Fundamental of Digital Images

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2. Fundamental of Digital Images
   - Image Acquisition
   - Image presentation
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   - Sampling and Quantization
   - Image Interpolation

Light and Electromagnetic Spectrum

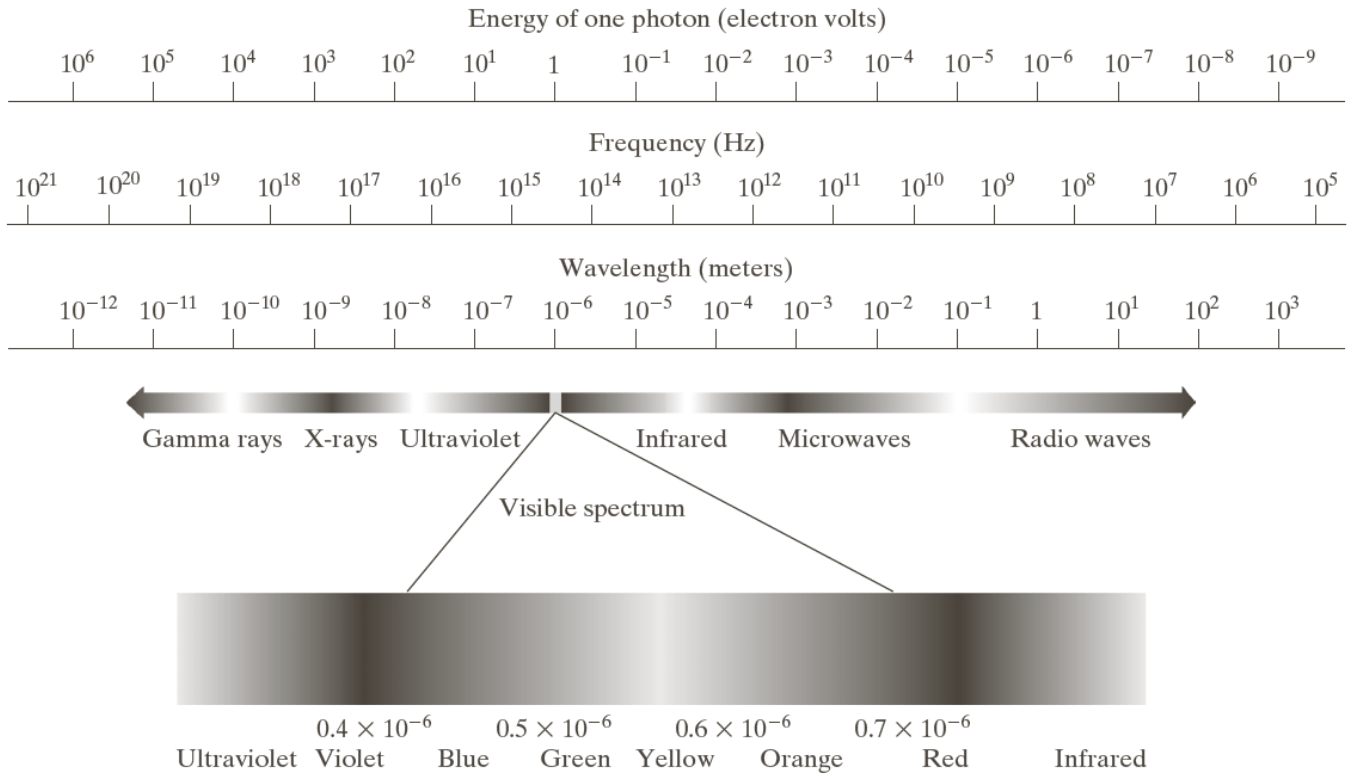
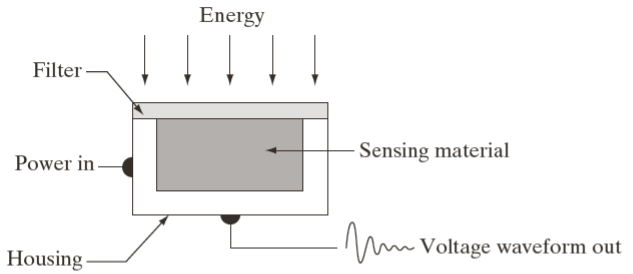


FIGURE 2.10 The electromagnetic spectrum. The visible spectrum is shown zoomed to facilitate explanation, but note that the visible spectrum is a rather narrow portion of the EM spectrum.

Image Acquisition

- Single imaging sensor:
  - A photodiode
  - Silicon material
  - Output voltage is proportional to light
- Line sensor
- Array sensor



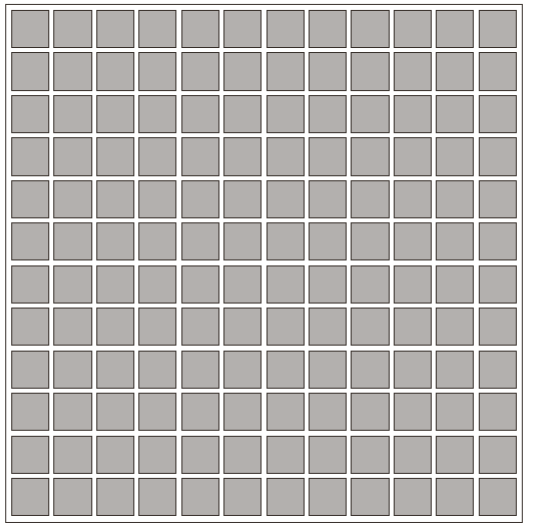
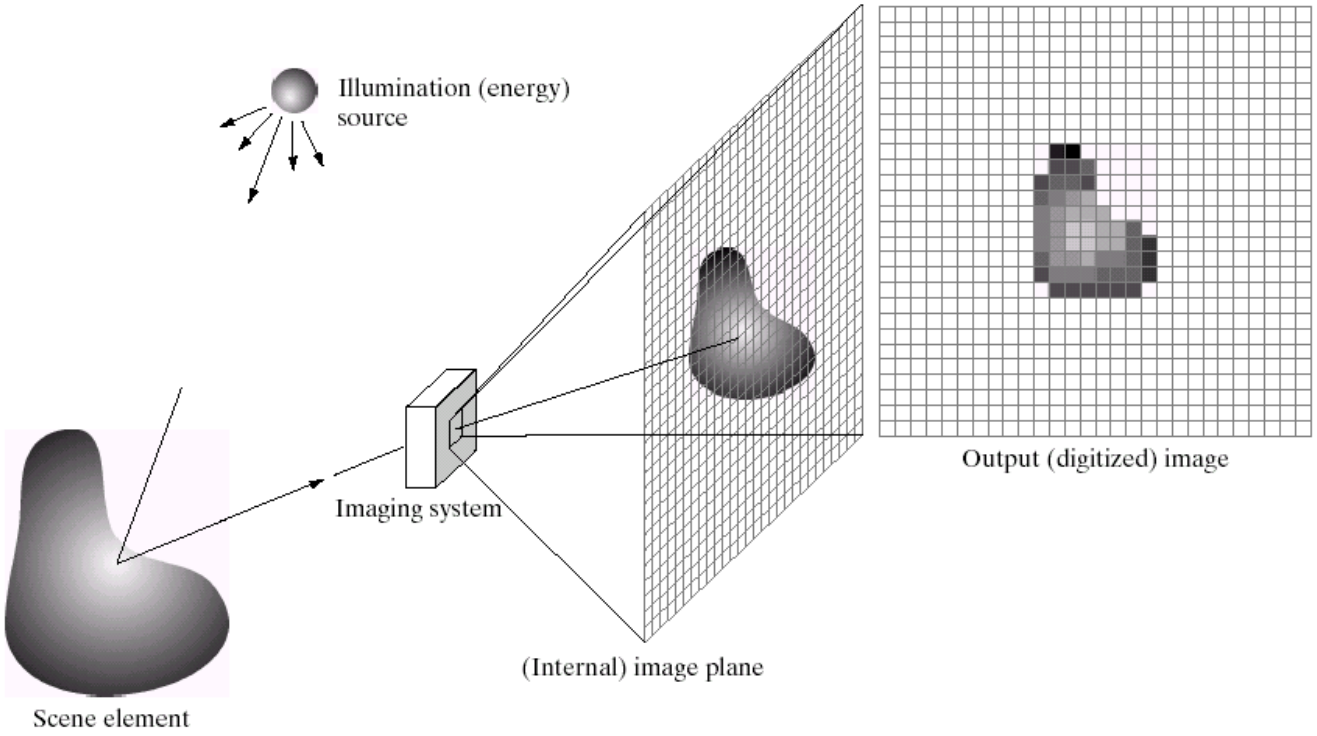


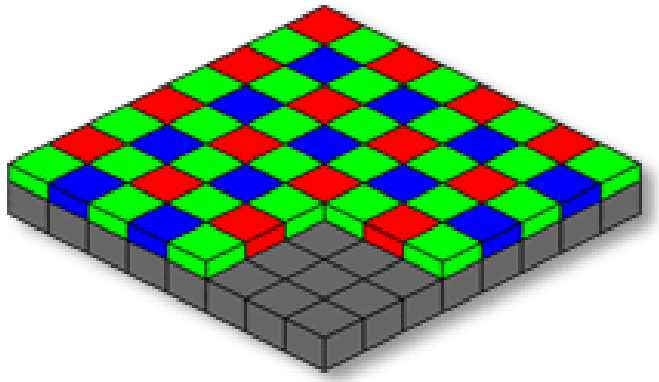
Image Acquisition



a
b c d e

FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

Color Image Acquisition



Color Filter Array Sensor

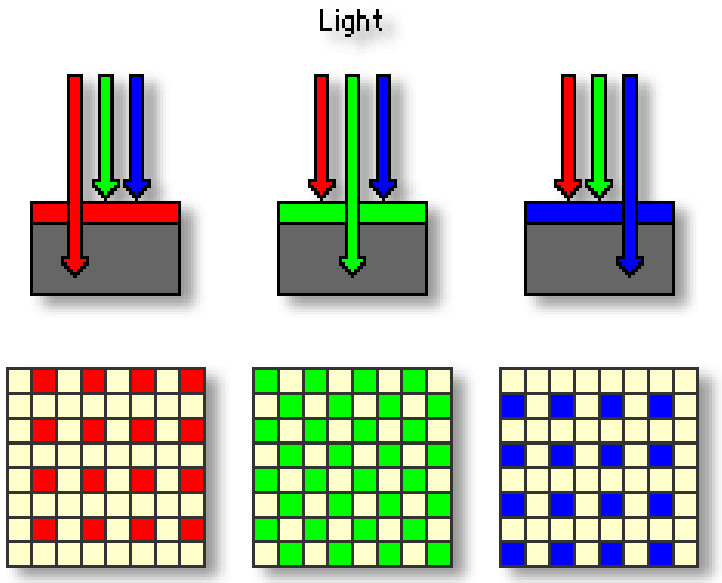


Image Acquisition

- Modern cameras

Image Sampling & Quantization

- Generating a digital image:
  - Scanning from A to B in the continuous image illustrating sampling and quantization

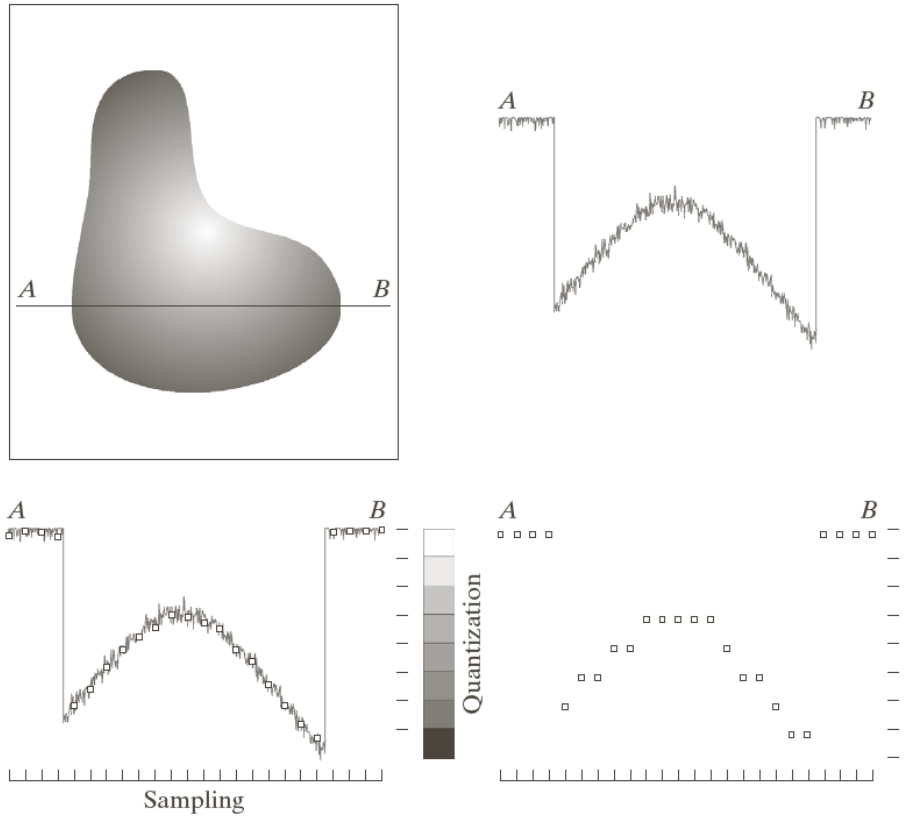
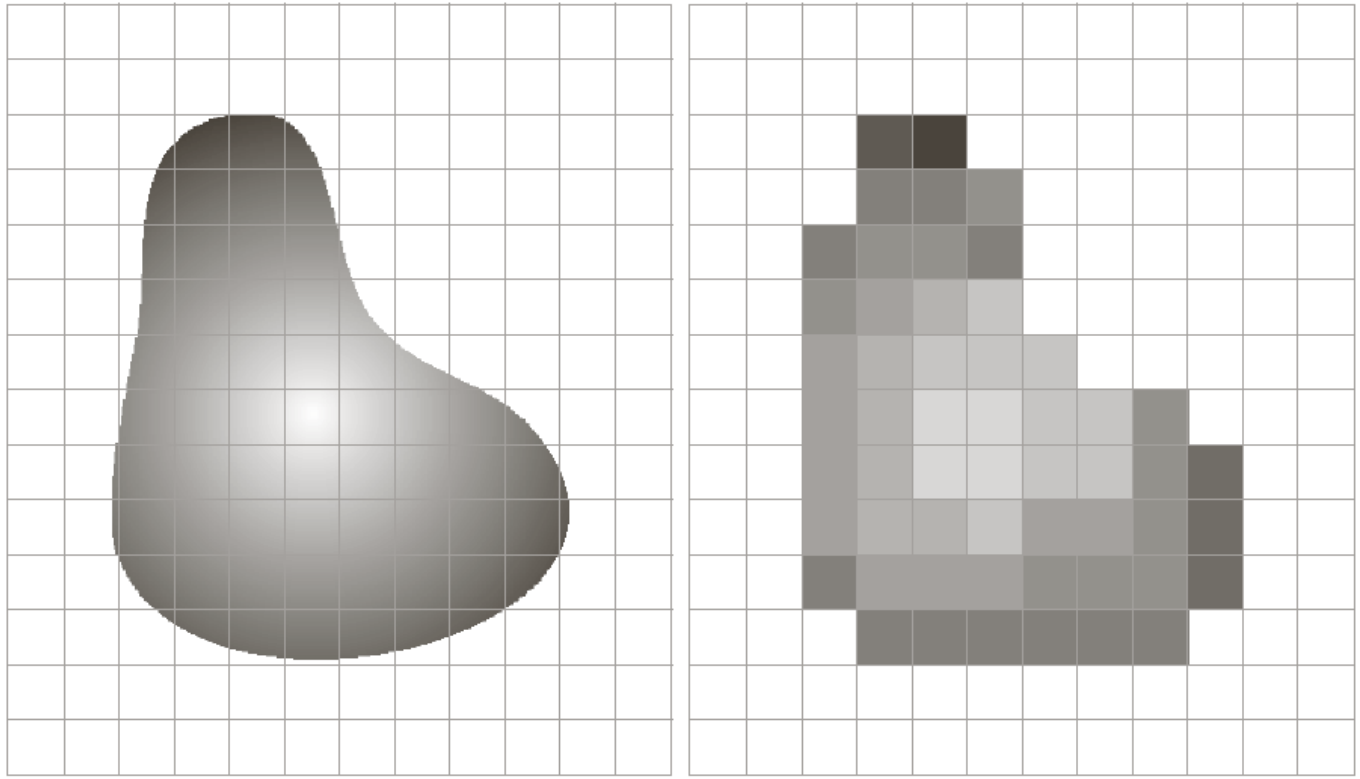


Image Sampling & Quantization



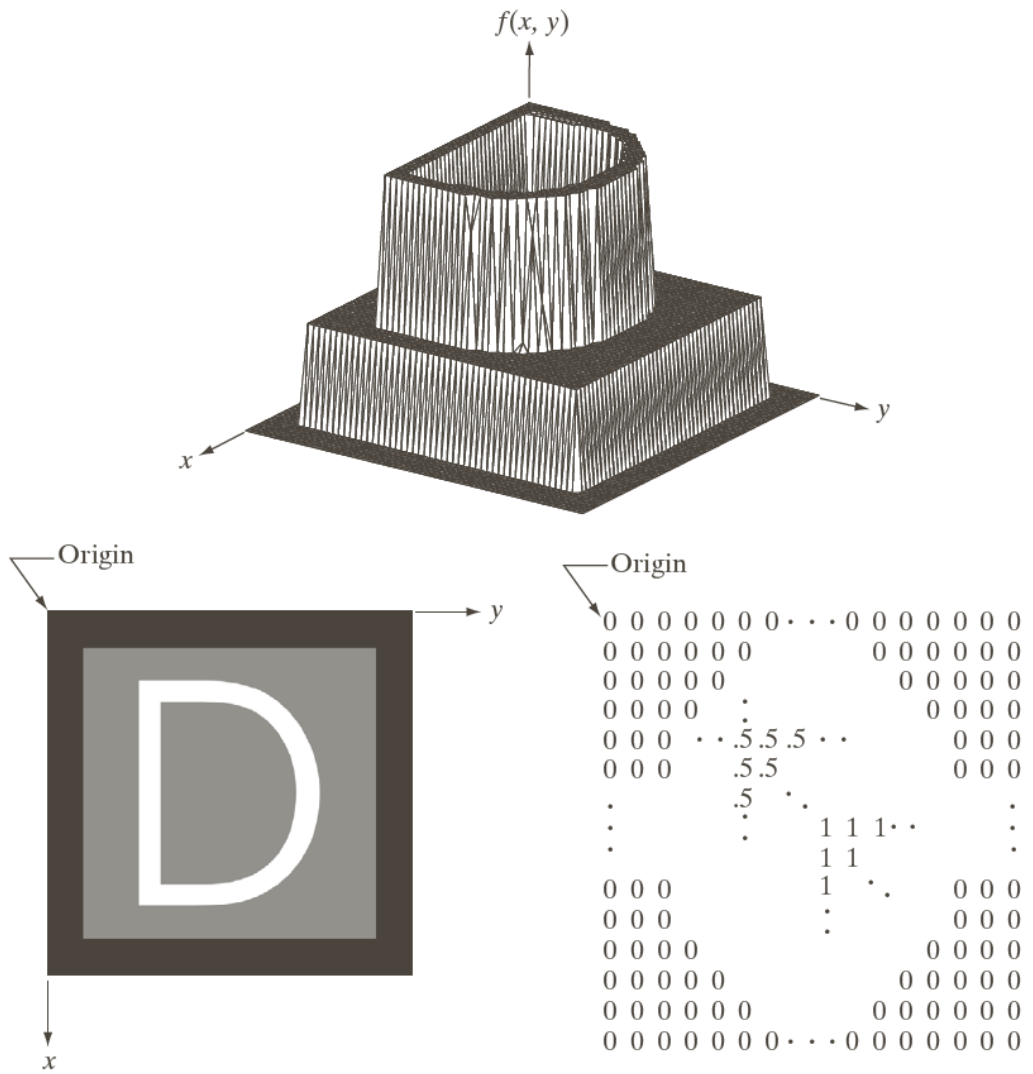
a b

FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

Image Presentation

- The result of sampling and quantization is a matrix of real numbers.

Image Sampling & Quantization



a
b c

FIGURE 2.18
(a) Image plotted as a surface.
(b) Image displayed as a visual intensity array.
(c) Image shown as a 2-D numerical array (0, .5, and 1 represent black, gray, and white, respectively).

Spatial Resolution

- Dots per inch (dpi) used for printer
  - Newspapers: 75 dpi
  - Magazines: 133 dpi
  - High quality book: 2400 dpi

- Image size used for image comparison
  - 640x480
  - 1024x768
  - 10-megapixel
  - 20-megapixel

Spatial Resolution

a b
c d

FIGURE 2.20 Typical effects of reducing spatial resolution. Images shown at: (a) 1250 dpi, (b) 300 dpi, (c) 150 dpi, and (d) 72 dpi. The thin black borders were added for clarity. They are not part of the data.

Intensity Resolution

- The number of bits used to quantize intensity:
  - 1 bits: binary image
  - 8 bits: 256 colors
  - 24 bits: 8 bits for each color channels

Intensity Resolution

e f
g h

FIGURE 2.21
(Continued)
(e)–(h) Image displayed in 16, 8, 4, and 2 gray levels. (Original courtesy of Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)

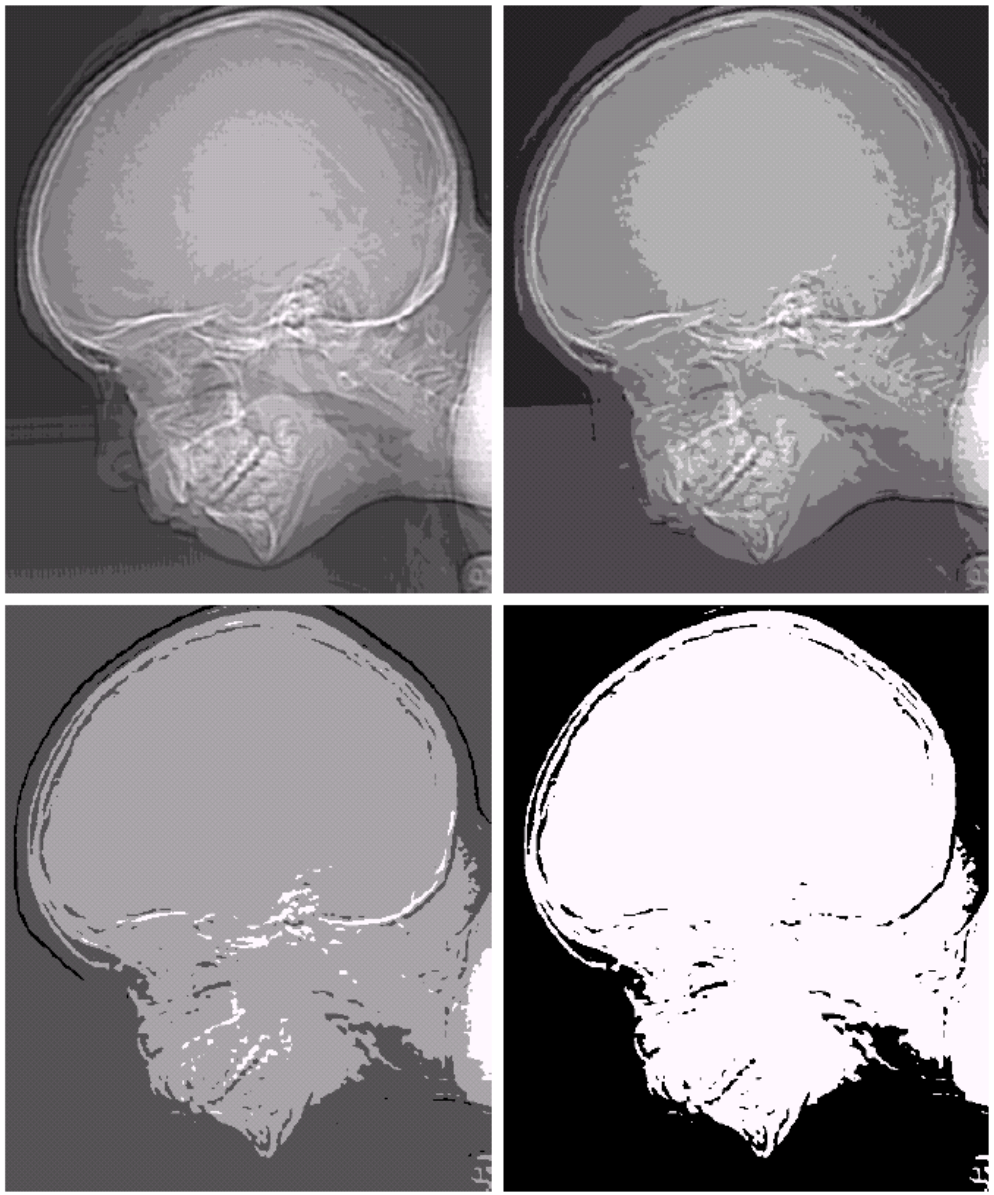


Image Interpolation

- Needed for some applications:
  - Resize
  - Rotation
  - Geometric correction
  - …

- Basically, Image interpolation is the resampling operator.

Image Interpolation

- Interpolation is the process of estimating the value at unknown locations from known data.
  - Nearest Neighbor
  - Bilinear
  - Bicubic
  - Mean Square Minimization
  - …

Image Interpolation

- Nearest Neighbor:
  - The missing value of pixel are copied from the nearest pixel value.
  - Simpleast interpolation method
  - Produce undesirable distortion

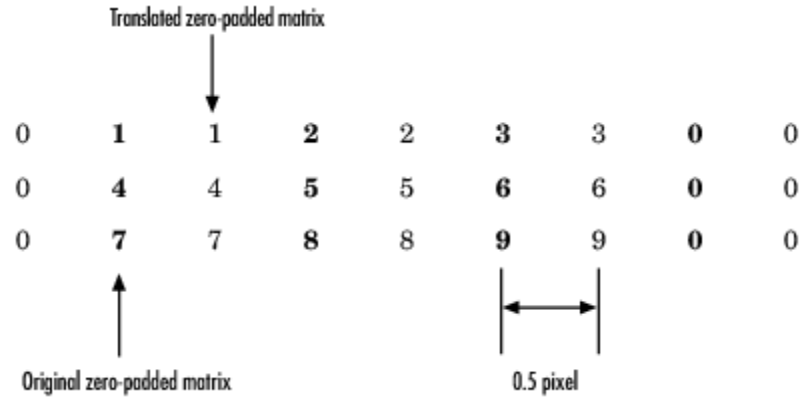


Image Interpolation

- Bilinear Interpolation
  - Use four neighbor pixels to compute the weighted average of the estimated pixel

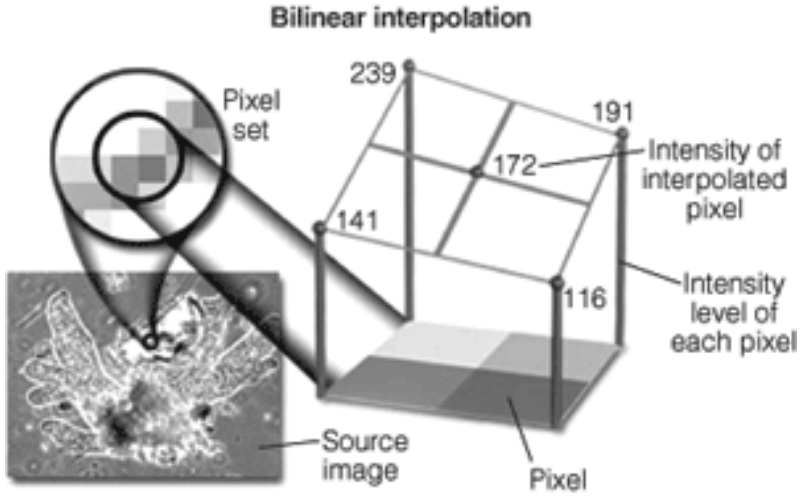


Image Interpolation

- Bicubic interpolation
  - It is better than nearest neighbor and bilinear interpolation in forms of producing less blurring edges. But it needs more computation.

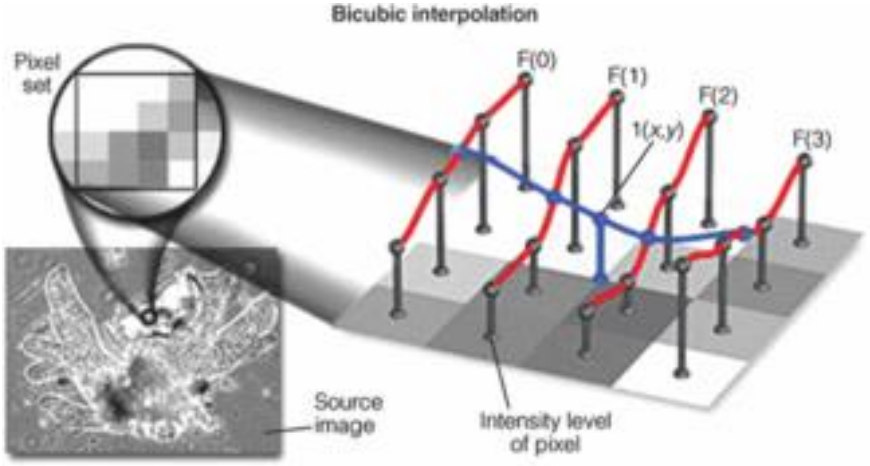


Image Interpolation

a b c
d e f

FIGURE 2.24 (a) Image reduced to 72 dpi and zoomed back to its original size (3692 × 2812 pixels) using nearest neighbor interpolation. This figure is the same as Fig. 2.20(d). (b) Image shrunk and zoomed using bilinear interpolation. (c) Same as (b) but using bicubic interpolation. (d)–(f) Same sequence, but shrinking down to 150 dpi instead of 72 dpi [Fig. 2.24(d) is the same as Fig. 2.20(c)]. Compare Figs. 2.24(e) and (f), especially the latter, with the original image in Fig. 2.20(a).