

Point Processing



CS194: Intro to Comp. Vision, and Comp. Photo
Alexei Efros, UC Berkeley, Fall 2020

Image Formation

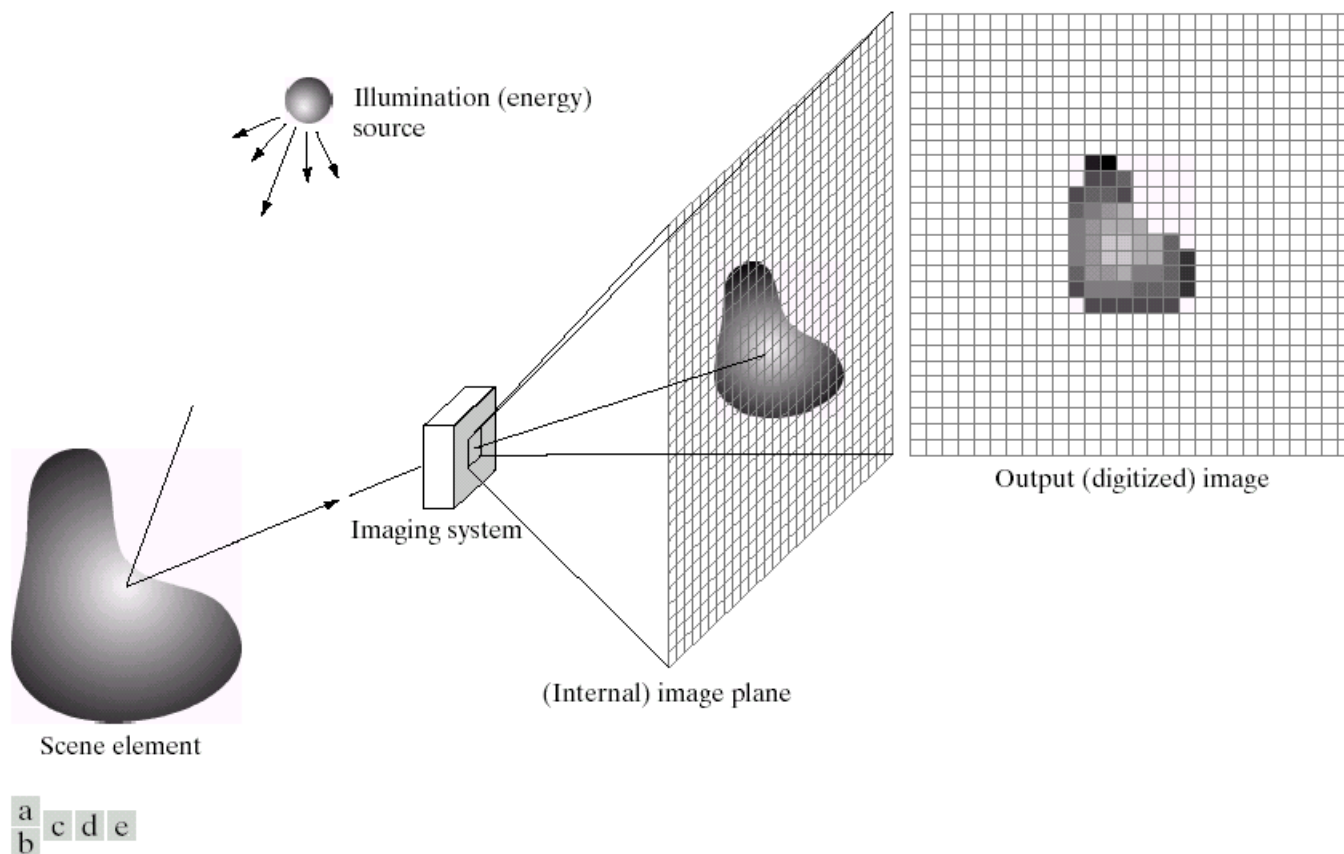


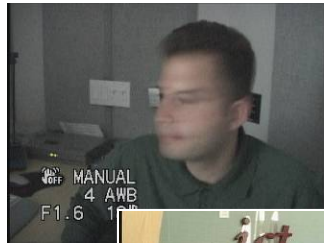
FIGURE 2.15 An example of the digital image acquisition process. (a) Energy (“illumination”) source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

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

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

Problem: Dynamic Range

The real world is
High dynamic range



1



1500



25,000

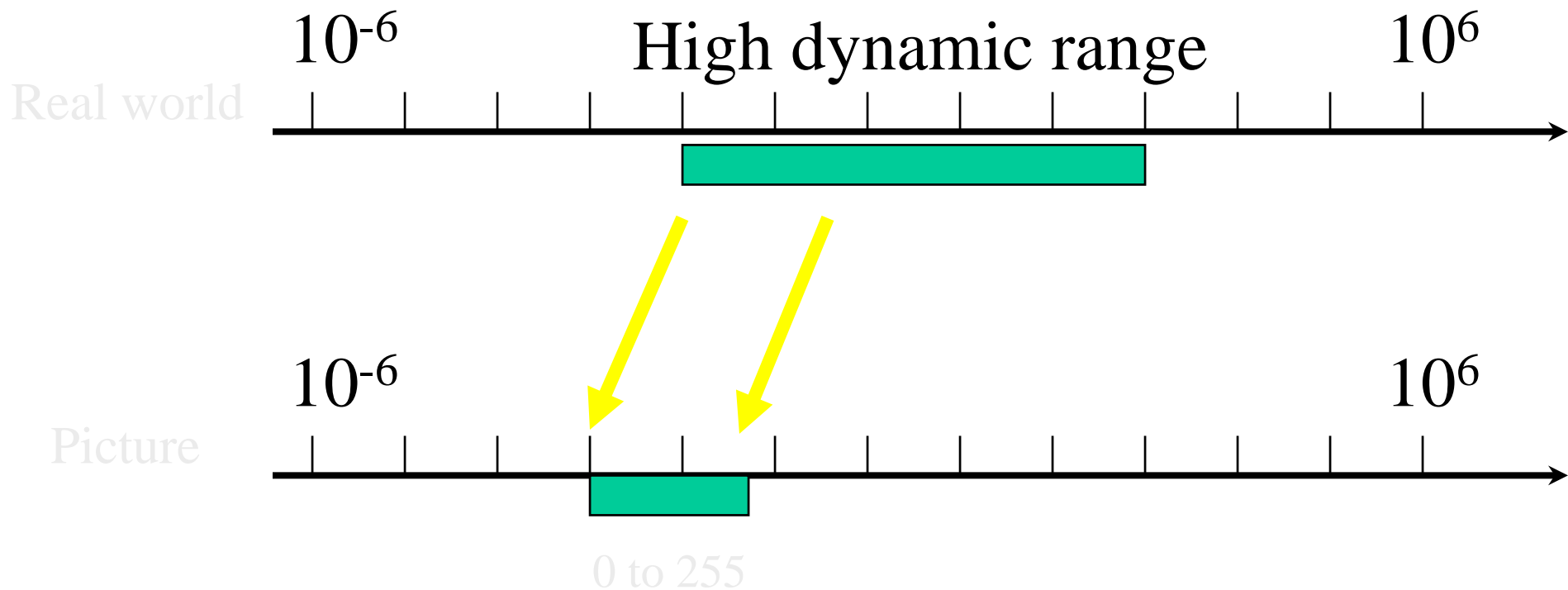


400,000



2,000,000,000

Long Exposure



Short Exposure

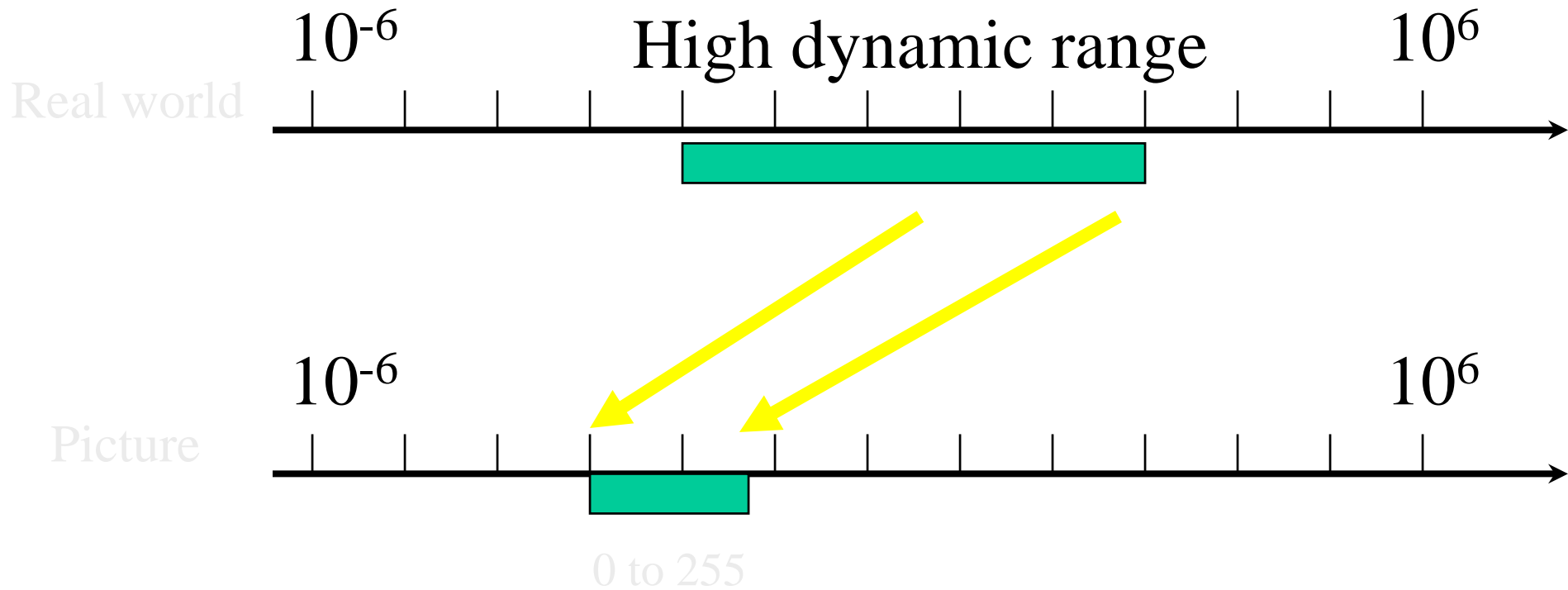
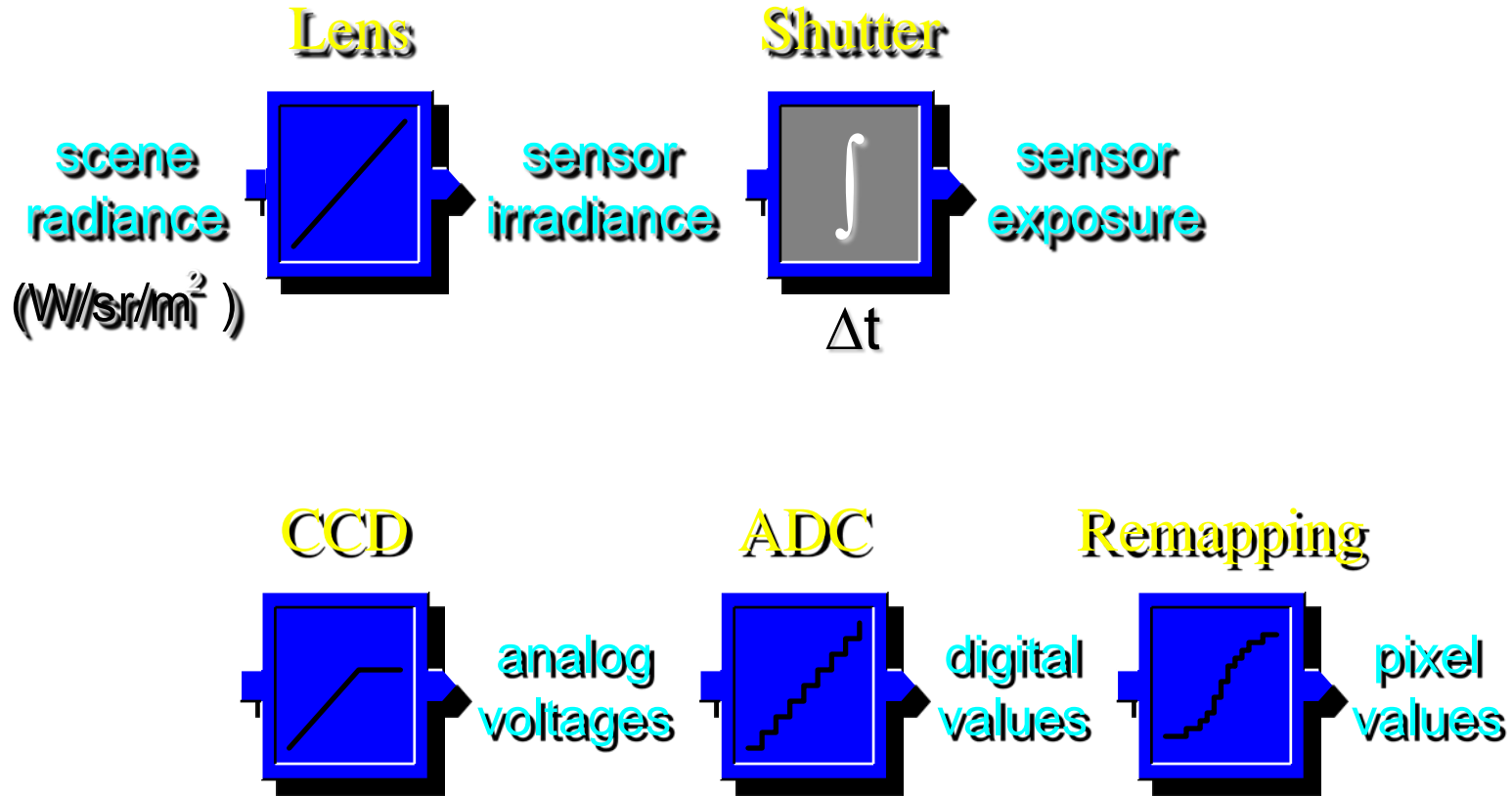


Image Acquisition Pipeline



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

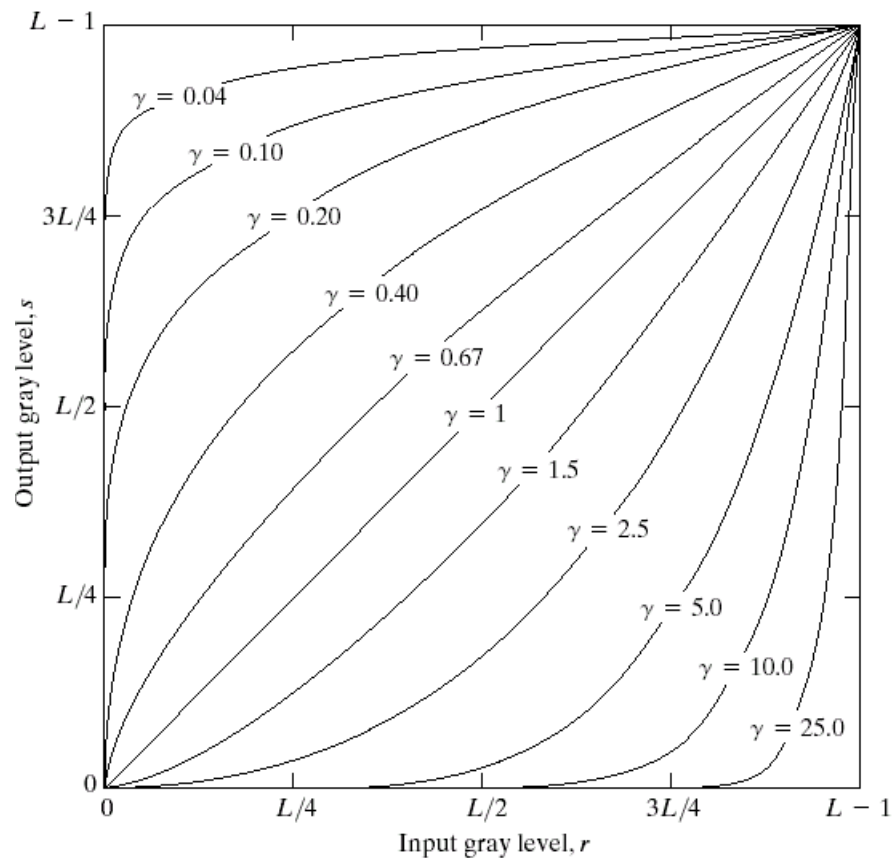
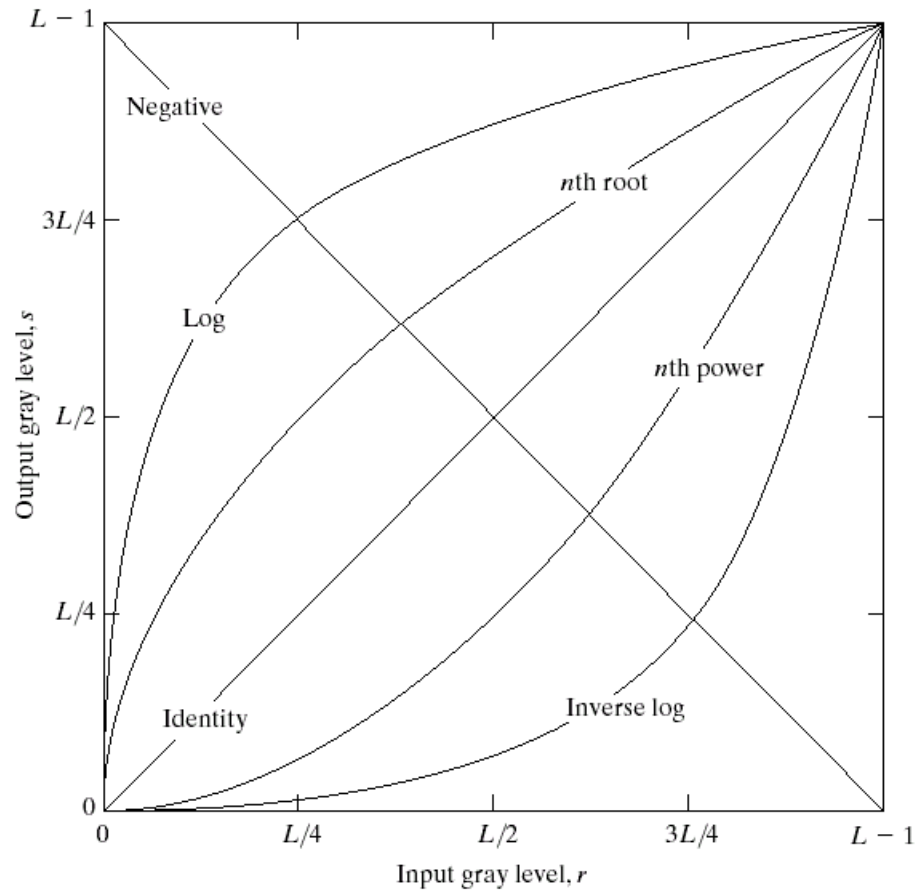


FIGURE 3.6 Plots of the equation $s = cr^\gamma$ for various values of γ ($c = 1$ in all cases).

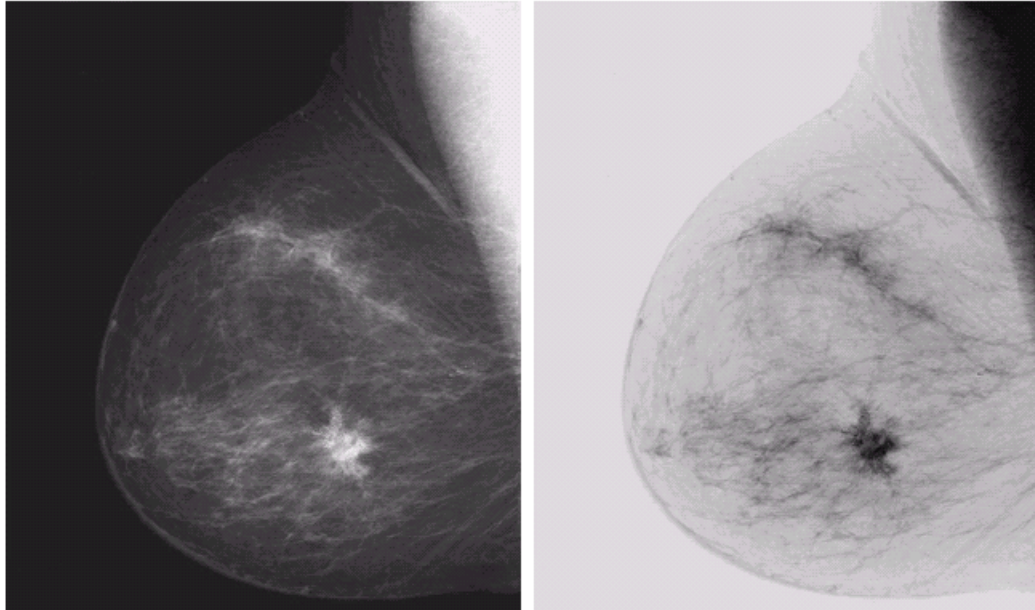
$$s = cr^\gamma$$

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.)

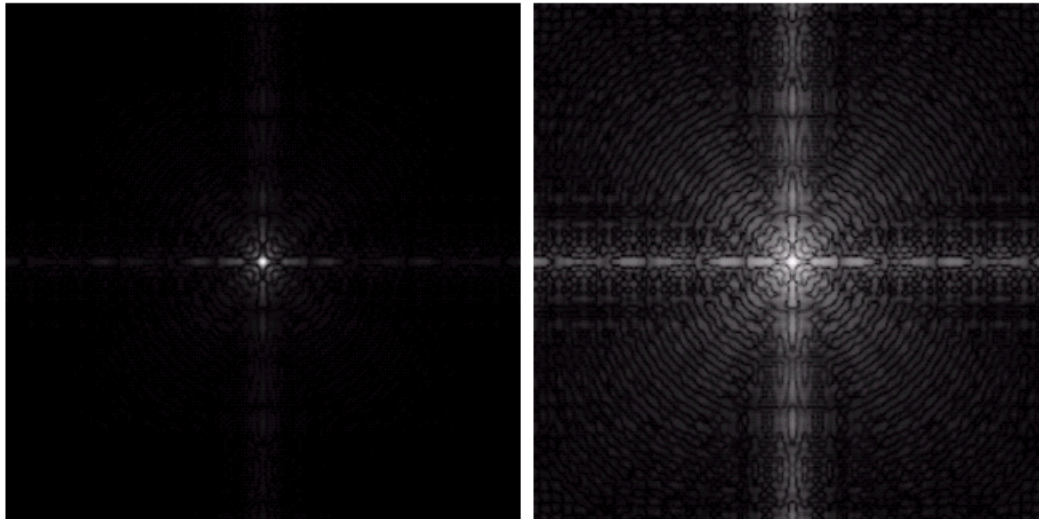
Log

a b

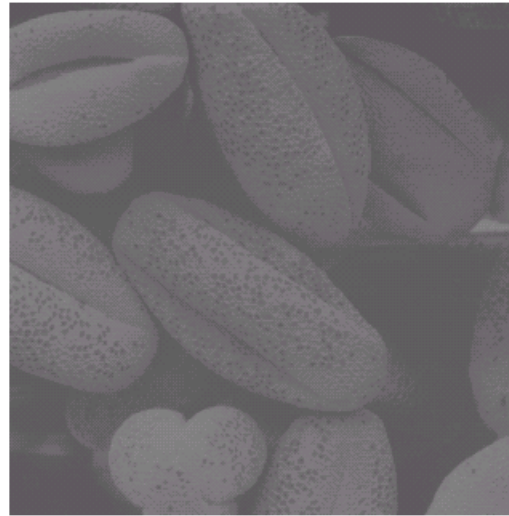
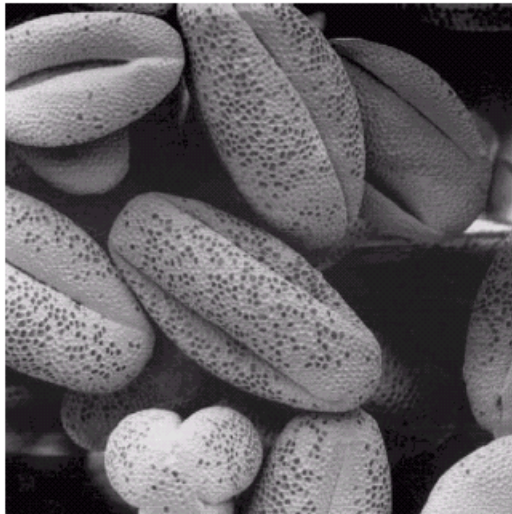
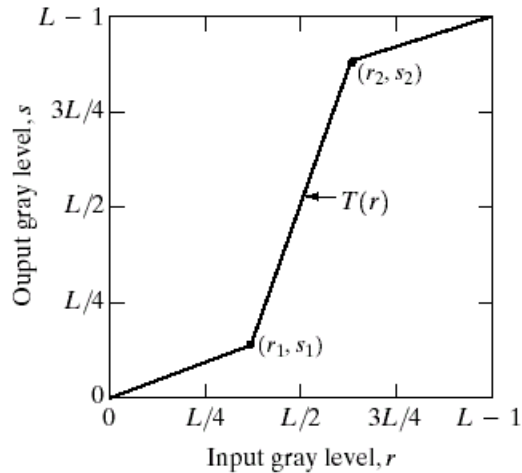
FIGURE 3.5

(a) Fourier spectrum.

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



Contrast Stretching

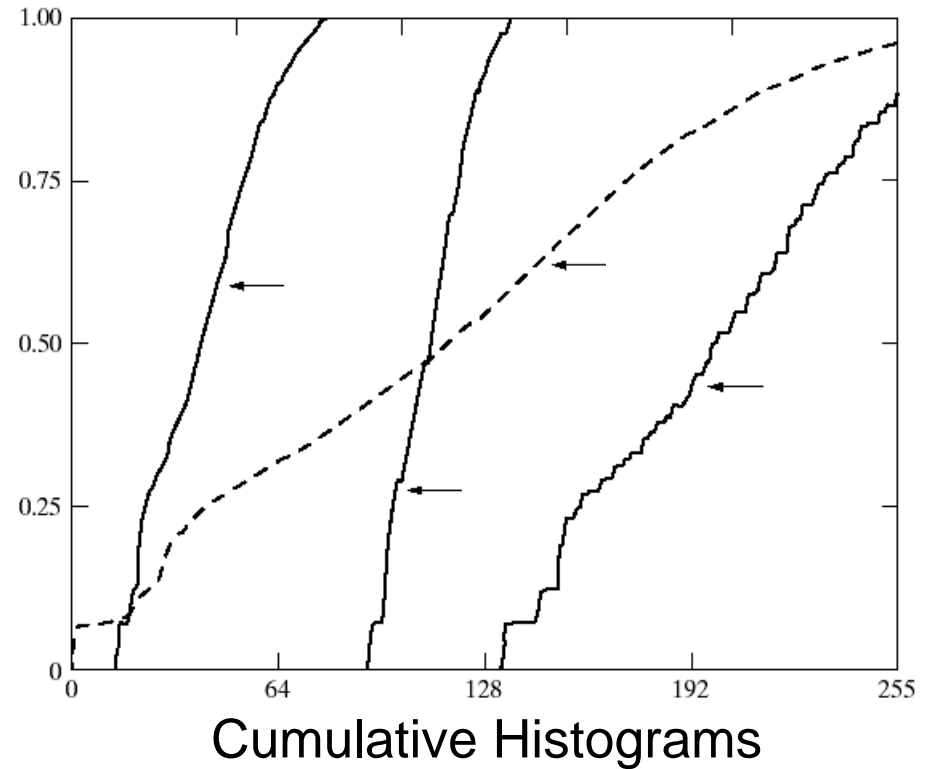
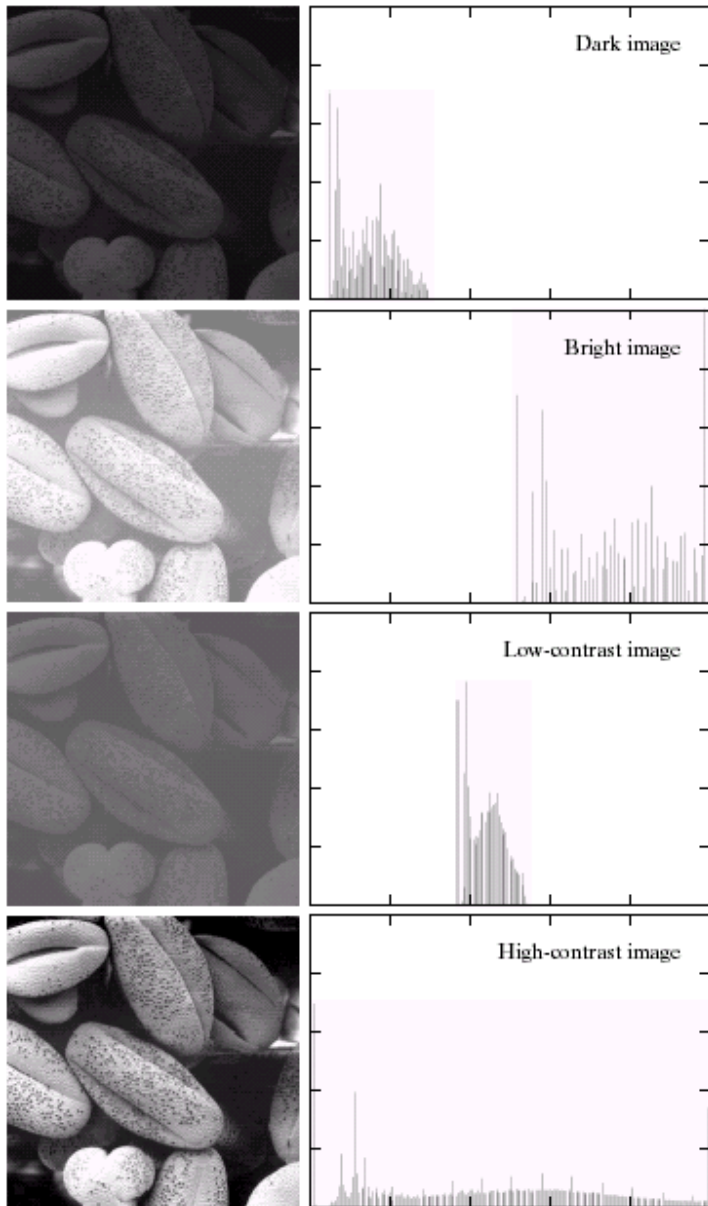


a b
c d

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

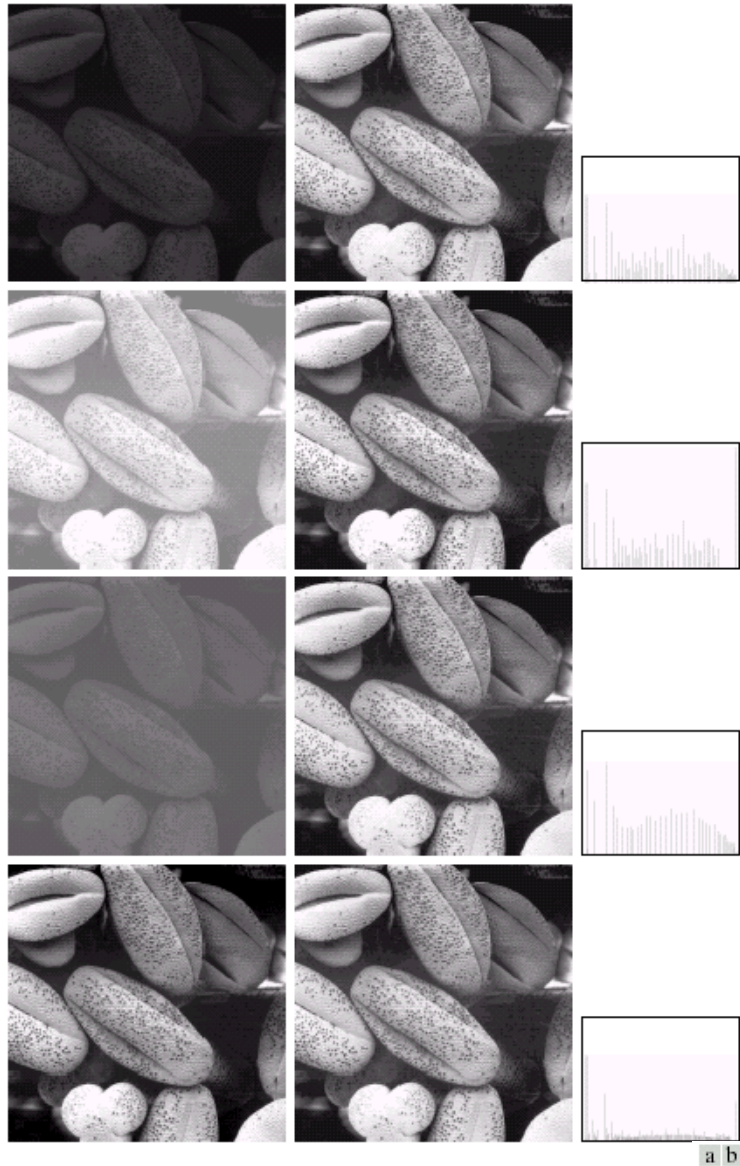


$$s = T(r)$$

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.)

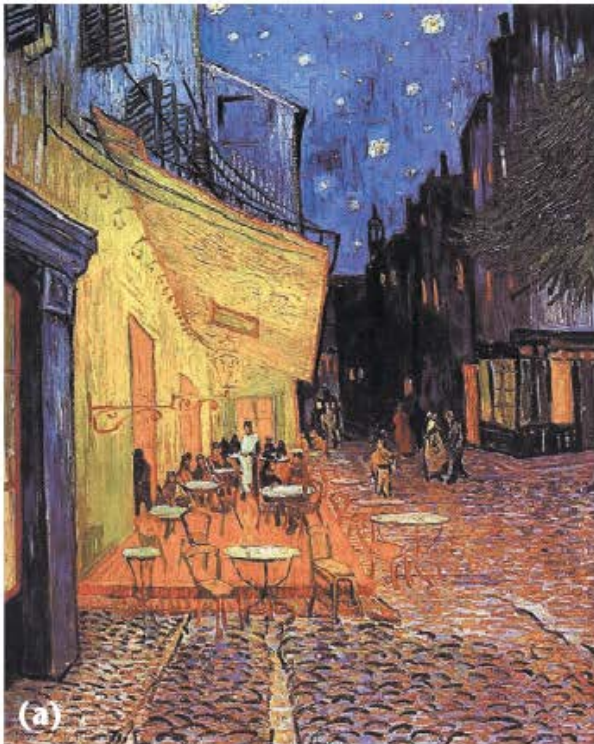
Histogram Equalization



a b c

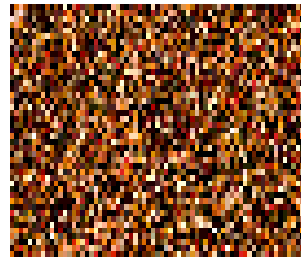
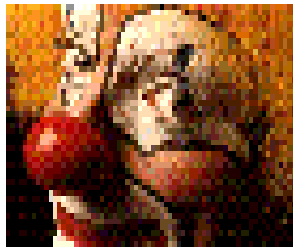
FIGURE 3.17 (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.

Color Transfer [Reinhard, et al, 2001]



Limitations of Point Processing

Q: What happens if I reshuffle all pixels within the image?



A: It's histogram won't change. No point processing will be affected...