Partitioning of Modified Histograms to Generate 27 Bins Feature Vector to Improve Performance of CBIR

H. B. Kekre, Kavita Sonawane

Abstract*—Content Based Image Retrieval is motivating the researchers to devise new techniques as the rate of retrieval is definitely gaining importance as multimedia databases are increasing day by day. In order to improve the retrieval accuracy of content-based image retrieval systems, research focus is on generating new efficient algorithms to extract image features and also to achieve the dimension reduction in order to reduce the processing time. In this paper, new algorithms are proposed to extract different types of image features based on the color contents of the RGB image. The feature extraction mainly deals with the original and the modified histograms of R, G and B planes. Four different modification functions namely Equalization (EQH), Logarithmic (LOG), Polynomial expression (POLY) and Linear equations 1, 2 and 3 (LINEQ 1, 2 and 3) are proposed to modify the histogram and their performance is compared in this paper. To implement the dimensionality reduction, this paper proposes two partitioning techniques namely Linear Partitioning (LP) and Centre of Gravity (CG)partitioning to partition the R, G and B histograms in three parts so that 27 bins can be generated from it. It directly reduces the size of the feature vector based on histogram from 256 bins to 27 bins only. Experimentation for the proposed methods is carried out using 2000 BMP images of 20 different categories. Comparison of query and database image feature vectors is worked out using three similarity measures namely Euclidean distance (ED), Absolute distance (AD) and Cosine Correlation distance (CD). To compare and evaluate the performances of all the proposed approaches along with different similarity measures three performance evaluation parameters are used namely Precision Recall Cross over Point , Longest String and Length of string to Retrieve all Relevant .

Index Terms*—About four key CBIR, Centre of Gravity, Equalization (EQH), Logarithmic (LOG), Polynomial expression(POLY), Linear Equations(LINEQ), Euclidean distance (ED),Linear Partitioning(LP), Centre of gravity(CG), Absolute distance (AD), Cosine Correlation Distance (CD), Precision Recall Cross over Point (PRCP), Longest String (LS), Length of String to retrieve all Relevant (LSRR).

I. INTRODUCTION

Content-based image retrieval (CBIR) has been an active area of research, promising to provide powerful tools for multimedia database management. Developing an efficient image retrieval system requires to work with various major aspects like system design, feature extraction, feature vector dimension, indexing schemes, similarity measures, evaluation parameters, image databases.

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***** Correspondence Author (s)
Dr. H. B. Kekre, Computer Engg. Dept., NMIMS/ MPSTME/ SVKM, Mumbai, India.
Ms. Kavita Sonawane, Computer Engg. Dept., NMIMS/ MPSTME SVKM, Mumbai, India

In this paper many of these issues are being handled by concentrating on the development of novel feature extraction techniques based on histograms and their modifications to improve the retrieval performance. The proposed methods are also able to achieve the reduction in the dimension of the feature vector. Feature extraction used here is focusing on color contents and indirectly on the texture information of the image. Each color content i.e R, G and B has given equal importance in this work by handling them separately using R, G and B histograms of R, G and B planes of each image. Normally the approaches design so far, as per the literature survey given in related work section II, is using all 256 bins of histogram for comparing the images [1],[2],[3],[[4]. It increases the computational complexity to very large extent. This drawback is overcome in this work by reducing the histogram based feature vector size to just 27 bins. This is achieved by partitioning the histogram in three parts using Linear partitioning (LP) and Centre of Gravity (CG) technique. Bins obtained using these techniques are containing the count of pixels falling in specific range of histogram (intensities). To increase the strength of the feature vector instead of taking just count of pixels we have calculated the statistical properties of the count of pixels into each bin. Here we compute the first four absolute moments namely Mean, Standard Deviation (STD), Skewness (SKEW) and Kurtosis (KURTO) of the intensities of the pixels counted into each bin. While working with original histograms it has been found that in many images the full range of intensities is not being utilized. This may lead to poor images which are actually carrying some meaningful data but not being utilized properly. To give significance to this information in the image a thought of modifying the histogram has been implemented in this paper. This implementation is carried out by means of four different modification functions as histogram specifications namely Equalization (EQH), Logarithmic (LOG), Polynomial expression (POLY) and Linear Equations (LINEQ 1, 2 and 3). This has brought positive effect in the retrieval results. Second major aspect after feature extraction to be considered for CBIR is comparing query and database images i.e similarity matching. This aspect is addressed here by using three similarity measures Euclidean distance (ED), Absolute distance (AD) and Cosine correlation distance (CD). First two are dissimilarity measures and the CD is similarity measure. Objective of CBIR systems is to retrieve maximum number of images which are relevant to query image. There are various ways through which the query can be given to the system. Query by sketch, query by example, query by contents etc [5], [6], [7], [8], [9], [10]. In this work all the proposed algorithms are executed with query by example approach.

Once the distances of query and database images are calculated, they are sorted in ascending order to retrieve the query relevant images. This is the stage where the system needs to attempt the next major issue i.e performance evaluation of the system with respect to new proposed algorithms. To evaluate the performance of all algorithms same set of three parameters have been used in this paper; are named as PRCP Precision Recall Cross over Point, LS: Longest String and LSRR- Length of String to Retrieve all relevant. Database of 2000 BMP images having 20 different classes has been created using few classes from Wang database [11]. Each class in the database includes 100 images of its own category. Multiple feature vector databases are prepared based on the types of the features calculated with respect to first four moments for each histogram modification function and also based on the R, G and B colors separately.

Organization of the paper is as follows; Section II discusses the literature survey under the title related work. Section III describes histogram and histogram modifications used in feature extraction process. Section IV describes the feature extraction and representation. Section V explains the similarity measures and Performance evaluation parameters used. Experimentation is discussed in Section VI which is followed by results and discussions in section VII. Finally the Proposed algorithms are compared and conclusions of work done are presented in section VIII.

II. RELATED WORK

CBIR attracting the researchers because of fast growing need of multimedia databases. Many researchers are working on various major aspects of CBIR systems which includes local and global image features or low level and high level features.[12],[13],[14], [15], [16], [17]. Some have suggested that the combination of the color and texture features of the image provides a robust feature set for image retrieval [18], [19].

Many approaches are based on histograms and Histogram equalization, which aims at information maximization, is widely used in different ways to perform contrast enhancement in images. [19]. Histogram specification (HS) is a class of image transformation techniques which changes the histogram of a given image to another desired one [20], [21], [22]. Many researchers have worked with color contents of the image with different color spaces. Color is also the most extensively used visual content for image retrieval which invariant to scaling and rotation. RGB space is a widely used color space for image display. It is composed of three color components red, green, and blue. These components are called "additive primaries" since a color in RGB space is produced by adding them together [23], [24], [25],[26].

III. HISTOGRAM AND HISTOGRAM MODIFICATIONS

A. Image Histogram

An image histogram is a graphical representation of the number of pixels in an image as a function of their intensities. Histograms are made up of bins, each bin representing a certain intensity value range. The histogram is computed by examining all pixels in the image and assigning each to a bin depending on the pixel intensity. Image histograms are an important tool for inspecting images [27], [28], [29]. Color histograms are frequently used to compare images in various multimedia applications. Color histograms are popular because they are trivial to compute, and tend to be robust against small changes in camera viewpoint. Histograms for RGB images can be obtained separately for R, G and B channels. In Section IV Fig. 4 shows the sample Kingfisher image separated into R, G and B planes with R, G and B histograms separately.

B. Histogram Modification Functions

Histogram tells us many things about the image that how the intensities are occupied by the image pixels, or what processing is done on the image and also about the device. Shape of histogram can be interpreted to generate useful information of the image. Like wider is the histogram better is the dynamic range that means image has better contrast. It also tells whether it is a low key image or high key image. If the histogram has the peaks concentrated along the left side of the bar graph (lower intensities) then that will be called low key image or underexposed image. If the image has peak concentrated towards higher range of intensities it is called high key image or overexposed image. Generally because of the limitations of the digital devices like camera we may have more images of low key than high key [29]. These low key images can be improved and their improved contents can be used for feature extraction process. To implement this thought, this paper explores some modification functions as histogram specifications so that the images if are low key, then can be improved to better images. These improved contents are used by means of features extracted from the images modified using following modification functions shown in following Fig1 to Fig. 3 [30], [31], [32], [33].

1. EQH: Histogram Equalization

This is widely used histogram specification technique that tries to distribute the all image pixels to cover entire range of available intensities.

2. LOG: Logarithmic functions

Logarithmic Transformations can be used to brighten the intensities of an image. More often, it is used to increase the detail (or contrast) of lower intensity values

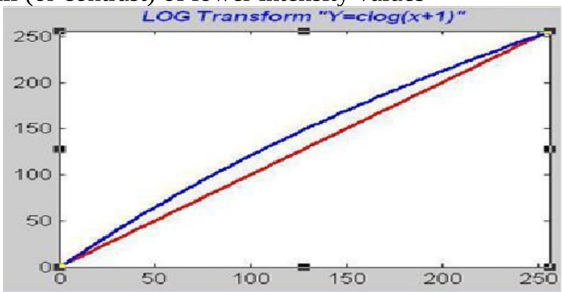

Fig.2 Log Function

3. *POLY: Polynomial functions:*

It is a simple polynomial expression which actually pushes the original histogram intensities from lower to upper side. It brings positive change in the low key images. We have worked out this with multiple polynomial functions for lower and upper side to push the intensities either to lower or to higher range to check all the possibilities. But here we are presenting the polynomial function better in performance among all of them.

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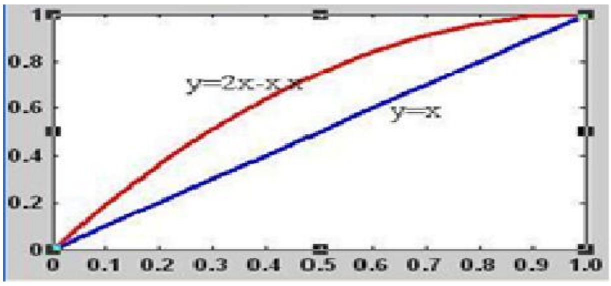

Fig.3 Polynomial Function

4. LINEQ : LinearEquation1, 2 and 3

The proposed linear equations are also designed to push the intensities from low to high level. To cover the entire range of intensities, equation of line has been designed and used in two parts. The amount of increment in the original intensities is actually depends on the three different values of Δ as shown in equation, three curves in Fig. 4.

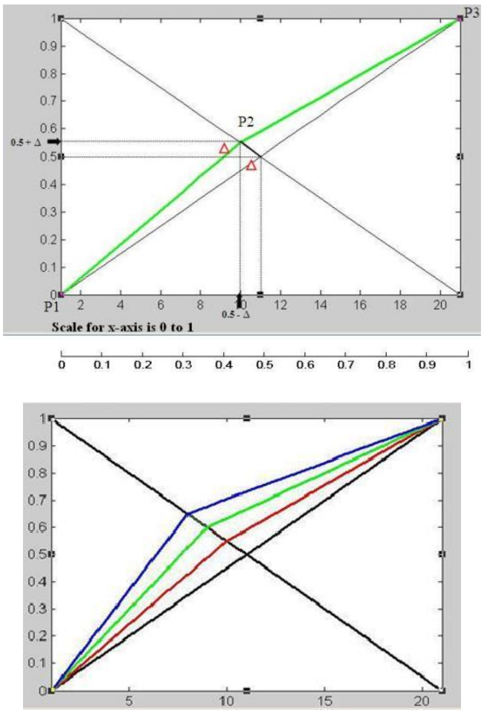

Fig.4 Linear Equation with three different Δ

Basically all of the above histogram modification functions are used to improve the contrast of the images. It gives the advantage that some details which are not being caught in the original image can be seen clearly in the modified images.

IV. FEATURE EXTRACTION BASED ON FORMATION OF 27 BINS

Feature extraction, indexing and retrieval are the core phases of content based image retrieval systems. Feature extraction is important because it has direct impact on the comparing and retrieval results and the associated computational complexity. This paper explores the new feature extraction method which achieves reduction in the feature vector dimension which in turn reduces the computational complexity. The detail process followed for feature extraction is discussed in the following phases.

Phase1: Histograms and Their Modifications

i. Spilt the image shown in Fig.4 into R, G and B planes as shown in Fig.5.

Fig.5 Kingfisher Image

Fig.5 Kingfisher Image with R, G and B Planes

ii. Compute the histograms of R, G and B planes as shown below in Fig.6

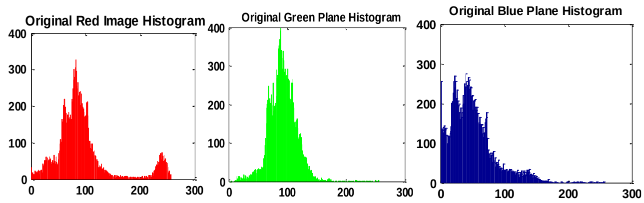

Fig.6 R, G and B Histograms of Kingfisher Image

iii. Modify the R, G and B histograms computed in step ii using all modification functions discussed in section III-B. Effect of polynomial modification function is shown in Fig.7 for R,G and B planes of the Kingfisher image

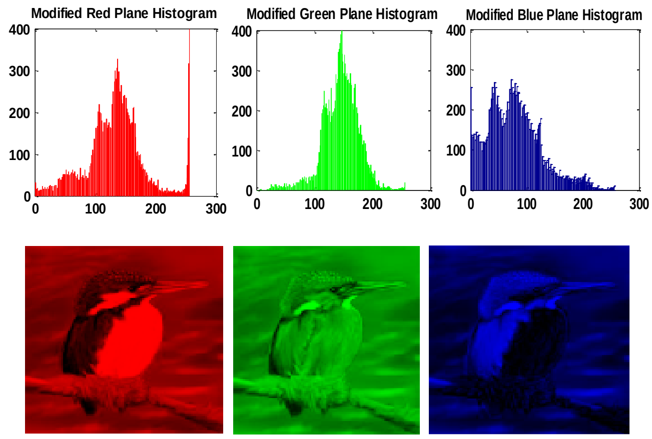

Fig.7 Polynomial Modified Histograms and their respective Images

In Fig.7, we can notice the effect of polynomial modification clearly. Histograms modified using polynomial, are shifted towards higher intensities. Effect of this shifting can be seen in the R, G and B plane images of respective histograms. Similar kinds of effects are obtained using the other modification functions mentioned in section III –B.

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Phase 2: Histogram Partitioning and Bins Formation

Partition the histogram into R, G and B planes using linear partitioning and CG partitioning. First this overall approach is explored with LP which partitions the histogram linearly such that each partition will have equal number of pixels. LP partitioning will not consider the intensities of the pixels while dividing the histogram into three equal parts rather it considers only the count of pixels. It uses the following equations (1) to obtain the two grey levels which are showing the linear division of histogram in three parts.

GL1= (m*n)/3 and **GL2**= 2(m*n)/3 (1)

In CG partitioning, we partition the histogram into three equal parts such that each partition will have same weight. Here weight is nothing but the pixels intensities which are considered to divide the pixels into three partitions so that each part will have equal intensities instead of taking the equal count of pixels. In CG partitioning pixel intensities have got significance in the bins formation process which was ignored in LP technique [34]. It uses the following equation (2) to compute the CG.

$$CG = \left[\frac{(L_1 w_1 + L_2 w_2 + \ldots + L_n w_n)}{\sum_{i=1}^{n} w_i} \right] \quad (2)$$

Further process used in feature extraction is exactly same for both the partitioning.

i. Using CG and LP partitioning techniques, two grey levels GL1 and GL2 are obtained to get partitions 0, 1 and 2. Following Fig.8 shows the histograms of kingfisher image are equalized and partitioned into three parts with part ids 0,1 and 2 using LP technique.

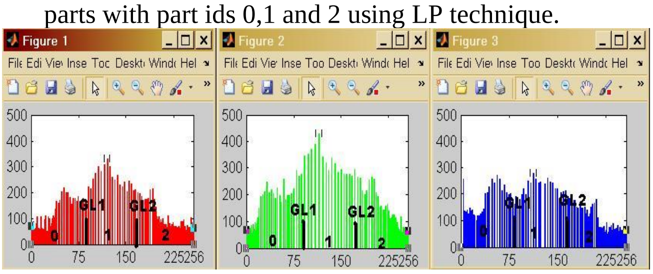

Fig.8 Equalized histograms of Kingfisher Image are partitioned using LP.

ii. Bins Formation: Pick up the pixels from the image under feature extraction process and check its R, G and B intensities to see that in which partition of the respective R, G and B histogram it falls. Accordingly assign the id or flag to that pixel which decides the destination bin address for that pixel to be counted. Three histogram divided into three partitions generates the 3^3 =27 combinations for the flag to be assigned to the pixels , in turn these are the 27 bins we have formed for the pixels to be counted..

E.g. if the pixel has got flag ‘010’ that means it will be counted in third bin.

This is the way the feature vector dimension is reduced to just 27 bins instead of taking all 256 bins of the histograms

Fig. 9 shows the sample 27 bins for kingfisher image for R, G and B colors mean parameters. Few bins are empty because count of pixels into those bins is zero like bin no. 7, 8, 9 etc.

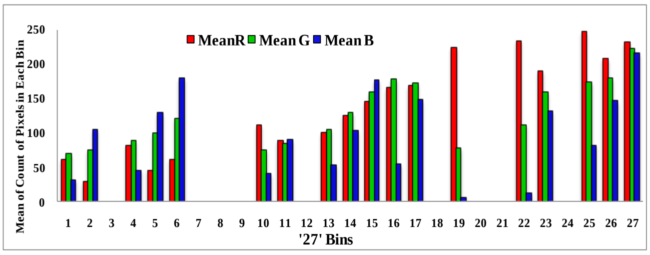

Fig 9. Sample 27 Bins of Mean Parameter of Kingfisher image.

Phase3: Feature vector Generation

In the step explained above we get the count of pixels distributed into 27 bins. This is the first feature of the image that has been taken into consideration for comparing the images. But after analysing the performance of this feature vector it has been observed that in this feature only count of pixels taken into each bin are considered but their intensities are totally ignored. To evaluate the role of the intensities in the feature vector we thought of computing the statistical properties of the intensities of the pixels counted into each bin. We have computed first four absolute centralize moments for the intensities acquired by the pixels counted into each of the 27 bins of the image under feature extraction process. First four Moments namely Mean, Standard deviation, Skewness and Kurtosis are computed using following four equations.3, 4 5 and 6 and are termed as MEAN, STD, SKEW and KURTO [34], [35].

Mean →	$\bar{R} = \frac{1}{N}\sum_{i=1}^{N} R_i$	(3)
Standard deviation →	$R_{SD} = \frac{1}{N}\sqrt{\sum_{i=1}^{N}(R-\bar{R})^2}$	(4)
Skewness →	$R_{SK} = \frac{1}{N}\sqrt[3]{\sum_{i=1}^{N}(R_i-\bar{R})^3}$	(5)
Kurtosis →	$R_{KU} = \frac{1}{N}\sqrt[4]{\sum_{i=1}^{N}(R_i-\bar{R})^4}$	(6)
Where $\bar{R}$ is Bin_Mean_R in eq. 3, 4, 5 and 6.		

This way we obtained four types of feature vectors based on four moments for each image of the database.

Phase4: Comparison, Indexing and Retrieval

This is second core phase of any CBIR system which facilitates the retrieval of the images. In this phase system accepts the user’s query image, calculates its feature vector and compares it with the database image features and generates the retrieval results as set of images retrieved from large image database which are similar to query.

Comparing images is nothing but calculating the distance between query and database image features by means of similarity measures. In this work we have used three similarity measures namely Euclidean distance, absolute distance and cosine correlation distance as given in following equations.

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Euclidean Distance $$D_{QI} = \sqrt{\sum_{i=1}^{n} \lvert (FQ_i - FI_i) \rvert^2} \quad (7)$$	Absolute Distance: $$D_{QI} = \sum_{1}^{n} \lvert (FQ_I - FI_I) \rvert \quad (8)$$
Cosine Correlation Distance $$\frac{\langle D(n) \mid Q(n) \rangle}{\sqrt{[\langle D(n) \mid D(n) \rangle \langle Q(n) \mid Q(n) \rangle]}} \quad (9)$$ Where D(n) and Q(n) are Database and Query feature Vectors resp.	

V. EXPERIMENTATION DETAILS

Approaches explored in this paper are based on the variations used in feature extraction process. Feature formations are mainly based on color and indirectly texture contents of the image. By separating the image into R, G and B planes each pixel's R, G, B color is exploited separately and also by calculating the moments their textural properties are addressed. Experimentation setup includes the image database, query images, feature vector databases as pre-processing work and the use of similarity measures to compare and retrieve the similar images.

A. Image Database and Query Images

Image Database: To carry out the experiments we have used database of 2000 BMP images having 20 different classes which includes few classes from Wang database. Sample image from each of the 20 classes is shown in the Fig. 10.

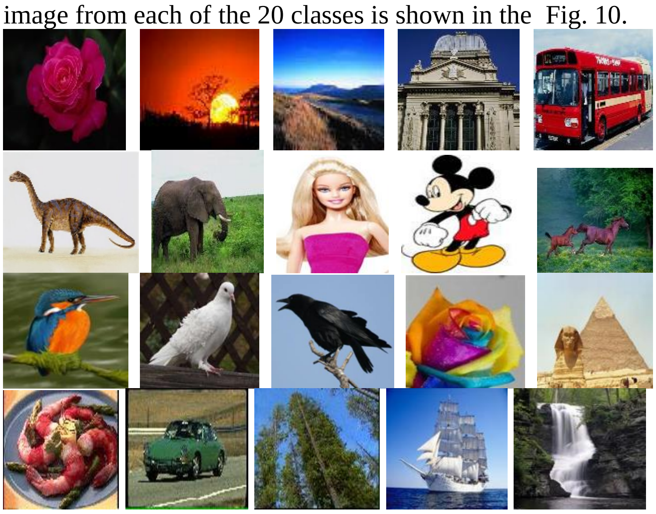

Fig.10. 20 Sample Images from database of 2000 BMP images from 20 classes

Query Images: We have selected 10 images from each of the 20 classes randomly to be given as query images. To evaluate the performance of all the approaches explored in this paper same set of these 200 images is used as query images and performance of all the approaches is observed, compared and analysed.

B. Generation of Multiple Feature vector Databases

Feature extraction process starts from separating the image into R, G and B planes. Further processing uses modification of histograms using four functions namely EQH, LOG, POLY, Linear EQ 1, 2 and 3. This is followed by two different partitioning techniques CG and LP to form 27 bins. Further each bins R, G and B intensities are considered separately to form the feature vector and first four absolute moments are calculated for them as mentioned earlier, Mean, STD, SKEW and KURTO. Based on this multiple variations, we have stored each feature vector of the image in a separate feature database. The same details are highlighted in following Fig.11.

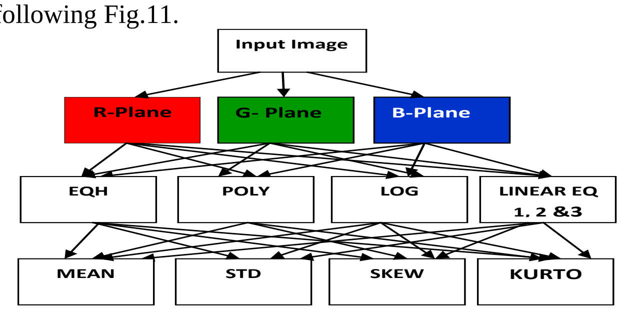

Fig.11. Multiple Feature vector Databases for all variations used in Feature Extraction Process.

According to this we have total 48 types feature vectors for one type of partitioning technique. As two partitioning techniques are used i.e LP and CG we have total 48 x 2= 96 features stored in separate database and we have prepared 96 feature vector databases for 2000 BMP images in the image database as preprocessing work.

C. Comparing Query and database Images

Once the feature vector databases are ready, query can be fired to the system. Here query is given as example image. Whenever query enters into the system a feature vector of the same will be extracted and then distance between the query and database image feature vectors will be calculated by means of three similarity measures ED, AD and CD. The distances obtained are then sorted in ascending order. This way images close to query image will be at top level. Most commonly used method to facilitate the retrieval by many CBIR systems is determine the threshold by trial and error for the distance and then image at distance less than the threshold will be retrieved from the database [36], [37]. Instead of using this trial and error method to determine the threshold which is time consuming, we have introduced a new parameter to retrieve the images from the database.

Parameters used for retrieval and evaluating the performances of these various approaches are discussed as follows [38], [39], [40], [41],[42].

D. Performance Evaluation Parameters

i.PRCP - Precision Recall Cross over Point

As discussed above instead of using the traditional methods to determine threshold the new parameter used is PRCP (Precision Recall Cross over Point) which facilitates the retrieval process and evaluates the strength of the system as well. PRCP equals to 1 indicates the system's idealness where precision and recall both are 1, means that the retrieval result contains all relevant images from database and at the same time it does not contain a single irrelevant image. PRCP value 0 indicates the worst case performance of the system where the retrieval set contains all irrelevant images.

In our case PRCP is taken at 100. As the database has 2000 images, we obtain 2000 distances with respect to one query which are sorted in ascending order.

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We are counting the relevant images appear in the first 100 images (according to sorted distances). As we have 100 images of each class in the database this is the point PRCP satisfies its definition of cross over point where precision and recall both are same. PRCP is derived from the two conventional parameters used in most of the CBIR systems, that are precision and recall which are defined as follows in Eq. 10 and 11.:

$$Precision = \frac{Relevant \quad Retreived \quad Images}{All \quad Retrieved \quad Images} \qquad (10)$$

$$Recall = \frac{Relevant \quad Retreived \quad Images}{All \quad Relevant\,Images \quad In \quad Database} \qquad (11)$$

ii. LS - Longest String

This is a new parameter introduced by us to evaluate the performance of the system. Many times it happens that we concentrate only on the top string of images relevant to query in the set of sorted images with respect to sorted distances. If we consider only initial string of relevant images and rest all are being ignored if we reach to irrelevant image; then it may happen initially we get very few relevant images which is not desired by any CBIR user. To overcome this issue and to satisfy the CBIR user's expectations, Longest string searches for the longest continuous string of relevant images not only at the beginning of the sorted image set but also till the end of the set . Because of it, if in between any continuous string of relevant images appears it will not be ignored will be taken as "Longest String".

iii. LSRR - Length of String to Retrieve all Relevant

Expected output and response time are the important aspects of any CBIR system. LSRR i.e Length of String to Retrieve all Relevant images is introduced to do the same. Ideal expected output for the CBIR system is that it should recall or retrieve all images relevant to query from the large database within short period of time. LSRR works for the same, it travels the set of sorted images, till it collects all relevant images present in the database. The best LSRR here will be 100 as each class has 100 images of its own category and the worst case it is 2000 as image database size 2000. The longer it has to travel, it increases the response time.

VI. RESULTS AND DISCUSSION

As mentioned in section V – B, we have prepared total 96 feature vector databases. Based on the histogram partitioning, histogram modification functions, and on the first four moments calculated for R, G and B colors separately. Performance of approaches based on these different variations are evaluated and discussed in this section using three parameters PRCP, LS and LSRR.

To have common base to compare all approaches, same set of 200 query images is executed for all of them over database of 2000 BMP images.

In first set of results we have executed the 27 bins formed using LP, CG partitioning with all four moments from the R, G and B colors from the original as well as modified histograms. The retrieval results in terms of PRCP are obtained separately for each color. Results for all parameters are obtained with respect to three similarity measures ED, AD and CD for all four moments. Table I and II are for CG and LP Partitioning of original histograms respectively. These results are shown with respect to only one type of feature vector that is first moment Mean, with respect to one distance measure ED. In Table I and II first three columns namely R, G and B are showing the results for R, G and B colors separately. Each value in first three columns is representing the total retrieval in terms of PRCP out of 1000 for 10 queries executed from each class.

Each query's PRCP result is the relevant retrieved images out of first 100 sorted in ascending order according to the distances. When we observed these results we found them very poor, it does not satisfy the CBIR user's requirements as per the ideal values for parameters precision and recall.

After observing these results we thought of refining and improving the retrieval of relevant images for each given query. To solve this issue we thought to combine these three results sets obtained with respect to R, G and B colors. To implement this thought a simple OR criterion is applied over the R, G and B results. Whatever output of this OR operation we get is determined or considered as final retrieval of relevant images from large database of 2000 BMP images for the given query.

Results obtained after OR operation over the R, G and B results of CG and LP partitioning over ORG histogram for MEAN ED feature vector are shown in last column of Table I and II respectively.

Here we can see that the results are improved with quiet good difference as compared to separate results of R, G and B colors. We can notice that the PRCP value now reached to 7441 from 4979 for CG and to 7825 from 5353 for LP. This is total retrieval out of 20,000 for 200 query images.

As mentioned in section V – A; set of 200 query images is executed over the preprocessed 96 feature vectors databases. For all these databases separate results for R, G and B are obtained and they are combined in the same way as explained above using OR operation so that their PRCP results can be improved further.

TABLE I. PRCP FOR ORG WITH CG : ED

R-ORG_CG	R	G	B	R 'OR' G 'OR' B
Flower	192	346	230	**483**
Sunset	230	228	282	**473**
Mountain	142	126	148	**248**
Building	138	154	132	**228**
Bus	323	214	246	**480**
Diansour	352	341	338	**385**
Elephant	189	143	110	**238**
Barbie	559	512	565	**609**
Mickey	149	129	137	**204**
Horses	347	252	354	**505**
Kingfisher	208	286	254	**405**
Dove	197	189	186	**224**
Crow	80	138	191	**213**
Rainbowrose	471	509	558	**715**
Pyramids	186	175	155	**266**

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Plates	160	225	286	**400**
Car	163	323	225	**423**
Trees	323	257	235	**408**
Ship	213	141	177	**288**
Waterfall	205	157	170	**246**
Total	4827	4845	4979	**7441**

TABLE II. PRCP FOR ORG WITH LP : ED

R-ORG_LP	R	G	B	R 'OR' G 'OR' B
Flower	245	292	280	**501**
Sunset	283	178	290	**479**
Mountain	137	136	147	**262**
Building	152	183	137	**257**
Bus	324	271	338	**527**
Diansour	393	400	412	**446**
Elephant	198	155	114	**233**
Barbie	524	474	523	**539**
Mickey	204	187	181	**254**
Horses	360	283	430	**548**
Kingfisher	192	256	231	**385**
Dove	483	446	395	**522**
Crow	67	94	160	**174**
Rainbowrose	331	328	351	**526**
Pyramids	281	276	202	**358**
Plates	146	179	236	**340**
Car	144	301	202	**380**
Trees	316	285	277	**457**
Ship	216	175	234	**333**
Waterfall	248	191	213	**304**
Total	5244	5090	5353	**7825**

All these results with respect all types of feature vectors and all three similarity measures after OR operation for both partitioning with all histogram modification functions are presented in the following tables from tables III to VIII. Tables III, IV and V are showing the results for LP technique and Tables VI, VII and VIII for CG partitioning with similarity measures ED, AD and CD respectively.

In all the following tables, Rows are representing the type of feature vector based on moments namely MEAN, STD, SKEW and KURTO. Columns are representing the different histogram modification functions used for feature extraction. Each value in the table is the result of 200 query images after OR operation over R, G and B results of that query. It means that each value is representing a count of relevant retrieved images for 200 query images out of 20, 000.

In above tables best results obtained in each row are highlighted in yellow. On observing these results we found that MEAN parameter is performing better in all tables for ORG histogram. Among modification functions Polynomial and LOG functions are performing better as compared to other functions in most of the cases. Comparing the results on the basis of partitioning used, LP is performing better as compared to CG. Comparing the results on the basis of similarity measures we found AD is performing best among three. If we analyze the performance of moments we found that even moments (STD and KURTO) are giving good results as compared to odd moments (MEAN and SKEW).

When look at the PRCP values, the maximum PRCP obtained is **10138 for AD** measure for the **KURTOSIS** moment of LOG modified image data. This is the highest value obtained among all results. Observing this value we can interpret that precision and recall are crossed **0.5** as an average of 200 query images. This is quiet good achievement in the CBIR field.

Now we present the discussion about the other parameters used in system to evaluate the performance of the approaches that are LS and LSRR. LS and LSRR results are also obtained by executing each individual query from the same set of 200 query images over 96 feature vector databases. As per the discussion section V –D , LS searches for the longest continuous string of relevant images and that means the expected LS should be as high as possible. However the expected value for other parameter LSRR should be as low as possible because it gives the length to be traversed among the sorted distances to collect all images relevant to query to make the recall 1.

Considering the expected performances of these two parameters here we are presenting the best results of LS and LSRR i.e. Maximum and Minimum respectively. Each max and min for LS and LSRR are chosen among the results of each of the 10 queries executed from each class for each of the three colors R, G and B separately.

Following tables IX to tables XI are showing the results for longest string obtained for LP using ED, AD and CD measure. Further three tables XII to XIV are showing the results for longest string using ED, AD and CD for CG partitioning.

TABLE III. PRCP : LP : ED

MOMENT	LP : 27 BINS ED 'R' OR 'G' OR 'B'						
	ORG	EQH	POLY	LOG	LIN EQUATION123		
					LINEQ1	LINEQ2	LINEQ3
MEAN	7825	6157	7310	7498	7309	7170	6931
STD	7043	8169	10124	10031	9911	9898	9798
SKEW	7005	8053	9292	9200	9197	9202	9103
KURTO	7314	8257	10053	10138	10040	9892	7809

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TABLE IV. PRCP : LP : AD

MOMENT	LP : 27 BINS AD 'R' OR 'G' OR 'B'						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	8237	6471	7858	7962	7809	7719	7590
STD	7669	8170	10019	9958	9805	9818	9739
SKEW	7557	8047	9432	9462	9365	9305	9267
KURTO	7914	8332	10072	10097	9867	9839	9684

TABLE V. PRCP : LP : CD

MOMENT	LP : 27 BINS CD 'R' OR 'G' OR 'B'						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	7437	6009	7113	7246	6884	6745	6536
STD	7121	8153	9395	9471	9272	9139	9033
SKEW	7062	8068	9167	9192	9100	8995	8882
KURTO	7406	8257	9499	9690	9505	9409	9171

TABLE VI. PRCP : CG : ED

MOMENT	CG : 27 BINS ED 'R' OR 'G' OR 'B'						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	7441	6214	7159	7180	7107	6840	6640
STD	9521	8100	9802	9697	9673	9703	9633
SKEW	9012	7978	8993	9021	9039	8942	8826
KURTO	9759	8156	9611	9731	9735	9623	9405

TABLE VII. PRCP : CG : AD

MOMENT	CG : 27 BINS AD 'R' OR 'G' OR 'B'						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	8063	6558	7936	7931	7820	7666	7593
STD	9491	8147	9695	9555	9583	9686	9640
SKEW	9106	8007	9190	9128	9153	9086	9005
KURTO	9695	8269	9639	9736	9005	9649	9532

TABLE VIII. PRCP: CG : CD

MOMENT	CG : 27 BINS CD 'R' OR 'G' OR 'B'						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	6498	5956	6474	6388	6310	6137	6110
STD	9395	7998	9327	9404	9416	9288	9153
SKEW	8975	8040	8838	8893	8867	8705	8648
KURTO	9518	8112	9290	9447	9527	9289	9115

As we are interested in maximum longest string; among these results we have highlighted the best in each row that is in each moment which modification is performing better is highlighted. In LP the max LS obtained is 86 for STD with LOG modification function.

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This is out of 100 images of that class in the database. Whereas in CG the max LS obtained is 76 for STD with Linear equation 1 as modification function. Observing these all values we can say that on an average system is able to retrieve **more than 40%** images for almost all types of feature vectors as continuous string of relevant images from database which is quiet good achievement in this field.

The next parameter used for performance evaluation is LSRR i.e Length of string to be traversed to collect all relevant images from the database. All the LSRR results obtained for LP with ED, AD and CD are shown in tables XV to XVII respectively. Whereas CG partitioning results are shown in tables XVIII to XX. Here we are looking for the minimum value because it determines the system's strength to collect all query relevant images from database as early as possible. The minimum it has to travel (i.e min is the LSRR) the less time it takes to collect the relevant images from database. Minimum values with respect each moment and the modification functions are highlighted in yellow color. It can be noticed that the best minimum value obtained among these all results is 7% for the even moments STD and KURTO of polynomial functions with AD measure in LP based results and it 10% for CG with linear equation1 with STD with AD measure. This indicates that at various queries this CBIR system is able to retrieve all relevant images by just travelling 7% of the total length of sorted distances. In this case it is 7% of 2000 means all relevant images (100) are collected till first 140 to 200 images from 2000 images.

TABLE IX. . LONGEST STRING : LP : ED

MOMENT	LP : 27 BINS ED 'LS' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	52	20	48	50	46	46	46
STD	44	49	64	68	57	58	55
SKEW	42	35	44	40	43	45	48
KURTO	43	49	60	63	57	54	47

TABLE X. LONGEST STRING : LP : AD

MOMENT	LP : 27 BINS AD 'LS' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	50	22	44	46	47	44	44
STD	47	45	76	86	68	74	69
SKEW	46	29	54	49	52	50	46
KURTO	46	45	74	80	63	68	61

TABLE XI. LONGEST STRING : LP : CD

MOMENT	LP : 27 BINS CD 'LS' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	58	25	50	48	48	48	47
STD	45	47	49	50	50	49	48
SKEW	43	36	48	45	46	49	50
KURTO	45	47	47	48	49	46	46

TABLE XII. LONGEST STRING : CG : ED

MOMENT	CG : 27 BINS ED 'LS' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	57	22	70	63	54	48	47
STD	49	48	53	48	40	47	53
SKEW	43	43	33	30	42	44	45
KURTO	51	47	53	49	54	47	51

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TABLE XIII. LONGEST STRING : CG : AD

MOMENT	CG : 27 BINS AD 'LS'						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	58	44	65	55	51	45	51
STD	64	47	71	61	65	76	67
SKEW	40	45	37	40	43	42	51
KURTO	64	47	67	62	67	71	69

TABLE XIV. LONGEST STRING : CG : CD

MOMENT	CG : 27 BINS CD 'LS' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	57	33	74	67	61	57	63
STD	50	48	38	40	44	42	40
SKEW	31	33	33	34	35	34	41
KURTO	41	48	45	43	43	49	44

TABLE XV. LSRR : LP : ED

MOMENT	LP : 27 BINS ED 'LSRR' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	27	51	47	46	46	47	44
STD	25	18	11	9	9	11	11
SKEW	24	25	17	22	20	22	17
KURTO	24	21	9	9	9	10	28

TABLE XVI. LSRR : LP : AD

MOMENT	LP : 27 BINS AD 'LSRR' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	13	45	42	23	28	31	38
STD	16	17	7	9	9	8	8
SKEW	16	26	12	12	13	14	10
KURTO	16	20	7	9	9	8	8

TABLE XVII. LSRR : LP : CD

MOMENT	LP : 27 BINS CD 'LSRR' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	20	53	8	12	39	28	39
STD	19	11	11	12	12	12	12
SKEW	18	29	17	19	16	17	17
KURTO	18	18	10	12	10	11	10

TABLE XVIII. LSRR : CG : ED

MOMENT	CG : 27 BINS ED 'LSRR' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	46	51	47	42	43	45	46
STD	13	17	15	14	14	15	20
SKEW	27	26	33	30	32	23	26
KURTO	14	21	19	14	18	18	18

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TABLE XIX. LSRR : CG : AD

MOMENT	CG : 27 BINS AD 'LSRR' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	16	46	29	21	23	20	38
STD	11	18	12	11	10	12	10
SKEW	20	25	17	21	19	19	16
KURTO	12	20	12	13	13	15	12

TABLE XX. LSRR : CG : CD

MOMENT	CG : 27 BINS CD 'LSRR' in Percentage (%)						
					LIN EQUATION123		
	ORG	EQH	POLY	LOG	LINEQ1	LINEQ2	LINEQ3
MEAN	16	52	15	14	19	19	21
STD	13	13	17	16	13	17	16
SKEW	26	31	25	28	28	24	20
KURTO	15	18	21	16	17	19	18

VII. CONCLUSION

Major aspects of any CBIR systems are : methods used for feature extraction, similarity measures for indexing and performance evaluation parameters. This paper has explored the work which is addressing all these major aspects to some extent.

Feature used for comparison is mainly from the color contents of the image. But the method used for feature extraction and representation is a novel idea based on “Bins Approach”.

The novelty of feature extraction explored in this paper is based on various functions used to modify the histogram of R, G and B planes. This has proved that instead of working with original histogram modified histograms are performing far better in terms of retrieval results of similar images [19], [20][21][42].

Feature extraction method explored in this paper has achieved many positive points in the CBIR field. It could reduce the dimension of the feature vector to just 27 components. Instead of comparing the entire histograms with 256 bins as done in various CBIR methods, this reduces the computational complexity required for comparing the images [4][5][18][22][27][28]. Many conclusions can be drawn on analyzing and observing the results obtained here with 96 types of feature vector databases. Few of them are as follows:

As discussed earlier modified histograms are performing far better than original histogram. Amongst modified histograms LOG and Polynomial modifications are proving themselves better than other functions.

Evaluating the performance in terms of R, G B color contents separately we found that Red and Green are far better than blue color.

Evaluating the role of similarity measures, we found AD is the best measure producing very good results as compared to ED and CD along with reductions in the computations. But many cases where ED and AD are not performing well for some classes of images there we found that CD is doing well at many places.

Observing the performance of First four moments as type of feature vectors we found that even moments(STD and KURTO) are far better than that of odd moments(MEAN and SKEW).

Instead of using all 256 bins of histogram as it is dimension reduction is achieved using the partitioning techniques namely LP and CG, comparing their performances in formation of 27 bins we found LP is proving better than CG.

Three novel performance evaluation parameters introduced in this work are PRCP, LS and LSRR. They have proved and evaluated the system’s performance to satisfy the CBIR user’s expectations to quiet good extent.

PRCP has measured the accuracy and completeness of the system in terms cross over point of two conventional parameters precision and recall. PRCP = 1 indicates the ideal system performance whereas PRCP = 0 indicates the worst case performance. PRCP between 0 to1 tell you that how far away you are from the ideal CBIR system. The highest PRCP obtained as an average of 200 query images is **0.5** which is quiet good achievement in the field of image retrieval.

LS i.e longest string and LSRR i.e length of string o retrieve all relevant; parameters are fulfilling the expectations of any user from the ideal CBIR system. LS finds out the longest continuous string of relevant images from database. Here the best LS obtained is **86%** (out of 100 in DB). The LSRR identifies the length required to be traversed or the time system takes to prove the completeness of the ideal CBIR systems i.e (Recall = 1). The best LSRR obtained here is **7%.** It means 7% traversal generates 100% recall for the given query. These parameters, PRCP (reflecting accuracy and completeness), LS and LSRR (evaluating strength and response time) are evaluating the performance of the system through all possible views.

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Dr. H. B. Kekre has received B.E. (Hons.) in Telecomm. Engg. from Jabalpur University in 1958,M.Tech (Industrial Electronics) from IIT Bombay in 1960, M.S. Engg. (Electrical Engg.) from University of Ottawa in 1965 and Ph.D. (System Identification) from IIT Bombay in 1970. He has worked Over 35 years as Faculty of Electrical Engineering and then HOD Computer Science and Engg. at IIT Bombay. For last 13 years worked as a Professor in Department of Computer Engg. at Thadomal Shahani Engineering College, Mumbai. He is currently Senior Professor working with Mukesh Patel School of Technology Management and Engineering, SVKM's NMIMS University, Vile Parle(w), Mumbai, INDIA. He has guided 17 Ph.D.s, 150 M.E./M.Tech Projects and several B.E./B.Tech Projects.

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His areas of interest are Digital Signal processing, Image Processing and Computer Networks. He has more than 450 papers in National / International Conferences / Journals to his credit. Recently twelve students working under his guidance have received best paper awards. Five of his students have been awarded Ph. D. of NMIMS University. Currently he is guiding eight Ph.D. students. He is member of ISTE and IETE.

Ms. Kavita V. Sonawane has received M.E (Computer Engineering) degree from Mumbai University in 2008. Pursuing Ph.D. from Mukesh Patel School of Technology, Management and Engg, SVKM's NMIMS University, Vile-Parle (w), Mumbai, INDIA. She has more than 10 years of experience in teaching. Currently working as a Assistant professor in Department of Computer Engineering at St. Francis Institute of Technology Mumbai. Her area of interest is Image Processing, Data structures and Computer Architecture. She has 23 papers in National/ International conferences / Journals to her credit. She is member of ISTE

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