IMAGE INFORMATION RETRIEVAL FROM INCOMPLETE QUERIES USING COLOR AND SHAPE FEATURES

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ABSTRACT

Content based image retrieval (CBIR) is the task of searching digital images from a large database based on the extraction of features, such as color, texture and shape of the image. Most of the research in CBIR has been carried out with complete queries which were present in the database. This paper investigates utility of CBIR techniques for retrieval of incomplete and distorted queries. Studies were made in two categories of the query: first is complete and second is incomplete. The query image is considered to be distorted or incomplete image if it has some missing information, some undesirable objects, blurring, noise due to disturbance at the time of image acquisition etc. Color (hue, saturation and value (HSV) color space model) and shape (moment invariants and Fourier descriptor) features are used to represent the image. The algorithm was tested on database consisting of 1875 images. The results show that retrieval accuracy of incomplete queries is highly increased by fusing color and shape features giving precision of 79.87%. MATLAB ® 7.01 and its image processing toolbox have been used to implement the algorithm.

KEYWORDS

Content based image retrieval, color image, incomplete query image, color feature, shape feature.

1. INTRODUCTION

Content based image retrieval CBIR systems uses the contents of a query image provided by the user to search similar images in a very large database. The most common methods used are based on color, shape, texture information or combinations of these [1]. Color, texture and shape are the most important visual features of image. Color feature plays an important role in CBIR due to its robustness to complex background and independent of image size and orientation. However, using color alone is insufficient to distinguish images because some images have the same color proportions but different spatial distributions. This results in CBIR scheme which combine multiple features in order to achieve better retrieval performance [2, 3]. HSV color space is widely used in computer graphics, visualization in scientific computing and other fields [4, 5]. Therefore, the proposed algorithm selects the HSV color space to extract the color features such as hue, saturation and value. An effective shape feature is a key component, since shape is a basic property of an object present in the image itself. Most of existing shape descriptors is usually either application dependent or non-robust, making them undesirable for shape description [6, 7]. In this paper we investigate and analyze color and shape feature to retrieve incomplete query from database consisting of large number of similar images. The proposed system results the images from the database which are most similar to input incomplete query image. The feature vector of the query image is compared with the feature vector of each image in the database image using Euclidean distance measure.

2. OVERVIEW OF FEATURE EXTRACTION

Generally, any CBIR techniques use visual features of images, such as color, shape and texture yielding vectors with hundreds or even thousands of features. As many features are correlated to others it brings extra knowledge and can deteriorate the ability of the system to correctly distinguish them. Moreover, having a large number of features leads to the "dimensionality curse" problem, where the indexing, retrieval and comparing techniques collapse, due to the fact that it is not possible to well separate the data, making the process of storing, indexing and retrieving extremely time consuming. Thus, the key challenges of searching similar images from a large database are the high computational overhead due to the "dimensionality curse" and the semantic gap [8, 9]. In this paper we use color and shape features. Collectively all these features were combining to form a single vector which we call as feature vector.

2.1. Shape Analysis

An effective, working and efficient shape descriptor is a key component of content description for an image, since shape is a basic property of an object present in the image itself [10]. These shape descriptors are broadly categorized into two groups, i.e., contour-based shape descriptors and region based shape descriptors. Due to the fact that contour-based shape descriptors exploit only boundary information, they cannot capture the interior shape of the objects and also these methods cannot deal with disjoint shapes or the shape which is not closed where contour information is not available. In region based techniques, shape descriptors are derived using all the pixel information within a shape region. Region-based shape descriptors can be applied to general applications [6]. Fourier Descriptor (FD) and Moment Invariants are used for shape analysis since they are perfect shape descriptor and do not produce redundant values. Since the colored image has several kinds of objects, Fourier descriptor may be the best possible descriptor for calculating the boundaries of the objects present in the images. The proposed shape descriptor is derived by applying 2-D Fourier transform on an image. The acquired shape descriptor is application independent and robust. Their main advantages are that they are invariant to translation, rotation and scaling of the observed object. Thus shape description become independent of the relative position and size of the object in the input image [11, 12].

In order to determine Fourier descriptors first the image is converted into the binary image and then filtered using a Gaussian mask of size 15x15 with variance, σ = 9 and threshold of 0.7.Then the image is segmented and boundary of the object is determined. The boundary is presented as an array of complex numbers which correspond to the pixels of the object boundary if the image is placed in the complex plane. Fourier descriptors are now calculated by combining Fourier transform coefficients of the complex array. Let the complex array $z_0, z_1, z_2 \ldots z_{N-1}$ represents the boundary belonging to the object whose shape needs to be described. The *k*-th Fourier transform Coefficient is calculated as [13].

$$Z_n = \sum_{n=0}^{N-1} Z_n e^{\frac{-2\pi k_{in}}{N}} \quad \text{Where k= 0, 1, 2,……., N-1} \tag{1}$$

The Fourier descriptors are obtained from the sequence Z_k by truncating elements z_1 and z_2, then by taking the absolute value of the remaining elements and dividing every element obtained array by $|z|$. To summarize, the Fourier descriptors are:

$$c_{k=2} = |z_k|/|z_1|,\ k = 2, \ldots \ldots, N-1 \quad (2)$$

For N-point digital boundary in the xy-plane, starting at an arbitrary point (x0, y0), coordinate pairs (x_0, y_0), (x_1, y_1) …, (x_{N-1}, y_{N-1}) are encountered in traversing the boundary, say, in the counterclockwise direction. These coordinates can be expressed in the form x (n) = x_n and y(n) =y_n. With this notation, the boundary itself can be represented as the sequence of coordinates s(n)=[x(n),y(n)], for n = 0, 1, 2,……., N-1. Moreover, each coordinate pair can be treated as a complex number so that

$$s(x) = x(n) + jy(n) \quad (3)$$

The Discrete Fourier Transform (DFT) of s (n) is

$$a(u) = \sum_{n=0}^{N-1} s(n) e^{\frac{-2jun}{N}} \text{ ,u=0, 1, 2, ……………N-1} \quad (4)$$

The complex coefficients a(u) are called the Fourier descriptors of the boundary. The inverse Fourier transform of these coefficients restores s (n). That is,

$$s(n) = \frac{1}{N} \sum_{u=0}^{N-1} a(u) e^{\frac{2\pi jun}{N}} \text{ ,n=0, 1, 2, ...N-1} \quad (5)$$

Suppose, however, that instead of all the Fourier coefficients, only the first P coefficients are used. This is equivalent to setting a(u) = 0 for u > P-1 in the preceding equation for a(u). This result is the following approximation to s (n):

$$s(n) = \frac{1}{p} \sum_{u=0}^{p-1} a(u) e^{\frac{2\pi jun}{N}} \text{ , n= 0, 1, 2..............N-1} \quad (6)$$

Although only P terms are used to obtain each component of ŝ (n), n still ranges from 0 to K-1. That is, the same number of points exists in the approximate boundary, but not so many terms are used in the reconstruction of each point. The high-frequency components account for fine detail, and low-frequency components determine global shape. Thus, loss of detail in the boundary increases as P decreases.Although only P terms are used to obtain each component of ŝ (n), n still ranges from 0 to K-1. That is, the same number of points exists in the approximate boundary, but not so many terms are used in the reconstruction of each point. The high-frequency components account for fine detail, and low-frequency components determine global shape. Thus, loss of detail in the boundary increases as P decreases.

The second feature which is used for shape description is Moment Invariants. Regular moment invariants are one of the most popular and widely used contour-based shape descriptors is a set of features derived by Hu (1962). Hu's moment invariants and extended Zernike moments were used as feature extractors.

A two-dimensional moment of a digitally sampled $M \times M$ image that has gray function $f(x, y = 0 \ldots\ldots M-1)$ is given as [14]:

$$m_{pq} = \sum_{x=0}^{M-1} \sum_{y=0}^{M-1} (x)^p (y)^q f(x,y), \qquad p,q = 0,1,2 \ldots \quad (7)$$

The moments *f (x, y)* translated by an amount *(a, b)*, are defined as

$$\mu_{pq} = \sum_x \sum_y (x+a)^p (Y+b)^q f(x,y) \tag{8}$$

Thus the central moments m'_{pq} or μ_{pq} can be computed from (2) on substituting $a = -x$ and $b = -y$ as,

$$\bar{x} = m_{10}/m_{00}, \ \bar{y} = m_{01}/m_{00} \tag{9}$$

$$\mu_{pq} = \sum_x \sum_y (x-\bar{x})^p (y-\bar{y})^q f(x,y) \tag{10}$$

When a scaling normalization is applied the central moments change as,

$$\eta_{pq} = \mu_{pq}/\mu_{00}^{\gamma} \tag{11}$$

$$\gamma = \left[\frac{p+q}{2}\right] + 1 \tag{12}$$

In particular, Hu (1962) defines seven values, computed by normalizing central moments through order three, that are invariant to object scale, position, and orientation.

2.2. Color Analysis

We use HSV color model for extracting color feature such as hue, saturation and value which is a type of color space. In HSV, hue represents color, Saturation indicates the range of grey in the color space and Value is the brightness of the color and varies with color saturation. The advantage of using HSV color space is that it selects various different colors needed from a particular image. In general it gives the color according to human perception [15].

3. PROPOSED METHODOLOGY

3.1. Development Environment

The functional code for our prototype system was implemented using MATLAB ® 7.0 on a Pentium dual core II, 2.48 GHz Windows-based PC.

3.2. Database Preparation

We use 1875 different digital color images of various categories collected from the open source [16]. Candidate image terminology is used for the image which is already stored in the database. Query image terminology is used for the image given to the CBIR system and it is incomplete image. We use two databases one for images and another for feature vector of these images. Feature vector of the incomplete query image is calculated at the run time.

3.3. Determining Feature Vector

Our database contains different objects like flowers, animals, monuments etc. The color and shape features discussed in section 2 were extracted and represented as a single array which we call as feature vector.

3.5 Distance Calculation

The efficiency and accuracy of the image retrieval is significantly affected by the ability of the distance calculation techniques. Let $X = [X1, X2 \dots \dots \dots \dots \dots Xn]$ be the feature vector of the candidate image and $Y = [Y1, Y2 \dots \dots \dots \dots Yn]$ be the feature vector of the incomplete query image. Euclidean distance between the candidate image feature vector and the query image feature vector is given by [17]. The result of the distance calculation is used for retrieving images similar to incomplete query image.

$$D = (\sum_{i=1}^{n} |X_i - Y_i|^2)^{\frac{1}{2}} \tag{13}$$

The result of the distance calculation is used for retrieving images similar to query image. Figure 1 shows the block diagram of proposed method.

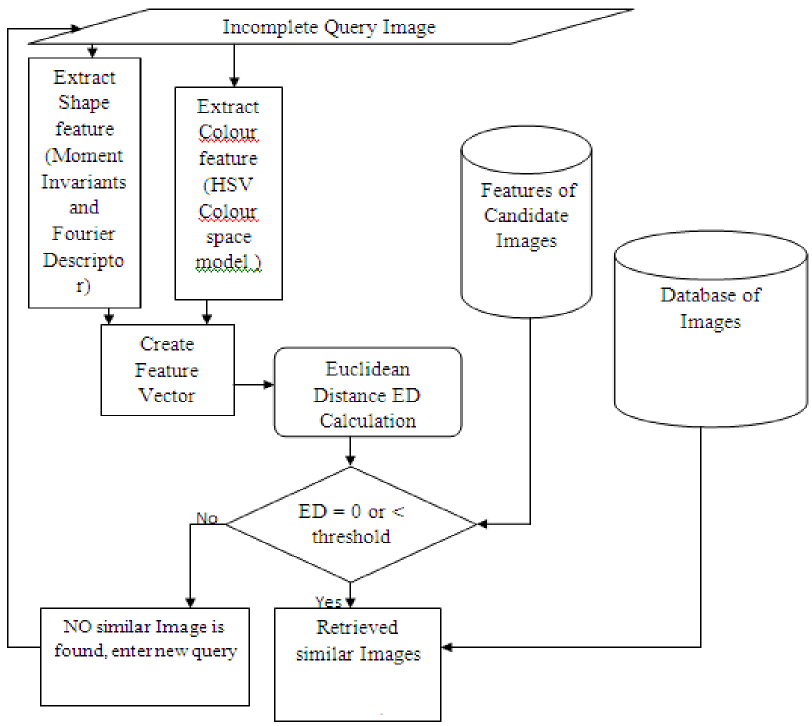

Figure 1. Block Diagram of Proposed Method

4. RESULTS AND CONCLUSIONS

Figure 2 to figure 5 shows the results of proposed methodology. It is verified from the figure 2 that when only shape feature is used for retrieval of query image the correct image is at sixth position, thus giving poor retrieval accuracy. Thus here we conclude that shape features are highly affected if query is incomplete and may result in very low retrieval efficiency. Thus to increase the retrieval efficiency of the proposed system we combine both color and shape features. We give more weightage to the color feature vector in the hybrid approach. Fig 3 to 5 shows retrieval results using both color and shape feature. When both color and shape features were combined it is observed from figure 3-5, that the query image is retrieved at first position thus increasing the retrieval accuracy.

For the performance evaluation of retrieval system, Precision calculation is used. Two class precision is calculated by categorizing the database into two classes. One class is Animal and other is Non-animal. The category of animal includes dolphin, tiger, fish , starfish , penguin , cougar , ant , butterfly ,etc and in the category of Non-animal there are sunflower , water lily , tree , fruits , etc. Precision is mathematically defined as:

$$\text{Precision} = \frac{t_p}{t_p + f_p} = \frac{r}{k} \tag{14}$$

t_p is the number of images retrieved relevant to the query, f_p is the number of images retrieved irrelevant to the query. In this result t_p is the number of animal images and f_p is the number of non – animal images, where r is the number of total number of relevant image retrieved and k is the total number of images retrieved. The incomplete/ distorted query is presented to the CBIR system and their precision is calculated. The precision is calculated for shape features, color features and their combined approach. The precision is calculated for the average 100 incomplete queries given to the system. Table 1 shows the results.

Figure 2. Query image (left) and similar images (right) retrieved by the system using only shape feature.

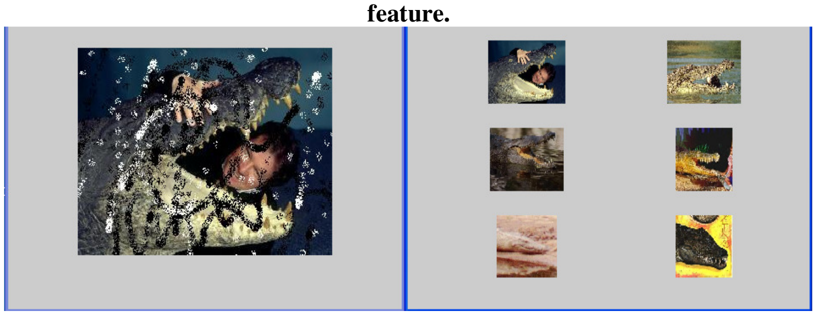

Figure 3. Query image (left) and similar images (right) retrieved by the system using shape and color feature.

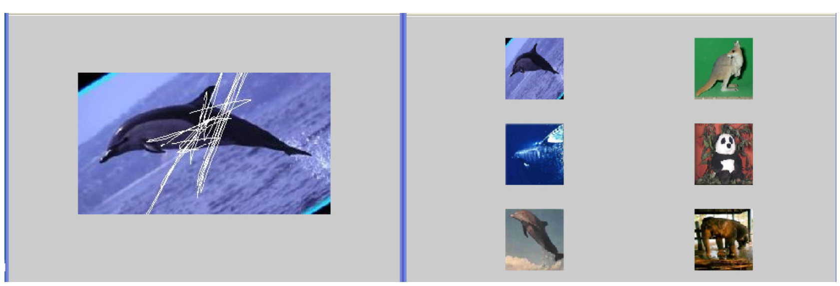

Figure 4. Query image (left) and similar images (right) retrieved by the system using shape and color feature.

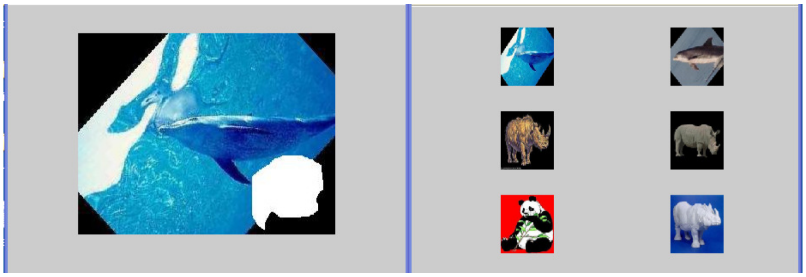

Figure 5. Query image (left) and similar images (right) retrieved by the system using shape and color feature.

Table 1. Precision calculation using color and shape features

S.No	Feature	Precision (%)
1	Shape (Moment invariant, Fourier descriptor)	68.42
2	Color (HSV color space model)	75.87
3	Combined Approach	79.87

5. CONCLUSIONS

In this research retrieval of incomplete/distorted queries using shape and color analysis is addressed. Experiments were conducted on 1875 color images collected from open source database. It is found that if shape features alone were used for retrieval of incomplete/distorted queries the retrieval accuracy is very poor giving precision of 68.42%. Thus shape feature is not sufficient if the query is incomplete or distorted. To address this problem we combine color features with shape features to retrieve query image from the database. The result shows that retrieval accuracy is highly increased by fusing color and shape features giving precision of 79.87%. The performance of the proposed system can be further improved by including other CBIR features such as textures features.

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