Chapter-8 **Representation and Description**

Introduction

Image representation and description is critical for successful detection and recognition of objects in a scene. After an image has been segmented into object and background regions, one intends to represent and describe them in characteristic features for computer processing during pattern recognition or in quantitative codes for efficient storage during image compression. The results of segmentation are a set of regions. Regions have then to be represented and described. Two main ways of representing a region:

(a) Internal and External characteristics

- External characteristics (its boundary): focus on shape
- Internal characteristics (its internal pixels): focus on color, texture

(b) The next step is Description.

E.g.: a region may be represented by its boundary, and its boundary described by some features such as length, regularity.

Features should be insensitive to translation, rotation, and scaling. Both boundary and regional descriptors are often used together.

8.1 Representation

- Segmentation techniques yield raw data in the form of pixels along a boundary or pixels contained in a region. These data sometimes are used directly to obtain descriptors
- Standard uses techniques to compute more useful data (descriptors) from the raw data in order to decrease the size of data. It deals with compaction of segmented data into representations that facilitate the computation of descriptors.
- Image regions (including segments) can be represented by either the border or the pixels of the region. These can be viewed as external or internal characteristics, respectively. The techniques of representations are generally:

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a. Chain Codes

b. Signatures

8.1.1 Chain Codes

Chain Codes represents a boundary of a connected region. It is list of segments with defined length and direction 4-directional chain codes and 8-directional chain codes. Chain codes are used to represent a boundary by a connected sequence of straight-line segments of specified length and direction a chain code can be generated by following a boundary and assigning a direction to the segments connecting every pair of pixels. This method generally is unacceptable for two principal reasons. The resulting chain tends to be quite long any small disturbances along the boundary due to noise or imperfect segmentation cause changes in the code that may not be related to the principal shape features of the boundary.

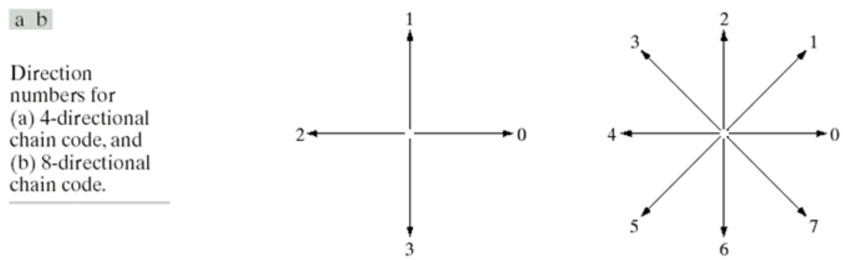

Figure 8.1 (a) 4-Directional Chain Code (b) 8-Directional Chain code

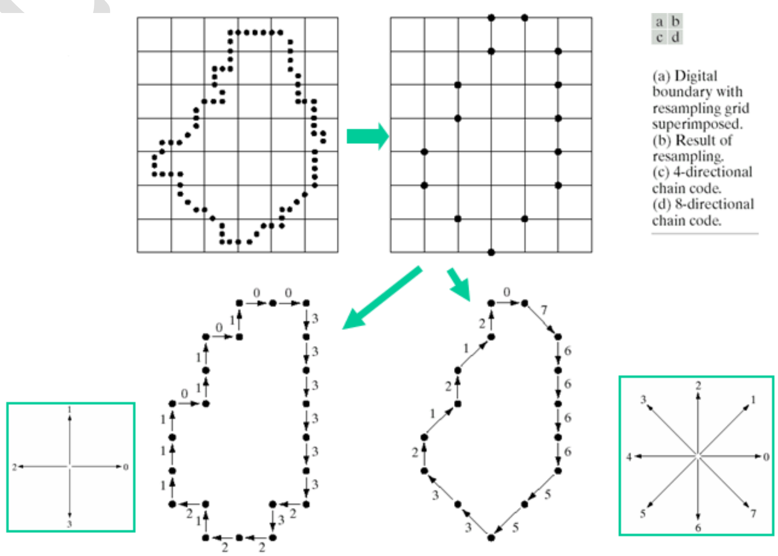

Figure 8.2 (a) Digital boundary with resampling grid (b) Result of Re-Sampling
(c) 4-Directional Chain code (d)8-Directional Chain Code

8.1.2 Signatures

- The idea behind a signature is to convert a two dimensional boundary into a representative one dimensional function. Signatures are invariant to location, but will depend on rotation and scaling.
  - Starting at the point farthest from the reference point or using the major axis of the region can be used to decrease dependence on rotation.
  - Scale invariance can be achieved by either scaling the signature function to fixed amplitude or by dividing the function values by the standard deviation of the function.

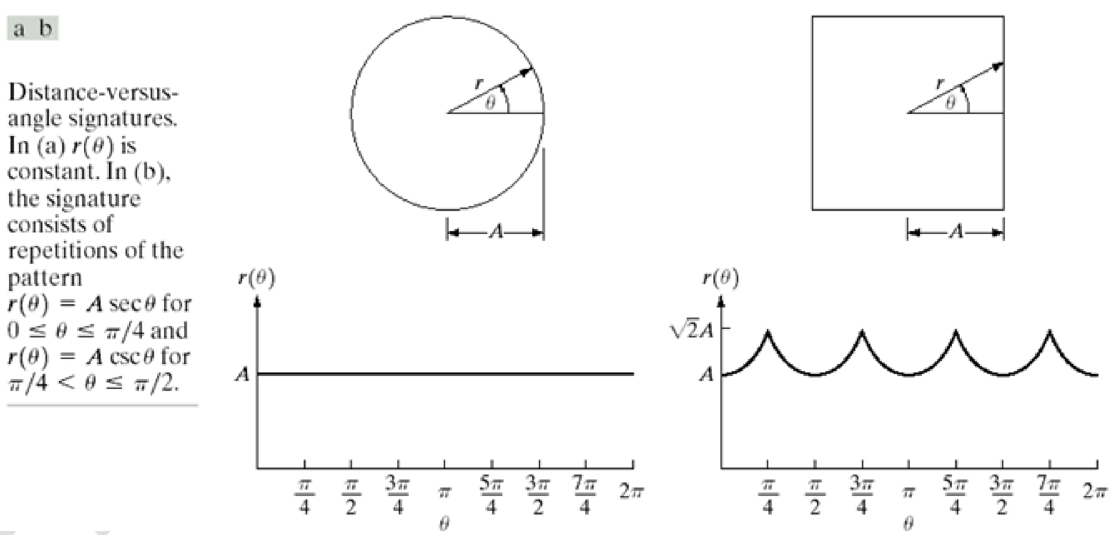

Figure 8.3 Distance –Versus Angle Signatures

8.2 Boundary Descriptors

(a)Length of a Contour /Boundary

It is calculated by counting the number of pixels along the contour. For a chain coded curve with unit spacing in both directions, the number of vertical and horizontal components plus $2^{1/2}$ times the number of components give the exact length of curve.

(b) Boundary Diameter

$$Diam(B) = \max_{i,j}[D(p_i, p_j)]$$

Where,

D is the distance measure which can be either Euclidean distance or D4 distance. The value of the diameter and the orientation of the major axis of the boundary are two useful Descriptors.

(c) Eccentricity

It is a ratio of the major to the minor axis, where major axis is the line connecting the two extreme points that comprise the diameter and minor axis is the line perpendicular to the major axis.

(d) Curvature

It is the rate of change of slope. Curvature can be determined by using the difference between the slopes of adjacent boundary segments at the point of intersection of the segments.

(e) Shape Number

The shape number of a boundary is defined as the first difference of smallest magnitude. The order *n* of a shape number is defined as the number of digits in its representation. The following figure shows all shapes of order 4 and 6 in a 4-directional chain code:

Example 1:

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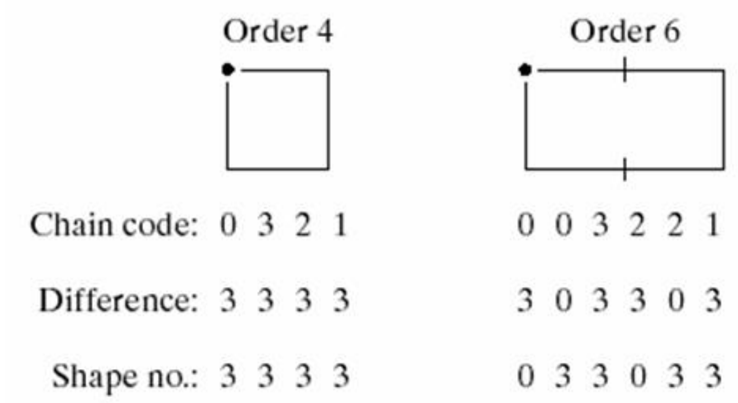
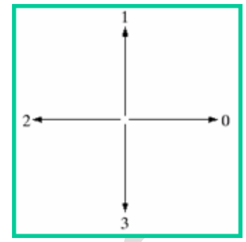
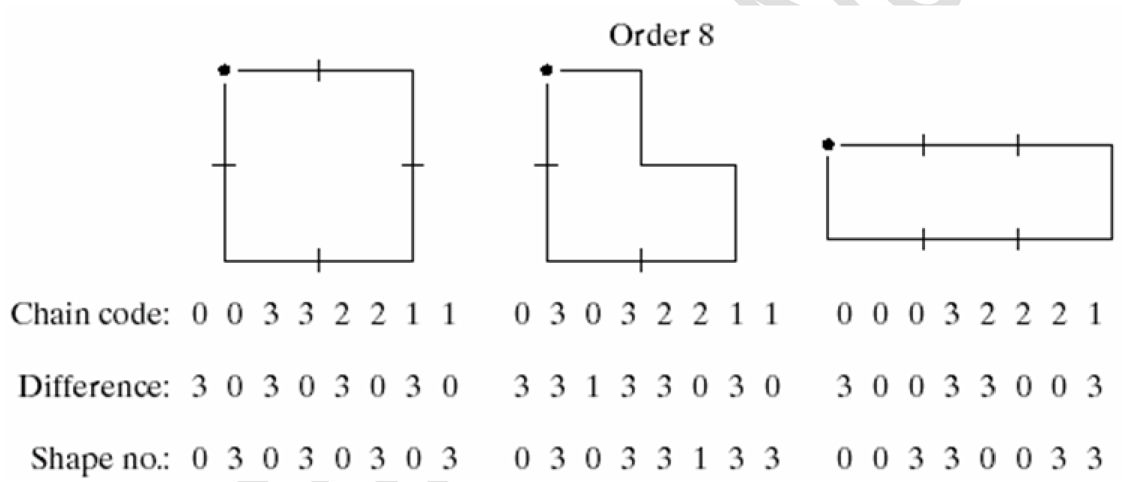
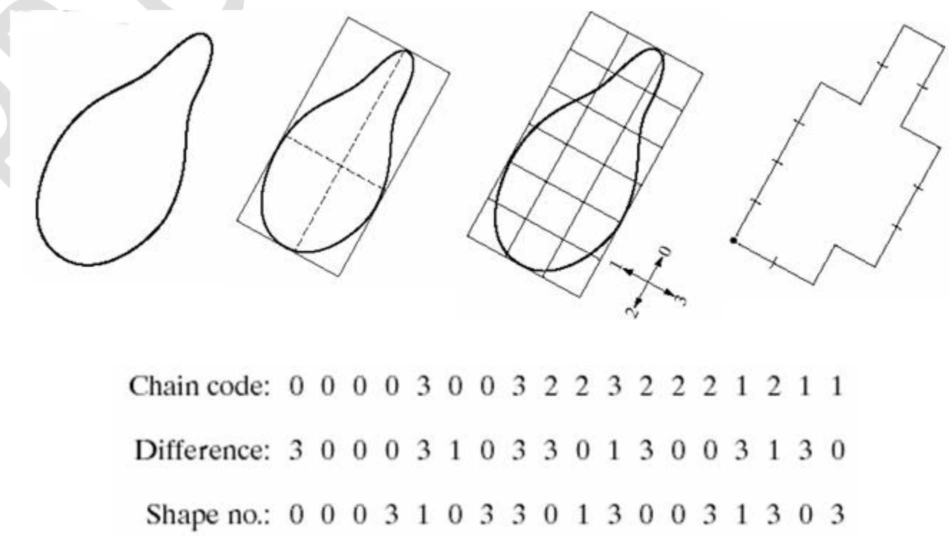




Example 2:



Example 3:



(f) Fourier Descriptors

Redefine the x- & y-coordinates of the boundary as the real and imaginary parts respectively of a complex number. Fourier transform of the new coordinates generates the Fourier descriptors. Inverse transformation will regenerate the original image .Doing an inverse transform on a part of the descriptors will result in an approximation of the shape. Represent the boundary as a sequence of coordinates. Treat each coordinate pair as a complex number (2D 1D)

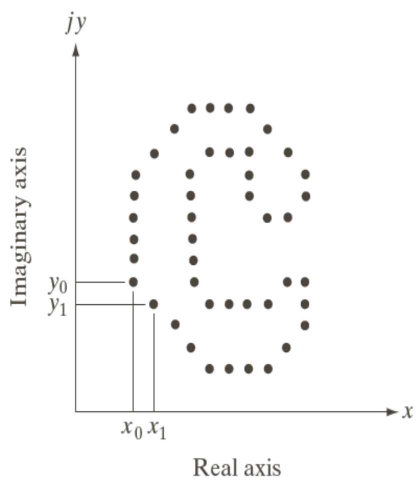


Figure 8.4 a digital boundary and its representation as a complex sequence. The points(x_0,y_0) and (x_1,y_1) shown are the two points in the sequence

$$s(k) = [x(k), y(k)], k = 0, 1, 2, \ldots, K-1$$

$$s(k) = x(k) + iy(k)$$

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- From the DFT of the complex number we get the Fourier descriptors (the complex coefficients, a(u))

$$a(u) = \sum_{k=0}^{K-1} s(k) e^{-j2\pi uk/K}, u = 0, 1, 2, \ldots, K-1$$

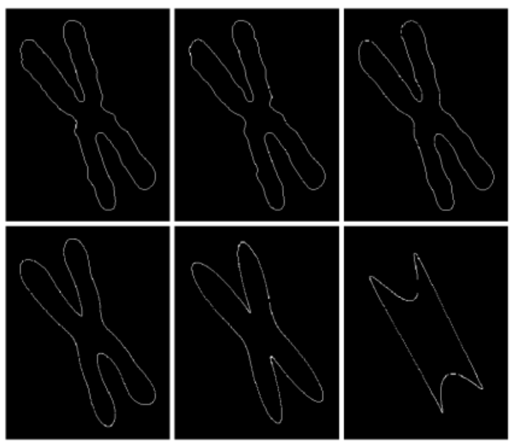
- The IDFT from these coefficients restores s(k)

$$s(k) = \frac{1}{K} \sum_{u=0}^{K-1} a(u) e^{j2\pi uk/K}, k = 0, 1, 2, \ldots, K-1$$

- We can create an approximate reconstruction of s(k) if we use only the first P Fourier coefficients

$$\hat{s}(k) = \frac{1}{P} \sum_{u=0}^{P-1} a(u) e^{j2\pi uk/K}, k = 0, 1, 2, \ldots, K-1$$

Boundary reconstruction using 546, 110, 56, 28, 14 and 8 Fourier descriptors out of a possible 1090.



This boundary consists of 64 point, P is the number of descriptors used in the reconstruction