Digital Image Processing Using MATLAB

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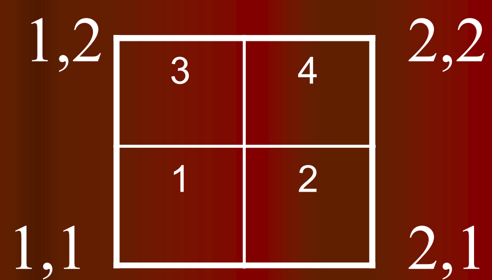
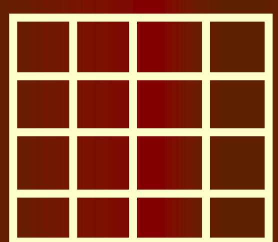
Image Zooming (1)
(Bi-linear Interpolation)





y

1,2	1.33,2	1.66,2	2,2
1,1,66	1.33,1.66	1.66,1.66	2,1.66
1,1.33	1.33,1.33	1.66,1.33	2,1.33
1,1	1.33,1	1.66,1	2,1

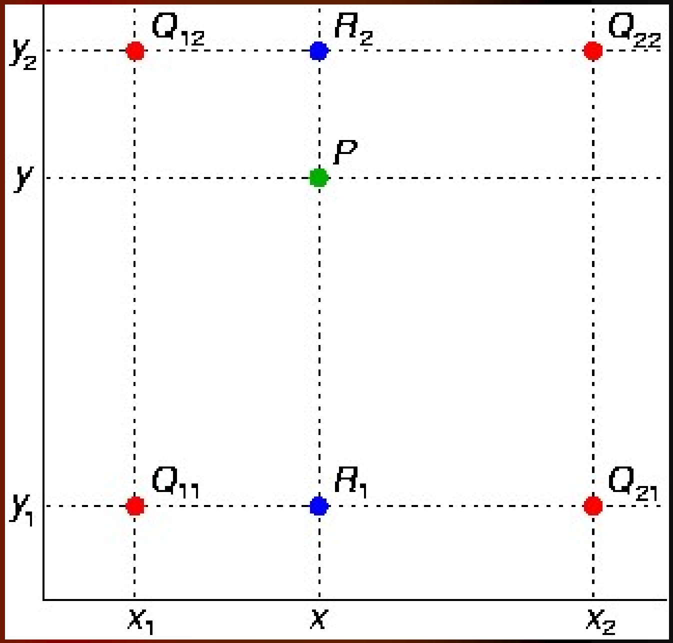
x

Image Zooming (2)
(Bi-linear Interpolation)

$$f(R_1) \approx \frac{x_2 - x}{x_2 - x_1} f(Q_{11}) + \frac{x - x_1}{x_2 - x_1} f(Q_{21}) \quad \text{where} \quad R_1 = (x, y_1),$$

$$f(R_2) \approx \frac{x_2 - x}{x_2 - x_1} f(Q_{12}) + \frac{x - x_1}{x_2 - x_1} f(Q_{22}) \quad \text{where} \quad R_2 = (x, y_2).$$

$$f(P) \approx \frac{y_2 - y}{y_2 - y_1} f(R_1) + \frac{y - y_1}{y_2 - y_1} f(R_2).$$



$$f(x, y) \approx \frac{f(Q_{11})}{(x_2 - x_1)(y_2 - y_1)} (x_2 - x)(y_2 - y) + \frac{f(Q_{21})}{(x_2 - x_1)(y_2 - y_1)} (x - x_1)(y_2 - y)$$

$$+ \frac{f(Q_{12})}{(x_2 - x_1)(y_2 - y_1)} (x_2 - x)(y - y_1) + \frac{f(Q_{22})}{(x_2 - x_1)(y_2 - y_1)} (x - x_1)(y - y_1).$$

Image Zooming (3)
(Bi-linear Interpolation)

$$f(1.33,1) = \frac{(2 - 1.33)}{(2-1)} * 1 + \frac{(1.33 - 1)}{(2-1)} * 2$$

$$f(1.33,1) = 0.67 + 0.66$$
$$= 1.33$$

$$f(1.33,2) = \frac{(2 - 1.33)}{(2-1)} * 3 + \frac{(1.33 - 1)}{(2-1)} * 4$$

$$f(1.33,2) = 0.67 * 3 + 0.33 * 4$$
$$= 3.33$$

$$f(1.66,1) = \frac{(2 - 1.66)}{(2-1)} * 1 + \frac{(1.66 - 1)}{(2-1)} * 2$$

$$f(1.66,1) = 0.34 + 1.32$$
$$= 1.66$$

$$f(1.66,2) = \frac{(2 - 1.66)}{(2-1)} * 3 + \frac{(1.66 - 1)}{(2-1)} * 4$$

$$f(1.66,2) = 0.34 * 3 + 0.66 * 4$$
$$= 3..66$$

Image Zooming (4)
(Bi-linear Interpolation)

$$f(1,1.33) = \frac{(2 - 1.33)}{(2-1)} * 1 + \frac{(1.33 - 1)}{(2-1)} * 3$$

$$f(1,1.33) = 0.67 + 0.99$$
$$= 1.66$$

$$f(2,1.33) = \frac{(2 - 1.33)}{(2-1)} * 2 + \frac{(1.33 - 1)}{(2-1)} * 4$$

$$f(2,1.33) = 0.67 * 2 + 0.33 * 4$$
$$= 2.66$$

$$f(1,1.66) = \frac{(2 - 1.66)}{(2-1)} * 1 + \frac{(1.66 - 1)}{(2-1)} * 3$$

$$f(1,1.66) = 0.34 + 1.99$$
$$= 2.33$$

$$f(2,1.66) = \frac{(2 - 1.66)}{(2-1)} * 2 + \frac{(1.66 - 1)}{(2-1)} * 4$$

$$f(2,1.66) = 0.34 * 2 + 0.66 * 4$$
$$= 3..33$$

Image Zooming (5)
(Bi-linear Interpolation)

$$f(1.33,1.33) = \frac{(2 - 1.33)}{(2-1)} * 1.66 + \frac{(1.33 - 1)}{(2-1)} * 2.66$$

$$f(1,1.33) = 1.11 + 0.88$$
$$= 1.99$$

$$f(1.66,1.66) = \frac{(2 - 1.66)}{(2-1)} * 2.33 + \frac{(1.66 - 1)}{(2-1)} * 3.33$$

$$f(2,1.66) = 0.34 * 2.33 + 0.66 * 3.33$$
$$= 0.79 + 2.19$$
$$= 2.99$$

Image Zooming (6)
(Bi-linear Interpolation)

3	4
1	2

3	3.33	3..66	4
2.33	2.67	2.99	3.33
1.66	1.99	2.33	2.66
1	1.33	1.66	2

Image Zooming (7)
(Bi-linear Interpolation)

```
a=imread('c:\house2.bmp');
a=double(a);
x=linspace(1,64,64);
y=linspace(1,64,64);
xi=linspace(1,64,128);
yi=linspace(1,64,128);
[xx, yy]=meshgrid(xi,yi);
zz=interp2(x,y,a,xx,yy,'bilinear');
imshow(mat2gray(zz));
```

Iso-preference Curve

a b c

FIGURE 2.22 (a) Image with a low level of detail. (b) Image with a medium level of detail. (c) Image with a relatively large amount of detail. (Image (b) courtesy of the Massachusetts Institute of Technology.)

Iso-preference Curve

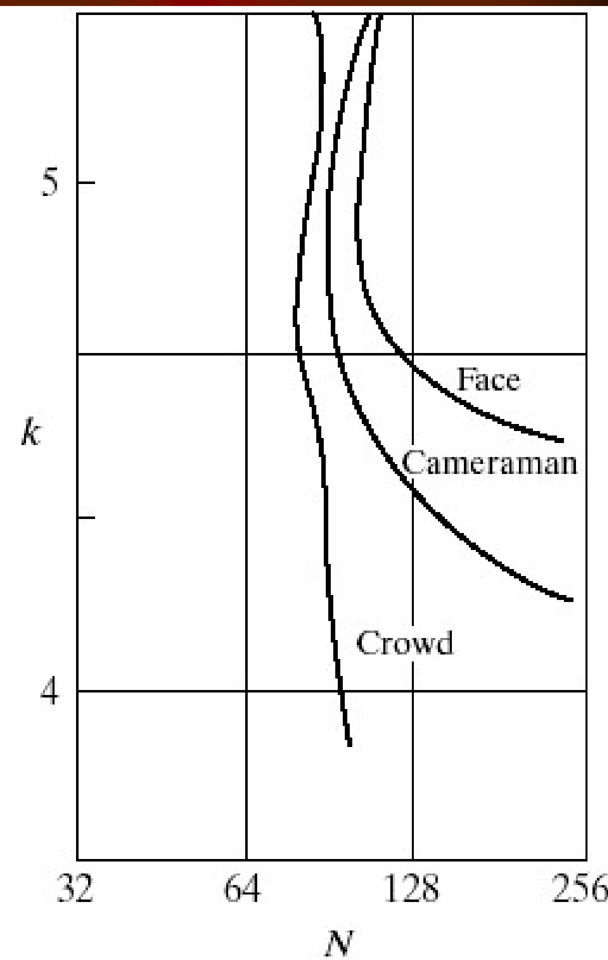
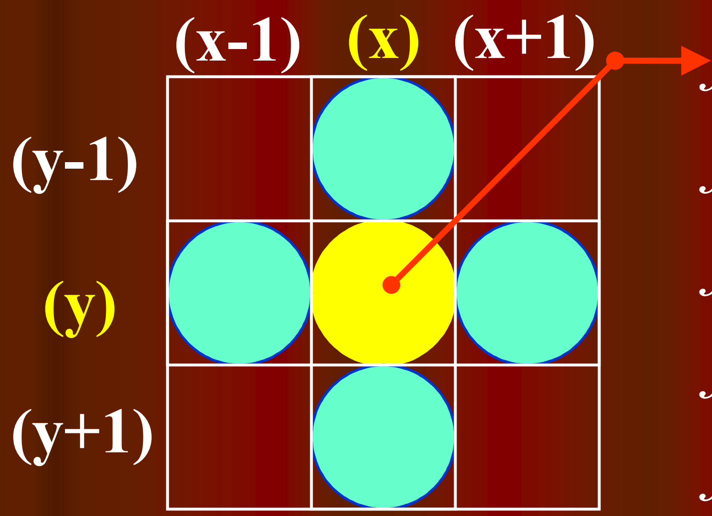


FIGURE 2.23 Representative isopreference curves for the three types of images in Fig. 2.22.

4-neighbors of pixel

- 4-neighbors of pixel is denoted by $N_4(p)$
- It is set of horizontal and vertical neighbors



$f(x,y)$ is a yellow circle

$f(x,y-1)$ is top one

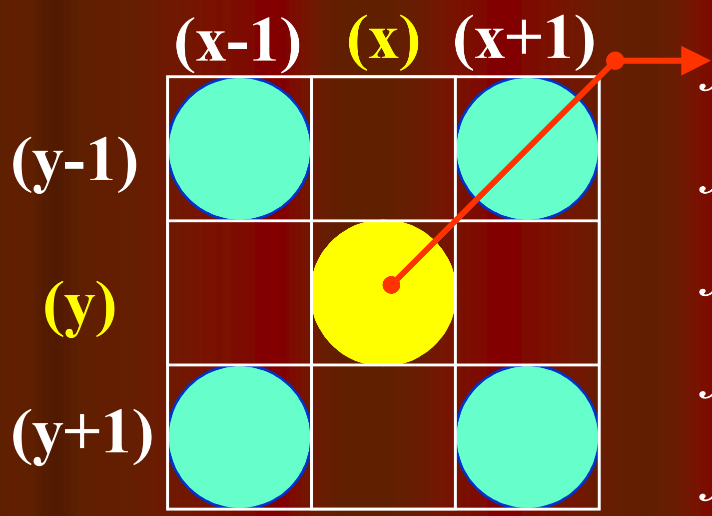
$f(x-1,y)$ is left one

$f(x+1,y)$ is right one

$f(x,y+1)$ is bottom one

Diagonal neighbors of pixel

- Diagonal neighbors of pixel is denoted by $N_D(p)$
- It is set of diagonal neighbors



f(x,y) is a yellow circle

f(x-1,y-1) is top-left one

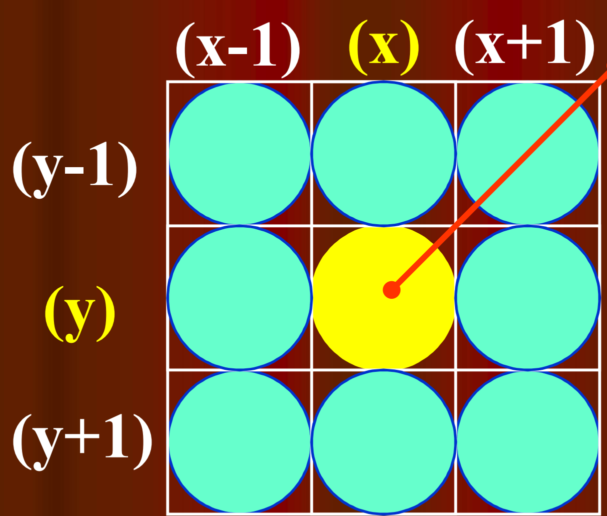
f(x+1,y-1) is top-right one

f(x-1,y+1) is bottom-left one

f(x+1,y+1) is bottom-right one

8-neighbors of pixel

- 8-neighbors of pixel is denoted by $N_8(p)$
- 4-neighbors and Diagonal neighbors of pixel



f(x,y) is a yellow circle

(x-1,y-1), (x,y-1),(x+1,y-1),
(x-1,y), (x,y), (x+1,y),
(x-1,y+1),(x,y+1), (x+1,y+1)

Connectivity

- Establishing boundaries of objects and components of regions in an image.
- Group the same region by assumption that the pixels being the same color or equal intensity will are the same region

Connectivity

- Let C is the set of colors used to define
- There are three type of connectivity:
  - 4-Connectivity : 2 pixels (*p* and *q*) with value in C are 4-connectivity if q is in the set $N_4(p)$
  - 8-Connectivity : 2 pixels (*p* and *q*) with value in C are 8-connectivity if q is in the set $N_8(p)$
  - M-Connectivity : 2 pixels (*p* and *q*) with value in C are 8-connectivity if

    (i) Q is in $N_4(p)$, or

    (ii) Q is in $N_D(p)$ and the set $N_4(p) \cap N_4(q)$ is empty

Binary Image Represent

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

Example 4-Connectivity

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

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

Example 8-Connectivity

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

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

Example M-Connectivity

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

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

4- Path, 8- Path and m-path

- Path: 4, 8, and m-paths
  - A sequence of distinct pixels from pixel p to q.

0	1	1 (p)
0	1	0
0	0	1 (q)

4-Path does not Exist

0	1	1 (p)
0	1	0
0	0	1 (q)

8-Path Exists

0	1	1 (p)
0	1	0
0	0	1 (q)

m-Path Exists

Connectivity

- Connectivity
  - Let S represent a subset of pixels in an image.
    Two pixels p and q are said to be connected in S if there exists a path between them entirely of pixels in S
  - There are 4, 8 and m-connectivity
  - Connect set: only has one connected component.

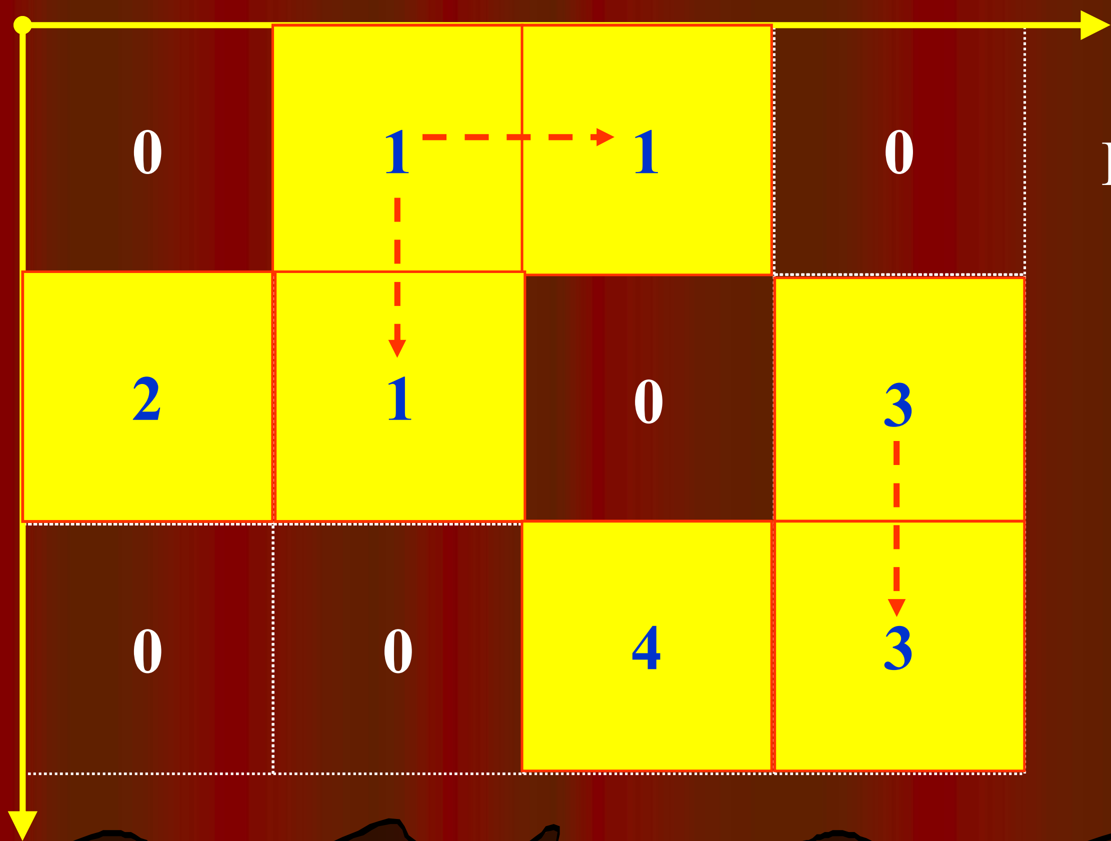
Labeling of connected Components

- Scan an image pixel by pixel from left to right and top to bottom
- Equivalent labeling

Step: 4-connected components

- P is pixel scanned process
- If pixel p is color value 0 move on the next scaning
- If pixel p is color value 1 examine pixel top and left
  - If top and left were 0, assign a new label to p
  - If only one of them're 1, assign its label to p
  - If both of them're 1 and have
    - the same number, assign their label to p
    - Different number, assign label of top to p and make note that two label is equivalent
- Sort all pairs of equivalent labels and assign each equivalent to be same type

Example 4-connected components



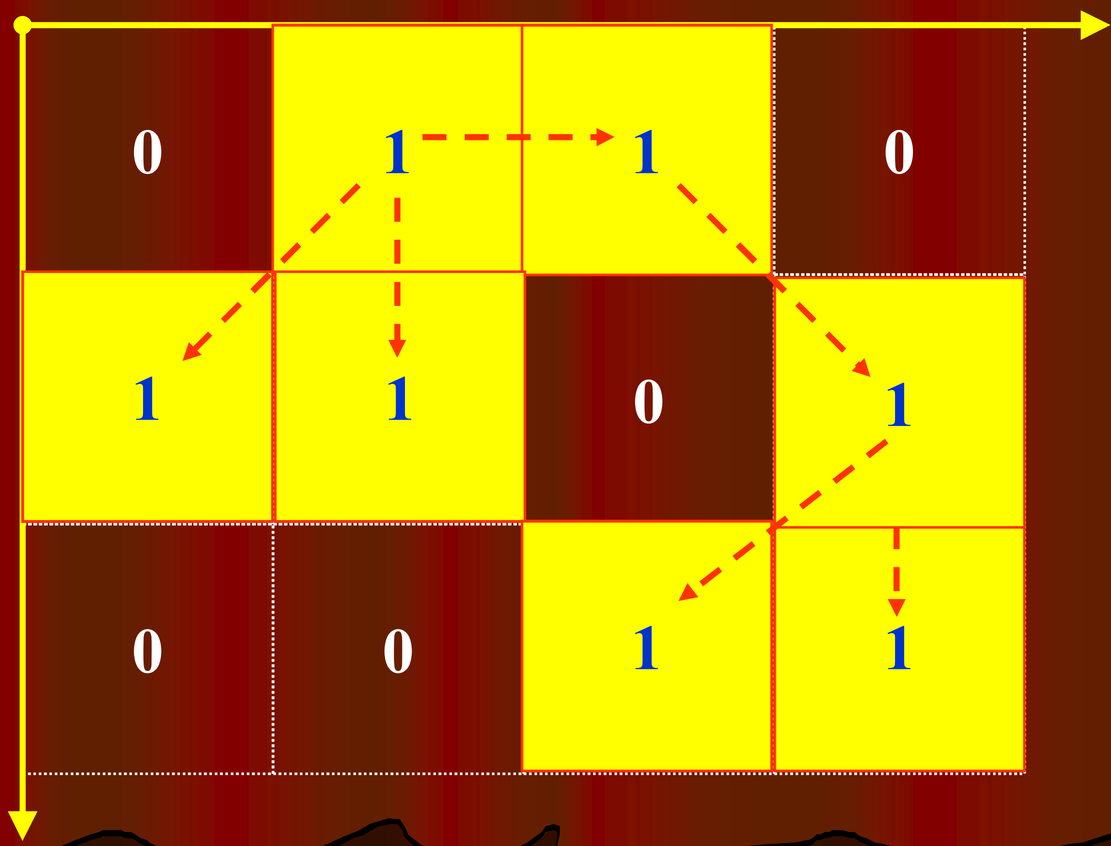
Equivalent Table

1	2
3	4

Step: 8-connected components

- Steps are same as 4-connected components
- But the pixel that are consider is 4 previous pixels (top-left, top, top-right, and left)

Example 8-connected components



Region and Boundary

- Region
  - Region is a connected set.

$$\left.\begin{matrix}1 & 1 & 1\\ 1 & 0 & 1\\ 0 & 1 & 0\end{matrix}\right\}\ R1$$

$$\left.\begin{matrix}0 & 0 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{matrix}\right\}\ R2$$

Only 8-path between two regions exists

Region and Boundary

- Boundary
  - The set of pixels in the region which has one or more neighbors that are not in the region.

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

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

Distance Measure

- For pixels p, q, and z, with coordinates (x,y), (s,t) and (u,v) respectively, D is a distance function or metric if
  (a) $D(p,q) \geq 0$ and
  (b) $D(p,q) = 0$ iff $p = q$ and
  (c) $D(p,q) = D(q,p)$ and
  (d) $D(p,z) \leq D(p,q) + D(q,z)$

The D_4 Distance

- Also called city-block distance
- Calculate between p and q is defined as

$$D_4(p,q) = | p_x - q_x | + | p_y - q_y |$$

		2		
	2	1	2	
2	1	0	1	2
	2	1	2	
		2		

The D_8 Distance

- Also called city-block distance
- Calculate between p and q is defined as

$$D_8(p,q) = \max(|p_x - q_x|, |p_y - q_y|)$$

2	2	2	2	2
2	1	1	1	2
2	1	0	1	2
2	1	1	1	2
2	2	2	2	2

Thank You