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# Sectorization of Full Walsh Transform for Feature Vector Generation in CBIR

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***Abstract*- We have introduced a novel idea of sectorization of complex Full Walsh 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 and mean of zero- and highest column components of Column transformed values for feature vector generation namely SS-CC Plane and SC-CS Plane. We have introduced the new performance evaluation parameters i.e. LIRS and LSRR apart from precision and Recall, the 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 Full walsh transform sectorization is experimented on both SS-CC and SC-CS Plane 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 Full Walsh sectors. The use of Absolute difference as similarity measure always gives lesser computational complexity and density distribution approach with sum of absolute difference as similarity measure of feature vector has the best retrieval performance.**

***Index Terms* -CBIR, Walsh Transform, Euclidian Distance, Absolute Difference, Precision, Recall**

## I. 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 aunique 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. 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.

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## II. WALSH TRANS FOR M

Walsh transform [10-13] 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 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 [10-13] is illustrated for N=16.However the algorithm is general and can be used for any N = 2k 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:

| Walsh Row Sequency | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hadamard Row Number | 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.

## III. FULL WALSH PLANES

The Full Walsh transformed image has the combination of sal and cal components arrangement as shown in the Figure 1 below, where S denotes the sal components and C denotes the cal components. The combination of sal and cal components according to their position of coordinates in the image is considered to generate the SS-CC plane and SC-CS Plane. The pixel values of transformed images are segregated in different vectors of components to be part of SS-CC and SC-CS Plane.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CC | CS | CC | CS | CC | CS | CC | CS |
| SC | SS | SC | SS | SC | SS | SC | SS |
| CC | CS | CC | CS | CC | CS | CC | CS |
| SC | SS | SC | SS | SC | SS | SC | SS |
| CC | CS | CC | CS | CC | CS | CC | CS |
| SC | SS | SC | SS | SC | SS | SC | SS |
| CC | CS | CC | CS | CC | CS | CC | CS |
| SC | SS | SC | SS | SC | SS | SC | SS |

Figure 1: The arrangement of Sal and cal components in Full Walsh Transformed image.

## IV. FEATURE VECTOR GENERATION

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 SS/CC and SC/CS for both planes respectively. However the values of tan are periodic with the period of π 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 by dividing each one into 2,3.4 parts respectively. We have proposed two different planes namely SS-CC and SC-CS for feature vector generation taking mean value of all the vectors in each sector with sum of absolute difference and Euclidean distance [7-9] [11-14] as similarity measures. In addition to these the feature vectors are augmentated by adding four 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 Walsh sectors 4, 8, 12 and 16 feature components along with augmentation of four extra components for each color planes i.e. R, G and B are generated. Thus all feature vectors are of dimension 36, 60, 84 and 108 components.

### A. *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:

TABLE I. FOUR WALSH SECTOR FORMATION

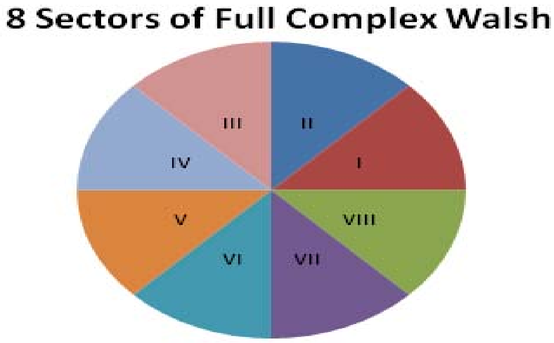
| Sign of SS/SC | Sign of CC/CS | Quadrant Assigned |
|---|---|---|
| + | + | I ($0 – 90^0$) |
| + | - | II ( $90 – 180^0$) |
| - | - | III( $180- 270^0$) |
| - | + | IV($270–360^0$) |

However, it is observed that the density variation in 4 quadrants is very small for all the images. 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.

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 Walsh Transform 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.




| Sectors | Conditions |
|---|---|
| I,IV,V,VIII | \|A\|>=\|B\| |
| II,III,VI,VII | \|B\| >= \|A\| |
| Where<br>A= CC in SS-CC Plane and CS in SC-CS Plane<br>B=SS in SS-CC Plane and SC in SS-CC Plane | |

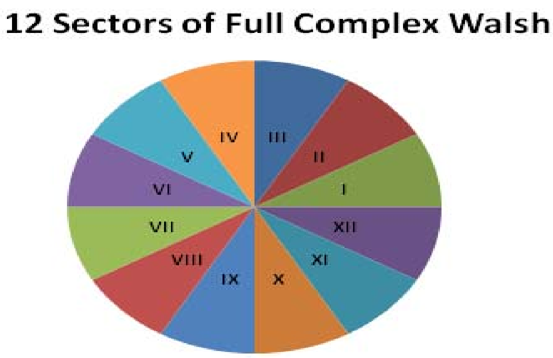
FIgure 2: Formation of 8 sectors of Full complex walsh

*C. 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 total we form 12 sectors for R,G and B planes separately as shown in the Figure 3.

*D. Sixteen Walsh Transform Sectors:*

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




| 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<br>A= CC in SS-CC Plane and CS in SC-CS Plane<br>B=SS in SS-CC Plane and SC in SS-CC Plane | |

FIgure 3: Formation of 12 sectors of Full complex walsh

## V. 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.

The sunset class image is taken as sample query image as shown in the Figure 5 for both Walsh planes i.e. SS-CC and SC-CS. The first 21 images retrieved in the case of sector mean in 4 Walsh sector used for feature vectors and sum of Absolute difference as similarity measure is shown in the Figure 6 and Figure 7 for both planes. It is seen that only 2 images of irrelevant class are retrieved among first 21 images and rest are of query image class i.e. sunset. Whereas in the case of SC-CS in 4 Walsh Sectors with sum of Absolute Difference as similarity measures there are only 1 image of irrelevant class and 20 images of the query class i.e. sunset is retrieved as shown in the Figure 7.

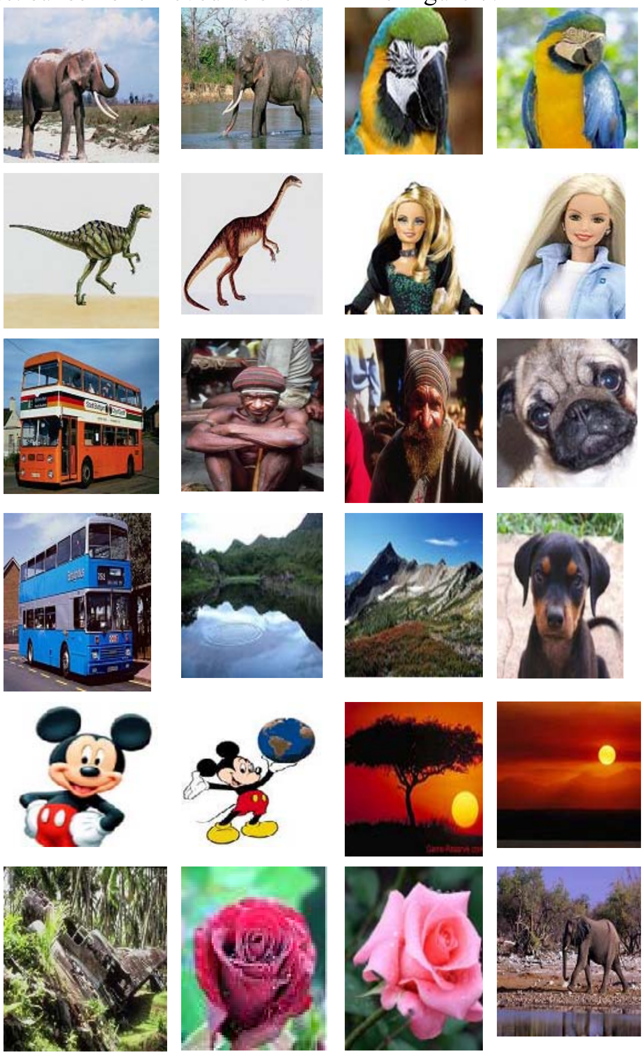


Figure 4. Sample Image Database

Figure 5. Query Image

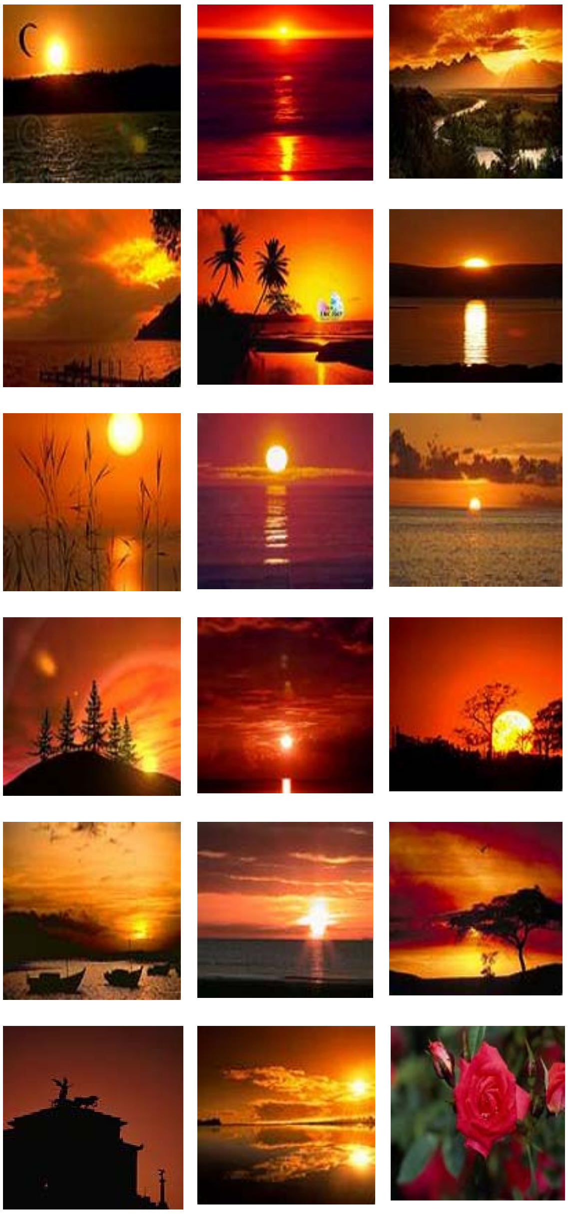
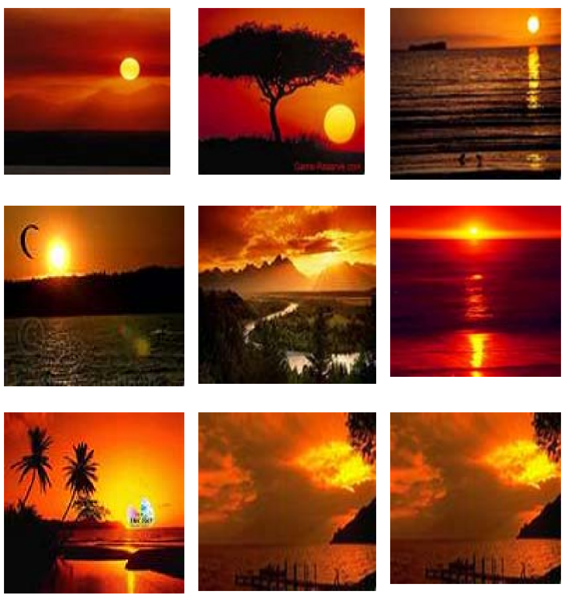


Figure 6: First 21 Retrieved Images of 4 Walsh Sectors in SS-CC Plane with sum of Absolute Difference as similarity measures for the query image shown in the Figure 3.



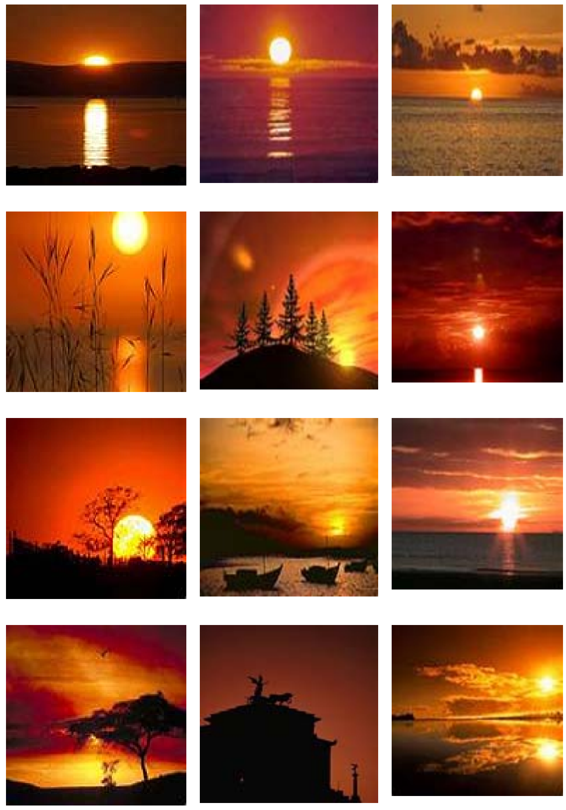


Figure 7: First 21 Retrieved Images of 4 Walsh Sectors in SC-CS Plane with sum of Absolute Difference as similarity measures for the query image shown in the Figure 3

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 (1) & (2) 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 (3) and (4):

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total Number of images retrieved}} \quad (1)$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in database}} \quad (2)$$

$$\text{LIRS} = \frac{\text{Length of initial relevant string of images}}{\text{Total relevant images retrieved}} \quad (3)$$

$$\text{LSRR} = \frac{\text{Length of string to recover all relevant images}}{\text{Total images in the Database}} \quad (4)$$

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 Full Walsh transformed SS-CC Plane in 4, 8, 12 and 16 sectors with absolute Difference and Euclidian distance respectively. Figure12-15 Overall Average Precision and Recall cross over point performance of Full Walsh transformed SC-CS Plane in 4, 8, 12 and 16 sectors with sum of Absolute Difference and Euclidian distance respectively. The comparison chart of new parameters of performance measuring is compared in Figure 16 and Figure 17 for both SS-CC plane and SC-CS Plane. The comparison bar chart of cross over points of overall average of precision and recall for 4, 8, 12 and 16 sectors of Full Walsh sectorization w.r.t. two different similarity measures namely Euclidean distance and Absolute difference is shown in the Figure18 and Figure19. It is observed that performance of all sectors are close to retrieval rate of 0.46 with sum of absolute difference as similarity measuring parameter.

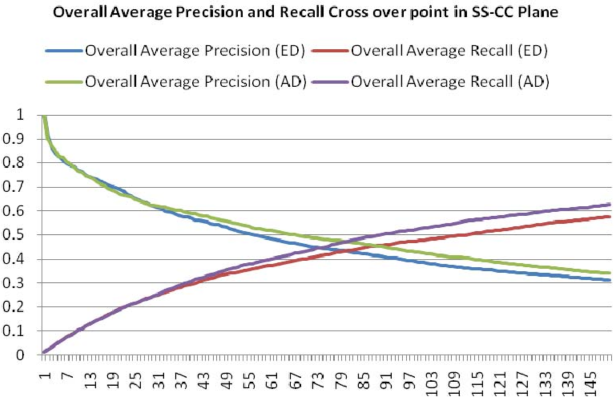



Figure 8: Overall Average Precision and Recall performance of SS-CC Plane in 4Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

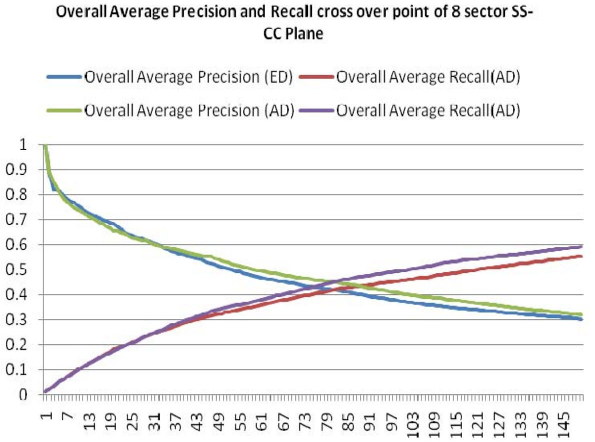



Figure 9: Overall Average Precision and Recall performance of SS-CC Plane in 8 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures

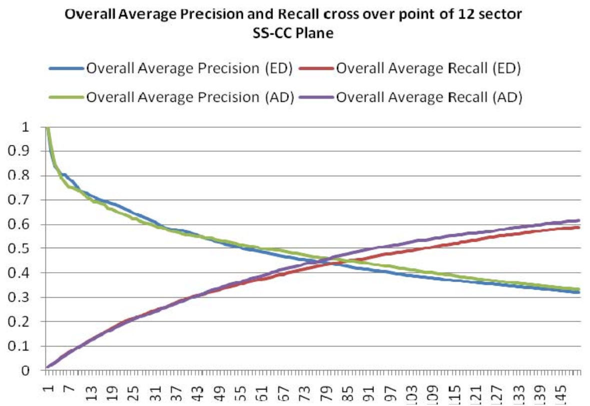



Figure 10: Overall Average Precision and Recall performance of SS-CC Plane in 12 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

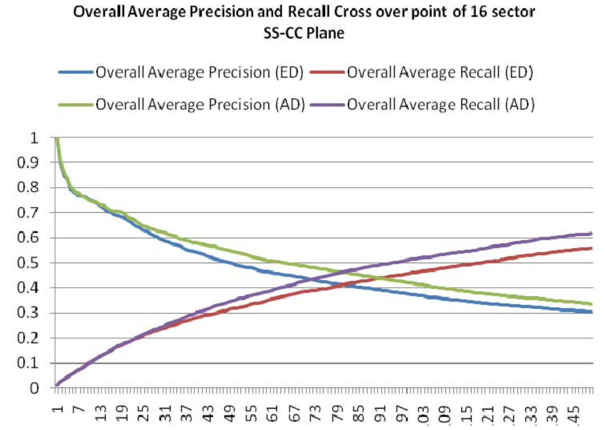



Figure 11: Overall Average Precision and Recall performance of SS-CC Plane in 16 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures..

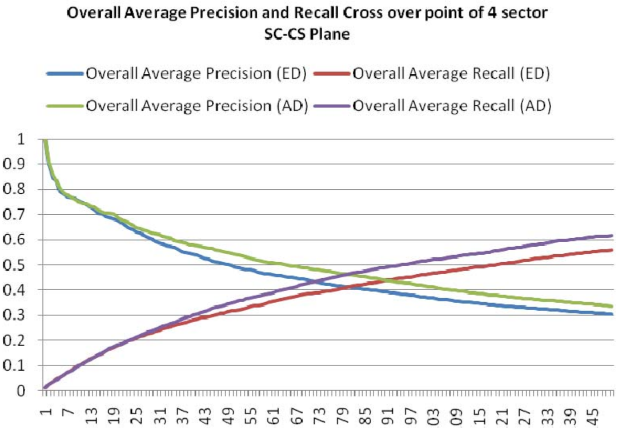



Figure 12: Overall Average Precision and Recall performance of SC-CS Plane in 4 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

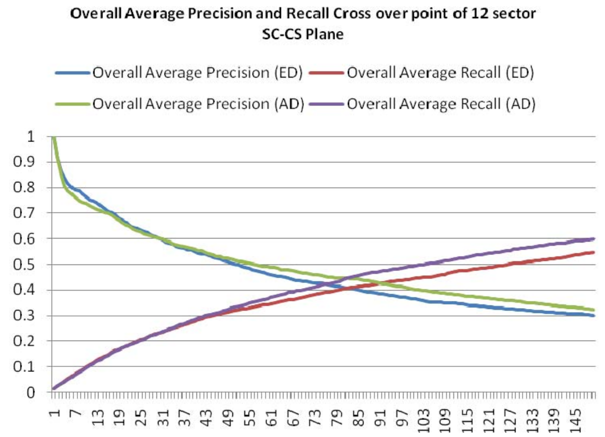



Figure 13: Overall Average Precision and Recall performance of SC-CS Plane in 8 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

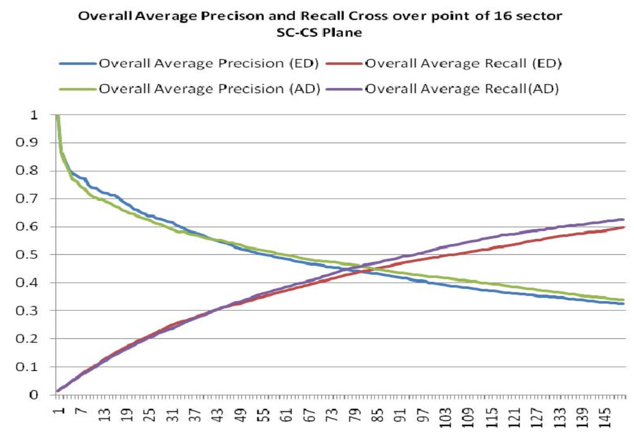



Figure 14: Overall Average Precision and Recall performance of SC-CS Plane in 12 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

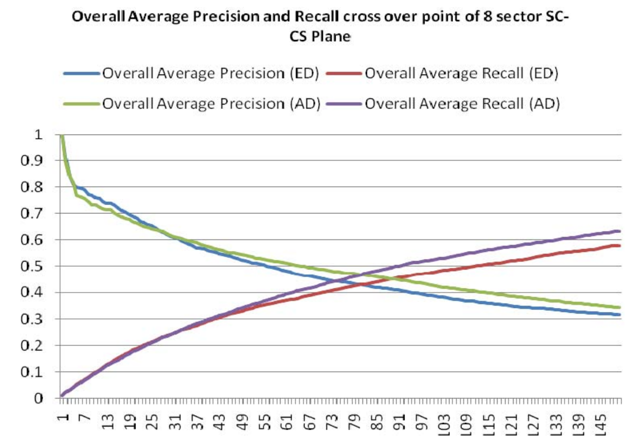



Figure 15: Overall Average Precision and Recall performance of SC-CS Plane in 16 Full Walsh Transform sectors with Augmentation .Absolute Difference(AD) and Euclidian Distance (ED) as similarity measures.

| | Average value of parameters | | | |
|---|---|---|---|---|
| Sectors | LIRS | Length1 | LSRR | Length2 |
| 4 | 0.16 | 9 | 0.65 | 650 |
| 8 | 0.14 | 7 | 0.56 | 590 |
| 12 | 0.12 | 5 | 0.60 | 633 |
| 16 | 0.14 | 7 | 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 Full Walsh sectors in SS-CC Plane

| | Average value of parameters | | | |
|---|---|---|---|---|
| Sectors | LIRS | Length 1 | LSRR | Length 2 |
| 4 | 0.16 | 9 | 0.66 | 649 |
| 8 | 0.16 | 9 | 0.65 | 651 |
| 12 | 0.16 | 9 | 0.65 | 651 |
| 16 | 0.12 | 5 | 0.63 | 620 |

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 Full Walsh sectors in SC-CS Plane.

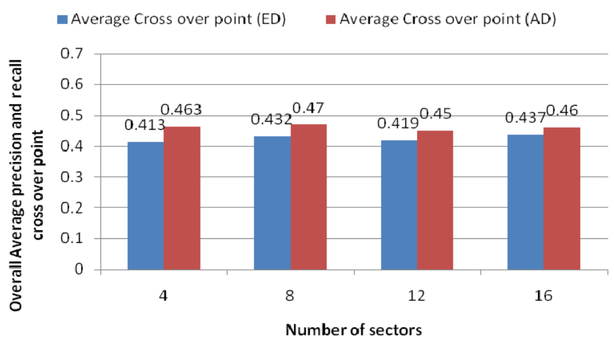



Figure 18: Comparison of Overall Precision and Recall cross over points of SS-CC planes in Full Walsh 4, 8, 12 and 16 sectors with Augmentation Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

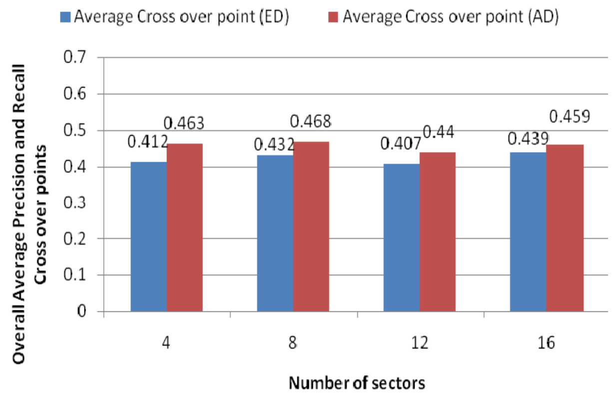



Figure 19: Comparison of Overall Precision and Recall cross over points of SC-CS planes in Full Walsh 4, 8, 12 and 16 sectors with Augmentation Absolute Difference (AD) and Euclidean Distance (ED) as similarity measure.

## VI. Conclusion

The Innovative idea of using complex Full Walsh transform 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 two different planes of Full walsh transformed image namely SS-CC plane and SC-CS plane. The overall precision and recall cross over point performance of both planes are checked with the consideration of augmentation of the feature vectors by adding four 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.. We found that The performance of Full walsh sectorization with augmentation for both planes give good result of retrieval on average 0.45 when using the Eucledian distance as similarity measure. The performance of Full walsh sectorization with augmentation for both planes give better result of retrieval on average close to 0.5 when using the sum of absolute difference as similarity measure.

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