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An Effective Relevance Feedbackbased Image Retrieval using Color and Texture

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ABSTRACT

In this paper, we proposed an image retrieval system with a simple and effective relevance feedback, called RAP(Reward and Punishment) algorithm. First, color and texture features were extracted from the images. Next, the extracted feature values were used for image retrieval in various forms. We applied the relevance feedback to the initial retrieved images from the image retrieval system, and compared its result with that of the conventional system. In the experiment using the test image database of 16 class 512 images, the proposed system showed the better retrieval performance of about 10~17 % than that of the conventional INRIA system in each relevance feedback step.

Key words: relevance feedback, content-based image retrieval, similarity, color and texture features

1. INTRODUCTION

The rapid growth of the computer and the communication technology has led to a great increase in multimedia information that may consist of image, video, audio, and text. Especially, image is one of the most frequently used media along with text. Therefore, effective image retrieval technology is required for searching and handling of image information.

In late 1970, Text-Based Image Retrieval(TBIR) using key word was used as the early technology of image retrieval. However, when it comes to the rapid increase of information, TBIR had some problems such as the difficulty of giving proper comments, the difference of interpretation, the assigning of inconsistent keyword. In early 1992, Content-Based Image Retrieval(CBIR) was introduced for solving these problems of TBIR[1].

CBIR uses the contents itself of an image such as color, texture, and shape. In the process of indexing of CBIR, it is possible to manage and retrieve images effectively by using the features automatically extracted from images. Therefore, this approach can solve some of the above-mentioned problems of TBIR.

Generally in this approach, the retrieval system is designed to retrieve similar images to a query image from the image database. It uses the user-selected features with some weighting factors for the image retrieval. However, in the process of the retrieval, this basic approach cannot cover the gap between the high level concepts of the user and the low level features of the images, and solve human's subjective problem of similarity[2].

Therefore, one of the recent trends of CBIR is adopting the user interactive mechanism, so called a relevance feedback(RF). The main concept of the RF is that a user can give the feedback interactively to the image retrieval system to redefine the high level query. The user can get a chance to express more exactly the initial query based on the low level features.

In this paper, we present a CBIR system with an effective relevance feedback, called RAP. It extracts the color and texture features as low level features and adopts a simple but effective relevance

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feedback. We compare its performance with a conventional system with a relevance feedback.

2. IMAGE RETRIEVAL SYSTEM

General block diagram of the CBIR system with a relevance feedback is shown in (Fig. 1).

2.1 Overview of Image Retrieval System

In (Fig. 1), when a query image is submitted to the image retrieval system, like other input images in the image database, it has to pass the feature extraction stage. First, the image retrieval system displays the initial retrieval result from the image database based on the similarity calculation with a query image. Next, the user evaluation on the first displayed results is used to give a feedback to the system through the relevance feedback. Then, the system redisplays the modified image output results, considering the user's feedback. This kind of user's feedback procedure will continue until the user gets the satisfied retrieval results.

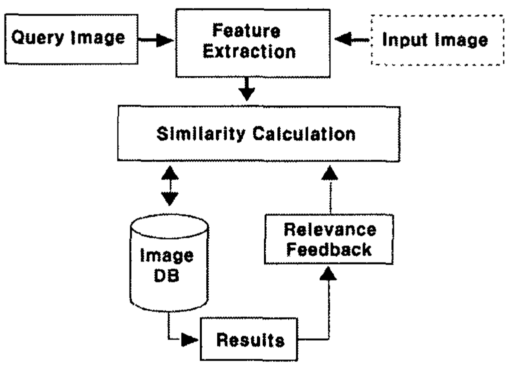


Fig. 1. The proposed image retrieval system.

2.2 Feature Extraction

An image retrieval system must make it easy to retrieve the images that users want from the image database. That is, for the image retrieval, the system calculates the similarity between feature values of a query and those of images in the image database, and retrieves the similar images based on the calculated similarity from the image database.

For the similarity calculation, we need to get the feature values that can represent the image contents itself. Mostly color, texture and shape features have been used to represent the image contents itself. The effective extraction of these low level features is one of the important research areas of CBIR.

Color is one of most effective features that can be used to distinguish the objects in an image. The smaller difference of color between two images, the closer images they might be. Usually color histogram method has been used to get color features [3]. The color distribution of histogram presents the general characteristics of an image rather than the detailed knowledge of each object within the image. Color histogram method is simple, but it shows to be relatively strong against the rotation and size change of an image. However, it has a disadvantage that the loss of location information of pixels happens in the image.

Shape is a feature of classifying an object's boundary. It represents a structural attribute to recognize an object. Shape information can be expressed as a boundary attribute, an approximation of polygon, or finite element model of an object. It has an advantage that the feature of boundary line might not be affected by the location or size of an object. However, it is difficult to define the shape of an object exactly because the subjective interpretation can be possible on the shape similarity of an object. It is also difficult to extract and model the shape of an object, because the boundary line of an object is sensitive to the transform of shape or its direction[4].

Texture is also an important component for the human vision. It has been used to describe objects in the real world. This texture attribute has been studied in the image processing and pattern recognition areas steadily. It has various application areas including the analysis of topography and forest zone based on aviation photograph, the analysis of cell tissues based on microscopic pictures and etc. As the color feature is determined by the distribution of color in the color space, so the texture feature by the spatial distribution of intensity of neighbor pixels[5].

In this study, to show the effect of the relevance feedback, we extract the simple color and texture features of each image in the image database, and we use them in the image retrieval. That is, Hue and Intensity of an image are extracted and used as the color features as shown in Eq.(1) and (2).

$$Hue = \cos^{-1}\left\{\frac{0.5[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{0.5}}\right\} \quad (1)$$

$$Intensity = (R+G+B)/3.0 \quad (2)$$

were R, G and B represent the red, green and blue components of the pixels in an image.

Homogeneity and Contrast of the image are also extracted and used as the texture features as shown in Eq.(3) and (4), respectively[6] .

$$Homogeneity = \sum_{i=0}^{M}\sum_{j=0}^{N}\frac{P[i,j]}{1+|i-j|} \quad (3)$$

$$Contrast = \sum_{i=0}^{M}\sum_{j=0}^{N}(i-j)^2 P[i,j] \quad (4)$$

where $P[i,j]$ is the (i,j) element of the co-occurrence matrix of the image.

After extracting the raw feature, we use the feature data as the various data types such as the normalized feature by the mean, the normalized one by the mean multiplied with a standard deviation, and the Gaussian normalization.

3. RELEVANCE FEEDBACK

The current researches on the relevance feedback (RF) adopt various approaches like the followings to improve the retrieval performance of CBIR systems.

3.1 Query Point Moving

This method moves the current query point by applying the user's feedback to the system. It tries to move the query point to the ideal query point. This method has been applied to the document processing area, based on Rocchio's vector space model. The basic equation is as shown in Eq.(5).

$$q' = q + b\left(\sum_{i=0}^{N_1} R_i\right)/N_1 - c\left(\sum_{i=0}^{N_2} NR_i\right)/N_2 \quad (5)$$

Where q' is the modified query, and q is the initial query. R_i and NR_i present the relevant and non-relevant document features. N_1 and N_2 are the numbers of the relevant and non-relevant document. b and c are the proper constants.

Rui and et al. tried to apply Eq.(5) to CBIR by generating the pseudo-document vector from image features[7]. Nastar and et al. used a parametric or non-parametric estimator to estimate the distribution of feature vector on the similar images[8].

3.2 Weight Updating

It is a method that modifies the weight of some feature values when it computes the similarity. For example, if the variance of the images related with a query is large along the i-th feature axis, we can reduce the weight of the feature values with i-th axis. For example, we may use Wt=1/σ, the inverse of the standard deviation of i-th axis as a weighting value.

Chua and et al. and Rui and et al. update the weight of each feature, according to the importance of each feature in the applications, by controlling the simple heuristic weight, respectively[9,10].

3.3 Other Methods

User's feedback can be applied to the system as various levels and ways, for example, modifying the low-level feature values or changing the parameter of the similarity measure. As a high level feedback, we can also modify the rank order of the retrieved images, instead of modifying the feature value itself or changing the parameter of similarity measure.

Ishikawa, Doulamis, and Wood and et al. used the approaches that modify the similarity measure or cost function that calculates the similarity distance between related or non-related images and a query image[11-13].

In this work, we present an effective relevance feedback that considers the user's feedback in the calculation of similarity value itself, as a high level feedback.

3.4 Relevance Feedback Algorithm

Generally user's high-level query cannot be expressed completely by the query that uses the low-level feature values only. Therefore, to retrieve the finally wanted images, The CBIR system with a relevance feedback is required. It redefines the user's query through a relevance feedback between the user and the system.

In this work, for the simplicity and effectiveness of the user's feedback, we propose a Reward and Punishment(RAP) relevance feedback algorithm. We apply it to the calculation of similarity by modifying the similarity value itself like the following Table 1.

Table 1. Pseudo code of RAP relevance feedback algorithm

```
for (i=0; i< # of image; i++)
if (image[i] is in the Top Rank List and relevant)
// Reward weight = Wr
similarity[i] = Wr*similarity[i];
else if (image[i] is in the Top Rank List and non-relevant)
// Punishment weight=Wp
similarity[i] = Wp*similarity[i];
else do not change similarity[i];
Reorder the similarities and display the next image set
```

4. EXPERIMENTAL RESULTS AND DISCUSSION

For the experiment, we used some VisTex images of MIT Media lab and built the test image database of 512 images of 16 classes. As the query images, 32 images from 16 classes are used.

To retrieve the similar images with a query from the image database, the similarity calculation based on a similarity measure is required. In this work, we use the similarity measure of the city-block distance as shown in Eq.(6).

$$D(q, d_i) = \sum_{i=1}^{N} |f_q - f_i| \qquad (6)$$

Where q is a query image, and d_i represents the images in the database. f_q and f_i are the feature vectors of the query and database images, respectively.

To evaluate the performance of the proposed CBIR system, we use Retrieval Precision(RP) as an objective measure of retrieval as shown in Eq.(7)

$$RP = \frac{R_r}{T_r} \times 100\% \qquad (7)$$

Whereis R_r the number of relevant images with a query image. In this work, it means that they belong to the same original 512×512 image, because original 512×512 images were divided into 128×128 test images and used. T_r presents the number of retrieved images in this system. We use the top 16 retrieved images in this work.

In this experiment, Top rank 16 images are considered by the user for the relevance feedback. In our RAP algorithm, for the simplicity, Reward weight Wr and Punishment weight Wp are chosen as 0.5 and 2.0, respectively.

Table 2 shows the Retrieval Precision of the

Table 2. Retrieval Precision according to the data type of feature

Type of Data	Without RF	1st RF	2nd RF	3rd RF
A	35.2	48.8	55.5	61.3
B	48.6	66.8	72.5	76.6
C	46.1	63.5	71.1	74.2
D	50.8	67.6	73.2	76.8

proposed system with the relevance feedback in the various ways of the data type. The type of data, A presents the raw feature data. B and C are the normalized feature by the mean and the normalized feature by the means multiplied with the standard deviation, respectively. D is the Gaussian normalization. In the table, the cases of the relevance feedback show the better performance of about 13 ~28% than the case without the relevance feedback. Especially the first RF improves the performance of the system greatly. The Gaussian normalization, D shows the best performance among the various data types.

The INRIA retrieval system is one of the typical relevance feedback-based image retrieval systems [8]. Table 3. presents the performance of INRIA's parametric approach. In the table, the first RF shows the best performance improvement like the case of Table 2. However, even if this relevance feedback system is complex when compared with the proposed approach, it has the lower performance of about 10~17% in each feedback.

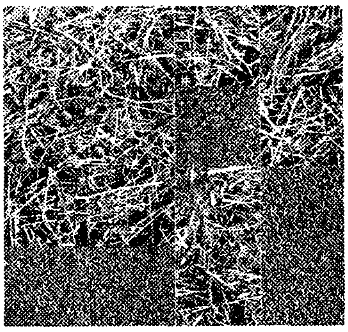
Fig. 3, 4 are the examples of retrieval results of the proposed system. The top-left image is a query image, and the other images are the retrieved images according to their similarity in the order of left-to-right and top-to bottom.

5. CONCULSION

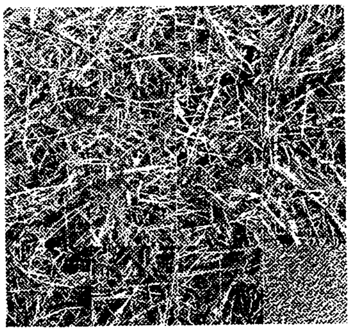
In this paper, we proposed the image retrieval system with a simple and effective relevance feedback and showed the performance of the proposed system. For this, we extracted the color and texture features, and then used them in the various ways of feature data type for the image

Table 3. Retrieval Precision by INRIA's parametric approach

Type of Data	Without RF	1st RF	2nd RF	3rd RF
D	50.8	57.4	59.4	60.3

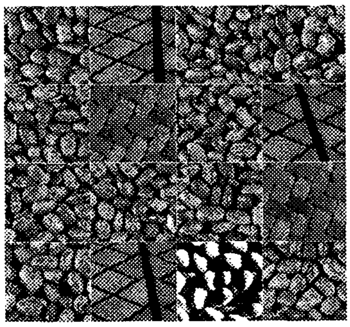


(a) Without RF

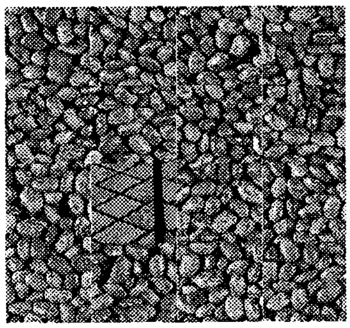


(b) The 1st RF

Fig. 3. The example of retrieval results without RF and the 1st RF.



(a) Without RF



(b) The 1st RF

Fig. 4. Another example of retrieval results without RF and the 1st RF.

retrieval. As the relevance feed back, a simple reward and punishment(RAP) algorithm was used and applied to the image retrieval system. We compared its performance with those of the system without RAP and also the typical conventional relevance feedback-based system, INRIA image retrieval system.

In the experiment of the test image database of 16 class 512 images, when compared with the system without a relevance feed back, the proposed system with the relevance feed back shows the better performance of about 13~28% in Retrieval Precision. It is also confirmed that the first relevance feed back can give the most effect to the system. The proposed system shows the better performance of about 10~17% when compared with that of the conventional INRIA retrieval system.

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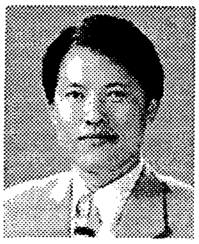

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