International Journal of Soft Computing and Engineering (IJSCE)
ISSN: 2231-2307, Volume-3 Issue-3, July 2013

Performance Evaluation of Bins Approach in YCbCr Color Space with and without Scaling

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Abstract— This paper explores novel idea of feature extraction based on bins approach. The bins formation process described in this approach is based on the partitioning of the different histograms of the image based on the color components of the image. Basically the feature extracted here deals with the color contents of the image. The use of color contents is explored using two different color spaces namely RGB and YCbCr color space in two forms with and without scaling. Feature extraction phase starts with the separation of the color planes of the image. In this work images in both (RGB and YCbCr) color spaces are separated into R, G, B and Y, Cb, Cr components respectively. Histogram for each plane is calculated and partitioned into two parts using Centre of Gravity (CG) technique. Three planes, two partitions generate total 2^3= 8 bins. Data contained by 8 bins is the count of pixels falling in particular range of intensities. This is further processed by computing the first four moments. It generates four types of feature vectors based on four moments namely Mean, Standard Deviation, Skewness and Kurtosis. Feature vector comparison with query is facilitated by means of three similarity measures namely Euclidean distance, Absolute distance and cosine correlation distance. Experimentation is carried out using 2000 images in the database with two color spaces RGB and YCbCr taken into consideration. Result analysis is done by using three performance evaluation parameters Precision Recall Cross over Point, Longest String and Length of String to Retrieve all Relevant images.

Index Terms—Bins, CG, Histogram, RGB, YCbCr, Mean, Standard deviation, Skewness, Kurtosis, ED, AD, CD, PRCP, LS, LSRR.

I. INTRODUCTION

This paper presents the novel technique based on bins approach for CBIR. Here the concept of 8 bins is explored in YCbCr color space along with the RGB color space. Performance of both color spaces is evaluated and compared in this paper. Content Based Image Retrieval, the name itself is clue that the techniques used for image retrieval are actually based on image contents rather than using text annotations. CBIR overcomes the drawback of text based retrieval techniques which are tedious and time consuming as well. Techniques invented for image retrieval based on contents are useful for many applications in various fields where text based retrieval will have no opportunity at all. CBIR can be used effectively for various kinds of databases like medical databases, scientific databases, in various forensics investigation processes and many more applications. Co paring the performance of CBIR techniques with the text based retrieval techniques, CBIR proves far better.

This is because here the image is represented or say identified by the contents from the image itself and not by means of image annotations. Image annotations may have same description for two images having different contents or may have different description having same contents. These possibilities cannot be avoided in text based retrieval as the techniques are based on perception of the image by the individual user. Vast research is going in CBIR field. Researchers are working on invention of different techniques to extract the image contents to identify that image separately from the other classes of images. Image contents include mainly three types; Color, Texture and Shape [1], [2], [3], [4]. Based on these three main contents of the image various approaches are designed and implemented for CBIR. Image features can be classified as global or local features. Global features are capable of generalizing an entire image with a single vector, describing color, texture, or shape. Local features are computed at multiple points on an image and are capable of recognizing objects [5], [6]. Some are using image segmentation techniques like region based segmentation, Image blocking etc. Different algorithms are invented to extract these contents and represent them in way that the image can be indentified uniquely from the other classes of images in the database. [7], [8], [9], [10]. Color is most widely used feature in most of the CBIR systems. It is extracted in various different ways; color correlogram, color histogram, local –global color histograms, Color moments, partitioning of color spaces and use of clustering algorithm etc [11], [12]. Color contents are invariant to scaling and rotation transformations this is also one of the big reason behind their wide use [13], [14], [15], [16]. We are also focusing mainly on color contents of the image and indirectly on the texture features too. We are dealing with the color histograms of the images for feature extraction purpose. This work is proving that instead of using the color histograms as a feature vector for the images to compare; new set of bins are generated out of 256 × 3 bins of each of the three histograms e.g. from R, G and B histograms of the BMP image. It reduces the size of the feature vector and also improves the retrieval result along with performance of retrieval process, [17], [18], [19], [20].
We are working with two different color spaces RGB and YCbCr. Work done for the proposed approaches is organized as follows. Section II describes the Block diagram of the CBIR system for the proposed approaches. Section III explains details of the performance evaluation parameters. Section IV describes the experimental set up. Experimental results and their analysis is discussed in section V. Conclusive remarks after analysis of the proposed work are given in section VI.

Manuscript Received July, 2013.

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II. CBIR: CONTENT BASED IMAGE RETRIEVAL

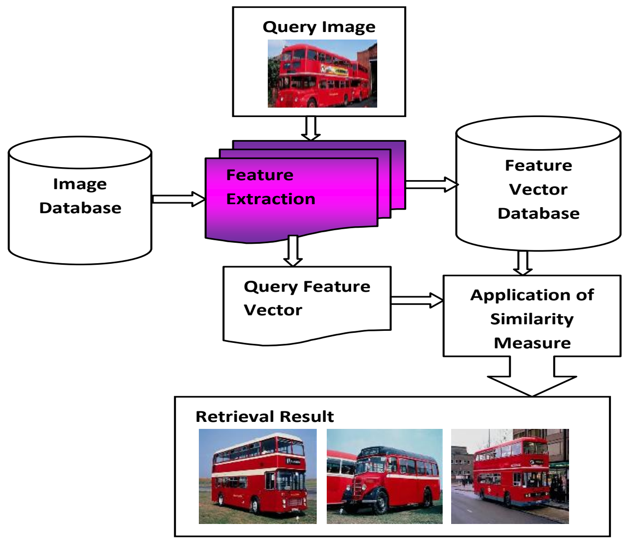

Fig. 1. Block Diagram : Content Based Image Retrieval

Fig. 1 shows the general framework applicable for all CBIR systems. The process starts from the left i.e images from the "Image database" will be read one by one and the feature extraction will be done for each of them. The feature vectors will be stored separately in a database called feature space. When query image enters into the system; feature vector for the same will be extracted and will be compared with the database feature vectors. Comparison is carried out by means of similarity measure and retrieval results will be obtained.

CBIR process in context of the method proposed in this paper is explained as follows:

Image Database: Image database contains the images from different categories and that will be used for the experimentation. We have used the database of 2000 BMP images having 20 classes, where each class has 100 images of its own category.

Feature Extraction: In CBIR systems image contents are extracted from the image and feature vector will be formed to represent that image. Image can be represented by means of single feature vector or sometimes combination of features will be used to represent that image. The most commonly used low level features are those based on color, texture, and shape of the image.

Color: Several methods for retrieving images on the basis of colour feature have been described in the literature. Color feature is easy and simple to compute. The color histogram is one of the most commonly used color feature representation in image retrieval as it is invariant to scaling and rotation.

Texture: Ability to compare the images based on texture can often be useful in distinguishing between areas of images with similar colour (such as sky and sea, or leaves and grass etc). Texture is an attribute representing the spatial arrangement of the grey levels of the pixels in a region or image. It can also be defined as repeating patterns of local variation of pixel intensities.

Shape: Shape is easy to identify according to the human perception as it is visually apparent to the user. But extracting the shape feature from the image is not that easy. Basically image segmentation techniques like region based segmentation or edge histograms are designed to obtain the shape information of the image.

In this work we are focusing on the color and texture contents of the image. Proposed feature extraction process mainly deals with the color histograms. The work has been carried out in two color spaces namely RGB color space and YCbCr. Color space is mathematical representation of the set of colors. The color spaces used are defined as follows.

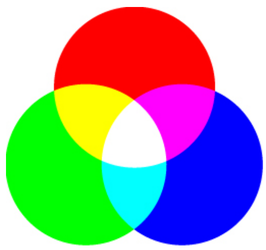

Fig.2. RGB Color Space

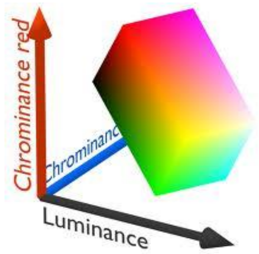

Fig.3 YCbCr Color Space

RGB Color Space: Fig.2 shows RGB color space. This is an additive color system based on tri-chromatic theory. Often found in systems that use a CRT to display images. It is device dependent and specification of colors is semi–intuitive. RGB is very common, being used in virtually every computer system as well as television etc [21].

YCbCr Color Space:

Fig.3 shows the YCbCr color space. The difference between YCbCr and RGB is that YCbCr represents color as brightness and two color difference signals, while RGB represents color as red, green and blue. In YCbCr, the Y is the brightness (luma), Cb is blue minus luma (B-Y) and Cr is red minus luma (R-Y). This color space exploits the properties of the human eye. The eye is more sensitive to light intensity changes and less sensitive to hue changes. When the amount of information is to be minimized, the intensity component can be stored with higher accuracy than the Cb and Cr components. The JPEG file format makes use of this color space to throw away unimportant information [21], [22], [23]. RGB images can be converted to YCbCr Color Space using following conversion process given in matrix form in equation 1.

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 0.2989 & 0.5866 & 0.1145 \\ -0.1688 & -0.3312 & 0.5000 \\ 0.5000 & -0.4184 & -0.0816 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (1)$$

Y component is luminance, Cb is blue chromaticity and Cr is red chromaticity. As we can notice in the YCbCr color space; it contains negative components. We thought of scaling them so that all negative components will become positive and the same is implemented and tested in this work. We are showing the images in both color spaces how they look in RGB and YCbCr color space without scaling and with scaling.

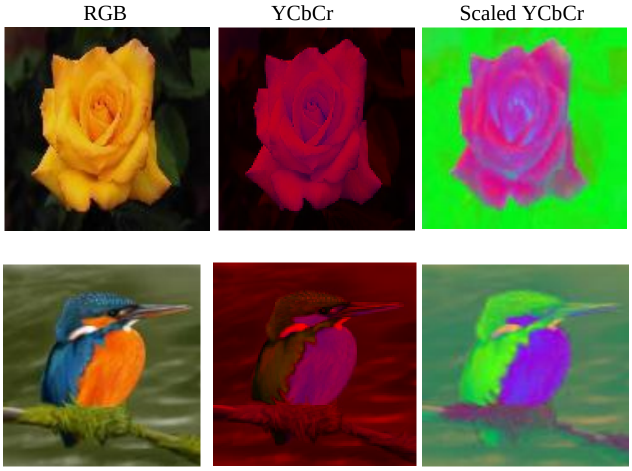

Fig. 4 Flower and Kingfisher Image in RGB (left) and YCbCr (right) without and with scaled Images

In Fig.4 we can observe the difference in the images displayed in RGB and YCbCr with and without scaling color spaces. The feature extraction process followed in this work is explained as follows. Feature extraction is based on the histograms and their partitioning into two parts which leads to generation of 8 bins. This is performed for all three color spaces RGB and YCbCr (Scaled and original).

A. Bins Formation by CG partitioning of Histograms

Very first step in the feature vector extraction is separating the image into three components as R, G and B for RGB images and Y, Cb and Cr components for YCbCr images. For each component the histogram will be calculated. Histogram is nothing but the representation of frequency of each intensity level in the image. Histograms for first component of each color spaces (R, Y and sY) are shown as sample in Fig.5.

Once the histograms are obtained we partitioned them into two parts by computing the center of gravity (CG). Each partition will get an id as 0 and 1for first and second part respectively. The CG is computed so that each partition will have equal moments around CG. This CG will be the intensity level treated as threshold for the pixels to be separated into two parts 0 and 1. This leads to the generation of bins

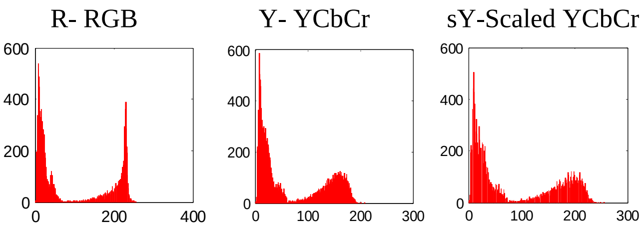

Fig.5 Histograms of first component of three color spaces

Bins Formation: CG computation can be done using equation 2. It is computed for histogram of each component (plane) of the image under feature extraction process.

$$CG = \left[\frac{(L_1W_1 + L_2W_2 + \ldots\ldots + L_nW_n)}{\sum_{i=1}^{n} W_i} \right] \quad (2)$$

Further discussion is continued with RGB color space. We partition the three components R, G and B each into two parts. Let pick up the pixel from the image under feature extraction process and check its R, G and B intensity values with the threshold (CG) intensity value. If it is less than CG in R, greater than CG in G and less than in B component then assign flag ‘010’ to that pixel. This flag determines the destination bin address for that pixel to be counted. These three planes divided in two parts each, generate 2^3=8 bins. Same process is repeated for all the image pixels and their destination bins will be indentified. This way we obtain the count of pixels into 8 bins. Initially the set of 8 bins is used as feature vector representing that image.

B. Multiple Feature Vectors Representing The Image

As discussed above, each image initially represented using the count of pixels. But this feature vector does not have the strong discrimination power which will be helpful for comparing the images for indexing and retrieval. To increase the discrimination power of the feature vector, instead of just taking the count of pixels we have computed the first four statistical moments. Moment namely Mean, Standard deviation, Skewness and Kurtosis are calculated separately the R, G and B intensities of the pixels counted into each of these 8 bins. Computation of moments is nothing but extracting the texture information of the image along with the color contents. This generates 4 moments into three color equals to 12 different types of feature vectors representing that image with good discriminating capability.

In this work, along with RGB color space this process is applied to YCbCr color space (with and without scaling) too. It generates 12 types for feature for each of them. In all total 36 feature vectors are computed for each image. After applying the feature extraction process over each image in the database, multiple feature vector databases (36) are prepared as each type of feature vector will be stored in a separate database. Many CBIR systems, it is preprocessing job to compute the feature vector for images in the database and keep ready the feature space well in advance before the query enters into the system. We are also following the same logic to prepare the feature space in advance with respect to all types of feature vectors for all images in the database [24], [25].

C. Application of Similarity Measure

The next important step in the working flow of CBIR is application of similarity measures. Similarity measure is playing important role in the system. It compares the query image feature vector with the feature vectors of database images. It actually calculates the distance between them. Images at less distance from query are tagged as relevant images and will be selected for final retrieval [26]. Three similarity measures have been used in this work in which two are dissimilarity measures that are Euclidean distance and absolute distance and third one is a similarity measure i.e. cosine correlation distance; it is quantified as cosine of the angle between two vectors. Definitions of all of them are given as follows in equations 3, 4 and 5. Last step shown in Fig.2 is the application of similarity measure which facilitates the indexing and retrieval of similar images from large databases.

Euclidean Distance

$$D_{QI} = \sqrt{\sum_{i=1}^{n} \left|(FQ_i - FI_i)\right|^2} \quad (3)$$

Absolute Distance:

$$D_{QI} = \sum_{i=1}^{n} \left|(FQ_i - FI_i)\right| \quad (4)$$

Cosine Correlation Distance

$$\frac{\langle D(n)|Q(n)\rangle}{\sqrt{\left[\langle D(n)|D(n)\rangle\langle Q(n)|Q(n)\rangle\right]}} \quad (5)$$

where D(n) and Q(n) are Database and Query feature Vectors resp.

The next phase we come across in any CBIR system is to evaluate the performance of the system. This is necessary to check the performance because it decides the potential of the system to retrieve the query relevant images. Following parameters are used here to do the same.

III. PERFORMANCE EVALUATION PARAMETERS

Application of similarity measures generates the set of images which may contain relevant as well as irrelevant images. Ideal system should generate only relevant images. To check the idealness of the system three parameters are used here, namely PRCP, LS and LSRR defined as follows.

A. PRCP

PRCP: It is termed as Precision Recall Cross over Point. It is the point in the retrieval stage where precision and recall both are same. Once we compute the distance between the query and database feature vectors we arrange them in ascending order. We are taking the count of relevant images from the first 100 images retrieved according to first 100 minimum sorted distances is giving value for precision. As we have 100 images of each class in the database recall will be the count of relevant out of 100 only and here we get the cross over point at 100 where precision and recall both will have same value. Formal definitions of precision and recall are given in equations 6 and 7 respectively.

$$Precision = \frac{Relevant\ \ Retreived\ \ Images}{All\ \ Retrieved\ \ Images} \quad (6)$$

$$Recall = \frac{Relevant\ \ Retreived\ \ Images}{All\ \ Relevant\ \ In\ \ Database} \quad (7)$$

B. LS

LS: It is termed as Longest String of relevant images. This parameter searches for the maximum continuous string of relevant images from the set of all database images sorted according the distance sorted in ascending order. It is designed to gain the CBIR user's satisfaction for fetching maximum number of relevant images. LS is expected to be as high as possible for the high potential performance of the proposed system.

C. LSRR

LSRR: LSRR is defined as Length of string to retrieve all relevant images. It can be defined as follows in equation 8.

$$LSRR = \frac{Length\ \ of\ \ string\ \ to\ \ retreive\ \ all\ \ relevant}{Total\ \ images\ \ in\ \ database} \quad (8)$$

It measures the length of traversal of all sorted database images with respect to sorted distances till we collect all images of query class from it. So LSRR should be as low as possible to prove the best performance of the system.

IV. EXPERIMENTAL SET-UP

Any new system or algorithm is being proposed experimentation is essential for it to prove the correctness and usefulness of the proposed approaches or methods. Experimentation details for the system proposed in this paper are as follows.

A. Image Database:

Image database is the essential component for experimentation and testing of CBIR system. Here we have used database of 2000 BMP images includes 20 different classes. Each class contains 100 images of its own category.. Sample database shown in Fig.6 is showing the images from RGB color space. As discussed earlier that this work is basically to check the performance of the proposed approaches in both color spaces RGB and YCbCr. We converted all the images from RGB to YCbCr. In YCbCbr also we have used two variations one is original and the other is Scaled YCbCr. This way we can say that along with the RGB image database two more databases are prepared on which the proposed methods are applied.

Fig. 6 Sample of Image Database having 20 classes.

B. Preprocessing Work

As part of experimentation the preprocessing work done in this paper is preparation of feature vector databases. As we are working with different color spaces and various types of approaches to represent the feature vectors based on color and texture information we have prepared multiple feature vector databases. According to the methods used for feature extraction each image in the database can be represented by 12 different types i.e four moments computed for three color components in one color space. This is done for all three color spaces (RGB, YCbCr, and Scaled YCbCr) and in all we have prepared total 36 types of feature vector databases as preprocessing work.

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The next part in the experimentation step is query fetch operation which is explained as follows

C. Query By Example

Once the preprocessing is done means the system is ready to fetch the query image to generate the retrieval result. There are various ways used by the researchers to input the query to the system like query by content, query by sketch or query by example etc [27]. In this work, query by example approach is used to fire the query to the system. Whenever query enters into the system a feature vector will be computed by execution of the respective algorithm. Query feature vector will be compared with the respective type of feature from the feature vector database. To check the performance of the system for all classes in the database a set of 200 query images is prepared by selecting 10 images from each of the 20 classes randomly. Same set is executed for all approaches so that their performance can be evaluated and compared.

V. RESULTS AND DISCUSSION

After execution of each individual query from set of 200 query images for all the proposed approaches is stored and analyze separately with respect to all three performance evaluation parameters PRCP, LS and LSRR and are discussed as follows.

A. PRCP

Table I. PRCP : MEAN

Separated Components	ED			AD			CD		
	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr
Plane 1	5567	5069	5302	5848	5316	5566	5651	4515	4528
Plane 2	5384	3567	5390	5485	3598	5302	5751	3981	4971
Plane 3	5264	4342	6340	5387	4258	6099	5210	4608	5431

MEAN: Observation: Out of 9 cases RGB = 5, YCbCr = 4

Table II. PRCP : STD

Separated Components	ED			AD			CD		
	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr
Plane 1	6046	4386	4686	6292	4672	4928	5604	4148	4225
Plane 2	6277	4453	5374	6422	4591	5448	6147	4386	4424
Plane 3	5700	4744	6130	5848	4888	6273	5485	4561	4594

STD : Observation: Out of 9 cases RGB = 7, YCbCr = 2

Table III. PRCP : SKEW

Separated Components	ED			AD			CD		
	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr
Plane 1	4576	3802	4213	4907	4035	4518	4330	3775	3892
Plane 2	4984	3499	4430	5264	3613	3984	4806	3463	3467
Plane 3	4799	4037	5405	5107	4196	4687	4658	3999	3957

SKEW : Observation: Out of 9 cases RGB = 8, YCbCr = 1

Table IV. PRCP : KURTO

Separated Components	ED			AD			CD		
	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr
Plane 1	6096	4736	5121	6311	4981	5310	5813	4588	4665
Plane 2	6704	4704	5512	6868	4730	5523	6344	4633	4630
Plane 3	6045	5015	6402	6191	5167	6513	5733	4932	4966

KURTO : Observation: Out of 9 cases RGB = 9

Above tables I, II, III and IV, are showing the results obtained for parameter PRCP for first four moments Mean, Standard deviation, skewness and kurtosis respectively. Each entry in the table is representing the total PRCP retrieved after adding the results of individual execution of 200 query images. i.e each value is out of 20,000. Results obtained separately for each plane of RGB, YCbCr and scaled YCbCr color spaces with respect to each similarity measure. Rows are representing the planes 1, 2 and 3 i.e. for RGB - R, G, B, YCbCr- Y, Cb , Cr and Scaled YCbCr – sYC, sCb, SCr respectively. We have analyzed these results and the best results with respect to each similarity measures are highlighted in yellow color. Observations written below each table are summarizing the comparative performances of each color space. Here we found many places RGB is better than YCbCr color space with two variations.

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Between scaled YCbCr and original YCbCr we found that original YCbCr is far better and performing equally better as RGB except few cases. We can notice the values are quite low as per the CBIR user's expectations from the better perspective. The PRCP has reached to maximum value i.e **35 %** as an average of 200 query images. To improve these results further we thought of combining them by applying OR operation over results obtained separately for each plane or component of the respective color space. After executing the OR operation e.g. **OR** ('R' 'G' 'B'), **OR**('Y' 'Cb' 'Cr') and **OR**('sY' 'sCb' 'sCr') results obtained for all four moments with respect to each similarity measure are shown in following table V.

Table V. PRCP RESULTS for OR ('R' 'G' 'B'), OR('Y' 'Cb' 'Cr') and OR('sY' 'sCb' 'sCr')

	ED			AD			CD		
Moments	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr	RGB	S-YCbCr	YCbCr
MEAN	8859	9035	10598	9192	9206	10503	8914	8836	9482
STD	10256	9209	10620	10404	9437	10744	9989	8928	9034
SKEW	9248	8330	9915	9522	8584	8950	8844	8300	8369
KURTO	10678	9712	11099	10826	9868	11202	10218	9605	9632

Observation: Out of 12 cases RGB = 4, YCbCr = 8

Chart 1: LS for RGB, Scaled YCbCr and YCbCr Moments

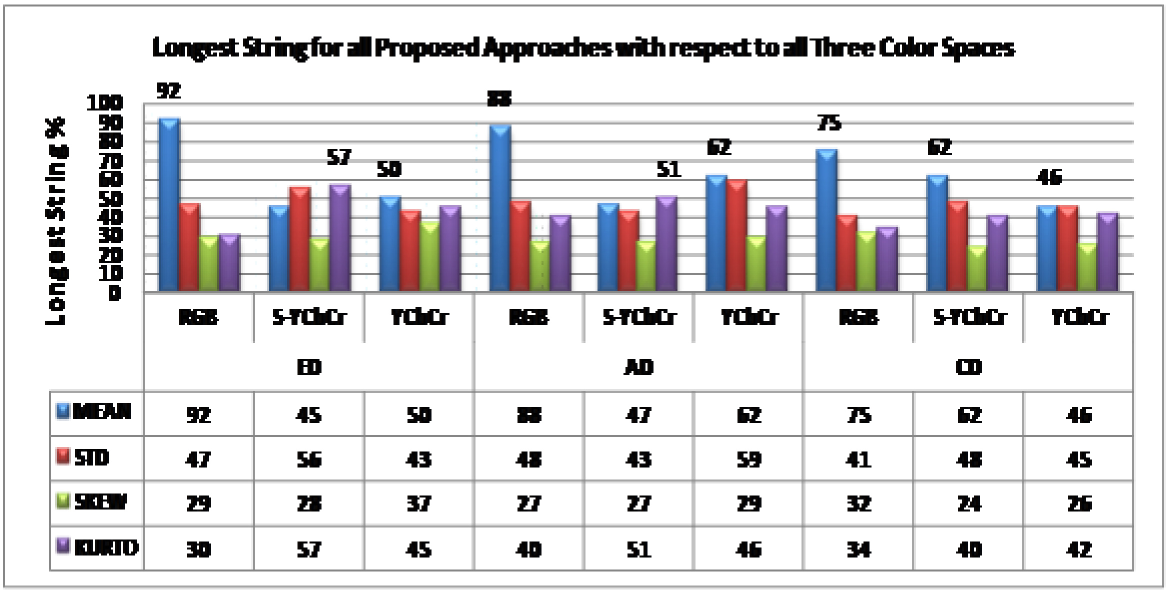
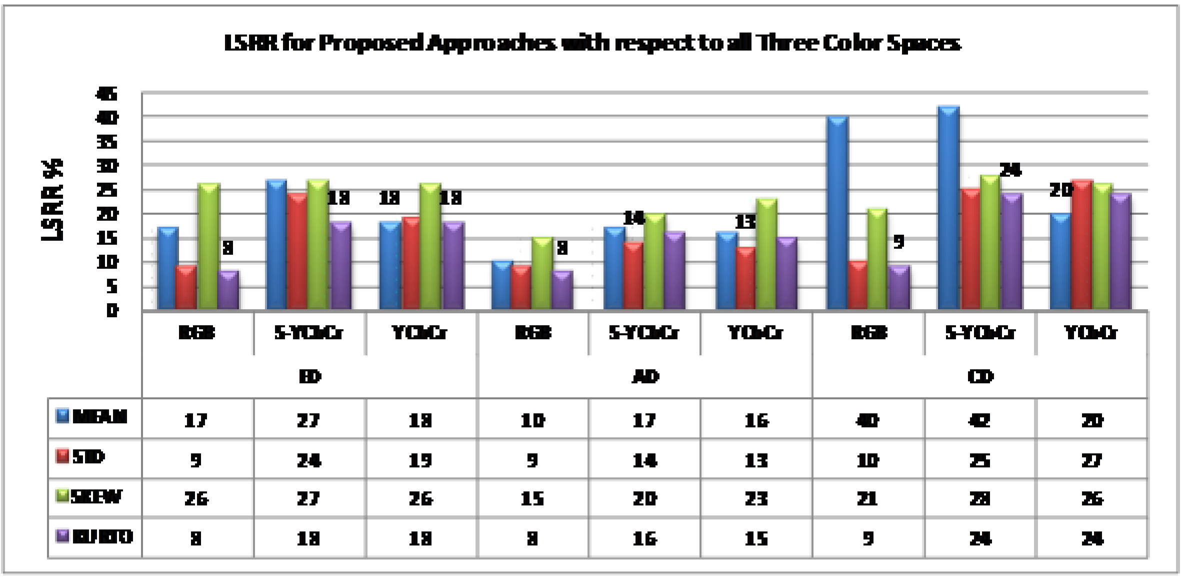


Chart 2: LSRR for RGB, Scaled YCbCr and YCbCr Moments



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In above table V, we can observe that after applying the OR operation the results are reached to quite good height in terms of PRCP. Each value is representing out of 20,000 i.e total retrieval at execution of 200 query images. In above results when we analyzed them with respect to color space for each similarity measure, we found scaled YCbCr is not performing well. Between RGB and YCbCr; it has been observed that out of total 12 cases, at 8 cases we found YCbCr is far better than RGB color space. Best results are highlighted in pink color as shown in table V. We can notice that the maximum PRCP obtained is 11,202 out of 20,000; means the PRCP has reached to 56% **,** which is very good achievement as an average result of 200 query images in the CBIR field

B. LS: Longest String

This parameter identifies the continuous longest string of relevant images from the entire set of database images sorted according to minimum to maximum distance with query image. Results obtained for LS are shown in Chart1. Analysis of these results indicates that in terms of longest string we found RGB is giving quite better height in LS upto 92. In scaled YCbCr it has reached to 57 where as in YCbCr maximum LS obtained is 62. Overall performance of all three color spaces is equally good in terms of LS. Highest values of each color space with respect to three similarity measures are shown with the data labels in the chart 1.

C. LSRR: Length of String to Retrieve all Relevant

It computes the length of traversal required to collect all the relevant images from the database for the given query. This traversal is carried out on the sorted set of images. Images are sorted according to the distance they are at from the query image. Less is the traversal time faster is the retrieval of all relevant images from the large size database. As traversal becomes lengthy it indicates the worst case performance of the system as it takes longer time to collect the query relevant images from the database. Results obtained for LSRR in this work are the traversal length computed across string of 2000 images. It is given in percentage. LSRR results obtained for all 200 query images selected for testing all the proposed approaches. Here we have shown the minimum LSRR obtained with respect to each parameter (similarity Measure, Color Space, moments and color component) taken into consideration. Chart 2 shows the LSRR results. In LSRR we are interested in minimum values only. The best results for each color space for each similarity measure are shown with data labels. The minimum LSRR obtained for RGB is 8%, whereas for scaled YCbCr it is 18% and for original YCbCr the minimum LSRR obtained is 13% of 2000.

VI. CONCLUSION

Proposed CBIR system discussed in this paper is actually focusing on the performance of RGB, scaled YCbCr and original YCbCr color spaces with bins approach. Based on the work done with this objective following conclusive remarks can be drawn.

CBIR based on bins approach is achieving the feature vector dimension reduction to just 8 bins instead of 256 bins of histogram. It reduces the computational complexity and speeds up the retrieval. Second element on which the computational complexity depends is the similarity measure used by the system for query image comparison with database images. Here three similarity measures are used and the best results are obtained by absolute distance i.e AD, which takes less computation and produces far better results as compared to other two similarity measures ED and CD .

First four moments Mean, standard deviation, skewness and kurtosis computed for each color component separately in all three color spaces proving the best use of texture feature. Here performance of even moments is far better than that of odd moments.

Results are computed for each color component of respective color space separately. It has reached to maximum Precision and recall values at 35%**;** which is further improved to good extent and reached to **56%** as an average of 200 query images. This is quite good achievement in this filed.

This best PRCP obtained is for YCbCr color space (better as compared (RGB and Scaled YCbCr spaces). This can be interpreted as precision and recall both are **above 50%** as an average for 200 query images from 20 different classes of the database.

LS and LSRR parameters are proving the system's potential to retrieve maximum number of images relevant to query with less time. The best values obtained for LS and LSRR are 92 (out of 100 images of that class in the database) and 8% traversal of 2000 images in the database respectively. It can be interpreted that out of 100 we could retrieve 92 images from the database for the given query. 8% traversal of 2000 i.e system just travels till 160^{th} image and makes the recall = 1.

Finally we can say that bins approach can be implemented efficiently and effectively in RGB as well as YCbCr color space where YCbCr is found to be better as compared to RGB.

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