Chapter 7

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Representation, Description and Recognition

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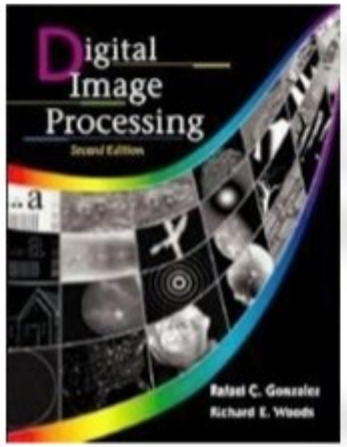
REFERENCES



"Digital Image Processing", Rafael C. Gonzalez & Richard E. Woods, Addison-Wesley, 2002

Much of the material that follows is taken from this book

Slides by Brian Mac Namee
Brian.MacNamee@comp.dit.ie

Overview

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Representing region in 2 ways

- In terms of its external characteristics (its boundary) → focus on shape characteristics
- In terms of its internal characteristics (its region) → focus on regional properties, eg: color, texture
- Sometimes, we may need to use both ways

Overview

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- Description describes the region based on the chosen representation
- ex.
  - Representation→ boundary
  - Description → length of the boundary, orientation of the straight line joining its extreme points, and the number of concavities in the boundary.

Sensitivity

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Features selected as descriptors should be as insensitive as possible to variations in

- Size
- Translation
- Rotation

Representation

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- 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.

Representation Types

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- Chain Codes
- Signatures

Chain Codes

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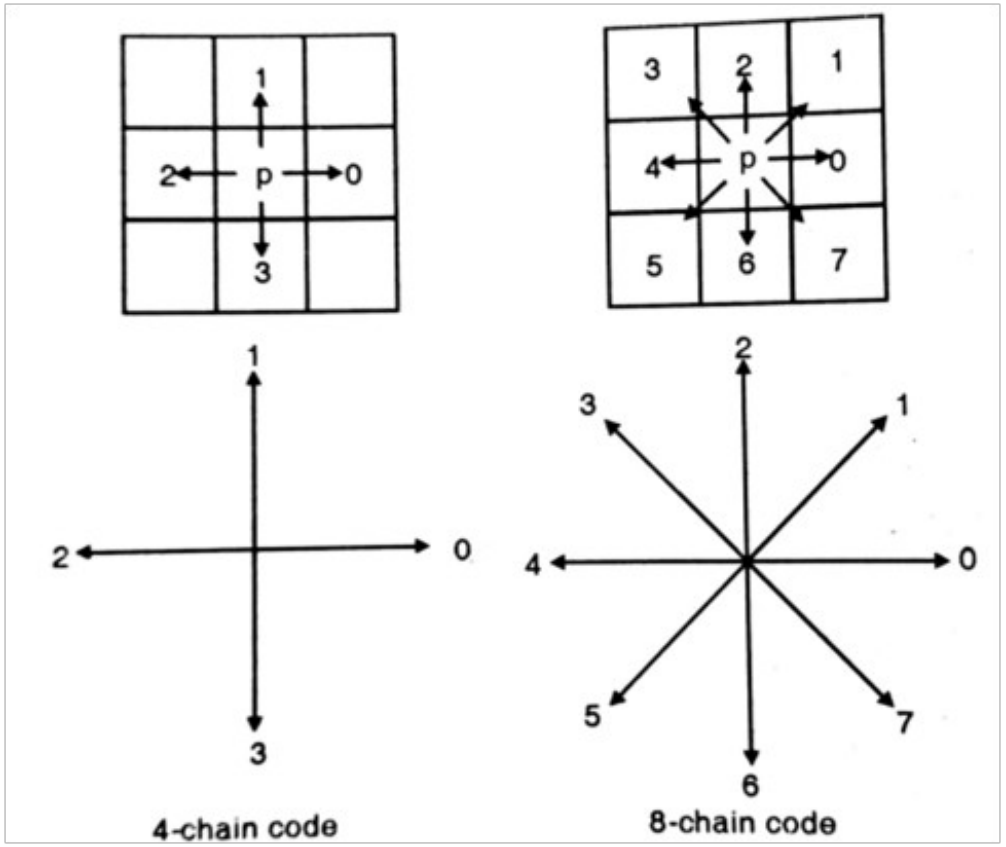
- Chain codes are used to represent the image by a connected sequence of straight – line segments. This represented is based on 4-connectivity and 8-connectivity of the segments.



Chain Codes

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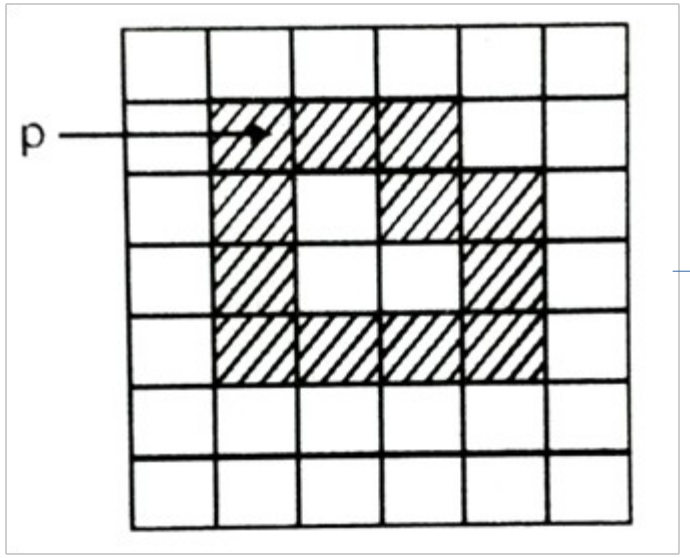

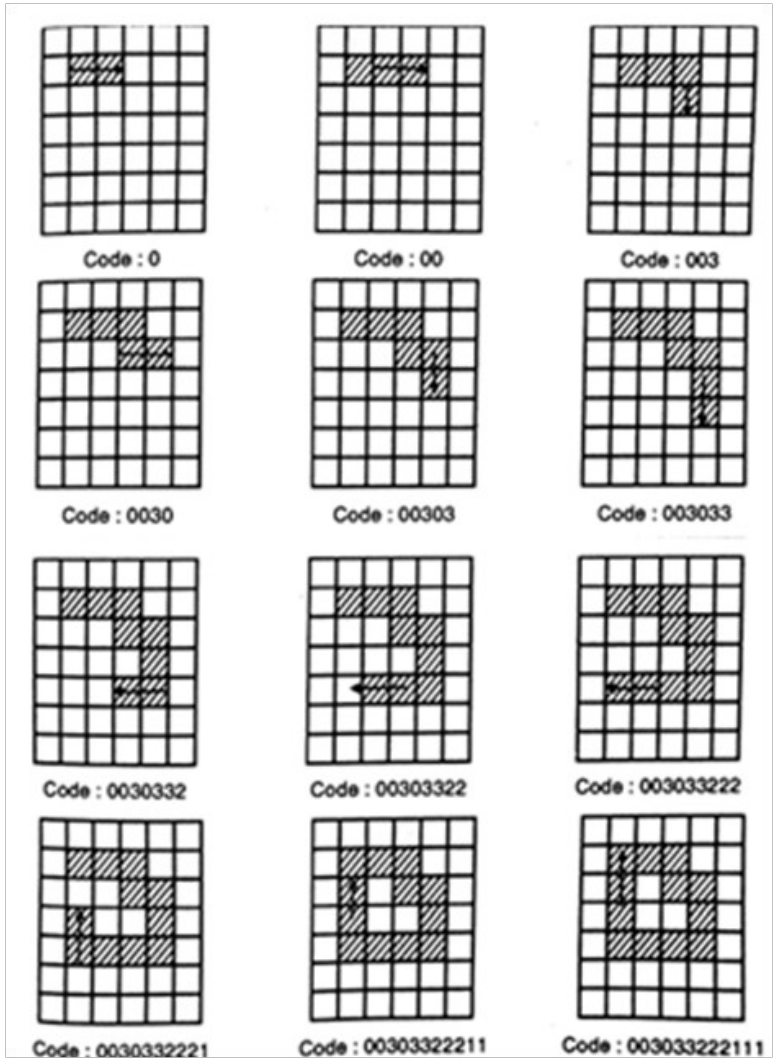

The 4-chain code is given edge is
0 0 3 0 3 3 2 2 2 1 1 1

Chain Codes

- Chain codes can be based on either 4-connectedness or 8-connectedness.
- The first difference of the chain code:
  - This difference is obtained by counting the number of direction changes (in a counterclockwise direction)
  - For example, the first difference of the 4-direction chain code 10103322 is 3133030.
- Assuming the first difference code represent a closed path, rotation normalization can be achieved by circularly shifting the number of the code so that the list of numbers forms the smallest possible integer.
- Size normalization can be achieved by adjusting the size of the re-sampling grid.

Chain Codes

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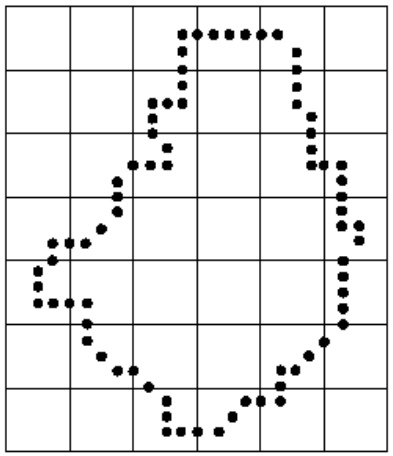
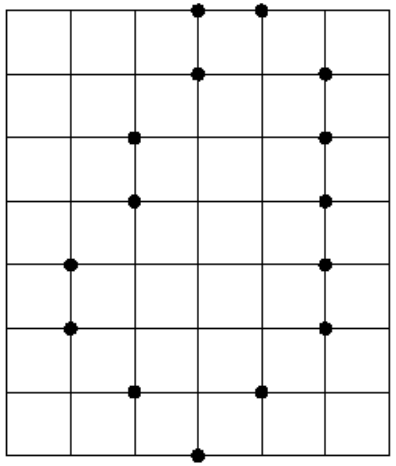
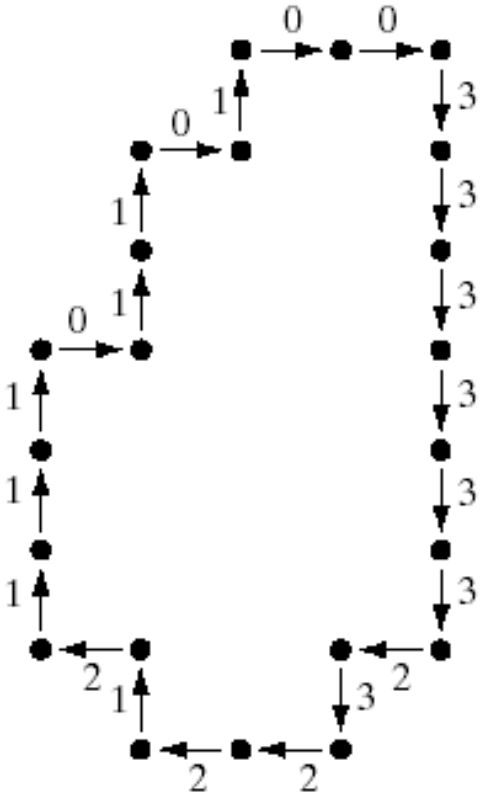
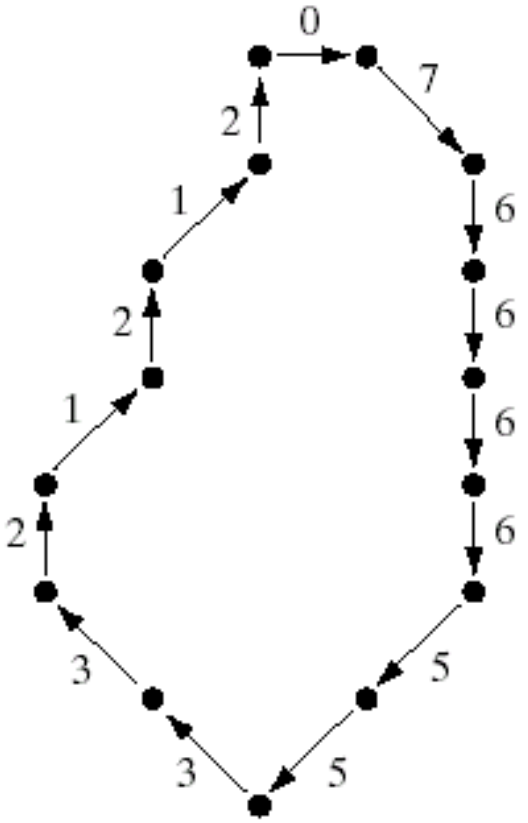






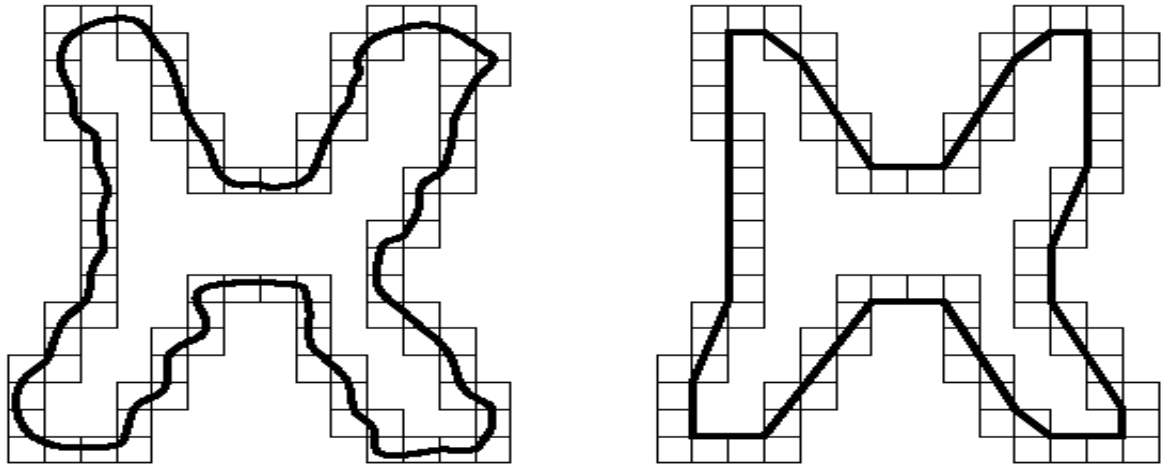


Polygonal Approximations

- Polygonal approximations: to represent a boundary by straight line segments, and a closed path becomes a polygon.
- The number of straight line segments used determines the accuracy of the approximation.
- Only the minimum required number of sides necessary to preserve the needed shape information should be used (Minimum perimeter polygons).
- A larger number of sides will only add noise to the model.

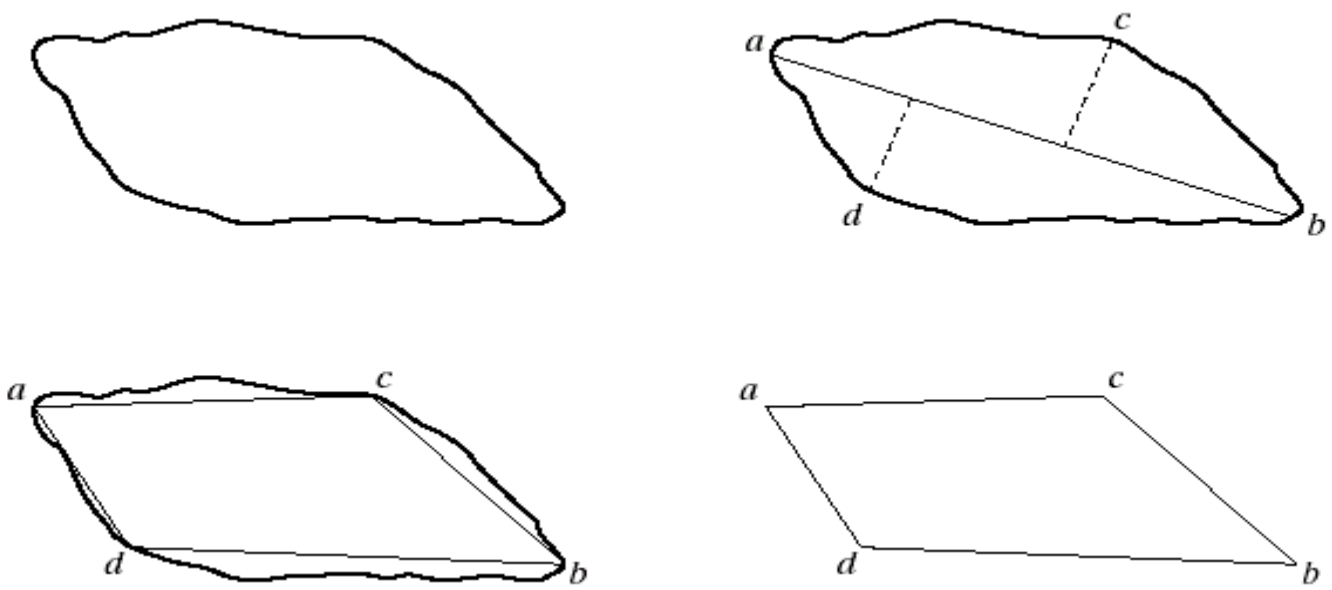
a b

FIGURE 11.3
(a) Object boundary enclosed by cells. (b) Minimum perimeter polygon.



Polygonal Approximations

- Minimum perimeter polygons: (Merging and splitting)
  - Merging and splitting are often used together to ensure that vertices appear where they would naturally in the boundary.
  - A least squares criterion to a straight line is used to stop the processing.



a b
c d

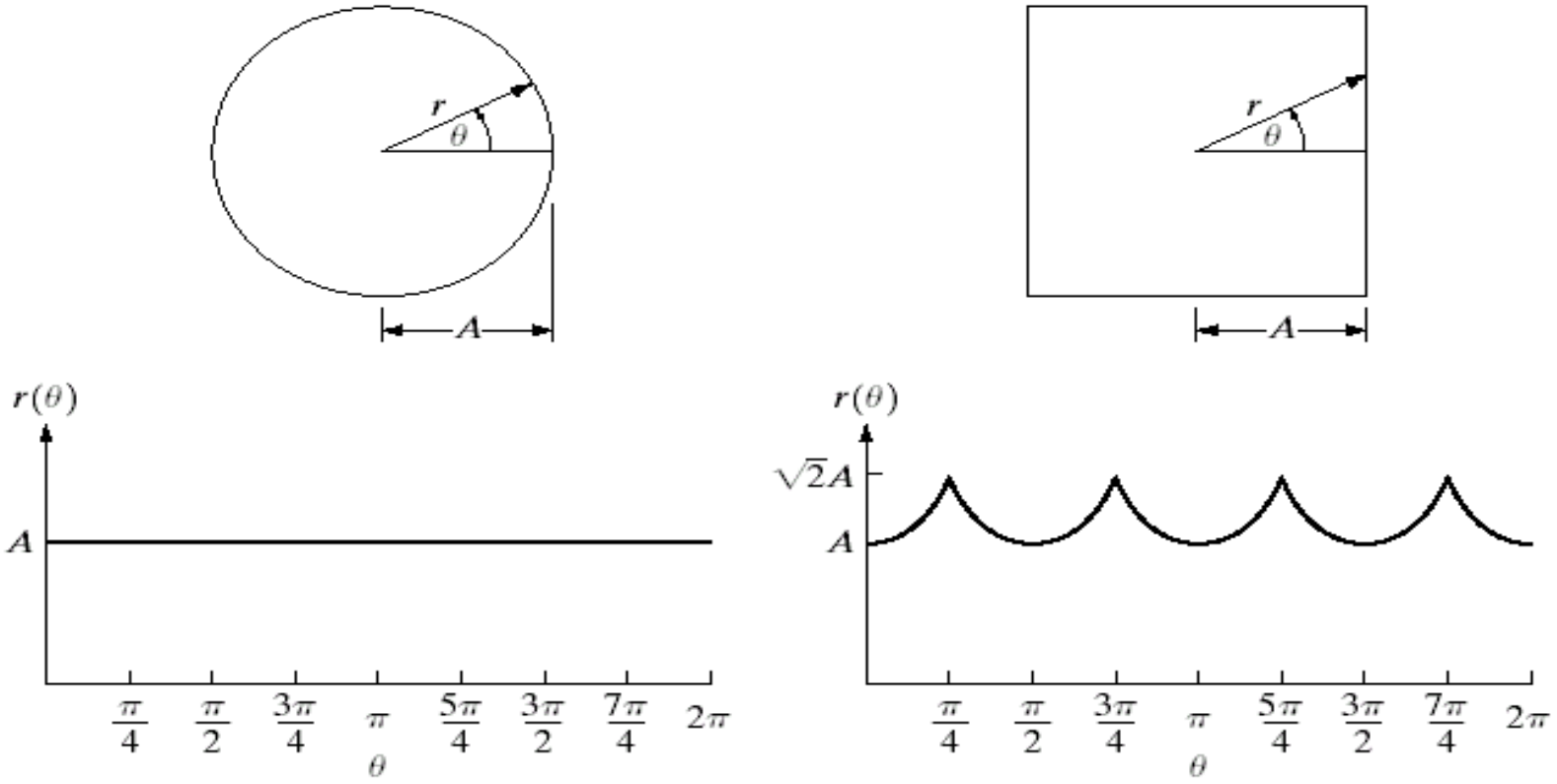
FIGURE 11.4
(a) Original boundary. (b) Boundary divided into segments based on extreme points. (c) Joining of vertices. (d) Resulting polygon.

Signature

- The idea behind a signature is to convert a two dimensional boundary into a representative one dimensional function.

a b

FIGURE 11.5 Distance-versus-angle signatures. In (a) $r(\theta)$ is constant. In (b), the signature consists of repetitions of the pattern $r(\theta) = A \sec\theta$ for $0 \leq \theta \leq \pi/4$ and $r(\theta) = A \csc\theta$ for $\pi/4 < \theta \leq \pi/2$.

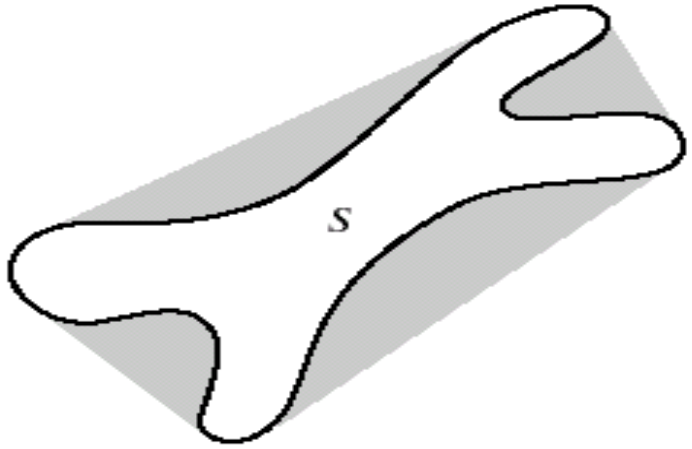


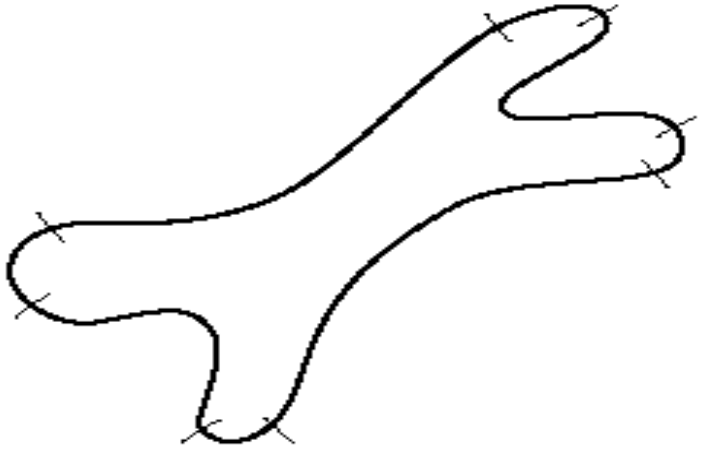
Signature

- 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.

Boundary Representation

- Boundary segments: decompose a boundary into segments.
- Use of the convex hull of the region enclosed by the boundary is a powerful tool for robust decomposition of the boundary.



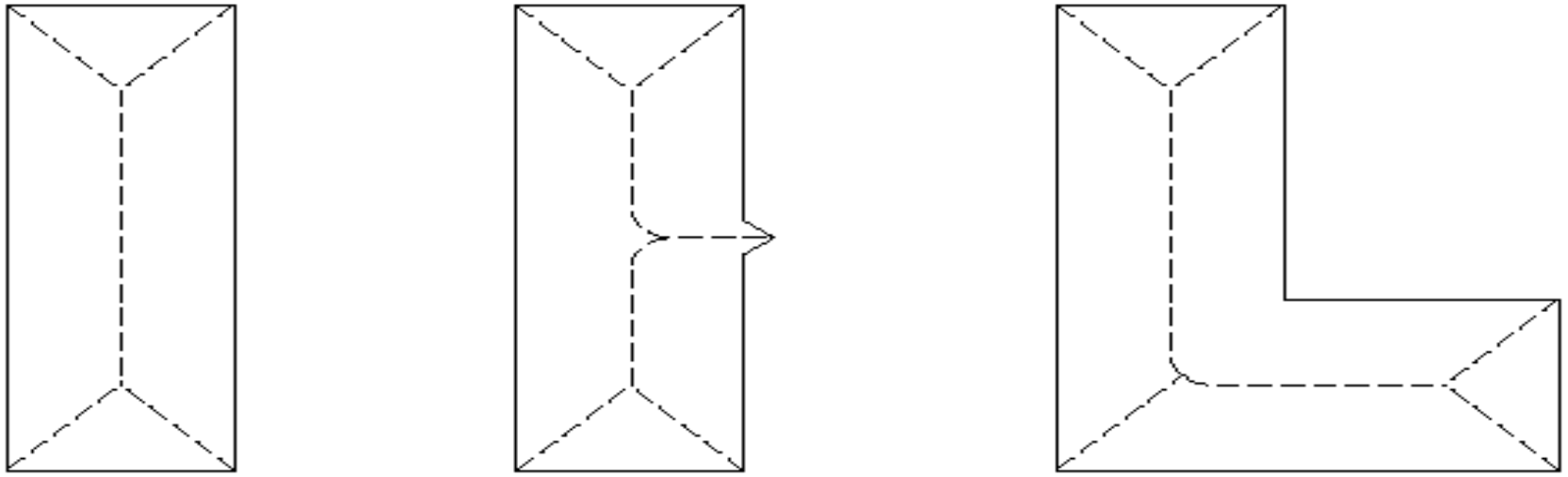


a b

FIGURE 11.6
(a) A region, S, and its convex deficiency (shaded). (b) Partitioned boundary.

Skeletons

- Skeletons: produce a one pixel wide graph that has the same basic shape of the region, like a stick figure of a human. It can be used to analyze the geometric structure of a region which has bumps and "arms".



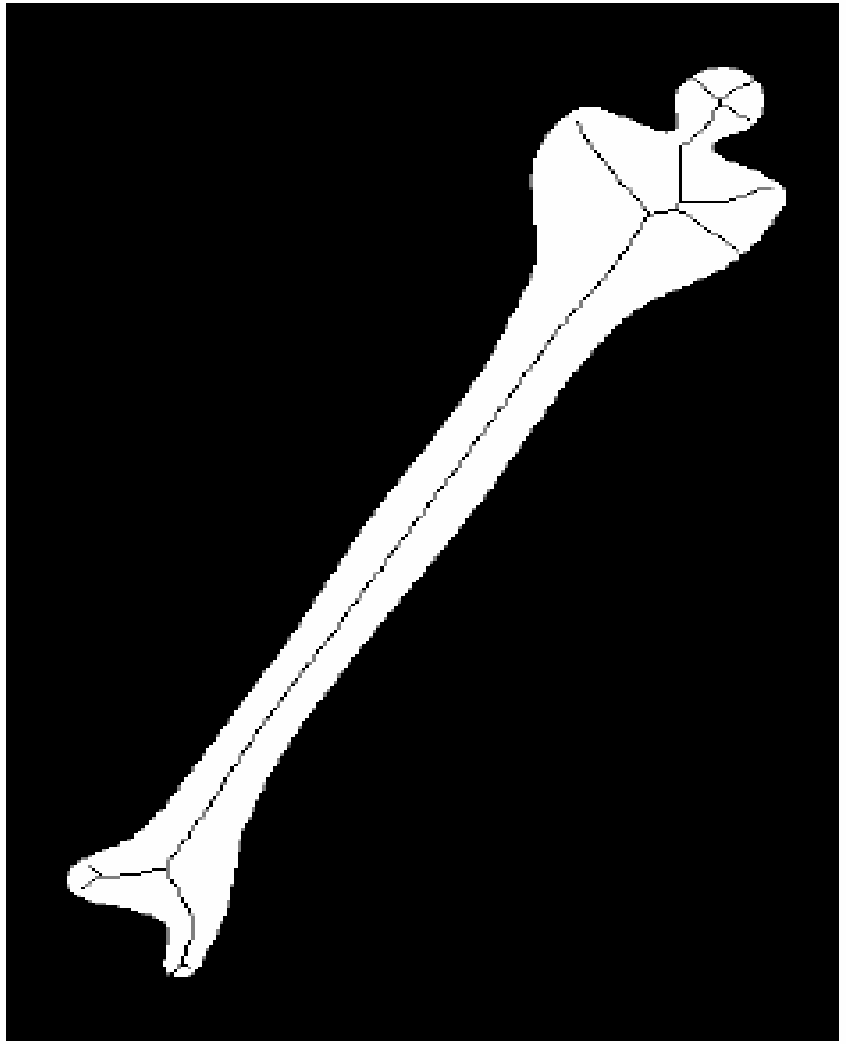
a b c

FIGURE 11.7 Medial axes (dashed) of three simple regions.

Skeletons

- One application of skeletonisation is for character recognition.
- A letter or character is determined by the center-line of its strokes, and is unrelated to the width of the stroke lines.

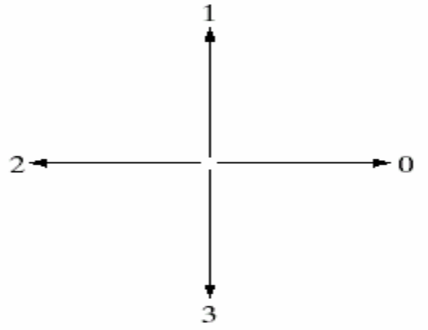
FIGURE 11.10
Human leg bone and skeleton of the region shown superimposed.



Boundary Descriptors

- There are several simple geometric measures that can be useful for describing a boundary.
  - The length of a boundary: the number of pixels along a boundary gives a rough approximation of its length.
  - Curvature: the rate of change of slope
    - To measure a curvature accurately at a point in a digital boundary is difficult
    - The difference between the slops of adjacent boundary segments is used as a descriptor of curvature at the point of intersection of segments

Shape Number



First difference

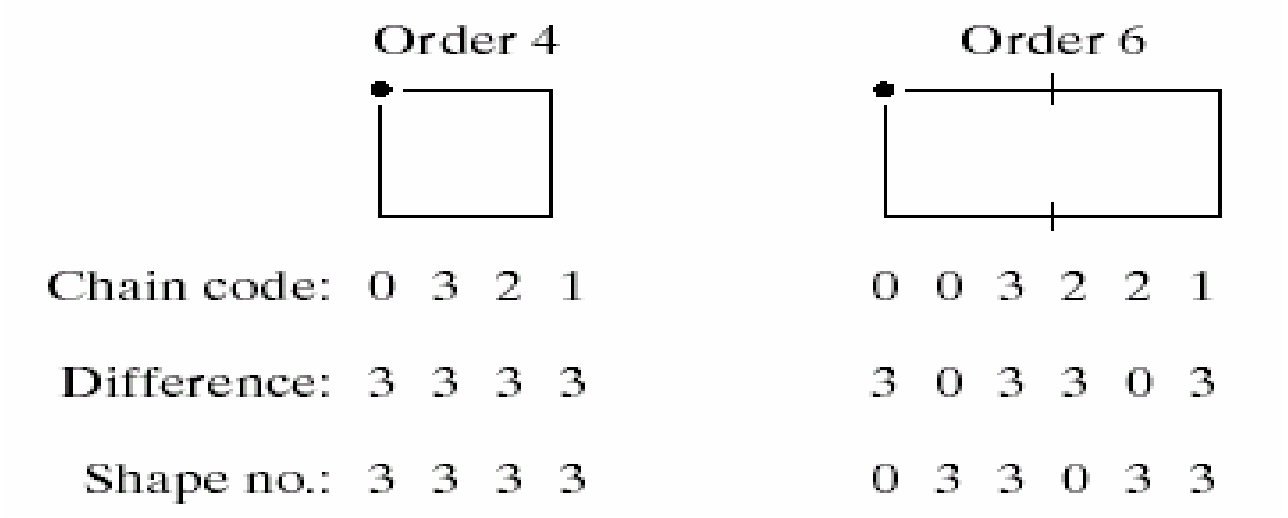


FIGURE 11.11 All shapes of order 4, 6, and 8. The directions are from Fig. 11.1(a), and the dot indicates the starting point.

- 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.

Shape Number

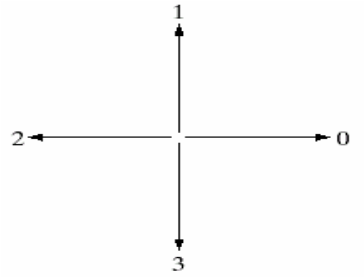
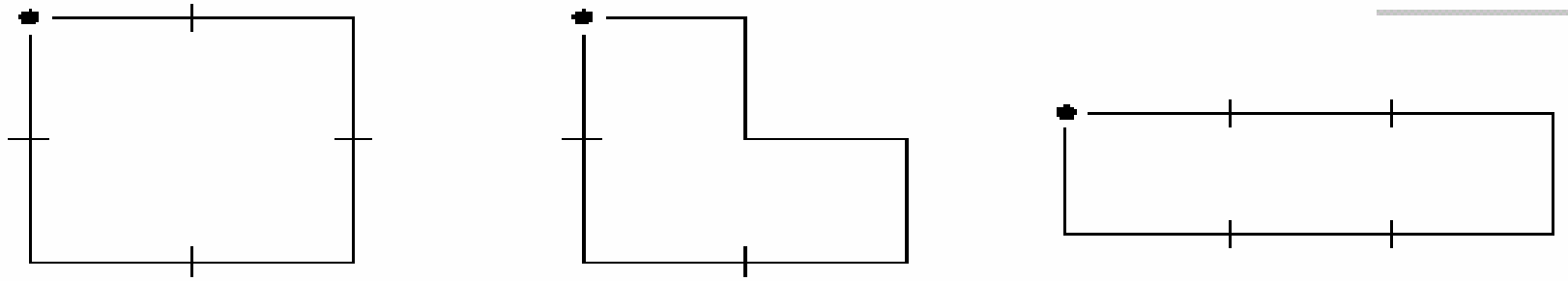


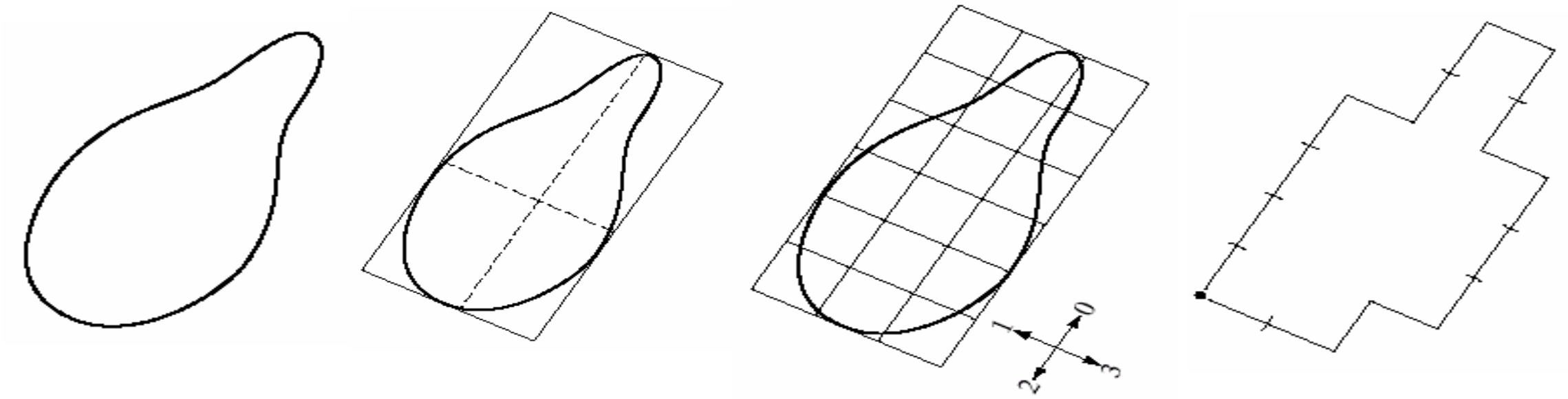
FIGURE 11.11 All shapes of order 4, 6, and 8. The directions are from Fig. 11.1(a), and the dot indicates the starting point.

Order 8



Chain code:	0	0	3	3	2	2	1	1	0	3	0	3	2	2	1	1	0	0	0	3	2	2	2	1
Difference:	3	0	3	0	3	0	3	0	3	3	1	3	3	0	3	0	3	0	0	3	3	0	0	3
Shape no.:	0	3	0	3	0	3	0	3	0	3	0	3	3	1	3	3	0	0	3	3	0	0	3	3

Shape Number



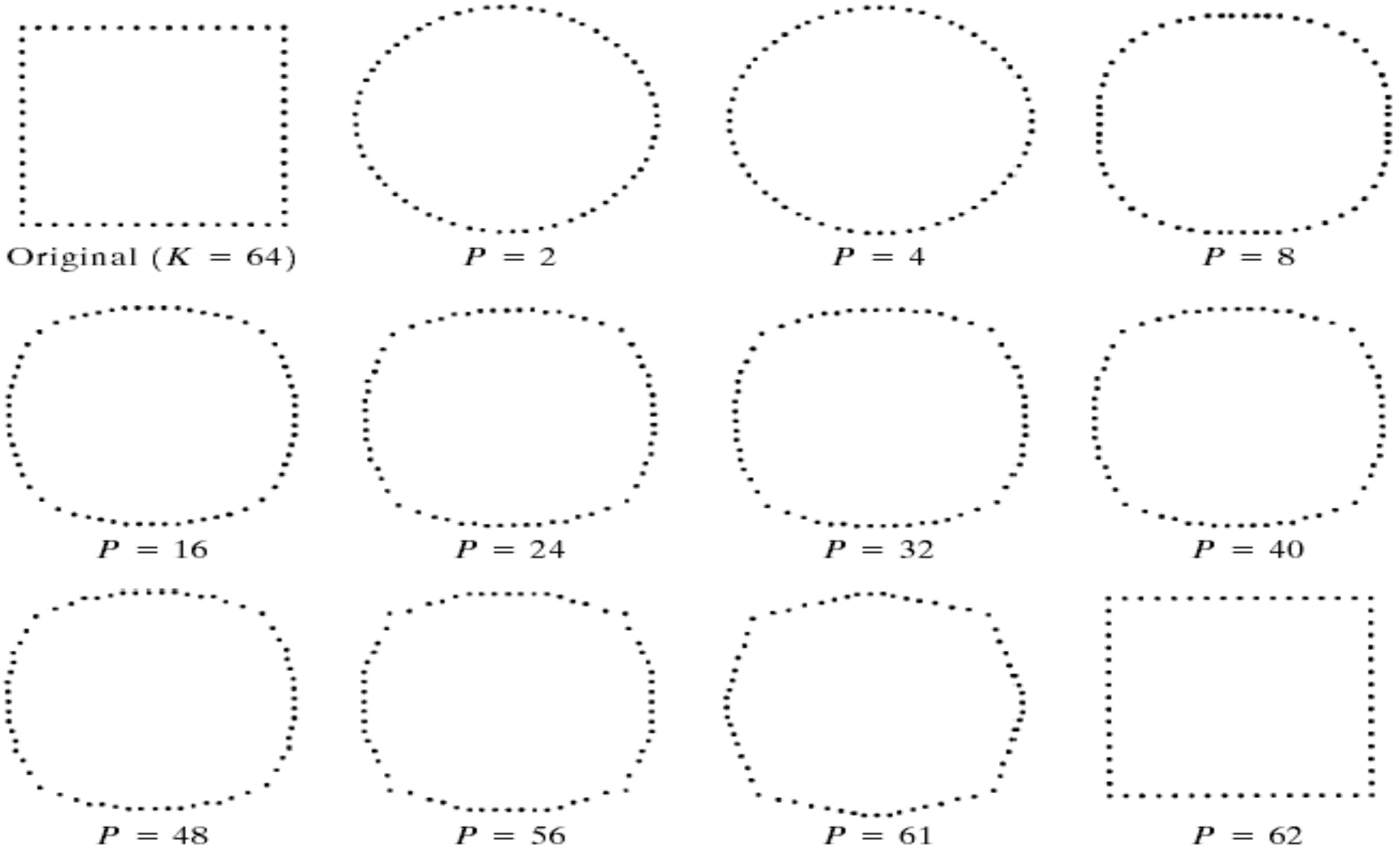
Chain code:	0	0	0	0	3	0	0	3	2	2	3	2	2	2	1	2	1	1
Difference:	3	0	0	0	3	1	0	3	3	0	1	3	0	0	3	1	3	0
Shape no.:	0	0	0	3	1	0	3	3	0	1	3	0	0	3	1	3	0	3

Fourier Descriptors

- This is a way of using the Fourier transform to analyze the shape of a boundary.
  - The *x*-*y* coordinates of the boundary are treated as the real and imaginary parts of a complex number.
  - Then the list of coordinates is Fourier transformed using the DFT.
  - The Fourier coefficients are called the Fourier descriptors.
  - The basic shape of the region is determined by the first several coefficients, which represent lower frequencies.
  - Higher frequency terms provide information on the fine detail of the boundary.

Fourier Descriptors

FIGURE 11.14 Examples of reconstruction from Fourier descriptors. P is the number of Fourier coefficients used in the reconstruction of the boundary.



Remaining AI part

Group Division for Presentation