University of Al-Hamdaniya
Computer Science Department
Digital image processing

Adjacency, Connectivity, Regions and Boundaries between pixels

Lec-6

By

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Adjacency, Connectivity, Regions and Boundaries

We consider three types of **adjacency**:

1. **4-adjacency:** Two pixels p and q with values from V are 4-adjacent if q is in the set $N_4(p)$.
2. **8-adjacency:** Two pixels p and q with values from V are 8-adjacent if q is in the set $N_8(p)$.
3. **m-adjacency (mixed adjacency):** Two pixels p and q with values from V are m-adjacent if (i) or (ii)

   (i) q is in $N_4(p)$.

   (ii) q is in $N_D(p)$ and the set has no pixels whose values $N_4(p) \cap N_4(q)$ are from V.

1. Adjacency

Adjacency: Two pixels are adjacent if they are neighbors and their intensity level 'V' satisfy some specific criteria of similarity.

e.g. V={1},

V = { 0, 2}

Binary image = { 0, 1}

Gray scale image = {0, 1, 2, , 255}

In binary images, 2 pixels are adjacent if they are neighbors & have some intensity values either **0 or 1**.

In gray scale, image contains more gray level values in range **0 to 255**.

1. Adjacency

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

e.g. V={0,1}

1	1	0
1	1	0
1	0	1

p in RED color q can be any value in Blue color

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

e.g. V={2,1}

0	1	1
0	2	0
0	0	1

p in RED color q can be any value in Blue color

1. Adjacency

c) m-adjacency (mixed adjacency): Two pixels p and q with values from V are m-adjacent if

(i) q is in $N_4(p)$., or

(ii) q is in N_D (p) and the set has no pixels whose values $N_4(p) \cap N_4(q)$ are from V.

e.g. V = { 1 }

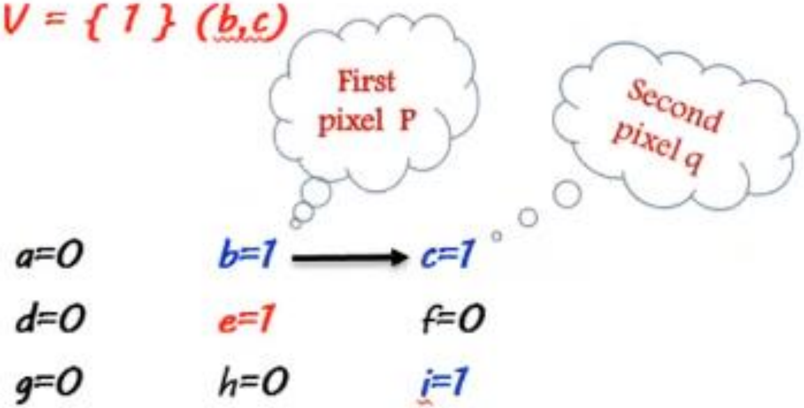
0	**1**	**1**
0	**1**	**0**
0	**0**	**1**

p in RED color q can be any value in Blue color

1. Adjacency

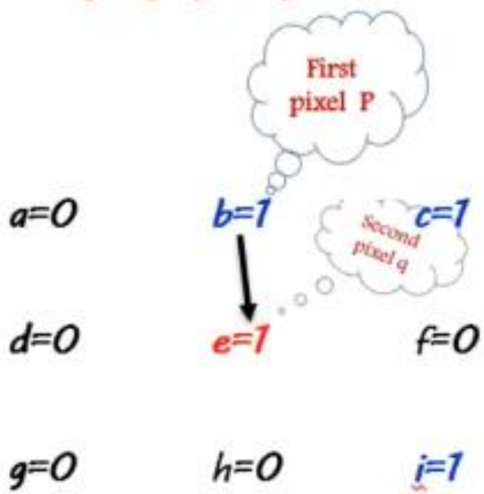
We can assume the following:

1) e.g. V = { 1 } (b,c)



we see b and c success the (i) q is in $N_4(p)$., so: b & c are m-adjacent.

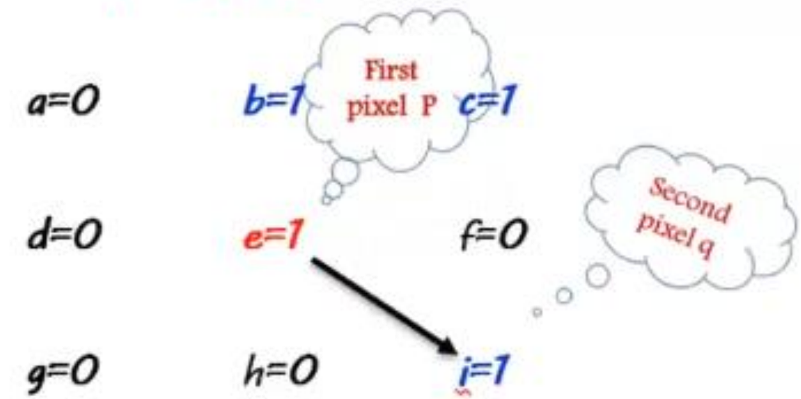
2) e.g. V = { 1 } (b, e)



we see b and e success the (i) q is in $N_4(p)$., so: b & e are m-adjacent.

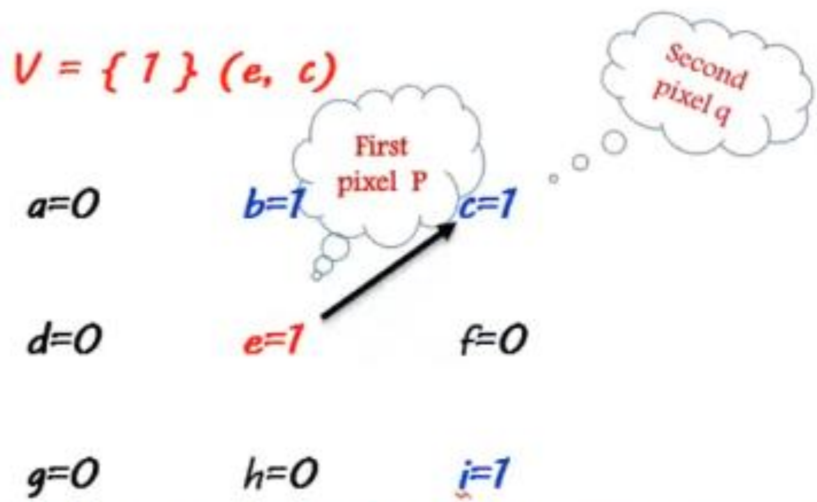
1. Adjacency

3) e.g. V = { 1 } (e, i)



set $N_4(p) \cap N_4(q)$ ={0} not in V, so: b & e are m-adjacent

1) e.g. V = { 1 } (e, c)



set $N_4(p) \cap N_4(q)$ ={ 1, 0} 1 in V, so: b & e are not m-adjacent

2. Path

Path

A (digital) path (or curve) from pixel p with coordinates (x_0, y_0) to pixel q with coordinates (x_n , y_n) is a sequence of distinct pixels with coordinates (x_0, y_0), (x_1, y_1),……, (x_n , y_n)

Here **n** is the length of the path.

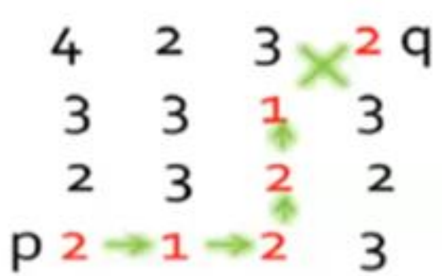
We can define 4-, 8-, and m-paths based on the type of adjacency used.

2. Path

Example: Consider the image segment shown in figure. Compute length to the **shortest-4**, **shortest-8** and **shortest-m** paths between pixels p & q where, **V = {1 , 2}.**

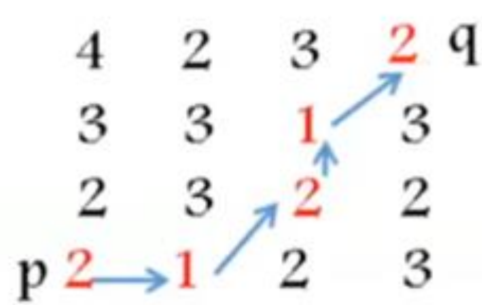
4	2	3	2 q
3	3	1	3
2	3	2	2
p 2	1	2	3

1. Shortest path N4



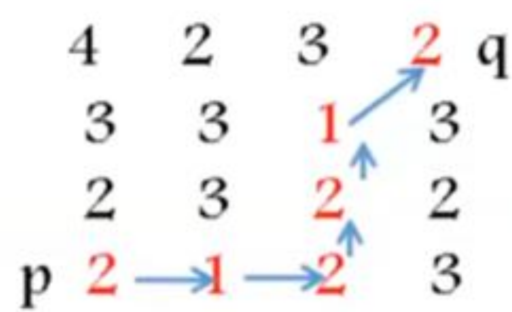
Shortest path N4 not exist

2. Shortest -8 path:



Shortest path N8=4

3. Shortest m-path



Shortest path m-path =5

3. Connectivity

Connectivity: **two pixels are said to be connected** if their exists a path between them. Let 'S' represent subset of pixels in an image.

Two pixels **p & q** are said to be connected in **'S'** if their exists a path between them consisting entirely of pixels in **'S'**.

Connected component and region

Let **S** represent a **subset of pixels in an image** • For every pixel **p** in **S**, the set of pixels in **S** that are connected to **p** is called a connected component of S.

- If **S** has only one connected component, then S is called **Connected Set**.
- We call **R** a region of the image **if R is a connected set**.
- Two regions, **Ri** and **Rj** are said to be adjacent if their **union** forms a **connected set**.
- **Regions** that are not to be adjacent are said to be **disjoint**.

4. Regions and boundaries

a) Boundary (or border)

The **boundary** of the region **R** is the set of pixels in the region that have **one** or **more neighbors** that are **not** in **R**.

If R happens to be an entire image, then its boundary is defined as the set of pixels in the first and last rows and columns of the image.

b) Foreground and background

An image contains **K** disjoint regions, $R_k = 1, 2, ..., K$.

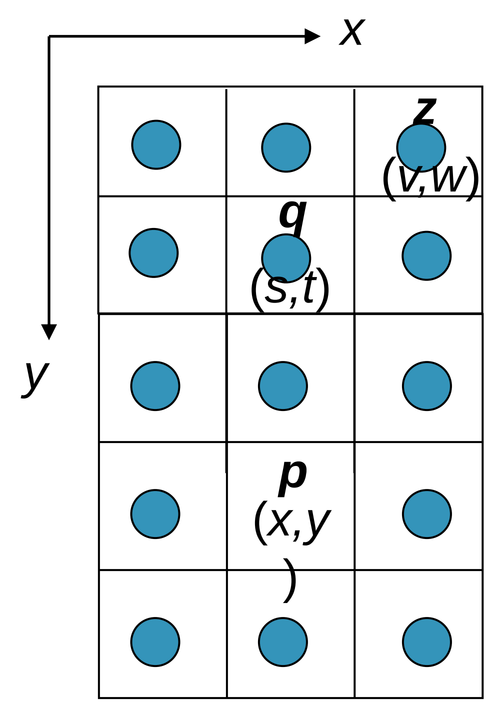
Let R_u denote the union of all the **K** regions, and let $\mathbf{(R_u)^c}$ denote its complement.

All the points in $\mathbf{R_u}$ is called **foreground**;

All the points in $\mathbf{(R_u)^c}$ is called **background**.

Distance Measure

- Suppose pixels *p*, *q*, and *z* are at coordinates (*x*,*y*), (*s*,*t*), and (*v*,*w*) respectively. *D* is a *distance function* or *metric* if
  1) $D(p,q) \geq 0$ ($D(p,q) = 0$ if $p = q$)
  2) $D(p,q) = D(q,p)$
  3) $D(p,z) \leq D(p,q) + D(q,z)$

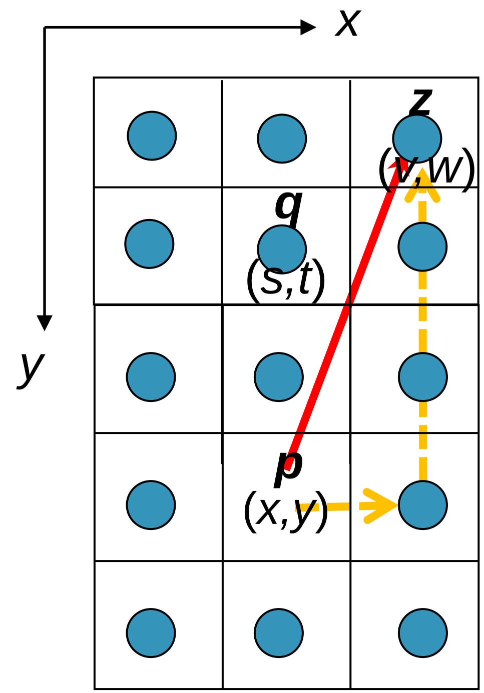


Distance Measure

- *Euclidean distance*

$$D_e(p,z) = \left[(x-v)^2 + (y-w)^2\right]^{\frac{1}{2}}$$

$$= \sqrt{10}$$

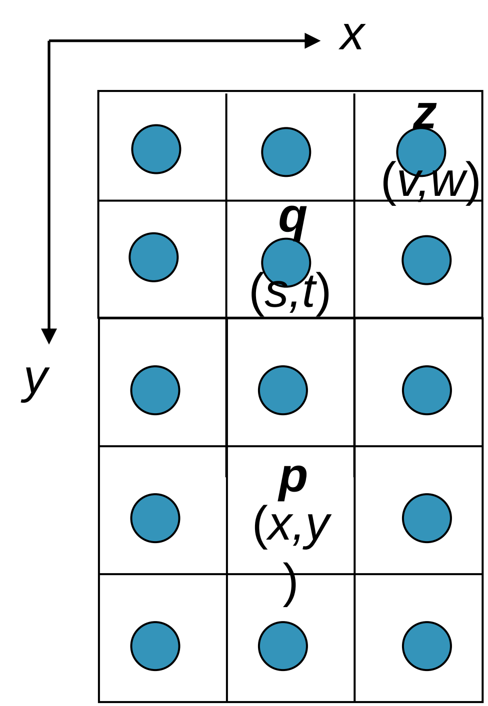


Distance Measure

- D_4 *distance* (*city-block distance*)

$$D_4(p,q) = |x - s| + |y - t|$$
$$= 2$$

$$D_4(p,z) = |x - v| + |y - w|$$
$$= 4$$

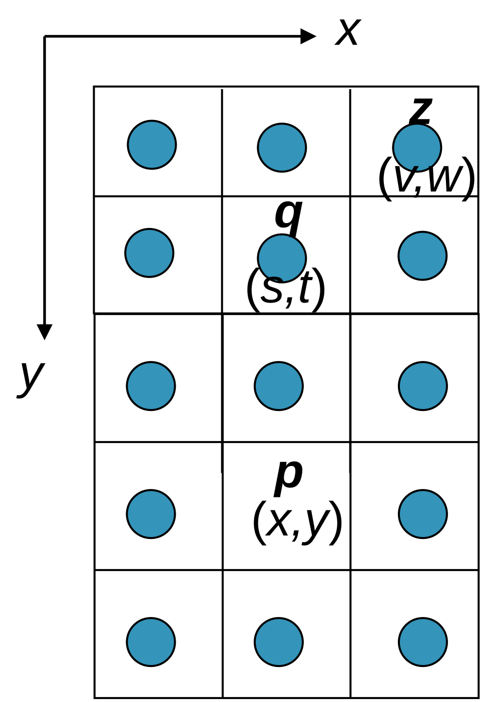


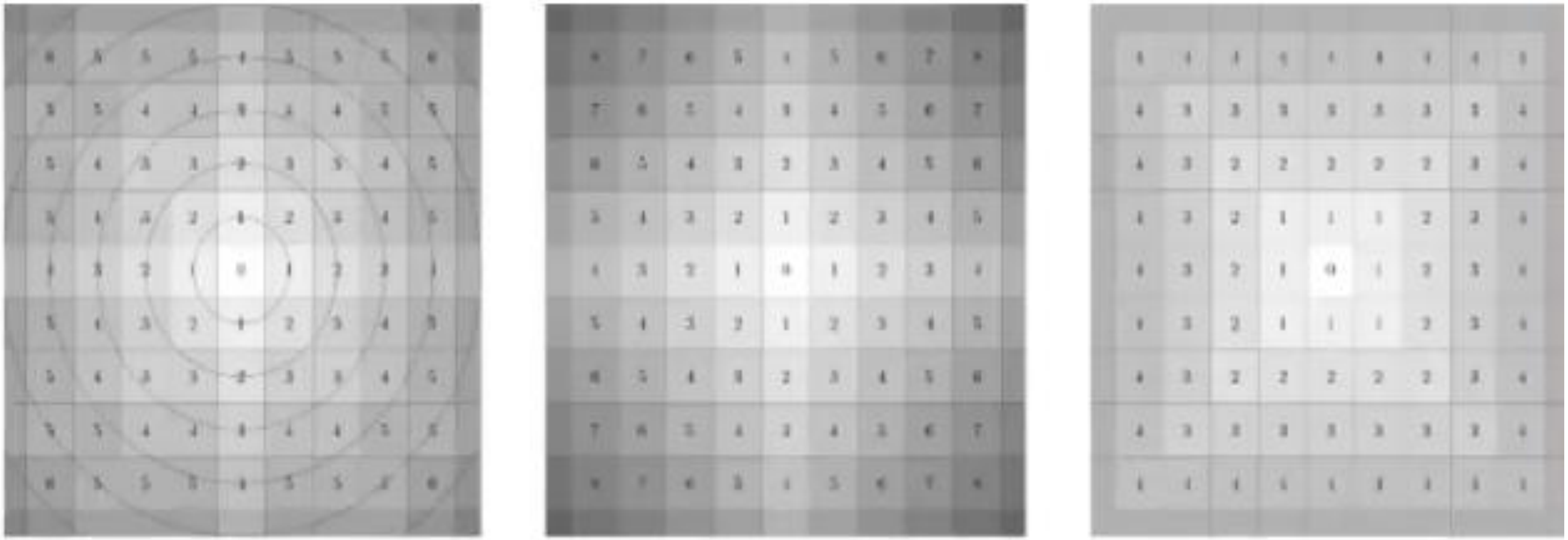
Distance Measure

- D_8 *distance* (*chessboard distance*)

$$D_8(p,q) = \max(|x-s|,|y-t|)$$
$$= 2$$

$$D_8(p,z) = \max(|x-v|,|y-w|)$$
$$= 3$$





D_e D_4 D_8

End of Lecture