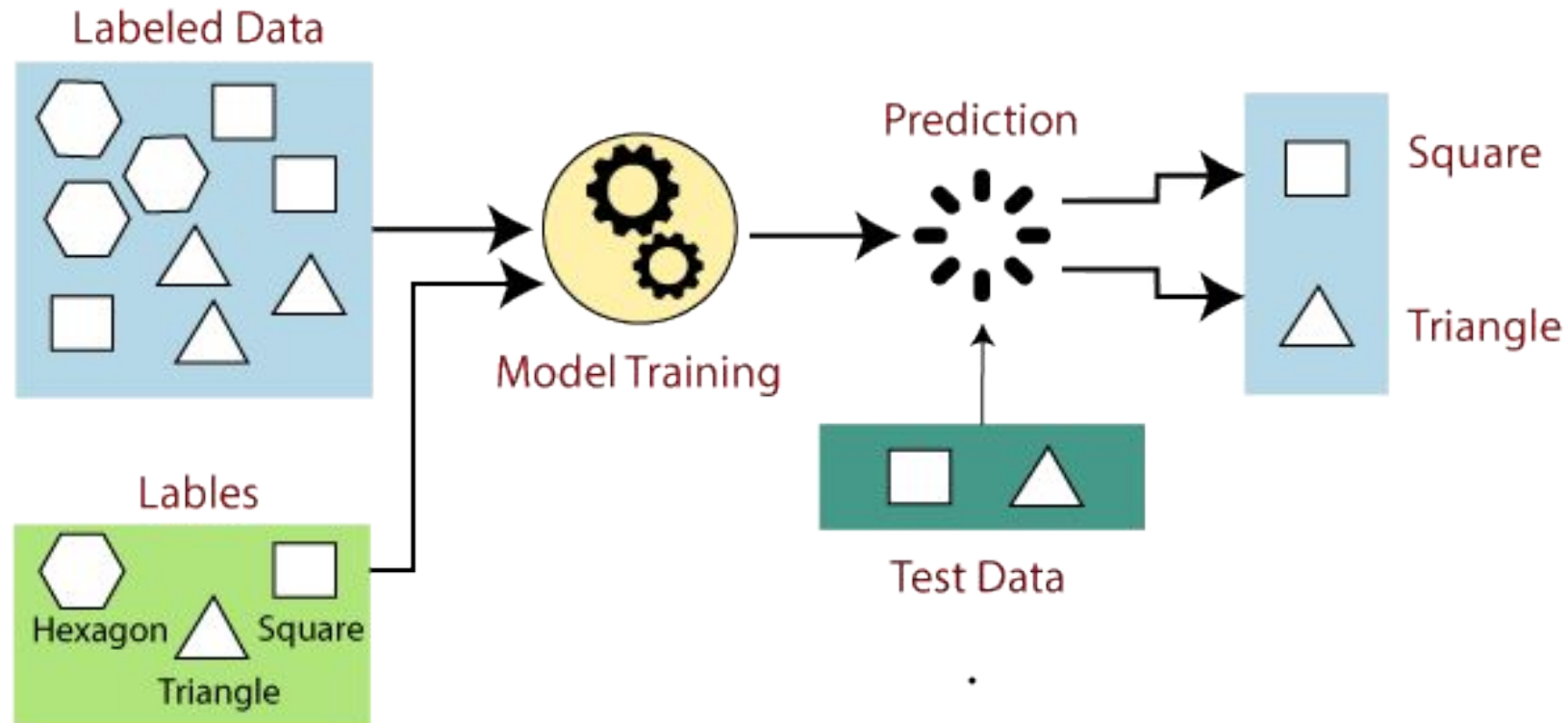


Pattern Recognition

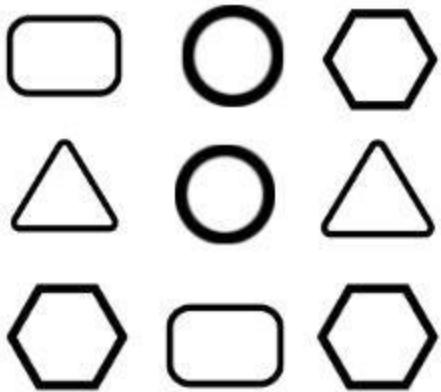
Module 1

Supervised Learning



Unsupervised Learning

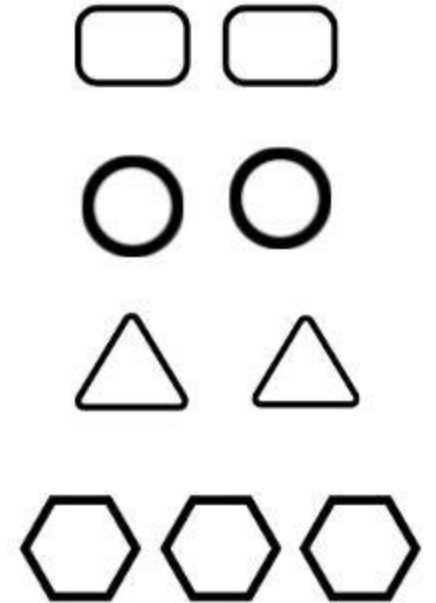
Unlabelled Data



Machine



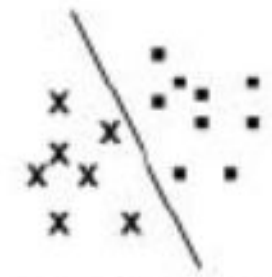
Results



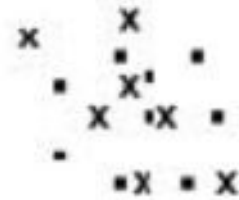
Features

- **Pattern recognition system should recognize familiar patterns quickly and accurate**
- Feature can be defined as any distinctive aspect, quality or characteristic which, may be symbolic (i.e., color) or numeric (i.e., height).
- The combination of d features is represented as a d -dimensional column vector called a feature vector. The d -dimensional space defined by the feature vector is called feature space.

Features

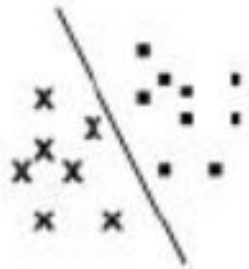


Good features



Bad features

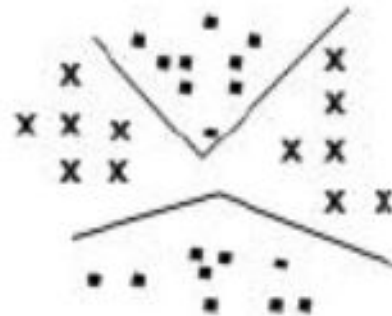
(a)



Linear separability



Non-linear separability



Multi-modal



Highly correlated

(b)

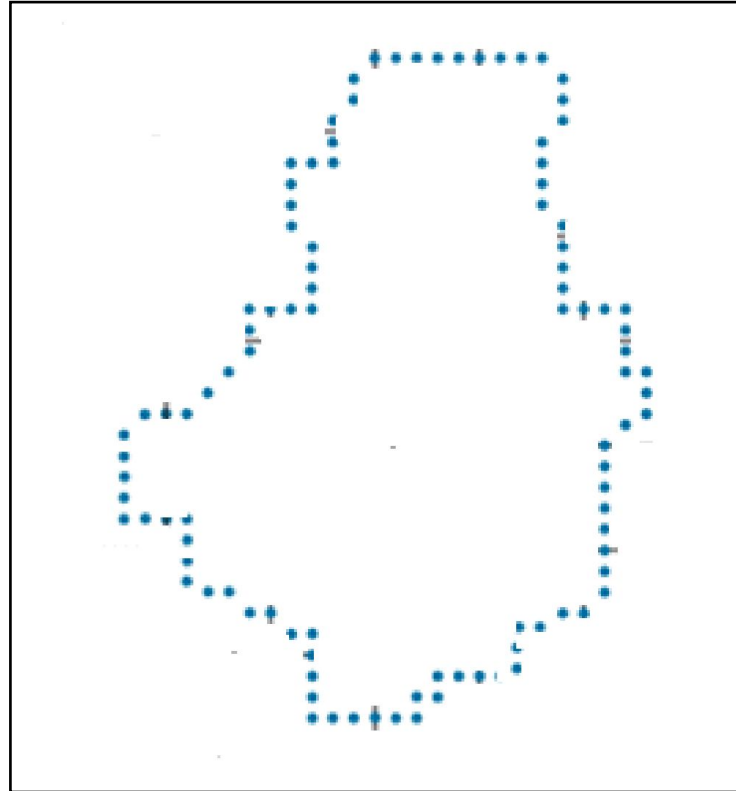
Features

Often the features are obtained from Shape and Region

- Boundary:
- The shape of the object
- Region:
- Color
- Area/perimeter covered
- Texture

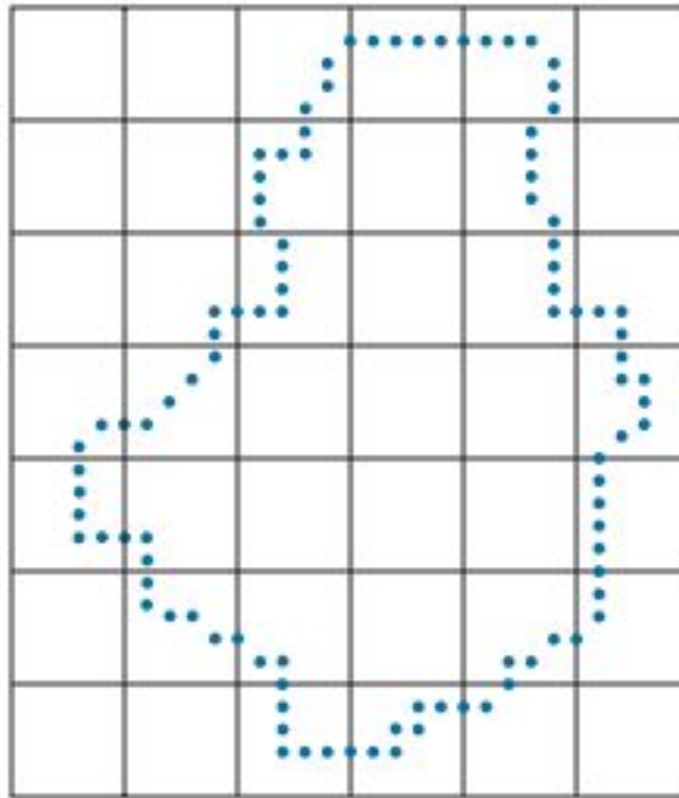
Features from shape

- Let the shape of an object be defined as a set of points linked a particular manner



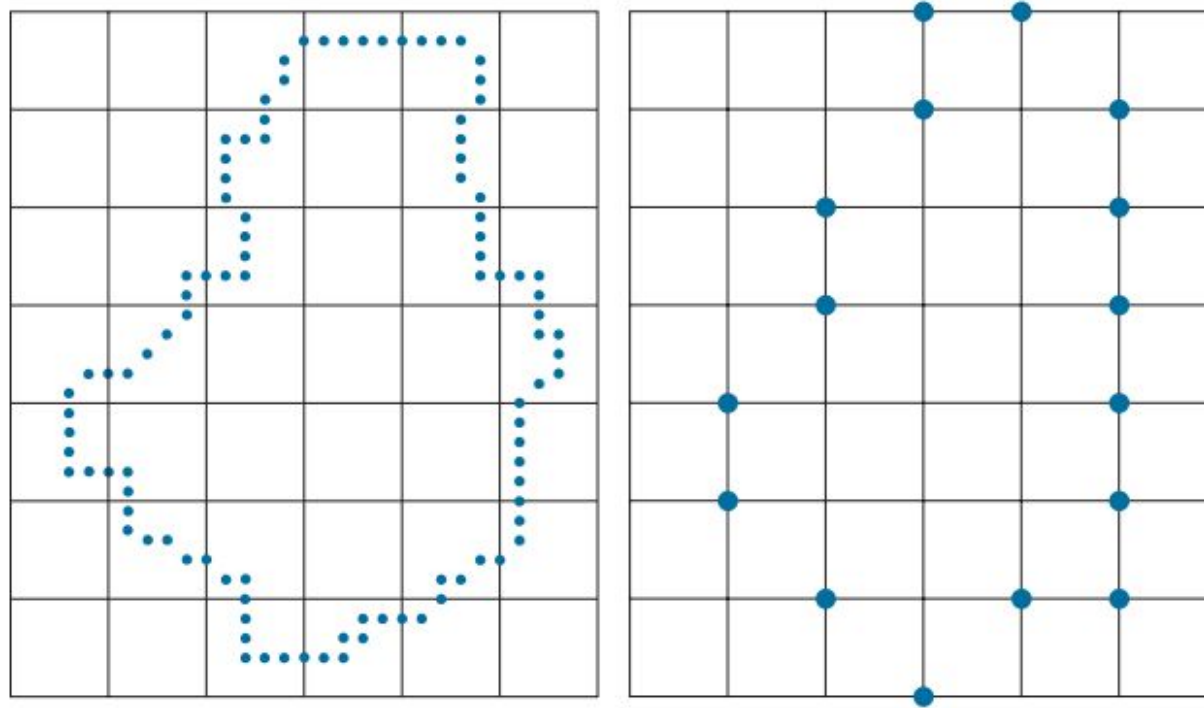
Features from shape

- Let us resample the boundary by selecting a larger grid spacing



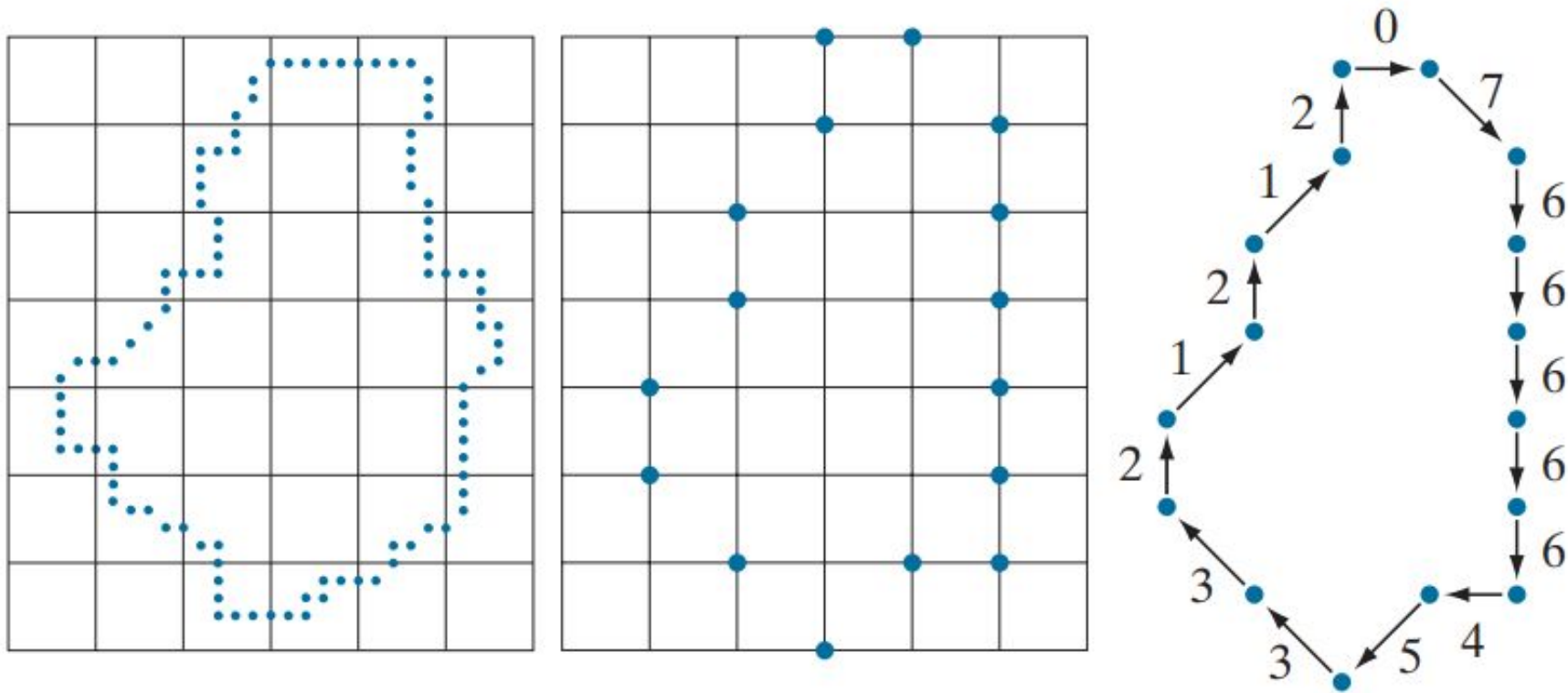
Features from shape

- Then, as the boundary is traversed, a boundary point is assigned to a node of the coarser grid, depending on the proximity of the original boundary point to that node



Chain Code Features

- Then the resampled boundary obtained in this way can be represented by a 4- or 8-code.



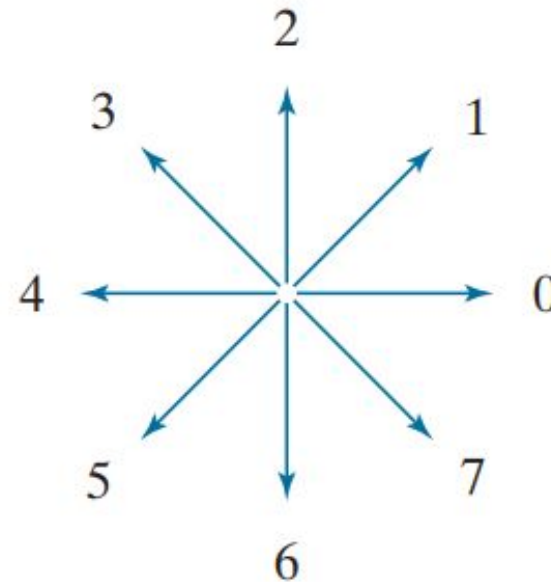
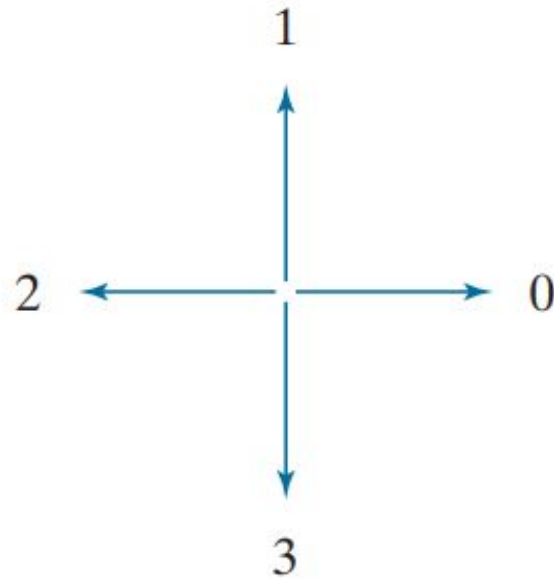
Chain Codes

- Chain codes are used to represent a boundary by a connected sequence of straight line segments of specified length and direction.
- We assume in this section that all curves are closed, simple curves s (i.e., curves that are closed and not self intersecting).
- Typically, a chain code representation is based on 4- or 8-connectivity of the segments.
- boundary code formed as a sequence of such directional numbers is referred to as a Freeman chain code.

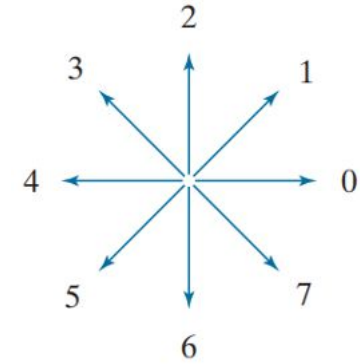
Chain Codes

- Typically, a chain code representation is based on 4- or 8-connectivity of the segments.

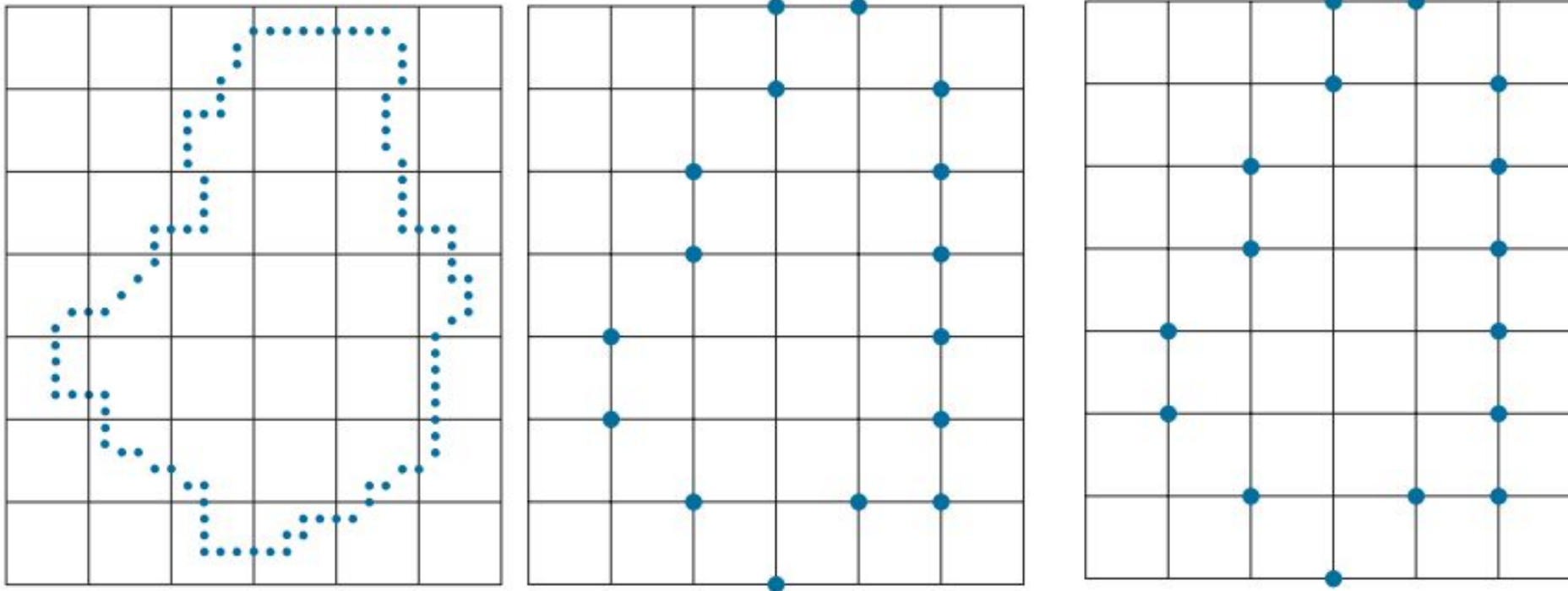
Direction
numbers for
(a) 4-directional
chain code, and
(b) 8-directional
chain code.



Chain Codes (8 Connectivity)

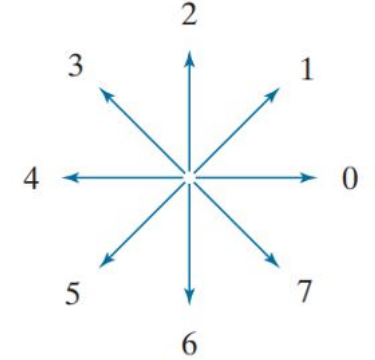


- We fix one starting point and start assigning directions

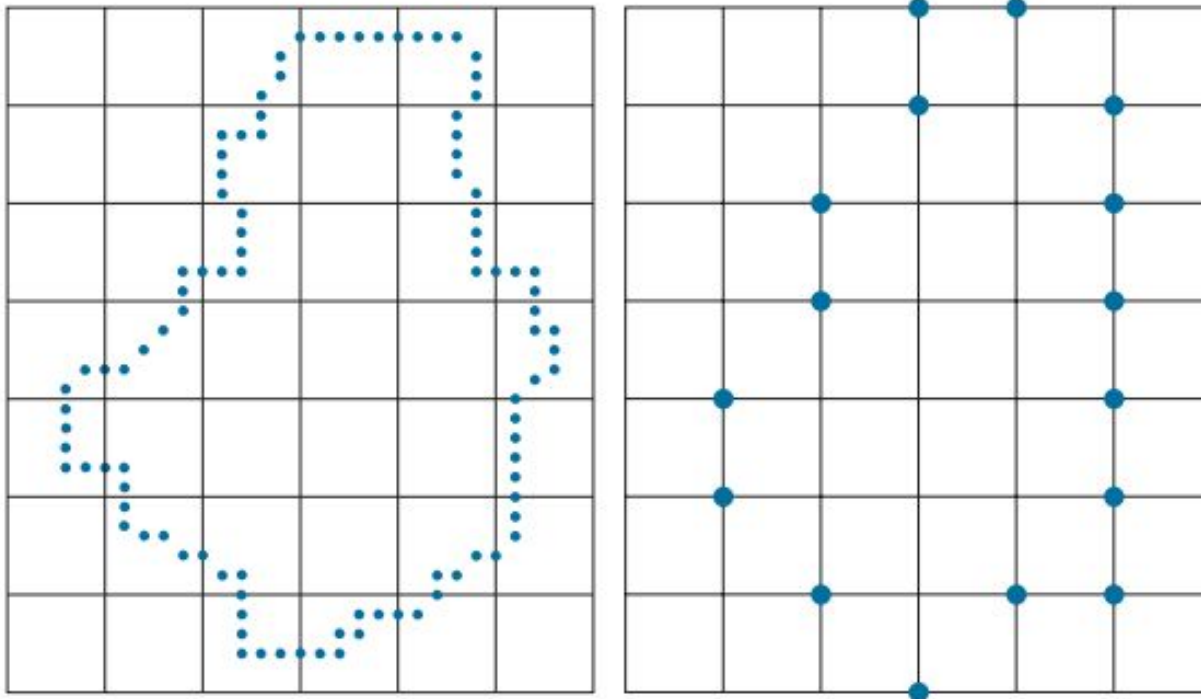


- the spacing of the resampling grid is determined by the application in which the chain code is used.

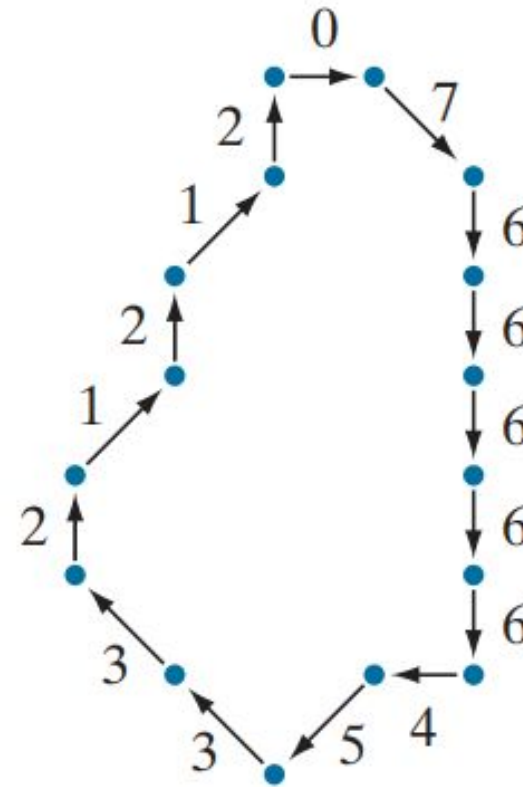
Chain Codes (8 Connectivity)



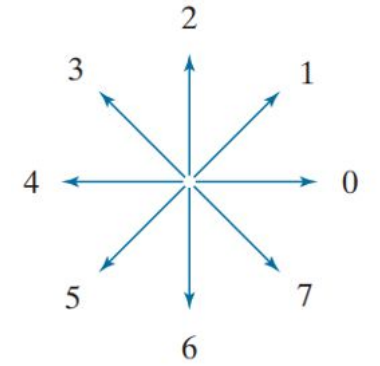
- The numerical value of a chain code depends on the starting point.



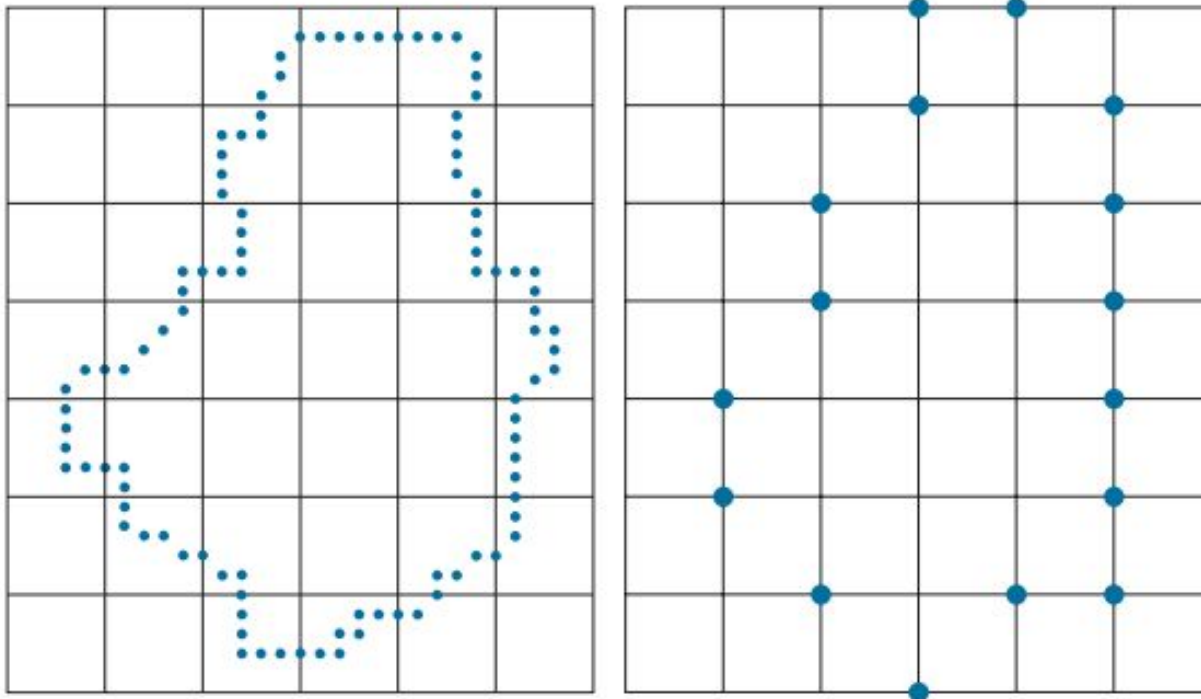
chain code 0766666454421212



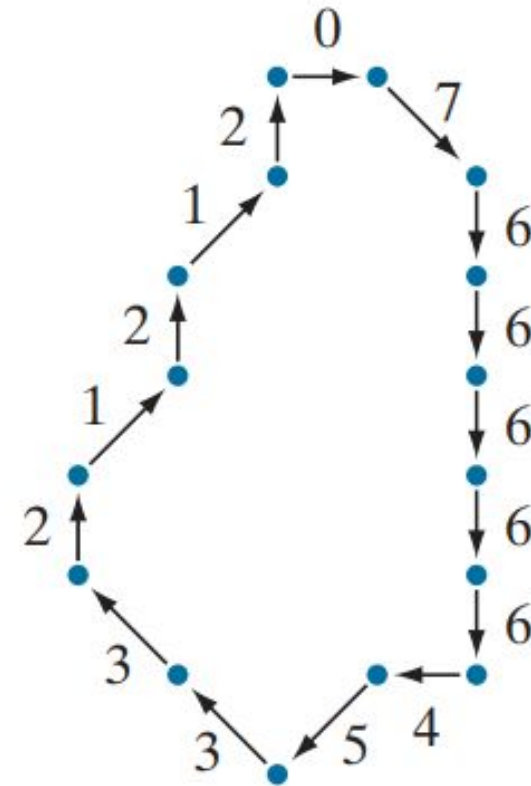
Chain Codes (8 Connectivity)



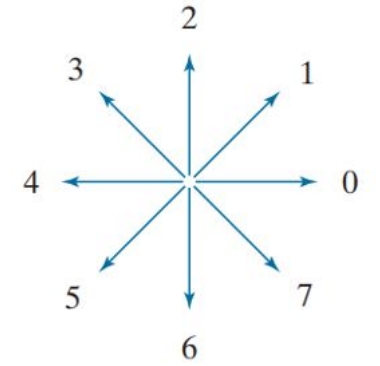
- The numerical value of a chain code depends on the starting point.



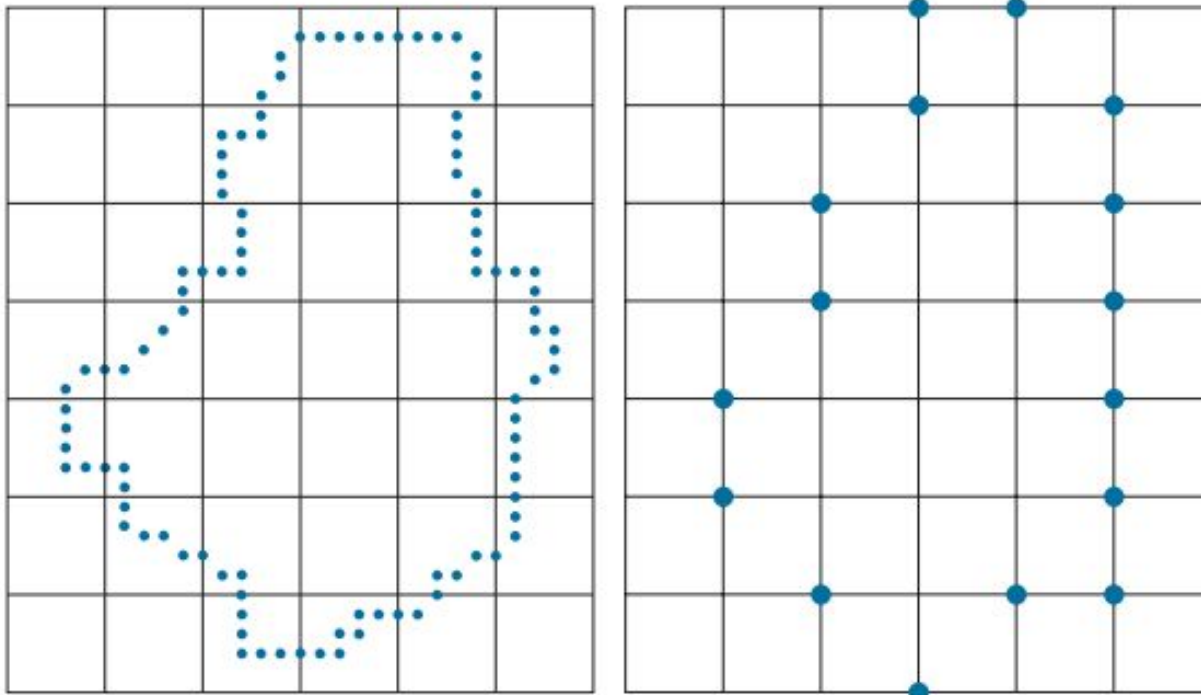
chain code 7666664544212120



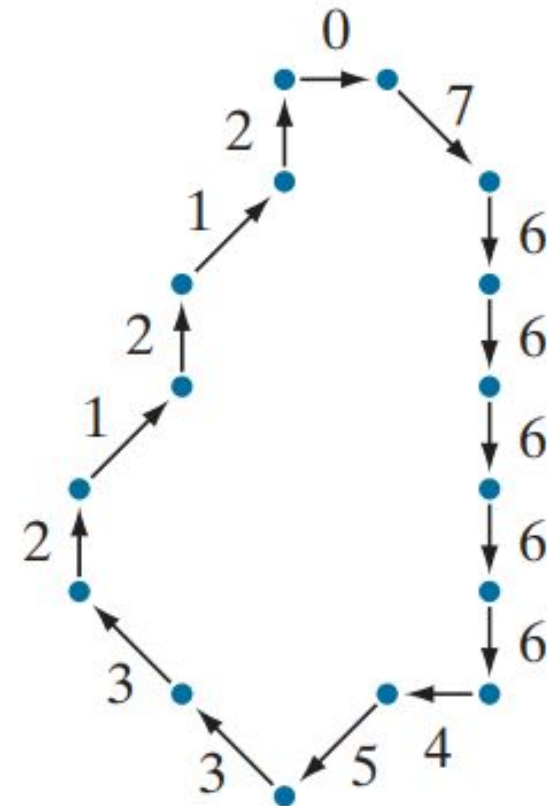
Chain Codes (8 Connectivity)



- The numerical value of a chain code depends on the starting point.



chain code 6666645442121207



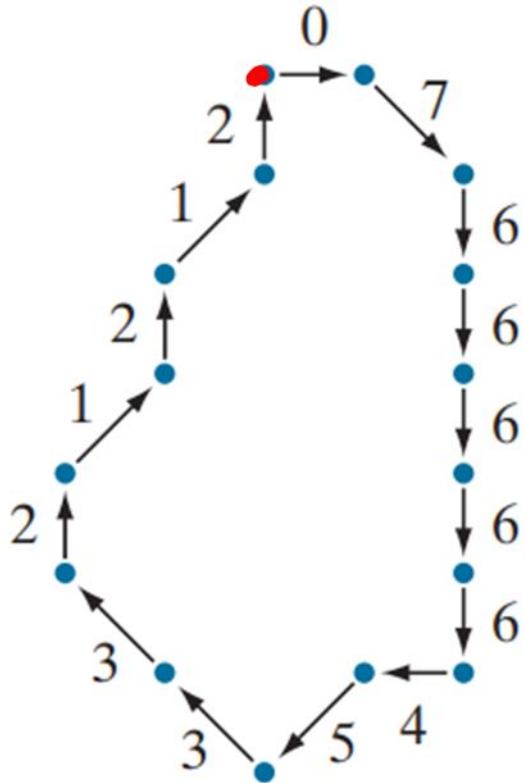
Normalize chain code

The code can be normalized with respect to the starting point by a straightforward procedure:

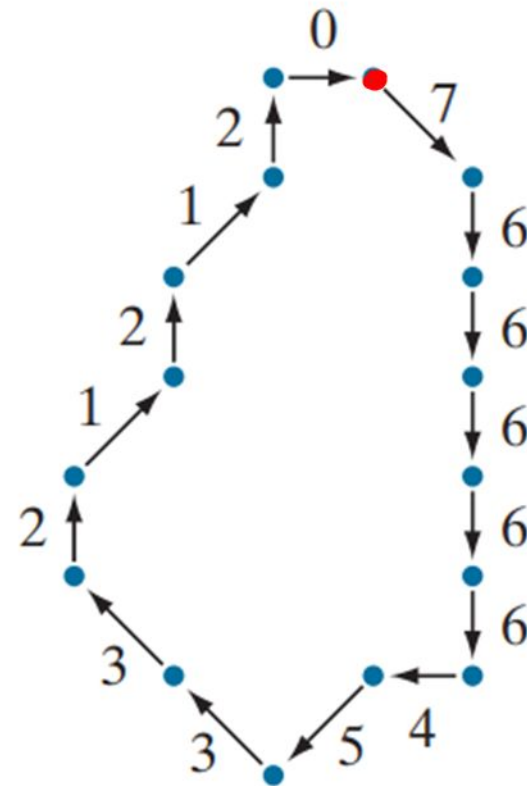
- We simply treat the chain code as a circular sequence of direction numbers and redefine the starting point so that the resulting sequence of numbers forms an integer of minimum/ maximum magnitude.

Normalize chain code

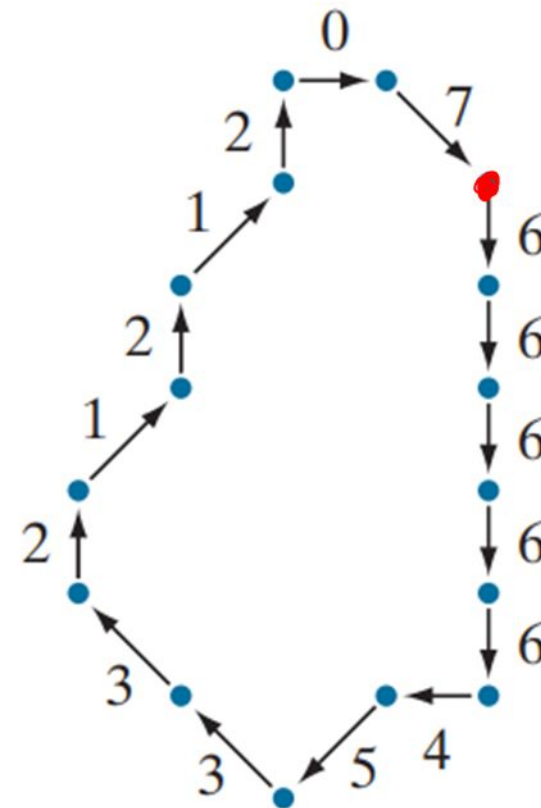
Form integer of minimum/ maximum magnitude



0766666454421212



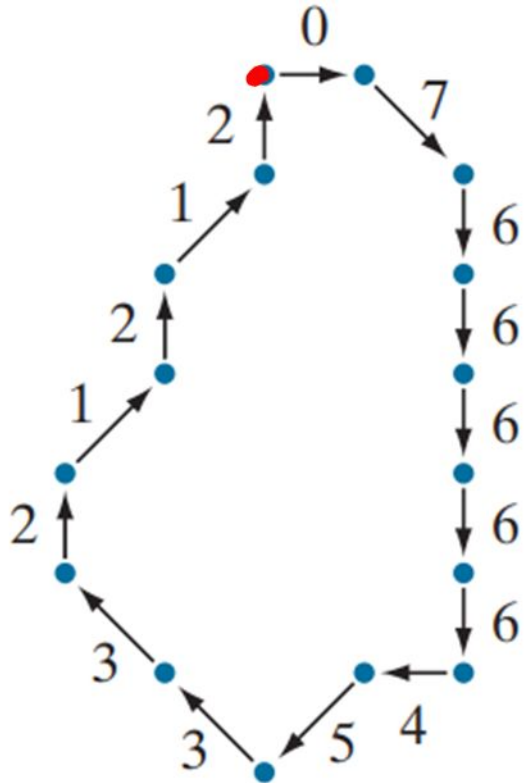
7666664544212120



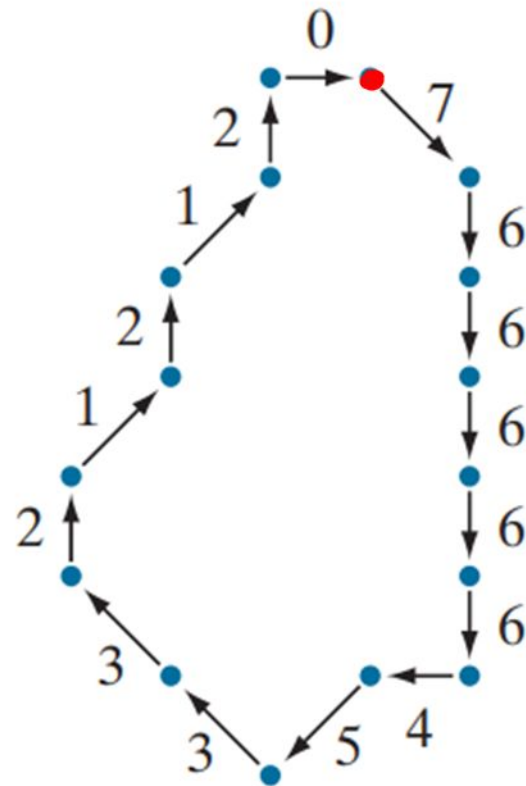
6666645442121207

Normalize chain code

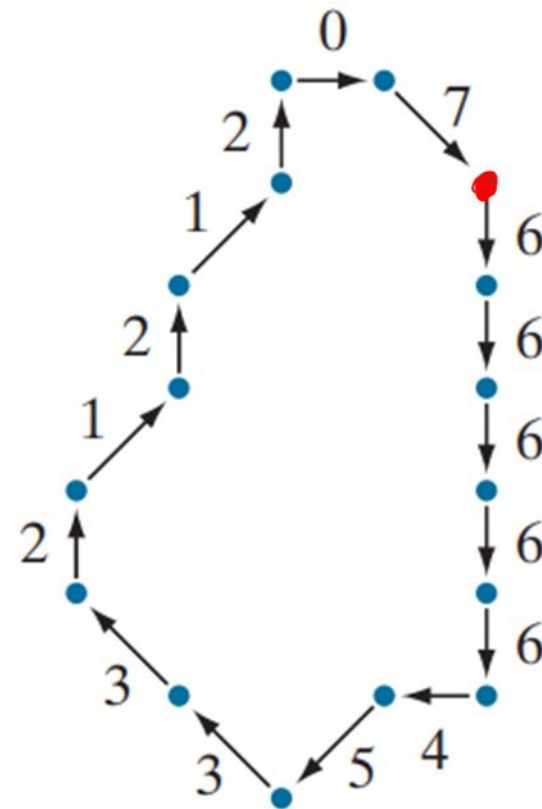
Form integer of minimum/ maximum magnitude



0766666454421212

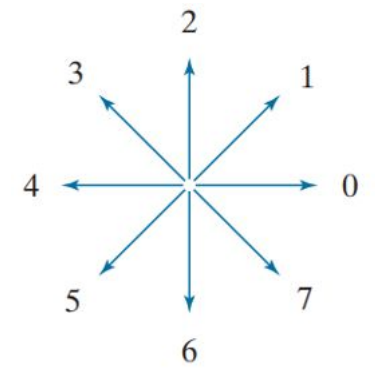


7666664544212120

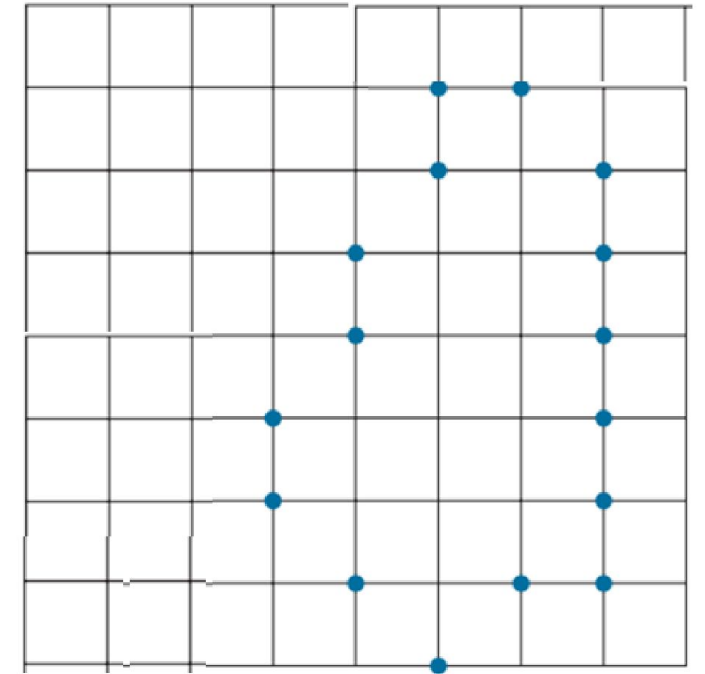
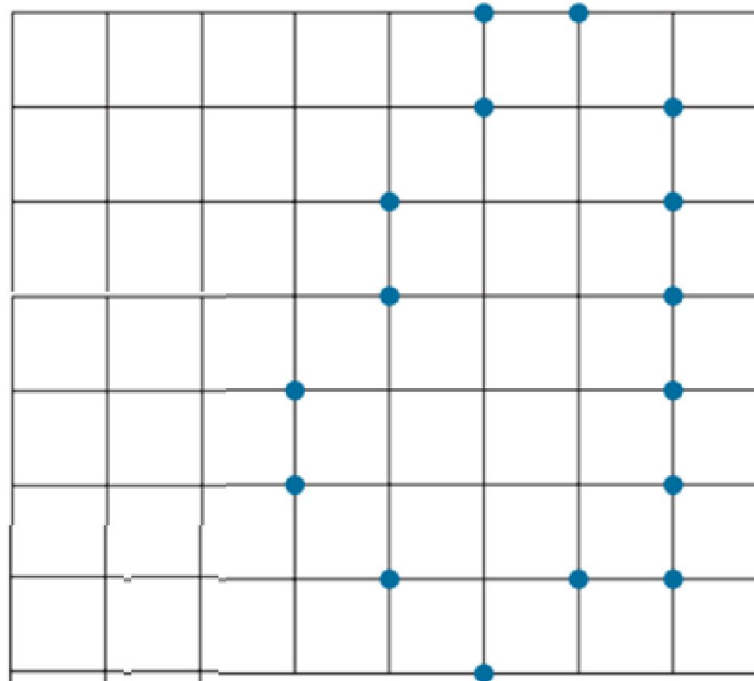
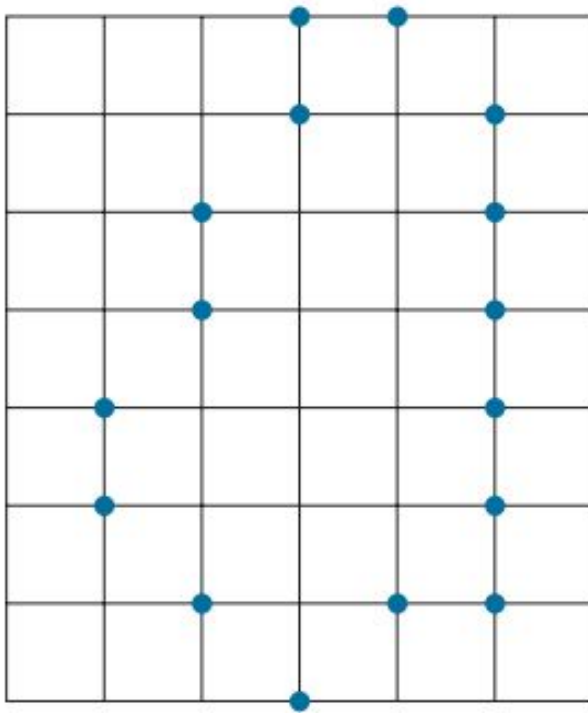


6666645442121207

Chain Codes – Invariant to translation

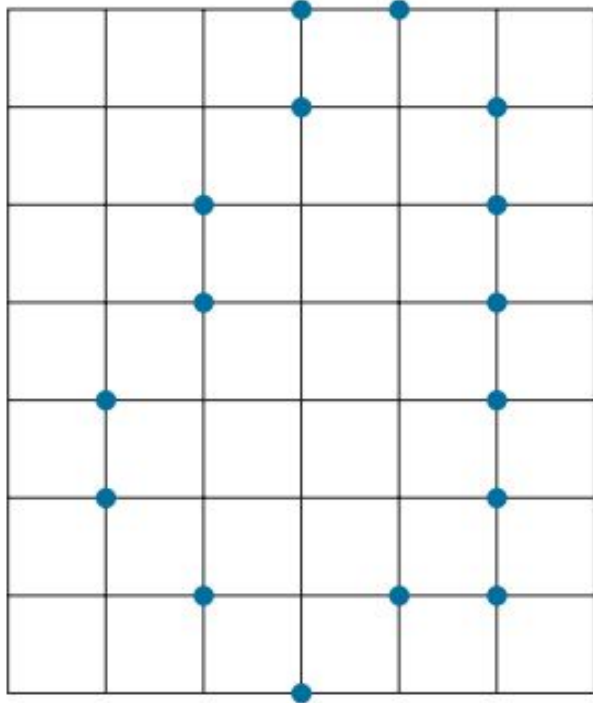
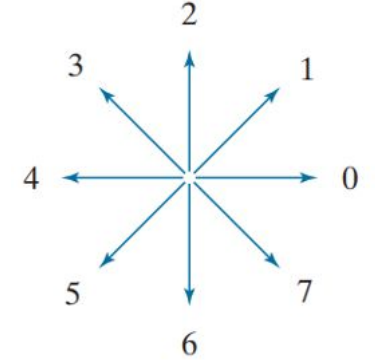


- For the same starting point

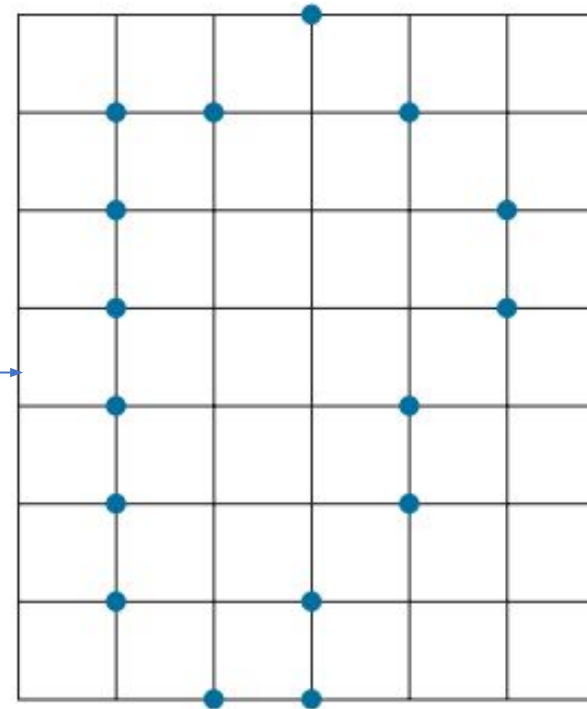


chain code 7666664544212120

Chain Codes and rotation



chain code 076666454421212



chain code

Properties

- Chain Codes depend upon starting points
- Chain Code are not affected by translations provided the starting point is fixed
- They change if the object is rotated...
- Then how to write a robust feature.

How to write Normalized chain codes?

The code can be normalized with respect to the starting point by a straightforward procedure:

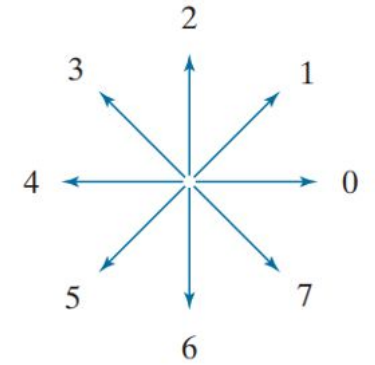
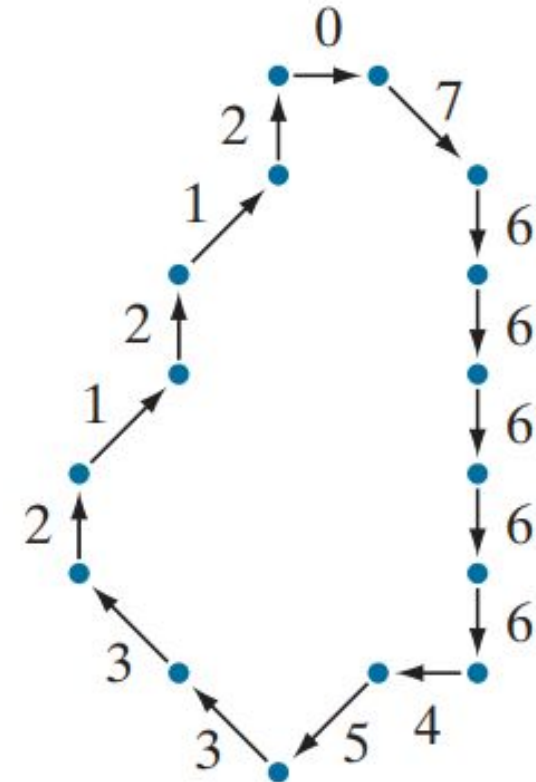
- We simply treat the chain code as a circular sequence of direction numbers and redefine the starting point so that the resulting sequence of numbers forms an integer of minimum magnitude.
- **We can normalize also for rotation** (in angles that are integer multiples of the directions) by using the first difference of the chain code instead of the code itself.

Normalized chain codes

- First Difference of chain code:

This difference is obtained by counting the number of direction changes (in a counterclockwise direction) that separate two adjacent elements of the code.

chain code 0 7 6 6 6 6 6 4 5 4 4 2 1 2 1 2

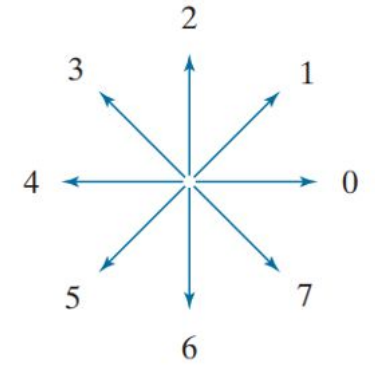
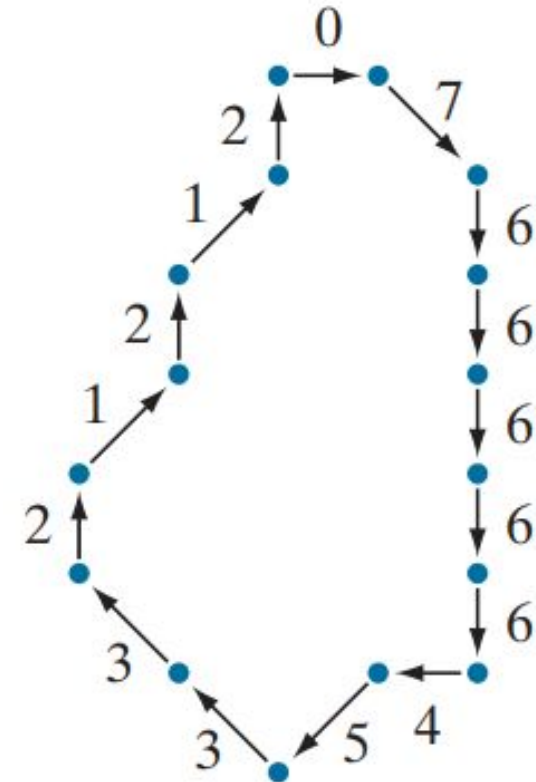


Normalized chain codes

- First Difference of chain code:

This difference is obtained by counting the number of direction changes (in a counterclockwise direction) that separate two adjacent elements of the code.

chain code	0	7	6	6	6	6	4	5	4	4	2	1	2	1	2
chain code	7	7	0	0	0	0	6	1	7	0	6	7	3	7	1

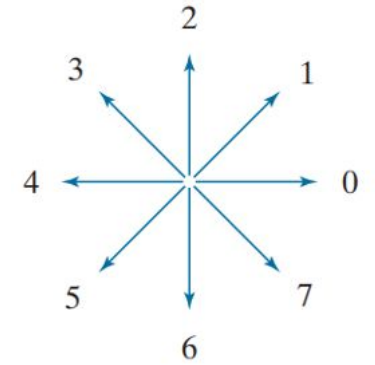
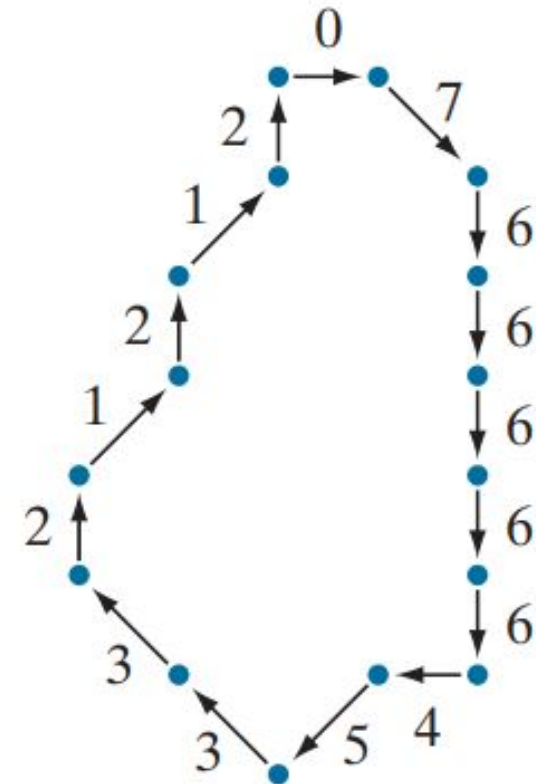


Normalized chain codes

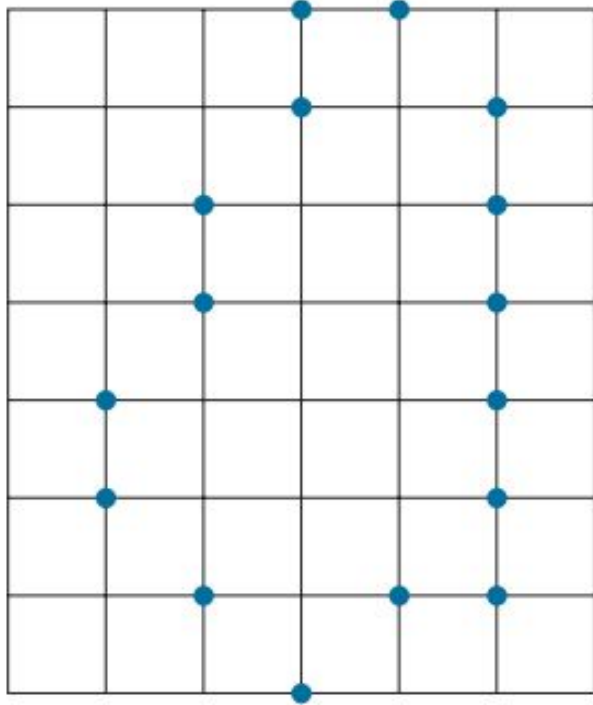
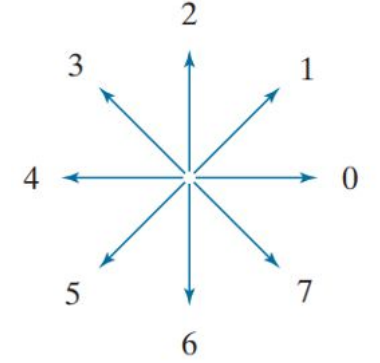
- First Difference of chain code:

This difference is obtained by counting the number of direction changes (in a counterclockwise direction) that separate two adjacent elements of the code.

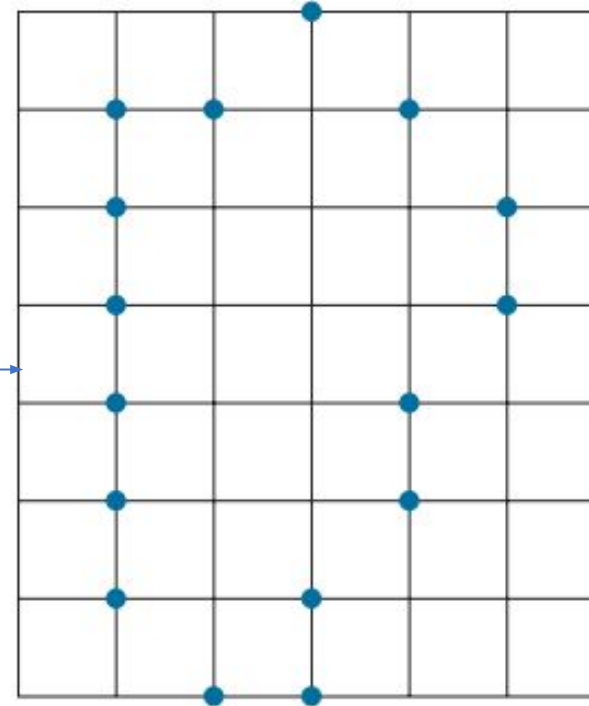
chain code 0 7 6 6 6 6 6 4 5 4 4 2 1 2 1 2
chain code 6 7 7 0 0 0 0 6 1 7 0 6 7 3 7 1



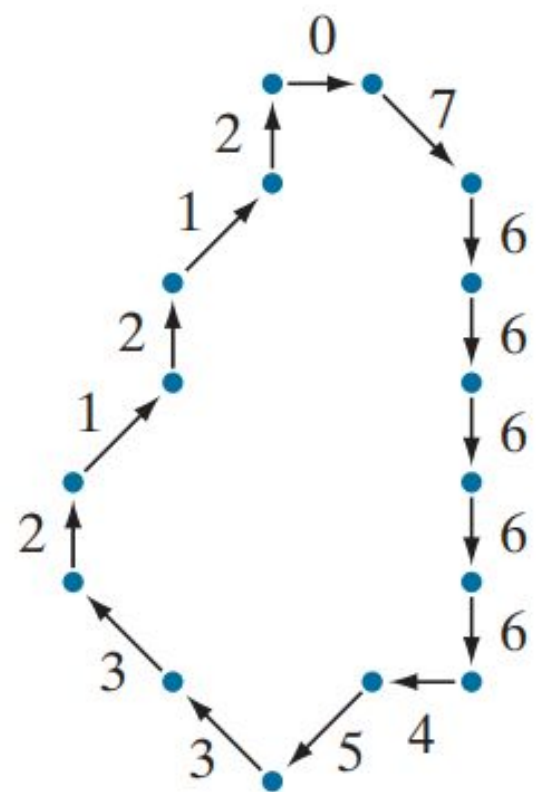
Chain Codes and rotation



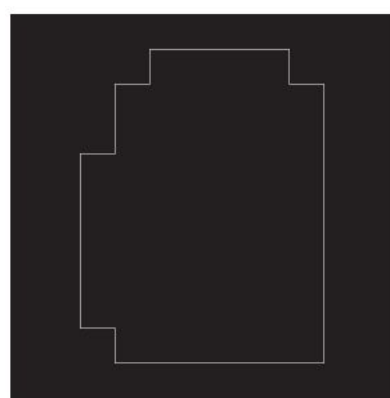
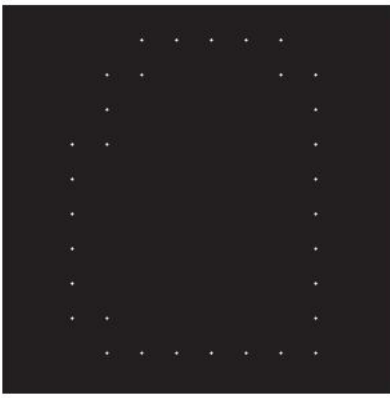
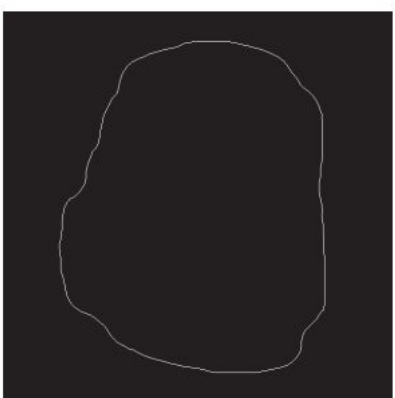
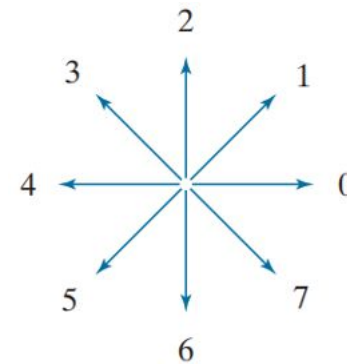
chain ccode:



chain code

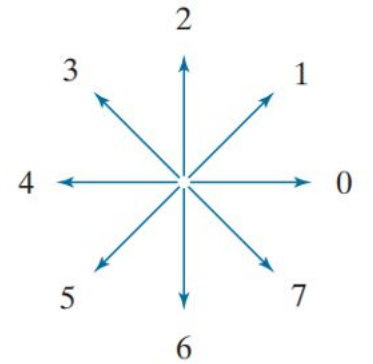
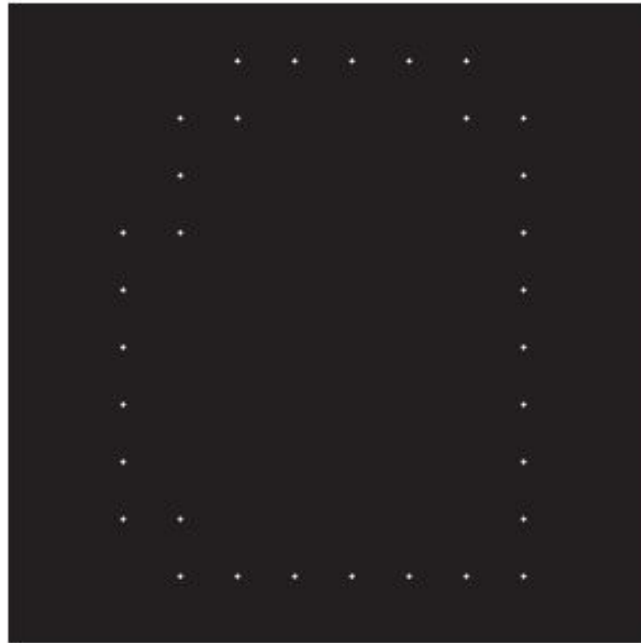


Application of freeman chain code



Application of freeman chain code

- Take simplified boundary



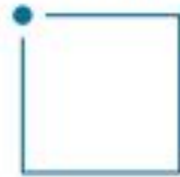
SHAPE NUMBERS

- The shape number of a Freeman chain-coded boundary is defined as the **first difference of smallest magnitude**.
- Again rearranged to form smallest magnitude number using **circular shift**
- The order, n , of a shape number is defined as the number of digits in its representation.
- Moreover, n is even for a closed boundary, and its value limits the number of possible different shapes

Shape Numbers

- Four connectivity

Order 4



Chain code: 0 3 2 1

Difference: 3 3 3 3

Shape no.: 3 3 3 3

Order 6



Chain code: 0 0 3 2 2 1

Difference: 3 0 3 3 0 3

Shape no.: 0 3 3 0 3 3

