

Supervised Learning.

Unsupervised Learning

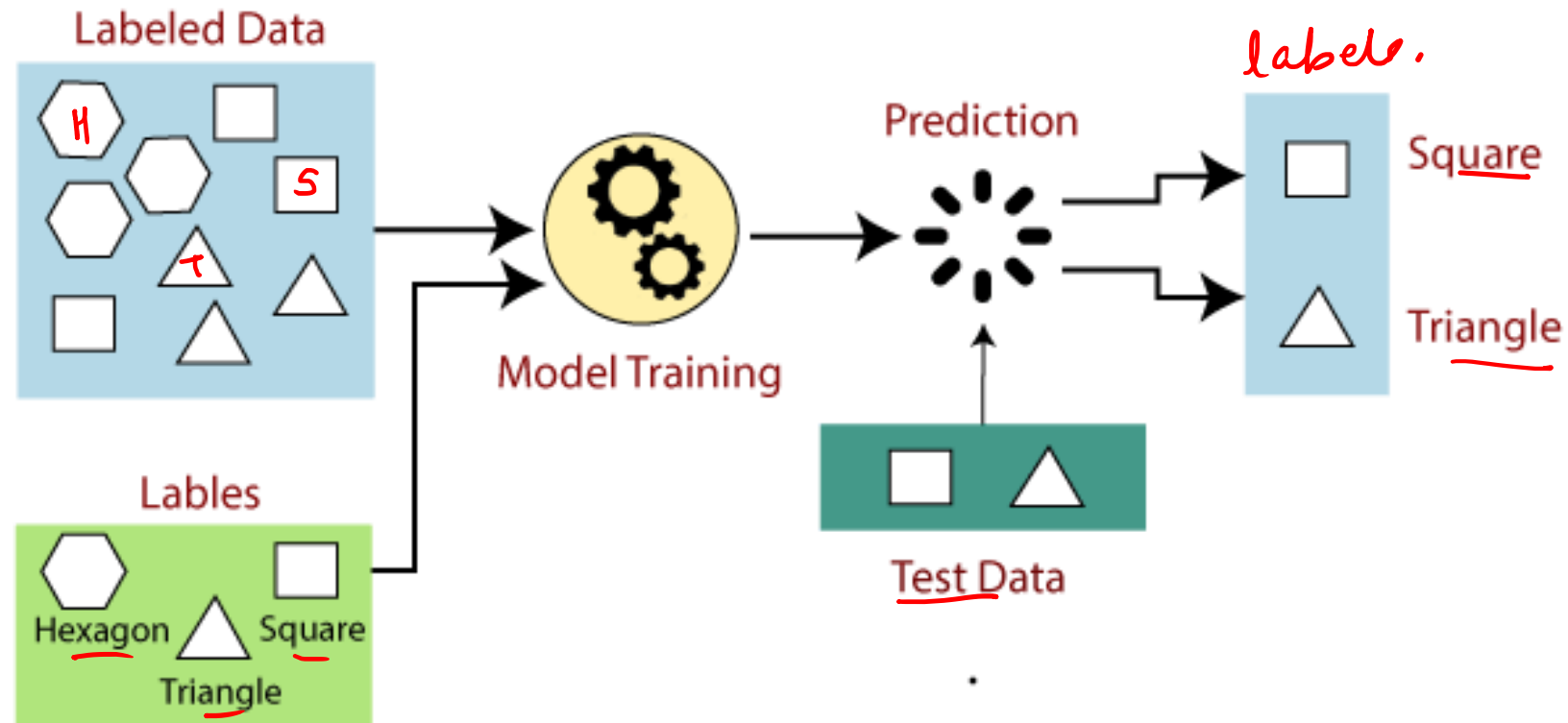
Pattern.

Pattern Recognition

Module 1

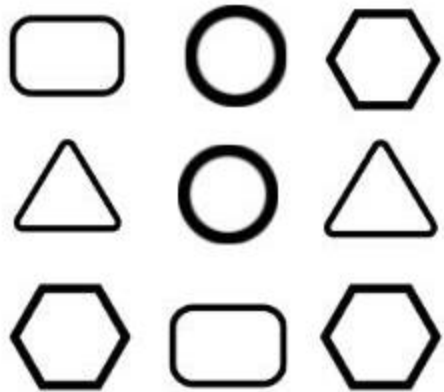
- ✓ Collect data
- ✓ Data processing and feature extr
- ✓ Design the classifier
- ✓ Evalⁿ accuracy.

Supervised Learning



Unsupervised Learning

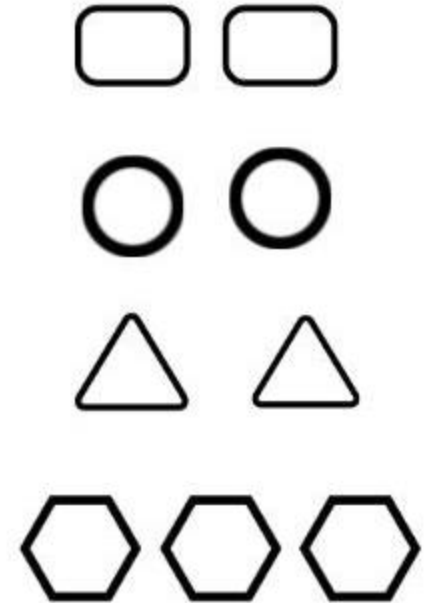
Unlabelled Data



Machine



Results



Features

Human =
height
weight
skin color
gender

- 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.

① Temp =
② Humidity. \Rightarrow
③ Windrate.
3 features

$\begin{bmatrix} \text{Temp} \\ \text{Hum} \\ \text{WR} \end{bmatrix}$
3-d. feature vector

$\begin{matrix} s_1 & s_2 & s_3 \\ \begin{bmatrix} 30 \\ 15 \\ 5 \end{bmatrix} & \begin{bmatrix} 22 \\ 8 \\ 15 \end{bmatrix} & \begin{bmatrix} 45 \\ 33 \\ 2 \end{bmatrix} \end{matrix}$
data. Sampled

Features

Human =

$\begin{bmatrix} \text{Height} \\ \text{weight} \end{bmatrix}$

$$\begin{matrix} h_1 & h_2 & h_3 \\ \begin{bmatrix} 130 \\ 25 \end{bmatrix} & \begin{bmatrix} 125 \\ 65 \end{bmatrix} & \begin{bmatrix} 100 \\ 100 \end{bmatrix} \end{matrix}$$

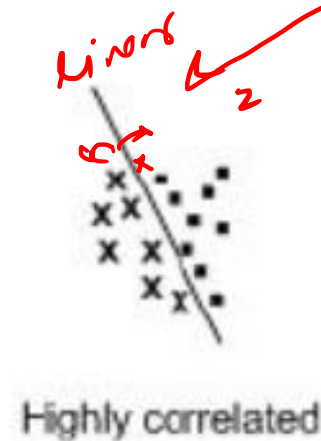
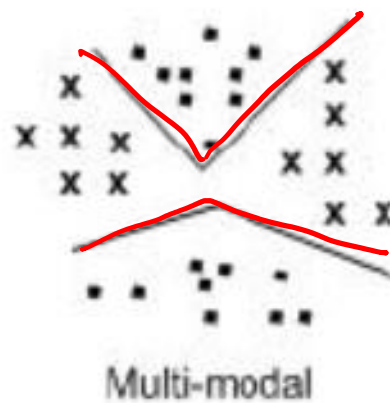
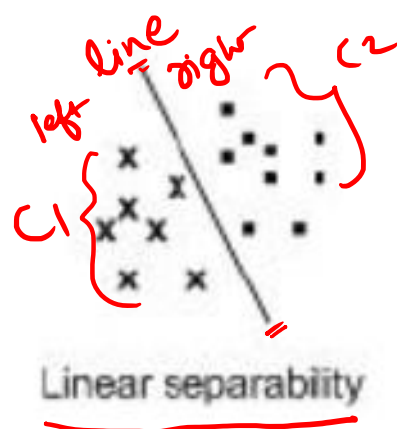
2D b.



-2D



(a)



(b)

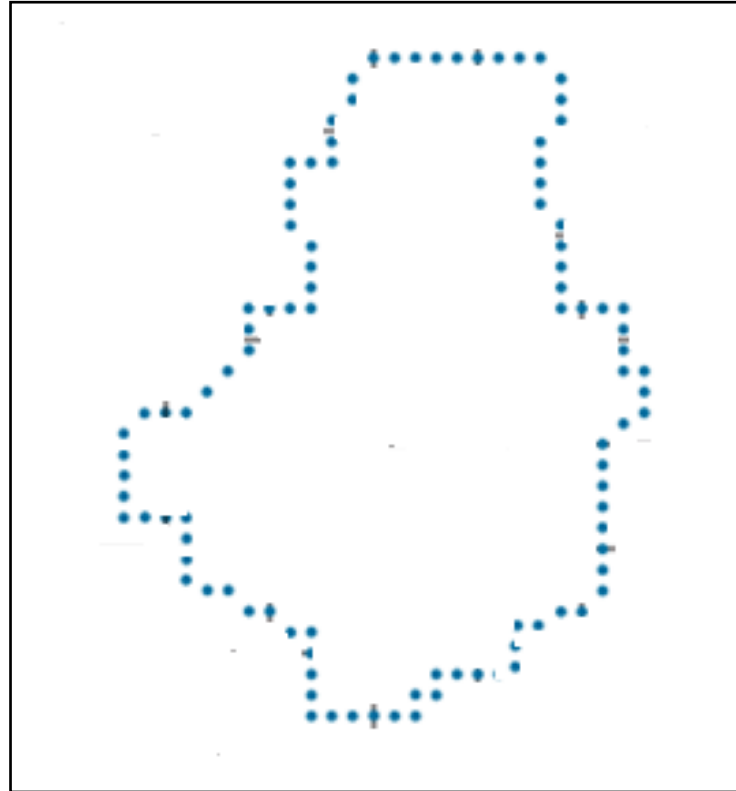
Features

Often the features are obtained from Shape and Region

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

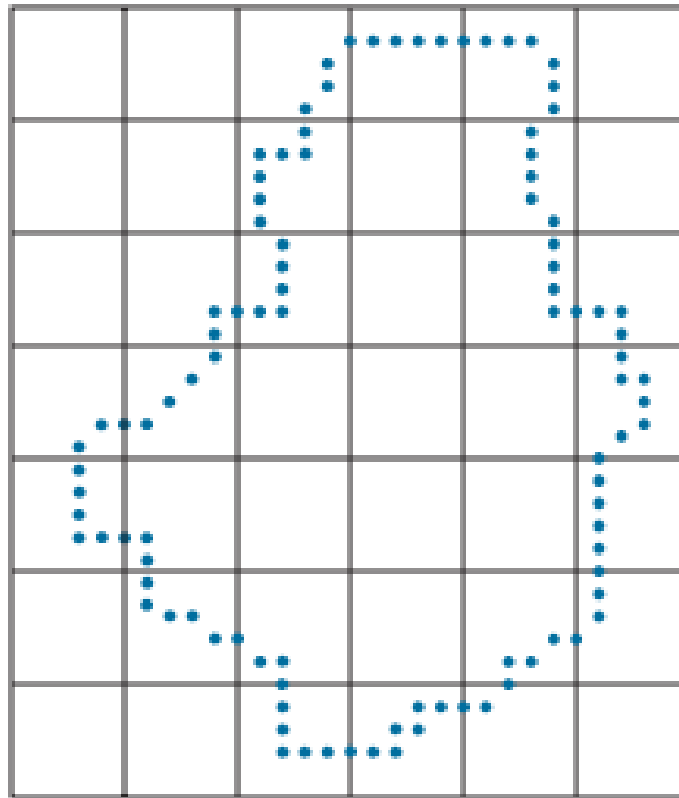
Features from shape

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



Features from shape

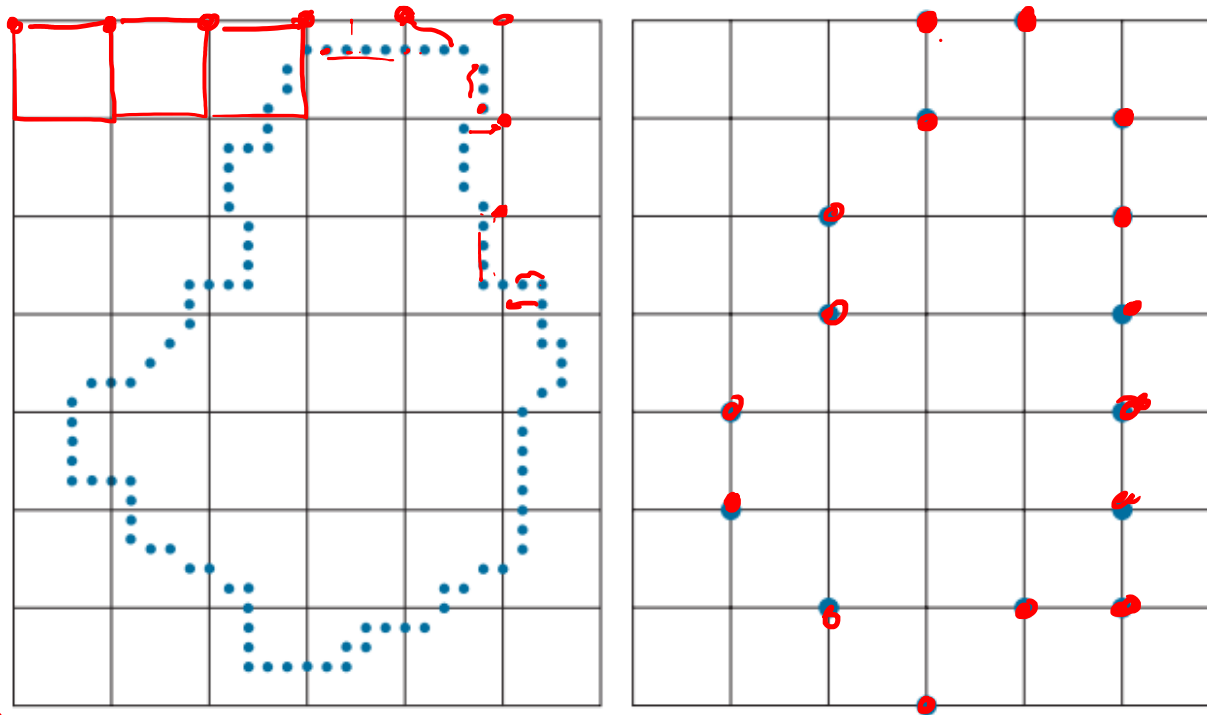
- Let us resample the boundary by selecting a larger grid spacing



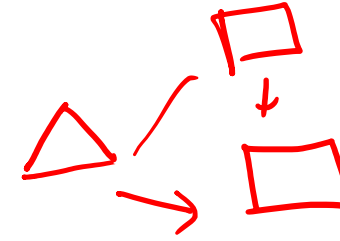
Features from shape

- 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

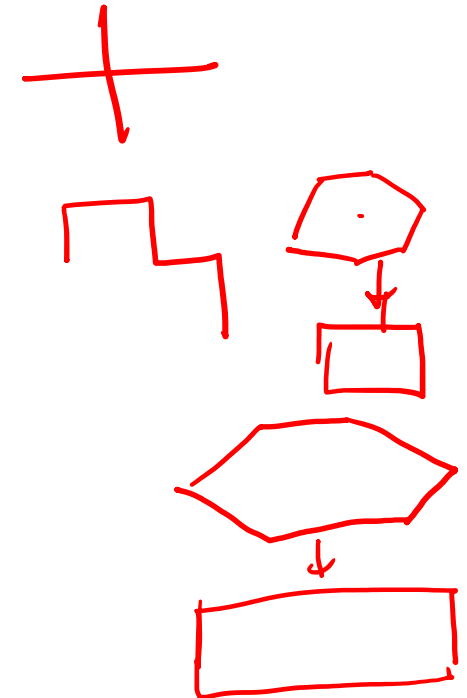
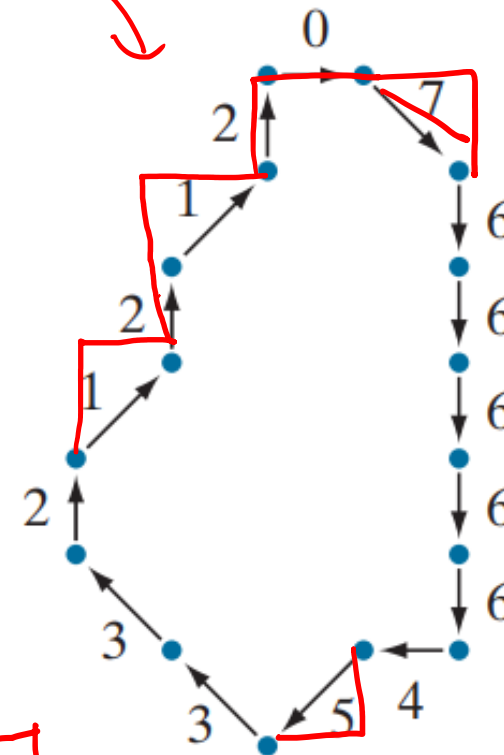
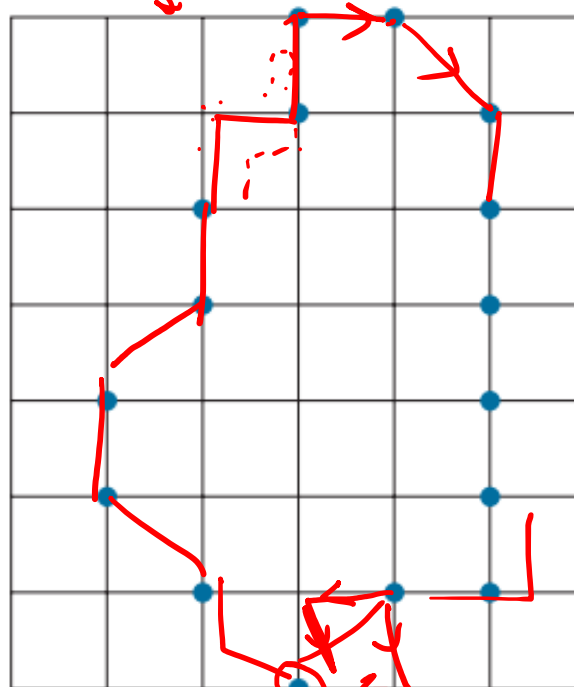
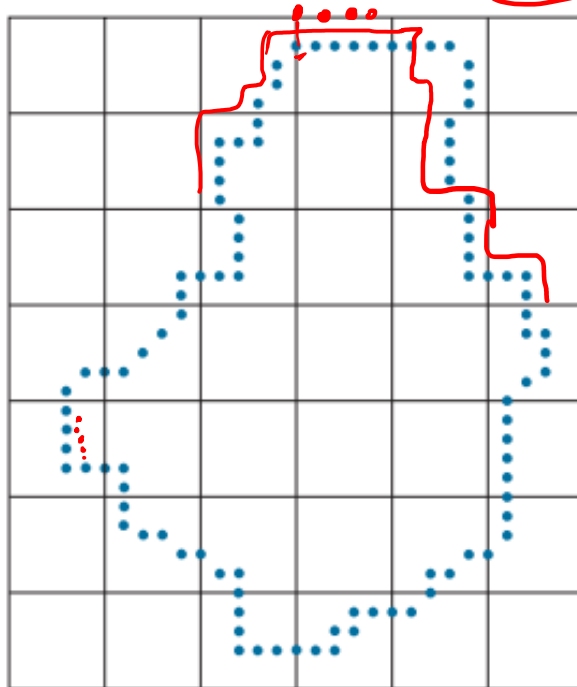
- ① group 7 pixels
- ② superimposed a grid
- ③ mapped pixels to the grid edge points to have an object-by-way



Chain Code Features



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



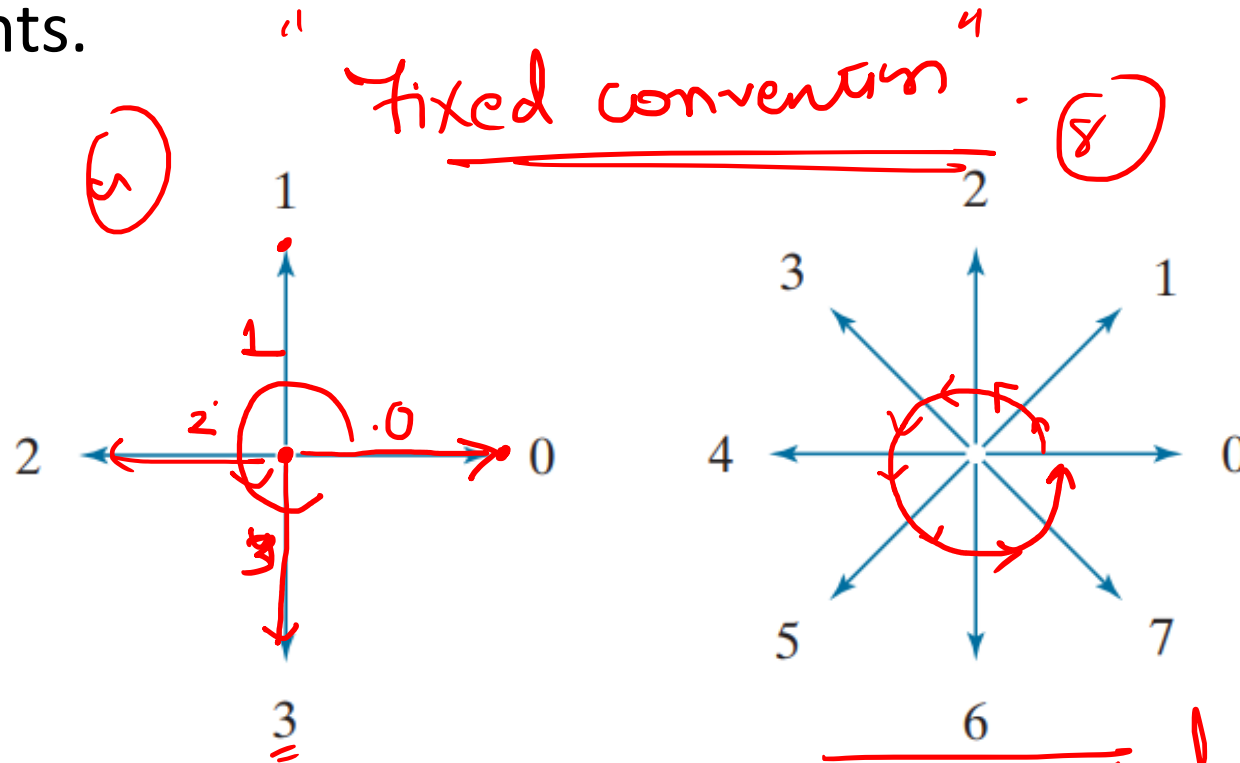
Chain Codes

- 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

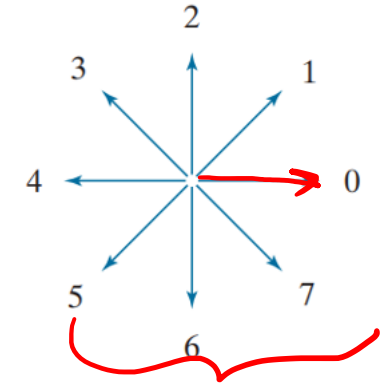
- Typically, a chain code representation is based on 4- or 8-connectivity of the segments.

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

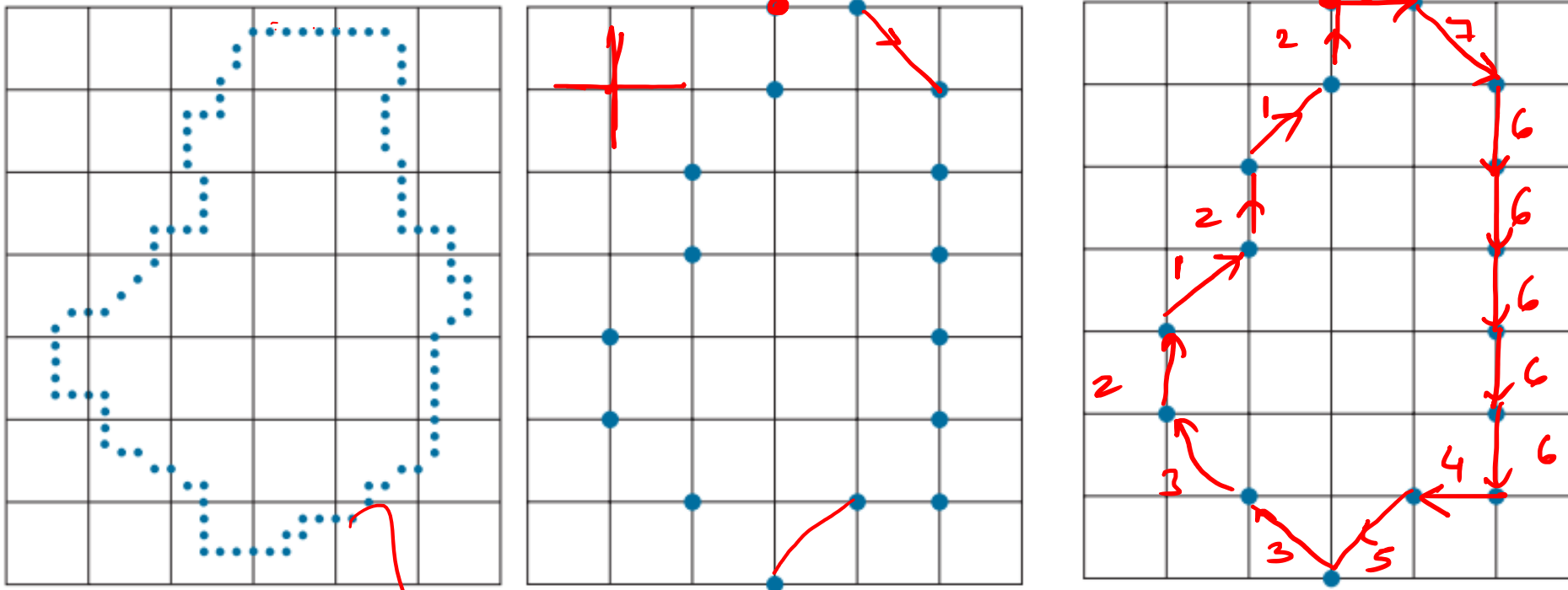


follow it throughout.

Chain Codes (8 Connectivity)

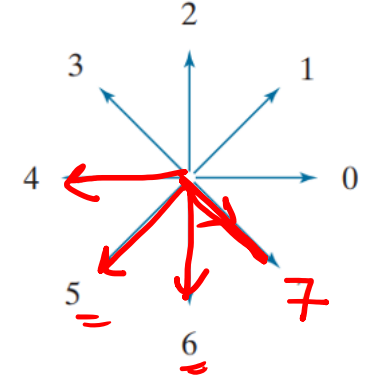


- We fix one starting point and start assigning directions

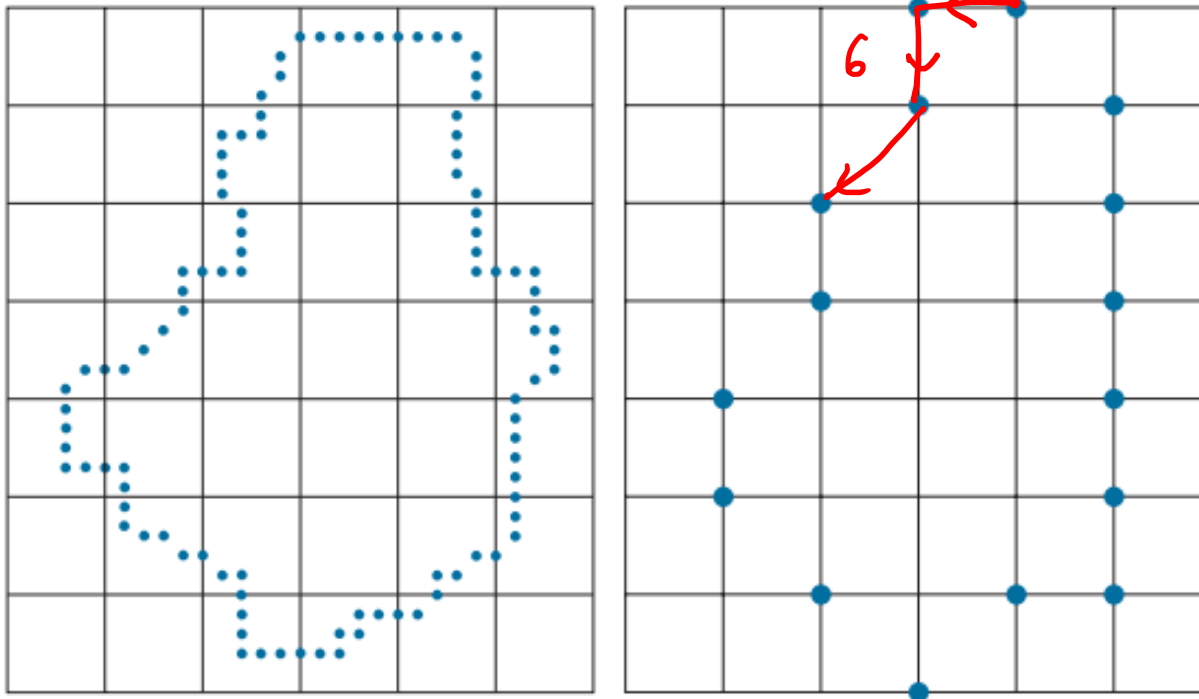


- the spacing of the resampling grid is determined by the application in which the chain code is used. → Chain code = 0 7 6 6 6 6 6 4 5 3 3 2 1 2 1 2
- numeric description*

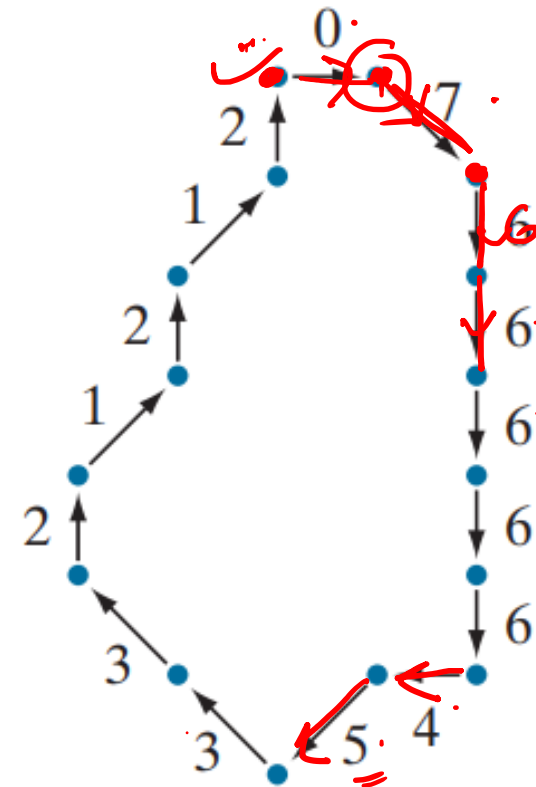
Chain Codes (8 Connectivity)



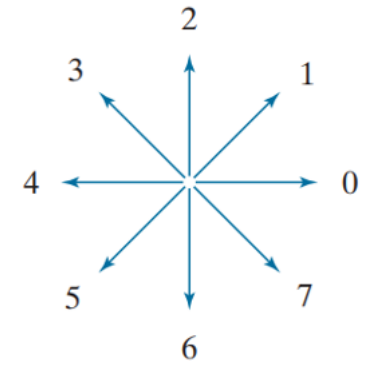
- The numerical value of a chain code depends on the starting point.



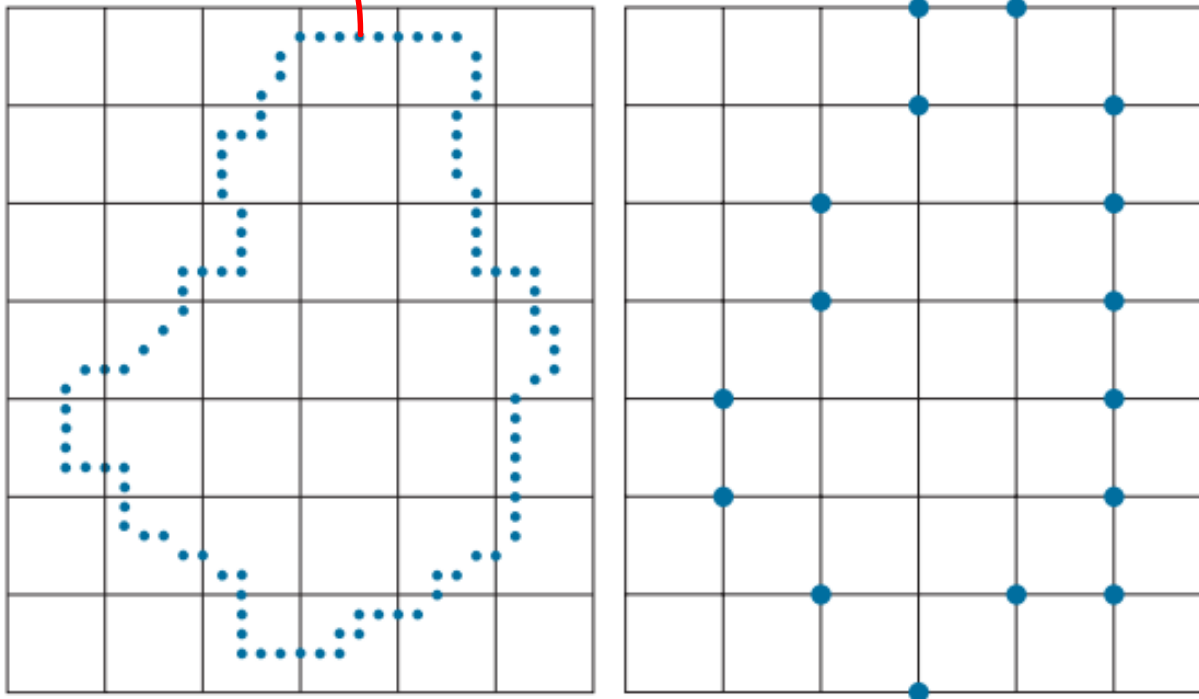
chain code 0766666454421212



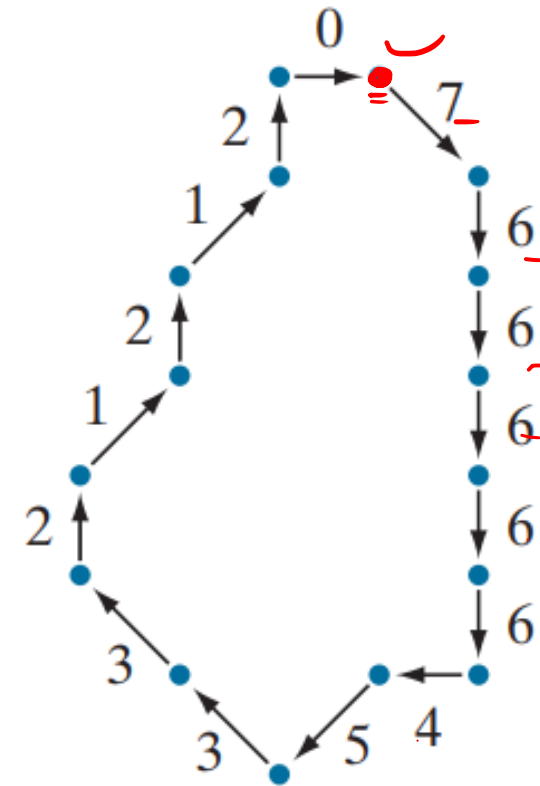
Chain Codes (8 Connectivity)



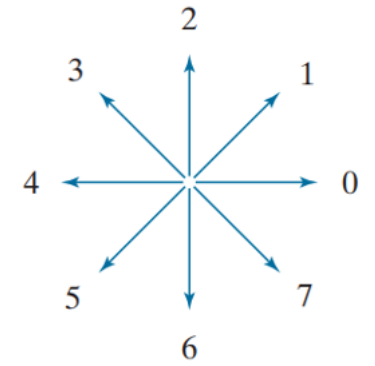
- The ^{nu}numerical value of a chain code depends on the starting point.



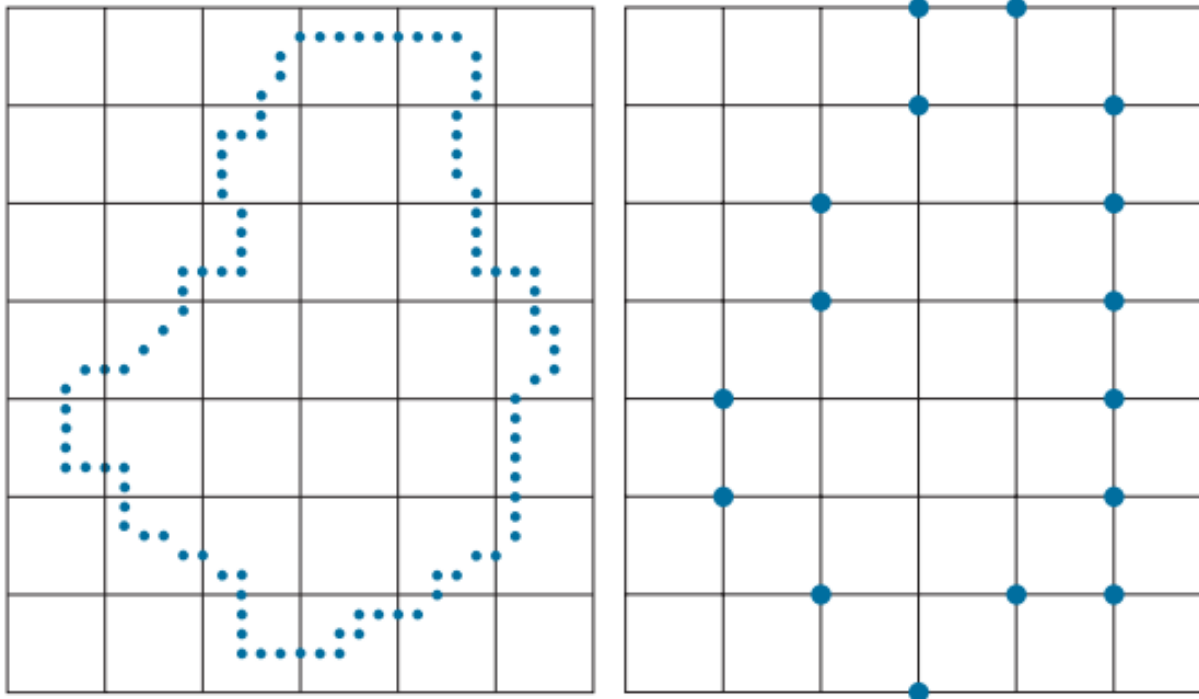
chain code 7666664544212120



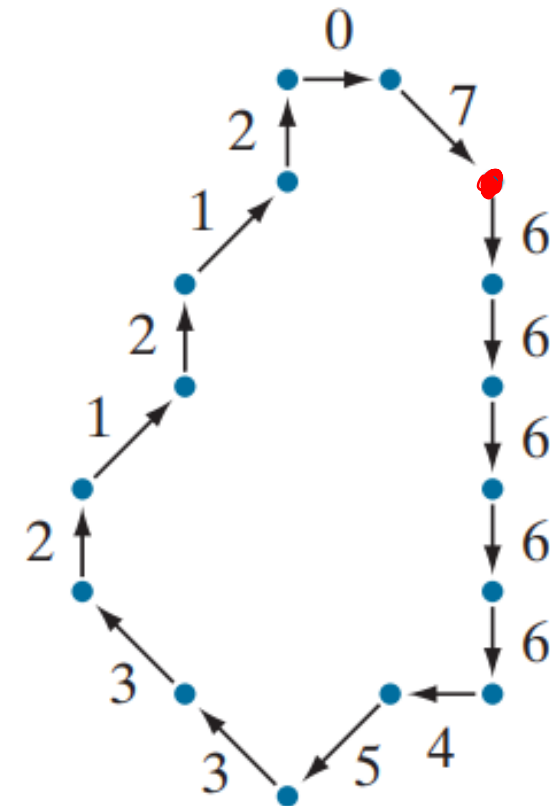
Chain Codes (8 Connectivity)



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



chain code 6666645442121207

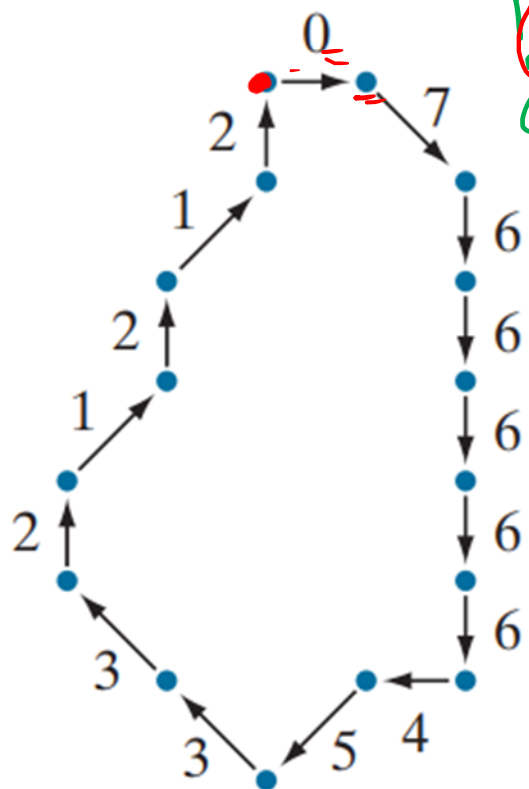
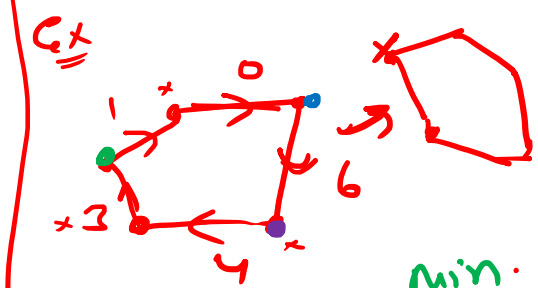
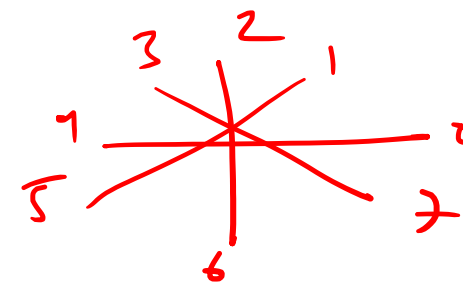


Normalize chain code

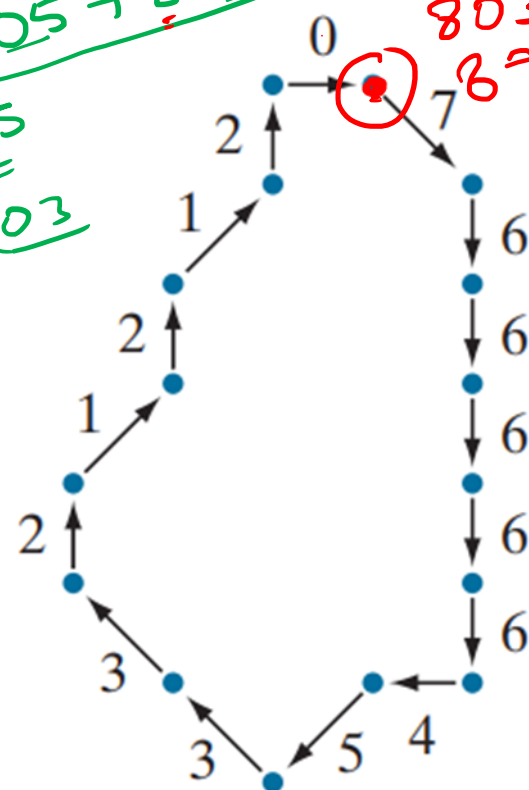
The code can be normalized with respect to the starting point by a straightforward procedure:

- 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.

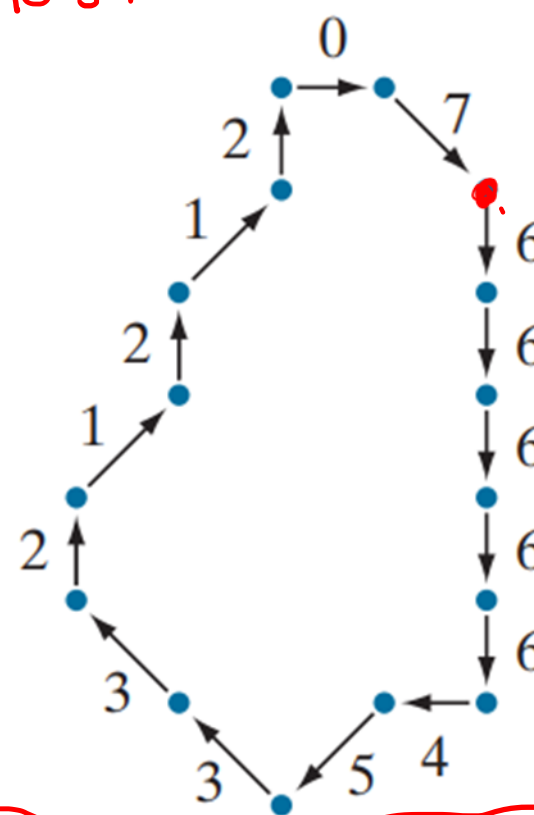
Normalize chain code



-0766666453321212°



-7666664544212120



666664542121207

4

min.
↓
0643

(1) 0 6 4 3 →

(2) 6 4 3 1 0 →

(3) 4 3 1 0 6 →

(4) 1 0 6 4 3 →

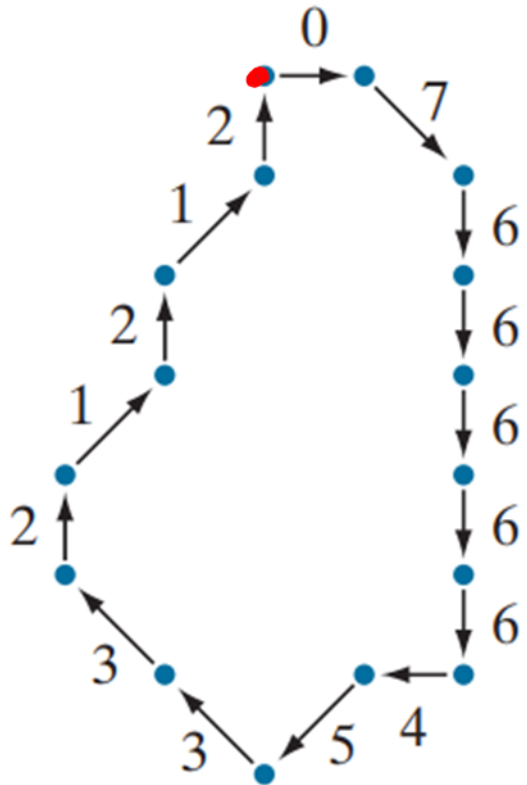
0643
064
0643

Handwritten diagram illustrating the reversal of the number 21207. The number 21207 is written with a red underline. Above it, the digits 64310 are written in a green box, with an arrow pointing from the box to the number 21207. To the right of 21207, the digits 06431 are written in a green box.

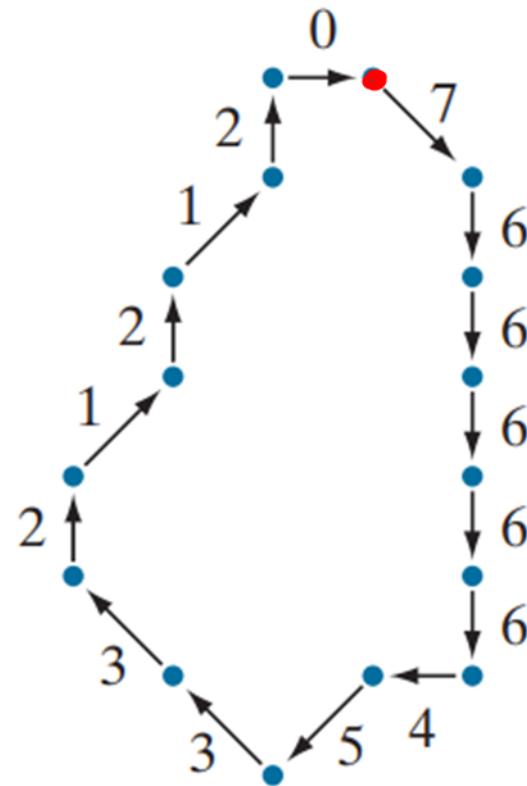
$[43106] \rightarrow 0, \underline{6431}$

Normalize chain code - *invariant to starting point.*

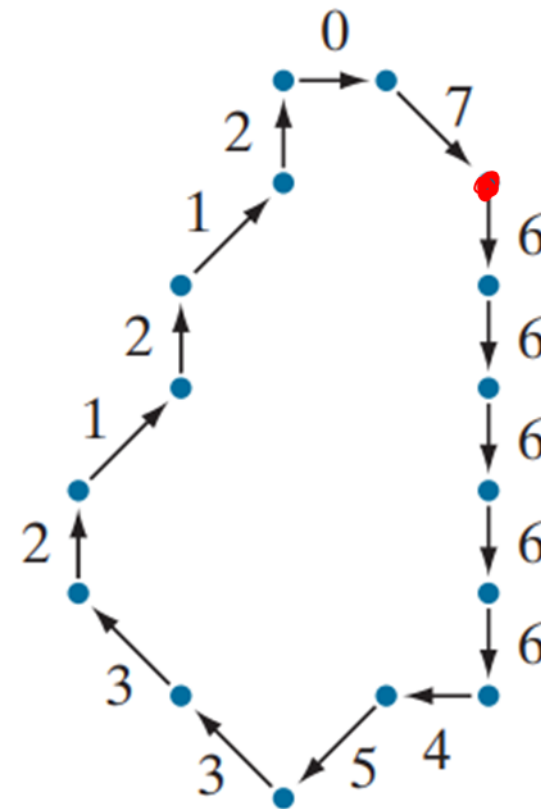
Form integer of minimum/ maximum magnitude



0766666454421212

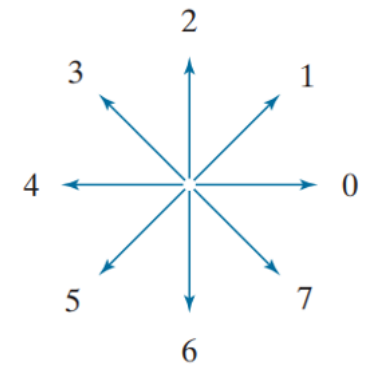


7666664544212120

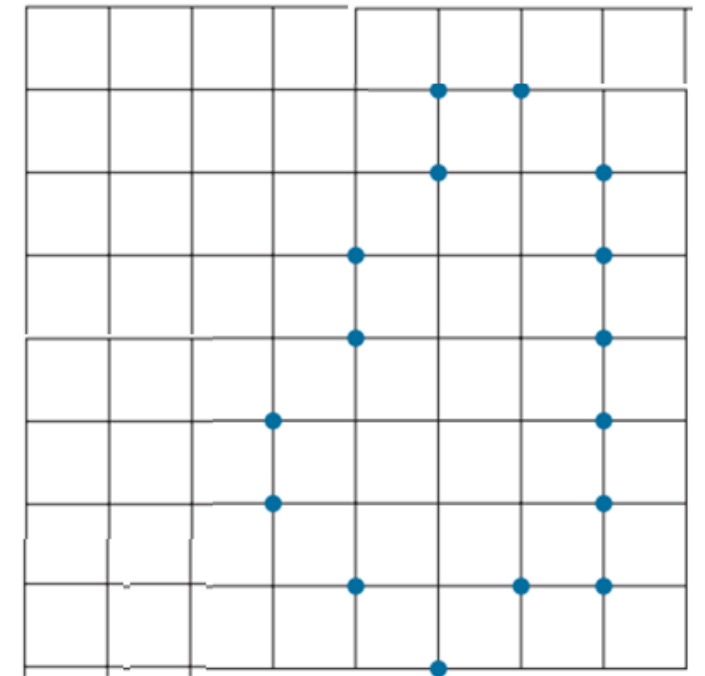
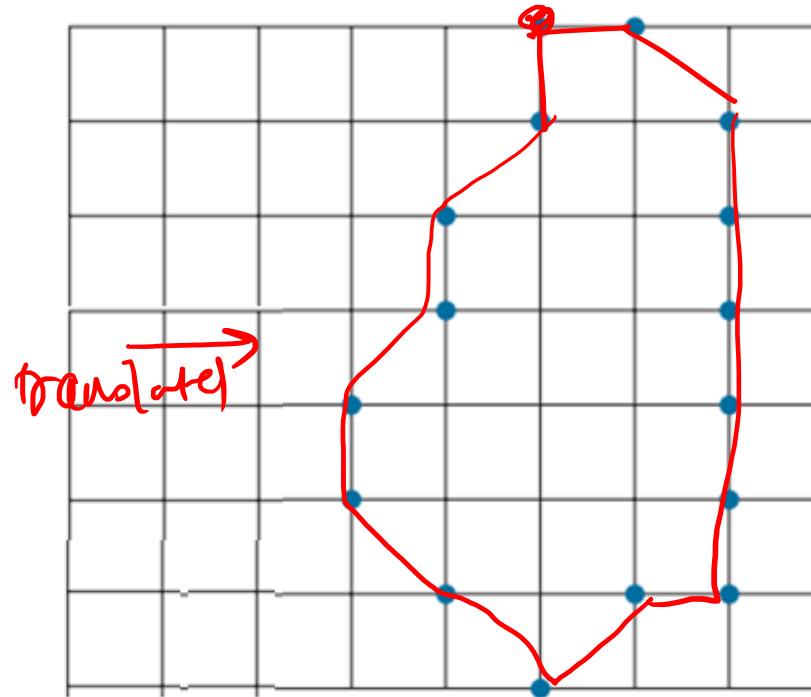
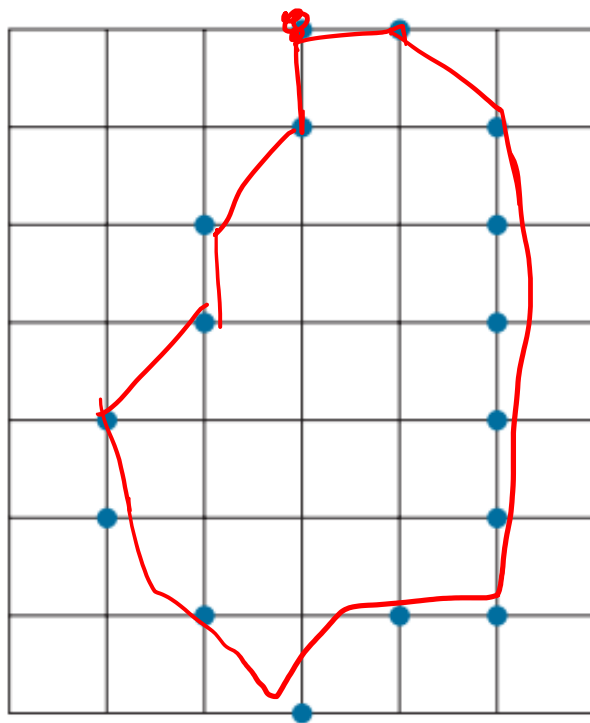


6666645442121207

Chain Codes – Invariant to translation

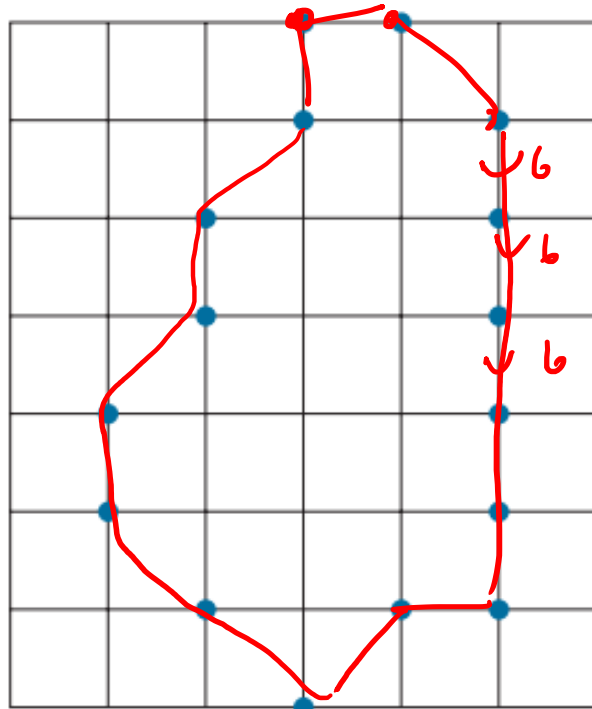
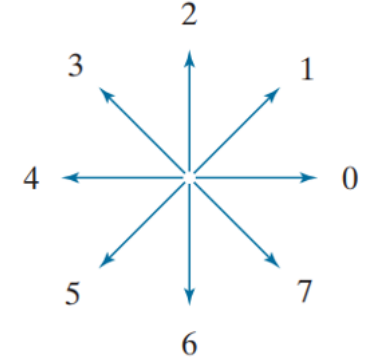
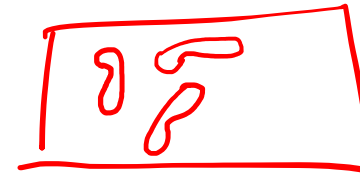


- For the same starting point

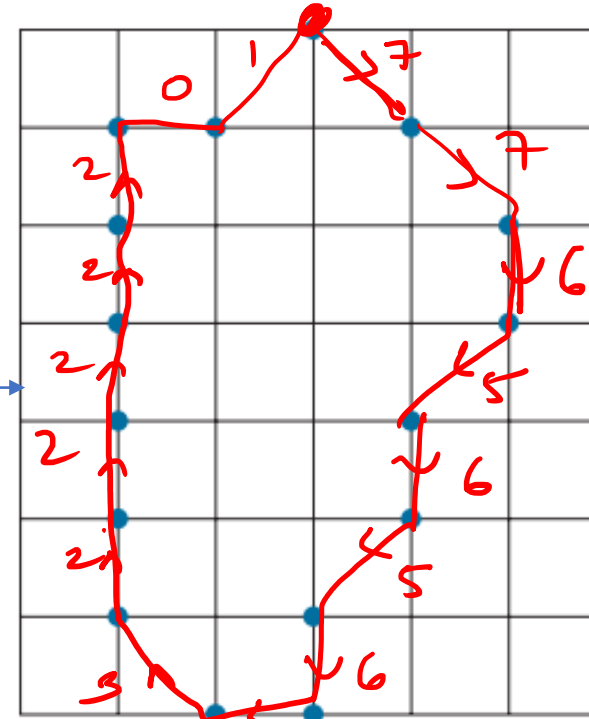


chain code 7666664544212120

Chain Codes and rotation



chain code 0766666454421212



chain code

7765656432222201

Properties

- Chain Codes depend upon starting points
- Chain Codes are not affected by translations provided the starting point is fixed. *invariant of SP. → max/min.*
- They change if the object is rotated.
- Then how to write a robust feature. *invariant to rotation.*

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.

The diagram shows a circle with eight blue arrows pointing outwards, labeled 0 through 7. Red curved lines and dots are drawn on the diagram, representing a specific arrangement of the eight queens. The red lines form a complex, symmetrical pattern that suggests a solution to the 8-queens problem.

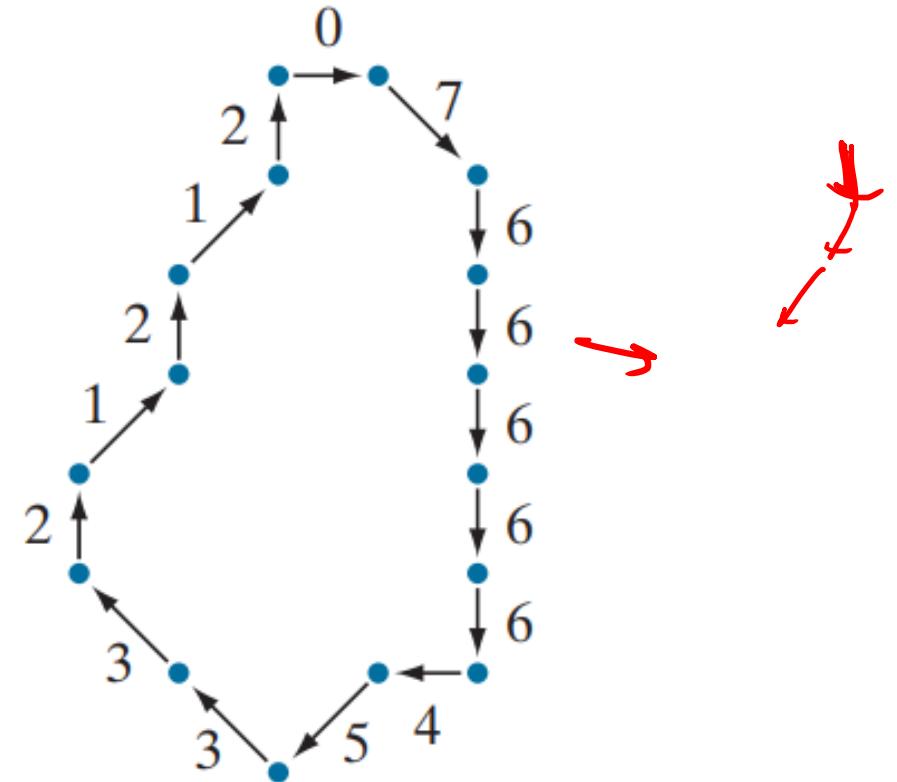
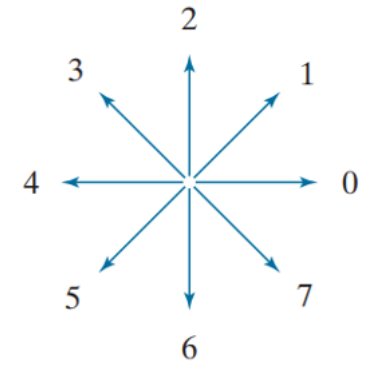
- This difference is obtained by counting the number of direction changes (in a counterclockwise direction) that separate two adjacent elements of the code.

Normalized chain codes

- First Difference of chain code:

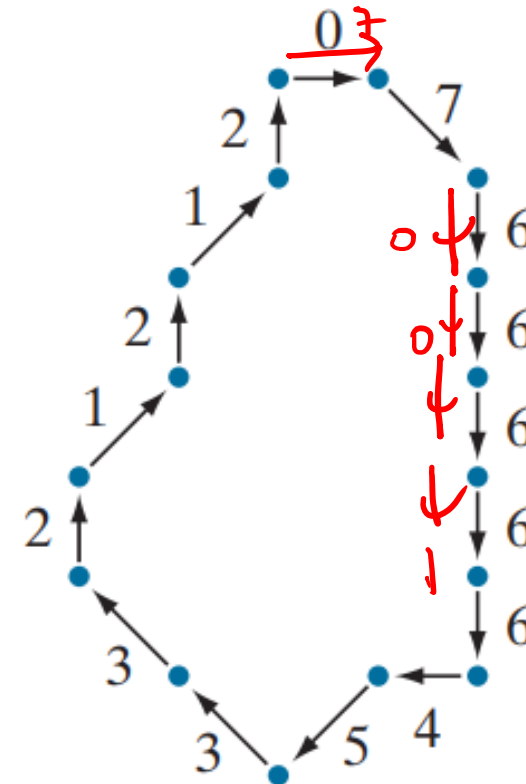
This difference is obtained by counting the number of direction changes (in a counterclockwise direction) that separate two adjacent elements of the code.

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

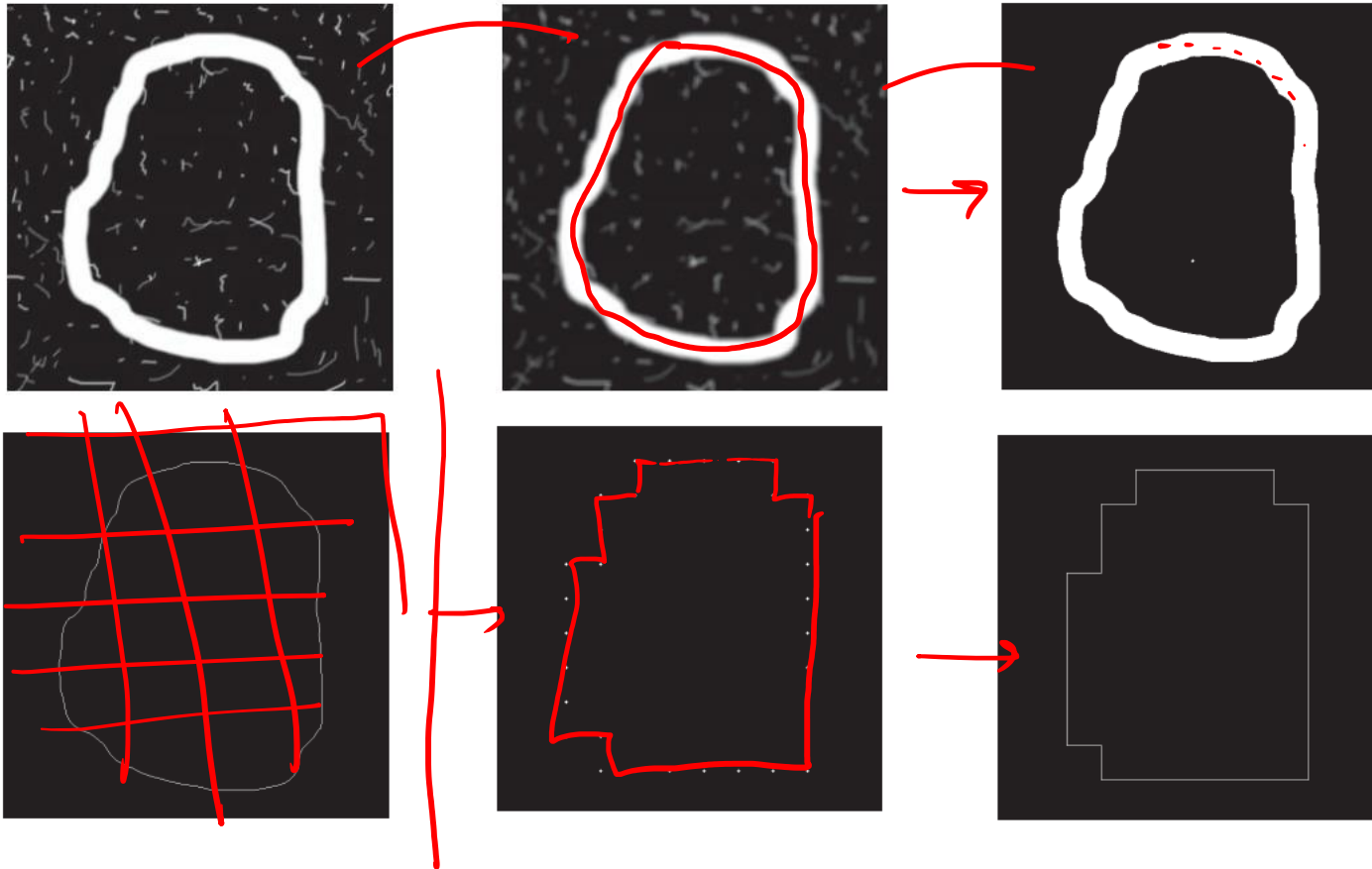
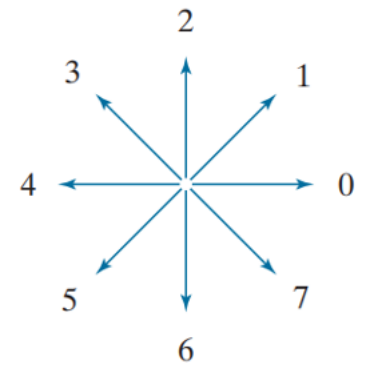


- This difference is obtained by counting the number of direction changes (in a counterclockwise direction) that separate two adjacent elements of the code.

✓ 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 #D
min / max. → 7 7 0 0 0 0 6 1 7 0 6 7 3 7 1 6
min 0 0 0 0 6 1 7 0 6 7 3 7 1 6 7 7

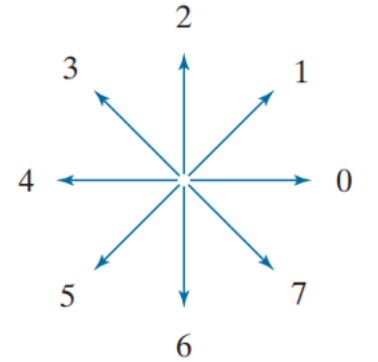
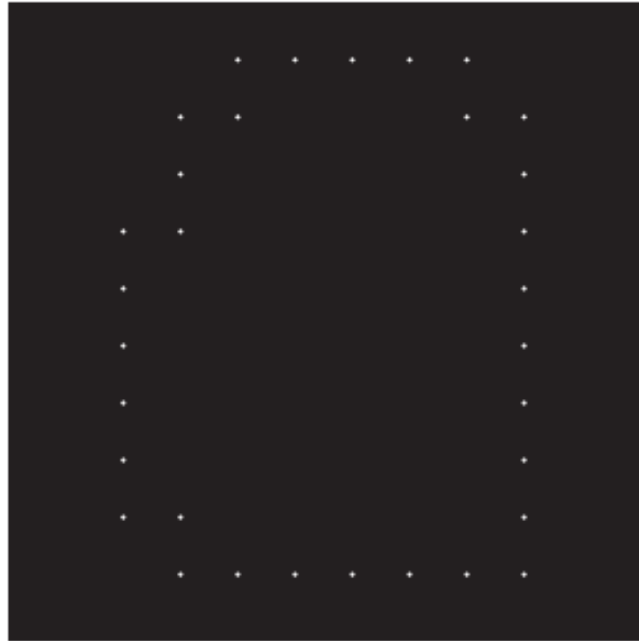


Application of freeman chain code



Application of freeman chain code

- Take simplified boundary



SHAPE NUMBERS

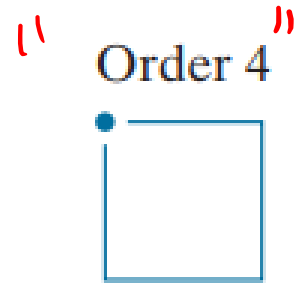
Write chain codes ✓
Normalize → min max ✓
First Diff

- 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

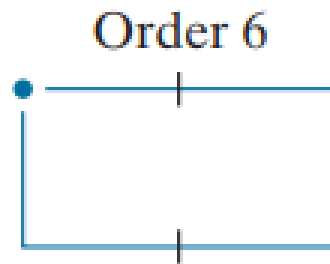
- Four connectivity



Chain code: 0 3 2 1

Difference: 3 3 3 3

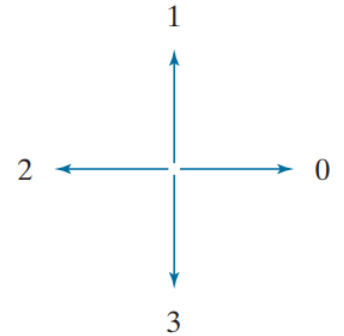
Shape no.: 3 3 3 3



0 0 3 2 2 1

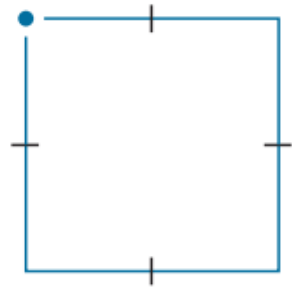
3 0 3 3 0 3

0 3 3 0 3 3

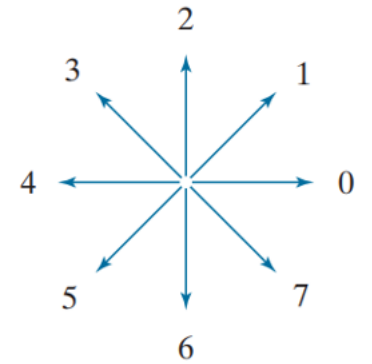
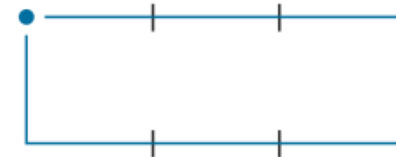
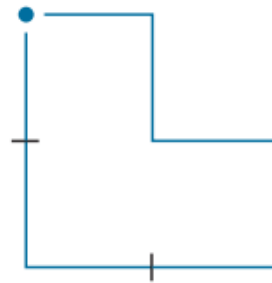


Shape Numbers

- Eight connectivity



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