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Content-Based Image Retrieval and Completion in DSP

Xia Dingyuan[1], Xiang Zhengquan
Dept. of Communication & Information Eng.
Guilin Institute of Electronic & Technology

Zhou Manli, Zhou Wenzhao, Xu Yiping
Dept. of Electronics & Information Eng.
Huazhong University of Science & Technology

Abstract

Analyzing the limitations which exist in content-based image retrieval (CBIR) systems on optimization model, generalization design and retrieval efficiency, a combinative model based on image features correlation retrieval is designed, using some proper algorithms of image retrieval, relevance feedback principle and the advantage of DSP chip in image signal processing. The work mode is useful for retrieving the specific images in large image database (e.g. remote sensing images in GIS) or general images in Internet. The rationality of the new scheme is validated by experimental results.

1 Introduction

In CBIR systems, the common features description and extraction of image for machine vision are color, texture, shape and object [1],[2],[3],[4]. Because of the complicacy for description, extraction and similarly measure of image features in CBIR systems, the technique of CBIR is rather immaturity, many problems need to solve in the field of theory and application [5],[6],[7].

The main problems above include three aspects: optimization model, generalization design and retrieval efficiency. In this paper, we give a solution by constructing a combined features retrieval model based on image features correlation retrieval. In the solution, some proper retrieval algorithms of image features, system design norm provided in the MPEG-7, interactive relevance feedback principle between man and computer, and the advantages of DSP chip in image signal processing are synthetically utilized.

2 Image Features Description

It is difficult to perfectly describe the image content by single image feature, such as color, texture, shape and object, etc., and the retrieval effect is not satisfied sometimes. Thus, the more efficacy retrieval method is combined features retrieval by synthetically using many different kinds of image features. There are three aspects of problems to need to solve in combinative retrieval. Firstly, inner normalization processing for single image feature; secondly, outer normalization processing for different image features; lastly, reasonable quantum of weights for inner features and outer features of image. The common adopted method of normalization is Gauss normalization processing and linear transform.

The main formulas are represented as:

$$D_{IJ} = \text{dis}(\mathbf{F}_I, \mathbf{F}_J),$$
$$f_{i,j}^{(N)} = (f_{i,j} - m_j) / \sigma_j,$$
$$D_{IQ}^{(N)} = [(D_{IQ} - M_Q)/(3\sigma_Q) + 1]/2.$$

Where D_{IJ} is a set of representations of similarity measure between feature vectors $\mathbf{F}_I$ and $\mathbf{F}_J$ for two given images I and J (I, J=1,2,...M, I $\neq$ J); M is the image number in given image database; m_j and σ_j is the measure for Expected value and Standard deviation respectively; $D_{IQ}^{(N)}$ is the measure of a query image Q, and there are 99% of the $D_{IQ}^{(N)}$ values distributed in the zone [0,1] after outer normalization processing.

After the normalization processing above, by using the relevance feedback principle [5],[6], a multimedia object O_M used as query is represented as:

$$O_M = O'_M(D, F, R).$$

Where D is the raw image data, such as a JPEG or GIF image; $F=\{f_i\}$ is a set of low-level visual features associated with the image object, such as color, texture, shape, etc.; $R=\{r_{ij}\}$ is a set of representations for a given feature f_i, e.g. color histogram is representations for the color feature and co-occurrence matrix for the texture feature.

In the systems given in this paper, the combinative retrieval algorithms for color and texture features are adopted, which the single algorithm used for retrieval is color accumulative histogram for the color features and co-occurrence matrix for the texture features. A set of similarity measures (e.g. Cosine, Euclidean, histogram intersection, etc) is applied.

3 Retrieval Model

Referring to multimedia content description interfaces provided in MPEG-7, the system is divided into three sections: microcomputer subsystem, DSP subsystem and image database subsystem. The microcomputer subsystem, used as correlation description of image features and fast retrieval, is constructed by PIV microcomputer. The core of DSP subsystem is TMS320C32 developed board, which is embedded in microcomputer subsystem and works in parallel mode [8],[9], for speeding extraction and index of image features. The image database subsystem, used as management and renewal of image data, is developed with VC++ 6.0, a kind of visual program tool.

The query process is carried through according to the interactive relevance feedback principle between man and computer, with the first query in terms of the random initialization and the other queries in terms of the previous query outcome respectively. During the relevance feedback process, the system, according to feedback outcome, adjusts the weights of color and texture features constantly and automatically until the satisfying result is attained.

For the given demonstrations of the images, in the system, first, the features of the images in the library are extracted to form the index document library by constituting the feature database with the feature vectors of all the images. Then, the feature vectors of the demonstrated images are calculated, and afterwards, the similarity measures are carried out by comparing them with all the feature vectors in the library, and each image is marked in terms of

1 Address: No. 1, Jinji Road, Guilin, 541004, Guangxi Province, P. R. China. E-mail: labxiady@263.net

similarity, and finally, the most similar images are outputted. The workflow of the system is shown in Fig. 1.

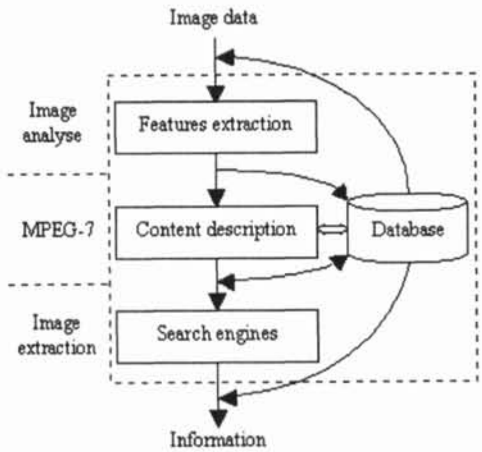
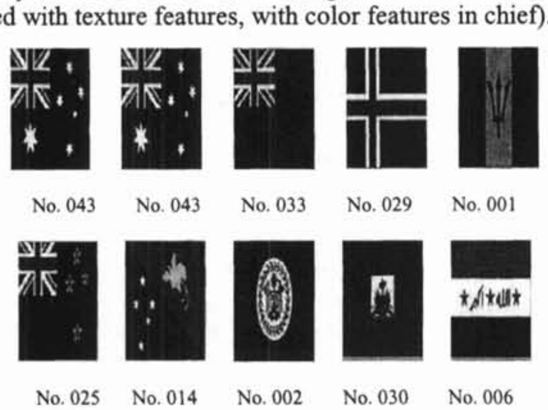


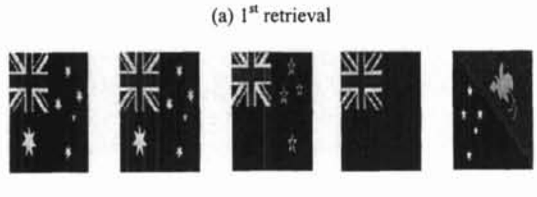
Fig. 1 Image retrieval model

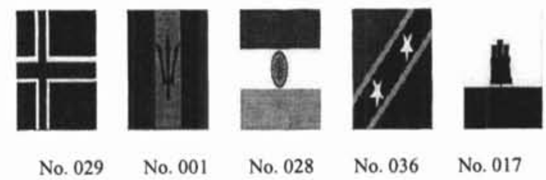
4 Experimental Results

For given image library, including nearly one thousand of national flags (color features combined with texture features, with texture features in chief), a relatively ideal query outcome can be attained by 1 to 2 times of retrievals if the first random initialization (i.e. W_1=0.5, W_2=0.5) has little difference with the actual query outcome. And if the first random initialization is comparably precise (i.e. W_1=0.3, W_2=0.7), then only one time of retrieval is needed. But on the contrary, if the first random initialization is not of precision enough (i.e. W_1=0.7, W_2=0.3), about 2 to 3 times of retrievals are needed and a stable outcome can also be attained. In the extreme, when single feature retrieval for color or texture is adopted (i.e. W_1=1, W_2=0 or W_1=0, W_2=1), longer time of retrieval process is needed to meet the relatively ideal query outcome. The image retrieval results are shown in Fig. 2 - 4, and the adjusted results of the corresponding weight parameters are summarized in Table 1 - 7. The result can also be gained closely in other different types of images libraries (e.g. fresh flowers, mostly in color features; buildings, color features combined with texture features, with color features in chief).



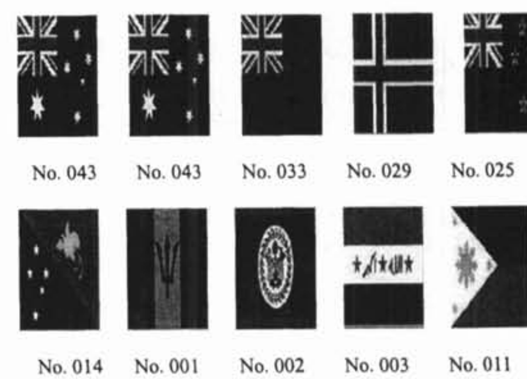
(a) 1st retrieval



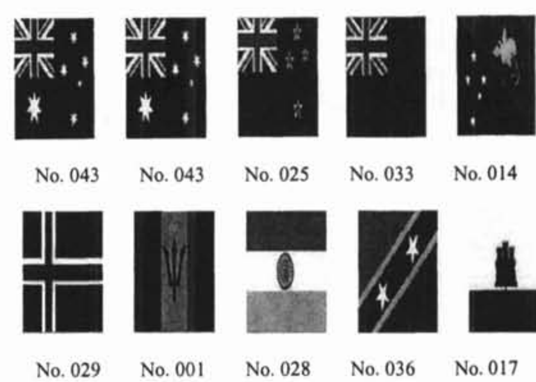


(b) 2nd retrieval

Fig. 2. Combined features retrieval of color and texture (Initial weights W_{11}=0.5,W_{21}=0.5)

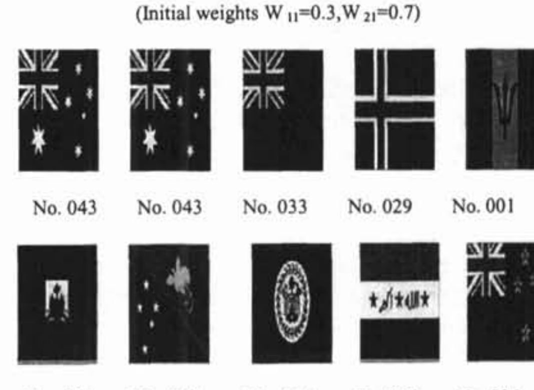


(a) 1st retrieval

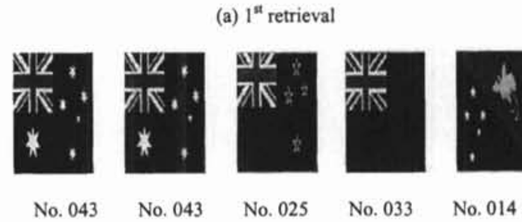


(b) 2nd retrieval

Fig. 3. Combined features retrieval of color and texture (Initial weights W_{11}=0.3,W_{21}=0.7)



(a) 1st retrieval



No. 029 No. 001 No. 028 No. 036 No. 017

(b) 2nd retrieval

Fig. 4. Combined features retrieval of color and texture

(Initial weights W_{11}=0.7,W_{21}=0.3)

TABLE 1 The outer weights of color and texture

(Three kinds of different initial weights)

	W_1	W_2	W_1	W_2	W_1	W_2
1st retrieval	0.5	0.5	0.5	0.5	0.5	0.5
2nd retrieval	0.01	0.99	0.01	0.99	0.01	0.99

TABLE 2 The inner weights of color features

(Initial weights W_{11}=0.5,W_{21}=0.5)

	W_{111}	W_{112}	W_{113}	W_{114}
1st retrieval	0.125	0.125	0.125	0.125
2nd retrieval	0.451	0.383	0.124	0.015
	W_{115}	W_{116}	W_{117}	W_{118}
1st retrieval	0.125	0.125	0.125	0.125
2nd retrieval	0.011	0.006	0.005	0.005

TABLE 3 The inner weights of color features

(Initial weights W_{11}=0.3,W_{21}=0.7)

	W_{111}	W_{112}	W_{113}	W_{114}
1st retrieval	0.125	0.125	0.125	0.125
2nd retrieval	0.451	0.383	0.124	0.015
	W_{115}	W_{116}	W_{117}	W_{118}
1st retrieval	0.125	0.125	0.125	0.125
2nd retrieval	0.011	0.006	0.005	0.005

TABLE 4 The inner weights of color features

(Initial weights W_{11}=0.7,W_{21}=0.3)

	W_{111}	W_{112}	W_{113}	W_{114}
1st retrieval	0.125	0.125	0.125	0.125
2nd retrieval	0.452	0.383	0.124	0.015
	W_{115}	W_{116}	W_{117}	W_{118}
1st retrieval	0.125	0.125	0.125	0.125
2nd retrieval	0.011	0.006	0.005	0.005

TABLE 5 The inner weights of texture features

(Initial weights W_{11}=0.5,W_{21}=0.5)

	W_{211}	W_{212}	W_{213}	W_{214}
1st retrieval	0.25	0.25	0.25	0.25
2nd retrieval	0.414	0.041	0.541	0.004

TABLE 6 The inner weights of texture features

(Initial weights W_{11}=0.3,W_{21}=0.7)

	W_{211}	W_{212}	W_{213}	W_{214}
1st retrieval	0.25	0.25	0.25	0.25
2nd retrieval	0.412	0.041	0.543	0.004

TABLE 7 The inner weights of texture features

(Initial weights W_{11}=0.7,W_{21}=0.3)

	W_{211}	W_{212}	W_{213}	W_{214}
1st retrieval	0.25	0.25	0.25	0.25
2nd retrieval	0.425	0.042	0.529	0.004

5 Conclusions and Discussion

The experimental results indicate that the reasonable initialization of weights can availably increase retrieval efficiency. And the further experiments show that the function of weights of the internal features as well as the changing speed of process are up to the adjustment of the outer weights, and inner weights will ultimately hold consistence after some relevance feedback for the different outer weight's initialization. And usually, only by 3 times or so of the interactive relevance feedbacks between man and computer, will the basically coherent retrieval outcome be ultimately attained, as well as the satisfying retrieval time to general users, which indicates the better astringency and stronger universality of the designed system.

Furthermore, this system is designed as test platforms of universal image retrieval algorithms with extended interfaces for adding other CBIR algorithms (such as shape, object, etc.), which makes the system more extensible and fit for any other combination of algorithms. For those various feature combinations of color, texture, shape, object, etc., the user should only embed the system with the corresponding algorithm and modify the outer weights to keep the sum of all outer weight equal to 1 so as to achieve the same result. And the final retrieval accuracy is related with the combined algorithms while the retrieval efficiency is in proportion with the times of the interactive relevance feedbacks between man and computer.

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