# Trademark Image Retrieval Using Hierarchical Region Feature Description

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## Introduction

Two important issues are associated with the trademark image retrieval. One is how to extract appropriate features to effectively represent the visual content of the trademark images, and the other is how to measure the dissimilarity between any two given trademark images based on their descriptors.

In this work, we treat the trademark as a general binary image and extract the regional features of the object for description. The contribution of our work is: A strategy which iteratively partitioning the region of the object into smaller parts along different directions is proposed for providing a hierarchical description and a shifting feature matching scheme is presented for a finely dissimilarity measure.

## Description Framework

A binary trademark image can be considered as a distribution of black pixels in a white two-dimensional space-background.Let $B_0$ be the set of the coordinate pair $(x, y)$ of all the black pixels.

Step 1. Partition the image region iteratively, in every iteration, the image region is partitioned by its centroid and the upper-left part of the region is obtained and used in next iteration.

Step 2. Rotate the image region around its centroid by an angle and a new image region will be generated, repeat the same iterative partition against the new image region. We uniformly sample the angle range $[0, 2\pi)$.

Partition the original image region $l$ levels along $m$ directions, the image region will be partitioned into progressively smaller regions and we can obtain $m * l$ sets $B_i^j : i = 1, 2, \cdots, l$ and $j = 0, 1, \cdots, m-1$.

A visual illustration of the above iteratively partitioning is shown in Fig. 1.

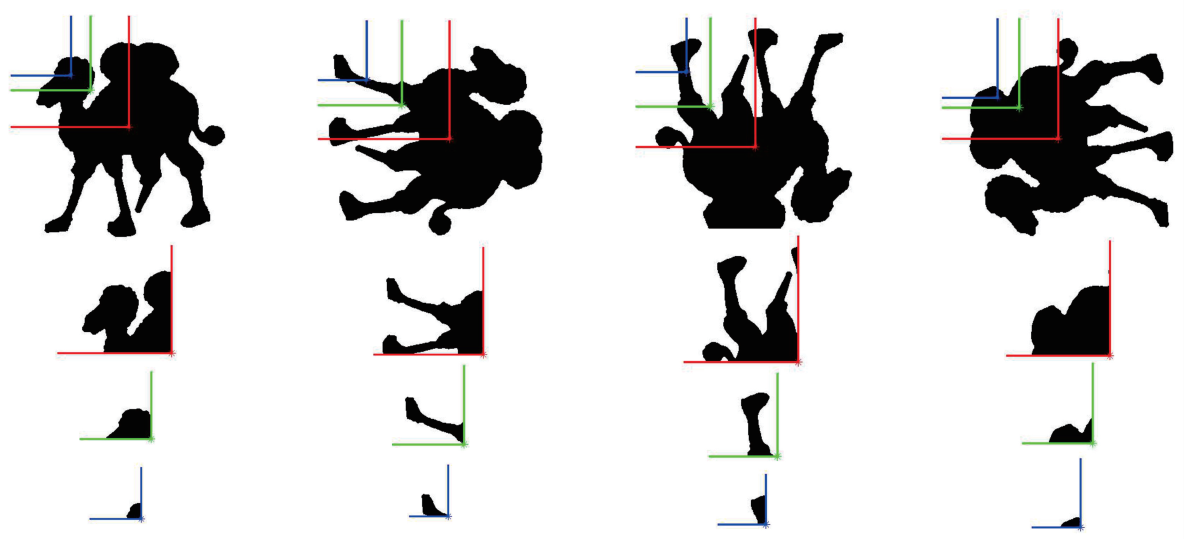

**Figure 1:** A visual illustration of iteratively partitioning the image region in progressively smaller one along different directions.

## Image Region Measure

Four region measurements are conducted for features extraction against the partitioned regions after region partitioning.

**Density**: Density $d_i^j$ is a measurement that represents the partition ratio of the region $B_i^j$ to $B_{i-1}^j$.

**Compactness**: Compactness $c_i^j$ represents how well the region $B_i^j$ fits the smallest enclosing circle centered at the centroid of $B_i^j$.

**Rectangularity**: Rectangularity $r_i^j$ represents how well the region $B_i^j$ fits its minimum enclosing rectangle.

**Eccentricity**: Eccentricity $e_i^j$ illustrates how the points in region $B_i^j$ scattered around the centre of the region.

## Feature Matching

By varying the index $j$ from 0 to $m-1$ and varying the index $i$ from 1 to $l$, we obtain four matrices $D = (d_i^j)_{m\times l}$, $C = (c_i^j)_{m\times l}$, $R = (r_i^j)_{m\times l}$ and $E = (e_i^j)_{m\times l}$. We combine the four matrices and assign each of them a different weighing factor,an $m * 4l$ feature matrix

$$F_0 = \left[ W_d \times D \; W_c \times C \; W_r \times R \; W_e \times E \right] \quad (1)$$

is extracted from an image.

Consider each row of the matrix $F_0$ as a vector $V_i, i = 0, 1, \ldots, m-1$, the matrix $F_0$ can be then denoted by a column vector as

$$F_0 = \begin{bmatrix} V_0 \\ V_1 \\ V_2 \\ \vdots \\ V_{m-1} \end{bmatrix} \quad (2)$$

The rotation of the trademark image will result in a circular shift of the column vector $F_0$. For a query image A, we prepare the feature matrix $F_0$ and its $m-1$ shifting versions:

$$F_1 = \begin{bmatrix} V_1 \\ V_2 \\ \vdots \\ V_{m-1} \\ V_0 \end{bmatrix}, F_2 = \begin{bmatrix} V_2 \\ \vdots \\ V_{m-1} \\ V_0 \\ V_1 \end{bmatrix}, \cdots, F_{m-1} = \begin{bmatrix} V_{m-1} \\ V_0 \\ V_1 \\ \vdots \\ V_{m-2} \end{bmatrix} \quad (3)$$

Then the dissimilarity between the query trademark image A and a database trademark image B can be measured by

$$dis(A, B) = \min_{j=0,1,\cdots,m-1} \|F_j^A - F_0^B\| \quad (4)$$

where $\| * \|$ represents $L$-1 distance.

## Experiment Results

We implemented our method in Matlab and conducted comparative experiments on two standard shape database with five state-of-the-art approaches: Adaptive Hierarchical Geometric Centroid, Zernike Moments, Polar Harmonic Transforms, Shape Contexts and Zernike Moment & Edge Gradient Technique.

MPEG-7 CE-2 shape database consists of 3621 trademark images. 651 shapes among them are organized into 31 groups with 21 samples in each one. Each one of the 651 shapes is taken as a query to retrieval similar shapes from the whole database. We plot the precision-recall curves of the proposed method and the other five approaches for trademark image retrieval in Fig.2.

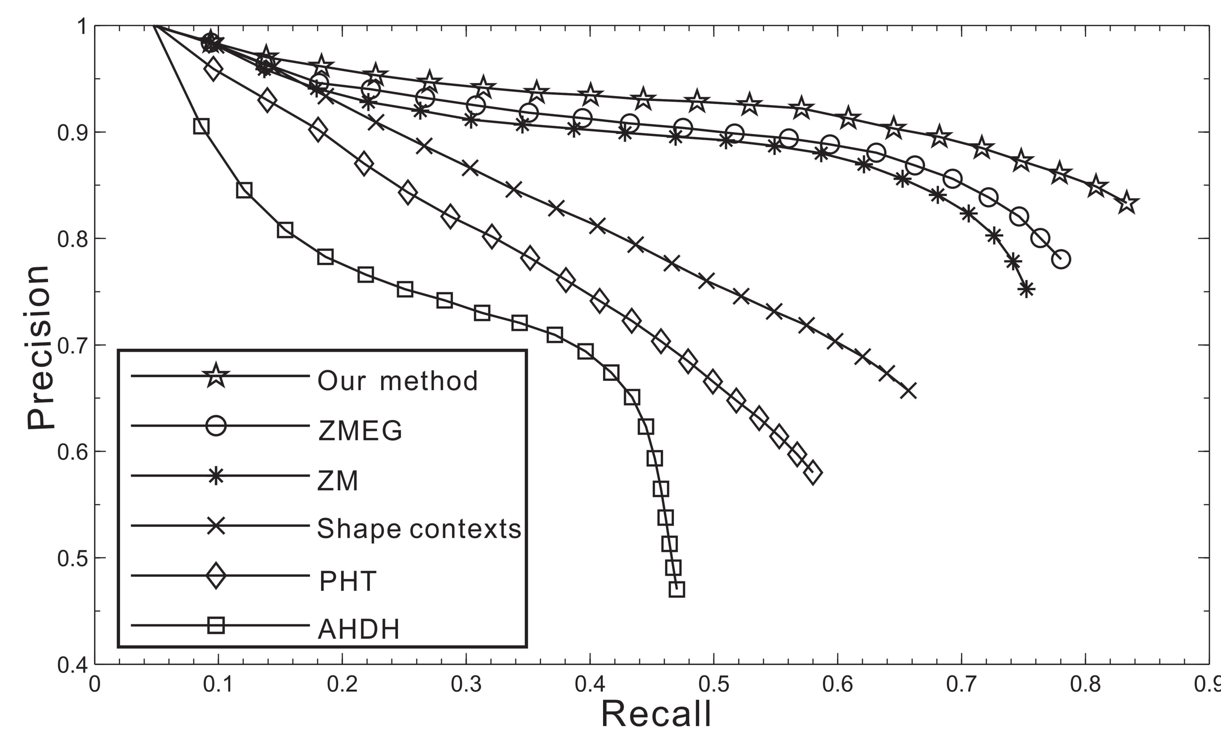


**Figure 2:** The precision-recall curves of different methods on the MPEG-7 CE-2 database.

MPEG-7 CE-1 shape database contains 1400 binary shapes organized into 70 groups with 20 similar shapes in each group. Each one of the 1400 shapes is taken as a query to retrieval similar shapes from the whole database. The precision-recall curves is shown in Fig.3.

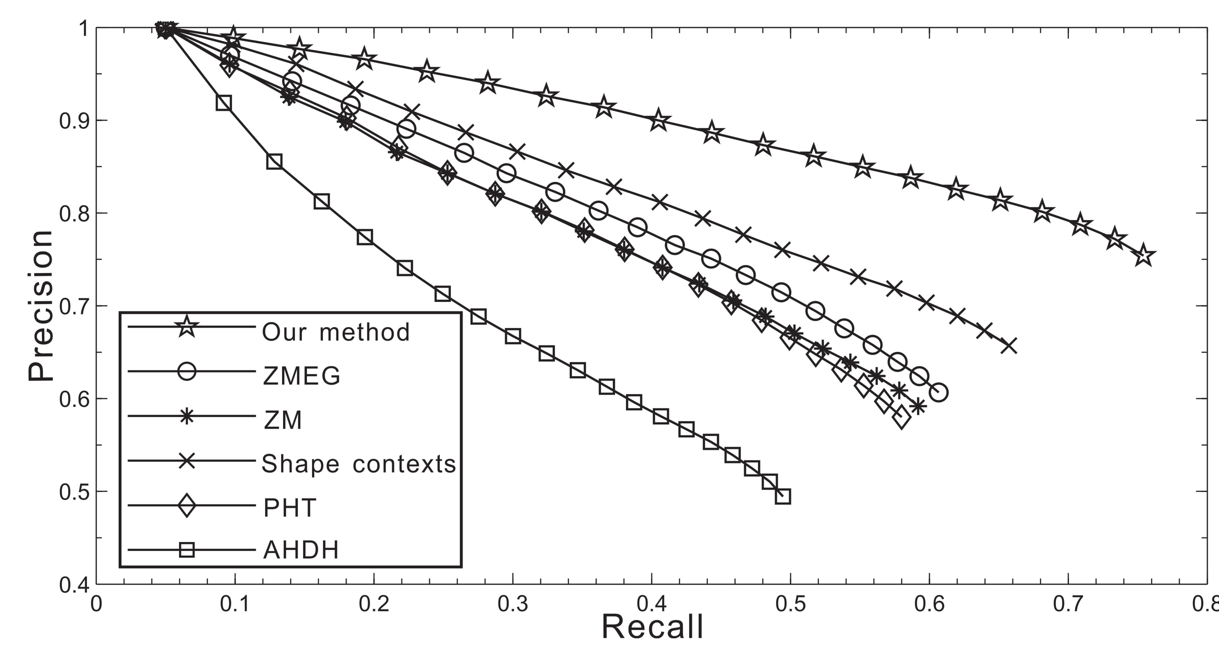


**Figure 3:** The precision-recall curves of different methods on the MPEG-7 CE-1 database.