Genetic –Based Face Retrieval Using Statistical Features

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Abstract

Content-based image retrieval has been keenly developed in numerous fields. This provides more active management and retrieval of images than the keyword-based method. So the content based image retrieval becomes one of the liveliest researches in the past few years. In a given set of objects, the retrieval of information suggests solutions to search for those in response to a particular description. The set of objects which can be considered are documents, images, videos, or sounds.

This paper proposes a method to retrieve a multi-view face from a large face database according to color and texture attributes. Some of the features used for retrieval are color attributes such as the mean, the variance, and the color image's bitmap.

In addition, the energy, and the entropy which based on the gray level values in an image is too considered as the features.

In addition to statistical approaches, models of artificial intelligence produce a desirable methodology that enhances performance in information retrieval systems, and the genetic algorithm depicts one of them. The GA is preferred for its power and because it can be used without any specific information of the domain.

The experimental results conclude that using GA gives a good performance and it decreases the average search time to (60.15 milliseconds) compared with (722.25milliseconds) for traditional search.

Key words: CBIR, Face Retrieval, Genetic Algorithm, Statistical Features, Wavelet

Introduction

Contemporary multimedia technology leads to the increasing needs of image and video applications in education, entertainment, remote sensing, medicine, and security [29].

As the technology improves, the use of internet and new progressive digital image sensor technologies increase and a very large database of image are being created by scientific, industrial, medical and educational presentations. There is a great need to professionally retrieve and store image data to perform assigned tasks and to produce a result. Hence, the development of an appropriate tool for image retrieving from huge image gathering is a challenge task.

The two different kinds of approaches generally adopted in image retrieval are: text and content based. In the text-based system, the images are manually marked by text descriptors and then they are used by a database management system for accomplishing image retrieval.

Though, the use of keywords has two limitations to accomplish image retrieval: the enormous labor necessary in manual image footnote and the description task of the content of image is extremely subjective. On the other hand, the viewpoint of textual descriptions specified by an annotator differs from the viewpoint of a user. That is, there are conflicts between user textual queries and image annotations. To reduce the problem of incompatibility, the image retrieval is performed depending on the contents of the image. This strategy is the referred to as Content-Based Image Retrieval (CBIR) [20].

The principal target of CBIR system is to gather relevant descriptions of visible attributes of images to simplify effective and valuable retrieval [1, 12].

Face retrieval technology is needed for searching the certain people in the surveillance video automatically. The goal of face retrieval is to retrieve the face images of certain people given a query face image. Such work could be used in various applications of different areas, such as in the security field, searching a criminal from the surveillance video. Face retrieval is performed based on feature representation extracted from images [27].

Feature extraction of faces plays an important role in security access control systems, law enforcement forensic investigation, and low bit video coding.

The color features of a color image used here are: the mean, variance, and energy values. While as the texture feature the entropy depending on the gray level values is used. The typical task of searching for the features is mathematically expensive, and hence genetic algorithm (GA) is used as a search algorithm. GA has several advantages that make it more convenient than traditional search algorithms [29].

In the present paper, a system is suggested that uses the genetic algorithm (GA) to deduce which images in the databases would be most significant to the user.

The Proposed System

The flowchart of the general steps of this system is shown in Figure (1). The details description of its steps are presented in the following sections:

Color Space

Color images can be represented by using three primaries of a color space [30]. Since the RGB space does not correspond to the perceiving colors by the human and does not isolate the component of luminance from the chrominance components [5]. The YUV color space is used in the proposed system to represent the face images. The YUV color space can be considered to be similar to human eye's retina, while the main channel – luminance (denoted as Y channel) or "luma" describes the intensity of light. In the YUV color space, two additional channels – chrominance components called "U" and "V" – carry the color information. There are many formulas to convert from RGB to YUV [18].The equations that are used in the proposed system are as follows:

$$Y = 0.299 * R + 0.587 * G + 0.114 * B$$
$$U = (-0.147 * R - 0.289 * G + 0.436 * B) + 128 \quad \ldots\ldots\ldots\ldots (1)$$
$$V = (0.498 * R - 0.417 * G - 0.081 * B) + 128$$

Wavelet Transform

The aim of the transform is the changing the representation of a signal or a function by using of a mathematical operation[17].

The wavelet transformation can be considered as the most effective transform which deals with image, sound, or any other pattern because it yields a robust representation of time-space (time-frequency) [8].

The wavelet transform comes in two different forms, the first form is the continuous wavelet transform (**CWT**) which is leading to a continuous input signal, the time and scale parameters can be continuous, and the second form is the discrete wavelet transform (**DWT**) which can be defined for discrete-time signals[23, 19]. The DWT is adopted in this paper.

The two-dimensional wavelet transform can be accomplished via sequentially employing one-dimensional wavelet transform to rows and columns of the two-dimensional data. In the figure (2), **L** indicates low-pass filtering (**LPF**) and **H** indicates high-pass filtering (**HPF**). In the final stage of decomposition for an image of size NxN -where N is a power of two- we have four sub-band images, each of **N/2×N/2** resolution: the scaling component**, LL**, containing global low-pass information, and three wavelet components, **LH**, **HL**, and **HH** corresponding respectively to the vertical, horizontal and diagonal details [7]. The data in subband "LH" was obtained from high pass filtering of the rows and then by low pass filtering of the columns [8].

A particular set of wavelets is specified by a particular set of numbers, called wavelet filter coefficients. The most localized embers often used are Haar coefficients. For easy notation we will use the notation h(0) and h(1) for Haar coefficients [15].

In the 2-D Haar bases wavelet, the matrix form will be as

$$T = \begin{bmatrix} h(0) & h(1) & 0 & 0 \\ 0 & 0 & h(0) & h(1) \\ h(1) & -h(0) & 0 & 0 \\ 0 & 0 & h(1) & -h(0) \end{bmatrix}_{N\times N} \quad \ldots\ldots (2)$$
$$= \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \\ 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$$

In our experimentations, we have selected two levels of decomposition according to the size of the face images. There is no need to perform a deeper decomposition, because the size of images, after the second level, becomes too small and no more beneficial information is acquired [9].

At the second level of decomposition, one image of approximation (low-resolution image) and 6 images of details are obtained as shown in figure (2)(b). Therefore, the face image is described by 7 wavelet coefficient sub-bands (matrices), that represent rather a massive amount of information (equal to the size of the input image). Figure (3) shows an example of tow-level wavelet decomposition of a face image.

Features Vector Extraction

Powerful feature extraction of image, frequently considered as a serious module in multimedia information processing, is not suitably paid attention. For effectively retrieving a related image in a huge database, some keywords should be used to describe the image or automatically extracted perceivable features from it. Though, a description of images by keywords will not be reasonable when the image database is huge. This not only demands valuable labour, but also there is a limited number of keywords exists to efficiently represent the image contents. Developing an algorithm for extracting image feature efficiently and effectively can profit majorly to emerging imagery applications like medical diagnosis, biometric, and geographical information system [29].

One of the essential problems in image databases querying by resemblance is how to choose related image descriptors and relative resemblance degrees [4].

The process of feature extraction is responsible for making up a feature vector that is well enough to depict the face image. The feature vector is generated using the Haar wavelet of color histograms.

Classification

It is common that, as the complication of a classifier increases quickly with the number of dimensions of the pattern space, it is essential to make decisions only on the most important, known as discriminatory information, which is carried by the extracted features. So, we are encounter the need of dimensionality reduction. Each matrix of the seven wavelet coefficients contains information concerning the texture of the face. An effective technique of reducing dimensionality and distinguishing textural information is to calculate a group of measures [9].

Thus, four statistical measures are extracted from each sub-band. These measures are used to describe a color and a texture of an image and some of them are histogram statistical-based features. We will present how to calculate these measures and what is the meaning of these measures. The measures that are used in the algorithm are:

Mean

It is a measure of the average, thus it states something concerning the universal image brightness. A dark image has a low mean, while a bright image has a high mean.

The total number of intensity levels is referred to as L thus, the gray levels vary from 0 to L − 1. For example, L = 256 and varies from 0 to 255 for image data of typical 8-bit. The value of mean can be specified as follows [25]:

$$\mu = \frac{1}{N}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1} C_{ij} \quad \ldots\ldots\ldots\ldots..(3)$$

Where:

N and *M*: are the dimensions of an image.

C_{ij} :is a wavelet coefficient.

Variance

Is a measure of average contrast[25]. The variance σ^2 measures the spread of a distribution, defined as the mean quadratic deviation of the variation from its mean value [2]. The variance gives a measure of average contrast in that region[11] .

The variance value can be calculated from the following equation:

$$\sigma^2 = \frac{1}{NM}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}(C_{ij}-\mu)^2 \ldots\ldots\ldots\ldots\ldots.(4)$$

Where:
μ : is the mean value,
N and *M*: are the dimensions of an image.

Energy

Energy is a measure of uniformity [14], homogeneity, or smoothness, by calculating the distribution among the gray levels. It is the total square of detailed coefficients of wavelet transform [16].

The energy of wavelet coefficient is changing across distinct degrees depending upon the input signals. The energy of wavelet coefficients[6] *c(t)* can be calculated from the following equation:

$$Energy = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} (P(C_{ij}))^2 \quad \dots\dots\dots\dots\dots (5)$$

Where:
N and *M*: are the dimensions of an image.
$P(C_{ij})$ is a probability of a wavelet coefficient.

Entropy

Entropy records texture information in an image. It indicates a degree of complexity of images. Higher entropy reflects complex textures [5].

When elements in the matrix are equal, the entropy is maximum while if all elements are different it is equal to 0 [14]. Entropy denotes the amount of information that kept in perceived signal. The use of entropy gives particular features of the signal and decreases the feature vector size [6]. The entropy can be defined as follows:

$$Entropy = -\sum_{i=0}^{N-1} \sum_{j=0}^{M-1} P(C_{ij}) * Log_2(C_{ij}) \dots\dots\dots\dots (6)$$

Where:
$P(C_{ij})$: is the probability of the wavelet coefficient (C_{ij}).

Similarity Measures and Distance

The feature vector is designed to describe the face image and classify it. We need techniques to compare two feature vectors in order to implement the classification. The essential techniques are to either evaluate the similarity, or the difference between the two. Two vectors which are almost associated will have a high similarity and a little difference. The measure of a distance in the feature space with n-dimensional can be used as the difference ; the lower the distance between two vectors, the smaller the similarity.

The most conventional metric of evaluating the distance between two vectors is Euclidean distance, and is calculated by the square root of the total of squares of the differences between vector components. The Euclidean distance between two vectors X and Y, each has *n* components, is calculated as:

$$d_E(X,Y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2} \quad \dots\dots\dots (7)$$

Another distance metric, referred to as the *city block* or *absolute value metric,* is given by:

$$d_{CB}(X, Y) = \sum_{i=1}^{n} |(x_i - y_i)| \quad \dots\dots\dots\dots(8)$$

This metric gives similar results, and it is computationally faster than the Euclidean distance. The *city block* or *absolute value metric* is used in the proposed system [25].

Hence, the distance measure between images (a query face image and a face image in the images database) is defined as

$$d_{CB}(Qf, Df) = \sum_{i=1}^{n} |(Qf_i - Df_i)| \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Where:

Qf is the query face image,
Df is an image in the images database,
Qf_i is the feature number (i) in the query face image, and
Df_i is the feature number (i) in the image in the database.

The proposed algorithm is given as follows:

Algorithm

Input: Query Face Image
Output: Retrieved Face Images.
Step 1: Change Image Color Space To YUV.
Step 2: Apply a Wavelet Transformation.
Step 3: Extract The Transformed Image Features.
Step 4: Apply The Genetic Algorithm to find the Best Matched Face:
i- Selection: Select two chromosomes randomly according to their fitness.
ii- Crossover: Apply crossover operator on the selected chromosomes.
iii- Mutation: Mutate a randomly selected chromosome.
iv- Stopping Criteria: Checking for goal found or maximum generation reached.
Step 5: Evaluate the Resulted Faces.
Step 6: End.

System Implementation

The experiments are performed on a Pentium 4 computer with CPU of 2.40 GHz and 4.0 GB RAM.

Some of images have been chosen as query examples and the original image database is used as test examples for verifying of the retrieval performance. The following sections give several aspects of the system implementation:

The database

In order to verify the robustness of our algorithm against aspects resulting from lighting conditions, pose change, and partial occlusion, the experiments are performed on test images chosen from UPC Face Database [26]. The images database comprises a set of 44 persons with 21 pictures for each person corresponding to various views of pose (0º, ±30º, ±45º,and ±60º) controlled by three lighting conditions (regular or environment light, bright light source from 45º angle, and a closely frontal mid-bright light source). The images resolution is 240X320 with BMP format. Five training models with five different conditions are shown in Figure (4).

GA Parameters

Representation of Solution

For a given problem In order to apply GA to, it should be a decision for finding a suitable genotype needed by the problem, i.e., the representation of a chromosome. In the proposed system, a chromosome denotes an index to an image in the image features database.

Initial population

At the start of the process of GA, an initialization of a population of possible solutions are involved. Typically, the initialization procedure is application-dependent; the random generation of binary strings is adopted as initial candidate faces.

Fitness function

To measure the value of the chromosomes in a population, the fitness function is utilized. Hence, in our approach, the quality of a chromosome C related to the query image Qf is defined as:

$$\text{Fitness}(Qf, C) = d_{CB}(Qf, C) \quad \ldots\ldots\ldots(9)$$

Where:

$d_{CB}(Qf, C)$ is the distance measure between images as given in Eq.(8).

Genetic operators

Selection: the tournament selection method is adopted in this system [3] because of the complexity of the its time is low. It can speed up the process of evolution because it does not involve an overall fitness comparison for every individuals in the population.

Crossover : the one-point crossover [31] is used in the proposed system. In order to generate quality preserving off-springs, it is swapped portions of two chromosomes selected according to their fitness.

Mutation: In order to increase the variation of the population, the mutation operator is used to create a new chromosome [20]. In mutation, randomly selected position in a chromosome is inverted.

Performance Evaluation

Experiments are run ten to twenty-two times, and the average results are reported. The performance of the adopted face retrieval algorithm is evaluated using two important performance evaluation methods: Retrieval Precision (RP), Recall Rate (RR), and Average Retrieval Time (ART).

Retrieval Precision

Retrieval Precision (RP) is defined as the ratio of number of relevant images retrieved (Nr) to the number of total retrieved images (N_C) [5] as shown in Equation (10).

$$RP = Nr / N_C \quad \ldots\ldots\ldots(10)$$

Recall Rate

Recall Rate (RP) is defined as the ratio of number of relevant images retrieved (Nr) to the total number of relevant images (N_{db}) as shown in Equation (11).

$$RR = Nr / N_{db} \quad \ldots\ldots\ldots(11)$$

Experimental Results

We have run several experiments of the program with different genetic parameters as shown in Table (1). So, Table (2) shows the performance evaluation metrics for different experiments of the system implementation.

The experimental results prove that the maximum Average Retrieval Time (ART) throughout all the experiments is much less than the Average Retrieval Time taken by the system when executed without using Genetic Algorithm. The Average Retrieval Time without using Genetic Algorithm is (722.25 milliseconds) which is computed throughout (20) system run. However, by referring to retrieval times given in Table (2) it has shown that shows that using GA decreases the average retrieval time to (60.15 milliseconds). An example of a query image given to the system together with the retrieved images is shown in Figure (5). Also, the results prove that the Retrieval based on GA gives good precision and recall rate.

Conclusions

In this system, a Content Based image Retrieval (CBIR) is presented which is new approach based on using with the support of genetic algorithm (GA). The face image is represented using YUV color space and is transformed by two-level wavelet transformation.

A feature extraction algorithm is used to extract color and texture features based on histogram statistical-based features such as mean, variance, energy, and entropy.

the similarity metric used in this system is the city block or absolute value metric which is faster than Euclidean distance.

GA which is a hopeful heuristic approach for determining near-optimal solutions in large search spaces is adopted to find the best match face image to the query face image. The genetic chromosome is represented by a string of binary numbers that represents an index to the image database. several experiments have been run on the system. these experiments are executed with different genetic parameters.

From the experimental results it can be concluded that the application of GA in information retrieval can be successful, and the GA gives a better performance compared with traditional image search. From the results of the simulation, it can be demonstrated that the features of faces are extracted effectively. GA was capable of searching successfully and decreasing calculative complication, and consequently decrease the time of search. The results show, also, that the adopted method is relatively strong to various facial constraints.

On the other hand, three evaluation metrics are used to measure the retrieval performance and calculative complication of the system: Retrieval Precision (RP), Recall Rate (RR), and Average Retrieval Time (ART).

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Table 1: GA Parameters Used in the Experiments

Experiment No.	Pop. Size	Max Gen.	Pc	Pm
1	20	50	0.8	0.1
2	50	20	0.7	0.05
3	10	50	0.8	0.05
4	40	20	0.8	0.05

Table(2): Performance Evaluation Metrics

Experiment No.	**RP (%)**	**RR (%)**	**Average Retrieval Time (in millisecond)**	**Average of Convergence Gen No.**
1	90	60	48.43866	8
2	79	70	53.57429286	5
3	47	44	81.27985333	32
4	81	94	43.90100476	5

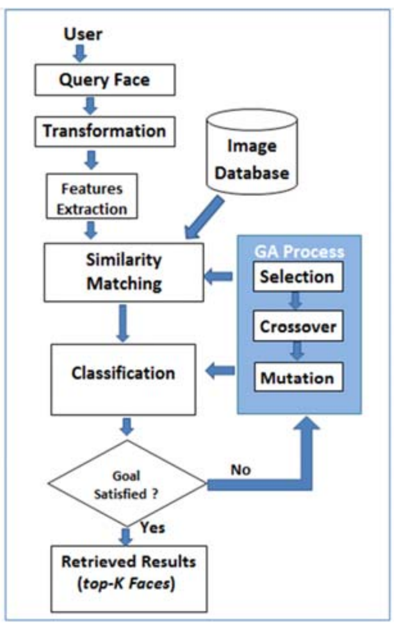

Figure (1): The Proposed System Flowchart

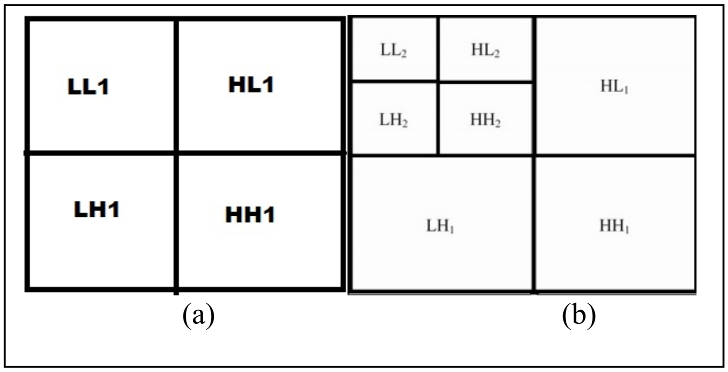

Figure (2) : Wavelet Decomposition: (a) One-Level (b) Two-Level

Figure (3) : An Example of Two-Level Wavelet Decomposition of a Face Image.

Figure (4): A single person examples from the UPC data base reflecting five face cases.

Figure(5):An Exampleof a query image and retriveved images

استرجاع الوجوه اعتمادا على الخوارزمية الجينية باستعمال الخصائص الاحصائية

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الخلاصة

استعملت عمليات استرجاع الصور اعتمادا على محتواها في العديد من المجالات اذ انها وفرت ادارة اكثر فعالية في استرجاع الصور من الطرائق القائمة على الاسترجاع اعتمادا على الكلمات المفتاحية. لذلك اصبحت عملية استرجاع الصور بناءً على محتوى الصور من اكثر الابحاث حيوية في السنوات القليلة الماضية.
تقترح عمليات استرجاع المعلومات حلولا للبحث في مجموعة من الكائنات التي تعكس وصفا معينا. في كثير من الاحيان هذه الكائنات هي وثائق، ولكن في احيان اخرى قد تكون صورا او ملفات صوتية او ملفات فديو.
يقترح هذا البحث طريقة استرجاع صور وجوه -بزوايا دوران متعددة- من قاعدة بيانات كبيرة تحوي صورا لوجوه بالاعتماد على الصفات اللونية وصفات نسيج الوجه.
الصفات اللونية مثل : المتوسط الحسابي والتباين والصورة النقطية هي الصفات المستعملة في استرجاع الصور الملونة. فضلا عن فان حساب طاقة الصورة وكمية المعلومات فيها استنادا الى المستويات الرمادية استعملت ايضا ضمن الصفات المستعملة في الاسترجاع.
الى جانب الطرق الاحصائية، نماذج الذكاء الاصطناعي تمثل نموذجا جيدا لتحسين الأداء في أنظمة الأشعة تحت الحمراء، والخوارزمية الجينية تمثل واحدة من هذه النماذج. تم اختيار الخوارزمية الجينية وذلك لقوتها ولانه يمكن تطبيقها على المشكلة دون اية معرفة خاصة عن مجال المشكلة.
خلصت النتائج التجريبية الى ان استعمال الخوارزمية الجينية يعطي أداءً جيدا ويقلل من متوسط وقت الاسترجاع الى (60,15 ملي ثانية) مقارنة بـ (722,25 ملي ثانية) الوقت الذي يستغرقه البحث التقليدي.