Image Processing & Pattern

E1425

Lecture 2

MATLAB Tutorials & DIP Fundamentals

INSTRUCTOR

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Contents

- Introduction to MATLAB
- Working with MATLAB
- Image Processing using MATLAB
- Introduction to Digital Image Processing

➢ Introduction to MATLAB

MATLAB : Matrix Laboratory

Numerical Computations with matrices

- Every number can be represented as matrix

Why MATLAB?

- User Friendly (GUI)
- Easy to work with
- Powerful tools for complex mathematics

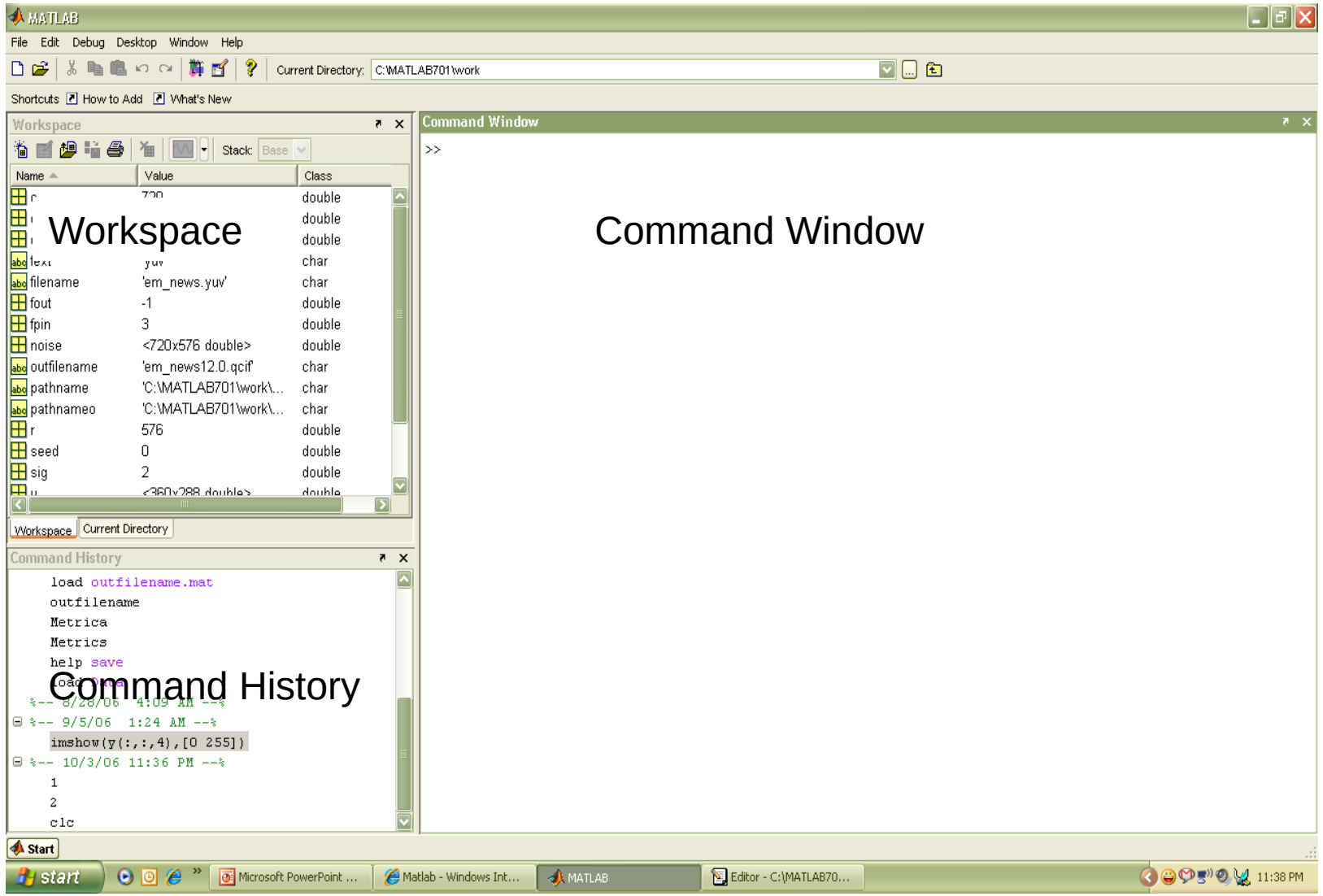


Fig: Snapshot of MATLAB

➢ Matrices in MATLAB

➢ To enter a matrix

$$\begin{matrix} 3 & 1 \\ 6 & 4 \end{matrix}$$

```
>> A = [3 1 ; 6 4]
>> A = [3, 1 ; 6, 4]
>> B = [3, 5 ; 0, 2]
```

➢ Basic Mathematical Operations

Addition:

>> C = A + B

Subtraction:

>> D = A – B

Multiplication:

>> E = A * B (Matrix multiplication)

>> E = A .* B (Element wise multiplication)

Division:

Left Division and Right Division

>> F = A . / B (Element wise division)

>> F = A / B (A * inverse of B)

>> F = A . \ B (Element wise division)

>> F = A \ B (inverse of A * B)

➢ Generating basic matrices

Matrix with ZEROS:

>> Z = ZEROS (r, c)

Matrix with ONES:

>> O = ONES (r, c)

IDENTITY Matrix:

>> I = EYE (r, c)

r Rows

c Columns

zeros, ones, eye → MATLAB functions

➢ Making the best from MATLAB

Need help ?

HELP <function name>

M files (.m)

To write and save MATLAB commands

Save time and easy to debug

Use of semicolon (;)

Comments (%)

Documentation

www.mathworks.com

Image processing and MATLAB

- Easy to work with; as Images are matrices
- Built in functions for complex operations and algorithms (Ex. FFT, DCT, etc…)
- Image processing toolbox (?)
- Supports most image formats (.bmp, .jpg, .gif, .tiff, etc.…)

➢ Image processing in MATLAB

➢ To read and display images

im = imread(“filename.fmt”)

im is r x c if gray scale

im is r x c x 3 if color image (RGB)

imshow(im) % displays image

imwrite(im, “filename.fmt”) % writes image

➢ Working with complex numbers

- **real and imaginary**

  real % real part of complex number

  imag % imaginary part of complex number

- **magnitude and phase**

  abs % magnitude of complex number

  angle % phase of complex number

➢ Plotting / displaying

- **PLOT(x,y)**

  Plots y versus x.

  Linear plot

  XLABEL(‘label’)

  YLABEL(‘label’)

  TITLE(‘title’)

- **IMAGE(x)**

  Displays image

- **3D PLOT:**

  MESH

  3D mesh surface (Ex. filters)

  MESHGRID

  Useful in 3D plots

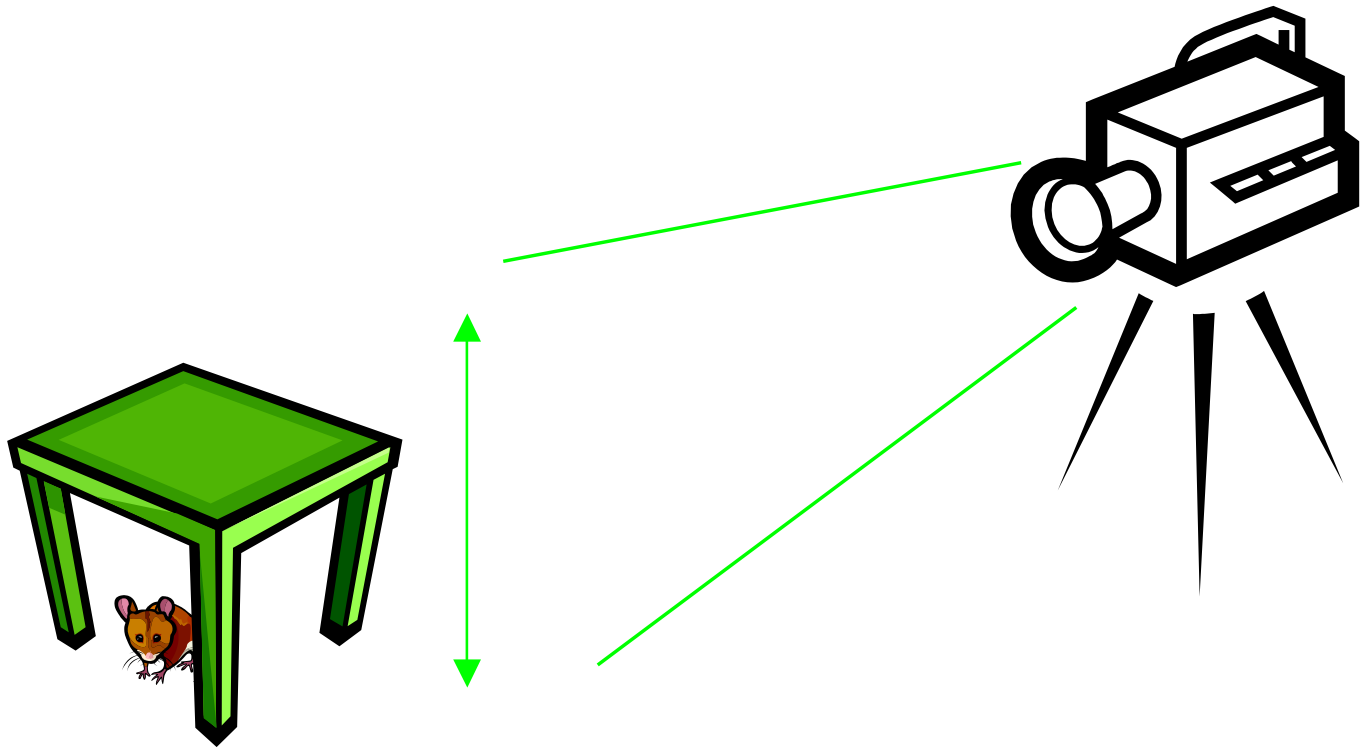
  SURF

  3D colored surface (Ex. filters)

➢ Introduction to Digital Image Processing - Fundamentals

Scales of Imaging

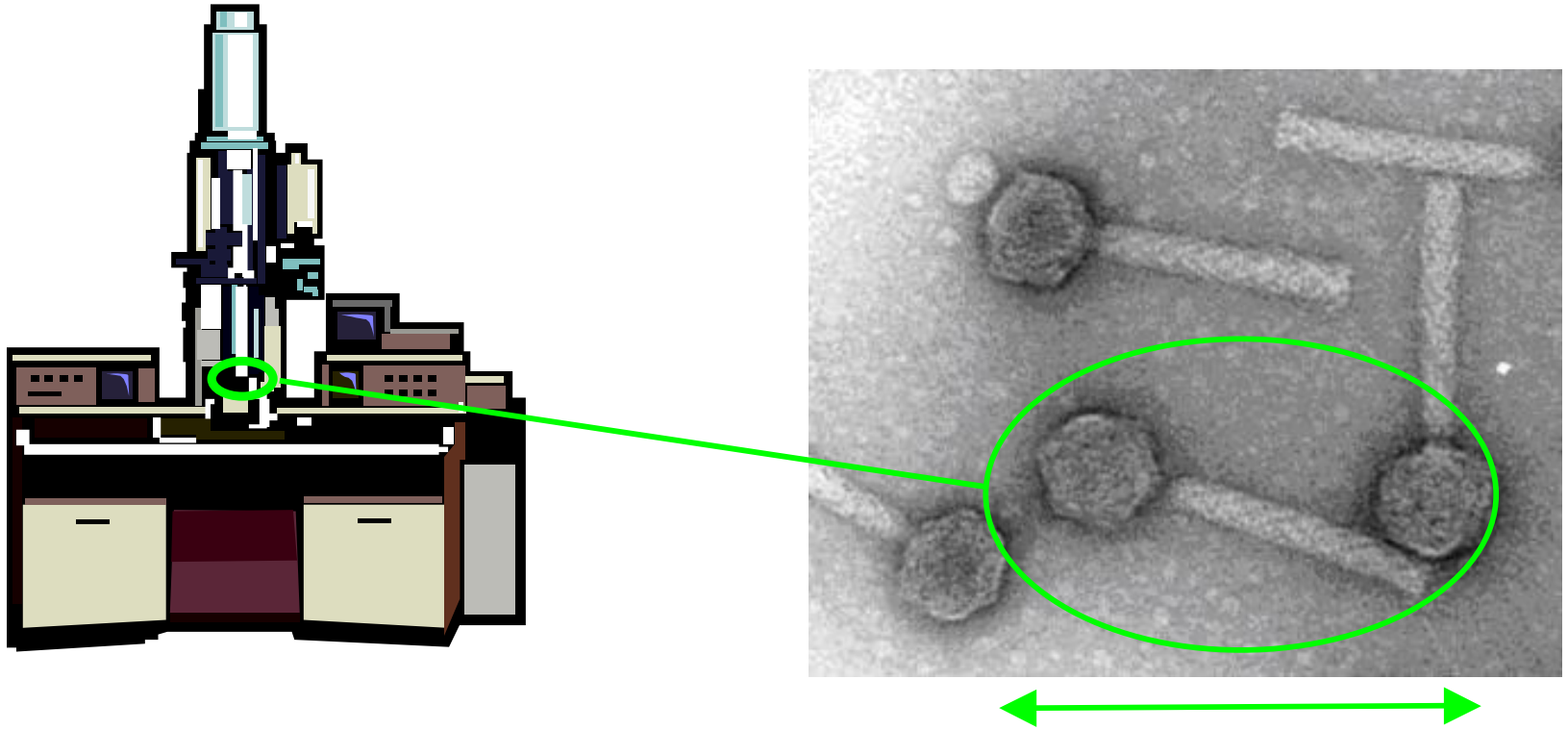
… to the everyday …



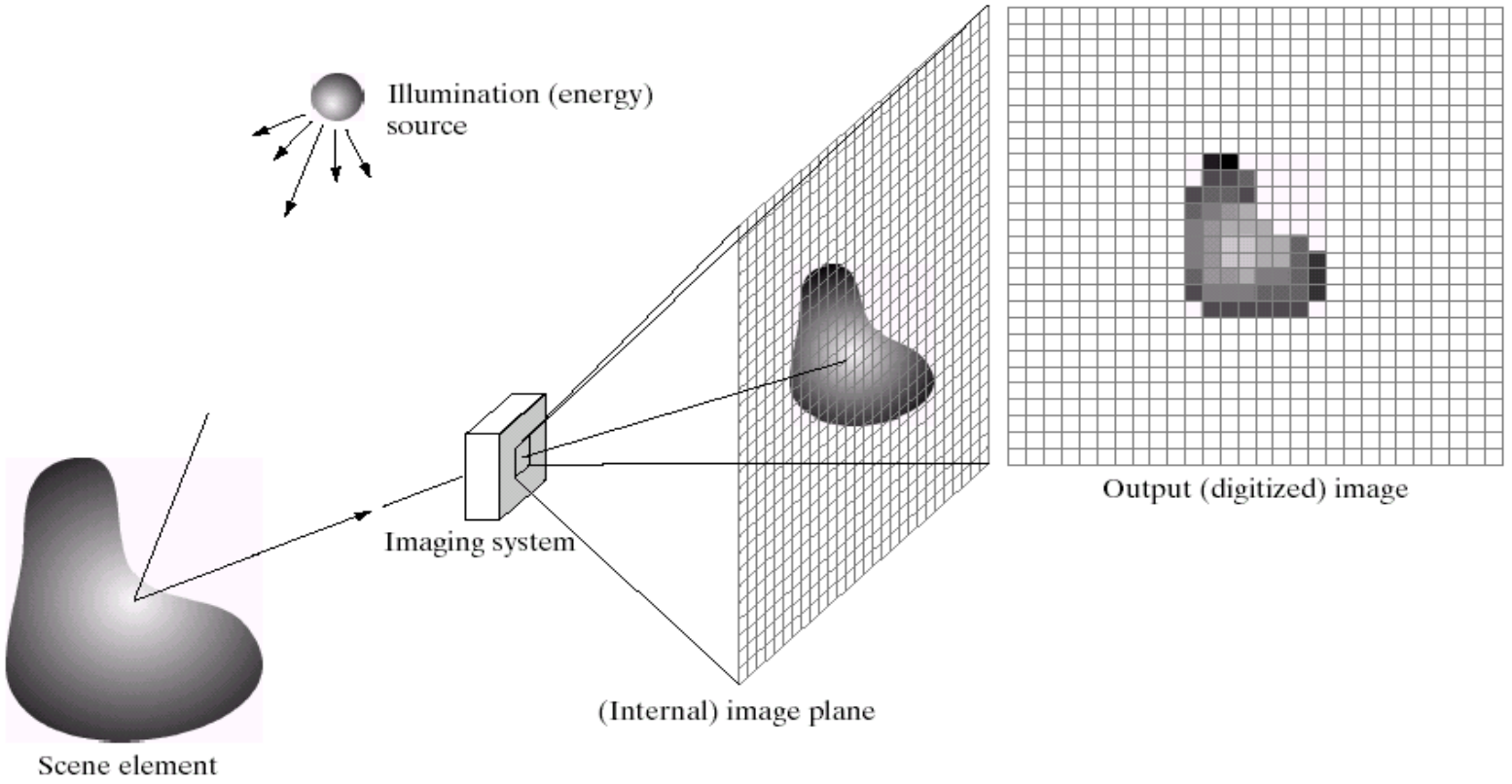
➢ Introduction to Digital Image Processing - Fundamentals

Scales of Imaging

… to the tiny …



➢ Digital Image Formation



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.

From [Gonzalez & Woods]

➢ Matrix Representation

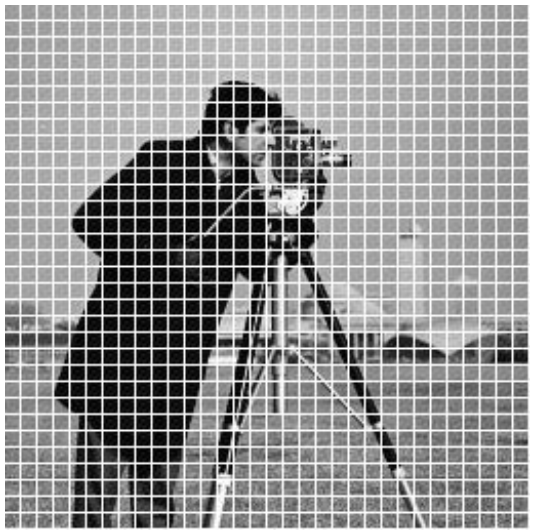
$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

$$\begin{bmatrix} 183 & 160 & 94 & 153 & 194 & 163 & 132 & 165 \\ 183 & 153 & 116 & 176 & 187 & 166 & 130 & 169 \\ 179 & 168 & 171 & 182 & 179 & 170 & 131 & 167 \\ 177 & 177 & 179 & 177 & 179 & 165 & 131 & 167 \\ 178 & 178 & 179 & 176 & 182 & 164 & 130 & 171 \\ 179 & 180 & 180 & 179 & 183 & 169 & 132 & 169 \\ 179 & 179 & 180 & 182 & 183 & 170 & 129 & 173 \\ 180 & 179 & 181 & 179 & 181 & 170 & 130 & 169 \end{bmatrix}$$

H=256

W=256

Divide into 8x8 blocks



From [Gonzalez & Woods]

➢ Image Resolution

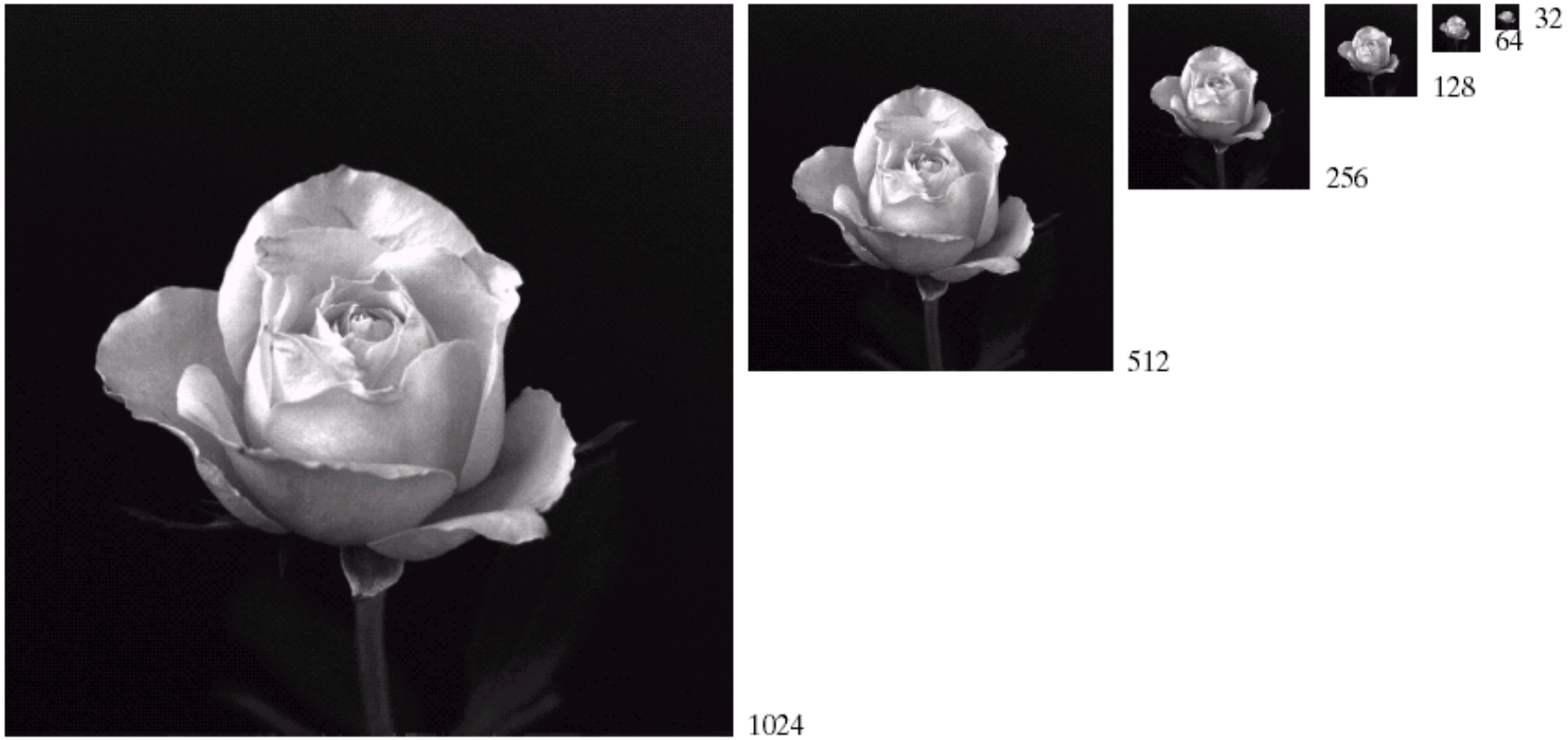


FIGURE 2.19 A 1024 × 1024, 8-bit image subsampled down to size 32 × 32 pixels. The number of allowable gray levels was kept at 256.

From [Gonzalez & Woods]

➢ Image 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.

➢ Bitplanes

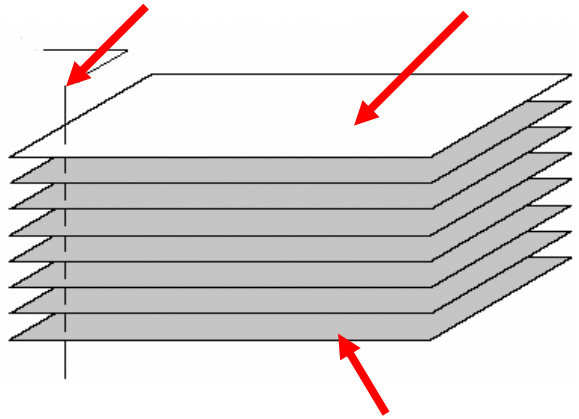
Original 8bits/pixel

Bitplane 7

Bitplane 6

one 8-bit byte

Bitplane 7



Bitplane 0

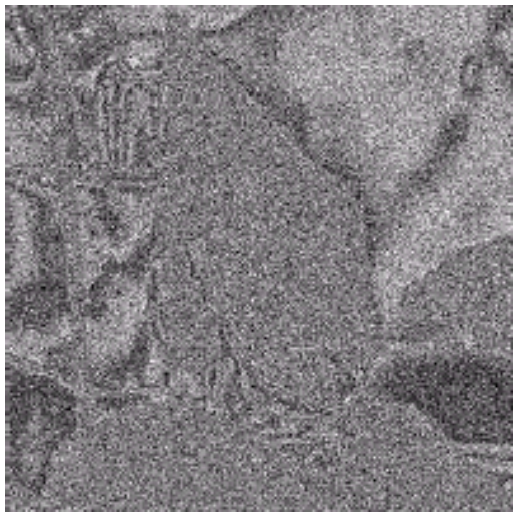
Bitplane 5

Bitplane 4

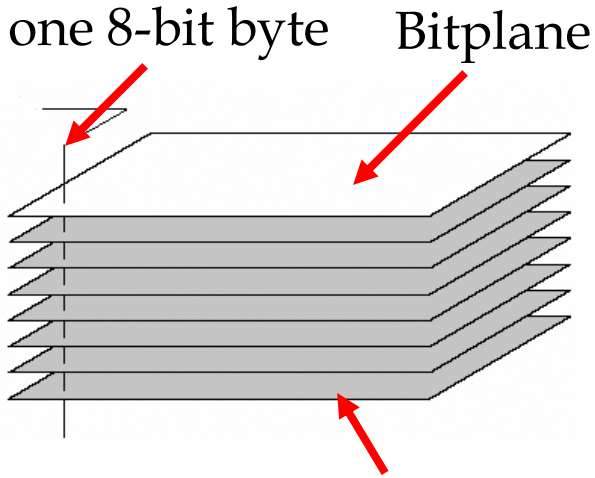
➢ Bitplanes

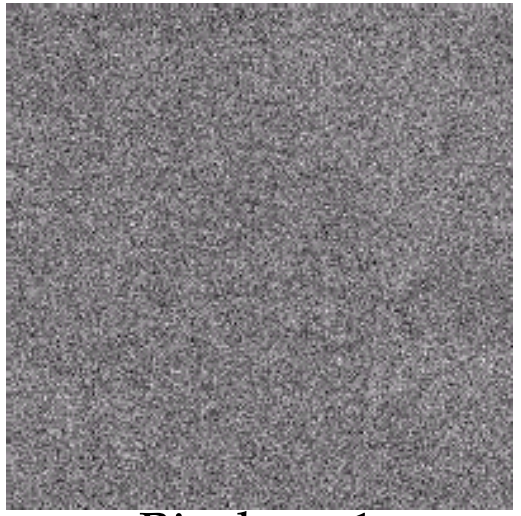
Original 8bits/pixel

Bitplane 3

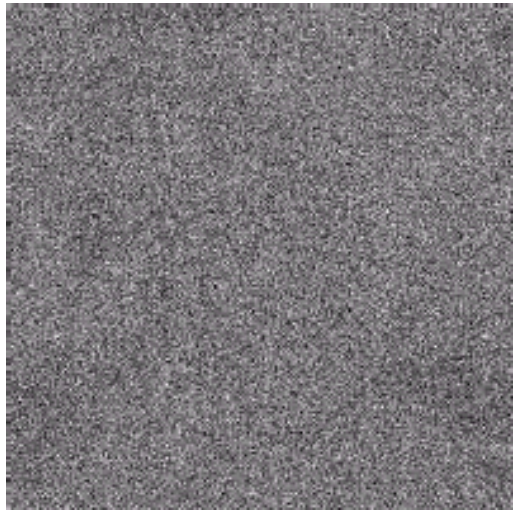


Bitplane 2





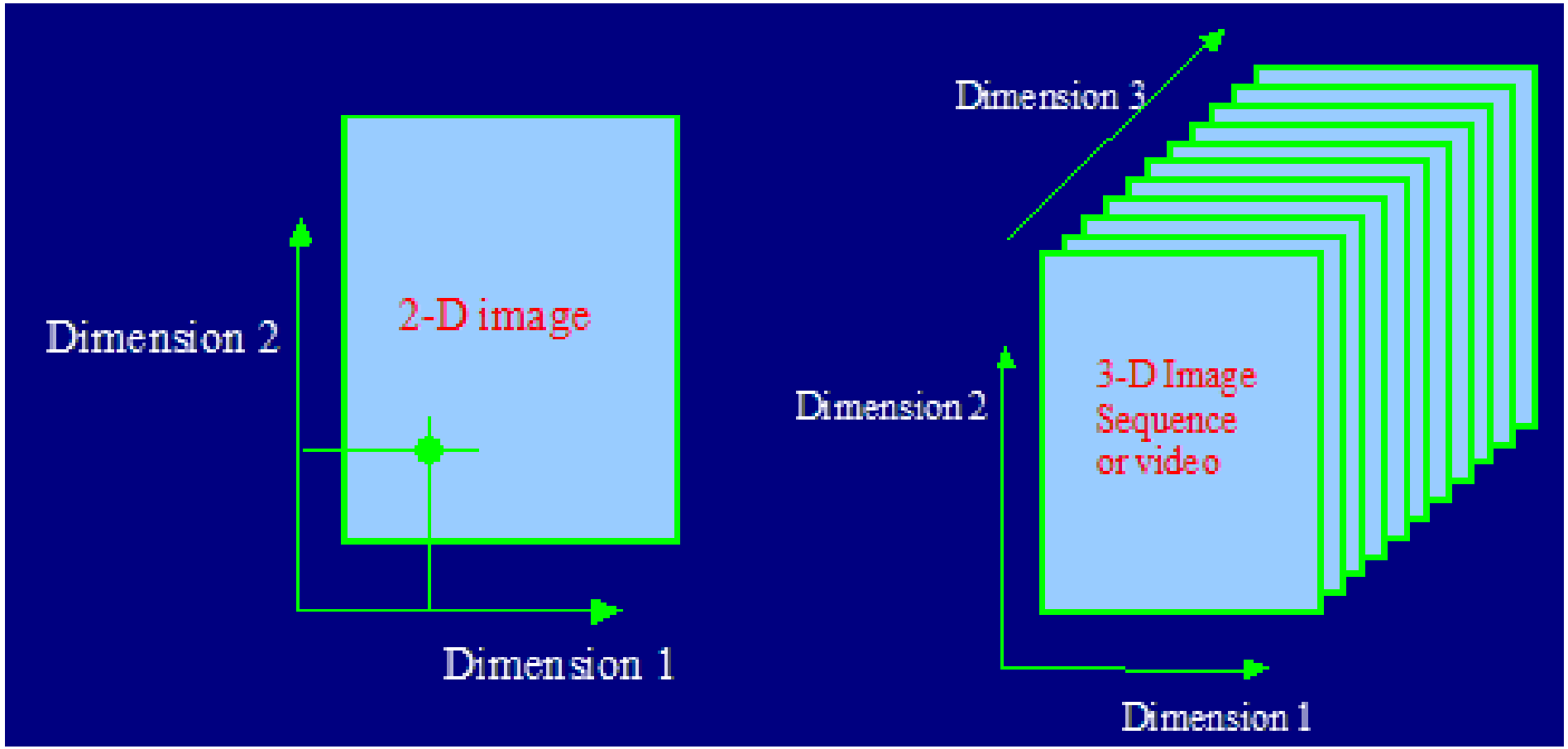
Bitplane 1



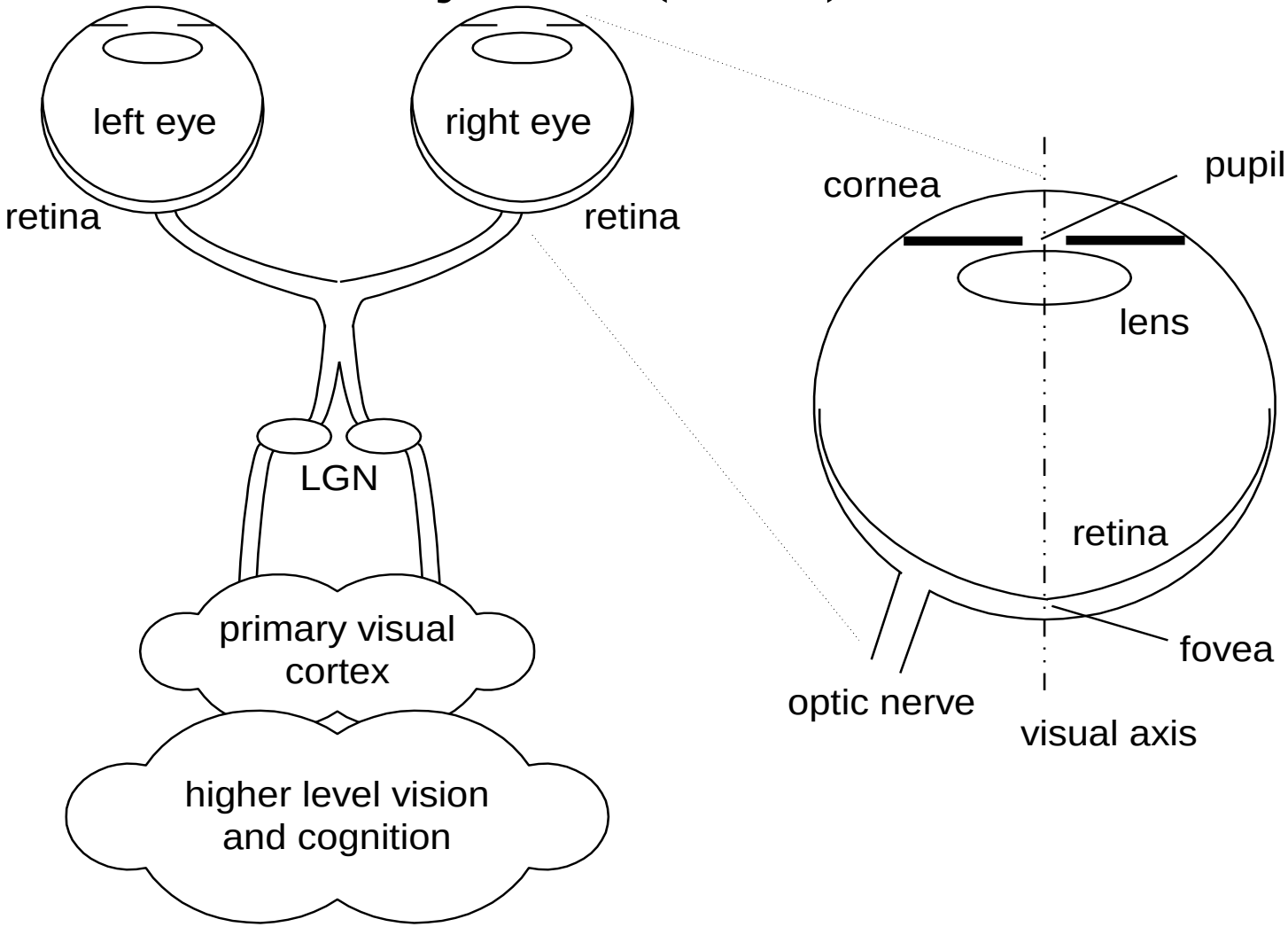
Bitplane 0

➢ Dimensionality of Digital Images

➢ Images and videos are multi-dimensional (≥ 2 dimensions) signals.



➢ The Human Visual System (HVS)



➢ HVS: Foveated Vision

➢ Foveated vision: non-uniform resolution of the visual field, highest at the point of fixation and decreasing rapidly

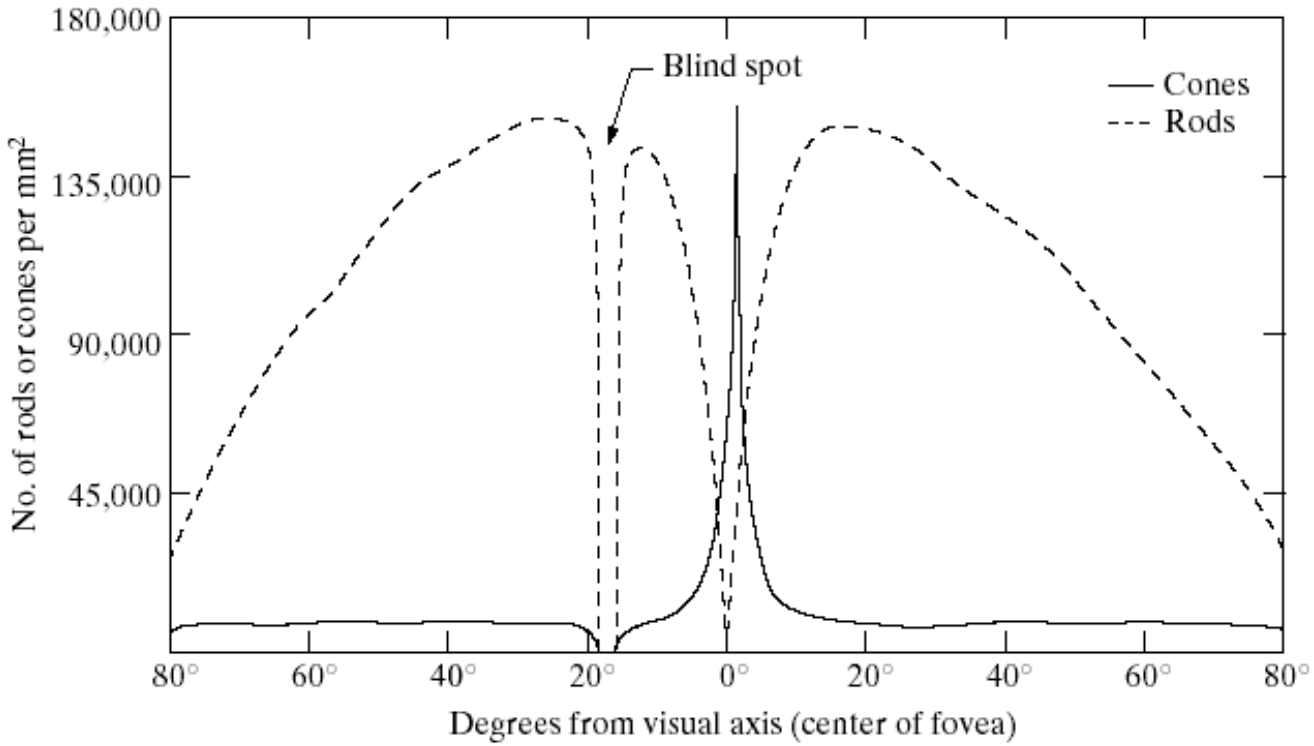
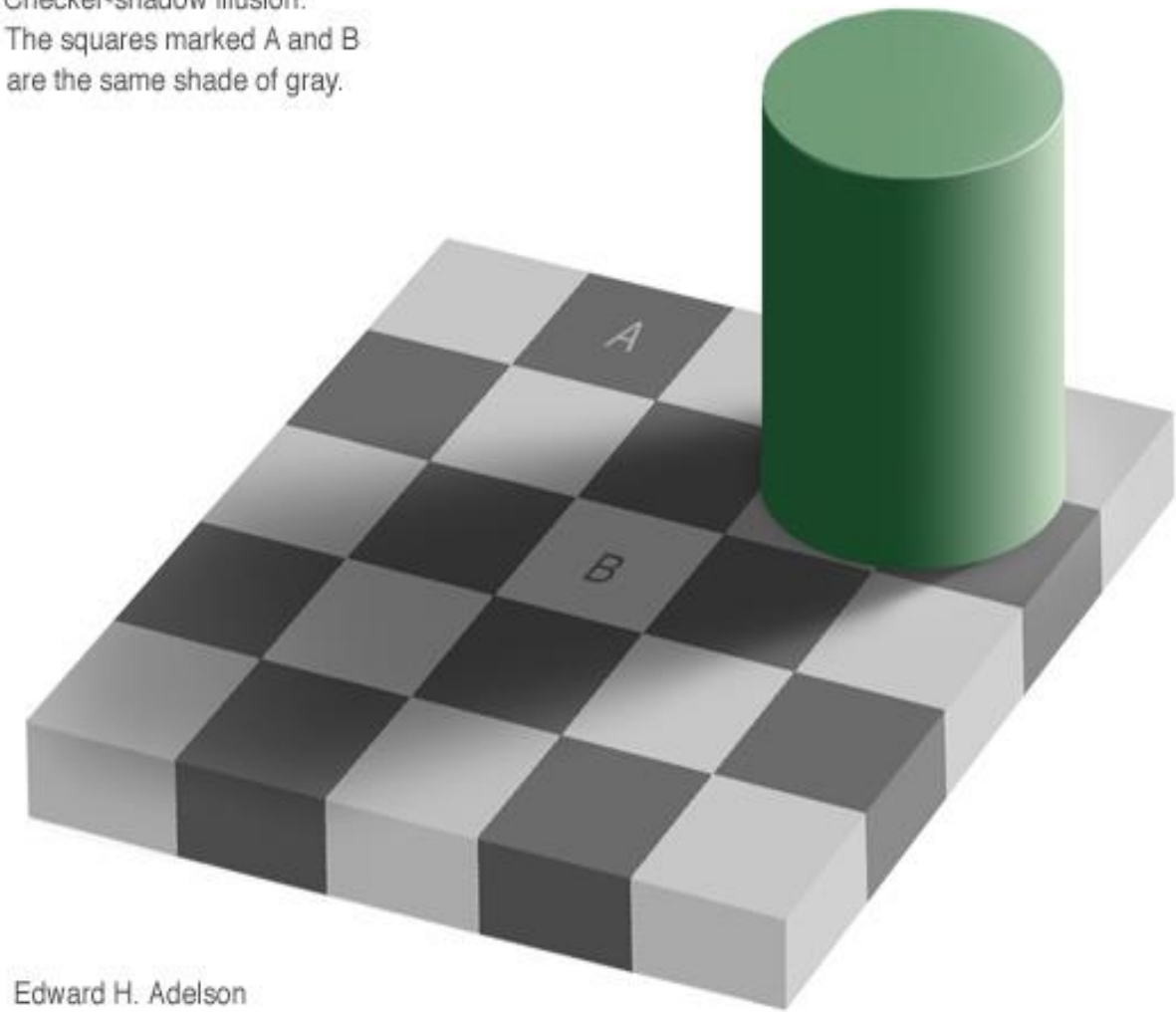


FIGURE 2.2
Distribution of rods and cones in the retina.

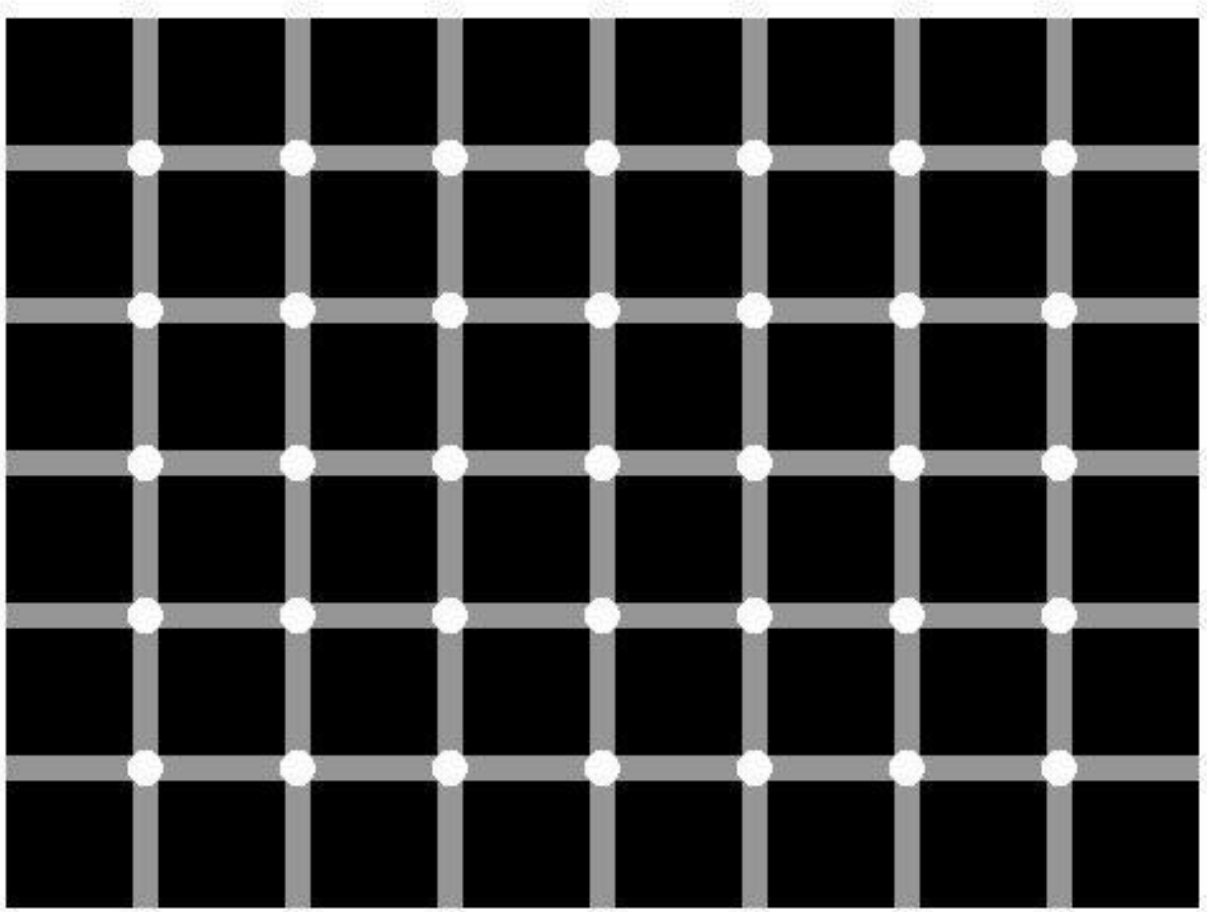
➢ HVS: Visual Illusion

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.



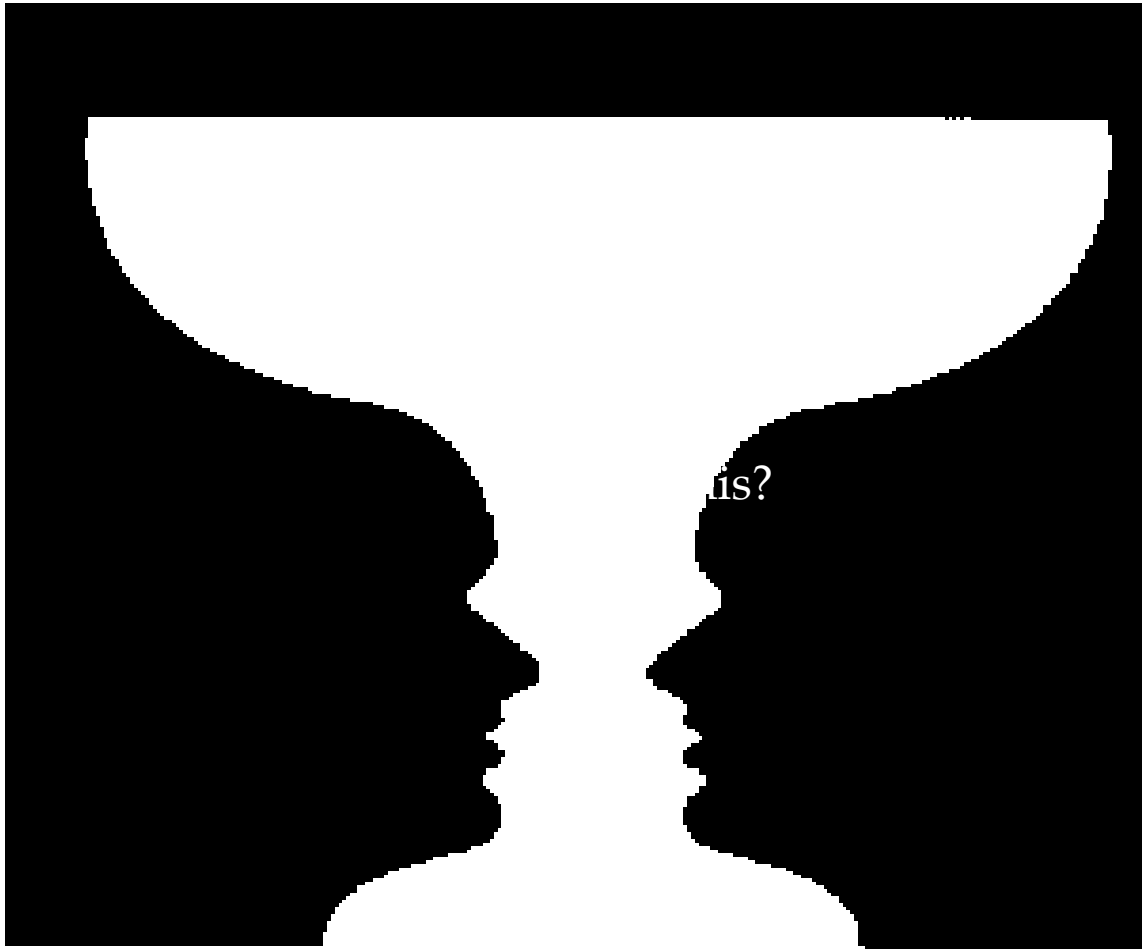
Edward H. Adelson

➢ HVS: Visual Illusion



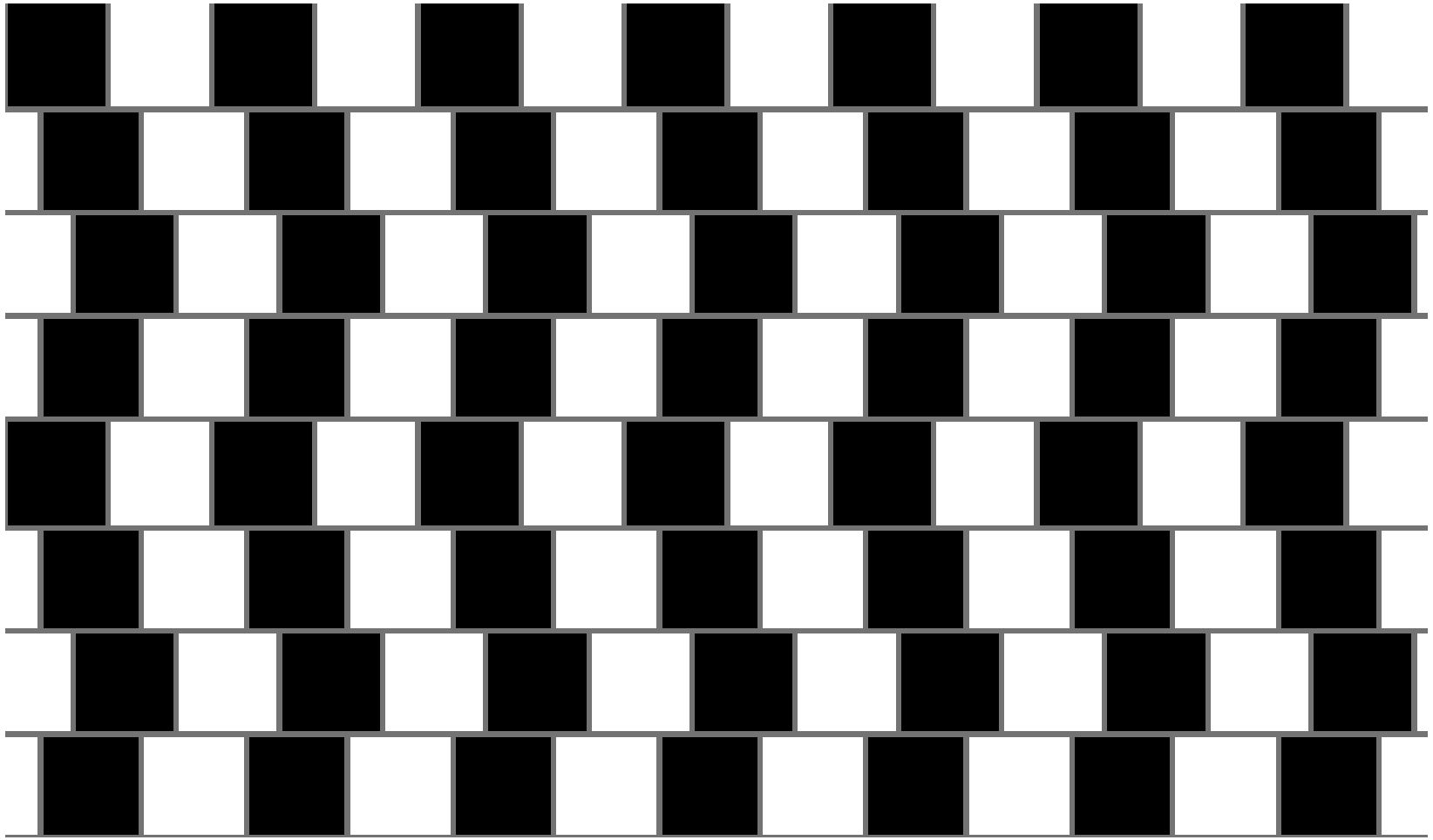
Find the black dot

➢ HVS: Visual Illusion



What is this?

➢ HVS: Visual Illusion



Which lines are straight?

➢ Color

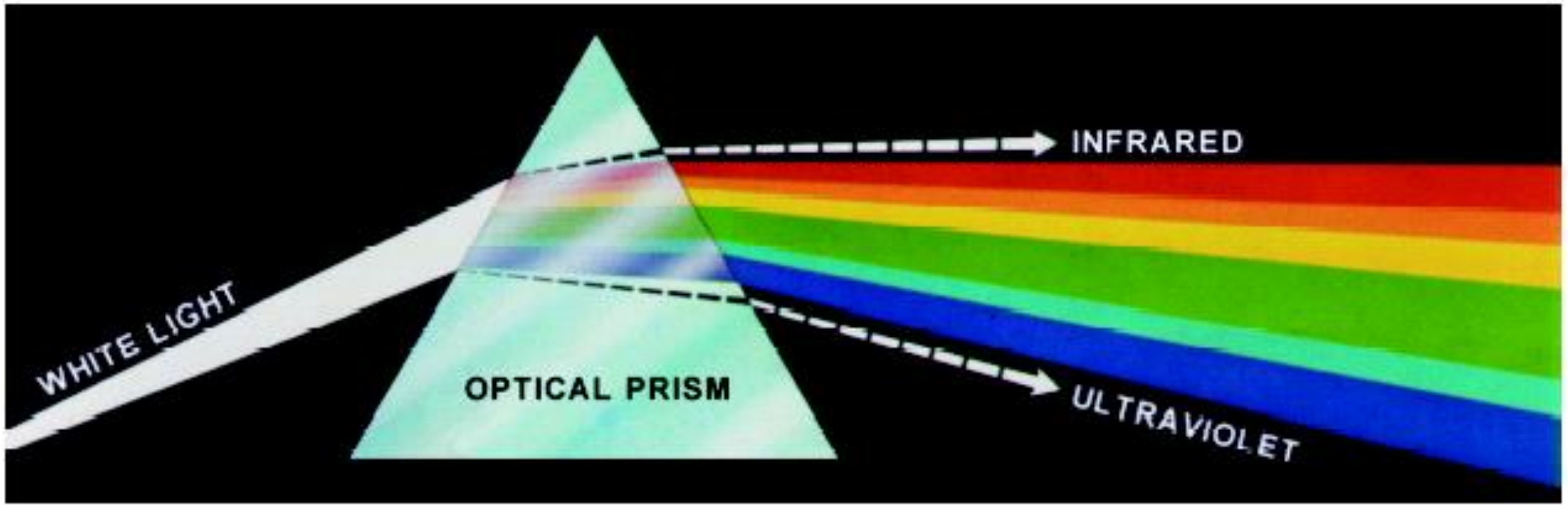
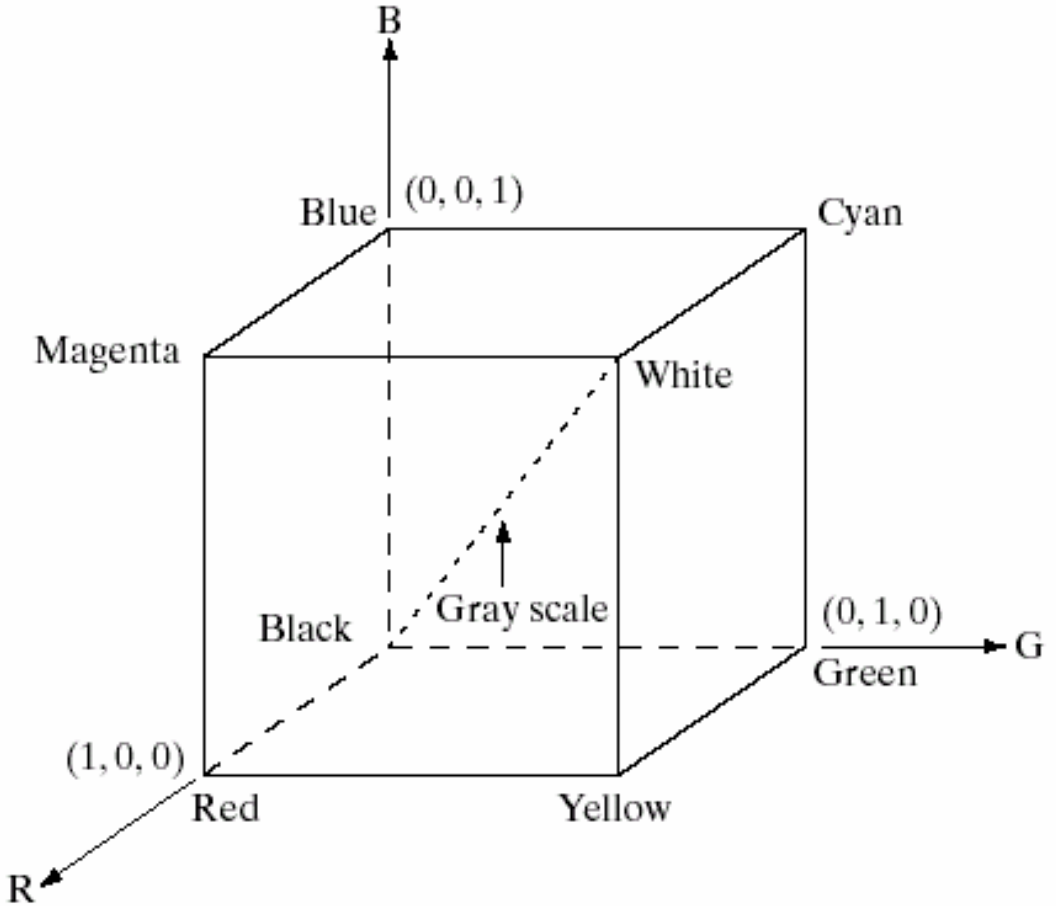
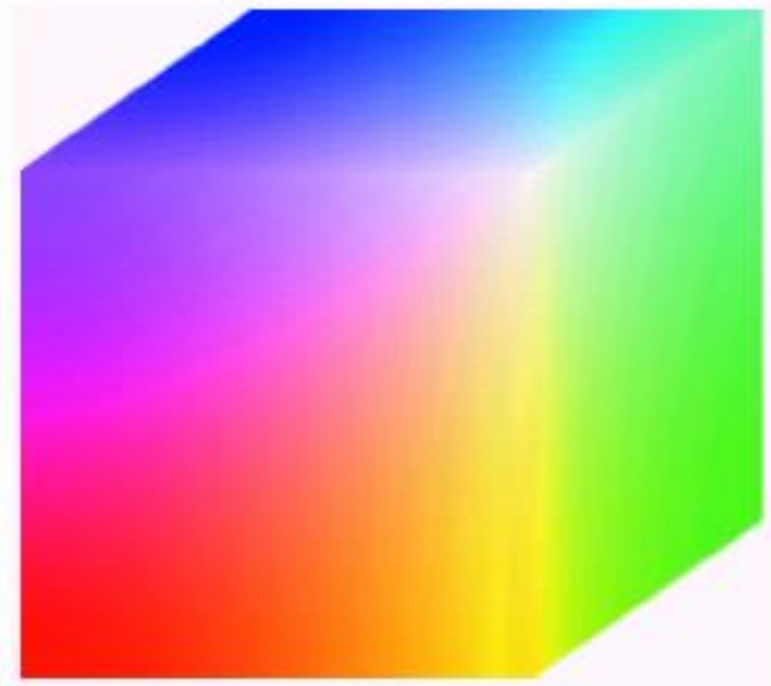


FIGURE 6.1 Color spectrum seen by passing white light through a prism. (Courtesy of the General Electric Co., Lamp Business Division.)

➢ Color: RGB Cube

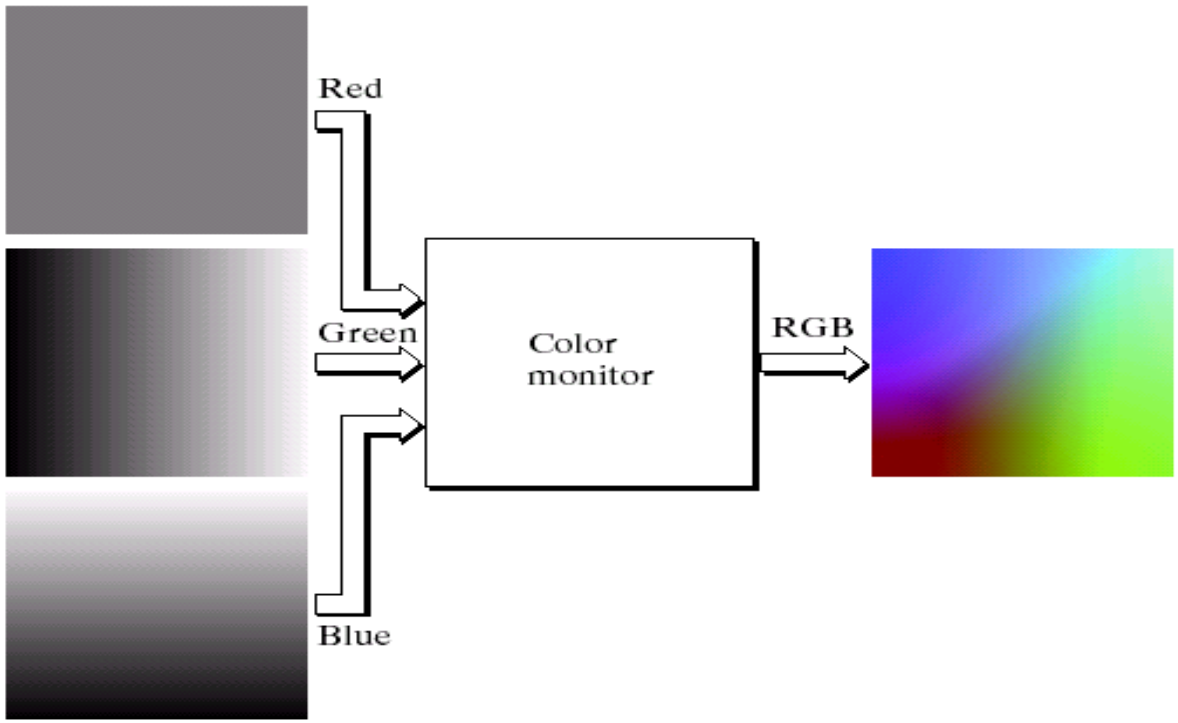


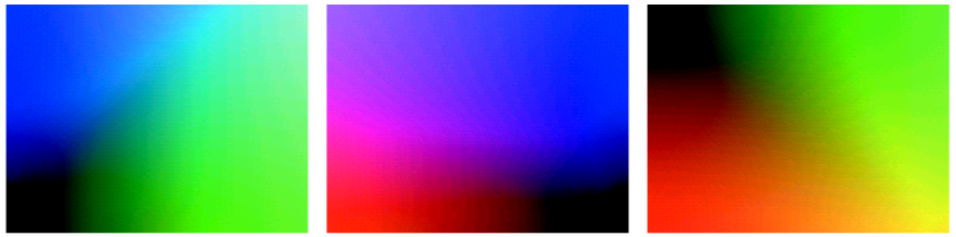


➢ Color: RGB Representation

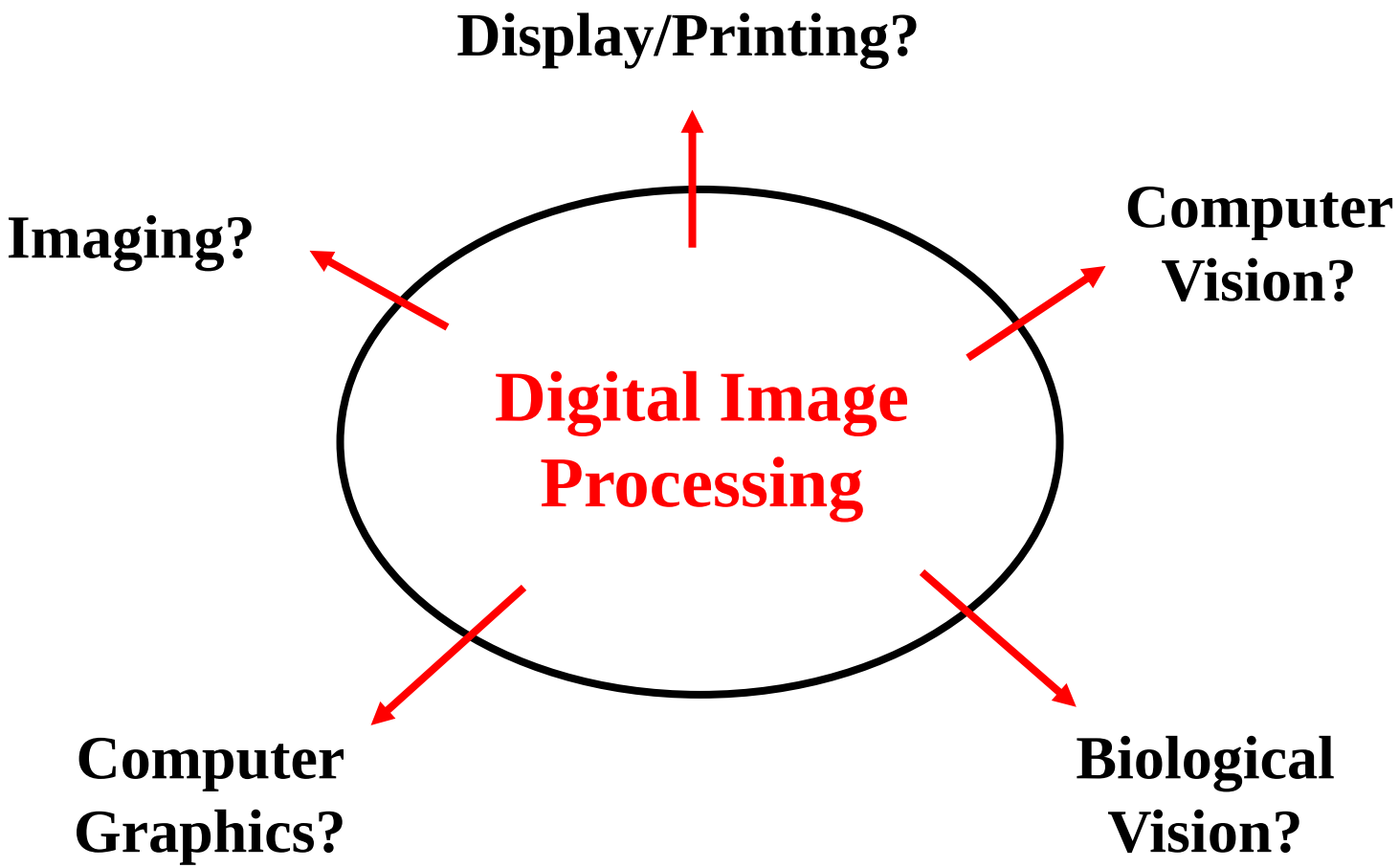
a
b

FIGURE 6.9
(a) Generating the RGB image of the cross-sectional color plane (127, G, B).
(b) The three hidden surface planes in the color cube of Fig. 6.8.





➢ Where Are We?


Display/Printing?
Imaging?
Computer Vision?
Digital Image Processing
Computer Graphics?
Biological Vision?

➢ What Do We Do?

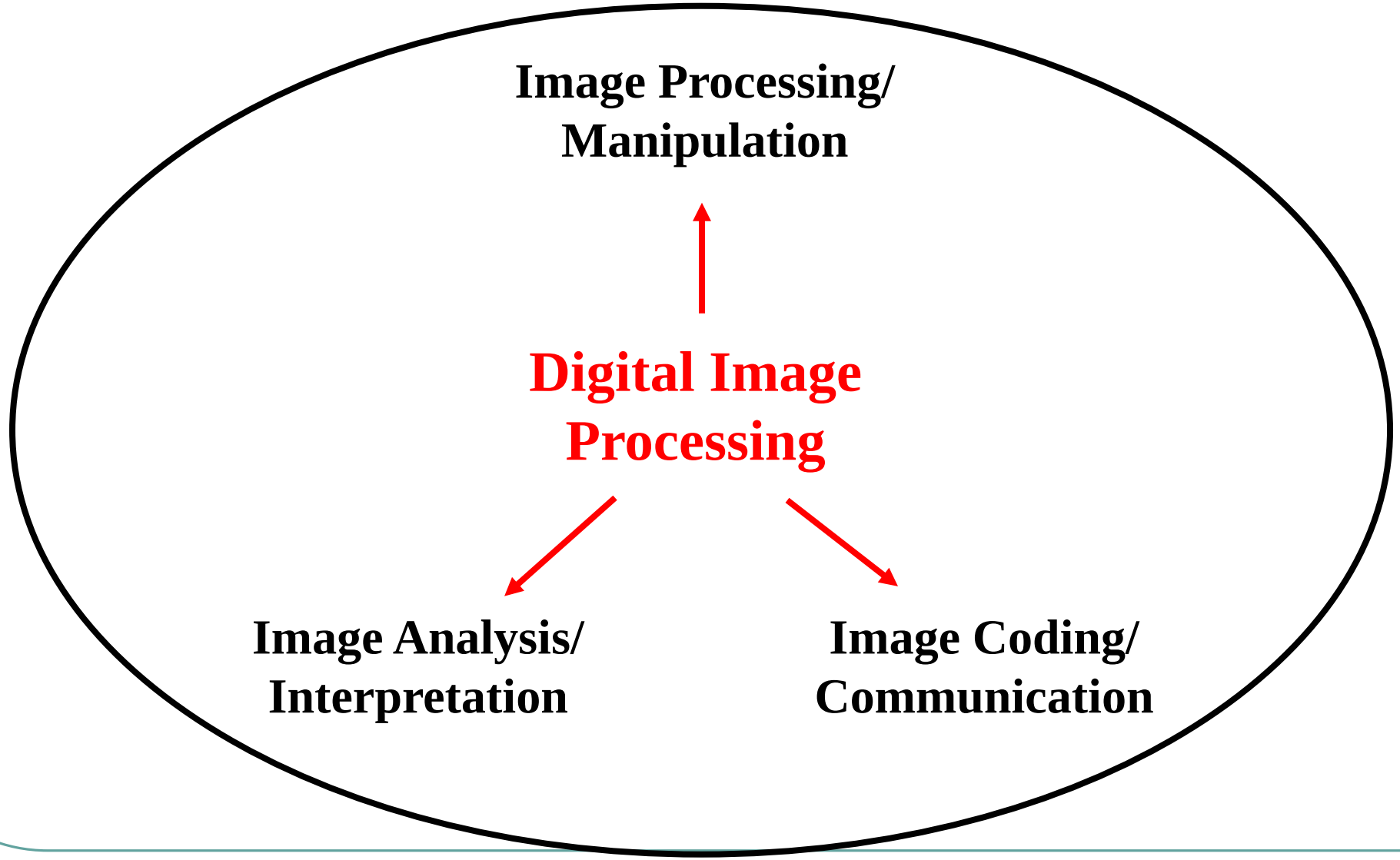
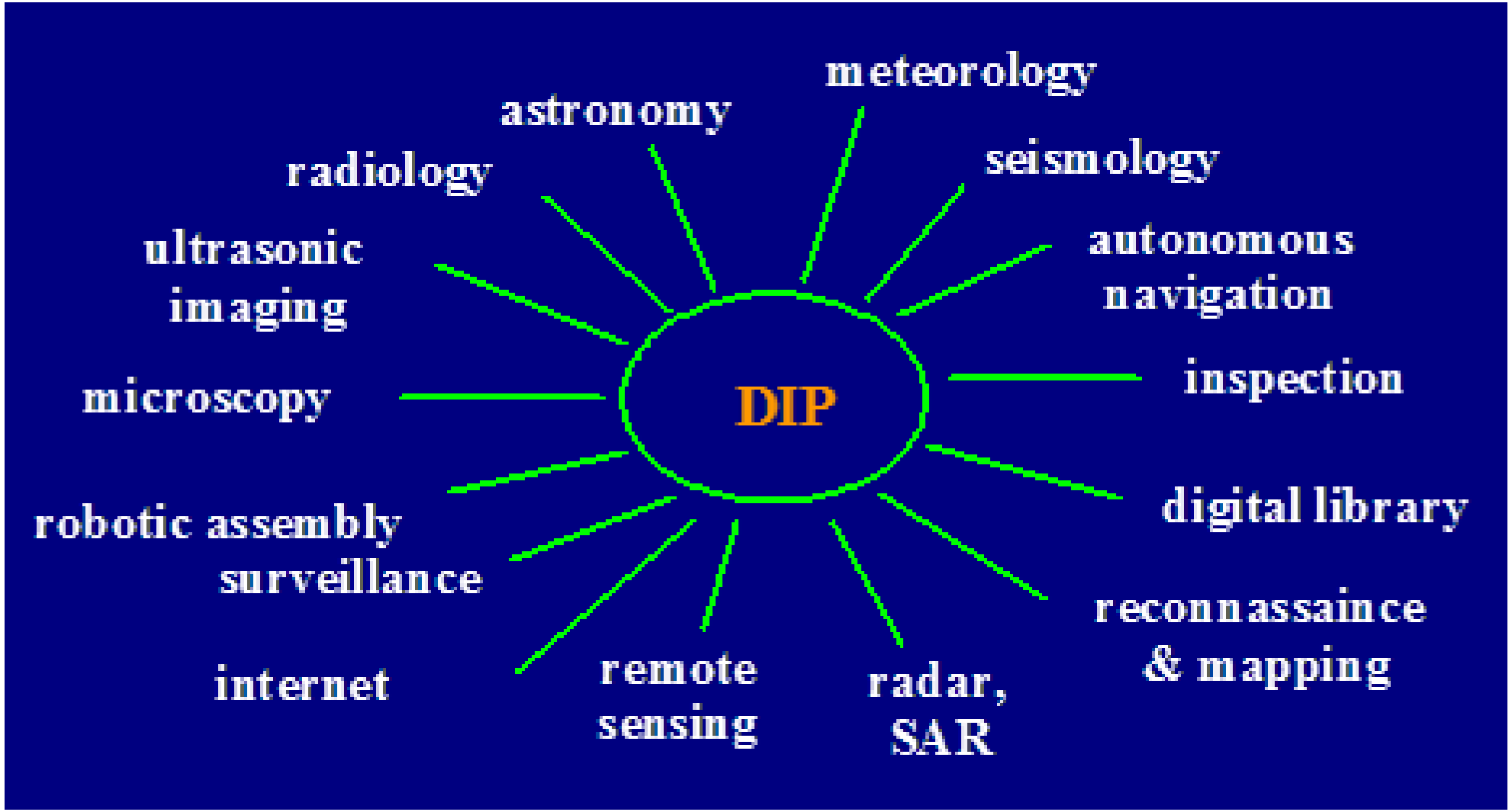


Image Processing/
Manipulation
Digital Image
Processing
Image Analysis/
Interpretation
Image Coding/
Communication

➢ Applications of DIP



➢ Image Processing: Image Enhancement

resolution

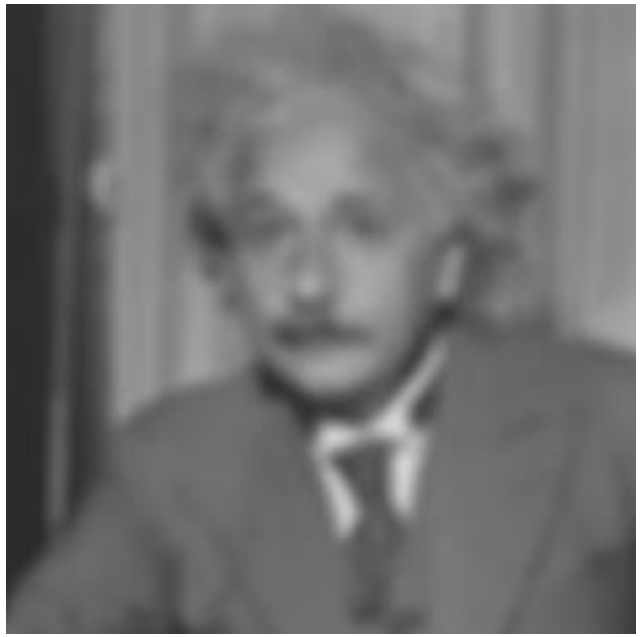
Enhance →

From [Gonzalez & Woods]

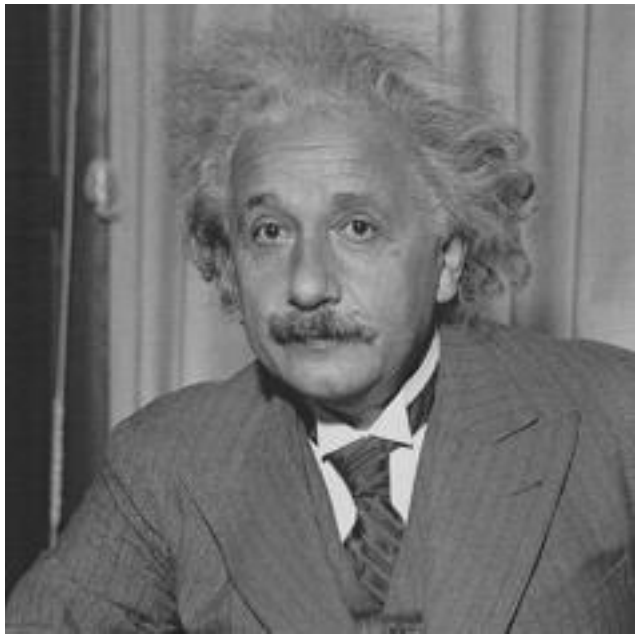
➢ Image Processing: Image Denoising

Denoise →

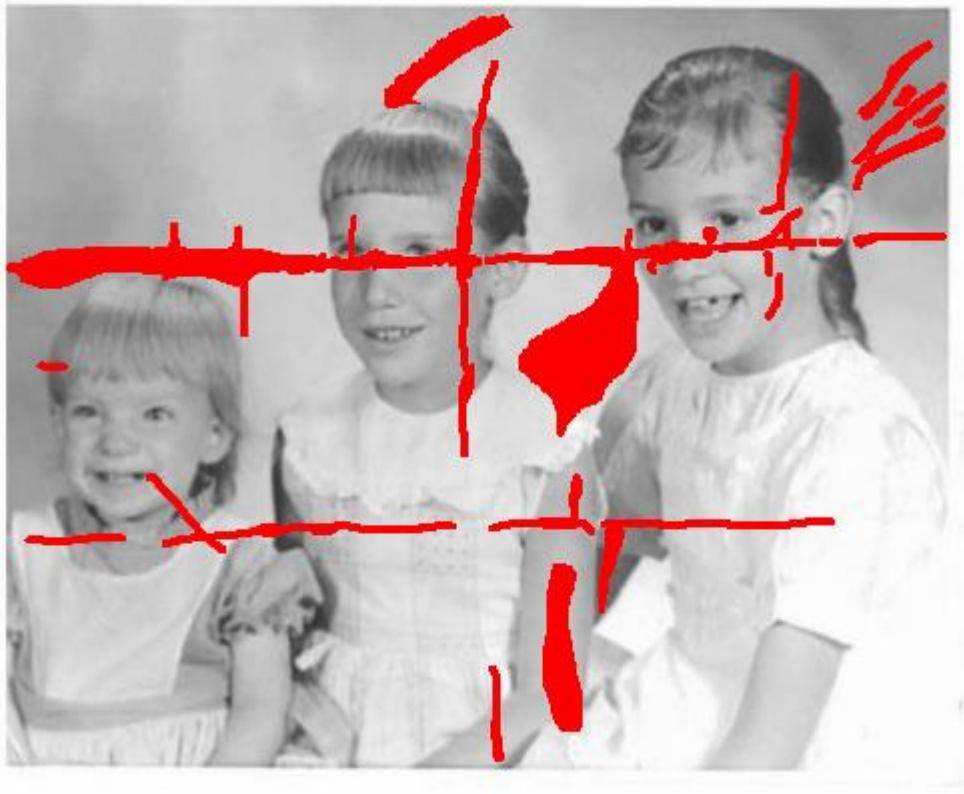
➢ Image Processing: Image Deblurring



Deblur



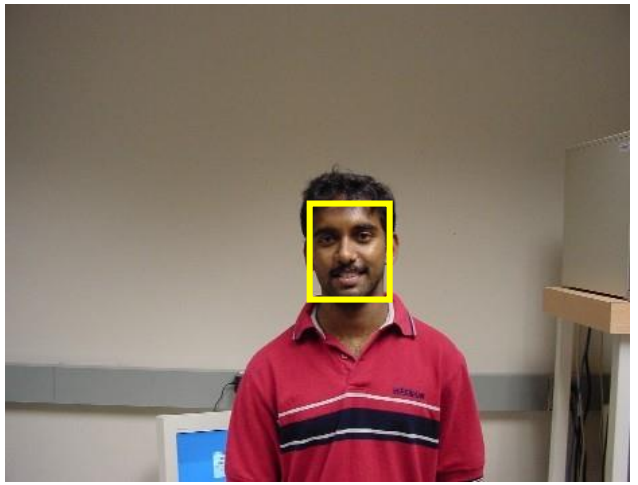
➢ Image Processing: Image Inpainting

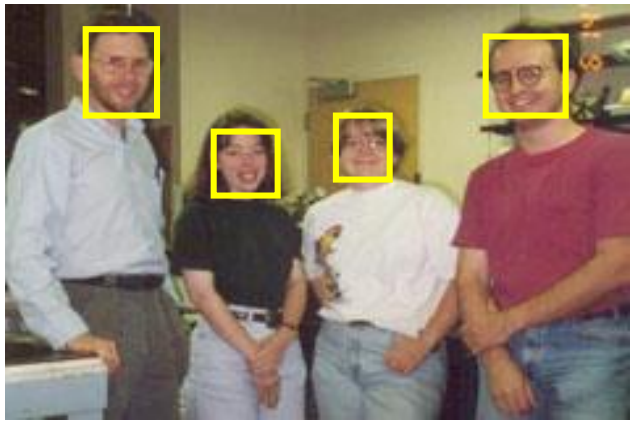


➢ Image Analysis: Edge Detection

From [Gonzalez & Woods]

➢ Image Analysis: Face Detection





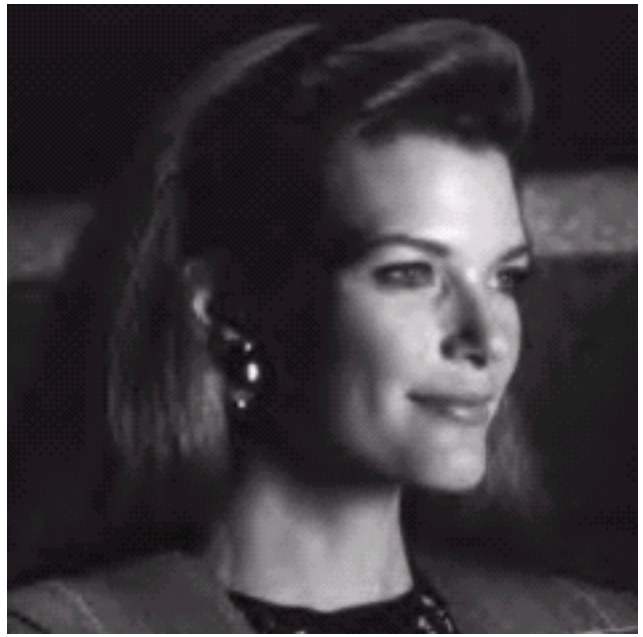
➢ Image Analysis: Image Matching

Two deceivingly similar fingerprints of two different people

➢ Image Coding: Image Compression

original image
262144 Bytes

From [Gonzalez & Woods]



From [Gonzalez & Woods]

image encoder → compressed bitstream 0011100001001101… (2428 Bytes) → **image decoder**

compression ratio (CR) = 108:1


Thank
you