



UNIVERSITY OF  
SOUTH CAROLINA

# CSCE 590 INTRODUCTION TO IMAGE PROCESSING

## Logical and Arithmetic Operations

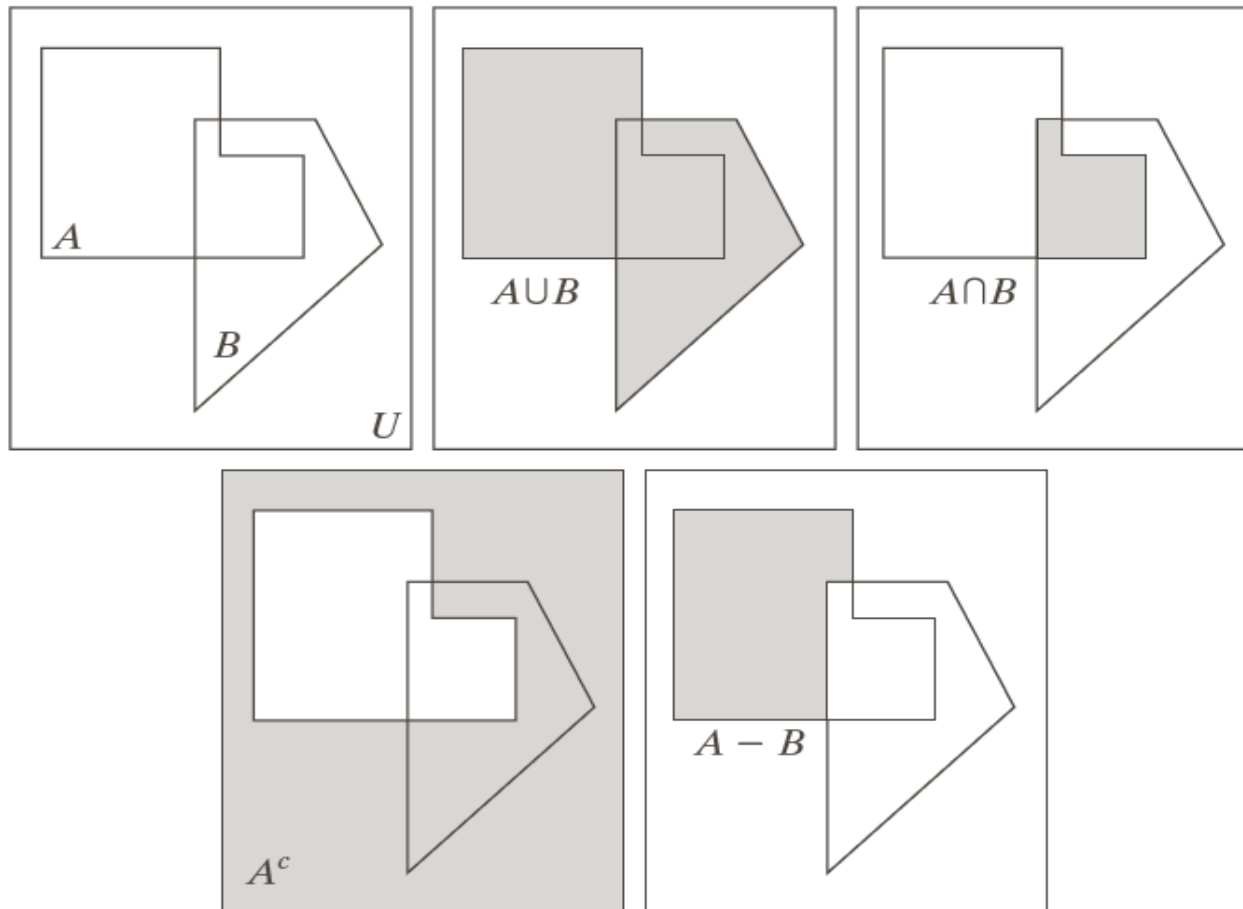
# Basic Set and Logical Operations

- **A is a set:  $A = \{.\}$**  e.g.  $A = \{1, \dots, 255\}$  or  $A = \{w | w = 1, \dots, 255\}$   
 $A = \emptyset$  for empty set
- **a is an element of A** ( $a \in A$ ) or a isn't an element of A ( $a \notin A$ )
- **A is a *subset* of B** if every element in A also is in B ( $A \subseteq B$ )
- **C is the *union* of two sets A and B** ( $C = A \cup B$ )
- **C is the *intersection* of A and B** ( $C = A \cap B$ )
- **Disjoint or mutual exclusive sets** ( $A \cap B = \emptyset$ )
- **Set universe** is the set of all elements in an application
- **Set difference** ( $A - B = \{w | w \in A, w \notin B\}$ )



# Set Operations Based on Coordinates

A region in an image is represented by a set of coordinates within the region

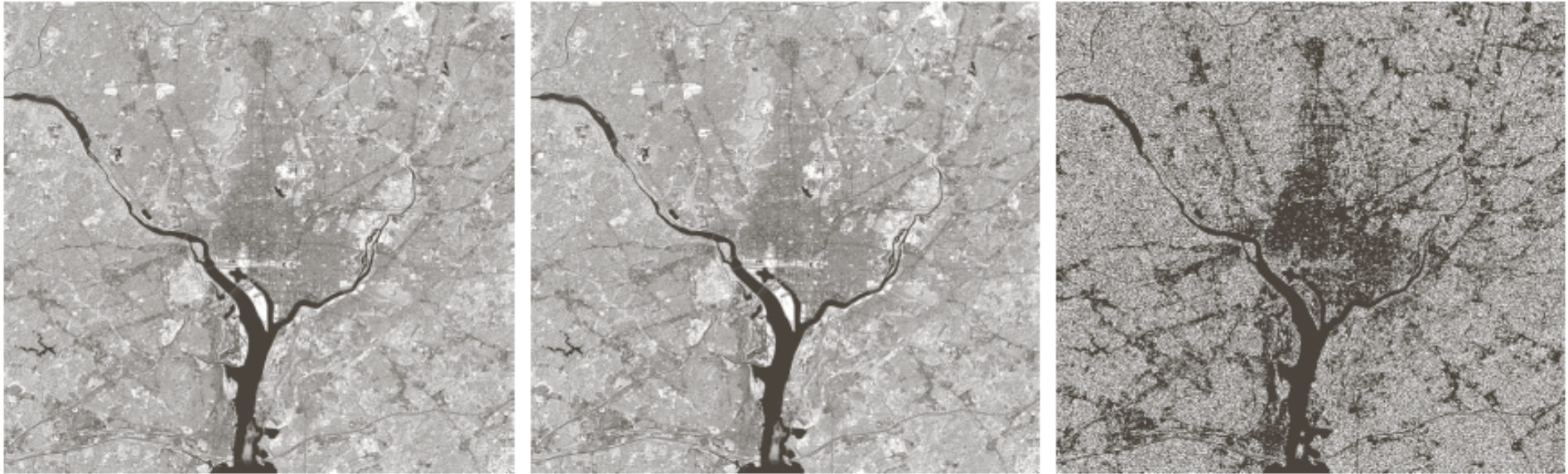


a	b	c
d	e	

**FIGURE 2.31**

(a) Two sets of coordinates,  $A$  and  $B$ , in 2-D space. (b) The union of  $A$  and  $B$ . (c) The intersection of  $A$  and  $B$ . (d) The complement of  $A$ . (e) The difference between  $A$  and  $B$ . In (b)–(e) the shaded areas represent the member of the set operation indicated.

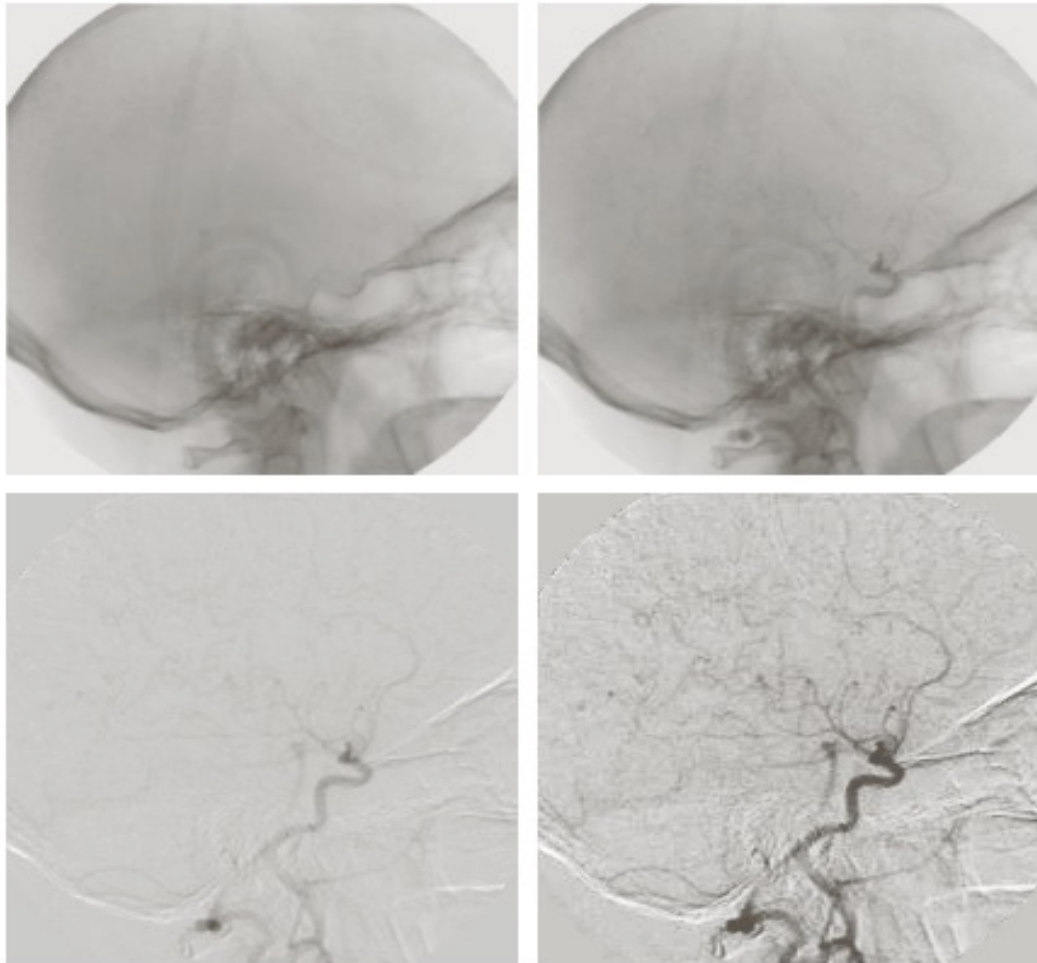
# Image Subtraction – Enhance Difference



a b c

**FIGURE 2.27** (a) Infrared image of the Washington, D.C. area. (b) Image obtained by setting to zero the least significant bit of every pixel in (a). (c) Difference of the two images, scaled to the range  $[0, 255]$  for clarity.

# Image Subtraction



a	b
c	d

**FIGURE 2.28**

Digital subtraction angiography. (a) Mask image. (b) A live image. (c) Difference between (a) and (b). (d) Enhanced difference image. (Figures (a) and (b) courtesy of The Image Sciences Institute, University Medical Center, Utrecht, The Netherlands.)

**The images used in averaging & subtraction must be registered!**



# Image Multiplication (Division)

$$g(x,y)=f(x,y)h(x,y)$$



a b c

**FIGURE 2.30** (a) Digital dental X-ray image. (b) ROI mask for isolating teeth with fillings (white corresponds to 1 and black corresponds to 0). (c) Product of (a) and (b).



a b c

**FIGURE 2.29** Shading correction. (a) Shaded SEM image of a tungsten filament and support, magnified approximately 130 times. (b) The shading pattern. (c) Product of (a) by the reciprocal of (b). (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)



# Notes on Arithmetic Operations

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**The images used in averaging & subtraction must be registered!**

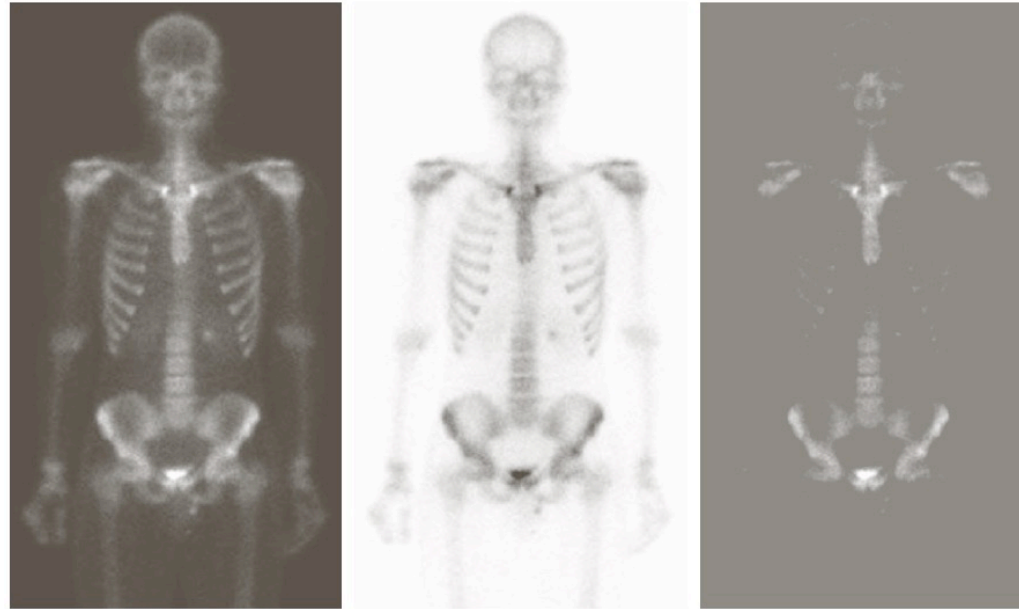
Output images should be normalized to the range of [0,255]

$$f_m = f - \min(f)$$

$$f_s = K[f_m / \max(f_m)]$$



# Set Operations Based on Intensities



a b c

**FIGURE 2.32** Set operations involving gray-scale images. (a) Original image. (b) Image negative obtained using set complementation. (c) The union of (a) and a constant image. (Original image courtesy of G.E. Medical Systems.)

Complement – negative image

$$A^c = \{(x, y, K - z) \mid (x, y, z) \in A\}$$

Thresholding

$$A \cup B = \left\{ (x, y, \max(z_a, z_b)) \mid (x, y, z_a) \in A, (x, y, z_b) \in B \right\}$$





# Logic Operations for Binary Image



## Foreground/background

- Binary image: 0/1
- Fuzzy set: [0,1]

## FIGURE 2.33

Illustration of logical operations involving foreground (white) pixels. Black represents binary 0s and white binary 1s. The dashed lines are shown for reference only. They are not part of the result.

# MATLAB

- `I=imread('zelda.pbm');`
- `G=rgb2gray(I);`
- `M1=zeros(576,787);`
- `mx=576/2; my=787/2;`
- `for x=1:576`
  - `for y=1:787`
    - `M1(x,y)=sqrt((x-mx).^2+(y-my).^2);`
  - `end`
- `End`
- `d=sqrt(mx^2+my^2);`



# MATLAB

- `imshow(G.*uint8(M1/d));`
- `imshow(G.*uint8(1-M1/d));`
- `histogram(M1);`
- `I=imread('zelda.pbm');`
- `imshow(I)`
- `I2=imread('monarch.pbm');`
- `imshow(I2)`
- `I3=(I(1:512,1:768)+I2)/2;`
- `imshow(I3)`
- `I3=(I(1:512,1:768)-I2)/2;`
- `imshow(I3)`



# MATLAB

- `sx=150;sy=80;`
- `for x=1:576`
  - `for y=1:787`
    - $M3(x,y)=\exp(-(((x-mx)^2)/(2*sx*sx)+((y-my)^2)/(2*sy*sy)));$
  - `end`
- `end`
- `image(double(G).*M3);`



# Questions?

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