Query based Image Retrieval using Kekre's, DCT and Hybrid wavelet Transform over 1st and 2nd Moment

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ABSTRACT
In order to improve the accuracy and efficiency of the image retrieval systems vast research is going on in the direction of Content Based Image Retrieval instead of text based search of images which has got many constraints and drawbacks in the retrieval process. In this paper, we describe the novel techniques to retrieve similar images from large volume of databases based on contents. Feature extraction strategy of the proposed system is based on transform domain. Three different techniques are used to extract the image features using three transforms namely Kekre's transform, Discrete Cosine transform and Hybrid wavelet transform which is constructed using combination of DCT and Kekre's Transform. Experimental results obtained using these three approaches for 100 queries using database of 1000 bmp images. Results are obtained in two levels. Level 1 gives results for R, G and B plane separately, Level 2 combines these results by taking combination of three planes based on three different criteria. Retrieval of similar images increases as we move forward from Criterion 1 to Criterion 3. It is observed that hybrid wavelet is giving fast and better retrieval results as compare to DCT and Kekre's transform.

Keywords
Row Mean, Column Mean, Row Variance, Column Variance, Kekre's transform (KT), DCT, Hybrid Wavelet transform(HWT), Criterion1, 2 and 3.

1. INTRODUCTION
Rapid advancement in image capturing devices has increased the use of large image databases which in turn generates the need of having faster and effective image retrieval techniques that will fulfill user's requirement and will give satisfactory results. Image retrieval is broadly classified into two strategies one is text based image retrieval and the other is content based image retrieval. Text based retrieval has got many limitations and is not even giving satisfactory results. It is subjective to the human perception and requires an image annotation which is really a tedious job. Whereas the image retrieval based on contents is quite popular research area which is performing better and satisfying the today's user needs to some extent and has got wide area of applications like crime detection, Medical diagnosis etc [1, 2, 3, 4]. To improve the performance of CBIR systems there is a need to achieve fast and reliable techniques which encourages the researchers to identify such methods to fulfill today's needs. To contribute in the same direction we have proposed three techniques experimented with 100 query images given as example and we have used database of 1000 BMP images holding 10 different categories. Feature extraction is the core part of all CBIR systems color, texture and shape are broadly used features of images. Similarity comparison can be achieved through many similarity measures available like Euclidean distance, Quadratic form distance, Mahalanobis distance, Minkowiski distance etc [5, 6, 7, 8]. Three techniques used for feature extraction in this paper are based on DCT, Kekre's transform and Hybrid wavelet transform. We are focusing on color and texture feature of the image. Color feature representation is obtained by separating the BMP image into R, G and B plane and texture representation is obtained by calculating the Mean and Variance vectors for all Rows and Columns of each plane of the image, which are further followed by the application of the three transforms mentioned earlier and multiple feature databases are prepared [9, 10, 11, 12, 13]. Euclidean distance is used as similarity measure for comparing the query image with database images. Results are obtained at first level thresholding are **further** refined in second level thresholding using three different criteria. Organization of this work is explained through different sections mentioned as follows.

Section 2 describes the transforms used for feature extraction along with the formation of hybrid wavelet (HWT) using KT and DCT transforms. Section 3 describes the formation of multiple feature databases; Algorithmic view with implementation details are explained in Section 4 Section 5 delineates the Experimental results and discussion. Work done is concluded in section 6.

2. KT, DCT and HYBRID WAVELET TRANSFORM

2.1 Kekre's Transform:
Kekre's Transform matrix is orthogonal transform and can be of any size NxN, which need not have to be in powers of 2 (as is the case with most of other transforms) [11]. All upper diagonal and diagonal values of Kekre's transform matrix are one, while the lower diagonal part except the values just below diagonal are zero. Generalized NxN Kekre Transform matrix is given as:

$$K_{NXN}=\begin{bmatrix} 1 & 1 & 1 & .. & 1 & 1 \\ -N+1 & 1 & 1 & .. & 1 & 1 \\ 0 & -N+2 & 1 & .. & 1 & 1 \\ : & : & : & .. & : & : \\ 0 & 0 & 0 & .. & 1 & 1 \\ 0 & 0 & 0 & .. & -N+(N-1) & 1 \end{bmatrix} \quad (1)$$

Each element in Kekre's transform is generated as follows:

$$K_{(i,j)} = \begin{cases} 1 & ,i \le j \\ -N + (i-1) & ,i = j+1 \\ 0 & ,i > j+1 \end{cases} \quad (2)$$

Required computations for Kekre's transform applied over N xN image are:
Multiplications : (N-1) and Additions: 2N(N-1)

2.2 Discrete Cosine Transform :

It has a strong "energy compaction" property. Most of the image information tends to be concentrated in a few low-frequency components of the DCT.

$$F[k,l] = \sum_{M=0}^{M-1} \sum_{N=0}^{N-1} f[m,n]\alpha(k)\alpha(l)\cos\left[\frac{(2m+1)k\Pi}{2M}\right]\cos\left[\frac{(2n+1)l\Pi}{2N}\right] \quad (3)$$

$$\text{Where } \alpha(k) = \begin{cases} \sqrt{\frac{1}{N}} & for \quad k = 0 \\ \sqrt{\frac{2}{N}} & for \quad k = 1,2,..N \end{cases} \quad (4)$$

2.3 Hybrid Wavelet Transform (HWT)

The wavelet transforms in many applications are proven to be better than respective orthogonal transforms [1, 14, 15 16, 17, 18, 19, 20, 21, 22]. Hybrid wavelet transform can be generated using any two orthogonal transforms. This concept of hybrid wavelet transform is that, best from both the orthogonal transforms is used to generate it to make use of this, in this paper we have used KT and DCT to generate the Hybrid wavelet transform [8], [23].

3. FEATURE VECTOR GENERATION USING KT, DCT and HWT

3.1 Row and Column Mean Vectors

In this feature extraction process image is separated into R, G, and B planes and then for each plane row mean vectors are calculated and KT, DCT and Hybrid wavelet are applied over each row mean vector. This process has created 3 feature databases for each transform as it is being applied over 3 plane's row mean vectors and this way total 9 feature databases are created for row mean vectors. Same process is applied and 9 feature databases are generated by applying KT, DCT and HWT over column mean vectors of R, G and B planes of an image.

3.2 Row and Column Variance-(SD) Vectors

As explained in section 3.1 we have created 9 feature databases for 3 planes using 3 transforms applied over 3 planes row column variance vectors. Here instead of calculating the mean we have calculated variance vectors for row and column of 3 planes separately. When these feature vectors are used and we have tried the results we found that instead of taking variance, standard deviation performs better and that is why the feature vectors are actually extracted using the standard deviation **(SD)** values instead of variance.

4. ALGORIOTHMIC VIEW WITH IMPLEMENTATION DETAILS

Separate into **R, G** and **B** plane

Calculate Row Column Mean and variance vectors using the following equations **Mean** = $\mu = \frac{1}{n}\sum_{i=1}^{n} f_i x_i$ and

Variance = $\sigma^2 = \frac{1}{n}\sum_{i=1}^{n} f_i\left(x_i - \mu^2\right)$ and

Standard deviation (SD) is $\sigma = \sqrt{\sigma^2}$

Apply **Kekre's transform**, **DCT** and **Hybrid wavelet transform** over Row , Column **Mean** and **SD** vectors of R, G, and B planes and select all the transform coefficients to form the 36 feature vector databases as follows:

R plane : KT over Row_Mean, Col_Mean, Row_SD , Col_SD
DCT over Row_Mean, Col_Mean, Row_SD , Col_SD
HWT over Row_Mean, Col_Mean, Row_SD , Col_SD

G plane : KT over Row_Mean, Col_Mean, Row_SD , Col_SD
DCT over Row_Mean, Col_Mean, Row_SD , Col_SD
HWT over Row_Mean, Col_Mean, Row_SD , Col_SD

B plane : KT over Row_Mean, Col_Mean, Row_SD , Col_SD
DCT over Row_Mean, Col_Mean, Row_SD , Col_SD
HWT over Row_Mean, Col_Mean, Row_SD, Col_SD

Calculate the **Euclidean distance** between query image feature vector and feature vectors in the database using following equation: $D_{QI} = \sqrt{\left(F_Q - F_I\right)^2}$

Sort the Euclidean distances in ascending order and retrieve the first 100 images for each query. 36 results sets are obtained for each

Total 36 databases are prepared using the above steps where feature extraction process is mainly concerned with application of three transformations over Row Column Mean and Standard deviation vectors.

5. EXPERIMENTAL RESULTS AND DISCUSSION

5.1 Database and Query Images

All approaches explained above are experimented with database of 1000 BMP images. This database holds 10 different classes and 100 images from each class. It includes Flowers, Sunset, Mountains, Building, Bus, Dinosaurs, Elephant, Barbie, Mickey and Horse images. For all the techniques based on three transforms same set of query images are selected. Total 100 queries are applied for testing each approach which includes 10 images from each category.

36 feature vector databases which are created for 3 planes 4 types of vectors Row, Column, mean and Standard deviation vectors followed by the application of 3 transforms KT , DCT and Hybrid wavelet transforms are experimented with 100 query images and results obtained are shown in Table II and III.

Table -1 shows results obtained for three transforms applied over Row Mean vectors of R, G and B planes. Each value in the table is total images retrieved for 100 queries out of 10,000 images per plane.

Similarly Table-1, Table-2, Table-3 and 4 are showing the results obtained for KT, DCT and HWT over Row Standard deviation, Column Mean, and Column Standard deviation vectors respectively.

5.2 Results and Discussion

Table 1. KT, DCT and HWT applied over Row Mean vectors of R, G and Planes

	KT	HWT	DCT
Rplane	3819	3823	3823
Gplane	3866	3871	3865
Bplane	4115	4110	4117

Table 2. KT, DCT and HWT applied over Row Standard deviation vectors of R, G and Planes

	KT	HWT	DCT
Rplane	2724	2731	2727
Gplane	2756	2758	2755
Bplane	3198	3204	3201

Table 3. KT, DCT and HWT applied over Col Mean vectors of R, G and Planes

	KT	HWT	DCT
Rplane	3597	3593	3597
Gplane	3429	3429	3428
Bplane	3687	3693	3694

Table 4. KT, DCT and HWT applied over Col Standard deviation vectors of R, G and Planes

	KT	HWT	DCT
Rplane	2655	2652	2652
Gplane	2639	2647	2646
Bplane	2893	3204	2885

All the above tables are indicating the count of images retrieved which are similar to query for 100 queries out of 10,000.

Plots for the same results are shown in chart 1, 2, 3 and 4 where we can compare the results of 3 planes, three transforms and 4 approaches.

Chart 1. KT, DCT and HWT applied over Row Mean vectors of R, G and Planes

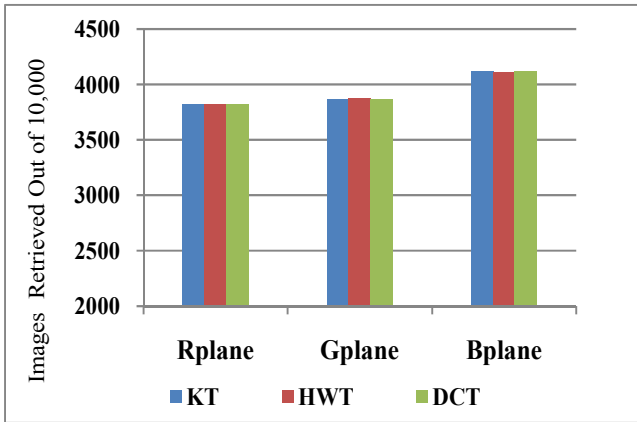


Chart 2. KT, DCT and HWT applied over Row Standard deviation vectors of R, G and Planes

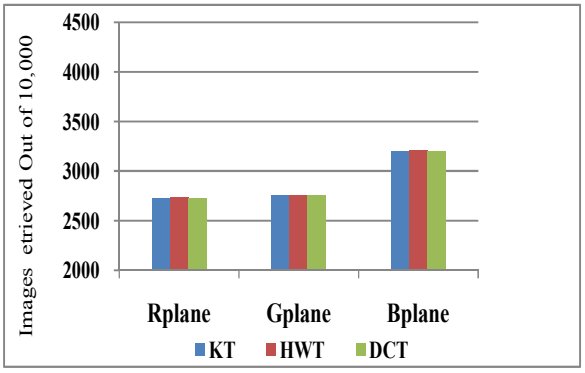


Chart 3. KT, DCT and HWT applied over Col Mean vectors of R, G and Planes

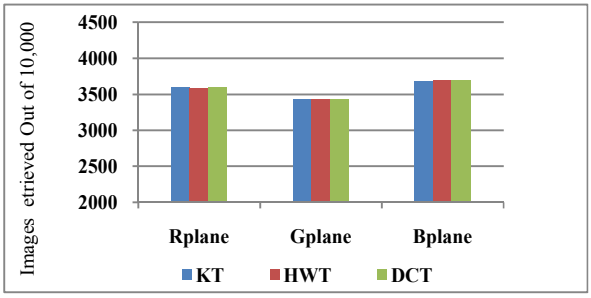
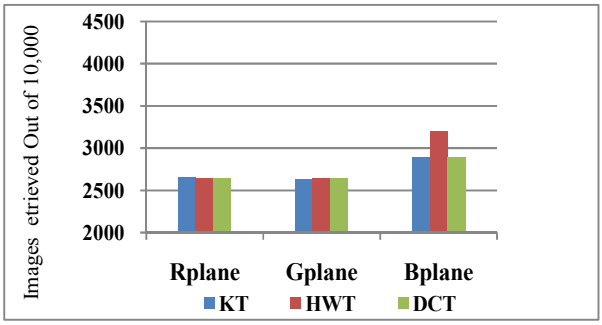


Chart 4. KT, DCT and HWT applied over Col Standard deviation vectors of R, G and Planes



Following observations are made after analyzing above results, tables with their respective charts.

Comparing the results of 3 planes, results obtained for blue plane are dominant to other two planes in all the approaches.

When we compare the results obtained the three transforms for their applications over Row Column Mean and Standard deviation vectors; we can say that performance of all three transform is quite similar. A little difference is noticed in above tables and charts where KT and HWT are performing better as compare to DCT.

Observation for the results based on approaches used that are Row Mean, Column mean, Row Standard deviation and Column Standard deviation; States that Mean vectors are performing better than Standard deviation vectors. We can see the falling performance in the chart 2 and 4 as compare to chart 1 and 3 respectively, where 1 and 3 are giving the results of Mean vectors and 3 and 4 are giving results for Standard deviation vectors. If we compare the results on Row and Column vectors basis, Row vectors are giving better results as compare to Column vectors.

After analyzing these results we came with decision of second level refinement in the results where, results obtained for three planes can be combined using the following three criteria.

Criterion 1: It states that, image will be retrieved in the final set if it is being retrieved in all the three planes R, G and B.

Criterion 2: It states that, image will be retrieved in the final set if it is being retrieved at least any two of the three planes.

Criterion 3: It states that, image will be retrieved in the final set if it being retrieved at least in one of three planes.

Results refined after application of these three Criteria are shown in following tables 5, 6, 7 with their respective charts in chart 5, 6 and 7.

Table 5 gives the results obtained for Kekre's transform over Row Column mean and Variance vectors refined with the combination of R, G, B planes along with the applications of 3 criteria.

Similarly results obtained for DCT and Hybrid wavelet transform are also refined using the same criterion and the results obtained are given in table 6 and 7.

Results obtained for Criterion 1, 2 and 3 for all the three transforms are plotted in charts 5, 6 and 7. X-axis is indicating the feature vectors used based on the approaches and Y- axis is giving the count of similar images retrieved out of 10,000 images on application of the criterion 1, 2 and 3.

Table 5. Combining results of KT for R, G and B planes for Row , Column Mean and Standard deviation vectors.

KT	Criterion 1	Criterion2	Criterion3
ROW_MEAN	2196	3840	5899
COL_MEAN	1802	3427	5593
ROW_VAR	1344	2661	4750
COL_VAR	965	2381	4913

Table 6. Combining results of HWT for R, G and B planes for Row, Column Mean and Standard deviation vectors

HWT	Criterion 1	Criterion2	Criterion3
ROW_MEAN	2194	3836	5900
COL_MEAN	1803	3431	5593
ROW_VAR	1342	2658	4758
COL_VAR	963	2381	4925

Table 7. Combining results of DCT for R, G and B planes for Row, Column Mean and Variance vectors

DCT	Criterion 1	Criterion2	Criterion3
ROW_MEAN	2195	3836	5903
COL_MEAN	1799	3429	5590
ROW_VAR	1342	2653	4757
COL_VAR	965	2376	4916

Chart 5. Combining results of KT for R, G and B planes for Row, Column Mean and Standard deviation vectors

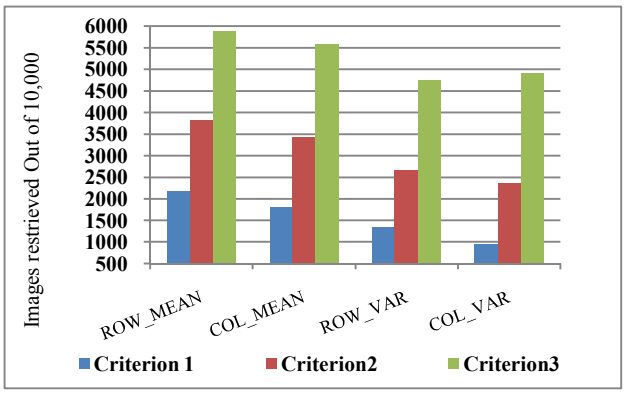


Chart 6. Combining results of HWT for R, G and B planes for Row, Column Mean and Standard deviation vectors

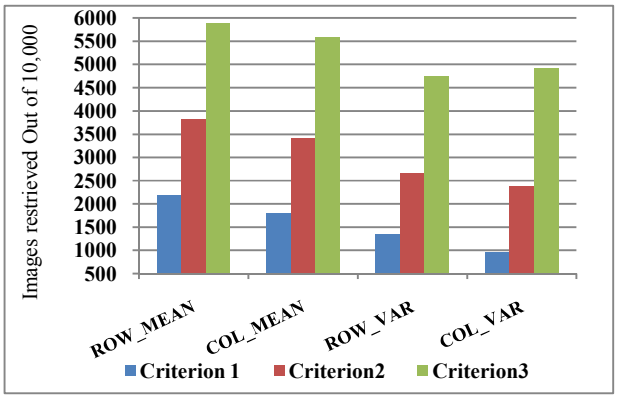
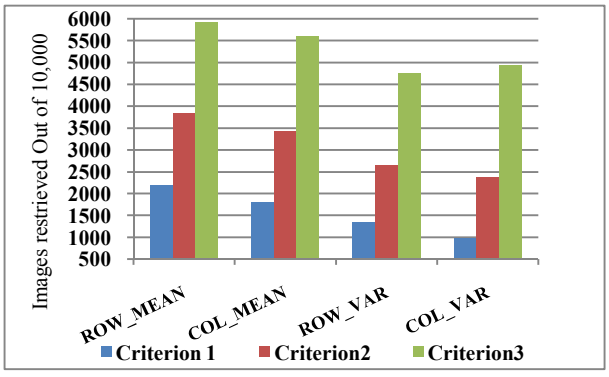


Chart 7. Combining results of DCT for R, G and B planes for Row, Column Mean and Standard deviation vectors



On observation of above results we can compare refined results of three criteria and three transforms used in this work.

In tables 5, 6 and 7 if we check for criterion 1, 2 and 3 in different types of approaches based on mean and variance vectors retrieval count of images similar to the query is in increasing order, means criterion 3 is giving best performance among all 3.

If we compare three transform for all approaches and all the criteria; overall performance of three transforms is quite similar. But if we check the fine details in the results obtained, we can say that Hybrid transform and Kekre's transform is giving better performance for all 3 criteria and four approaches.

6. CONCLUSION

In this work, available transform and new hybrid wavelet transform generated using available transforms are used to design the new approaches for the CBIR system. This work is based on the application of three transforms namely, Kekre's transform, DCT transform and Hybrid wavelet transform. These transforms are applied over Row - Column Mean and Standard deviation vectors of R, G and B planes of each database image and this way different feature databases are prepared.

All the approaches are experimented with 1000 BMP images; that include Flowers, Sunset, Mountains, Building, Bus, Dinosaurs, Elephant, Barbie, Mickey and Horse images. Out of these 1000, total 100 images given as query images, that is 10 from each class to test the performance of each of the four approaches based on three transforms.

When we compare four approaches, Row Mean, Column Mean, Row Standard deviation and Column Standard deviation; Mean vector based approaches are giving better performance as compare to standard deviation vectors and we can also note that Row vectors are giving far better results than Column vectors for either Mean or standard deviation.

An observation made for the results obtained using three criteria indicates that the performance of all approaches is in increasing order from criterion 1 to criterion 3.

Comparative study of three transforms tells that Hybrid Wavelet and Kekre's transform are performing better as compare to DCT transform in most of the results. Especially if we compare the computational time required for these three transform to extract the feature vector for database or the query images Kekre's transform and hybrid wavelet transform are taking less time as compare to DCT transform.

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