ECE 468: Digital Image Processing

Lecture 2

Prof. Sinisa Todorovic

sinisa@eecs.oregonstate.edu

OSU Oregon State University

Outline

- MATLAB
- Image elements
- Image interpolation
- Affine transforms of images

MATLAB Image Processing Toolbox

Basic MATLAB Commands

- imread
- size
- whos
- imshow
- imwrite
- im2double
- rgb2gray, im2uint8, im2bw
- img1 = img(1:end-4,:), img1 = img(1:3:end,1:4:end)
- zeros(m,n), ones(m,n)
- rand(m,n), randn(m,n)
- min(min(I1)), max(max(I2))

Basic MATLAB Commands

```
•  figure;
•  subplot(2,2,1);
•  imshow(I1);
•  title('Fig. 1 caption');

•  subplot(2,2,2);
•  imshow(I2);
•  title('Fig. 2 caption');

•  subplot(2,2,3);
•  imshow(I3);
•  title('Fig. 3 caption');

•  Scaled = uint8( 255.0 * ( I1 - min(min(I1)) ) ...
•                          /(max(max(I1))-min(min(I1))));
•  subplot(2,2,4);
•  imshow(Scaled);
•  title('Fig. 4 caption');
```

Basic MATLAB Commands

- print -dpsc hw1.ps
- print -djpeg hw1.jpg

Basic MATLAB Commands

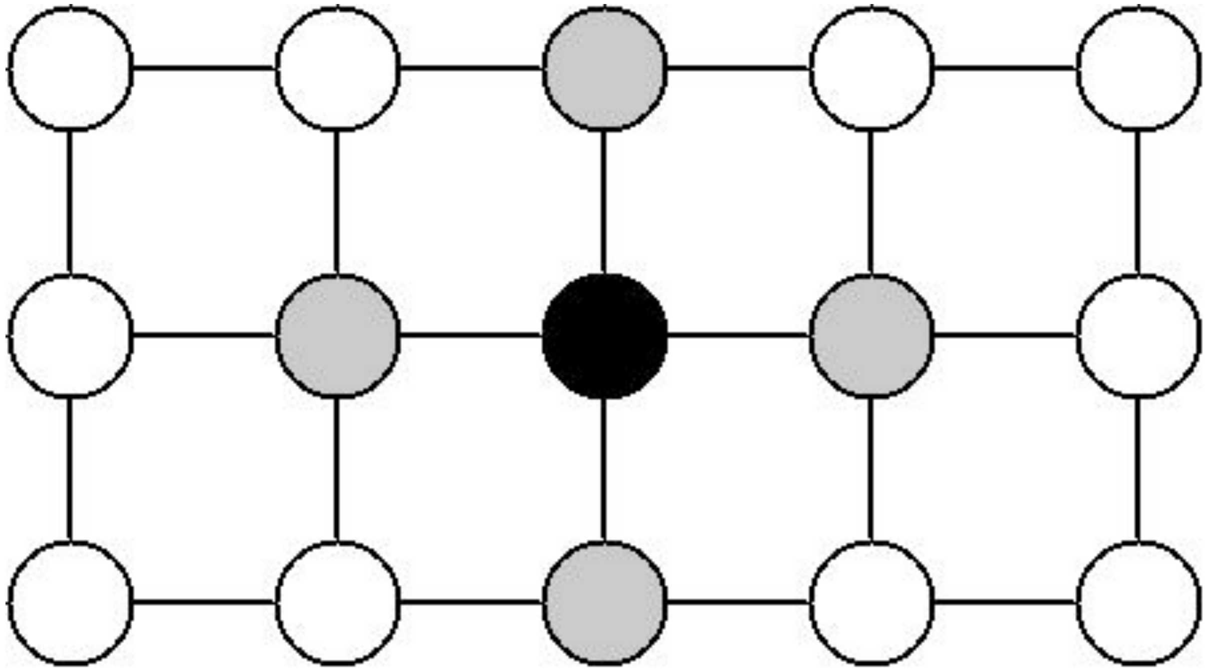
- ismember, isempty
- intersect, union
- for, while
- meshgrid
- imadjust
- imhist

- function [outputs] = name_func(inputs)
- return

Image Structure

Image Structure

- Pixels, 4-adjacency, 8-adjacency, m-adjacency



4-adjacency

Image Structure

- Region = Connected set of pixels
- Region boundary, inner and outer contour

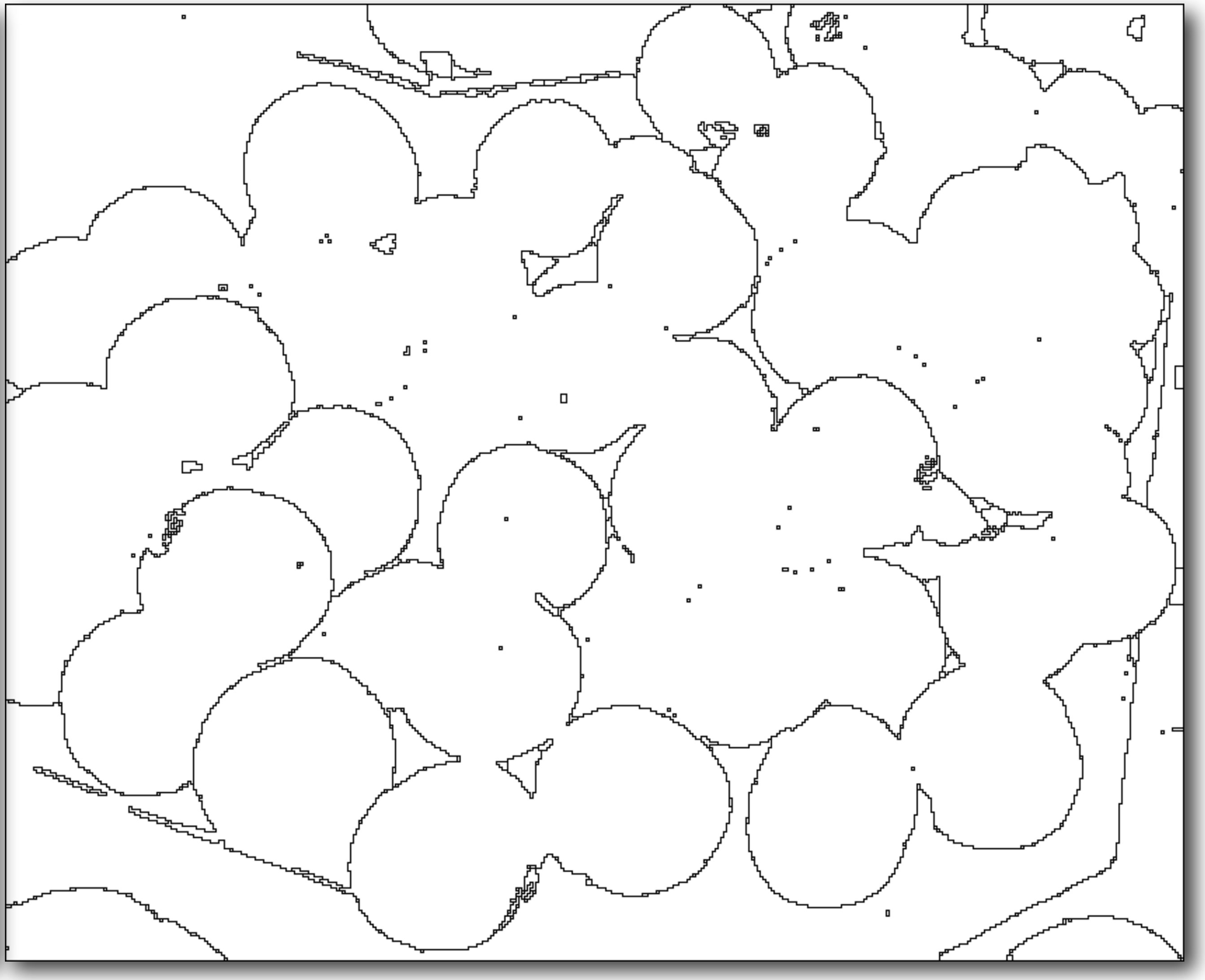


Image Structure

- Foreground - Background

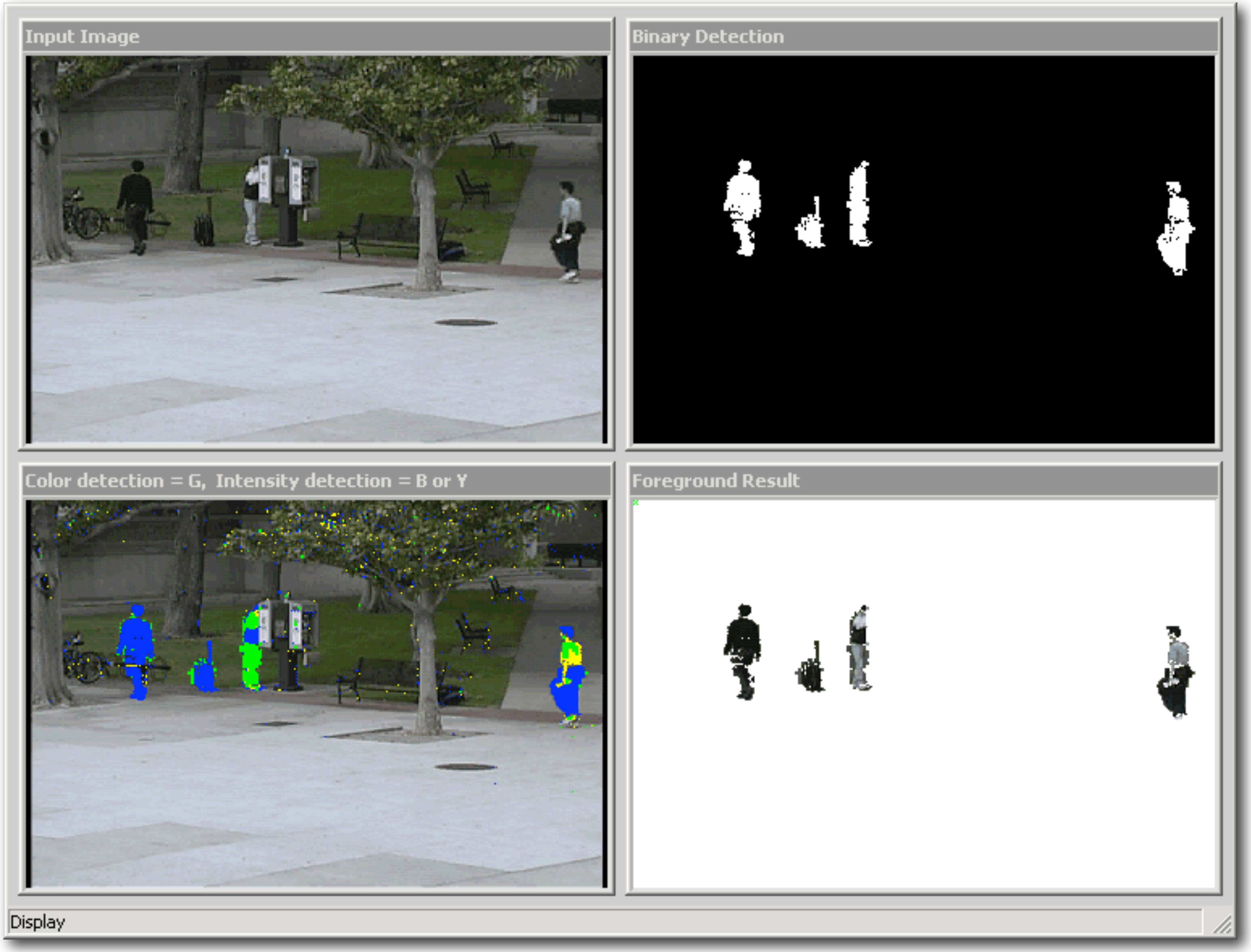
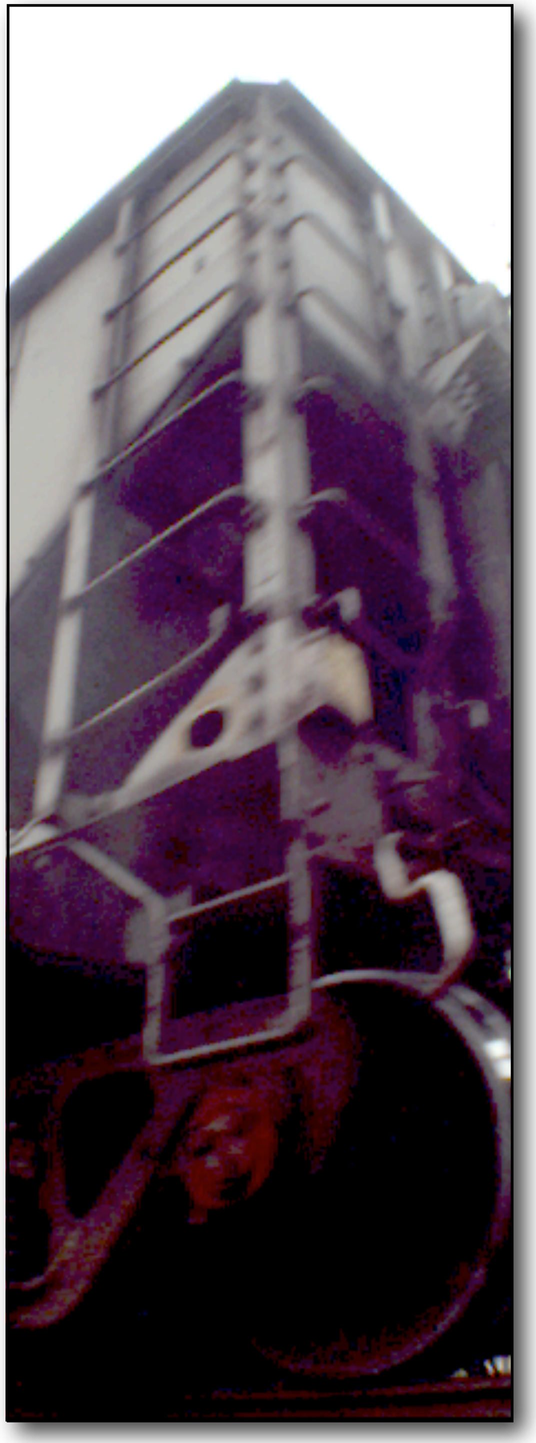


Image Structure

- Edge = Connected pixels with high gradient values



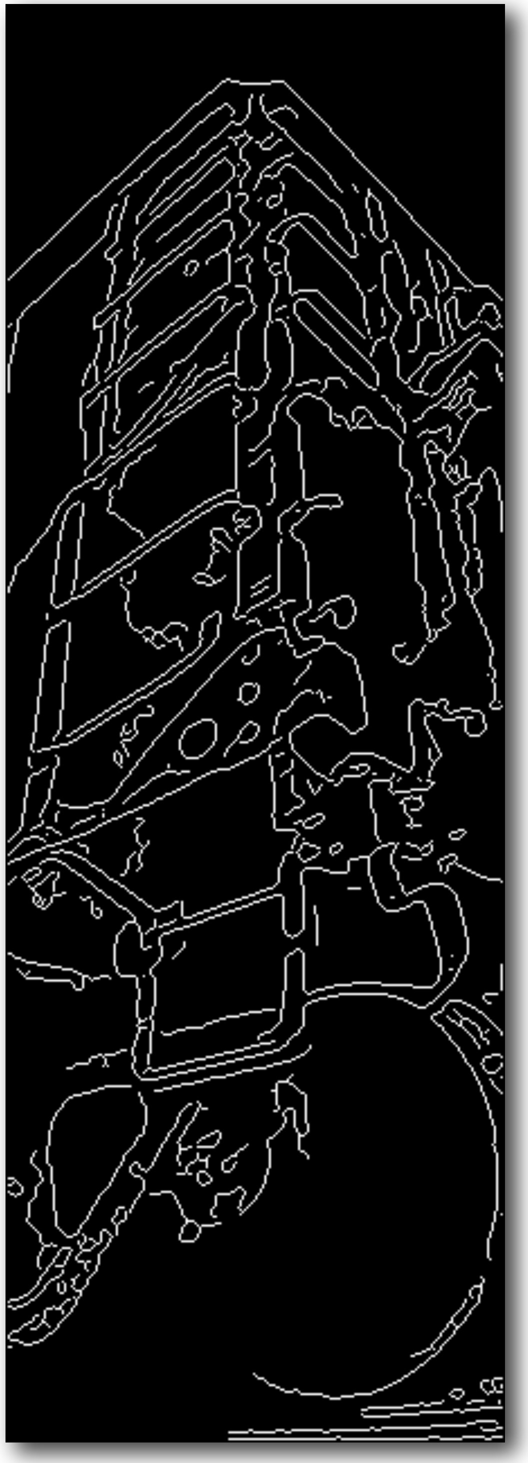


Image Structure

- Specularity = Highlights

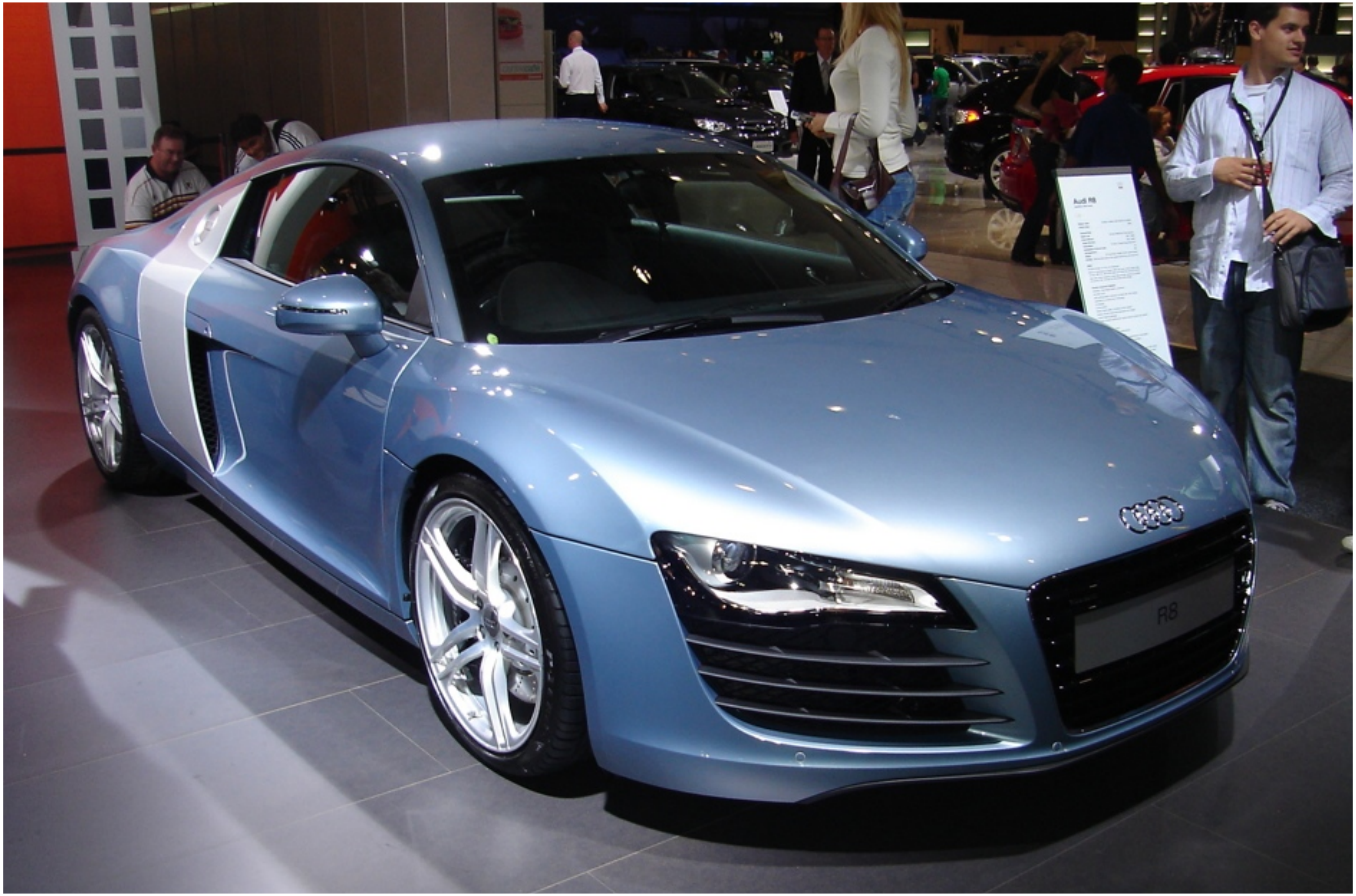
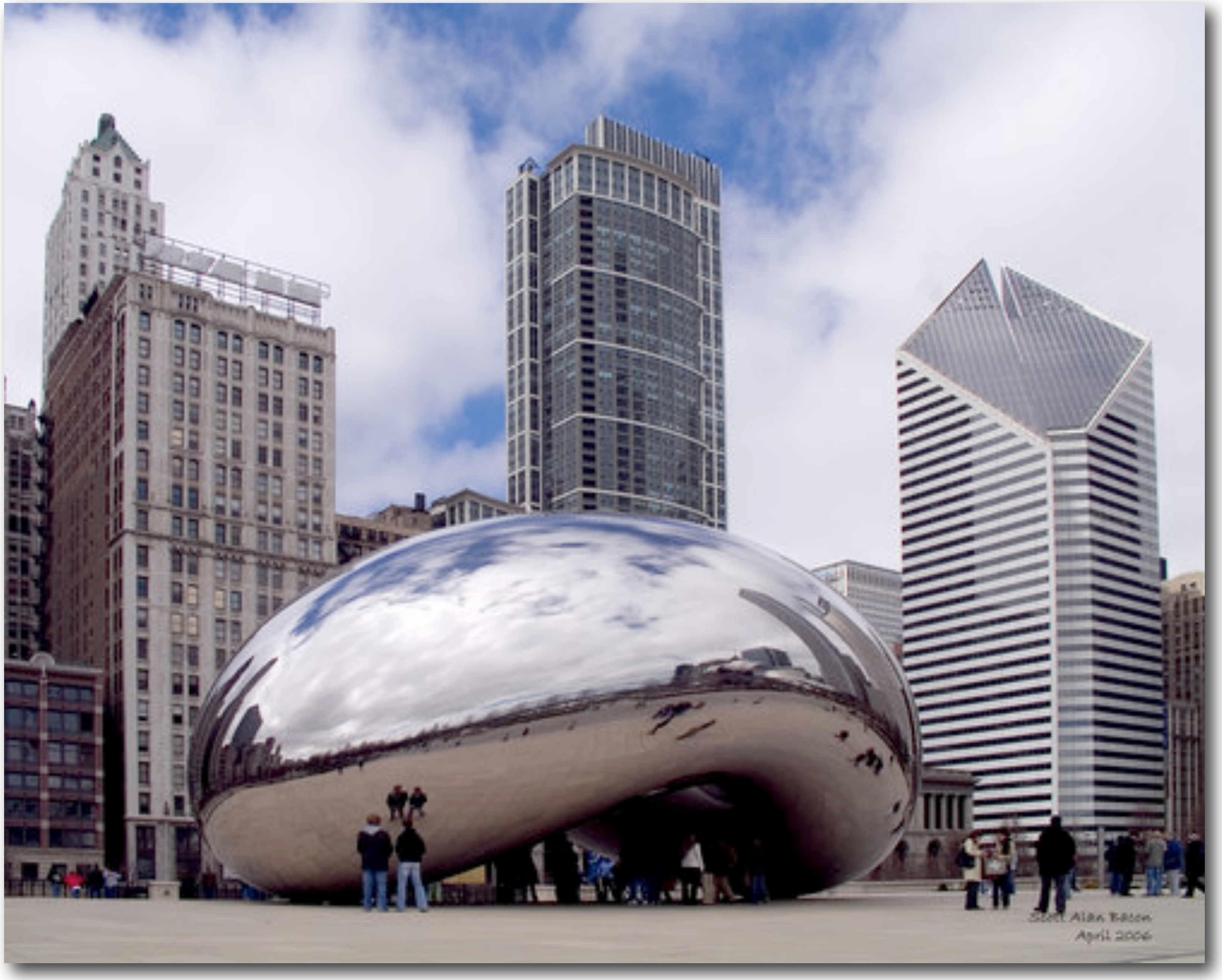


Image Structure

- Highlights or specularities
- Lambertian surface = isotropic reflectance
- Specular surface = zero reflectance except at an angle

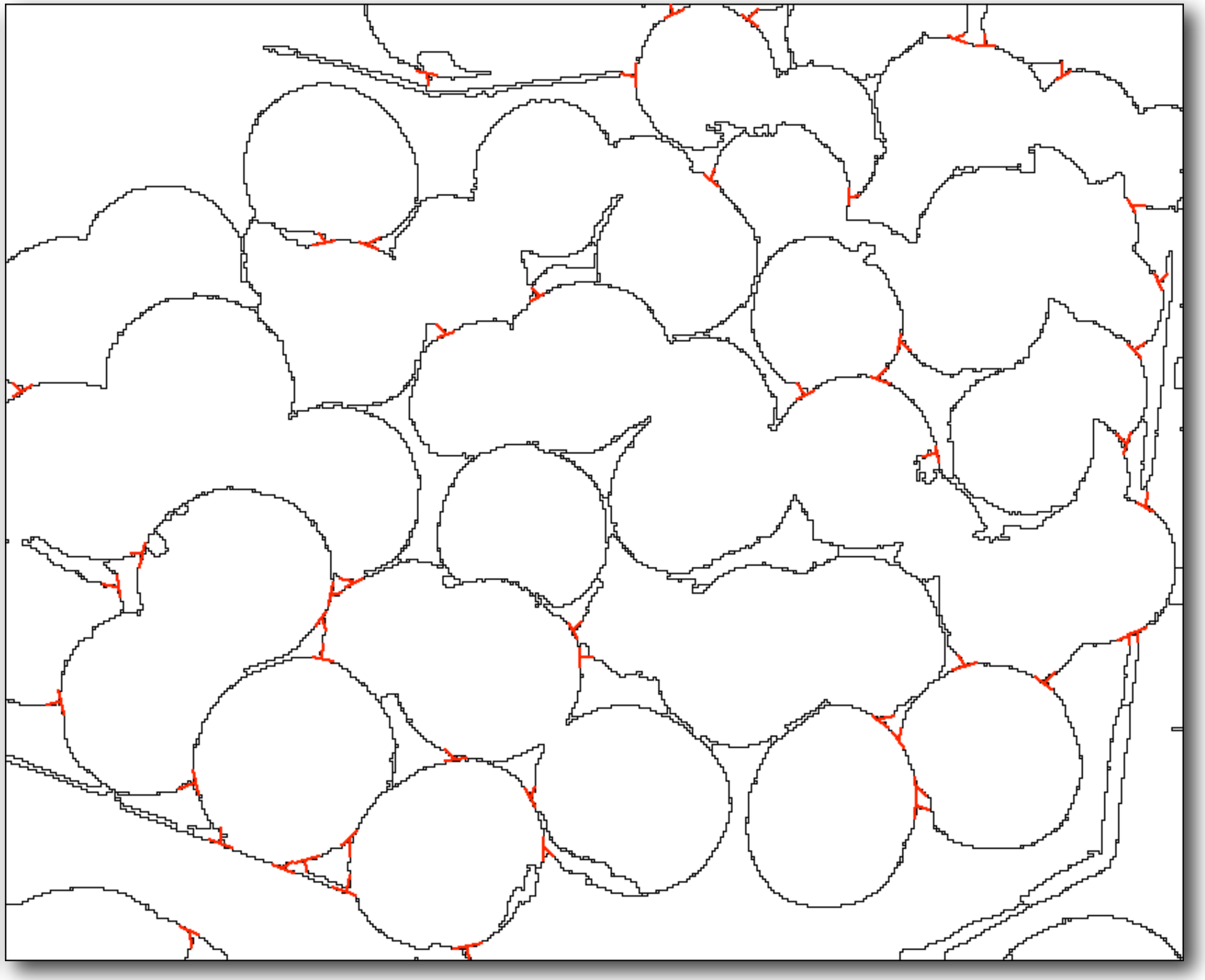


Scott Alan Bacon
April 2006

Image Structure

- Interest points: T-junctions, Y-junctions

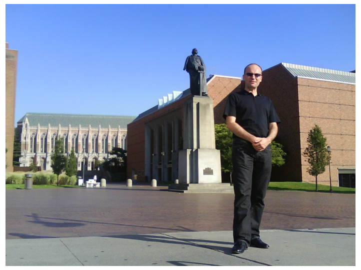
original



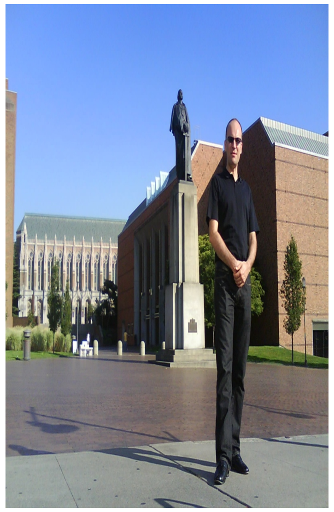
T-junctions

Image Interpolation

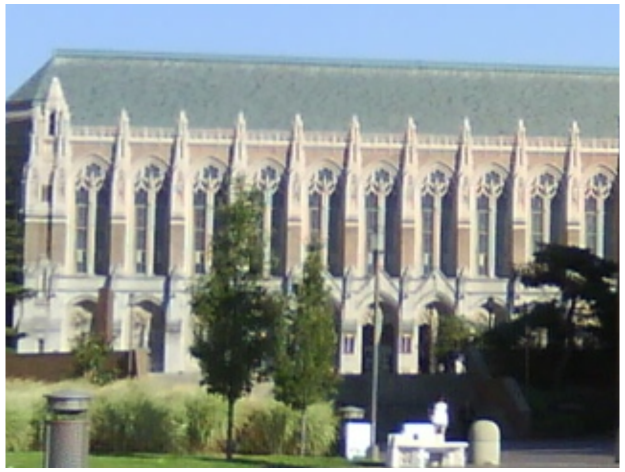
original



resampling

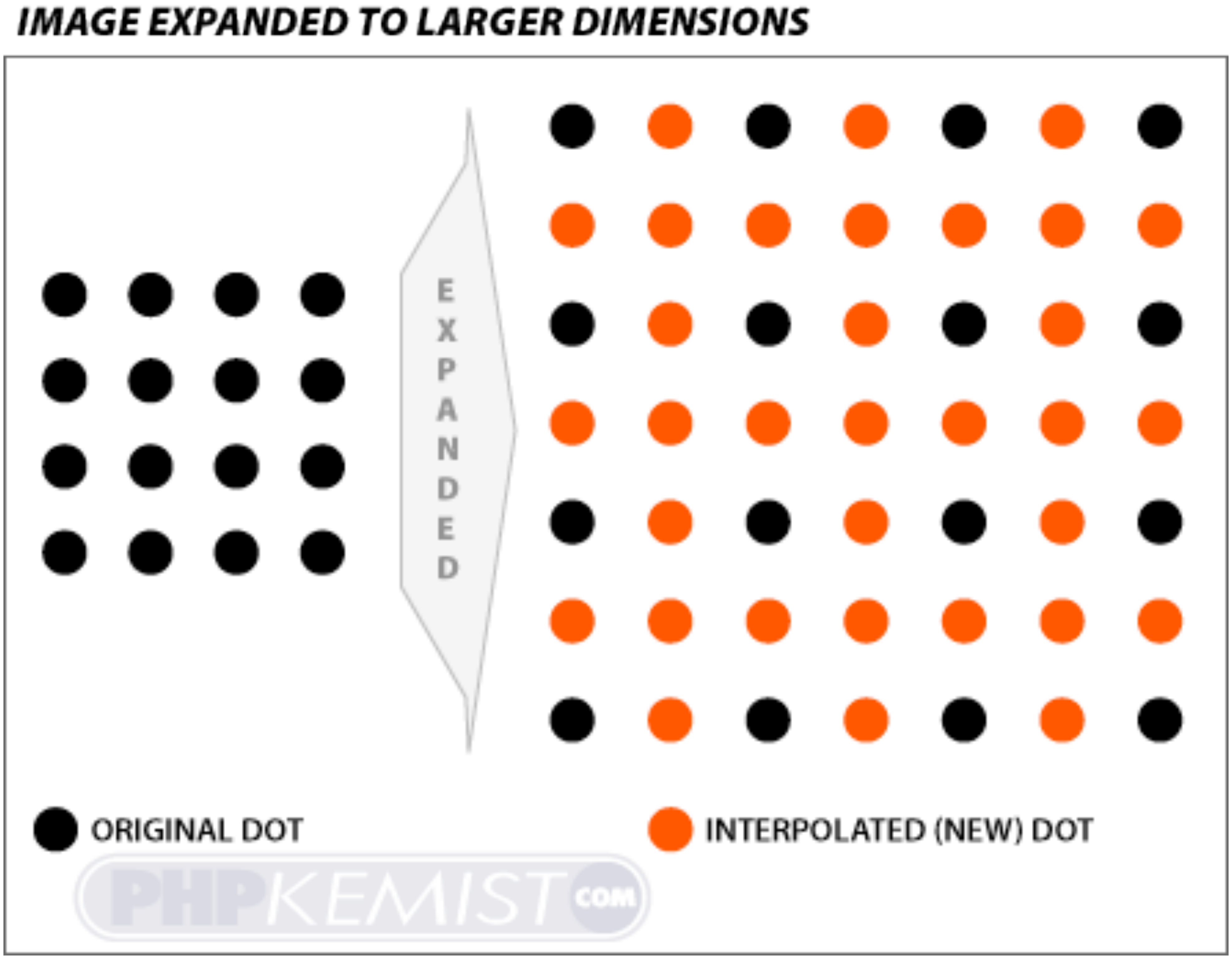


shrinking

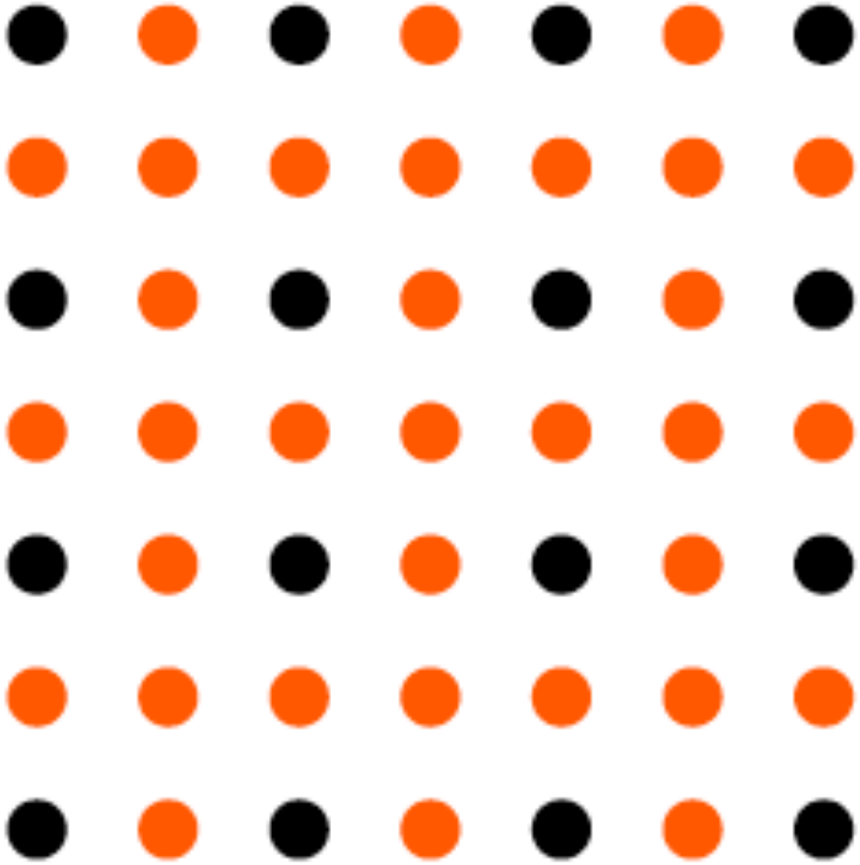


zooming

Image Interpolation



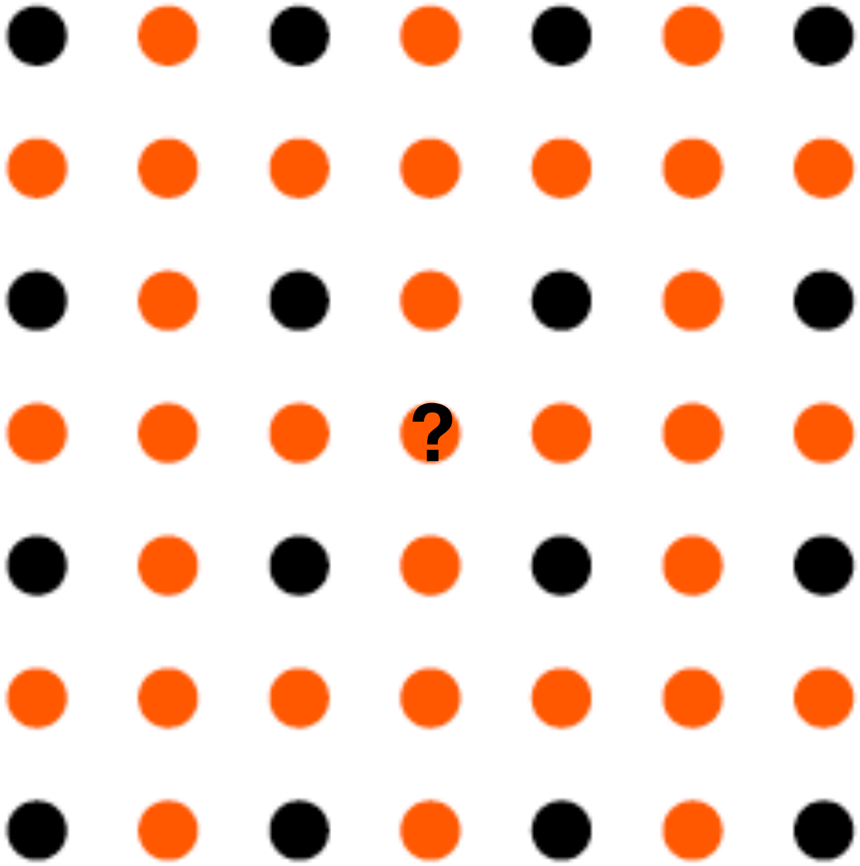
Bilinear Interpolation



$$f(x,y) = \underbrace{a}x + \underbrace{b}y + \underbrace{c}xy + \underbrace{d}$$

coefficients that need to be estimated

Bilinear Interpolation



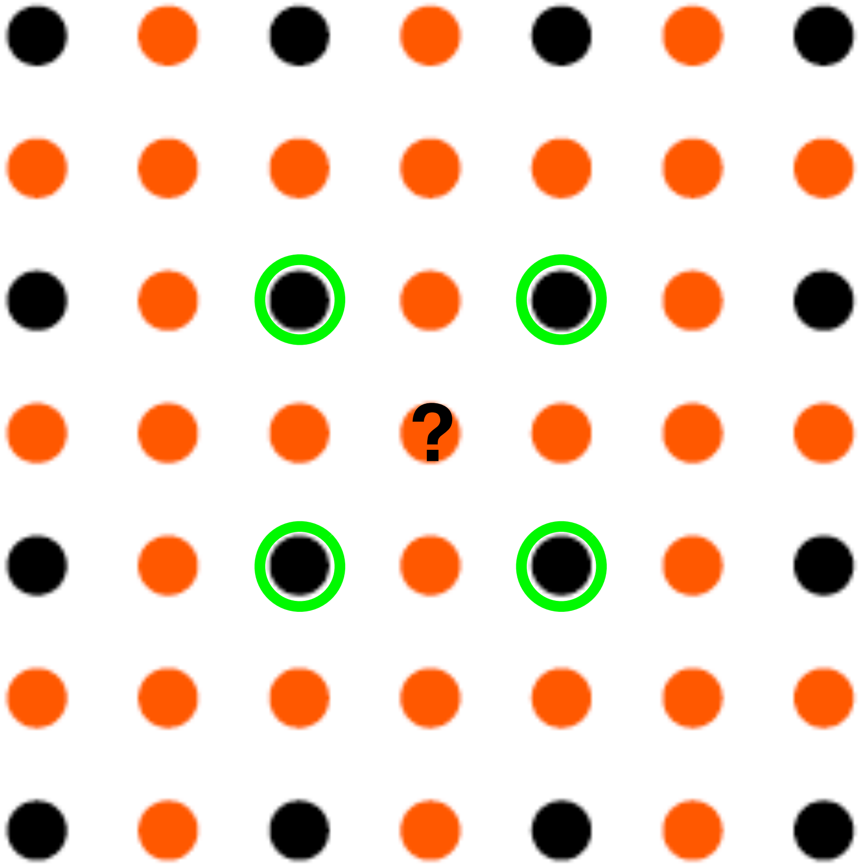
$$f(x,y) = ax + by + cxy + d$$

coefficients that need to be estimated

Bilinear Interpolation

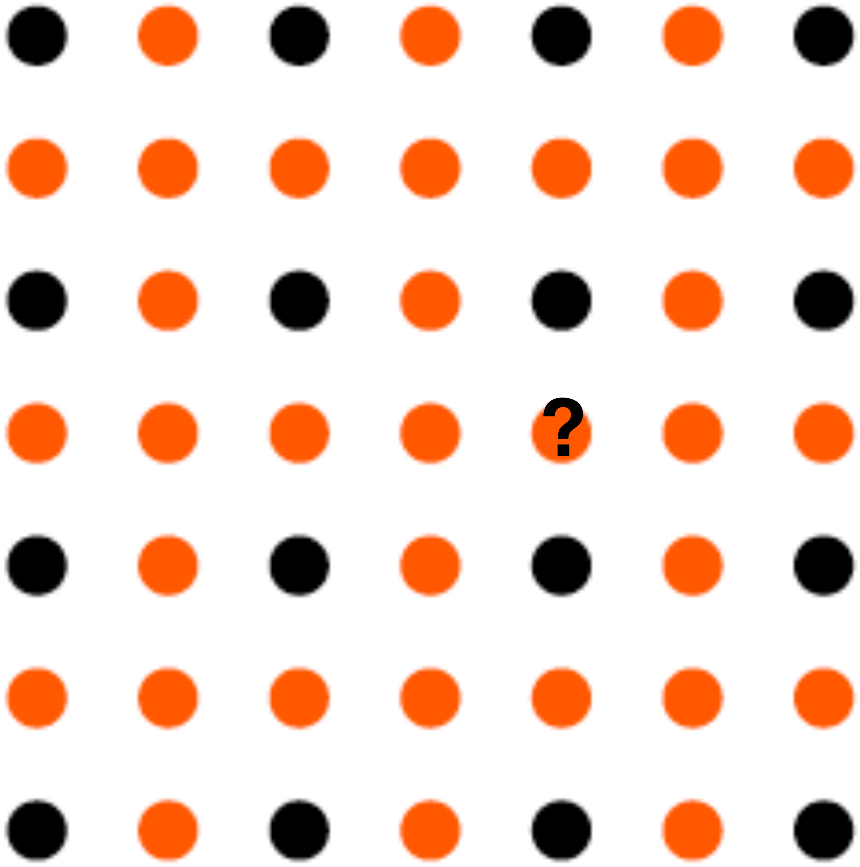
$$f(x,y) = ax + by + cxy + d$$

coefficients that need to be estimated



○ nearest neighbor

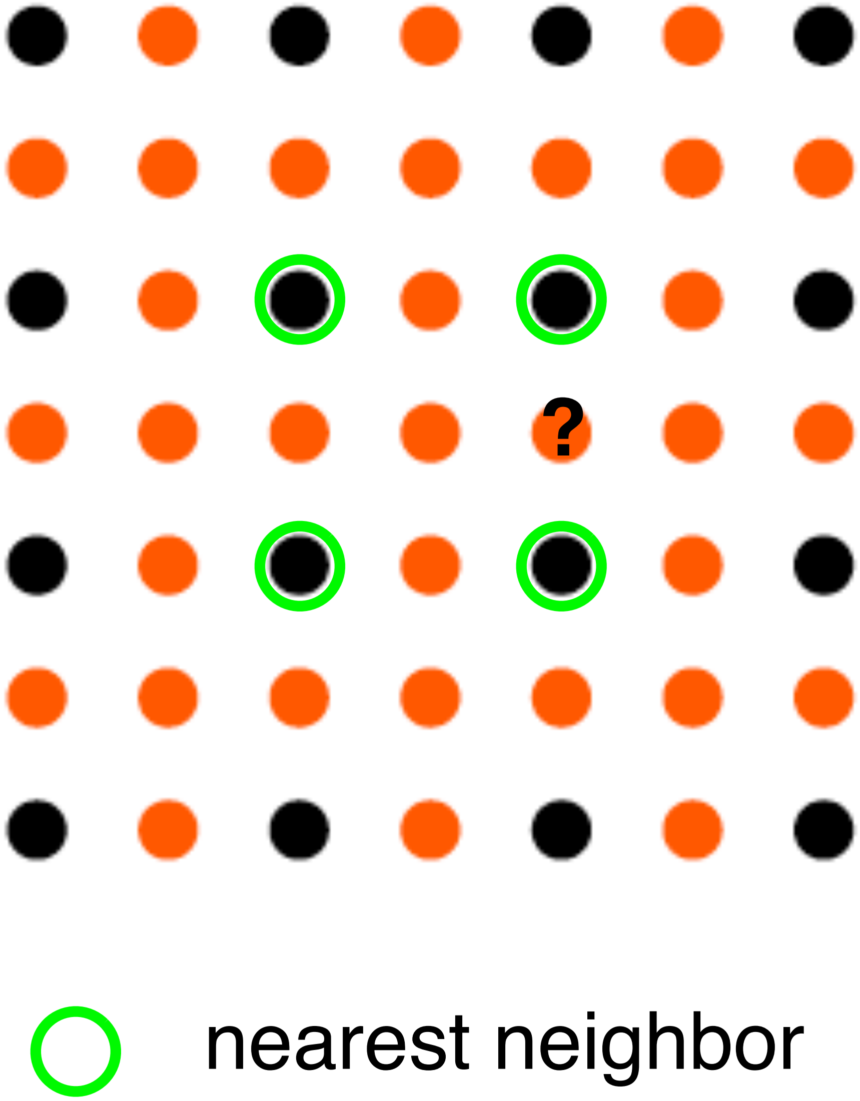
Bilinear Interpolation



$$f(x,y) = ax + by + cxy + d$$

coefficients that need to be estimated

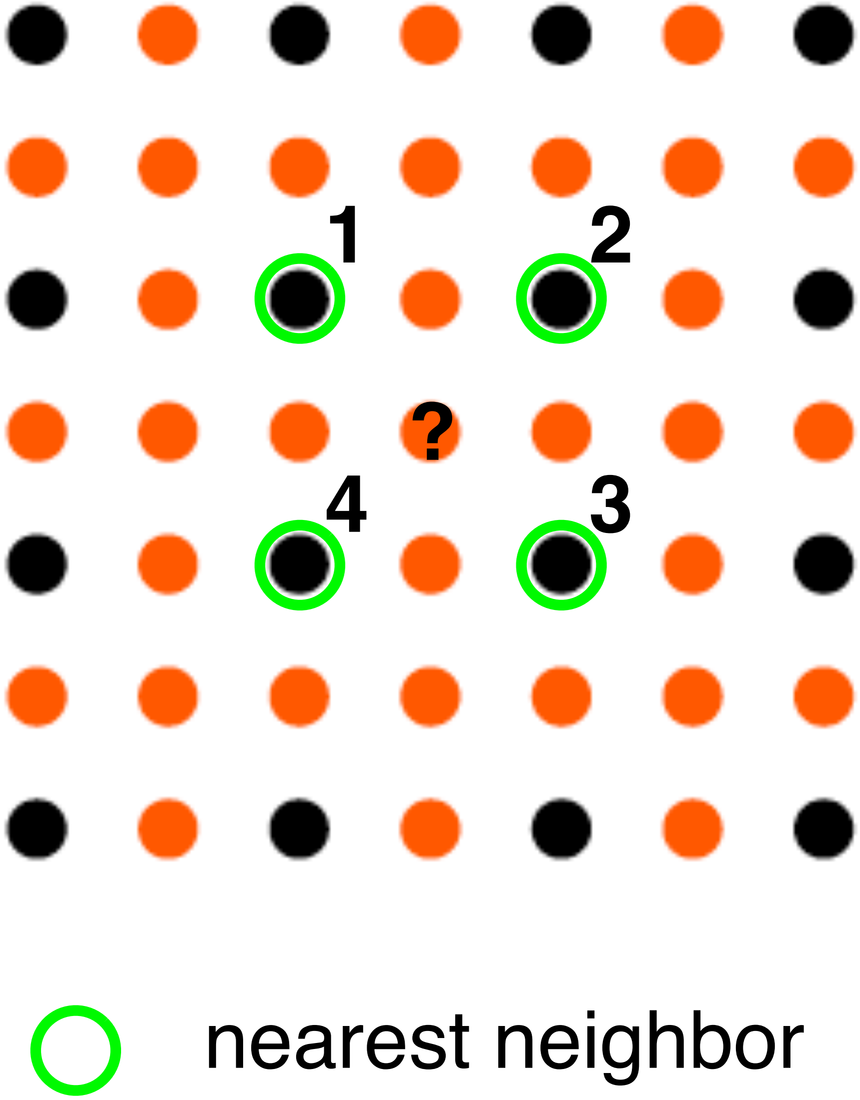
Bilinear Interpolation



$$f(x,y) = ax + by + cxy + d$$

coefficients that need to be estimated

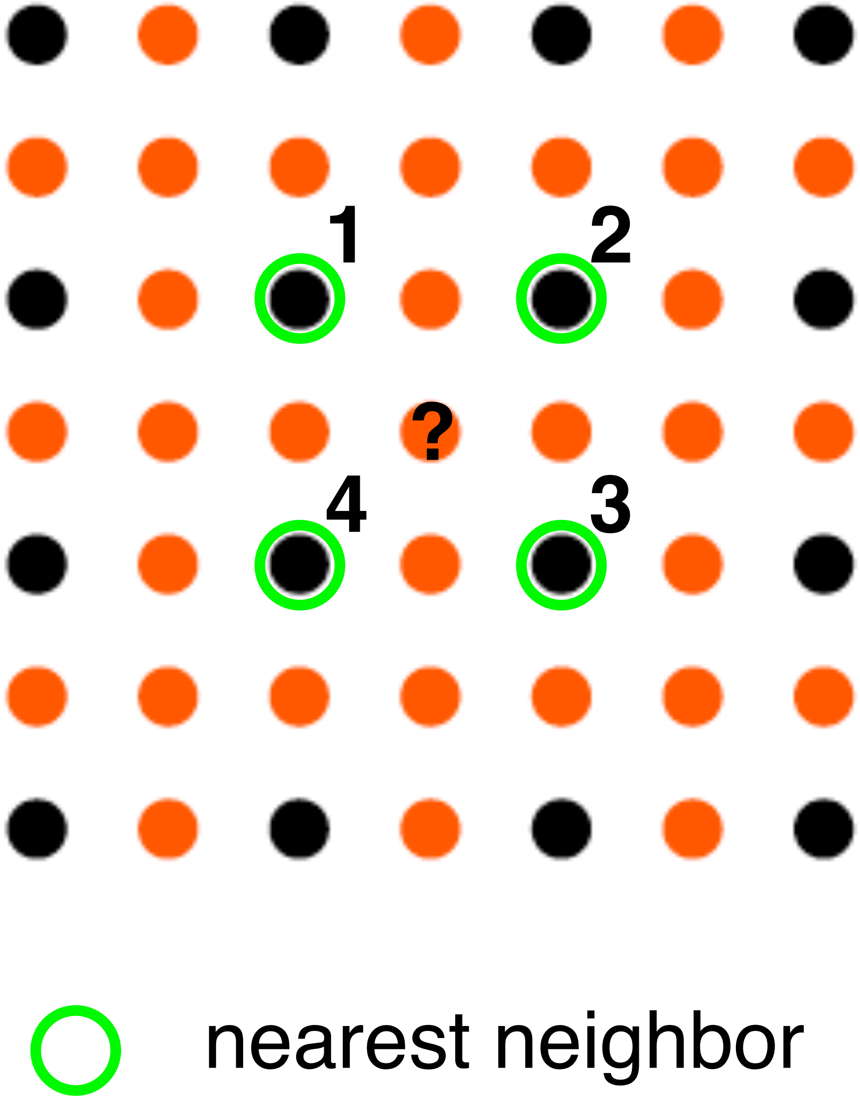
Bilinear Interpolation



$$f(x, y) = \underbrace{a}x + \underbrace{b}y + \underbrace{c}xy + \underbrace{d}$$

coefficients that need to be estimated

Bilinear Interpolation



$$f(x, y) = ax + by + cxy + d$$

coefficients that need to be estimated

$$ax_1 + by_1 + cx_1y_1 + d = f(x_1, y_1)$$

$$ax_2 + by_2 + cx_2y_2 + d = f(x_2, y_2)$$

$$ax_3 + by_3 + cx_3y_3 + d = f(x_3, y_3)$$

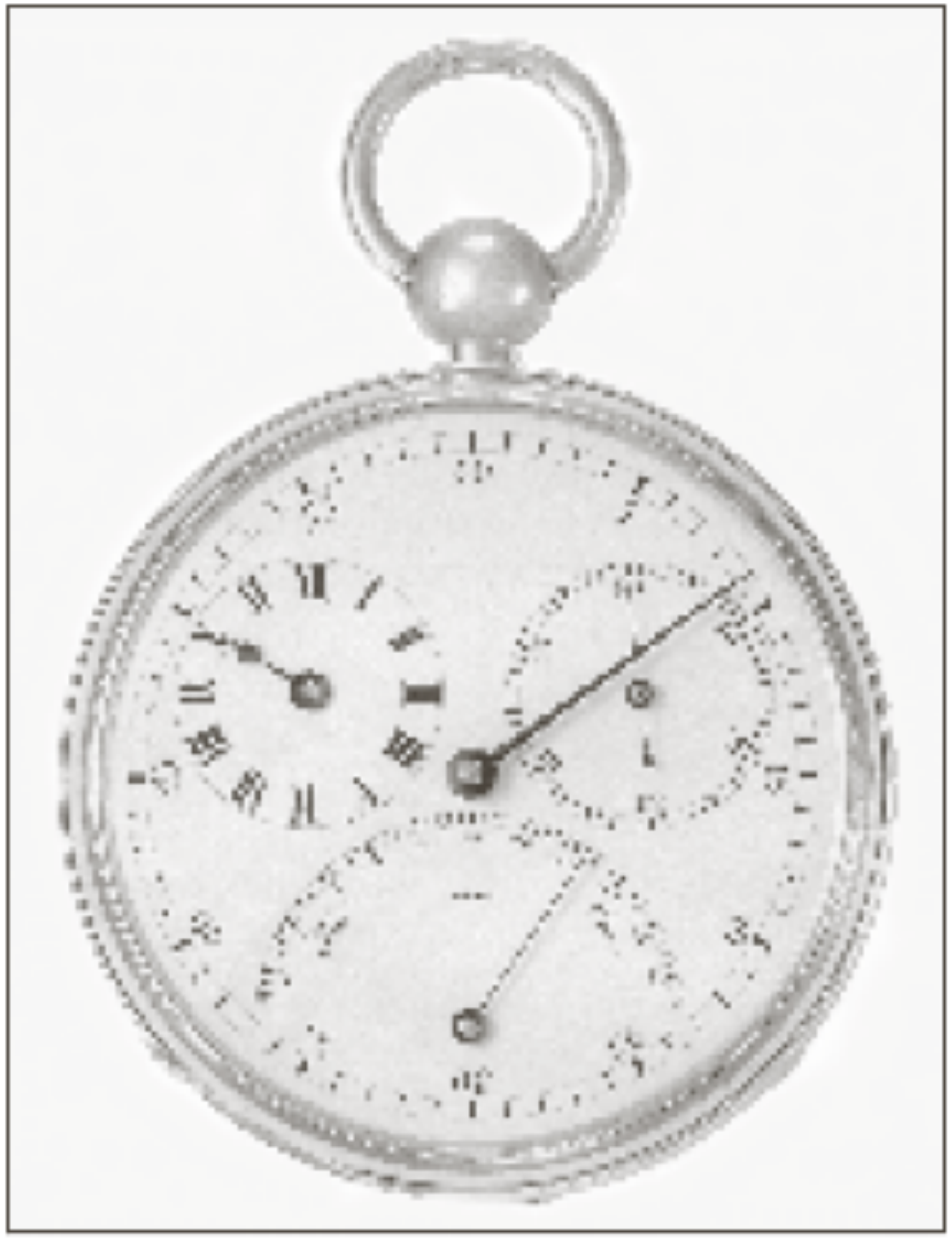
$$ax_4 + by_4 + cx_4y_4 + d = f(x_4, y_4)$$

$$\Downarrow$$

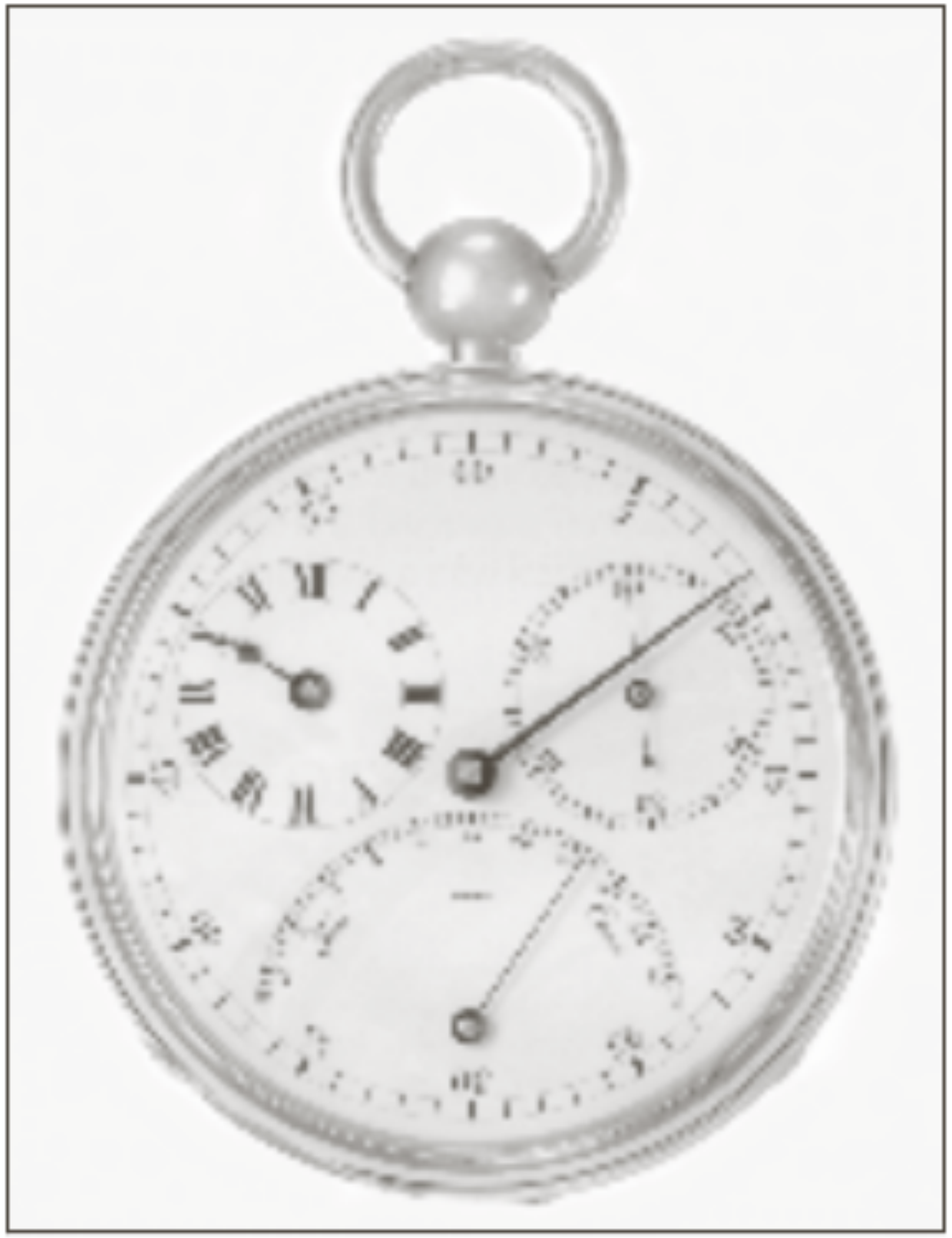
$$a,\ b,\ c,\ d$$

Nearest Neighbor vs. Bilinear Interpolation

zoomed in images



nearest neighbor



bilinear

Image Interpolation

- Bilinear N = 1
- Bicubic N = 3

$$f(x,y) = \sum_{i=0}^{N}\sum_{j=0}^{N} a_{ij} x^i y^j$$

new locations

new locations

estimated from the known neighboring locations

Spatial-Domain Operations on Images

Spatial-Domain Filtering of Images

$$\underset{\uparrow \atop \text{transformed input}}{g(x, y)} = T\{\underset{\uparrow \atop \text{input}}{f(x, y)}\}$$

Basic Operations on Images

- Addition
- Multiplication

Example: Shading Correction

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

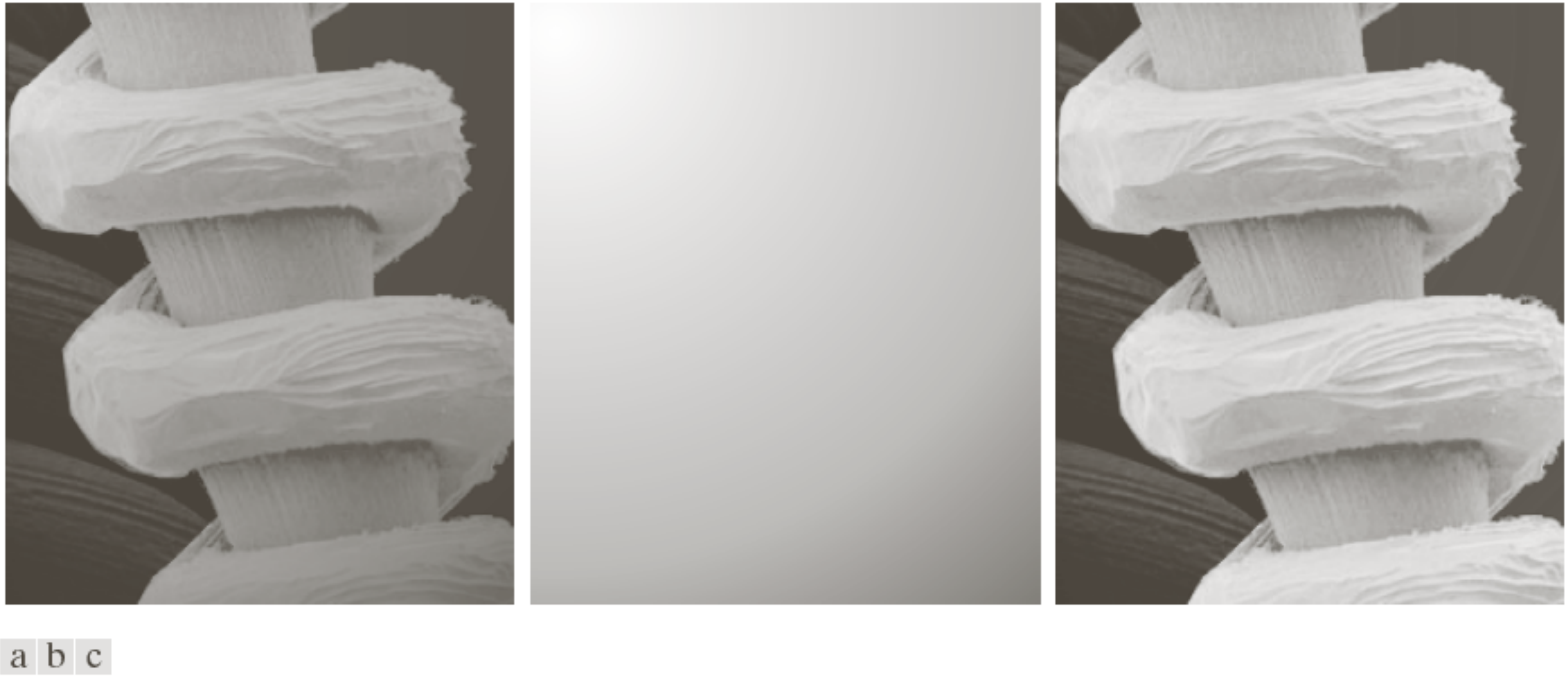


FIGURE 2.29 Shading correction. (a) Shaded SEM image of a tungsten filament and support, magnified approximately 130 times. (b) The shading pattern. (c) Product of (a) by the reciprocal of (b). (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)

Example: Masking

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

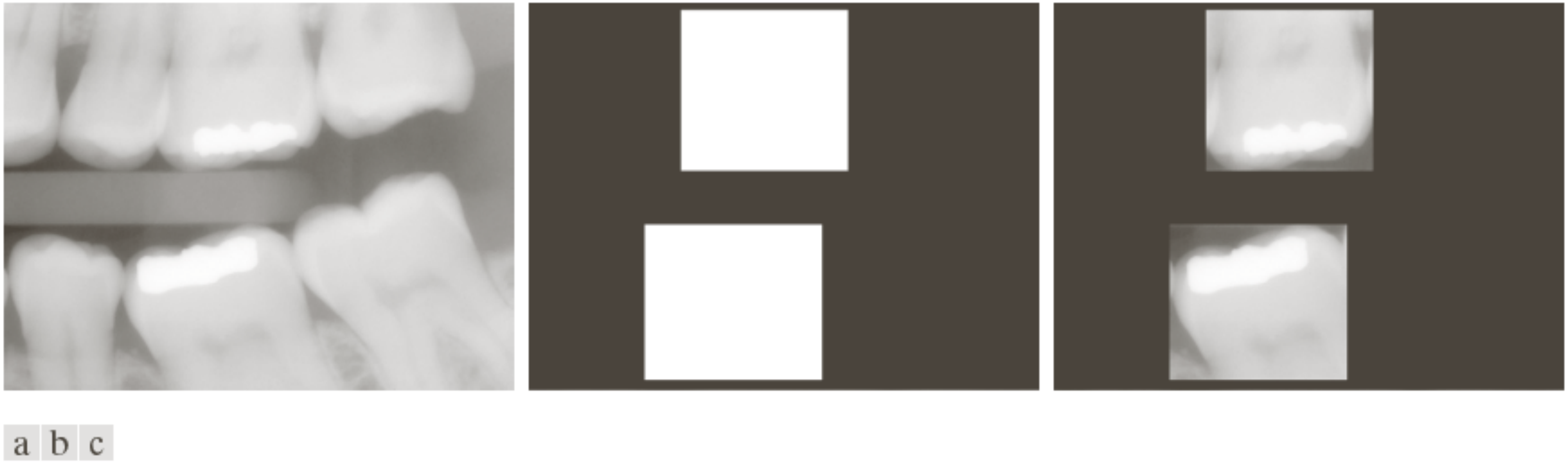


FIGURE 2.30 (a) Digital dental X-ray image. (b) ROI mask for isolating teeth with fillings (white corresponds to 1 and black corresponds to 0). (c) Product of (a) and (b).

Next Class

- Spatial-Domain Operations on Images
- Intensity Transformations (Textbook: 3.2);