Performance Comparison of Density Distribution and Sector mean of sal and cal functions in Walsh Transform Sectors as Feature Vectors for Image Retrieval

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Abstract

In this paper we have proposed two different approaches for feature vector generation with absolute difference as similarity measuring parameter. Sal-cal vectors density distribution and Individual sector mean of complex Walsh transform. The cross over point performance of overall average of precision and recall for both approaches on all applicable sectors sizes are compared. The complex Walsh transform is conceived by multiplying sal components by $j=\sqrt{-1}$. The density distribution of real (cal) and imaginary (sal) values and individual mean of Walsh sectors in all three color planes are considered to design the feature vector. The algorithm proposed here is worked over database of 270 images spread over 11 different classes. Overall Average precision and recall is calculated for the performance evaluation and comparison of 4, 8, 12 & 16 Walsh sectors. The overall average of cross over points of precision and recall is of all methods for both approaches are compared. The use of Absolute difference as similarity measure always gives lesser computational complexity and Individual sector mean approach of feature vector has the best retrieval.

Keywords: CBIR, Walsh Transform, Euclidian Distance, Precision, Recall, Kekre's Algorithm

1. INTRODUCTION

The explosive growth in the digital information in the form of videos and images has given the birth to issue of its storage and management [1].Digital information in the form of images are very widely used on web and in various applications like medical, biometric, security etc. Management of such large image databases requires search and retrieval of relevant images to use it in time. The earlier methods of search and retrieval of relevant images from the database were based on texts which used to be ambiguous and involved lot of human intervention. The need of better method of search and retrieval of images has given the birth to the content based Image retrieval approach. Here the image itself is used as a query and images having similar contents are retrieved from the large database. The earliest use of the term content-based image retrieval in the literature seems to have been by Kato [3] to describe his experiments into automatic retrieval of images from a database by using color, texture and shape as features. The term has since been widely used to describe the process of retrieving desired images from a large collection on the basis of features (such as colors, texture and shape) that can be automatically extracted from the images themselves. The typical CBIR system [2-6] performs two major tasks. The first one is feature extraction (FE), where a set of features, called image signature or feature vector, is generated to closely represent the content of each image in the database. A feature vector is much smaller in size than the original image, typically of the order of hundreds of elements (rather than millions). The second task is similarity measurement (SM), where a distance between the query image and each image in the database using their signatures is computed so that the top —closest images can be retrieved.[8-10]. Various methods of CBIR like Bit truncation coding (BTC)[14], use of Transforms[15],[16],[18],[20],[21], Vector quantization [12],[19] has already been proposed for feature vector generation. The basic features of images like color [12][13], shape, texture are taken into consideration. Here in this paper we have proposed the innovative idea of sectorization of complex Walsh transform and use of density distribution of sal and cal elements in sectors of complex Walsh transform and individual mean of sal and cal distributions in each sector as two different methods to generate the feature vector. We have also proposed the use of absolute difference which is faster as similarity measuring parameter for CBIR instead of Euclidian distance which requires large computations .

2. Walsh Transform

These Walsh transform [16] matrix is defined as a set of N rows,
denoted Wj, for j = 0, 1, ... , N - 1, which have the following properties:

- Wj takes on the values +1 and -1.
- Wj[0] = 1 for all j.
- Wj x W^T_k=0, for j ≠ k and Wj x Wk^T =N, for j=k.
- Wj has exactly j zero crossings, for j = 0, 1, ., N-1.
- Each row Wj is either even or odd with respect to its midpoint.

Walsh transform matrix is defined 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 [17]:

Step 1:

Arrange the 'n' coefficients in a row and then split the row in '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/2' 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 computation complexity is very low.

3. Feature Vector Generation and Similarity Measure

The proposed algorithm makes novel use of Walsh transform to design the sectors to generate the feature vectors for the purpose of search and retrieval of database images. The complex Walsh transform is conceived by multiplying all sal functions by $j= \sqrt{-1}$ and combining them with real cal functions of the same sequency. Thus it is possible to calculate the angle by taking $\tan^{-1}$ of sal/cal. However the values of tan are periodic with the period л radians hence it can resolve these values in only two sectors. To get the angle in the range of 0-360 degrees we divide these points in four sectors as explained below. These four sectors are further divided into 8, 12 and 16 sectors. We have proposed two different approaches for feature vector generation with absolute difference as similarity measure which is compared with Euclidean distance [8-10], [12-15] which is widely used as similarity measuring parameter. Sa-cal density distribution in complex transform plane and Individual sector mean are two different approaches to generate feature vectors. In the first approach the density distribution of sal and cal in each sector is considered for feature vector generation. Each Walsh sector is represented by single percentage value of sal cal distribution in particular sector w.r.t. all sectors for feature vector generation; calculated as follows:

$$\frac{\text{(Total number of sal in particular sector)}}{\text{(Total number of sal in all sectors)}} \times 100 \qquad (1)$$

Thus for 8, 12 and 16 Walsh sectors with 8, 12 and 16 feature components for each color planes i.e. R, G and B are generated. The feature vector is of dimension 24, 36 and 48 components. In the second approach mean of the vectors which has sal and cal as components in each sector is calculated to represent each sector for all three color planes i.e. R. G and B. Thus forming the feature vector of dimension 12, 24, 36 and 48 for 4, 8, 12 and 16 complex Walsh transform sectors.

3.1 Four Walsh Transform 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 Walsh transform of the color image is calculated in all three R, G and B planes. The complex rows representing sal components of the image and the real rows representing cal components are checked for positive and negative signs. The sal and cal Walsh values are assigned to each quadrant. as follows:

Sign of Sal	Sign of Cal	Quadrant Assigned
+	+	I (0 – 90 Degrees)
+	-	II (90 – 180 Degrees)
-	-	III(180- 270 Degrees)
-	+	IV(270–360 Degrees)

TABLE 1. Four Walsh Sector formation

The equation (1) is used to generate individual components to generate the feature vector of dimension 12 considering three R, G and B Planes. The sal and cal density distribution in all sectors is used for feature vector generation. However, it is observed that the density variation in

4 quadrants is very small for all the images. Thus the feature vectors have poor discretionary power and hence higher number of sectors such as 8,12 and 16 were tried. In the case of second approach of feature vector generation i.e. individual sector mean has better discretionary power in all sectors. Absolute difference measure is used to check the closeness of the query image from the database image and precision recall are calculated to measure the overall performance of the algorithm. These results are compared with Eucledian distance as a similarity measure.

3.2 Eight Walsh Transform Sectors:

Each quadrants formed in the previous section obtained 4 sectors. Each of these sectors are individually divided into 2 sectors using angle of 45 degree as the partitioning boundary. In all we form 8 sectors for R,G and B planes separately as shown in the Table 2. The percentage density distribution of sal and cal in all 8 sectors are determined using equation (1) to generate the feature vector.

Quadrant of 4 Walsh sectors	Condition	New sectors Formed
I (0 – 90 ^{0})	Cal >= Sal	I (0-45 Degrees)
	Sal > Cal	II (45-90 Degrees)
II (90 – 180^0)	|Sal | > |Cal|	III(90-135 Degrees)
	|Cal| >= |Sal|	IV(135-180 Degrees)
III (180- 270 ^{0})	|Cal| >= |Sal|	V (180-225 Degrees)
	|Sal| > |Cal|	VI (225-270 Degrees)
IV (270 – 360^0)	|Sal| > |Cal|	VII (270-315 Degrees)
	|Cal| >= |Sal|	VIII (315-360 Degrees)

TABLE 2. Eight Walsh Sector formation

3.3 Twelve Walsh Transform 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 all we form 12 sectors for R,G and B planes separately as shown in the Table 3. The percentage density distribution and mean value of sal and cal in all 12 sectors are determined to generate the feature vector

4 Quadrants	Condition	New sectors
I (0 – 90^0)	Cal >= √3 * Sal	I (0-30 ^{0})
	1/√3 cal <=sal<= √3 cal	II (30-60 ^{0})
	Otherwise	III (60-90 ^{0})
II (90 – 180^0)	Cal >= √3 * Sal	IV (90-120 ^{0})
	1/√3 |cal| <=|sal|<= √3 |cal|	V (120-150 ^{0})
	Otherwise	VI (150-180 ^{0})
III (180- 270^0)	|Cal|>= √3 * |Sal|	VII (180-210 ^{0})
	1/√3 cal <=|sal|<= √3 |cal|	VIII(210- 240 ^{0})
	Otherwise	IX (240-270 ^{0})
IV (270 – 360^0)	|Cal|>= √3 * |Sal|	X (270-300 ^{0})
	1/√3 |cal| <=|sal|<= √3 |cal|	XI (300-330 ^{0})
	Otherwise	XII (330-360 ^{0})

TABLE3. Twelve Walsh Sector formation

4. Results and Discussion

FIGURE 2: Query Image

The image of the class Bus is taken as sample query image as shown in the FIGURE. 2 for both approaches of sal cal density distribution and individual sector mean. The first 21 images retrieved in the case of sector mean in 12 Walsh sector used for feature vectors and Absolute difference as similarity measure are shown in the FIGURE, 3. It is seen that only 7 images of irrelevant class are retrieved among first 21 images and rest are of query image class i.e. Bus. Whereas in the case of sal cal density in 12 Walsh Sectors with Absolute Difference as similarity measures there are only 3 images of irrelevant class and 18 images of the query class i.e. Bus is retrieved as shown in the FIGURE.4.

FIGURE 3: First 21 Retrieved Images based on individual sector mean of 12 Walsh Sectors with Absolute Difference as similarity measures for the query image shown in the FIGURE 2.

FIGURE 4: First 21 Retrieved Images based on individual sector sal cal density in 12 Walsh Sectors with Absolute Difference as similarity measures for the query image shown in the FIGURE 2.

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:

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

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

The FIGURE.5 - FIGURE.7 shows Overall Average Precision and Recall performance of sal cal density distribution in 8, 12 and 16 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures. The bar chart Comparison of Overall Precision and Recall cross over points based on individual sector mean of Walsh 4, 8,12 and 16 sectors and sal and cal density distribution with Euclidian distance (ED) and Absolute difference (AD) as similarity measure are shown in FIGURE 12 and FIGURE 13 respectively. It is observed that the Individual sector mean approach of feature vector generation gives the better retrieval compared to sal cal density distribution with both methods of similarity measures i.e. ED and AD.

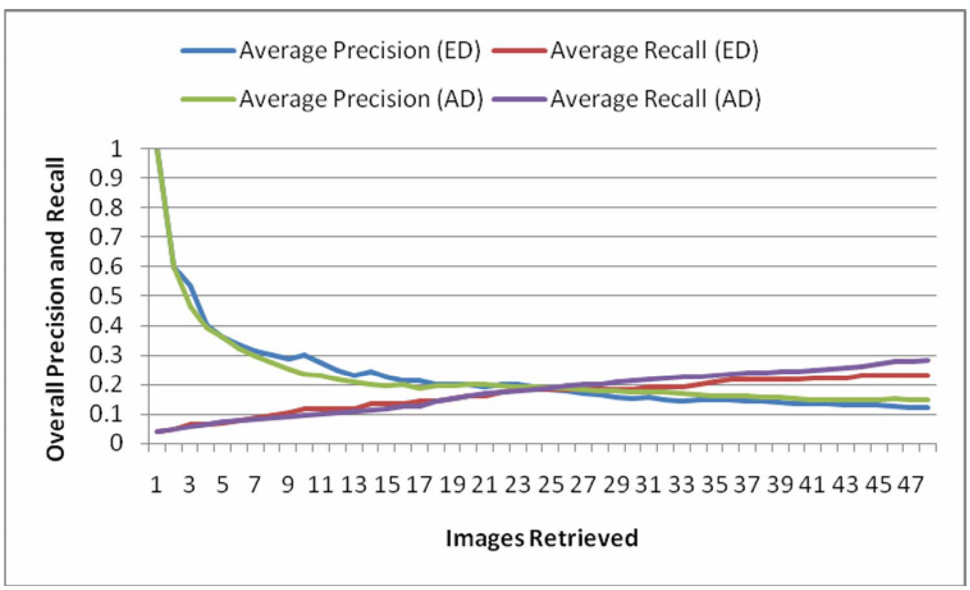

FIGURE. 5: Overall Average Precision and Recall performance of sal cal density distribution in 8 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

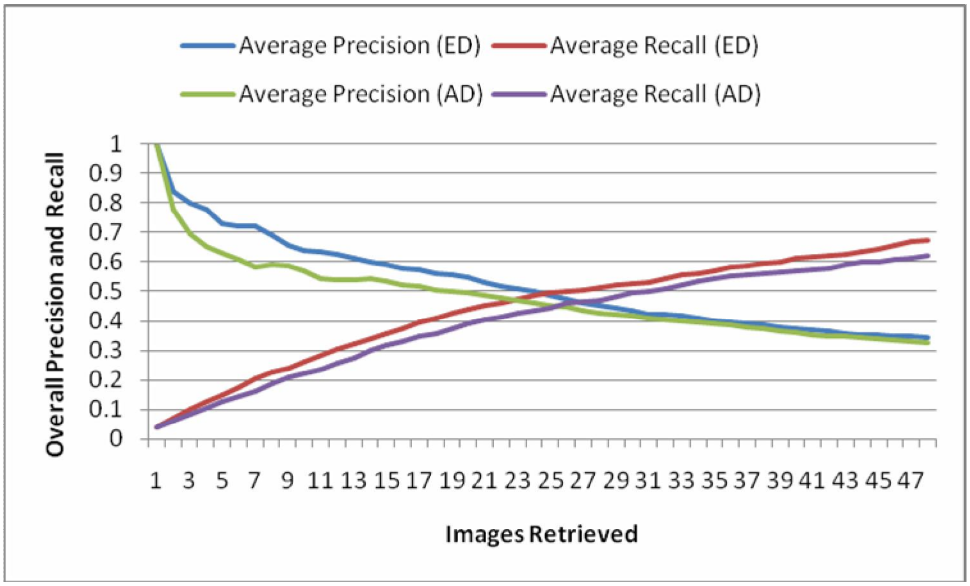

FIGURE. 6: Overall Average Precision and Recall performance of sal cal density distribution in 12 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

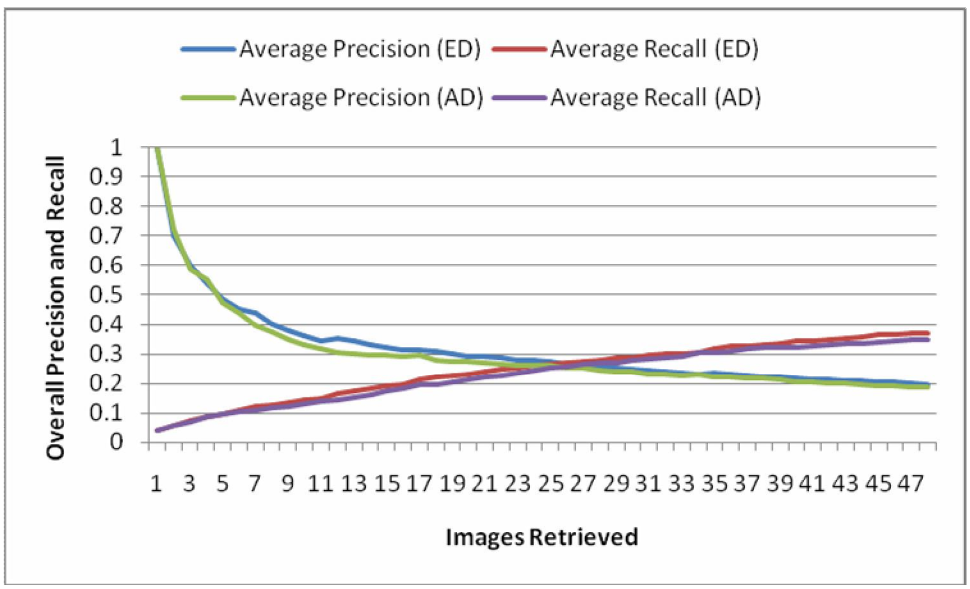

FIGURE 7: Overall Average Precision and Recall performance of sal cal density distribution in 16 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

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The FIGURE.8 - FIGURE.11 shows the Overall Average Precision and Recall performance of individual sector mean of 4, 8, 12 and 16 Walsh Transform sectors with Euclidian Distance(ED) and Absolute Difference (AD) respectively. The performance of 4, 8, and 12 sectors give better retrieval rate of 0.59,0.568,0.512 in case of ED and 0.54,0.54 and 0.50 in case of AD .

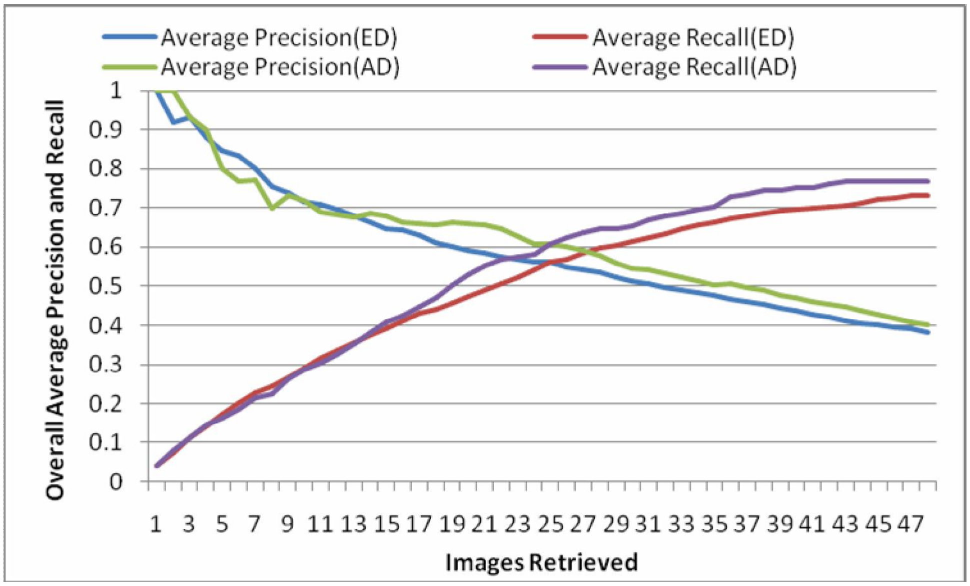

FIGURE 8: Overall Average Precision and Recall performance of individual sector mean in 4 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

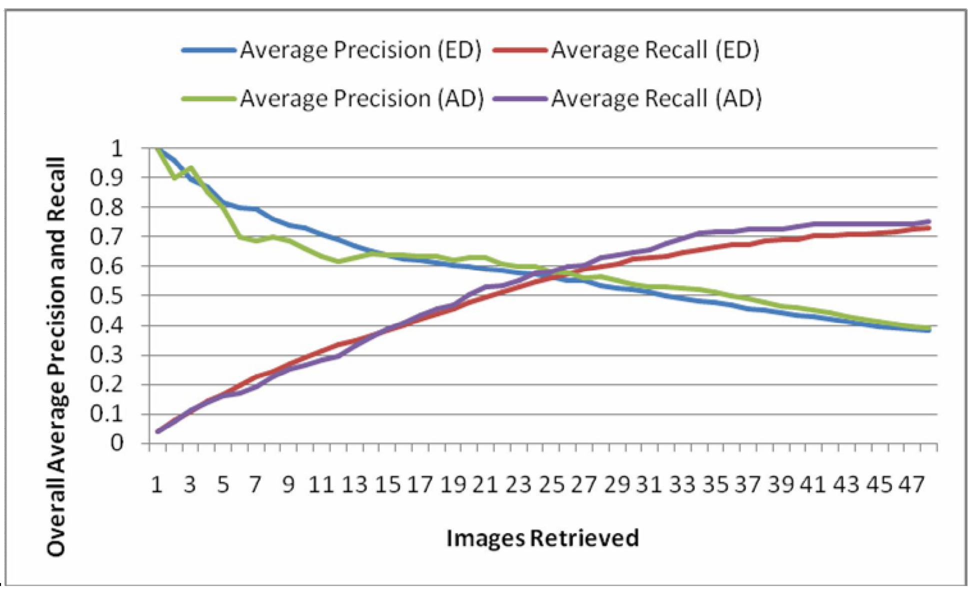

FIGURE 9: Overall Average Precision and Recall performance of individual sector mean in 8 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

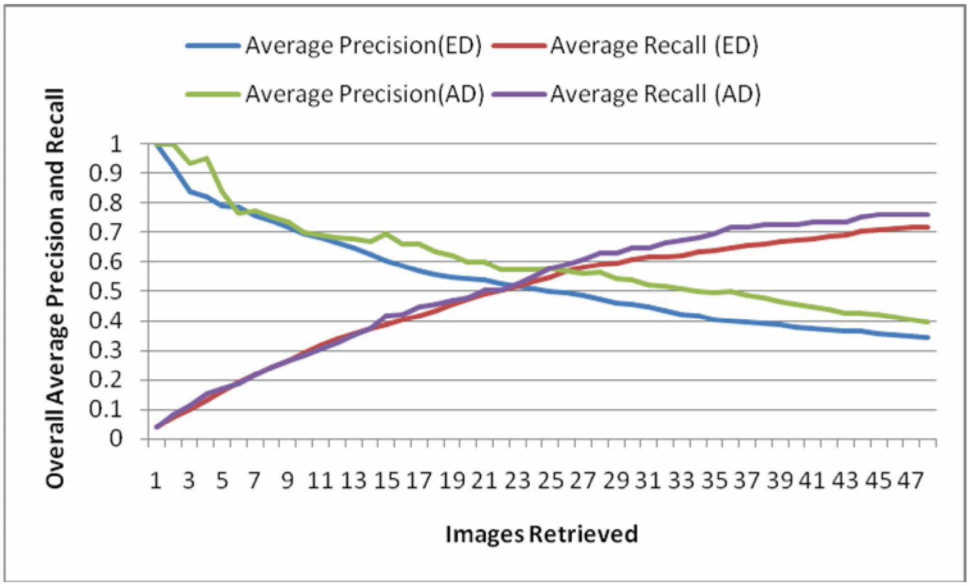

FIGURE 10: Overall Average Precision and Recall performance of individual sector mean in 12 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

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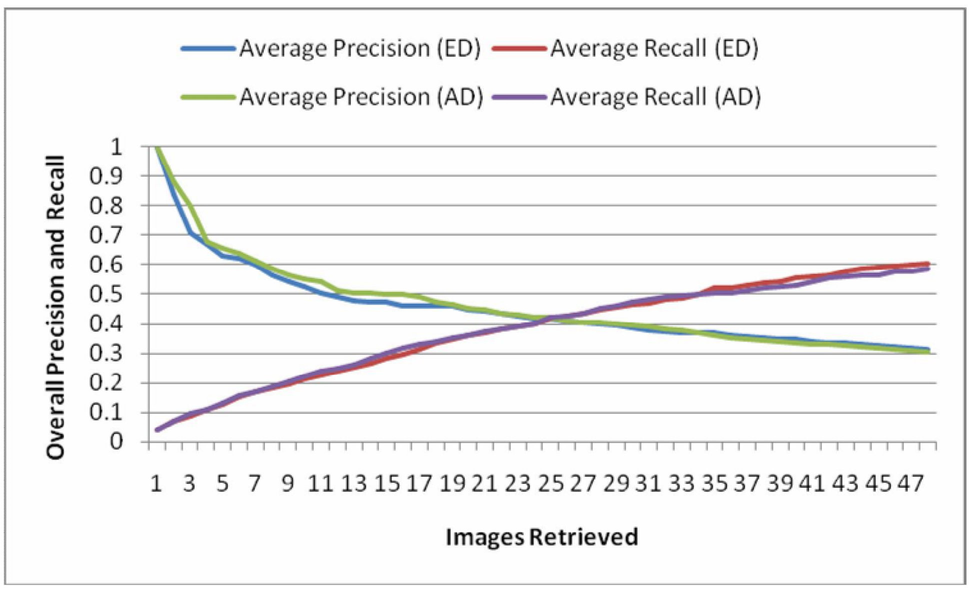

FIGURE 11: Overall Average Precision and Recall performance of individual sector mean in 16 complex Walsh Transform sectors with Euclidian Distance (ED) and Absolute difference (AD) as similarity measures.

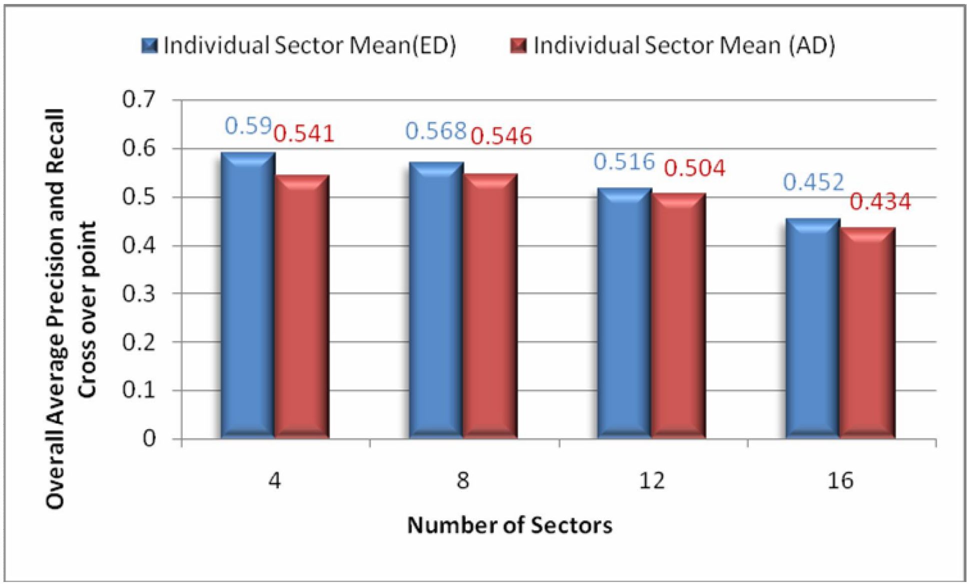

FIGURE 12: Comparison of Overall Precision and Recall cross over points based on individual sector mean of Walsh 4, 8,12 and 16 sectors with Euclidian distance (ED) and Absolute difference (AD) as similarity measure.

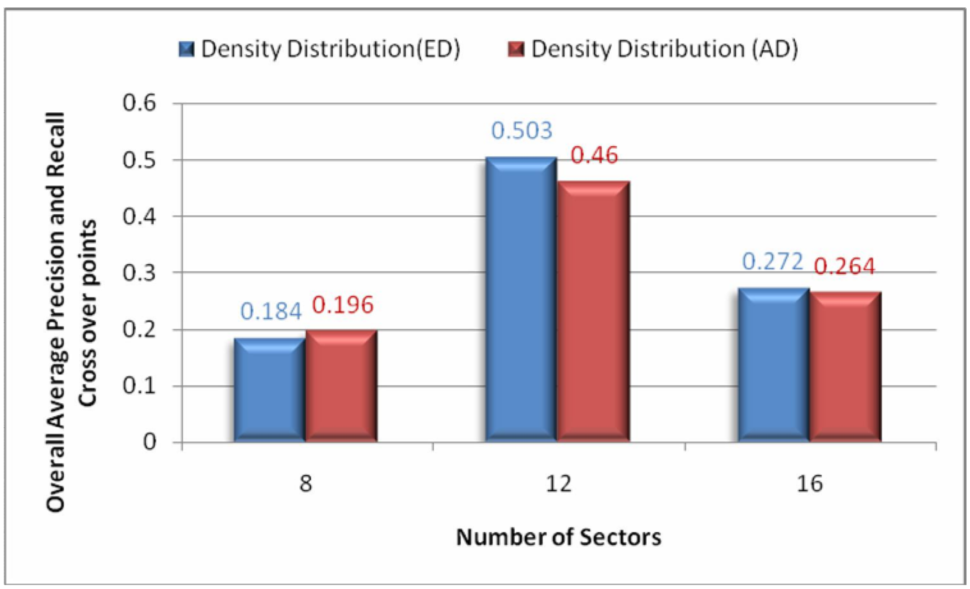

FIGURE 13: Comparison of Overall Precision and Recall cross over points based on sal and cal density distribution in Walsh 8,12 and 16 sectors with Euclidian distance (ED) and Absolute difference (AD) as similarity measure.

.5. CONCLUSION

The Innovative idea of using complex Walsh transform 4, 8, 12 and 16 sectors of the images to generate the feature vectors for content based image retrieval is proposed. We have proposed two different approaches for feature vector generation namely density distribution and mean value of the vectors having sal and cal components of same sequency. In addition we have proposed a new similarity measure namely sum of absolute difference of feature vector components and its results are compared with commonly used Euclidian distance. The cross over point performance of overall average of precision and recall for both approaches on all applicable sectors are compared. We have used the database of 270 images having 11 different classes. The results are summarized below:

Using Walsh transform and absolute difference as similarity measuring parameter which requires no multiplications reduces the computational complexity reducing the search time and calculations by a factor of 8.

The performance of 8, 12 and 16 sectors is compared for density distribution. It is found that 12 sectors give the best result followed by 16 and 8. 12 sectors give the best outcome of overall average precision and recall cross over point at 0.503 compared to 0.184 and 0.272 for 8 and 16 sectors respectively as shown in the FIGURE. 12.

For mean value the best results are obtained for sector 4. Here also the Euclidian distance measure gives cross over point as 0.59 compared to 0.541 in case of Absolute difference. It is also observed that the mean value approach has better discretion as compared to density distribution. Finally it seems that absolute difference similarity measure is much faster than Euclidian distance measure but this happens at slight degradation of the performance.

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