Extended Performance Appraise of Image Retrieval Using the Feature Vector as Row Mean of Transformed Column Image

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Abstract

The extension to the content based image retrieval (CBIR) technique based on row mean of transformed columns of image is presented here. As compared to earlier contemplation three image transforms, now the performance appraise of proposed CBIR technique is done using seven different image transforms like Discrete Cosine Transform (DCT), Discrete Sine Transform (DST), Hartley Transform, Haar Transform, Kekre Transform, Walsh Transform and Slant Transform. The generic image database with 1000 images spread across 11 categories is used to test the performance of proposed CBIR techniques. For each transform 55 queries (5 per category) were fired on the image database. Every technique is tested on both the color and grey version of image database. To compare the performance of image retrieval technique across transforms average precision and recall are computed of all queries. The results have shown the performance improvement (higher precision and recall values) with proposed methods compared to all pixel data of image at reduced computations resulting in faster retrieval in both gray as well as color versions of image database. Even the variation of considering DC component of transformed columns as part of feature vector and excluding it are also tested and it is found that presence of DC component in feature vector improvises the results in image retrieval. The ranking of transforms for performance in proposed gray CBIR techniques with DC component consideration can be given as DST, Haar, Hartley, DCT, Walsh, Slant and Kekre. In color variants of proposed techniques with DC component, the performance ranking of image transforms starting from best can be listed as DCT, Haar, Walsh, Slant, DST, Hartley and Kekre transform.

Keywords- CBIR, DCT, DST, Haar, Walsh, Kekre, Slant, Hartley,Row Mean.

1. INTRODUCTION

The hefty sized image databases which are being generated from a variety of sources (digital camera, video, scanner, the internet etc.) have posed technical challenges to computer systems to store/transmit and index/manage image data effectively to make such large collections easily accessible. Storage and transmission challenges are taken care by Image compression. The challenges of image indexing are studied in the context of image database [2,6,7,10,11], which has become one of the most important and promising research area for researchers from a wide range of disciplines like computer vision, image processing and database areas. The need for faster and better 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].

1.1 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 color and shape feature. 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 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 the 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 [23,28]. But taking transform of image is time consuming. Reducing the size of feature vector by applying transform on columns of the image and finally taking row mean of transformed columns and till getting the improvement in performance of image retrieval is the theme of the work presented here. 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'.

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

Total seven well-known image transforms [10,11,18,28] like Discrete Cosine Transform (DCT), Walsh Transform, Haar Transform, Kekre Transform, Discrete Sine Transform (DST), Slant Transform and Hartley Transform are used for performance comparison of the proposed CBIR techniques.

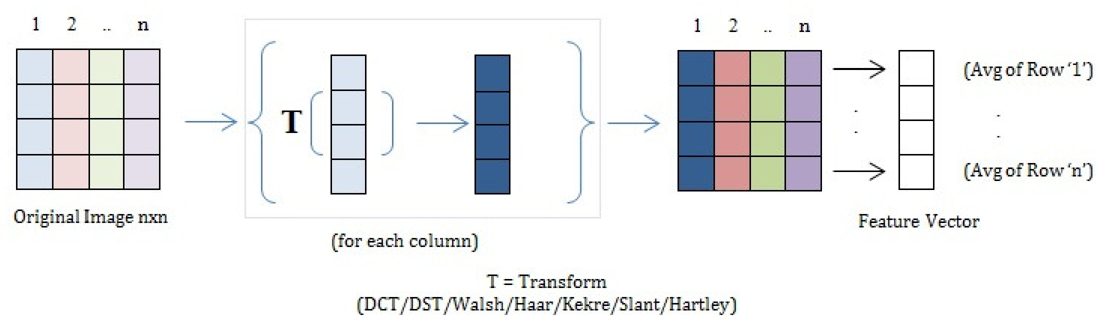

FIGURE 1: Feature Extraction in Proposed CBIR Technique with Row Mean of Transformed Image Columns

2. CBIR USING ROW MEAN OF TRANSFORMED COLUMN IMAGE [28]

Here image transform is applied on each column of image. Then row mean of the transformed columns is used as feature vector. Figure 1 shows the Feature Extraction in Proposed CBIR Technique with Row Mean of Transformed Image Columns. The obtained feature vector is used in two different ways (with and without DC component) to see the variations in retrieval accuracy. As indicated by experimental results, image retrieval using DC component value proves to be better than retrieval excluding it.

The following steps need to be followed for image retrieval using the proposed image retrieval techniques:

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) = $[T_{NxN}]$ $[I_{NxN}]$ (2)

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.

Applying transform on image columns instead of applying transform on the whole image, saves 50% of computations required resulting in faster retrieval [28]. Again row mean of column transformed image is taken as feature vector which further reduces the required number of comparisons among feature vectors resulting in faster retrieval. The results obtained from proposed techniques of row mean of column transformed image with DC component and row mean of column transformed image without DC component are compared with applying transform on full image and spatial row mean of image in both gray and color versions of image database.

3. IMPLEMENTATION

3.1 *The Platform and Image Database*

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.
The proposed CBIR techniques are tested on the image database of 1000 variable size images spread across 11 categories of human being, animals, natural scenery and manmade things. This image database in augmented version of Wang image database [15]. 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]

3.2 *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.

$$\text{Precision} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (3)$$

$$\text{Recall} = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (4)$$

4. RESULTS AND DISCUSSIONS

For testing the performance of each proposed CBIR technique, per technique 55 queries (5 from each category) are fired on the database of 1000 variable size generic images spread across 11 categories. The query and database image matching is done using Euclidian distance. The average precision and average recall values for each proposed technique with respective image transform are computed and plotted against number of retrieved images for performance comparison.

The crossover point of precision and recall plays very important role in performance analysis of image retrieval method. At this crossover point value of precision equals to that of recall, which means all the relevant images from database have been retrieved and are exactly equal to the number of retrieved result images. In ideal situation the height of precision and recall crossover point should be at value one, which means all the retrieved images are relevant and all relevant from database are retrieved. Always the performance of image retrieval technique is compared to this ideal situation. The height of crossover point of precision and recall gives idea about how much the proposed technique is deviating from ideal one, more the height better the technique is.

The performance of proposed techniques with DC component (referred as 'Transform-RM-DC') and without DC component (referred as 'Transform-RM') for each transform is compared with CBIR using complete transformed image as feature vector (referred as 'Full'), spatial row mean vector of image as feature vector (referred as 'RM').

The proposed techniques are tested for both grey and color versions of image database. In all image transforms the color versions of the discussed CBIR techniques give higher performance as compared to gray versions.

4.1 Results on Gray Version of Image Database

In Figure 3 the precision-recall crossover points of DCT applied to the full gray image (Full), gray row mean (RM), the proposed technique of row mean of DCT transformed gray columns applied with DC component (DCT-RM-DC) and without DC component (DCT-RM) are shown. Here the proposed method with DC component gives the highest crossover point indicating best performance. Even the computational complexity in proposed retrieval technique is less than that of applying full transform. This proves proposed image retrieval method is faster and better with DCT. The performance of proposed CBIR method degrades if the DC component is not considered.

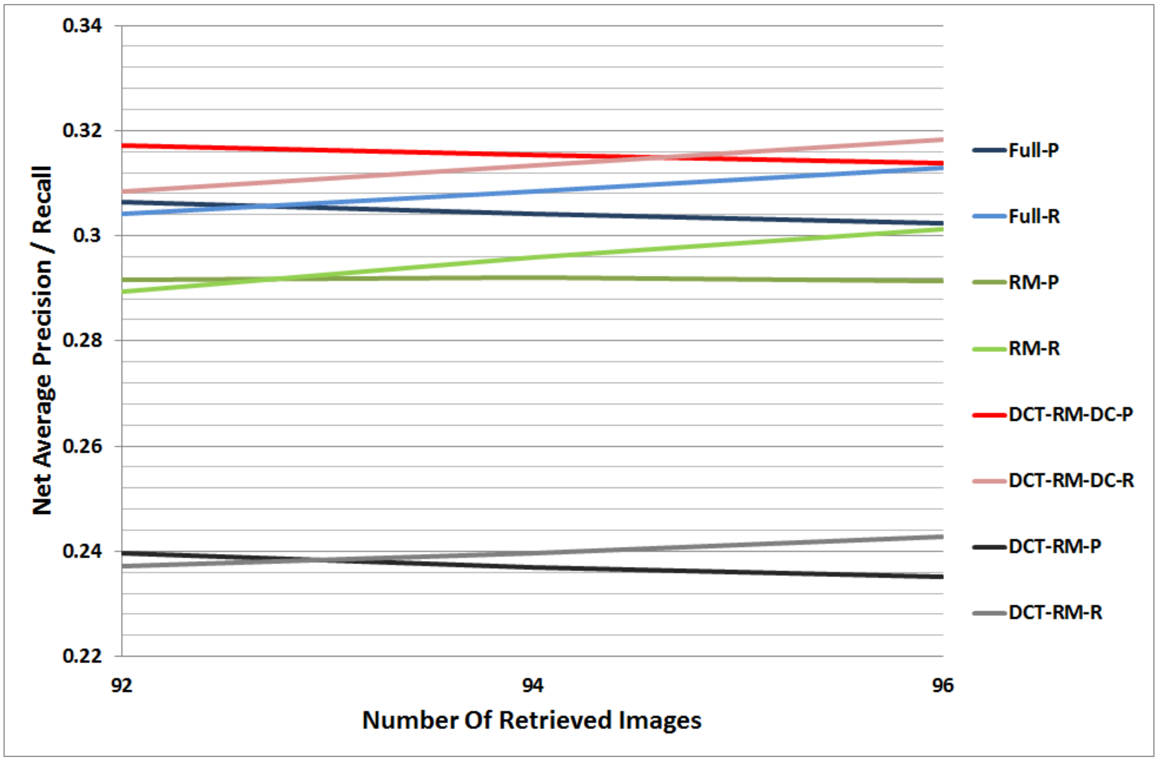

FIGURE 3: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using DCT

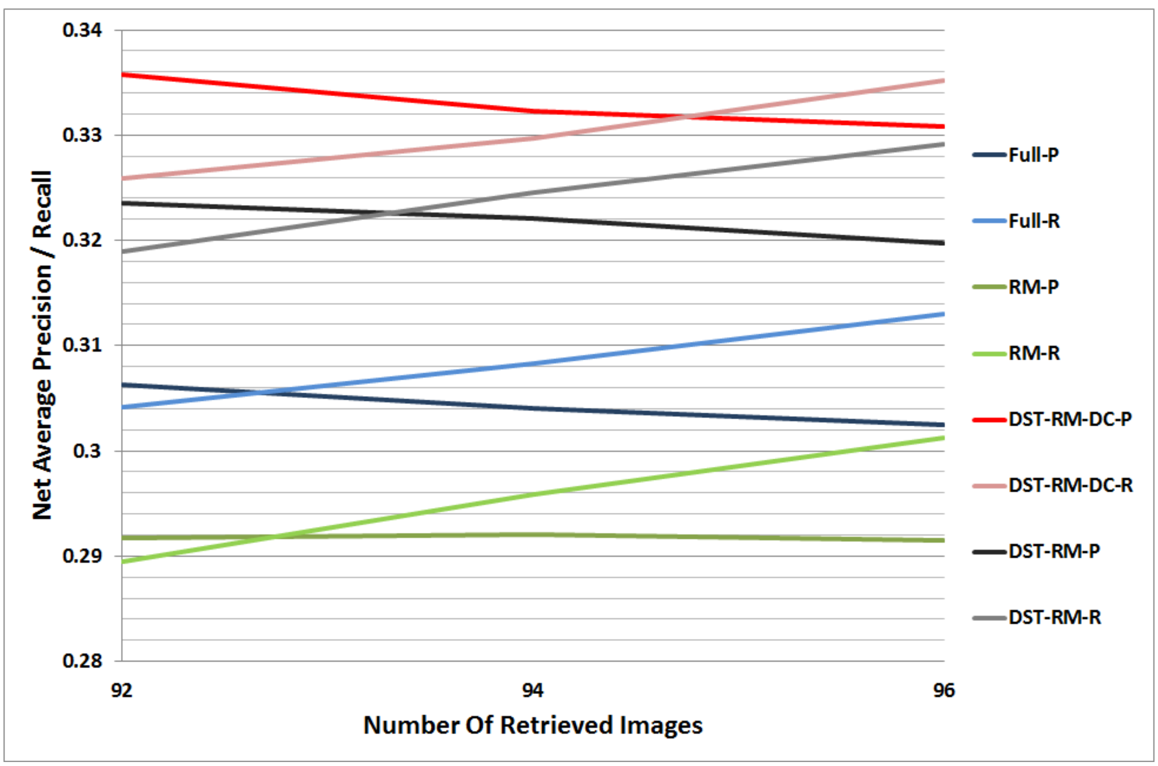

FIGURE 4: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using DST

In Figure 4 the performance of proposed gray CBIR method with DST is shown. The gray crossover point of DST based proposed technique with DC component is highest indicating best performance. Therefore better retrieval of images is possible with lower computations in the proposed CBIR technique with DST. Even here the performance degrades if the DC component is neglected in proposed image retrieval technique.

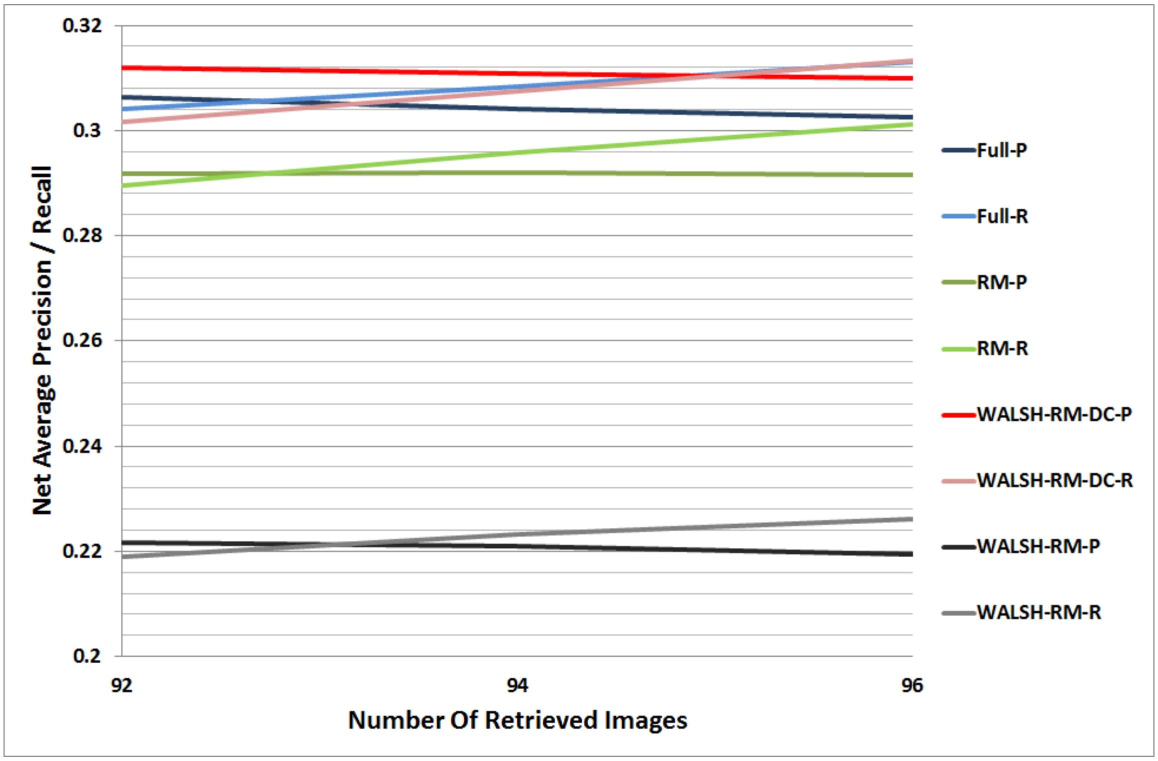

FIGURE 5: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using Walsh Transform

In Figure 5 the performance comparison of gray proposed CBIR methods for Walsh transform is given. Here also the best results are obtained using the proposed technique with DC component and the performance degrades if the DC component is not considered.

In Figure 6 the precision-recall crossover points of gray CBIR using Haar Transform applied to the full image (Full), row mean of image mage (RM), the proposed technique with DC component (HAAR-RM-DC) and without DC component (HAAR-RM) are shown. Also in case of Haar transform, the proposed technique with DC component gives best performance indicated by highest crossover point value and the performance degrades if the DC component is not considered. In Figure 7 the performance comparison of Slant transform based proposed gray CBIR techniques is shown, which again proves the proposed image retrieval technique with DC component to be the best.

In Figure 8 the gray crossover points of precision and recall for proposed CBIR methods with Hartley Transform are given. The result that proposed gray CBIR technique with DC component is best is again proved even in case of Hartley transform as indicated by highest precision-recall crossover point value. Here also performance degrades drastically of DC component is neglected in proposed image retrieval method. In Kekre transform used in proposed gray CBIR methods the techniques with DC component considered gives almost same performance to that of complete Kekre transform applied to image as shown in figure 9, but at great complexity reduction and performance of proposed method of CBIR degrades with negligence of DC component.

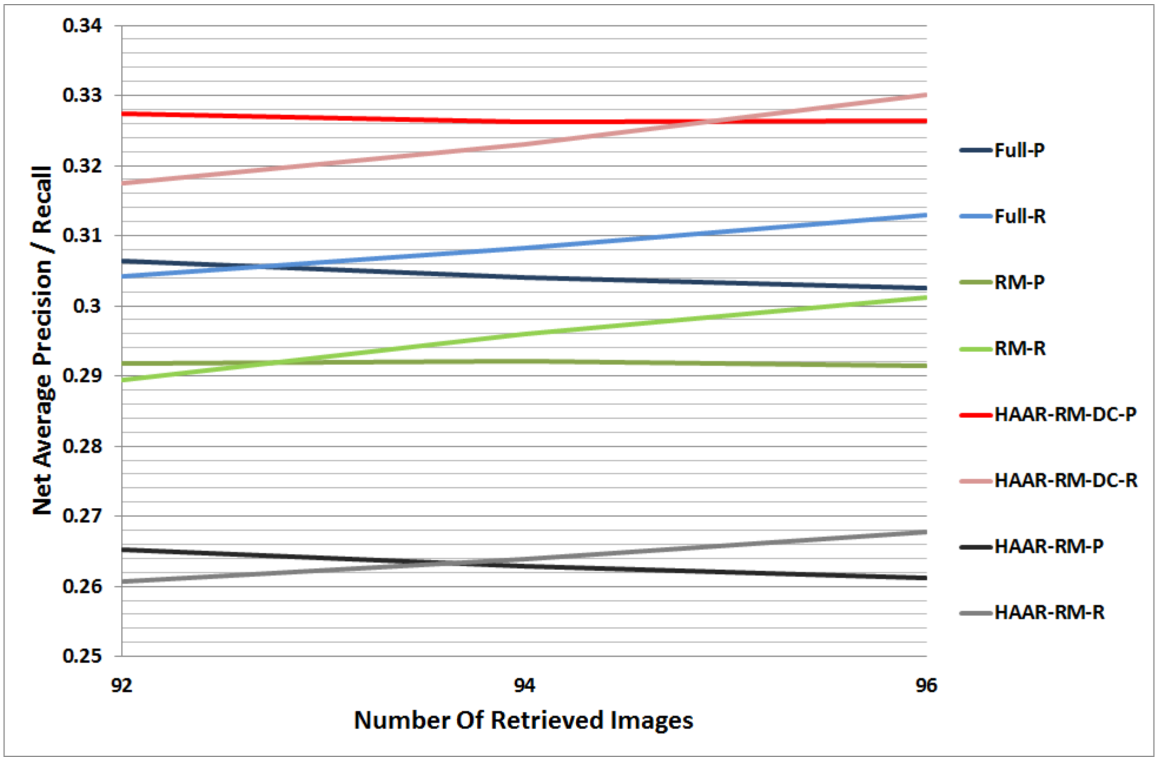

FIGURE 6: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using Haar Transform

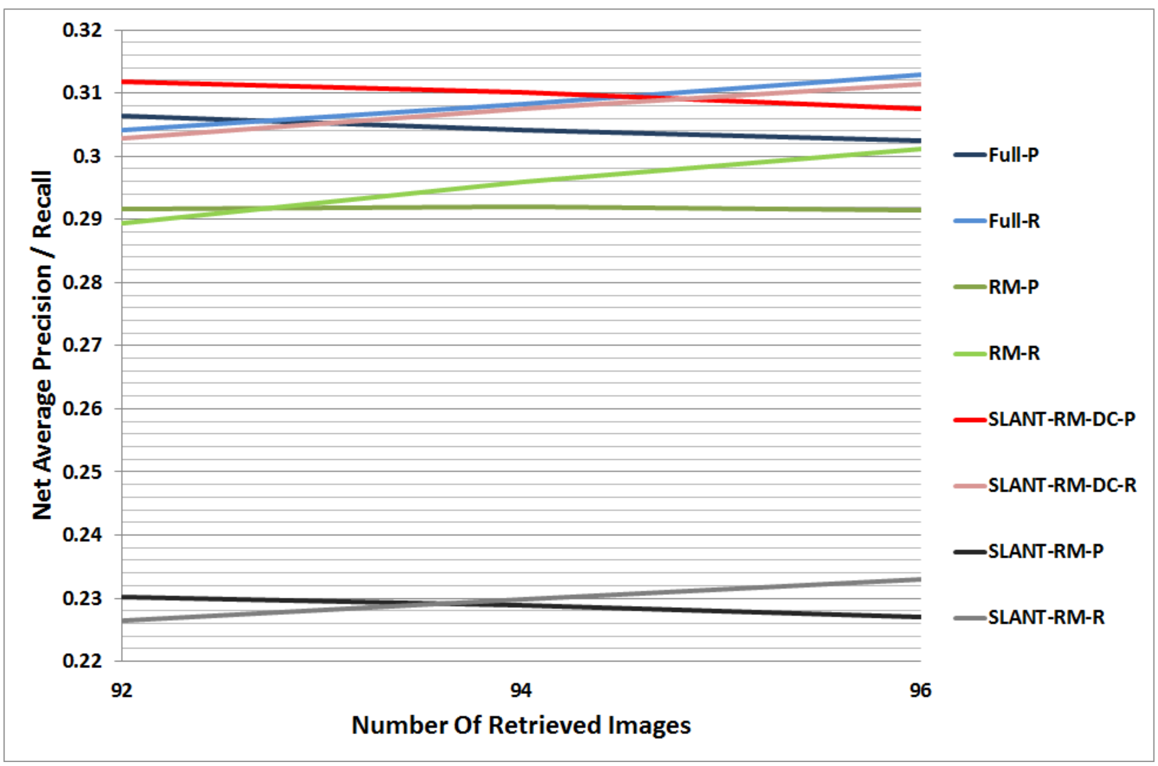

FIGURE 7: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using Slant Transform

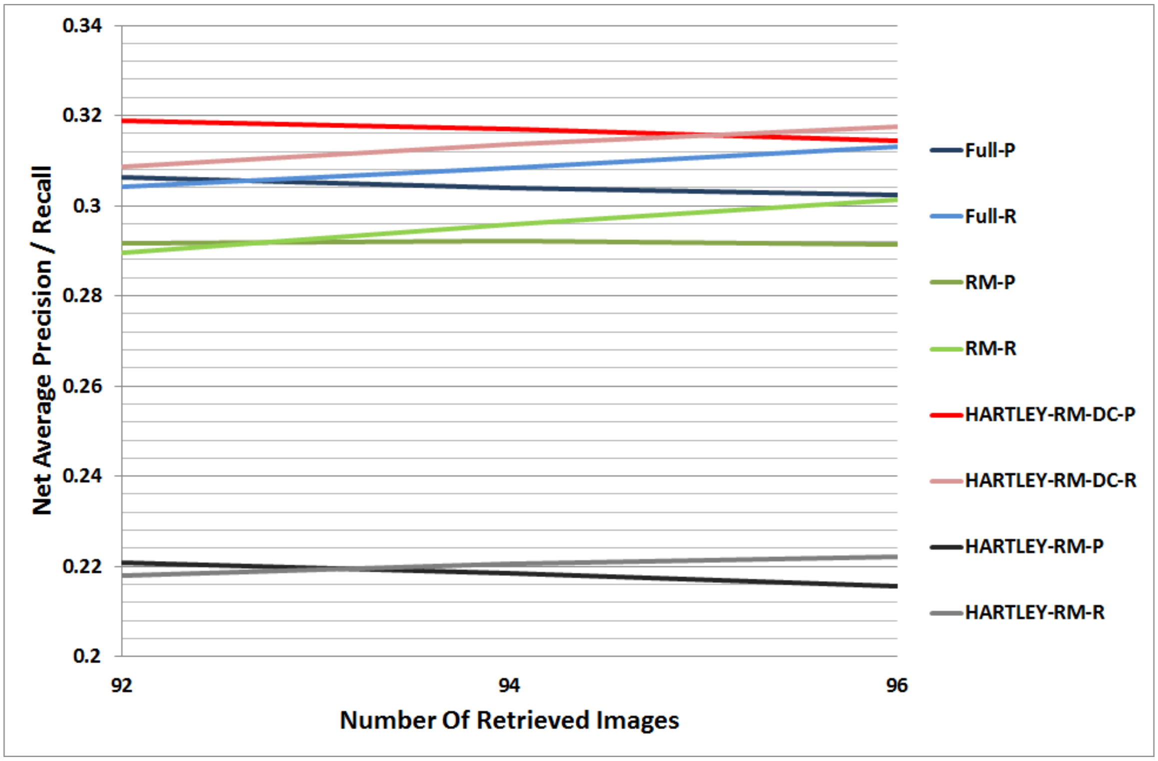

FIGURE 8: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using Hartley Transform

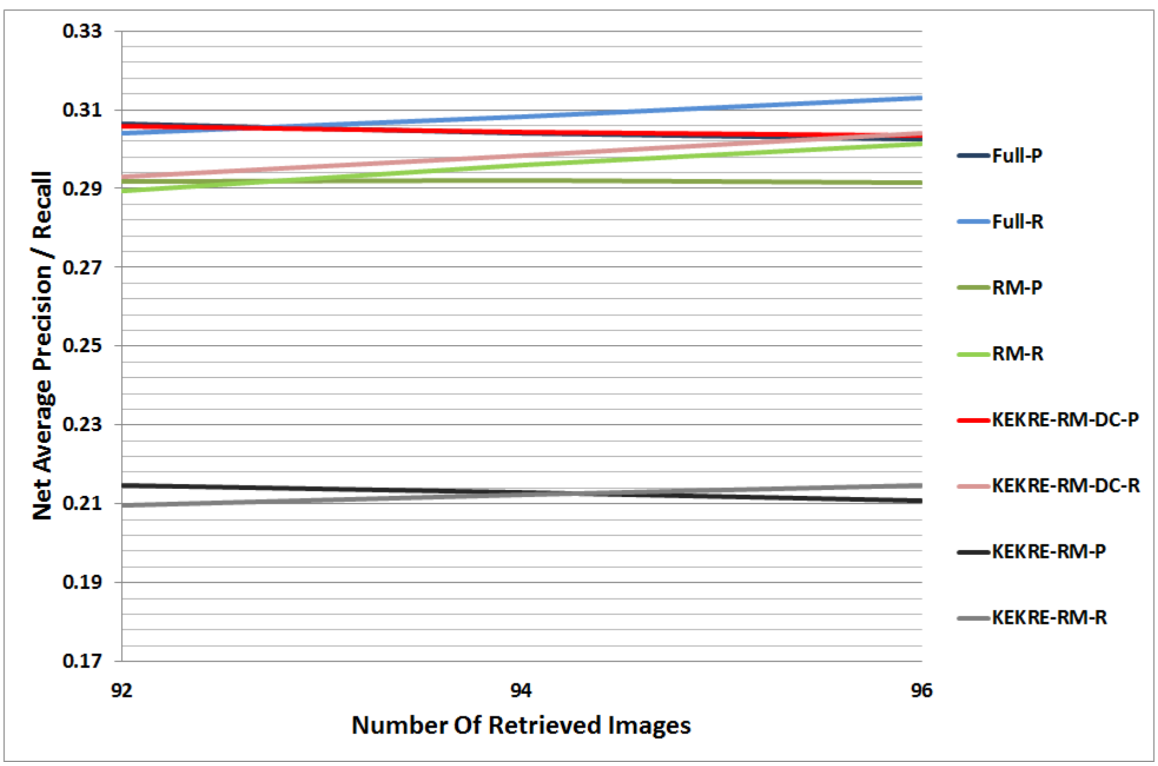

FIGURE 9: Gray Crossover Point of Precision and Recall v/s Number of Retrieved Images using Kekre Transform

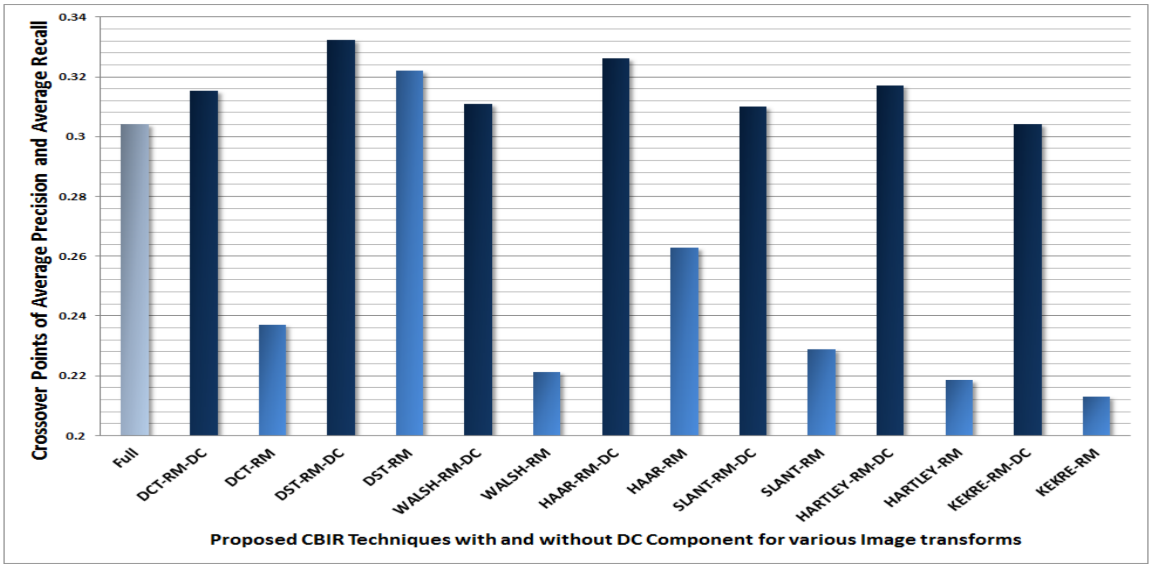

FIGURE 10: Gray Crossover Point of average Precision and Recall v/s Row Mean with & without DC component for all transforms with Full Image

To decide which image transform proves to be the best for proposed gray CBIR methods, the crossover points of proposed gray CBIR techniques with and without DC coefficient are shown in figure 10. Here it is observed that the proposed technique for all transforms is giving better performance in DC component consideration than neglecting it. Also in all transforms proposed gray CBIR method with DC component outperforms the complete transform based gray CBIR technique. Here the best results are obtained using DST-RM-D followed by HAAR-RM-DC. The ranking of transforms for performance in proposed CBIR techniques with DC component consideration can be given as DST, Haar, Hartley, DCT, Walsh, Slant and Kekre. All transforms with proposed gray CBIR technique are showing improvement in performance as compared to gray CBIR based on complete transform of image as feature vector at great reduction in computational complexity. Therefore better and faster image retrieval is achieved using proposed gray CBIR technique.

4.2 *Results on Color Version of Image Database*

The performance comparison of CBIR using Image transformed full image as feature vector (referred as ‘Full’), CBIR using simple row mean feature vector of image (referred as ‘RM’) and the proposed CBIR techniques with DC coefficient (referred as ‘Transform-RM-DC’) and without DC component (referred as (‘Transform-RM’) is given in Figure 11 to figure 17 in the form of color crossover points of precision and recall obtained by applying all these image retrieval techniques on color version of image database. In all transforms it is observed that consideration of DC coefficient in feature vector improves the CBIR performance (as indicated by higher precision and recall crossover point values). Also for all image transforms the proposed CBIR method with DC component have given best performance as indicated by uppermost height of crossover point of precision and recall. Even on color version of image database for al image transforms the proposed image retrieval techniques using row mean of column transformed image with DC component gives best performance. Figure 11 to figure 17 are showing the color crossover points of precision and recall plotted against number of retrieved images obtained by firing the queries on color version of image database respectively for image transforms like DCT, DST, Walsh transform, Haar transform, Slant transform, Hartley transform and Kekre transform.

FIGURE 11: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using DCT

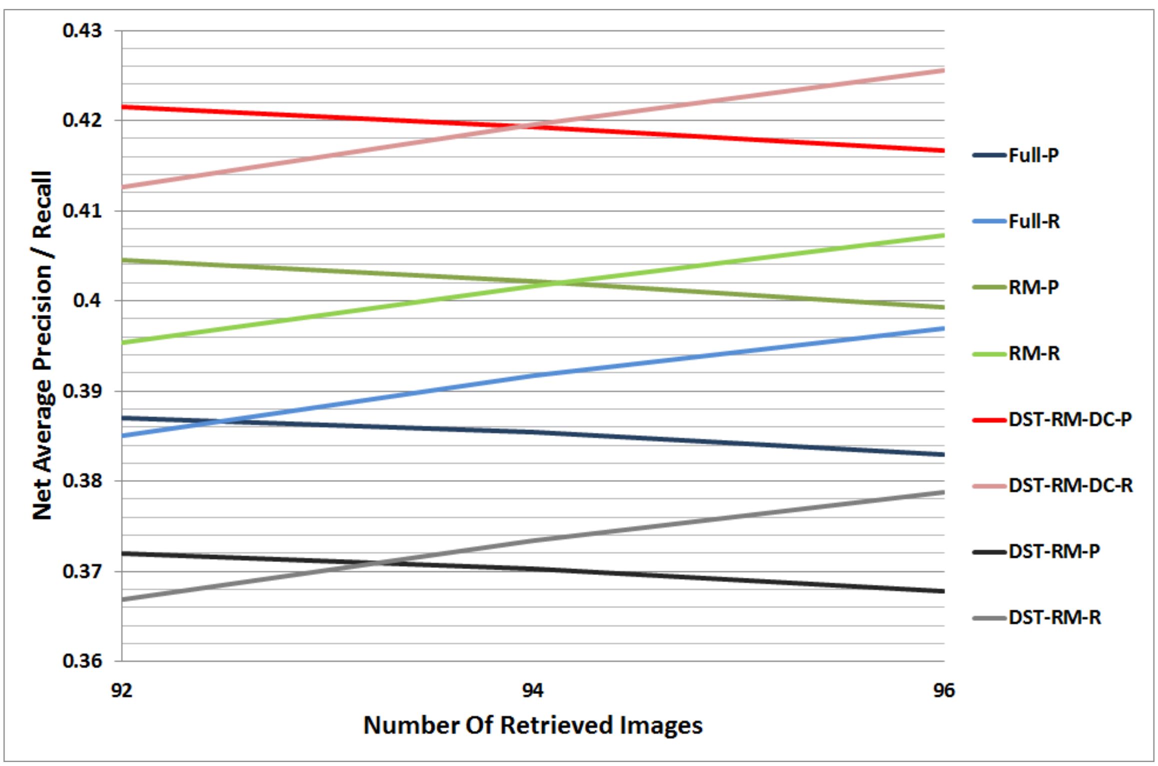

FIGURE 12: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using DST

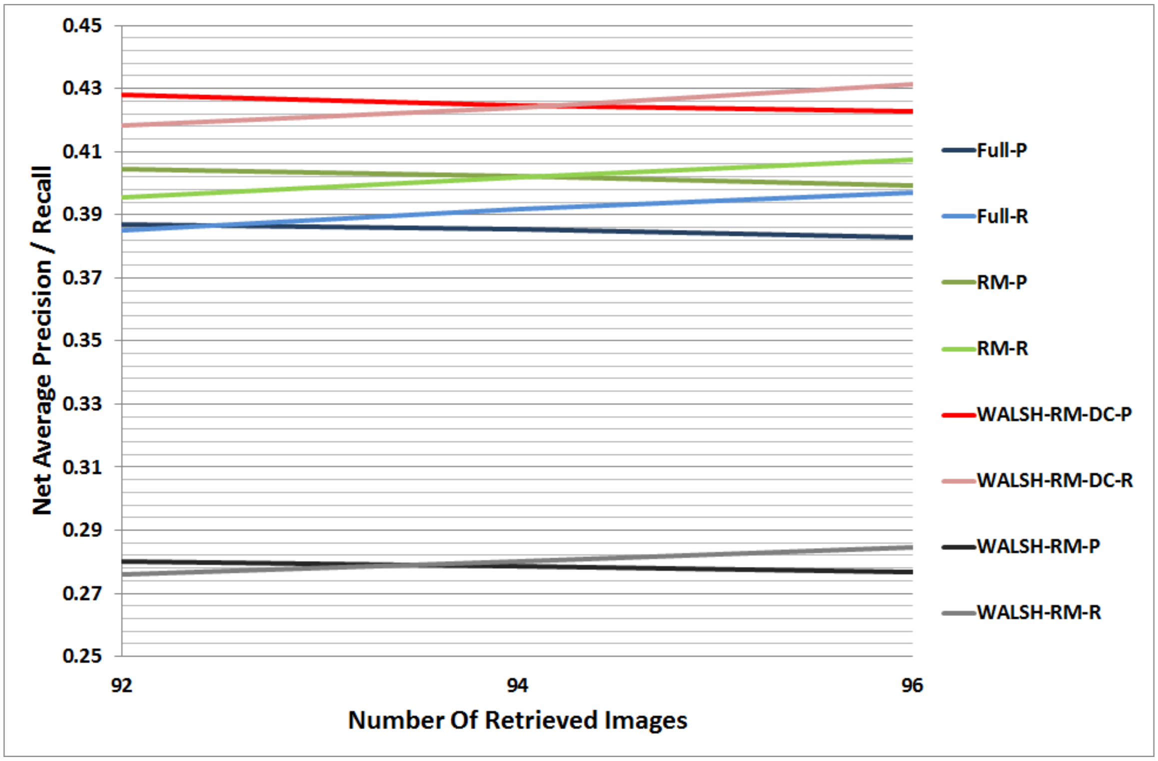

FIGURE 13: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using Walsh Transform

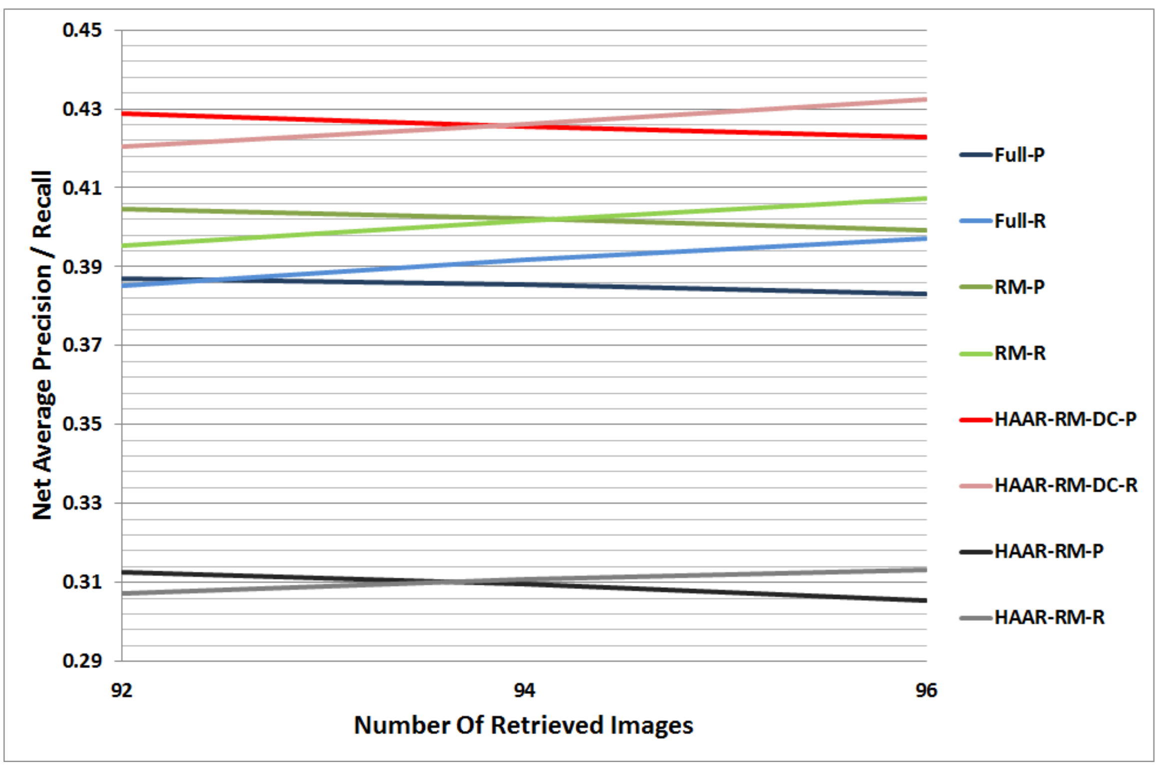

FIGURE 14: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using Haar Transform

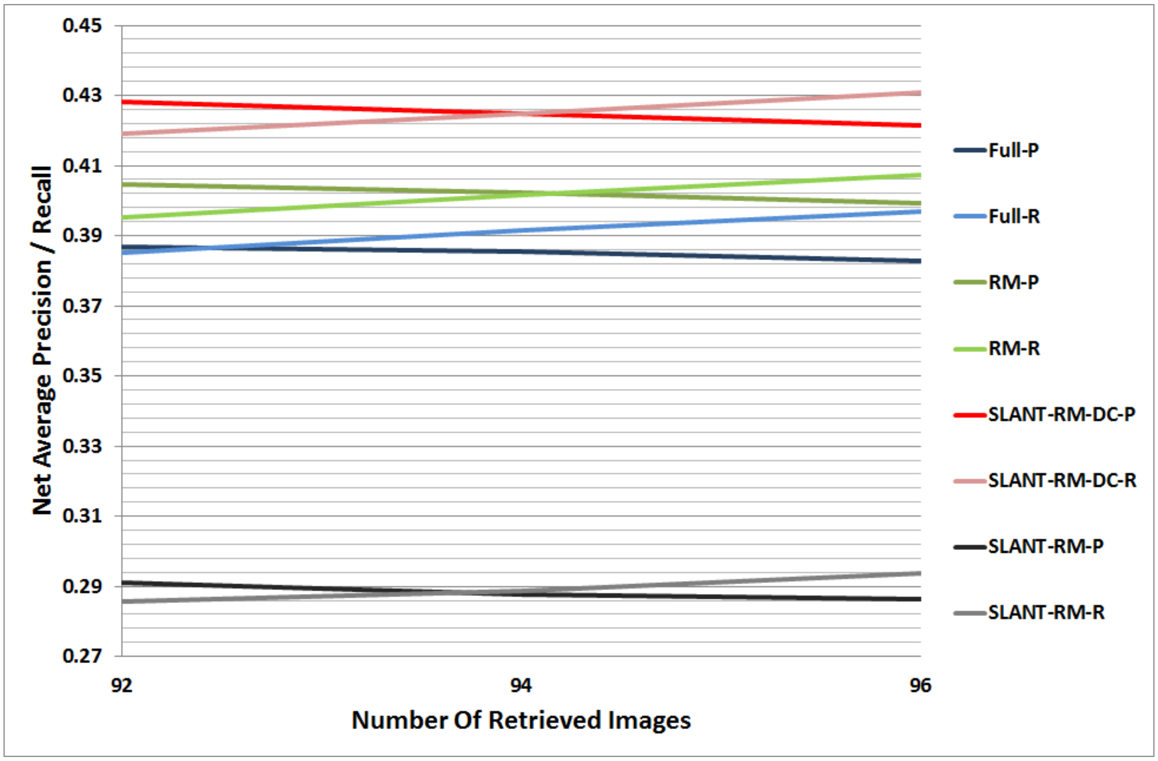

FIGURE 15: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using Slant Transform

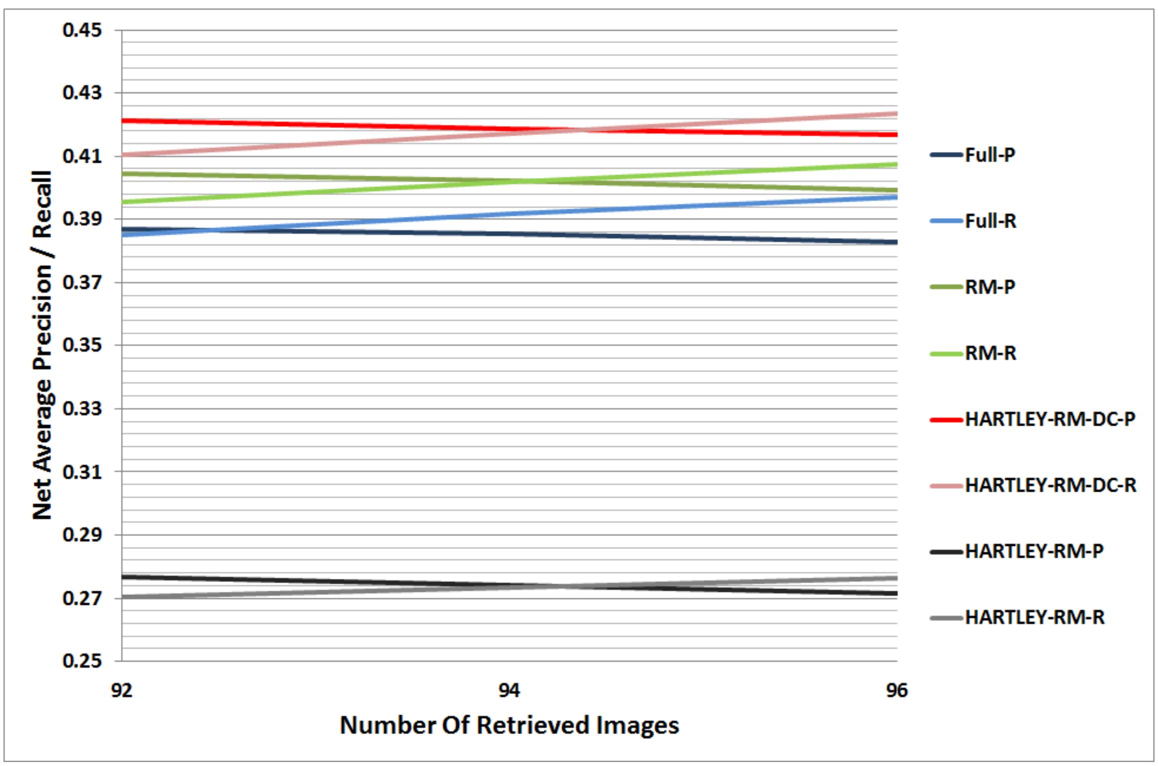

FIGURE 16: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using Hartley Transform

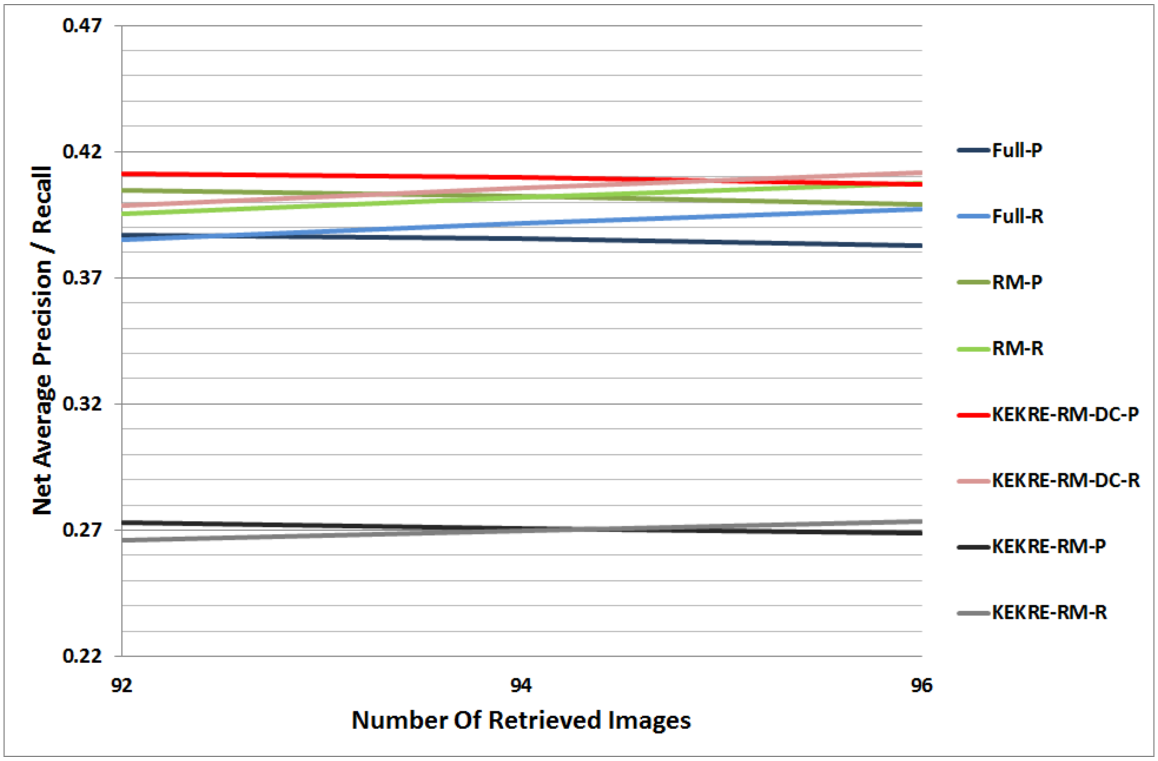

FIGURE 17: Color Crossover Point of Precision and Recall v/s Number of Retrieved Images using Kekre Transform

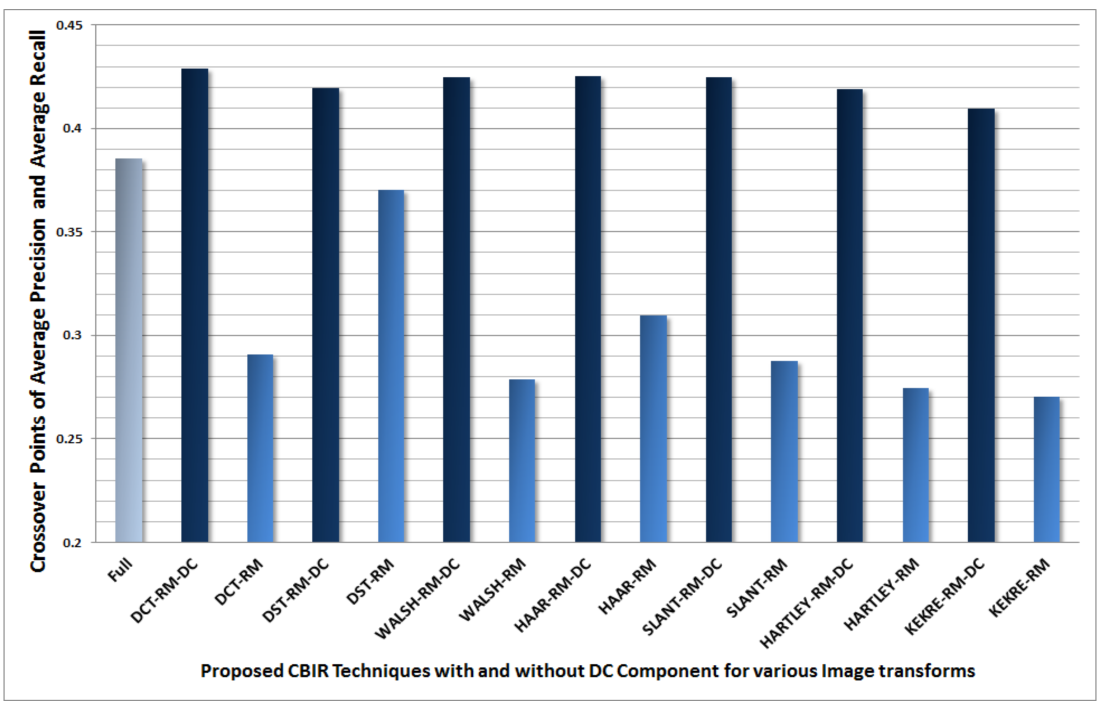

FIGURE 18: Color Crossover Point of average Precision and Recall v/s Row Mean with & without DC component for all transforms with Full Image

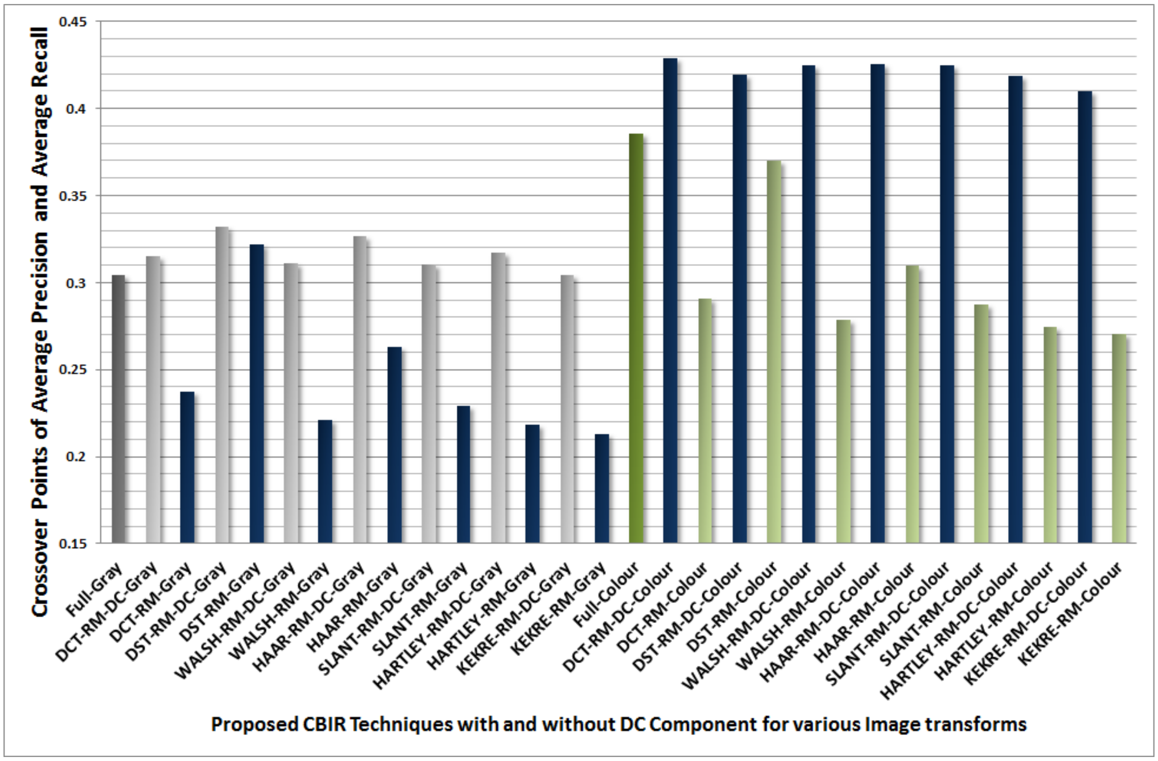

FIGURE 19: Gray and Color Crossover Point of average Precision and Recall v/s Row Mean with & without DC component for all transforms with Full Image

To decide which image transform proves to be the best for proposed color CBIR techniques, the crossover points of proposed gray CBIR methods with and without DC coefficient are shown in figure 18. Here it is observed that the proposed technique for all transforms is giving better performance in DC component consideration than neglecting it. Also in all transforms proposed color CBIR method with DC component outperforms the complete transform based color CBIR technique. Here the best results are obtained using DCT-RM-DC followed by HAAR-RM-DC. The ranking of transforms for performance in proposed color CBIR techniques with DC component consideration can be given as DCT, Haar, Walsh, Slant, DST, Hartley and Kekre. All transforms with proposed color CBIR technique are showing improvement in performance as compared to color CBIR based on complete transform of image as feature vector at great reduction in computational complexity. So better and faster image retrieval is achieved using proposed color CBIR technique.

Figure 19 shows the performance comparison between gray and color images, we can see a considerable improvement in performance using color images.

5. CONCLUSION

The thirst for improvising content based image retrieval techniques with respect to performance and computational time has still not been satisfied. The herculean task of improving the performance of image retrieval and simultaneously reducing the computational complexity is achieved by proposed image retrieval technique using row mean of transformed column image. The performance of proposed techniques is compared with CBIR using complete transformed image as feature vector and row mean of image as feature vector. Total seven image transforms like DCT, DST, Haar, Hartley, Kekre, Walsh and Slant are considered.

The techniques were tested on generic image database with 1000 images spread across 11 categories. Experimental results show that in all transforms proposed CBIR technique with DC component outperforms other methods with great reduction in computation time. Consideration of

DC component in proposed image retrieval techniques gives higher performance as compared to neglecting it.

In all transforms DST gives best performance for proposed gray image retrieval method with DC component and DCT proves to be the best for color image retrieval method with DC component. The ranking of transforms for performance in proposed gray CBIR techniques with DC component consideration can be given as DST, Haar, Hartley, DCT, Walsh, Slant and Kekre. In case of proposed color CBIR methods he performance ranking can be given as DCT, Haar, Walsh, Slant, DST, Hartley and Kekre.

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