Sectorization of Walsh and Walsh Wavelet in CBIR

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Abstract— **This paper proposes the new Walsh Wavelet generation and its use in the Content Based Image Retrieval. The Walsh Wavelet has been used to transform the images and sectored it into various sector sizes to generate the feature vectors of those images. The transformation of all images in the database has been tried three fold i.e. column wise, row wise and full transformation (with two planes plane1 and plane2). The retrieval performance results of these approaches has been compared with the results of Walsh transformed (row wise, column wise, full- plane1 and plane 2) image sectorization. The comparison of these results has been done based on individual class wise average performance of five randomly selected images per class for each sector sizes. The overall average performance comparison of all methods proposed has been done and it has been found that the column wise approach performs well. The performance measurement has been done by means of average precision-recall cross over point, LIRS (Length of initial relevant string of images), LSRR (Length of string to recover all relevant images).Since similarity measures play a very important role in CBIR. We have employed two similarity measures i.e. Euclidian distance and sum of absolute difference.**

Keywords-CBIR,Precision,recall,LIRS,LSRR,Feature extraction,sectorization

I. INTRODUCTION

The digital world Innovations has evolved itself to a very large extent. The result of which has increased the more and more dependency on the digital data and in turn on computer system. The information of any form i.e. multimedia, documents, images etc. everything has got its own place in the in this digital world. The computer system has been accepted to be the very powerful mechanism to use these digital data, for its secured storage and efficient accessibility whenever required.

Digital Images play a very important role for describing the detailed information about man, money, machine etc. almost in every field. The various processes of digitizing the images to obtain it in the best quality for the more clear and accurate information leads to the requirement of more storage space and better storage and accessing mechanism in the form of hardware or software. As far as the accessing of these images are concerned one needs to have the good mechanism of not only for accessing of the images but also for any other image processing to be done one needs to have the faster, accurate, efficient retrievals of these images. There are various approaches of proposing the methodologies of retrieving the images from the large databases consisting of millions of images stored.

Content Based Image Retrieval (CBIR) [1-4] is one of the evolving fields of image processing. CBIR needs to have the innovative algorithm to extract the perfect features to define the identity of an image. It is proposed to use content of the image itself to define its unique identity. This unique identity can make one to differentiate the images with each other with better and accurate retrieval of images. There are mainly three attributes, shape, color and textures of the image which can be used to define the contents of a image. These contents leads one to extract the exact feature of the image which can be well utilized to compare with all images available in the database by means of some similarity measures like Euclidean distance, sum of absolute difference etc. The tremendous use of images in the digital world of today has proved the CBIR as very useful in several applications like Finger print recognition[5], Iris Recognition[6], face recognition[7], palm print recognition[8], speaker identification[9] etc.

There are various approaches which have been experimented to generate the efficient algorithm for image feature extraction in CBIR. These approaches advocate different ways of extracting features of the images to improve the result in the form of better match of the query image in the large database. Some papers discuss the variation in the similarity measures in order to have its lesser complexity and better match [10-20]. Methods of feature extraction using Vector Quantization [21], bit truncation coding [22, 23], Walsh Transform [25,26] has also provided the new horizon to the feature extraction methodology. The method of sectorization has already been experimented on DCT [27], DST [28], DCT-DST Plane [29,32], Haar Wavelet [30] and Kekre's Transform [31] earlier.

This paper proposes the use of sectorization of Walsh Wavelet for feature extraction in CBIR. The outcome of which has been compared with the Walsh sectorization performance.

II. Walsh and Walsh Wavelet Generation

A. Walsh Transform[18]

Walsh transform matrix is generated using a Hadamard matrix of order N. The Walsh transform matrix row is the row of the Hadamard matrix specified by the Walsh code index, which must be an integer in the range [0, ..., N - 1]. For the Walsh code index equal to an integer j, the respective Hadamard output code has exactly j zero crossings, for j = 0, 1, ... , N - 1.

Kekre's Algorithm to generate Walsh Transform from Hadamard matrix is illustrated for N=16.However the algorithm is general and can be used for any $N = 2^k$ where k is an integer.

Step 1:
Arrange the 'N' numbers in a row and then split the row at 'N/2', the other part is written below the upper row but in reverse order as follows:

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
15 14 13 12 11 10 9 8

Step 2:
We get two rows, each of this row is again split in 'N/4' and other part is written in reverse order below the upper rows as shown below.

0 1 2 3
15 14 13 12
7 6 5 4
8 9 10 11

This step is repeated until we get a single column which gives the ordering of the Hadamard rows according to sequency as given below:

0 ,15, 7, 8, 3,12,4,11,1,14,6,9,2,13,5,10

Step 3:
According to this sequence the Hadamard rows are arranged to get Walsh transform matrix. Now a product of Walsh matrix and the image matrix is calculated. This matrix contains Walsh transform of all the columns of the given image. Since Walsh matrix has the entries either +1 or -1 there is no multiplication involved in computing this matrix. Since only additions are involved computational complexity is very low.

B. Walsh Wavelet Generation

The wavelet analysis procedure is to adopt a wavelet prototype function, called an *analyzing wave* or *mother wave*. Other wavelets are produced by translation and contraction of the mother wave. By contraction and translation infinite set of functions can be generated. This set of functions must be orthogonal and this condition qualifies a transform to be a wavelet transform. Thus there are only few functions which satisfy this condition of orthogonality. Generation of Walsh Wavelet transform matrix of size N^2xN^2 from Walsh matrix of size NxN is given in [4].However in this case we require Walsh matrix of size 128x128 where 128 is not a square. To simplify this situation, this paper proposes an algorithm to generate discrete Walsh wavelet transform from Walsh transform of size 8x8 and 16x16.

In this paper the Walsh Wavelet has been generated using the contraction and translation. Due to the size of images in the database is 128x128 we need the wavelet transform to be of size 128x128. The 128x128 Wavelet transform matrix generated from 16x16 orthogonal Walsh matrix and 8x8 Walsh matrix. First 16 rows of Wavelet transform matrix are generated by repeating every column of Walsh matrix of dimension 16x16, 8 times. To generate next 17 to 32 rows, second row of Walsh (8X8) is translated using groups of 8 columns with horizontal and downward shifts. To generate next 33 to 48 rows, third row of Walsh (8X8) matrix is used in the same manner. Like wise to generate last 113 to 128 rows, 8th row of transform Walsh (8x8) matrix is used. Note that by repeating every column of the basic transform 8 times we get global components. Other wavelets are generated by using rows of Walsh matrix of size 8x8 giving local components of the Walsh Wavelet.

III. Feature vector Generation

The steps followed to generate feature vectors

1. The image is transformed using the Walsh (row/column/full-plane1/full-plane2) transform and Walsh wavelets (row/column/full-plane1/full-plane2) transform separately.
2. Sectorization of each transformed images (all color planes i.e. R, G and B) for each approaches has been performed into various sector sizes i.e.4, 8, 12 and 16.
3. The transformed components of images are assigned to each sector.
4. The average value of each sectors generate individual components for feature vectors.

A. Sectorization [12-18][28-33]

The individual components of row and column wise transformed (Walsh and Walsh Wavelet separately) images are distributed into different co-ordinates of Cartesian coordinate system according to their sign change to form four sectors.

The division of each of these 4 sectors into 2 partitions forms the 8 sectors which distributes the transformed image components into its appropriate sectors.

Continuing the same division concept further the 4 sectors already generated has been divided into 3 parts with consideration of 30 degree angle to generate sector sizes of 12.

Each sector of 8 sectors are individually divided into two to obtain 16 sectors. For each individual sector sizes the mean of each sectors are taken as the feature vector component. The feature vector components of each plane i.e. R, G and B has been calculated and concatenated together with the average of first row/column and last row/column to form the final feature vector for each sector separately. The size of the feature vector and its component varies for each sector sizes the maximum sector size will have maximum feature vector components.

The feature database consists of feature vectors of all images. The features of the query image extracted are compared with the feature database using similarity measures. There are two similarity measures used in this experiment i.e. Eucledian distance (ED) and sum of absolute difference (AD) as given in the equation (1) and (2) shown below:

$$ED(P,Q) = \sum_{i=1}^{N} (Pi - Qi)^2 \qquad (1)$$

$$AD(P,Q) = \sum_{i=1}^{N} |Pi - Qi| \qquad (2)$$

The match of query image feature with the feature database with the minimum value of ED/AD gives the perfect match.

The performance measure of the algorithms proposed is done with the calculation of the precision-recall and LIRS (Length of initial relevant string of retrieval) and LSRR (Length of string to recover all relevant images in the database) refer equations (3) to (6).

$$Precision = \frac{\text{Number of relevant images retrieved}}{\text{Total Number of images retrieved}} \qquad (3)$$

$$Recall = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in database}} \qquad (4)$$

$$LIRS = \frac{\text{Length of initial relevant string of images}}{\text{Total relevant images in the Database}} \quad (5)$$

$$LSRR = \frac{\text{Length of string to recover all relevant images}}{\text{Total images in the Database}} \quad (6)$$

The performance of the proposed methods are checked by means of calculating the class wise average performance and overall average performance of each approach with respect to the transformation method applied, the way of applying the transformation i.e. row wise, column wise, full, sector sizes used and type of similarity measures used.

IV. Experimental Results

A. *Image Database*

The sample Images of the augmented Wang database [34] consists of 1055 images having 12 different classes such as Cartoons, Flowers, Elephants, Barbie, Mountains, Horses, Buses, Sunset, Tribal, Beaches, Monuments and Dinosaur shown in the Figure 1.

Figure 1. Sample images in the Database

The class wise distribution of all images in its respective classes such as there are 46 images of cartoon in the class, there are 100 images for flower and so on are shown in the Table 1 below.

Table 1: The Class wise distribution of images in the database

Cartoon:46	Flower:100	Elephants:100	Barbie:59	Mountains:100	Horses:100
Bus:100	Sunset:51	Tribal:100	Beaches:99	Monuments:100	Dinosaur:100

B. *Sectorization of Walsh Transformed (Row wise) images.*

The Figure 2 shows the average precision-recall cross over point plot for Walsh transform (Row wise) sectorization. The plot has considered the five randomly selected images per class for the sake of average performance measurement. The performance of the algorithm with respect to retrieval rate is obtained as 80% (8 and 16 Sectors with AD), more than 60% (4,8 Sectors),Close to 60% (12 sectors with ED), Above 50% for dinasaour, flowers, horses, sunset and elephant classes respectively. The LIRS .LSRR plot as shown in the Figure 3 and Figure 4 depicts the performance of the algorithm in terms of the length of initial relevant retrievals and the length of images to retrieve all relevant images. It can be seen that both of these parameters perform well for dinasaour and horse class.

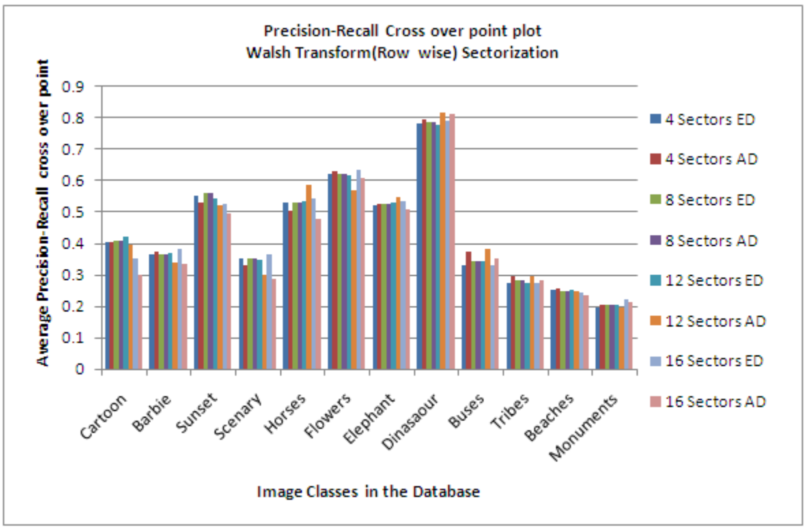

Figure2. Class wise Average Precision-Recall cross over point plot of WALSH row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

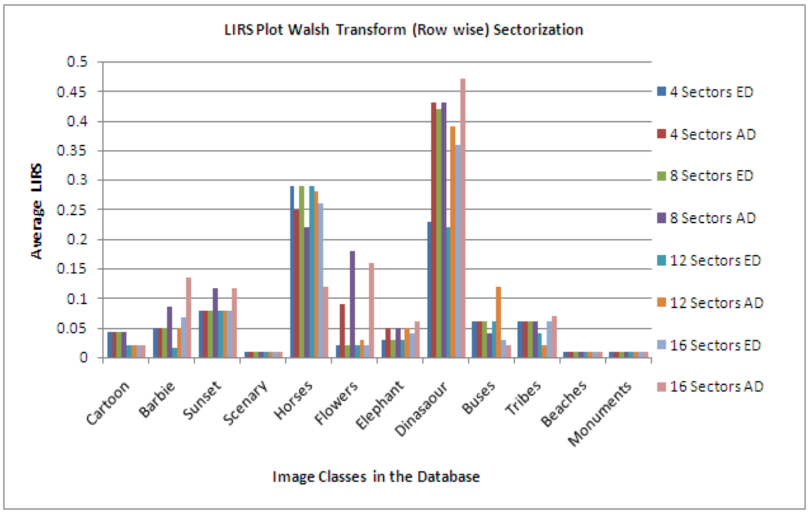

Figure3. Class wise LIRS plot of WALSH row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

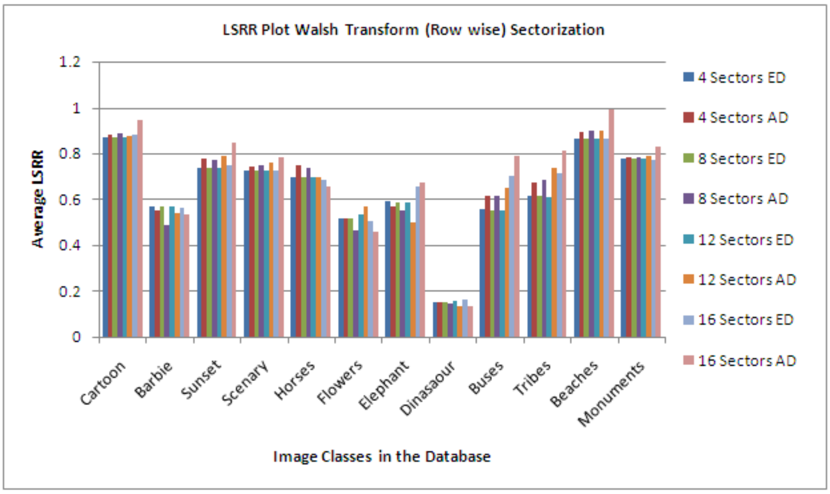

Figure4. Class wise LSRR plot of WALSH row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

C. Sectorization of Walsh Wavelet Transformed (Row wise) images

This section discusses the retrieval performance of the sectorization of Walsh wavelet transformed (row wise) images by means of all three parameters. The average precision-recall cross over point provides the average retrieval rate per class. Comparing with the previous method this has lots of variations in the result of retrieval for all sector sizes. Walsh wavelet sectorization provides the retrieval up to 90% for dinosaur class which is far better than Walsh (row wise) sectorization. There is good combination of the performance based on the use of similarity measures. The sum of absolute difference performs better for some classes like dinosaur while Eucledieean distance has better retrieval performance for classes like sunset, scenery, horses and flower.

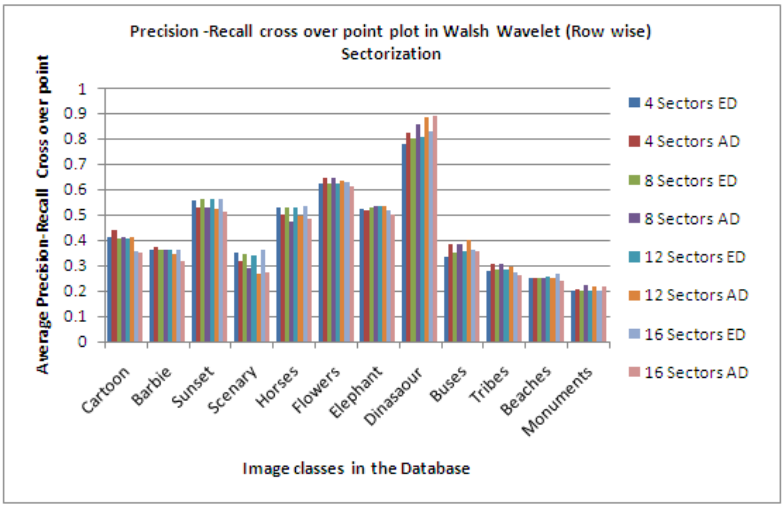

Figure5. Class wise Average Precision-Recall cross over point plot of WALSH Wavelet row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

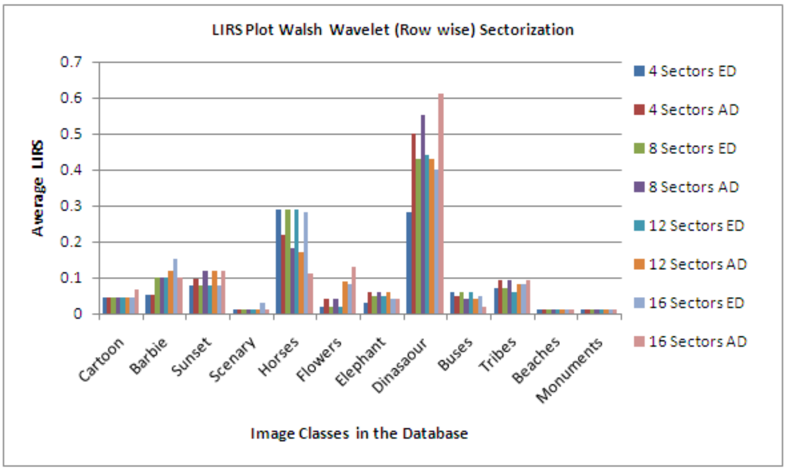

Figure 6. Class wise LIRS plot of WALSH Wavelet row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

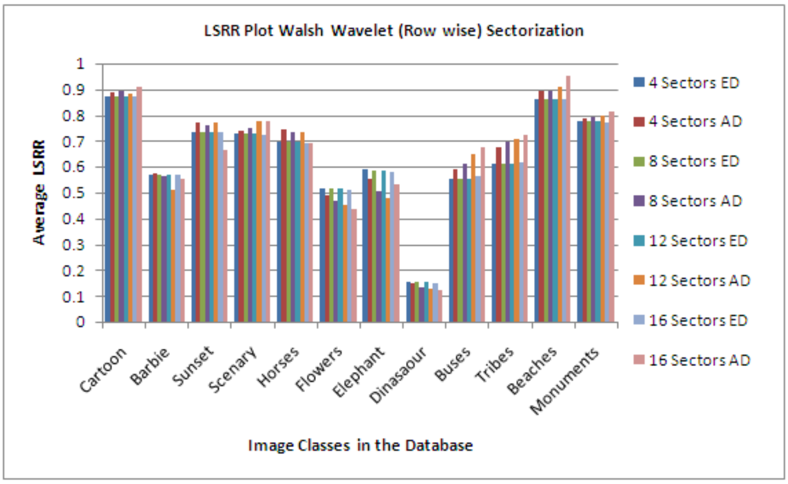

Figure7. Class wise LSRR plot of WALSH Wavelet row wise sectorization for all sector sizes with respect to similarity measures i.e. Eucledian distance (ED) and sum of absolute difference (AD)

D. Sectorization of Walsh Transformed (Column wise) Images.

In this approach of transformation and sectorization has better retrieval result in the classes like flower goes up to 75%. The Barbie class has the better retrieval more than 40% as compared to row wise transformed. The sum of absolute difference has outperformed in for all sectors for Barbie, Flowers ,Buses, scenery and diansour classes The cross over point retrieval rates for all sectors have little or no variations in the result as shown in the Figure 7. The LIRS performance for Horse, flowers and dinasaour classes are better as shown in the Figure 9. The minimum of LSRR is the good performance measure (see the Figure 10).

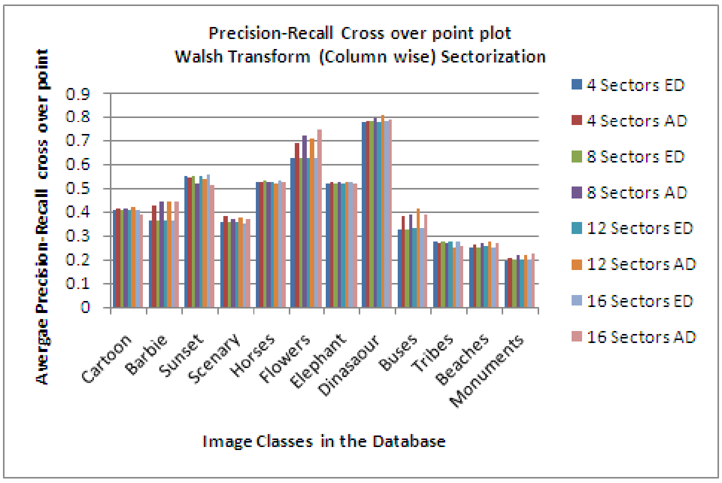

Figure8. Class wise Average Precision-Recall cross over point plot of WALSH column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

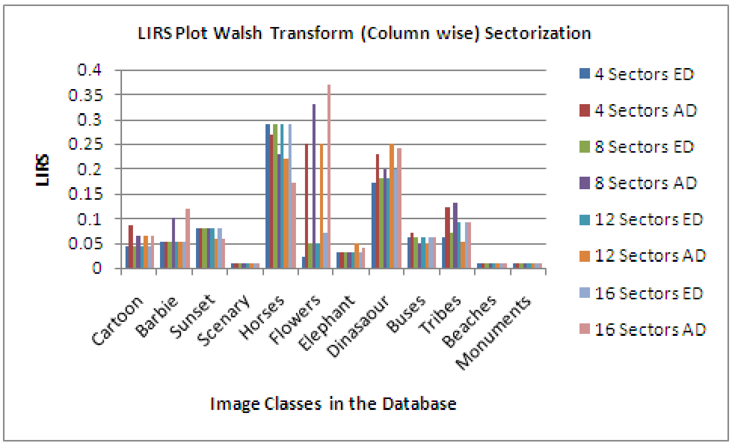

Figure 9. Class wise LIRS plot of WALSH column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

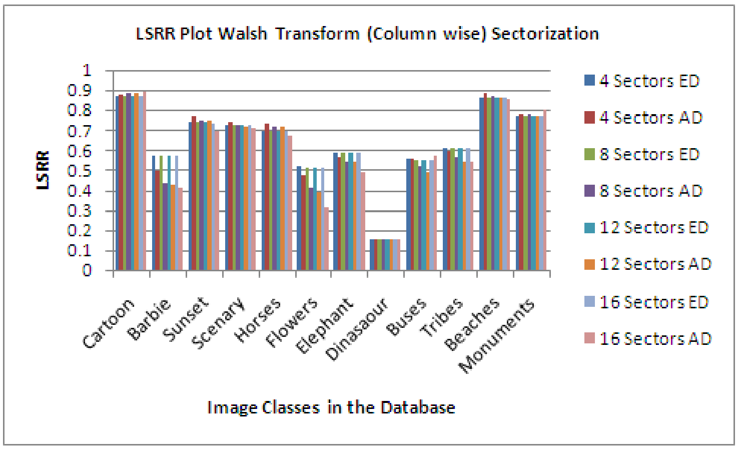

Figure10. Class wise LSRR plot of WALSH column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

E. Sectorization of Walsh Wavelet transformed (Column wise) Images

Looking at the Figure 11 for the sectorization of the Walsh wavelet (column wise) sum of absolute difference as similarity measure provides the good output of retrieval compared to the Euclidian distance for monuments, beaches, flowers, Barbie, cartoon and buses classes. The LIRS plot shows the up to 30% images of the class has been retrieved as the part of the initial relevant string for dinasaour, flower and horses classes (see the Figure 12).The faster the retrieval of all relevant images in the class provides the minimum LSRR and better performance. The figure 13 depicts the same. As shown the LSRR for dianasaour, flower and barbie classes are 15%, 50%, 60%.Among which the dianasaour has the best outcome.

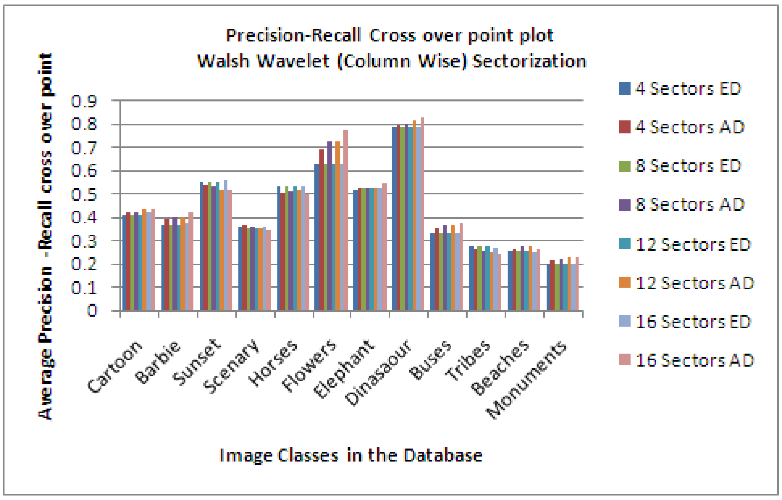

Figure11. Class wise Average Precision-Recall cross over point plot of WALSH Wavelet column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

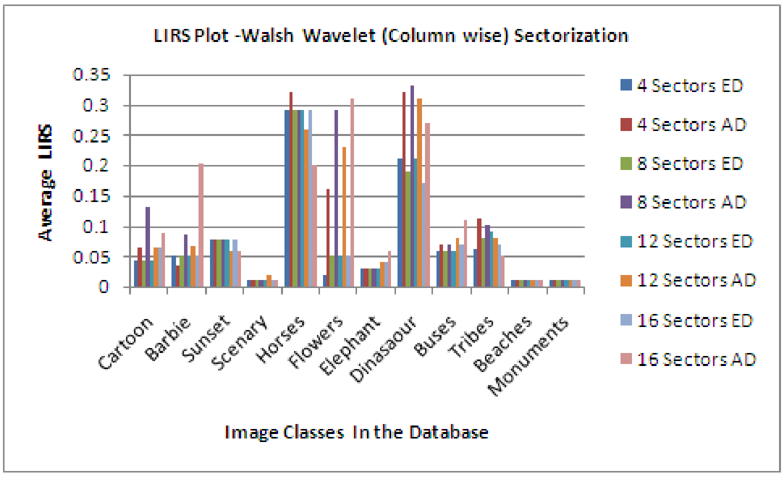

Figure12. Class wise LIRS plot of WALSH Wavelet column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

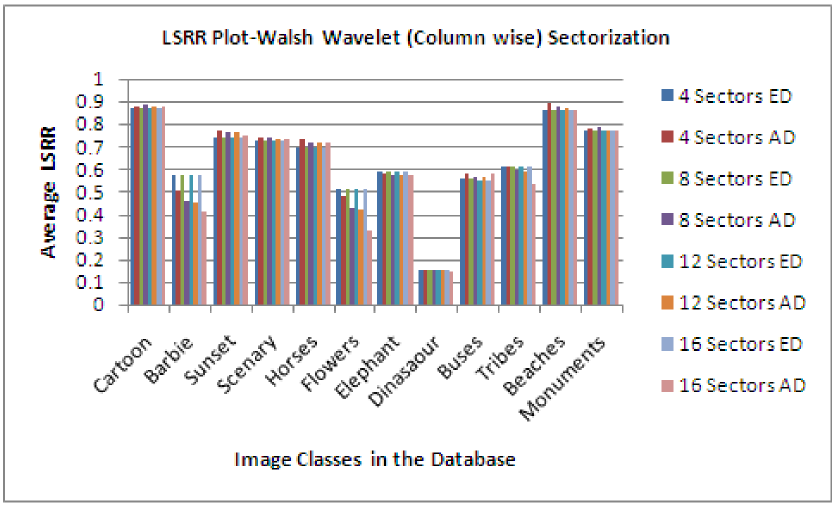

Figure13. Class wise LSRR plot of WALSH Wavelet column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

F. Overall Comparison of all Approaches.

The Figure 14-Figure 16 compares the overall average performance of all proposed methods employed in CBIR. As far as precision-recall cross over point plot performance goes .The average retrieval is 40%.However the Walsh Wavelet (column wise) sectorization (4,8,12 and 16 sectors with AD) has the best retrieval up to 45% whereas the Walsh (column wise) is very close to 45%.The second best performance has been given by the Walsh wavelet Row wise followed by Walsh row wise transformation. Comparing the LIRS Performance the Walsh Wavelet (Full transformation –Plane2 with sum of absolute difference as similarity measure) has the maximum relevant retrieval as the part of first initial retrievals. The graph clearly shows that each class has the relevant retrievals as the part of initial retrievals.

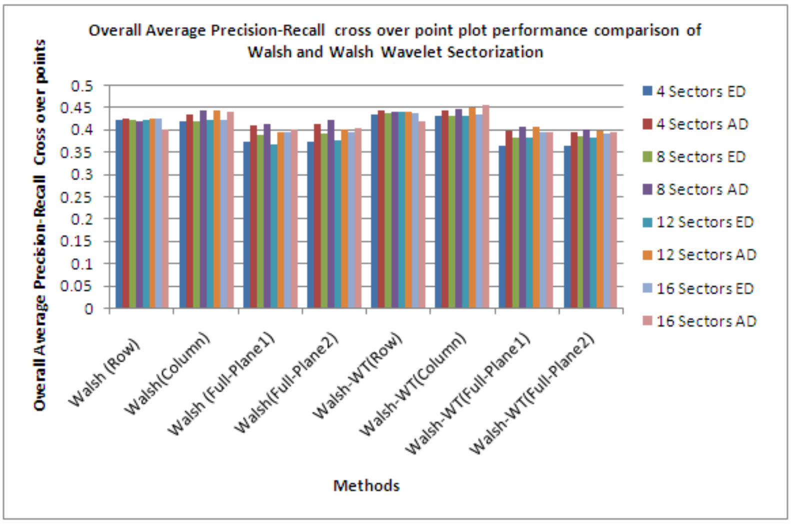

Figure14. Overall Average Precision-Recall cross over point plot comparison of WALSH and WALSH Wavelet Sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

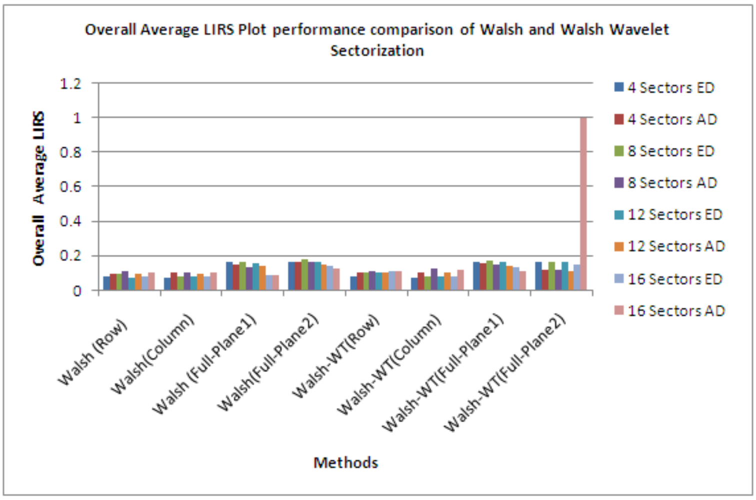

Figure15. Overall Average LIRS plot comparison of WALSH and WALSH Wavelet Sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

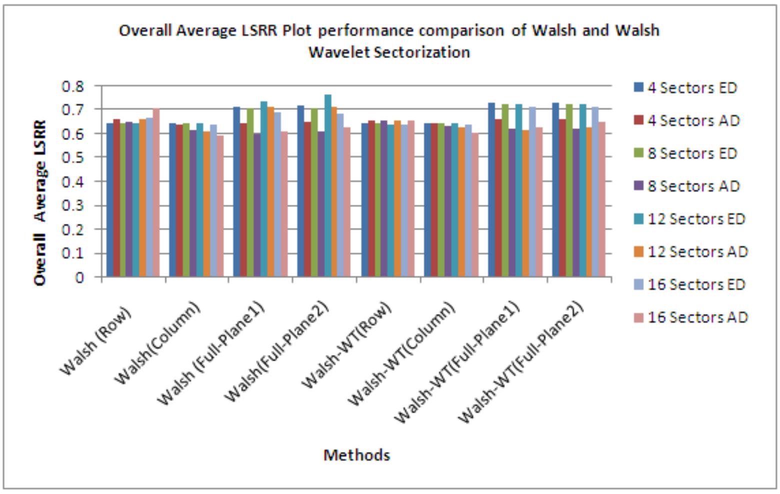

Figure16. Overall Average LSRR plot comparison of WALSH and WALSH Wavelet Sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

V. CONCLUSION

The content based image retrieval has very wide scope in the recognition system as one of the crucial part of the image processing. This paper proposes the various ways of transforming the images, sectoring it in various sector sizes i.e. 4,8,12 and 16 to generate feature vectors. Walsh Wavelet transform has been introduced for the first time. The retrieval performances of all these approaches i.e. Walsh (row, column, full-plane1, plane2) and Walsh Wavelet transform (row, column, full-plane1, plane2) has been measured by means of Average precision-recall cross over point plot, LIRS and LSRR. The effect of two similarity measures on the retrieval rate has also been compared and studied. The class wise average retrievals have lots of variations in the result. Focusing on the overall average performance comparison of all methods (see Figure14-16) ;It is very easy to comment that sectorization of Walsh Wavelet (Column wise) and Walsh (Column wise) with sectors 8,12,16 with sum of absolute difference give the best result. The sectorization of Walsh Wavelet (Row wise) is close to 45% retrieval for all of its sector sizes. The overall Performance of the LIRS shows that the initial string of retrievals definitely consists of the relevant images as it can be seen from the graph that none of the classes or sectors have 0% of LIRS. The LSRR performance is up to the 60% (on average) which could be reduced further with further experiments.

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