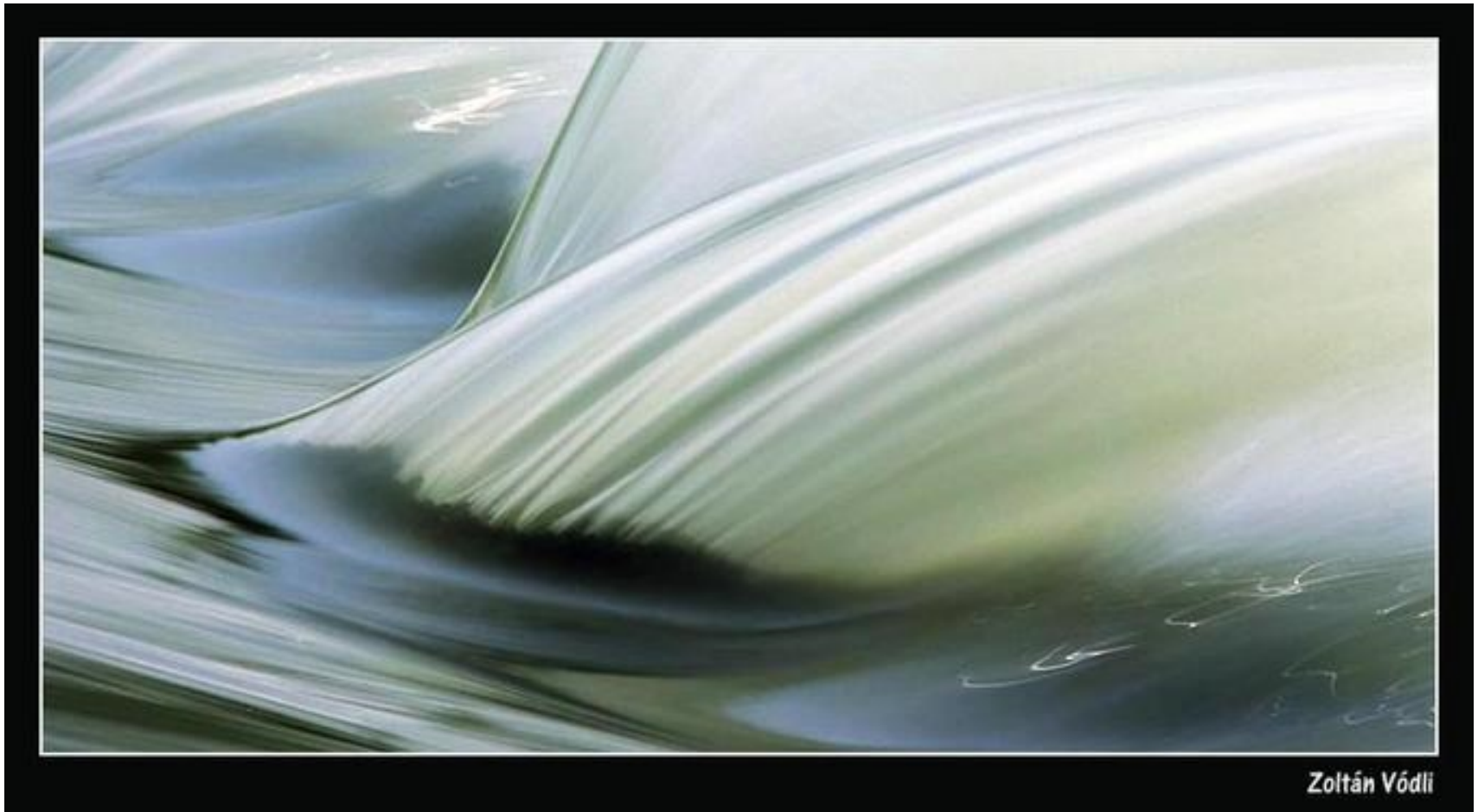


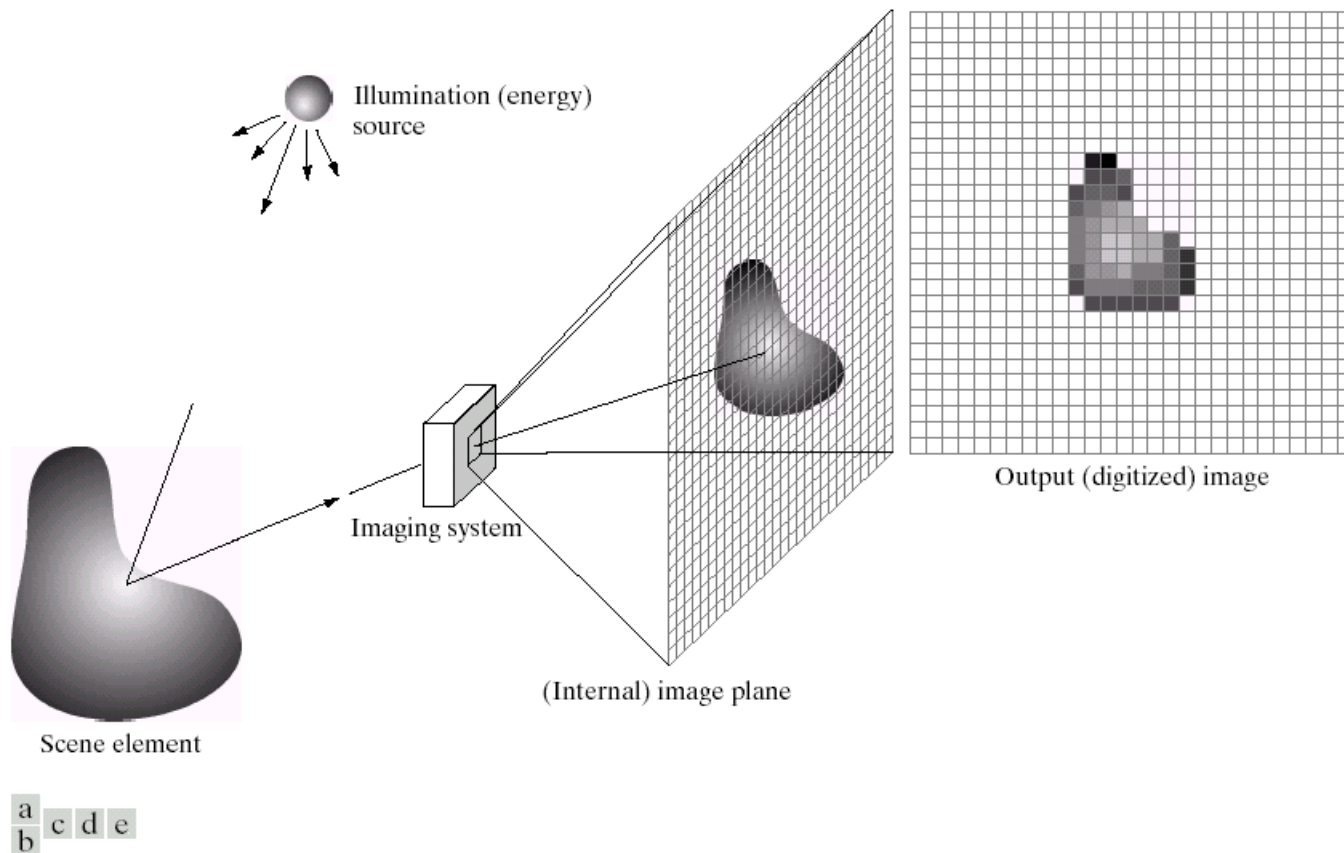
# Point Processing

---



CS194: Image Manipulation & Computational Photography  
Alexei Efros, UC Berkeley, Fall 2017

# Image Formation



**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.

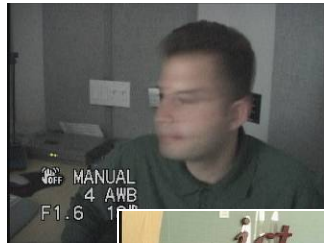
$$f(x,y) = \text{reflectance}(x,y) * \text{illumination}(x,y)$$

*Reflectance in  $[0, 1]$ , illumination in  $[0, \text{inf}]$*

# Problem: Dynamic Range

---

The real world is  
High dynamic range



1



1500



25,000



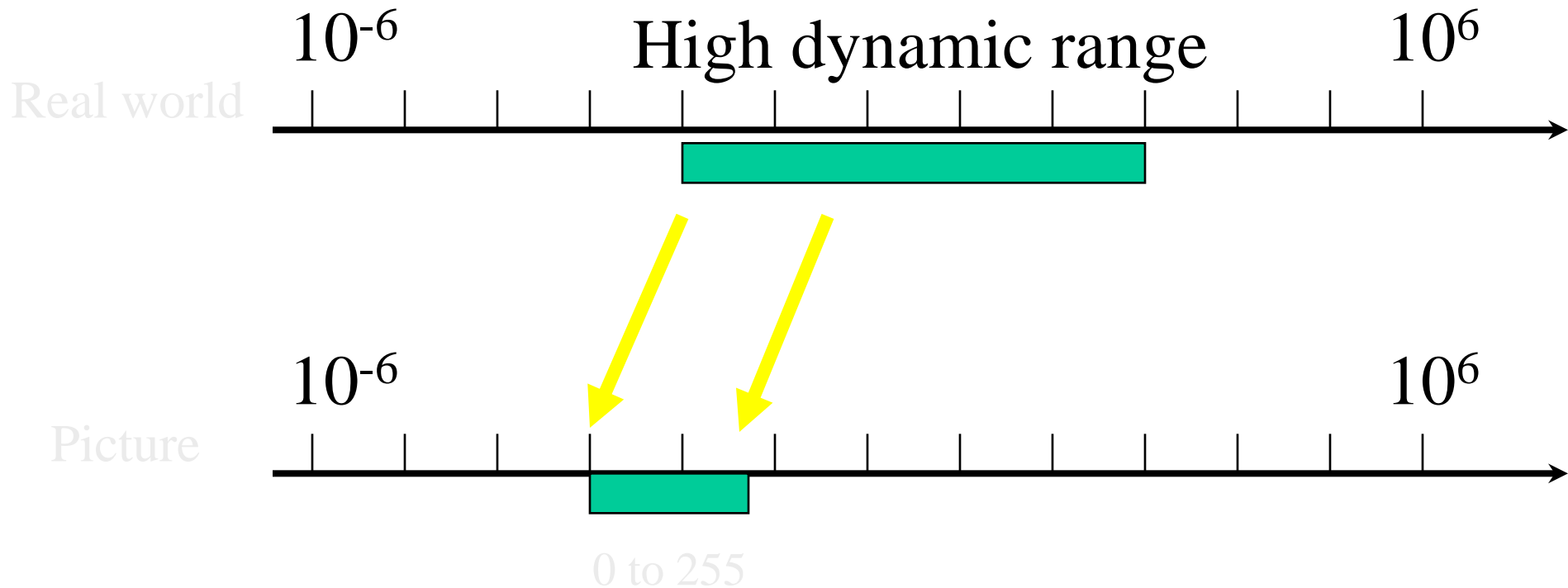
400,000



2,000,000,000

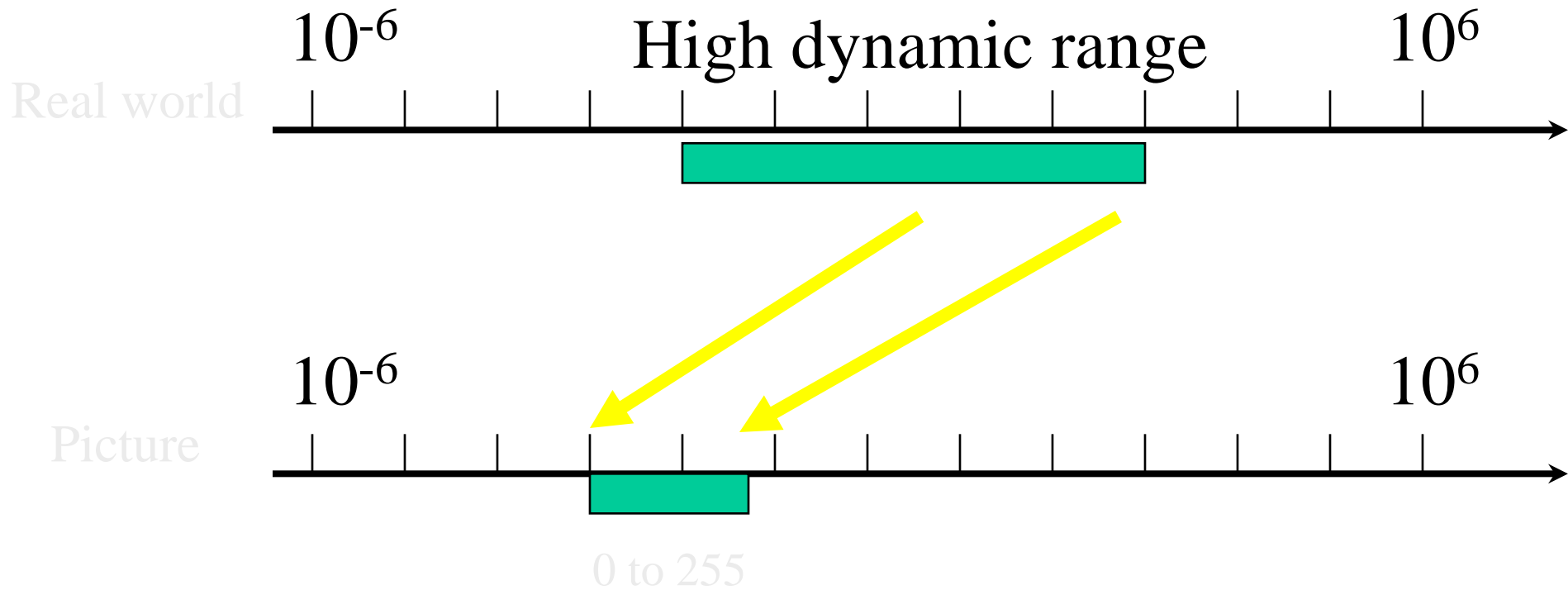
# Long Exposure

---



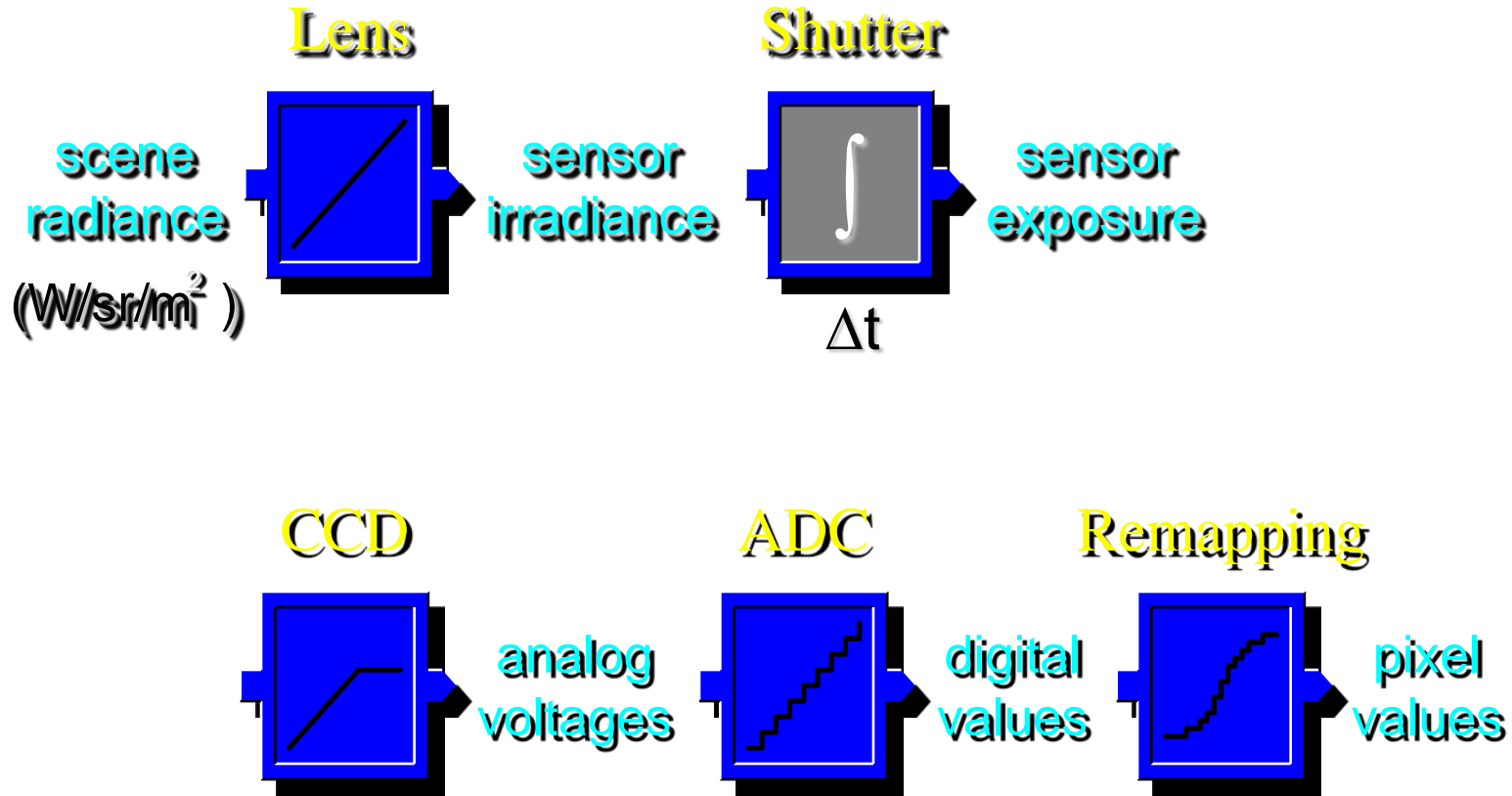
# Short Exposure

---



# Image Acquisition Pipeline

---



# Simple Point Processing: Enhancement

---

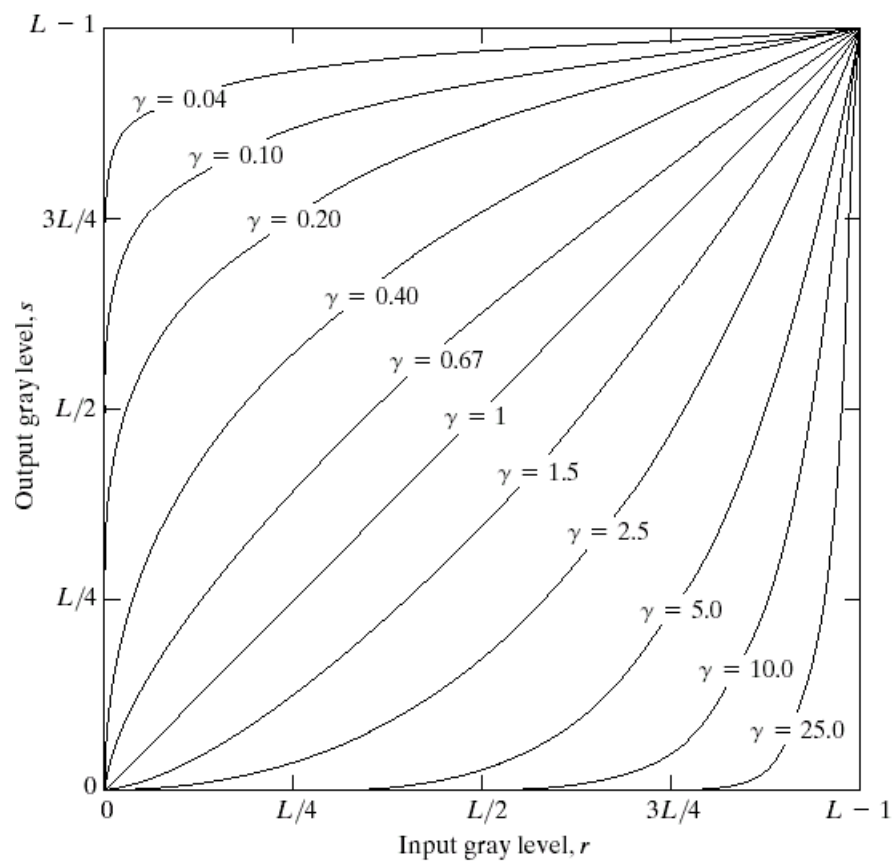
a b  
c d

**FIGURE 3.9**

(a) Aerial image.  
(b)–(d) Results of applying the transformation in Eq. (3.2-3) with  $c = 1$  and  $\gamma = 3.0, 4.0,$  and  $5.0$ , respectively. (Original image for this example courtesy of NASA.)



# Power-law transformations



**FIGURE 3.6** Plots of the equation  $s = cr^\gamma$  for various values of  $\gamma$  ( $c = 1$  in all cases).

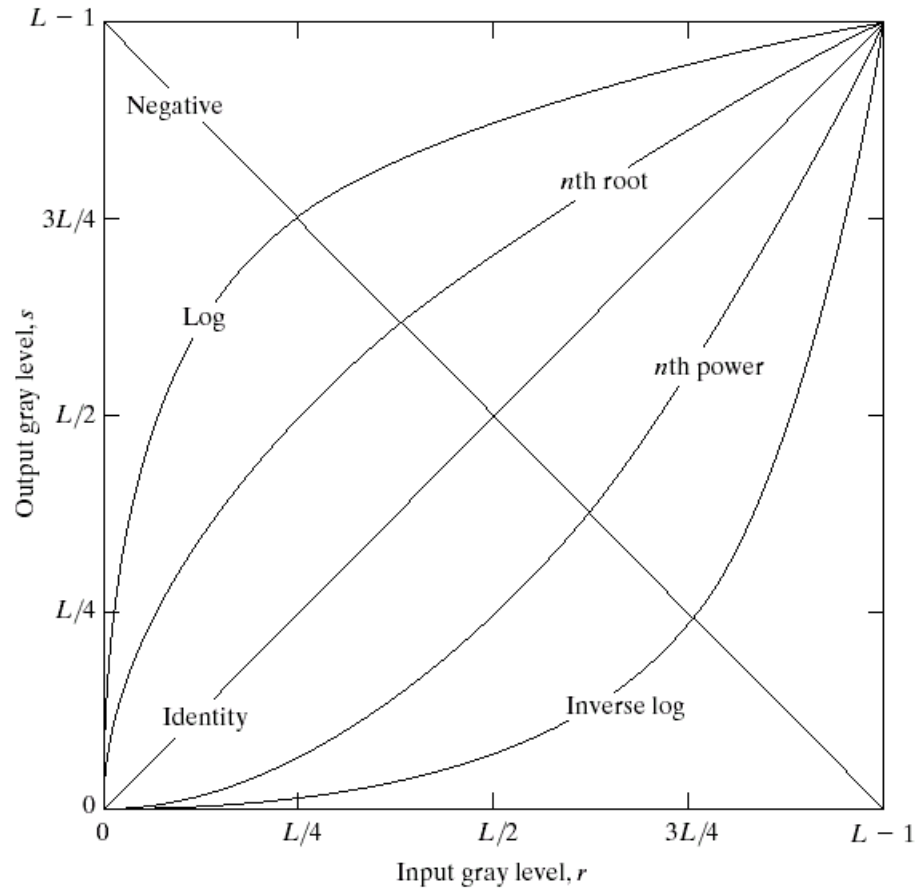
$$s = cr^\gamma$$



# Basic Point Processing

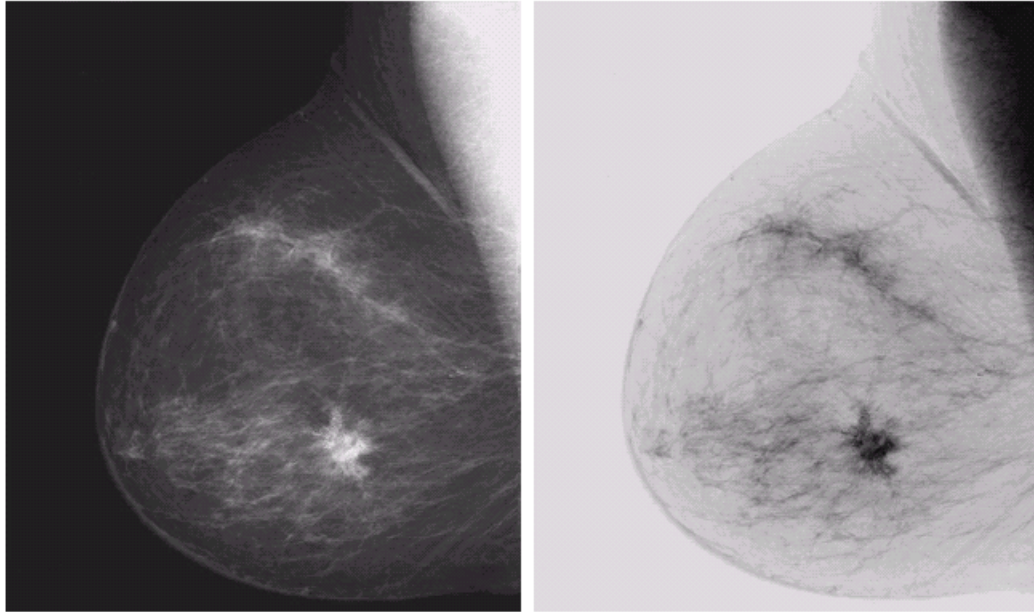
---

**FIGURE 3.3** Some basic gray-level transformation functions used for image enhancement.



# Negative

---



a b

**FIGURE 3.4**

(a) Original digital mammogram.  
(b) Negative image obtained using the negative transformation in Eq. (3.2-1).  
(Courtesy of G.E. Medical Systems.)

# Log

---

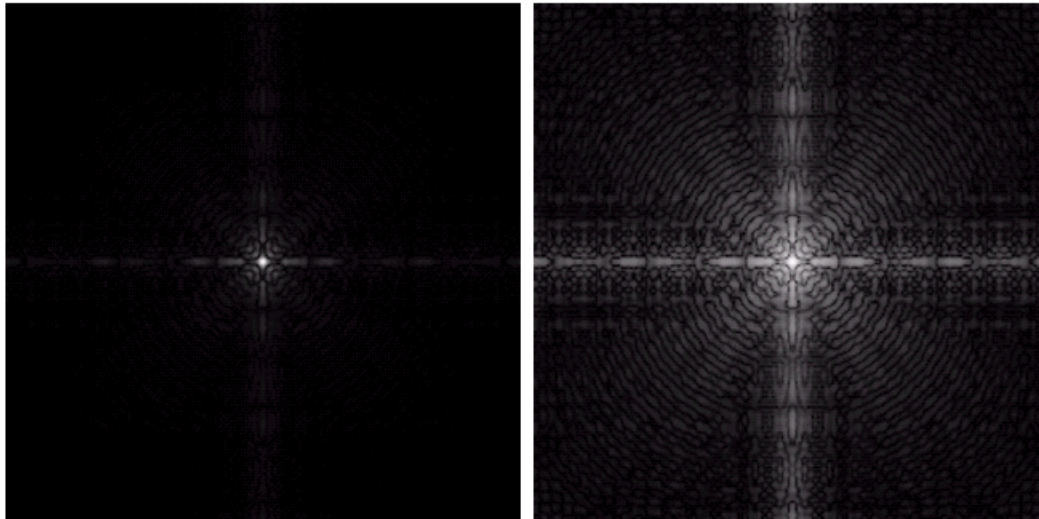
a b

**FIGURE 3.5**

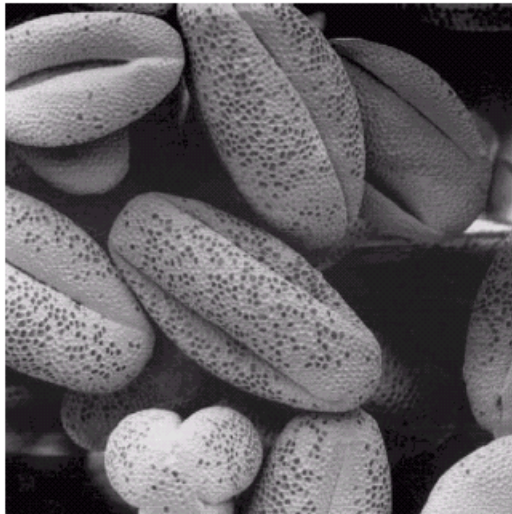
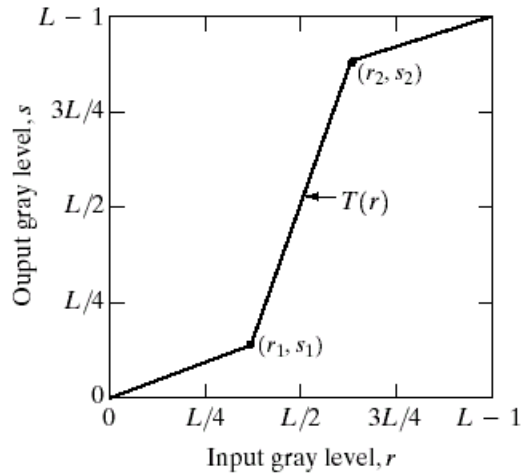
(a) Fourier spectrum.

(b) Result of applying the log transformation given in Eq. (3.2-2) with  $c = 1$ .

---



# Contrast Stretching

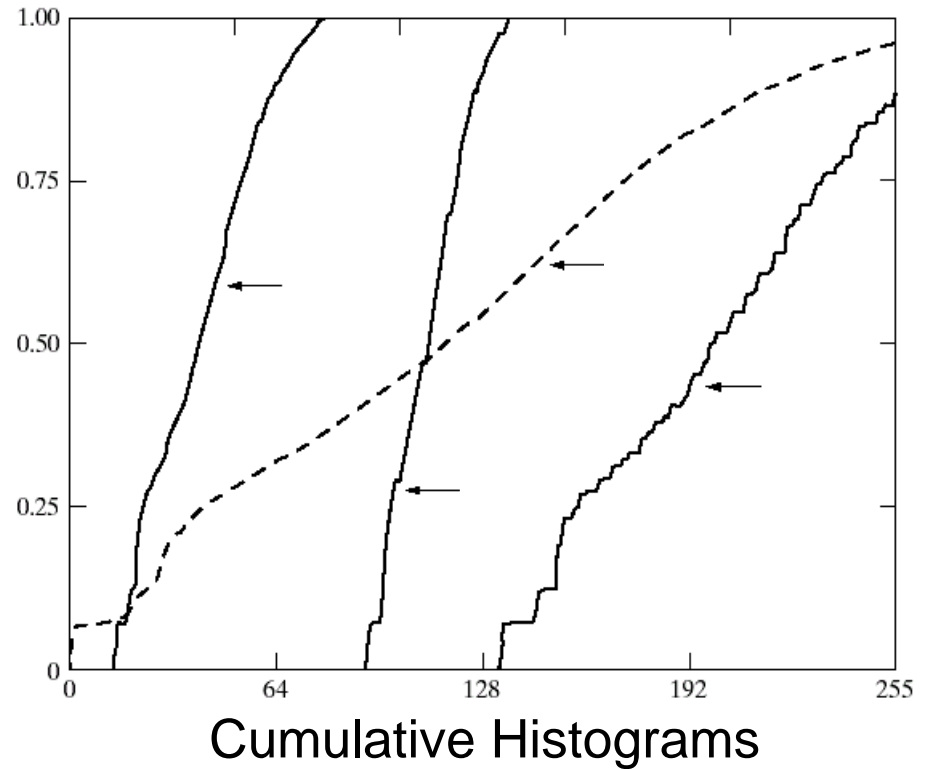
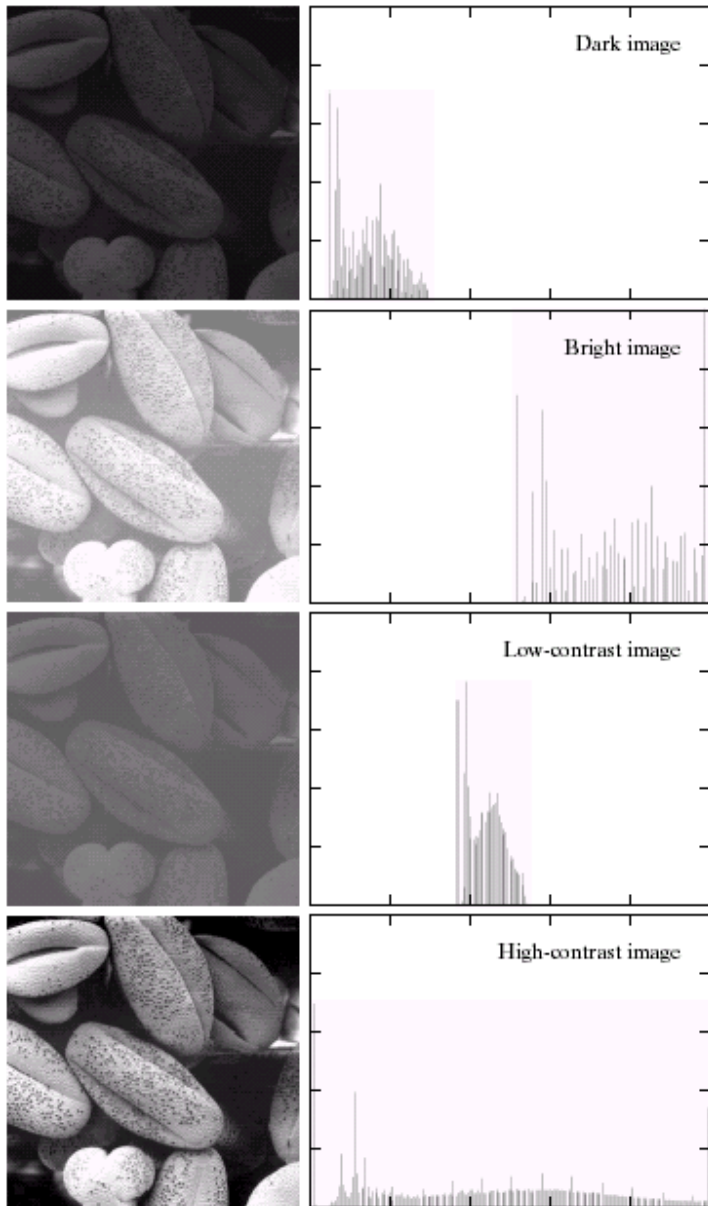


a b  
c d

**FIGURE 3.10**

Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

# Image Histograms



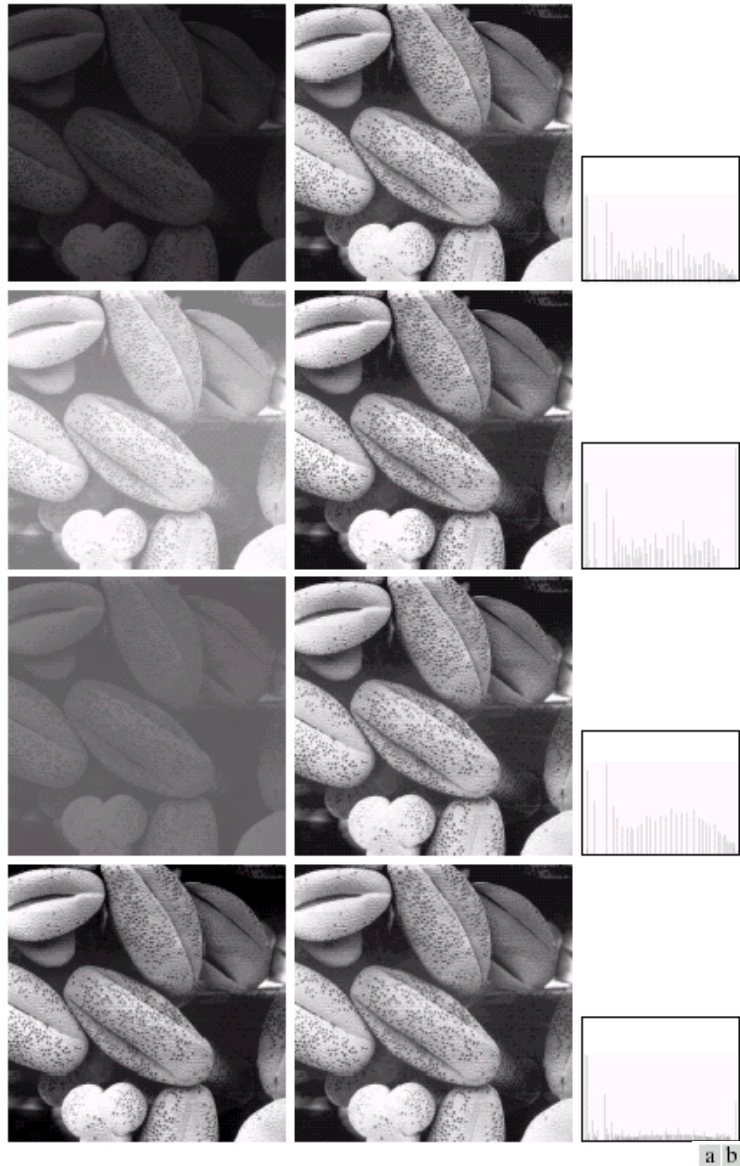
$$s = T(r)$$

a b

**FIGURE 3.15** Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

# Histogram Equalization

---



a b c

**FIGURE 3.17** (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.

# Color Transfer [Reinhard, et al, 2001]

---

