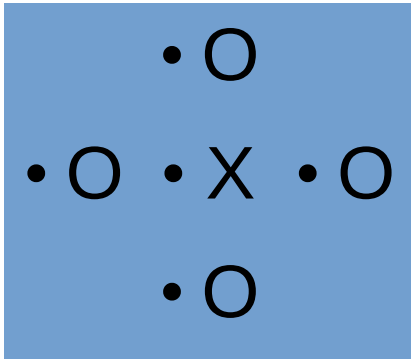
Connectivity

Neighbors of a Pixel

- A pixel p at coordinates (x,y) has four horizontal and vertical neighbors whose coordinates are given by:
  (x+1,y), (x-1, y), (x, y+1), (x,y-1)

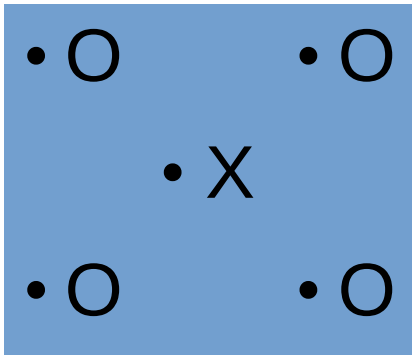


- This set of pixels, called the 4-neighbors or p, is denoted by $N_4(p)$.
- Each pixel is one unit distance from (x,y)

Neighbors of a Pixel

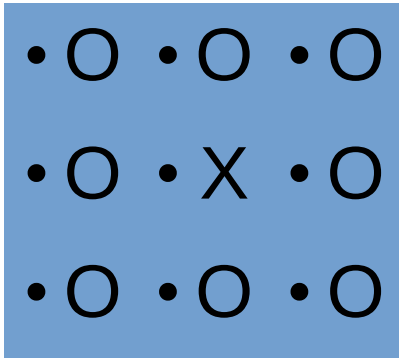
- The four diagonal diagonal neighbors of p have coordinates:

(x+1, y+1), (x+1, y-1), (x-1, y+1), (x-1, y-1) and are denoted by $N_D(p)$.



- Each of them are at Euclidean distance of 1.414 from P.

- The $N_D(p)$ points, together with the 4-neighbors, are called the 8-neighbors of p, denoted by $N_8(p)$.



- Some of the neighbors of p lie outside the digital image if (x,y) is on the border of the image.

Connectivity of a Pixels

- Connectivity between pixels is a fundamental concept that simplifies the definition of numerous digital image.

- Establishing boundaries of objects and components of regions in an image.

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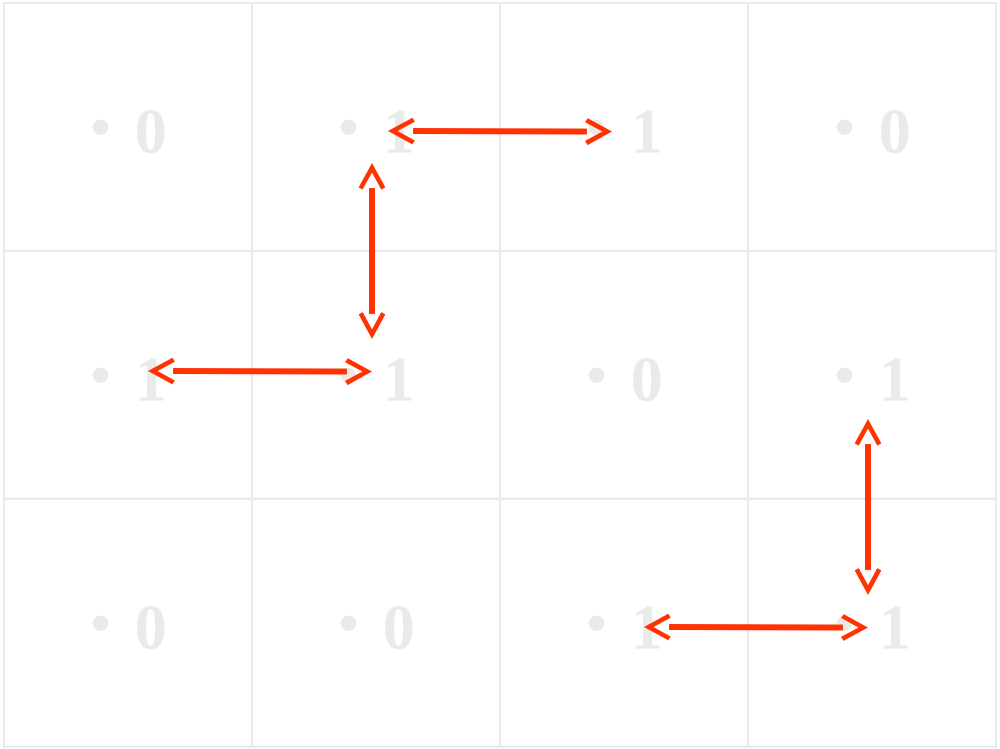
- Two pixels are said to be connected
  - if they are neighbours and
  - If their gray levels satisfy a specified criterion of similarity (if the gray-level values are equal)

- For example, in a binary image two pixels are connected if they are 4-neighbors and have same value (0/1).

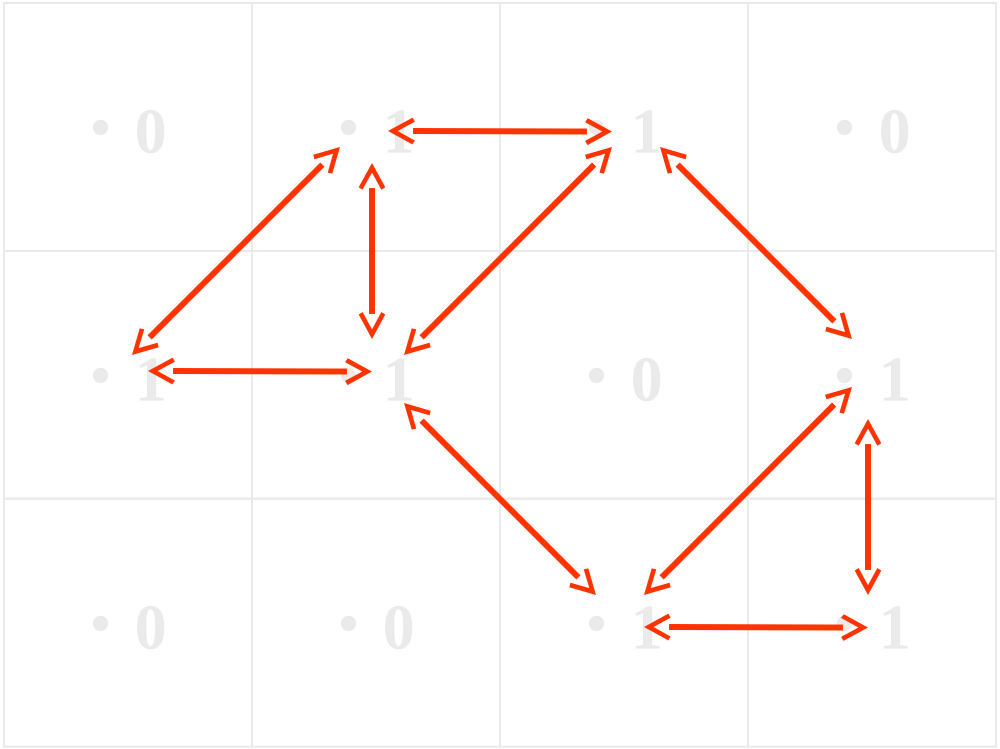
- Example 4-Connectivity

Set of color consists of color 1 ; C ={1}



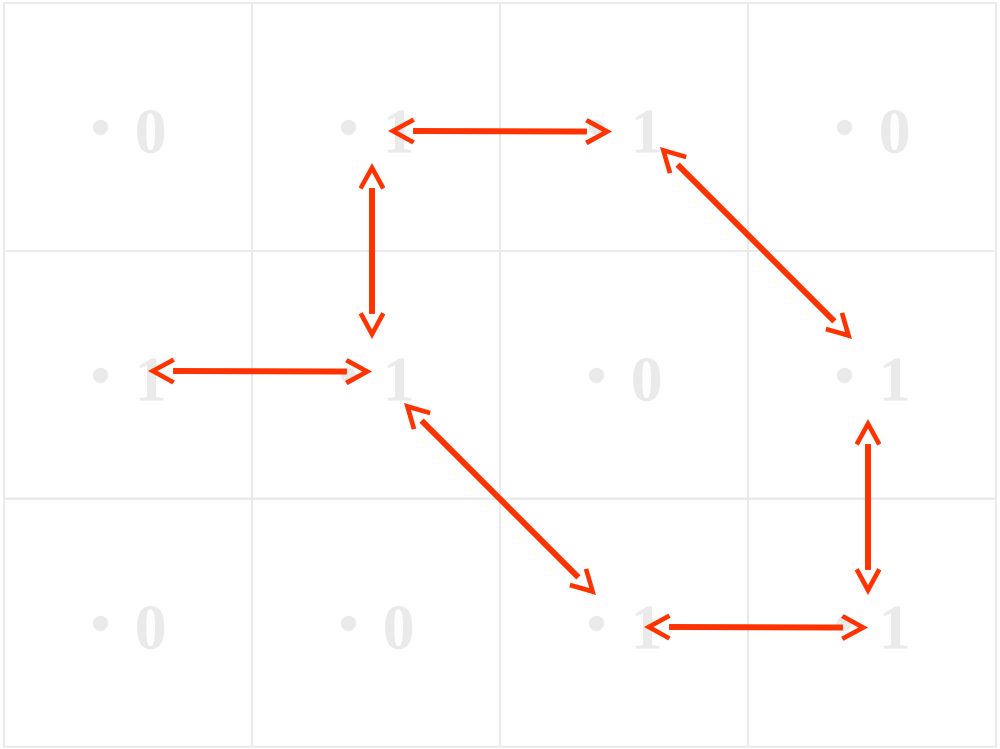
- Example 8-Connectivity

- Set of color consists of color 1 ; C ={1}



- Example M-Connectivity

- Set of color consists of color 1 ; C ={1}



Adjacency

- Let *V*: a set of intensity values used to define adjacency
- In a binary image, $V = \{1\}$, if we are referring to adjacency of pixels with value 1.
- In a gray-scale image, the idea is the same, but *V* typically contains more elements, for example, $V = \{180, 181, 182, \ldots, 200\}$
- If the possible intensity values 0 – 255, *V* set can be any subset of these 256 values.
- 3 types of adjacency

Types of Adjacency

- **4-adjacency:** Two pixels *p* and *q* with values from *V* are 4-adjacent if *q* is in the set 4 neighbors of 'p' $N_4(p)$.

V = {2, 5}

1 **2** 0
4 **2** **5**
1 3 1

- **8-adjacency:** Two pixels *p* and *q* with values from *V* are 8-adjacent if *q* is in the set 8 neighbors of 'p' $N_8(p)$.

v={1,2,3}

3 4 2
2 **1** 0
3 **1** **1**

-

Types of Adjacency

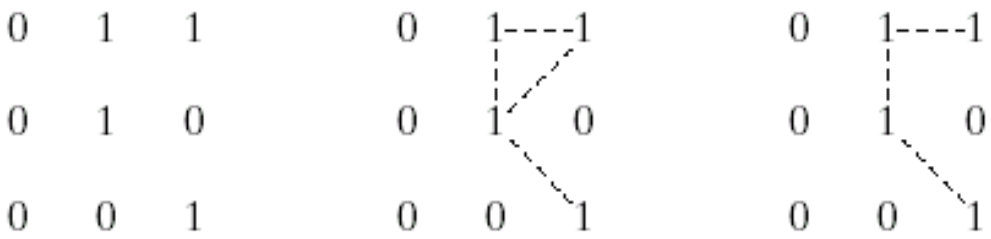
m-adjacency =(mixed adacency) Two pixels *p* and *q* with values from *V* are m-adjacent if :
(i) *q* and *p* are 4-adjacent, or
(ii) *p* and *q* are diagonally adjacent q is in $N_D(p)$ and the set $N_4(p) \cap N_4(q)$ is empty. (has no pixels whose values are from V)

$$\begin{matrix} 0_a & 1_b & 1_c \\ 0_d & 1_e & 0_f \\ 0_g & 0_h & 1_i \end{matrix}$$

V = {1} (1) b & c (2) b & e (3) e & I (4) e & c

- Some Basic Relationships Between Pixels

- An example of adjacency:



a b c

FIGURE 2.26 (a) Arrangement of pixels; (b) pixels that are 8-adjacent (shown dashed) to the center pixel; (c) *m*-adjacency.

Paths & Path lengths

- A path from pixel p with coordinates (x, y) to pixel q with coordinates (s, t) is a sequence of distinct pixels with coordinates:

$(x_0, y_0), (x_1, y_1), (x_2, y_2) \ldots (x_n, y_n)$,

where $(x_0, y_0) = (x, y)$ and $(x_n, y_n) = (s, t)$;

(x_i, y_i) is adjacent to (x_{i-1}, y_{i-1}) $1 \leq i \leq n$

Here n is the length of the path.

We can define 4-, 8-, and m-paths based on type of adjacency used.

If $(x_0, y_0) = (x_n, y_n)$, then the path is closed

Connected Set

- S – subset of pixels in an image
- Two pixels p and q said to be connected if there exists a path between them within S
- The set of pixels connected to p are called connected component of S
- If S has only one connected component then S is called Connected Set.

Connectivity by shortest paths

4 2 3 2

3 3 1 3

2 3 2 2

2 1 2 3

- Is there any path between the pixel 2 to 2
- V={1,2}
- 2->1->2->2->1-> no path for 2
- Shortest 4 path
-
- Shortest 8-path=4
-
- Shortest m-path=5
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Region and boundary

- Let ‘R’ be a subset of pixels in an image
- R is a region if it is a connected set
- Boundary or border or contour of a region is a set of pixels in the region that have one or more neighbours that are not in R
- If R is the entire image then the boundary will be set of pixels in the first row and last rows & first and last columns of the image.