Image Retrieval using DWT with Row and Column Pixel Distributions of BMP Image

N S T Sai
Tech Mahindra Limited,
Mumbai, India.
nstsai@techmahindra.com

R C Patil
Department of Electronics Engineering,
MPSTME, NMIMS University, Mumbai, INDIA.
ravindra_patil21@yahoo.co.in

***Abstract*—With the rapid development of technology of multimedia, the traditional information retrieval techniques based on keywords are not sufficient, content - based image retrieval (CBIR) has been an active research topic. The large amount of image collections available from a variety of sources has posed increasing technical challenges to computer systems to store/transmit and index/manage the image data to make such collections easily accessible. Here to search and retrieve the expected images from the database we need Content Based Image Retrieval system. CBIR extracts the features of query image and try to match them with the extracted features of images in the database. Then based on the similarity measures and threshold the best possible candidate matches are given as result. Wavelet transform is used to generate feature vector based on the row and column wise pixel distribution of binary bit mapped image (BMP)and row and column mean value of R,G,B color plane of color image. Wavelet coefficients and moments of wavelet coefficients make a variable feature vector size. In this paper 4 novel techniques are discussed with their precision and recall performance. Simple Euclidean Distance used to compute the similarity measures of images for Content Based Image Retrieval application. The proposed image retrieval techniques are applied on a image database of 500 images include 5 classes. All this approaches gives acceptable results.**

Keywords- Content Based Image Retrieval, Wavelet Transform, Euclidean distance, Binary bitmapped image, Precision, Recall.

I. INTRODUCTION

Content Based image retrieval aims at developing new effective techniques to search and browse similar images from the large image database by analyzing the image contents. There are two main approaches to design an Image Retrieval System, first is text based approach in this method images are first annotated with text and then text-based image retrieval uses traditional database techniques to manage images. Through text descriptions, images can be organized by topical or semantic hierarchies to facilitate easy navigation and browsing based on standard Boolean queries. However, since automatically generating descriptive texts for a wide spectrum of images is not feasible, most text-based image retrieval systems require manual annotation of images. Obviously, annotating images manually is a cumbersome and expensive task for large image databases, and is often subjective, context-sensitive and incomplete [22],[23]. As a result, it is difficult for the traditional text-based methods to support a variety of task-dependent queries. Because of all these factors in recent years, there has been a growing interest in developing these effective methods for searching large image databases based on image contents by ranking the relevance between query image feature vector and database image feature vector. According to the scope of the representation these features roughly fall into two categories global features and local features. The former category includes texture histogram, color histogram; color layout of the whole image, and features selected from multidimensional discriminant analysis of a collection of images [1], [2], [3],[4]. While color, texture, and shape features for sub images [9], segmented regions[5], [6], [7], [8], or interest points [11] belong to the latter category. Similarity measure is significant factor which quantifies the resemblance in database image and query image [10].

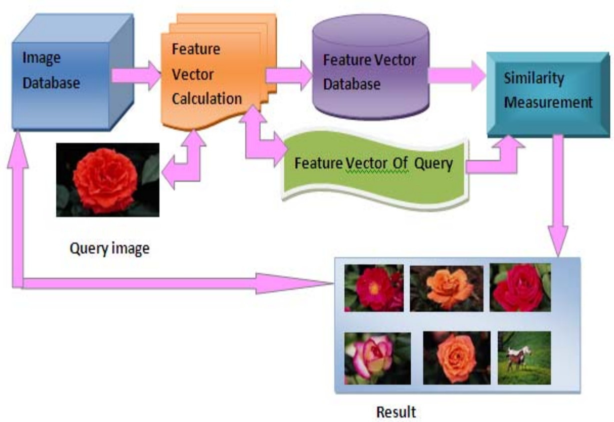

Figure 1. Content Based Image Retrieval System.

Most approaches to image database management have focused on “search-by query”. The users provide the query, for which the database is searched exhaustively for images that are most similar to query image [15]. The query image can be an existing image in the database or can be given by the user. The problems of image retrieval are becoming widely recognized, and the search for solutions is becoming an increasingly active area of research and development. A considerable amount of information exists in images, and it would be advantageous to have an automatic method for indexing and retrieving them based on their content [20]. The growing need for robust image retrieval systems has led to a need for additional retrieval methodologies[29].

The typical CBIR system performs two major tasks as shown in Fig. 1. The first one is feature extraction (FE), where a set of features called image signature or feature vector is generated to accurately represent the content of each image in the database.

II. Wavelet Transform

Wavelet transform [1,4,32] is a relatively recent signal processing tool that has been successfully used in a number of areas. Wavelet becomes more popular tool for image compression. Wavelets provide multiresolution capability, good energy compaction and adaptability to human visual system characteristics. The conventional Discrete wavelet transform (DWT) may be regarded as equivalent to filtering the input signal with a bank of filters whose impulse response are all approximately given by scaled version of a mother wavelet. The images in a database are likely to be stored in a compressed form. Superior indexing performance can therefore be obtained if the properties of the coding scheme are exploited in the indexing technique. Recently, discrete wavelet transform (DWT) has become [29]popular in image coding applications. Wavelet transform represents a function as a superposition of a family of basic functions called wavelets. A set of basic functions can be generated by translating and dilating the mother wavelet corresponding to a particular basis. The signal is passed through a lowpass (LPF) and a highpass filter (HPF) and the outputs of the filter are decimated by two. Thus, wavelet transform extracts information from the signal at different scales. For reconstruction, the coefficients are up sampled and passed through another set of lowpass and highpass filters. Single-level discrete 2-D wavelet transform [20,32]given by equation

$$W(j,k)=\sum_{j}\sum_{k}x(k)2^{-j/2}\psi(2^{-j}n-k) \quad \text{......} (2)$$

Where $\psi(t)$ is a time function with finite energy and fast decay called as mother wavelet. The DWT analysis can be performed using a fast, pyramidal algorithm related to multirate filter banks.

This paper organized in the following sections: Section III, proposed CBIR techniques. Implementation is given in Section IV. Result and discussion Section V and finally conclusion given in section VII .

III. Propased Techniques

In this paper four different techniques used here for image retrieval, which is listed below,

- Discrete Wavelet Transform on row and column pixel distribution of BMP image.
- Moments of wavelet coefficients of Discrete Wavelet Transform row and column pixel distribution of BMP image.
- Discrete Wavelet Transform on row mean and column mean image.
- Moments of wavelet coefficients of Discrete Wavelet Transform row mean and column mean of image.

Binary bitmapped Image (BMP) image is obtained and then Wavelet Transform is applied on pixel distribution of row and column to get feature vector of image in other technique Wavelet Transform is applied on the row mean and column mean of image to get a feature vector.

A. Creation of Bit mapped Image (BMP) [10,30]

Most color images are recorded in RGB space, which is perhaps the most well-known color space. So for a given query image the color spaces are shown in Fig. 2

Original Image (Rose)

Red Green Blue

Figure 2. Seperation of R,G & B component

To create binary bit map compare the each pixel with threshold value. Let X=r(i,j),g(i,j),b(i,j) i=1,2,…..m. j=1,2,……n be an m x n color block in RGB space. then consider R, G, B components to compute three different thresholds .Let the thresholds be T1 for red color plane , T2 for green color plane and T3 for blue color plane. which could computed as per the equations given below.

$$T_1=\frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n}r(i,j) \qquad (3)$$

$$T_2=\frac{1}{m\times n}\sum_{i=1}^{m}\sum_{j=1}^{n}g(i,j) \qquad (4)$$

$$T_3 = \frac{1}{m \times n} \sum_{i=1}^{m} \sum_{j=1}^{n} b(i,j) \qquad (5)$$

Here three binary bitmaps will be computed as bm1,bm2 and bm3 using equation 5,6 and 7. If a pixel in each component (R,G and B) is greater than or equal to the respective threshold, the corresponding pixel position of the bitmap will have a value of 1 otherwise it will have a value of 0.

$$bm_1 = \begin{cases} 1 & if \quad r(i,j) \geq T_1 \\ 0 & if \quad r(i,j) < T_1 \end{cases} \qquad (6)$$

$$bm_2 = \begin{cases} 1 & if \quad g(i,j) \geq T_2 \\ 0 & if \quad g(i,j) < T_2 \end{cases} \qquad (7)$$

$$bm_3 = \begin{cases} 1 & if \quad b(i,j) \geq T_3 \\ 0 & if \quad b(i,j) < T_3 \end{cases} \qquad (8)$$

This BMP planes now used for the feature extraction purpose.

B. *Row and column pixel distribution of BMP image*

After creation of BMP image [15]bitmaps compute row pixel distribution & column pixel distribution of each plane. The row vector is number of 1s of the respective binary rows. The column vector is no of 1s in respective columns. Fig. 3 is representating the sample image 5 rows and 5 columns the row and column vector is given below.

	Col 1	Col2	...	Col n	
Row1	1	0	....	1	1st Row=1+0 ..+1
Row2	1	1	....	...	
:	....	....	....		
Row n	0	1	....	1	
	↓	↓	↓	↓	

1st col =1+1+.....0

Figure 3. Calculation of row & column pixel Distribution

C. *Wavelet coefficients of DWT on row and column pixel distribution of BMP image*

After creation of Binary Bitmapped Image[10 11] each row and column pixel distribution [15]. For query image row and column pixel distribution plots are shown in Fig.4

Figure.4. Row & Column pixel distribution for R, G & B Components.

Now Discrete Wavelet Transform (DWT) applied on row vector and column vector. Both DWT on row and DWT on column are considered for feature vector. Then generated approximate coefficients are playing role of feature vector of image. Take row vector all approximate coefficients and column vector approximate coefficient as a feature vector .Thus feature vector for all the database images are obtained and stored in feature vector table. For image retrieval select a query image in given data base and compute feature using same method and compute Euclidean distance between query image feature and database feature vector using the formula given in equation 1. Select those images where the distances are less than preselected value for threshold .Threshold is selected on trial and error. Then result images are grouped together to get precision and recall using formulae as given below equation 9 and equation 10.

$$\text{Precision} = \frac{\text{Number\_of\_relevant\_images\_retrived}}{\text{Total\_number\_of\_images\_retrived}} \qquad (9)$$

$$\text{Recall} = \frac{\text{Number\_of\_relevant\_images\_retrived}}{\text{Total\_number\_of\_relevant\_images\_in\_database}} \qquad (10)$$

D. *Moments of wavelet coefficients of Discrete Wavelet Transform row and column pixel distribution of BMP image*

In this method first Binary Bitmapped (BMP) image as given in above section A. and then pixel distribution of each row and column vector is calculated as given in section B. DWT applied on each row and column vector of each color space. When consider all approximate coefficient of row and column vector then feature vector size is quite large. So to make compact feature vector take mean, Standard deviation [1,3,12] and cube root of third moment of row vector approximate coefficients and column vector approximate coefficients for each color space using formula given in equation 11 and 12.

$$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} WA_i \qquad (11)$$

Where WA is n wavelet approximate coefficients and $\bar{X}$ is mean value .

$$SD = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (WA_i - \bar{X})^2} \qquad (12)$$

Where SD is standard deviation.

$$M3 = \left(\frac{1}{n} \sum_{i=1}^{n} (WA_i - \bar{X})^3\right)^{1/3} \qquad (13)$$

Where M3 is cube root of third moment.

Now feature vector size is small which is now 18 coefficients for each color image. Thus feature vector for all the database images are obtained and stored in feature vector table. For image retrieval select a query image in given data base and compute feature using same method and compute Euclidean distance between query image feature and database feature vector using the formula given in equation 1.

Select those images where the distances are less than preselected value for threshold .Threshold is selected on trial and error. Then result images are grouped together to get precision and recall using formulae as given below equation 8 and equation 9.

E. *Calculating Row mean and column mean vector[16,17]*

The row vector is a set of mean of all the intensity value of respective rows[14]. The column mean vector is a set of mean of all the intensity value of respective columns [15].In Fig. 5 represent sample image having 4 row and 4 column. The row mean vector and column mean vector for this image given below.

Row Mean Vector=[avg(row1),avg(row2)……………
……………..avg(row n)] (14)

Column Mean Vector= [avg(column1), avg(column2)……
……………..avg(column n)] (15)

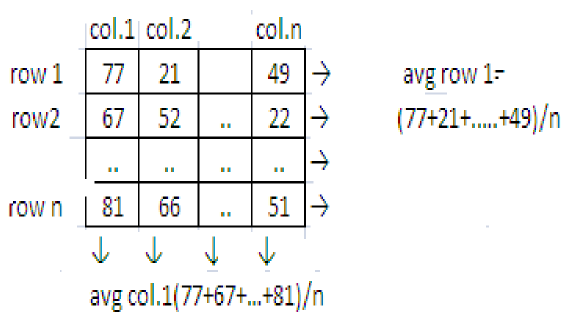

Figure 5. Calculation of row mean vector& column mean vector.

Thus compute row mean and column mean vector for each color space .so 3 row mean vector and 3 column mean vectors are formed.

F. *Discrete Wavelet Transform on row mean and column mean image*

The DWT is applied on row mean vector and column mean vector obtained in above section E. for each color plane. Three approximate coefficient row vector and three approximate coefficient column vector .Then combine these DWT approximate coefficient of rows and columns[16]to form a feature vector for whole color image.

FV=[RRWA,RCWA,GRWA,GCWA,BRWA,BCWA] (16)

FV: Feature vector.

RRWA: Red plane Row mean Wavelet Approximate coefficients.

RCWA: Red plane Column mean Wavelet Approximate coefficients.

GRWA: Green plane Row mean Wavelet Approximate coefficients.

GCWA: Green plane Column mean Wavelet Approximate coefficients.

BRWA: Blue plane Row mean Wavelet Approximate coefficients.

BCWA: Blue plane Column mean Wavelet Approximate coefficients.

Thus feature vector for all the database images are obtained and stored in feature vector table. For image retrieval select a query image in given data base and compute feature using same method and compute Euclidean distance between query image feature and database feature vector using the formula given in equation 1. Select those images where the distances are less than preselected value for threshold. Threshold is selected on trial and error. Then result images are grouped together to get precision and recall using formulae as given below equation 8 and equation 9.

G. *Moments of wavelet coefficients of Discrete Wavelet Transform row mean and column mean of image.*

Here DWT applied on row mean and column mean which gives approximate coefficients and horizontal coefficient for row mean vector on the other hand approximate and vertical coefficients for column mean vector for each color space. When all this coefficients are considered for feature vector size is quite large. So to make compact feature vector take mean, Standard deviation [1, 3, 12] and cube root of third moment of row vector approximate coefficients and column vector approximate coefficients for each color space using formula given in equation 10 and 11.

Now feature vector size is small which is now 36 coefficients for each color image. Thus feature vector for all the database images are obtained and stored in feature vector table. For image retrieval select a query image in given data base and compute feature using same method and compute Euclidean distance between query image feature and database feature vector using the formula given in equation1.Select those images where the distances are less than preselected value for threshold. Threshold is selected on trial and error. Then result images are grouped together to get precision and recall using formulae as given below equation 8 and equation 9.

IV. IMPLIMENTATION

The implementation of CBIR technique is done in MATLAB 7.0 using a computer with Intel Core 2 Duo Processor T8100 (2.1GHz) and 2 GB RAM. The CBIR technique are tested on the image database [28] of 500 variable size images spread across 5 categories of animals, buses, flowers etc. Sample images from each category shown in Fig.7 for 25 query images (five from each category from database) the precision and recall is calculated for four methods and average recall precision is plotted against category. The simulation engine consists of feature extraction process, batch feature extraction and storage process for a collection of images, and the interactive process.

Figure 6.Sample images from database.

The feature extraction process is based upon the following steps also shown in figure 1.Which the batch feature extraction and storage process as described in the following steps.

a. Images are acquired from a collection one after another.
b. Feature extraction process is applied to them.
c. The resultant vector is saved in a database against the image name under consideration.

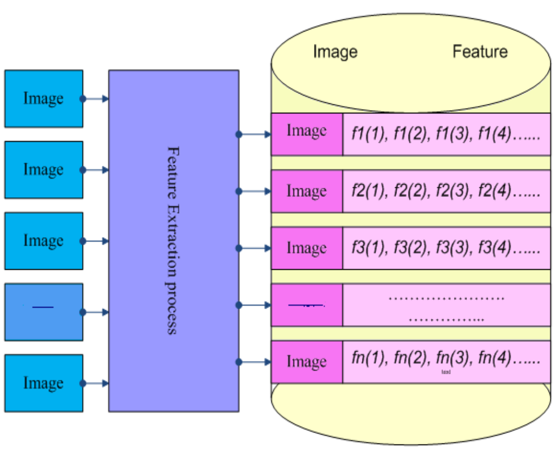

Figure 7.Feature extraction and storage process for an image collection

Depending on the type of features, the formulation of the similarity measure varies greatly. The different types of distances which are used by many typical CBIR systems are city block distance, chess board distance [24], intersection distance [12], the Earth mover's distance (EMD), Euclidian distance [14,18]. Minkowski (Euclidean distance when r=2) distance is computed between each database image & query image on feature vector to find set of images falling in the class of query image.

$$Ed(Q,I) = \left(\sum_{M=0}^{M-1} \left| H_Q - H_I \right|^r \right)^{1/r} \qquad (1)$$

Where Q-Query image
I-Database image.
HQ-Feature vector query image.
HI-Feature vector for database image.
M-Total no of component in feature vector.

In [21] Jain et al. address some of the features of an efficient CBIR system such as accuracy, stability and speed.

V. RESULT AND DISCUSSION

Database of 500 images of 5 different classes is used to check the performance of the algorithms developed. Some representative sample images which are used as query images are shown in Fig.6.the query image and database image matching is done using Euclidean distance. The average precision and average recall is calculating by using following equation 17,18. The average precision for images belonging to the qth category (Aq) has been computed by:

$$\bar{P}_q = \sum_{k \in Aq} P(I_K) / \left|(A_q)\right|, q = 1,2,....5 \qquad (17)$$

Finally, the average precision is given by:

$$\bar{P} = \sum_{q=1}^{5} \bar{P}_q / 5 \qquad (18)$$

TABLE I. RETRIEVAL RESULT FOR WAVELET COEFFICIENTS OF DWT APPLIED ON ROW AND COLUMN PIXEL DISTRIBUTION OF BMP

Sr.No.	Image Category	Precision	Recall
1	Bus	0.582	0.408
2	Dinosaur	0.85	1
3	Elephant	0.55	0.262
4	Horse	0.634	0.538
5	Flower	0.6896	0.616
Average precision=0.658		Average Recall=0.56	

Fig.8 gives average precision and recall plots against the category of images for Wavelet coefficients of DWT on row and column pixel distribution of BMP image CBIR method. Average precision and recall for proposed method Wavelet coefficients of DWT on row and column pixel distribution of BMP image is shown in table I. Third and fourth column show average precision for each category .Overall precision and recall value is greater than 55 % this means that this method gives us acceptable result. Catagoriwise Dinosaurs, bus, Horse and flower precision value is very good. Fig.9 gives average precision and recall plots against the category of images for moments of Wavelet coefficients of DWT on row and column pixel distribution of BMP image CBIR method. Average precision and recall for proposed method moments of Wavelet coefficients of DWT on row and column pixel distribution of BMP image is shown in table II.

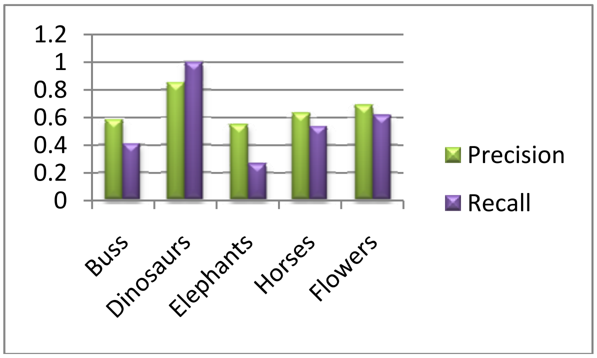

Figure 8.Average precision and recall plot for Wavelet coefficients of DWT on the row and column pixel distribution of BMP image approach.

TABLE II. RETRIEVAL RESULT FOR MOMENTS OF WAVELET COEFFICIENTS OF DWT APPLIED ON ROW AND COLUMN PIXEL DISTRBUTION OF BMP IMAGE

Sr.No.	Image Category	Precision	Recall
1	Buss	0.507	0.58
2	Dinosaur	1	0.86
3	Elephant	0.32	0.38
4	Horse	0.5	0.53
5	Flower	0.587	0.59
Average precision=0.58		Average Recall=0.585	

Third and fourth column show average precision for each category .Overall precision and recall value is greater than 50 % this means that this method gives us acceptable result. Catagoriwise Dinosaurs, bus and flower precision value is very good. Recall values are improved compare to the previous technique I. But precision decreases. For improvement in precision and recall value DWT applied on row mean and column mean vector.

As like above two technique wavelet coefficients of row mean and column mean DWT use as a feature vector and moments of that wavelet coefficients use as feature to reduce feature vector size.

Fig.10 gives average precision and recall plots against the category of images for Wavelet coefficients of DWT applied on row mean and column mean image CBIR method. Average precision and recall for proposed method Wavelet coefficients of DWT applied on row mean and column mean of image is shown in table III. Third and fourth column show average precision for each category.

Overall precision and recall value is greater than 75 % this means that this method gives us acceptable result.

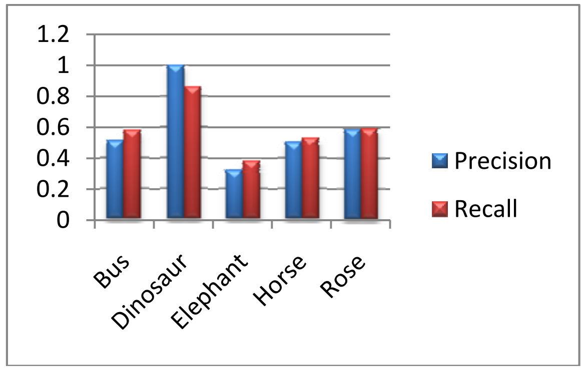

Figure 9.Average precision and recall plot for Moments of Wavelet coefficients of DWT on the row and column pixel distribution of BMP image approach

TABLE III. RETRIEVAL RESULT FOR WAVELET COEFFICIENTS OF DWT APPLIED ON ROW MEAN AND COLUMN MEAN IMAGE

Sr.No.	Image Category	Precision	Recall
1	Bus	0.55	0.68
2	Dinosaur	1	1
3	Elephant	0.74	0.69
4	Horse	0.56	0.64
5	Flower	0.93	0.83
Average precision=0.75		Average Recall=0.76	

Catagoriwise Dinosaurs, Elephant and flower precision value is very good. Bus and Horse category precision and recall values are average but it is acceptable.

As like second method to reduce feature vector size moments of wavelet coefficients are used as a feature vector. Fig.11 gives average precision and recall plots against the category of images for moments of Wavelet coefficients of DWT on row mean and column mean image CBIR method.

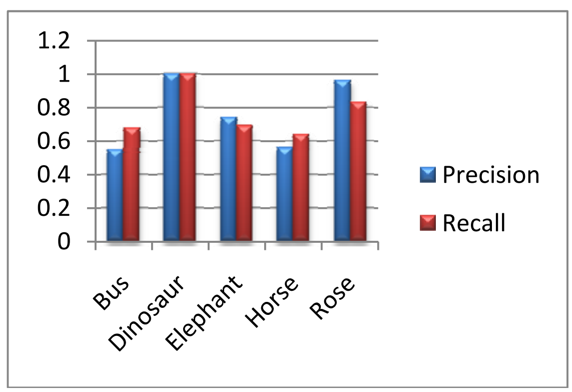

Figure 10.Average precision and recall plot for of Wavelet coefficients of DWT on the row mean and column mean of image approach

Average precision and recall for proposed method moments of Wavelet coefficients of DWT applied on row mean and column mean of image is shown in table IV. Third and fourth column show average precision for each category.

TABLE IV. RETRIEVAL RESULT FOR MOMENT OF WAVELET COEFFICIENTS OF DWT ON ROW MEAN AND COLUMN MEAN OF IMAGE

Sr.No.	Image Category	Precision	Recall
1	Bus	0.55	0.68
2	Dinosaur	1	1
3	Elephant	0.74	0.69
4	Horse	0.56	0.64
5	Flower	0.93	0.83
Average precision=0.75		Average Recall=0.76	

Overall precision and recall value is greater than 75 % this means that this method gives us acceptable result. Catagoriwise Dinosaurs and flower precision value is very good. Bus, Elephant and Horse category precision and recall values are good but it is acceptable.

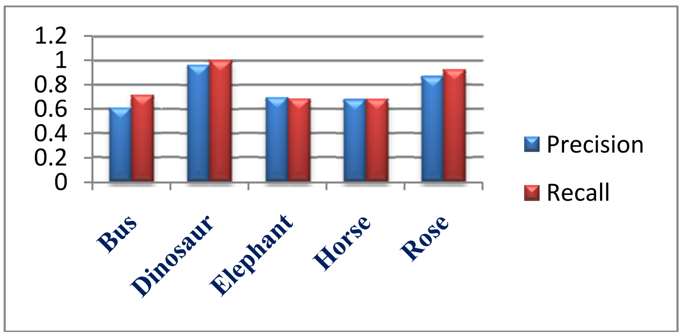

Figure 11.Average precision and recall plot for of moments of Wavelet coefficients of DWT applied on the row mean and column mean of image approach

Comparisons between all this four approaches are given in Fig 12. In this figure overall average precision and overall average recall plotted against the all four approaches. All these four approaches feature vector size is different.

Overall average precision of DWT applied on row and column pixel distribution of BMP image is very good compare to the moments of wavelet coefficients of DWT applied on row and column pixel distribution of BMP image. But size of second approach is small compare to the first. In remaining two methods overall average precision and recall values are same. But moments of wavelet coefficients of DWT applied on row mean and column mean of image performing better because feature vector size is small than the DWT applied on row mean and column mean of image.

VI. CONCLUSION

The search for the relevant information in the large space of image databases has become more challenging. More précised retrieval techniques are needed to access the large image achieves being generated, for finding relatively similar images. The proposed methods are DWT on row and column pixel distribution of BMP image and DWT on row mean and column mean of image.

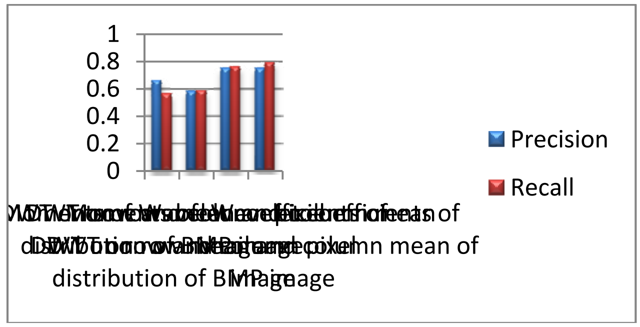

Figure 12. overall average precision and overall average recall plotted against the all four approaches.

By using such type of approaches feature vector size is variable. Over all Precision and recall for wavelet coefficient of DWT applied on row mean and column mean of image and moments of same wavelet coefficients is very good compare to other two method. The proposed approaches were tested on 500 database images. In these techniques DWT applied on row mean and column mean performance is better than the DWT applied on row and column pixel distribution of BMP image .

REFERENCES

[1] M. K. Mandal, T. Aboulnasr, and S. Panchanathan,, "Image Indexing Using Moments and Wavelets", *IEEE Transactions* on Consumer Electronics, Vol. 42, No. 3, August 1996.

[2] S. A. Dudani, K. J. Breeding, and R. B. McGhee.,"Aircraft identification by moment invariants.",*IEEE Trans*. on Computers, C-26(1):pp. 39-46, 1977.

[3] A. Khotanzad and Y. H. Hongs. , "Invariant image recognition by Zernike moments." *IEEE Trans*. on Pattern Analysis and Machine Intelligence, 12(5):pp. 489-497, 1990.

[4] C. Teh and R. T. Chin., "On image analysis by the method of moments", *IEEE Trans*. on Pattern Analysis and Machine Intelligence, 10(4):pp. 496-513, 1988.

[5] J. J. Li., J. Z. Wang, G. Wiederhold, "SIMPLIcity: semantic sensitive integrated matching for picture libraries," *IEEE Trans*. Pattern Anal. Machine Intelligence, 23(9):947-963, Sep. 2001.

[6] T. Hamano, "A similarity retrieval method for image databases using simple graphics," Proc. of *IEEE* Workshop on Languages for Automation, Symbiotic and Intelligent Robotics, pp. 149-154, University of Maryland, August 29-33, 1988.

[7] Long Wen Chang, and Ching Yang Wang, 1999, "Image Compression Using Optimal Variable Block Truncation Coding, Multimedia Signal Processing", *IEEE* 3rd Workshop on, 1999, pp. 413-418, 1999.

[8] Mohamed Kamel, Sun C. T., and Lian Guan, "Image Compression by Variable Block Truncation Coding with Optimal Threshold", *IEEE Transactions* on Signal Processing. Vol. 39, No. 1, pp. 208-212, 1991.

[9] Kai-Krung Ma, and Sarah A. Rajala, 1991, Sub band Coding of Digital Images Using Absolute Moment Block Truncation, *IEEE Transactions* on Acoustics, Speech, and Signal Processing, 1991. ICASSP-91., International Conference on, 1991 Vol. 4, pp. 2645-2648.

[10] Guoping Qiu, "Colour Image Indexing Using BTC", *IEEE Transition* on Image Processing, vol. 12, Janauary 2003.

[11] H. J Bae & S. H Jung, "Image retrieval using texture based on DCT," IEEE Int. Conf. on Information, Communication and Signal Processing, ICIC'97, Singapore, 9-12 September 1997.

[12] J. A. Lay and L. Guan, "Image Retrieval Based on Energy Histograms of the Low Frequency DCT Coefficients," *IEEE* International Conference on Acoustics, Speech and Signal Processing, 1999, vol. 6, pp. 3009-3012.

[13] M. Shneier & M. Abdel mottaleb, "Exploiting the JPEG compression Scheme for image Retrieval," IEEE Trans. On Pattern analysis and Machine Intelligence, August1996, vol. 8, n° 8.

[14] B. M. Mehtre, M. S. Kankanhalli, A. D. Nasasunhalu and G. C. Man, "Color marching for image retrieval," Pattern Recognition Letters, March 1995, vol. 16, pp. 325-331. Proceedings of the 2005 5th International Conference on Intelligent Systems Design and Applications (ISDA'05) 0-7695-2286-06/05 $20.00 © 2005 *IEEE*.

[15] H.B.Kekare, V.A.Bharadi, "Walsh Coefficients of the Horizontal & Vertical Pixel Distributions of Signature Template", SP-37, National Conference on Communication & signal processing, NCCSP-07, Thadomal Shahani Engg. College, Bandra (E), 51.

[16] .H.B.Kekre, Ms Tanuja Sarode, Sudeep D. Thepade, "DCT Applied to Row Mean and Column Vectors in Fingerprint Identification", In Proceedings of International Conference on Computer Networks and Security (ICCNS), 27-28 Sept. 2008, VIT, Pune.

[17] H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shaha, Prathmesh Verlekar, Suraj Shirke, "Image Retrieval using DCT on Row Mean, Column Mean and Both with Image Fragmentation", (Selected), ACM-International Conference and Workshop on Emerging Trends in Technology (ICWET 2010), TCET, Mumbai, 26-27 Feb 2010, The paper will be uploaded on online ACM Portal.

[18] C. Liu & M. Mandal, "Image Indexing in the JPEG2000 Framework," In Proc. of the SPIE, Boston - USA, Nov. 5-8 2000, vol. 4210, pp. 272-280.

[19] E. Albuz & E. Kocalar, "Scalable color image indexing and retrieval using vector wavelets," *IEEE Tran.* On Knowledge and data engineering, September 2001, vol. 13,n° 5, pp. 851-861.

[20] Ordonez J, Cazuguel G, Puentes & J, Solaima, "Medical image indexing and compression based on vector quantization: image retrieval efficiency evaluation," 23rd Conference of the IEEE Engineering in Medicine and Biology Society, 2001.

[21] Jain, A K et al (1997) "Multimedia systems for art and culture: a case study of Brihadisvara Temple" in Storage and Retrieval for Image and Video Databases V, Proc SPIE 3022, pp 249-261.

[22] J. R. Ordóñez, G. Cazuguel, & J. Puentes, "Spatialtextural medical image indexing based on vector quantization," 25th annual conference of the IEEE EMBS, Cancun Mexico, 17-21 September 2003.

[23] J. R. Smith and & F. Chang, "Transform features for texture classification and discrimination in large image databases," Proc. of *IEEE Inti*. Conf on image Processing, 1994, vol. 3, pp. 407-411.

[24] R. Reeves, K. Kubik and W. Osberger, "Texture characterization of compressed aerial images using DCT coefficients," Proc. Of SPIE: Storage and Retrieval for image and Video Databases V, Feb 1997, vol. 3022, pp. 398-407.

[25] M. Shneie and M. A. Mottaleb, "Exploiting the JPEG compression scheme for image retrieval," *IEEE Trans* on Pattern Analysis and Machine intelligence, August 1996 vol. 18, n°. 8, pp. 849-853.

[26] A. A. Abdel-Malek and J. E. Hershey, "Feature cueing in the discrete cosine domain," Journal of Electronic Imaging, Jan. 1994, vol. 3, pp. 71-80.

[27] . B. Shen and 1. K. Sethi, "Direct feature extraction from compressed images," Proc. Of SPIE, 1996, vol. 2670, pp. 404– 414.

[28] http://wang.ist.psu.edu/docs/related/Image.orig (Last referred on 23 Sept 2008).

[29] Dr. Fuhui Long, Dr. Hongjiang Zhang and Prof. David Dagan Feng, "Fundamentals of Content-Based Image Retrieval,"

[30] H.B.Kekre, Tasneem Mirza, "Content Based Image Retrieval using BTC with Local Average Threshholding".In Proceeding of ICCBIR 2008, pp 5-9.

[31] Ritendra Datta, Dhiraj Joshi, Jiali, and James Z.Wang, "Image Retrieval: Ideas, Influences, and Trends of the New Age", ACM Computing Surveys, Vol. 40, No. 2, Article 5, Publication date: April 2008.

[32] Sitaram Bhagathy, kapil, Kapil Chhabra, "A Wavelet Based Image Retrieval System",Vision Research Laboratory Department of Electrical and Computer Engineering University of California, Santa Barbara,Project Report.

NST Sai obtained PhD in 1985 from IIT Delhi. He served as faculty at BITS, Pilani during 1985-89 and RAIT, a Mumbai University Affiliate 1990 - 2001 before joining Tech Mahindra Limited in 2001. He has been a mentor and supervisor for several students of BE/MS/MBA programs pursuing from BITS, Pilani, University of Mumbai, University of Pune and NMIMS university over the past several years. He has a total experience of over 25 years. He has several pioneering initiatives to his credit both in technical and behavioral domains. His areas of technical interest include Multimedia Computing, Robotics and Signal processing. His areas of interest in behavioral domain include human resource management, training, skill development and work integrated learning. Currently he is facilitating the pursuit of higher education programs of employees and program managing the delivery of the same in collaboration with various universities.

Ravindra C. Patil has received M.E (degree in Electronics Engineering from University of Mumbai. He is currently working as a faculty member at Department of Computer Engineering at TCET affiliated to University of Mumbai and pursuing the doctoral research at MPSTME affiliated to NMIMS Deemed University, Mumbai. His area of interest is CBIR techniques in Image Processing.