Performance Comparison of Sectorization of DCT and DCT Wavelet Transformed Images in CBIR

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ABSTRACT

This paper mainly discusses the use of discrete cosine transform and its wavelet for feature extraction in the application of content based image retrieval. The proposed method has been experimented based on the concept of sectorization of the transformed images using DCT and DCT Wavelet. For the detailed study of the behavior of the method the sector sizes are varied in 4,8,12 and 16 sector sizes. For each sector sizes two separate similarity measures namely Euclidean distance (ED) and the sum of absolute difference (AD) are considered. So the performance of the proposed methods are compared and analyzed based on the sector sizes and type of similarity measures used. The various parameters like precision, recall and its cross over point plots, LIRS and LSRR are used to measure the overall as well as the class wise performances. The sizes of the image database consist of 1055 images distributed among 12 different classes. Comparing the performance of DCT and DCT Wavelet on the broader term it has been observed that 4 sectors and 8 sectors of DCT (column wise) and DCT Wavelet (column wise) with sum of Absolute difference as similarity measure provide the best outcome of the retrieval i.e. close to 45%.

General Terms

CBIR, Image retrieval, pattern recognition

Keywords

CBIR, Precision, Recall, LSRR, LIRS, Euclidean distance, sum of absolute difference.

1. INTRODUCTION

The innovations taking place in the digital world has evolved itself to very large extent. The result of which has caused the maximum dependency on the computer. All the information being in any form i.e. multimedia, documents, images etc. everything has got the right place in the computer. The computer has been proved to be the very powerful mechanism to use these digital data, storage them securely and access it efficiently 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 approaches which has been researched upon to use content of the image itself to draw out its uniqueness. This uniqueness can make one to differentiate the images with each other which can provide the retrieval of the relevant images as per the requirement. There are mainly three attributes i.e. shape, color and textures of the image as of now is being experimented by many researchers. These attributes 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 so on. The tremendous use of images in the digital world of today has proved the CBIR as very useful in various applications like Finger print recognition, Iris Recognition, Face recognition, Palm print recognition, Speaker identification, Pattern matching and recognition etc.

There are various approaches which have been experimented to generate the efficient algorithm for CBIR. The approaches proposed by various researchers are based on both spatial domain and frequency domain. 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 [5-15]. Methods of feature extraction using Vector Quantization [16], Bit Truncation Coding [17,18],Walsh Transform[20,21] has also provided the new horizon to the feature extraction methodology. The method of sectorization has already been experimented on DCT [22], DST [23], DCT-DST Plane [24], Haar Wavelet [25] and Kekre's Transform [26] earlier. This paper we propose new transform named as DCT Wavelet generated from DCT matrix. The use of sectorization of DCT Wavelet for feature extraction in CBIR has been discussed. The outcome of which has been compared with the DCT sectorization performance.

The section 2 of this paper focuses on the concept of Wavelet formation from the discrete cosine transform and its sectorization.

The section 3 discusses the sectorization of the transformed images and extraction of features to generate the feature database. It also focuses on the basic definition of row wise, column wise and full transformations. The algorithmic performance measuring parameters are discussed.

Section 4 organizes the discussion of the results plotted in the form of class wise average precision –recall cross over point, Length of initial relevant string (LIRS) and Length of string to recover all relevant images (LSRR) for all approaches. Finally concludes with overall comparison of DCT and DCT Wavelet.

Finally the paper discusses the conclusion of the outcome for the methodologies proposed

2.DCT AND DCT WAVELET

2.1 Discrete cosine Transform [22]

DCT is formed consisting of cosine functions considered over half the interval with division of this half interval into N equal parts. Sampling each function at the center of these parts gives orthogonal sequences. The DCT matrix is formed by arranging these sequences row wise. The DCT definition of 1 dimensional Sequence of Length N is given as [22]

$$C(u) = \alpha(u) \sum_{x=0}^{N-1} f(x) \cos\left[\frac{\pi(2x+1)u}{2N}\right],$$

(1)

For u= 0,1,2….N-1

Similary inverse transform is given as :

$$f(x) = \sum_{u=0}^{N-1} \alpha(u) C(u) \cos\left[\frac{\pi(2x+1)u}{2N}\right],$$

(2)

For x = 0,1,2…N-1 and α(u) for both equations (1) and (2) is defined as :

$$\alpha(u) = \begin{cases} \sqrt{\frac{1}{N}} & for \quad u = 0 \\ \sqrt{\frac{2}{N}} & for \quad u \neq 0. \end{cases}$$

(3)

2.2 DCT Wavelet Generation [4]

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 DCT Wavelet transform matrix of size $N^2 x N^2$ from DCT matrix of size NxN is given in [4].However in this case we require DCT matrix of size 128x128 where 128 is not a square. To simplify this situation, this paper proposes an algorithm to generate discrete cosine wavelet transform from discrete cosine transform of 8x8 and 16x16.

In this paper the DCT 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 DCT matrix and 8x8 DCT matrix. First 16 rows of Wavelet transform matrix are generated by repeating every column of DCT matrix of dimension 16x16, 8 times. To generate next 17 to 32 rows, second row of DCT (8X8) is translated using groups of 8 columns with horizontal and downward shifts. To generate next 33 to 48 rows, third row of DCT (8X8) matrix is used in the same manner. Like wise to generate last 113 to 128 rows, 8th row of transform DCT (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 DCT matrix of size 8x8 giving local components of the DCT Wavelet.

3. SECTORIZATION AND FEATURE EXTRACTION

Once the DCT Wavelet has been generated, Images in the database and query images are transformed using row wise, column wise and full transformation for both DCT and DCT Wavelet. The figure given below shows the formal steps of feature vector generation in brief.
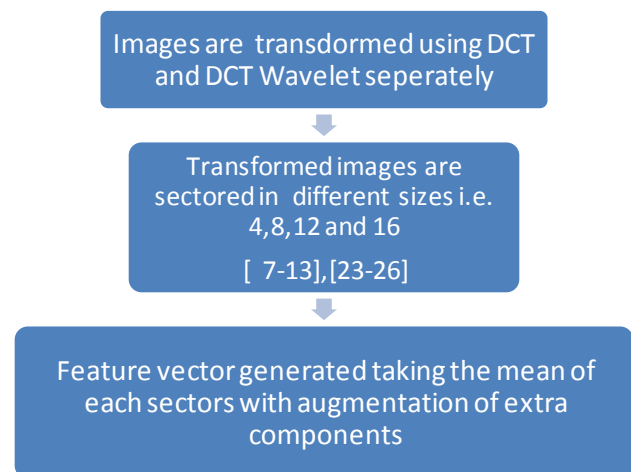
Images are transdormed using DCT and DCT Wavelet seperately

Transformed images are sectored in different sizes i.e. 4,8,12 and 16

[7-13],[23-26]

Feature vector generated taking the mean of each sectors with augmentation of extra components

Figure 1 Steps to generate the feature vectors

3.1 Row wise Transformation [24]

The row wise transformation of DCT and DCT Wavelet

[DCT_ WT] is given by :

F = f *[DCT]^T

F= f*[DCT_WT]^T

Where F is transformed image, f is input image to be transformed

3.2 Column wise Transformation [27]

The column wise transformation of DCT and DCT Wavelet [DCT_WT] is given by :

F = [DCT]*f

F= [DCT_WT]*f

Where F is transformed image, f is input image to be transformed

3.3 Full Transformation [28]

The row wise transformation of DCT and DCT Wavelet [DCT_ WT] is given by :

F = [DCT]* f * [DCT]^T

F= [DCT_WT]* f * [DCT_WT]^T

Where F is transformed image, f is input image to be transformed

In the full transformation methods two complex planes have been conceptualized [28]. These two planes are sectored in the various sector sizes for the experiment. These two planes have been formed by ignoring first and last rows and columns. Remaining elements have been partitioned in a group of size 2x2.The two complex planes, plane1 and plane2, are formed by taking combination of all the elements X(i,j), Y(i+1,j+1) and X(i+1,j), Y(i,j+1) for i,j = 2 ,3,4,…, N-1 as shown below.

X(i,j)	Y(i,j+1)
X(i+1,j)	Y(i+1,j+1)
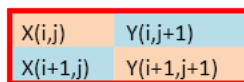
3.4 Sectorization [7-13][23-28]

The individual components of row and column wise transformed images are distributed into different co-ordinates of Cartesian coordinate system according to their sign change with 45 degree of angle of division to form four sectors. The division of each of these 4 sectors into 2 partitions forms the 8 sectors which distributed the transformed image components into its appropriate sectors. Continuing the same division concept further with change in the angle size the sector sizes of 12 and each sectors 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

Once features of the all images in the database are extracted using the procedure as explained the feature database is generated. The query image to be retrieved from the database has been transformed using DCT/DCT Wavelet and the extracted feature of the query image is compared with the feature database using two similarity measures i.e. Eucledian distance (ED) and sum of absolute difference (AD) as given in the equation (4) and (5) shown below :

$$ED(P.Q) = \sum_{i=1}^{N}(Pi - Qi)^2 \qquad (4)$$

$$AD(P.Q) = \sum_{i=1}^{N}|Pi - Qi| \qquad (5)$$

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 (6) to (9).

$$Precision = \frac{\text{Number of relevant images retrieved}}{\text{Total Number of images retrieved}} \qquad (6)$$

$$Recall = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in database}} \qquad (7)$$

$$LIRS = \frac{\text{Length of initial relevant string of images}}{\text{Total relevant images in the Database}} \qquad (8)$$

$$LSRR = \frac{\text{Length of string to recover all relevant images}}{\text{Total images in the Database}} \qquad (9)$$

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.

4. RESULTS AND DISCUSSION
4.1 Image Database

The sample Images of the augmented Wang database [29] 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 2.

Figure 2. Sample images in the Database

The class wise distribution of all images in its respective classes such as ther are 46 images of cartoon in the class, there are 100 images for flower and so on are shown in the Figure 3 below.

Cartoon 46	Flower 100	Elephants 100	Barbie 59	Mountains 100	Horse 100
Sunset 51	Tribal 100	Beaches 99	Monuments 100	Dinasaour 100	

Figure 3. Class wise distribution of images

4.2 Sectorization of Row wise Transformed (DCT) images

This section mainly discusses the algorithmic performance of the sectorization of row wise DCT transformed images in CBIR. The class wise precision-recall cross over point plot shown in the Figure 4 depicts the variation in the performance in all class of images. It can be very clearly seen that the sector 12 of most of the classes has good retrieval rate with maximum of 80% for dinosaur; for flowers it's more that 60% and 50% for horse, sunset and elephant class (see Figure 4). LIRS performance checks number of relevant images retrieved as he part of initial string of retrievals before getting the first irrelevant. So the maximum of LIRS can show the best retrieval performance. At the same time the LSRR performance checks the total length of retrievals carrying all relevant images. So the minimum LSRR shows good performance. The dinosaur class shows the ideal performance As shown in the Figure 5 and Figure 6.It varies for rest of the classes.
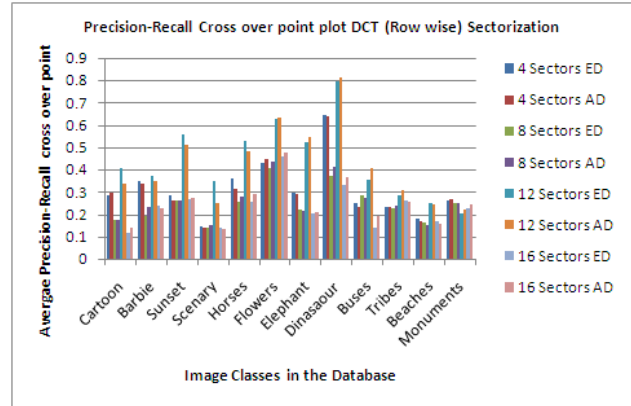

Figure4. Class wise Average Precision-Recall cross over point plot of DCT row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
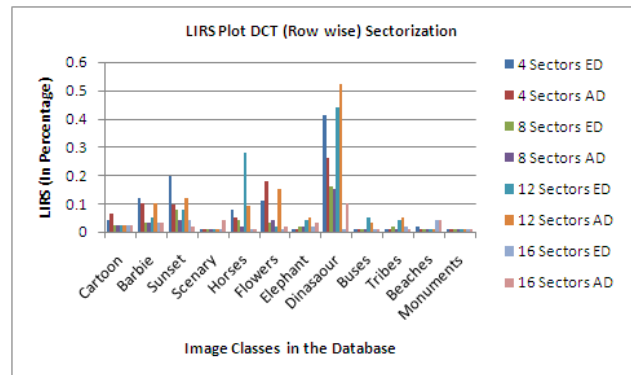

Figure5. Class wise LIRS plot of DCT row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
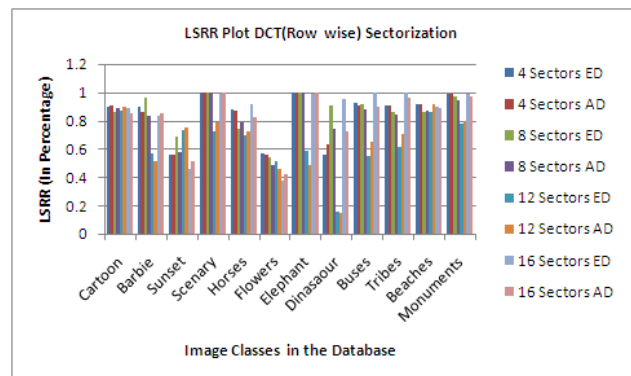

Figure6. Class wise LSRR plot of DCT row wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

4.3 Sectorization of Column wise Transformed (DCT) images

Sectorization of the column wise DCT transformed images provide the better performance of precision –Recall cross over point compared to the row wise transformation. It it shown in the Figure 7 as for the dinosaur class the sector sizes 4,8 and 16 reaches up to 80% of retrieval. The sectors 4,8 with AD gives 70% of retrieval for flower class whereas sector 16 with AD of the same class gives the retrieval more than 75%.Sector 12 as not performed well for most of the classes apart from Barbie class which has up to 70% retrieval rate with ED (see the Figure 7).on average performance with respect to LIRS plot is up to 20% with the maximum of 30% for horse, Dinosaur class. LSRR plots shown in the Figure 9 shows the better performance for dinosaur, flower classes and it varies from sector to sector.
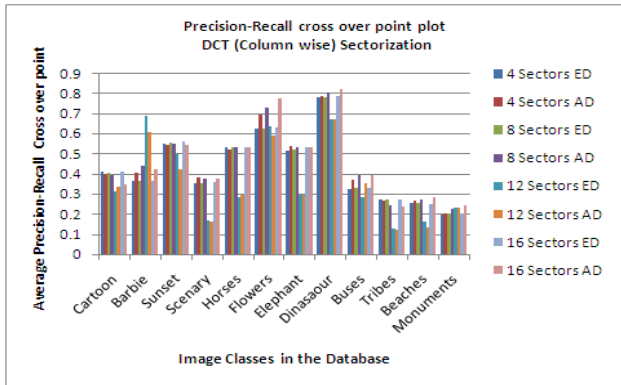

Figure7. Class wise Average Precision-Recall cross over point plot of DCT column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
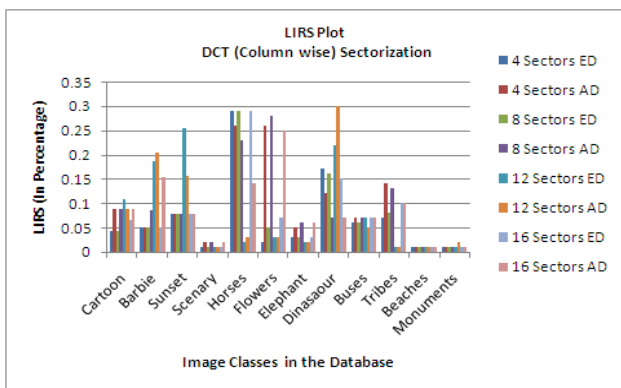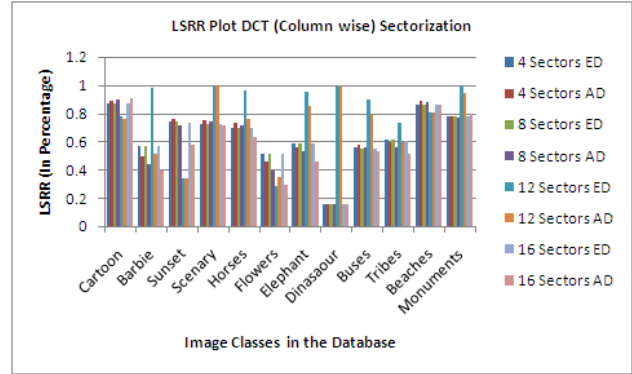

Figure 8. Class wise LIRS plot of DCT column wise sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

Figure9. Class wise LSRR plot of DCT column wise sectorization for all sector sizes with respect to similarity measures i.e. Eucledian distance (ED) and sum of absolute difference (AD)

4.4 Sectorization of Full Transformed (DCT) images

In this section the performance of Full DCT sectorization with respect to two different planes i.e. Plane1 and plane2 has been plotted in the form of average precision-recall cross over point in Figure 10; LIRS plot in Figure 11 and LSRR plot in Figure 12. According to the precision-recall cross over point The best retrieval is again for dinosaur class given by all sectors with AD as similarity measure which makes the count to reach to 80%.The second ranked retrieval outcome is for flower class well above 78% sector 8,12,16 with AD. Next comes with the Barbie class which has retrieval up to 65% (sector size 8,12,16 with AD) . The plane2 plane has almost same retrieval rate as compared to plane1 with slight difference in flower ,cartoon class as shown in the Figure 13-15.
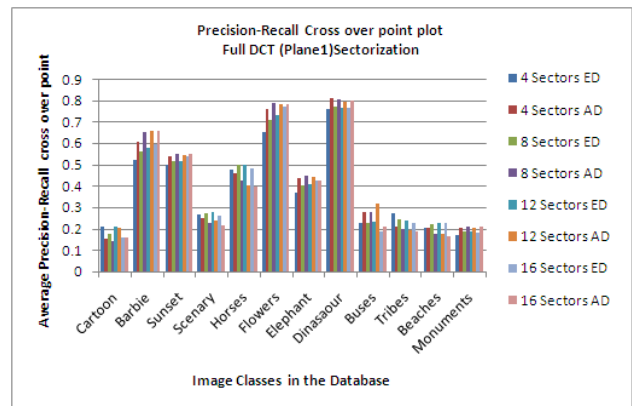

Figure 10. Class wise Average Precision-Recall cross over point plot of Full DCT (Plane1) sectorization for all sector sizes with respect to similarity measures i.e. Eucledian distance (ED) and sum of absolute difference (AD)
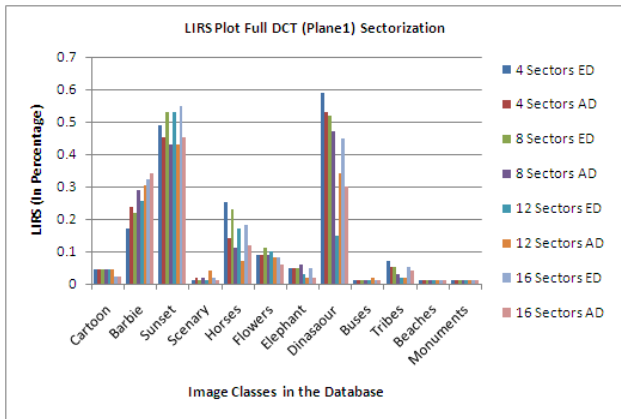
Figure 11. Class wise LIRS plot of Full DCT (Plane1) sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

Figure 12. Class wise LSRR plot of Full DCT (Plane1) sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
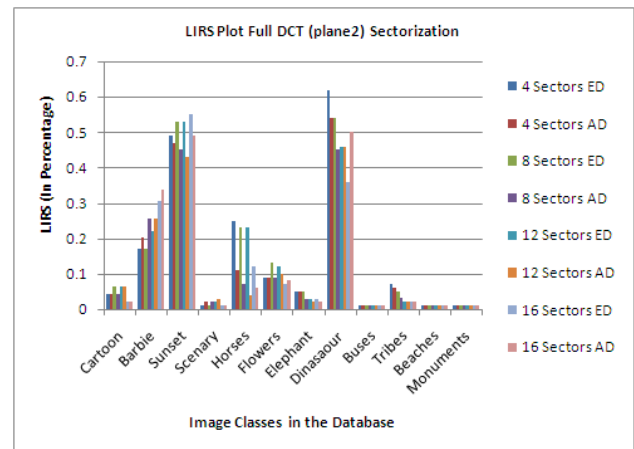

Figure 13. Class wise Average Precision-Recall cross over point plot of Full DCT (Plane2) sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
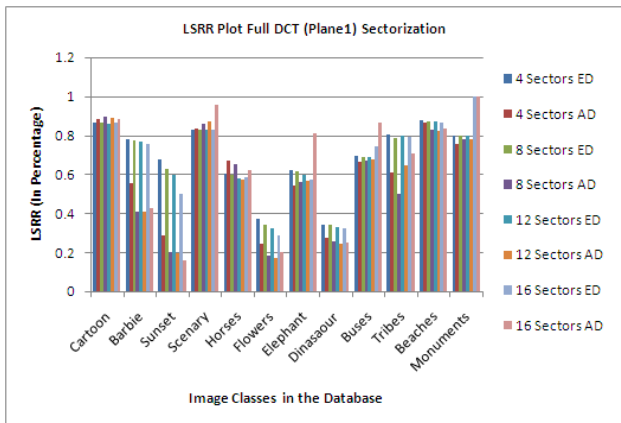

Figure 14. Class wise LIRS plot of Full DCT (Plane2) sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
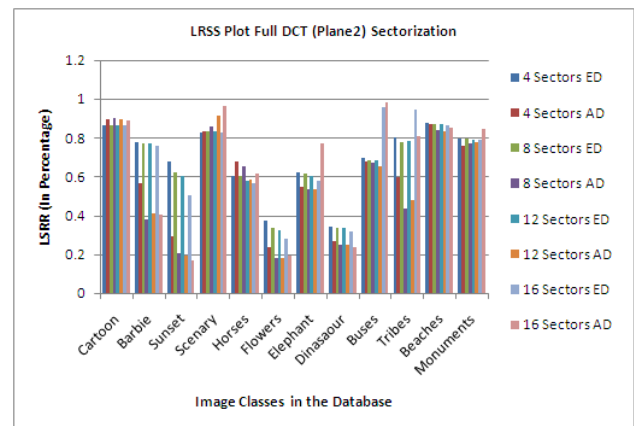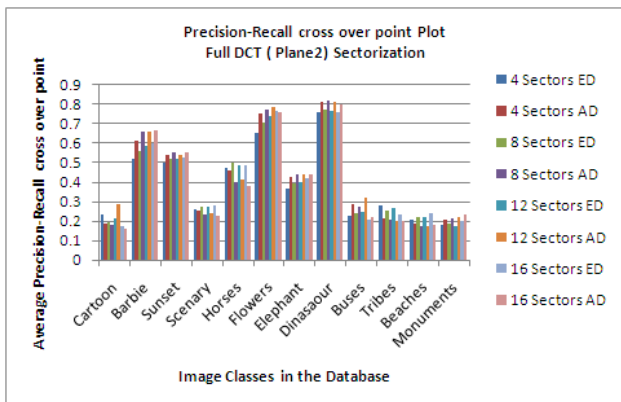

Figure 15. Class wise LSRR plot of Full DCT (Plane2) sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

4.5 Overall Comparison

This section compares the overall performance of all methods implemented i.e. DCT (row, column, full), DCT Wavelet (row, column, full) with respect to all performance measuring parameters namely precision-recall cross over point plot shown in Figure 16,the Overall average LIRS plot shown in the Figure 17 and the overall average LSRR plot in the figure 18. It is seen from the graph to comment that the column wise approach in all cases provide the better performance as compared to row wise transformation. For full transformation sectorization of both planes provide the retrieval up to 40%. It is found that the all sectors of DCT Wavelet (row wise and column transformation) has retrieval performance closer to 45%.
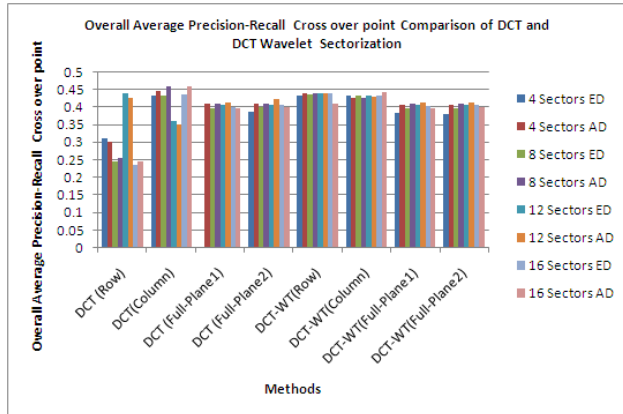
Figure16. Overall Average Precision-Recall cross over point plot comparison of DCT and DCT Wavelet Sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

Figure17. Overall Average LIRS plot comparison of DCT and DCT Wavelet Sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)

Figure18. Overall Average LSRR plot comparison of DCT and DCT Wavelet Sectorization for all sector sizes with respect to similarity measures i.e. Euclidian distance (ED) and sum of absolute difference (AD)
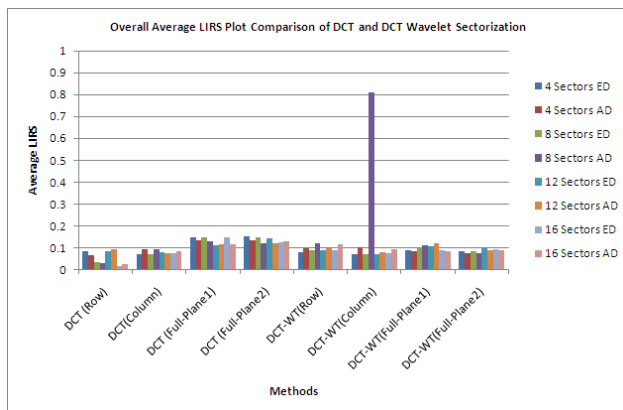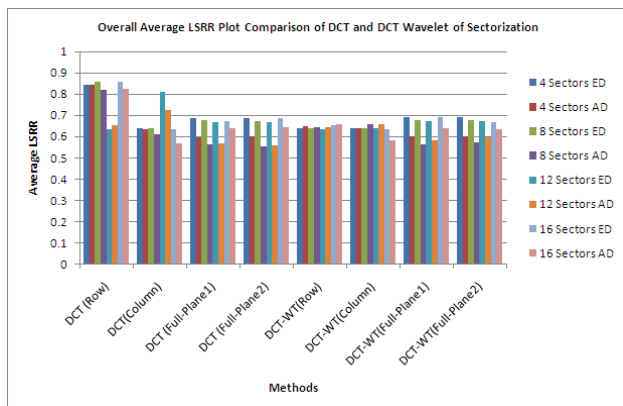
5. CONCLUSION

The paper compares the retrieval performance of DCT and DCT Wavelet sectorization. The performance of both of these approaches has been analyzed based on the variation in the sizes of the sectors and the type of similarity measures namely Euclidian distance (ED) and sum of absolute difference (AD) and the transformation approaches i.e. row wise, column wise and full. Two planes namely have been formed in the Full transformation. These two planes are sectored in various sizes to check its effect in the final outcome. The performance measuring parameters like precision-recall cross over point plot, LIRS Plot and LSRR Plot has been used. Comparing the performance of DCT and DCT Wavelet on the broader term it has been observed that 8 sectors and 16 sectors of DCT (column wise) with Absolute difference provide the best outcome of the retrieval i.e. more than 45%.The outcome of retrieval for DCT Wavelet (row wise and column wise) is close to 45%. There is variation in the results with respect to the sector sizes in these approaches. All sector sizes perform well up to 40% in the case of the DCT(column wise) except sector 12. whereas for DCT Wavelet all sectors has good performance. All sectors with both ED and AD of DCT Wavelet (row wise) sectorization has retrieval rate more than 40% which is far better than DCT (row wise) which is only up to 30%. In general column wise and full plane sectors give better performance as compared to row wise. Whereas for full transform plane1 and plane2 give similar performance. The best performance is obtained for dinasour and flowers class which is up to 80% .

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