Image Retrieval using Fractional Energy of Row Mean of Column Transformed Image with Six Orthogonal Image Transforms

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Abstract*— The thirst of better and faster retrieval techniques has always fuelled to the research in content based image retrieval (CBIR). The paper presents innovative content based image retrieval (CBIR) techniques based on feature vectors as fractional coefficients of row mean of column transformed images using Discrete Cosine, Walsh, Haar, Slant, Discrete Sine, and Hartley transforms. Here the advantage of energy compaction of transforms in low frequency coefficients in transform domain is taken to greatly reduce the feature vector size per image by taking fractional coefficients of row mean of column transformed image. The feature vectors are extracted in six different ways from the transformed image, with the first being considering all the coefficients of row mean of column transformed image and then six reduced coefficients sets (as 50%, 25%, 12.5%, 6.25%, 3.125%, 1.5625% of complete row mean of column transformed image) are considered as feature vectors. The six transforms are applied on the colour components of images to extract row mean of column transformed RGB feature sets respectively. Instead of using all coefficients of transformed images as feature vector for image retrieval, these six reduced coefficients sets for RGB planes are used, resulting into better performance and lower computations. The proposed CBIR techniques are implemented on a database having 1000 images spread across 10 categories. For each proposed CBIR technique 40 queries (4 per category) are fired on the database and net average precision and recall are computed for all feature sets per image transform. The results have shown performance improvement (higher precision and recall values) with fractional coefficients compared to complete transform of image at reduced computations resulting in faster retrieval. Finally Discrete Cosine Transform (DCT) surpasses all other discussed transforms in performance with highest precision and recall values for 50% of fractional coefficients.

Index Terms*— CBIR, Cosine Transform , Walsh Transform, Haar Transform, Sine Transform , Slant Transform, Hartley Transform, Fractional Coefficients, Row Mean.

I. INTRODUCTION

The computer systems have been posed with large number of challenges to store/transmit and index/manage large numbers of images effectively, which are being generated from a variety of sources. Storage and transmission is taken care by Image compression with significant advancements been made [1, 4, 5]. Image databases deal with the challenge of image indexing and retrieval [2, 6, 7, 10], which has become one of the 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 till appetising to the researchers working in some of important applications for CBIR technology like art galleries [12,14], museums, archaeology [3], architecture design [8,13], geographic information systems [5], weather forecast [5,22], medical imaging [5,18], trademark databases [21,23], 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 their experiments into automatic retrieval of images from a database by colour and shape features. The typical CBIR system performs two major tasks [16,17]. The first one is 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 a distance between the query image and each image in the database using their feature vectors is used to retrieve the "closest" images [16, 17, 26]. For CBIR feature extraction the two main approaches are feature extraction in spatial domain [5] and feature extraction in transform domain [1]. The feature extraction in spatial domain includes the CBIR techniques based on histograms [5], BTC [2, 16, 23], VQ [11, 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 [1]. Transform domain results in energy compaction in few elements, so large number of the coefficients of transformed image can be neglected to reduce the size of feature vector [1]. Reducing the size feature vector using fractional coefficients of transformed image and till getting the improvement in performance of image retrieval is the theme of the work presented here. Many Current Retrieval systems take a simple approach by using typically norm-based distances (e.g., Euclidean distance [2]) on the extracted feature set as a similarity function. The main premise behind these CBIR systems is that given a "good set" of features extracted from the images in the database (the ones that significantly capture the content of images.) then for two images to be "similar" their extracted features have to be "close" to each other. The Mean Square Distance between an image P and query image Q can be given as the Eq (1) below

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

Where, Vpi and Vqi be the feature vectors of image P and Query image Q respectively size 'n'.

II. IMAGE TRANSFORMS USED

Here six orthogonal image transforms namely Cosine [1, 10, 21, 22, 24], Walsh [1, 11, 18, 19, 26], Haar [27], Slant [27], Hartley [27] and Sine [27] are used for transforming the image columns

III. ROW MEAN

Figure 1 is representing the image with n rows and n columns, the row mean vectors [17], [24] for this image will be as given below.

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

	Col 1	Col 2	… .	Col n
Row 1	35	34	…	25
Row 2	78	24	…	68
. .	…	…	…	…
Row n	68	76	…	45

Avg (Row1) = (35 + 34+…+25)/n

Fig. 1 Sample Image Template (with size nxn)

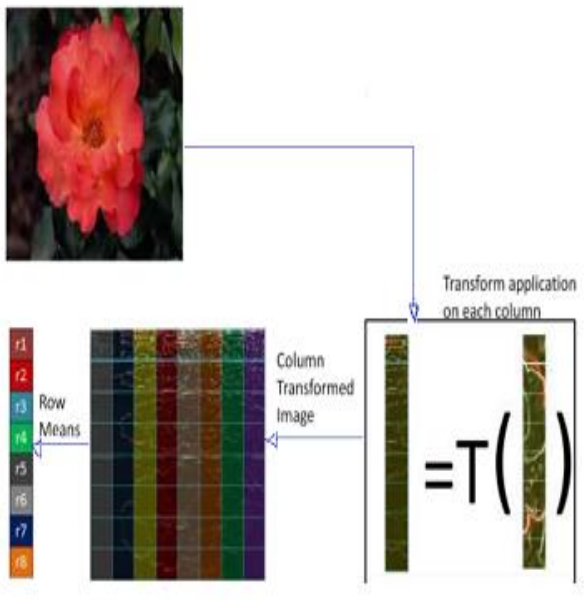

Fig. 2 Color Feature Extraction using Image Transform

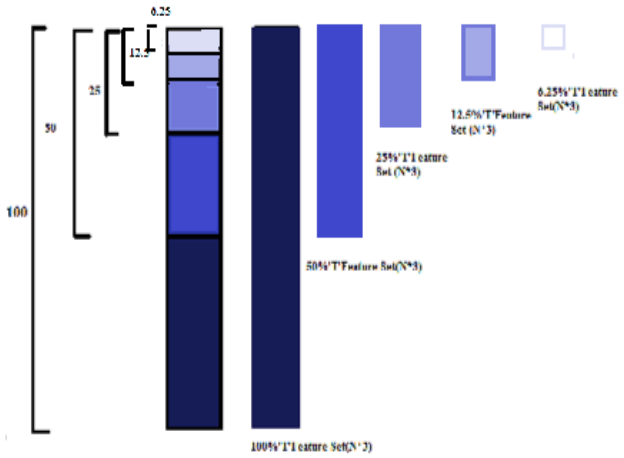

Fig. 3 Fractional Co-efficient of row mean of column transformed Images

IV. PROPOSED CBIR-RGB TECHNIQUES

Figure 2 and Figure 3 explains the feature sets extraction methods used to extract feature sets for proposed CBIR techniques using fractional coefficients of row mean of column transformed images

A. Feature Extraction for feature vector 'T-RGB'

Here the feature vector space of the image of size NxNx3 has Nx3 number of elements. This is obtained using following steps of T-RGB

i. Extract Red, Green and Blue components of the color image.

ii. Apply the transform 'T' on each column of the individual color planes of image to extract feature vector.

iii. Compute the row mean vector to obtain the feature vector.

iii. The result is stored as the feature vector 'T-RGB' for the respective image.

Thus the feature vector database for DCT, Walsh, Haar, Slant, Hartley and DST transform is generated as DCT-RGB, Walsh-RGB, Haar-RGB, Slant-RGB, Hartley-RGB and DST-RGB respectively. Here the size of feature database is Nx3.

B. Query Execution for 'T-RGB' CBIR

Here the feature set of Nx3 for the query image is extracted using transform 'T' applied on the red, green and blue planes of query image. This feature set is compared with other feature sets in feature database using Mean Square distance as similarity measure. Thus DCT, Walsh, Haar, Slant, Hartley, DST transform based feature sets are extracted for query image and are compared respectively with DCT-RGB, Walsh-RGB, Haar-RGB, Slant-RGB, Hartley-RGB and DST-RGB feature sets to find Mean Square distance

C. CBIR using 'Fractional-T-RGB'

As explained A and B of section IV, the 'T-RGB' feature extraction and query execution are extended to get 50%,25%, 12.5%, 6.25%, 3.125% and 1.5625% of T-RGB image retrieval techniques

V. IMPLEMENTATION

The implementation of the three CBIR techniques is done in MATLAB 7.0 using a computer with Intel Core 2 Duo Processor T8100 (2.1GHz) and 2 GB RAM. The CBIR techniques are tested on the image database [15] of 1000 images spread across 10 categories of human being, animals, natural scenery and manmade things. The categories and distribution of the images is shown in Table 1.

Table 1. Image Database: Category-wise Distribution

Category	Tribes	Buses	Dinosaurs	Elephants	Roses
No. of Images	100	100	100	100	100
Category	Monuments	Horses	Mountains	Food Items	Beaches
No. of images	100	100	100	100	100

Fig. 4 Sample from Database

[Image database contains total 1000 images with 10 categories]

Figure 4 gives the sample database images from all categories of images including scenery, flowers, buses, animals, food items, monuments, and tribal people. 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 of these two measures are given by equations Eq (3), (4) below:

$$Precision = \frac{No.of\ relevant\ imagess\ Received}{Total\ \ of\ images\ retrieved} \quad (3)$$

$$Recall = \frac{Number\ of\ relevant\ images\ retrieved}{No.of\ relevant\ images\ in\ the\ database} \quad (4)$$

VI. RESULTS AND DISCUSSIONS

For testing the performance of each proposed CBIR technique, per technique 40 queries (4 from each category) are fired on the database of 1000 variable size generic images spread across 10 categories. The query and database image matching is done using mean square distance. The average precision and average recall are computed by grouping the number of retrieved images sorted according to ascending average mean square distances with the query image. The crossover point of precision and recall of the CBIR techniques acts as one of the important parameters to judge their performance [1, 2, 19, 20].

Figure 5 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using DCT. Uniformly in all image retrieval techniques based on color DCT features 50% fractional feature set based image retrieval gives highest precision and recall crossover point value.

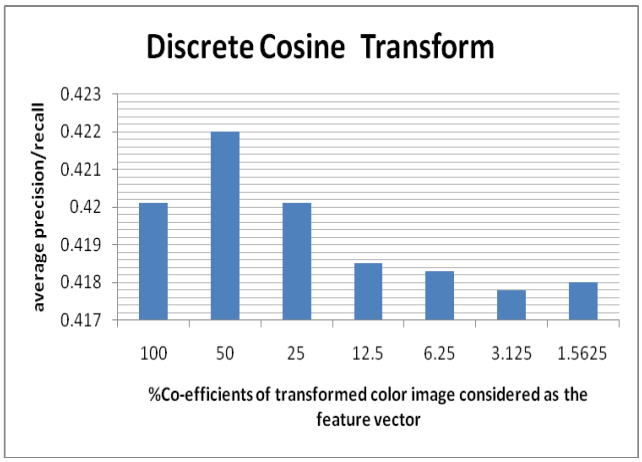

Fig. 5 DCT-RGB based CBIR

Figure 6 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using slant transform. Uniformly in all image retrieval techniques based on colour slant transform features 50% fractional feature set based image retrieval gives acceptable crossover point of precision and recall values, which is just 2% less than the crossover point of the full set of coefficients considered.

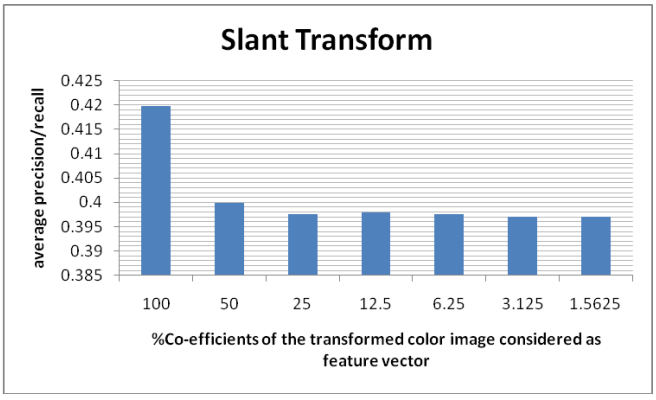

Fig. 6 Slant-RGB based CBIR

Figure 7 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using Haar transform.

Uniformly in all image retrieval techniques based on color slant transform features 50% fractional feature set based image retrieval gives same precision and recall crossover point value as that with the full set of coefficients considered. Also image retrieval techniques based on color Haar transform features 12.5% fractional feature set based image retrieval gives acceptable precision and recall crossover point values with only 0.05% less than that given by full set of coefficients are considered for CBIR.

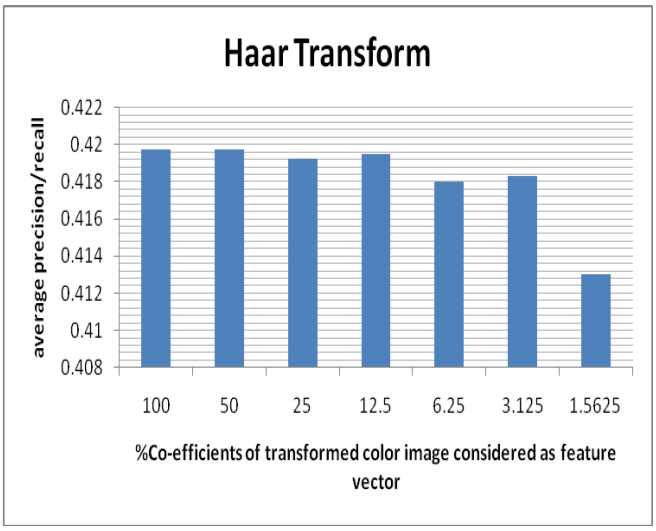

Fig. 7 Haar-RGB based CBIR

Figure 8 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using Hartley transform. Uniformly in all image retrieval techniques based on color slant transform features 50% fractional feature set based image retrieval gives acceptable performance with the precision-recall crossover point value only 2.4% less than the full set of coefficients considered.

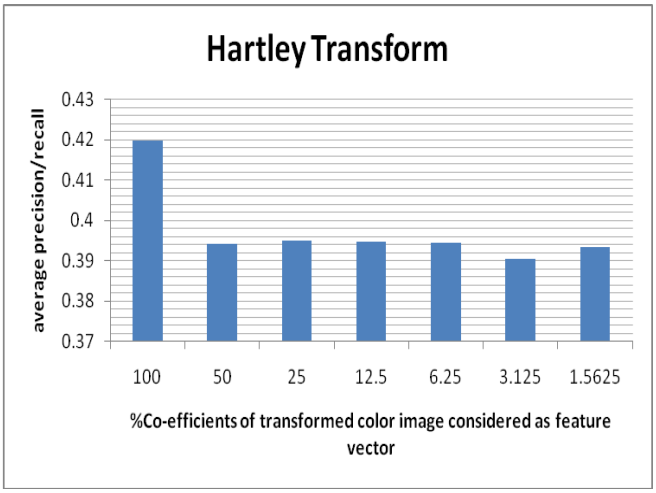

Fig. 8 Hartley-RGB based CBIR

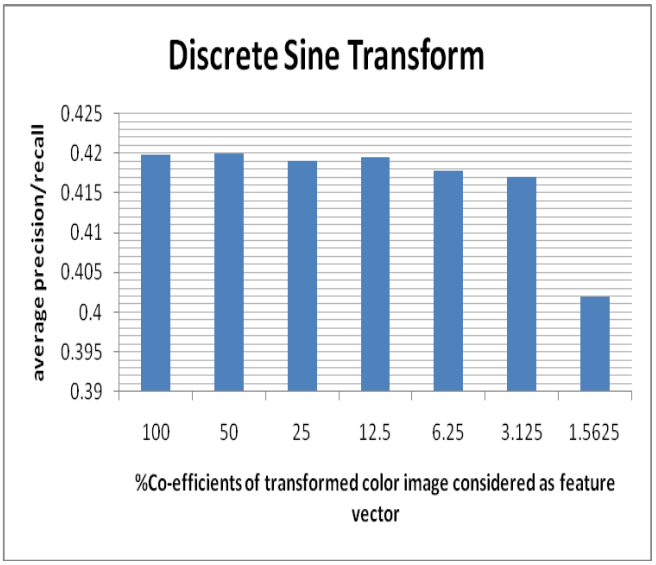

Fig. 9 DST-RGB based CBIR

Figure 9 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using DST transform. Uniformly in all image retrieval techniques based on colour DST transform features 50% fractional feature set based image retrieval gives highest precision-recall crossover point values as that with the full set of coefficients considered.

Figure 10 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using Walsh transform. Uniformly in all image retrieval techniques based on colour Walsh transform features full feature set based image retrieval gives highest precision and recall values. However, 25% fractional feature set based image retrieval gives acceptable precision and recall crossover point values with only 3.325% less than the full set of coefficients are considered.

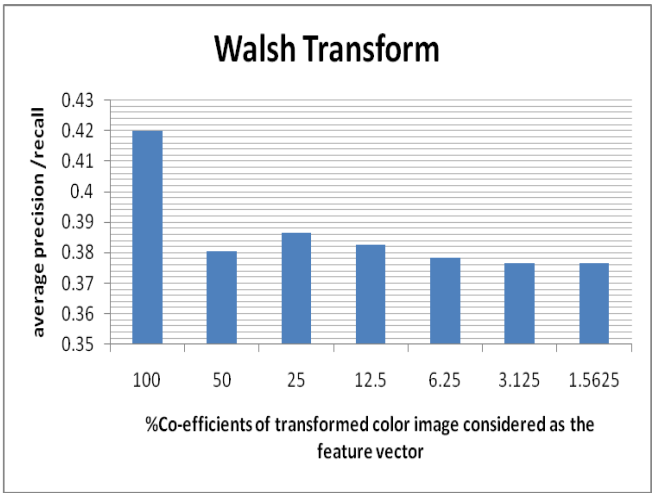

Fig. 10 Walsh-RGB based CBIR

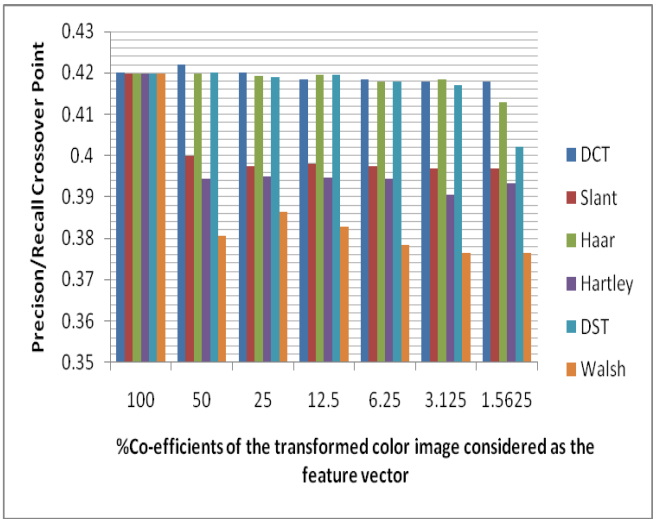

Fig 11 Transform Comparison in RGB based CBIR

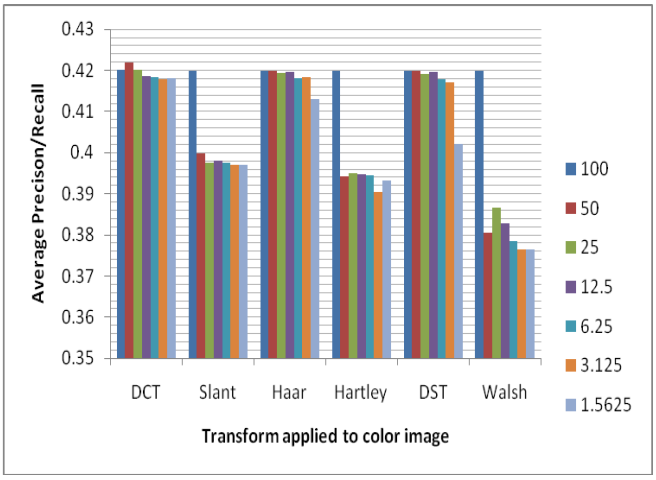

Fig. 12 Transform Comparison in RGB based CBIR

Figure 11 and Figure 12 gives the comparisons of the six transforms used in proposed CBIR method. DCT surpasses all other discussed transforms in performance with highest precision and recall values for 50% of fractional coefficients. In DCT , Haar and DST the fractional coefficients are proven to be better for CBIR than the full set of coefficients in the proposed feature extraction technique.

VII. CONCLUSIONS

In the information age where the size of image databases is growing exponentially more precise retrieval techniques are needed, for finding relatively similar images. Computational complexity and retrieval efficiency are the key objectives in the image retrieval system. Nevertheless it is very difficult to reduce the computations and improve the performance of image retrieval technique. Here the performance of image retrieval is improved using fractional coefficients of transformed images at reduced computational complexity. In the transforms (DCT, DST, and Haar), the average precision and average recall crossover point values for CBIR using fractional coefficients are higher than CBIR using full set of coefficients. Hence the feature vector size for image retrieval could be greatly reduced, which ultimately will result in faster query execution in CBIR with better performance. In all DCT transform with fractional coefficients (50 % in RGB) gives best performance with highest crossover points of average precision and average recall. Thus feature extraction in lesser time is possible with increased performance. Finally the conclusion that the fractional coefficients gives better discrimination capability in CBIR than the complete set of transformed row mean of column coefficients and image retrieval with better performance at much faster rate can be drawn.

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