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Image Retrieval System with Interactive Genetic Algorithm Using Distance

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Abstract— Digital images have produced a large amount of image data in various areas, such as entertainment, fashion design, education, graphics, medicine, industry, etc. However in order to effectively retrieve the desired images from a large image database, a content-based image retrieval (CBIR) system has become an important research issue to be developed. As no. of the proposed approaches emphasize on finding the best representation for different image features. Because of that a user-oriented mechanism for CBIR method based on an interactive genetic algorithm (IGA) is developed. Color, texture and edge features of an image are extracted quickly using content-based image retrieval (CBIR) system with IGA. The mean value, the standard deviation, and the image bitmap of a color image are used as the features for retrieval. In addition to that entropy based on the gray level co-occurrence matrix and the edge histogram of an image is also considered. The experiments show that the method developed is very fast and retrieval performance achieved 100%.

Keywords— Interactive Genetic Algorithm (IGA), Content Based Image Retrieval (CBIR), Gray Level Concurrence Matrix (GLCM) .

I. INTRODUCTION

An image retrieval system is a computer system for browsing, retrieving and searching images from a large database of digital images. Most of the common methods of image retrieval utilize some method of adding metadata such as captioning, descriptions to the images so that retrieval can be performed over the annotation words. Manual image annotation has draw bags as it require time, more labour and it is so expensive. To overcome this, there has been a large amount of research done on automatic image annotation.

To alleviate these inconsistency problems, the image retrieval is carried out according to the image contents. Such strategy is so-called Content Based Image Retrieval (CBIR). The primary goal of the CBIR system is to construct meaningful descriptions of physical attributes from images to facilitate efficient and effective retrieval [1], [2]. It involves feature extraction and matching. According to the methods used for CBIR, features can be classified into low-level features and high-level features. The low-level features are used to eliminate the sensory gap between the object in the world and the information in a description derived from a recording of that scene. The high-level features are used to eliminate the semantic gap between the information that one can extract from the visual data and the interpretation that the same data has for a user in a given situation. The most commonly used low-level features include those reflecting color, edge and texture in an image. Because of the robustness, effectiveness, implementation simplicity and low storage requirements advantages, color has become the most effective feature and almost all CBIR systems employ colors. HSV spaces are used to represent color instead of the RGB space as they are much better with respect to human perception [10]. In addition, user gives subjective evaluation in the image matching by considering only human preference [11].

II. INTERACTIVE GENETIC ALGORITHM (IGA)

GAs [8], within the field of evolutionary computation, are robust, stochastic and computational search procedures modeled on the mechanics of natural genetic systems. In general, a GA contains a fixed-size population of potential solutions over the search space. These potential solutions over the search space are encoded as binary, called chromosomes. The initial population can be created randomly or based on the problem specific knowledge.

Interactive Genetic Algorithm is a branch of evolutionary computation. The primary difference between IGA and GA is the deciding the fitness function, as the fitness is determined by the user's evaluation and not by the predefined mathematical formula. The IGA adopts the users choice as fitness, when the fitness function cannot be determined explicitly. This allows a developing system operated on human intuition or emotion. It has become applied to several fields, such as graphics and art. For example, Caldwell and Johnston applied it to tracking a criminal suspect, which produced montages by the fitness based on the face of criminal suspect given by witness. Baker [10] had implemented a line drawing system based on the users aesthetic criteria using the IGA.

III. IMAGE FEATURES

A. Color Descriptor

HSV is an intuitive color space is used in the sense that each component contributes directly to visual perception and it is common for image retrieval systems [47], [49]. Hue is used to distinguish colors and saturation gives a measure of the percentage of white light added to a pure color. Value gives light intensity. The important advantages of HSV color space are as follows: good compatibility with human intuition, separability of chromatic from achromatic components, and one component is compared with the other component.

The color distribution of pixels in an image contains sufficient information. The mean of pixel colors states the principal color of the image, and the standard deviation of pixel colors can depict the variation of pixel colors. The variation degree of pixel colors in an image is called the color complexity of the image. These two features are used to represent the global properties of an image. The mean (μ) and the standard deviation (σ) of a color image are defined in (1) and (2):

$$\mu = \frac{1}{N} \sum_{i=1}^{N} P_i \quad (1)$$

$$\sigma = \left[\frac{1}{N-1}\sum_{i=1}^{N}(P_i - \mu)^2\right]^{\frac{1}{2}} \quad (2)$$

Where $\mu = [\mu H, \mu S, \mu V]$ T and $\sigma = [\sigma H, \sigma S, \sigma V]^T$ each component of μ and σ indicates the HSV information, respectively, P_i indicates the i^{th} pixel of an image.

B. Texture Descriptor

Texture is an important feature that refers the image relationship to the surrounding environment. If appropriate texture descriptors were choose, the performance of the CBIR should be improved. A Gray Level Co-Occurrence Matrix (GLCM) is used, which is a simple and effective method for representing texture [25]. The GLCM represents the probability $p\ (i, j; d, \theta)$ that two pixels in an image that are located with distance d and angle θ, have gray levels i and j. The GLCM is calculated as follows:

$$p\ (i, j; d, \theta) = \#\{(x_1, y_1)(x_2, y_2) | g(x_1, y_1)=i,\ g(x_1, y_2)=j,\ |(x_1, y_1) - (x_2, y_2)| = d, <((x_1, y_1), (x_2, y_2)) = \theta\}$$

where # denotes the number of occurrences inside the window, with i and j refers to the intensity levels of the first pixel and the second pixel at positions (x_1, y_1) and (x_2, y_2), respectively. To simplify and reduce the computation effort, the GLCM is computed according to one direction (*i.e.,* $\theta = 0°$) with a given distance d (= 1) and calculated the entropy, which is used to capture the textural information in an image and is defined as follows:

$$E = -\sum_{i,j} C_{i,j} \log C_{i,j}$$

Where $C_{i,j}$ is the GLCM. Entropy gives a measure of complexity of the image. Complex textures represent higher entropy.

C. Edge Descriptor

Edges in images constitute an important feature to represent their content. Human eyes are sensitive to edge features for image perception. One way of representing such an important edge feature is to use a histogram. An edge histogram in the image space represents the frequency and the directionality of the brightness changes in the image. Here the Edge Histogram Descriptor (EHD) describes edge distribution with a histogram based on local edge distribution in an image. The extraction process of EHD [17] consists of the following stages.

1) An image is divided into 4 × 4 subimages.
2) Each subimages is further partitioned into non overlapping image blocks with a small size.
3) The edges in each image block are categorized into five types: vertical, horizontal, 45° diagonal, 135°diagonal, and non directional edges.
4) Thus, the histogram for each subimage represents the relative frequency of occurrence of the five types of edges in the corresponding subimages.
5) After examining all image blocks in the subimages, the five-bin values are normalized by the total number of blocks in the subimages. Finally, the normalized bin values are quantized for the binary representation. These normalized and quantized bins constitute the EHD.

IV. ALGORITHM FOR SYSTEM

Step 1. Start
Step 2. Initially feature extraction is done.
Step 3. User inputs a query image (Query by example).
Step 4. The simple search gives related images than IGA is applied.
Step 5. Extracted features are compared with the stored feature of the images in the database i.e. similarity matching function is applied as follows

$$sim(q, C) = \sqrt{\sum_{t\in\{H,S,V\}} \left(\mu_t'^q - \mu_t'^C\right)^2 + \sum_{t\in\{H,S,V\}} \left(\sigma_t'^q - \sigma_t'^C\right)^2 + \frac{H(BM^q, BM^C)}{3\times m} + \left|E^q - E^c\right| + \frac{|EHD^q - EHD^c|}{5\times 80}}$$

Step 6. By using Euclidean distance preferences are set according to user, after examining the searched result. Euclidean distance is calculated as:

$$D = \sqrt{\sum_{i=1}^{n}(X_i - Y_i)^2)}$$

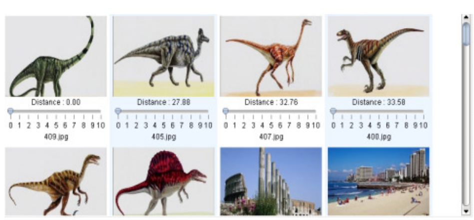
Step 7 .Result is displayed.
Step 8. If user satisfied then searching get finished.
Step 9.Else repeat step from 4, unless he is not satisfied.
Step 10. End.

V. PRACTICABILITY OF SYSTEM DEMONSTRATION

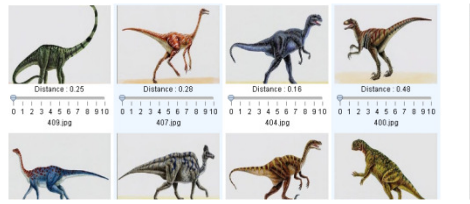
To show the effectiveness of the proposed system, some experiments will be reported. In these experiments, the database of the SIMPLIcity project [20] is used covering a wide range of semantic categories from natural scenes to artificial objects for experiments.

At first, an example is given to illustrate the practicability of proposed system. A user submits an image containing a dinosaur as the query image fig.1 (a) into the system, and then, the similarity measurement module of the system compares the query features with those images in the database and finds the most similar images to the query image. These images are ranked based on the similarity. Under each image, a slide bar is attached so that the user can tell the system which images are relevant or irrelevant. The amount of slider movement represents the degree of relevance. After the user evaluates these images, the system adjusts the similarity measure according to the user's point of view and provides refined search results. The user can repeat this process until he/she is satisfied with the retrieval results. fig.1 (b) shows the first display of returned images and the fig.1 (c) shows retrieved results after applying the IGA process with distance vector.

The results are ranked in ascending order of similarity to the query image from left to right and then from top to bottom. From the results, we can find that if the retrieval only considers the low-level features, some irrelevant images are retrieved. By adopting user's subjective expectation, the retrieval results are effectively increased in very few generations.



(a) Query (b)Retrieved Result with IGA



(c) Retrieved Result with IGA and distance Image preference

Fig. 1: Practicability of System Demonstration

VI. RETRIEVAL PRECISION/RECALL EVALUATION

To evaluate the effectiveness of the proposed approach, it is examined that how many relevant images to the query were retrieved. The retrieval effectiveness can be defined in terms of precision and recall rates. Experiments are run five times, and average results are reported. In every experiment, an evaluation of the retrieval precision is performed so that ten images that were randomly selected from each specific category of the database are used as query images. For each query image, relevant images are considered to be those and only those which belong to the same category as the query image. Based on this concept, the retrieval precision and recall are defined as

Precision = $\frac{N_{A(q)}}{N_{R(q)}}$

Recall = $\frac{N_{A(q)}}{N_t}$

Where $N_{A(q)}$ denotes the number of relevant images similar to the query, $N_{R(q)}$ indicates the number of images retrieved by the system in response to the query, and N_t represents the total number of relevant images available in the database. Here, the top 20 retrieved images are used to compute the precision and recall. When each precision and recall for ten images is obtained, the best value is discarded and the worst one and then average these values to obtain the average precision and average recall. It shows that the tendency of average precision for the randomly selected images in each specific category is toward higher value with the proposed approach, and they can achieve 93.28% within few generations of IGA.

VII. PERFORMANCE ANALYSIS

This section presents and discusses the results of the experiment performed to evaluate the proposed IGA-based approach to image retrieval.

In order to show the superiority of approach, there is comparison between proposed approach with IGA and normal search. Since the precision is achieved 100% and the recall is achieved 20% finally by using the IGA of the proposed approach, the retrieval results is used obtained from low-level visual features in comparison with the aforementioned methods. In normal search method it considered the RGB color space and adopted the color distributions, as well as the image bitmap, as the visual features. The experimental results are shown in following tables. These comparisons reveal that the proposed approach outperforms other two methods.

In this proposed method the contribution is to give users preference to retrieve images which he/she wants by setting the distance parameter over there. In contrast to conventional approaches that are based on visual features, this method provides an interactive mechanism to bridge the gap between the visual features and the human perception. Experimental results of the proposed approach have shown the significant improvement in retrieval performance.

Table 1: Performance Comparison (precision values)

Sr. No	**Category of Images**	**Normal Search**	**IGA/CBIR**	**Proposed Method**
		Precision%		
1	African People	6.75	12.12	12.62
2	Dinosaurs	22	28	28
3	Beach	12	12	14
4	Building	28	22	34
5	Food	6	8	12
6	Elephant	16	18	18
7	Buses	22	6	22
8	Horses	12	12	16
9	Flowers	16	12	16
10	Mountains/ glaciers	16	18	22
11	Average Precision%	15.675	15.81	19.46
12	Response time(s)	1.504	1.104	1.096

Table 2: Performance Comparison (Recall values)

Sr. No	**Category of Images**	**Normal Search**	**IGA/CBIR**	**Proposed Method**
		Recall %		
1	African People	4	11.12	10.13
2	Dinosaurs	19	22	26
3	Beach	10	10	12
4	Building	26	20	30
5	Food	5	6	10
6	Elephant	12	16	13
7	Buses	19	3	19
8	Horses	10	10	13
9	Flowers	13	13	13
10	Mountains/ glaciers	15	14	20
11	Average Precision%	12.12	12.21	16.5
12	Response time(s)	1.6	1.3	1.1

VIII. CONCLUSION

As shown by experiments, IGA-based with distance vector achieves better results when compared with only IGA-based CBIR system used as baseline. There is improvement of 10% with traditional approach.

Experimental result shows that the precision is achieved 93.28% as shown in table1 and the recall is achieved 20% in image retrieval process with propose approach as shown in table2.

Other significant result from experiment is that IGA-based approach automatically finds fitness function with user's preference not by any mathematical computation. This is extremely useful for the users in fashion design, who does not have to worry about setting of the fitness value for various designs.

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