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Content-Based Image Retrieval (CBIR) System Based on the materialized views and Genetic Algorithm

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Abstract:

Content Based Image Retrieval (CBIR) is the technique by which an image is searched for in a multimedia database based on its features not by its name or description. CBIR is process of searching and retrieval from multimedia database depend on query of image. Then compare all images in database with Query image for best match by this way the retrieval time depend on database size. This type of searching is not work well in large database. If we want system work more efficient we need to match query image with part of database. In this paper we propose a approach to speedup image retrieval by using materialized views instead of all database and genetic algorithm to catch optimal image.

Key words: CBIR, Feature Extraction, Genetic Algorithm, materialized views, Image Retrieval.

INTRODUCTION

Multimedia environment, much talked- topic in computers, is adding new dimensions in the area of information technology and all relevant fields. Multimedia databases contain text, audio, video and image data help us to deal with enormous amounts of information and which has brought fundamental changes in our life style.

To retrieve any image, we have to search for it among the database using some search engine. Then, this search engine will retrieve many of images related to the searched one. Text-based and content-based are the two techniques adopted for search and retrieval in an image database.

The image contents, features of the image, like color, texture and shape that are automatically extracted from the images themselves have been used for image retrieval. This method is called content-based image retrieval (CBIR). CBIR enables the elimination of the difficulties that exist in traditional text-based query for large image database and then the system will provide better indexing and return more accurate results [1].

The common applications of CBIR include medical diagnosis by comparing X-ray images with old cases, or in criminal investigation by finding the faces of criminals from an image of a crowd

FEATURE EXTRACTION

As human beings, they are able to inform a story from an image based on what they see and their background knowledge. Also a computer program can discover semantic concepts from images. The first step for a computer program in semantic understanding is to extract efficient and effective visual Features and build models from them rather than human background knowledge. As we known, the most common visual features include color, texture and shape, etc, and mainly image retrieval systems have been constructed based on these features.

COLOR FEATURE

Color is one of the very important features of images. Color features are defined subject to a particular color space or model. A number of color spaces have been , such as RGB, LUV, HSV and HMMD. After the color space is specified, color feature can be extracted from images or regions. We have different color methods such as Histogram it is simple to compute and intuitive, also Common Moment (CM) is one of the simplest and very effective features [2]. The first-order (mean), the second (standard deviation), and the third-order (skewness) color moments have been proved to be efficient and effective in representing color distributions of images. If the value of the i th color channel at the j th image pixel is $pi\ j$ then the color moments are as follows.

Moment 1. Mean

$$Ei = \frac{1}{N}\sum_{j=1}^{N} Pij \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [15]$$

Moment 2. Standard deviation

$$\sigma_i = \sqrt{\frac{1}{N}\sum_{j=1}^{N}(Pij - Ei)\,2} \quad \ldots\ldots\ldots\ldots\ldots\ldots [16]$$

Moment 3. Skewness

$$S_i = \sqrt[3]{\frac{1}{N}\sum_{j=1}^{N}(Pij - Ei)3} \quad \ldots\ldots\ldots\ldots\ldots\ldots [17]$$

Where Pij is the color value of the i-th color component of the j-th image pixel and N is the total number of pixels in the image. Ei, σi, Si denote the mean, standard deviation and skewness of each channel of an image respectively.

TEXTURE FEATURES

Texture is another important visual feature to characterize the content of image and also can provide powerful information for image retrieval. Gabor wavelet is the most common method for texture feature extraction, and it has been widely used in image texture feature extraction. The image is filtered with a bank of Gabor filters or Gabor wavelets. Each wavelet captures energy at a specific frequency and direction which provide a localized frequency as a feature vector. so, texture features can be extracted from this group of energy distributions. Given an input image I(x,y), Gabor wavelet transform convolves I(x,y) with a set of Gabor filters of different spatial frequencies and orientations [2]. A two-dimensional Gabor function g(x, y) can be defined as follows:

$$g(x,y) = \frac{1}{2\pi\sigma x\sigma y}\exp\left[-\frac{1}{2}\left(\frac{x2}{\sigma 2}+\frac{y2}{\sigma 2}\right)+2\pi jWx\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [2]$$

Where σx and σy are the scaling parameters of the filter (the standard deviations of the Gaussian envelopes), W is the center frequency, and θ determines the orientation of the filter.

MATERIALS AND METHODS

Several general-purpose systems have been developed for content based information and image retrieval. For each system, we will focus on the features that are used to extract information from the image and matching between the query image and the database. We will mention some of them below:

Faster image retrieval can be achieved by categorizing images according to this reference. The images are first decomposed by mathematical functions (by wavelet function), then their featured are extracted also using functions and clustering of features are used to categorize the data (images) in the database. They are then divided into different categories according to their features. When the query image is it makes comparison between each features in new image and features of images in cluster and finding candidate matching features based on Euclidean distance of their feature vectors. The new retrieval strategy try to balance between accuracy of retrieval and complexity, the image is then filtered through three phases before being returned to the user. In the first phase the query image is found from the database. In the second phase high level and low level frequency components are dealt with. In the third step similar images are retrieved from the database. They mentioned that fast image retrieval can be achieved through their categorized system. We however think their system however can be efficient in terms of accuracy because the images are retrieved by using three filtering processes first. However, in terms of speed we disagree because filtering the results three times after categorizing is time consuming. Also, the fact that they decomposed the image first is time consuming [3].

In this reference an image mining technique for image retrieval was implemented. The main objective of the image mining is reducing data loss and extracting the meaningful potential information to the humans' expected needs. In this system the database images and query images all first go through an enhancement process to remove any distortion, then their average RGB values are computed. They are then grouped according to their texture value, high, low or average [4].

There are many techniques in CBIR; all techniques try to improve performance of retrieval process used different approaches. There are many factors effect in retrieval process but we think time and optimal solution are the most important factors.

As we know CBIR is process of searching and retrieval from multimedia database depend on query of image. Then compare all images in database with Query image for best match by this way the retrieval time depend on database size. This type of searching is not work well in large database. If we want system work more efficient we need to match query image with part of database.

Materialized view came to solve this problem. A Materialized View is a database object, which contain the result of a query. It can be a local copy of data located remotely or it can be a summary table based on aggregations of table's data. Materialized views are stored in database physically, it contains original data and metadata.

MATERIALIZED VIEW

Firstly, the feature of image query to lead to creation depends on specific algorithm. In the Second step after the features are extracted from the query image, the images are then classified according to their features and a materialized view is created for each classification, where the images are then inserted. By the same way we create many materialized views which have similar features but different from each other. By using this process, we will have many materialized views each contains images with identical features [5].

Materialized views very effective in speed up the query images because it removes the overhead which is case by joins and aggregations functions for huge queries. Materialized views used high level feature because it is better than low level feature but it is more difficult.

GENETIC ALGORITHMS

Most of CBIR techniques use set of features not all features in image; by this way perhaps not catch the optimal image. Genetic Algorithm came to solve this problem. It extracted all set of features from images. It used color histogram features, shape and texture in the feature extraction process. A Genetic Algorithm (GA) is a search algorithm based on the idea of evolution and genetics of living organisms that works to find the optimal solution to a problem by applying the techniques inspired by natural selection. In their technique which they named GA-based similarity measure, chromosomes are first created from search space which consists of strings. The strings contain all possible solution to the problem. The genes of these chromosomes are the indices of the database images. The number of images in the queried database determines the values of the genes. The extracted features of each image are grouped as the GA algorithm generates a number of chromosomes (images) which are the most relevant to the given query image. This process is repeated until the number of specified similar images is obtained (optimal chromosomes). The optimal chromosome (image) is then used to retrieve the similar images from database [6].

In GA there is many candidate hypotheses we search to find the best hypothesis. This "best hypothesis" called fitness. GA can be divided to four operations namely as population, selection, crossover and mutation as presented in Figure 1. The GA opreations iteratively updating a group of hypotheses known as population. In any iteration all members of population are weighed according to fitness, then new population are generated by selecting the member with high weighed "better the chromosomes". The crossover operation creates two new children from two parent strings by selected bits from each parent. Then the mutation operation created random changes to the bits string by selecting a single bit at random.

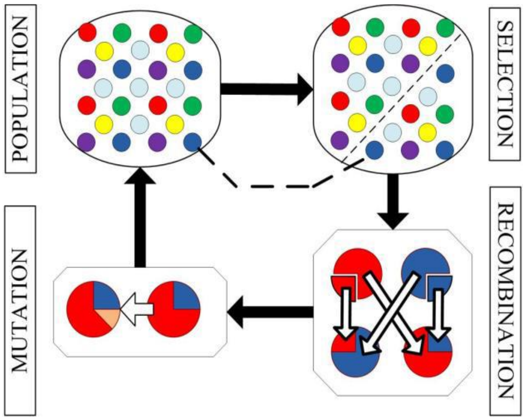


Figure 1: Main opreations of GA

THE PROPOSED WORK

In our proposed system we will use Materialized views for indexing. Within these views, the search process will be performed using the GA. The proposed system is composed of two phases, Offline and Online. In the Offline phase the system administrator will input a large amount of images into the system. Specific image features are then extracted and each feature will be given a specific weight by the GA. The GA will optimize the weights, which will then be saved in the features database. The images will then be inserted into materialized views in the database by the GA. In the Online phase, when the user submits a query image the features vector of the image will be extracted and the GA will calculate a specific weight for the query image. The features weight of the query image is then compared with the previously stored weights in the materialized views to select the most corresponding view. The GA will then search in the selected view for the best matching image.

The proposed algorithm phase (1) Offline:

Purpose: Create the features database and the index files.
Input: RGB images.

Output: Image's features database and its index files.
Procedure:
{
Step1: The input images are color images in RGB color space.
Step2: Calculate the color features.
Step3: Calculate the texture feature.
Step4: Make features vectors that will represent the images.
Step5: Using genetic algorithm to optimize features weights.
Step6: Save weighted features vectors in the features database.
Step7: insert the images in the Materialized view database using GA algorithm.
Step8: Save index files which indexing each Materialized view along with its associated view ID. }

The proposed algorithm phase (2) Online:
Purpose: Retrieving N images similar to the input image.
Input: RGB image, number of retrieved images N.
Output: Images similar to the input image.
Procedure:
{
Step1: The input images color image in RGB color space.
Step2: Extract the features vector for the input image by using the same techniques as given in phase 1.
Step3: Calculate the weighted features vector for the input image by multiplying its features vector by the optimal weight vector that generated by GA.
Step4: compare the features of the query image(s) with the features of materialized views.
Step5: search the image(s) in the materialized view.
Step6: Retrieve the first N images that are more similar to the input image.}

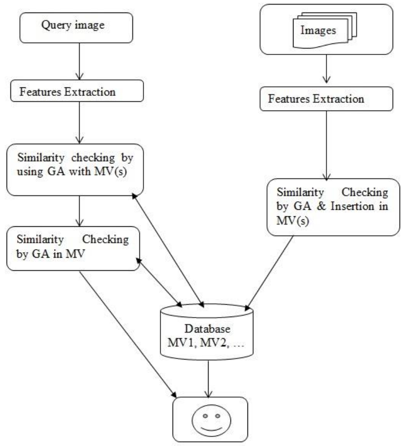


Figure 2: the Proposed CBIR System.

RESULTS AND EVALUTION

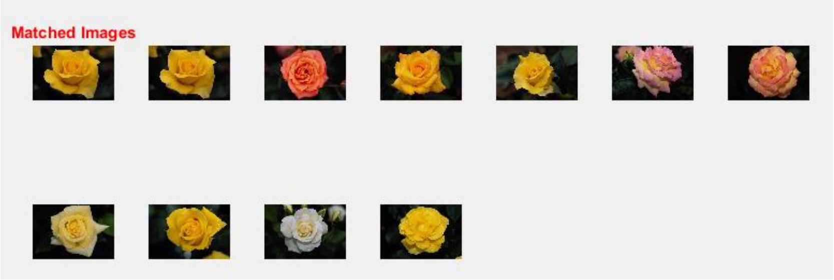
We used in our evaluation WANG database [7], it is subset of Corel database og 1000 images. These images are grouped into 10 classes, each class contain 100 images. We use MATLAB language and statistical tools for implementation. Usually precision and recall are used in CBIR system to measure retrieval performance. Precision, P, is defined as the ratio of the number of retrieved relevant images to the total number of retrieved images.

$$P = \frac{\text{Number of relevant images retrieved}}{\text{Total number of images retrieved}}$$

Recall, R, is defined as the ratio of the number of retrieved relevant images to the total number of relevant images in the whole database [8].

$$R = \frac{\text{Number of relevant images retrieved}}{\text{Number of relevant images in database}}$$

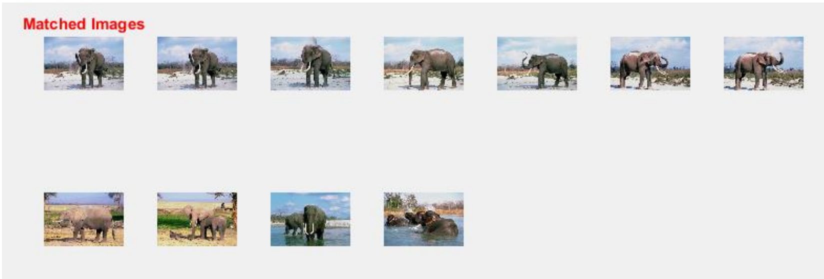
To test the efficiency of our algorithm, we select 5 images randomly form different classes, Flowers, Horses, Dinosaurs, Elephants, Beaches. Each query returens the top 10 images from the database , shown in figure 3. As we can see from these figures, all the images are similar to the query image and belong to the same class except the Beaches guery.



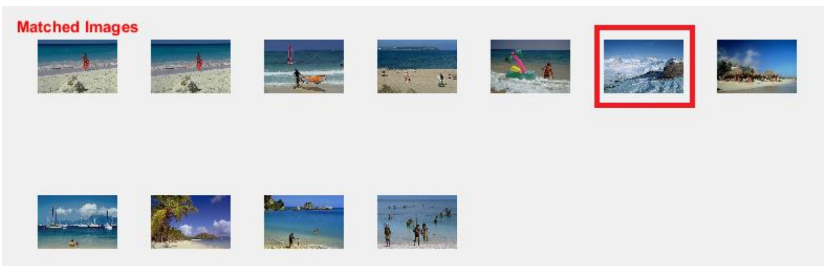
a) Flowers Query, 10 Matches from Top 10 Retrieved Images.

b) Horses Query, 10 Matches from Top 10 Retrieved Images.

c) Dinosaurs Query, 10 Matches from Top 10 Retrieved Images.



d) Elephants Query, 10 Matches from Top 10 Retrieved Images.



e) Beaches Query, 9 Matches from Top 10 Retrieved Images.

Figure 3: Five Query Response Examples of Our Proposed System.

From the above testing, we can see the system has very good retrieving results over the randomly selected images as queries. The precision values of the retrieval results for top 5, 10, 15and 20 retrieved images in response to each of the five queries are given in Table 1. As can be noticed from this table, the precision values are high for small number of retrieved images, and these values decrease as the number of retrieved image increases, indicating that the system gives a good ranking of the retrieved images.

Table1: Precision of the propsed system for top 5, 10, 15, and 20 retrieved images for different queries.

Query	Top 5	Top 10	Top 15	Top 20
Flowers	1	1	1	1
Horses	1	1	0.86	0.85
Dinosaurs	1	1	1	1
Elephants	1	1	0.93	0.8
Beaches	1	0.8	0.8	0.75

To further evaluate the proposed system we compared our proposed system with some of the existing region based algorithms, we used the same approach as that of Lakshmi et al [9], 20 images are randomly selected as queries from each of the 10 semantic classes in the database, we have 200 query images. For each query, we examined the precision of the retrieval based on the relevance of the semantic meaning between the query and the retrieved images. Each of the 10 categories in the database portrays a distinct semantic topic, therefore this assumption is reasonable to calculate the precision. The average precisions for each group based on the returned top 20 images were recorded. The result of this study is compared against the performance of IRM [10], Fuzzy Club [11], Geometric Histogram [12], and Signature Based [9], ERBIR system [13]; they use the same database for evaluation, the comparison is recorded in Table 2.

Table 2: Comparison of Precision of Proposed System with Previously Existed Systems.

Semantic Group	Fuzzy Club	IRM	Geometric Histogram	Signature Based CBIR	ERBIR System	Proposed System
Africa	0.65	0.47	0.125	0.42	0.70	**0.712**
Beaches	0.45	0.32	0.13	0.46	**0.57**	0.515
Building	0.55	0.31	0.19	0.25	0.49	**0.567**
Buses	0.70	0.61	0.11	0.83	0.87	**0.887**
Dinosaurs	0.95	0.94	0.16	0.92	0.99	**1**
Elephants	0.30	0.26	0.19	**0.95**	0.57	0.720
Flowers	0.30	0.62	0.15	0.96	0.83	**0.961**
Horses	0.85	0.61	0.11	0.89	0.93	**0.935**
Mountains	0.35	0.23	0.22	0.32	0.50	**0.504**
Foods	0.49	0.49	0.15	0.28	**0.65**	0.597

Table 2 shows that our proposed system performs better than other systems for all classes except for classes Beaches, Elephants, and Foods. This is a good indicator for the effectiveness of our system. The reason behind the limitation in three classes is that those classes' images are very similar in term of the dominant color and texture so, our system may confuse between them.

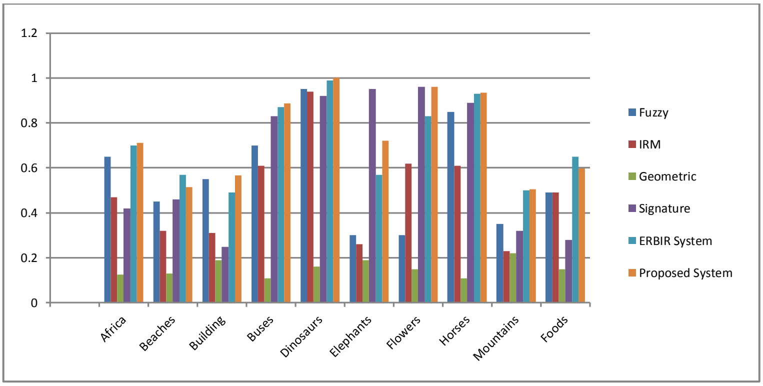


Figure 4: Comparison of Precision of the Proposed System with Previously Existed Systems.

CONCLUSION

Content-based image retrieval is a hot topic research, many researches have been done to develop some algorithms that solve some problems and achieve the accuracy when retrieving images. Materialized view selection includes two costs, query processing cost and view maintenance cost. Designers hope to get good query performance, while access to low maintenance costs. In our proposed system we try to get best query performance by materialize all views in database, it takes up the maximum physical space and the high view maintenance cost but we will doing Offline to get fast response time. In our research Color and Texture features were extracted; for color features, the moments of the color distribution were calculated from the images and used as color descriptor. For texture features, We used Gabor filter, which is a powerful texture extraction technique in describing the content of image and the maximum average precision of 0.73 at recall value is 0.14. We also compared our proposed system with other existing CBIR systems that use the same database we have used for system evaluation. The comparison shows that our system outperforms the other systems and the results are satisfactory.

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