Digital Image Processing

Representation

Topics

- Representation
  - Introduction
  - Chain Codes
  - Polygonal Approximations
  - Signatures
  - Boundary Segments
  - Skeletons
  - Convex Hull
  - Shape Number
  - Fourier Descriptors

Representation

- The result of segmentation should be represented and described in a form suitable for further computer processing.
  - A region can be represented in terms of its external characteristics (boundary).
  - A region can be represented in terms of its internal characteristics.

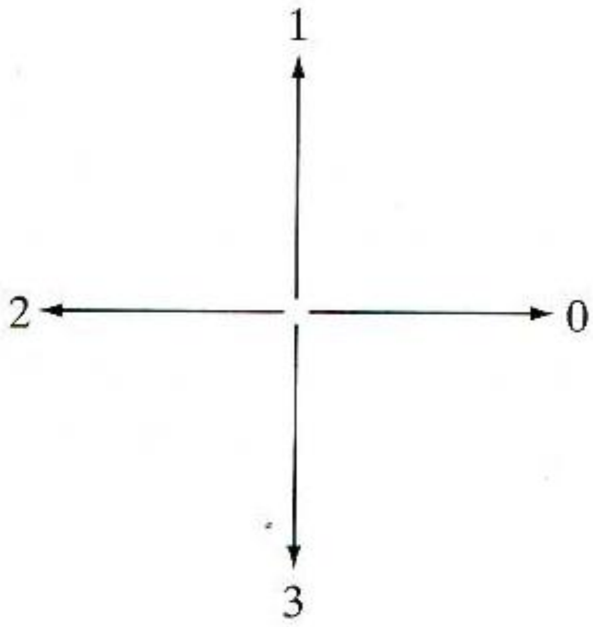
Chain Codes

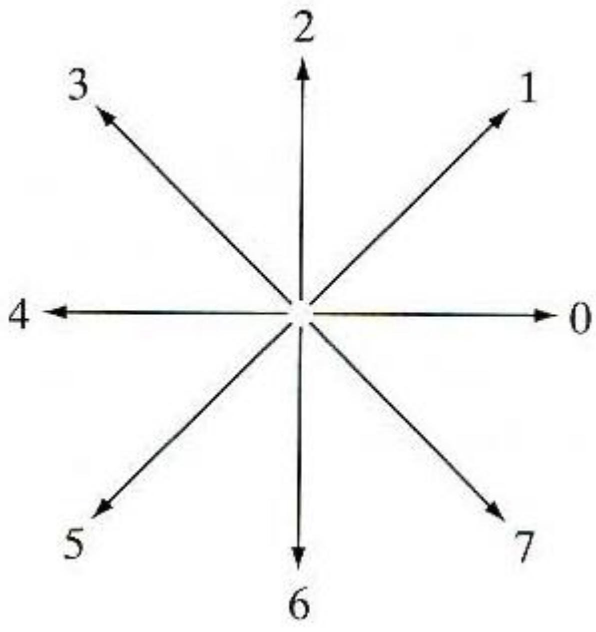
- Chain codes are generated by following a boundary in a clockwise or counter-clockwise direction and assigning a direction to the segments connecting every pair of pixels.

- Disadvantage: Can be unacceptably long.
- Solution: Re-sampling (down sample) the boundary

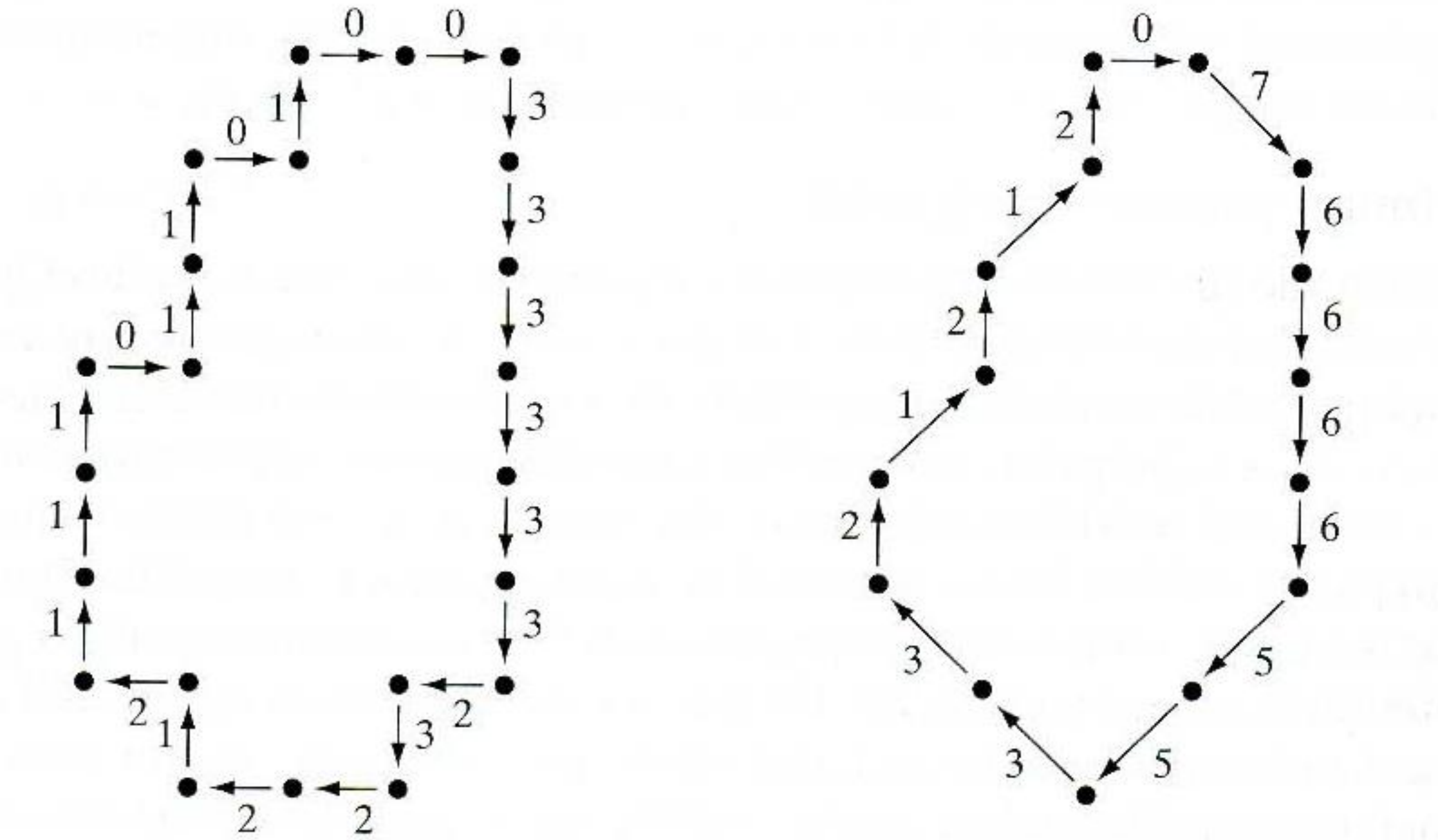
- Disadvantage: Is starting point dependent
- Solution: Normalize the representation string to the smallest integer.

Chain Code Directions

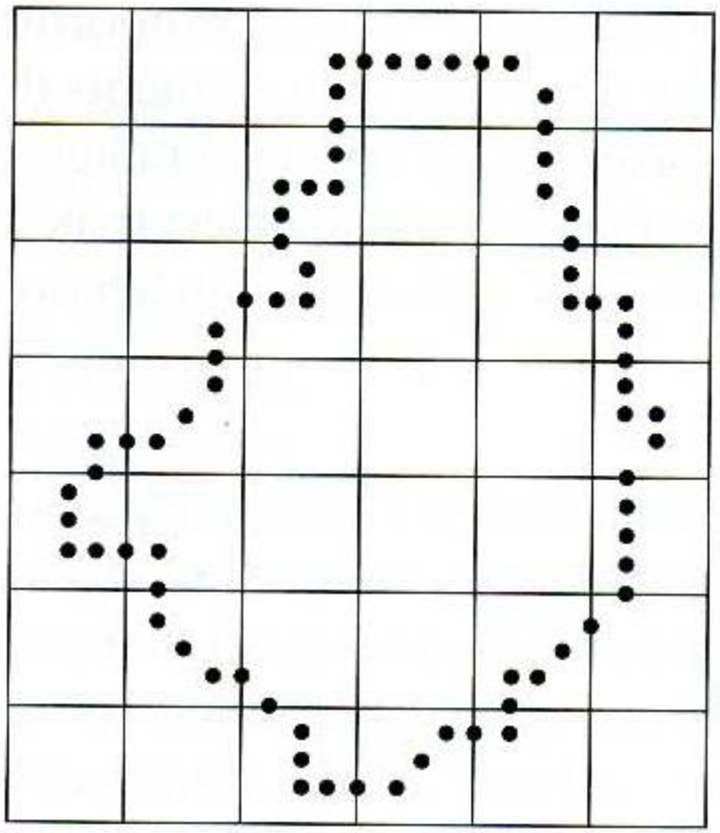


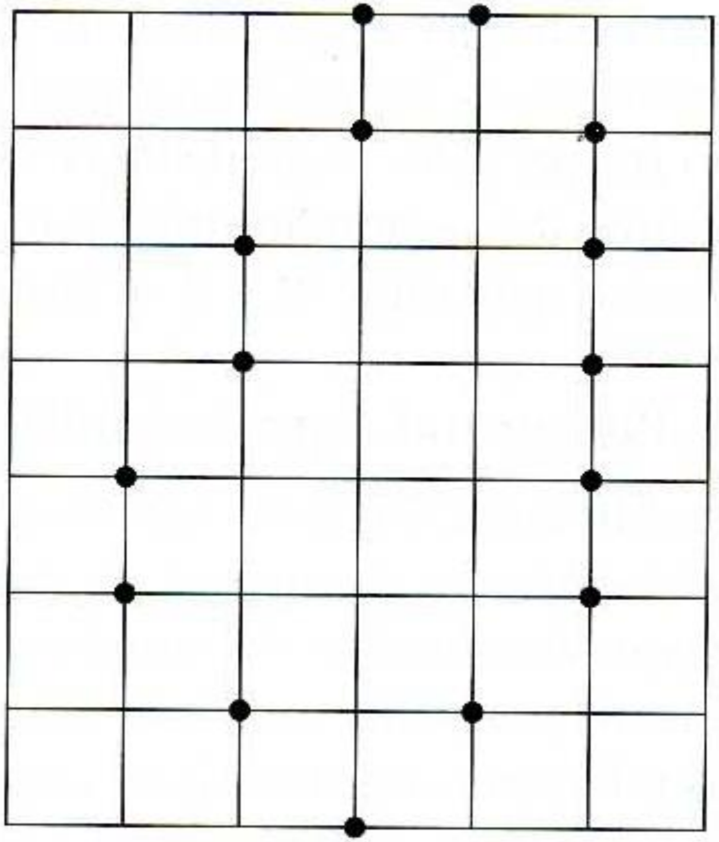


Sample Chain Code



Down Sampling

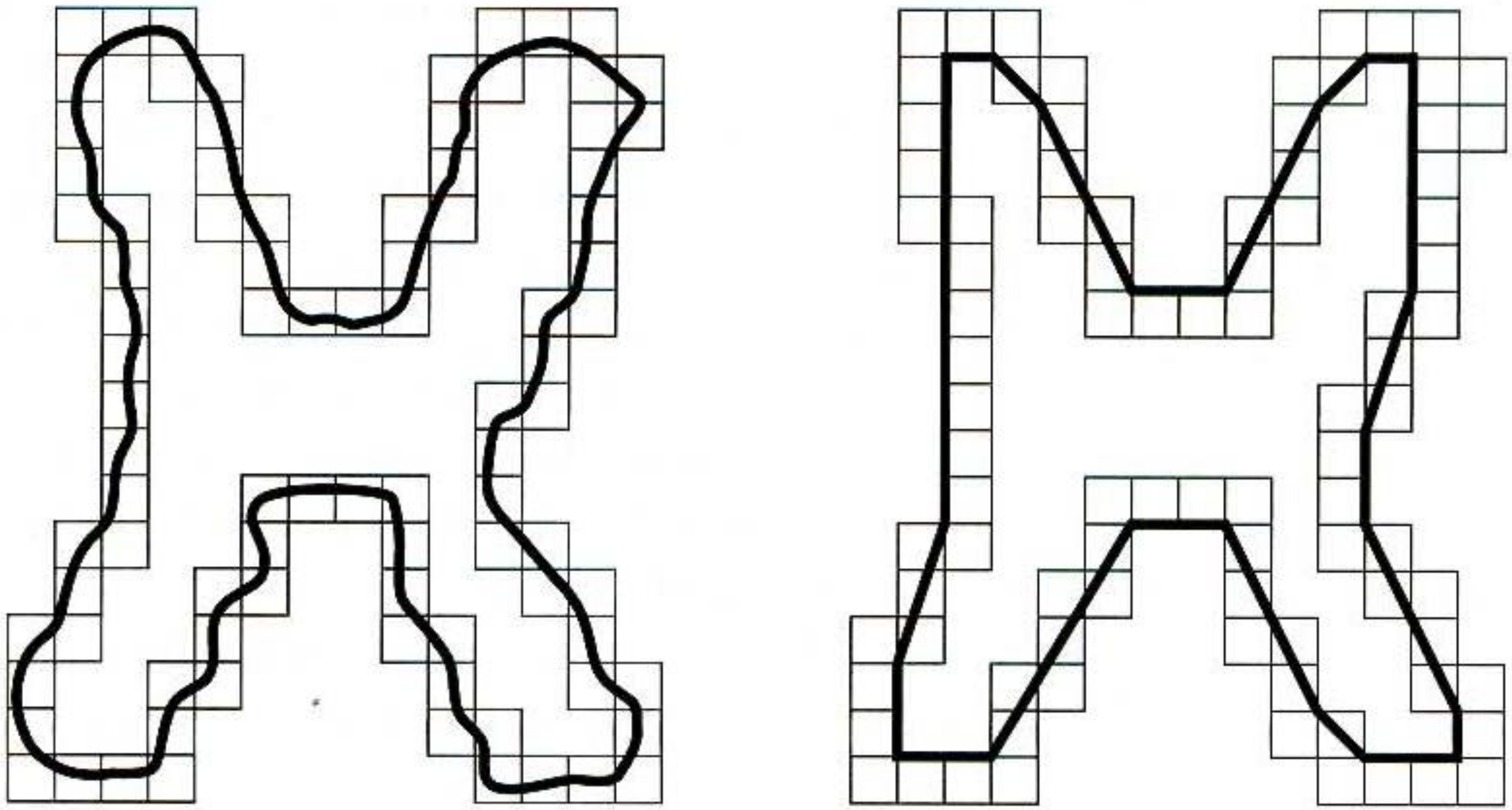




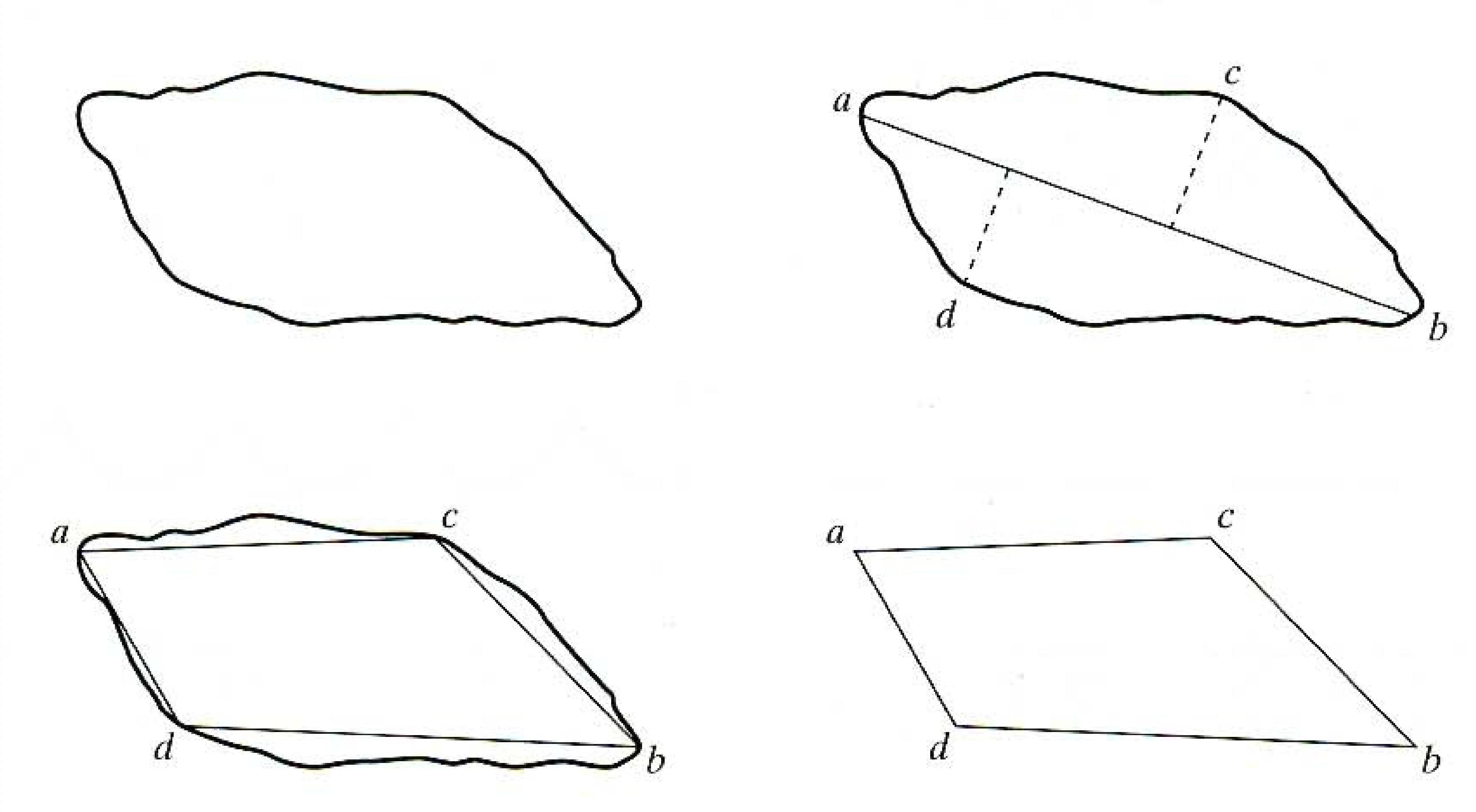
Polygonal Approximation

- A boundary can be represented with arbitrary accuracy by a polygon.
- The approximation is exact when the number of sides is equal to the number of points in the boundary.
- Finding a polygonal representation can be very time-consuming.

Minimum Perimeter Polygons



Splitting Techniques

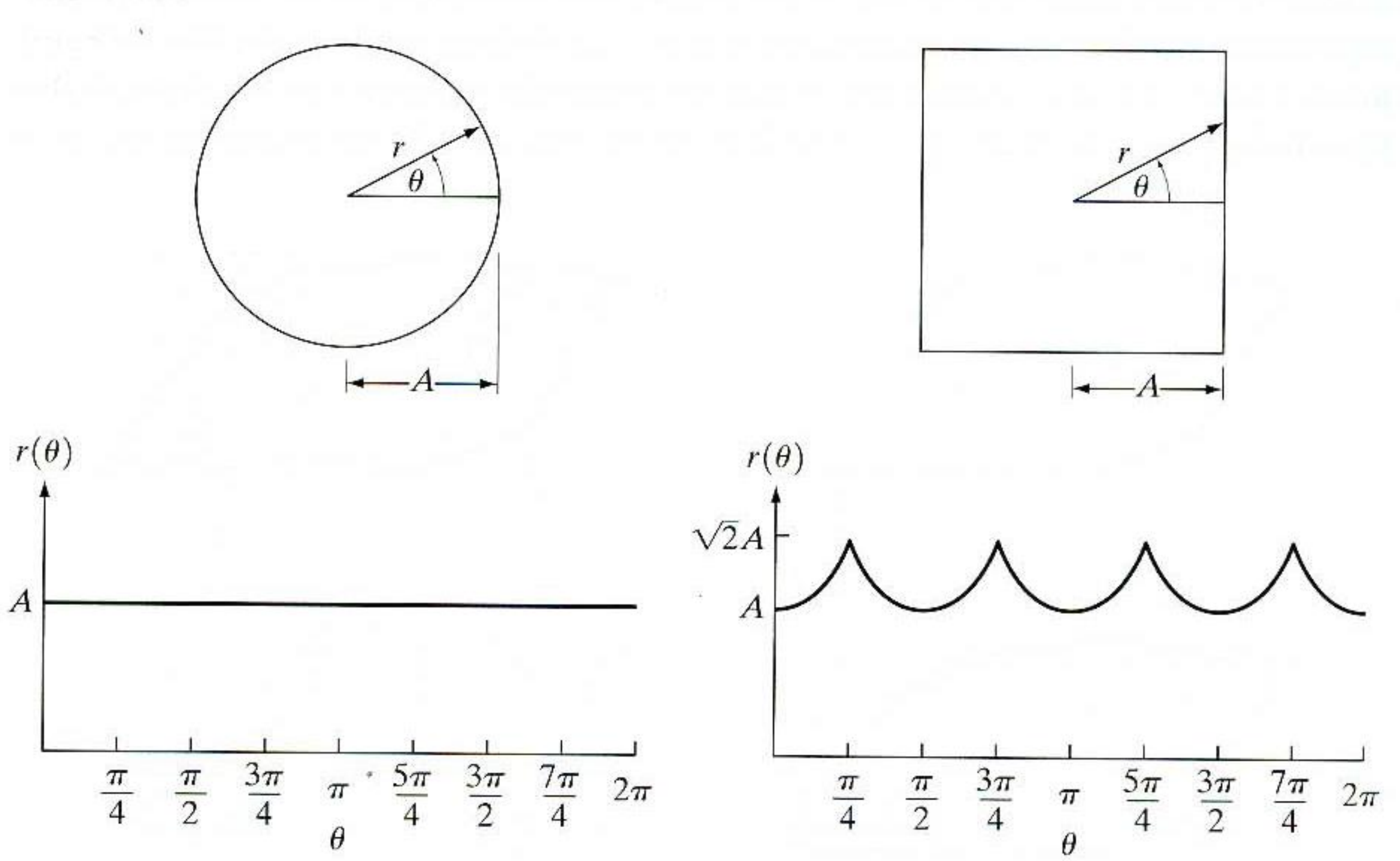


Signature

- A signature is a 1D representation of a boundary.
- e.g. Plotting distance to centroid as a function of angle
  - Invariant to translation

- Disadvantages:
  - Rotation and scaling dependant
  - Defined only for convex regions

Signature Example

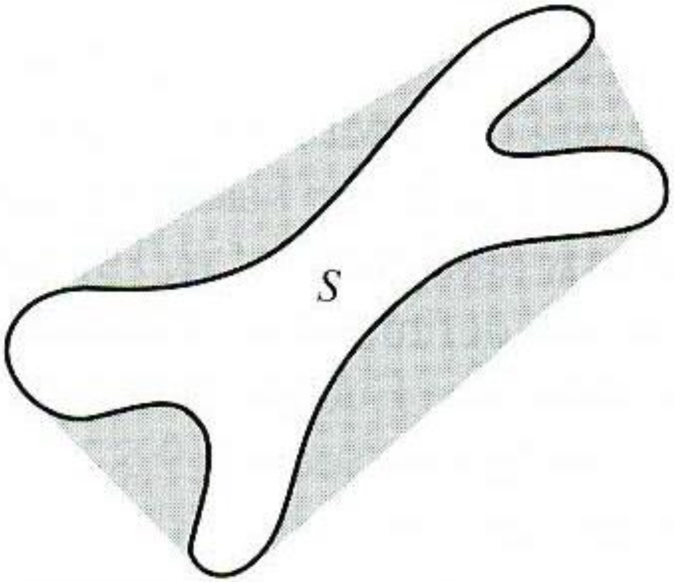


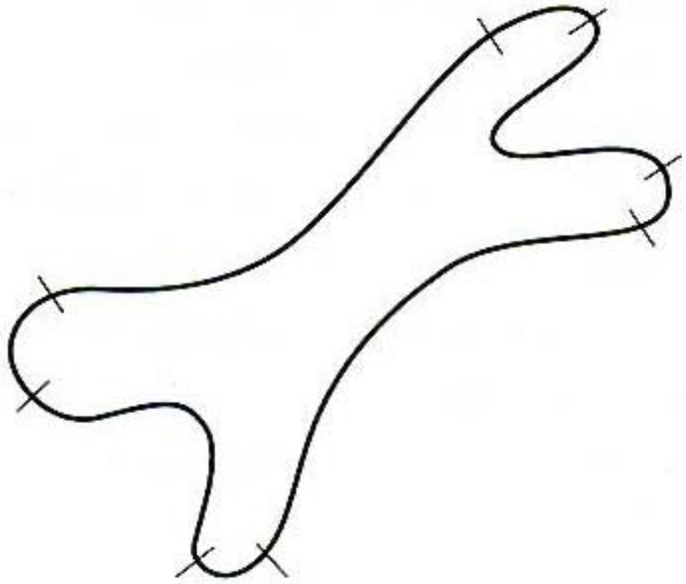
Boundary Segments

- Decomposing a boundary into segments simplifies representation.
- Convex Hull can be used for decomposition.

- A new segment can be started whenever a Convex Hull deficiency is entered or exited.

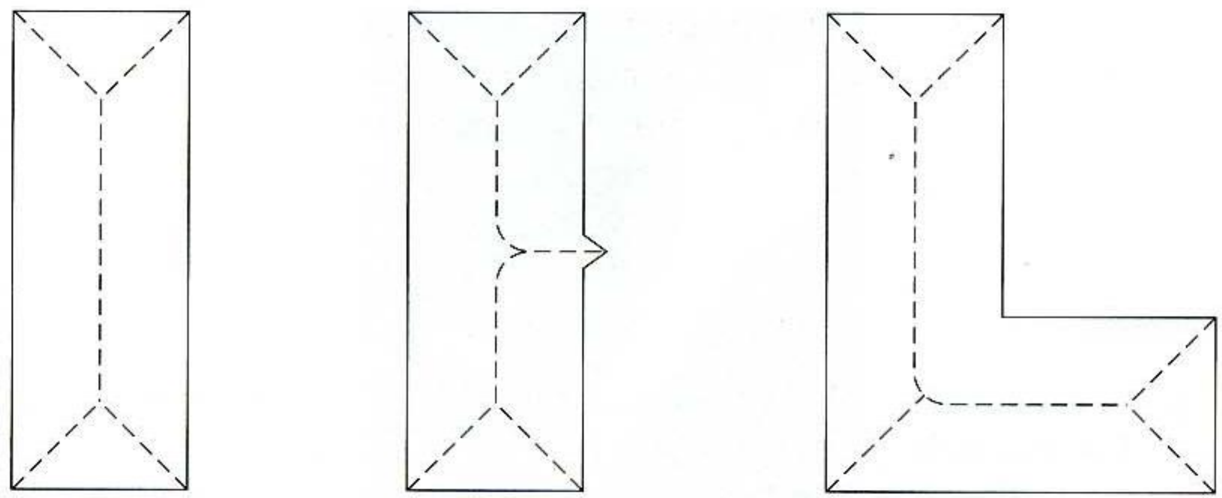
Boundary Segments Example





Skeleton

- The structural shape of a region can be represented by a graph.
- The structural graph is obtained by thinning the region and finding the skeleton.



The Convex Hull

- If S is the figure surface and H is the convex hull surface, H-S is called the convex deficiency. The boundary is partitioned at the points of deviation between the boundaries of S and H.

- This concept is useful to describe both an entire region and its boundary.

Boundary Descriptors

- Some Simple Descriptors:
  - The *length* of the boundary
  - The *curvature*: the rate of change of the slope.

Shape Number

- Based on 4-directional-chain code, the shape number is the difference with the smallest magnitude. The number of digits in the shape number is the called *the order.*
- The shape number can also be defined using 8-directional-chain code

Fourier Descriptors

The N Cartesian coordinates (x_i, y_i) of a digital boundary can be represented as:

$s(k) = x(k) + j.y(k)$ for k=0 to N-1.

The DFT of s(k):

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

for u=0 to N-1.

The complex coefficients a(u) are called the *Fourier Descriptors* of the boundary.

Then s(k) can be written as:

$$s(k) = \sum_{u=0}^{N-1} a(u)e^{j2\pi uk/N}$$ for k=0 to N-1.

Fourier Descriptors

- Since the high frequency DFT components of s(k) only account for details, the Fourier series representation of s(k) can be truncated to $M < N$ elements, resulting in the approximation S'
- Note that it still represents all N points of the boundary, however, with less Fourier components.

Regional Descriptors

- Some Simple Descriptors
  - *The Area*
  - *The Perimeter*
  - *The Compactness = perimeter2/Area^2*

Topological Descriptors

- *The Number of Holes: H*
  - *The number of Connected Elements: C*
  - *Euler's Number = C – H*

Questions?