Session 1

Shiraz University

Digital Image Processing

Using MATLAB

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SIPL

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Outline

- 1. Introduction
  - What are we going to do?
  - Digital image processing platforms
  - What you should know before starting!
  - Fields that use digital image processing
  - Useful Books and references

- 2. Digital Image Fundamentals
  - Human eye
  - Imaging devices
  - Pixels, resolution, intensity, color
  - Different color spaces and how to use them

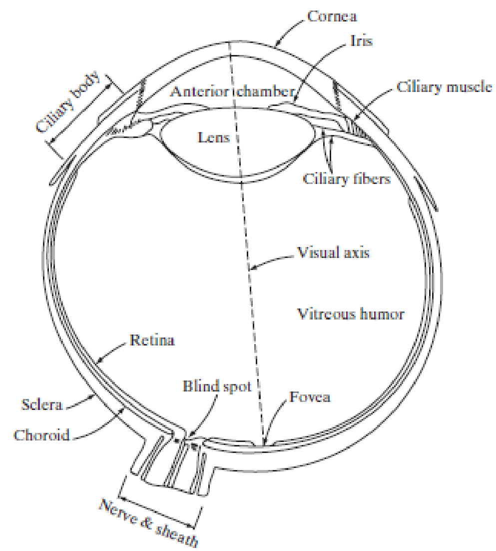
- 3. Basic Histogram Processing
  - Why is histogram useful?
  - Histogram equalizing

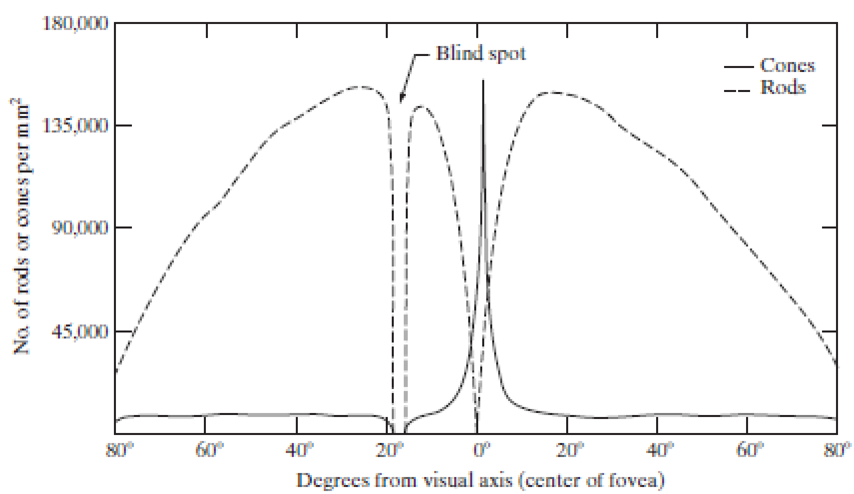
We are HERE!

Digital Image Fundamentals

Digital Image Fundamentals

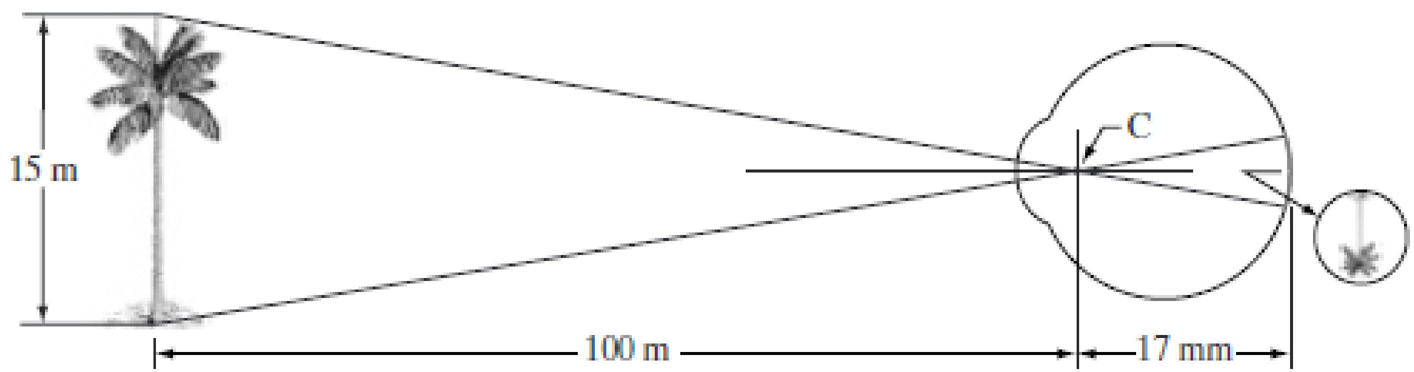
- Human Eye
  - Anatomy





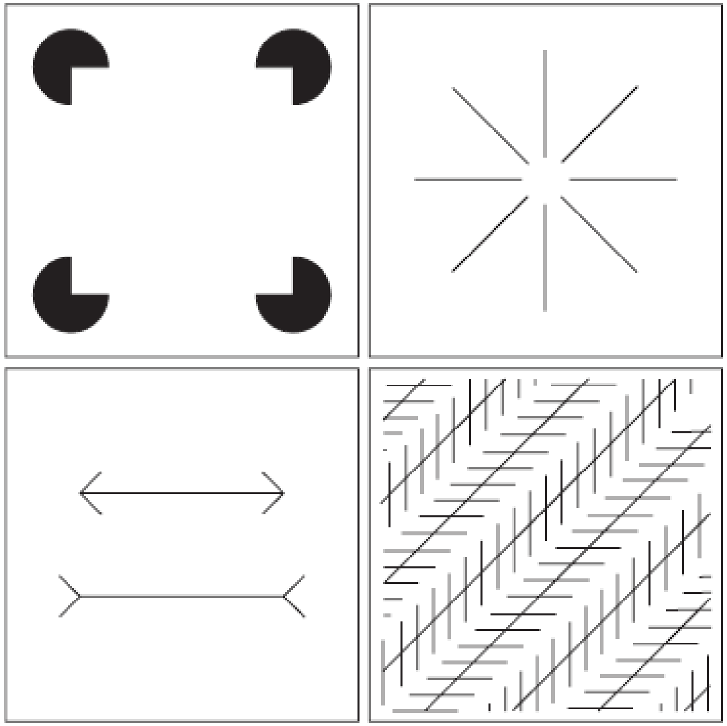
Digital Image Fundamentals

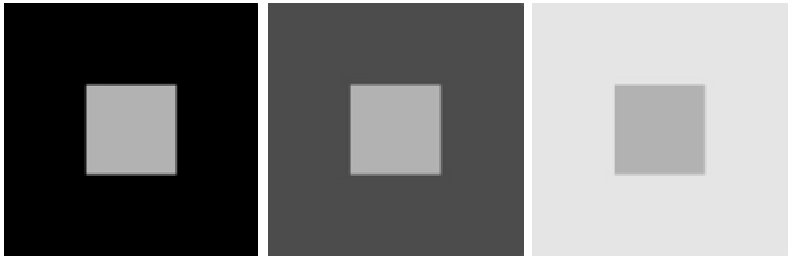
- Human eye
  - Sense of vision



Digital Image Fundamentals

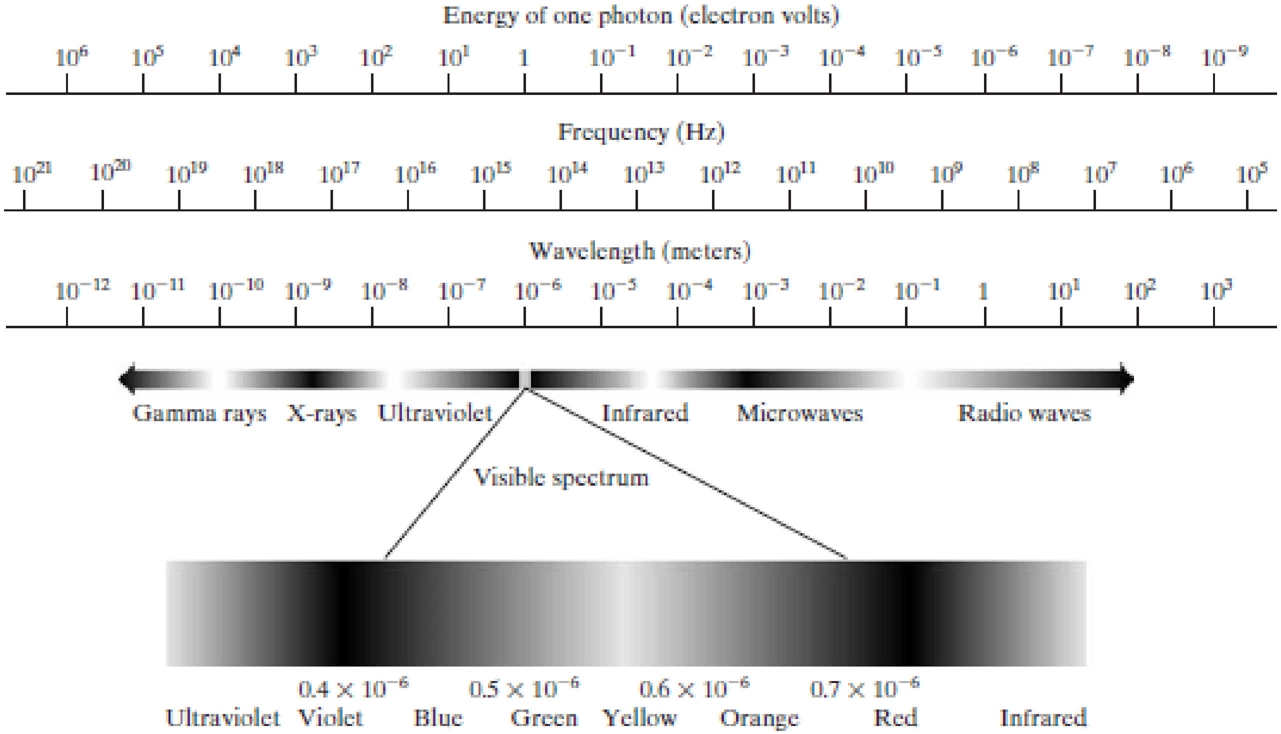
- Human Eye
  - Limitations





Digital Image Fundamentals

- Human Eye
  - Visible Spectrum



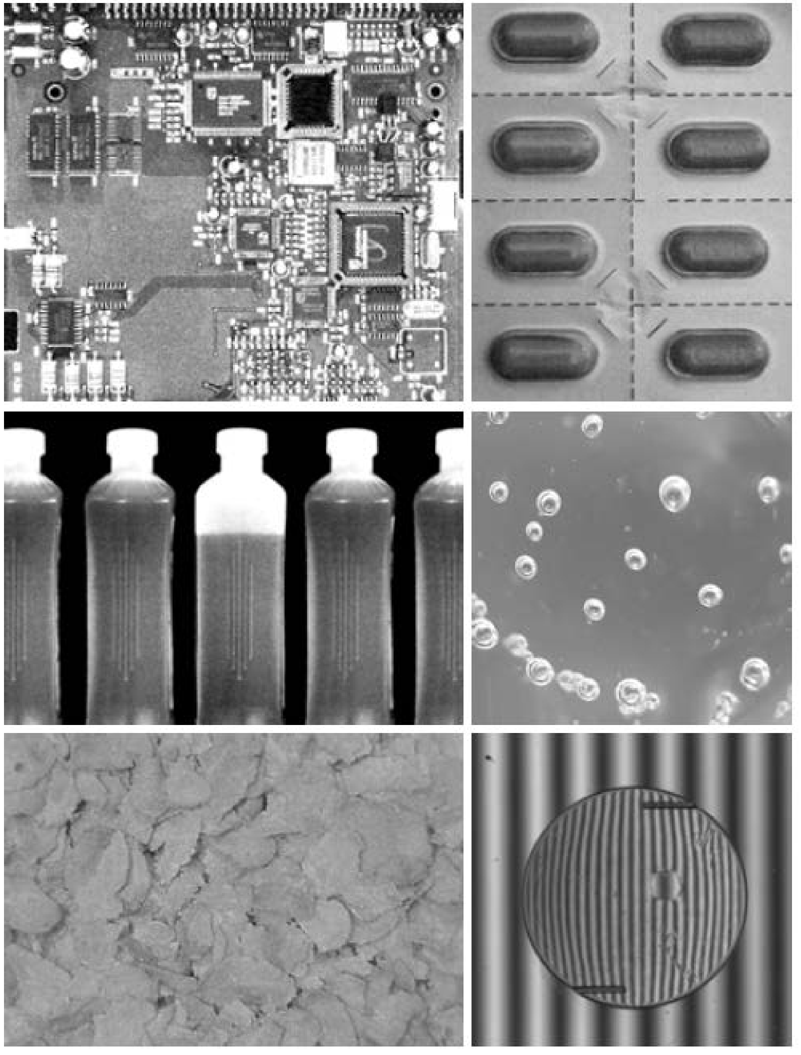
Digital Image Fundamentals

- Image Acquisition
  - Other Spectrums

FIGURE 1.18 Images of the Crab Pulsar (in the center of images) covering the electromagnetic spectrum. (Courtesy of NASA.)

Digital Image Fundamentals

- Applications
  - Some Examples



a b
c d
e f

FIGURE 1.14 Some examples of manufactured goods often checked using digital image processing. (a) A circuit board controller. (b) Packaged pills. (c) Bottles. (d) Bubbles in clear-plastic product. (e) Cereal. (f) Image of intraocular implant. (Fig. (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)

Digital Image Fundamentals

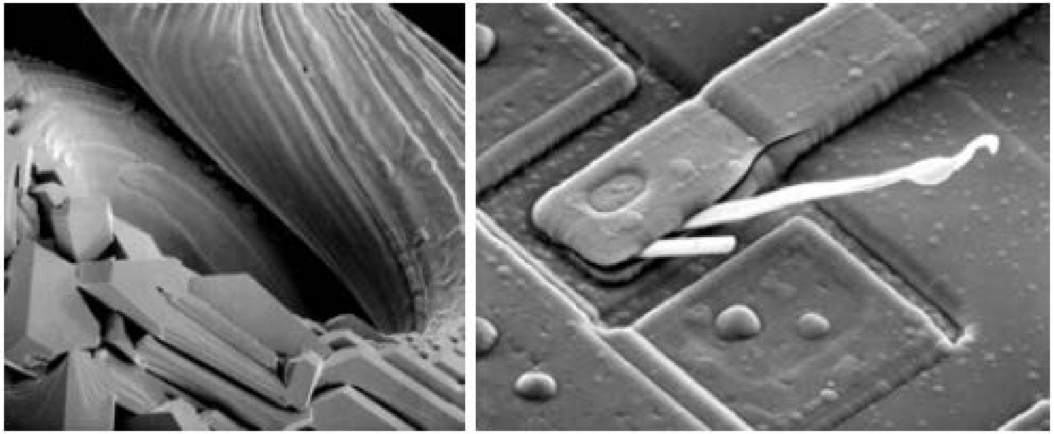
- Applications
  - Some Examples

a b
c
d

FIGURE 1.15 Some additional examples of imaging in the visual spectrum. (a) Thumb print. (b) Paper currency. (c) and (d). Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)

Digital Image Fundamentals

- Applications
  - Some Examples



a b

FIGURE 1.21 (a) 250× SEM image of a tungsten filament following thermal failure. (b) 2500× SEM image of damaged integrated circuit. The white fibers are oxides resulting from thermal destruction. (Figure (a) courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene; (b) courtesy of Dr. J. M. Hudak, McMaster University, Hamilton, Ontario, Canada.)

Digital Image Fundamentals

- Applications
  - Some Examples

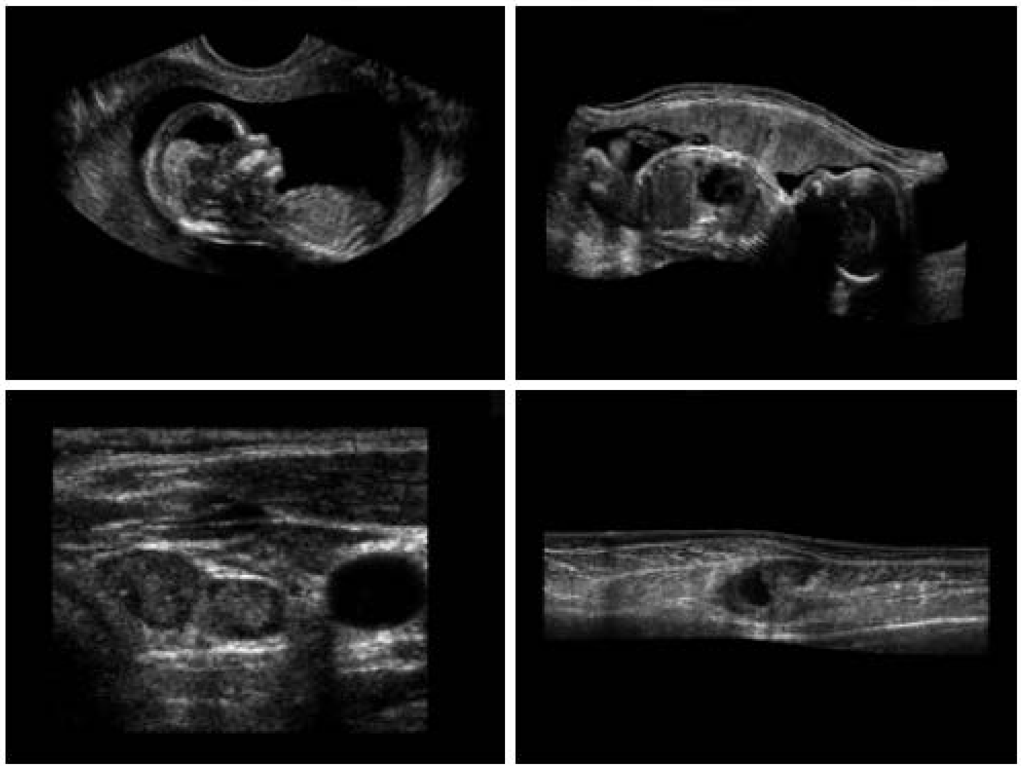


FIGURE 1.20 Examples of ultrasound imaging. (a) Baby. (2) Another view of baby. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)

- Applications
  - Some Examples

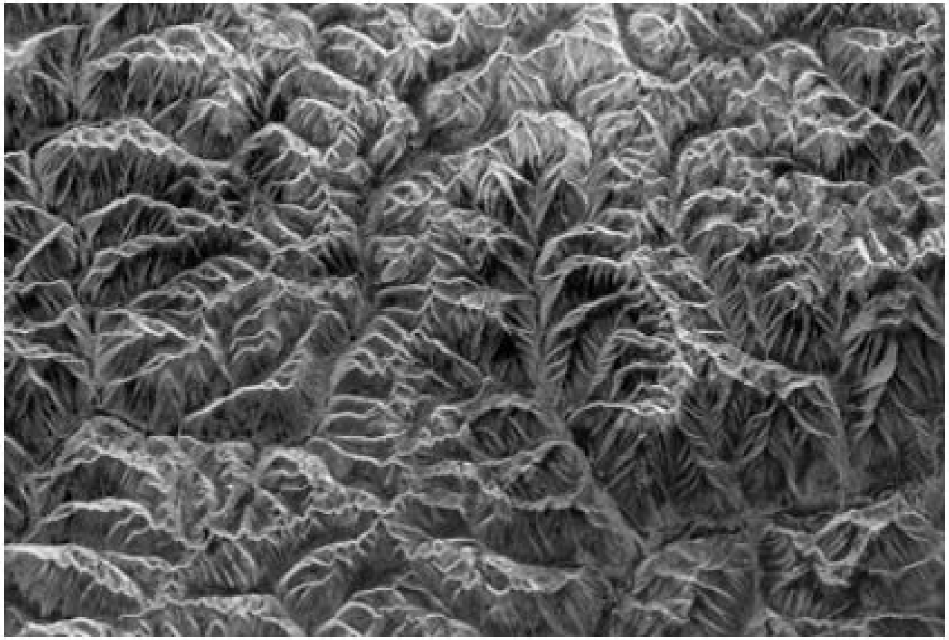
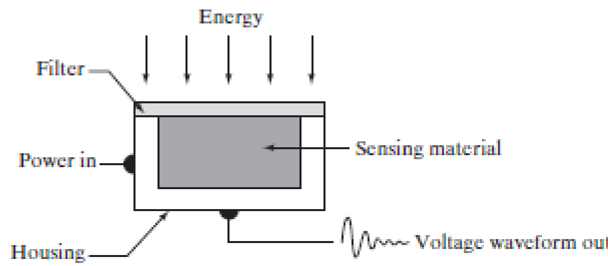
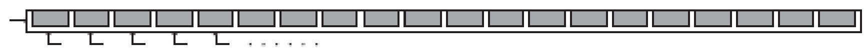


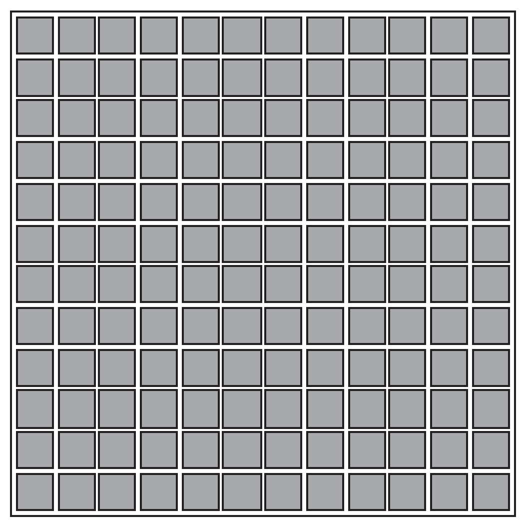
FIGURE 1.16 Spaceborne radar image of mountains in southeast Tibet. (Courtesy of NASA.)

Digital Image Fundamentals

- Imaging Devices
  - Imaging Sensor







Digital Image Fundamentals

- Imaging Devices
  - Multidimensional Images

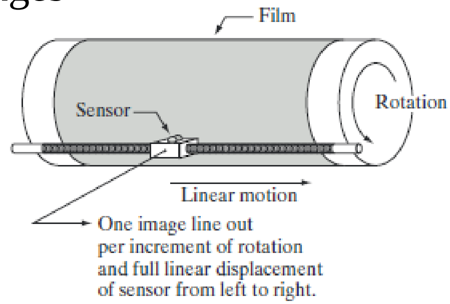
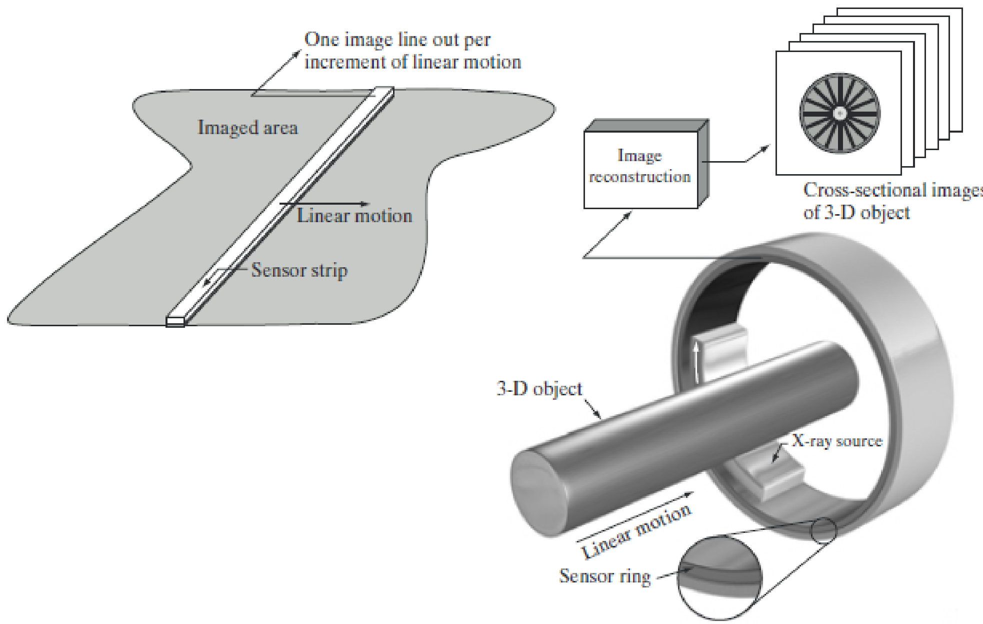


FIGURE 2.13 Combining a single sensor with motion to generate a 2-D image.

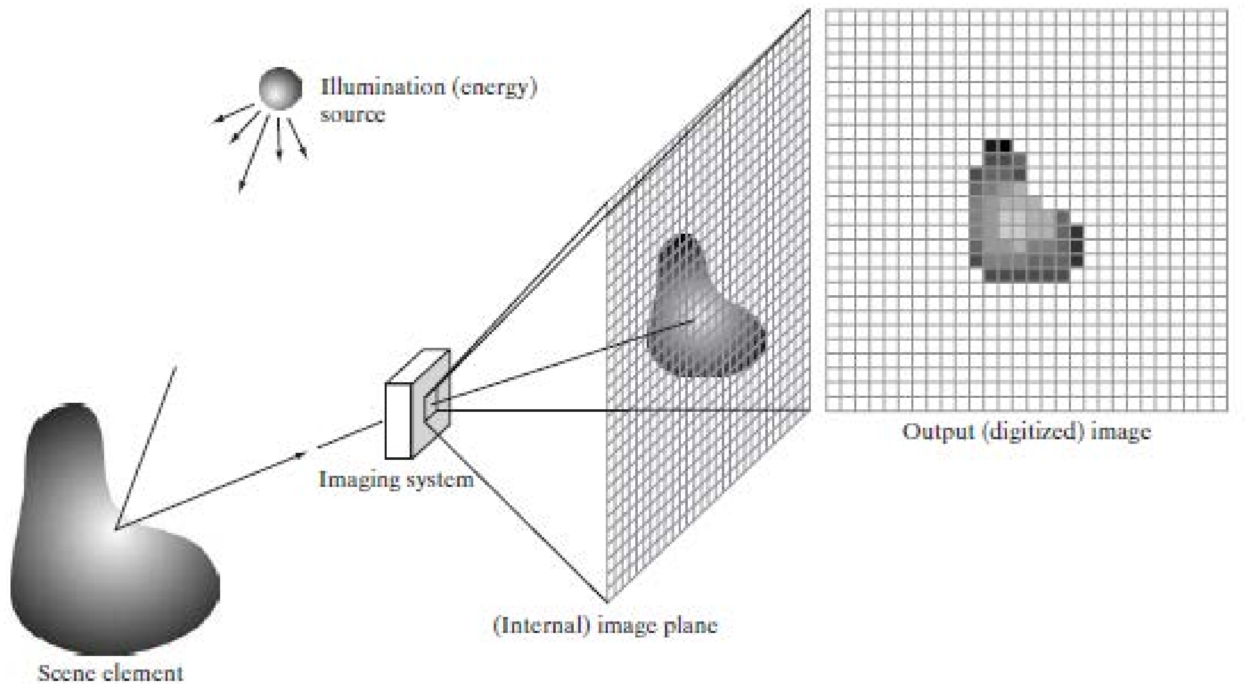


a b

FIGURE 2.14 (a) Image acquisition using a linear sensor strip. (b) Image acquisition using a circular sensor strip.

Digital Image Fundamentals

- Imaging Devices
  - Limitations



Digital Image Fundamentals

- Imaging Devices
  - Limitations

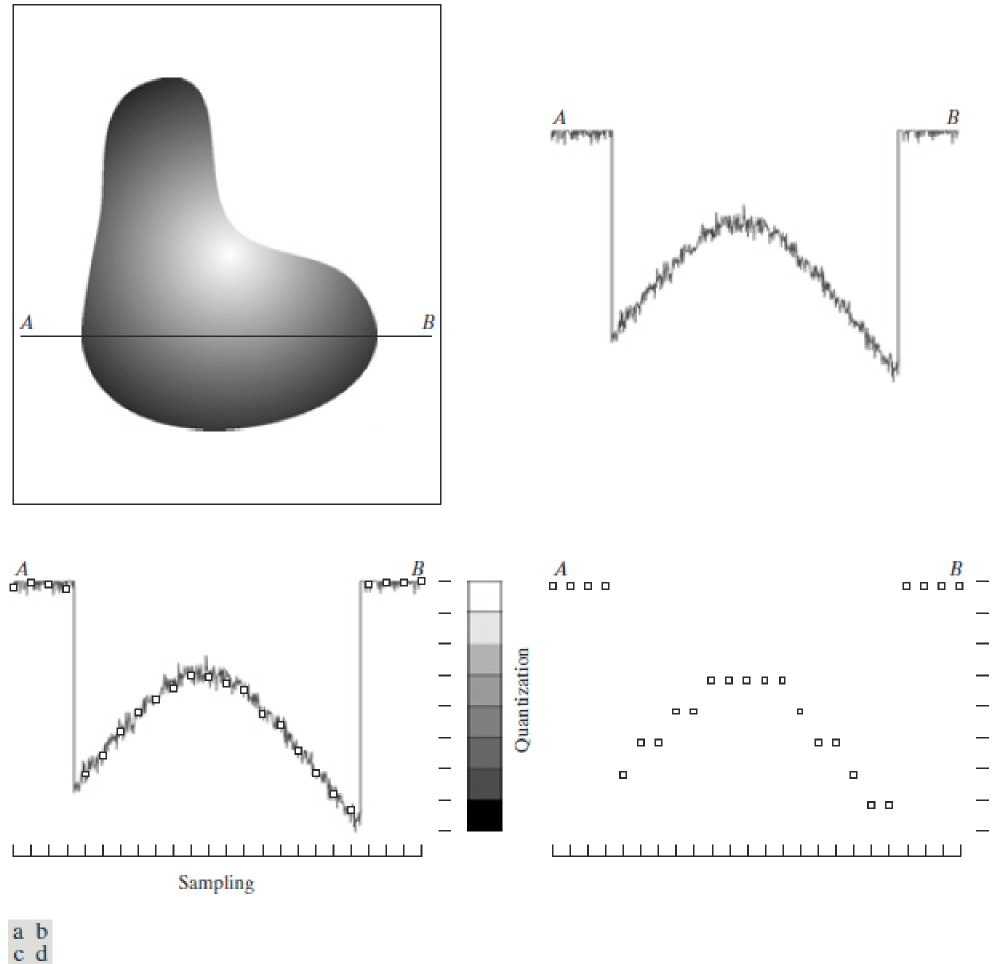
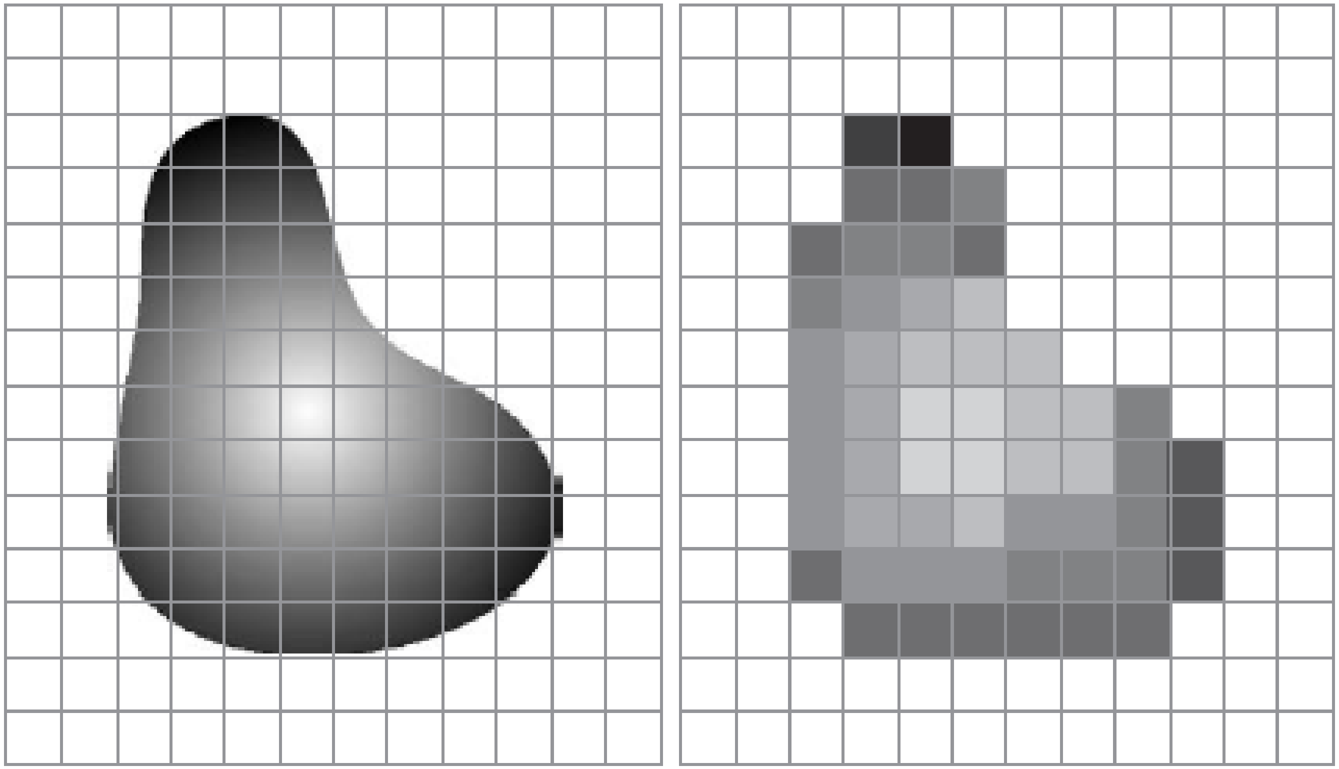


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from A to B in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

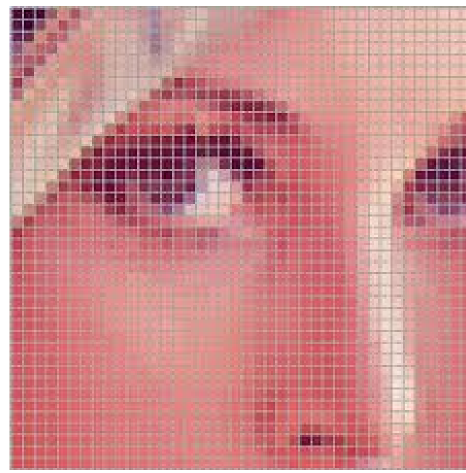
Digital Image Fundamentals

- Imaging Devices
  - Limitations

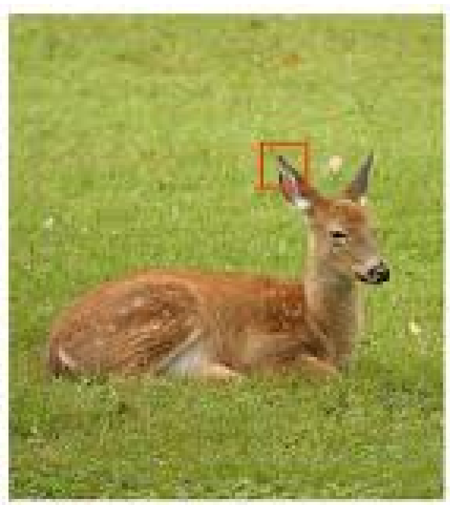


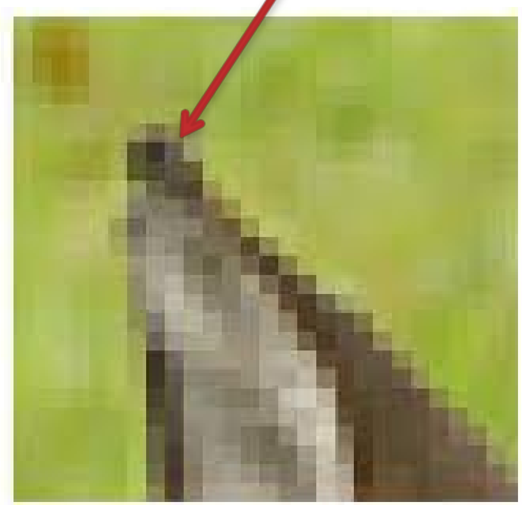
Digital Image Fundamentals

- Fundamentals
  - Pixels



PIXEL!

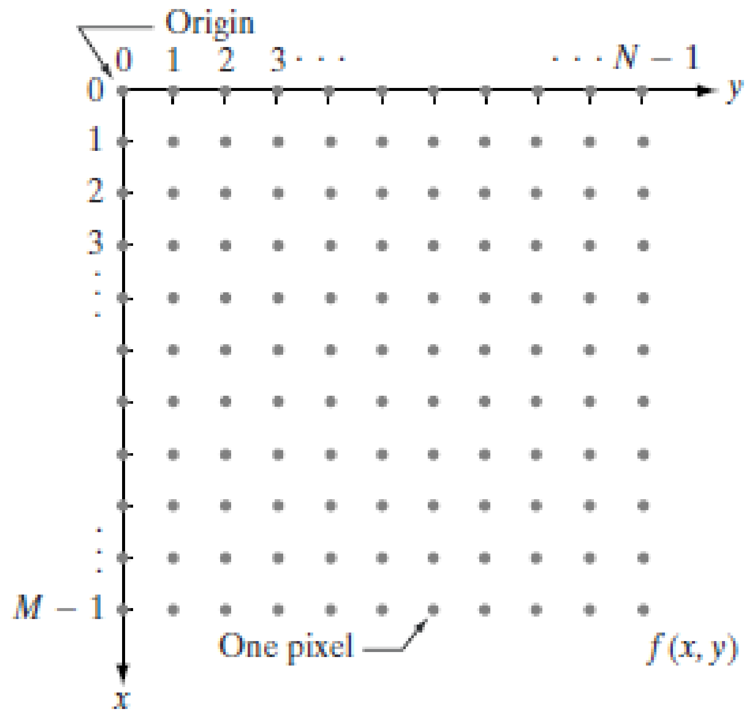




See Ex1.docx

Digital Image Fundamentals

- Fundamentals
  - Pixels, resolution



Digital Image Fundamentals

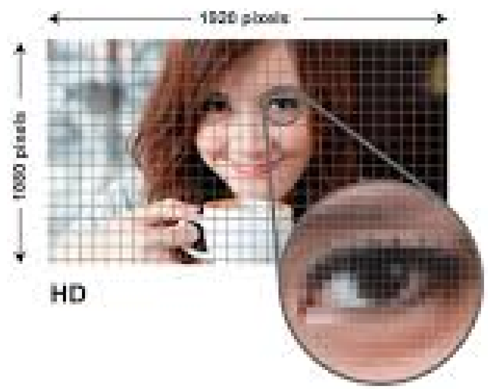
- Fundamentals
  - Pixels, resolution

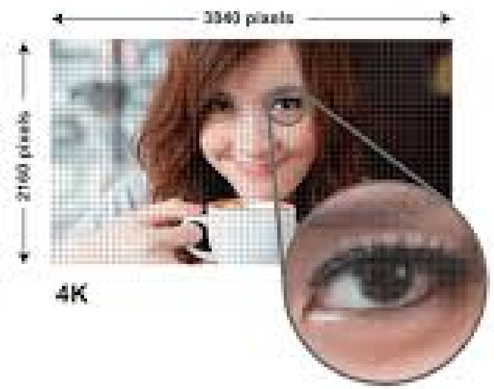
Number of Pixel in x,y direction = (Spatial) Resolution in x,y direction

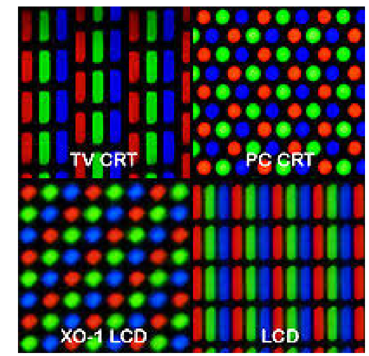
FIGURE 2.19 A 1024 × 1024, 8-bit image subsampled down to size 32 × 32 pixels. The number of allowable gray levels was kept at 256.

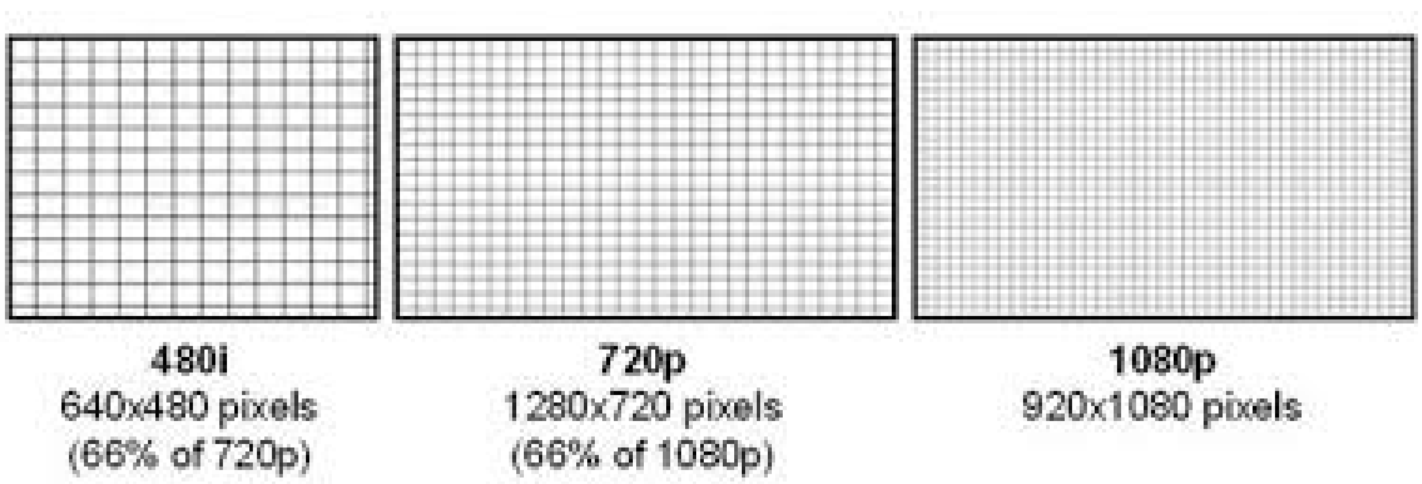
Digital Image Fundamentals

- Fundamentals
  - Pixels, resolution

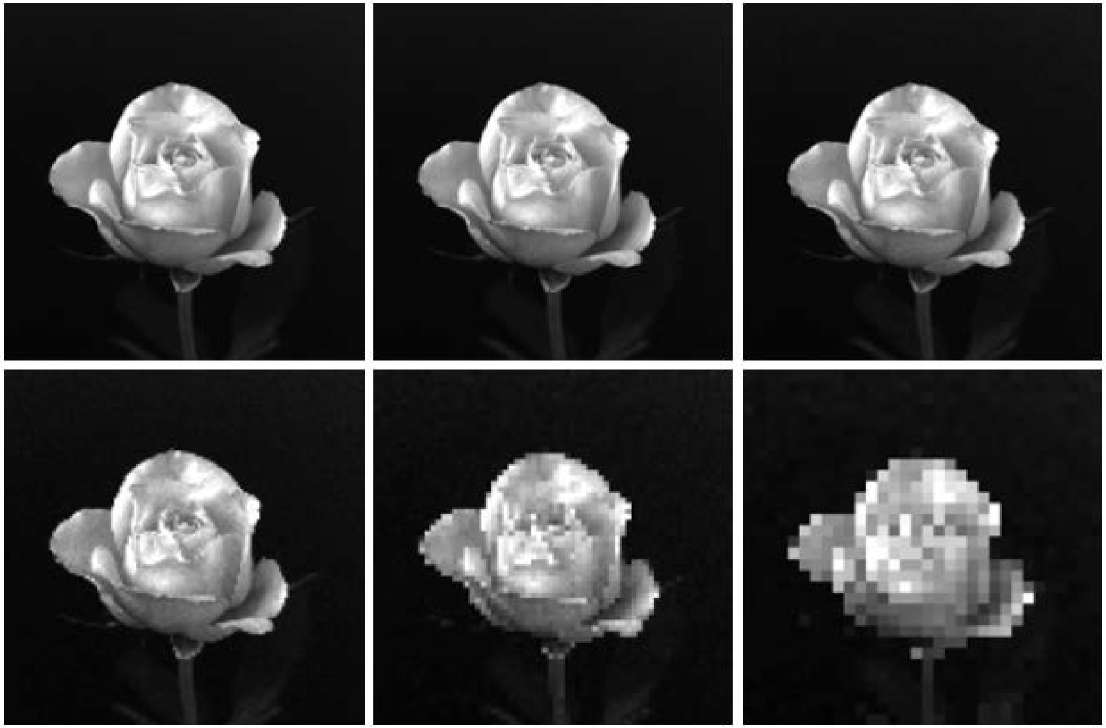








- Fundamentals
  - Pixels, resolution

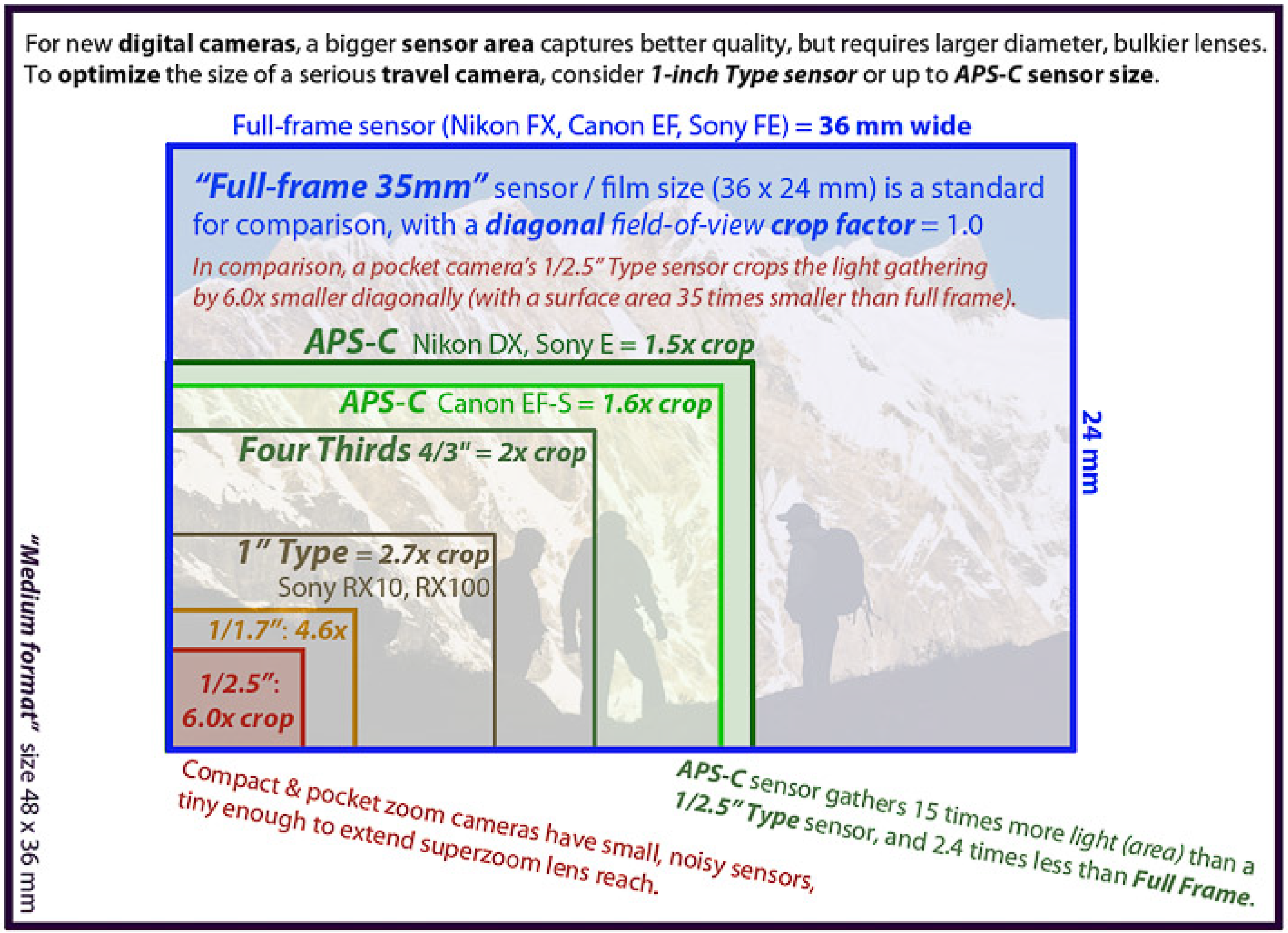


a b c
d e f

FIGURE 2.20 (a) 1024 × 1024, 8-bit image. (b) 512 × 512 image resampled into 1024 × 1024 pixels by row and column duplication. (c) through (f) 256 × 256, 128 × 128, 64 × 64, and 32 × 32 images resampled into 1024 × 1024 pixels.

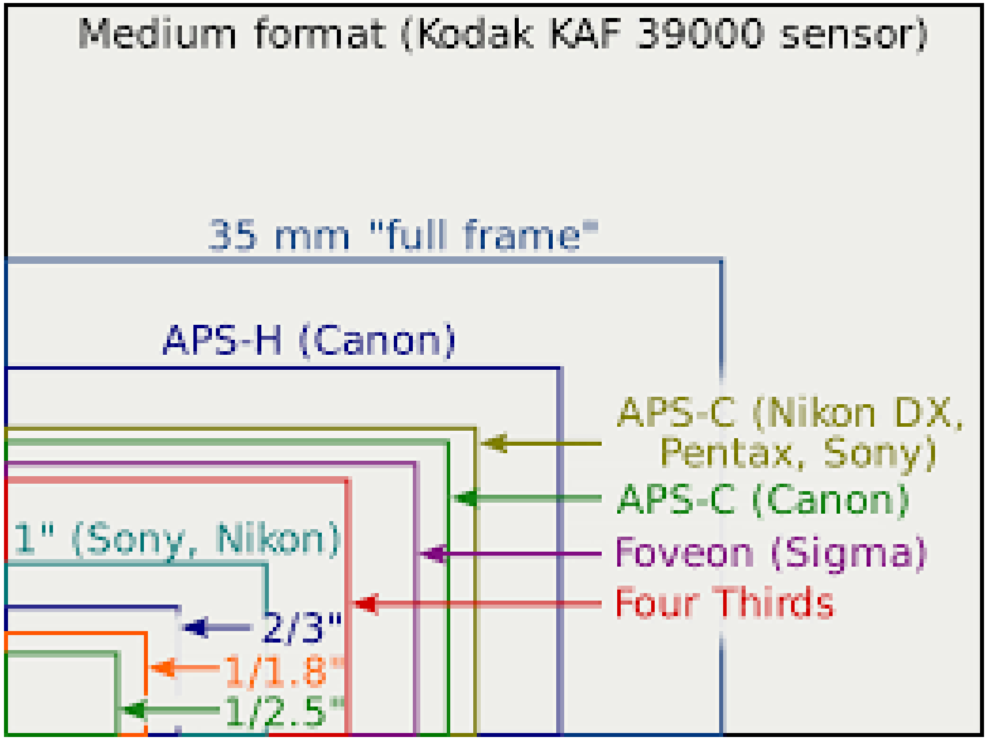
Digital Image Fundamentals

- Fundamentals
  - Pixels, resolution



Digital Image Fundamentals

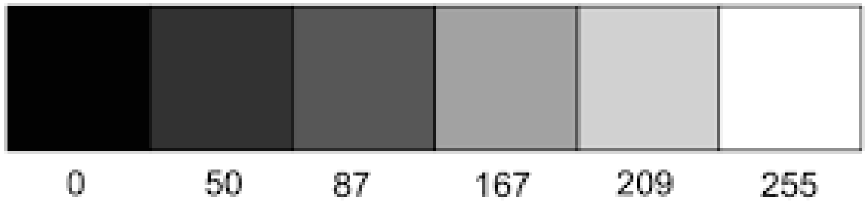
- Fundamentals
  - Pixels, resolution



Digital Image Fundamentals

- Fundamentals
  - Pixels, resolution, intensity

Colors can be different shades of gray >>>> GrayScale



Digital Image Fundamentals

- Fundamentals
  - Pixels, resolution, intensity

Grayscale is not the same as Black and White!

Grayscale

Black and White

Digital Image Fundamentals

- Fundamentals
  - Grayscale vs. Black and White

MATLAB Time!

- Fundamentals
  - Grayscale vs. Black and White

MATLAB Time!

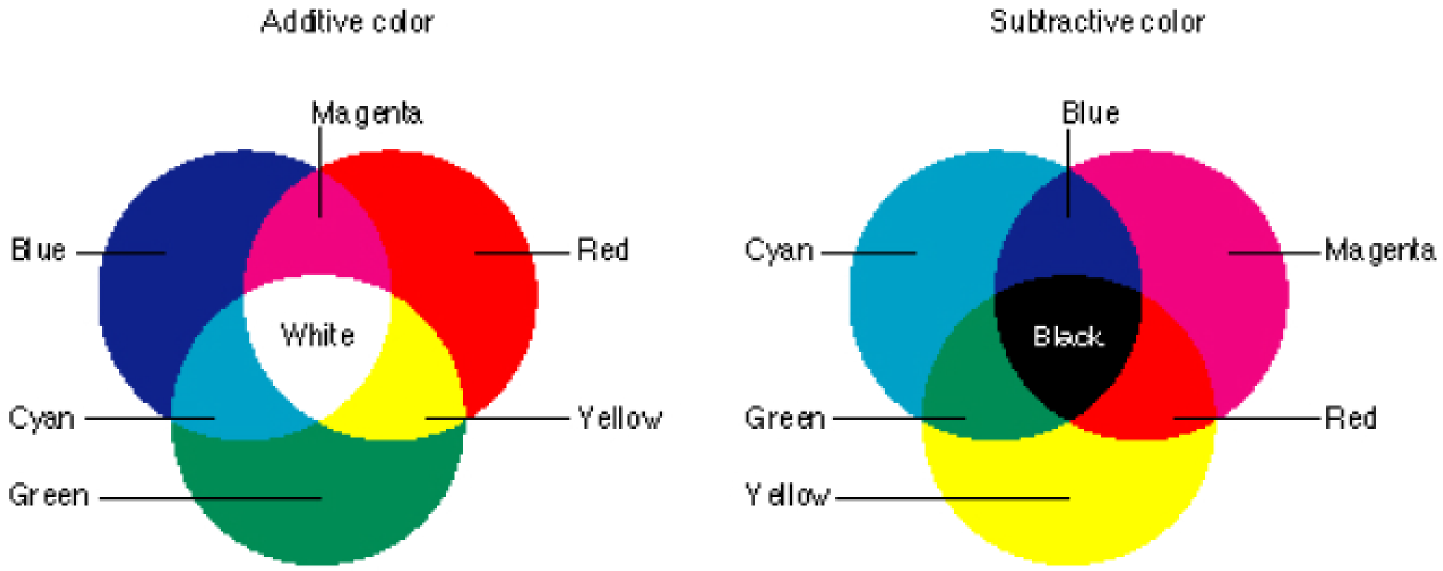
>>MATLAB Example 1.1:

>> Read image 'Cameraman_GS.jpg' using MATLAB
>> Find spatial resolution of it
>> Convert it to black and white
>>Show both versions and visually compare them

Hint :
Read the helps for imread, imbinaraze, imshow commands

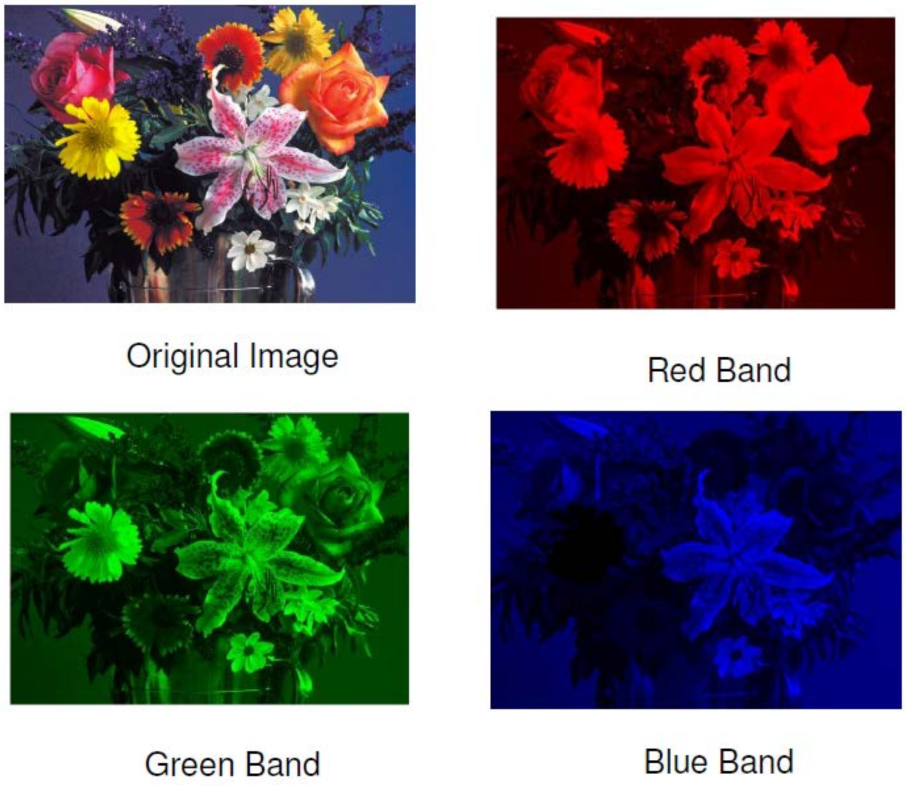
Digital Image Fundamentals

- Fundamentals
  - Different color spaces and channels



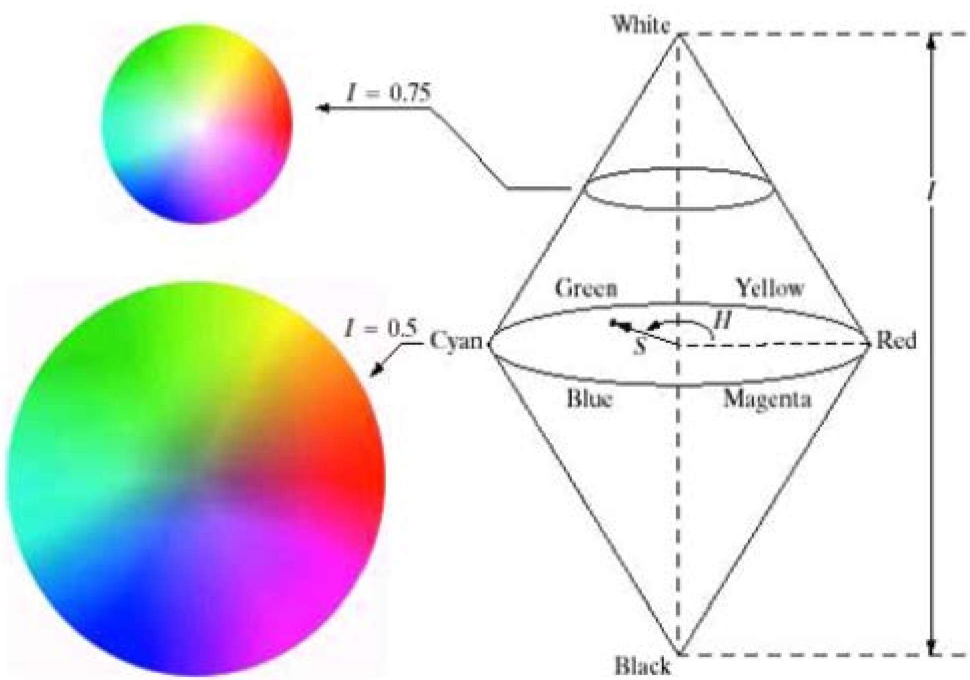
Digital Image Fundamentals

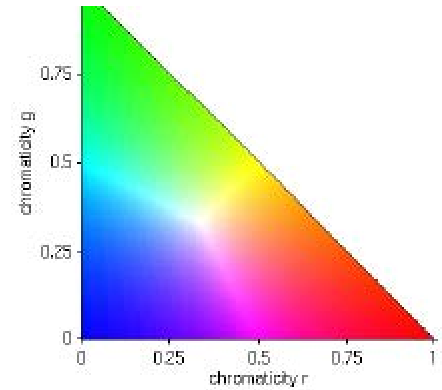
- Fundamentals
  - Different color spaces and channels

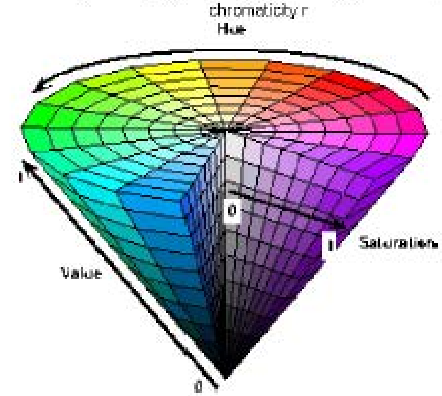


RGB=Red, Green , Blue

- Fundamentals
  - Different color spaces







HSI=Hue, Saturation, Intensity

- Digital Image Fundamentals
  - Different color spaces

RGB To HSI

First, we convert RGB color space image to HSI space beginning with normalizing RGB values:

$$r = \frac{R}{R+G+B},\ g = \frac{G}{R+G+B},\ b = \frac{B}{R+G+B}.$$

Each normalized H, S and I components are then obtained by,

$$h = \cos^{-1}\left\{\frac{0.5\cdot[(r-g)+(r-b)]}{[(r-g)^2+(r-b)(g-b)]^{1/2}}\right\} \qquad h \in [0,\pi] \text{ for } b \le g$$

$$h = 2\pi - \cos^{-1}\left\{\frac{0.5\cdot[(r-g)+(r-b)]}{[(r-g)^2+(r-b)(g-b)]^{1/2}}\right\} \qquad h \in [\pi, 2\pi] \text{ for } b > g$$

- Digital Image Fundamentals
  - Different color spaces

RGB To HSI

$$s = 1 - 3 \cdot \min(r, g, b); \quad s \in [0,1]$$

$$i = (R + G + B)/(3 \cdot 255); \quad i \in [0,1].$$

For convenience, h, s and i values are converted in the ranges of [0,360], [0,100], [0, 255], respectively , by:

$$H = h \times 180/\pi; \quad S = s \times 100 \text{ and } \quad I = i \times 255.$$

- Digital Image Fundamentals
  - Different color spaces

HSI to RGB

$$h = H \cdot \pi / 180; \quad s = S / 100; \quad i = I / 255$$

$$x = i \cdot (1 - s)$$

$$y = i \cdot \left[1 + \frac{s \cdot \cos(h)}{\cos(\pi / 3 - h)} \right]$$

$$z = 3i - (x + y);$$

when $h < 2\pi / 3$, $b = x$; $r = y$ and $g = z$.

when $2\pi / 3 \leq h < 4\pi / 3$, $h = h - 2\pi / 3$, and $r = x$; $g = y$ and $b = z$.

when $4\pi / 3 \leq h < 2\pi$, $h = h - 4\pi / 3$, and $g = x$; $b = y$ and $r = z$.

The result r, g and b are normalized values, which are in the ranges of [0,1], therefore, they should be multiplied by 255 for displaying.

- Digital Image Fundamentals
  - Different color spaces

RGB to YCbCr

$$
\begin{aligned}
Y' &= 16 + \frac{65.738 \cdot R'_D}{256} + \frac{129.057 \cdot G'_D}{256} + \frac{25.064 \cdot B'_D}{256} \\
C_B &= 128 - \frac{37.945 \cdot R'_D}{256} - \frac{74.494 \cdot G'_D}{256} + \frac{112.439 \cdot B'_D}{256} \\
C_R &= 128 + \frac{112.439 \cdot R'_D}{256} - \frac{94.154 \cdot G'_D}{256} - \frac{18.285 \cdot B'_D}{256}
\end{aligned}
$$

Digital Image Fundamentals

- Digital Image Fundamentals
  - Different color spaces

YCbCr to RGB

$$R'_D = \frac{298.082 \cdot Y'}{256} + \frac{408.583 \cdot C_R}{256} - 222.921$$

$$G'_D = \frac{298.082 \cdot Y'}{256} - \frac{100.291 \cdot C_B}{256} - \frac{208.120 \cdot C_R}{256} + 135.576$$

$$B'_D = \frac{298.082 \cdot Y'}{256} + \frac{516.412 \cdot C_B}{256} - 276.836$$

Digital Image Fundamentals

- Fundamentals
  - Different color spaces

MATLAB Time!

Digital Image Fundamentals

- Fundamentals
  - Different color spaces

>>MATLAB Example 1.2:

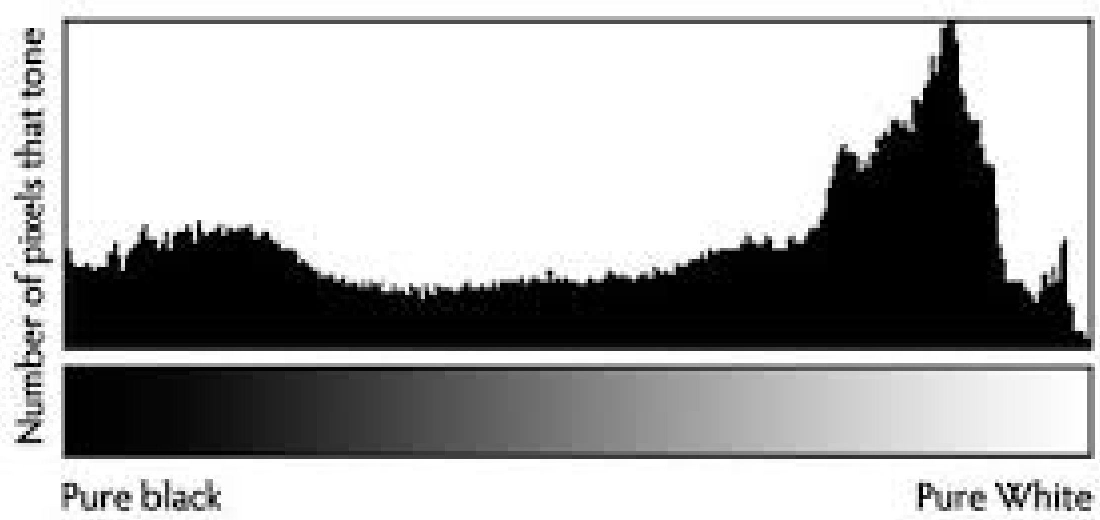
>> Read image ‘pasta.tif’ using MATLAB
>> Find spatial resolution of it
>> Show this image
>> Show R,G and B channels of this image
>> Convert Color space to HSI
>> Show Hue, Saturation and Intensity channels
>> Convert Color space to YCbCr
>> Show Y, Cb and Cr channels
>> Convert Original image to grayscale
>> Show this image
>> Save the grayscale version
>> Compare all four versions

Hint :
Read the helps for imwrite, rgb2hsv, rgb2ycbcr, rgb2gray commands

Basic Histogram Processing

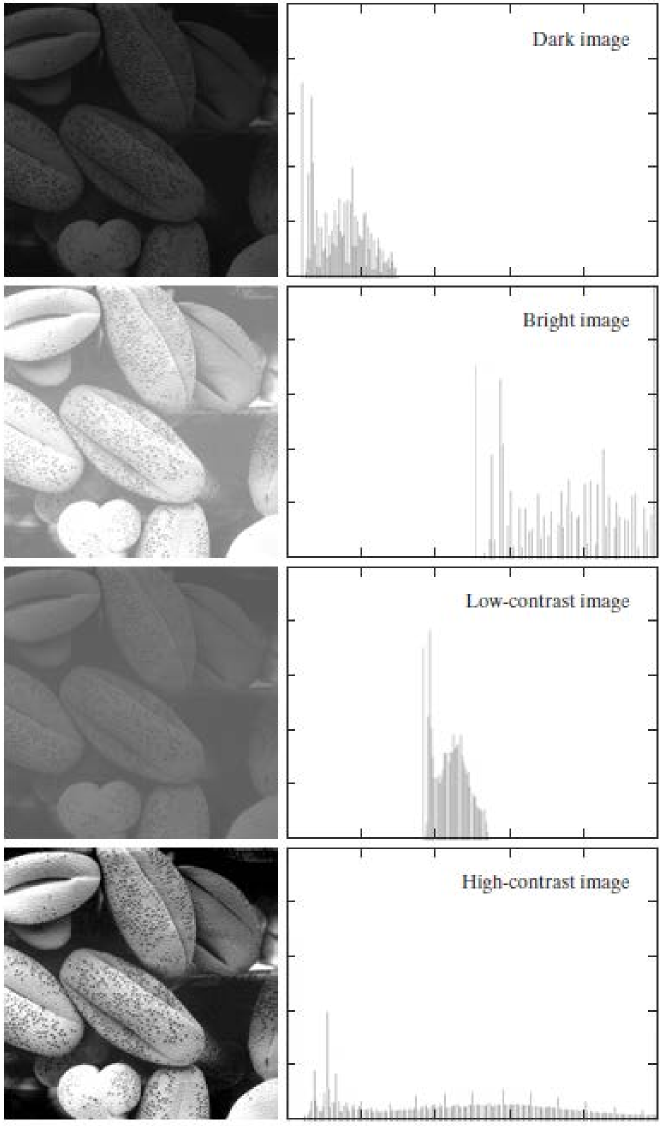
Basic Histogram Processing

- Histogram
  - Is Histogram useful?



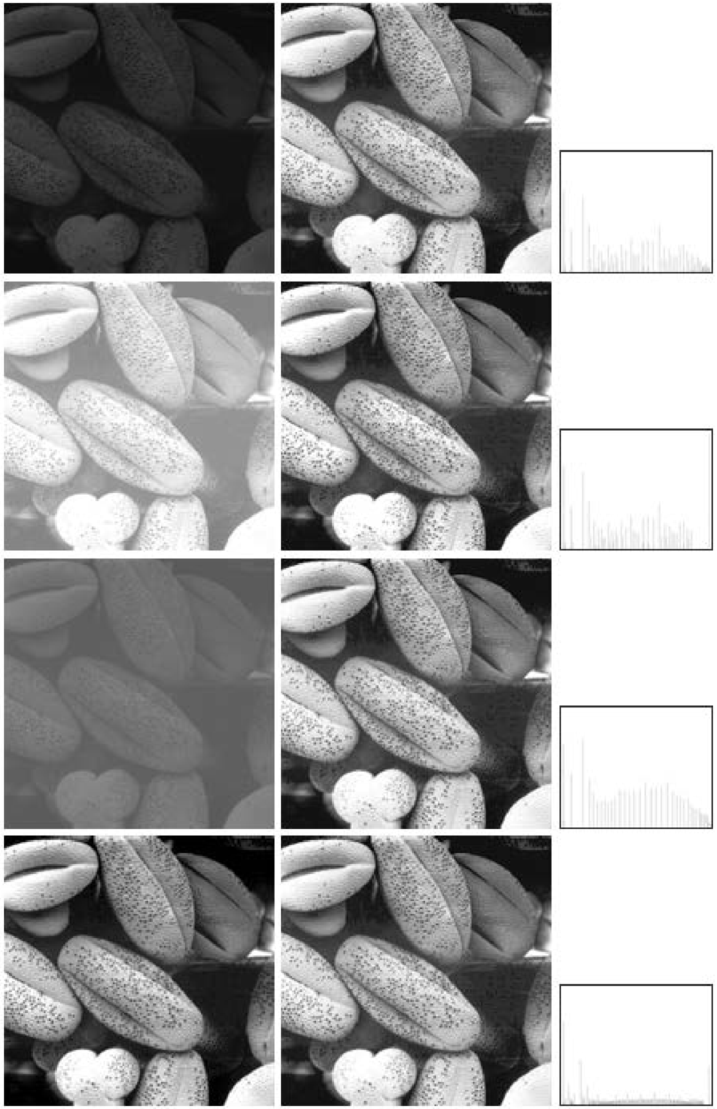
Basic Histogram Processing

- Histogram
  - Histogram effect



Basic Histogram Processing

- Histogram
  - Histogram equalizing

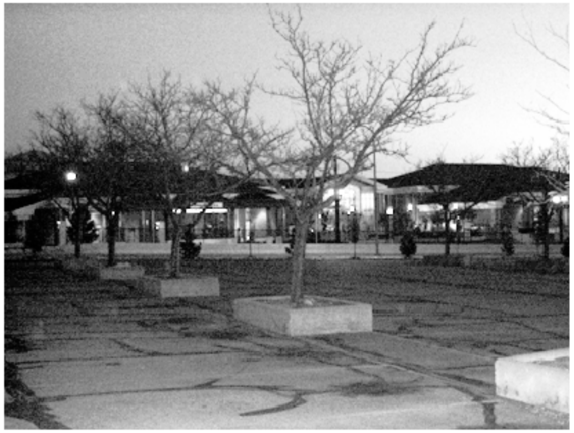


Basic Histogram Processing

- Histogram
  - Histogram equalizing

Input Image

Output Image



Idea:

For each pixel with intensity ‘k’ >>>>>>>>>> change intensity to ‘j’

HOW?

Basic Histogram Processing

- Histogram Processing
  - Histogram equalizing

$$P_r(r_k) = \frac{n_k}{n} \qquad\qquad k = 0,1,2,\ldots,L-1$$

$$\begin{aligned} s_k &= T(r_k) = \sum_{j=0}^{k} p_r(r_j) \\ &= \sum_{j=0}^{k} \frac{n_j}{n} \qquad k = 0, 1, 2, \ldots, L-1 \end{aligned}$$

Basic Histogram Processing

- Histogram Processing
    - Histogram equalizing

MATLAB Time!

Basic Histogram Processing

- Histogram Processing
  - Histogram Equalizing

>>MATLAB Example 1.3:

>> Read image ‘image_dark.pgm’ using MATLAB
>> Show this image
>> Plot its histogram
>> Try to enhance histogram by shifting values (add offset)
>> Show the results
>>Write a program to apply histogram equalizing
>> Show the resulting image and its histogram
>>Save the best version
>>Compare all versions

Hint :
Read the helps for imwrite, uint8 commands

Questions?