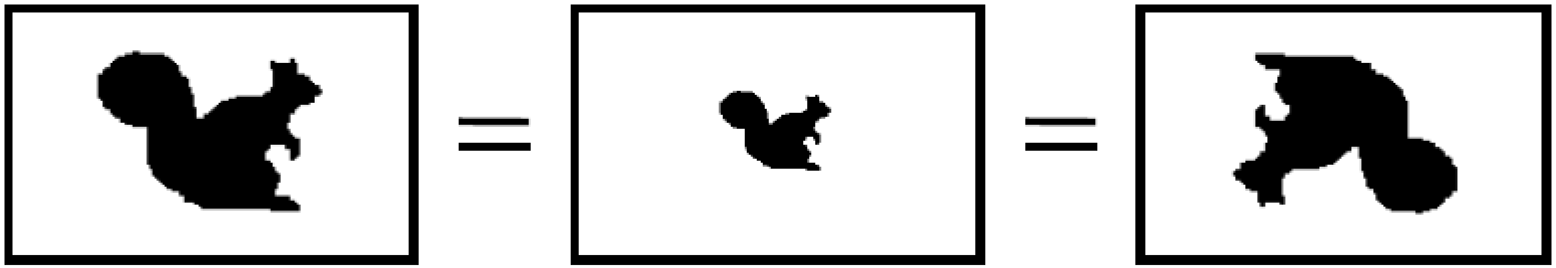
Object Descriptors

Object 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.
  - External characteristics – boundary
  - Internal characteristics-pixels comprising the region
  - Descriptors should be insensitive to changes in size, translation, rotation.

Object Descriptors

Most of the time we are interested to choose descriptors that are invariant of variations of scale, rotation and translation whenever possible



Simple boundary descriptors

- Length of the boundary:
  - No of pixels along a boundary gives rough approximation of its length.
  - For a chain coded cure with unit spacing the no of vertical components and horizontal components + $\sqrt{2}$ times the no of diagonal components

Simple boundary descriptors

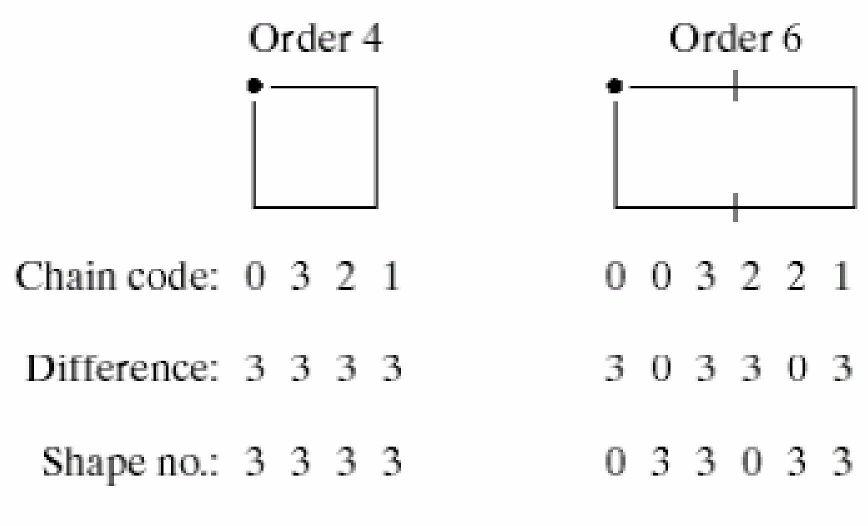
- Diameter of the boundary is defined as
  - $Diam(B) = \max_{(I,j)}[D(pi,pj)]$
  - D is the distance measure points (pi,pj) are points on the boundary
- Major Axis: Two extreme points that comprise the diameter
- Minor Axis: Line perpendicular to the major axis
- Basic rectangle: Box passing the outer four points of intersection of the boundary with two axes completely encloses the boundary

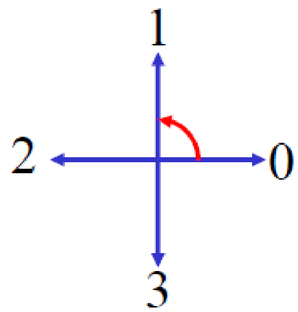
Simple boundary descriptors

- Eccentricity: The ratio of major to the minor axis
- Curvature: Rate of change of slope
  - Vertex point p is said to be part of convex segment if the change in slope is nonnegative
  - Else it is said to be concave segment
  - P is a part of straight segment if the change is less than 10°
  - If changes exceeds 90° then it is corner point

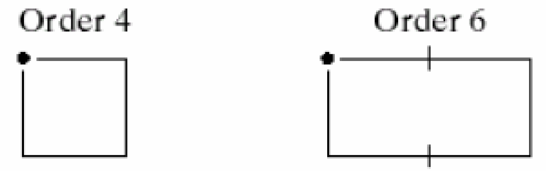
Shape Numbers

- First difference of the chain coded value depends on the starting point
- Shape number: first difference of smallest magnitude
- Oder: Defined as number of digits in its representation

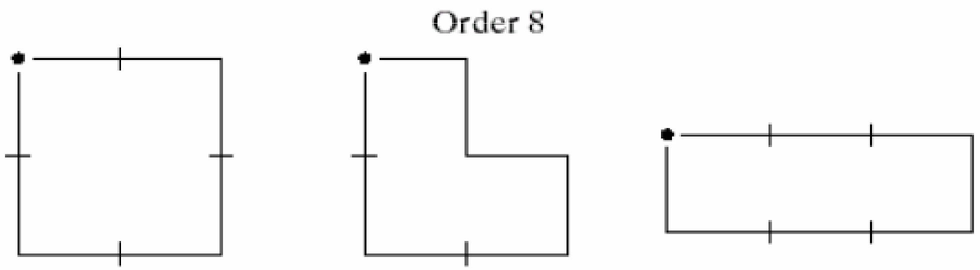




Shape Numbers



	Order 4	Order 6
Chain code:	0 3 2 1	0 0 3 2 2 1
Difference:	3 3 3 3	3 0 3 3 0 3
Shape no.:	3 3 3 3	0 3 3 0 3 3

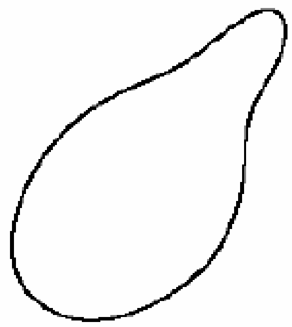


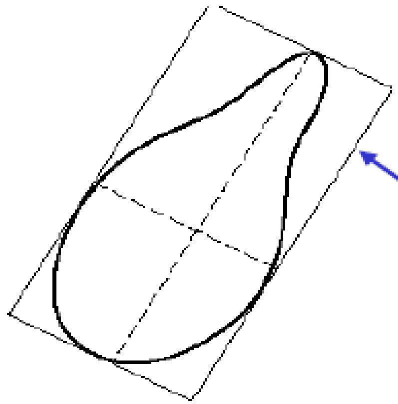
	Order 8		
Chain code:	0 0 3 3 2 2 1 1	0 3 0 3 2 2 1 1	0 0 0 3 2 2 2 1
Difference:	3 0 3 0 3 0 3 0	3 3 1 3 3 0 3 0	3 0 0 3 3 0 0 3
Shape no.:	0 3 0 3 0 3 0 3	0 3 0 3 3 1 3 3	0 0 3 3 0 0 3 3

Shape numbers of order 4, 6 and 8

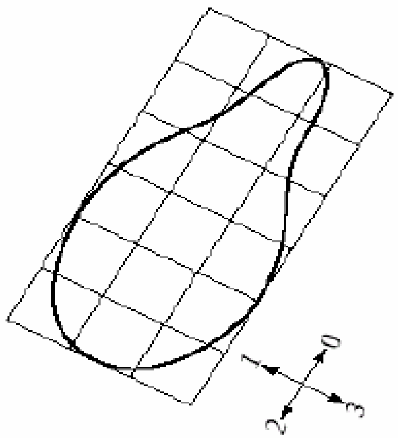
(Images from Rafael C. Gonzalez and Richard E. Wood, Digital Image Processing, 2nd Edition.

Shape Numbers

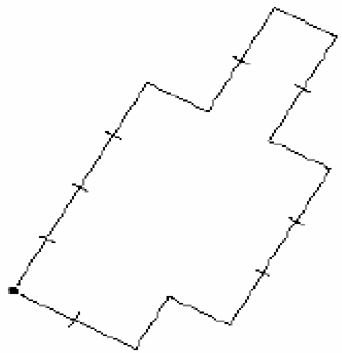




2. Find the smallest rectangle that fits the shape



Create grid



4. Find the nearest Grid.

Chain code:
0 0 0 0 3 0 0 3 2 2 3 2 2 2 1 2 1 1

First 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

•Let (x0,y0),(x1,y1),(x2,y2) ….. (xk-1,yk-1) are encountered in traversing the boundary

•View coordinate point (x,y) as complex number (x=real and y=imaginary point)

•Apply the Fourier transform to a sequence of boundary points.

•Let s(k) be a coordinate of boundary point

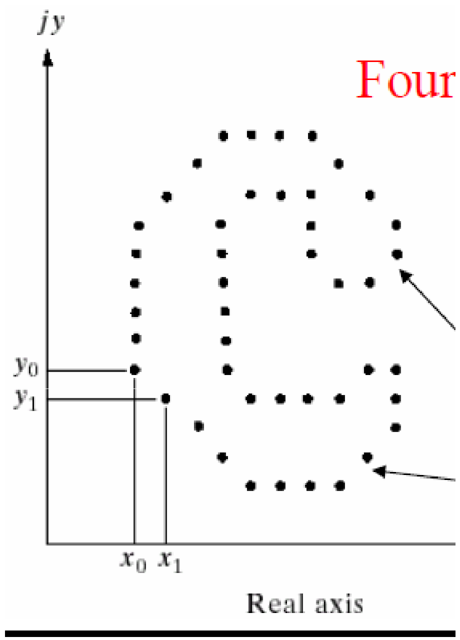
$$s(k) = x(k) + jy(k)$$

For k=0,1,2,3……..,K-1.

• It produces a 2-D to a 1-D problem

•The DFT of s(k) is

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



Fourier Descriptors

- The complex coefficients a(u) are called Fourier descriptors of the boundary.
- Inverse Fourier transform of these coefficients restores s(k)

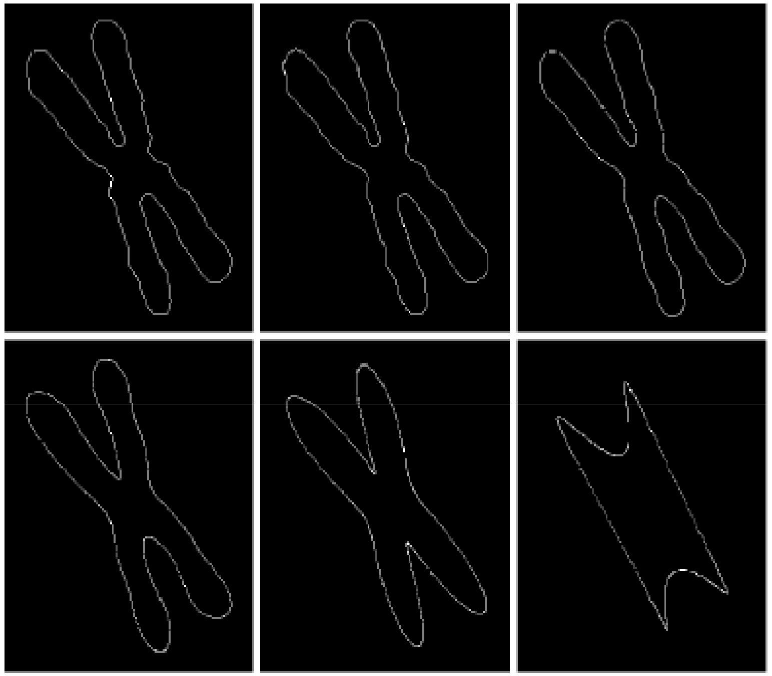
$$s(k) = \frac{1}{K}\sum_{k=0}^{K-1} a(u)e^{2\pi uk/K}$$

- Suppose if first p coefficients are used a(u)=0 for u>p-1. the result of approximation to s(k).

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

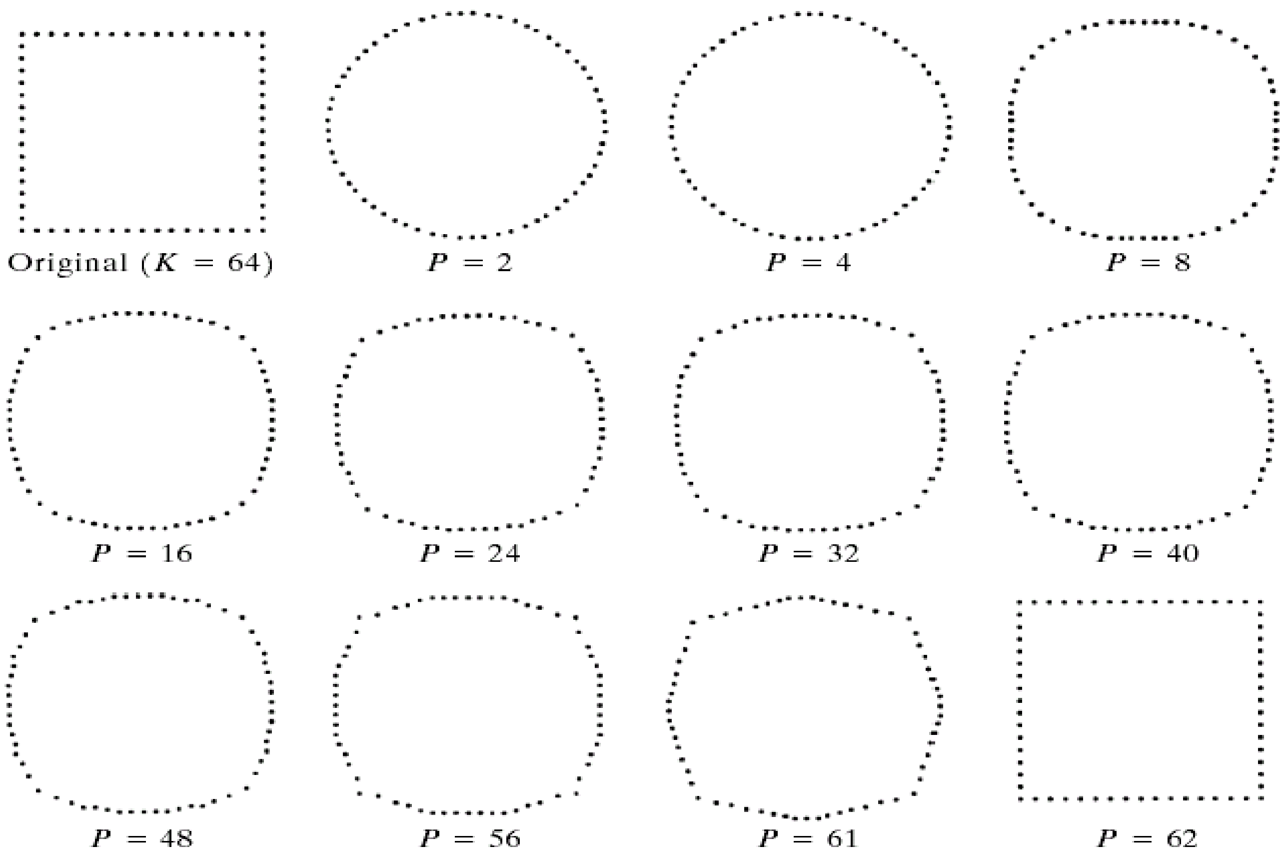
Boundary Reconstruction

- Boundary reconstruction using 546,110,56,28,14 and 8 descriptors out of a possible 2868 descriptors
  - Using 8 principal feature set is lost but in using 14possible to reconstruct



Boundary Segments- 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.



Basic Properties of Fourier Descriptors

- Descriptors are insensitive to translation, rotation, scaling and to starting point
- Changes in the parameters can be related to simple transformations on the descriptors.

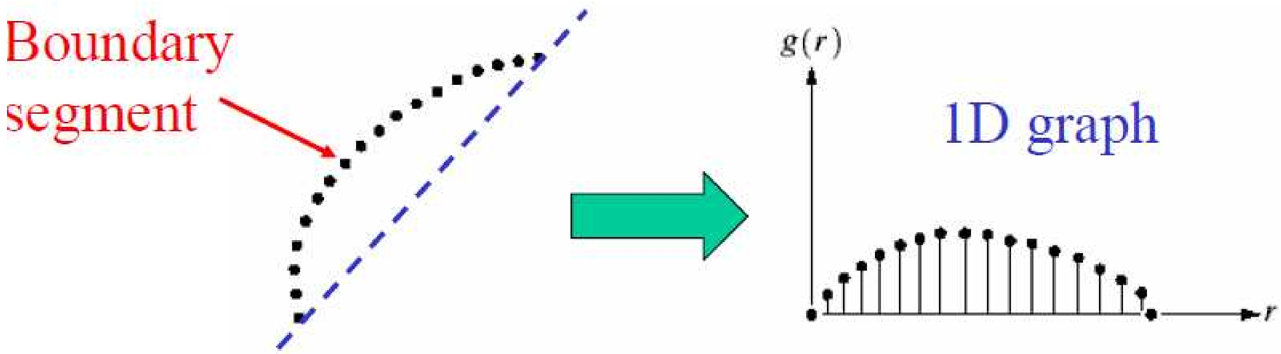
Transformation	Boundary	Fourier Descriptor
Identity	$s(k)$	$a(u)$
Rotation	$s_r(k) = s(k)e^{j\theta}$	$a_r(u) = a(u)e^{j\theta}$
Translation	$s_t(k) = s(k) + \Delta_{xy}$	$a_t(u) = a(u) + \Delta_{xy}\delta(u)$
Scaling	$s_s(k) = \alpha s(k)$	$a_s(u) = \alpha a(u)$
Starting point	$s_p(k) = s(k - k_0)$	$a_p(u) = a(u)e^{-j2\pi k_0 u/K}$

Boundary Descriptors
Statistical Moments

- Moments are statistical measures of data.
  - They come in integer orders.
  - Order 0 is just the number of points in the data.
  - Order 1 is the sum and is used to find the average.
  - Order 2 is related to the variance, and order 3 to the skew of the data.
  - Higher orders can also be used

Statistical Moments

- Shape of the boundary segments can be described by using statistical moments like mean, variance and higher order moments.
- Convert the boundary segment as 1D graph g(r) of an arbitrary variable r
- View 1D graph AS PDF function and compute nth moment of graph



Boundary Descriptors
Statistical Moments

- Treat amplitude of *g* as discrete random variable v , and form an amplitude histogram $p(v_i)$.
- P(vi) is the probability of value v_i occurring, then the nth moment of v about the mean
- M is the mean or average value of v.

$$\mu_n(v) = \sum_{k=0}^{A-1} (v_i - m)^n \, p(v_i)$$

$$\text{where } m = \sum_{i=0}^{A-1} v_i \, p(v_i)$$

Boundary Descriptors
Statistical Moments

- Let r be a random variable, and $g(r_i)$ be normalized (as the probability of value r_i occurring), then the moments are

$$\mu_n(r) = \sum_{k=0}^{K-1} (r_i - m)^n g(r_i)$$

$$\text{where } m = \sum_{i=0}^{K-1} r_i g(r_i)$$

a b

FIGURE 11.15
(a) Boundary segment.
(b) Representation as a 1-D function.