Content-based Image Retrieval System by Using Color Homogram Filter and Spatial Filter

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Abstract

Content-based image retrieval (CBIR) system retrieves relevant images based on their contents such as color, texture, shape, volume, spatial constraints and etc. In this paper, a CBIR system is implemented by using color homogram filter and spatial filter to improve the image retrieval system according to the image visual content by computer vision. The color feature and spatial feature information are retrieved in offline feature extraction. The color feature of an image is retrieved by using the color homogram of a CIE Lab color space and the spatial feature of an image is retrieved by the proposed spatial algorithm. A CBIR system is created by using color homogram filter and spatial filter sequentially in online query processing. The color-spatial query results from the final query ranking are ranked according to the total normalized distance in color and spatial features as the query presentation. This system is implemented by using MATLAB programming.

Keywords: CBIR System, CIE Lab Color Space, Spatial Algorithm, Color Homogram Filter, Spatial Filter

1. Introduction

In content-based retrieval (CBR) system, the multimedia database is stored and managed a large collection of multimedia objects such as audio data, image data, video data and etc. CBR systems support retrieval based on the image content, such as color histogram, texture, shape, objects, and wavelet transforms. Content-Based Image Retrieval (CBIR) System is required to effectively and efficiently use information from the image repositories. CBIR system is based on only the image data in the multimedia database. Multimedia data mining methods are Similarity Search in Multimedia Data, Multidimensional Analysis, Classification and Prediction Analysis and Mining Associations in Multimedia Data. The CBIR system and description-based retrieval system are defined into the similarity-based multimedia indexing and retrieval systems [3].

CBIR system protects the disadvantages of the traditional way of retrieving (text-based or description-based) approach. The same image may be described by the different people in the different ways as the rich semantics of an image is difficult to be precisely described. To overcome this drawbacks of the text-based approach, the content-based image retrieval (CBIR) approach that retrieves images directly and automatically based on their contents [5][7] such as color, texture, sketch, shape, volume, spatial constraints, browsing, objective attributes, motion, text, and domain concepts is used [4].

CBIR System has two kinds of queries: Image-sample-based queries which find all of the images that are similar to the given image sample and Image feature specification queries which specify or sketch image features like color, texture or shape, which are translated into a feature vector to be matched with the feature vectors of the image in the database. QBIC (Query By Image Content) supports both these queries. QBIC allows queries on large image and video databases based on example images, user-constructed sketches and drawings, selected color and texture patterns [2]. Some systems support both content-based and description-based retrieval systems. This paper is applied a color homogram filter and spatial filter to retrieve the similar color and spatial image from our Content-based Image Database.

The rest of the paper is organized as follows. In Section 2, we reviews related work. Section 3 describes CIE Lab color space. We show system design of the CBIR system in Section 4. Section 5 shows the implementation and Section 6 describes the analysis of the proposed system. Section 7 describes conclusion of the system.

2. Related Work

This CBIR system is applied "*query by example"* query pattern, which searches the top N images similar to an example image or the user query image based on color and spatial query features. Because each image has many features, similarity comparison based on a single feature is not enough. Some hierarchical approaches to content-based image retrieval system are combined by using multiple visual features.

A color label histogram filter, wavelet texture filter and spatial segmentation filter were utilized to query the similarity images with their contents. All images passing the three filters were ranked based on the total normalized distance in color, texture, and spatial information [5].

The color label histogram filter and class parameters filter were utilized to query and screen objectionable images [6].

The color homogram filter, wavelet texture filter and spatial filter were used in sequence to eliminate images that are dissimilar to a query image in color, texture, and spatial information from the search ranges respectively. The final query ranking is based on the total normalized distance in color, texture, and spatial information of all images passing the three filters and the experimental results showed the effectiveness of this approach [7].

3. CIE Lab Color Space

CIE stands for the Commission Internationale de l'Éclairage. CIE L*a*b* (CIELAB) is the most complete color model used conventionally to describe all the colors visible to the human eye. The three parameters in the model represent L*, a* and b*. Since the Lab model is a three dimensional model, it can only be represented properly in a three dimensional space.

L*: The L* coordinate of an object is the lightness intensity as measured on a scale from 0 to 100, where 0 represents black and 100 represents white.

a*: The a* coordinate of an object represents the position of the object's color on a pure green and pure red scale, where -127 represents pure green and +127 represents pure red.

b*: The b* coordinate represents the position of the object's color on a pure blue and pure yellow scale, where -127 represents pure blue and +127 represents pure yellow.

4. System Design of CBIR System

There are two major processing units: offline feature extraction, online query processing. In offline feature extraction, color feature which takes into account both the occurrence of colors of pixels and the colors of the neighboring pixels is extracted from color homogram computation by applying CIE Lab color space, and spatial feature is obtained by using a spatial algorithm. This system design is shown in Figure 1.

4.1. Color Homogram Computation

Color is one of the most prominent perceptual features. It is a feature of the great majority of content-based image retrieval systems. The color homogram can be created by using these three definitions.

Definition 1: consider the neighboring pixels of similar colors, not just of the same colors.

$$\delta(\Delta C) = Z(\Delta C, a, b, c) = \begin{cases} 1 & 0 \le \Delta C \le a; \\ 1-2\left(\frac{\Delta C - a}{c-a}\right)^2 & a \le \Delta C \le b; \\ 2\left(\frac{\Delta C - c}{c-a}\right)^2 & b \le \Delta C \le c; \\ 0 & c \le \Delta C \le L. \end{cases} \quad \text{-------} \quad (1)$$

Where,

ΔC = Euclidean distance between color values of two pixels (i, j) and (k, l)

δ(ΔC) = degree of homogeneity in terms of color

Z(ΔC, a, b, c) = standard fuzzy Z function

If a is assigned to 0, b to L/2 and c to L, then, Z(ΔC, 0, L/2, L)

Definition 2: The fuzzy set technique is utilized to encode the degree of color similarity.

$$h(C,\theta) = \sum_{P_c} \delta(\Delta C(P_c, N_\theta)) \quad \text{-----} \quad (2)$$

Where,

h(C, θ) = fuzzy color homogeneity vector at angle θ

P_c = a pixel of color c

N_θ = specific neighbor at angle θ

ΔC= Euclidean distance between color values of two pixels

δ (ΔC) = degree of homogeneity in terms of color

Definition 3: Color categorization is incorporated in color space quantization. Color homogram is obtained by normalizing, summing up and averaging four color homogeneity vectors for each C.

$$H(C) = \frac{1}{4}\left\{ \frac{h(C,0)}{M(N-1)} + \frac{h(C,45)}{(M-1)(N-1)} + \frac{h(C,90)}{(M-1)(N)} + \frac{h(C,135)}{(M-1)(N-1)} \right\} \quad \text{----} \quad (3)$$

Where,

H(C) = function value at specific color C of homogram H

M-by-N = size of image.

4.2. Spatial Algorithm

Spatial algorithm of our system is as follows.

1. Use label function to find the connected object and count the numbers of containing each label.
2. Find the largest object
   LargestObject = Find (Largestobject (labels));
3. Calculate the positions of this largest object by using five points such as top_left, top_right, bottom _ left, bottom_right, and center point.

4. These five positions are the Spatial Features.
5. Then, calculate the Spatial Filter by using difference of spatial features between the query image and the images in the database.

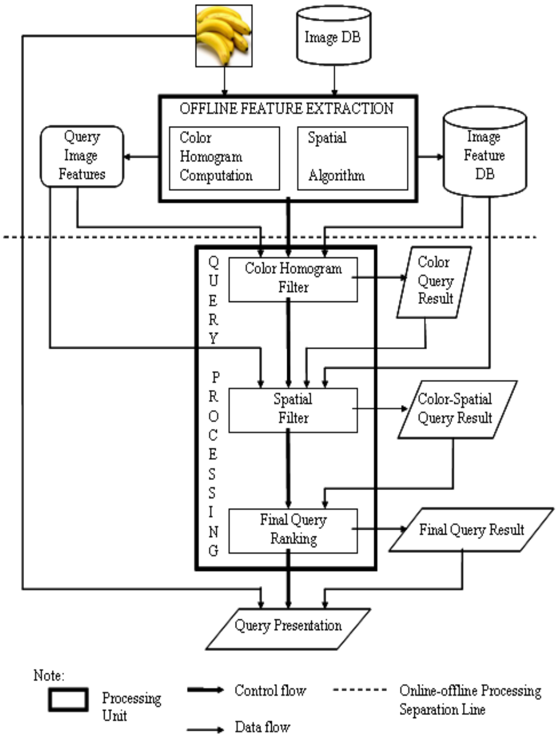


Figure 1. System design of CBIR system by using color homogram filter and spatial filter

4.3. Color Homogram Filter

Digital images can be processed in a variety of ways. The most common one is called filtering and creates a new image as a result of processing the pixels of an existing image. Each pixel in the output image is computed as a function of one or several pixels in the original image, usually located near the location of the output pixel.

Color Homogram Filter eliminates the images whose color homogram distance is larger than a threshold and filters out the images that are not similar to the query image in color.

$$D^{(q,d)}_{c\,homog} = \sum_{k=1}^{B} \left| h_k^q - h_k^d \right| \quad \text{------} (4)$$

Where,
$D^{(q,d)}_{c\,homog}$ = L1-Distance between the color homo - grams of q and d
q = query image
d = image in the image database
h_k = homogeneity value of the k^{th} color category
B = total number of color categories

4.4. Spatial Filter

Spatial Filtering has two types of filtering. They are Linear Spatial Filtering and Nonlinear Spatial Filtering.

If the computations performed on the pixels of the neighborhoods are liner, the operation is called linear spatial filtering (the term spatial convolution also used); otherwise it is called nonlinear spatial filtering [1]. The spatial filter computes the spatial information similarity between a query image q and the color query result images by using the spatial algorithm.

Spatial Filter removes images dissimilar to the query image in spatial information from the query results of the color homogram filter by using a threshold.

$$D_{spatial(q,d)} = SF(q) - SF(d) \quad \text{---------} \quad (5)$$

Where,
$D_{spatial(q,d)}$ = spatial information similarity between q and d.
SF (q) = spatial feature for query image
SF (d) = spatial feature for images in the database.

4.5. Final Query Ranking and Presentation

$$D_{sim(q,d)} = D_{color(q,d)} / MAX_{d \in [1,k]} (D_{color(q,d)}) + D_{spatial(q,d)} / MAX_{d \in [1,k]} (D_{spatial(q,d)}) \quad \text{------} \quad (6)$$

Where,
k = the number of images that passed two filters.
$D_{sim(q,d)}$ = total similarity distance between q and d
q=query image
d=images in the database

In online query processing, the query image's features are compared to each image feature in the image feature database by using color homogram filter and spatial filter. A total normalized distance is used to rank the images in the query result obtained from the spatial filter. The query presentation shows the outputs such as final query results from the color homogram filter and spatial filer together with the query image.

5. Implementation

In this paper, the input image or query image is color image (RGB) with jpg extension. RGB color space is converted to CIE Lab color space. The images in the database have the same size and the same the file format. In this paper, the number of image database is 500 images and all images have size 134 * 134. All images have the same file format (.jpg). The main GUI menu of the CBIR System by using Color Homogram Filter and Spatial Filter is shown in Figure 2. The main GUI menu consists of six processing buttons. They are "Load Query Image", "Show Image Database", "Change to CIE Lab Color Space", "Color Homogram Filter", "Spatial Filter", and "Final Query Ranking".

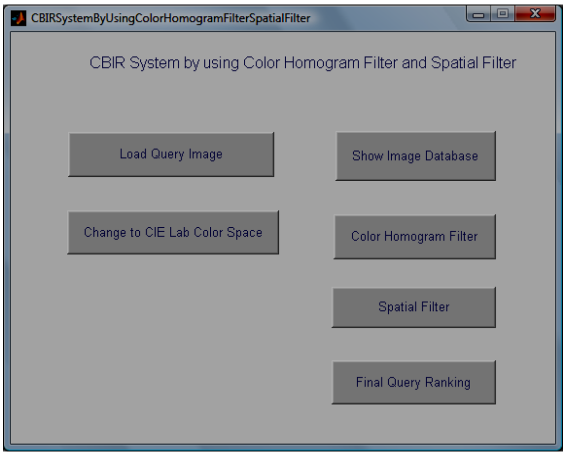
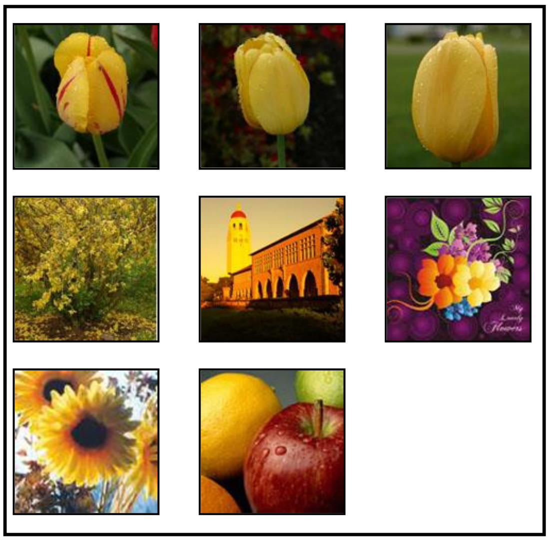


Figure 2. Main menu of the CBIR system by using color homogram filter and spatial filter

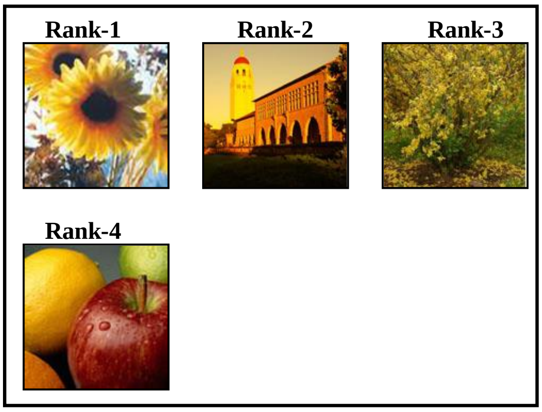
Then the color space of the query image has to change into the CIE Lab. So, the user clicks the "Change to CIE Lab Color Space" button, the color space of the query image is changed to CIE Lab color space. The color homogram feature of query image is extracted.

(a) Query image



(b) Color query results

(c) Color-spatial query results



(d) Final query ranking

Figure 3. Query image and its color-spatial results (from a to d)

When the "Color Homogram Filter" button is clicked, the images which are similar to the color of the query image appear in Figure 3(b). By clicking "Spatial Filter" button, the images that are similar to the spatial feature of the query image appear. The color-spatial query results appear as the output images in Figure 3(c).

The "final query ranking" button arranges the color-spatial query results that the image which are closest distance with the query image appears at first in Figure 3(d). 500 images are stored in the image database when the user wants to look the image database, the user can click the "Show Image Database" button.

6. Analysis

In this experiment, the color groups are divided into sixteen groups according to the color homogram of our image feature database. They are Brown, Blue, Black, Green, Orange, Pink, Purple, Red, White, Yellow, Light_Pink, Light_Blue, White_Green, Green_Blue, Green_Yellow and Yellow_Green. The deatail analysis is shown in Table 1.

If the threshold values of T_a* and T_b* are 5 for all brown images, and white images, the results are Fair. For Light_Pink images with these thresholds, the results are Poor. When the threshold values of T_a* and T_b* are 10 for Yellow images, White_Green images and Red images, the results are Fair. If the threshold values of T_a* and T_b* are 20 for the Light_Pink images, Yellow_Green images and White_Green images, the results are Fair. The convenient threshold value of T_L* is 25. Then, the values of the threshold of T_L*, T_a* and T_b* are shown in Table 1 for this color feature.

Table 1. Threshold values of L*, a* and b* for color feature

No	Color	T_L*	T_min_a*	T_max_a*	T_min_b*	T_max_b*	Anal-ysis
1	Brown	25	10	10	5	20	Good
2	Blue	25	10	10	5	20	Good
3	Black	25	10	10	5	20	Good
4	Green	25	10	10	20	20	Good
5	Orange	25	10	10	5	20	Good
6	Pink	25	5	20	10	10	Good
7	Purple	25	10	10	5	20	Good
8	Red	25	10	10	5	20	Good
9	White	25	10	10	5	20	Good
10	Yellow	25	10	10	5	20	Good
11	Light_ Pink	25	5	20	10	10	Good
12	Light_ Blue	25	5	20	10	10	Good
13	White_ Green	25	10	10	20	20	Good
14	Green_ Blue	25	10	10	5	20	Good
15	Green_ Yellow	25	20	5	10	10	Good
16	Yellow _Green	25	10	10	20	20	Good

In this Table 1, T_L* means the lightness of the image. The T_min_a* defines the value of the differencing from the threshold value T_a*of the query image and the T_min_b* defines the value of the differencing from the threshold value T_b* of the query image. The T_max_a* defines the value of the adding to the threshold value T_a* of the query image and the T_max_b* defines the value of the adding to the threshold value T_b* of the query image.

If the spatial image feature is center, spatial analysis is good. If other natures of spatial foreground image are left, right, top and bottom, the results are Fair. In this spatial filter stage, the threshold of small_value_x and large_value_y are -20 and the threshold of large_value_x and large_value_y are 20.

Therefore the color and spatial filtering for the query image results the output-images which have the similar color and the similar spatial features.

7. Conclusion

There are 500 images with the seven semantic categories. These categories are animals with 80 images, buildings with 41 images, cars with 5 images, flowers with 160 images, fruits with 48 images, jewels with 10 images, and scenes with 156 images. The features of these images are extracted by using color homogram computation with CIE Lab color space and spatial algorithm. These images are filtered by using color homogram filter and spatial filter. Therefore, the similar color and spatial results are retrieved by a query image.

8. References

[1] C.G.Rafael, E.W.Richard and L.E.Steven, *Digital Image Processing Using MATLAB*, 2004.

[2] F.Myron, S.Harpreet, N.Wayne, A.Jonathan and etc, “Query by Image and Video Content: The QBIC System”.

[3] H.Jiawei and K.Micheline, *Data Mining Concepts and Techniques*.

[4] N.G. Venkat and V.R. Vijay, “Content-Based Image Retrieval Systems”, pp. 18-22, 1995.

[5] Xiuqi Li, Shu-Ching Chen, Mei-Ling Shyu, and BorkoFurht, “An Efficient Multi-Filter Retrieval Framework For Large Image Databases”, 2002.

[6] Xiuqi Li, Shu-Ching Chen, Mei-Ling Shyu, and BorkoFurht, “A Novel Hierarchical Approach For Image Retrieval Using Color and Spatial Information”, 2002.

[7] Xiuqi Li, Shu-Ching Chen, Mei-Ling Shyu, and BorkoFurht, “Image Retrieval By Color, Texture, And Spatial Information”, NSF CDA-9711582.