# Query by Image Content Using Colour Averaging Techniques

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**Abstract**

The paper presents six innovative content based image retrieval (CBIR) techniques based on colour averaging. The color averaging methods used here are row mean, column mean, forward diagonal mean, backward diagonal mean, row & column mean and forward & backward diagonal mean.

Here the feature vector size per image is greatly reduced by using row, column and diagonal mean, then colour averaging is applied to calculate precision and recall to calculate the performance of the algorithm. Instead of using all pixel data of image as feature vector for image retrieval, these six feature vectors can be used, resulting into better performance and lower computations.

The proposed CBIR techniques are tested on generic image database having 1000 images spread across 11 categories and COIL image database having 1080 images spread across 15 categories. For each proposed CBIR technique 75 queries (5 per category) are fired on the generic image database and 55 queries (5 per category) are fired on the COIL image database. To compare the performance of image retrieval techniques 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.

**Keywords**: Content Based Image Retrieval (CBIR), Row Mean, Column Mean, Diagonal Mean.

## 1. INTRODUCTION

The large numbers of images are being generated from a variety of sources (digital camera, digital 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 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 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], 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 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 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]. But taking transform of image is time consuming. 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 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'.

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

## 2. ROW MEAN (RM) & COLUMN MEAN (CM) [22,27]

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. In 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)] (2)

Column Mean Vector =
[Avg(Col. 1), Avg(Col. 2), …., Avg(Col. n)] (3)

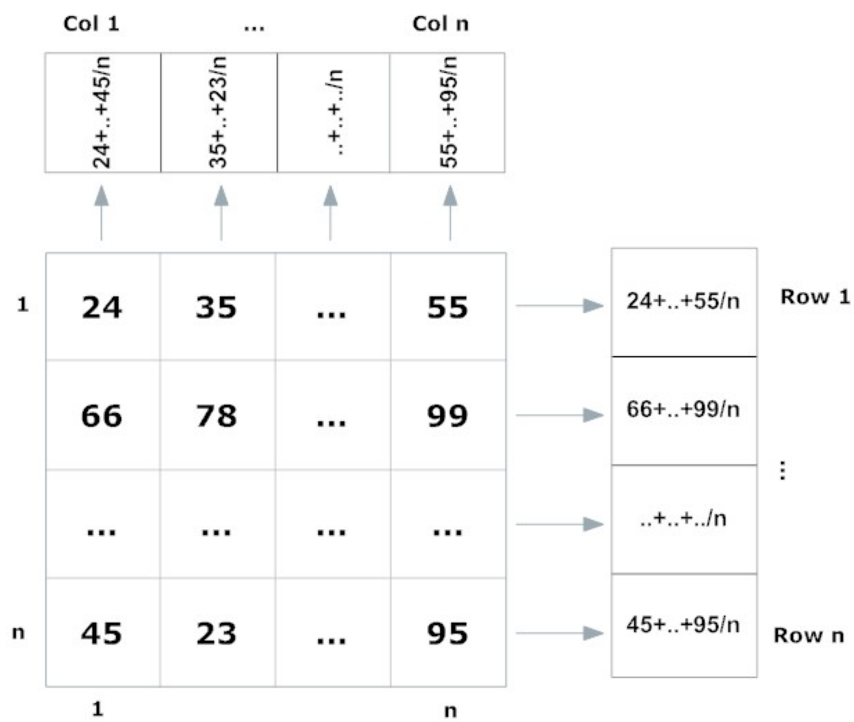



Fig 1. Sample Image Template (with size nxn) showing row & column mean vector

## 3. FORWARD DIAGONAL MEAN (FDM) & BACKWARD DIAGONAL MEAN (BDM)

The forward diagonal mean vector is the set of averages of the intensity values of the all forward diagonal elements. The backward diagonal mean vector is the set of averages of the intensity values of the backward diagonal elements. Figure 2 and 3 are representing the sample image with 'n' rows and 'n' columns, the forward diagonal mean and forward diagonal mean vectors for this image are as given below.

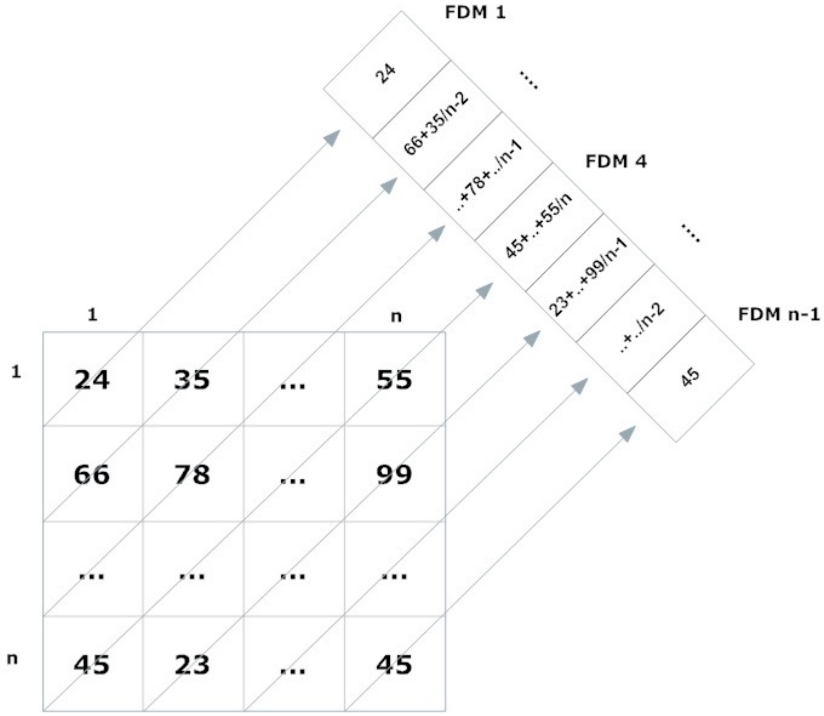



Fig 2. Sample Image Template (with size nxn) showing forward diagonal mean vector

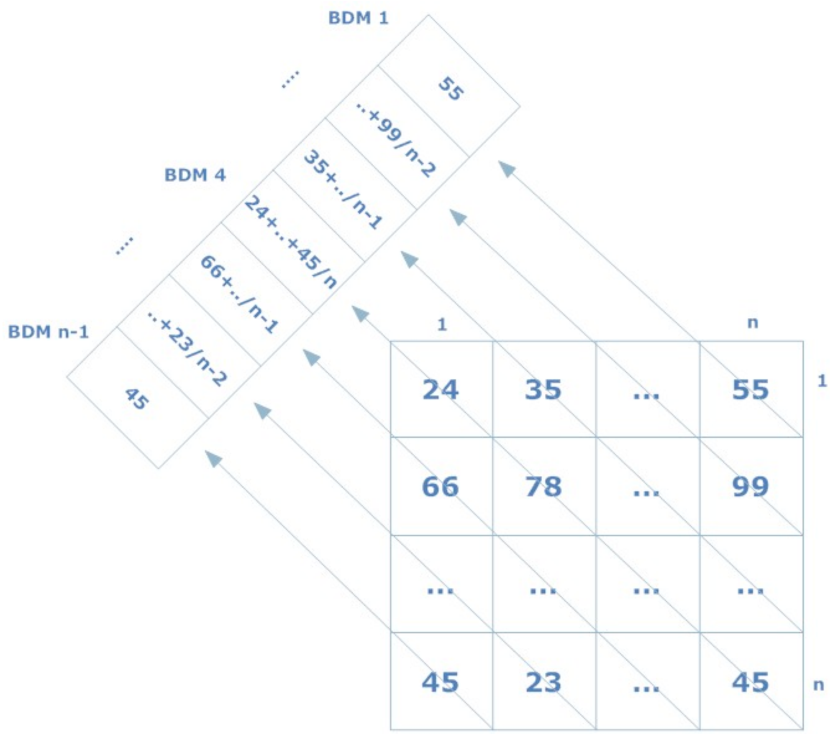



Fig 3. Sample Image Template (with size nxn) showing backward diagonal mean vector

Forward Diagonal Mean Vector =
[Avg(FDM 1), Avg(FDM 2), …., Avg(FDM n)] (4)

Backward Diagonal Mean Vector = (5)

[Avg(BDM 1), Avg(BDM 2), …., Avg(BDM n)]

## 4. PROPOSED COLOUR AVERAGING TECHNIQUES

The various proposed techniques are:

### A. All Image Coefficients

In this method all image pixels are considered as feature vector and Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

### B. Row Mean of Image (RM)

In this method row mean of image is calculated to be feature vector and then Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

### C. Column Mean of Image (CM)

Here feature vector is composed of column mean of image is calculated and then Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

### D. Row & Column Mean of Image (RCM)

In this method row and column mean of image are considered together as feature vector and then Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

### E. Backward Diagonal Mean of Image (BDM)

In this method backward diagonal mean of image is considered as feature vector and then Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

### F. Forward Diagonal Mean of Image (FDM)

In this method forward diagonal mean of image is calculated and then Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

### G. Forward & Backward Diagonal Mean of Image (FBDM)

In this method forward and backward diagonal mean both are considered together as feature vector of image and then Euclidean distance is used in RGB plane to find the best match, which is used to calculate precision and recall.

Table 1. Computational Complexity for applying partial coefficients to image of size NxN for 1000 images in the database

| | All | RM/CM | RCM | FDM/BDM | FBDM |
|---|---|---|---|---|---|
| Number of Additions | $3N^2$-1 | 3N-1 | 6N-2 | 6N-4 | 12N-8 |
| Number of Multiplications | $N^2$ | N | 2N | 2N-1 | 4N-2 |
| Total Additions for transform of 128x128 image | 180223 | 1407 | 2814 | 2804 | 5608 |
| Percentage Complexity Analysis (All pixel data is considered 100 %) | 100 % | 0.78% | 1.56% | 1.55% | 3.11% |

[Here one multiplication is considered as eight additions for last row computations]

## 5. IMPLEMENTATION

### A. Platform

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.

### B. Databases

Figure 4 and 5 gives the sample database images from generic image database and COIL image database respectively.

Fig 4.Sample Images from Generic Image Database
[Image database contains total 1000 images with 11 categories]


Fig 5. Sample Images from COIL Image Database
[Image database contains total 1080 images with 15 categories]

**(i) Generic Database [15]**

The CBIR techniques are tested on the image database [15] of 1000 variable size images spread across 11 categories of human being, animals, natural scenery and manmade things. The categories and distribution of the images is shown in table 2.

Table 2. Image Database: Category-wise Distribution

| Category | Tribes | Buses | Beaches | Dinosaurs | Elephants | Roses |
|---|---|---|---|---|---|---|
| No. of Images | 85 | 99 | 99 | 99 | 99 | 99 |
| Category | Horses | Mountains | Airplanes | Monuments | Sunrise | |
| No. of Images | 99 | 61 | 100 | 99 | 61 | |

**(ii) Coil Database [28]**

COIL image database consists of total 1080 images of size 128x128x3. There are 15 different categories consisting of 72 images in each categories To test the proposed method, from every class five query images are selected randomly. So in all 75 query images are used. Figure 3 gives sample 15 object images of COIL image database.

## 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.

$$\Pr ecision = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (6)$$

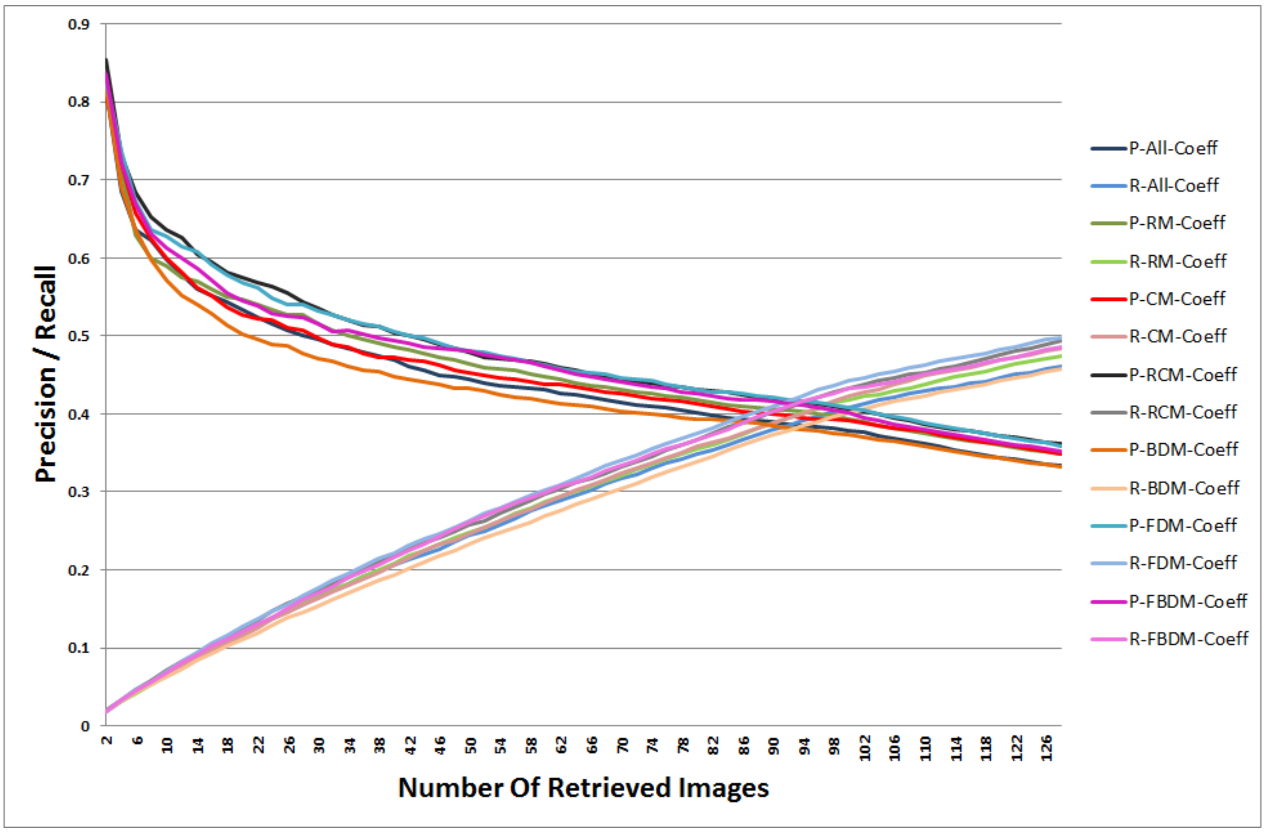
$$\operatorname{Re} call = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (7)$$

## 6. RESULTS AND DISCUSSION

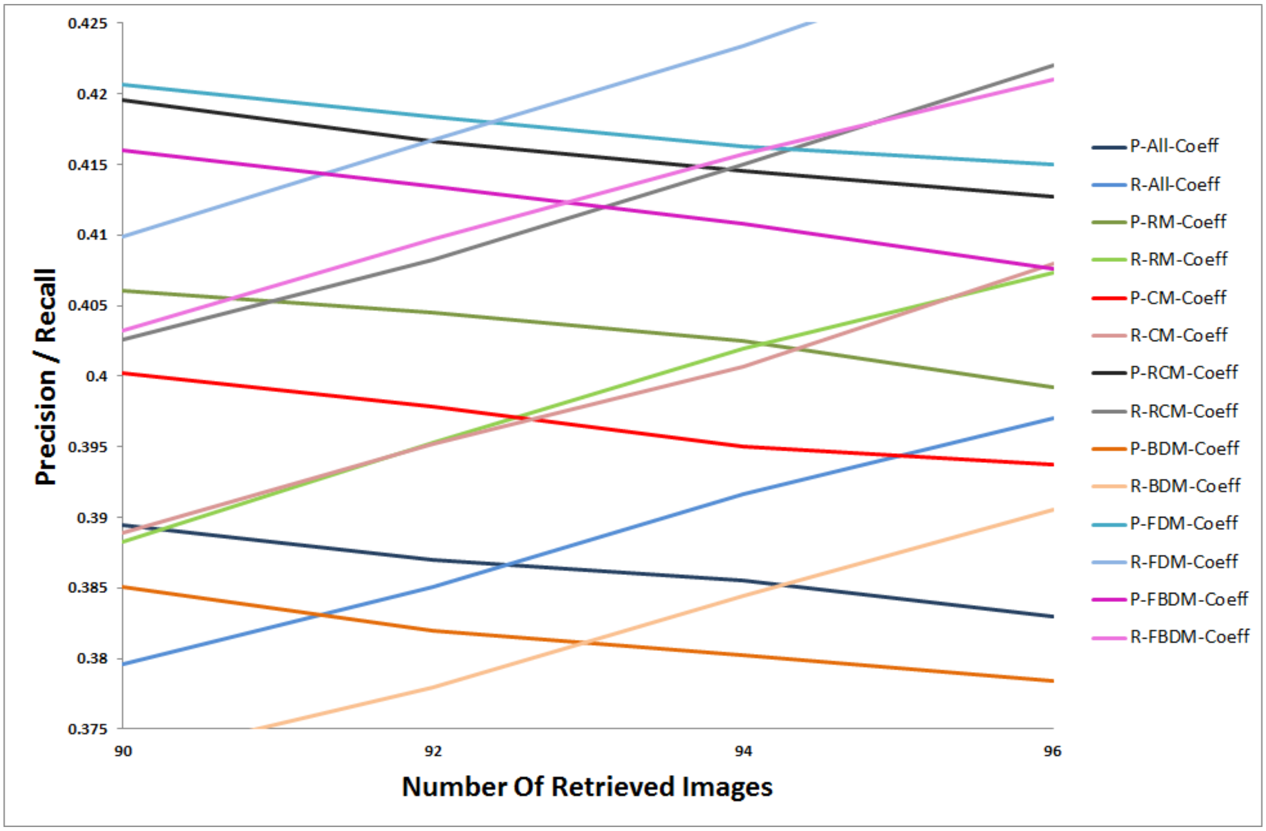
For testing the performance of each proposed CBIR technique first five images from each category are fired on the database as queries. The average precision and average recall are computed by grouping the number of retrieved images sorted according to ascending Euclidian distances with the query image.

### A. Generic Database

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 in RGB plane based on colour averaging technique used. The average precision and average recall are computed by grouping the number of retrieved images sorted according to ascending Euclidian distances with the query image.




6.a. Crossover Point of Precision and Recall v/s Number of Retrieved Images



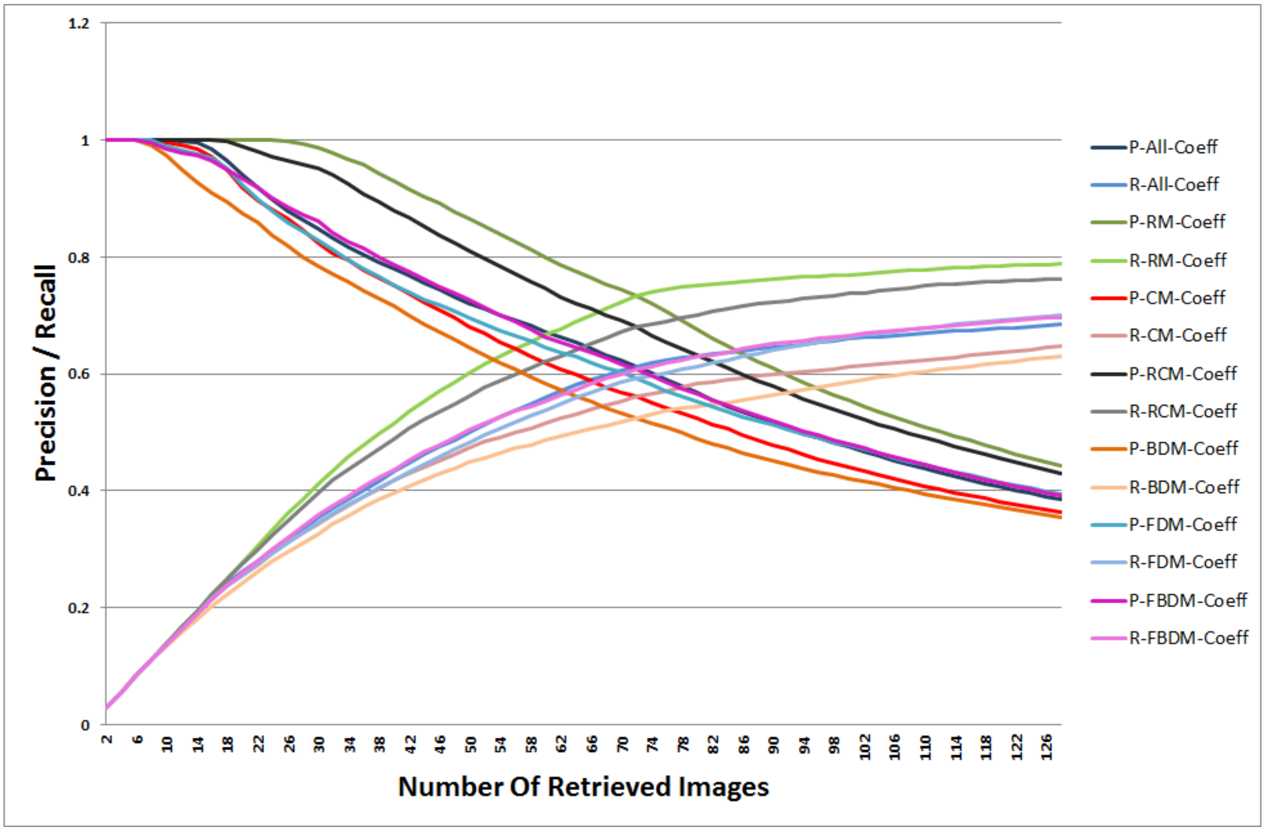

6.b. Zoomed Crossover Point of Precision and Recall v/s Number of Retrieved Images

Figure 6: Crossover Point of Precision and Recall v/s Number of Retrieved Images for proposed techniques on Generic database

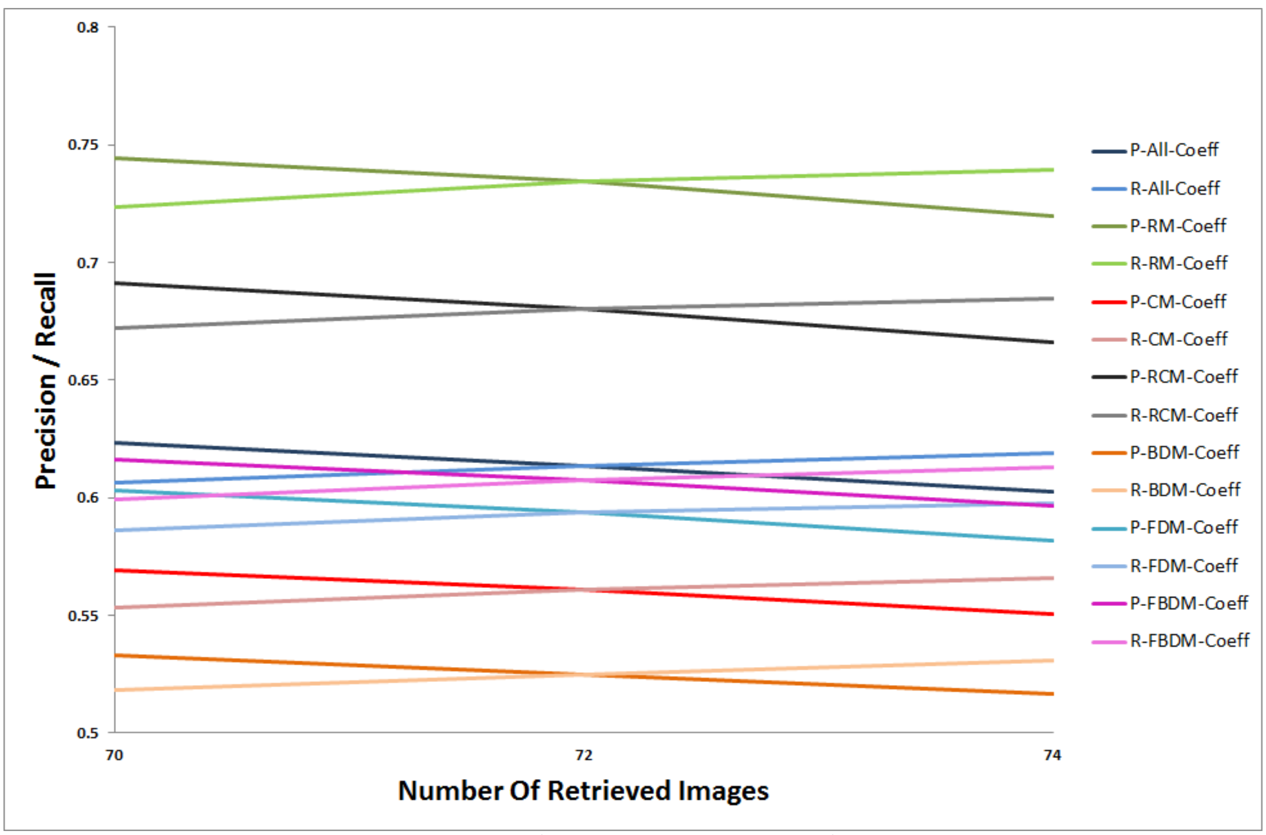
Figures 6.a and 6.b respectively shows the graphs of precision/recall values plotted against number of retrieved images for all proposed colour averaging based image retrieval techniques. Here forward diagonal mean (FDB) colour averaging based image retrieval technique gives the highest precision/recall crossover values specifying the best performance.

### B. Coil Database

For testing the performance of each proposed CBIR technique, per technique 75 queries (5 from each category) are fired on the database of 1080 images spread across 15 categories. The query and database image matching is done using Euclidian distance in RGB plane based on colour averaging technique used. The average precision and average recall are computed by grouping the number of retrieved images sorted according to ascending Euclidian distances with the query image.



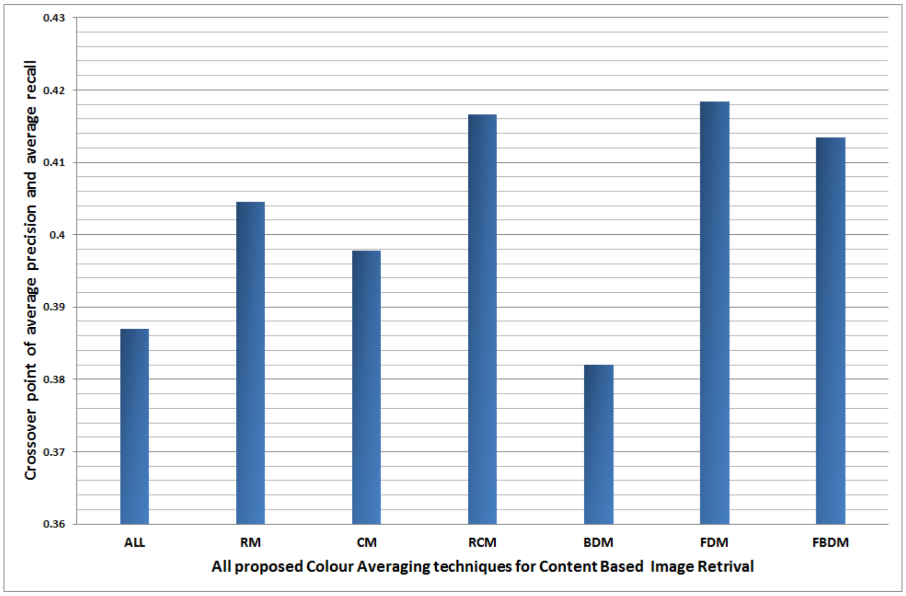

7.a. Crossover Point of Precision and Recall v/s Number of Retrieved Images



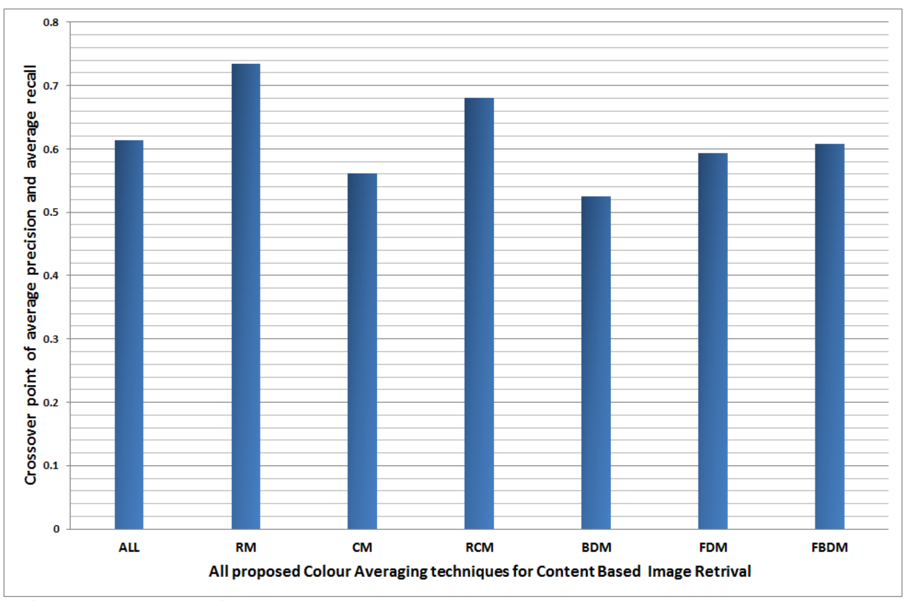

7.b. Zoomed Crossover Point of Precision and Recall v/s Number of Retrieved Images

Figure 7: Crossover Point of Precision and Recall v/s Number of Retrieved Images for proposed techniques on COIL database

Figures 7.a and 7.b respectively shows the graphs of precision/recall values plotted against number of retrieved images for all proposed colour averaging based image retrieval techniques. Here row mean (RM) based colour averaging based image retrieval technique gives the highest precision/recall crossover values specifying the best performance.
Figure 8 shows the performance comparison of all proposed colour averaging based techniques on both databases. Figure 8.a is indicating that nearly all proposed CBIR techniques give better performance than using all image coefficients indicating better performance with lesser computations. For Generic database forward diagonal mean (FDM) gives the best performance.
Figure 8.b is indicating that most proposed CBIR techniques give better performance than using all image coefficients indicating better performance with lesser computations. For Coil database row mean (RM) gives the best performance.




8.a. Performance comparison of all proposed colour averaging based image retrieval techniques on Generic image database




8.b. Performance comparison of all proposed colour averaging based image retrieval techniques on COIL image database
Figure 8: Performance Comparison of all proposed techniques on both databases

## 7. CONCLUSION

So far many CBIR techniques have been proposed. But the researchers are till craving for better and faster image retrieval solutions. The paper has presented novel image retrieval techniques based on colour averaging using row mean, column mean, forward diagonal mean and backward diagonal mean. The techniques were tested on two different image databases as generic image database with 1000 images and COIL image database with 1080 images.

The experimental results have shown that the colour averaging techniques outperform the CBIR technique using all pixel data. In generic image database forward diagonal mean gives highest precision and recall crossover value indicating best performance and all other proposed techniques perform better than all pixel data. Even in COIL image database row mean technique outperforms the all pixel data based CBIR.

The difficult task of improving the performance of content based image retrieval techniques with reduction in time complexity is achieved here with help of colour averaging based techniques.

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