اصول پردازش تصویر

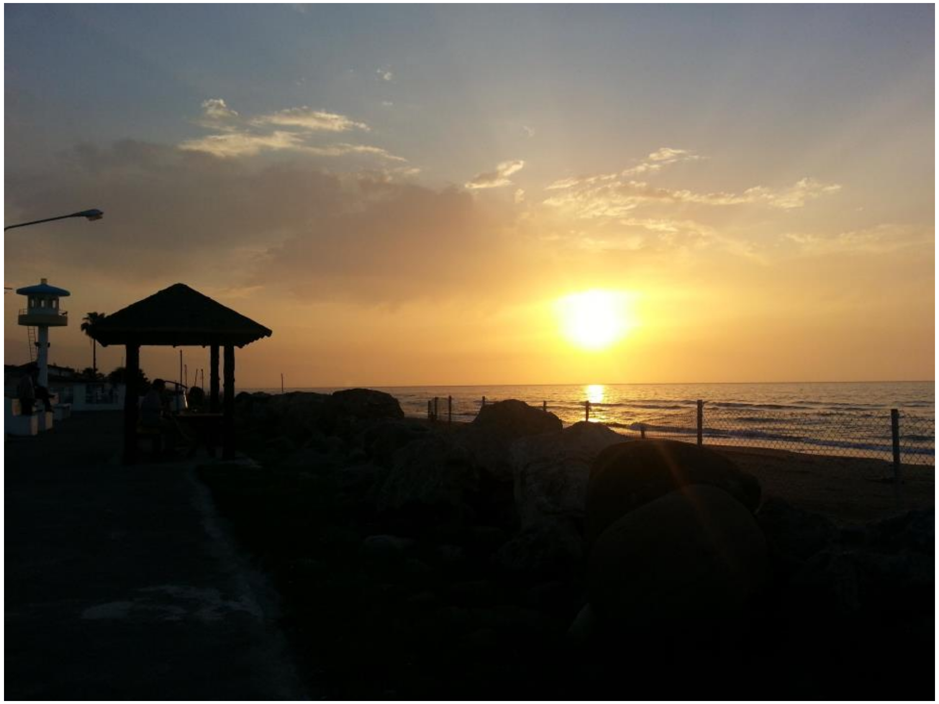
Principles of Image Processing

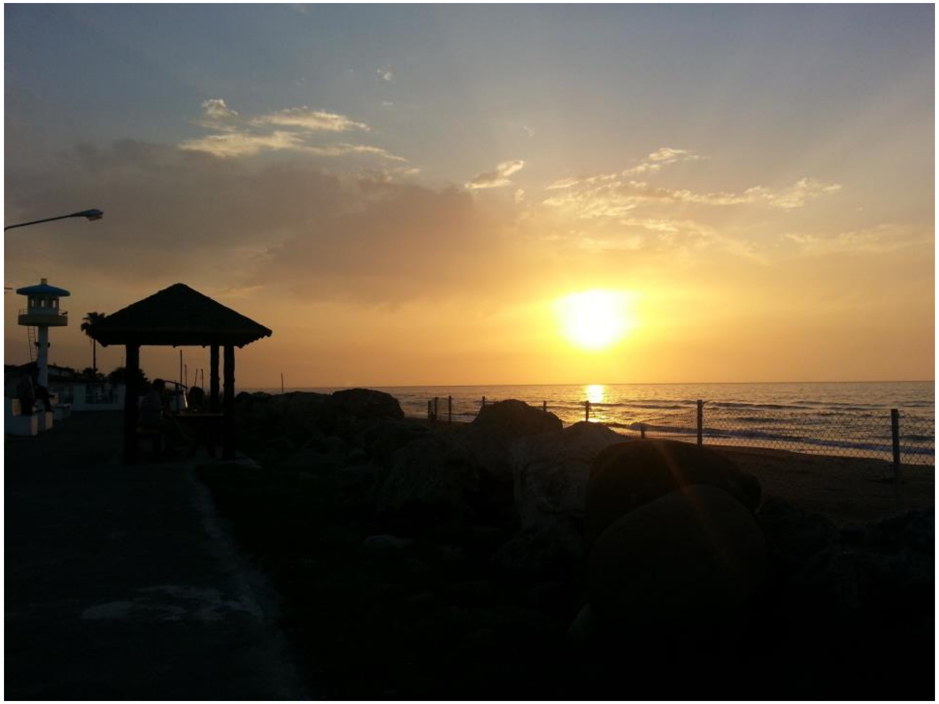
مصطفی کمالی تبریزی

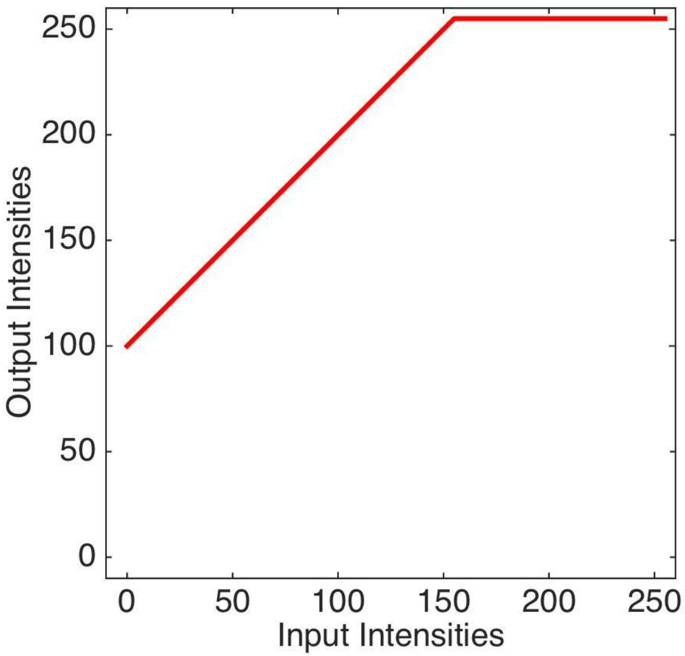
۷ مهر ۱۳۹۹

جلسه چهارم

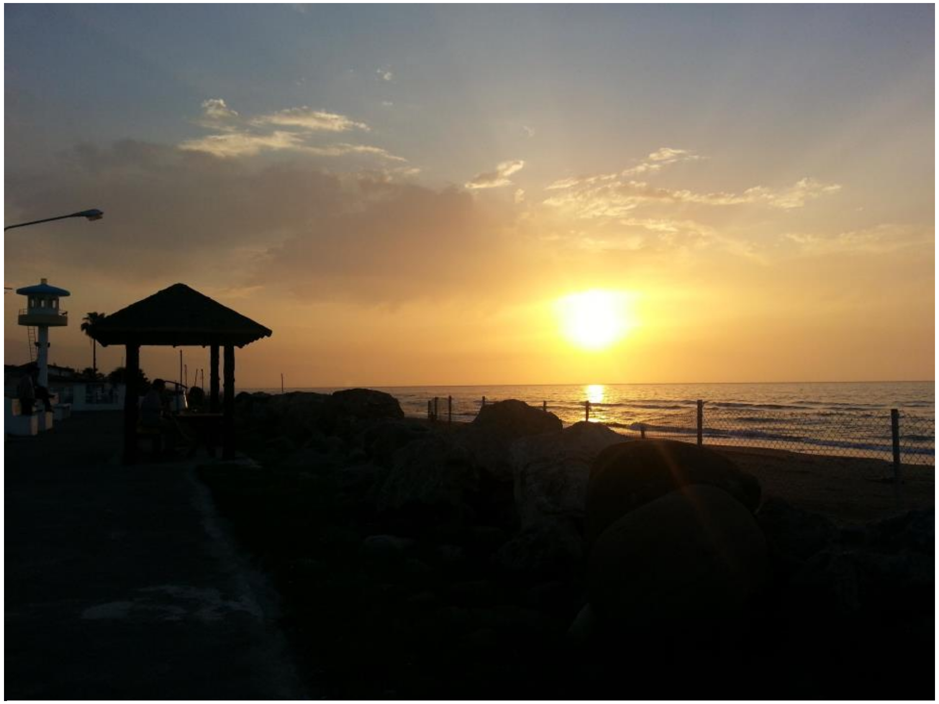
Image Enhancement (Point Operations)

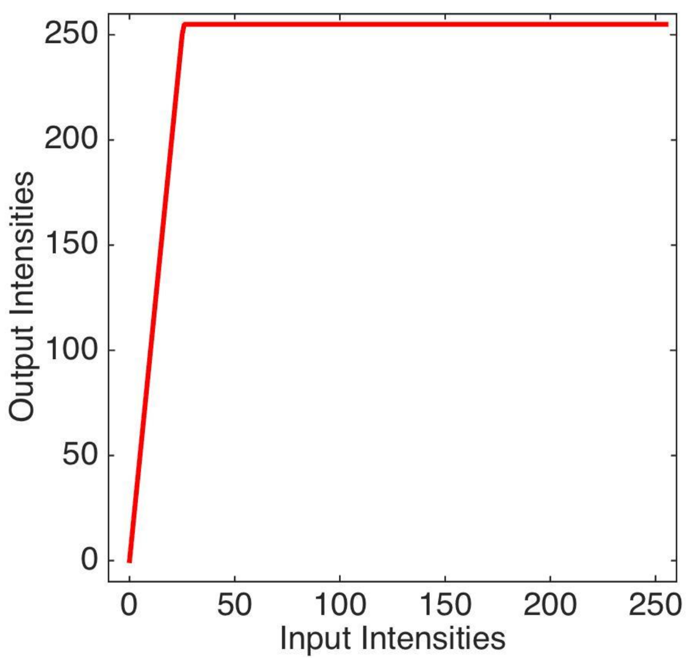




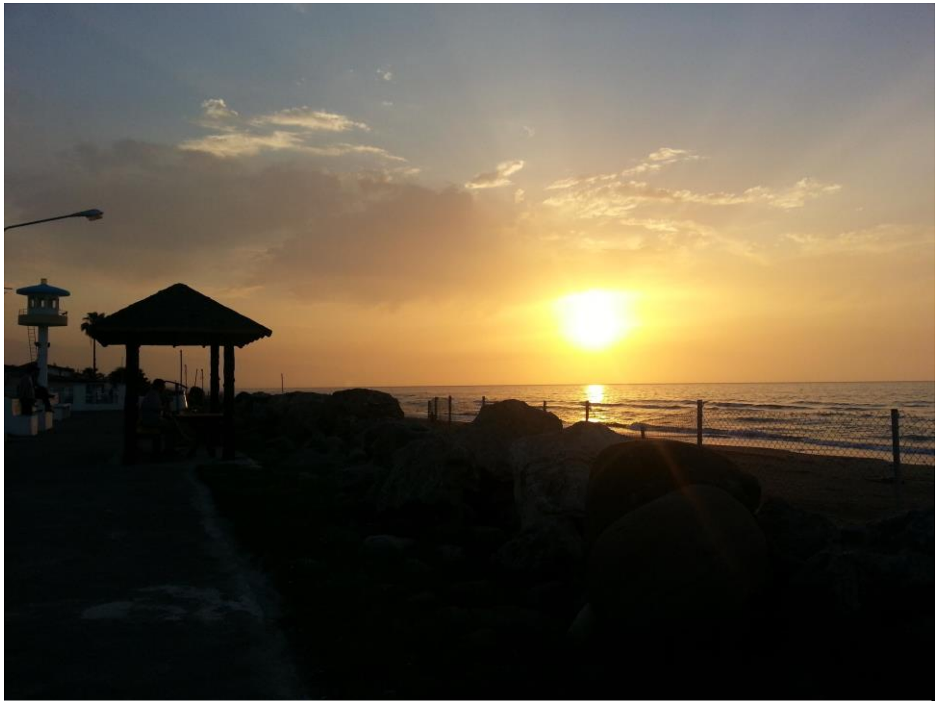


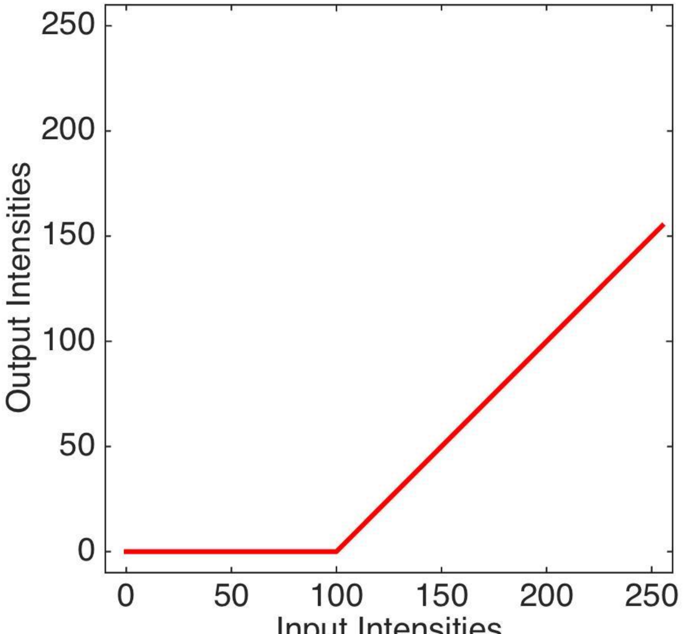
$$y = \begin{cases} x + 100 & x \leq 155 \\ 255 & x > 155 \end{cases}$$



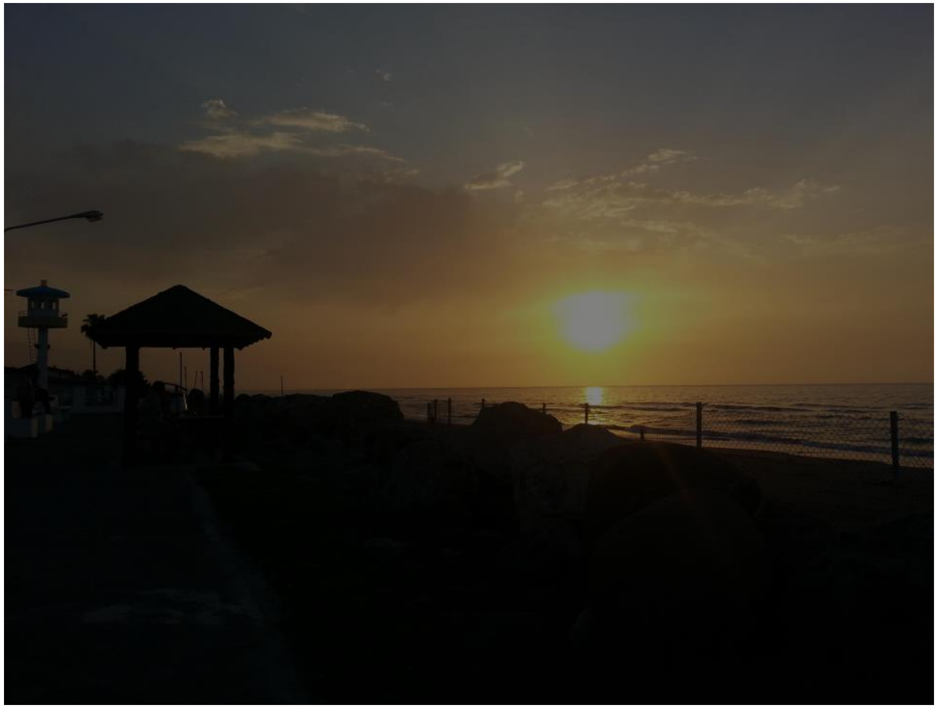


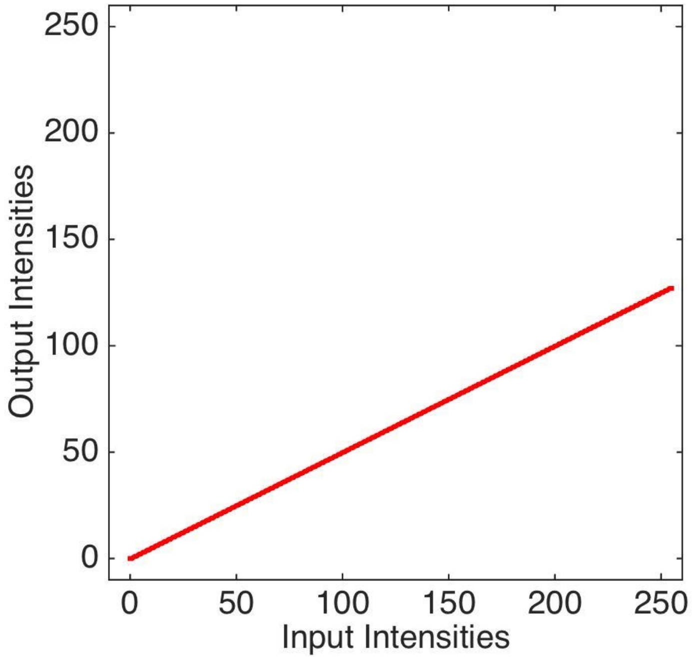
$$y = \begin{cases} 10x & x \leq 25 \\ 255 & x > 25 \end{cases}$$



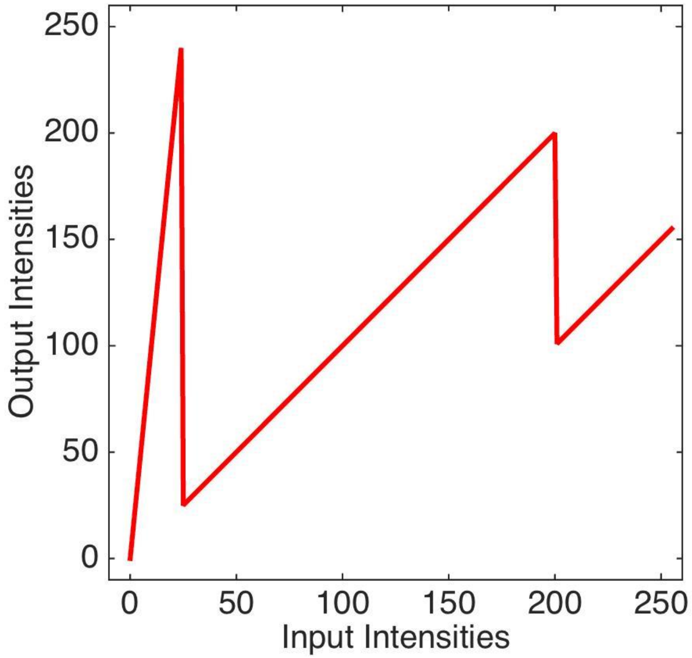


$$y = \begin{cases} x - 100 & x \geq 100 \\ 0 & x < 100 \end{cases}$$

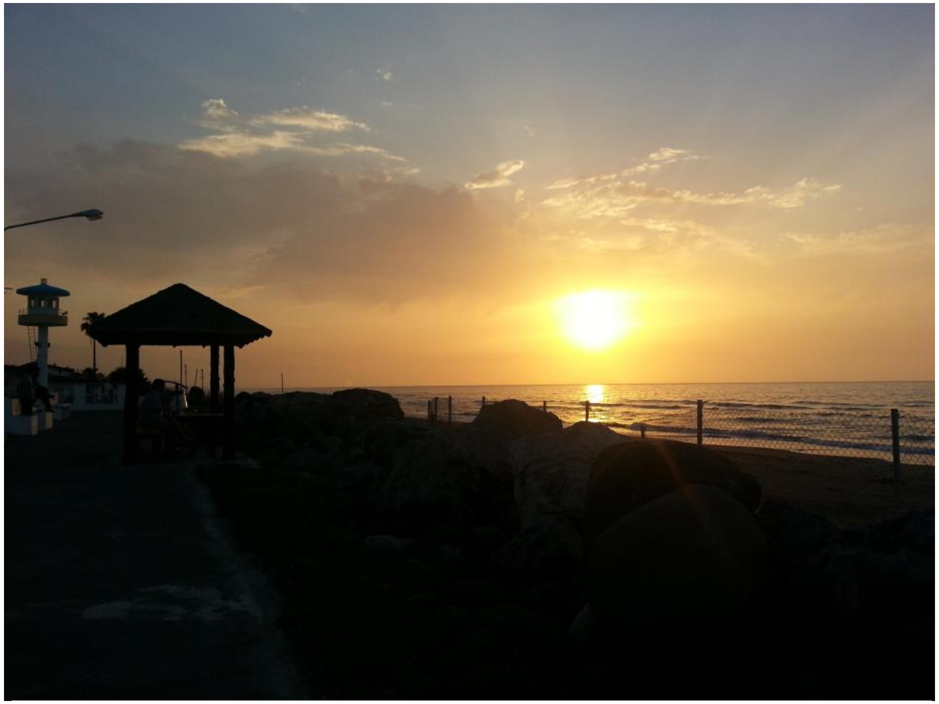


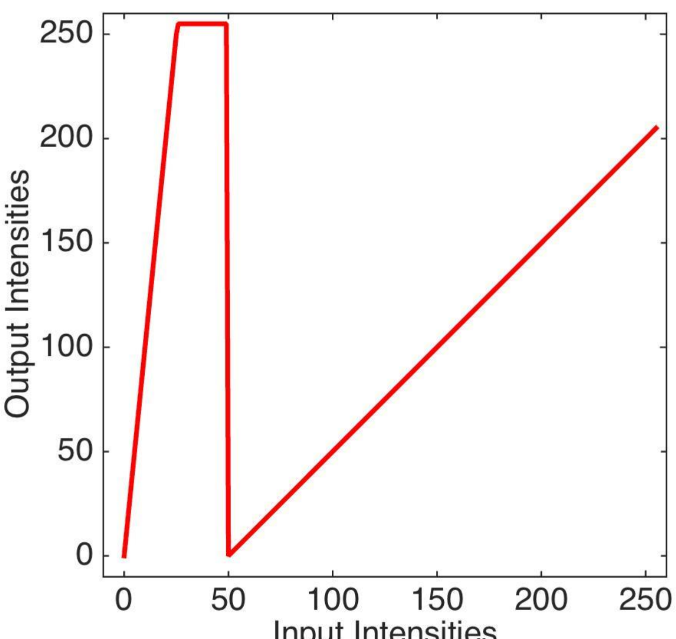


$$y = \left\lfloor \frac{x}{2} \right\rfloor$$



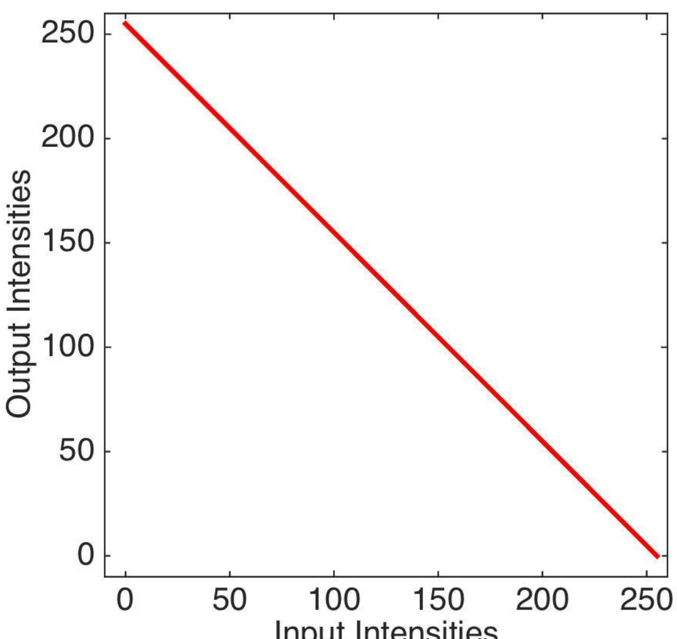
$$y = \begin{cases} 10x & x < 25 \\ x & 25 \leq x < 200 \\ x - 100 & 200 < x \end{cases}$$

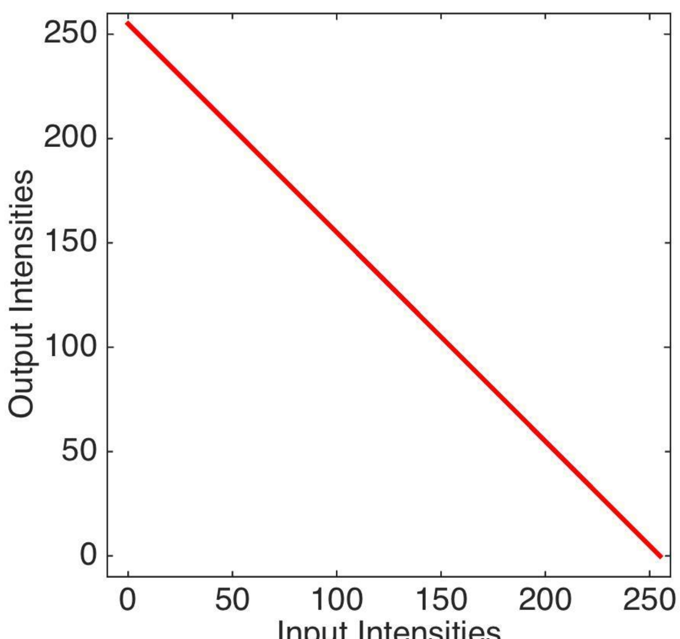




$$\bar{x} = \frac{x_R + x_G + x_B}{3}$$

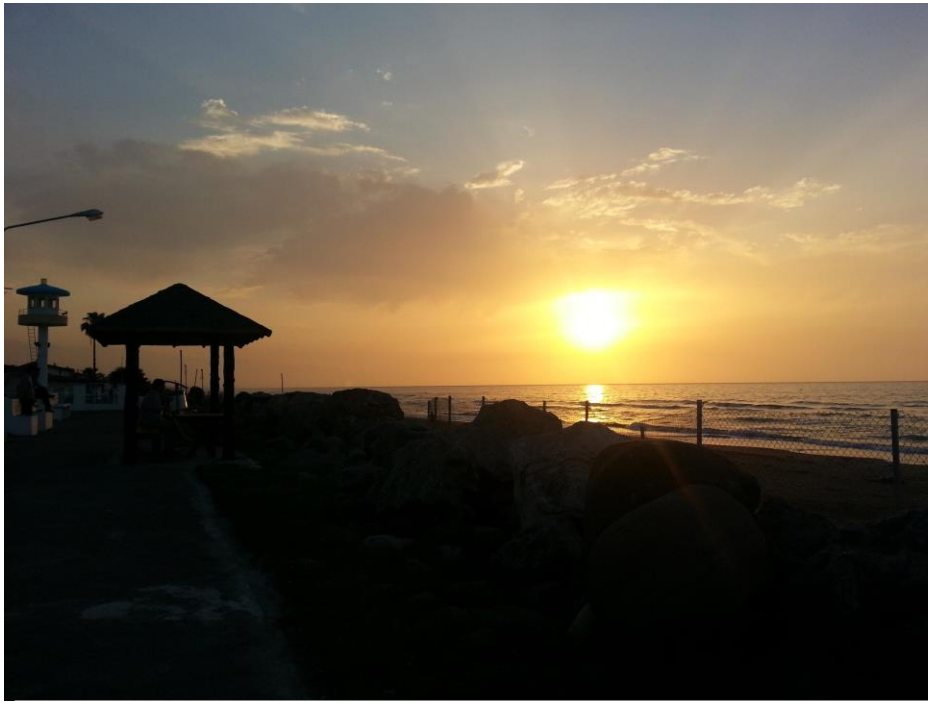
$$y = \begin{cases} 10x & \bar{x} \leq 25 \\ 255 & 26 < \bar{x} < 50 \\ x - 50 & 50 \leq \bar{x} \end{cases}$$

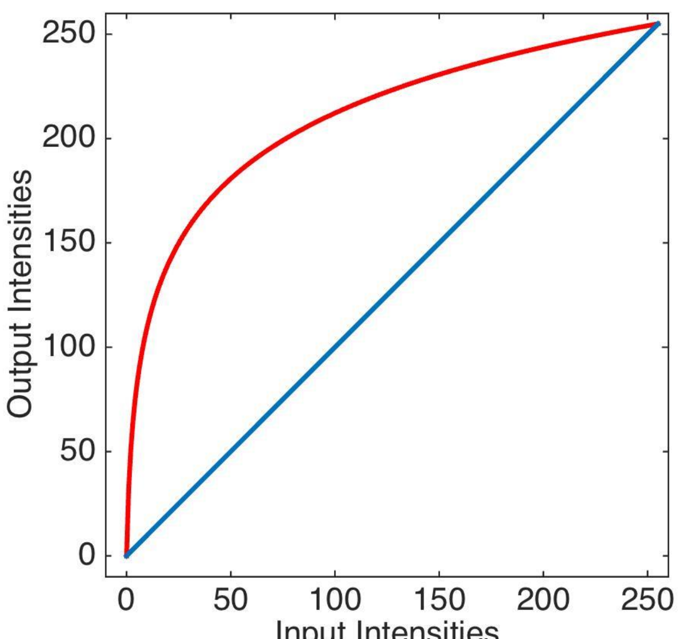

Output Intensities
Input Intensities
0
50
100
150
200
250



Negative Transformation

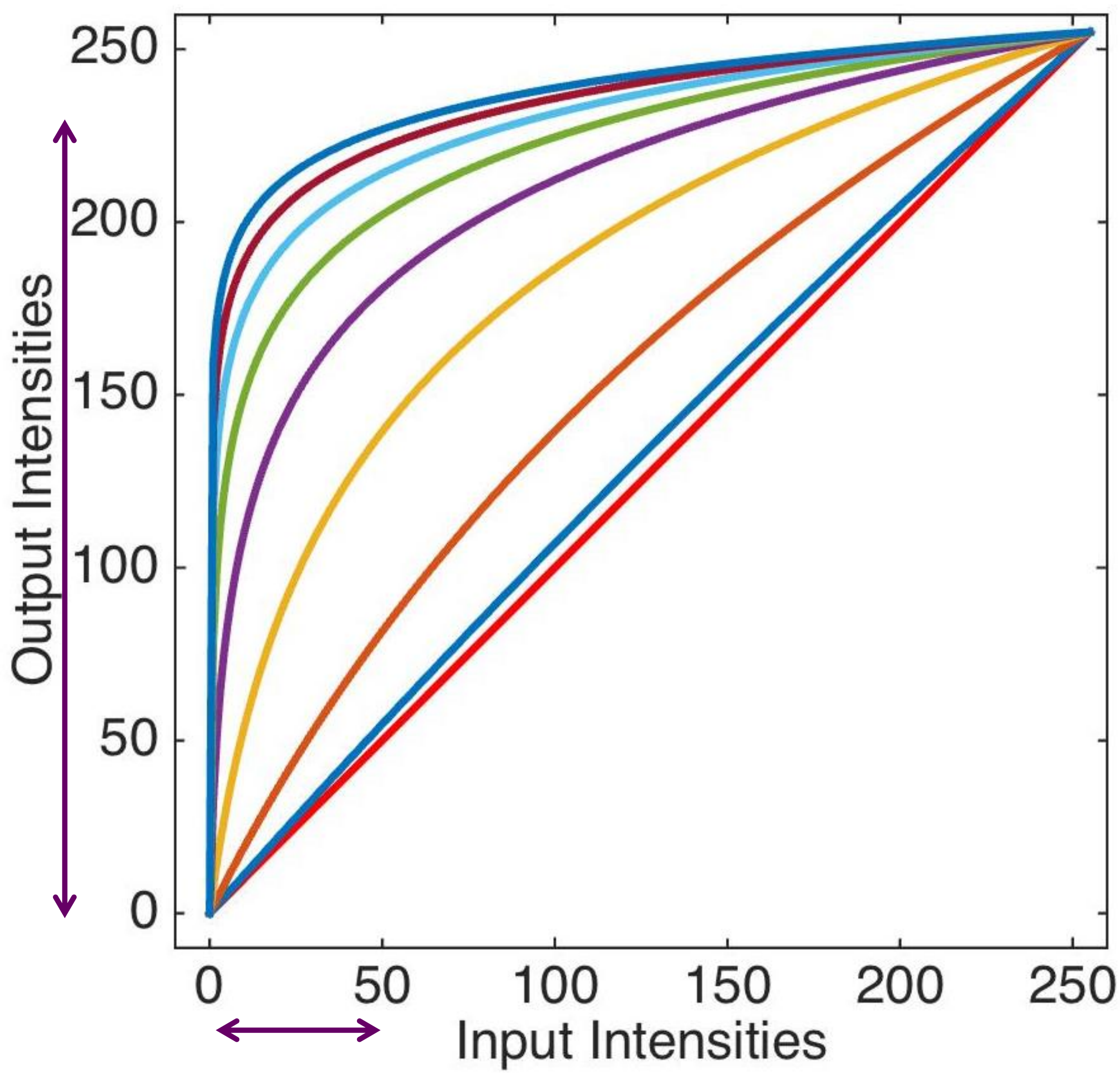
$$y = 255 - x$$





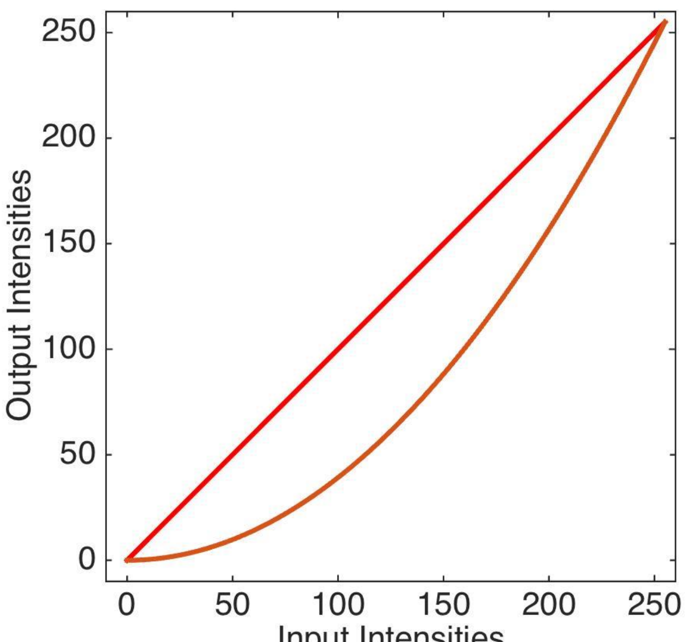
Log Transformation

$$y = \frac{255}{\log(256)} \log(1 + x)$$



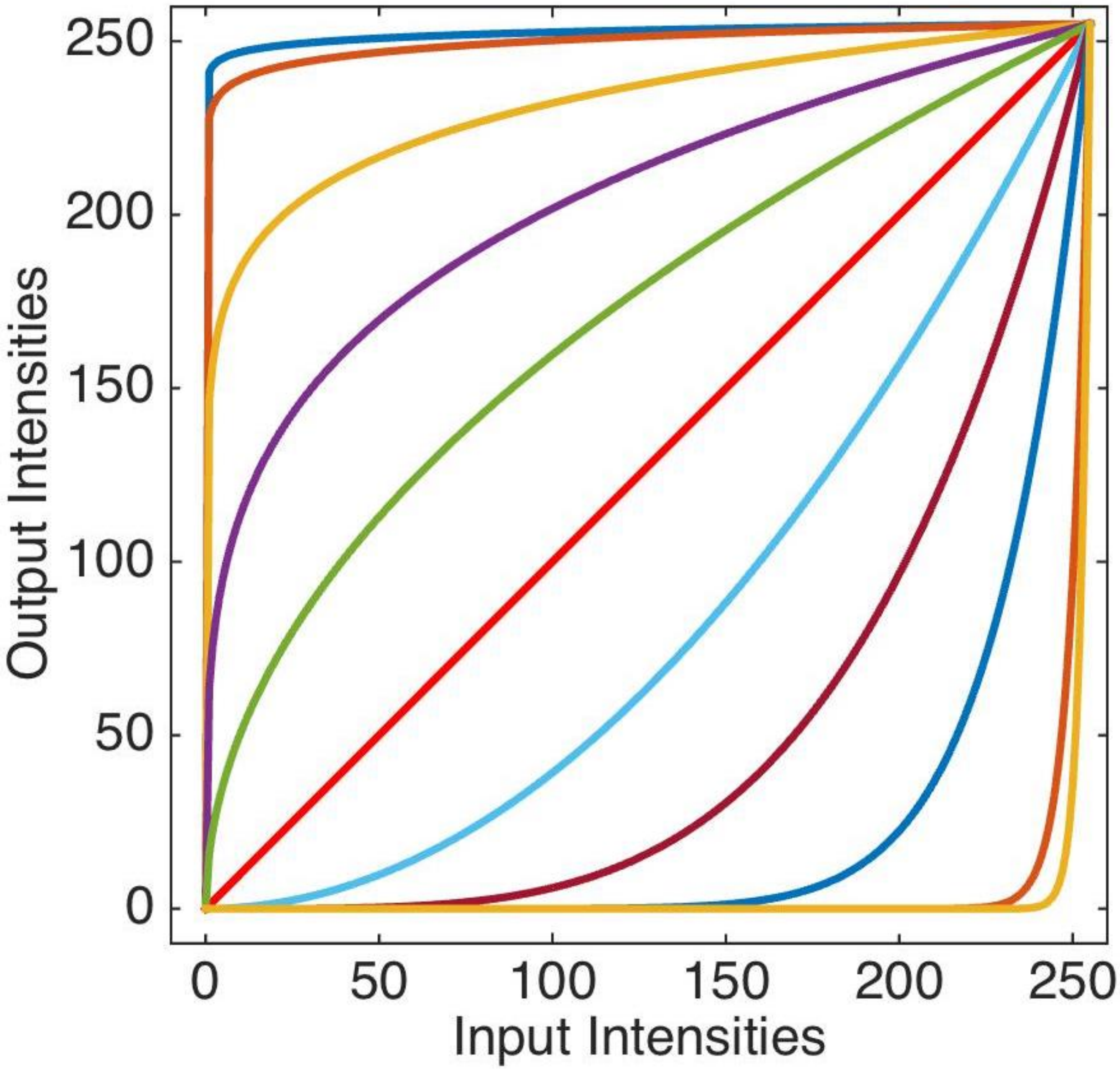
$$y = \frac{255\log(1+ax)}{\log(1+255a)}$$

a= 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000



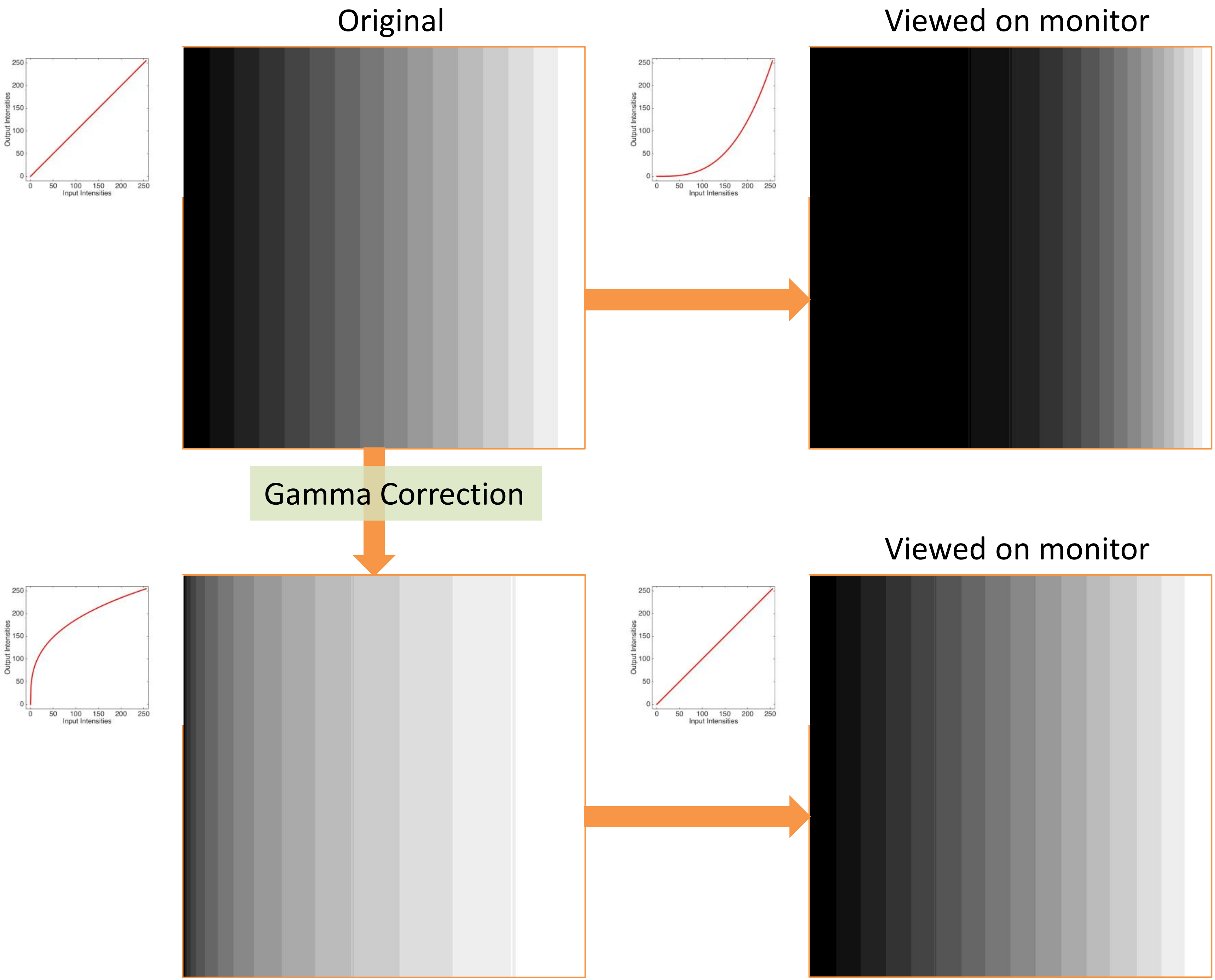
Power-Law Transformation

$$y = 255\left(\frac{x}{255}\right)^2$$

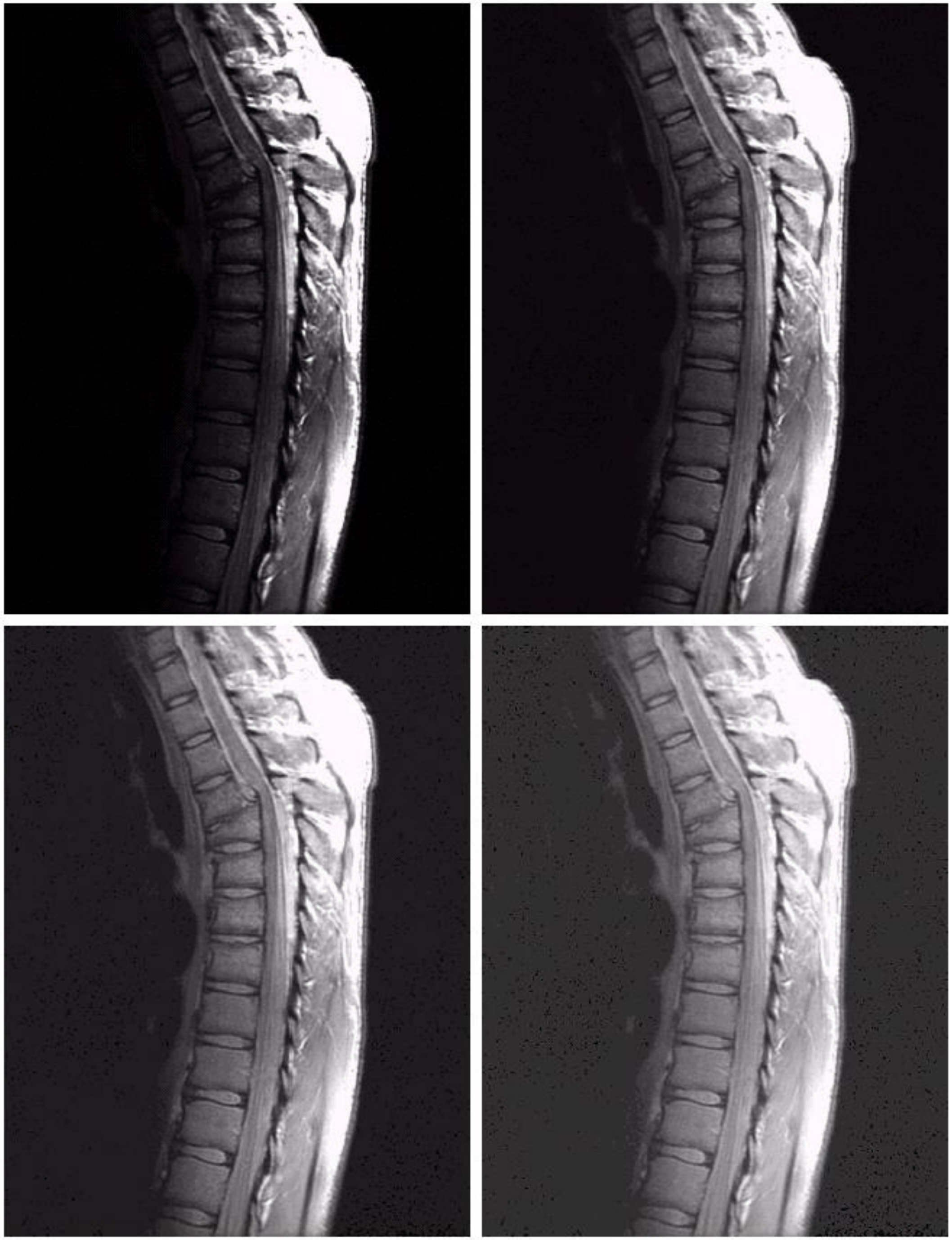


$$y = 255\left(\frac{x}{255}\right)^{\gamma}$$

$$g = \frac{1}{100}, \frac{1}{50}, \frac{1}{10}, \frac{1}{4}, \frac{1}{2}, 2, 4, 10, 50, 100$$



Original
Viewed on monitor
Gamma Correction
Viewed on monitor
Output Intensities
Input Intensities
0
50
100
150
200
250



a b
c d

FIGURE 3.8 (a) Magnetic resonance (MR) image of a fractured human spine. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 0.6, 0.4$, and 0.3, respectively. (Original image for this example courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

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.)

References

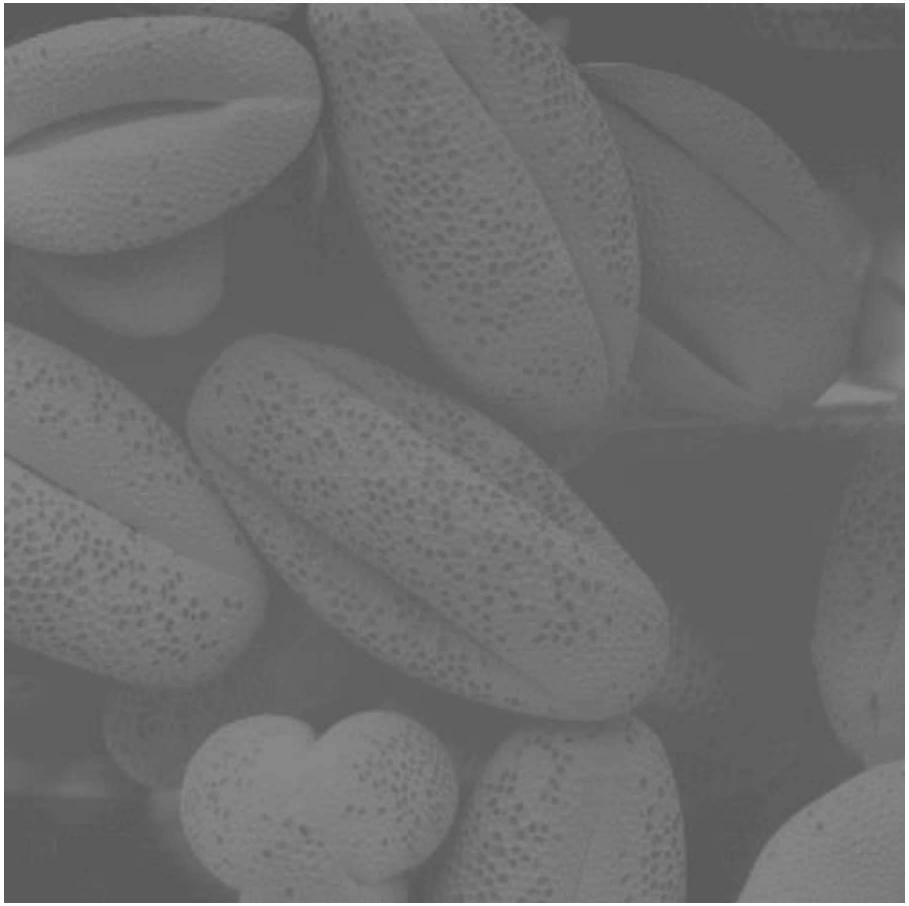
- Gonzalez
  Section 4.1 and 4.2

- Szeliski
  Section 2.3 and 3.1

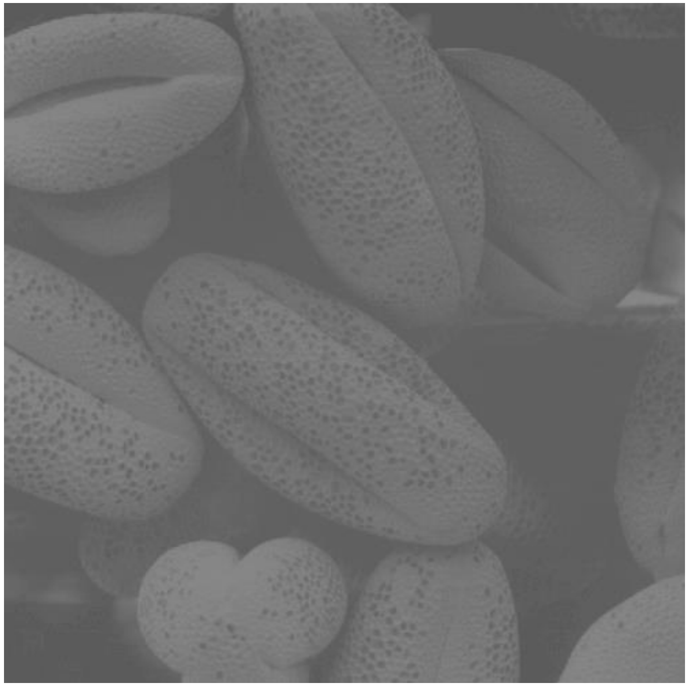
Image Enhancement (Contrast)

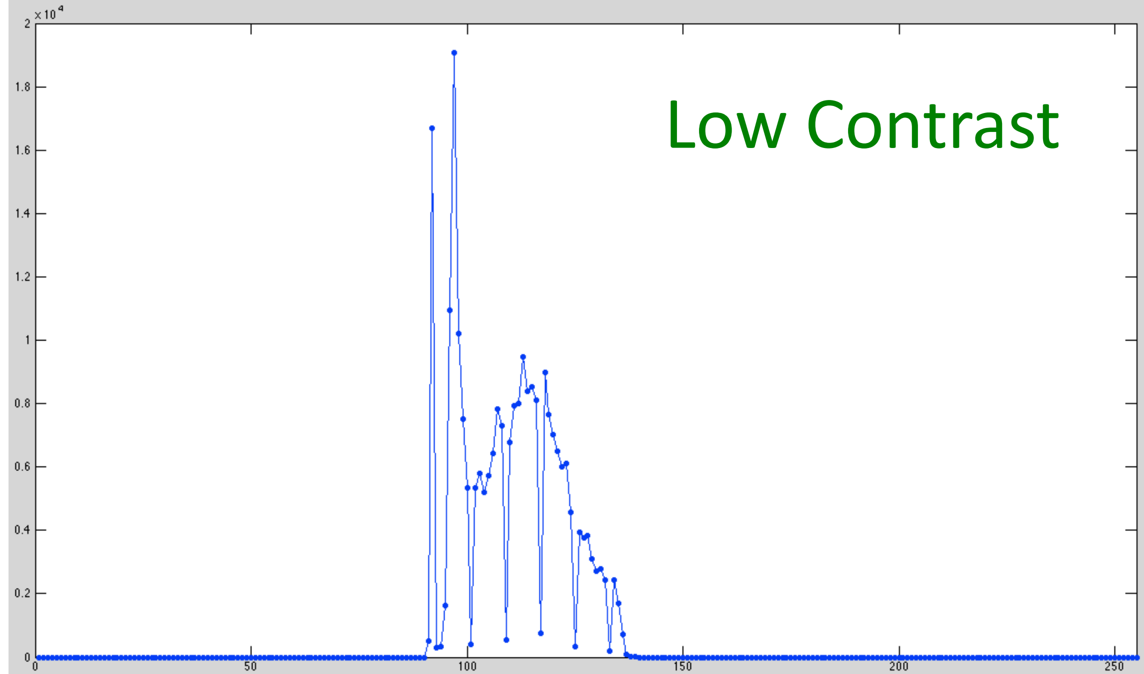
Contrast

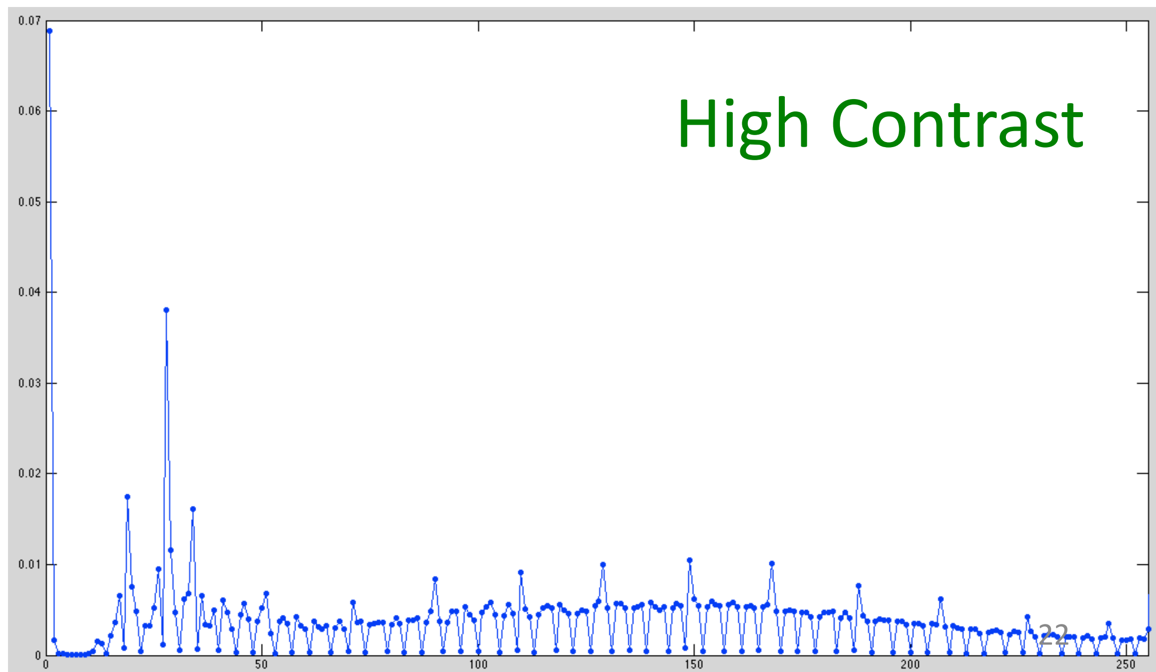
Low Contrast



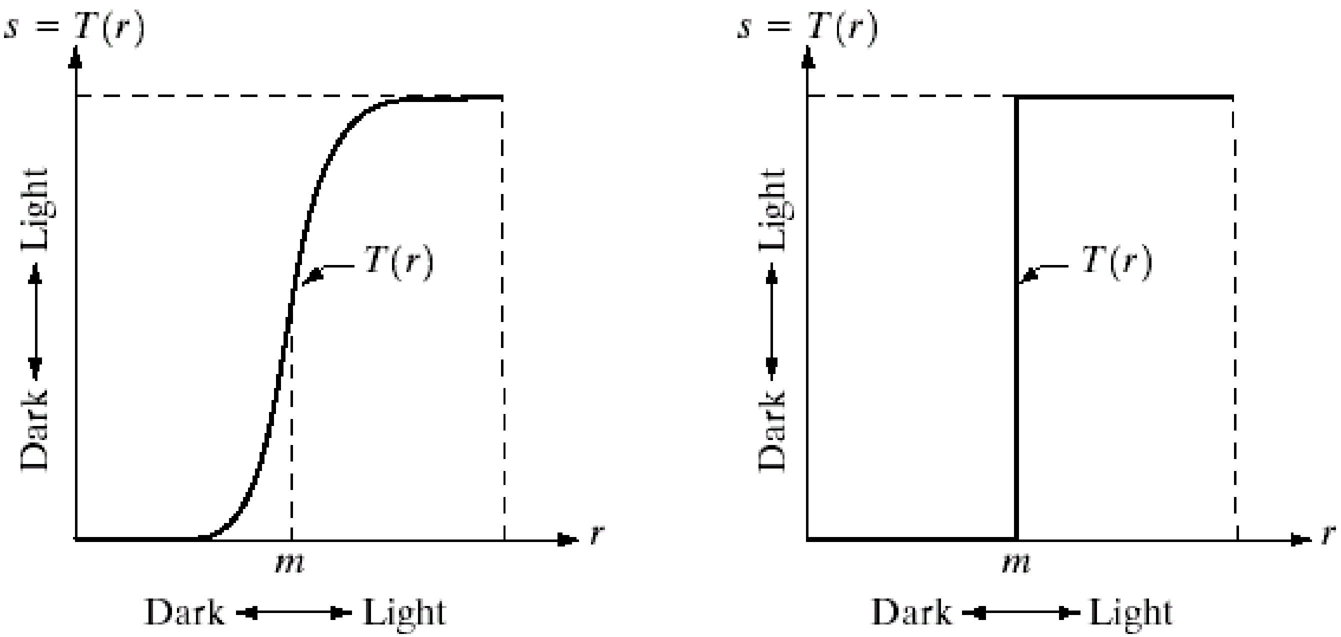
High Contrast




Low Contrast
x 10^4
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250


High Contrast
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
50
100
150
200
250

Contrast Enhancement

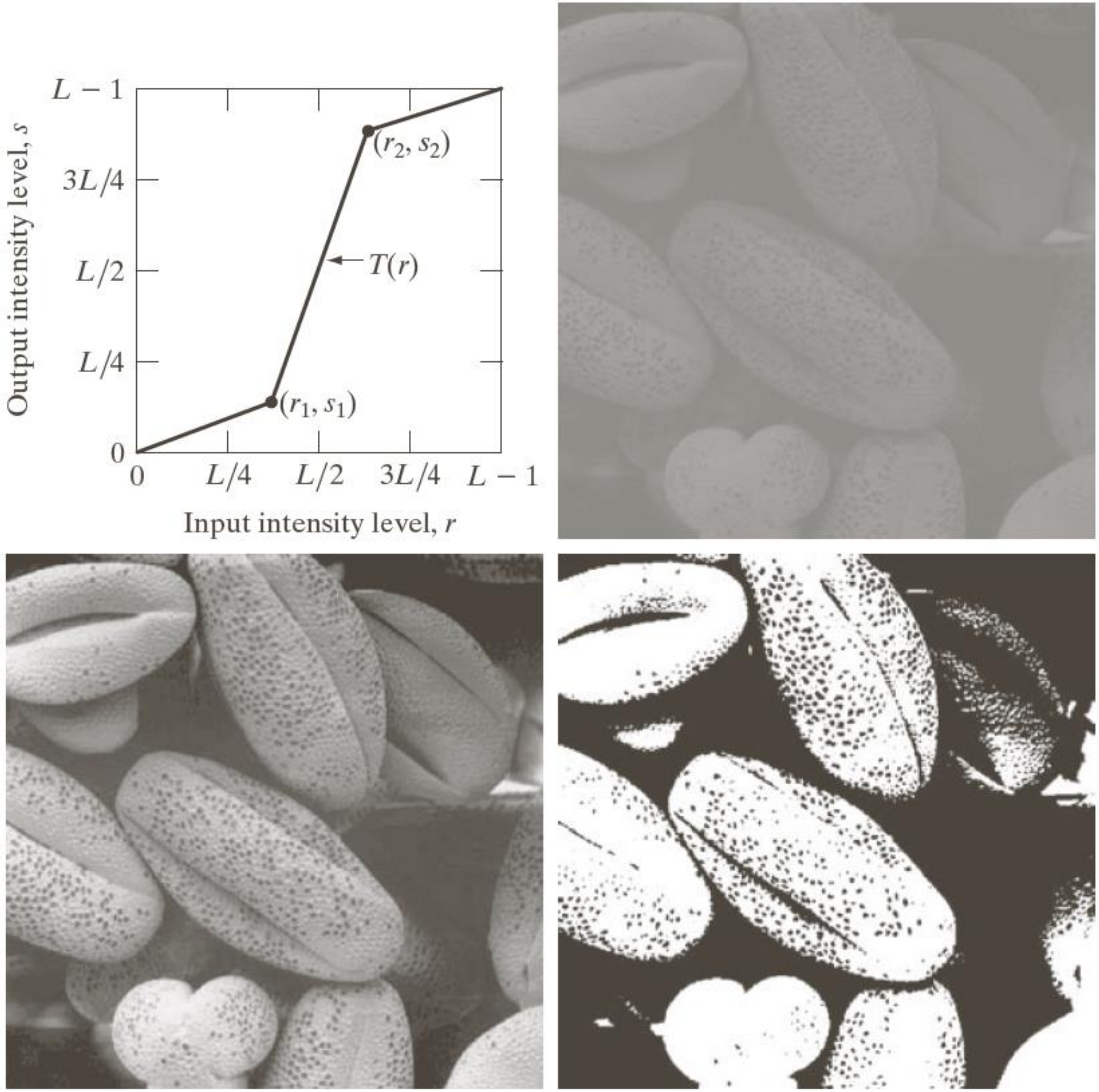


Contrast Enhancement

Threshold (Binary)

a b

FIGURE 3.2 Gray-level transformation functions for contrast enhancement.



Contrast Stretching

Contrast Stretching

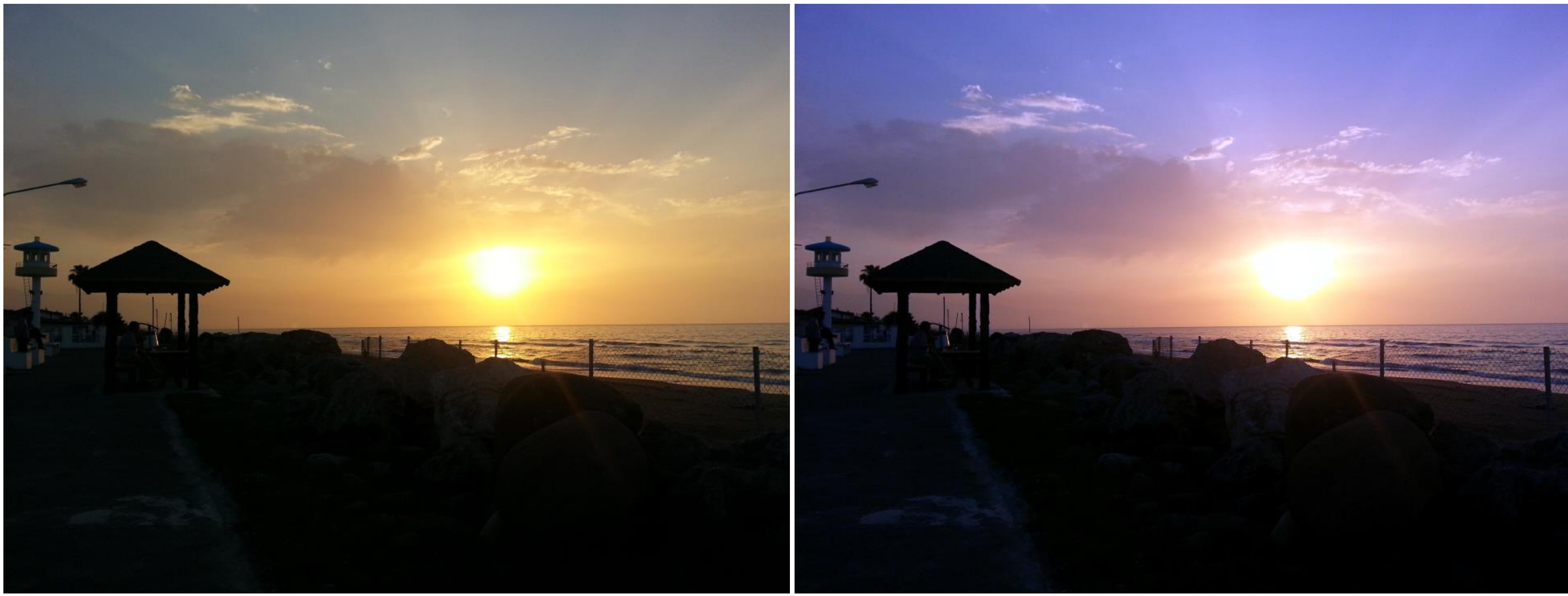
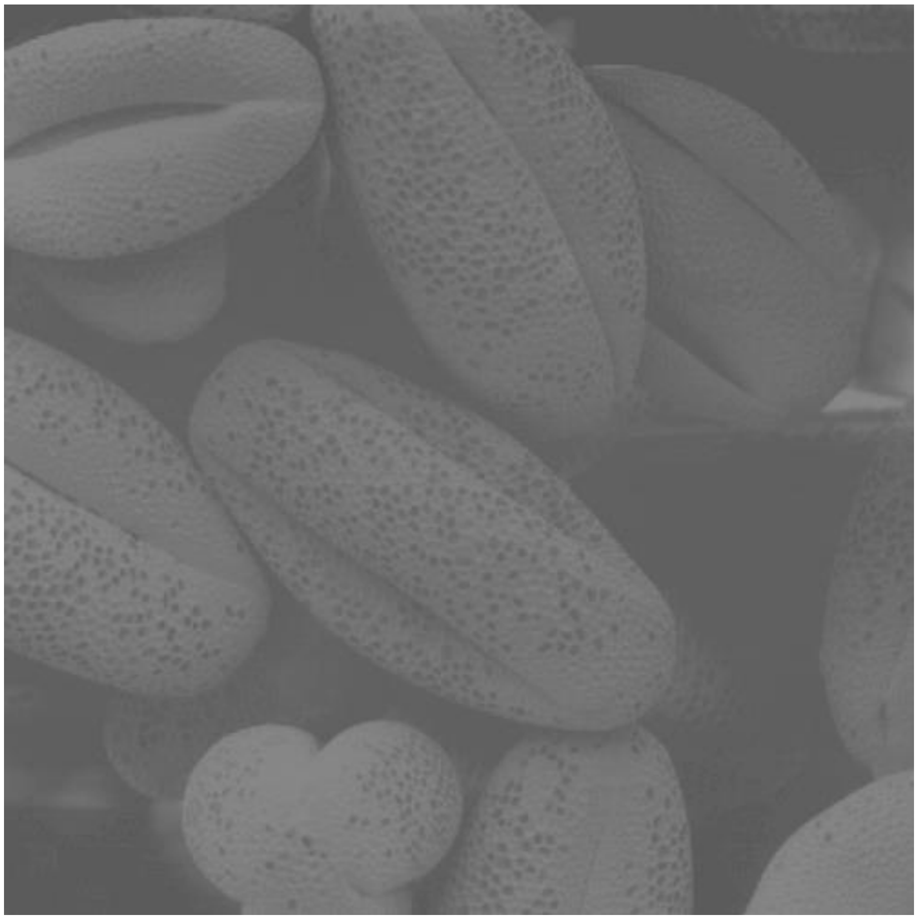
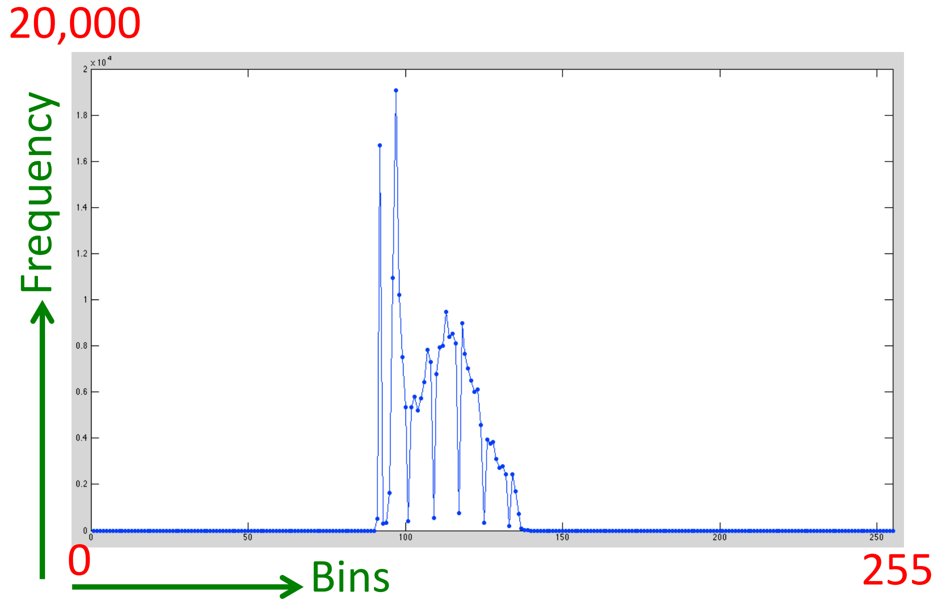
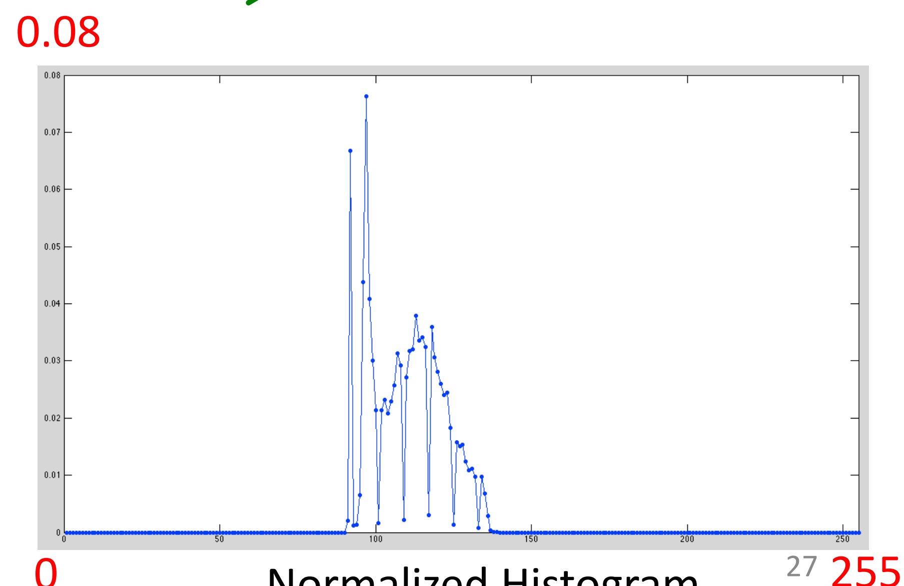


Image Enhancement (Histogram Processing)

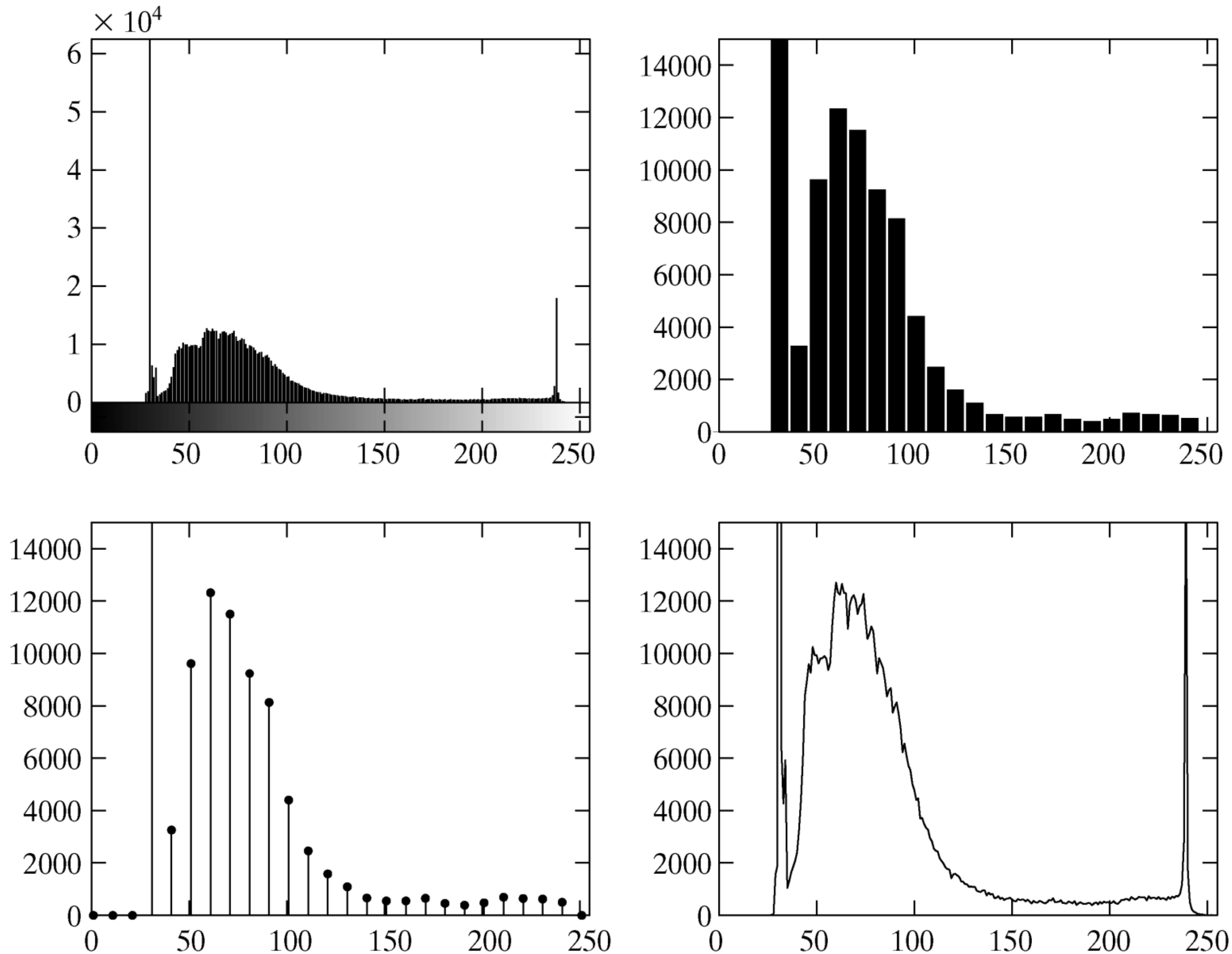
Histogram





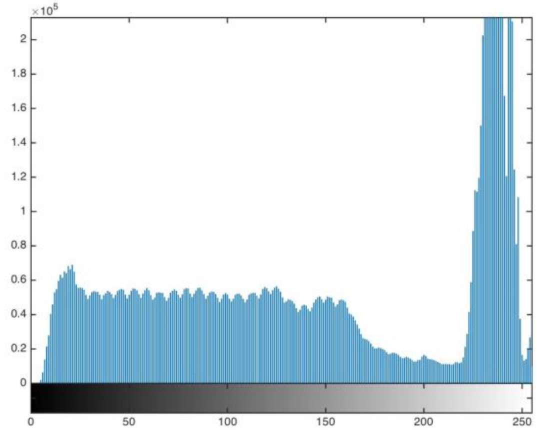


Normalized Histogram

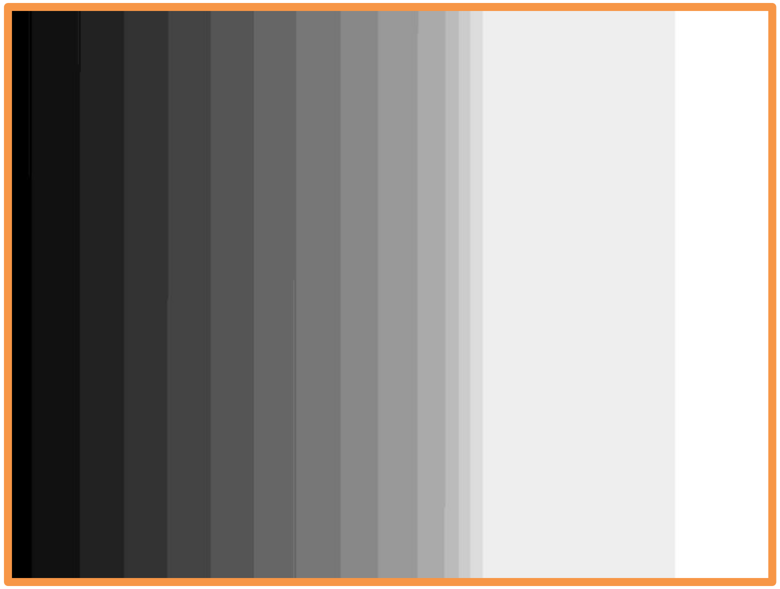


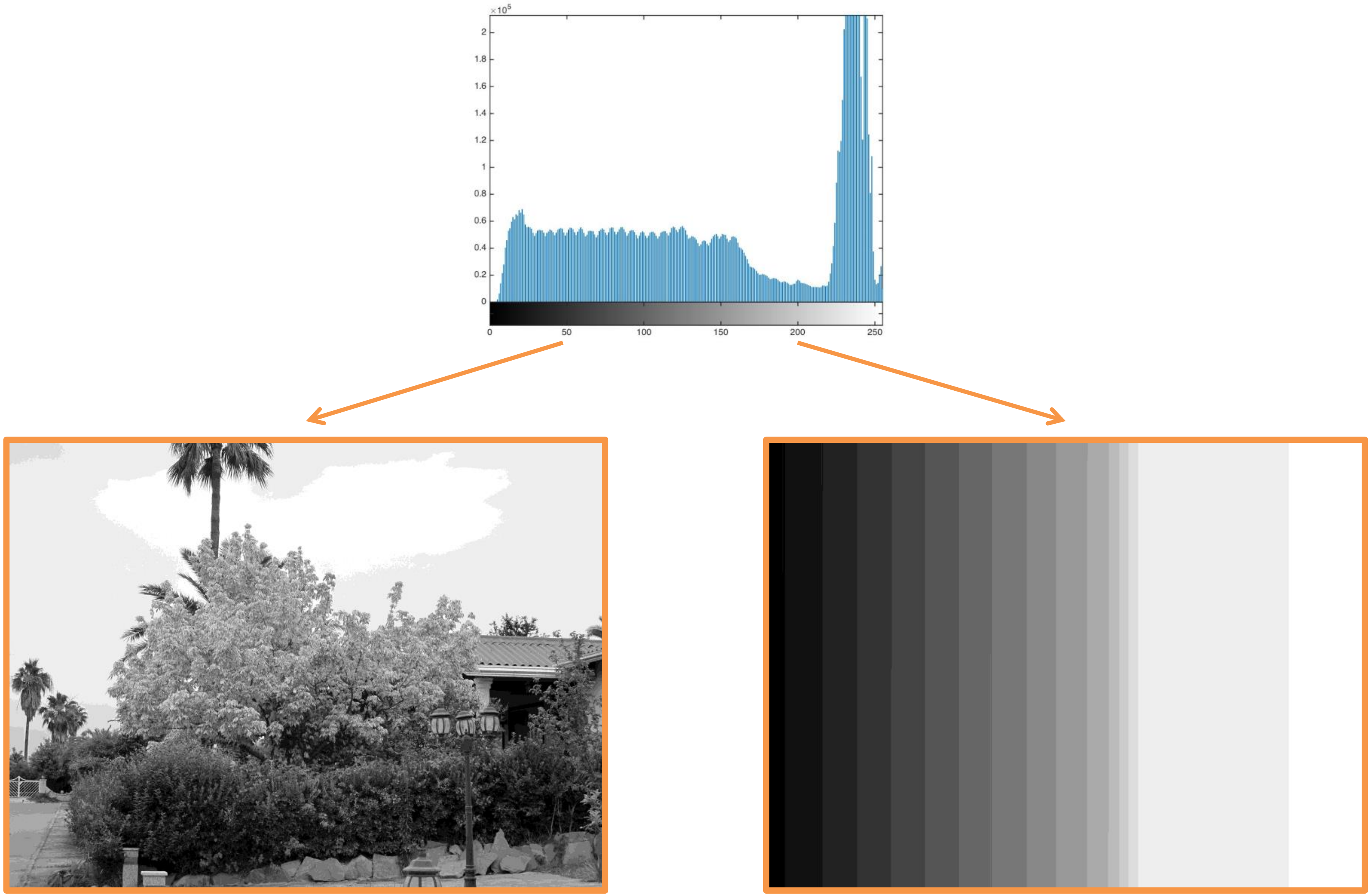
a	b
c	d

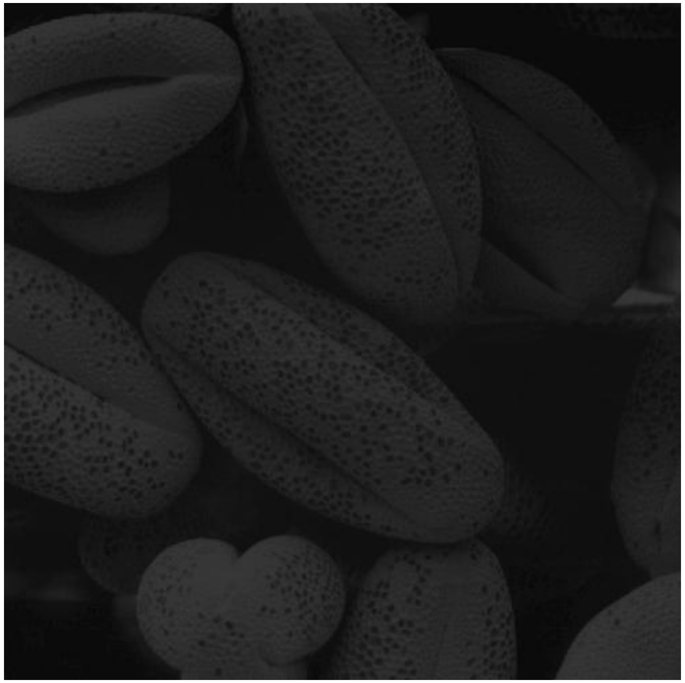
FIGURE 3.7 Various ways to plot an image histogram. (a) `imhist`, (b) `bar`, (c) `stem`, (d) `plot`.

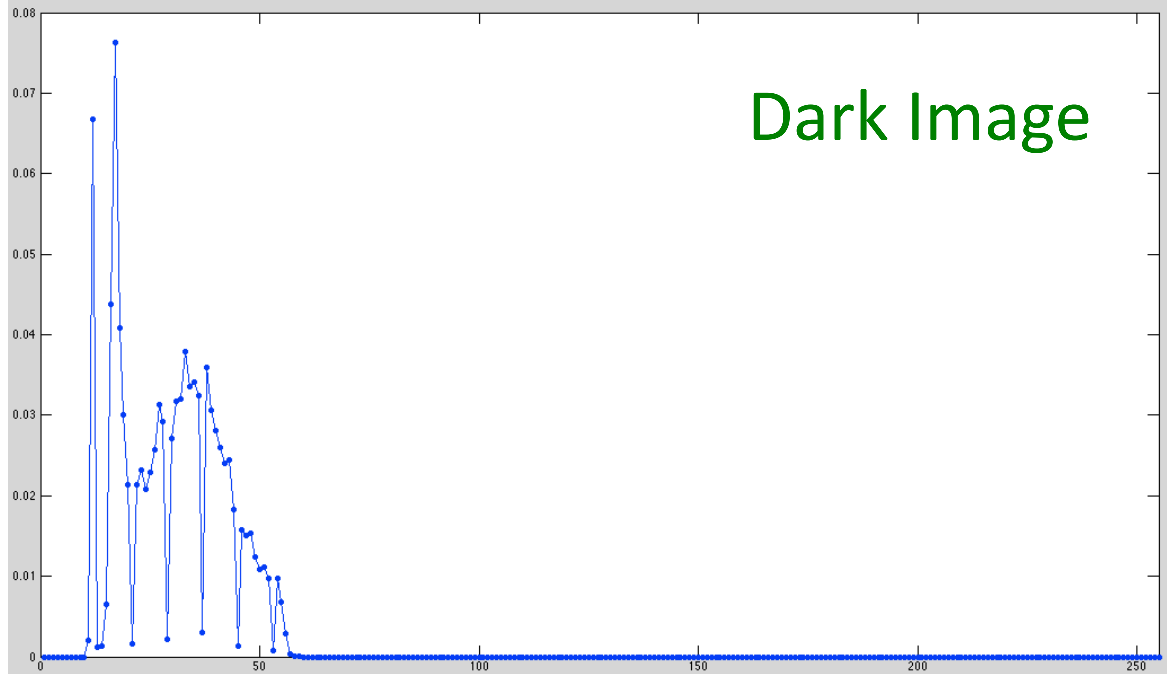


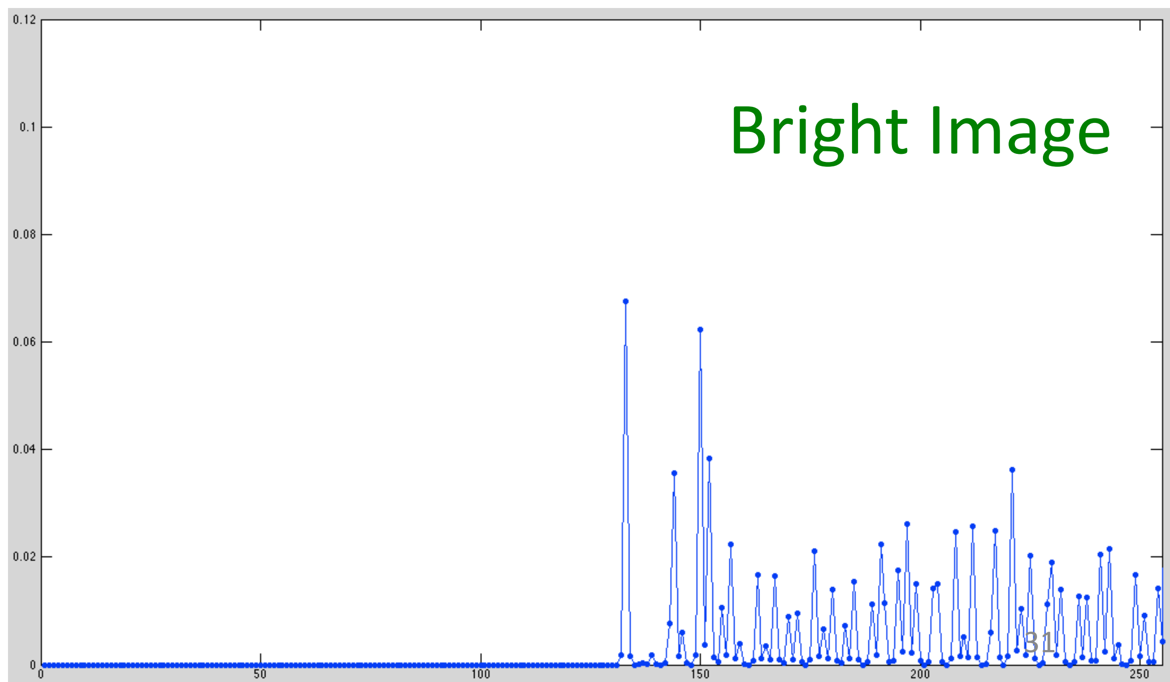
×10^5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250

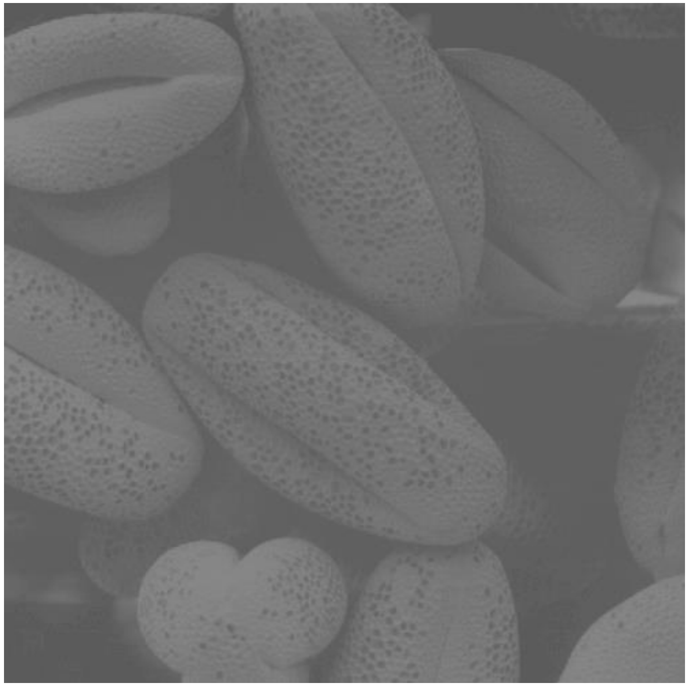


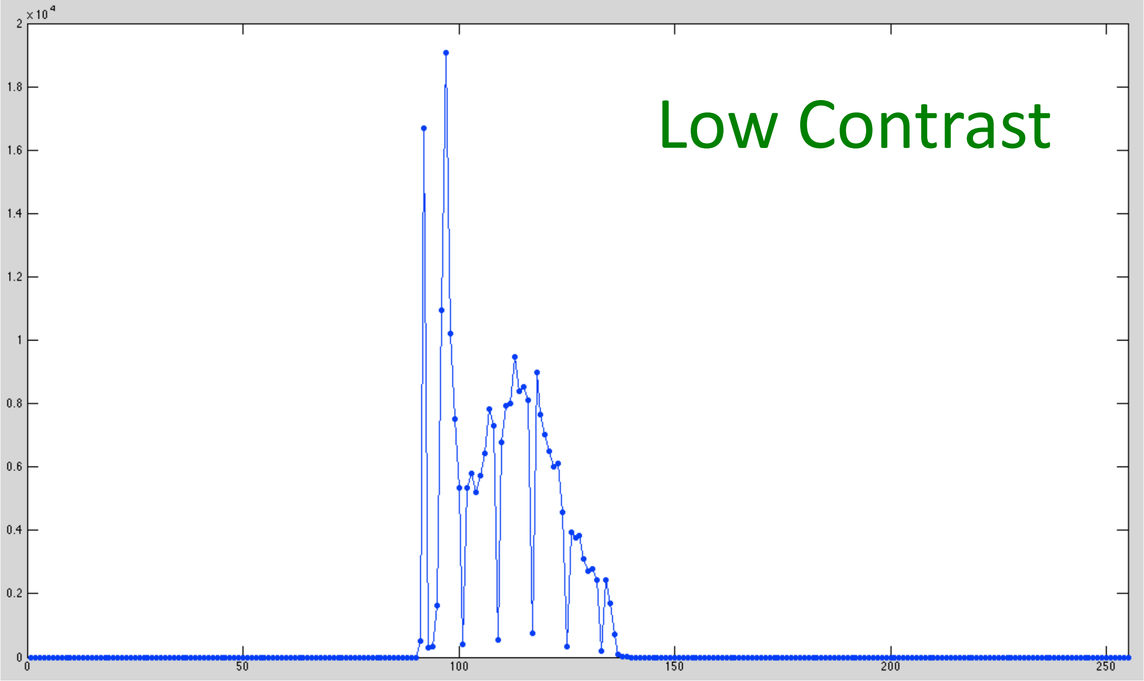

×10^5
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250



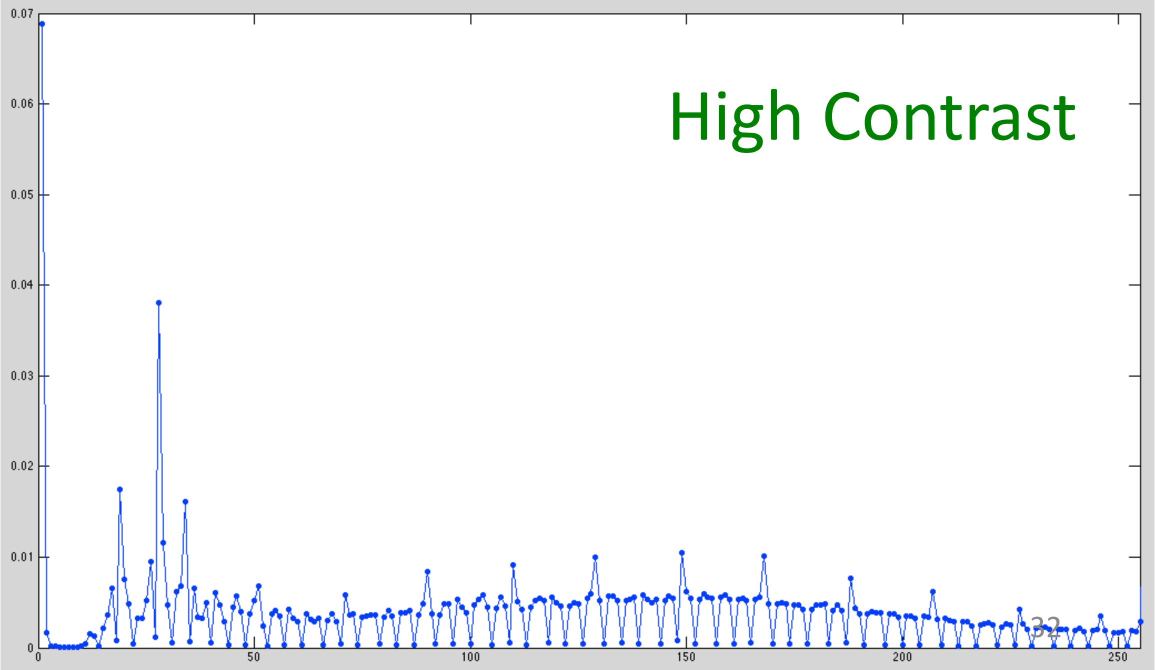

Dark Image
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
50
100
150
200
250


Bright Image
0.12
0.1
0.08
0.06
0.04
0.02
0
0
50
100
150
200
250





x 10^4
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
Low Contrast

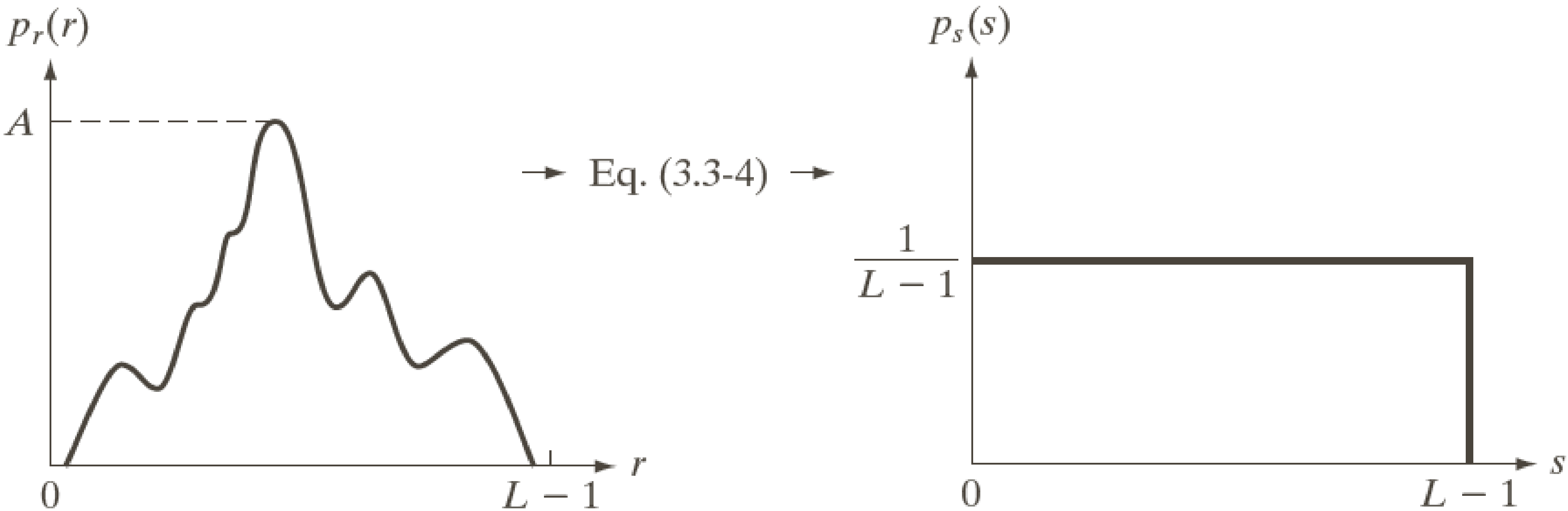


0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
50
100
150
200
250
High Contrast

Histogram Equalization

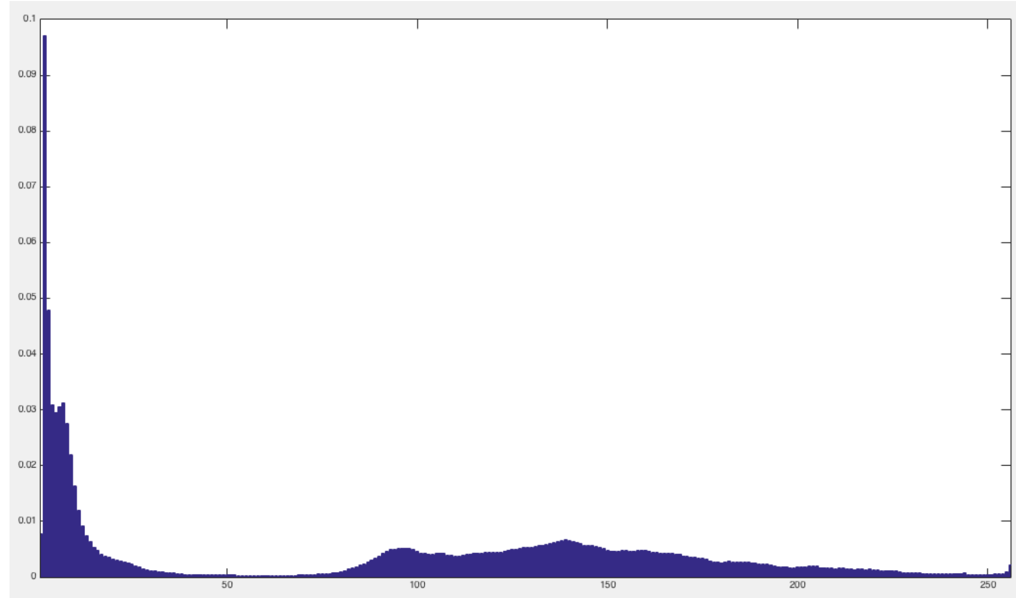
It is reasonable to say that an image whose pixels tend to occupy the entire range of possible gray levels and, in addition, tend to be distributed uniformly, will have an appearance of high contrast and will exhibit a large variety of gray tones.

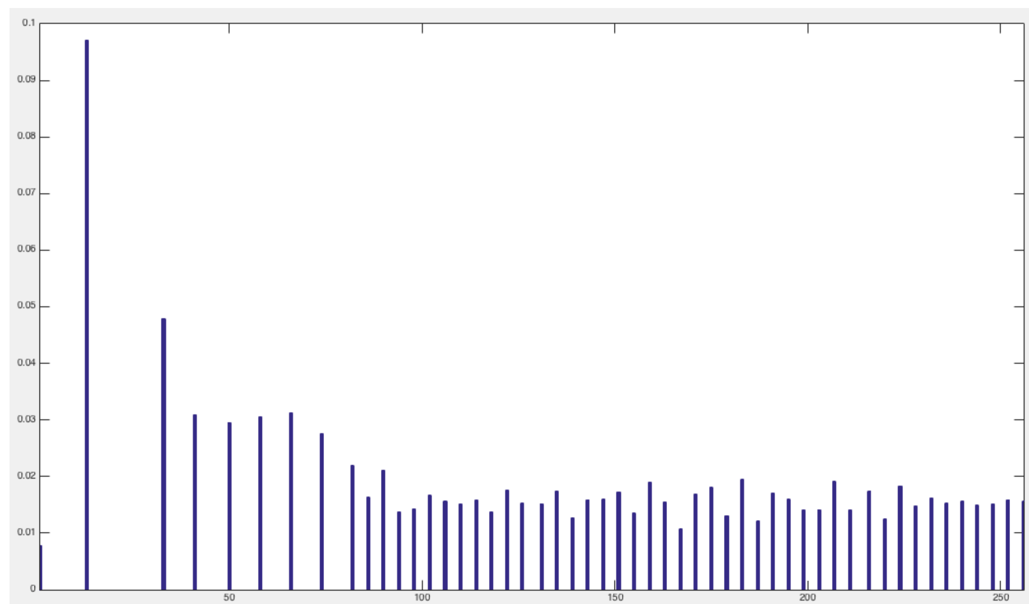
Histogram Equalization



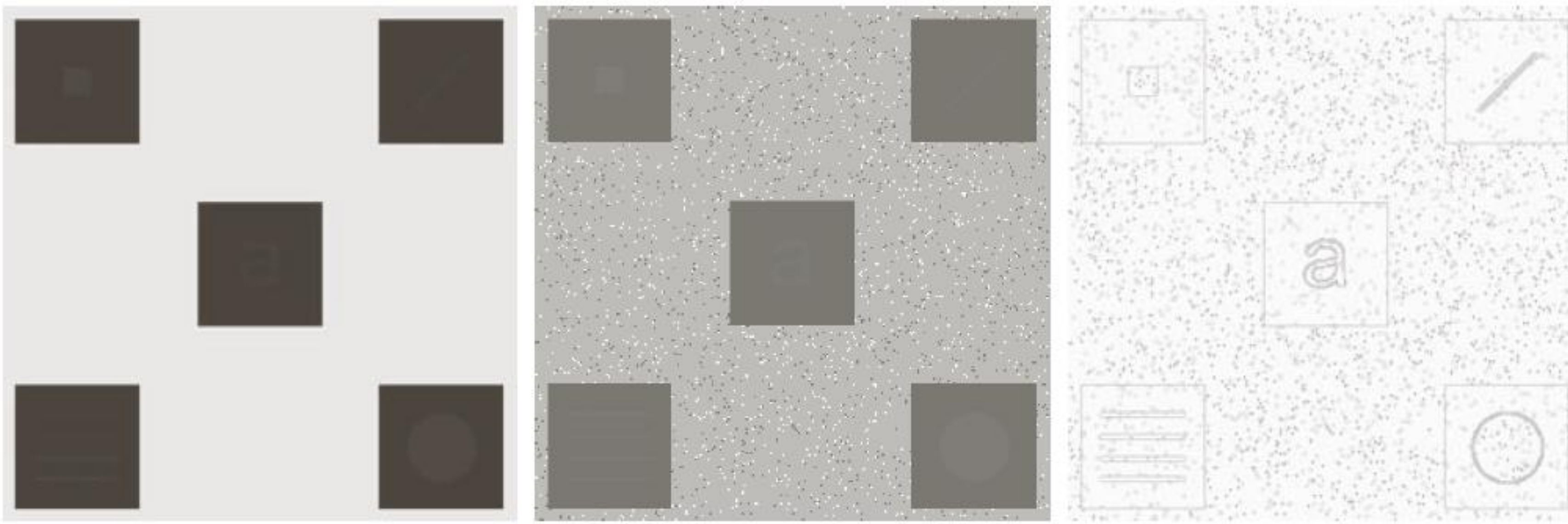
a b

FIGURE 3.18 (a) An arbitrary PDF. (b) Result of applying the transformation in Eq. (3.3-4) to all intensity levels, r. The resulting intensities, s, have a uniform PDF, independently of the form of the PDF of the r's.


0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
50
100
150
200
250


0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
50
100
150
200
250

Local Histogram Equalization

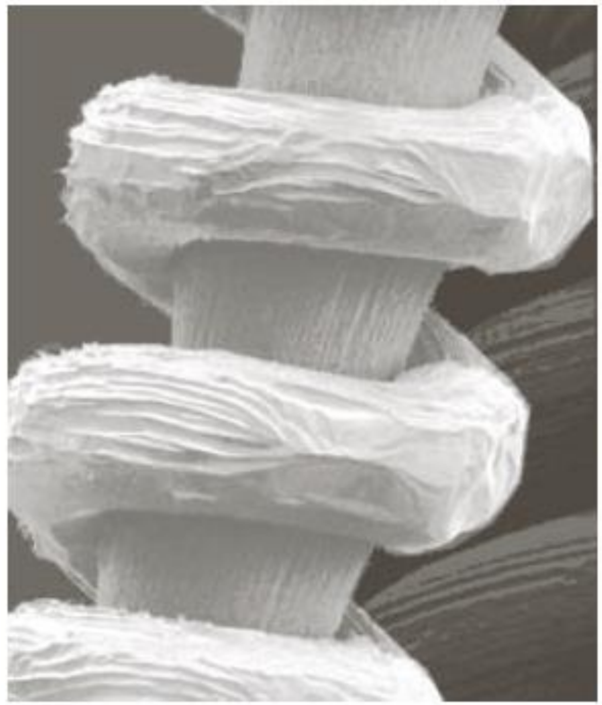


a b c

FIGURE 3.26 (a) Original image. (b) Result of global histogram equalization. (c) Result of local histogram equalization applied to (a), using a neighborhood of size 3×3.

Local Histogram Equalization

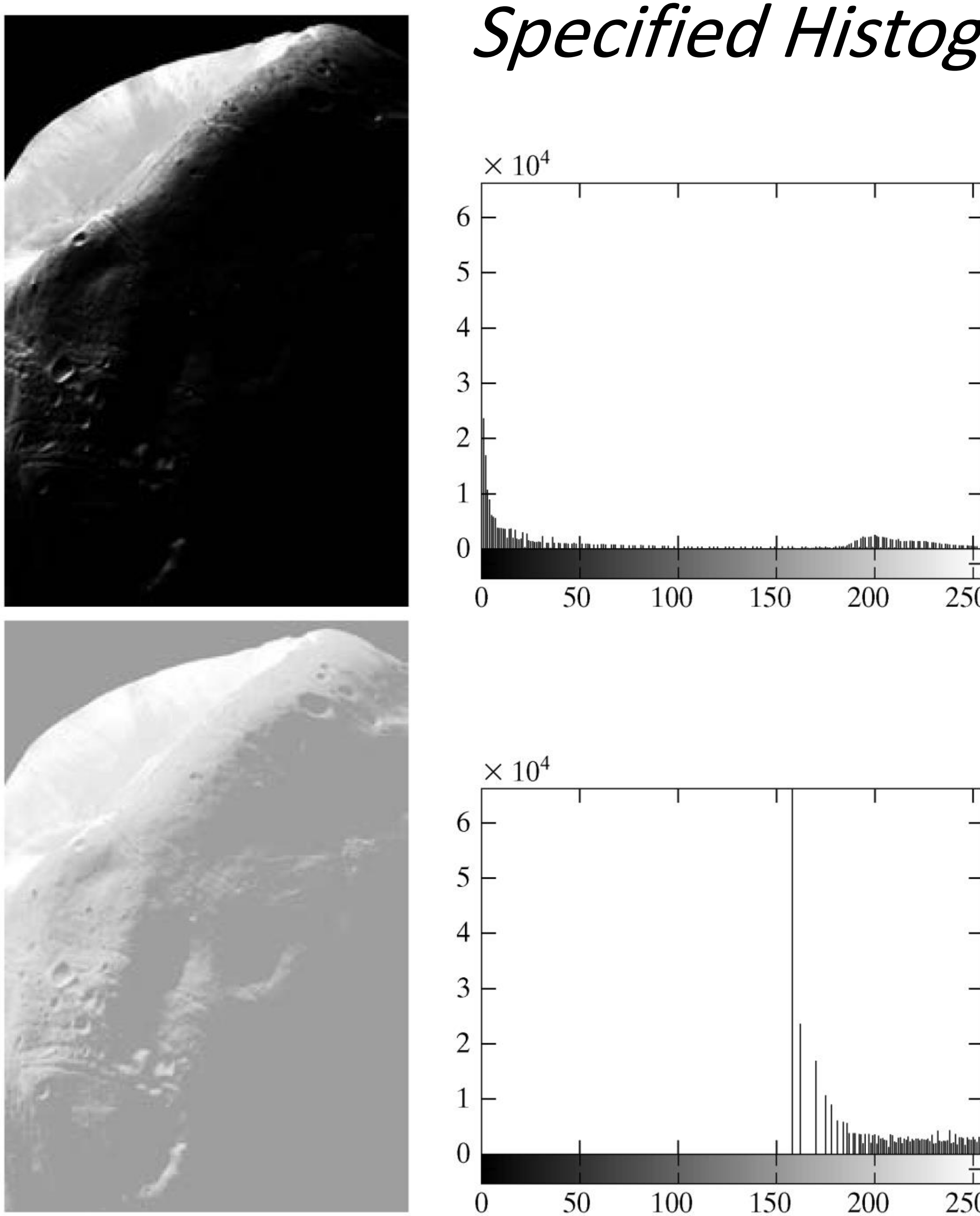
Original



Global Histogram Equalization

Local Histogram Equalization

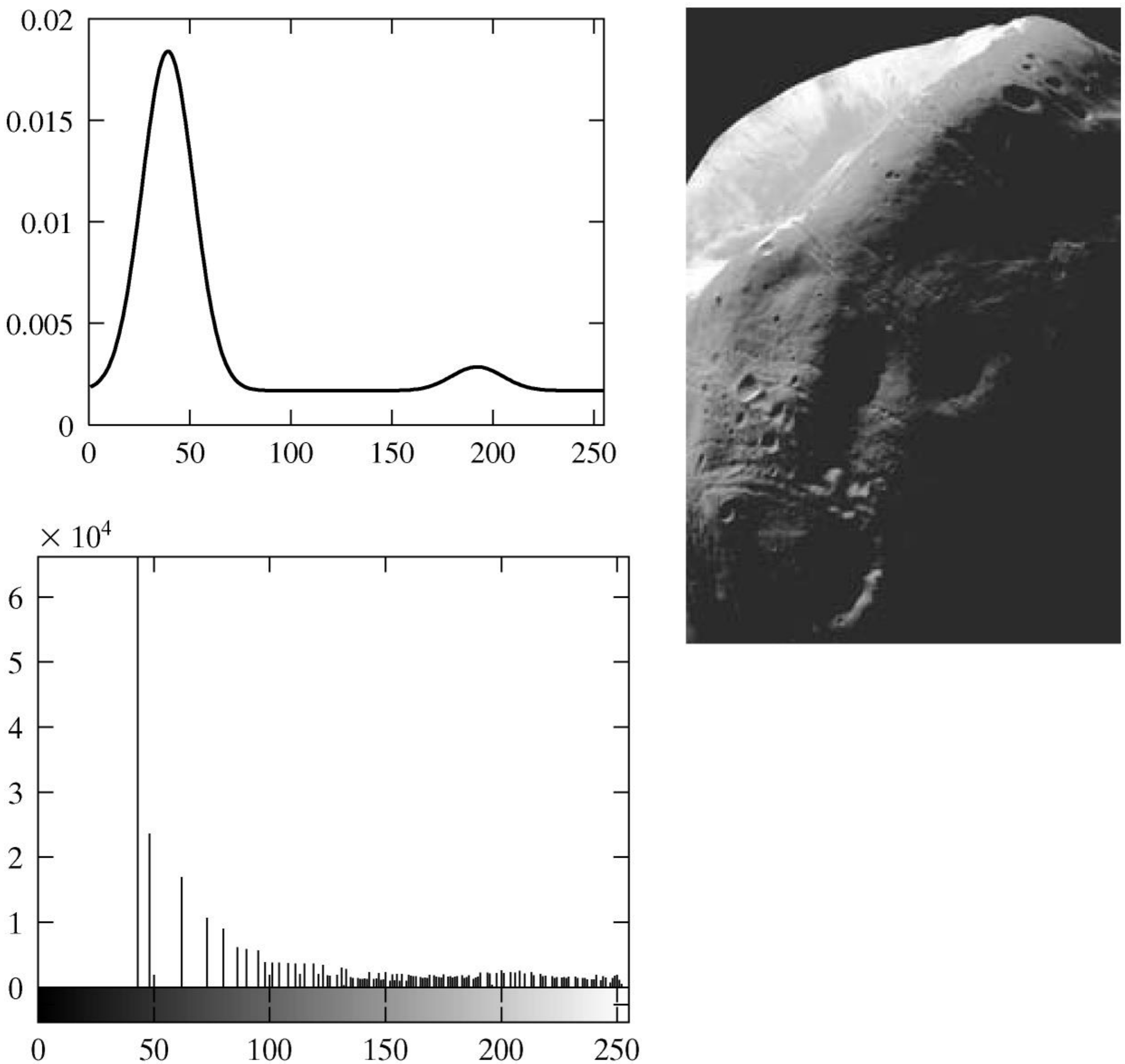
Specified Histograms



a	b
c	d

FIGURE 3.10 (a) Image of the Mars moon Phobos. (b) Histogram. (c) Histogram-equalized image. (d) Histogram of (c). (Original image courtesy of NASA).

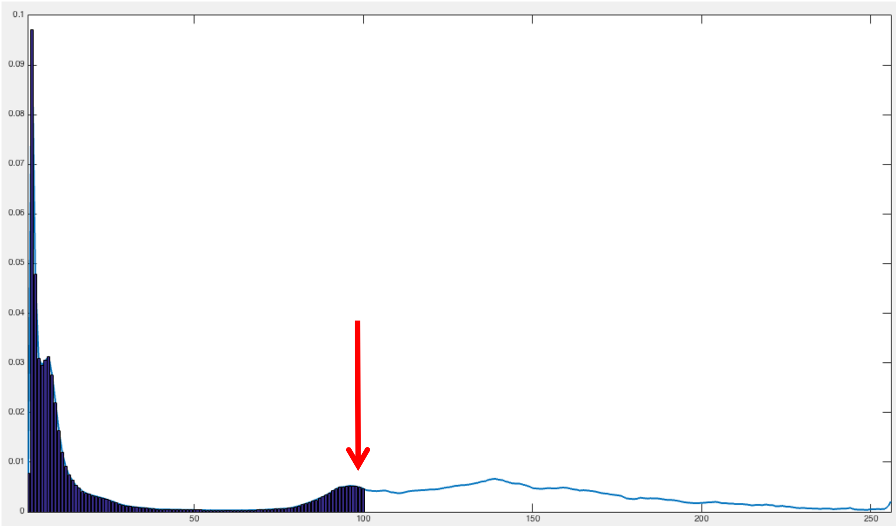
Specified Histograms



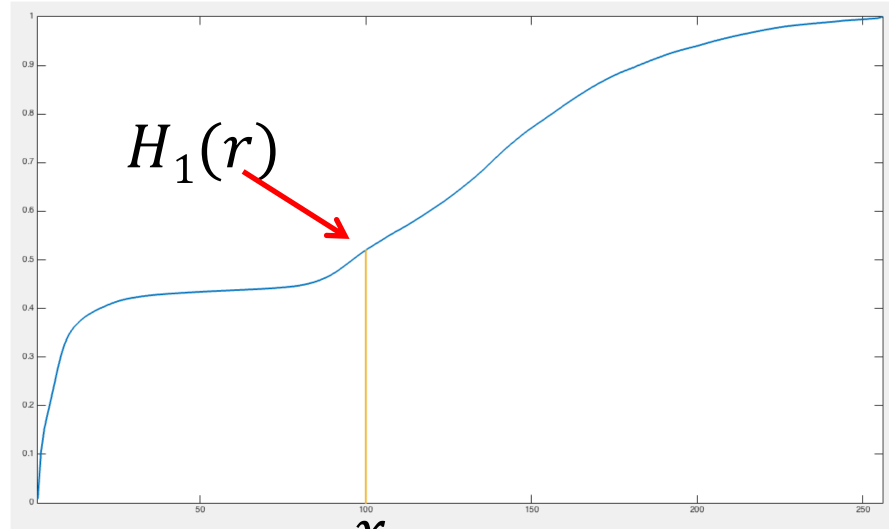
a b
c

FIGURE 3.11
(a) Specified histogram.
(b) Result of enhancement by histogram matching.
(c) Histogram of (b).

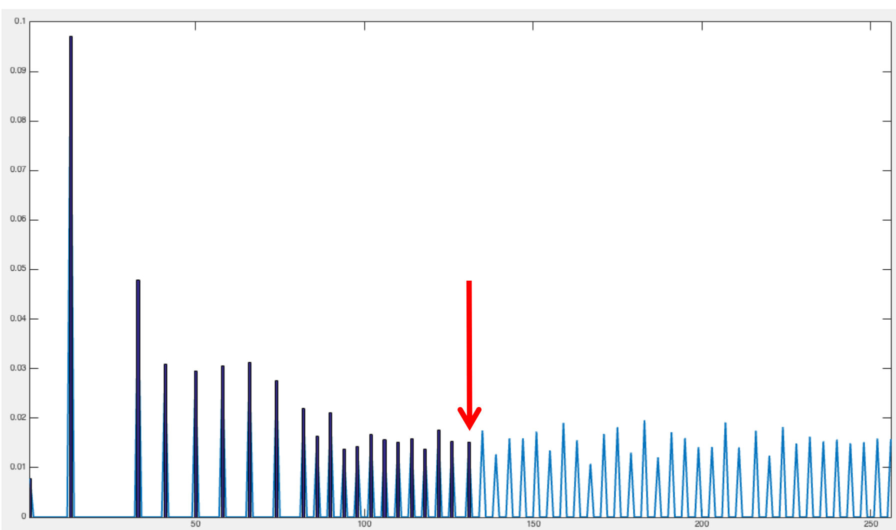
Original Histogram



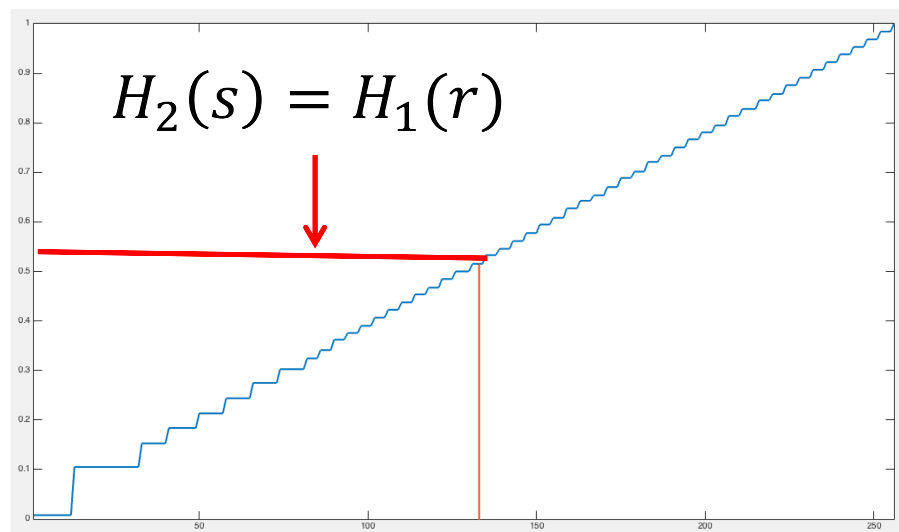
Cumulative Function



Target Histogram

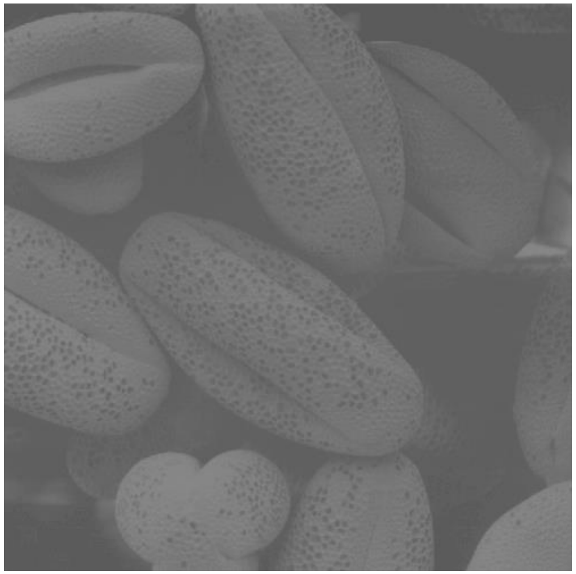


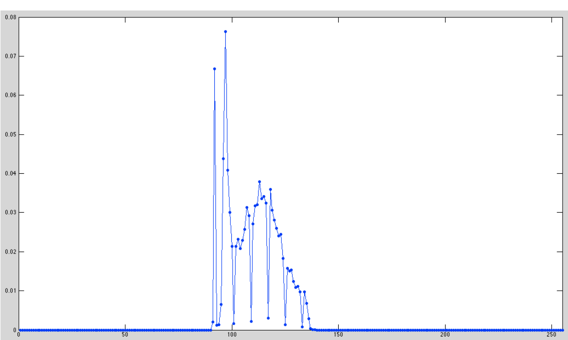
Cumulative Function

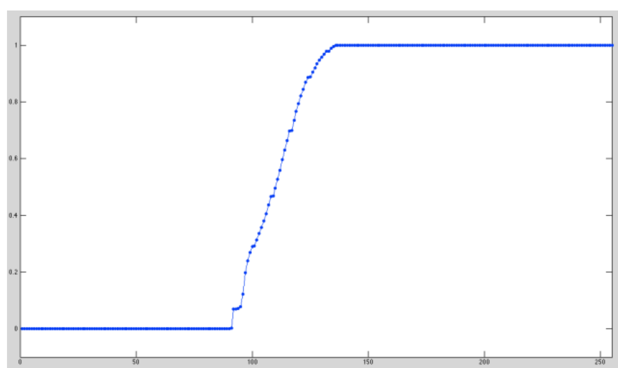


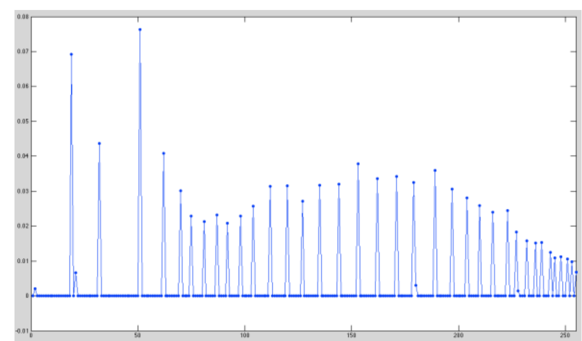
$$s = H_2^{-1}(H_1\,(r))$$

Histogram Equalization









Cumulative Distribution Function
OpenCV Function: *equalizeHist*

References

- Gonzalez
  Section 3.3, Histogram Processing

- Szeliski
  Section 3.1, Point Operators