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Impact on Image Retrieval with Successive Truncation of DCT

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ABSTRACT
The process of digitization does not in itself make image collections easier to manage. Some form of cataloguing and indexing is still necessary – the only difference being that much of the required information can now potentially be derived automatically from the images themselves. The extent to which this potential is currently being realized is discussed below. This paper presents the method developed to search and retrieve the similar image using feature vector computed from the image which is truncated successively using DCT. Truncated image coefficients are reducing after each level. So the impact of this successively truncated DCT on the retrieving the image is discussed in this paper .Gray scale image, RGB color image and YCbCr color image is used to compute the feature vector. So we can compare the result of these three types of color plane for the proposed method. Similarity between the query image and database image measured here by using simple Euclidean distance and Bray Curtis distance. The average precision and average recall of each image category and overall average precision and overall average recall is considered for the performance measure.

General Terms
Pattern Recognition, Database management ,Image Processing et. al.

Keywords
CBIR,DCT Truncation, RGB, YCbCr, precision, recall, mean, standard deviation, Euclidean distance,Bray Curtis Distance.

1. INTRODUCTION
The need for efficient storage and retrieval of images – recognized by managers of large image collections such as picture libraries and design archives for many years – was reinforced by a workshop sponsored by the USA's National Science Foundation in 1992 [Jain, 1993]. After examining the issues involved in managing visual information in some depth, the participants concluded that images were indeed likely to play an increasingly important role in electronically-mediated communication. However, significant research advances, involving collaboration between a numbers of disciplines, would be needed before image providers could take full advantage of the opportunities offered. They identified a number of critical areas where research was needed, including data representation, feature extractions and indexing, image query matching and user interfacing.

The term CBIR[10-25] seems to have originated in 1992, when it was used by T. Kato to describe experiments into automatic retrieval of images from a database, based on the colors and shapes present. Since then, the term has been used to describe the process of retrieving desired images from a large collection on the basis of syntactical image features. The techniques, tools and algorithms that are used originate from fields such as statistics, pattern recognition, signal processing, and computer vision. Historians from a variety of disciplines – art, sociology, medicine, etc. – use visual information sources to support their research activities. Archaeologists also rely heavily on images. In some instances (particularly, but not exclusively, art), the visual record may be the only evidence available. Where access to the original works of art is restricted or impossible, perhaps due to their geographic distance, ownership restrictions or factors to do with their physical condition, researchers have to use surrogates in the form of photographs, slides or other pictures of the objects, which may be collected within a particular library, museum or art gallery. Photographic and slide collections are maintained by a wide range of organizations, including academic and public libraries.

2. TEXT BASED IMAGE RETRIEVAL
Current indexing practice for images relies largely on text descriptors or classification codes, supported in some cases by text retrieval packages designed or adapted specially to handle images. Again, remarkably little evidence on the effectiveness of such systems has been published. User satisfaction with such systems appears to vary considerably. Text based image retrieval required manual annotation for every image. Describing every image by using the text string is very time consuming task. Text string describes the content of image that dependent on the user. For image perception of different user are different so text string for same image by different user will be different. So there is need of Content Based Image Retrieval. Content-based Image Retrieval (CBIR) is fast growing technology and is the field that deals with application of computer vision for retrieval of images from digital libraries.

3. CONTENT BASED IMAGE RETRIEVAL
Content-based image retrieval (CBIR), also known as query by image content (QBIC) and content-based visual information retrieval (CBVIR) is the application of computer vision to the image retrieval problem, that is, the problem of searching for digital images in large databases. "Content-based" means that the search will analyze the actual contents of the image. The term 'content' in this context might refer to colors, shapes, textures, or any other information that can be derived from the image itself. Without the ability to examine image content, searches must rely on metadata such as captions or keywords, which may be laborious or expensive to produce. The need to find a desired image from a collection is shared by many professional groups, including journalists, design engineers and art historians.

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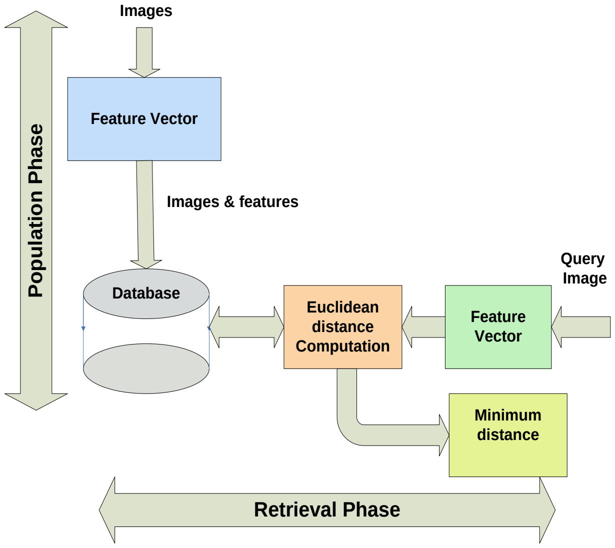

Fig.1.Block diagram of Content Based Image Retrieval.

There are two tasks in the Content Based Image Retrieval first is the population phase and second is retrieval phase. As shown in the Figure1 in the population phase feature vector (signature) extracted for every image in the database. This feature vector accurately represents the image. Feature vector size should be smaller than the image. Make a feature vector database for all the images. In the second task take a query image compute the feature vector and find out the Euclidean distance (similarity).The images with minimum Euclidean distance can be retrieved [3], [13], [14],[15]. To make feature vector effective and smaller Wavelet Transform , DCT and Walsh Transform applied on the row mean and column mean [1,2,3] and row and column pixel distribution of BMP image. We can make a feature vector compact by taking moments of wavelet coefficients [4].

4. THEROTICAL BACKGROUND

4.1 Discrete Cosine Transform(DCT)[28]

Discrete Cosine Transform (DCT) is a technique which converts signal into the frequency components [28,27]. Some of the researchers have been presented image retrieval methods in the DCT domain for the JEPG image format. Even for the MPEG compression .Some of the methods use partial DCT coefficients for the feature vector calculation[29] .One dimensional DCT is used for the one dimensional signal processing for example speech processing. While the 2-D DCT is used for the analysis of image .2-D DCT for an image computed by using 1-D DCT on each row and on each column.

Two dimensional DCT is calculated mathematically as following:

For forward DCT:

$$F(j,k) = \alpha(j)\alpha(k)\sum_{m=0}^{N-1}\sum_{n=0}^{N-1} f(m,n)\cos[\frac{(2m+1)j\pi}{2N}]\cos[\frac{(2n+1)k\pi}{2N}] \quad (1)$$

Where as

$$\alpha(k) = \begin{cases} \sqrt{1/N} \text{ if } k=0 \\ \sqrt{2/N} \text{ if } k=1,2,\cdots,N-1 \end{cases}$$

F(j,k) are the DCT coefficients and f(m,n) is the given image pixel value.

- F(0,0) is the DC coefficient which represent average luminance.
- Remaining coefficients are the AC coefficients which represent the intensity change in the pixel value.
- The low frequency coefficients concentrate at the upper left corner of the transformed plane and high frequency coefficient are the remaining part.

4.2 DCT Truncation

As per above discussion when we apply DCT on given N X N image we get N X N transformed image DCT coefficients. All the DCT coefficients are not used as a feature vector. To truncate the DCT coefficients we select the upper left corner low frequency coefficient. Which is N/2 X N/2 upper part of N X N image shown in Figure 2.

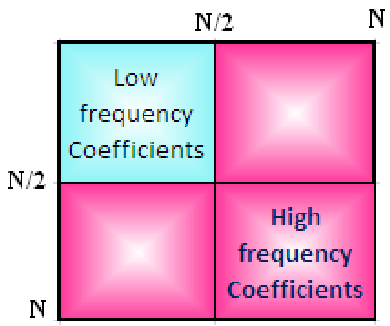

Fig.2.DCT low frequency coefficients and high frequency coefficients.

Selected part is low frequency coefficients having size N/2XN/2.Now when we apply inverse DCT on this selected part then we get same image having size N/2XN/2. So these coefficients are used to compute feature vector. This is the first stage truncation of DCT .For the second stage apply DCT on the first stage upper part low frequency coefficient having size N/2XN/2 image .We will get N/2XN/2DCT coefficients in which N/4 X N/4 upper corner low frequency coefficient and remaining high frequency coefficients. Select only low frequency coefficients and apply the same method which is applied for the first stage. As like this we can apply this truncation further as shown in Figure 3.

In this paper we use this truncation up to fifth level and find out the impact of this truncation on the retrieving results for each truncation level.

4.3 Feature Vector Extraction

Feature vector computed of a given image is explained in Figure 4.In this paper we use gray scale, RGB color and YCbCr color plane for comparison of result of proposed methods. Some of the researchers compute the feature vector by applying [27]DCT on the YCbCr color plane .

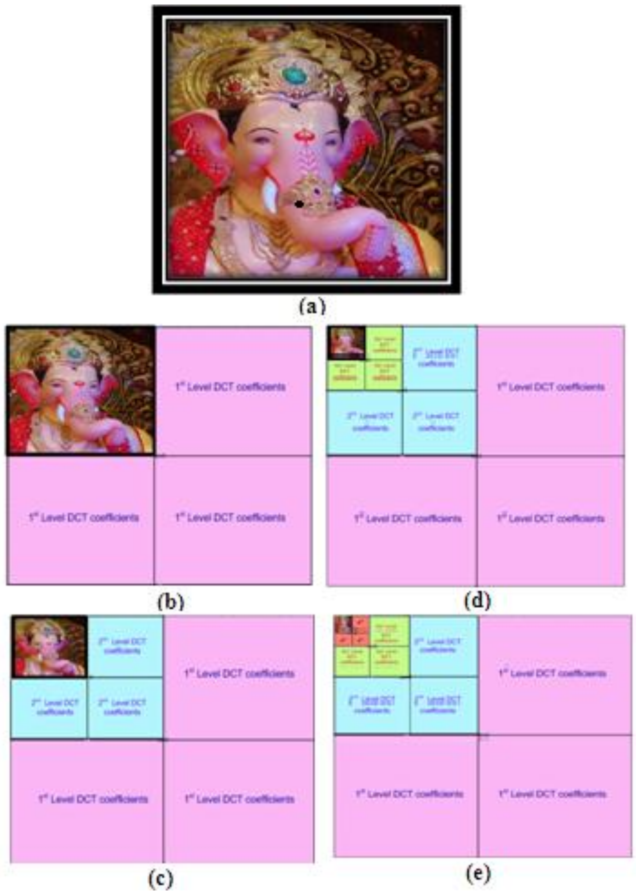

Fig.3.(a) Given Image,(b)(c)(d)and(e) are first level, second level, third level and fourth level DCT truncation of the given image respectively.

Y represents the luminance information and CbCr represent the chrominance information .YCbCr is more suitable than the RGB for human visual system. Feature vector computations steps for these three color planes are same. Which is given as :

a. For L level DCT truncation read image having size

NXN(gray scale, RGB color image ,YCbCr color image).

b. Apply 2D-DCT on the given image.

c. Select upper left corner low frequency coefficients having size N/2 X N/2.

d. Compute the feature vector.

e. Repeat the steps a to d on the above first level DCT truncated image to get L level DCT truncation.

Feature vector from the DCT truncated image at each level calculated by using following techniques.

- Truncated image coefficients used as a feature vector.
- Row and Column Mean (RC Mean).
- Row and Column Standard Deviation (RC Standard Deviation).
- Row and Column variance (RC Variance).

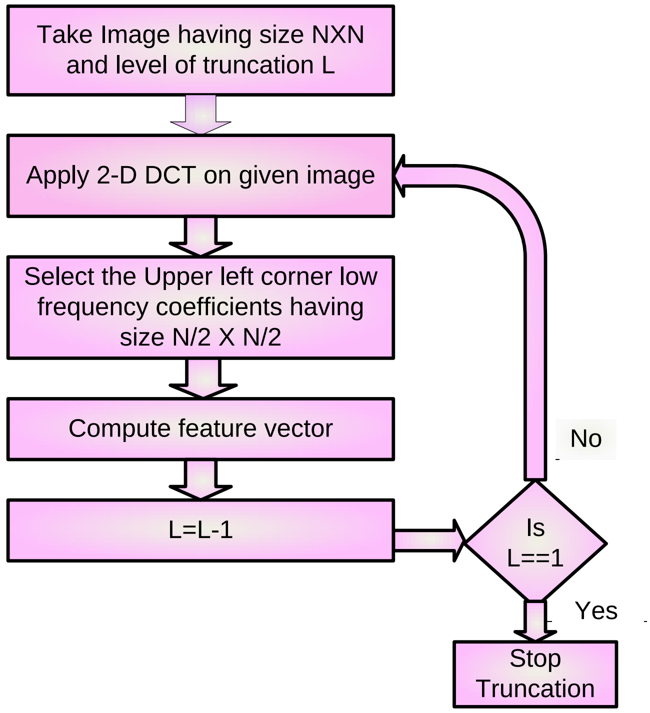

Fig.4.DCT truncation and feature vector computation.

4.4 Truncated DCT Coefficients for Feature Vector

For each level we get a truncated image when we apply inverse DCT on the low frequency coefficients. The coefficients of this truncated image used as feature vector .At level-1 we get feature vector having size 1X N, at level-2 we get 1XN/2,level-3 1XN/4 and so on. For gray scale image, RGB mage and YCbCr image feature vector is extracted.

4.5 Row and Column Mean of Truncated DCT Coefficients as Feature Vector[32,29]

For DCT truncated coefficients calculate row wise mean and column wise mean. 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 Figure 5 shows 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)] (3)

Column Mean Vector= [avg(column1), avg(column2)……avg(columnn)] (4)

Thus compute row mean and column mean vector for each color space at each level .So feature vector size at each level is given below for N X N image.

So feature vector is :

For gray scale image

FV=RC mean =[Row Mean Column Mean] (5)

For RGB color image

FV =[RRow Mean RColumnMean GRow Mean GColumn Mean BRow Mean BColumn Mean] (6)

For YCbCr color image

FV=[YRow Mean YColumn Mean CbRow Mean CbColumn Mean CrRow Mean CrColumn Mean]

(7)

Table 1. Feature vector size for each DCT truncated image

Image	Feature vector size
Gray scale image	N/2 *2*1
Color image	N/2*2*3

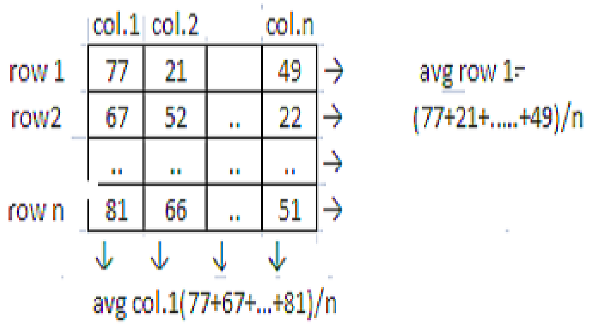

Fig. 5. Calculation of row mean vector & column mean vector.

4.6 Row and Column Standard Devation of Truncated DCT Coeffcients as Feature Vector

Same way as in section IV.E we calculate row wise standard deviation and column wise standard deviation of truncated DCT coefficients.

Row Standard deviation Vector = [std.deviation (row1), std.deviation(row2)…………std.deviation(rown)] (8)

Column Standard deviation Vector= [std.deviation (column1), std.deviation(column2)……std.deviation(columnn)] (9)

4.7 Row and Column Variance of Truncated DCT Coeffcients as Feature Vector

We calculate row wise variance and column wise variance of truncated DCT coefficients

Row Variance Vector = [Var.(row1), Var. (row2)………

Var.(rown)] (10)

Column Variance Vector= [Var.(column1), Var.(column2)……Var.(columnn)] (11)

So format for feature vector using Row and Column Std. Deviation and Row and Column Variance is same as given in equation (5),(6),(7).

5. EXPERIMENTAL RESULT

5.1 Feature Vector Matching

When a query image is submitted by a user, we need to compute the feature vector as before and match it to the precomputed feature vector in the database. This is shown in Figure 6. Block diagram of retrieval process consists of feature extraction process, feature vector storage process and similarity measure process. The feature extraction process is based upon the following .Which the batch feature extraction and storage process as described in the following steps.

a. Images taken one by one from the database.
b. Feature is computed using the feature extraction process.
c. Make feature vector database for given database images.

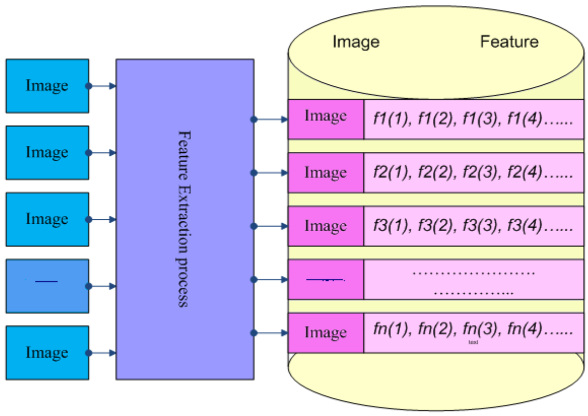

Fig.6. Feature extraction and storage process for an image

After that query image and database image matching is done using similarity measures. Two similarity measures are used Euclidean Distance(ED) and Bray Curtis Distance (BCD) for the comparison. 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.

$$Ed(Q,I) = \left(\sum_{M=0}^{M-1} \left| H_Q - H_I \right|^r \right)^{1/r} \quad (12)$$

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

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Bray Curtis Distance is computed between query image and database image using equation.13

$$Bd(Q,I) = \frac{\sum_{k=1}^{n} |H_{Qk} - H_{Ik}|}{\sum_{k=1}^{n} (H_{Qk} - H_{Ik})} \quad (13)$$

Where n-Total no of component in feature vector.
Q-Query image
I- Database image.
H_{Qk}-Feature vector query image.
H_{Ik}-Feature vector for database image.

5.2 Performance of CBIR

Performance of image retrieval system can be analyzed by using two parameters precision and recall. As shown in Figure 7. Testing the effectiveness of the image search engine is about testing how well can the search engine retrieve similar images to the query image and how well the system prevents the return results that are not relevant to the source at all in the user point of view. A sample query image must be selected from one of the image category in the database. When the search engine is run and the result images are returned, the user needs to count how many images are returned and how many of the returned images are similar to the query image. The first measure is called Recall. All the relevant images from the database is recall. The equation for calculating recall is given below:

$$\text{Recall} = \frac{\text{Number\_of\_relevant\_images\_retrived(A)}}{\text{Total\_number\_of\_relevant\_images\_in\_database(A+D)}} \quad (14)$$

The second measure is called Precision. It is accuracy of a retrieval system to present relevant as well as non relevant images from the database which is mathematically given as:

$$\text{Precision} = \frac{\text{Number\_of\_relevant\_images\_retrived(A)}}{\text{Total\_number\_of\_images\_retrived(A+B)}} \quad (15)$$

5.3 Implementation and Result

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.

Figure.8. Shows a sample of general database images by randomly selecting one image from each category. The database has 15 categories, for a total of 1200 images. Categories and total no of images are given below

The average precision is calculating by using following equation 16, 17. The average precision for images belonging to the qth category (A_q) has been computed by:

$$\bar{P}_q = \sum_{k \in Aq} P(I_K)/|(A_q)|, q = 1,2,....5 \quad (16)$$

Where $P(I_k)$ is the precision for query image I_k .

Finally, the average precision is given by:

$$\bar{P} = \sum_{q=1}^{5} \bar{P_q} / 5 \quad (17)$$

The average recall is also calculated in the same manner.

The average precision and average recall of this CBIR technique act as a important parameter to find out performance. To determine which DCT truncation stage and which color space have better performance.

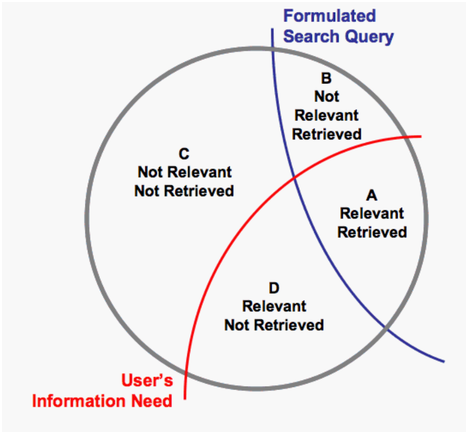

Fig. 7. Evaluation of CBIR

Table 2. Image Categories and Number of Images

Sr. No.	Name of Category	No. of Images
1	Motorbikes	100
2	Beaches	100
3	Historical Mountains	100
4	Buses	100
5	Dinosaurs	100
6	Elephants	100
7	Flowers	100
8	Horses	100
9	Tribal Peoples	68
10	Mountains	62
11	Flying Birds	63
12	Flower lawn	48
13	sunset	48
14	Butterfly Scenery	52
15	Guitar	59

For general database Figure 9 – 11 shows DCT truncation coefficients as a feature vector overall average precision and overall average recall plots against the DCT truncation stages using Euclidean Distance (ED) and Bray Curtis Distance (BCD) for Gray scale image, RGB image and YCbCr image respectively. It is observed that for Gray scale image Bray Curtis Distance (BCD) performance for 5th DCT truncation stage better than the other stages also using Euclidean Distance measure and it is 37%.

Fig. 7 Sample images from general database.

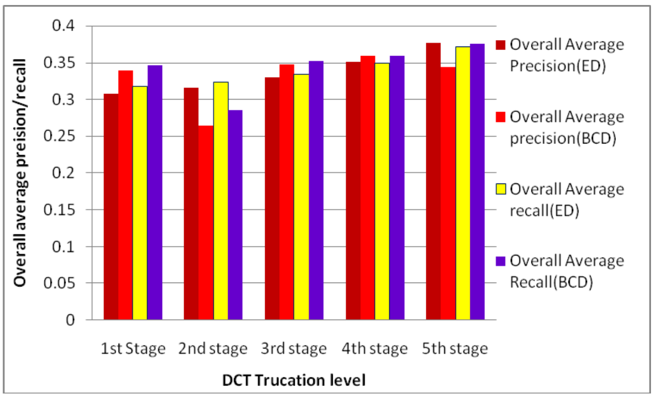

Figure 9. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of DCT truncation coefficients of gray scale image .

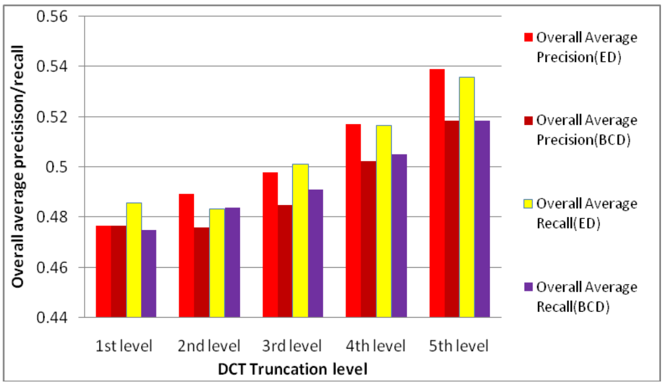

Figure 10. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of DCT truncation coefficients of RGB image .

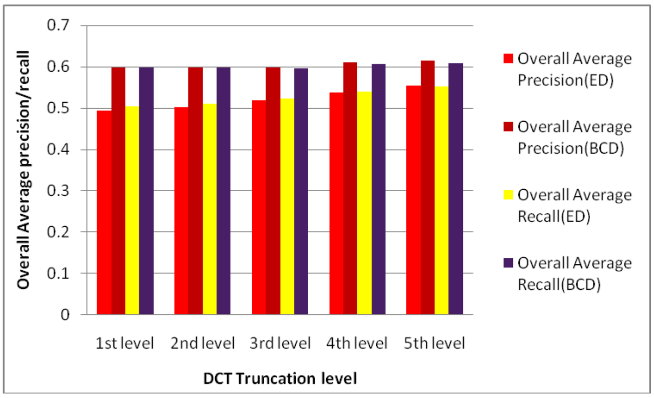

Figure 11. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of DCT truncation coefficients of YCbCr image .

and 35% for Bray Curtis Distance measure similarity . For 1st stage ,3rd and 4th stage of DCT truncation Bray Curtis Distance performance is good.

For RGB color image performance goes on increasing from 1st stage to 5th stage .Euclidean Distance(ED) performance is good and highest performance is 53 % . But in YCbCr color image Bray Curtis Distance measure performance is good and highest performance is 61%

This DCT truncation coefficients feature vectors can be reduced by tacking row mean and column mean of this DCT truncation coefficients for each stage .This row mean and column mean feature vector compared for each DCT truncation stage for gray scale image, RGB image and YCbCr image using Euclidean Distance measure and Bray Curtis Distance measure and it is shown in Figure 12-14. It is seen that 1st stage DCT truncation row mean and column mean Euclidean Distance similarity measure performance is better than the Bray Curtis Distance similarity measure performance and it is 35%. But 5th stage DCT truncation row mean and column mean Bray Curtis Distance similarity measure performance is better than the Euclidean Distance similarity measure and it is 32%.For the remaining stages performance of Euclidean Distance similarity measure is better. For RGB and YCbCr color image 2nd stage DCT truncation row mean and column mean Bray Curtis Distance similarity measure performance is better than the Euclidean Distance similarity measure . it is 50% and 49% for RGB color image and 53% and 50% for YCbCr using Bray Curtis Distance and Euclidean Distance measure respectively.

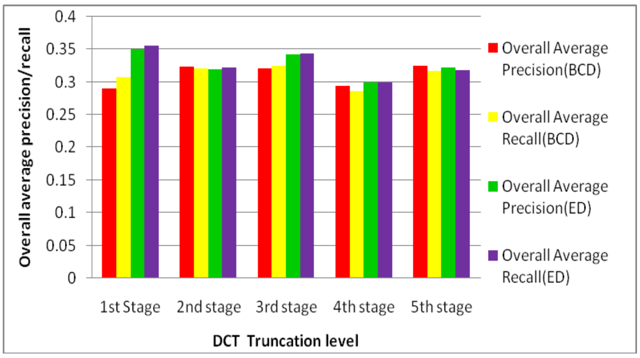

Figure 12. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column Mean of DCT truncation coefficients of Gray Scale Image .

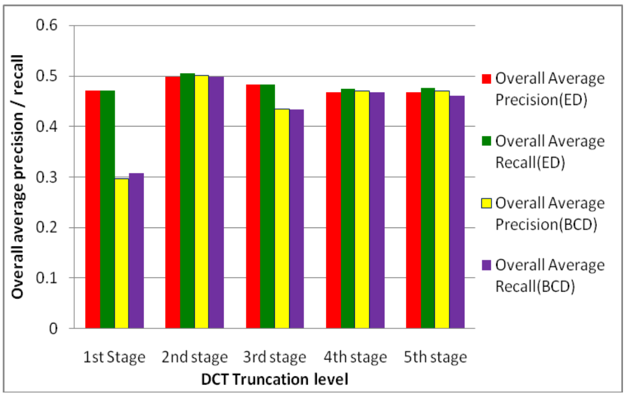

Figure 13. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column Mean of DCT truncation coefficients of RGB image .

Figure 15-17 show the performance plot of DCT truncation coefficients row and column standard deviations as a feature vector for each stage for general database. It is observed that Bray Curtis Distance measure performance of 1st stage is good compared with the other stages .Overall average maximum Bray Curtis Distance and Euclidean Distance measure performance is 50% and 46% for Gray scale image,60% and 58% for RGB color image and 66% and 61% for YCbCr color image respectively. Figure 18-20 shows the overall average precision and overall average recall plots using row and column variance of DCT truncated coefficients as a feature vector. Comparison is to be take place for each stage by using Euclidean Distance similarity measure and Bray Curtis Distance similarity measure.

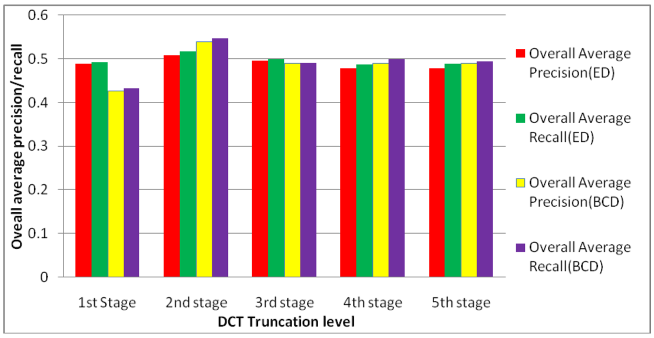

Figure 14. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column Mean of DCT truncation coefficients of YCbCr image.

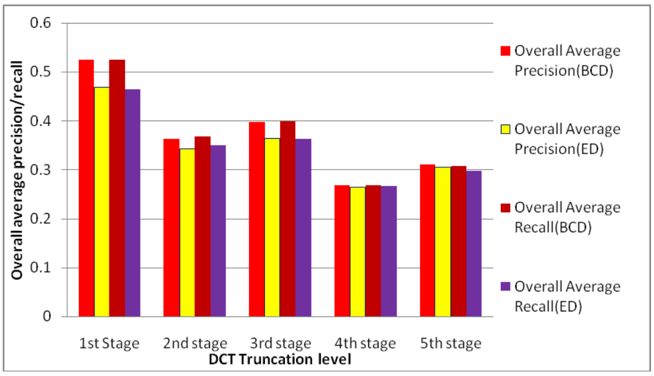

Figure 15. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column standard deviation of DCT truncation coefficients of gray scale image.

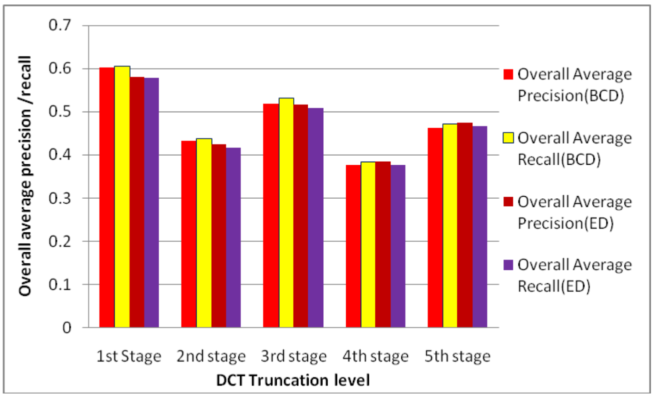

Figure 16. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column standard deviation of DCT truncation coefficients of RGB image.

It is observed that 1st stage performance is better than the other stages. Using Euclidean Distance similarity measure performance is 31% for gray scale image,48% for RGB color image and 50% for YCbCr color image .On the other hand using Bray Curtis Distance measure similarity performance is 36% for gray scale,52% for RGB and 54% for YCbCr color image. So for this approach Bray Curtis Distance (BCD) performance is good.

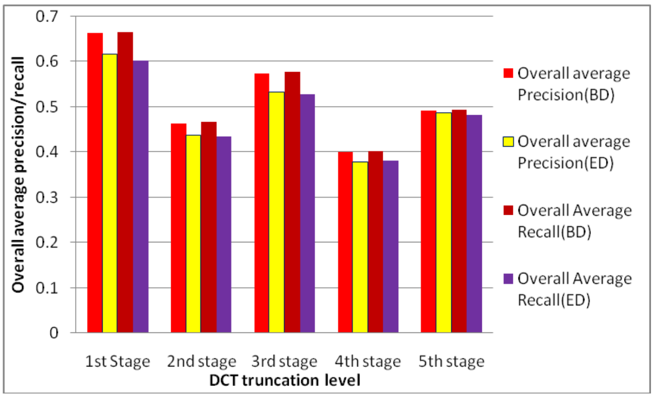

Figure 17. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column standard deviation of DCT truncation coefficients of YCbCr color image.

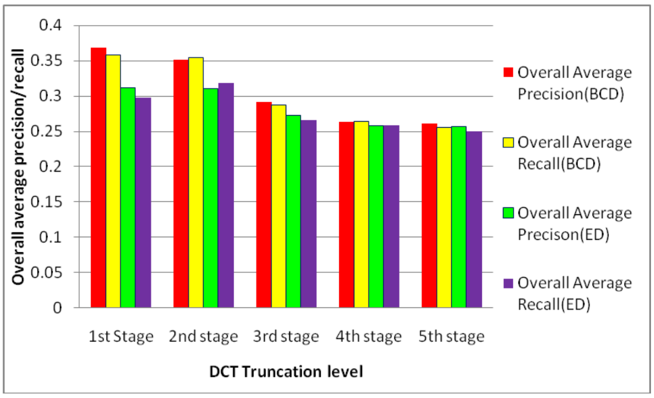

Figure 18. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column variance of DCT truncation coefficients of gray scale image .

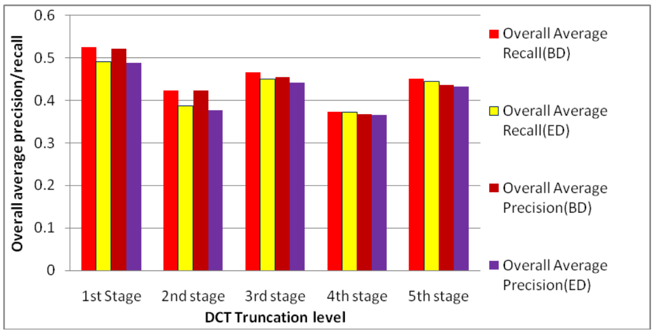

Figure 19. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column variance of DCT truncation coefficients of RGB image .

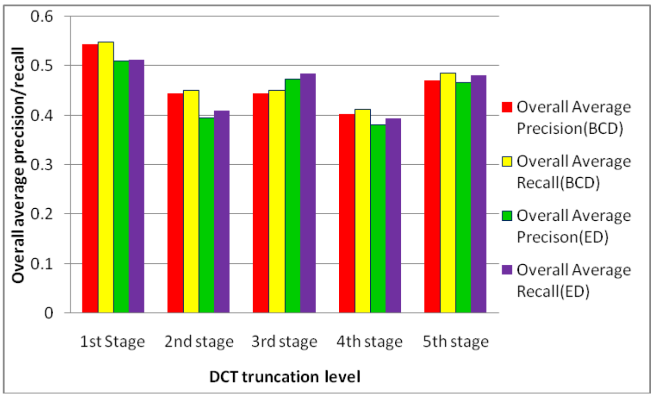

Figure 20. Overall average precision and recall with Bray Curtis Distance (BCD) and Euclidean Distance(ED) similarity measure of Row Column variance of DCT truncation coefficients of YCbCr color Image .

6. CONCLUSION

We have presented a new algorithm for digital image search and retrieval in this paper. We have used DCT truncated image coefficients at each level as a feature vector, row and column mean, row and column standard deviation and row and column variance of DCT truncated image as a feature vector for gray scale, RGB and YCbCr image. For the comparison we use Euclidean Distance similarity measure and Bray Curtis Distance similarity measure. Due to DCT truncation of image to the higher level feature vector size goes on decreasing. Bray Curtis Distance similarity measure performances of YCbCr image DCT truncation coefficients row column standard deviation is good and it is 66%.

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