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Content Based Image Retrieval using Color and Shape Features

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Abstract: This paper proposes, a method is used for Content-Based Image Retrieval (CBIR) using color and shape features. Active research in CBIR is geared towards the development of methodologies for analyzing, interpreting, cataloging and indexing image databases. In addition to their development, efforts are also being made to evaluate the performance of image retrieval systems. The quality of response is heavily dependent on the choice of the method used to generate feature vectors and similarity measure for comparison of features. The speed of shape based retrieval can be enhanced by considering approximate shape rather than the exact shape. In addition to this a combination of color and shape based is also included to improve the accuracy of the result. We have implemented the CBIR system which takes into consideration the low level features of image which is more comprehensive when compared to high level features. Here the distance between database images and query image in found and the images with minimum distance will be displayed as output. For Shape Based Image Retrieval, the retrieved images are displayed based on the similarity of the shape of object in image with the shape of query image shape. The images are ranked depending on the similarity using Euclidean Distance i.e. more similar images are displayed at the top and the images with less similarity will be displayed later. From the comparison of Color Based Image Retrieval and Shape Based Image Retrieval result, we notice that the accuracy of Shape Based Image Retrieval is more than the accuracy of Color Based Image Retrieval. Though the complexity of Shape Based Image Retrieval is more than the Color Based Image Retrieval, Shape Based Image Retrieval consumes less time and gives more accuracy in retrieved results.

Keywords: CBIR, Shape Based Image Retrieval, Color Based Image Retrieval, Euclidean Distance.

I. INTRODUCTION

CBIR is the process of retrieving images from a database or library of digital images according to the visual content of the images. In other words, it is the retrieving of images that have similar content of colors, textures or shapes[5]. In CBIR system, it is usual to group the image features in three main classes: color, texture and shape. Ideally, these features should be integrated to provide better discrimination in the comparison process [1]. Color is by far the most common visual feature used in CBIR, primarily because of the simplicity of extracting color information from images [3]. To extract information about shape and texture feature are much more complex and costly tasks which are usually performed after the initial filtering, provided by color features.

In this paper we describe a color-based method for comparing images which are similar to color histograms, but which also takes spatial information into account. We begin with a review of color histograms. Then describe CCV's and how to compare them. Examples of CCV-based image queries demonstrate that they can give superior results [4]. Finally, we present some possible extensions to CCV's. This paper also presents an approach to retrieve images through an automatic segmentation technique. This allows us to get approximate information about the shape of the regions in the images. Shape description or representation is an important issue both in object recognition and classification. Many techniques, including chain code, polygonal approximations, curvature.

In this algorithm, the given image is first segmented into dominant components and then the features of these components are extracted to perform retrieval. The features corresponding to each component are used to calculate the distance between components in the matching process.

A. RBG Color space

An RGB color space can be understood by thinking of it as all possible colors that can be made from three colored lights for red, green, and blue [8]. Imagine, for example, shining three lights together onto a white wall in a dark room: one red light, one green light, and one blue light, each with dimmers. If only the red light is on, the wall will be red. If only the green light is on, the wall will look green. If the red and green lights are on together, the wall will look yellow. Dim the red light and the wall will become more of a yellow-green. Dim the green light instead, and the wall will become more orange. Bringing up the blue light a bit will cause the orange to become less saturated and more whitish. In all, each setting of the three dimmers will produce a different result, either in color or in brightness or both. The set

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of all possible results is the gamut defined by those particular color lamps. Swap the red lamp for one of a different brand that is slightly more orange, and there will be a slightly different gamut, since the set of all colors that can be produced with the three lights will be changed.
For the RGB model, this is represented by a cube using non-negative values within a 0–1 range, assigning black to the origin at the vertex (0, 0, 0), and with increasing intensity values running along the three axes up to white at the vertex (1, 1, 1), diagonally opposite black.

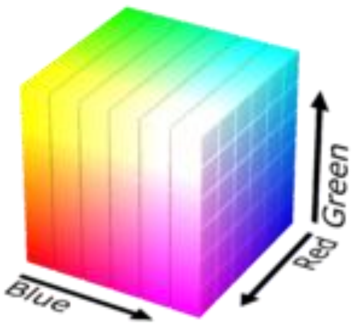

Fig.1. RGB Color model

An RGB triplet (R, G, B) represents the three-dimensional coordinate of the point of the given color within the cube or its faces or along its edges. This approach allows computations of the color similarity of two given RGB colors by simply calculating the distance between them: the shorter the distance, the higher the similarity[13]. Out-of-gamut computations can also be performed this way.

B. HSV Color space
HSV color space is preferred for manipulation of hue and saturation to shift colors or adjust the amount of color) since it yields a greater dynamic range of saturation [6]. The hue (H) of a color refers to which pure color it resembles. All tints, tones and shades of red have the same hue.
Hue is described by a number that specifies the position of the corresponding pure color on the color wheel, as a fraction between 0 and 1 [7]. Value 0 refers to red; 1/6 is yellow; 1/3 is green; and so forth around the color wheel.The saturation (S) of a color describes how white the color is. A pure red is fully saturated, with a saturation of 1; tints of red have saturations less than 1; and white has a saturation of 0.The value (V) of a color, also called its lightness, describes how dark the color is. A value of 0 is black, with increasing lightness moving away from black.This diagram, called the single-hex cone model of color space, can help you visualize the meaning of the H, S, and V parameters.

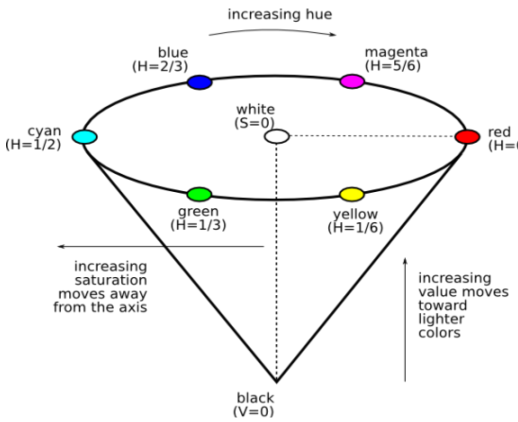

Fig.2. HSV Color model

The outer edge of the top of the cone is the color wheel, with all the pure colors. The H parameter describes the angle around the wheel [9].The S (saturation) is zero for any color on the axis of the cone; the center of the top circle is white. An increase in the value of S corresponds to a movement away from the axis.The V (value or lightness) is zero for black. An increase in the value of V corresponds to a movement away from black and toward the top of the cone.The Ostwald diagram corresponds to a slice of this cone. For example, the triangle between red, white, and black is the Ostwald diagram for the varieties of red.

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II. METHODOLOGY

A. CBIR DEFINATION

Content Based Image Retrieval is an application for retrieving the images from a huge set of image databases based on the image features such as color, texture and some other attributes. Here we take image feature as the index to that image and retrieve that particular image. Retrieve similar images using Euclidean Distance.
The above mentioned methods are implemented in Matlab 7 and have been successfully run.

B. BLOCK DIAGRAM OF CBIR

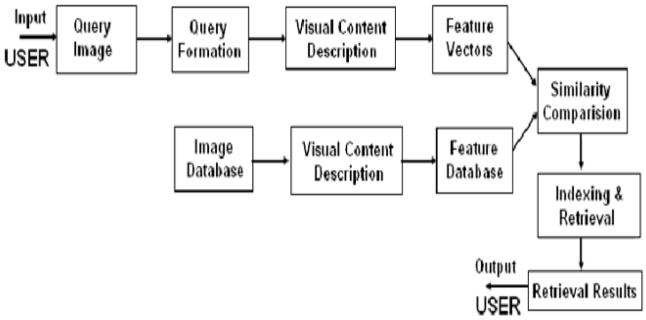

Fig. 3. Block diagram of CBIR

Image the user enters in order to obtain information and get retrieved images similar to it. Query image is also known as input image. Different implementations of CBIR make use of different types of user queries.Query by example is a query technique that involves providing the CBIR system with an example image.
Options for providing example images to the system include:

- A preexisting image may be supplied by the user or chosen from a random set.
- The user draws a rough approximation of the image they are looking for, for example with blobs of color or general shapes.

An organized collection of digital images aimed at the efficient management and the processing of queries is done on this image collection. Image databases vary significantly in ease-of-use and level of functionality. They keep track of your files, provide search and retrieval functions.
Visual content can be very general or domain specific. General visual content include color, texture, shape, spatial relationship, etc. Domain specific visual content, like human faces, is application dependent and may involve domain knowledge. A visual content descriptor can be either global or local. A global descriptor uses the visual features of the whole image, whereas a local descriptor uses the visual features of regions or objects to describe the image content.

C. Color Feature

For the initial process of histogram matching, we use the HSV color space. The HSV color space is preferred for manipulation of hue and saturation (to shift colors or adjust the amount of color) since it yields a greater dynamic range of saturation [12]. Figure4 illustrates the single hex cone HSV color model. The top of the hex cone corresponds to V = 1, or the maximum intensity of colors. The point at the base of the hex cone is black and here V = 0. Complementary colors are 180° opposite one another as measured by H, the angle around the vertical axis V, with red at 0°. The value of S is a ratio, ranging from 0 on the center line vertical axis V to 1 on the sides of the hex cone. Any value of S between 0 and 1 may be associated with the point V = 0. The point S = 0, V = 1 is white. Intermediate values of V for S = 0 are the grays. Note that when S = 0, the value of H is irrelevant. From an artist's viewpoint, any color with V = 1, S = 1 is a pure pigment whose color is defined by H. Adding white and black corresponds to decreasing S without changing V and corresponds to decreasing V without changing S respectively. Tones are created by decreasing both S and V.

Unlike general techniques of forming bins we divide the color space into parts depending on perception. Color coherence vector is double color histograms which consist of coherent vector and incoherent vector. We define a color's coherence as the degree to which pixels of that color are members of large similarly-colored regions. We refer to these significant regions as coherent regions, and observe that they are of significant importance in characterizing images. Our coherence classifies pixels as either coherent or incoherent. Coherent pixels are a part of some sizable contiguous region, while incoherent pixels are not.

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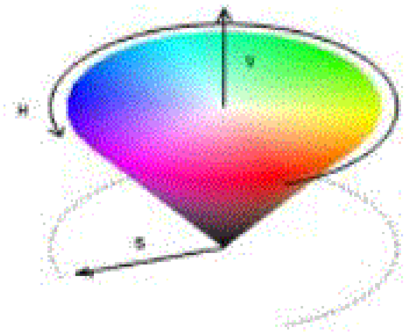

Fig.4.HSV cone

A color coherence vector represents this classification for each color in the image. This notion of coherence allows us to make fine distinctions that cannot be made with simple color histograms. The initial stage in computing a CCV is similar to the computation of a color histogram.
First blur the image slightly by replacing pixel values with the average value in a small local neighborhood including the 8 adjacent pixels. The next step is to classify the pixels within a given color bucket as either coherent or incoherent. A coherent pixel is part of a large group of pixels of the same color, while an incoherent pixel is not. After words determine the pixel groups by computing connected components. When this is complete, each pixel will belong to exactly one connected component.
Classify pixels as either coherent or incoherent depending on the size of its connected component. A pixel is coherent if the size of its connected component exceeds a fixed value τ; otherwise, the pixel is incoherent. For a given discredited color, some of the pixels with that color will be coherent and some will be incoherent. Let us call the number of coherent pixels of the j^{th} discrete color αj and the number of incoherent pixels βj. Clearly, the total number of pixels with that color is $\alpha j + \beta j$, and so a color histogram would summarize an image as

$$(\alpha_1 + \beta_1 + \ldots\ldots\ldots\ldots + \alpha_n + \beta_n) \quad (1)$$

Instead, for each color we compute the pair $(\alpha j, \beta j)$ which we will call the coherence pair for the j^{th} color. The color coherence pairs vector for the image consists of $((\alpha_1, \beta_1), \ldots\ldots, (\alpha_n, \beta_n))$. Classification of coherence is determined by a fixed value τ. Each pixel is checked whether coherent or not. A pixel is coherent if its surrounding pixels have the same values to form a large contiguous region.

D. Shape Feature

Shape is an important visual feature and it is one of the basic features used to describe image content. However, shape representation and description is a difficult task. This is because when a 3-D real world object is projected onto a 2-D image plane, one dimension of object information is lost. As a result, the shape extracted from the image only partially represents the projected object. To make the problem even more complex, shape is often corrupted with noise, defects, arbitrary distortion and occlusion. Further it is not known what is important in shape. Current approaches have both positive and negative attributes.
These shape parameters are Mass, Center of gravity(Centroid), Mean, Variance, Dispersion, Axis of least inertia, Digital bending energy, Eccentricity, Circularity ratio, Elliptic variance, Rectangularity, Convexity, Solidity, Euler number, Profiles, Hole area ratio, etc. Some of these are described as follows. Mass is the no. of pixels in one class. It is given as

$$\text{Mass}=\sum_{x, y} h(x, y) \quad (2)$$

Where, $h=\begin{cases} 1, & \text{if } s(x,y) \in C \\ 0, & \text{if } s(x,y) \in C \end{cases}$

Centroid is also called as the center of mass; h is a mask of cluster C, over image S(x, y). The co-ordinates (x_c, y_c) of the Centroid are defined as

$$x_c==\sum_{x, y} x*h(x, y)/\text{mass} \quad (3)$$
$$y_c==\sum_{x, y} y*h(x, y)/\text{mass} \quad (4)$$

The mean and variance features of the class c are computed over the original image I considering the resulting segmentation S, and they are respectively denoted by μ_c and $\sigma_c^{\,2}$

$$\mu_c =\sum_{x, y} I_{x, y} *h_c(x, y)/\text{mass} \quad (5)$$
$$\sigma_c^{\,2}==\sum_{x, y}(I_{x, y} - \mu_c)* h_c(x, y)/\text{mass} \quad (6)$$

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Dispersion is the sum of the distances of each region of a class from the class Centroid. The distance is calculated by Euclidean distance formula. The dispersion can be given as

$$Disp=\sum_I dist\ (O_c, O_{i,c}) \qquad (7)$$

Where, $=\sum_I dist\ (O_c, O_{i,c})$ is the Euclidean distance
Oc= centroid of the class c
Oi,c= centroid of region I of class c

E. FEATURE VECTOR
1) Color Feature Vector:

- In the first stage, Histogram based comparison is done and matching images are short listed. Color histograms are a popular solution to retrieve similar images, the histogram describes the gray-level or color distribution for a given image, they are computationally efficient, but generally insensitive to small changes in camera position. A color histogram provides no spatial information; it merely describes which colors are present in the image, and in what quantities. In addition, color histograms are sensitive to both compression artifacts and changes in overall image brightness.
- In the second stage, the Color Coherence Vectors of the short listed images (stage 1) are used to refine the results. Numbers of coherent and non-coherent pixels for all color intensities are calculated in the image. Then size of coherency array, coherency array and no. of coherency pixels are stored as a vector.

2) Shape Feature Vector:

- The proposed shape retrieval system based on the automatic segmentations process to get approximate information about the shape of an object. It begins with 4 classes in image. Then three attributes: Mass, Centroid and Dispersion for each class are calculated and stored as the shape vector.

F. SIMILARITY COMPARISON
1) Color Based Similarity Measure:
In this algorithm we propose that matching is done on color by color basis. Retrieval result is not a single image but a list of images ranked by their similarities with the query image since CBIR is not based on exact matching. If I is the database image and I' is the query image, then the similarity measure is computed as follows,

- Calculate histogram vector vI = [vI1, vI2…..vIn] and ccv vector cI = [cI1, cI2…….cIn] of the database images.
- Calculate the vectors vI' and cI' for the query image also.
- The Euclidean distance between two feature vectors can then be used as the similarity measurement. It is given as

$$d=\sqrt{\sum_{i=1}^{n}(v1_i + v1'_i)^2} \qquad (8)$$

It operates by assuming each vector as a point in an n-dimensional vector space and computes the physical distance between the 2 points.

2) Shape Based Similarity Measure:
- Segmenting the query image into 4 classes
- Mass, centroid and dispersion parameters are calculated for each class.
- These features are compared with database images stored features
- Calculate the Euclidean distance between the respective classes of query image and database image attributes.

III. IMPLEMENTATION

A. Color Based Image Retrieval
- If $d \leq \tau$ (threshold) then the images match.
- The retrieved are ranked based on the similarity between images after comparison.
- From all the matching images we display top 24 images as a result.

B. Shape Based Image Retrieval
The features values which are less than defined threshold are sorted based on increasing difference between query and database images then stored separately.

C. ALGORITHM OF COLOR RETRIEVAL
Step1: Read the image

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Step2: Convert from RGB to HSV
Step3: Find HSV histogram and create vectors v1.
Step4: Read the vectors from database and compare one by one by one with vector v1.
Step5: Shortlist all the images which fall within the threshold.
Step6: find coherency of the query image for each color and create coherency vector c1.
Step7: Compare coherency vectors of all the short listed images from step5 with c1.
Step8: Store all matching images in results folder and also display them.

D. ALGORITHM OF SHAPE RETRIEVAL
Step1: read the image
Step2: convert it from RGB to grayscale
Step3: determine the range and number of classes.
Step4: calculate the number of pixels i.e. mass belonging to each class.
Step5: calculate the centroid and dispersion for each class.
Step6: compare centroid of each class of query image with the centroids of each class from database image and extract out that class.
Step7: compare that class's mass and dispersion with respective class.
Step8: increase the count if it satisfies certain threshold.
Step9: consider second class and repeat steps 6-8 till all classes get over.
Step10: take another image from the database and repeat the comparison.
Step11: display the images with maximum count.

IV. RESULTS AND DISCUSSIONS

Both color and shape retrieval algorithms are implemented in MATLAB with the database of 570 images. All the images are stored in JPEG format with size 384 × 256 or 256 × 384. There are six different categories; which includes 100 horse, 100 rose, 100 dinosaur, 100 bus, 100 elephants and 70 bikes. To evaluate the performance of the image retrieval algorithm we use the two most well-known parameters; precision and recall.

$$\text{Precision} = \frac{\text{retrieved relevant images}}{\text{total no.of images retrieved}} \qquad (9)$$

$$\text{Recall} = \frac{\text{retrieved relevant images}}{\text{all relevant images in database}} \qquad (10)$$

The system is executed with 10 images from each of the six categories and calculated the average precision and average recall parameters for all of them. The results obtained using shape and color based for different category of images is shown in Table1. Retrieval result images with query image of shape and color based are shown in Figure 6a-6c and 7a-7c respectively. In table1 average accuracy of the proposed method is about more than 70 % which is much greater than the histogram based method.

This CBIR system is implemented in Matlab and SQL is used as a backend tool for database creation and management. When user starts using this system first, they are directed to GUI window where they get an option to select whether they want to search or they want to insert into database. In both the windows they will have the option of selecting the one of the implemented methods. In the search window they will have an option of browsing the image they want to search and that very image will be displayed on the screen.

Once user browses the image they will have to select one of the options for searching either for color or gray image. Once they select the option there are two possibilities, either they will get the relevant images if it is available in database otherwise they will get a dialogue box stating "no images to display".

TABLE1 COLOR AND SHAPE BASED IMAGE RETRIEVAL PRECISION AND RECALL ANALYSIS

Category	Shape		Color	
	Precision	Recall	Precision	Recall
Rose	0.875	0.18	0.76	0.18
Bus	0.8	0.13	0.91	0.22
Nature	0.78	0.06	0.71	0.15
AVG	0.81	0.12	0.79	0.18

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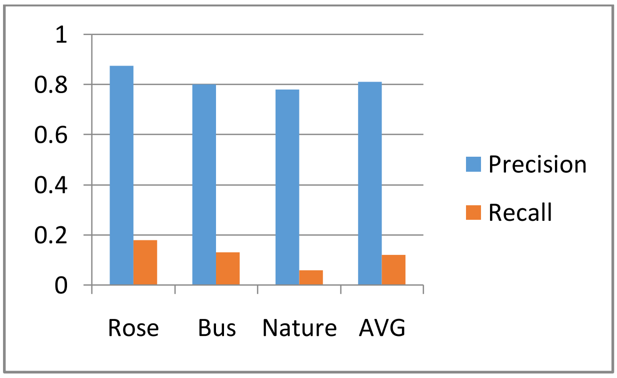

Fig. 5. Graphical Representation of Shape Based Image Retrieval Precision and Recall Analysis

In the above Figure 5, we observe that the precision of rose is the greatest among all other database images. Precision of Bus is moderate whereas the precision of nature is lowest among all. The category with higher precision gives better result. Rose has more accuracy due to highest Precision in Shape based Retrieval.

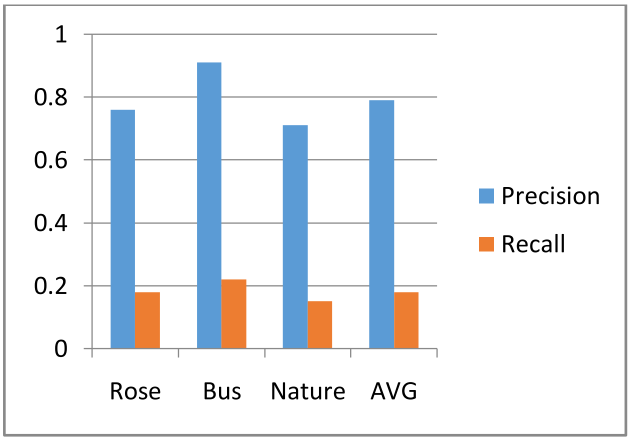

Fig.6. Graphical Representation of Color Based Image Retrieval Precision and Recall Analysis

In the above Figure6, we observe that the precision of Bus is the greatest among all other database images. Precision of Rose is moderate whereas the precision of Nature is lowest among all. The category with higher precision gives better result. Rose has more accuracy due to highest Precision in Color based Retrieval.

For Color Based Image Retrieval, the retrieved images are displayed based on the similarity of their color with the query image color. The images are ranked depending on the similarity using Euclidean Distance i.e. more similar images are displayed at the top and the images with less similarity will be displayed later.

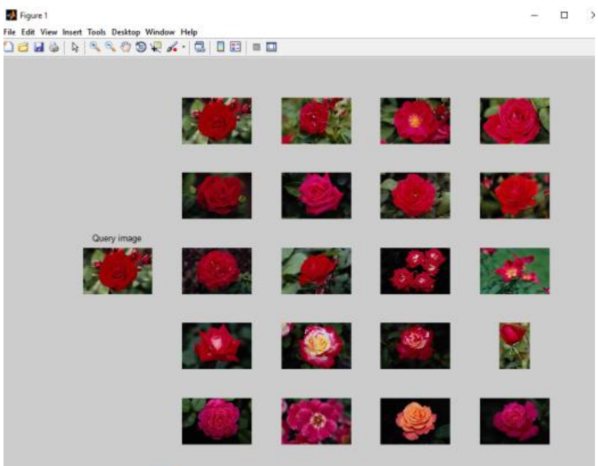

Fig.7a. Result of Color Based Image Retrieval for Rose

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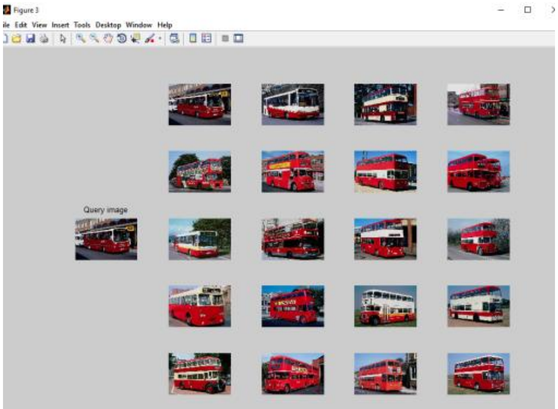

Fig. 7b. Result of Color Based Image Retrieval for Bus

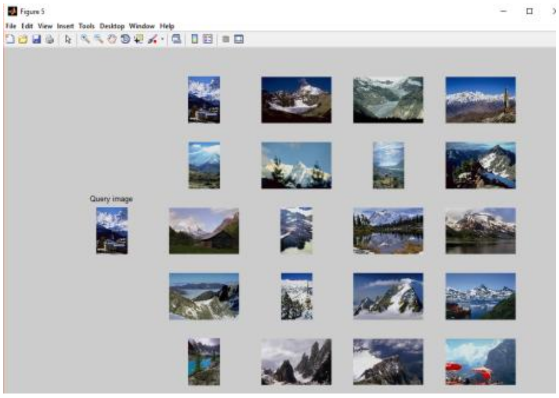

Fig. 7c. Result of Color Based Image Retrieval for Nature

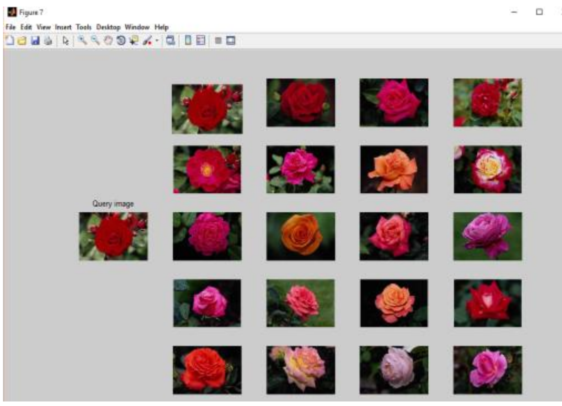

Fig. 8a: Result of Shape Based Image Retrieval for Rose

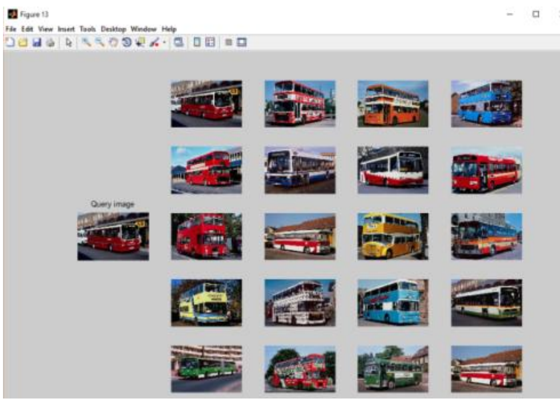

Fig. 8b: Result of Shape Based Image Retrieval for Bus

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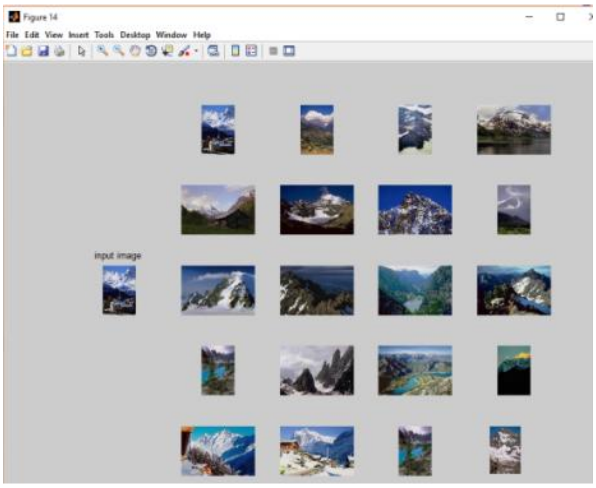

Fig.8c: Result of Shape Based Image Retrieval for Nature

For Shape Based Image Retrieval, the retrieved images are displayed based on the similarity of the shape of object in image with the shape of query image shape. The images are ranked depending on the similarity using Euclidean Distance i.e. more similar images are displayed at the top and the images with less similarity will be displayed later. From the comparison of Color Based Image Retrieval and Shape Based Image Retrieval result, we notice that the accuracy of Shape Based Image Retrieval is more than the accuracy of Color Based Image Retrieval. Though the complexity of Shape Based Image Retrieval is more than the Color Based Image Retrieval, Shape Based Image Retrieval consumes less time and gives more accuracy in retrieved results

V. CONCLUSION AND FUTURE SCOPE

The purpose of this paper was to improve the accuracy (precision) of a CBIR application by allowing the system to retrieve more images similar to the source image. Also each new algorithm is always seen to have certain reasons where it works best and poor. We have implemented the CBIR system which takes into consideration the low level features of image which is more comprehensive when compared to high level features. Here the distance between database images and query image in found and the images with minimum distance will be displayed as output. For Shape Based Image Retrieval, the retrieved images are displayed based on the similarity of the shape of object in image with the shape of query image shape. The images are ranked depending on the similarity using Euclidean Distance i.e. more similar images are displayed at the top and the images with less similarity will be displayed later. From the comparison of Color Based Image Retrieval and Shape Based Image Retrieval result, we notice that the accuracy of Shape Based Image Retrieval is more than the accuracy of Color Based Image Retrieval. Though the complexity of Shape Based Image Retrieval is more than the Color Based Image Retrieval, Shape Based Image Retrieval consumes less time and gives more accuracy in retrieved results.

Developments and studies are going on for further improvements in design and performance of "CONTENT BASED IMAGE RETRIEVAL SYSTEMS". This research work improves the understanding of various techniques for feature extraction and similarity measurement.

A. Suggested future enhancements are as follows:
- Extraction of texture feature and its incorporation in the CBIR algorithms.
- Incorporation of indexing techniques for faster query response.
- The fine-tuning may be done adding some texture information in well-determined form with the already existing color and shape information to suit the application.
- This work can be further extended to some domain-based applications such as finger print recognition, retina identification, and object detection etc. for large image database.

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