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Discrete Sine Transform Sectorization for Feature Vector Generation in CBIR

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Abstract- **We have introduced a novel idea of sectorization of DST transformed components. In this paper we have proposed two different approaches along with augmentation of mean of zero and highest row components of row transformed values in row wise DST transformed image and mean of zero- and highest column components of Column transformed values in column wise DST transformed image for feature vector generation. The sectorization is performed on even-odd plane. We have introduced two new performance evaluation parameters i.e. LIRS and LSRR apart from precision and Recall, the well-known traditional methods. Two similarity measures such as sum of absolute difference and Euclidean distance are used and results are compared. The cross over point performance of overall average of precision and recall for both approaches on different sector sizes are compared. The DST transform sectorization is experimented on even-odd row and column components of transformed image with augmentation and without augmentation for the color images. The algorithm proposed here is worked over database of 1055 images spread over 12 different classes. Overall Average precision and recall is calculated for the performance evaluation and comparison of 4, 8, 12 & 16 DST sectors. The use of Absolute difference as similarity measure always gives lesser computational complexity and better performance.**

Keywords-CBIR, DST, Euclidian Distance, Sum of Absolute Difference, Precision and Recall, LIRS, LSRR.

1. INTRODUCTION

Content-based image retrieval (CBIR), [1], [2] is any technology that in principle helps to organize digital picture archives by their visual content. By this definition, anything ranging from an image similarity function to a robust image annotation engine falls under the purview of CBIR. This characterization of CBIR as a field of study places it at a unique juncture within the scientific community. People from different fields, such as, computer vision, machine learning, information retrieval, human-computer interaction, database systems, Web and data mining, information theory, statistics, and psychology contributing and becoming part of the CBIR community[3][4]. Amidst such marriages of fields, it is important to recognize the shortcomings of CBIR as a real-world technology. One problem with all current approaches is the reliance on visual similarity for judging semantic similarity, which may be problematic due to the *semantic* between low-level content and higher-level concepts. While this intrinsic difficulty in solving the core problem cannot be denied, it is believed that the current state-of-the-art in CBIR holds enough promise and maturity to be useful for real-world applications if aggressive attempts are made. For example, many commercial organizations are working on image retrieval despite the fact that robust text understanding is still an open problem. Online photo-sharing has become extremely popular, which hosts hundreds of millions of pictures with diverse content. The video-sharing and distribution forum has also brought in a new revolution in multimedia usage. Of late, there is renewed interest in the media about potential real-world applications of CBIR and image analysis technologies, There are various approaches which have been experimented to generate the efficient algorithm for CBIR like FFT sectors [5-8], Transforms [16], [17], Vector quantization[16], bit truncation coding [17][18]. In this paper we have introduced a novel concept of complex Full Walsh transform and its sectorization for feature extraction (FE).Two different similarity measures namely sum of absolute difference and Euclidean distance are considered. The performances of these approaches are compared.

II. DISCRETE SINE TRANSFORM

The discrete sine transform matrix is formed by arranging these sequences row wise. The NxN Sine transform matrix y(u,v) is defined as

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$$y(u,v) = \sqrt{2/(N+1)}\,\sin[\pi(u+1)(v+1)/(N+1)]$$
$$\text{for } 0 <= u, v <= N-1 \qquad (1)$$

III. FEATURE VECTOR GENERATION

The proposed algorithm makes novel use of DST transform to design the sectors to generate the feature vectors for the purpose of search and retrieval of database images. The rows in the discrete cosine transform matrix have a property of increasing sequency. Thus zeroeth and all other even rows have even sequences whereas all odd rows have odd sequency. To form the feature vector plane we take the combination of co-efficient of consecutive odd and even co-efficient of every column and putting even co-efficient on x axis and odd co-efficient on y axis thus taking these components as coordinates we get a point in x-y plane as shown in figure 1.

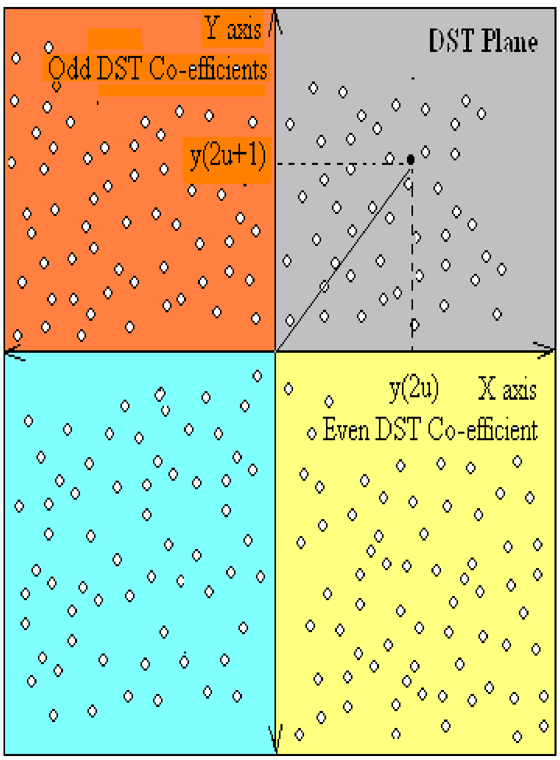


Figure 1: The DST Plane used for sectorization

We have proposed plane namely even-odd component plane for feature vector generation taking mean value of all the vectors in each sector with sum of absolute difference [7-13] and Euclidean distance [7-9] [11-14] as similarity measures. In addition to these the feature vectors are augmented by adding two components which are the average value of zaroeth and the last row and column respectively. Performances of both these approaches are compared with respect to both similarity measures. Thus for 4, 8, 12 & 16 DST sectors 8, 16, 24 and 32 feature components along with augmentation of two extra components for each color planes i.e. R, G and B are generated. Thus all feature vectors are of dimension 30, 54, 72 and 102 components.

A. *Four DST Sectors:*

To get the angle in the range of 0-360 degrees, the steps as given in Table 1 are followed to separate these points into four quadrants of the complex plane. The DST of the color image is calculated in all three R, G and B planes. The even rows/columns components of the image and the odd rows/columns components are checked for positive and negative signs. The even and odd DST values are assigned to each quadrant. as follows:

TABLE I. FOUR DST SECTOR FORMATION

Sign of Even row/column	Sign of Odd row/column	Quadrant Assigned
+	+	I ($0 – 90^0$)
+	-	II ($90 – 180^0$)
-	-	III($180- 270^0$)
-	+	IV($270–360^0$)

However, it is observed that the density variation in 4 quadrants is very small for all the images. Higher number of sectors such as 8, 12 and 16 were tried.

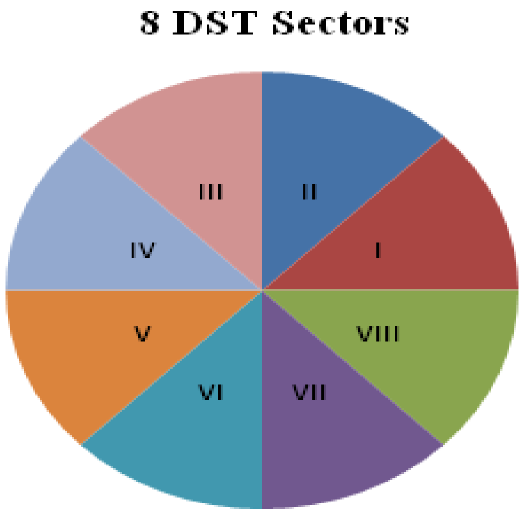
Sum of absolute difference measure is used to check the closeness of the query image from the database image and precision and recall are calculated to measure the overall performance of the algorithm.

B. *Eight DST Sectors:*

Each quadrants formed in the previous obtained 4 sectors are individually divided into 2 sectors each considering the angle of 45 degree. In total we form 8 sectors for R, G and B planes separately as shown in the Figure 2.

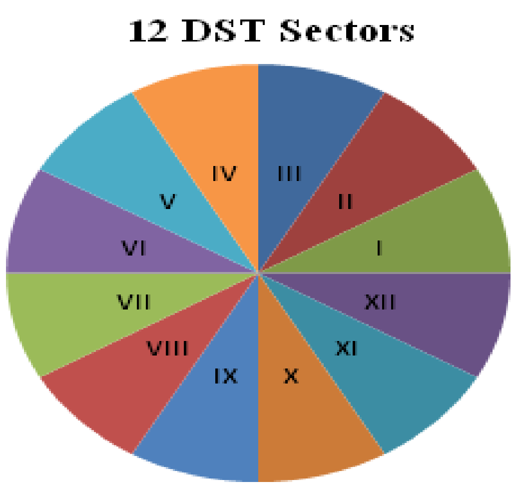
C. *Twelve DST Sectors:*

Each quadrants formed in the previous section of 4 sectors are individually divided into 3 sectors each considering the angle of 30 degree. In total we form 12 sectors for R,G and B planes separately as shown in the Figure 3.



Sectors	Conditions
I,IV,V,VIII	|A|>= |B|
II,III,VI,VII	|B| >= |A|
Where A= Even Row / Column of Transformed Image B = Odd Row / Column of Transformed Image	

Figure 2: Formation of 8 sectors of DST



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= Even Row / Column of Transformed Image B = Odd Row / Column of Transformed Image	

Figure 3: Formation of 12 sectors of DST

D. Sixteen DST Sectors:

Sixteen sectors are obtained by dividing each one of eight sectors into two equal parts.

IV. RESULTS AND DISCUSSION

The sample Images of the database of 1055 images of 12 different classes such as Flower, Sunset, Barbie, Tribal, Puppy, Cartoon, Elephant, Dinosaur, Bus, Parrots, Scenery, Beach is shown in the Figure 4.

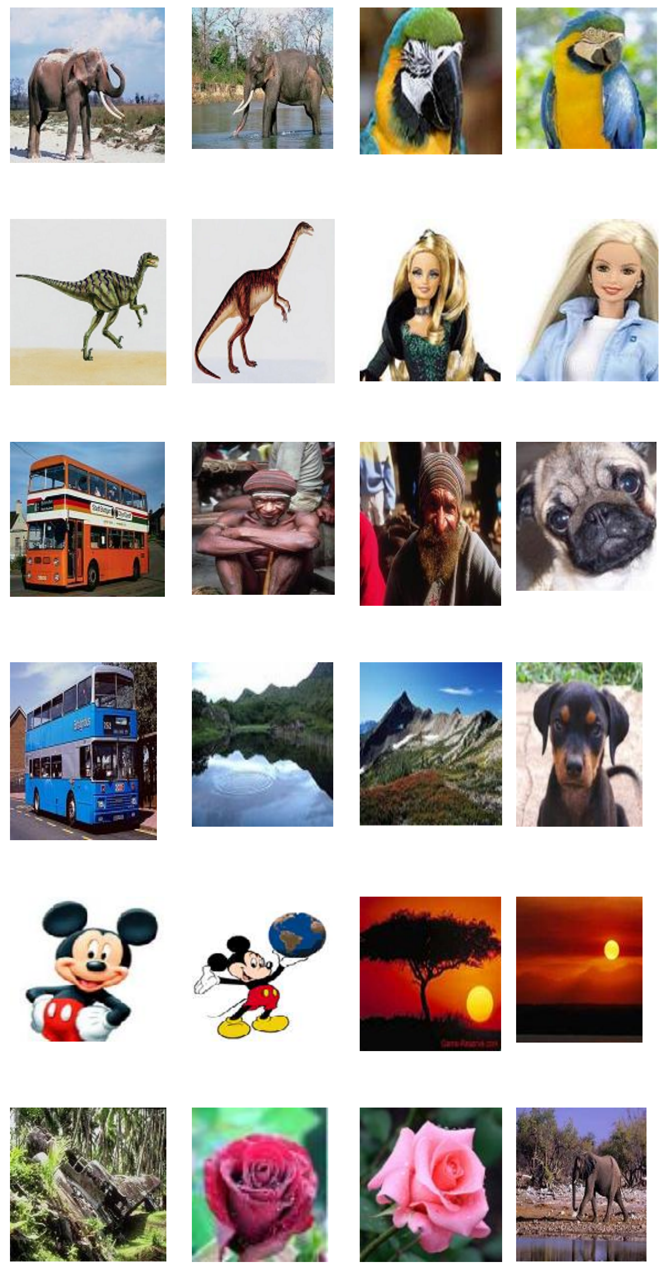
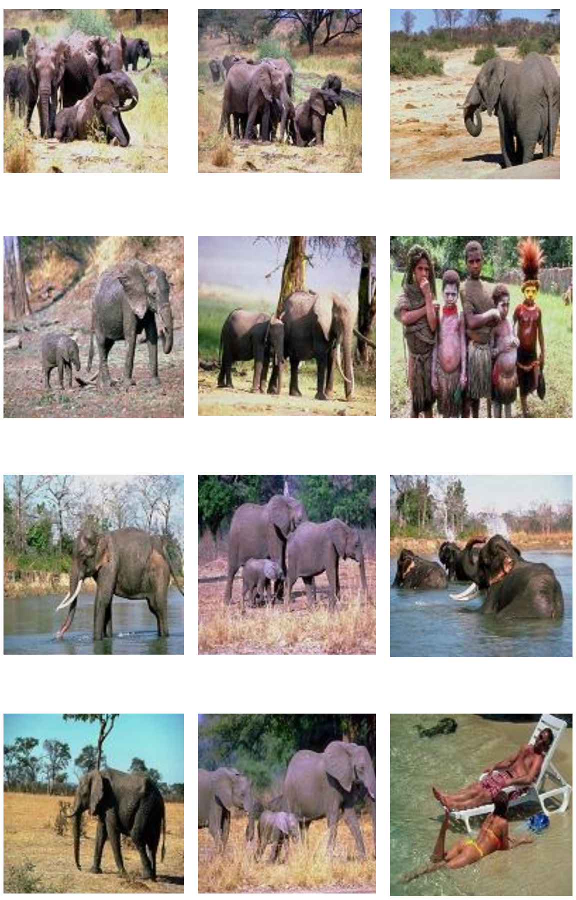


Figure 4: Sample Image Database

Figure 5: Query Image

The elephant class image is taken as sample query image as shown in the Figure 5 for both approaches i.e. row wise and column wise. The first 21 images retrieved in the case of sector mean in 16 DST sectors used for feature vectors and sum of Absolute difference as similarity measure is shown in the Figure 6 and Figure 7 for both approaches. It is seen that only 4 images of irrelevant class are retrieved among first 21 images and rest are of query image class i.e. elephant in column wise DST transformation. Whereas in the case of row wise in 16 DST Sectors with sum of Absolute Difference as similarity measures there are only 6 images of irrelevant class and 15 images of the query class i.e. elephant is retrieved as shown in the Figure 7.



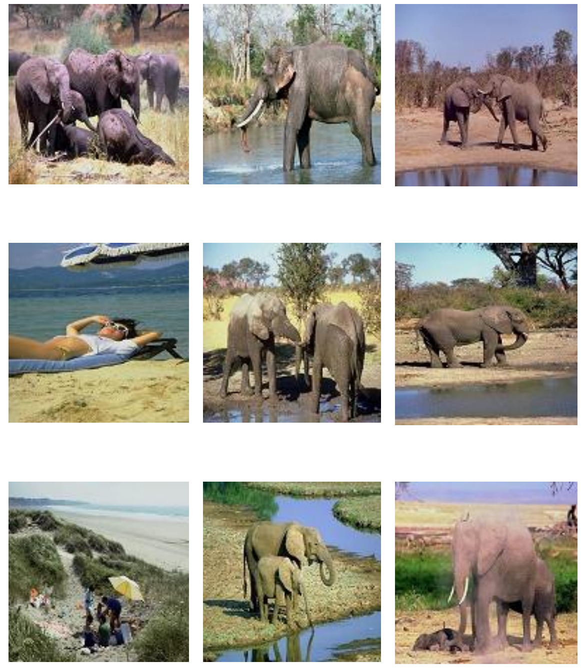
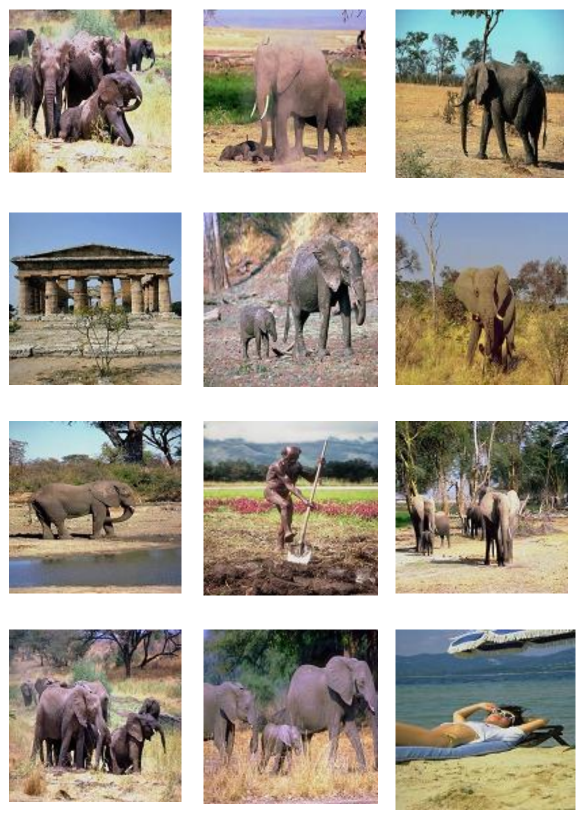


Figure 6: First 21 Retrieved Images of 16 DST Sectors (column wise) with sum of Absolute Difference as similarity measures for the query image shown in the Figure 5



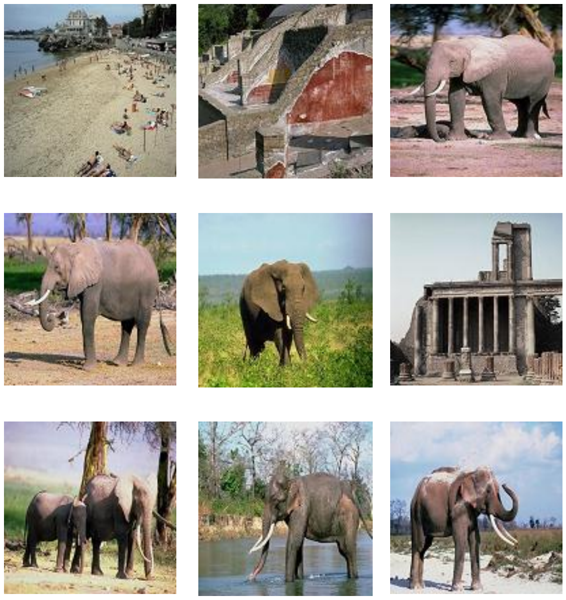


Figure 7: First 21 Retrieved Images of 16 DST Sectors (row wise) with sum of Absolute Difference as similarity measures for the query image shown in the Figure 5

Once the feature vector is generated for all images in the database a feature database is created. A query image of each class is produced to search the database. The image with exact match gives minimum absolute difference. To check the effectiveness of the work and its performance with respect to retrieval of the images we have calculated the precision and recall as given in Equations (2) & (3) below along with this we have introduced two new performance evaluation parameters for the first time namely length of initial relevant string of images (LIRS) and Length of string to recover all relevant images (LSRR) in the database as given in equation (4) and (5):

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total Number of images retrieved}} \qquad (2)$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in database}} \qquad (3)$$

$$\text{LIRS} = \frac{\text{Length of initial relevant string of images}}{\text{Total relevant images retrieved}} \qquad (4)$$

$$\text{LSRR} = \frac{\text{Length of string to recover all relevant images}}{\text{Total images in the Database}} \qquad (5)$$

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.

The Figure 8 – Figure 11 shows the Overall Average Precision and Recall cross over point performance of column wise DST transformed image with augmentation in 4, 8, 12 and 16 sectors and sum of absolute Difference and Euclidian distance as similarity measures respectively. Figure12-15 Overall Average Precision and Recall cross over point performance of row wise DST transformed image with augmentation in 4, 8, 12 and 16 sectors and sum of Absolute Difference and Euclidian distance as similarity measures respectively. The comparison chart of new parameters of performance measuring is compared in Figure 16 and Figure 17 for both column wise DST and row wise DST. The comparison bar chart of cross over points of overall average of precision and recall for 4, 8, 12 and 16 sectors of DST sectorization w.r.t. two different similarity measures namely Euclidean distance and sum of Absolute difference is shown in the Figure18 It is observed that performance of all sectors are retrieval rate of 45% with sum of absolute difference as similarity measuring parameter for column wise DST and 47% for row wise DST.

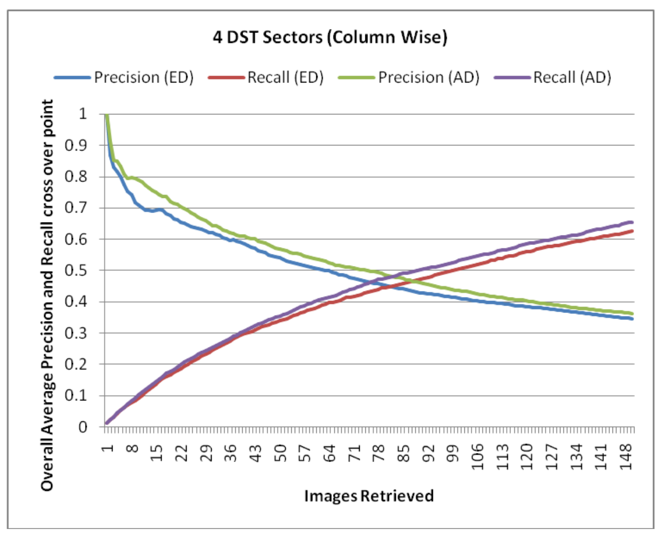


Figure 8: Overall Average Precision and Recall performance of column wise DST Transformation in 4 DST sectors with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures.

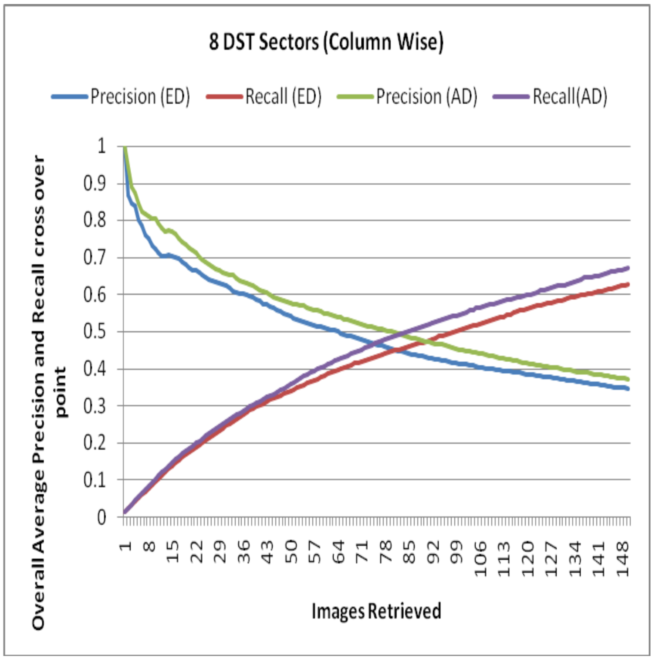


Figure 9: Overall Average Precision and Recall performance of column wise DST Transformation in 8 DST sectors with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

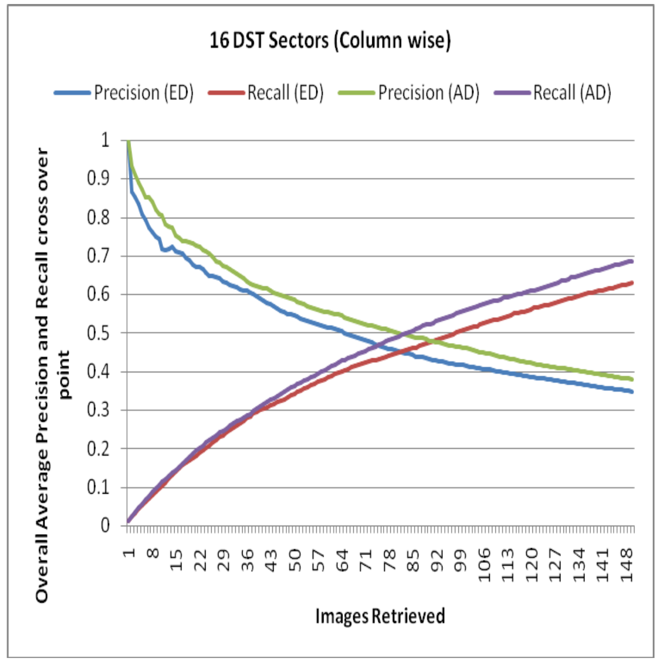


Figure 11 Overall Average Precision and Recall performance of column wise DST Transformation in 16 DST sectors with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

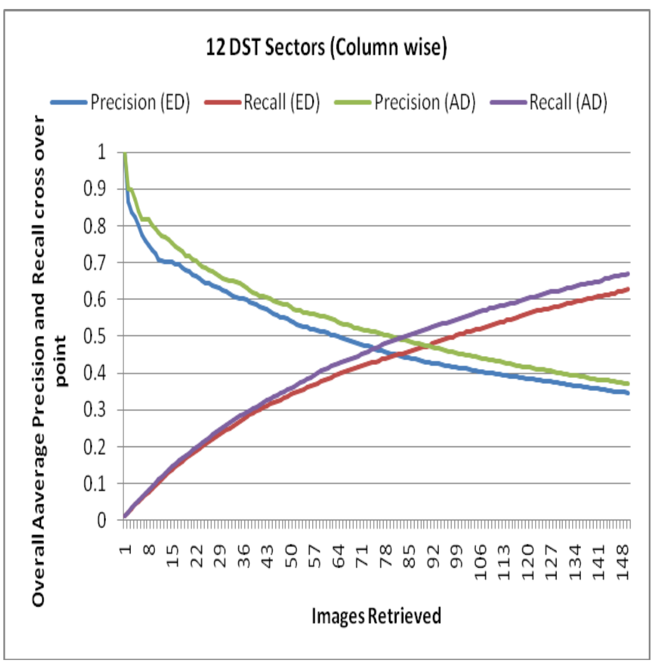


Figure 10: Overall Average Precision and Recall performance of column wise DST Transformation in 12 DST sectors with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures.

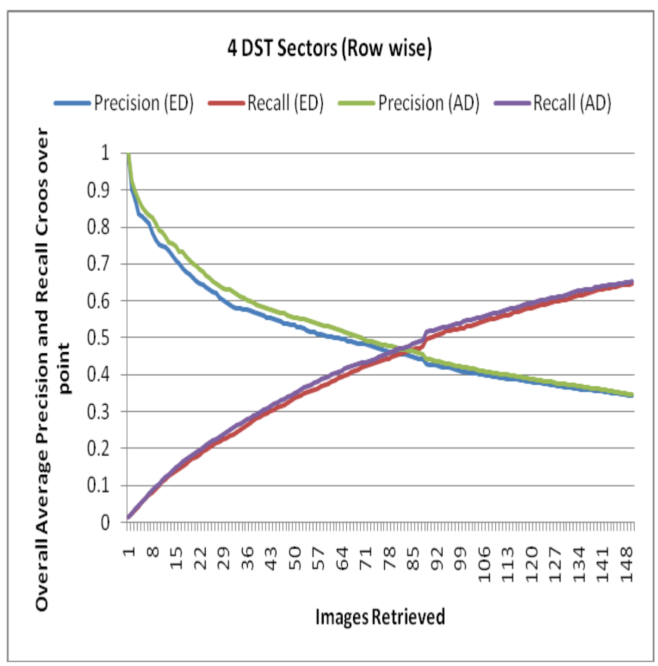


Figure 12 Overall Average Precision and Recall performance of column wise DST Transformation in 4 DST sectors (Row wise) with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

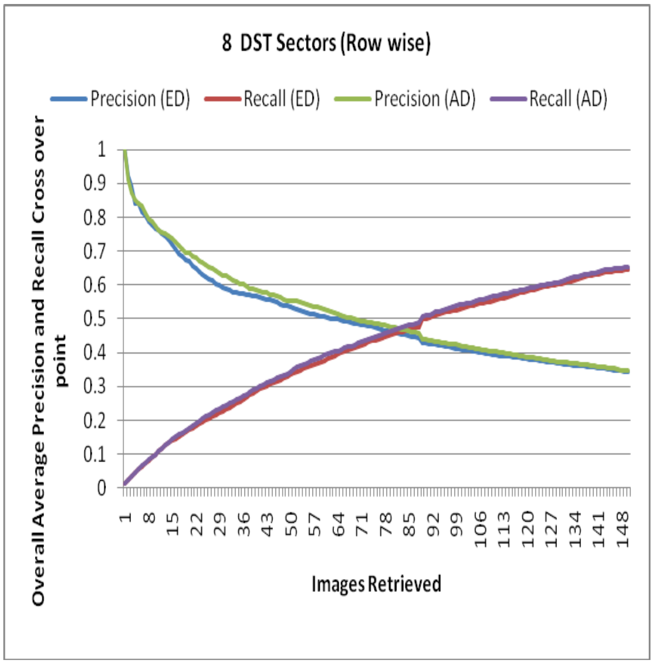


Figure 13: Overall Average Precision and Recall performance of column wise DST Transformation in 8 DST sectors (Row wise) with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

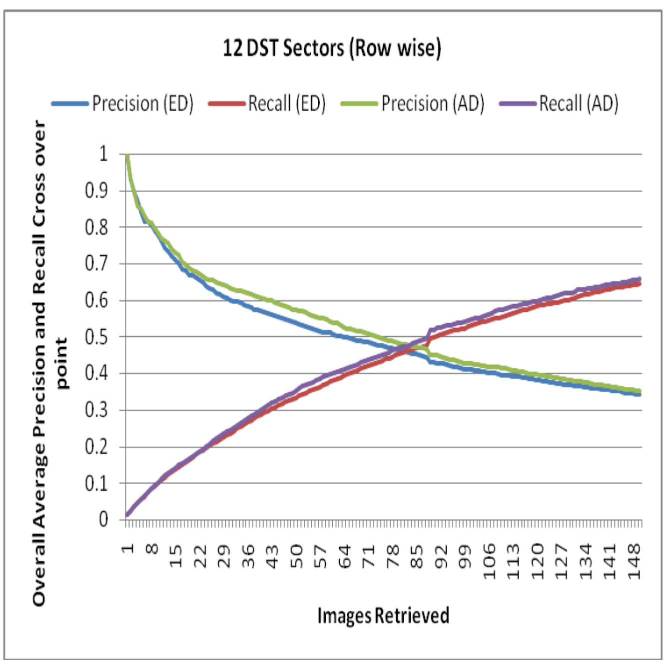


Figure 14: Overall Average Precision and Recall performance of column wise DST Transformation in 12 DST sectors (Row wise) with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

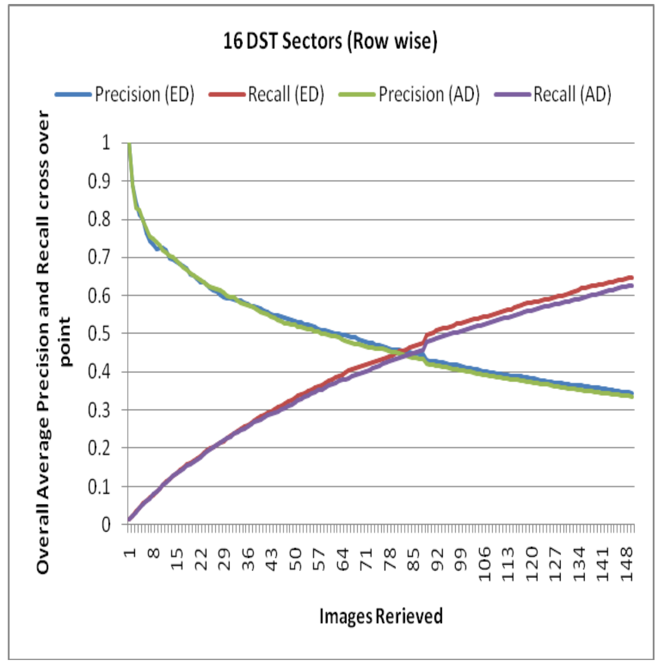


Figure 15: Overall Average Precision and Recall performance of column wise DST Transformation in 16 DST sectors (Row wise) with Augmentation .Absolute Difference (AD) and Euclidian Distance (ED) as similarity measures

	Average value of parameters			
Sectors	**LIRS**	**Length1**	**LSRR**	**Length2**
4	0.12	5	0.60	631
8	0.13	5	0.59	591
12	0.10	7	0.58	580
16	0.13	3	0.61	642

Figure 16: Comparison chart of LIRS **(**with Length1 = Length of initial relevant string of images) **and LSRR (**with Length2= Length of string to retrieve all relevant images) of all DST sectors in column wise DST.

	Average value of parameters			
Sectors	**LIRS**	**Length 1**	**LSRR**	**Length 2**
4	0.11	4	0.61	610
8	0.12	5	0.62	620
12	0.10	9	0.65	651
16	0.14	3	0.63	629

Figure 17: Comparison chart of **LIRS (**with Length1 = Length of initial relevant string of images) and **LSRR (**with Length2= Length of string to retrieve all relevant images) of all DST sectors in row wise DST.

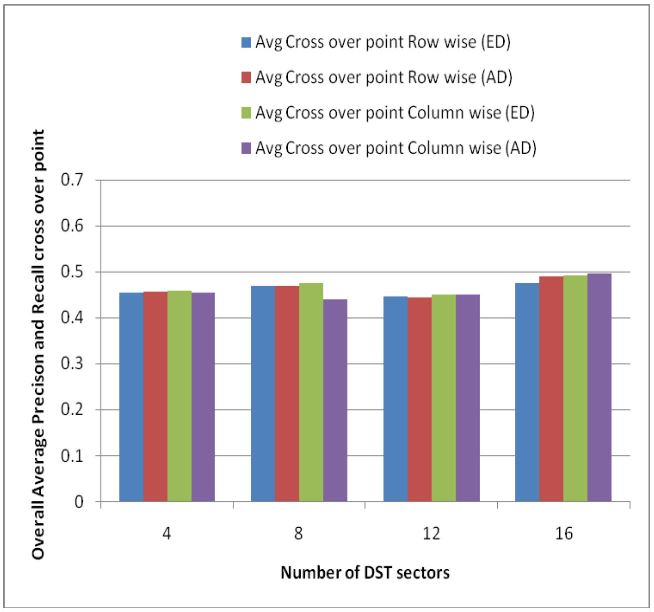


Figure 18: Comparison of Overall Precision and Recall cross over points of Column wise transformation in DST 4, 8, 12 and 16 sectors with Augmentation Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

V. CONCLUSION

The Innovative idea of sectorizing DST transform plane into 4, 8, 12 and 16 sectors of the images to generate the feature vectors for content based image retrieval and a new performance measuring parameter for CBIR is proposed. The work is experimented over even-odd row/column component planes of DST transformed image. The overall precision and recall cross over points performance of both planes are checked with the consideration of augmentation of the feature vectors by adding two components which are the average value of zaroeth and last row/column respectively. Performances of both these approaches are compared with respect to Eucledian distance and sum of absolute difference similarity measures. We found that the performance of DST sectorization with augmentation for both planes gives good result of retrieval on average 45% when using the Euclidian distance as similarity measure and 46% when using the sum of absolute difference as similarity measure. Thus it is advisable to use sum of absolute difference as similarity measure because of its simplicity and less computational complexity as compared to Eucledian distance. Further dividing the transformed image into 12 sectors seems to give better performance results of LIRS and LSRR parameters.

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Dhirendra Mishra has received his BE (Computer Engg) degree from University of Mumbai. He completed his M.E. (Computer Engg) from Thadomal shahani Engg. College, Mumbai, University of Mumbai. He is PhD Research Scholar and working as Associate Professor in Computer Engineering department of Mukesh Patel School of Technology Management and Engineering, SVKM's NMIMS University, Mumbai, INDIA. He is life member of Indian Society of Technical education (ISTE), Member of International association of computer science and information technology (IACSIT), Singapore, Member of International association of Engineers (IAENG). His areas of interests are Image Processing, Operating systems, Information Storage and Management.