Fundamentals of Image Processing- Part II (Week-01, Lecture #2)

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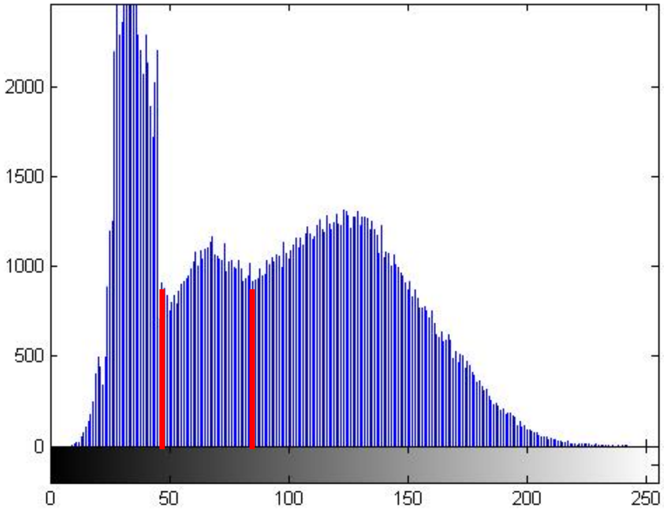
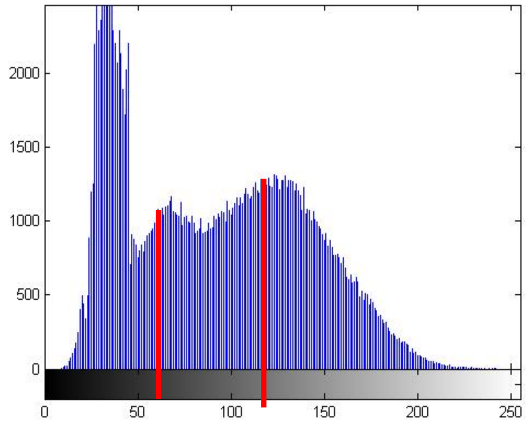
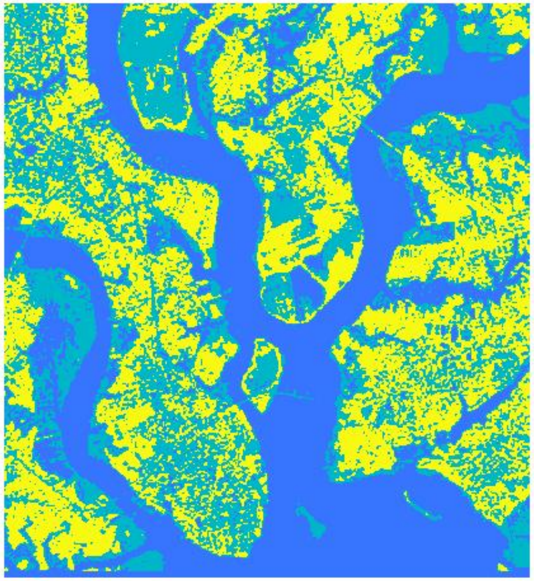
Segmentation

- Partitioning image pixels into meaningful non-overlapping sets.
  - Binarization: A special case.
  - Can be extended to group pixels in more than two labels.



Multilevel thresholding: An example





Intervals: [0,60], [61, 119], [120,255]

Blue Green Yellow

Component Labeling

- Partitioning connected image pixels into meaningful non-overlapping sets.
  - Neighborhood definition.
  - 4-neighbor, 8-neighbor

	o	
o	o	o
	o	

4-neighbors

o	o	o
o	o	o
o	o	o

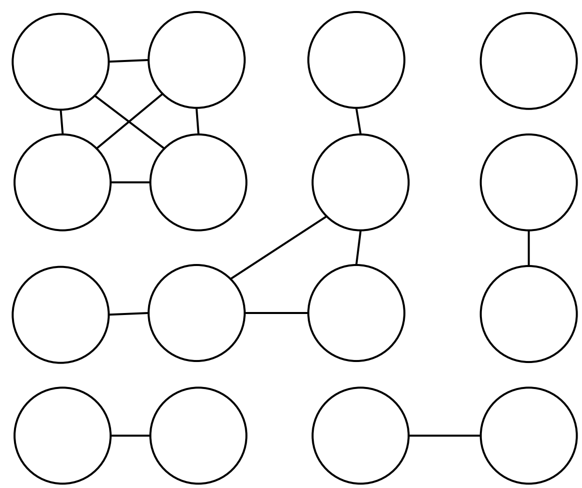
8-neighbors

o	o	o
o	o	o
o	o	o

Component Labeling

- Form a graph with edges between neighboring pixels having same labels.
- Compute connected components.
  - Graph traversal algorithms

20	20	50	20
20	20	50	100
50	50	50	100
100	100	20	20

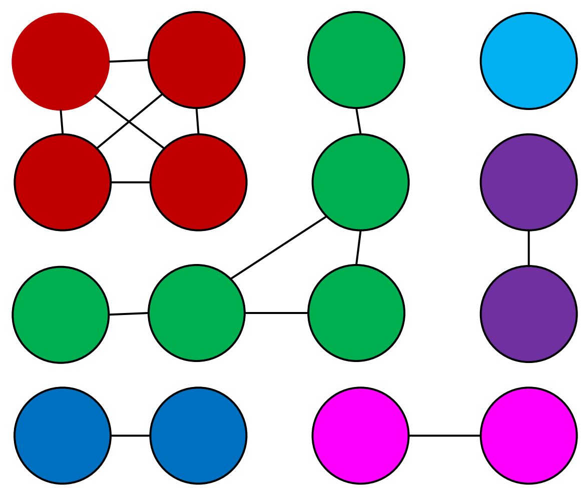


o	o	o
o	o	o
o	o	o

Component Labeling

- Form graph with edges between neighboring pixels having same labels.
- Compute connected components.
  - Graph traversal algorithms

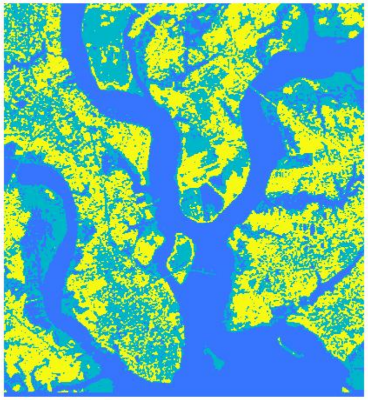
20	20	50	20
20	20	50	100
50	50	50	100
100	100	20	20

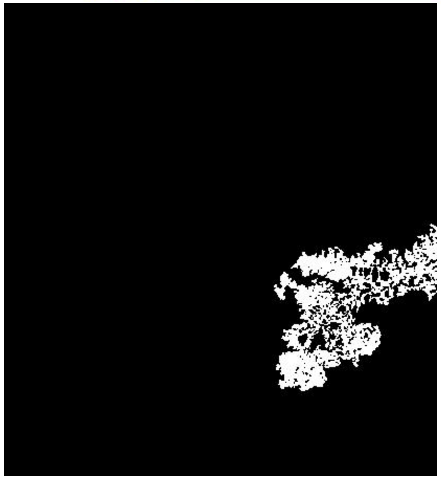


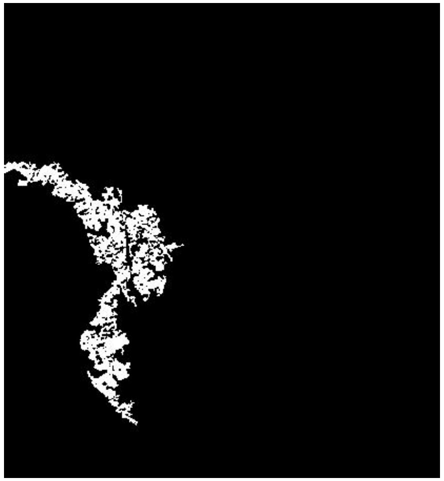
Do you require an explicit graph representation?

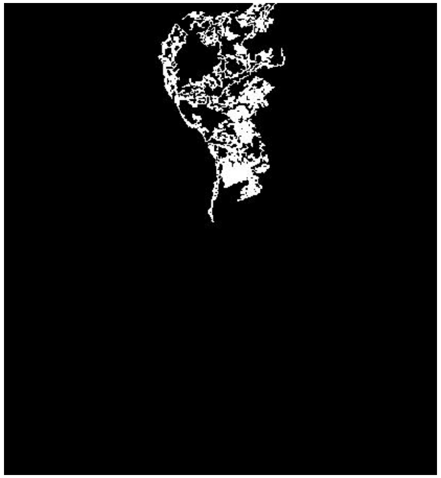
Can you compute using only the image array?

Examples of components

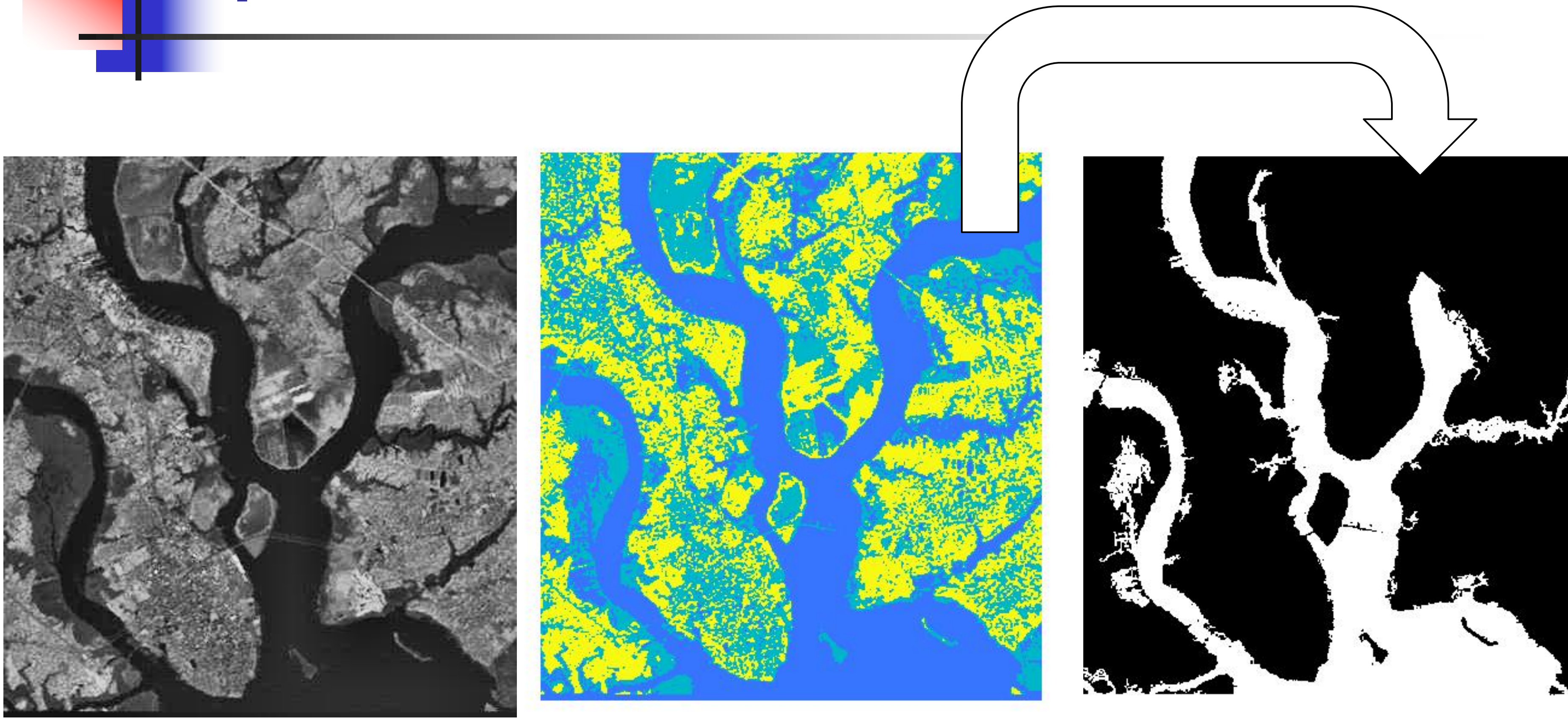








?



Why a part of river channel is missing?

Gradient Operations

Consider the image as a 2D function: $f(x, y)$

$$\frac{\partial f(x,y)}{\partial x} = f(x+1, y) - f(x, y)$$

$$\frac{\partial f(x,y)}{\partial y} = f(x, y+1) - f(x, y)$$

$$\nabla f(x,y) = \frac{\partial f(x,y)}{\partial x}\hat{i} + \frac{\partial f(x,y)}{\partial y}\hat{j}$$

Computation with mask

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

Weights

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

1. Scan the image top to bottom and left to right.
2. At every point (x,y) place the mask and compute the weighted sum.

$$g(x,y)=(1).f(x,y+1)+(-1).f(x,y)$$

3. Write the value $g(x,y)$ at (x,y) pixel position of the processed image.

Robust gradient computation

Averaging neighboring gradient values

-1	-1 1	1
-1	-1 1	1
-1	-1 1	1

-1	0	1
-1	0	1
-1	0	1

1	1	1
0	0	0
-1	-1	1

Prewitt operator

(6 times of the gradient value in any direction)

Robust gradient computation

Weighted average of neighboring gradient values

1x	-1	-1 1	1
2x	-1	-1 1	1
1x	-1	-1 1	1

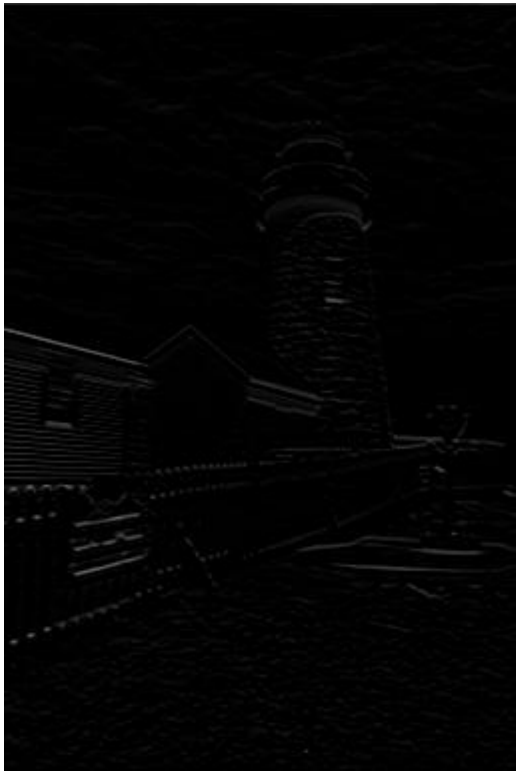
-1	0	1
-2	0	2
-1	0	1

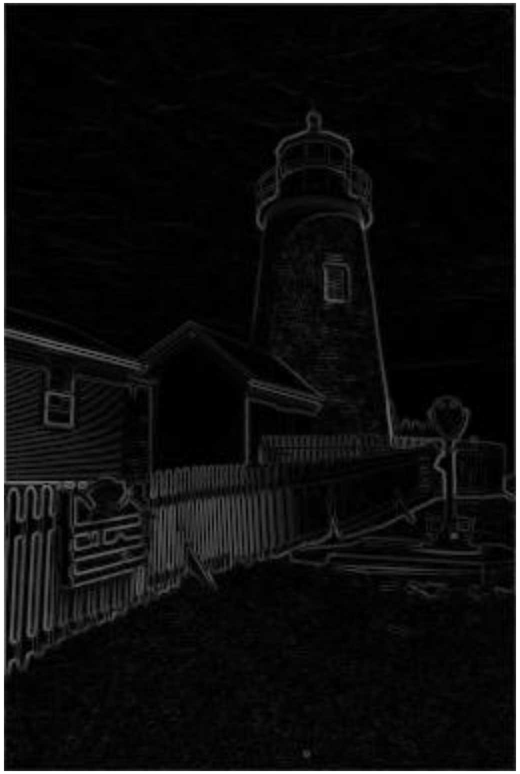
1	2	1
0	0	0
-1	-2	1

Sobel operator

(8 times of the gradient value in any direction)

Results of gradient operations





Vertical　　Horizontal　　Resultant

More on computation with mask

w_1	w_2	w_3
w_4	w_c	w_5
w_6	w_7	w_8

Convolution operation

Filtering

Mask→ Filter Response ($h(x,y)$)

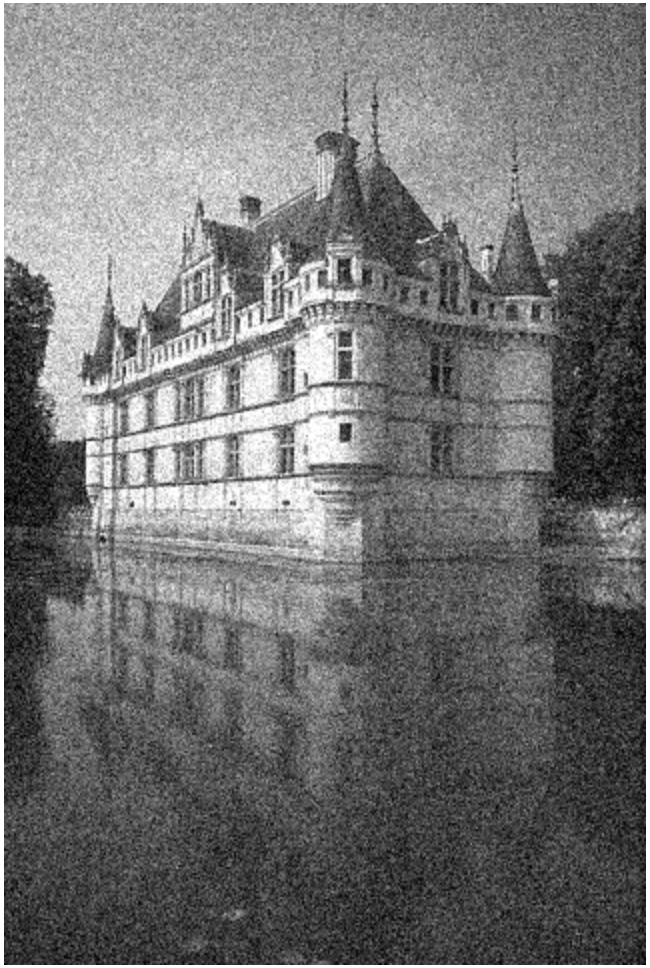
$$f(x,y) \longrightarrow \boxed{h(x,y)} \longrightarrow g(x,y)$$

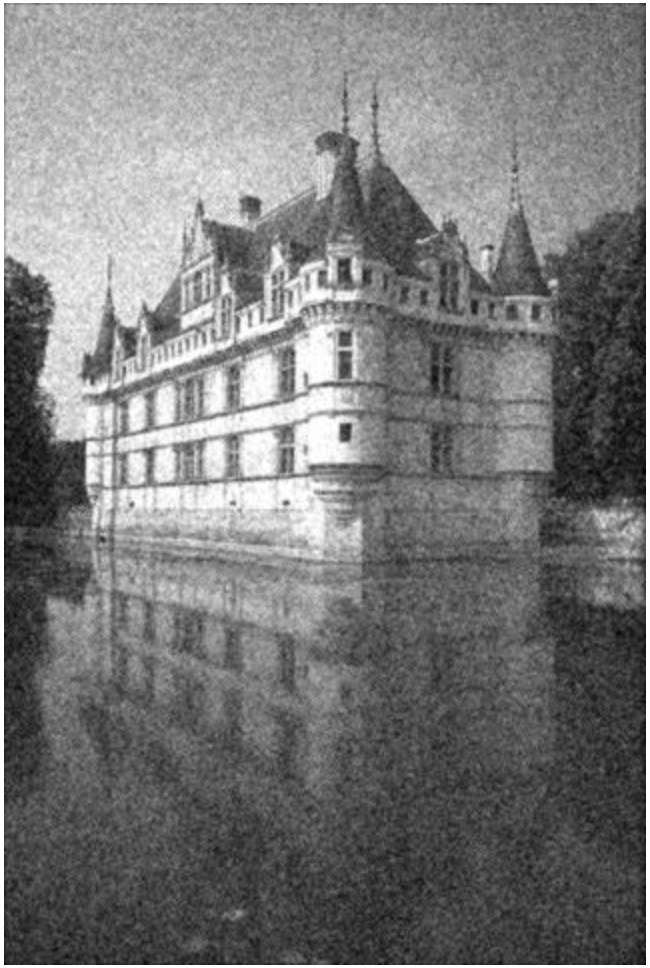
$$g(x,y) = w_1 f(x-1,y+1) + w_2 f(x,y+1) + w_3 f(x+1,y+1) + w_4 f(x-1,y) +$$
$$w_c f(x,y) + w_5 f(x+1,y) + w_6 f(x-1,y-1) + w_7 f(x,y+1) + w_8 f(x+1,y+1)$$

Noise Filtering

c	b	c
b	a	b
c	b	c

$a=0.5$, $b=0.3/4$, and, $c=0.25/4$





Gaussian Smoothing

$$G(x,y)=\frac{1}{2\pi\sigma^2}e^{\frac{-((x-x_c)^2+(y-y_c)^2)}{2\sigma^2}}$$

$$g(x,y)=f(x,y)*G(x,y)$$

σ=2
Mask size: 9x9

Median Filtering

$g(x,y) =$ the median value among the neighbors.

Summary

1. Images formed by optical camera through perspective projection.
2. Discussed different operations in image processing.

- Binarization
  - Thresholding.
- Contrast enhancement.
- Segmentation
  - Component Labeling
- Gradient computation.
  - Computing edges
- Convolution operation
  - Filtering
- Median filtering