Content Based Image Classification And Retrieval Using Support Vector Machine

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Abstract

Content-based image retrieval (CBIR) systems are a special type of Information Retrieval (IR) system where the elements in the repository are pictures. IR works with finding digital resources in large databases. CBIR is developed to retrieve the desired target image from the large collection of images based on the contents of the given query image. The Contents of image can be extracted from any images which are specified color, shape, texture or any other characteristics of images. The system derived two types of different color features - color moment and color auto-correlogram. The moments of image can be used to indicate color distribution of an image which can be described as a probability distribution of colors. To calculate the spatial correlation of pairs of color different with distance, color correlogram is introduced in the system. Gabor wavelets are used to express texture of natural image. The characteristics of Gabor wavelets are similar to those of human visual features. The system firstly created the features vector with these three types of features and used to get higher retrieval results of system. To gives the better result in retrieval of system and classify the query image, Support Vector Machine classifier is used with the combination of these visual features.

Keywords: *color moment, color auto-correlogram, Gabor wavelet, feature vector, Support Vector Machine, visual features*

1. Introduction

Nowadays, most people are using multimedia data which includes images and videos processing. The rate of media usages are dramatically increased in our life because of the popularity of digital devices and personal computers. The efficient retrieving and searching contents from large-scale multimedia databases is the critical point of challenges in huge volumes of media data usage.

Image retrieval is a technique to browse, search and retrieve similar images from a big database of digital images. There are different methods to find out similar image from large database;

1. Text Based Image Retrieval (TBIR) which is given a keywords or textual description for searching an image by user as shown in Figure 1.

Image is searched using the keywords or textural description in TBIR. It is easy to develop and generate the retrieval results quickly. But TBIR approach needs to manually assign the descriptions of images. It is impossible for large database and require lots of work load with very time consuming process. Another one is different textual description of image by different people may lead to loss of information for results.

2. Content Based Image Retrieval (CBIR) which is used the basic visual features of an image such as color, shape, texture and spatial layout to represent and index the images.

CBIR methods developed specifically for various image retrieval applications could prove the solution to the difficulties of TBIR. CBIR used low level feature of image like color, shape, texture and high level feature entropy, mean, standard deviation which are contents or information of images to get efficiency results. The system firstly derived the visual contents features and stored in feature vector for further use. Firstly, the desired input data of system must be image format then it proceeds for the training and read the required features of all images stored in the database. When the user input query image, the same feature extraction steps are brought for it. Then the similarity matching process is bringing out to retrieve the similar images of query image. It performs the matching between the features of query image and images in the database. It is most widely used in various kinds of fields like medical, search engines, crime prevention, and many more because it can provide the fast and accurate results as compared to TBIR.

Most of CBIR used the content of images such as color, shape and texture features for the process of searching or retrieving image. Color based image retrieval system commonly computed the color histogram as color features. Shape of the image can

be determined by applying segmentation or edge detection to express the shape of particular region. Texture features are used to find visual patterns which appear in the image. Some of CBIR system developed the combination of these types of visual contents to improve the results of system. To increase and analyze the performance of the system, CBIR combined with other feature selection or classification algorithm.

This system presents color moments and color auto-correlogram for extraction of color features. Color moment characterizes one dimensional color distributions with the first three moments. Color auto correlogram integrates spatial information with color histograms to overcome the weak point of the histogram method. These two color features are more robust and effective than the histogram based method. Gabor wavelets with different directions and frequencies are used to detect the slight differences between various types of images. Texture features are calculated with Gabor wavelets which discriminate the texture features of various images. Support Vector Machine (SVM) with the above three types of feature vector is implemented to classify the type of image and to improve the retrieving process.

The reminder of the paper is organized as follows. The related work is described at Section 2. The overview of Content-based Image Retrieval system is presented in Section 3. Section 4 explains the detail structure of the developed methodology of system. Support Vector Machine Algorithm is described in Section 5. Section 6 includes Evaluation of the System Performance and the system is concluded in Section 7.

2. Related Work

Most people access and use online digital image and videos due to the rapid development of internet and digital image processing technology. The huge databases are needing to store and available much more images to satisfy the users' requirements. Searching the related images by the querying image is becoming very difficult. Image retrieval is a technique for retrieving and querying images from a digital image of big database. The researchers are interested at the image retrieval processing as attractive field of research area. They adopted various type of algorithm to implement for image retrieval. Some methods have used global color and texture features while others have applied based on local colors and texture. The combination of color, texture and shape features techniques are also developed to get higher accuracy of searching image.

Authors in [1] present a framework for combining all the three i.e. color, texture and shape information, and achieve higher retrieval efficiency. It used the integration of the local color, texture and shape features and also the global color, texture and shape features. Color histogram method is applied as color features and Grey Level Co-occurrence matrix is calculated as features vector of texture. To calculate the feature of shape, Canny edge detection algorithm is implemented. Even though the system provided better results of other system based on each color, texture and shape features method, the results sometime contain different images.

Enhanced Color histogram based on SVM is developed in [2]. Most of color based CBIR extracted and used only global color features such as color histogram. Using the color histogram may case the problem which is including different images with same color in the output of system because of depending on color information. To reduce the unexpected errors of color histogram, the author introduce Enhanced color histogram that retrieved images by using color histogram and rank them according to how these are recognized by the learning algorithm. A SVM classifier can be learned from training data of relevant images and irrelevant images marked by users. The system demonstrated with the comparison between query of color histogram and enhanced color histogram with SVM to show the improvement of retrieval system.

Author in [3] implemented the combination of color, texture and shape features based CBIR to produce efficient image retrieval results. It extracts the color, texture, shape features of query image and then makes a combined feature vector. After this, the system retrieves similar images from database which have minimum distance by comparing feature vector of query image to feature vector of database images using Euclidean distance as similarity measure. Author presented the effectiveness of the system comparing with the result of each feature and fusion of three features.

The combination of the texture and color features which are extracted through discrete wavelet transformation and color histogram methods is introduced at [4]. Although Texture analysis is generally a very time-consuming process the output of the system is more satisfactory than the traditional method based on single visual feature.

The system in [5] clarified the flow of an efficient and accurate in image searching system by

using Gaussian Measure Model (GMM) and Relevance Feedback. The values of features between of low-level feature and high-level features of image are always different. According to the system, Relevance Feedback can adjust the difference values of features and support to get more accurate result.

Author in [6] implemented a multi-feature model for the Content Based Image Retrieval System which is combined the features of image such as color histogram, color moment, texture, and edge histogram descriptor features. The users can choose desired feature extraction method for retrieving the images. if the relevance feedback process added to this system the further result will be improved.

A method for indexing of images in the large database with Block Truncation Coding (BTC) is developed in [7]. This system used two different color feature extraction methods - Color Moment and Color Auto-correlogram. The original image is divided into multiple non-overlapping blocks due to Block truncation coding technique and then retrieves the required features.

Although various type of CBIR system is already developed, it is still valuable and required in research area to get more relevant results of user requirements. The system also has been introduced image matching or retrieval system to fulfill the users' satisfaction in digital image processing.

3. Content-based Image Retrieval System

Content-based image retrieval is used to browse and access the images from a volume of image database matching the distance value of the visual contents of images. The visual features of each image in the database are extracted based on its pixel values. The features include color, shape, texture and other spatial information of the image. The values of respective features are stored in another database as features vector. When the users submit a desired query image, the system must extract the required features and create feature vector. In this system, color auto-correlogram, color moments, gabor wavelet are used as features of query image. Then it calculated and ranked the distances between similarity measures of the feature vector of the query image and images in the feature database. After ranking the distance of similar images and returns the results that are most similar to the query image. The developed method comprises the main two types of techniques to retrieve the content-based images retrieval. They are as follows:

(i) Image retrieval based on combined the three types of features

(ii) Image retrieval based on combined the three types of features with SVM

The fundamental processes of CBIR is presented in Figure 1.

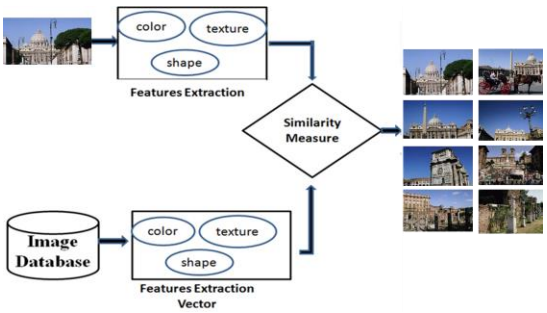


Figure 1. Fundamental Structure of Content-based Image

4. Methodology of the CBIR

The developed system contains the four main phases. Figure 2 shows the conceptual architecture for Content-based Image Retrieval with SVM.

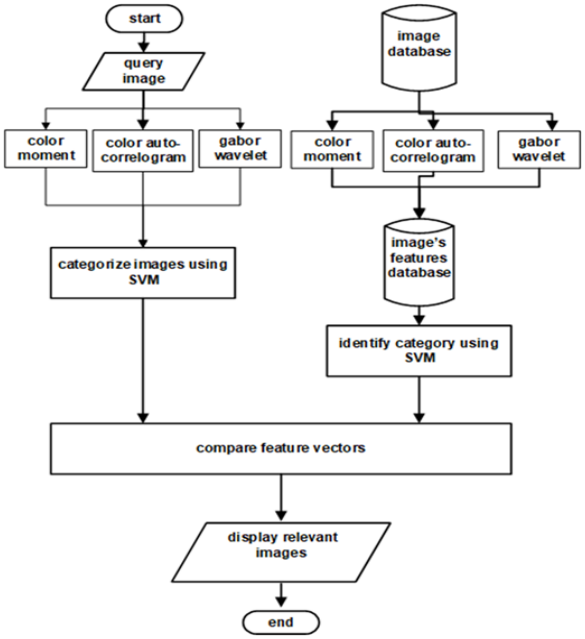


Figure 2. The Conceptual Architecture for Content-based Image Retrieval with SVM

The first phase is the creation of images features database. The system extracts the Color Moment, Color Auto-Correlogram and Gabor

Wavelet features of each image from images database to get the characteristics of images and stored them in the feature vector. The second is accessing the input query image and extracting the features of query image. The third brings similar images retrieval based on the three types of visual features. In these stages, the system continues to match the distance values between the feature values of query image and the values from image database by using the fusion of features. The final one of these stages is the retrieval of similar images from database by showing from the above matching the feature of query image with similarity value. The fourth step is the combination of classification and image retrieval with SVM to get better results of the CBIR. SVM classifier will be used Color Moment, Color Auto-Correlogram and Gabor Wavelet features as attributes of classifier to generate retrieval results.

4.1. Color Moments Feature Extraction

Color moments are measures that can be used differentiate images based on their features of color. Once calculated, these moments provide a measurement for color similarity between images. These values of similarity can then be compared to the values of images indexed in a database for tasks like image retrieval.

It specifies the distribution of color in image. To compare the similarity of two images based on color feature, the usage of color distribution is main factor for color indexing purposes as features in image retrieval applications. The process of Color distribution is to encode the shape and color information of an image. These two features are reasonable features to use under changing lighting conditions. Any color model such as RGB, HSV, HIS, etc. allows to compute color moments features.

If the system interprets the color distribution of an image as a probability distribution, then the color distribution can be characterized by its moments. If the value of the i^{th} color channel at the j^{th} image pixel is P_{ij} and the number of pixels is N.

Mean: The first color moment can be interpreted as the average color in the image, and it can be calculated by using the following formula:

$$E_i = \sum_{j=1}^{N} \frac{1}{N} p_{ij}$$

- where N is the number of pixels in the image and pij is the value of the j^{th} pixel of the image at the i^{th} color channel.

Standard Deviation: The second color moment is the standard deviation, which is obtained by taking the square root of the variance of the color distribution.

$$\sigma_i = \sqrt{\left(\frac{1}{N}\sum_{j=1}^{N}(p_{ij} - E_i)^2\right)}$$

- where E_i is the mean value, or first color moment, for the i^{th} color channel of the image

The two types of color moment values of query image are as shown in Figure 3.

Figure 3. The Color Moment values of query image

4.2. Color Auto-correlogram Feature

Color histogram is one of the most important techniques in content-based image retrieval. The weak point of the histogram method is there is no any space information in color histogram.

Color auto-correlogram techniques proposed to integrate spatial information with color histograms. It can define the auto-correlogram of image I for color Ci, with distance k.

$$\gamma_{C_i}^{(k)}(I) \equiv \Pr[\mid p_1 - p_2 \mid = k, p_2 \in I_{C_i} \mid p_1 \in I_{C_i}]$$

Correlogram shows how the spatial autocorrelation of color changes with distance. Auto-correlogram integrates the color information and the space information. For each pixel in the image, the auto-correlogram method needs to go through all the neighbors of that pixel. The correlogram method is more stable to color change than the histogram. Figure 4 illustrates the auto-correlogram value of query image.

Figure 4. The Color auto-correlogram values of query image

4.3. Gabor Wavelets Texture Feature

Texture is defined as structure of surfaces formed by repeating particular element different relative spatial positions. The repetition involves local variations of scale, orientation of the elements. Image textures are defined as images of natural textured surfaces. It contains important information about the structural arrangement of the surface i.e., clouds, leaves, bricks etc and also describes the relationship of the surface to the surrounding environment. The feature describes the distinctive physical composition of a surface.

Gabor wavelet is widely adopted to extract texture from the images for retrieval. Each wavelet specifies a specific frequency and specific orientation to capture the energy at these specific points. Figure 5 presents the values of Gabor Wavelets. Gabor filter can be represented by the following equation:

$$\psi(x, y, \lambda, \theta) = \frac{1}{2\pi S_x S_y} e^{-\frac{1}{2}\left(\frac{x_1^2}{S_x^2} + \frac{y_1^2}{S_y^2}\right)} e^{j\frac{2\pi x_1}{\lambda}}$$

- where (x, y), the pixel position in the spatial domain, λ means Wavelength of frequency of pixels, Θ is Orientation of a gabor filter and S_x, S_y, Standard deviation of the x & y directions

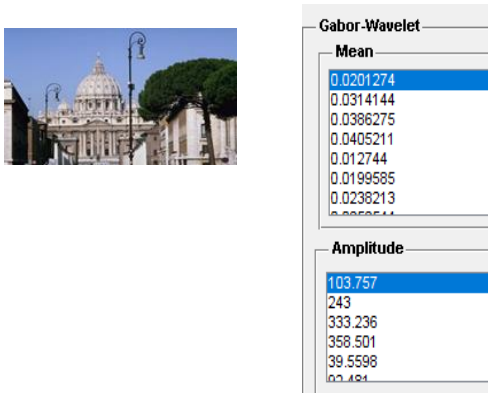


Figure 5. The Wavelet values of query image

4.4. Images Searching with fusion of color and Texture Features

To extract the similar images from database, the user provides the query image to the system as an input. The system then extracts the features of query image and change into the internal representation of feature vectors. After extracting of relevant features of query image, the system continues the matching similarity measures of features values for their similar image retrieval from the database. Similarity measure is done by Manhattan or Euclidean distance for the feature vector values of combined features. The similarities/distances between the feature vectors of the query image and those of the images in the database are then calculated and retrieval the top similar images.

The results for the fusion of color and texture features are as shown in Figure 6.

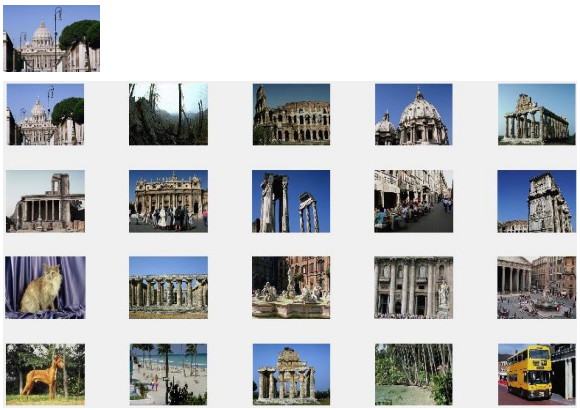


Figure 6. Image Retrieval for moments with three visual Features

The query image of user submitted is a moment with white, green, blue color and then the system returns 20 images containing 14 moments having almost white, blue, green color and 6 are other images.

Figure 7 also contains the 2 different images in the results of bus query image. The system just displays based on especially color and texture features. The most similar values of all images are included in results. The system need to improve the retrieval result of query image.

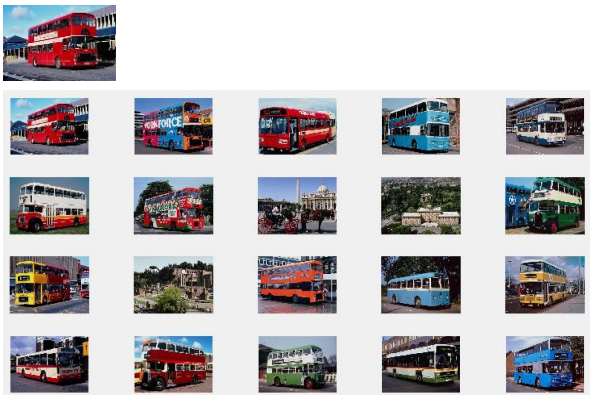


Figure 7. Image Retrieval for buses with three visual Features

5. Support Vector Machine Classifier

Support Vector Machine is supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. It works by taking the whole set of input then reading it and then for each of the input, the relevant output is extracted. The whole process is assumed as classification which classifies data by finding the best hyperplane that separates all data points of one class from those of the other class. Support Vector Machine learning algorithm is applied to produce the classification parameters according to calculated features.

The result can be obtained in two forms either as discrete or continuous. It works by the mapping of input space to the feature space. Feature space is defined as the space which is kept for the purpose of calculating similarity by usage of the kernel function.

Support Vector Machine Algorithm

Training vectors : x_i , i = 1, . . . ,L

Consider a simple case with two classes:

Define a vector y:

$$y_i = \begin{cases} 1 & \text{if } x_i \text{ in class } 1 \\ -1 & \text{if } x_i \text{ in class } 2, \end{cases}$$

A hyperplane which separates all data and separating hyperplane with: $w^T x + b = 0$

$(w^T x_i) + b > 0 \quad \text{if } y_i = 1$

$(w^T x_i) + b < 0 \quad \text{if } y_i = -1$

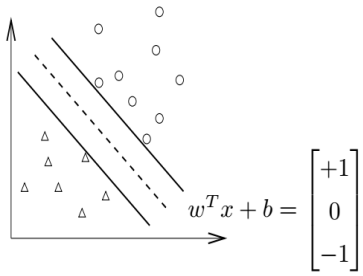
Decision fı $f(x) = \text{sign}(w^T x + b)$, x: test data

Variables: w and b are coefficients of a plane

Select w, b with the maximal margin.

Maximal distance be $w^T x + b = \pm 1$

➢ Eg:



The system used Holdout Method cross validation model to divide training and testing dataset and model evaluation. The input dataset is partitioned into 2 subsets for training and testing purpose using Holdout Method cross validation method. The training algorithm runs 2 times. On the first training run, it uses the part of the training data to train as shown in Figure 8, and then compute the performance of model using the next part of remaining data to test to classify the category of images with SVM classifier as shown in Figure 9. After finished training and testing cycles, the system generates the retrieval results of query images and class of image. And then, the system calculates the estimate of the accuracy of the model for target images and output images.

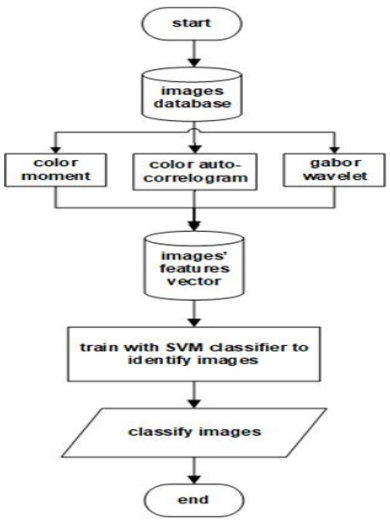


Figure 8. The training part of SVM classifier

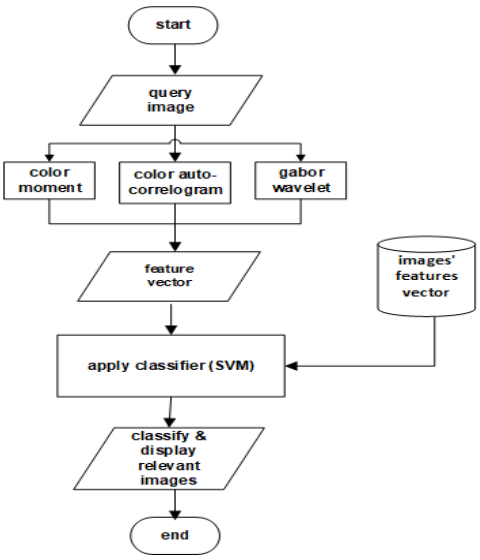


Figure 9. The testing part of SVM classifier

The relevant results of SVM classifier and three visual features are shown in Figure 10.

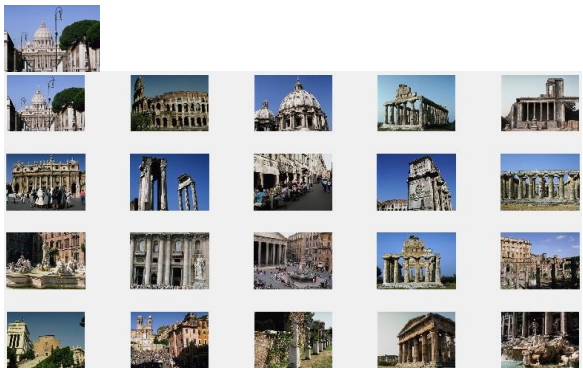


Figure 10. Image Retrieval for moments with three visual Features combined with SVM

The system classifies which type of images and filter the irrelevant image in the retrieval results. The result is manipulated all the moments images and almost white, green and blue color for query image moment. The results image of bus is cleaned the different images containing above the retrieval results as illustrated in Figure 11. The system used the features vector of visual contents as attribute of SVM to filter and classify the type of the images.

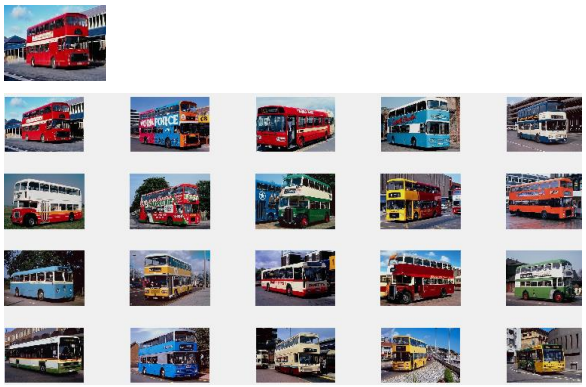


Figure 11. Image Retrieval for buses with three visual Features combined with SVM

6. Evaluation of the System Performance

To know the class of query image and evaluate the performance of the system, SVM classifier is conducted. The accuracy values of each image are calculated to identify the performance of retrieval of the system. The accuracy of the system is the measurement of the retrieved relevant images to the query of the total retrieval images. The system will calculate the accuracy values of each class in images database.

To evaluate the system, it has collected 1000 images which contain the images of Arabian Horses, buses, moments, Roses, etc. database and used 100 images of Roses, cat, dog, drinks, tree and leaves, moment etc. that is not contained in database. Then it retrieves 20, 40, 60, 80, and 100 numbers of images respectively for each type of image by using SVM classifier. Table 1 shows the average accuracy values of each type of image regarding SVM classifier with three types of combine features of image retrieval method. The system can retrieve relevant similar image for Dinosaurs with 85 % accuracy and 82.8 % accuracy for Trees and Leaves. The system can retrieve for all types of image database with 83.82% average accuracy for trained images.

The system is tested with no trained images to retrieve the relevant images for above ten types of image. It can generate the relevant results with reasonable accuracy for no train image because the feature of images are obviously similar with trained data. The system can retrieve all type of images with _____ average accuracy for no trained images.

Table 1. The accuracy values of the classifier

Class of Data	Accuracy for Trained Images (%)	Accuracy for no Trained Images (%)
Drink	84.4	83.8
Buses	83.8	80.2
Cats	83	83.4
Dogs	83.4	81.8
Moment	84.2	81.2
Roses	83.8	82.8
Beach	83.8	80.4
Dinosaurs	85	82.4
Trees& Leaves	82.8	82
Arabian_Horses	83.8	80

7. Conclusion

The concepts of image classification and Content Based Image Retrieval have been combined in the system is to classify the images and retrieve the formation of query image. Classifier is generally used to classify the category of each image. The system presents (i) the fusion of auto-correlogram, color

moments, gabor wavelet features and (ii) the combination of these three features and support vector machine technique, in similarity image retrieval system. Using a single feature is hard to attain satisfactory retrieval results because an image contains various visual characteristics. SVM classifier can be efficiently used to learn from training data of relevant images and irrelevant images identified by users. The results of system experiment demonstrate that there is considerable improve in retrieval efficiency when the three types of visual features and SVM classifier are combined.

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