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Image Retrieval Using Genetic Algorithm

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ABSTRACT: Image retrieval system is an active research area in the past two decades. Content based image retrieval (CBIR) systems analyse the visual content and find images in the database. Single feature describes image content only from one point of view, which has a certain one-sided effects. Fusion of multifeature similarity score will improve the system's retrieval performance. Different from the conventional methods, each region-wise similarity is computed using a different combination of image features (color, shape, and texture). In this paper, the retrieval results from color feature and texture feature are analysed. Then Multi-feature similarity scores are fused. For fusing weights of multi-feature similarity scores reasonably, the genetic algorithm is applied. Genetic algorithm reduces the semantic gap between retrieval results and user expectations. The experimental results show that the proposed method is superior to other methods.

KEYWORDS: image retrieval; Content Based Image Retrieval; fusion; genetic algorithm.

I. INTRODUCTION

During the last decade, due to rapid development of multimedia and network technology, people can access a large number of multimedia information. This led to the rapid growth of the image retrieval field, and, as a consequence, the development of a number of image retrieval systems. For these people, the primary question is how to query the multimedia information of interest. Image retrieval system can be classified into two different types: text based (TBIR) and content based (CBIR). Text query can be applied to multimedia information retrieval, but it has some drawbacks. The drawbacks are: (1) Large number of labour required for manual image annotation and (2) for a particular image different user annotates different keywords. It is subject to impact of individual difference and state of human and environment, and the described results may be more one-sided. Also it is clearly incomplete to describe content-rich multimedia information with a small amount of text. These drawbacks of the TBIR initiate the researcher to do the research in the field of CBIR. It solves the problems of TBIR well. It uses low-level features like colour, texture and shape to describe image content. It breaks through the limitation of traditional text query technique.

CBIR system can be implemented based on single feature. It describes the content of an image from a specific angle. It can be suitable for some images, but it also may be difficult to describe other images. So this method of image retrieval is not sufficient for retrieving good results. Representing an image with multi-features from multi-angles is expected to achieve better results. Colour, shape and texture are three low-level features widely used for image retrieval. The problem is how to organize multi-source information in a suitable way to achieve the intended results. This attracts extensive attention from the researchers in this field.

II. RELATED WORK

Information fusion can be carried out in feature level [3]. Information fusion in feature level has advantage in some extent. B.G. Prasad et al. [5] proposed a technique to retrieve images by region matching using a combined feature index based on colour, shape, and location within the framework of MPEG-7. Dominant regions within each image are indexed using integrated colour, shape, and location features. Young Deok Chun et al. [7] proposed a content-based image retrieval method based on an efficient combination of multiresolution colour and texture features. Colour autocorrelograms of the hue and saturation component images in HSV colour space are taken as colour features. BDIP and BVLC moments of the value component image are adopted as texture features. The colour and texture features are

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extracted in multiresolution wavelet domain and combined. Tai X. Y. et al. [9] defined a new image feature called colour-texture correlogram which is the extension of colour correlogram. The texture feature extracted by texture spectrum algorithm is combined with colour feature vector, and then calculate the spatial correlation of colour-texture feature vector. Hui Yu et al. [11] adopted local Fourier transform as a texture representation scheme and derive eight characteristic maps for describing different aspects of co-occurrence relations of image pixels in each channel of colour space. Then they calculate the first and second moments of these maps as a representation of the natural colour image pixel distribution, resulting in a 48-dimensional feature vector. The novel low-level feature is named colour texture moments (CTM), which can also be regarded as a certain extension to colour moments in eight aspects through eight orthogonal templates.

Anil K. Jain et al. [13] integrated the results of the shape-based retrieval and the colour-based retrieval by combining the associated similarity values with appropriate weights. Xiuqi Li et al. [15] proposed a novel approach to image retrieval using colour, texture and spatial information. Colour homogram filter, wavelet texture filter, and spatial filter are used in sequence to eliminate images that are dissimilar to a query image in colour, texture, and spatial information from the search ranges respectively. The final query ranking is based on the total normalized distance in colour, texture, and spatial information of all images passing the three filters. Ilya Markov et al. [17] proposed a technique to combine image similarity measures which takes into account a particular query-image. They introduced mixed-metrics obtained from colour and texture metrics by using their weighted linear combination. Mladen Jovic et al. [19] proposed an image similarity method based on the fusion of similarity scores of feature similarity ranking lists. It takes an advantage of combining the similarity value scores of all feature types representing the image content by means of different integration algorithms when computing the image similarity.

Figure 1 shows the block diagram of the proposed system. It proposes an image retrieval method based on multi-feature similarity score fusion using genetic algorithm.

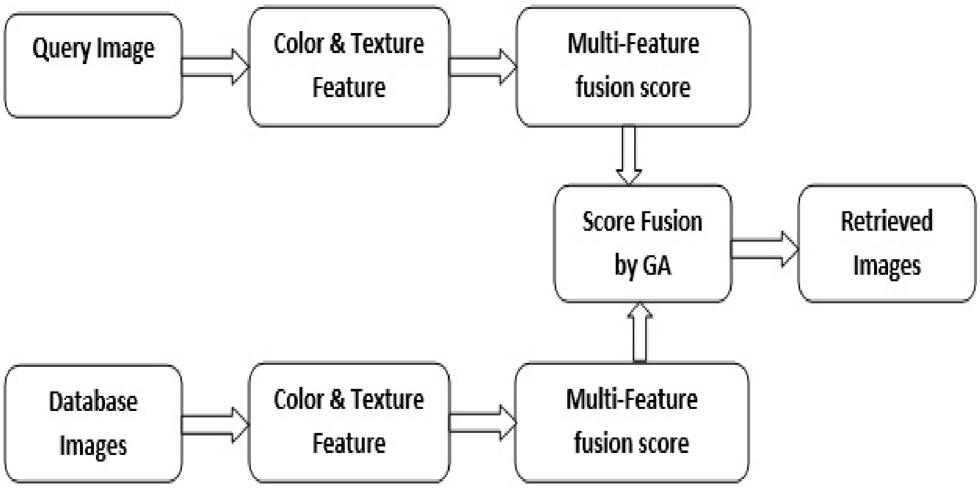

Fig. 1. Proposed Method

It analyzes image retrieval results based on color feature and texture feature, and proposed a strategy to fuse multi-feature similarity score. Further, with genetic algorithm, the weights of similarity score are assigned automatically, and a fine image retrieval result is gained. Color & Texture Features are taken for similarity score.

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III. IMAGE FEATURE EXTRACTION

The image content is mainly embodied in colour, texture and shape etc. The colour feature, texture feature and shape feature describe the image content from different angle. More features will provide more information on the image content. This paper focuses on fusion method of multifeature similarity score. For convenience, this paper only discusses the fusion method of two-feature similarity score. Without loss of generality, the used features are colour feature and texture feature. The following part describes the used extraction method of colour feature and texture feature.

A. Colour feature extraction

HSV colour model forms a uniform colour space. It uses a linear gauge. The distance between colours is in proportion to Euclidean distance between corresponding pixels in HSV colour model, and conforms to eye's feeling about colour. So it is very suitable for colour based image similarity comparison. Here, the colour histogram in HSV colour space is taken as the colour feature describing image content. For calculating colour histogram in HSV colour space, HSV colour space must first be quantified. According to human cognitive about colour, three components of HSV space are quantified in non-uniform manner. Hue is quantized into 16 bins and is among [0, 15]. Saturation is quantized into 4 bins and is among [0, 3]. Value is quantized into 4 bins and is among [0, 3]. Among those three components, human cognitive about colour is mainly based on hue, and then saturation, finally value. So, quantized results are coded as

$$C = 16H + 4S + V \qquad (1)$$

Where C is an integer between 0 and 255. Thus the colour feature can be obtained by calculating histogram of an image in HSV space.

B. Texture feature extraction

In this paper, the statistical properties of image co-occurrence matrix are taken as texture features of an image. Firstly, colour image is converted to grayscale image, and the image co-occurrence matrix is gained. Then, the following five statistical properties are calculated to describing image content. They are contrast, energy, entropy, correlation and local stationary. All these statistical properties are calculated in 4 directions, so we can get 20 texture features. At last, we calculated the means and variances of these five kinds of statistical properties, and took the results as the ultimate texture features, denoted as

$$T = (\mu_1, \mu_2, \mu_3, \mu_4, \mu_5; \sigma_1, \sigma_2, \sigma_3, \sigma_4, \sigma_5) \qquad (2)$$

IV. MULTI-FEATURE SIMILARITY SCORE FUSION

Since the physical meanings of different features are different, and value ranges are totally different, similarity scores of different features cannot be compared. So, before multi-feature similarity score are fused, they should be normalized. Similarity scores can be normalized through the following ways. Let Q be the query image. By calculating distances between the query image and images in database, similarity score set $\{S_i\}$ can be gotten, where $i = 1\ldots\ldots N$, N is the number of images in database. Thus, similarity score normalization can be implemented as

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$$S_{Ni} = \frac{S_i - \min\{S_i\}}{\max\{S_i\} - \min\{S_i\}} \quad (3)$$

The results of multi-feature similarity scores is

$$S_{Fi} = \frac{S_{NCi} \cdot W_c + S_{NTi} \cdot W_T}{W_c + W_T}, \quad (4)$$

Where, S_{Fi} is the fused similarity score, S_{NCi} is the normalized colour feature similarity score, S_{NTi} is the normalized texture feature similarity score, W_C is the weight of colour feature similarity score, and W_T is the weight of texture feature similarity score. By assigning appropriate values to W_C and W_T, a fine similarity score fusion can be gained.

V. GENETIC ALGORITHM

A Genetic Algorithm (GA) is a method used to get quite accurate solutions to search problems through application of the values of evolutionary biology. Genetic algorithms (GAs) are not new to image retrieval systems [8][9]. A GA is an Artificial Intelligence technique which uses interactive methods to solve problems of searches that satisfies certain requirements. GAs have been broadly valuable in many areas of engineering such as signal processing, system identification, image retrieval and data mining problems [10][11][12][13]. In [14], GAs is applied to exercise difficulty-level adaptation in schools and universities with very good results. Beligiannis et al.[15] applied GAs to the problem of intelligent medical diagnosis of male incompetence. Wu et al.[16] proposed a genetic-based solution for a coordinate transformation test of Global Positioning System positioning. Pan [17] designed robust D-stable IIR filters by using GAs with embedded stability criterion. The GA consists of an iterative process that evolves a working set of individuals called a population toward an objective function, or fitness function. GAs also has been successfully applied in the research of CBIR [18][19][20]. Working of GA is shown in figure (1). There are the three terms used in Genetic algorithm as follows:

- **Crossover** – exchange of genetic material (substrings) denoting rules, structural components, features of a machine learning, search, or optimization problem. Each individual must then be evaluated to produce a fitness function. Fitness functions refer to a quantifiable scalar-valued measure of the fitness of an individual. In the case of business processes the fitness functions of each process will most likely be generated by evaluating the time it would take to complete each process. Faster processes would receive high fitness functions, and slower ones would receive lower functions.

- **Selection** – the application of the fitness criterion to choose which individuals from a population will go on to reproduce. Once each individual has been evaluated, the individuals with the highest fitness functions will be combined to produce a second generation. In general the second generation of individuals can be expected to be „fitter" than the first, as it was derived only from individuals carrying high fitness functions.

- **Replication –** the propagation of individuals from one generation to the next.

Begin i=0;

Initialize S(i);

Evaluate S(i);

While (not termination condition)

Do

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Begin

i=i+1;

Select s(i) from S(i-1);

After (cross and mutation)

S(i);

Evaluate S (i);

end;

end;

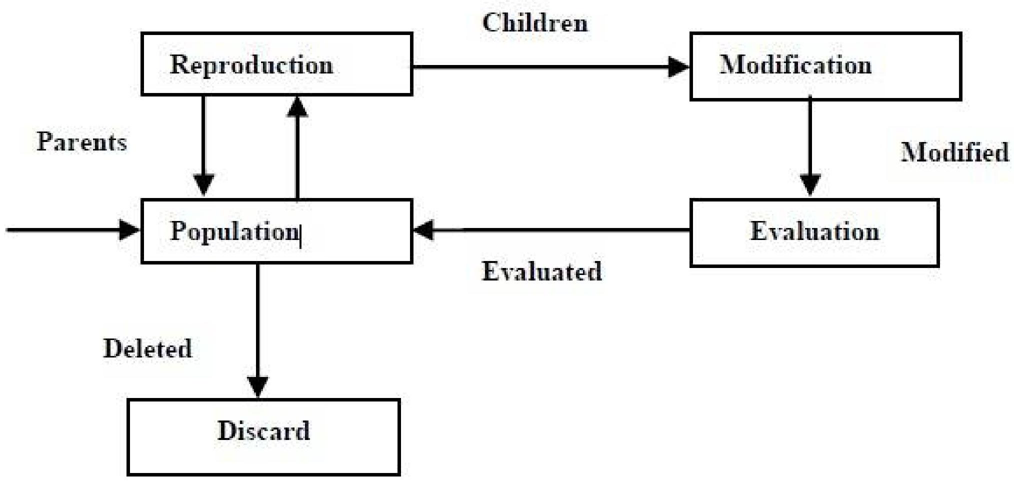

Fig. 2. Block Diagram of Working of Genetic Algorithm

VI. SIMILARITY SCORE FUSION USING GENETIC ALGORITHM

During the course of similarity score fusion, a key problem is how to assign the weights of similarity score. It affects directly the retrieval performance of the system. It can be considered as an optimization problem to assign reasonably the weights of colour feature similarity score and texture feature similarity score. That is to find the optimum in weight value space. So, this problem can be resolved by genetic algorithm. This paper proposed a similarity score fusion method using genetic algorithm. With genetic algorithm the weights of colour feature similarity score and texture feature similarity score are assigned optimally.

A. Determination of solution space

The aim of fusing similarity scores is to assign the weights of colour feature similarity score and texture feature similarity score to gain a better image retrieval performance. With the consideration of (4), the weight of colour feature similarity score W_C can be an integer between 0 and I, where I is a positive integer. Without loss of generality, the weight of texture feature similarity score can be assigned to $I - W_C$. The positive integer I determined the accuracy of solution. The bigger the value of I is, the higher the accuracy of solution is. But this may take a long time to resolve, and vice versa. To resolve using genetic algorithm, the weights should be encoded. The solution should be expressed as a binary number. So generally the value I is taken as 2^L, where L is a positive integer, the encoding length of the solution.

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B. Population Initialization

In genetic algorithm, the number of individuals in population and the initial values of the individuals will influence the solution greatly. In this paper, the number of individuals in population N is taken as $\sqrt{I}$. N is set a bigger value, the aim of which is to gain the optimal solution quickly. The individuals are initialized as follows. The solution space is divided into N equal portions, the centers of which are taken as the initial values of the individuals.

C. Determination of fitness function

The fitness of individuals can be evaluated as follows. According to the weights W_C and W_T of N individuals, we can get N groups of image retrieval results. For every group, the top M images are considered. Total number of images is MN. By calculating occurrence frequency of images of every group in all images, the fitness of every individual is evaluated. Specific operations are as follows.

Let N_{ijk} denote if kth image A_{ik} of ith group G_i is in jth group G_j or not. That can be formulated as

$$N_{ikj} = \begin{cases} 1, A_{ik} \in G_j \\ 0, A_{ik} \notin G_j \end{cases} \quad (5)$$

Then the occurrence frequency of kth image A_{ik} of ith group G_i in all MN images is

$$N_{ik} = \sum_{j=0}^{N} N_{ikj} \quad (6)$$

The occurrence frequency of all images of ith group G_i in all MN images is

$$N_i = \sum_{k=1}^{M} N_{ik} . \quad (7)$$

The normalized version of it is

$$P_i = \frac{N_i}{\sum_{l=0}^{N} N_l} . \quad (8)$$

The bigger P_i indicates that the images in ith group G_i possess a high proportion in all MN images, and the solution is considered a good one. In this paper, it is taken as fitness function.

D. Solving for optimal solution

The genetic algorithm is implemented in classic mode. The condition for ending the iteration is that the number of iteration is equal to 3. When the iteration is ended, the maximum $P^* = \max P_i$ is taken as the optimal solution. According to the optimal solution the weights W_C and W_T are assigned, then the image retrieval results with these two weights are taken as the ultimate retrieval results.

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VII. EXPERIMENTS AND ANALYSIS

Corel image library is used to evaluate the proposed algorithm. Initially feature extraction of all the images, stored in the database is performed and all the extracted features are stored separately. It contains dozens categories, each of which has about 60 images. The total number of images is about 600. They are alphabets, flower, automobile, beach, mountain, building and animals and so forth. Now query image is loaded by just browsing the image from anywhere in the system. The colour feature and texture feature of every image are extracted to build feature database. Precision rate and recall rate are employed to evaluate the performance of the proposed method. After this, feature extraction of the query image takes place. The numbers of returned images are 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50. For comparison, the image retrieval methods based on colour feature, texture feature and two-feature similarity score fusion with equal weights are implemented. The precision rate and recall rate relationship of these methods are shown in Fig. 3.

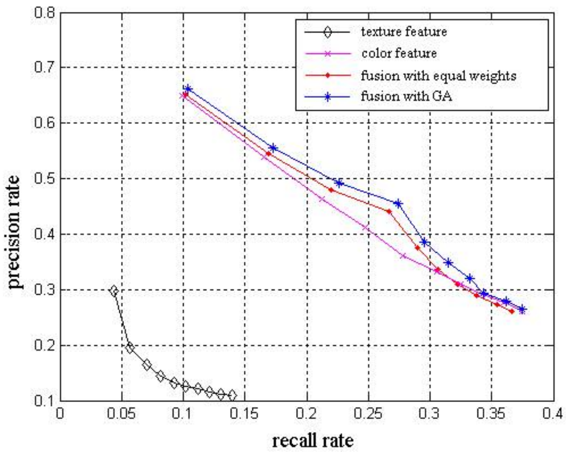

Figure 3. Relationship diagram of precision rate and recall rate.

Fig. 3 showed that image retrieval method based on multi-feature similarity score fusion using genetic algorithm ranked the first. The method with equal weights followed. The method based on colour feature is better than the method based on texture feature. The relationship showed in figure 3 reflects mainly the impact of multi-feature similarity score fusion on retrieval results. However, relative to the colour based image retrieval method, performance of these two image retrieval methods based on multi-feature similarity score fusion doesn't increase much. This is mainly due to that compared with image retrieval method based on colour feature, the performance of image retrieval method based on texture feature is poor. There are two possible reasons for it. One is that the colour difference of different images in this image library is more obvious, and the performance of image retrieval method based on colour feature is better. The other is that for this image library, the extracted texture feature may be insufficient to reflect the differences between different classes, which make performance of image retrieval based on texture feature poor. Better performance of image retrieval method based on texture feature is expected to increase the performance of image retrieval method based multi-feature similarity score fusion.

VIII. CONCLUSIONS

In this paper we have presented a new approach which is based on user oriented support with genetic algorithm. It proposed an image retrieval method based multi-feature similarity score fusion. Conventional methods are based on visual features which are not producing efficient result but our approach reduces the gap between the visual features and human perception. For a query image, multiple similarity score lists based on different features are obtained. Then using genetic algorithm, multi-feature similarity scores are fused, and better image retrieval results are gained. In this paper, when we evaluated the fitness of an individual, we considered only the occurrence frequencies of an image in retrieval result, and not the location of an image in retrieval result. However, the location of an image in retrieval result reflects directly the similarity of it and query image. So, this factor should be taken into account when evaluating the fitness of an individual, which is also our future work. Also our future work will emphases on filtering out the noisy

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data from log files at regular intervals of time and also maintains the history of user interaction with the retrieval system in an efficient way.

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