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# A novel method for shape representation

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## Abstract
The expansion of multimedia information has generated requirements for easy and effective access to large image databases. *Content Based Image Retrieval* (CBIR) has become a major area of research and has received increasing attention. Shape representation and description is one of the major problems in (CBIR). There are generally two types of shape representations: Region-based and Contour-based techniques employed in the field of shape retrieval. This paper provides a summary of these two Shape representation techniques. We will propose our novel Structural–based shape representation method which falls under contour-based techniques. It is worth mentioning that the proposed method is a part of our project which is image retrieval based on shape using the user's sketch as a query input.

***Keywords:*** *CBIR, Shape descriptor, shape representation, Structural–based shape representation*

## 1. Introduction
With the rapid growth of the Internet and the increasing popularity of the use of large volume image databases in various applications, this raises the challenging problem of designing techniques that support effective searching through the entire database. Techniques using textual attributes for annotations are common to text retrieval applications [1]. However, images have attributes which set them apart from text, and which make provision for access far from simple.

Eakins in [2] defined Content-based image retrieval CBIR as a *"technique for retrieving images on the basis of automatically-derived features such as colour, texture and shape"*. In order to determine which images must be retrieved, content representations of all stored images are compared with the representation extracted from the query image. The most important considerations in the design and implementation of CBIR systems are: image feature extraction, features representation, features matching, database organizing and querying mechanisms.

Since shapes bear semantic meanings, shape representation through a set of features, modeling prominent attributes of the shape, is the most popular technique in (CBIR) used to describe image content [3]. In shape feature extraction, there are two major steps, *Object segmentation and shape representation***.** Object Segmentation based on shape is one of the most difficult aspects of content-based image retrieval. Several robust image segmentation techniques are currently becoming available such as the region growing technique, the texture-based technique, the global threshold-based technique, and the colour-based technique. It is difficult to do a precise segmentation due to the complexity of the individual object shape, see [4] and [5]. For Shape representations see section (2).

The remainder of the paper is organized as follows: Section (2) focuses on the classification of Shape representations techniques. Section (3) presents our new Structural–based shape representation method. Section (4) provides summary and conclusions. Section (5) is the References.

## 2. Shape Representation
Shape representation generally looks for effective ways to capture the essence of the shape features that make it easier for a shape to be stored, transmitted, compared against, and recognized. These features must also be independent of translation, rotation, and scaling of the shape.

A powerful shape representation method must satisfy several criteria, including:

- Efficiency: simplicity and compactness.
- Accuracy: accurate and complete reconstruction.

- Effectiveness: suitability for shape analysis and shape recognition [6].

Zhang and Lu In [7] classified Shape representations into two categories: *boundary-based* (also called Contour-based) and *region-based. In boundary-based,* objects are represented in terms of their external characteristics (i.e. the pixels along the object boundary), while in *region-based;* shape features are extracted from the whole shape region (i.e. the pixels contained in the region). Under each of these two classes, the different methods are further divided, (Fig.1). In the following sections, Structural method of *boundary-based* techniques is discussed in some details.

reliable information from such boundaries is considered as a very difficult process.

On the other hand the user sketch may not exactly match any of the shapes in database, so using approximate representation and description should be sufficient, Shape in database with minimum difference from the query shape is considered the best match to the query.

In our solution, we only exploit shape boundary (outline), which will be decomposed to reduce the boundary's complexity and simplify the process of information extraction. Next we will introduce our novel method for shape representation.

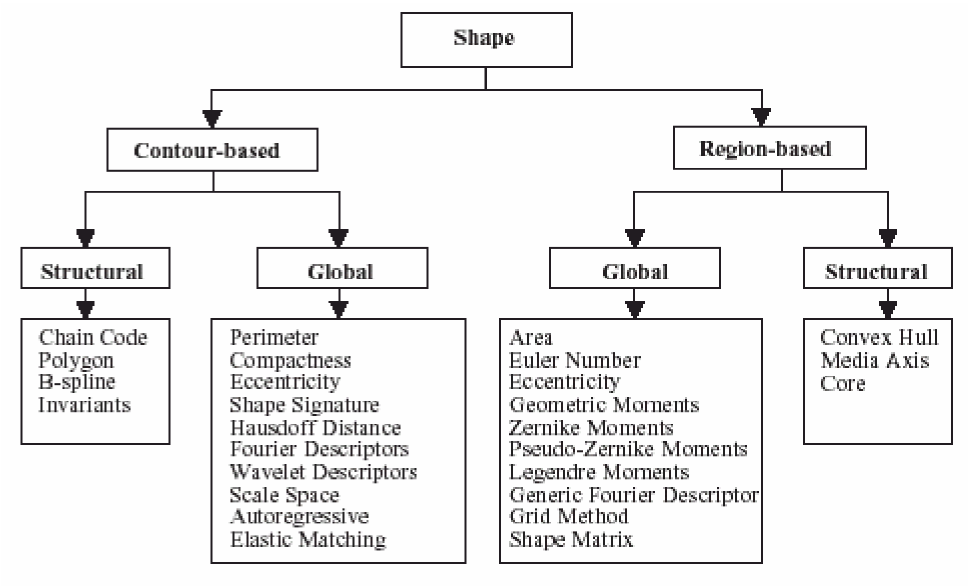


Fig. 1. Classification of shape representation techniques.

## 2.1 Structural–Based Shape Representation

With Structural–based shape representation, shapes are broken down into boundary segments called primitives. Different Structural methods use different ways in selecting and organizing the primitives in a form suitable for further computer processing. For example: the primitives can be extracted based on Common methods such as, polygonal approximation, curvature decomposition and curve fitting, then encode and organize the extracted primitives in a form of strings or graphs that can be directly used for description or as input to a higher-level syntactic analyzer [7].

## 3. Toward A New Approach To CBIR

Shape representation and description is one of the major problems in database image retrieval. Our own research efforts are directed towards searching image databases for shapes, which are similar or partially similar to a given user sketch.

Two problems arise with this approach: On one hand, the most straightforward way to describe a shape is by using information from its boundary, but in general raw digital boundaries tend to be complicated (ragged), so obtaining

### 3.1 Shape Representation

The soul of this method is to decompose the boundary into sequence of straight-line segments (lengths and directions), which lead to generate an approximate representation of the original boundary of an object.

Our goal here is to capture the essence of the boundary shape with the fewest possible segments.

First we assume extracting only the boundary outline of an object with single-pixel thick (8 connected curves), generating what we call boundary-image, This step is fully automated with today's technology, Therefore Getting the outline of the object, is beyond the scope of this study.

The boundary-image is divided into fixed size blocks (e.g. 10 X 10 or 20 X 20 pixels), we deal with each block as a two dimensional array of pixels (matrix), (Fig. 2).

The algorithm replaces the pixels along a boundary within each block by a straight-line joining its two end pixels, which are located on the sides (boundaries) of the block. The algorithm deals with end pixels only instead of tracing pixels one by one. In other word, this algorithm

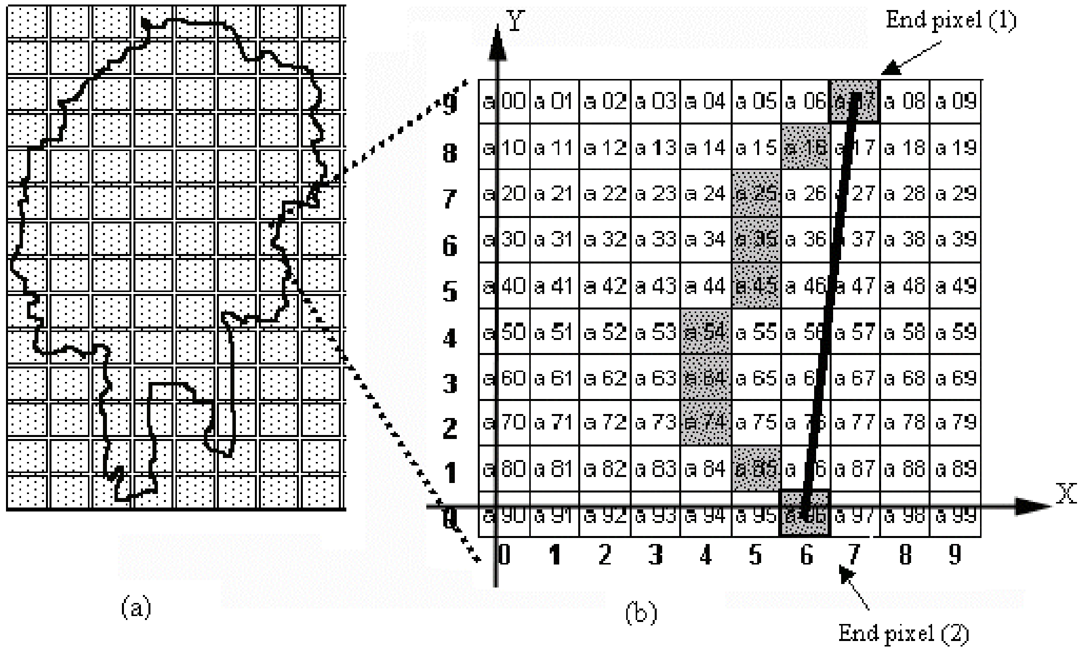


Fig. 2. a) Dividing Boundary-image d into fixed size blocks. b) Replacing the boundary's pixels by a straight-line

marks the pixel as an end pixel (key point) if the location of the pixel falls within the block boundaries. The end pixels of a strait-line segment are pixels in the original boundary, Fig. (2).

We will call each strait-line segment formed by two end-pixels *primitive* (P). The algorithm traverses the blocks that contain the boundary segments in a specific (clockwise or anticlockwise) direction until it reaches the first block where it started.

Assume that each block lies in the first quadrant of a Cartesian coordinate system where Y coordinate points up and X points to the right and the origin is located at the lower left corner of the block, Fig. (2).

We calculate the slope and length of each *primitive* directly from the pixel coordinate in the block, by the following formulas:

$$Slope\,(\mathbf{S}) = \frac{i - i'}{j' - j} \qquad \text{.........................(1)}$$

$$Length\,(\mathbf{L}) = \sqrt{(i' - i)^2 + (j' - j)^2} \quad \text{......(2)}$$

i = 0,1,2,….n-1 , j = 0,1,2,….n-1

Where n is the block size n X n

We can create a lookup-table, which contains slope and length for all possible lines formed by end-pixels in the block. Since all blocks are identical, using lookup-table will facilitate and fasten the process of representation and description.

As might be expected, the accuracy of the resulting representation depends on the size of the blocks. The emphasis is not only on the accuracy of the representation, but also on efficiency (i.e. speed) of the operation.

After having created the lookup-table, finding the slope and length for each segment is rather simple. We only need to identify the end pixels for each block.

We can calculate the difference in the slopes between any primitive Pk+1 and the previous adjacent primitives Pk by the following formula:

$$\mathbf{D}(S_{P(k+1)}, S_{P(k)}) = \frac{S_{P(k+1)} - S_{P(k)}}{1 + (S_{P(k+1)})(S_{P(k)})} \qquad \text{----(3)}$$

k=0,1,2………..n-1
Where *n* is the no. of primitives

## 3.2 Primitives Merging

A large number of Primitives can cause the boundary descriptor to be more complicated and the size of the index to increase unnecessarily. To avoid these problems, we can eliminate some Primitives by allowing adjacent Primitives with similar slopes to be replaced by a single Primitive. This operation is called "Merging", for any adjacent Primitives if the difference between their slopes is zero or not more than a predetermined value (threshold), the Primitives are considered similar and should be merged. Merging will help to capture the essence of the boundary shape with the fewest possible segments.

## 3.3 Shape Descriptor

A Sequence of the lengths and the differences between the slopes of adjacent primitives can be used as a reliable descriptor of the boundary. We apply the same process on the query image (user-defined sketch) and images in database.

The natural characteristic of this Shape descriptor makes itself invariant to translation. Furthermore, it can be made invariant to scale by a simple normalization, where the total length of all primitives that represent the shape divides the length of each primitive.

Since the differences in the slopes between adjacent primitives remain unchanged no matter how you geometrically transform a shape. We treat this descriptor as a circular sequence of primitives; Circular shifting makes it robust to rotation.

A shape in database is considered the best match to the query shape if they have the minimum difference between their primitives Sequences (descriptors).

## 4. Summary and Conclusions

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