www.ijecs.in
International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 2 Issue 12 Dec,2013 Page No. 3465-3471

An Enhanced Content Based Image Retrieval System using Color Features

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Abstract: ***This paper was motivated by the desire to improve the effectiveness of retrieving images on the basis of color content by Color Averaging technique. In this paper, a combined set of methods based on color averaging technique is proposed to achieve higher retrieval efficiency and performance. Firstly, an average mean based technique with reduced feature size is proposed. Secondly, a feature extraction technique based on central tendency is proposed. The proposed CBIR techniques are tested on Wang image database and indexed image database. Results obtained are compared with the existing technique based on memory utilization and query execution time. The experimental results show that proposed technique gives the better performance in terms of higher precision and recall values with less computational complexity than the conventional techniques.***

Keywords: average mean, central tendency, precision, recall**.**

1. Introduction

Information Retrieval is a field of knowledge that deals with the representation, storage and access to information data. When the retrieved information is in the form of images, this field of knowledge is called Image Retrieval [15,18]. The origin of Image Retrieval can be traced back to 1979 where a conference on Database Techniques for Pictorial applications was held in Florence [3]. Since, then the application potential of image database management technique has attracted the attention of researchers. Retrieval of query-relevant images from exponentially increasing digital image database is a challenging need of today. Many web-search-engines retrieve query similar images by searching and matching textual metadata associated with digital images. For better precision of the retrieved resultant images, this type of search requires associating meaningful image-descriptive-text-labels as metadata to all images of the database. Manually annotating every single image in the exponentially increasing image database is a tedious task and it poses several limitations like semantic gap, human perception, image annotation and problem of deeper needs.

Semantic gap is the difference between the human perception of a concept and machine level representation. It is the lack of coincidence between the information that one can retrieve from a given image and the interpretation that the same image have for a user in a given situation. Moreover manual annotation is an expensive and time consuming process as it requires human involvement for annotating an image. In 1997, a new concept of retrieval known as Content Based Image Retrieval (CBIR) based on the visual features of an image was proposed with a constraint to address the limitations of manual annotation and to provide fully automatic search tool to save time. CBIR is an application of computer vision to image retrieval problem. It is a concept of searching digital images from large collection of image database based on the content of an image.

Content based image retrieval techniques aim to respond to a query image (or sketch) with query-similar images obtained from the digital image database. The database images are pre-processed for extracting the features of images and then storing – indexing corresponding image features. The query image is processed at the query execution time for extracting features which are compared with feature image database by applying appropriate similarity measures for retrieving query similar-images.

One of the major issues for CBIR system lies in incorporating versatile techniques to process images of diversified characteristics and categories. Currently, various algorithms are available for processing of low level features and matching the images from database. The performance of these algorithms is based on various factors like background complication, image resolution, illumination variations, viewing angle, non homogeneity of intra and inter-region textures etc.

One of the most important technical challenges faced by today information technology experts lies in storing and indexing image data. Due to tremendously increasing image database size and with the continuous inflow of images into digital libraries an effective and efficient image retrieval system is required. Image indexing is studied in the perspective of image database as one of the promising and important research area for researchers from disciplines like computer vision, image processing, pattern recognition and database areas. The hunger of superior and faster image retrieval techniques is increasing day by day.

CBIR technology is now beginning to move out of the laboratory and is now available in market, in the form of commercial products like QBIC [12] and WALRUS [12].The applications for CBIR technology includes biometrics, satellite image analysis, photo collections[19], museum images, logos, surveillance, TV news processing, 3D images , weather forecast, financial , sales, economic series, medical monitoring like EEG, ECG etc., civil infrastructure, automobile traffic monitoring, fashion designing, archaeology, architecture design, fabric design, geographic information systems, weed identification in agriculture, environment monitoring, trademark databases, cartoon database, criminal investigations, forensic, image search on the Internet.

2. Content Based Image Retrieval

Content Based Image Retrieval is the retrieval of images based on visual features such as color, texture and shape. It is used for automatic indexing and retrieval of images depending on the contents of images known as features. The features may be low level or High level. The low level features include color, texture and shape. The high level feature describes the concept of human brain. Reasons for its rapid growth in today's market is that in many large image databases, the conventional method [8] of image indexing have proven to be insufficient, laborious, time consuming and expensive. The elderly methods [3] of image indexing, starting from storing an image in the database to tagging it with an accurate keyword or number and associating it with a semantic description have become obsolete. In CBIR, every image that is stored in the database has its features extracted and compared to the features of the query image. It involves two modules:

- Feature Extraction: The first step in the process is extracting image features to a distinguishable extent. The features include color, texture and shape.
- Matching: The next step involves matching these features to yield a result that is visually similar. Matching is based on the distance measures.

3. Related Work

Content based image retrieval for general-purpose image database is a highly challenging problem because of various issues like increasing database size, difficulty of formulating a query, complexity of understanding images both by people and computers and the issue of evaluating results.

Bhalke [3] briefly gave an overview of retrieving images from a large database. The paper explained about the low level features and high level semantics of CBIR and the possible ways to reduce the semantic gap. Here color histogram, color mean, color structure descriptor are used for feature extraction and similarity measure was based on Euclidean distance.

Zauner [6] explained an image identification system implemented by combining block mean value based image hash function together with Marr-Hildreth operator based function. The block mean value based function would process the images in the first cycle. The candidates it identifies would then be passed on to Marr-Hildreth operator based function. The image identification system gives excellent performance in terms of speed and posses a great discriminative capability. Still the Marr-Hildreth operator function would itself be a limiting factor in terms of robustness of the identification system.

Kumar [2] developed a content based image retrieval system using hierarchical and k-means clustering technique. Images are initially clustered into groups having similar color content and the preferred group is clustered using k-means. Hierarchical clustering assists faster image retrieval and allows the search for most relevant images in large image databases. Since each cluster obtained is a unique set of similar images, the user can select an image set of their choice and further refine the search by applying k-means algorithm. A major challenge involved here lies in the selection of initial partition of cluster, which is done random as a result it poses a threat of converging at a local minimum of the criterion value than converging at a global optimum value.

Shih and Chen [16] used partition-based color-spatial technique where an image is divided into 100 blocks. For each block, the first three color moments of each color component is extracted and clustered into several classes based on a clustering algorithm. The mean vector of each cluster is regarded as primitive of the image. This can be considered quite a simple approach; however it is not suitable for certain images containing background occupying a large area of the image since the method only represents the image by mean of the principal color.

Similar to the technique above, Chan and Chen [14] also considered the mean value of the color component at each block. However, instead of using 100 blocks, they divided the image into 3 x 3 blocks. The mean value is calculated separately for each R, G, and B color components for each block. The advantage of considering the mean value is that effects from noises in the images and the variations in sizes of images are significantly reduced. However the disadvantage is that it is easily affected by shift variants of objects in images.

Ruan [9] considered color feature vector as a combination of ratio between mean value of red and mean value of green and ratio between mean value of blue and mean value of green. Kekre [5] extracted feature vector from an RGB image by combining row mean and column mean of an image. Similarly, Madhavi [1] generated feature vector by considering row mean, column mean and diagonal mean for an RGB image. Even thou the retrieval efficiency is improved the performance of the algorithm is greatly affected by the feature vector size.

Despite the huge efforts made in the last few years, research on visual retrieval is still in its infancy. In summary, many aspects are yet to be exploited in relation to CBIR, especially on color-spatial features.

4. Proposed Work

One of the fundamental operations of CBIR is feature extraction. In this work, color averaging based feature vector is used. It involves averaging the intensity values of row mean and column mean of an image. The advantage of taking average color as the feature vector is that, the complexity is minimum and the technique gives better performance with high precision and recall values compared to other efficient techniques

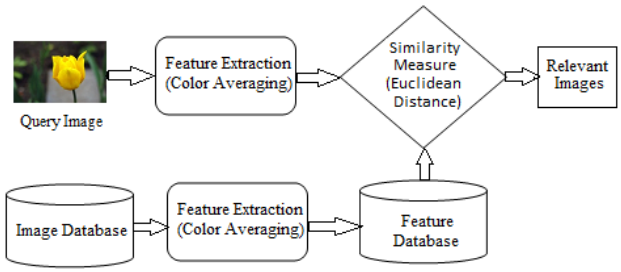


Figure 1: Image retrieval system based on color averaging.

4.1 Need for Color in Image Retrieval

Color is one of the dominant and distinguishable visual features used in CBIR, primarily because of the simplicity of extracting color information from images. It leads to minimum error as it is relatively robust to background complication, viewing angle, translation and independent of image size and orientation. Color is used in various applications like trademark [17], as an identifying feature in objects that occur in artificial environments, such as packaged goods, advertising signs, road signs, etc. Also color is used in robotic vision systems [13] to represent objects that are heavily personalized to achieve efficient behaviors. For example, it may not be helpful to model saucers as being brown and white, but the color combination helps in locating and recognizing it. Shape cues, in contrast to color, are highly resolution dependent which include a highly restricted set that is view invariant (eg., corners, zeros of curvature), and may require elaborate processing to extract them from an image.

One of the main advantages of using color identification algorithm over shape and texture is that, color can be used to identify deformable objects and substances described by mass nouns, something that most other recognition algorithms cannot be used for. Although color-based image retrieval provides an intelligent and automatic solution, a better performance can be obtained by using a combination of multiple features for image retrieval which indirectly results in a complex algorithm with increased memory space for storing feature vectors and increased query execution time.

A digital image in this context is a set of pixels and each pixel has intensity and color. Colors can be represented using different color models depending on the standards used by the researcher or depending on the application such as Red-Green-Blue (RGB) or Hue-Saturation-Value (HSV) or HSB (Hue, Saturation, and Brightness). The RGB color model is widely used to represent digital images on most computer systems. In the proposed technique, RGB color model is used for feature extraction.

Today, RGB color is the basis for most color CRT monitors and color raster graphics as it is easy to extract. It is the simplest method of color data storage and by far the most widespread in computational applications. In a true-color image, each pixel has a red, green and blue value ranging from 0 to 255 giving a total of 16777216 different colors. They are considered as "additive primaries" since the colors are added together to produce the desired color. The standard method uses 8 bits per color resulting in a 24-bit representation with 0 indicating no amount of a particular color and 255 indicating the maximum amount of that color.

The importance of the RGB color model is that it relates very closely to the way the human eye perceives color. The choice of the RGB color space simplifies the architecture and design of the system. Besides, a system that is designed using the RGB color space can take advantage of a large number of existing software routines, because this color space has been around for a number of years.

4.2 Feature Extraction by mean

Feature extraction proposed by Madhavi [1] is based on the combination of row mean, column mean and diagonal mean of a gray scale image. Here, the size of feature vector is 3 for a gray scale image. And in Kekre [5] technique, features of an RGB image is extracted using a combination of row mean and column mean of an image. Here, the size of the feature vector is 6, which includes 3 features for row mean and 3 features for column mean which is given by,

Feature vector $_{(Kekre)}$ = [(Rrm,Rcm) (Grm,Gcm) (Brm,Bcm)]

The size of feature vector plays a major role in optimisation of algorithm. As the feature vector size is reduced, the memory space required for storing the feature vector also gets reduced. In order to reduce the dimension of the feature vector a new approach based on the mathematical property is proposed which states the average of row-mean or the average of column-mean of an mxn matrix results to be same. It uses the property, that it does not matter whether sum over rows first and then over columns or sum over columns first and then over rows. Both cases will end up summing over all the elements in the matrix and hence the result will not change. Thus, average of row mean and average of column mean results in the same value.

$$\text{Row Mean} = \sum_{i=1}^{n} Rmi / nr \quad (1)$$

$$\text{Column Mean} = \sum_{i=1}^{n} cmi / nc \quad (2)$$

Where,
Rm = row pixels
Cm = column pixels
nr, nc = No. of rows and No. of Columns respectively.

For example consider a matrix of size 2 x 2
A = [2 3 ; 4 5]
Average of row mean = (2.5+4.5)/2 = 3.5
Average of column mean = (3+4)/2 = 3.5

From the results obtained it clearly shows that average of row mean is same as average of column mean. Hence, the proposed mean technique with reduced feature vector, the feature vector is generated by considering the row mean alone.

Feature vector = [(Rrm Grm Brm)]

It is important to note that, dimension reduction based on reduction in the size of feature vector from 6 features to 3 features does not significantly change the retrieval results. But with reduction in the dimension of feature vector greatly reduces the memory utilised for storing the image features in feature database. As the memory required for storing image features in feature database is reduced, the time taken to retrieve relevant images from image database also gets reduced.

Feature database is created using cell array. A cell array [20] is a data type with indexed data containers called cells. It is a general purpose matrix where each cell contains data of different type such as text or numbers or a combination of text and numbers. Each cell in a cell array is independent of data type and data size. Memory required for storing features in feature database is given by

Memory requirement = (Total Number of cells x 112 bytes per cell) + (field size x Total Number of cells)

The header file stores a fixed number of 112 bytes per cell for storing the cell information such as field name , data type, field size , attributes etc ., The size of the database is the total number of cells in cell array. Each cell in a cell array is used to store the features of every single image in the database. Field size represent the memory required for storing the feature of a single image in feature database.

For a single image, the memory required for storing its feature vector is given by,

Name	Field Size	Bytes	Class	Attributes
Blue	1x1	8	double	
Green	1x1	8	double	
Red	1x1	8	double	

Field size = (3*8)* 8(double) = 24*8 = 192 bytes.
Each plane in RGB image is allocated a field size of 8 bytes. Thus, the field size for a 6 feature vector is 48 bytes and for 3 features vector is 24 bytes.

Table 1: Memory requirement for a feature database

Size of database	*Kekre Technique*	*Madhavi Technique*	*Proposed Mean*
5000	1.92GB	0.96GB	0.96GB
10000	3.84GB	1.92GB	1.92GB

From Table I, the proposed mean technique with reduced feature vector uses only 50 % of the memory required in Kekre mean technique for saving the features of RGB images in image database. As the dimension of feature vector is reduced to half (from 6 features to 3 features) in proposed mean, the memory required for storing the features in feature database also gets reduced to half. And when compared to Madhavi technique the complexity of calculating the feature vector is reduced as the proposed mean uses just one variable for calculation of feature vector which is row mean. Thus the proposed mean based technique outperforms the existing mean based techniques [1] and [5] in memory utilization.

4.3 Feature Extraction by Central Tendency

Median, mode, max and min are used to represent image data or information. They are collectively called as the measures of central tendency. These descriptive measures have bit differences from one another that play an important role in feature extraction. The mode is the most dominant pixel in the image. Median is a middle pixel from an ordered set of data that is in the middle of an image. Max and Min are the maximum and minimum intensity pixel in the image.

Pseudo code for proposed method

```
input= image('*.jpg');
. . . . . .
--Calculate mode feature vector
row mode = [redmode    greenmode    bluemode]
col mode = [redmode    greenmode    bluemode]
mode FV = cat(2,row mode, col mode

--Calculate median feature vector
Row median = [redmedian   greenmedian    bluemedian]
Col median = [redmedian    greenmedian    bluemedian]
median FV = cat(2,row median, col median)

--Calculate min feature vector
min FV =min[redmin  greenmin   bluemin]

-- Calculate max feature vector
max FV = max[redmax    greenmax    bluemax]

Feature vector =[modeFV  medianFV  minFV   maxFV]
…….
```

The distance between the feature vector of query image and images in database is calculated using euclidean distance. An image with minimum distance is considered as better match and it is given by Eq. 3.

$$D(x,y) = \sqrt{\sum_{i=1}^{n}(xi - yi)^2} \quad (3)$$

where xi and yi are the extracted features of database image and query image respectively with size 'n'.

5. Performance Measures

The measure of performance used in image retrieval borrows from the field of information retrieval and are based on two primary figures of metric which is precision and recall. Precision is the number of relevant documents retrieved. Recall is the number of relevant documents in the database which should have been retrieved [4,7].

$$Precision = \frac{No.\ of\ relevant\ \ images\ in\ the\ retrieved\ \ images}{No.\ of\ the\ retrieved\ \ images} \quad (4)$$

$$Recall = \frac{No.\ of\ relevant\ \ images\ in\ the\ retrieved\ \ images}{No.\ of\ relevant\ \ images\ in\ database} \quad (5)$$

Precision can be interpreted as a measure of exactness, whereas recall provides a measure of completeness. A perfect precision score of 1.0 means that every retrieved image is relevant but it does not provide any insight as to whether all relevant documents are retrieved. A perfect recall score of 1.0 means that all relevant images is retrieved but says nothing about how many irrelevant images might have also been retrieved.

6. Experimental Results and Analysis

For analysis purpose, experiments were conducted on two different databases - a generic image database and intensity database.

Wang Image database consist of 1000 corel images of ground truth. It consists of 10 categories with each category comprising of 100 images. The categories include mountain,

elephant, dinosaurs, African people, buses, horses, flowers, beaches, buildings, food. Images are of size 256 x 384.

Figure 2: Wang mage Database

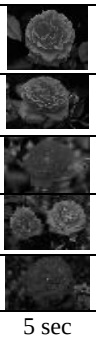
Images in Intensity database are taken from Tineye Labs. Database images were taken by varying intensity of a particular color. All the images are either of size 256 x 384 or 384 x 256 pixels.

Figure 3: Indexed Image Database

Feature vector of a query image and all images in database are generated. Euclidean distance of all images in database with respect to query image is calculated. The query image with minimum value of Euclidean distance is considered as better match. The proposed technique based on the measures of central tendency is implemented using MATLAB R2010a Image Processing toolbox.

The proposed mean based technique with reduced feature vector is compared against existing mean based image retrieval [1] and [5]. In general, feature extraction in mean based image retrieval is done by taking the average of RGB pixels.

Table 2: Comparison of existing mean and proposed mean

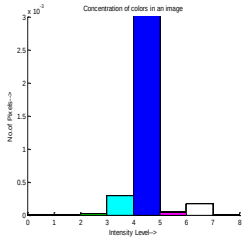
Query Image	*Madhavi Technique*	*Kekre Technique*	*Proposed Mean*
			
Retrieval Time	5 sec	8 sec	6 sec

From the results shown in Table I, it clearly states that the retrieval results are least affected with variations in the feature vector dimension. Also from the results it is observed that with change in dimension there is no change in the retrieval results but the retrieval time decreases with reduction in feature dimension.

As the dimension of feature vector is reduced the time required for retrieving query relevant images from database also gets reduced. Since, time is inversely proportional to speed; as retrieval time decreases the speed of retrieving relevant images increases thereby optimizing the algorithm. Thus the proposed mean based technique with reduced feature vector performs faster compared to the existing techniques [5].

Table 3: Comparisons of proposed mean and Measures of Central Tendency

Query	*Mean with reduced FV*	*Central Tendency*
		
		
		
		
		



(a) (b)

Figure 4: Intensity graph for Query Image (a) Query image (b) Intensity graph

Table III, shows the retrieval results of proposed mean and the measures of central tendency. In the retrieval results, it is observed that few images are retrieved from different categories, the reason being as the comparisons between query image and database images is made on the bases of the color scheme and moreover these retrieved irrelevant images have their basic color shade matching with the query image color, blue is prominent as shown in figure 4.

To study the limitation of mean based technique, the algorithm is tested on indexed image database. Query image is tested indexed image database for retrieval effectiveness.

Table 4: Retrieval results from Intensity based image database

Query	*Mean with reduced FV*	*Central Tendency*
		
		

In Table 4, considering the rose colored flower, it is observed that in first 20 retrieved images, the mean based technique contains 14 relevant images and 6 irrelevant images. Whereas the retrieval results based on the measures of central tendency contains 18 relevant images and 2 irrelevant images. This is because in mean based technique all image pixels are taken into consideration for feature extraction which includes the outliers as well. As a result the detail of image is lost in extracted features whereas in the process of measures on central tendency the useful detail in the image is preserved thereby eliminating the outliers in image feature extraction. Thus the measures of central tendency improve the effectiveness of retrieving query relevant images compared to mean based techniques.

Table 5: Parameters for performance evaluation

Query Image	*Average Precision*		*Average Recall*	
	Mean	*CT*	*Mean*	*CT*
	0.5	0.62	0.8	0.87
	0.3	0.4	0.9	1
	0.52	0.56	0.53	0.81
	0.4	0.4	0.95	0.95
	0.5	0.8	0.76	0.84

The performance of the proposed mean and measures of central tendency is theoretically evaluated using precision and recall. From Table V, it is obvious that the precision and recall rate is high for measures of central tendency compared to proposed mean with reduced feature vector.

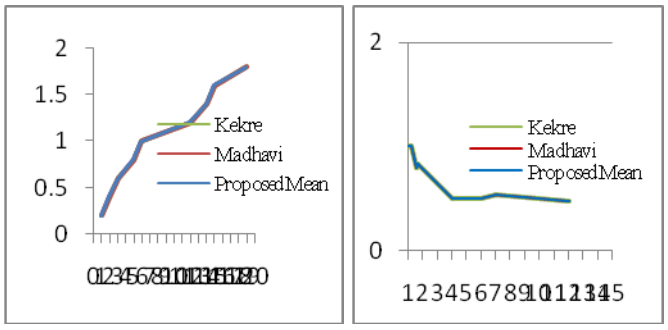


Figure 5: Precision and Recall Graph of mean based techniques

From figure 5, it is observed that there appears no deviation in the plotted precision graph and recall graph for the existing mean based techniques, Madhavi[1] technique and Kekre Technique and the proposed mean based technique with reduced feature vector. The reason is same as stated above. The retrieval results are independent and are least affected with change in the dimension of feature vector.

The graph also explains that there is an exponential increase in the recall rate which states that all relevant images are retrieved. And the decrease in the precision graph describes the accuracy of the algorithm.

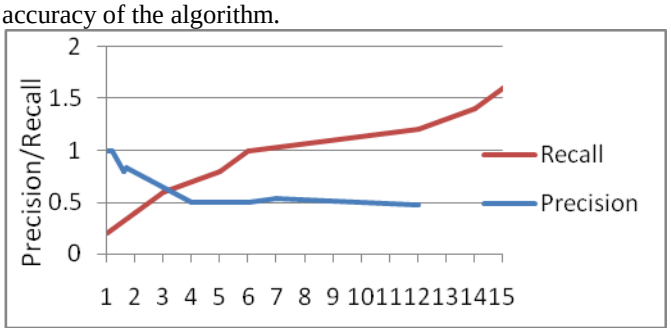


Figure 6: Precision and Recall graph for Proposed Mean Technique

Figure 6 shows the point of crossover for precision and recall. Crossover point can be used in a way to measure the correctness of the algorithm. Higher the crossover point better is the performance of the algorithm.

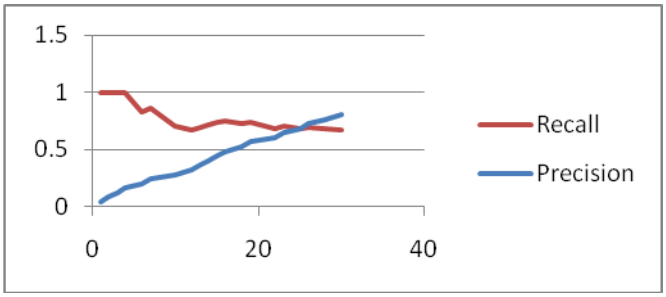


Figure 7: Precision and Recall graph for Central Tendency

Figure 7 shows the crossover point for precision and recall. As the point of crossover increases the efficiency of the algorithm gets increased.

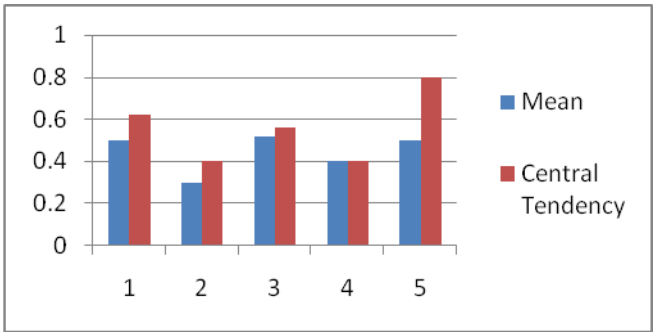


Figure 8: Performance Graph for proposed mean and Central Tendency

Figure 8, shows the performance graph of proposed techniques. From the graph it is observed that the performance of central tendency outperforms the proposed mean based technique with higher average precision and recall.

7. Conclusion

In this paper, a CBIR method based on the measures of central tendency and mean based technique with reduced feature vector is proposed. The experimental results shows that image retrieval by central tendency performs extremely well when compared to mean based feature extraction technique. In mean based technique all image pixels including outliers are considered for feature extraction as a result the detail in image is lost which greatly affects the performance of retrieval whereas in case of retrieval by central tendency, the feature vector preserves the useful detail in the image and it greatly aids in fine tuning the efficiency of image retrieval.

The proposed feature vector extraction in CBIR is based on simple color based search and as future work, the proposed work will be integrated with texture and shape based image retrieval techniques for better retrieval results and performance.

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