A Partitioning Image Retrieval Method Based on Regional Division and Polymerization

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***Abstract*-In order to further improve the retrieval accuracy of the image retrieval system based on shape feature. A partitioning image retrieval method based on regional division and polymerization is proposed in this paper. Firstly, an image is segmented by the regional division and polymerization method. Secondly, the shape and spatial features of different objects in the image are extracted by the invariant moment. Finally, images are retrieved by calculating the similarity of images, and five different types of images are tested by group. The experimental results show that it is more accurate for the algorithm to retrieve the user's interested images.**

Keyword-shape feature;image segmentation; spatial information; image retrieval

I. INTRODUCTION

In order to accurately discover the images that people need from a huge mass of image set, the content-based image retrieval technology more and more become the research focus with the development of multimedia and network technology. The general steps of content-based image retrieval method are that firstly extracting the main features of an image, such as color, texture or shape, secondly retrieving images according to these features. Identifying the objects, people can easiest distinguish the different objects in terms of shape of aim. Thus, the shape feature becomes vital[1].

The image retrieval technology based on shape mainly includes two kinds method based on outline[2] and area[3]. The most typical method separately is Fourier method and seven invariant moments[4], by which the translation, scaling or rotation of objects is invariant. Image retrieval algorithm based on invariant moment is proposed by reference five.

Image feature is expressed by seven invariant moments and the contour moment in reference six. There is better retrieval effort for these ways, but they have some shortcomings. For example, the whole shape feature of images is only extracted by invariant moment, and the local shape characteristics of images can not be described well. Position relation of objects being in an image can not express exactly, and spatial distribution information of objects is lost.

In view of above problems, a new image retrieval algorithm based on regional division and polymerization is proposed in this paper. There are many merits for the algorithm, such as not only describing the feature of different objects, but the position relation of different objects in an image. There being much distinct objects in an image, the test proves that retrieval speed and accuracy is better.

II. RETRIEVAL BASED ON SHAPE AND SPATIAL INFORMATION

A *Image Segmentation*

There being different objects in an image, the area where some interested objects in an image are located in will be acquired by image preprocessing and segmentation technology. Firstly, the color image will be changed into gray image. Secondly, the scaling of gray image will be standardized. Finally, the image will be segmented by the algorithm of regional division and polymerization[7].

The steps of image segmentation are as follows:

1) An image should be divided into four areas, such as R1, R2, R3 and R4.

2) Supposing that H means entropy, R_i means the area i in an image, a means the gray value, the probability density function of R_i means $p_i=P(a=i)$, i=0, 1. Thus, $H(R_i)$ that is Shannon entropy of R_i is as below by the Shannon mutual information theory[8].

$$H(R_i) = -\sum_i p_i \log p_i \tag{1}$$

The fist area of top left corner will be compared with its adjacent area by Shannon mutual information. Take nearly area R_i, R_j for example, $I(R_i, R_j)$ that is their Shannon mutual information is as below.

$$I(R_i, R_j) = \sum_{i,j} p_{ij} \log \frac{p_{ij}}{p_i p_j} = H(R_i) + H(R_j) - H(R_i, R_j) \tag{2}$$

p_i and p_j means the gray probability distribution of R_i, R_j; p_{ij} means joint probability distribution; $H(R_i, R_j)$ means the joint entropy of R_i, R_j. Shannon mutual information means the information content that two images contain each other. If the value of $I(R_i, R_j)$ is more than T(T=0.85), there will be the wonderful similarity between two adjacent areas and they should be polymerized together. If two adjacent areas are dissimilar, the fist area should be identified into unfinished status.

3) The area being polymerized should continue to be compared with other adjacent areas by Shannon mutual information. The area that is similar with polymerized area should be combined together, until areas can no longer merge. Finally, the polymerized area will be identified into finished status.

4) The area being unfinished status will continue to be divided into four domains and repeat the above steps, until all areas will be identified into finished status.

Result of image segmentation is as shown in Figure 1.

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(a) original image (b) gray image (c)segmented image

Figure 1 Result of image segmentation

B *Extracting of Shape and Spatial Information*

Some different objects will be obtained by the image segmentation. In order to describe these objects accurately, the shape and spatial feature of every object should be extracted, and form the feature vector of their own.

1) Shape feature: the invariant moment of objects indicates the shape feature of image. There is invariant of translation, scaling and rotation for these features[5].

In a two dimensional image, p+q order moment of an object f(i,j) is as below.

$$m_{pq} = \sum_{i=1}^{m}\sum_{j=1}^{n} f(i,j) i^{p} j^{q},\ p,q = 0,1,2,...,n \tag{3}$$

p+q order center moment of an object f(i,j) is as below.

$$\mu_{pq} = \sum_{i=1}^{m}\sum_{j=1}^{n} f(i,j)(i-\bar{i})^{p}(j-\bar{j})^{q},\ p,q = 0,1,2,...,n \tag{4}$$

$\bar{i} = m_{10}/m_{00}, \bar{j} = m_{01}/m_{00}$, $(\bar{i},\bar{j})$ is the gravity coordinate of an object.

The center moment should be normalized, such as $\eta_{pq} = \mu_{pq}/\mu_{00}^{\gamma}$, $\gamma = (p+q)/2+1$. There is scaling invariant for this invariant moment. η_{11}、η_{20}、η_{02} that is normalized two order center moment, and $\eta_{12},\eta_{21},\eta_{30},\eta_{03}$ that is three order center moment can be combined to form seven invariant moments for which there is invariant of translation, scaling and rotation.

$$\begin{aligned}
u_1 &= \eta_{20}+\eta_{02}\\
u_2 &= (\eta_{20}-\eta_{02})^2+4\eta_{11}^2\\
u_3 &= (\eta_{30}-3\eta_{12})^2+(3\eta_{21}+\eta_{03})^2\\
u_4 &= (\eta_{30}+\eta_{12})^2+(\eta_{21}+\eta_{03})^2\\
u_5 &= (\eta_{30}-3\eta_{12})(\eta_{30}+\eta_{12})[(\eta_{30}+\eta_{12})^2-3(\eta_{21}+\eta_{03})^2]+\\
&\quad (3\eta_{21}-\eta_{03})(\eta_{21}+\eta_{03})[3(\eta_{30}+\eta_{12})^2-(\eta_{21}+\eta_{03})^2]\\
u_6 &= (\eta_{20}-\eta_{02})[(\eta_{30}+\eta_{12})^2-(\eta_{21}+\eta_{03})^2]+\\
&\quad 4\eta_{11}(\eta_{30}+\eta_{12})(\eta_{21}+\eta_{03})\\
u_7 &= (3\eta_{21}-\eta_{03})(\eta_{30}+\eta_{12})[(\eta_{30}+\eta_{12})^2-3(\eta_{21}+\eta_{03})^2]+\\
&\quad (3\eta_{12}-\eta_{30})(\eta_{21}+\eta_{03})[3(\eta_{30}+\eta_{12})^2-(\eta_{21}+\eta_{03})^2]
\end{aligned} \tag{5}$$

2) Spatial feature: Supposing that gravity coordinate of object i in an image means (x_i, y_i), position of this object should be indicated by normalized coordinate of gravity[9].

$$(\bar{x_i},\bar{y_i}) = (\frac{\bar{x_i}}{Width},\frac{\bar{y_i}}{Height}) \tag{6}$$

The Width and Height is the width and height of an image respectively.

C *Calculation of Similarity*

Supposing that the feature vector of an object means $X = \{f_1^X, f_2^X, ..., f_9^X\}$. $f_1^X, f_2^X, ..., f_7^X$ means the seven invariant moments of the object. The gravity coordinate of object means f_8^X, f_9^X. The distance of feature between arbitrary object A and B from two images is as below.

1) The distance of shape feature

$$d_s(A,B) = \sum_{i=1}^{7} w_{si}\sqrt{(f_i^A - f_i^B)^2} \tag{7}$$

2) The distance of spatial feature

$$d_r(A,B) = \sum_{i=8}^{9} w_{ri}\sqrt{(f_i^A - f_i^B)^2} \tag{8}$$

w_{si}, w_{ri} is the weight of corresponding feature. The distance between object A and B is as below.

$$d(A,B) = w_s \times d_s(A,B) + w_r \times d_r(A,B) \tag{9}$$

w_s, w_r is weight of shape and spatial feature separately.

Supposing that there are m main objects in sample image P, and n main objects in image P' from image database. Similarity of image P being relative to image P' is as fellow.

$$S(P,P') = \sum_{i=1}^{m} d(i, R_{P'}(i)) \tag{10}$$

$R_{P'}(i)$, i=1,2,⋯,m, returns an object in the image P'that is the most similar with an object i in the image P.

Ultimately, the similarity between sample image P and queried image P' from image database should be calculated by similarity equation. The query result returns according to the similarity from large to small.

III. THE RESULT AND ANALYSIS OF TEST

A *Result of Test*

The test of image retrieval has finished in the Windows XP operation. The testing image set is from the famous Corel image database. There are five kinds of images, such as horse, elephant, beach, mountain and bus.

In order to validate the effort of retrieval method, the algorithm that proposed in this paper will be compared with reference five and reference six. The retrieval result is as shown from figure two to figure four.

The sample image lies in the left of the first row, and also is the first image of retrieval result. There are twelve images being as the retrieval result. A retrieval result based on this paper is as shown in the figure two, and the correct rate is 85 percent. A retrieval result based on reference five is as shown in the figure three, and the correct rate is 61 percent. A retrieval result based on reference six is as shown in the figure four, and the correct rate is 63 percent.

Figure 2 Retrieval result of this paper

Figure 3 Retrieval result of reference five

Figure 4 Retrieval result of reference six

B Experimental Performance Analysis

In order to evaluate retrieval effort of proposed algorithm. The evaluation standard will employ the precision ratio and recall ratio. Three images should be extracted from every kind of images in the experiment. There are fifteen queries. The retrieval result will choose the most similar twelve images every query. The average of precision ratio and recall ratio should be counted for every kind of images. The experiment result is as shown from table one to table two.

TABLE I. AVERAGE OF RECALL RATIO

Image classes	Proposed	Reference five	Reference six
Horse	0.75	0.57	0.52
Elephant	0.62	0.48	0.43
Beach	0.82	0.61	0.55
Mountain	0.61	0.42	0.36
Bus	0.71	0.47	0.42

TABLE II. AVERAGE OF PRECISION RATIO

Image classes	Proposed	Reference five	Reference six
Horse	0.6	0.42	0.38
Elephant	0.51	0.39	0.35
Beach	0.7	0.58	0.48
Mountain	0.4	0.32	0.25
Bus	0.56	0.28	0.23

The statistics from table one to table three indicate that the retrieval accuracy and efficiency of image is advanced by the algorithm in this paper. In order to further check the robustness of algorithm in this paper, the original image will be translated, rotated and scaled separately. The performance of three kinds of algorithm will be compared. The experiment result is as shown from figure five to figure seven.

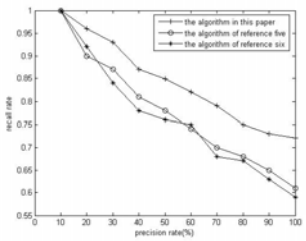

Figure 5 Retrieval result of translating

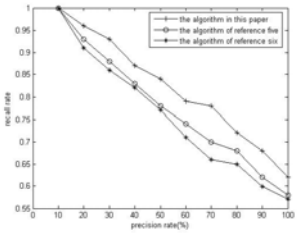

Figure 6 Retrieval result of rotating

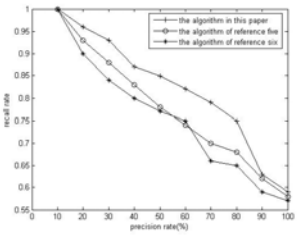

Figure 7 Retrieval result of scaling

The experiment result indicates that the retrieval effort of reference five and reference six is similar and lower. Because when lots of objects arise in an image, the global shape feature of image is only extracted by the invariant moment. The main objects of the image will not be outstanding, and the spatial information of image will not be acquired. The retrieval method of image that combines the shape and spatial information will be superior in the average of precision ratio and recall ratio.

IV. CONCLUSION

The image retrieval based on content is a kind of general new technology. It is vital for algorithm extracting image feature to enhance the performance of retrieval system. A new kind of image retrieval method that proposed in this paper composes the shape and spatial information. The experiment result indicates that the main objects of image not only are considered, but the spatial feature between objects is emphasized. The user can return the retrieval result, and express the interested image by adjusting the weight of object feature accurately. In order to further enhance the retrieval precision in the future, a variety of image features and feedback technology based on the human computer interaction should be combined. They are some problems to solve for next step.

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