Performance Comparision of Image Retrieval using Row Mean of Transformed Column Image

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*Abstract***— The paper presents innovative content based image retrieval (CBIR) techniques based on row mean of transformed column image as feature vector. For proposed CBIR techniques three different image transforms like Discrete Cosine Transform (DCT), Walsh Transform and Kekre Transform are considered here. For performance comparison the proposed CBIR techniques are tested on gray version of generic image database of 1000 images spread across 11 categories. For each image retrieval technique 55 queries (5 per category) were fired on the image database. Average precision and average recall values for all these queries are computed and used for performance comparison. The proposed CBIR method is considered with DC component as part of feature vector as well as without it. In all three transforms and variation of consideration/ignorance of DC coefficient results into total 6 novel proposed CBIR techniques. These techniques are compared with CBIR using full transformed image as feature vector. The results have shown the performance improvement (higher precision and recall values) with proposed methods compared to full transformed image as feature vector with great reduction in computational complexity. The negligence of DC component causes performance degradation in proposed techniques. The DCT with consideration of DC component gives best performance among the considered image transforms. The performance ranking of image transforms in proposed CBIR methods can be given as DCT, Walsh transform and Kekre transform.**

Keywords-content based image retrival (CBIR); row mean; DCT, Walsh transform, Kekre transform.

I. Introduction

The large numbers of images are being generated from a variety of sources (digital camera, video, scanner, the internet etc.) which have posed technical challenges to computer systems to store/transmit and index/manage image data effectively to make such large collections easily accessible. Image compression deals with the challenge of storage and transmission, where significant advancements have been made [1,4,5]. The challenge to image indexing is studied in the context of image database [2,6,7,10,11], which has become one of the most promising and important research area for researchers from a wide range of disciplines like computer vision, image processing and database areas. The thirst of better and faster image retrieval techniques is increasing day by day. Some of important applications for CBIR technology could be identified as art galleries [12,14], museums, archaeology [3], architecture design [8,13], geographic information systems [5], trademark databases [21,23], weather forecast [5,22], medical imaging [5,18], criminal investigations [24,25], image search on the Internet [9,19,20].

A. *Content Based Image Retrieval*

In literature the term content based image retrieval (CBIR) has been used for the first time by Kato et.al. [4], to describe his experiments into automatic retrieval of images from a database by colour and shape feature. The typical CBIR system performs two major tasks [16,17]. The first being feature extraction (FE), where a set of features, called feature vector, is generated to accurately represent the content of each image in the database. The second task is similarity measurement (SM), where distance between the query image and each image in the database using their feature vectors is used to retrieve the top "closest" images [16,17,26].

For feature extraction in CBIR there are mainly two approaches [5] feature extraction in spatial domain and feature extraction in transform domain. The feature extraction in spatial domain includes CBIR techniques based on histograms [5], BTC [1,2,16], VQ [21,25,26]. The transform domain methods are widely used in image compression, as they give high energy compaction in transformed image [17,24]. So it is obvious to use images in transformed domain for feature extraction in CBIR [23]. But taking transform of image is time consuming, this complexity is reduced to a great extent by the proposed technique. Reducing the size of feature vector using pure image pixel data in spatial domain only and till getting the improvement in performance of image retrieval is the theme of the work presented. Many current CBIR systems use Euclidean distance [1-3,8-14] on the extracted feature set as a similarity measure. The Direct Euclidian Distance between image P and query image Q can be given as equation 1, where Vpi and Vqi are the feature vectors of image P and Query image Q respectively with size 'n'.

$$ED = \sqrt{\sum_{i=1}^{n} (Vpi - Vqi)^2} \qquad (1)$$

II. Transforms Discussed

The various transforms [10,11,18] used for proposed CBIR techniques are discussed below:

A. Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) is closely related to the discrete Fourier transform. It is a separable linear transformation; that is, the two-dimensional transform is equivalent to a one-dimensional DCT performed along a single dimension followed by a one-dimensional DCT in the other dimension. The definition of the two-dimensional DCT for an input image A and output image B is.

$$B_{pq} = \alpha_p \alpha_q \sum\sum A_{mn} \cos\frac{\pi(2m+1)p}{2M} \cos\frac{\pi(2n+1)q}{2N}, \begin{matrix} 0 \le p \\ 0 \le q \end{matrix} \quad (2)$$

$$\alpha_p = \begin{cases} 1/\sqrt{M} & , p = 0 \\ \sqrt{2/M} & , 1 \le p \le M-1 \end{cases} \quad (3)$$

$$\alpha_q = \begin{cases} 1/\sqrt{N} & , q = 0 \\ \sqrt{2/N} & , 1 \le q \le N-1 \end{cases} \quad (4)$$

where M and N are the row and column size of A, respectively. If you apply the DCT to real data, the result is also real. The DCT tends to concentrate information, making it useful for image compression applications and also helping in minimizing feature vector size in CBIR.

B. Walsh Transform

The Walsh transform matrix [12] 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 xWkT=0, for j k and Wj xWkT =N, for j=k.
- Wj has exactly j zero crossings, for j = 0, 1, ..., N-1.
- Each row Wj is either even or odd w.r.t. to its midpoint.

C. Kekre's Transform

Kekre's transform matrix is the generic version of Kekre's LUV color space matrix [1,8,12,13,15,22]. Kekre's transform matrix 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). All upper diagonal and diagonal values of Kekre's transform matrix are one, while the lower diagonal part except the values just below diagonal is zero.

Generalized NxNKekre's transform matrix can be given as:

$$K_{NxN} = \begin{bmatrix} 1 & 1 & 1 & .. & 1 \\ -N+1 & 1 & 1 & .. & 1 \\ 0 & -N+2 & 1 & .. & 1 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & .. & 1 \\ 0 & 0 & 0 & .. & -N+(N-1) \end{bmatrix} \quad (5)$$

The formula for generating the term $K_{xy}$of Kekre's transform matrix is:

$$K(x,y) = \begin{cases} 1 & , x \le y \\ -N+(x-1) & , x = y+1 \\ 0 & , x > y+1 \end{cases} \quad (6)$$

III. Row Mean Vector [22,25]

The row mean vector is the set of averages of the intensity values of the respective rows. The column mean vector is the set of averages of the intensity values of the respective columns. Fig.1 is representing the sample image with size 'nxn', the row and column mean vectors for this image will be as given below.

Row Mean Vector =
[Avg(Row 1), Avg(Row 2), …., Avg(Row n)] (7)

Column Mean Vector =
[Avg(Col. 1), Avg(Col. 2), …., Avg(Col. n)] (8)

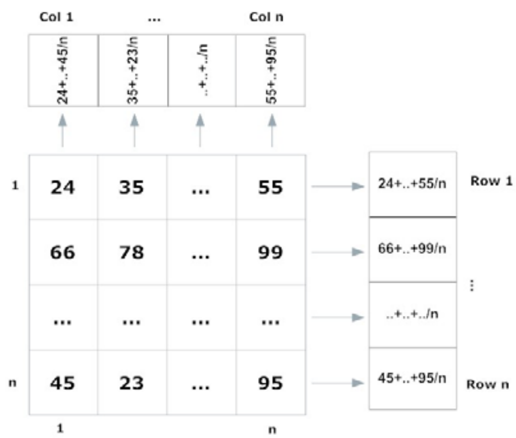

Figure 1 Row Mean Vector of Sample Image (with size nxn) [27]

IV. Proposed Technique

Here the image transform is first applied on each column of the image, instead of applying transform on the whole image, this saves great amount of computations needed resulting in faster retrieval. Then row mean of this transformed column image is obtained for generating the feature vector of image. The obtained feature vector is used in two different ways (with and without DC component) to see the variations in results obtained

The proposed techniques of CBIR can be explained using following steps:

1. Apply transform T on the column of image of size NxN (I_{NxN}) to get column transformed image of the same size (cI_{NxN})
   cI_{NxN} (column transformed) = [T_{NxN}] [I_{NxN}] (9)
2. Calculate row mean of column transformed image to get feature vector of size N (instead of N^2)

3. The feature vector is considered with and without DC component to see variations in results. Then Euclidean Distance is applied to obtain precision and recall.

The proposed CBIR techniques are used with three different image transforms. The performance of proposed CBIR techniques is compared with image retrieval using complete transformed image as feature vector.

V. IMPLEMENTATION

A. The Platform

The implementation of the proposed CBIR techniques is done in MATLAB 7.0 using a computer with Intel Core 2 Duo Processor T8100 (2.1GHz) and 2 GB RAM.

B. Database

The CBIR techniques are tested on the augmented Wang image database [15] of 1000 variable size generic images spread across 11 categories of human being, animals, natural scenery and manmade things. Figure 2 shows sample image of generic database.

Figure 2 Sample Images from Generic Image Database
[Image database contains total 1000 images with 11 categories]

C. Precision/Recall

To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters [1,2] for the proposed CBIR techniques. The standard definitions for these two measures are given by following equations.

$$Precision = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (10)$$

$$Recall = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (11)$$

VI. RESULTS AND DISCUSSIONS

For performance comparison of proposed CBIR techniques, per technique 55 queries (5 from each image category) are fired on the gray version of generic image database. The query and database image matching is done using Euclidian distance. The average precision and average recall are plotted against number of retrieved images. The crossover point of precision and recall gives important performance measure for image retrieval techniques. Higher the crossover point is better will be the performance of CBIR method.

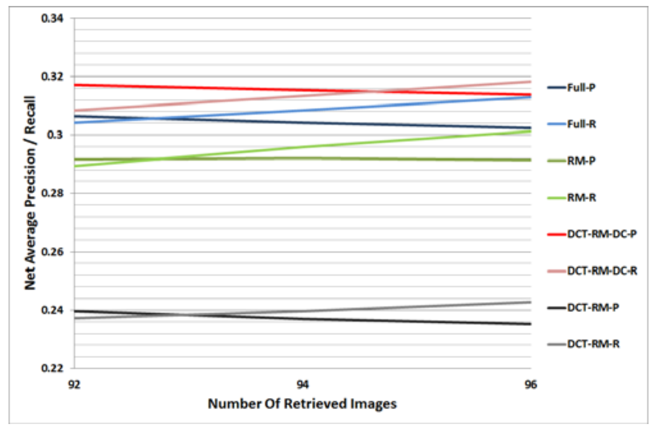

Figure 3 Crossover Point of Precision and Recall v/s Number of Retrieved Images using DCT

In figure 3 the crossover points of CBIR using DCT applied to the full image (Full), CBIR using simple row mean of image (RM), the proposed techniques of row mean of transformed column image with DC component (DCT-RM-DC) and without DC component (DCT-RM) are shown. Here the proposed CBIR technique with DC component gives the best performance. The DC component consideration gives better performance than its negligence.

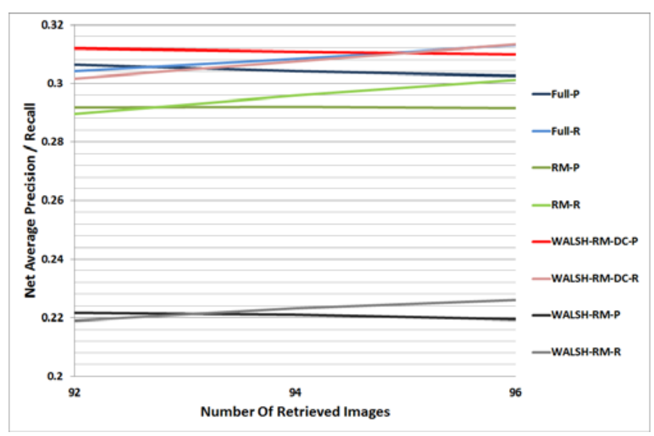

Figure 4 Crossover Point of Precision and Recall v/s Number of Retrieved Images using Walsh Transform

Figure 4 gives the performance comparison of the crossover points of CBIR with Walsh Transform applied to the full image (Full), CBIR using row mean of image (RM) and the proposed techniques with/without DC components (WALSH-RM-DC and WALSH-RM). Here also proposed CBIR method with DC coefficient proves to be the best. The performance degrades if the DC component is not considered in proposed image retrieval method.

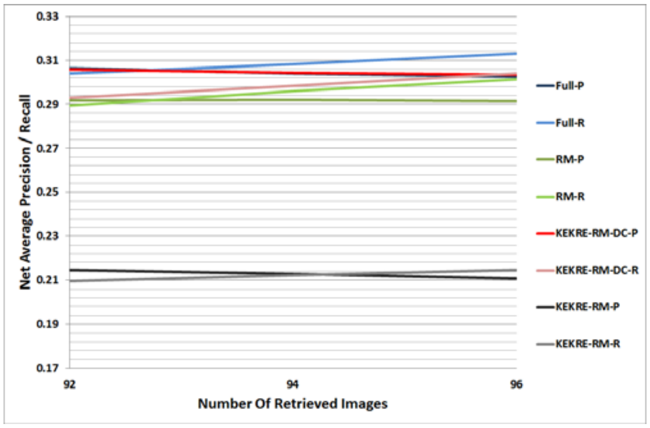

Figure 5 Crossover Point of Precision and Recall v/s Number of Retrieved Images using Kekre Transform

The crossover points of CBIR using Kekre transform applied to the full image (Full), CBIR using row mean applied to transformed image (RM) and proposed techniques with DC component (KEKRE-RM-DC) and without DC component (KEKRE-RM) are shown in figure 5. Here the best results are given by proposed technique with DC component (KEKRE-RM-DC). Even here the performance of proposed technique degrades considerably if the DC component is not considered.

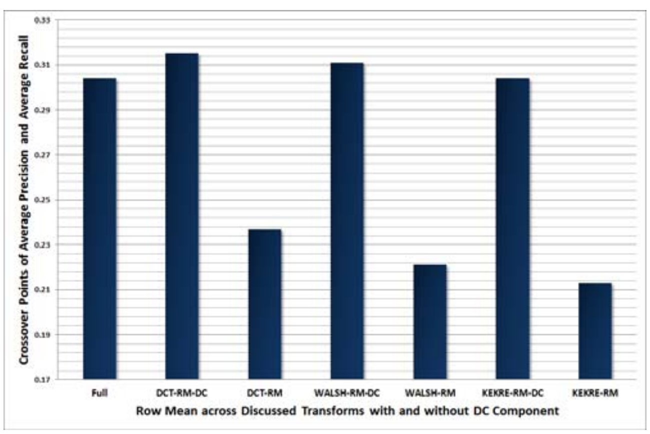

Figure 6 Crossover Point of average Precision and Recall v/s Row Mean with & without DC component for all transforms with Full Image

In figure 6 the crossover points of average precision and average recall of all the proposed techniques are shown. Here all transforms for proposed CBIR method with DC component gives better performance as compared to CBIR using full transformed image as feature vector. In all DCT outperforms other image transforms. The performance ranking of image transforms for proposed image retrieval techniques is DCT followed by Walsh transform and then Kekre transform.

VII. CONCLUSION

The prodigious task of improving the performance of image retrieval technique and simultaneously reducing the computational complexity has been achieved by proposed CBIR techniques based on row mean of column transformed image. The proposed techniques with and without DC component are tested using gray version of generic image database. The proposed techniques are considered in combination with three image transforms like DCT, Walsh ransform and Kekre transform. In all transforms DC component based CBIR performs better that the one without DC component. All transforms with proposed CBIR techniques gives better and faster image retrieval as compared to CBIR using complete transformed image as feature vector. The performance of DCT is the best followed by Walsh transform and then Kekre transform.

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