Content Based Image Retrieval Using Full Haar Sectorization

H.B.Kekre hbkekre@yahoo.com
Sr. Professor, Computer Engineering Dept
SVKM's NMIMS (Deemed-to be University)
Mumbai, 400056, INDIA

Dhirendra Mishra dhirendra.mishra@gmail.com
Associate Professor & PhD Research Scholar
SVKM's NMIMS (Deemed-to be University)
Mumbai, 400056, INDIA

Abstract

Content based image retrieval (CBIR) deals with retrieval of relevant images from the large image database. It works on the features of images extracted. In this paper we are using very innovative idea of sectorization of Full Haar Wavelet transformed images for extracting the features into 4, 8, 12 and 16 sectors. The paper proposes two planes to be sectored i.e. Forward plane (Even plane) and backward plane (Odd plane). Similarity measure is also very essential part of CBIR which lets one to find the closeness of the query image with the database images. We have used two similarity measures namely Euclidean distance (ED) and sum of absolute difference (AD). The overall performance of retrieval of the algorithm has been measured by average precision and recall cross over point and LIRS, LSRR. The paper compares the performance of the methods with respect to type of planes, number of sectors, types of similarity measures and values of LIRS and LSRR.

Keywords: CBIR, Haar Wavelet, Euclidian Distance, Sum of Absolute Difference, LIRS, LSRR, Precision and Recall.

1. INTRODUCTION

Content based image retrieval i.e. CBIR [1-4] is well known technology being used for the retrieval of images from the large database. CBIR has been proved to be very much needed technology to be researched on due to its applicability in various applications like face recognition, finger print recognition, pattern matching [15][17][21], verification /validation of images etc. The concept of CBIR can be easily understood by the figure 1 as shown below. Every CBIR systems needs to have module to extract features of an image it could be shape, color, feature which can be used as unique identity of the image. The features of the query image are compared with the features of all images in the large database using various similarity measures. These mathematical similarity measuring techniques checks the similarity of features extracted to classify the images in the relevant and irrelevant classes. The research in CBIR needs to be done to explore two things first is the better method of feature extraction having maximum components of uniqueness and faster the accurate mathematical models of similarity measures.

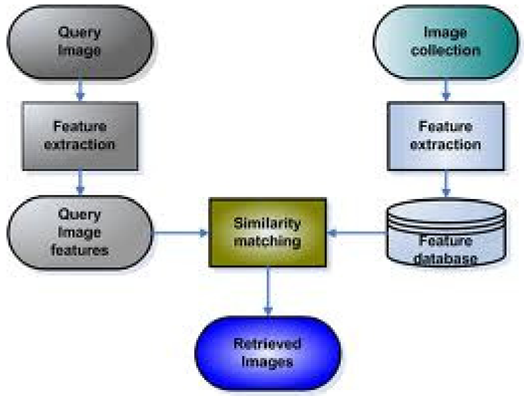


FIGURE 1: The CBIR System

There are lots of researches going on in the field of CBIR to generate the better methodologies of feature extractions in both spatial domain and frequency domain .Some methodologies like block truncation coding[19-21], clustering like vector quantization[18], various transforms: Kekre's Wavelet[5], DCT[16], DST[21][24], FFT[6-9], Walsh[10-11][22-23], Contourlet transform[3], using various methodologies like Complex Walsh sectors [12-14][17-23] has already been developed.

In this paper we have introduced a novel concept of Sectorization of Full Haar Wavelet transformed color images for feature extraction. Two different similarity measures parameters namely sum of absolute difference and Euclidean distance are considered. Average precision, Recall, LIRS and LSRR are used for performances study of these approaches.

2. HAAR WAVELET [5]

The Haar transform is derived from the Haar matrix. The Haar transform is separable and can be expressed in matrix form

$$[F] = [H]\,[f]\,[H]T$$

Where f is an NxN image, H is an NxN Haar transform matrix and F is the resulting NxN transformed image. The transformation H contains the Haar basis function hk(t) which are defined over the continuous closed interval t Є [0,1].

The Haar basis functions are When k=0, the Haar function is defined as a constant

$$hk(t) = 1/\sqrt{N}$$

When k>0, the Haar Function is defined as

$$h_k(t) = \frac{1}{\sqrt{N}} \begin{cases} 2^{p/2} & (q-1)/2^p <= t < (q-0.5)/2^p \\ -2^{p/2} & (q-0.5)/2^p <= t < q/2^p \\ 0 \text{ otherwise} & \end{cases} \qquad (1)$$

$$\text{Where } 0 \le p < \log_2 N \text{ and } 1 \le q \le 2^p$$

3. SECTORIZATION OF TRANSFORMED IMAGES [8-14]

3.1 Haar Plane Formation

The components of Full Haar transformed image shown in the red bordered area (see Figure 2) are considered for feature vector generation. The average value of zeoeth row, column and last row and column components are considered only for augmentation purpose. We have used color codes to differentiate between the co-efficients plotted on Forward (Even) plane as light red and light blue for co-efficients belonging to backward (Odd) plane. The co-efficient with light red background i.e. at position (1,1),(2,2);(1,3),(2,4) etc. are taken as X1 and Y1 respectively and plotted on Even plane. The co-efficient with light blue background i.e. at position (2,1),(1,2);(2,3),(1,4) etc. are taken as X2 and Y2 respectively and plotted on Odd plane.

	0	1	2	3	4	5
0	0,0	0,1	0,2	0,3	0,4	0,5
1	1,0	1,1	1,2	1,3	1,4	1,5
2	2,0	2,1	2,2	2,3	2,4	2,5
3	3,0	3,1	3,2	3,3	3,4	3,5
4	4,0	4,1	4,2	4,3	4,4	4,5
5	5,0	5,1	5,2	5,3	5,4	5,5

FIGURE 2: Haar component arrangement in an Transformed Image.

Even plane of Full Haar is generated with taking Haar components into consideration as all X(i,j), Y(i+1, j+1) components for even plane and all X(i+1, j), Y(i, j+1) components for odd plane as shown in the Figure 3. Henceforth for our convenience we will refer X(i,j) = X1, Y(i+1,j+1) =Y1 and X(i+1,j) = X2 and Y(i,j+1) = Y2.

X(i,j)	Y(i,j+1)
X(i+1,j)	Y(i+1,j+1)

FIGURE 3: Snapshot of Components considered for Even/Odd Planes.

As shown in the Figure 3 the Even plane of Full Haar considers X1 i.e. all light red background cells (1,1), (2,2),(1,3),(2,4) etc. on X axis and Y1 i.e. (1,2), (2,1),(1,4),(2,3) etc. on Y axis. The Odd plane of Full Haar considers X1 i.e. all light blue background cells (1,2), (2,1),(1,4),(2,3) etc. on X axis and Y1 i.e. (1,2), (2,1),(1,4),(2,3) etc. on Y axis.

3.2 4 Sector Formation

Even and odd rows/columns of the transformed images are checked for sign changes and the based on which four sectors are formed as shown in the Figure 4 below:

Sign of X1/X2	Sign of Y1/Y2	Quadrants
+	+	I (0 – 900)
+	-	II (90 – 1800)
-	-	III(180- 2700)
-	+	IV(270–3600)

FIGURE 4: Computation of 4 Sectors

3.3. 8 Sectors Formation

The transformed image sectored in 4 sectors is taken into consideration for dividing it into 8 sectors. Each sector is of angle 45o. Coefficients of the transformed image lying in the particular sector checked for the sectorization conditions as shown in the Figure 5.

Sectors	Conditions
I,IV,V,VIII	$\|A\| >= \|B\|$
II,III,VI,VII	$\|B\| >= \|A\|$
Where A = X1 / X2 Component of the Transformed Image B = Y1 / Y2 Component of the Transformed Image	

FIGURE 5: Computation of 8 Sectors

3.4 12 Sector Formation
Division each sector of 4 sectors into angle of 30^o forms 12 sectors of the transformed image. Coefficients of the transformed image are divided into various sectors based on the inequalities shown in the Figure 6.

Sectors	Conditions
I, IV, VII, X	$\|A\| >= \sqrt{3} * \|B\|$
II, V, VIII, XI	$1/\sqrt{3} * \|A\| <= \|B\| <= \sqrt{3} * \|A\|$
III,VI, IX, XII	Otherwise
Where A = X1 / X2 Component of the Transformed Image B = Y1 / Y2 Component of the Transformed Image	

FIGURE 6: Computation of 12 Sectors

3.5 16 Sector Formation
Similarly we have done the calculation of inequalities to form the 16 sectors of the transformed image. The even/odd rows/ columns are assigned to particular sectors for feature vector generation

4. RESULTS OF EXPERIMENTS
We have used the augmented Wang image database [2] The Image database consists of 1055 images of 12 different classes such as Flower, Sunset, Barbie, Tribal, Cartoon, Elephant, Dinosaur, Bus, Scenery, Monuments, Horses, Beach. Class wise distribution of all images in the database has been shown in the Figure 7.

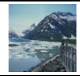
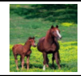
Class						
No. of Images	45	59	51	100	100	100
Class						
No. of Images	100	100	100	100	100	100

FIGURE 7: Class wise distribution of images in the Image database

FIGURE8: Query Image

The query image of the class dinosaur has been shown in Figure 8. For this query image the result of retrieval of both approaches of Full Haar wavelet transformed image sectorization of even and odd planes. The Figure 9 shows First 20 Retrieved Images sectorization of Full Haar wavelet Forward (Even) plane (16 Sectors) with sum of absolute difference as similarity measure. It can be observed that the retrieval of first 20 images are of relevant class i.e. dinosaur; there are no irrelevant images till first 77 retrievals in first case. The result of odd plane sectorization shown in Figure 10; the retrieval of first 20 images has 2 irrelevant images and 18 of relevant class.

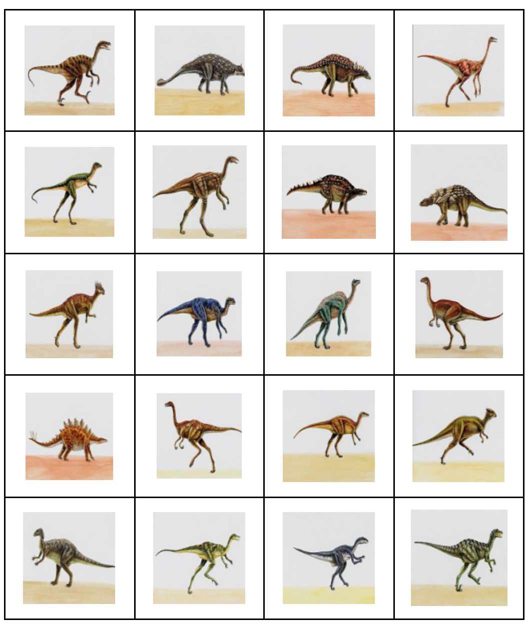


FIGURE 9: First 20 Retrieved Images sectorization of Full Haar wavelet Forward (Even) plane(16 Sectors)

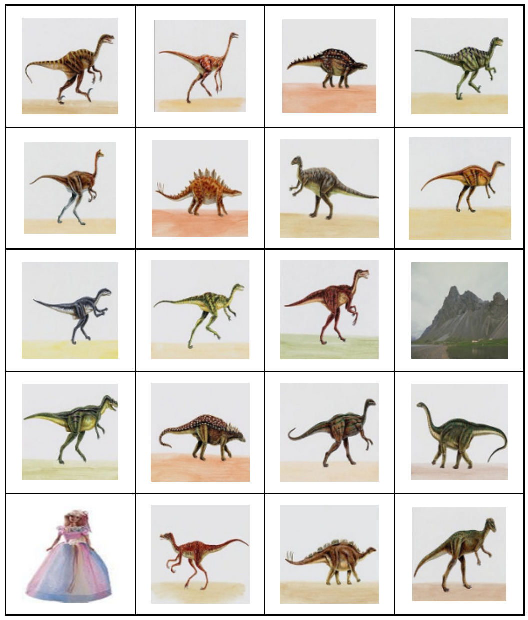


FIGURE 10: First 20 Retrieved Images of Full Haar wavelet Backward (odd) plane Sectorization (16 Sectors).

Feature database includes feature vectors of all images in the database. 5 randomly chosen query images of each class produced to search the database. The image with exact match gives minimum sum of absolute difference and Euclidian distance. To check the effectiveness of the work and its performance with respect to retrieval of the images we have calculated the overall average precision and recall as given in Equations (2) and (3) below. Two new parameters i.e. LIRS and LSRR are introduced as shown in Equations (4) and (5).

$$\text{Precision} = \frac{\text{Number of Relevant Images Retrieved}}{\text{Total Number of Images Retrieved}} \quad (2)$$

$$\text{Recall} = \frac{\text{Number of Relevant Images Retrieved}}{\text{Total Number of Relevant Images in the Database}} \quad (3)$$

$$\text{LIRS} = \frac{\text{Length of Initial Relevant string of images}}{\text{Total Relevant images Retrieved}} \quad (4)$$

$$\text{LSRR} = \frac{\text{Length of string to Recover all Relevant Images}}{\text{Total Images in the Database}} \quad (5)$$

All these parameters lie between 0-1 hence they can be expressed in terms of percentages. The newly introduced parameters give the better performance for higher value of LIRS and Lower value of LSRR [8-13].

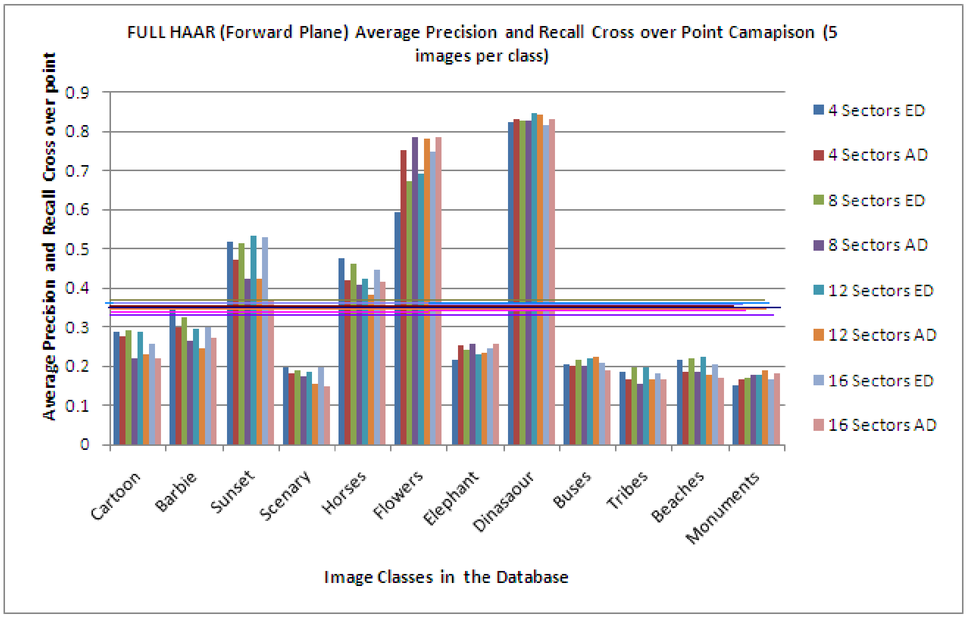


FIGURE 11: Class wise Average Precision and Recall cross over points of Forward Plane (Even) sectorization of Full Haar Wavelet with sum of Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

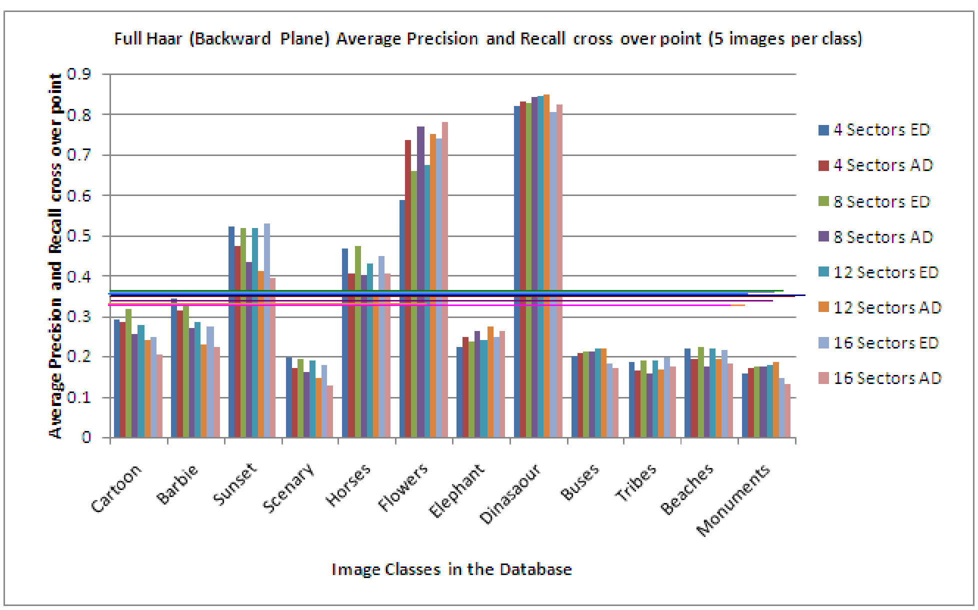


FIGURE 12: Class wise Average Precision and Recall cross over points of Backward Plane (Odd) sectorization of Full Haar Wavelet with Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

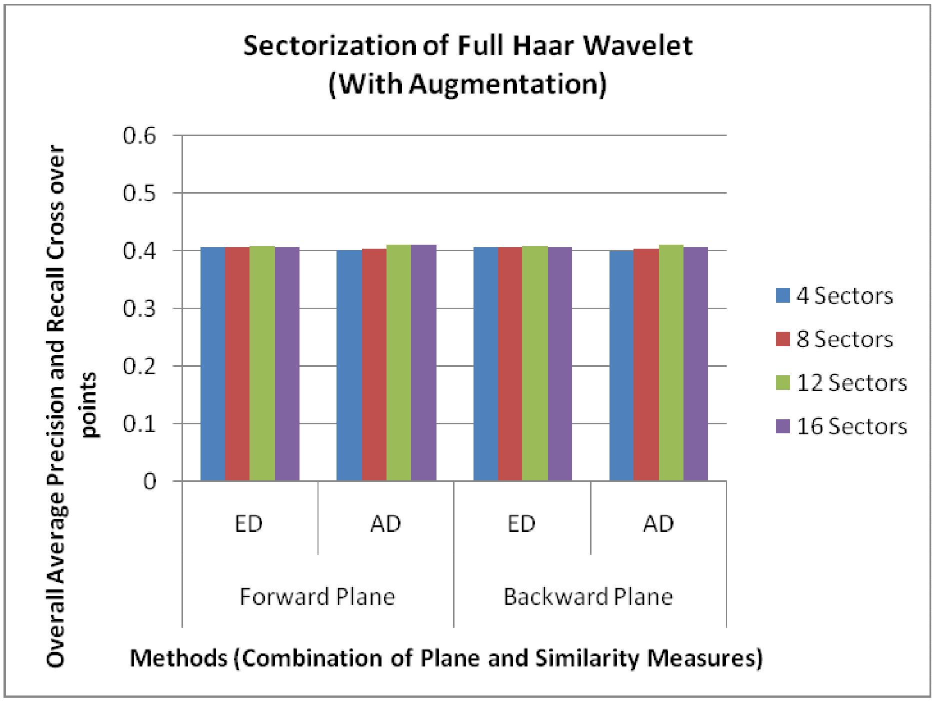


FIGURE 13: Comparison of Overall Precision and Recall cross over points of sectorization of Full Haar Wavelet with sum of Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

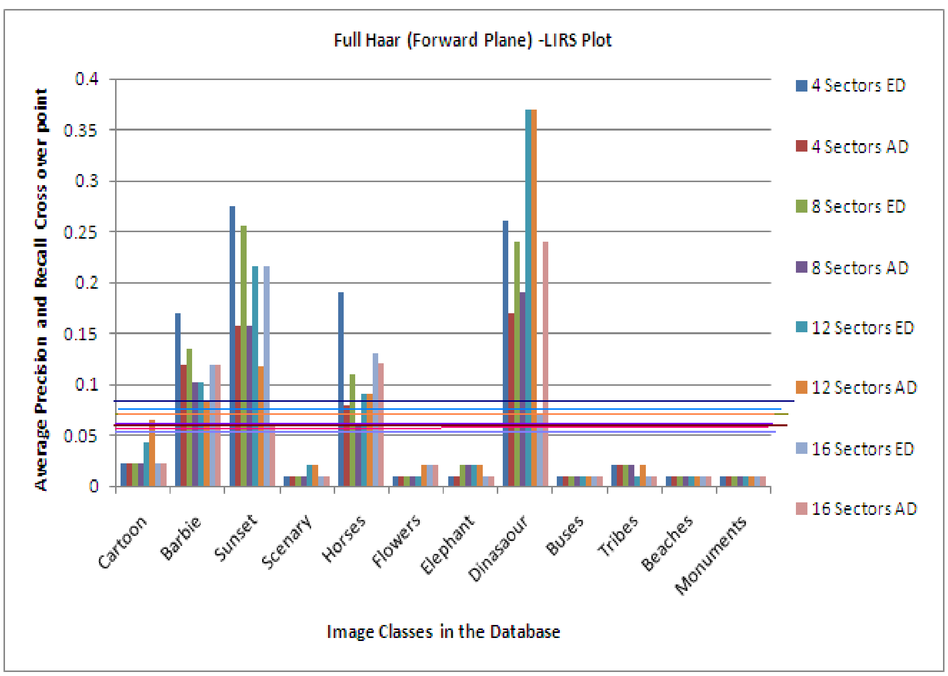


FIGURE 14: The LIRS Plot of sectorization of forward plane of Full Haar transformed images . Overall Average LIRS performances (Shown with Horizontal lines :0.082 (4 Sectors ED), 0.052 (4 Sectors AD), 0.071(8 Sectors ED), 0.051(8 Sectors AD), 0.075(12 Sectors ED), 0.069(12 Sectors AD), 0.053(16 Sectors ED), 0.053(16 Sectors AD)).

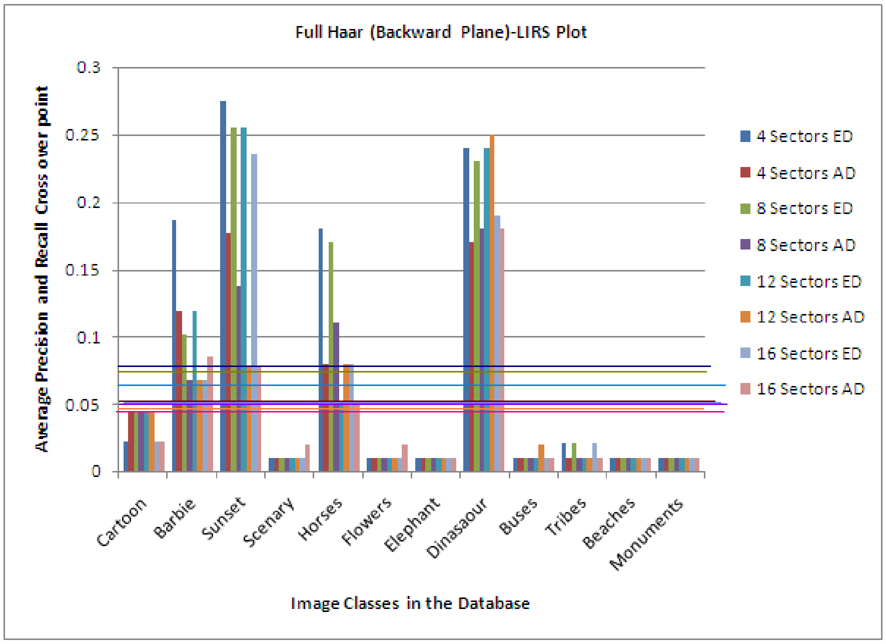


FIGURE 15: The LIRS Plot of sectorization of Backward plane of Full Haar transformed images . Overal Average LIRS performances (Shown with Horizontal lines :0.081 (4 Sectors ED), 0.054 (4 Sectors AD), 0.073(8 Sectors ED), 0.050(8 Sectors AD), 0.064(12 Sectors ED), 0.049(12 Sectors AD), 0.056(16 Sectors ED), 0.042(16 Sectors AD)).

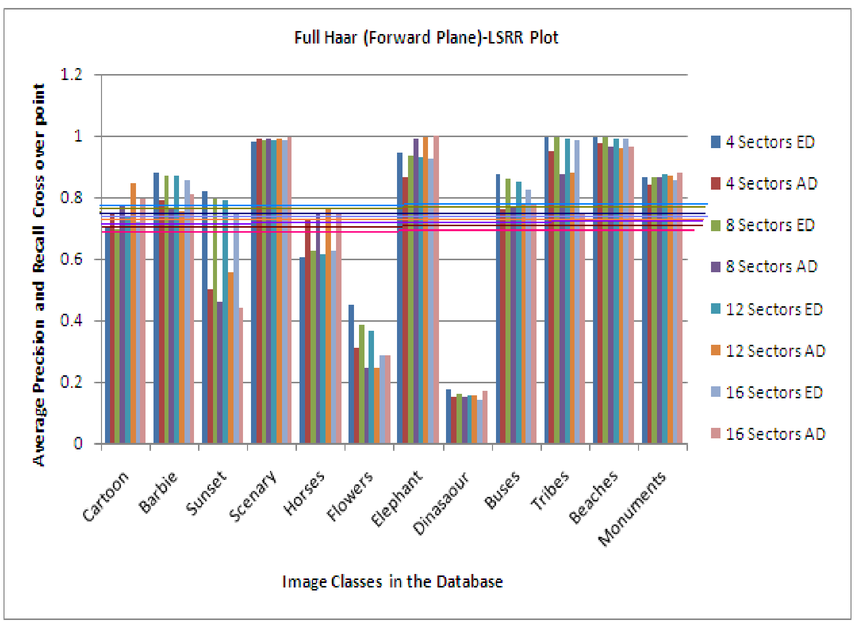


FIGURE 16: The LSRR Plot of sectorization of forward plane of Full Haar transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.77 (4 Sectors ED), 0.71 (4 Sectors AD), 0.76(8 Sectors ED), 0.71(8 Sectors AD), 0.76(12 Sectors ED), 0.73(12 Sectors AD), 0.74(16 Sectors ED), 0.71(16 Sectors AD)).

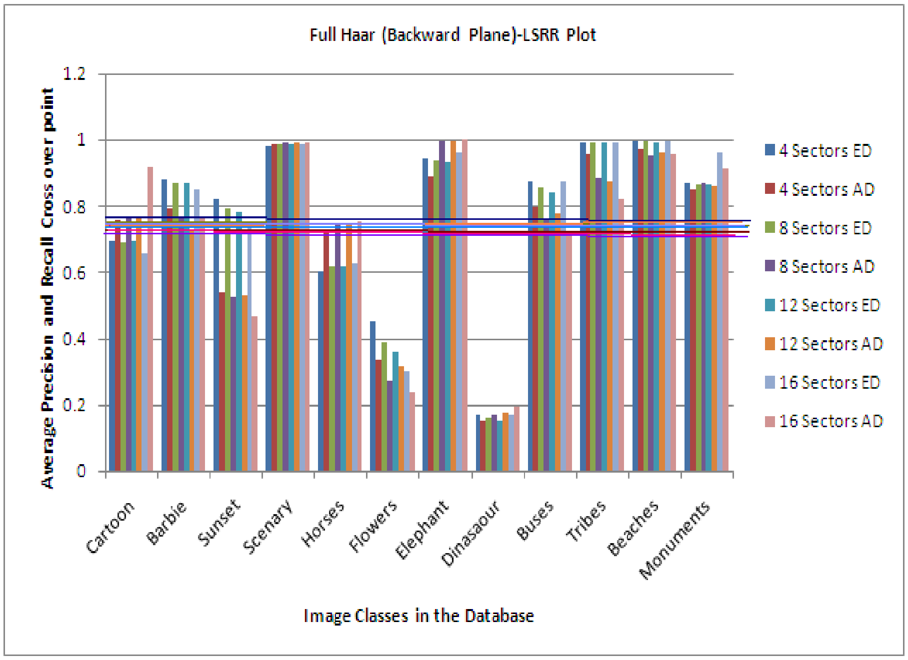


FIGURE 17: The LSRR Plot of sectorization of backward plane of Full Haar transformed images . Overall Average LSRR performances (Shown with Horizontal lines :0.77(4 Sectors ED), 0.729 (4 Sectors AD), 0.76(8 Sectors ED), 0.725(8 Sectors AD), 0.756(12 Sectors ED), 0.726(12 Sectors AD), 0.759(16 Sectors ED), 0.727(16 Sectors AD)).

5. CONCLUSION

The work experimented on 1055 image database of 12 different classes discusses the performance of sectorization of Full Haar wavelet transformed color images for image retrieval. The work has been performed with both approaches of sectorization of forward (even) plane and backward (odd) planes. The performance of the methods proposed checked with respect to various sector sizes and similarity measuring approaches namely Euclidian distance and sum of absolute difference. We calculated the average precision and recall cross over point of 5 randomly chosen images of each class and the overall average is the average of these averages. The observation is that sectorization of both planes of full Haar wavelet transformed images give 40% of the overall average retrieval of relevant images as shown in the Figure 13. The class wise plot of these average precision and recall cross over points as shown in Figure 11 and Figure 12 for both approaches depicts that the retrieval performance varies from class to class and from method to method. Few classes like sunset, horses flower and dinosaur has performance above the average of all methods as shown by horizontal lines. New parameter LIRS and LSRR gives good platform for performance evaluation to judge how early all relevant images is being retrieved (LSRR) and it also provides judgement of how many relevant images are being retrieved as part of first set of relevant retrieval (LIRS).The value of LIRS must be minimum and LSRR must be minimum for the particular class if the overall precision and recall cross over point of that class is maximum. This can be clearly seen in Figures 14 to Figure 17. This observation is very clearly visible for dinosaur class however the difference of LIRS and LSRR of other classes varies. The sum of absolute difference as similarity measure is recommended due to its lesser complexity and better retrieval rate performance compared to Euclidian distance.

6. REFERENCES

1. Kato, T., “Database architecture for content based image retrieval in Image Storage and Retrieval Systems” (Jambardino A and Niblack W eds),Proc SPIE 2185, pp 112-123, 1992.

2. Ritendra Datta,Dhiraj Joshi,Jia Li and James Z. Wang, “ Image retrieval:Idea,influences and trends of the new age”,ACM Computing survey,Vol 40,No.2,Article 5,April 2008.

3. Ch.srinivasa rao,S. srinivas kumar,B.N.Chaterjii, “content based image retrieval using contourlet transform”, ICGST-GVIP Journal, Vol.7 No. 3, Nov2007.

4. John Berry and David A. Stoney “The history and development of fingerprinting,” in Advances in Fingerprint Technology, Henry C. Lee and R. E. Gaensslen, Eds., pp. 1-40. CRC Press Florida, 2nd edition, 2001.

5. H.B.Kekre, Archana Athawale and Dipali sadavarti, “Algorithm to generate Kekre’s Wavelet transform from Kekre’s Transform”, International Journal of Engineering, Science and Technology, Vol.2No.5,2010 pp.756-767.

6. H. B. Kekre, Dhirendra Mishra, “Digital Image Search & Retrieval using FFT Sectors” published in proceedings of National/Asia pacific conference on Information communication and technology(NCICT 10) 5TH & 6TH March 2010.SVKM’S NMIMS MUMBAI

7. H.B.Kekre, Dhirendra Mishra, “Content Based Image Retrieval using Weighted Hamming Distance Image hash Value” published in the proceedings of international conference on contours of computing technology pp. 305-309 (Thinkquest2010) 13th & 14th March 2010.

8. H.B.Kekre, Dhirendra Mishra, “Digital Image Search & Retrieval using FFT Sectors of Color Images” published in International Journal of Computer Science and Engineering (IJCSE) Vol. 02,No.02,2010,pp.368-372 ISSN 0975-3397 available online at http://www.enggjournals.com/ijcse/doc/IJCSE10-02-02-46.pdf

9. H.B.Kekre, Dhirendra Mishra, “CBIR using upper six FFT Sectors of Color Images for feature vector generation” published in International Journal of Engineering and Technology(IJET) Vol. 02, No. 02, 2010, 49-54 ISSN 0975-4024 available online at http://www.enggjournals.com/ijet/doc/IJET10-02-02-06.pdf

10. H.B.Kekre, Dhirendra Mishra, “Four Walsh transform sectors feature vectors for image retrieval from image databases”, published in international journal of computer science and information technologies (IJCSIT) Vol. 1 (2) 2010, 33-37 ISSN 0975-9646 available online at http://www.ijcsit.com/docs/vol1issue2/ijcsit2010010201.pdf

11. H.B.Kekre, Dhirendra Mishra, “Performance comparison of four, eight and twelve Walsh transform sectors feature vectors for image retrieval from image databases”, published in international journal of Engineering, science and technology(IJEST) Vol.2(5) 2010, 1370-1374 ISSN 0975-5462 available online at http://www.ijest.info/docs/IJEST10-02-05-62.pdf

12. H.B.Kekre, Dhirendra Mishra, “ density distribution in Walsh Transform sectors ass feature vectors for image retrieval”, published in international journal of compute applications (IJCA) Vol.4(6) 2010, 30-36 ISSN 0975-8887 available online at http://www.ijcaonline.org/archives/volume4/number6/829-1072

13. H.B.Kekre, Dhirendra Mishra, “Performance comparison of density distribution and sector mean in Walsh transform sectors as feature vectors for image retrieval”, published in international journal of Image Processing (IJIP) Vol.4(3) 2010, ISSN http://www.cscjournals.org/csc/manuscript/Journals/IJIP/Volume4/Issue3/IJIP-193.pdf

14. H.B.Kekre, Dhirendra Mishra, “Density distribution and sector mean with zero-sal and highest-cal components in Walsh transform sectors as feature vectors for image retrieval”, published in international journal of Computer science and information security (IJCSIS)

Vol.8(4) 2010, ISSN 1947-5500 available online http://sites.google.com/site/ijcsis/vol-8-no-4-jul-2010

15. Arun Ross, Anil Jain, James Reisman, "A hybrid fingerprint matcher," Int'l conference on Pattern Recognition (ICPR), Aug 2002.

16. H.B.Kekre, Dhirendra Mishra, "DCT sectorization for feature vector generation in CBIR", International journal of computer application (IJCA),Vol.9, No.1,Nov.2010,ISSN:1947-5500 http://ijcaonline.org/archives/volume9/number1/1350-1820

17. A. M. Bazen, G. T. B.Verwaaijen, S. H. Gerez, L. P. J. Veelenturf, and B. J. van der Zwaag, "A correlation-based fingerprint verification system," Proceedings of the ProRISC2000 Workshop on Circuits, Systems and Signal Processing, Veldhoven, Netherlands, Nov 2000.

18. H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, "Image Retrieval using Color-Texture Features from DST on VQ Codevectors obtained by Kekre's Fast Codebook Generation", ICGST International Journal on Graphics, Vision and Image Processing (GVIP), Available online at http://www.icgst.com/gvip

19. 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. 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. Available online at ACM portal.

21. H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, "DST Applied to Column mean and Row Mean Vectors of Image for Fingerprint Identification", International Conference on Computer Networks and Security, ICCNS-2008, 27-28 Sept 2008, Vishwakarma Institute of Technology, Pune.

22. H.B.Kekre, Vinayak Bharadi, "Walsh Coefficients of the Horizontal & Vertical Pixel Distribution of Signature Template", In Proc. of Int. Conference ICIP-07, Bangalore University, Bangalore. 10-12 Aug 2007.

23. J. L. Walsh, "A closed set of orthogonal functions" American Journal of Mathematics, Vol. 45, pp.5-24,year 1923.

24. H.B.Kekre, Dhirendra Mishra, "DST Sectorization for feature vector generation", Universal journal of computer science and engineering technology (Unicse),Vol.1, No.1Oct 2010 available at http://www.unicse.oeg/index.php?option=comcontent and view=article&id=54&itemid=27