Image Retrieval Using Fractal Feature

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Abstract: - Content-based image retrieval attracted many researchers of various fields in an effort to automate data analysis and indexing. In contemporary image databases one finds many images with the same content perturbed by zooming, scaling, rotation and noise. For the purpose of image recognition in such databases we employ features based on statistics stemming from fractal transforms of gray-scale images through fractal image compression. Experimental results show that the fractal features derived from these statistical aspects can be made robust subject to perturbations.

Key-Words: - Fractal, Histogram, Fixed Point, Image Retrieval

1 Introduction

In recently years, the diffusion of multimedia applications has aroused a significant interest for research in multimedia database. In particular, the search of image databases is a complex issue. Content-based image retrieval (CBIR) techniques utilize the information embodied in an image and are not restricted to a textual description about it. Several methods have been used including color histogram, shape, texture and others [1-3].

Fractal image compression (FIC) provides high compression ratio and high restored image qualities. The idea of FIC is based on the assumption that the image redundancies can be efficiently exploited by means of block self-affine transformations [4-7]. Vissac et al. [8] and Julie et al. [9] have proposed some fractal indexing techniques in which the fractal codes are used as the image features. Schouten et al. [10,11] proposed to employ histogram of contrast scaling parameters as an image index. Although the retrieval speed is fast, the index technique dose not result in high accuracy.

In this paper, we propose a modified method to improve the work in [10,11] by adding luminance as additional features. Both of the contrast scaling and luminance offset are combined to represent the index of an image. We aim to acquire an invariant feature for image perturbations such as zooming, rotation and translation. Experimental results indicate that the proposed index provides good retrieval performance.

2 Fractal Coding

A given image is partitioned into a number of $B \times B$ non-overlapping range blocks and $M \times M$ overlapping domain blocks along the vertical and horizontal directions. The size of domain blocks is larger than range blocks to fulfill the contractive requirement (typically, $M = 2B$). For each range block R_i, the fractal encoder searches from the set of domain blocks a domain block D_i and a contractive mapping w_i which minimizes $d(R_i, w_i(D_i))$ where

$$w_i \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a & b & 0 \\ c & d & 0 \\ 0 & 0 & p \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \\ q \end{bmatrix}. \quad (1)$$

The transforms w_i are also called the affine transform. The parameters (a, b, c, d) constitute the eight isometry transforms, (t_x , t_y) is the position of the domain block, p is the contrast scale factor and q is the luminance offset.

After the appropriate affine transforms was found for all range blocks, the parameters t_x , t_y , p , q and the orientation of eight isometry transforms are stored, which are the fractal codes.

In the decoding phase, one chooses an arbitrary initial image, and then uses the fractal codes to compute the attractor of each transform w_i . After appropriate times of iterations, the image can be reconstructed, which has some degree of loss corresponding to the original image.

3 Fractal Feature Extraction

Since both contrast scaling p and luminance offset q of the fractal codes reflect important properties of the image, we propose a composite index including p and q.

Let X be a complete metric space with metric d and $f: X \to X$ be a contractive mapping with contractivity s, where

$$d(w(x), w(y)) \le sd(x, y),\ s < 1, \forall x, y \in X. \quad (2)$$

Then by the Contractive Mapping Fixed-Point Theorem, there exists a unique point $x_f \in X$ such that for any point $x \in X$

$$x_f = f(x_f) = \lim_{n\to\infty} f^{(n)}(x), \quad (3)$$

The point x_f is called the fixed point or the attractor of the mapping f.

In fractal decoding process, each rang block R is approximated by applying the transform $\widetilde{R} = pD + q$ iteratively. When a whole block is replaced by a pixel, the general decoding process can be written as follows:

$$r^{(n+1)} = p \times r^{(n)} + q, \quad (4)$$

$$if\ |p| < 1, \quad then$$

$$r_f = p \times r_f + q, \quad (5)$$

$$r_f = \frac{q}{1-p}, \qquad 0 \le r_f \le 255. \quad (6)$$

We call r_f in (6) the fractal luminance fixed-point feature. To demonstrate the property of r_f, we lists three images including the original (left), r_f-value blocked (middle) and mean-value blocked (right) in Fig.1.

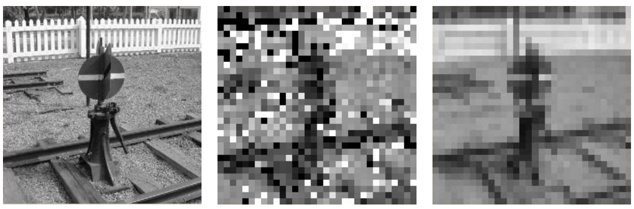

Fig.1. Original, r_f blocked and mean blocked images.

Based on the additional fractal feature, we propose a new feature vector as the index. First, we construct the normalized histogram fractal contrast feature vector [11],

$$\{h_j\}_{j=1}^{J}, \quad \text{where } \sum_{j=1}^{J} h_j = 1,\ h_j \ge 0. \quad (7)$$

J refers to the quantized level for p. Then we derive the fractal luminance fixed-point r_f of every block from fractal codes, and quantize the r_f into L levels. After normalization, we can build the histogram fractal fixed-point feature vector,

$$\{h_l\}_{l=1}^{L}, \quad \text{where } \sum_{l=1}^{L} h_l = 1,\ h_l \ge 0. \quad (8)$$

Finally, we combine the two vectors (7) and (8) with different weights as our new feature vector.

4 Experimental Results

The test image database consists of 120 miscellaneous gray-scale nature images of size 256×256. Each image has nine perturbed images subject to different degrees of rotation, zoom-in, zoom-out, and translation, etc. The perturbed image is compared to all members of the database. The performance measure is the AFIM [11]:

$$v(D, p) = (1 - \frac{\sum_{j=1}^{N} r_j}{(N-1)N}) \cdot 100, \quad (9)$$

D: the database with *N* images,

p: a given perturbation (e.g. zoom in, out),

r: ranking number (*r*=0 is the best, *r*=*N*-1 is the worst),

For v =100, it means all queries are recognized without fault.

The proposed feature vector combines $\{h_j\}_{j=1}^{8}$ and $\{h_l\}_{l=1}^{8}$ in different weights. The weighting value we used is 0.8 for the former and 0.2 for another. Fig.2 is the processing diagram.

We perform the experiments to acquire the AFIM in batch mode. Then, using the GUI system to find the top eight high-scored images for the query image. Fig. 3, Fig.4 and Fig.5 show the experimental results with perturbations zooming, rotation and translation respectively.

5 Conclusion

In this paper, fractal transforms are employed with the aim of image recognition in multimedia database. Based on the principle that fractal transform is determined by contrast scaling and luminance offset, we proposed the technique to build image feature vectors dealing with the problem of different kinds of perturbed images. Experimental results testify our expectation and show superior performance.

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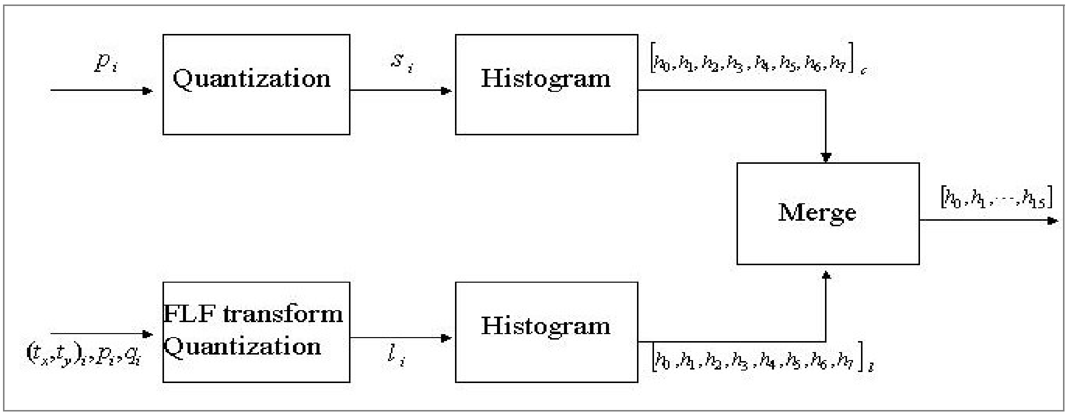

Fig.2. Composite fractal feature vector

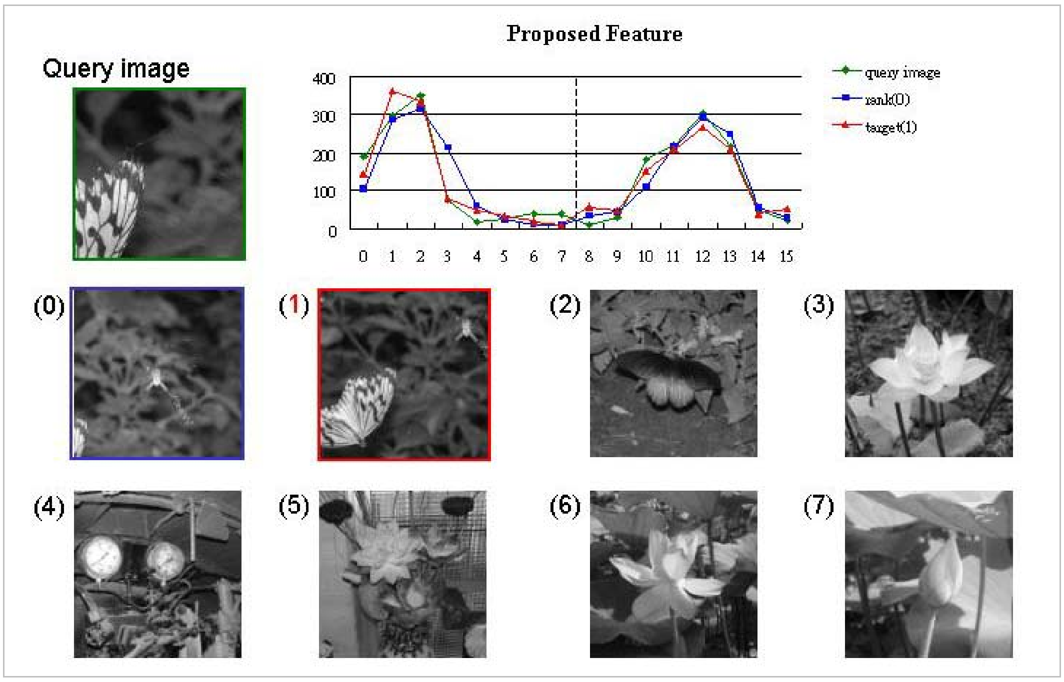

Fig.3. Query by zoom-in sample image, AFIM = 84.23.

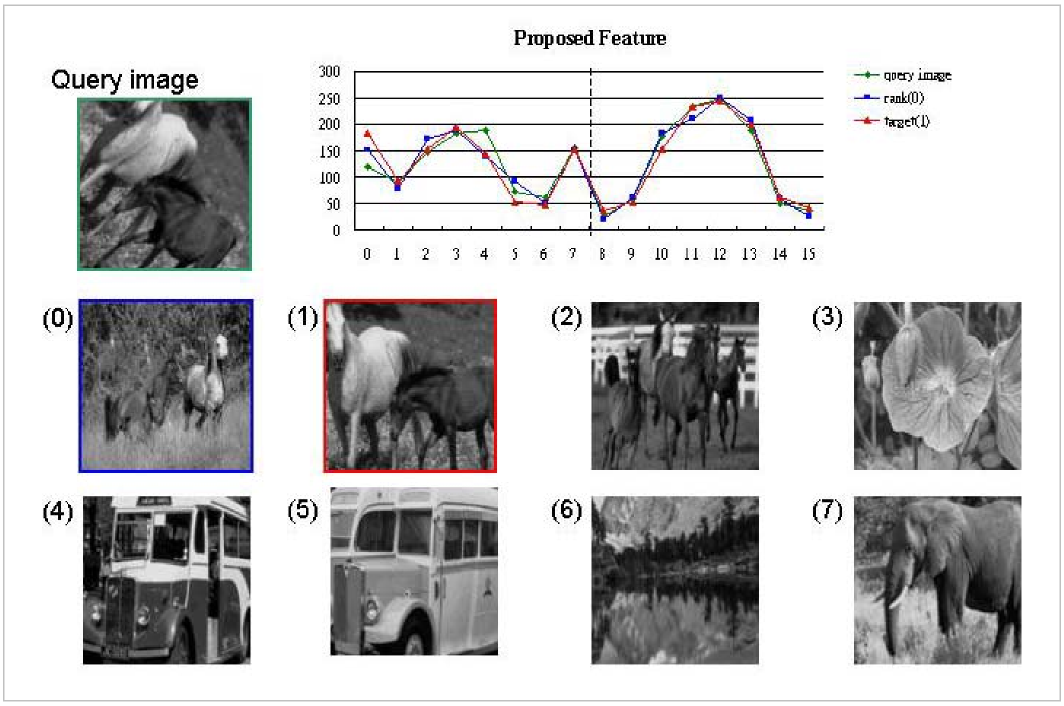

Fig.4. Query by rotated sample image, AFIM = 93.34.

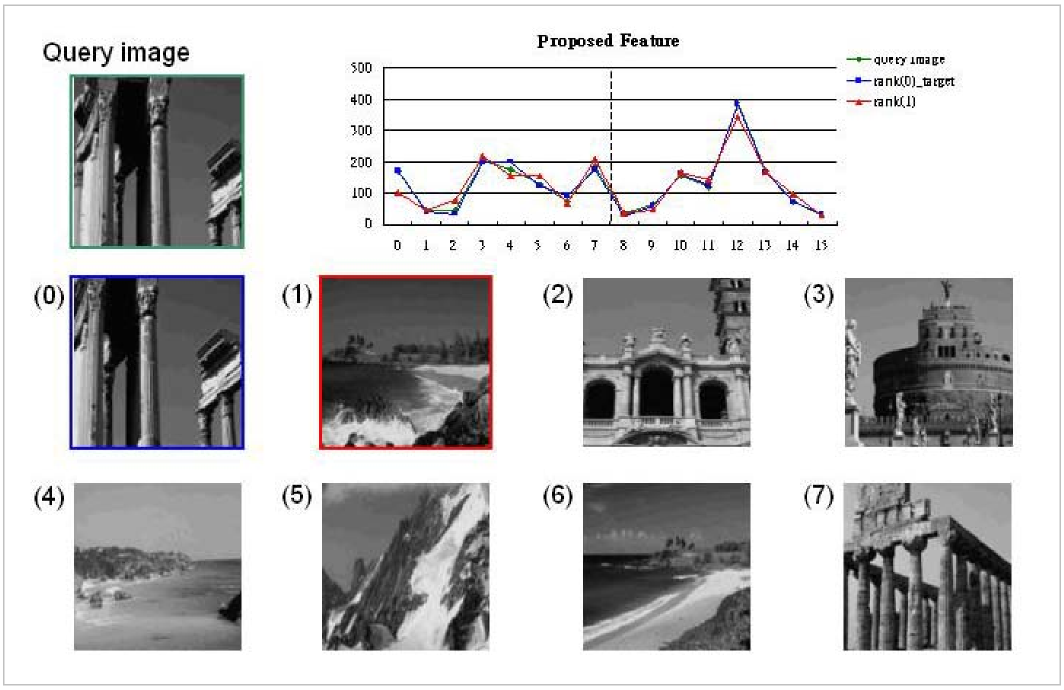

Fig.5. Query by translated sample image, AFIM = 99.69.