Extended Performance Analysis of Various Combinations of Hybrid Wavelet Transforms for Sectorisation Based Image Retrieval

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***Abstract*—In Content Based Image retrieval (CBIR) process, images are retrieved by using contents like shape, texture, color and transformed image content. Hybrid Wavelet Transform (HWT) can be formed using any two orthogonal transforms combining qualities of constituting transforms. Previous work has proved that image retrieval using sectorisation of Hybrid Wavelet Transformed images with Cosine first HWT Combinations performs better than respective individual orthogonal transforms. In this paper, extended performance analysis of various combinations of Hybrid Wavelet Transforms for sectorisation (with 4, 8, 12 and 16 sectors) based image retrieval is done. Here seven orthogonal transforms like Sine, Cosine, Haar, Walsh, Kekre, Slant and Hartley are used for generating Hybrid Wavelet Transforms. Experimentation is done on image dataset containing 1000 images of different categories. Performance is evaluated by using Average Precision. Manhattan Distance is used as a similarity measurement criterion. Results of proposed work show that Hybrid Wavelet Transforms having Sine as first transform performs better than the other considered HWT. Also Image Retrieval based on Hybrid Sine-Cosine transform sectorisation performs best in all experimented combinations.**

***Keywords*— CBIR; Hybrid Wavelet Transform; Manhattan Distance; Sectorisation; Orthogonal Transform; Precision.**

I. INTRODUCTION

Text based image retrieval involves annotations manually added on images which results into many drawbacks like depends on human, complex and time consuming [1]. Content Based Image Retrieval (CBIR) automates the process of image retrieval. It retrieves images based on contents of images. Content may be color, shape, texture or transformed image content.

In CBIR first features of the images in database are extracted using some feature extraction algorithm andthen features of query image are extracted using same feature extraction algorithm and compared with all features of images in database using similarity measurement criteria and more similar images to query image are retrieved as a result.

II. LITERATURE SURVEY

Color feature is simple and easy to extract by using techniques like Color Histogram [2], Color averaging [3], Block Truncation Coding [4] etc. Color based image retrieval get affected due to illumination differences among images. Shape Feature can be extracted with Slope Magnitude Method [5], Morphological Operations [5], and Gradient Operators [6]. Techniques like Gray level Co-occurrence matrix [7] and Wavelet Pyramid [8] can be used for extraction of Texture feature. Shape and texture features are having drawbacks of not being rotation invariant. In case of Transformed image based CBIR, size of feature vector is large.

CBIR using sectorisation of transformed image content is free from limitations like rotation invariant, needing same sized images in database, illumination differentiation etc. Previously, sectorisation of Hybrid Wavelet Transforms with Cosine-Walsh, Cosine-Kekre, Cosine-Hartley combinations for image retrieval has been done [9]. In this paper, the previous work has been extended to all remaining combinations of Hybrid Wavelet Transforms with the orthogonal transforms like Sine, Haar, Walsh, Kekre, Slant and Hartley. Here a total 42 hybrid wavelet transform combination has considered.

III. PROPOSED CBIR WITH SECTORISATION

In sectorisation process, contents of transformed image is gathered into number of sectors and then column wise average of each sector is taken and concatenated to form feature vector of each color component. The process of sectorisation starts with augmentation of transformed image and then this augmented image is divided into number of non-overlapping window of size 2×2. Assign variable X1, X2, Y1, Y2 as shown in fig. 1.

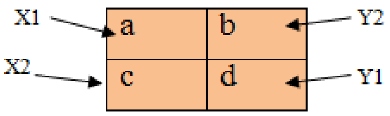

Fig. 1. Snapshot of window of augmented image

For each window of augmented image, calculate value of A and B where A=X1/X2 and B=Y1/Y2. Check sign of A and B to decide sector of each window as given in table 1. After getting four sectors containing number of windows, it can be further divided to get 8, 12 and 16 sectors by dividing each sector into 2, 3, and 4 subsectors respectively [9].

Hybrid Wavelet transforms (HWT) is orthogonal transform formed by combining two orthogonal transforms showing qualities of both transforms [9]. HWT of size $n^2 \times n^2$ can be generated using two orthogonal transforms A and B having size n×n. First n rows of HWT are generated by multiplying elements of first row of first orthogonal transform with the all columns of the second orthogonal transform. Next n rows are formed by padding second row of first transform with zeroes to get size $n^2 \times n^2$ and then shift rotate this row. To get remaining rows of HWT same process of rotation is followed for other rows of first orthogonal transform as shown in the following fig. 2.

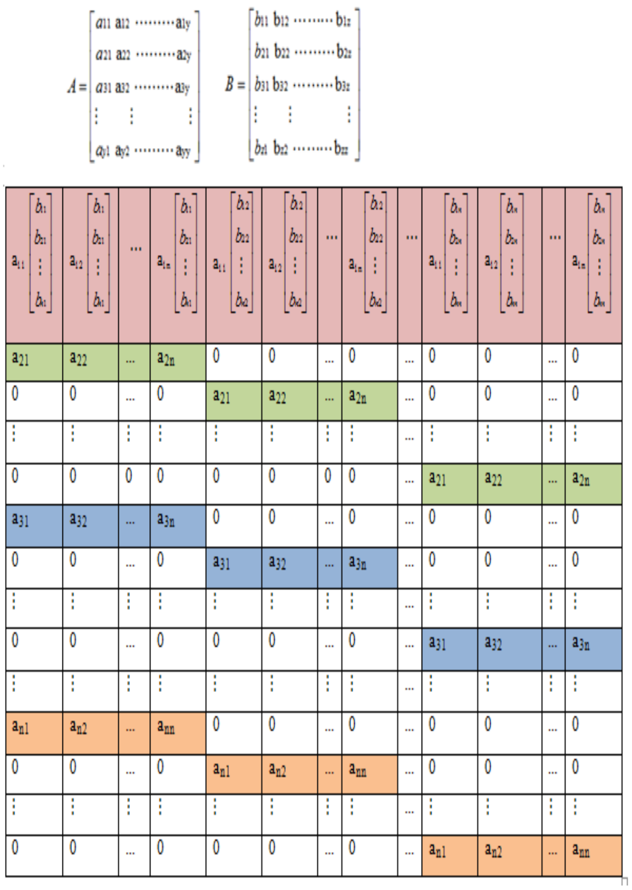

Fig. 2. Generation of Hybrid Wavelet Transform matrix

In proposed algorithm Hybrid wavelet transform is applied on image to get transformed image and then sectorisation of transformed image is done to extract unique feature of an image. Features of query image and database images are compared using some similarity measurement. Here Manhattan Distance [8] is used for this purpose.

TABLE I. FORMATION OF FOUR SECTORS

Sign of A	Sign of B	Sector Number
+	+	1
+	-	2
-	-	3
-	+	4

IV. EXPERIMENTATION AND ENVIRONMENT

Experimentation is done on set of 1000 images of different categories taken from Wang dataset [10]. There are 100 images of each category. Platform used for experimentation is MATLAB under Windows environment.

Fig. 3. Sample images in Database

V. RESULTS AND DISCUSSION

Here total 42 Combinations of Hybrid Wavelet Transforms which are formed using 7 orthogonal transforms like Sine, Cosine, Haar, Walsh, Kekre, Slant and Hartley etc are considered. Sectorisation of Hybrid wavelet transformed images is done in feature extraction. Manhattan distance is used as a similarity measurement. Performance is evaluated by calculating average precision.

Table II shows the results of combinations of Hybrid Wavelet Transform with Sine Transform as first component in a combination. Sine-Cosine Transform with 4 sectors in Feature extraction performs better than other combinations in table II.

Table III shows the results of combinations of Hybrid Wavelet Transform with Cosine Transform as first component in a combination. Cosine-Sine Transform with 4 sectors in Feature extraction performs better than other combinations in table III.

TABLE II. RESULTS OF PROPOSED METHOD WITH DIFFERENT DIFFERENT HYBRID SINE COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Sine-Cosine	60.52	60.34	59.8	56.10
Sine-Haar	59.18	59	58.94	55.38
Sine-Walsh	59.86	60.32	59.1	56.58
Sine-Kekre	58.54	60.02	59.64	56.44
Sine-Slant	57.26	57.98	58.32	55.38
Sine-Hartley	59.5	60.08	59.9	56.02
Average	59.14	59.62	59.28	55.98

TABLE III. RESULTS OF PROPOSED METHOD WITH DIFFERENT HYBRID COSINE COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Cosine-Sine	50.32	48.64	46.28	40.9
Cosine-Haar	32.72	30.42	29.98	28.74
Cosine-Walsh	34.8	31.82	31.14	29.88
Cosine-Kekre	34.08	32.4	31.38	30.4
Cosine-Slant	30.56	30.1	28.8	28.86
Cosine-Hartley	34.38	32.3	31.1	29.54
Average	36.14	34.28	33.11	31.38

Table IV shows the results of combinations of Hybrid Wavelet Transform with Haar Transform as first component in a combination. Haar-Sine Transform with 4 sectors in Feature extraction performs better than other combinations in table 4.

TABLE IV. RESULTS OF PROPOSED METHOD WITH DIFFERENT DIFFERENT HYBRID HAAR COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Haar-Sine	48.24	46.3	44.64	40.34
Haar-Cosine	34.8	30.44	29.66	29.22
Haar-Walsh	33.84	31.32	30.62	29.24
Haar-Kekre	33.42	32	31.5	29.74
Haar-Slant	31.58	30.46	30.06	28.7
Haar-Hartley	33.7	31.5	30.3	29.04
Average	35.93	33.67	32.79	31.04

Table V shows the results of combinations of Hybrid Wavelet Transform with Walsh Transform as first component in a combination. Walsh-Sine Transform with 4 sectors in Feature extraction performs better than other combinations in table V.

TABLE V. RESULTS OF PROPOSED METHOD WITH DIFFERENT DIFFERENT HYBRID WALSH COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Walsh-Sine	48.56	47	45.44	41.34
Walsh-Cosine	32.26	30.22	29.5	29.36
Walsh-Haar	31.98	30.82	30.1	29.2
Walsh-Kekre	33.76	31.74	31.54	29.54
Walsh-Slant	31.46	30.66	29.26	29.5
Walsh-Hartley	33.26	31.58	29.82	29.56
Average	35.21	33.67	32.61	31.41

TABLE VI. RESULTS OF PROPOSED METHOD WITH DIFFERENT DIFFERENT HYBRID KEKRE COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Kekre-Sine	40.42	40.34	39.26	35.74
Kekre-Cosine	30.56	32.4	29.42	30.08
Kekre-Haar	30.82	30.18	29.88	29.18
Kekre-Walsh	31.16	30.24	30.04	29.52
Kekre-Slant	29.92	29.46	29.46	28.6
Kekre-Hartley	31.28	29.78	29.36	29.48
Average	32.36	32.06	31.23	30.43

Table VI shows the results of combinations of Hybrid Wavelet Transform with Kekre Transform as first component in a combination. Kekre-Sine Transform with 4 sectors in

Feature extraction performs better than other combinations in table VI.

Table VII shows the results of combinations of HybridTransform with Slant Transform as first component in a combination.Slant-Sine Transform with 4 sectors in Feature extraction performs better than other combinations in table 7.

Table VIII shows the results of combinations of Hybrid Wavelet Transform with Hartley Transform as first component in a combination. Hartley-Sine Transform with 4 sectors in Feature extraction performs better than other combinations in table VIII.

TABLE VII. RESULTS OF PROPOSED METHOD WITH DIFFERENT DIFFERENT HYBRID SLANT COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Slant-Sine	48.36	47.64	44.88	41.68
Slant-Cosine	32.16	30.32	29.94	29.12
Slant-Haar	32.64	31.62	30.94	29.76
Slant-Walsh	34.28	32	31.22	29.64
Slant-Kekre	32.48	31.3	31.02	29.94
Slant-Hartley	33.54	32.1	31.51	28.72
Average	35.57	34.16	33.25	31.47

TABLE VIII. RESULTS OF PROPOSED METHOD WITH DIFFERENT DIFFERENT HYBRID HARTLEY COMBINATIONS

Hybrid Wavelet Transform	Average Precision			
	4 sectors	8 sectors	12 sectors	16 sectors
Hartley-Sine	48.28	46.38	44.24	40.44
Hartley-Cosine	30.52	29.58	29.28	28.78
Hartley-Haar	31.72	30.52	29.68	28.92
Hartley-Walsh	32.32	31.1	30.68	29.2
Hartley-Kekre	32.54	31.84	31.06	30
Hartley-Slant	30.18	29.2	29.18	29.04
Average	32.36	32.06	31.23	30.43

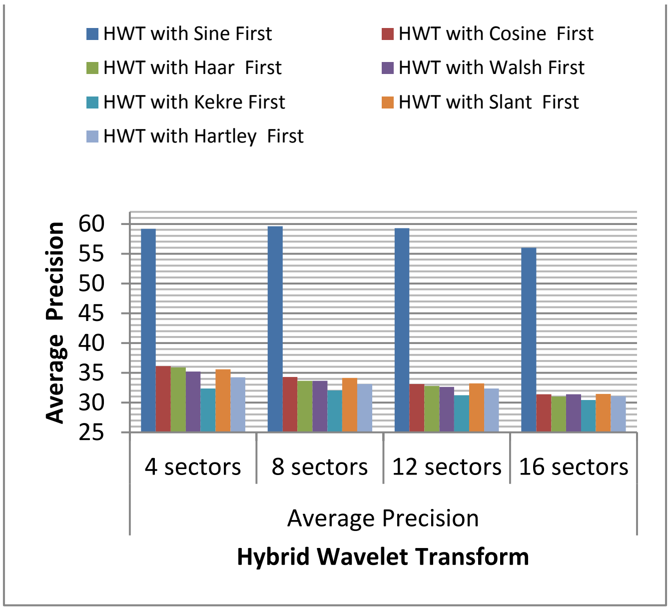

Fig. 4.Performance Comparison of proposed algorithm with number of sectors

Fig. 4 gives overall performance comparison of proposed method with number of sectors used in feature extraction for all considered HWTs. It shows that proposed algorithm gives best performance with HWT with Sine transform and 8 sectors used in feature extraction.

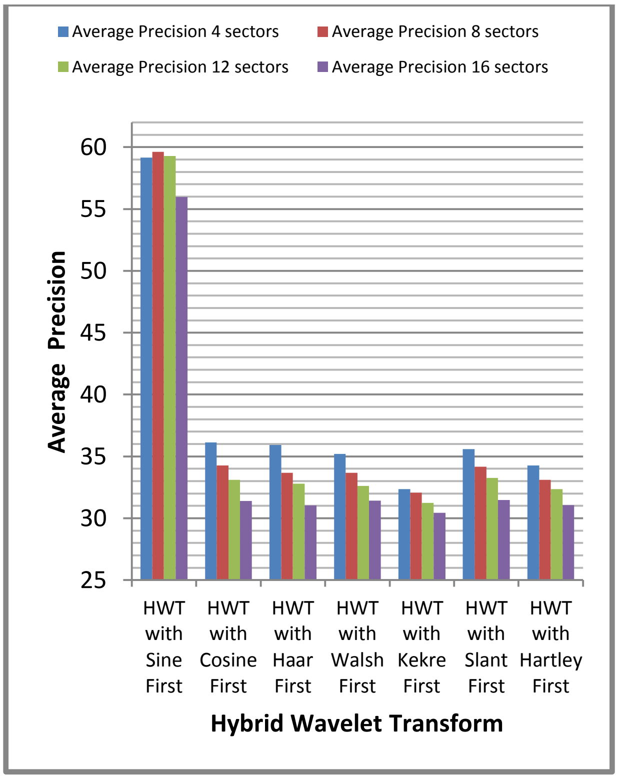

Fig. 5.Performance Comparison of proposed algorithm with number of sectors

Fig. 5 shows that proposed algorithm performs better with Hybrid wavelet transforms with Sine Transform as first component across all sectors as indicated by highest average precision.

VI. CONCLUSION

Proposed CBIR technique involves Sectorisation of Hybrid Wavelet Transformed Images for feature extraction. Among all tried combinations, proposed technique gives better performance with 4 sectors used in feature extraction. With 4 sectors size of feature vector is 48 and is very small as compared to other transformed domain CBIR techniques. Here Sine- Cosine transform with 4 sectors gives best precision (i.e. 60.52%).

Proposed algorithm is robust as is free from limitations like rotation invariant, needing same sized images used in database, illumination differentiations among images.

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