SNS COLLEGE OF TECHNOLOGY

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Department of Biomedical Engineering

Course Name: 19BMB304 & Biomedical Image Processing

III Year : VI Semester

Unit I –DIGITAL IMAGE FUNDAMENTALS

Topic : Digital Image Processing – Relationships Between Pixels

Basic Relationships Between Pixels

- Neighborhood
- Adjacency
- Connectivity
- Paths
- Regions and boundaries

Basic Relationships Between Pixels

- **Neighbors** of a pixel p at coordinates (x,y)

➢ **4-neighbors of p**, denoted by $\mathbf{N_4(p)}$:
(x-1, y), (x+1, y), (x,y-1), and (x, y+1).

➢ **4 diagonal neighbors of p**, denoted by $\mathbf{N_D(p)}$:
(x-1, y-1), (x+1, y+1), (x+1,y-1), and (x-1, y+1).

➢ **8 neighbors of p**, denoted $\mathbf{N_8(p)}$
$N_8(p) = N_4(p) \cup N_D(p)$

Basic Relationships Between Pixels

- **Adjacency**

  Let V be the set of intensity values

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

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

Basic Relationships Between Pixels

- **Adjacency**

  Let V be the set of intensity values

➢ **m-adjacency**: Two pixels p and q with values from V are m-adjacent if

(i) q is in the set $N_4(p)$, or

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

Basic Relationships Between Pixels

- **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

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

Where (x_i, y_i) and (x_{i-1}, y_{i-1}) are adjacent for $1 \leq i \leq n$.

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

➢ If $(x_0, y_0) = (x_n, y_n)$, the path is ***closed*** path.

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

Examples: Adjacency and Path

V = {1, 2}

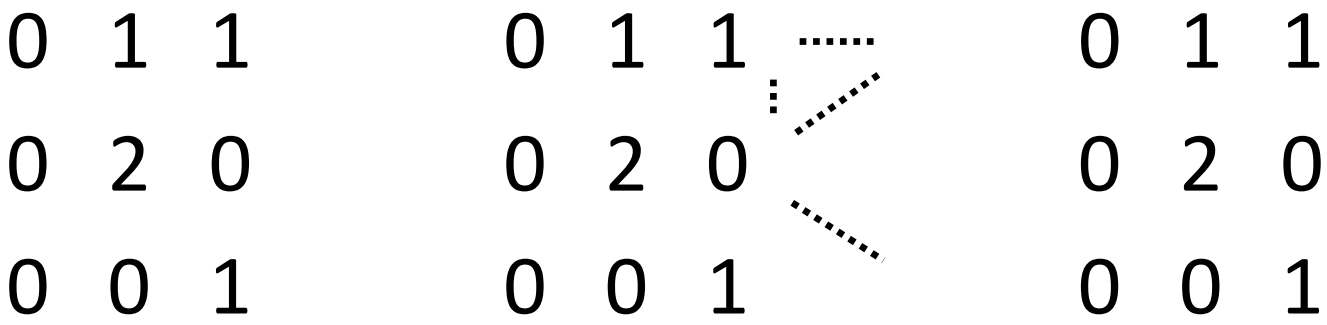
0	1	1
0	2	0
0	0	1

0	1	1
0	2	0
0	0	1

0	1	1
0	2	0
0	0	1

Examples: Adjacency and Path

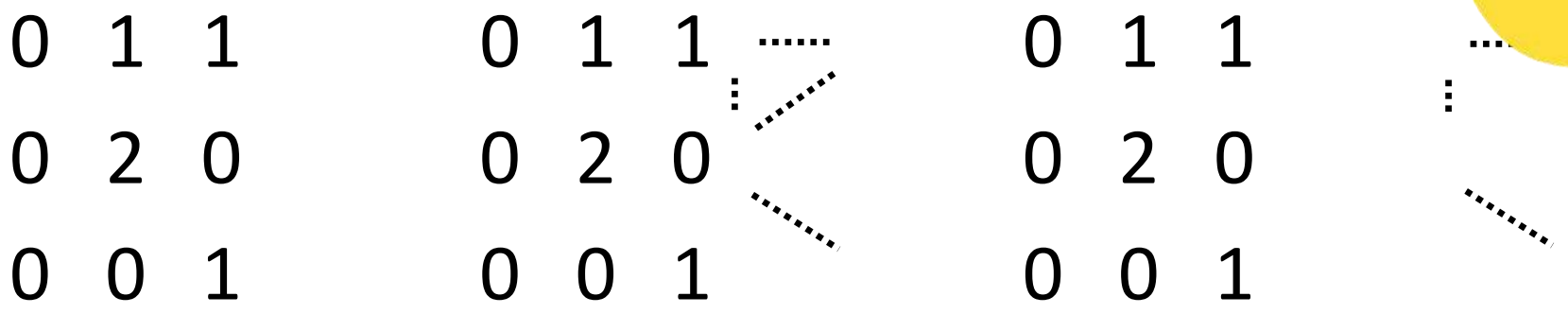
V = {1, 2}



8-adjacent

Examples: Adjacency and Path

V = {1, 2}



8-adjacent **m-adjacent**

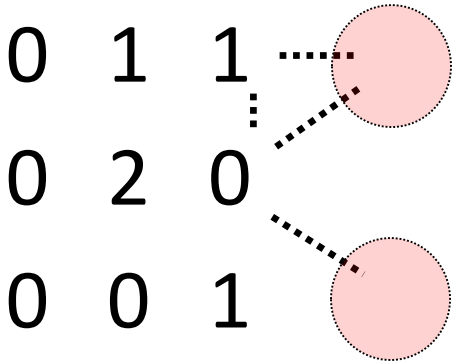
Examples: Adjacency and Path

V = {1, 2}

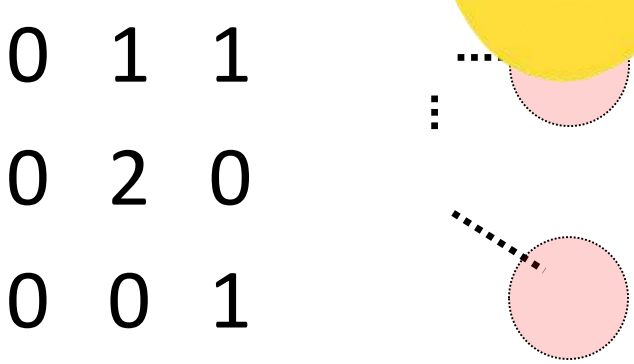
$0_{1,1}$ $1_{1,2}$ $1_{1,3}$

$0_{2,1}$ $2_{2,2}$ $0_{2,3}$

$0_{3,1}$ $0_{3,2}$ $1_{3,3}$



8-adjacent



m-adjacent

The 8-path from (1,3) to (3,3):
(i) (1,3), (1,2), (2,2), (3,3)
(ii) (1,3), (2,2), (3,3)

The m-path from (1,3) to (3,3):
(1,3), (1,2), (2,2), (3,3)

Basic Relationships Between Pixels

- **Connected in S**

Let S represent a subset of pixels in an image. Two pixels p with coordinates (x_0, y_0) and q with coordinates (x_n, y_n) are said to be **connected in S** if there exists a path

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

Where $\forall i, 0 \le i \le n, (x_i, y_i) \in S$

Basic Relationships Between Pixels

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, R_i and R_j are said to be ***adjacent*** if their union forms a connected set.
- Regions that are not to be adjacent are said to be ***disjoint.***

Basic Relationships Between Pixels

a =

1	1	0	0	0	0	0
1	1	0	0	1	1	0
1	1	0	0	0	1	0
1	1	0	0	0	0	0
0	0	0	0	0	1	0
0	0	0	0	0	0	0

Basic Relationships Between Pixels

a =

1	1	0	0	0	0	0
1	1	0	0	2	2	0
1	1	0	0	0	2	0
1	1	0	0	0	0	0
0	0	0	0	0	3	0
0	0	0	0	0	0	0

Basic Relationships Between Pixels

```
BW = logical ([1     1     1     0     0     0     0
               1     1     1     0     1     1     0
               1     1     1     0     1     1     0
               1     1     1     0     0     0     1     0
               1     1     1     0     0     0     1     0
               1     1     1     0     0     0     1     0
               1     1     1     0     0     1     1     0
               1     1     1     0     0     0     0     0]);

L = bwlabel(BW,4)
```

Basic Relationships Between Pixels

```
BW = imread('text.png');
imshow(BW);
CC = bwconncomp(BW);
numPixels =
cellfun(@numel,CC.PixelIdxList);
[biggest,idx] = max(numPixels);
BW(CC.PixelIdxList{idx}) = 0;
figure, imshow(BW);
```

Basic Relationships Between Pixels

- **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.

- **Foreground and background**

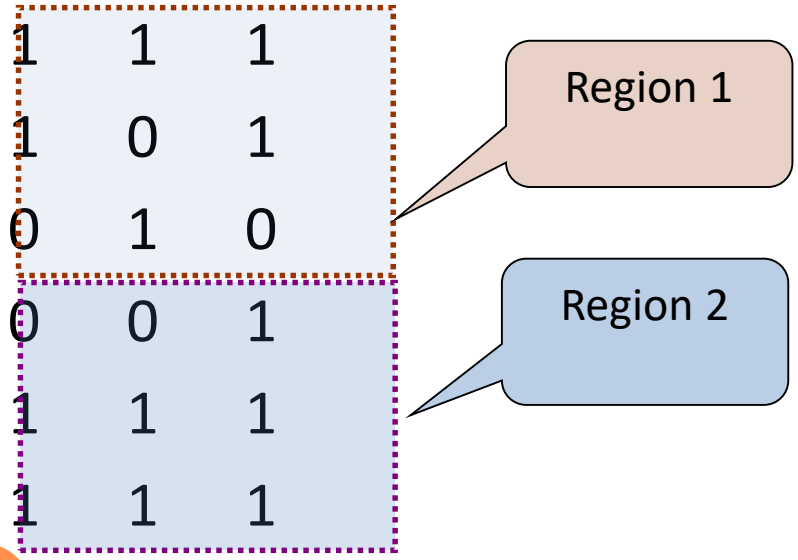
➢ An image contains K disjoint regions, R_k, k = 1, 2, …, K. Let R_u denote the union of all the K regions, and let $(R_u)^c$ denote its complement.

All the points in R_u is called **foreground**;

All the points in $(R_u)^c$ is called **background**.

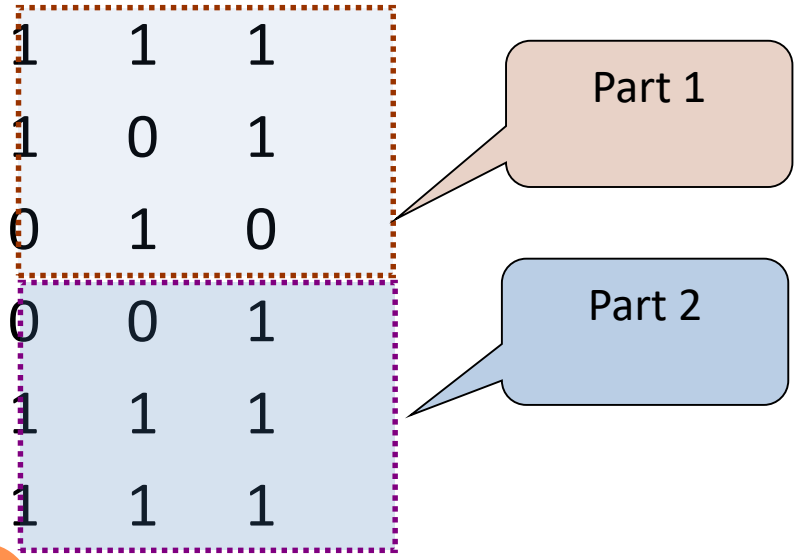
Question 1

- **In the following arrangement of pixels, are the two regions (of 1s) adjacent? (if 8-adjacency is used)**



Question 2

- **In the following arrangement of pixels, are the two part[illegible] adjacent? (if 4-adjacency is used)**



Question 3

- **In the following arrangement of pixels, the circled point is part of the boundary of the 1-valued pixels if 8-adjacency is used, true or false?**

0	0	0	0	0
0	1	1	0	0
0	1	1	0	0
0	1	1	1	0
0	1	1	1	0
0	0	0	0	0

Thank You