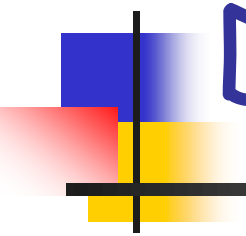
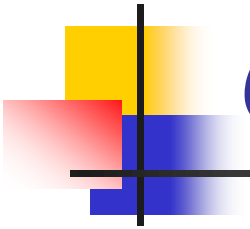


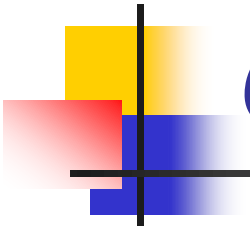
Digital Image Processing

Chapter 11: Representation & Description



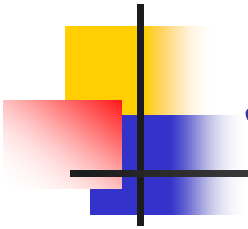
Overview

- 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, e.g., color, texture
- sometimes, we may need to use both ways



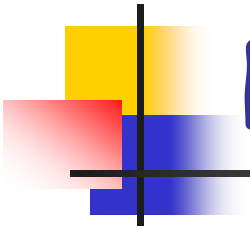
Overview

- 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

- feature selected as descriptors should be **as insensitive as** possible to variations in
  - size
  - translation
  - rotation
- following descriptors satisfy one or more of these properties.



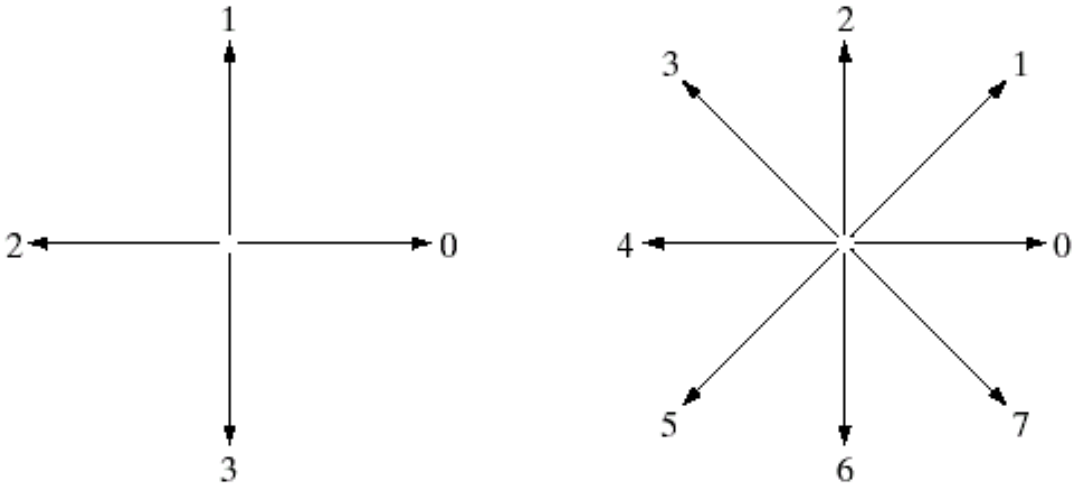
Representation

- 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.

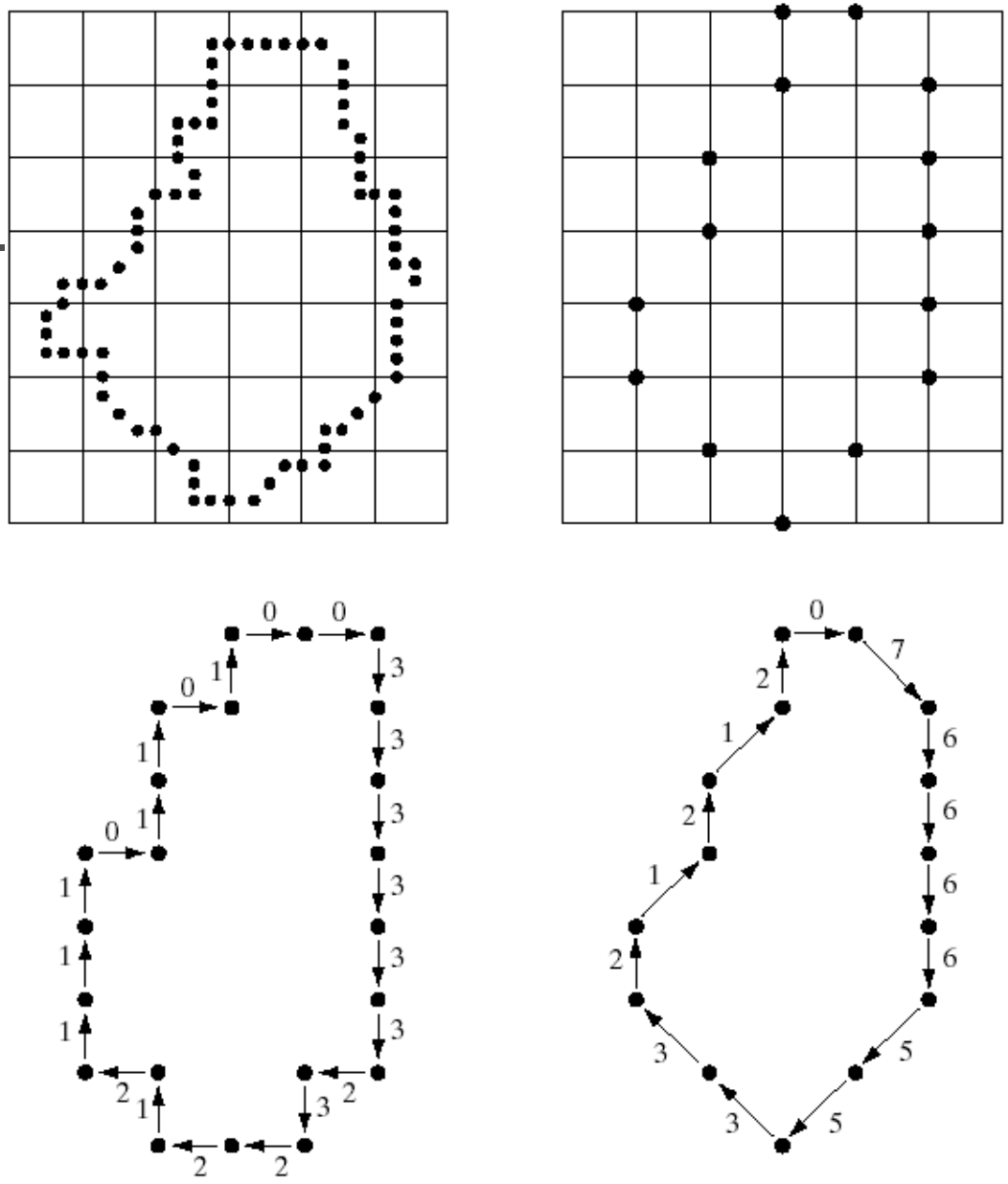
Chain codes

a b

FIGURE 11.1 Direction numbers for (a) 4-directional chain code, and (b) 8-directional chain code.

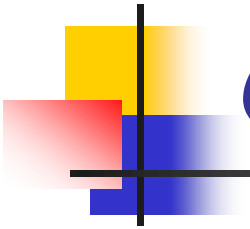


- based on 4 or 8 connectivity



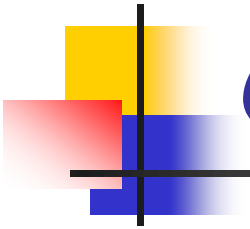
a b
c d

FIGURE 11.2
(a) Digital boundary with resampling grid superimposed. (b) Result of resampling. (c) 4-directional chain code. (d) 8-directional chain code.



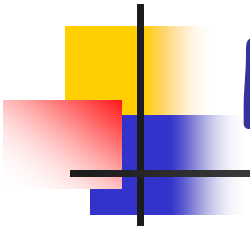
Chain codes

- unacceptable because
  - the resulting chain of codes 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 shape of the boundary



Chain codes

- Solve the problems by
  - resample the boundary by selecting a larger grid spacing
  - however, different grid can generate different chain codes
- starting point is arbitrary



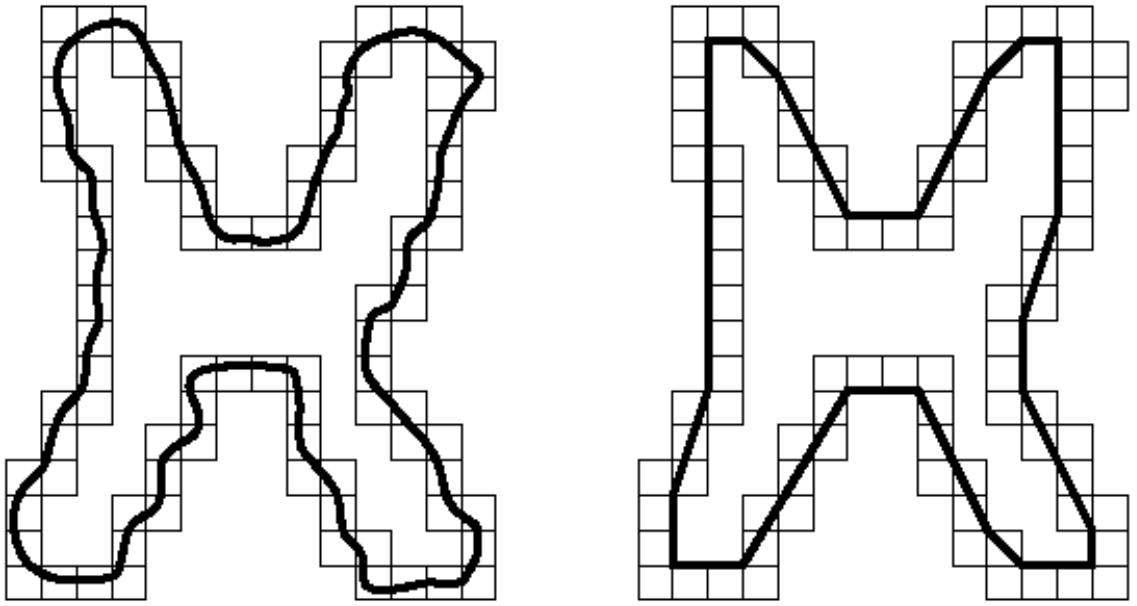
Polygonal Approximations

- boundary can be approximated with arbitrary accuracy by a polygon
- try to capture the "essence" of the boundary shape with the fewest possible polygonal segments.
- not trivial and time consuming

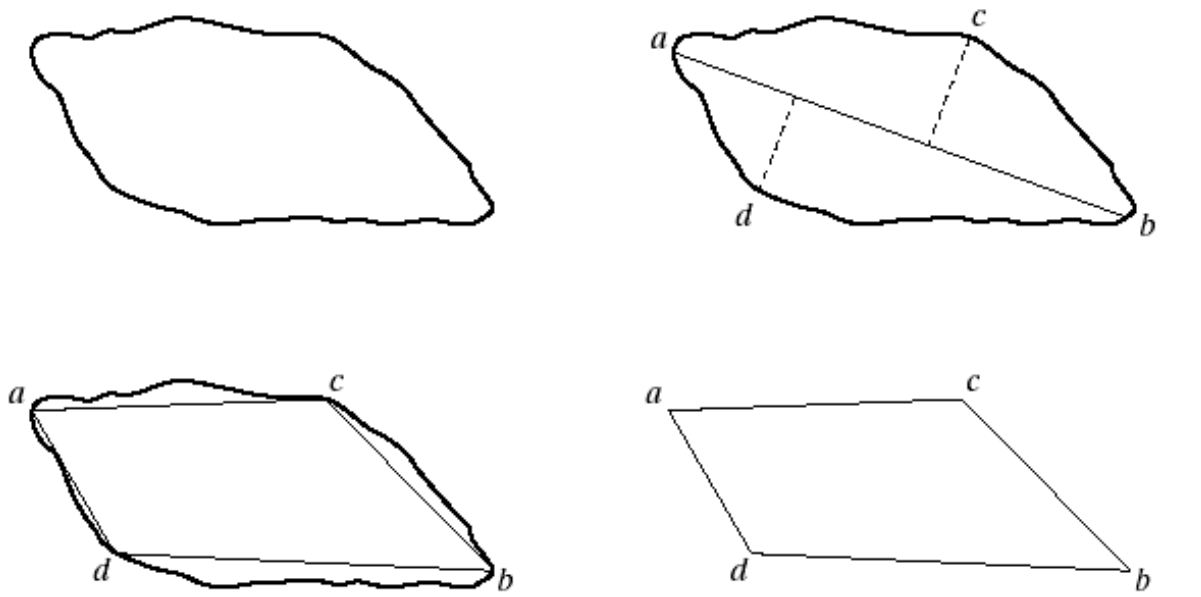
Minimum perimeter polygons

a b

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



Splitting techniques



a b
c d

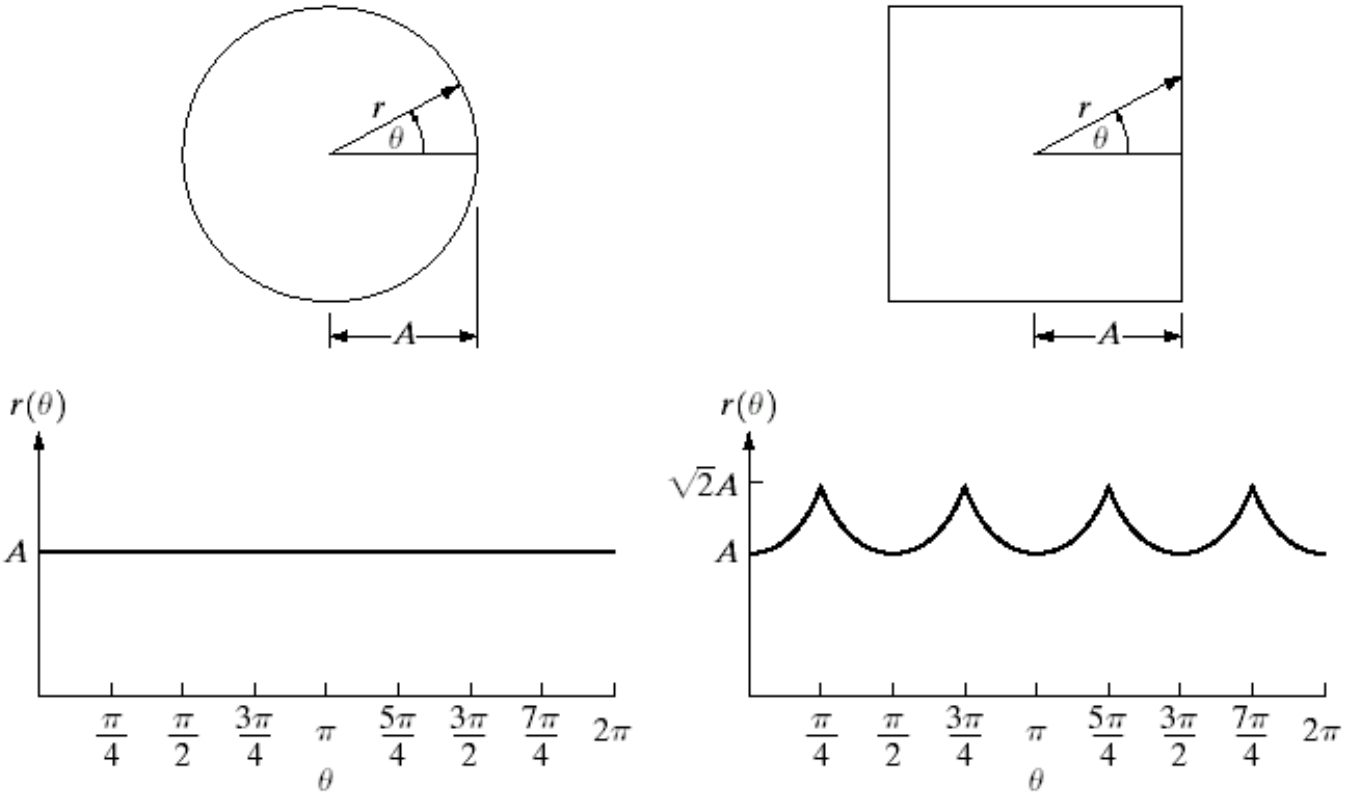
FIGURE 11.4
(a) Original boundary. (b) Boundary divided into segments based on extreme points. (c) Joining of vertices. (d) Resulting polygon.

1. find the major axis
2. find minor axes which perpendicular to major axis and has distance greater than a threshold
3. repeat until we can't split anymore

Signatures

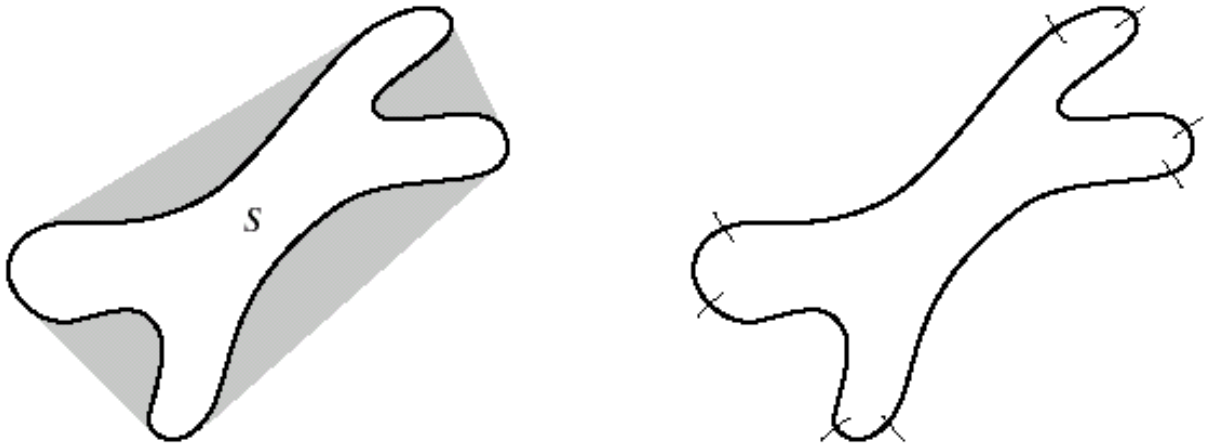
a b

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 $0 \le \theta \le \pi/4$ and $r(\theta) = A \csc\theta$ for $\pi/4 < \theta \le \pi/2$.



map 2D function to 1D function

Boundary Segments

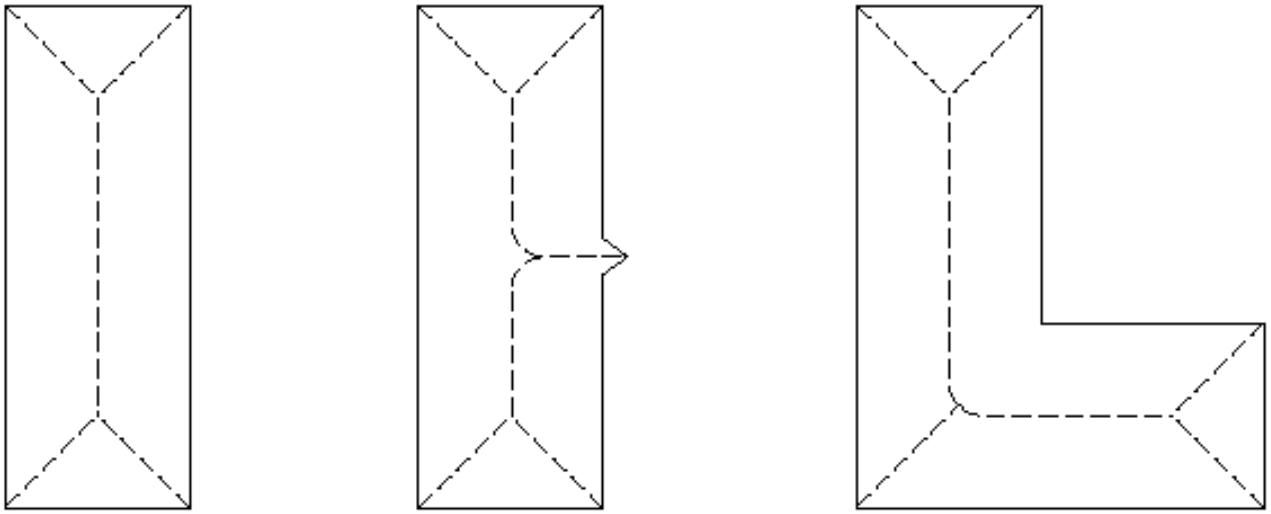


a b

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

- convex hull H of an arbitrary set S is the smallest convex set containing S
- the set different H-S is called convex deficiency D of the set S

Skeletons



a b c

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

medial axis (skeleton)

Example

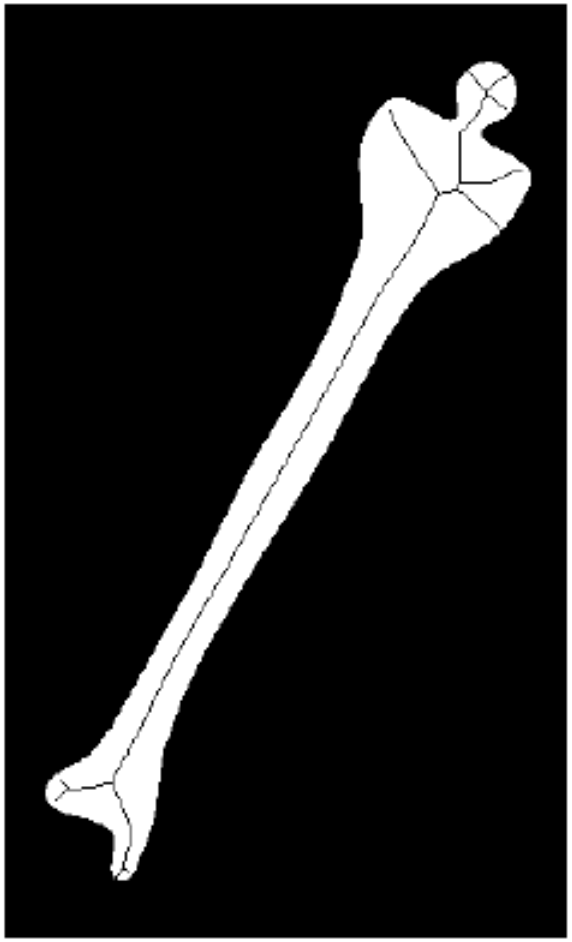
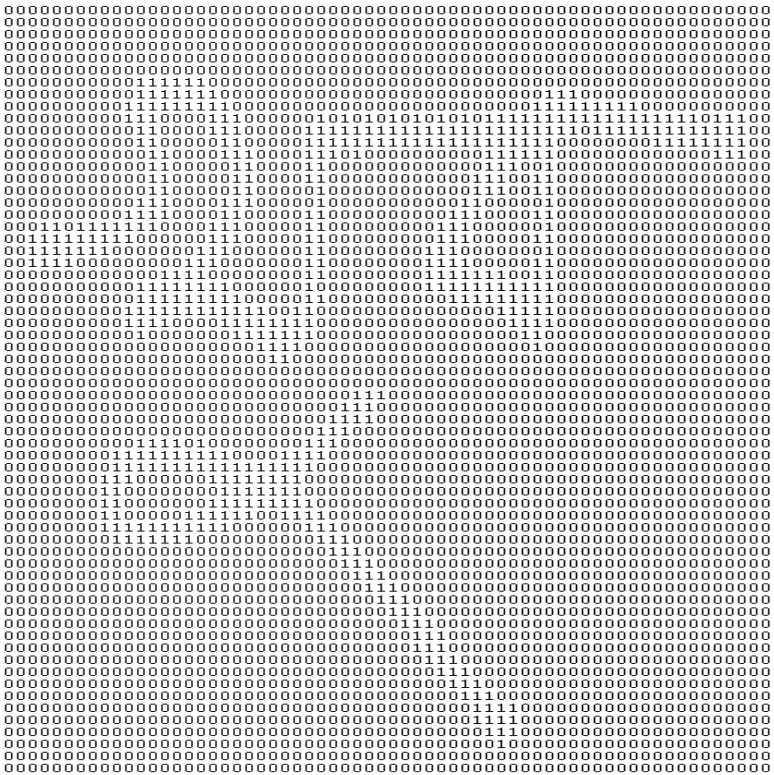
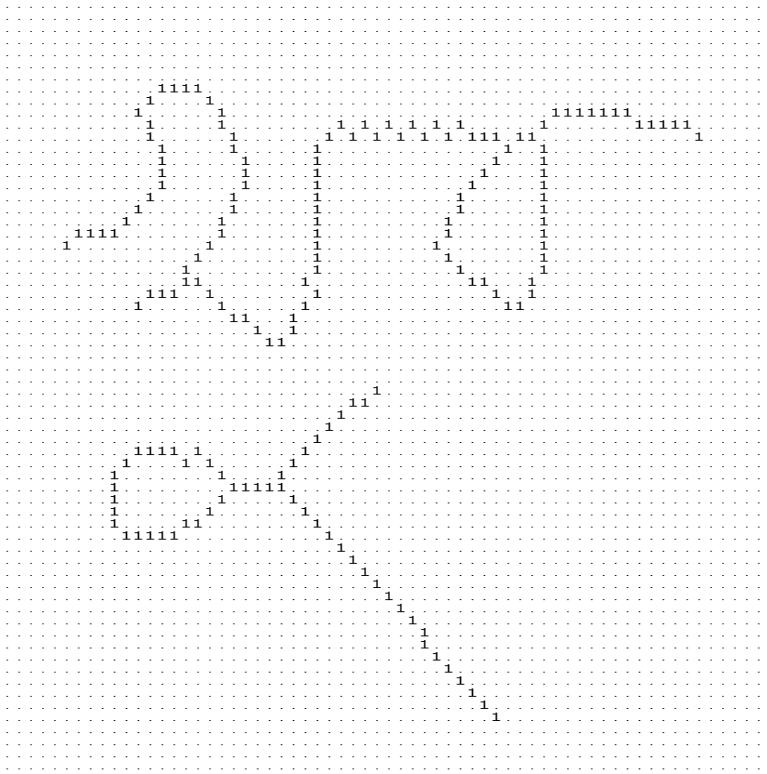
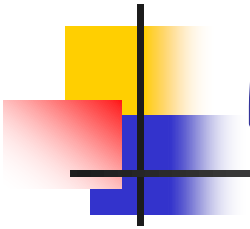


FIGURE 11.10
Human leg bone and skeleton of the region shown superimposed.

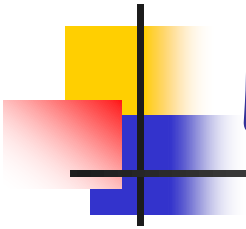






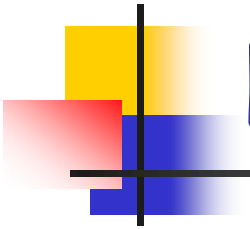
Boundary Descriptors

- length of a boundary
- diameters
- eccentricity
- shape numbers



Length of a boundary

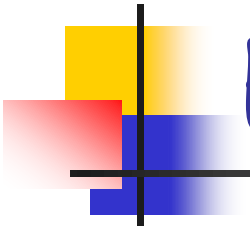
- the number of pixels along a boundary
- give a rough approximation of its length



Diameters

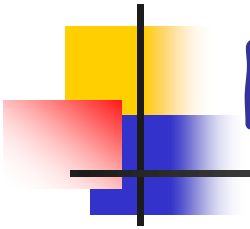
$$Diam(B) = \max_{i,j}[D(p_i, p_j)]$$

- D is a distance measure
- p_i and p_j are points on the boundary B



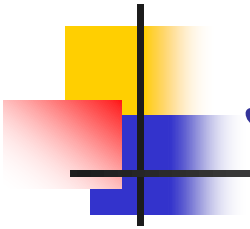
Eccentricity

- ratio of the major to the minor axis
- major axis = the line connecting the two extreme points that comprise the diameter
- minor axis = the line perpendicular to the major axis



Regional Descriptors

- area
- perimeter
- compactness
- topological descriptors
- texture



Simple descriptors

- area = the number of pixels in the region
- perimeter = length of its boundary
- Compactness = $(\text{perimeter})^2/\text{area}$

Topological descriptors

$$E = C - H$$

E = Euler number
C = number of connected region
H = number of holes

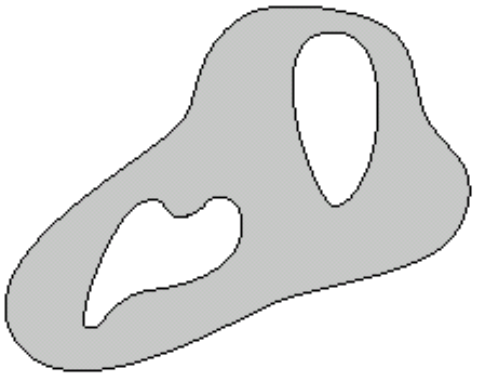


FIGURE 11.17 A region with two holes.

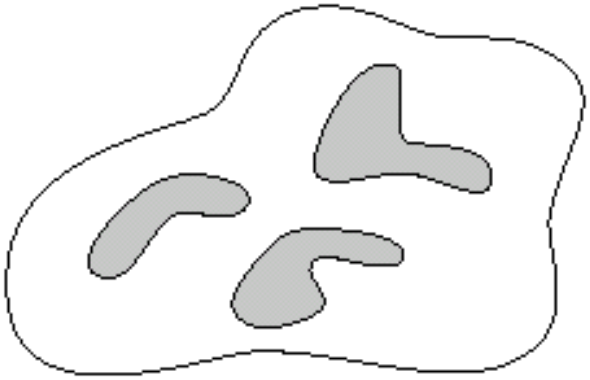
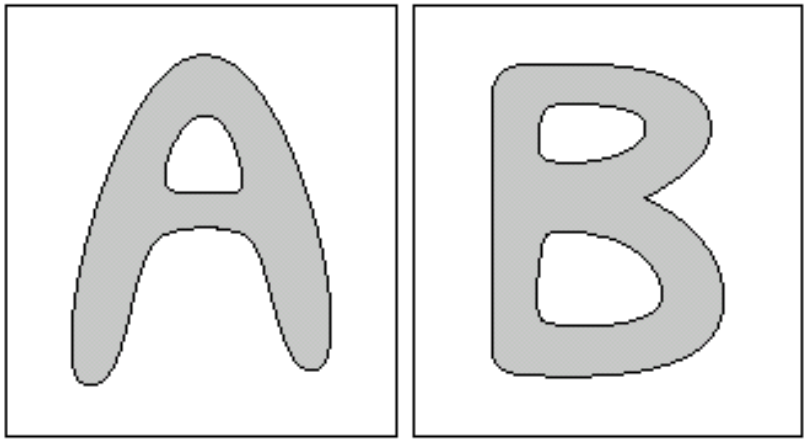


FIGURE 11.18 A region with three connected components.

Euler number



a b

FIGURE 11.19 Regions with Euler number equal to 0 and −1, respectively.