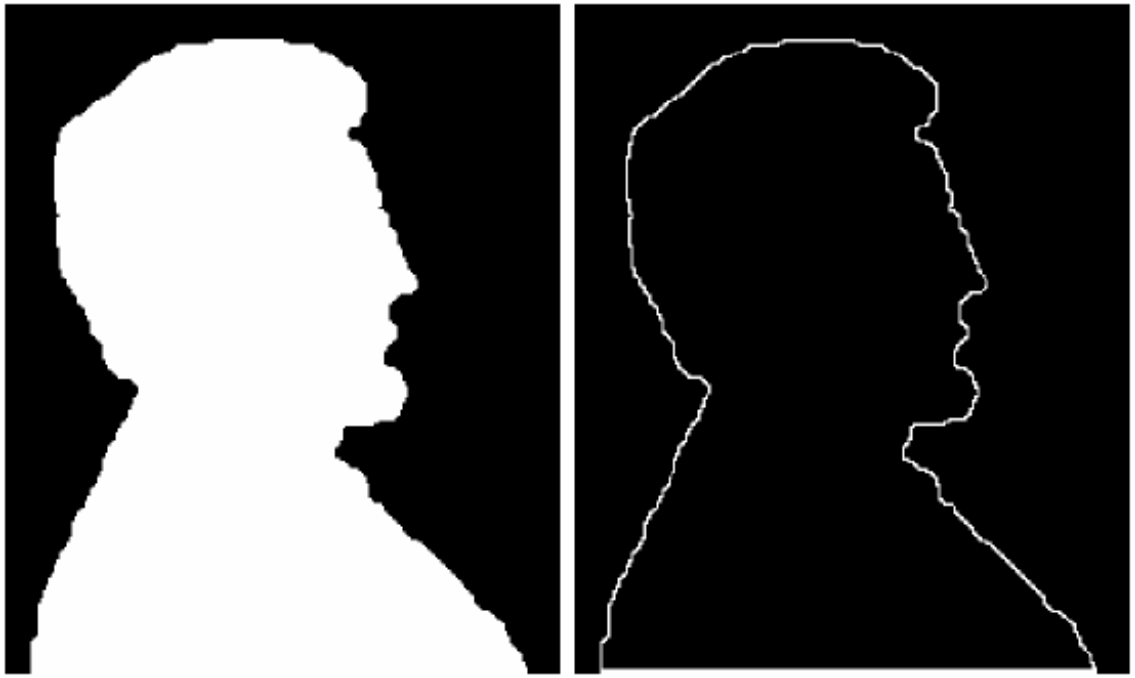
Representation by using Chain Code

Why we focus on a boundary?

The boundary is a good representation of an object shape and also requires a few memory.

Boundary of Binary Objects



X ∂X

- After an image has been segmented into regions, it is used for further computer processing.
- Image regions (including segments) can be represented by either the border or the pixels of the region.
- This can be represented in terms of its external (boundaries)/ internal (pixel representing the region)
- The external representation primary focus is in shape characteristics.
- An internal representation is selected when the primary focus is on regional properties(color/texture…..)
- Chain codes: represent a boundary of a connected region.

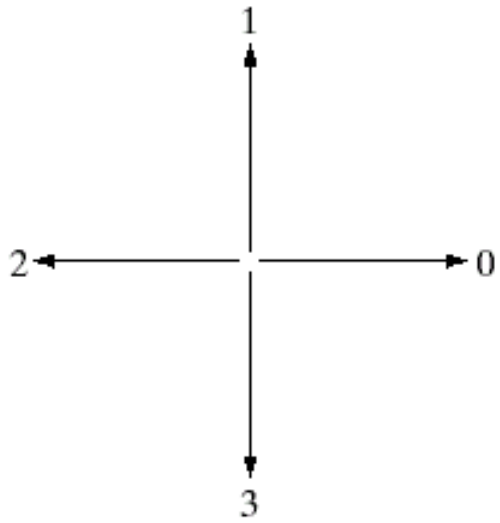
Chain Codes

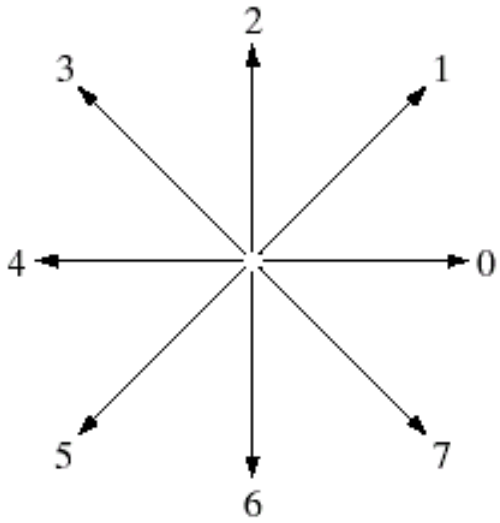
- This is used to represent a boundary by a connected sequence of straight line segments of specified length and direction.
- This is based on 4 or 8 connectivity.
- The direction of each segment is coded by using numbering scheme.
- Boundary code is formed as a sequence of such directional numbers is referred to as a Freeman chain code.
- The chain code of a boundary depends on the starting point.

Representation

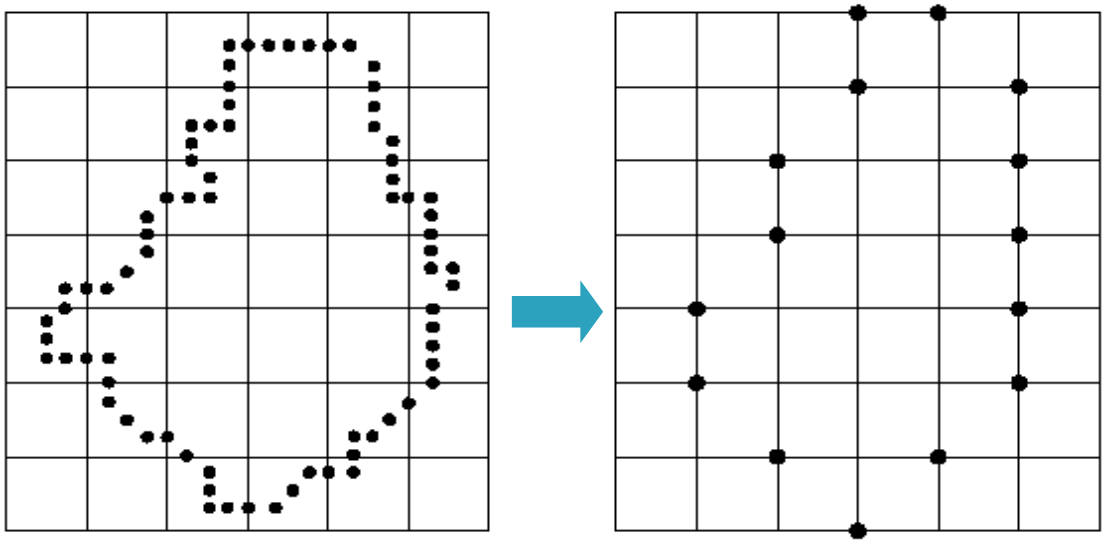
a b

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



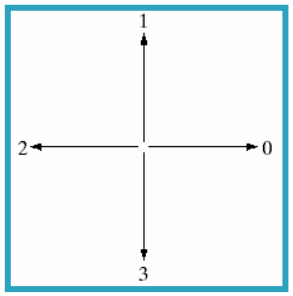


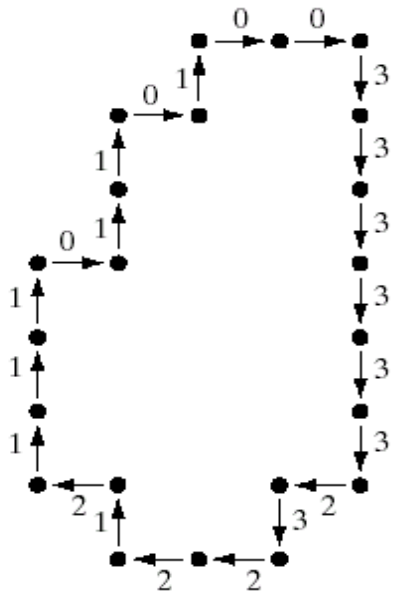
Representation Chain Codes

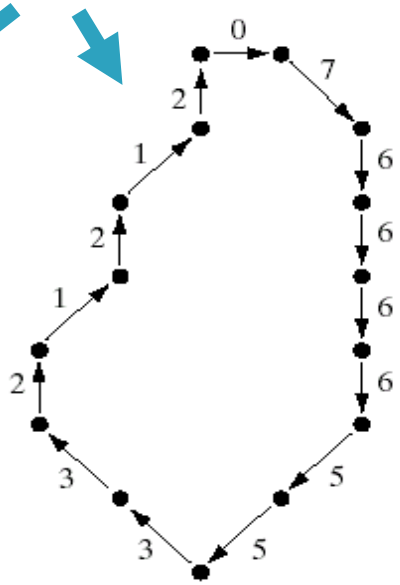


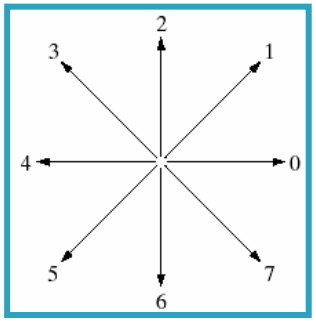
a b
c d

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









4-directional chain code:
00333333223221211101101

8-directional chain code:
076666553321212

- The chain code of a boundary depends on the starting point.
- We can normalize also for rotation by using the *first difference* of the chain code instead of the code itself.
- The first-difference of the 4-direction chain code 10103322 is 3133030.
- If we elect to treat the code as a circular.
- Here, the result is 33133030.

The first difference is rotational invariant.

The normalized/first difference boundary code results in a significant reduction in the amount of data needed to store the boundary.

For Ex:

The 8-directional freeman chain code of the boundary is

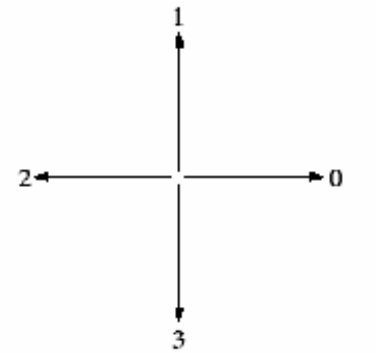
0 0 0 0 6 0 6 6 6 6 6 6 6 6 4 4 4 4 4 4 2 4 2 2 2 2 2 0 2 2 0 2

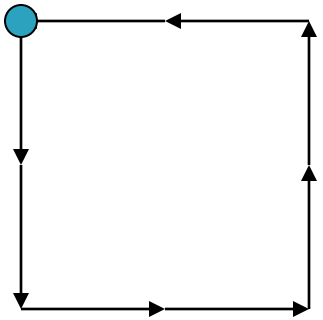
The first difference code is

0 0 0 6 2 6 0 0 0 0 0 0 0 6 0 0 0 0 0 6 2 6 0 0 0 0 6 2 0 6 2 6

- The method generally is unacceptable for two principal reasons:
  - (1) The resulting chain of codes tends to be quite ling and,
  - (2) 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.

Normalization Strategy





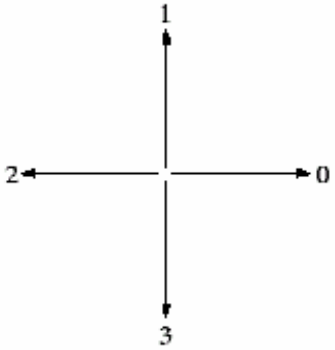
33001122

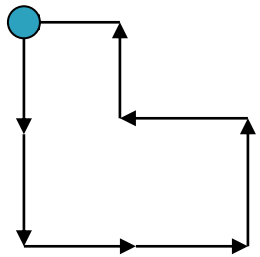
33001122		00112233
30011223		01122330
00112233		11223300
01122330	Sort rows →	12233001
11223300		22330011
12233001		23300112
22330011		33001122
23300112		30011223

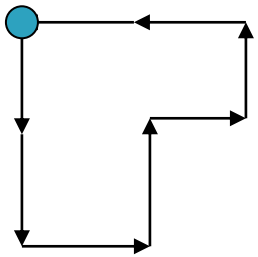
→ First row gives the normalized chain code

00112233

Shape Numbers= Normalized Differential Chain Codes







Differential code:
$d_k=c_k-c_{k-1}$ (mod 4)

33001212
↓ differentiate
10101131
↓ normalize
01011311

33010122
↓ differentiate
10113110
↓ normalize
01011311

Note that the shape numbers of two objects related by 90^o rotation are indeed identical

Direction is Anti-clock wise
2 to 3 is 1, 3 to 0 is 1 etc....

Chain Codes

Noisy 570x570 image

9x9 averaging mask

Otsu thresholded

Single-point from Otsu thresholding (ignored)

8-directed chain code:
00006066666666444444242222202202
Minimum magniture integer:
00006066666666444444242222202202
First difference:
00062600000006000006260000620626

Longest outer boundary

Resampled on a 50x50 pixel grid

Joining resampled pixels by straight lines

a b c
d e f

FIGURE 11.5 (a) Noisy image. (b) Image smoothed with a 9×9 averaging mask. (c) Smoothed image, thresholded using Otsu's method. (d) Longest outer boundary of (c). (e) Subsampled boundary (the points are shown enlarged for clarity). (f) Connected points from (e).