Table 2: Performance Comparison of Hybrid Wavelet Transforms used in Shape-texture based Image Retrieval

Comparative Performance Rank	Hybrid Wavelet Transform	Average Crossover Point Value
1	**HW-Global**	**0.435461**
2	KW-Global	0.4352
3	KK-Global	0.428633
4	HK-Global	0.428393
5	WW-Local	0.423957
6	WK-Local	0.423941
7	KK-Local	0.418494
8	KW-Local	0.416991
9	HK-Local	0.416904
10	HH-Global	0.416117
11	HW-Local	0.4161
12	KH-Global	0.415732

Table 3: Performance Comparison of Scope of Hybrid Wavelet Transforms used in Shape-texture based Image Retrieval

Comparative Performance Rank	Scope of Hybrid Wavelet Transform	Average Crossover Point Value
1	**Global**	0.426589
2	Local	0.419398

Table 4: Performance Comparison of Gradient Operators used in Shape-texture based Image Retrieval

Comparative Performance	Thresholding Method	Average Crossover Point Value
1	**Sobel**	**0.444803**
2	Prewitt	0.431059
3	Robert	0.39312

11. 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 2, Issue 1, 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] 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.pp.1-8 (ISBN: 978-93-80746-62-5), Available online at http://www.ijcaonline.org

[38] Dr. H. B. Kekre, Dr. Sudeep D. Thepade, Varun K. Banura, Aanchal Bhatia, "Image Retrieval using Fractional Coefficients of Orthogonal Wavelet Transformed Images with Seven Image Transforms", International Journal of Computer Applications (IJCA),Volume 30 , Number 1, Article 3, 2011.pp.14-20 (ISBN: 978-93-80864-84-7), Available online at http://www.ijcaonline.org

[39] Dr. H. B. Kekre, Dr. Sudeep D. Thepade, Varun K. Banura, Ankit Khandelwal "Introducing Global and Local Walsh Wavelet Transform for Texture Pattern Based Image Retrieval", International Journal of Computer Science and Network Security (IJCSNS), Volume 11, Number 9, 2011.pp.65-72, Available online at http://ijcsns.org

[40] Dr. H. B. Kekre, Dr. Sudeep D. Thepade, Dr. Tanuja K. Sarode, Varun K. Banura, "Reduction in Feature Vector Size of Colour Averaging Based Image Retrieval Techniques using Walsh Wavelet Pyramid Levels", International Journal of Computer Applications (IJCA), Volume 32, Number 3, Article 5, 2011.pp.28-35 (ISBN: 978-93-80865-16-7), Available online at http://www.ijcaonline.org

[41] Dr. H. B. Kekre, Dr. Sudeep D. Thepade, Dr. Tanuja K. Sarode, Varun K. Banura, "Performance Comparison of Image Retrieval Using KFCG with Assorted Pixel Window Sizes in RGB and LUV Color Spaces", International Journal of Electronics and Communication Technologies (IJECT), Volume 3, Issue 1, 2012.pp.177-182, Available online at http://iject.org

[42] Dr. H. B. Kekre, Dr. Sudeep D. Thepade, Varun K. Banura, Ankit Khandelwal, "Augmentation of Image Retrieval using Fractional Coefficients of Hybrid Wavelet Transformed Images with Seven Image Transforms", International Journal of Computer Science and Technology (IJCST), Volume 3, Issue 1, 2012.pp.557-563, Available online at http://ijcst.com

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