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RESEARCH ARTICLE

CONTENT BASED IMAGE RETRIEVAL USING COLOR HISTOGRAM

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ABSTRACT

With the availability of easy and inexpensive methods to create and store images in digital formats, the visual information preserved and shared electronically has grown dramatically. Since the non-textual information like images, audio and video preserved in digital format are increasing day by day, effective applications to manage and retrieve these content are essential, which are commonly known as content based image retrieval (CBIR). Firstly, keyword annotation is labor intensive, and it is not even possible when large sets of images are to be indexed. Secondly, these annotations are drawn from a predefined set of keywords which cannot cover all possible concepts images may represent. Finally, keywords assignment is subjective to the person making it. This paper focuses on color based image retrieval to develop a system that uses the color as a visual feature to represent the images. To improve the efficiency and effectiveness of color-based retrieval, color histogram method has been proposed. Experimental results show that the color histogram features containing spatial structural relations are robust to image translation, scaling and rotation, and for retrieval of visually similar object from the image sequences, the color histogram method gives good retrieval precision with speed.

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INTRODUCTION

Content-Based Image Retrieval (CBIR) systems are search engines for image databases, which index images according to their content. A typical task solved by CBIR systems is that a user submits a query image or series of images and the system is required to retrieve images from the database as similar as possible. Another task is a support for browsing through large image databases, where the images are supposed to be grouped or organized in accordance with similar properties (Datta *et al.*, 2008; Smeulders *et al.*, 2000). The goal of content-based image retrieval systems is to extract a set of similarity features, such as color, shape and texture features which can effectively characterize the visual content of images, and then use them for retrieval purpose, which is called query by image example. The features should be robust enough for image content representation and simple enough for practical retrieval application (Aigrain *et al.*, 1996). Histogram is the most commonly used scheme to represent the features composition of an image. Generally speaking, the existing histogram features can be divided into two categories: spatial-domain histogram and frequency-domain histogram (Datta *et al.*, 2005). Color is one of the most important identifying features that are local and largely independent of view and resolution. The most widely used spatial-domain histogram is the global color histogram which represents the color composition and distribution of the whole image (Swain and Ballard, 1991).

Content-Based Image Retrieval (CBIR) is the process of retrieving images from a database on the basis of features that are extracted automatically from the images themselves (Eakins and Graham, 1999). This paper focuses on the use of a single image feature for retrieval purposes, namely color. Color is a visual feature that one can immediately perceives when looking at an image (Del Bimbo, 1999).

Image Retrieval

Basically they are divided into two frameworks:

i) Text based image retrieval
ii) Content based image retrieval.

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Text-Based Retrieval

The traditional image retrieval employed text as the primary means by which to represent and retrieve images from databases (Del Bimbo, 1999). Text-based image retrieval can be traced back to the 1970's; images were represented by textual descriptions and subsequently retrieved using a text-based database management system (Thomas *et al*., 1997). In addition, the annotator's perception of an image may not necessarily reflect that of the user, since description and meaning of a visual image is open to individual interpretation (Enser, 1993). Researchers concluded that some means of interaction with the visual content of the images themselves was needed to perform effective retrieval. This led to the development of content-based image retrieval, wherein images are retrieved based on their visual features (Venters and Cooper, 2000).

Content-Based Image Retrieval

In Content-based image retrieval, the images are indexed by their visual contents, such as color, texture, shape, structure, motion and combination of these. Initial research in the retrieval of images based on their inherent features has been reported in (Eakins and Graham, 1999). Content-based image retrieval utilizes representations of features that are automatically extracted from the images themselves. The system extracts the features of the query image, searches through the database for images with similar features, and displays relevant images to the user in order of similarity to the query (Myron Flickner *et al*., 1995; Patrick and Kelly, 1995; Chad Carson *et al*., 1999; Das *et al*., 1997).

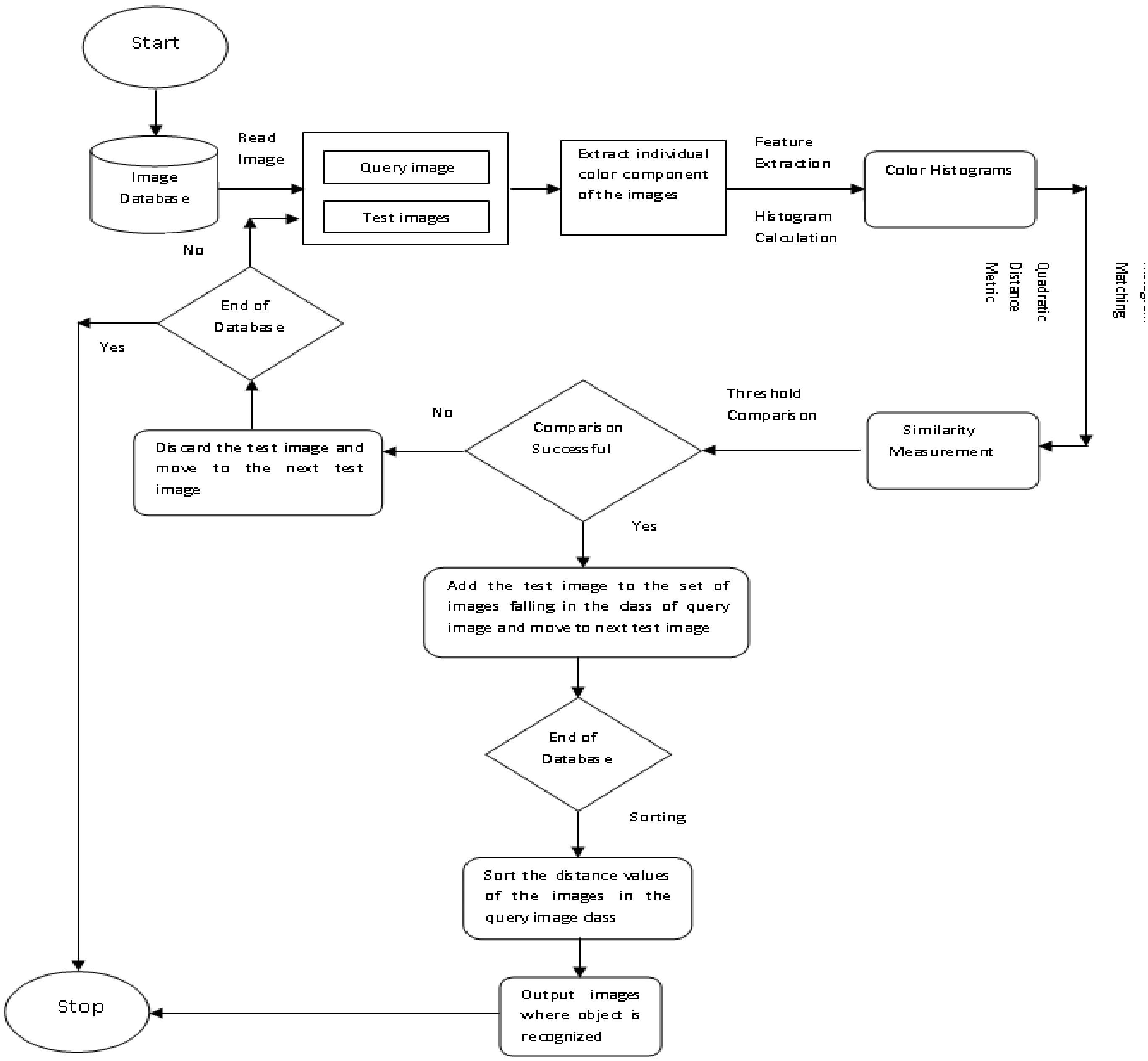


Figure 1.1. Diagram for Content Based Image Retrieval System (Panda *et al*., 2010)

Many CBIR systems have been developed that analyze, compare and retrieve images based on one or more of these features. Some systems have achieved various degrees of success by combining both content-based and text-based retrieval (Ma *et al*., 1997; Ogle and Stonebraker, 1995; Michael Ortega *et al*., 1997). In typical Content Based Image retrieval systems Figure 1.1 shows the visual contents of the images in the database are extracted and described by feature vector.

Image Content Descriptors

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. To obtain the local visual descriptors, an image is often divided into parts first.

Color-Based Retrieval

Since color is a low-level image feature that does not appear to classify images distinctly, few CBIR systems exist that utilize only color as the image retrieval feature (Petteri Kerminen and Moncef Gabbouj 2000). Yet color does have its advantages for image retrieval. It provides multiple measurements at a single pixel of the image, enabling classification to be done without the need for complex spatial decision-making (Stockman and Shapiro, 2001; Vishal Chitkara, 2001). Color content is also independent of view and resolution and is easy to extract from an image and to manipulate (Swain and Ballard, 1990). In this paper, we revisit the issue of using color as the dominant image feature in a CBIR system.

Objective of Work

The objective of this paper is to develop a simple Content-based image retrieval system for image databases using low-level feature as color and improve the performance of image retrieval. Content-based image retrieval (CBIR) techniques could be valuable to many image processing areas that could assist with decision support. From the previous section it is found that there are still many challenges open in the area of content-based image retrieval.

The ultimate goal of the work in this paper is:

- To propose an accurate and efficient algorithm for retrieval of similar images form an image database and to develop a Graphical user interface for retrieval of image based on image content that could be as similar to human perception.
- Secondly, steps will be taken to reduce both sensory and semantic gap. The semantic gap can be considered to be a break or discontinuity in the aspect of image understanding, with human understanding on one side of the gap and machine understanding on the other. The second gap is the sensory gap that describes the loss between the actual structure and the representation in a digital image.

RELATED WORKS

CBIR describes the process of finding images from a large data collection that match to a given query image. Many general-purpose systems have been developed. QBIC (Flickner *et al*., 1995), VIR (Gupta and Jain, 1997), and AMORE (Mukherjea *et al*., 1999) are examples of commercial general purpose systems. Recently, academic systems have been developed such as MIT Photobook (Pentland *et al*., 1997). Berkeley Blobworld (Carson *et al*., 1999), Columbia Visualseek and Webseek (Smith and Chang, 1996), Netra (Ma and Manjunath, 1997), and Stanford WBIIS (Wang *et al*., 1998) are some of the recent well known systems.

General Purpose CBIR Systems

Several CBIR systems have been proposed recently. Even though a few of them be- came commercial products, many CBIR systems were proposed as research prototype, being developed in universities and research laboratories. QBIC (Query by Image Content) by IBM (Flickner *et al*., 1995), Photobook (Pentland *et al*., 1997; Veltkamp and Tanase, 2002), developed by the Mas-sachusetts Institute of Technology (MIT), Chabot, Netra, and VisualSEEK (Smith and Chang, 1996) allow query by image content. Chabot (Ogle and Stonebraker, 1995) integrates image content retrieving based on color information with text-based queries. Its interface allows user to search and update the image database. Ma *et al*. (1997) describe a toolbox for browsing large database collections called Netra. This prototype uses color, texture, shape, and spatial location of image segmented regions to retrieve similar images from a database. More recently, Cox *et al*. (2000) present the PicHunter system. In this system, a Bayesian framework is used to model user needs during query formulation. KIWI (Key-point Indexing Web Interface) (Loupias and Bres, 2001) has been developed in France by INSA Lyon in 2001. ImageMiner (Kreyss *et al*., 1997) has been developed by Technologie-Zentrum Informatik at Univerity of Bremen in Germany in 1997. It uses color, texture, and shape to describe the image. VisualSEEK and WebSEEK were developed by the Department of Electrical Engineering, Columbia University. Both these systems support colour and spatial location matching as well as texture matching (http://www.jtap.ac.uk/reports/htm/jtap-054.html).

Color Histogram Based Approaches

In 1996, Stricker and Dimai (1996) proposed CBIR system that partitioned the image into five overlapped blocks and computed the Color Moments for each block. The computation was done using the HSV color space for each channel. In 2000, Stehling *et al*. (2000) developed a method based on color histograms. He used a variable number of histograms called color-shape histograms (CSHs) instead of using a fixed number of cells or a single histogram. In 2006, Mahdy, Shaaban, and Abd El-Rahim (2006) proposed to extract the features from the image using its color histogram. The image is segmented into four blocks and converted from RGB color space to CIE XYZ color space then to LUV color space. In 2009, Lin, Chen, and Chan (2009) proposed a smart method for image retrieval. Three image features and a feature selection technique are used for that. The first and the second image features are for color and texture features that are respectively called color co-occurrence matrix (CCM) and difference between pixels of scan pattern (DBPSP). The third image feature is for color distribution called color histogram for k-mean (CHKM). In 2002, Shin and Chen (2002) proposed the partition-based color-spatial method. The query image is divided into 100 blocks and for each block the three color moments are computed for each color layer. The mean vector of each block is considered as the primitive, of the image. This method is not suitable for image databases containing large images. However, Chan and Chen (2004) proposed a similar method of considering the mean value of the color component at each block. They divided the image into 3 x 3 blocks instead of 100m blocks. The mean value is computed for each block color layer (R, G, and B) separately. In 2008, another system is proposed by Mustaffa, Ahmad, Rahmat, and Mahmod based on color-spatial features (Mustaffa *et al*., 2008). In 2004, Zhang (2004) computed color and texture features from the image database. So, for each image, color and textures features are computed. When a query image is submitted, the color and texture features are computed. In 2010, Kekre and Mishra (2010) presented a new algorithm for digital search and retrieval. They used Fast Fourier Transform for each image color components (R, G, and B). In March 2011, Sharma, Rawat and Singh (Sharma *et al*., 2011) proposed an efficient CBIR using color histogram processing. The proposed method used color moments and color histograms. In Feb 2012, Singha and Hemachandran (Singha and Hemachandran, 2012) proposed Content Based Image Retrieval using Color and Texture content based image retrieval, using features like texture and color, called WBCHIR (Wavelet Based Color Histogram Image Retrieval). In 2013, Altaff Hussain Venkata Rao (2013) proposed content based; color has been taken as the property for searching.

METHODOLOGY

The main method of representing color information of images in CBIR systems is through color histograms (Swain and Ballard, 1991). A color histogram is a type of bar graph, where each bar represents a particular color of the color space being used. An improvement of the color histogram method includes the cumulated color histogram (Stricker and Orengo, 1995).

The histogram of an image refers to the probability density function of the image intensities with gray levels in the range $(0, L-1)$ and defined as (Gonzalez and Woods, 2002; Pratt, 2007):

$$p(r_k) = {n_k}/{n} \quad \text{where, } k = 0,1,2,....,L-1 \quad \text{..................(1)}$$

L = number of levels, r_k = the kth gray level, n_k = number of pixels in the image having gray level, n = total number of pixels in the image

The histogram of color image refers to the joint probabilities of the intensities of the three color channels and defined as:

$$h_{A,B,C}(a,b,c) = N.\Pr ob(A = a, B = b, C = c) \quad \text{.........(2)}$$

Where, A, B and C represent the three color channels like RGB or HSV and N is the number of pixels in the image. The histogram expresses the frequency distribution of color bins in an image and each bin in the color histogram contains the information about the number of pixels belong to the color bin.

Many distance formulas related to histogram matching has been described in literature out of which three distance formulas that have been used widely for image retrieval includes histogram Euclidean distance, histogram intersection distance and histogram quadratic (cross) distance (Color and texture feature-based image retrieval by using Hadamard matrix in discrete wavelet transform, 2013).

Let h and g represent two color histograms with n bins. The Euclidean distance between the color histograms h and g is defined as (Li *et al*., 2003):

$$d^2(h,g) = \sum_A \sum_B \sum_C (h(a,b,c) - g(a,b,c))^2 \quad \text{...........(3)}$$

Where, A, B and C represent the three color channels (R, G, B) and a,b and c are the corresponding histogram components of the channels. Using this distance metric, there is only comparison between the identical bins in the respective histograms.

The Histogram intersection between the color histograms h and g is defined as:

$$d(h,g) = \frac{\sum_A \sum_B \sum_C \min(h(a,b,c), g(a,b,c))}{\min(|h|,|g|)} \quad \text{.........(4)}$$

Histogram intersection is special for object tracking because it does not require the accurate separation of the object from its background. The result of the intersection of a query image histogram with a test image histogram is the number of pixels from the query image that have corresponding pixels of the same color in the test image.

The Quadratic distance between color histograms h and g is defined as:

$$d(h,g) = (h-g)^T A(h-g) \quad \text{................................(5)}$$

where A is a similarity matrix and the $a(i,j)th$ element in the similarity matrix for RGB color space is defined as:

$$a_{ij} = 1 - d_{ij} / \max(d_{ij}) \quad \text{.......................................(6)}$$

where d_{ij} is the Euclidean distance between the color i and j in the RGB color space.

The quadratic distance represents the cross-correlation between histogram bins based on the perception of similar colors represented by the bins and the set of all cross-correlation values are represented by the similarity matrix.

As a result of histogram matching using a distance metric, the distances between the query image and the test images are calculated and compared against a predefined threshold value. The successful candidate images are ranked by their similarities with the query image. Finally, in order to evaluate the performance of the object tracking model using different distance measures, two metrics called recall and precision are used (Li *et al*., 2003).

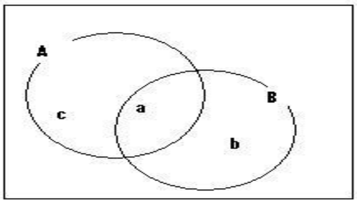


Figure 3.5. Sets for explaining retrieval effectiveness

Let A be the set of relevant items, B be the set of retrieved items, a be the retrieved relevant images, b be the retrieved irrelevant images, and c be the unretrieved relevant images, then

$$\text{Recall} = P(B/A) = \frac{P(A \cap B)}{P(A)} = \frac{a}{a+c}$$

$$\text{Recall} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of relevant images in the database}} \quad (7)$$

$$\text{Precision} = P(A/B) = \frac{P(A \cap B)}{P(B)} = \frac{a}{a+b}$$

$$\text{Precision} = \frac{\text{Number of relevant images retrieved}}{\text{Total number of retrieved images}} \quad (8)$$

Algorithm: Image Retrieval using Color Histogram

Algorithm: Image retrieval using color histogram method

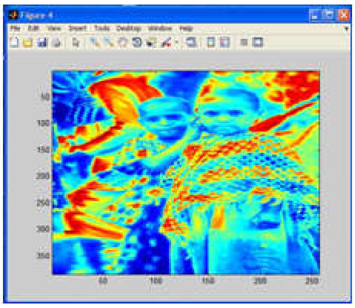
Input: N = Total number of images in the database
P = Total number of individual color component in the image
d_t = predefined distance threshold
C = Total number of images present in the class of query image
E = Number of images to be extracted sequentially from C
A = Total number of images in E where object is found
Begin
Step 1: For each query image Q_i in the database, i = 1 to N do
Step 2: For each test image T_j in the database, j = 1 to N do
Step 3: If (Number of pixels in Q_i $\neq$ Number of pixels in T_j) then Scale the image T_j to have the same number of pixels as Q_i End if
Step 4: Extract the individual color component of the images
Step 5: For each color component of the image, p = 1 to P do
Step 6: Extract the color component by computing histogram of $Q_i(k)$ and $T_j(k)$
Step 7: Compute normalized histogram of $Q_i(k)$ and $T_j(k)$ and extract histogram parameters
Step 8: Compute d_j = distance_between (histogram parameters of $Q_i(k)$ and histogram parameters of $T_j(k)$, using a distance metric
Step 9: Compare d_j with a predefined distance threshold d_t
Step 10: If (the value of d_j satisfy the required relation with the pre-defined threshold d_t) then flag = 'object may be present' Add test image T_j to the set of output images falling in the class of query image Q_i Else Flag = 'object not found' Discard the test image T_j and move to the next image in the database End if
Step 11: Sort the distance values of the output images in the class of query image either ascending or descending as required by the used distance metric
Step 12: Count the number of output images C falling in the class of query image Q_i after sorting End

EXPERIMENT AND RESULTS ANALYSIS

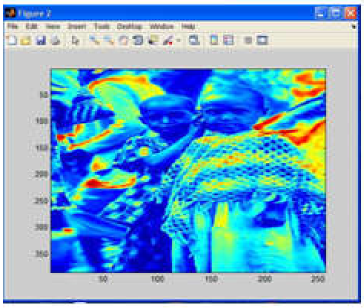
We carry out the experiments on image database from James Z. Wang Research Group (Li *et al*., 2003). The original database consists of 1000 JPEG images with 10 categories like African people, Beach, Building, Bus, Dinosaur, Elephant, Flower, Horse, Mountain and Food. But we have taken 06 categories like African people, Bus, Dinosaur, Elephant, Flower and Horse with 300 images from the original databases with 50 images from each category. All the images are RGB images of size 384×256 or 256×384 with bit depth of 24 bits per pixel. The sample images of image database are shown in Figure 4.1, the Original RGB image and its extracted Red, Green and blue components are shown in Figure 4.2, histogram of an image and histogram of individual color components are shown in Figure 4.3, the Graphical User Interface(GUI) of image retrieval system is shown in Figure 4.4, the retrieved flower class result using quadratic distance is shown in Figure 4.5, the result retrieved using quadratic distance for flower class is given in Table 4.1, Retrieved results for Bus class using quadratic distance is shown in Figure 4.6, the Result retrieved using quadratic distance for Bus class is given in Table 4.2, the Retrieved results for Elephant class using quadratic distance is shown in Figure 4.7, the Result retrieved using quadratic distance for Elephant class is given in Table 4.3, the Retrieved results for Horse class using quadratic distance is shown in Figure 4.8, the Result retrieved using quadratic distance for Horse class is given in Table 4.4, the Retrieved results for Dinosaur class using quadratic distance is shown in Figure 4.9, the Result retrieved using quadratic distance for Dinosaur class is given in Table 4.5, the Retrieved results for People class using quadratic distance is shown in Figure 4.10, the Result retrieved using quadratic distance for People class is given in Table 4.6 and the corresponding recall rate, retrieval precision and retrieval time for each image class with the color histogram method are given in Table 4.7.

Figure 4.1. Sample images from the database

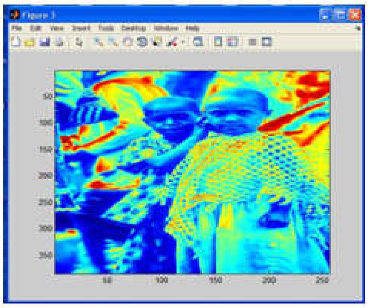
(a)



(b)

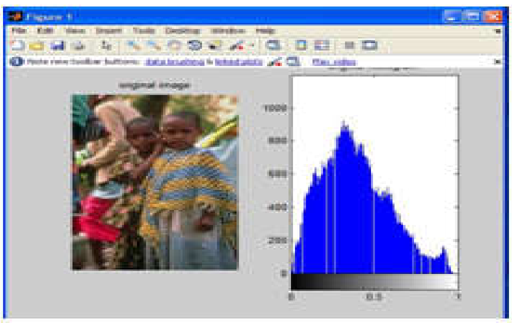


(c)

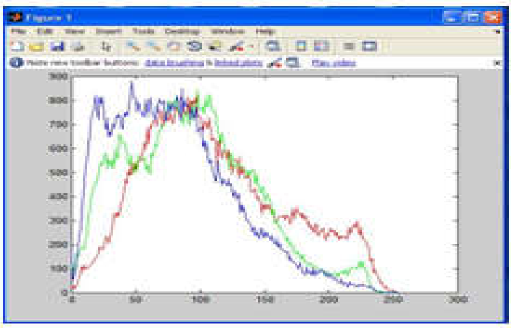


(d)

Figure 4.2. (a) Original RGB image (b) extracted Red components, (c) extracted Green components, (d) extracted Blue components



(a)



(b)

Figure 4.3. (a) Histogram of an image (b) histogram of individual color components

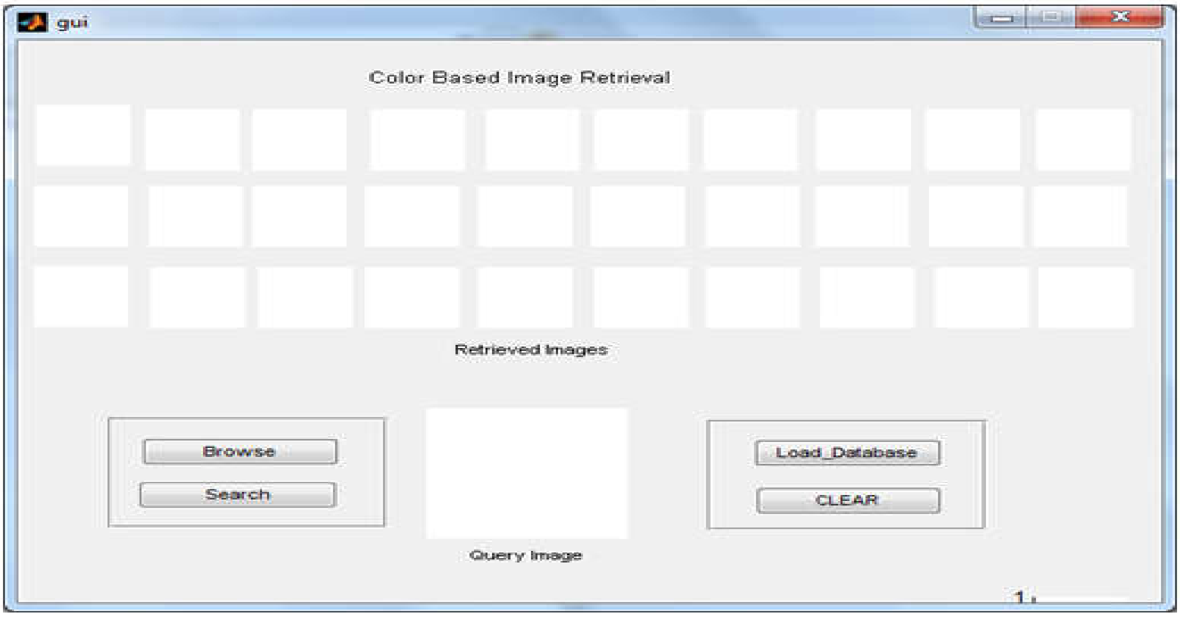


Figure 4.4. Graphical User Interface (GUI) of image retrieval system

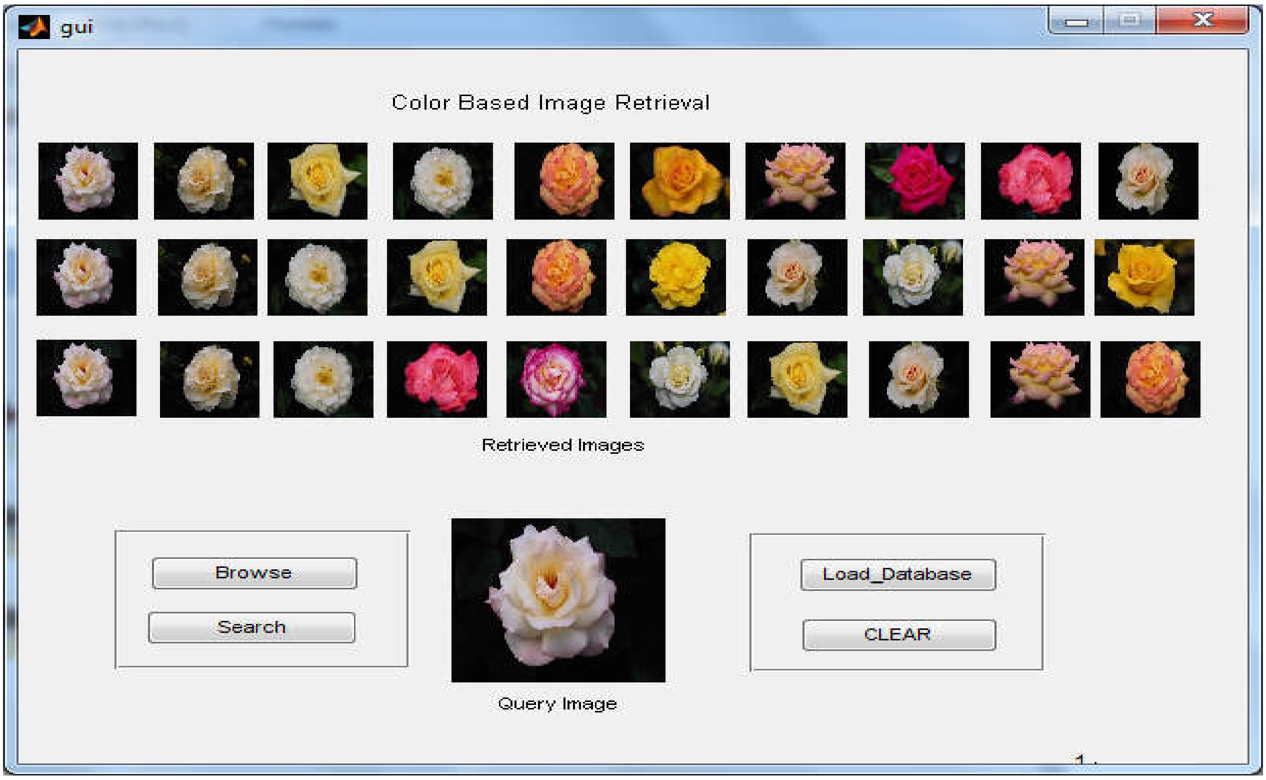


Figure 4.5. Retrieved results for Flower class using quadratic distance

Table 4.1. Result for retrieved quadratic distance for Flower class

Retrieved Images No.	Red Color Chanel	Green Color Chanel	Blue Color Chanel
1	0	0	0
2	0.2335	0.1331	0.3017
3	0.3246	0.3082	0.3699
4	0.3988	0.3482	0.6265
5	0.5230	0.5319	0.6752
6	0.7161	0.5517	0.6764
7	0.8048	0.6849	0.7060
8	0.8425	0.8448	0.7649
9	0.9046	0.9695	0.9378
10	1	1	1

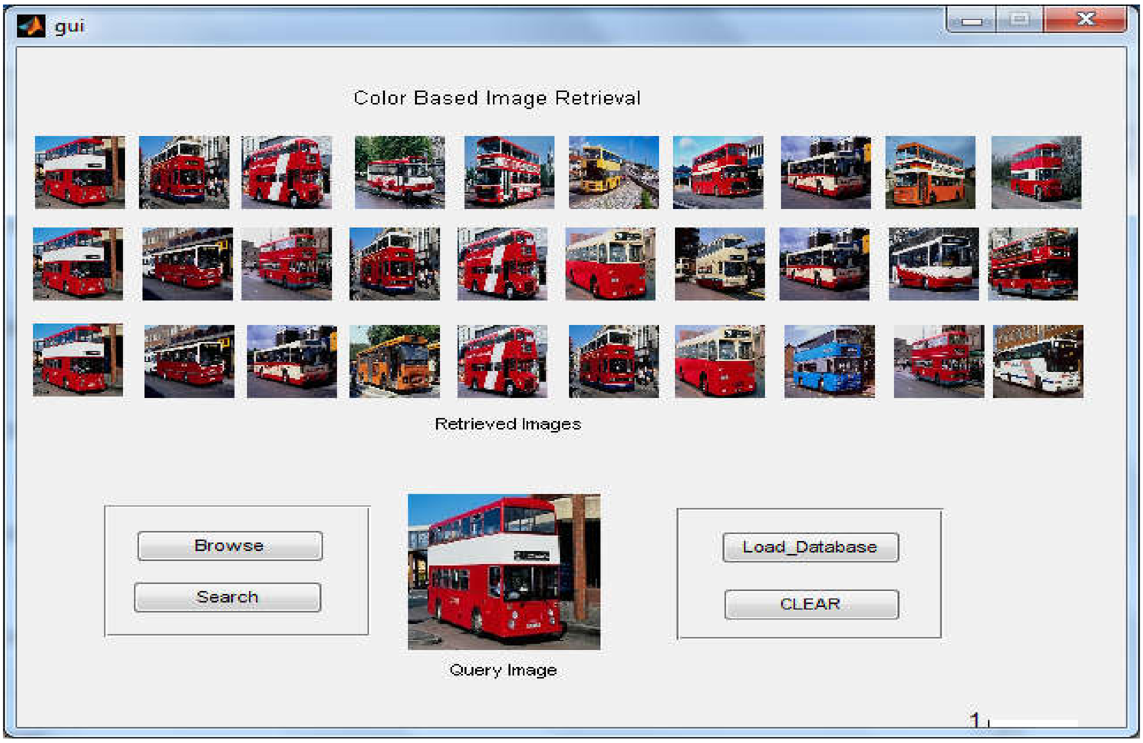


Figure 4.6. Retrieved results for Bus class using quadratic distance

Table 4.2. Result for retrieved quadratic distance for Bus class

Retrieved Images No.	Red Color Chanel	Green Color Chanel	Blue Color Chanel
1	0	0	0
2	0.5597	0.6531	0.7727
3	0.7245	0.6997	0.8749
4	0.7675	0.7156	0.8970
5	0.8095	0.7515	0.9043
6	0.8939	0.8804	0.9073
7	0.9077	0.9085	0.9115
8	0.9093	0.9484	0.9134
9	0.9098	0.9794	0.9622
10	1	1	1

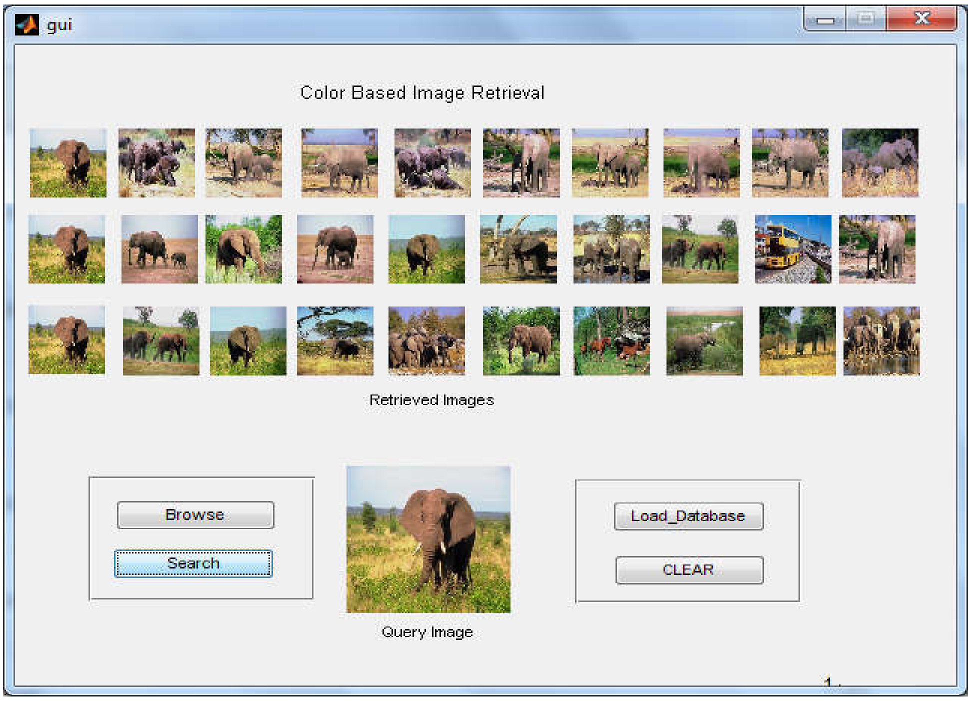


Figure 4.7. Retrieved results for Elephant class using quadratic distance

Table 4.3. Result for retrieved quadratic distance for Elephant class

Retrieved Images No.	Red Color Chanel	Green Color Chanel	Blue Color Chanel
1	0	0	0
2	0.6125	0.4643	0.4992
3	0.6464	0.5354	0.8070
4	0.8322	0.6218	0.8467
5	0.8621	0.7616	0.8758
6	0.8848	0.7631	0.9127
7	0.9079	0.8047	0.9255
8	0.9263	0.8378	0.9309
9	0.9394	0.8995	0.9710
10	1	1	1

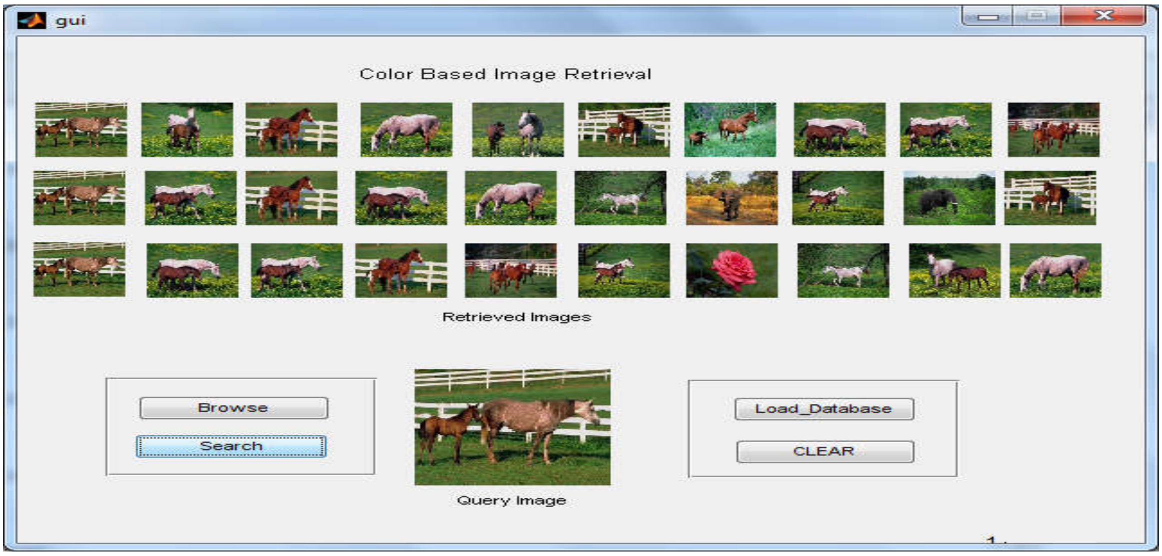


Figure 4.8. Retrieved results for Horse class using quadratic distance

Table 4.4. Result for retrieved quadratic distance for Horse class

Retrieved Images No.	Red Color Chanel	Green Color Chanel	Blue Color Chanel
1	0	0	0
2	0.3550	0.2985	0.3798
3	0.3588	0.3755	0.4750
4	0.3774	0.4992	0.5903
5	0.6027	0.5846	0.8122
6	0.7255	0.5854	0.8368
7	0.7735	0.7139	0.8695
8	0.8738	0.7305	0.9648
9	0.8888	0.9681	0,9933
10	1	1	1

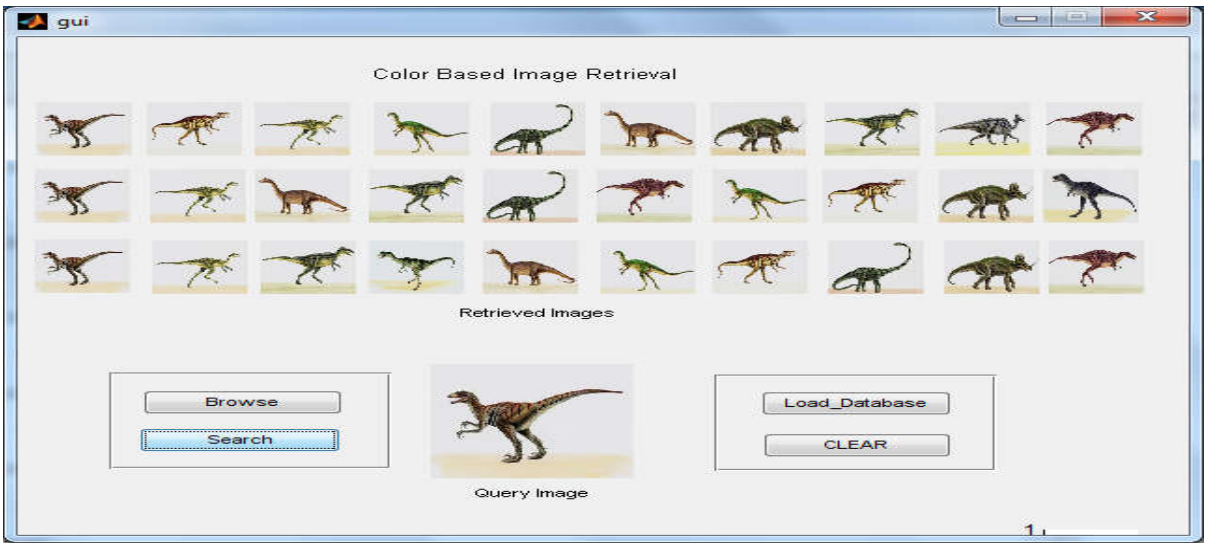


Figure 4.9. Retrieved results for Dinosaur class using quadratic distance

Table 4.5. Result for retrieved quadratic distance for Dinosaur class

Retrieved Images No.	Red Color Chanel	Green Color Chanel	Blue Color Chanel
1	0	0	0
2	0.1627	0.1394	0.2706
3	0.1755	0.2072	0.3462
4	0.2308	0.2118	0.3800
5	0.3639	0.4662	0.4043
6	0.4655	0.4869	0.4608
7	0.5252	0.5151	0.6993
8	0.6365	0.5334	0.7246
9	0.6521	0.6583	0.7675
10	1	1	1

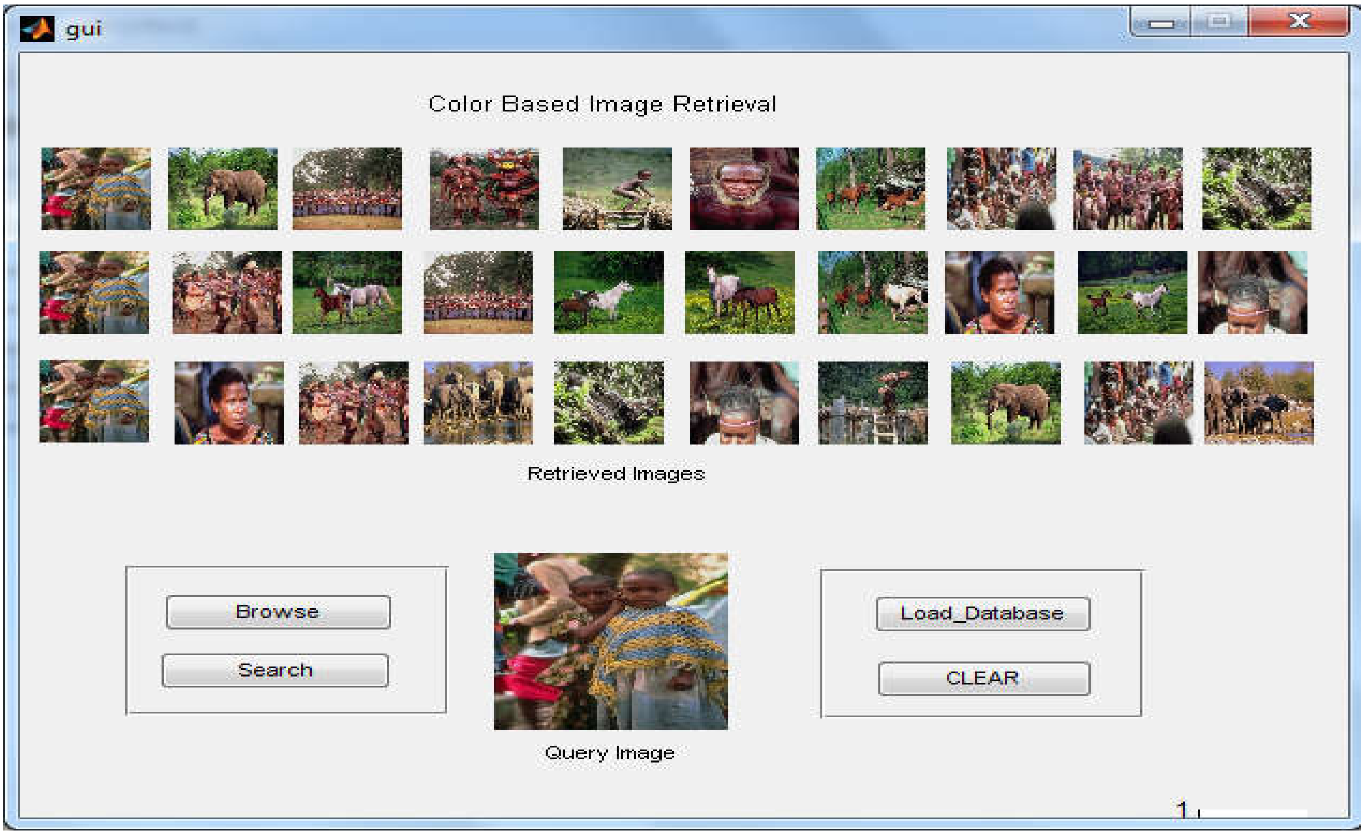


Figure 4.10. Retrieved results for People class using quadratic Distance

Table 4.6. Result for retrieved quadratic distance for People class

Retrieved Images No.	Red Color Chanel	Green Color Chanel	Blue Color Chanel
1	0	0	0
2	0.4666	0.6584	0.3782
3	0.6060	0.6681	0.4160
4	0.7209	0.6762	0.4469
5	0.8407	0.7374	0.6787
6	0.8966	0.7713	0.7119
7	0.8988	0.7825	0.8972
8	0.9219	0.8190	0.9098
9	0.9358	0.9501	0.9362
10	1	1	1

Table 4.7. Recall, Precision and Retrieval Time

Category Name	Recall	Precession	Retrieval Time in sec
Flower	0.6	1	37.6260
Bus	0.6	1	38.0040
Elephant	0.6	0.9	38.2680
Horse	0.5	0.9	42.7620
Dinosaur	0.6	1	45.8940
African People	0.4	0.7	46.0020

Conclusion and Future work

Content-Based Image Retrieval (CBIR) systems are search engines for image databases, which index images according to their content. Content-based image retrieval is the application of computer vision techniques to the problem of digital image search in large databases. During the last several years; CBIR emerged as powerful tool to efficiently retrieve images visually similar to query image. This paper presents image retrieval using Color Histogram Method (CHM). The primary goal of the proposed method is to improve the matching efficiency. The process of image retrieval using CHM involves steps like selection of the color space, quantization of the color space, extraction of the color feature using histogram, finding the distance between the query and test images using an appropriate distance function, sorting the retrieved distance values and finally ranking the retrieved images. In general, the color histogram method using quadratic distance metric showed good performance of image retrieval in considering both computation time and retrieval effectiveness with high precision values with good speed. Of course, this paper does not mark the end of research in the domain of content based image retrieval. To further improve the retrieval results, segmentation may be used to extract regions and objects from the image.

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