Image & Video Processing

Image Enhancement

(Histogram Processing)

Contents

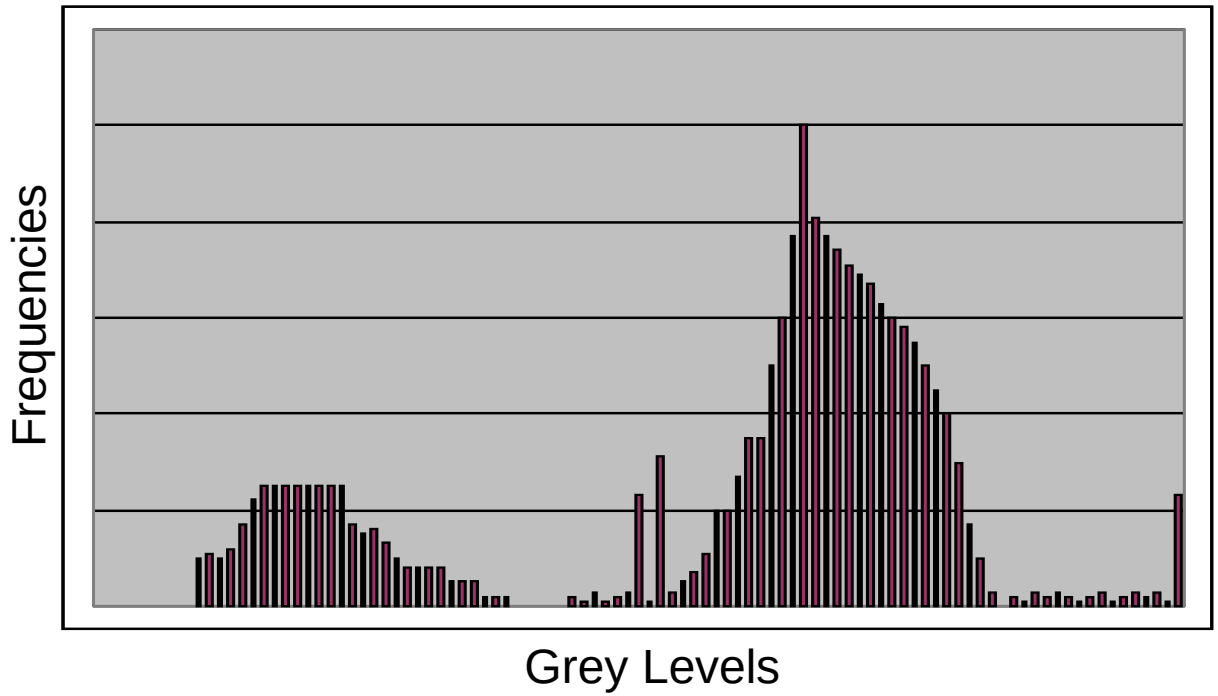
we are looking at image enhancement techniques working in the spatial domain:

- What is image enhancement?
- Different kinds of image enhancement
- Point processing
- **Histogram processing**
- Neighbourhood operations

Image Histograms

The histogram of an image shows us the distribution of grey levels in the image

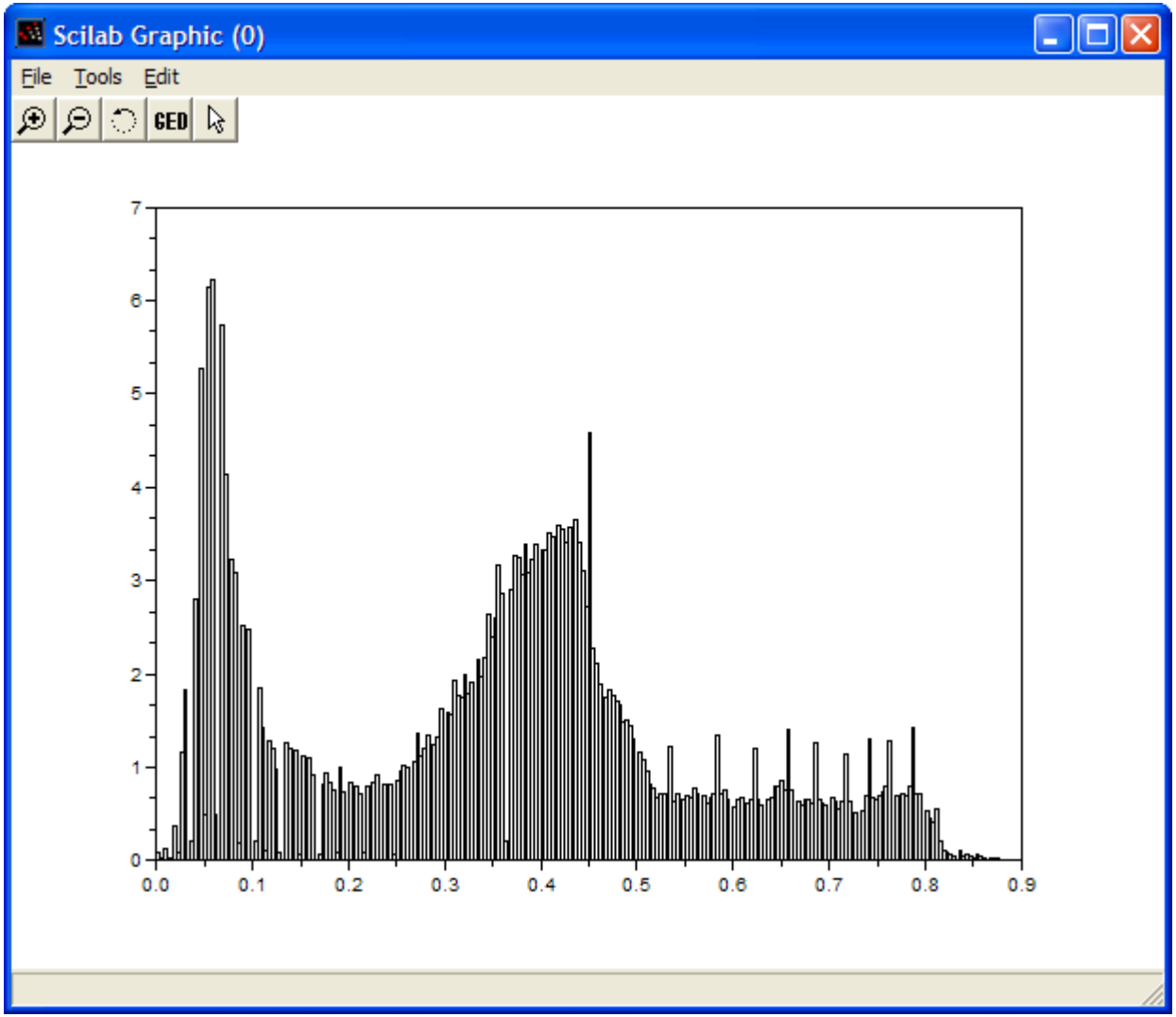
Massively useful in image processing, especially in segmentation



Histogram Examples

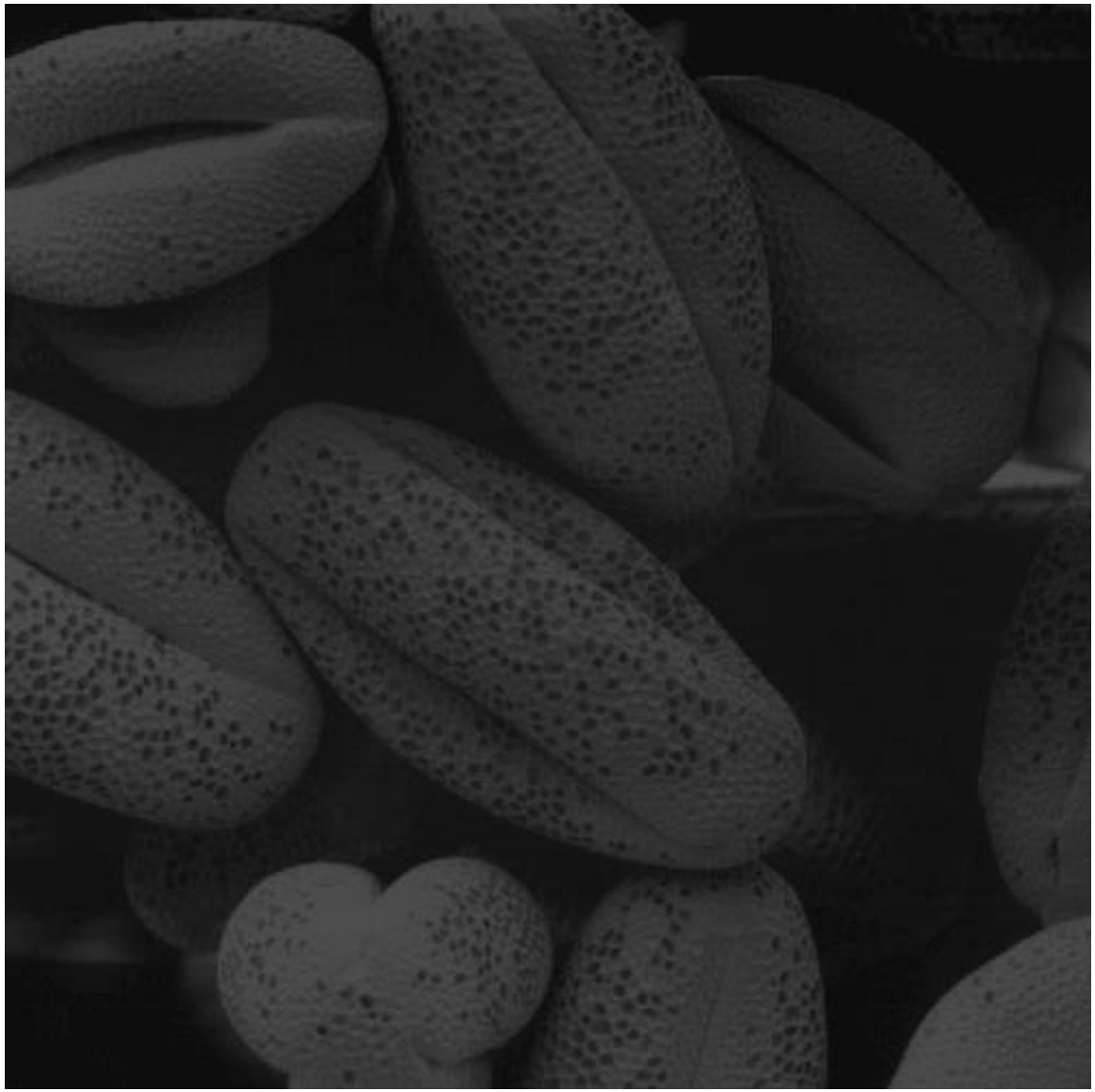
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Examples (cont…)

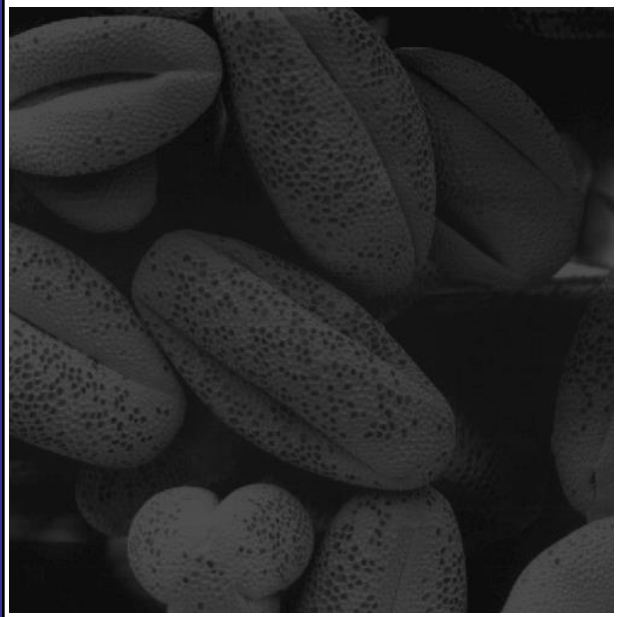


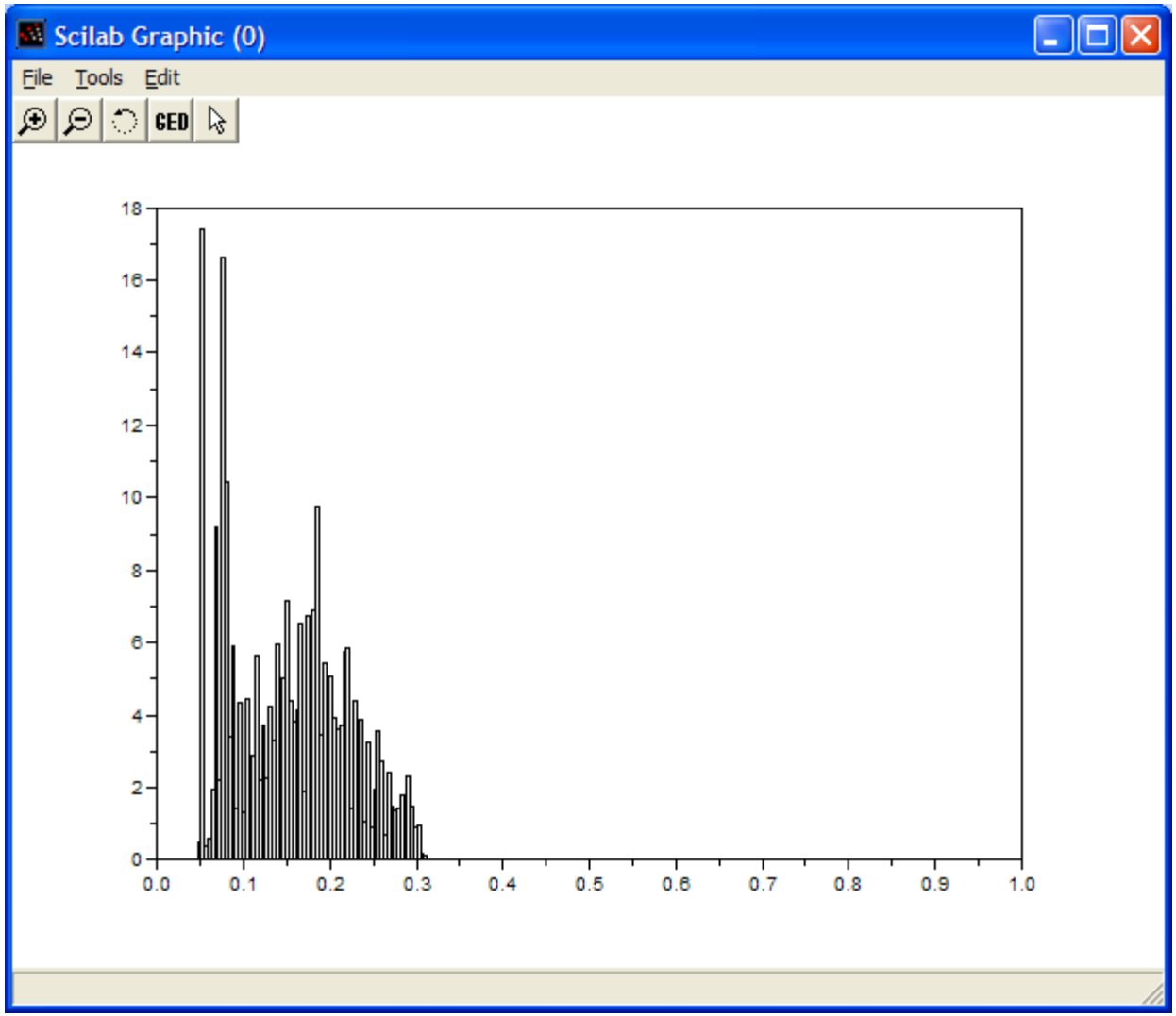
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Examples (cont…)



Histogram Examples (cont…)

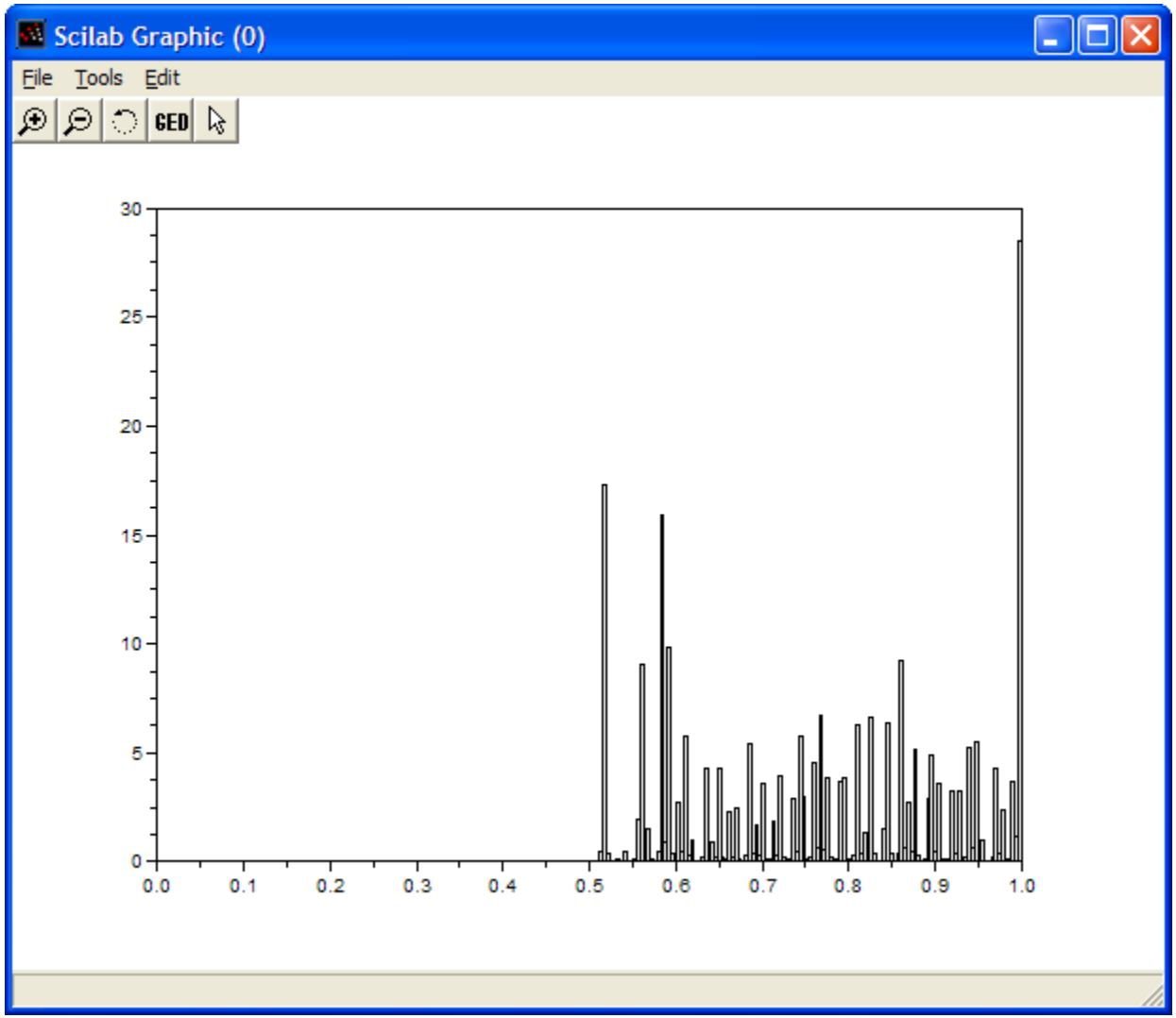




Images taken from Gonzalez & Woods, Digital Image Processing (2002)

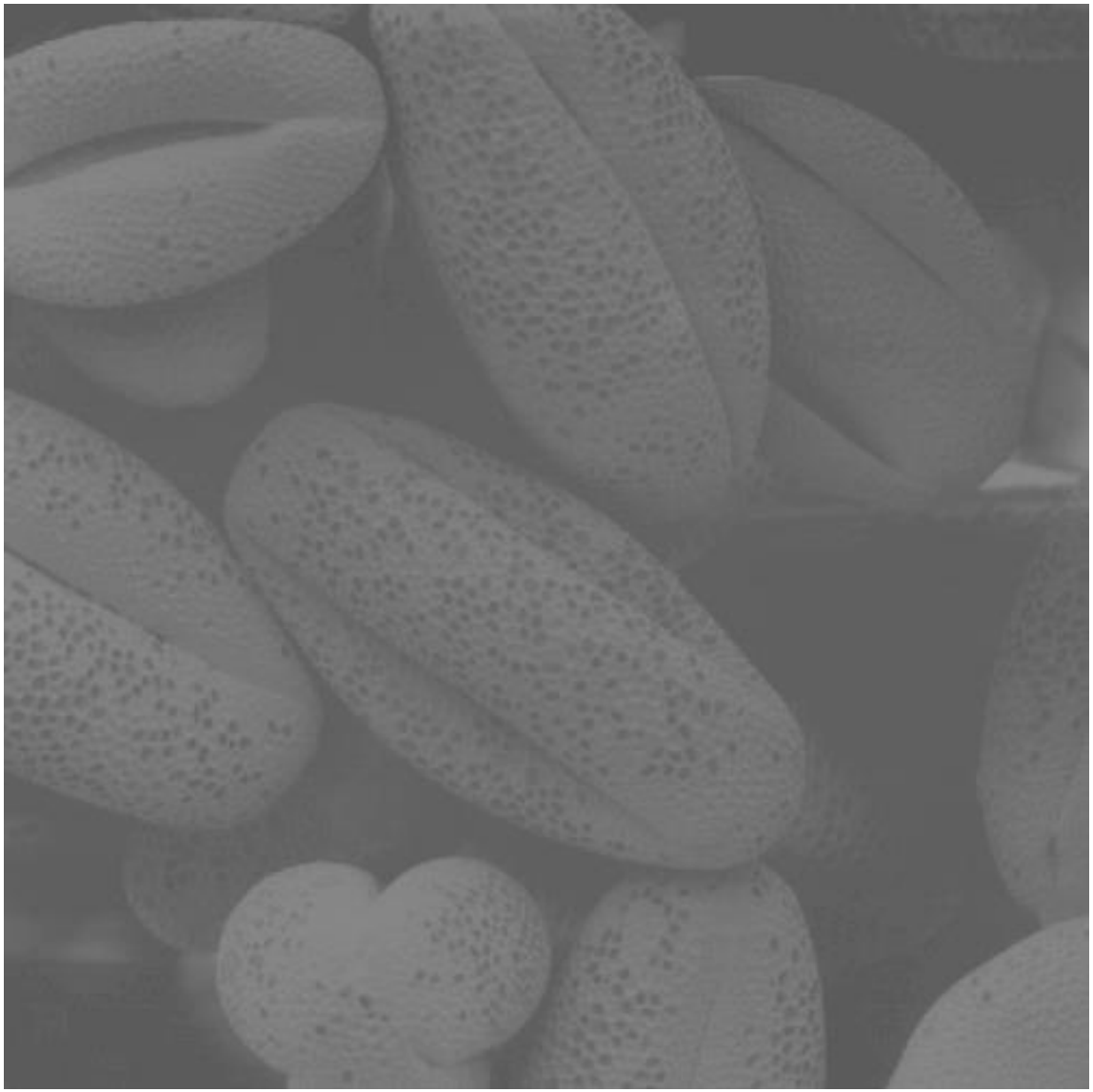
Histogram Examples (cont…)

Histogram Examples (cont…)

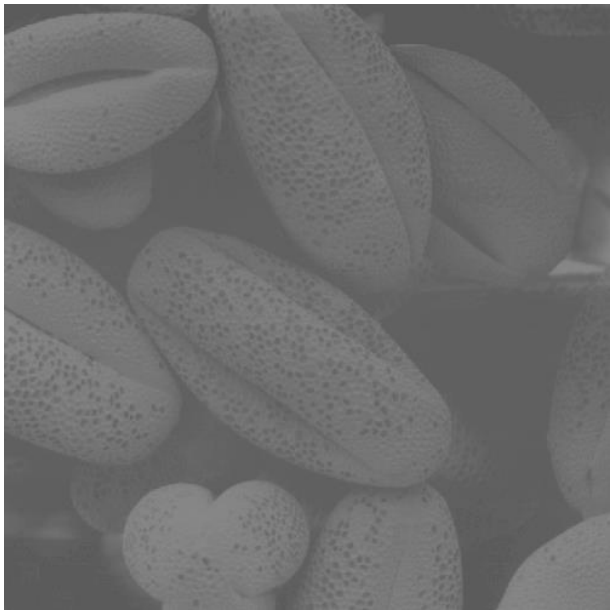


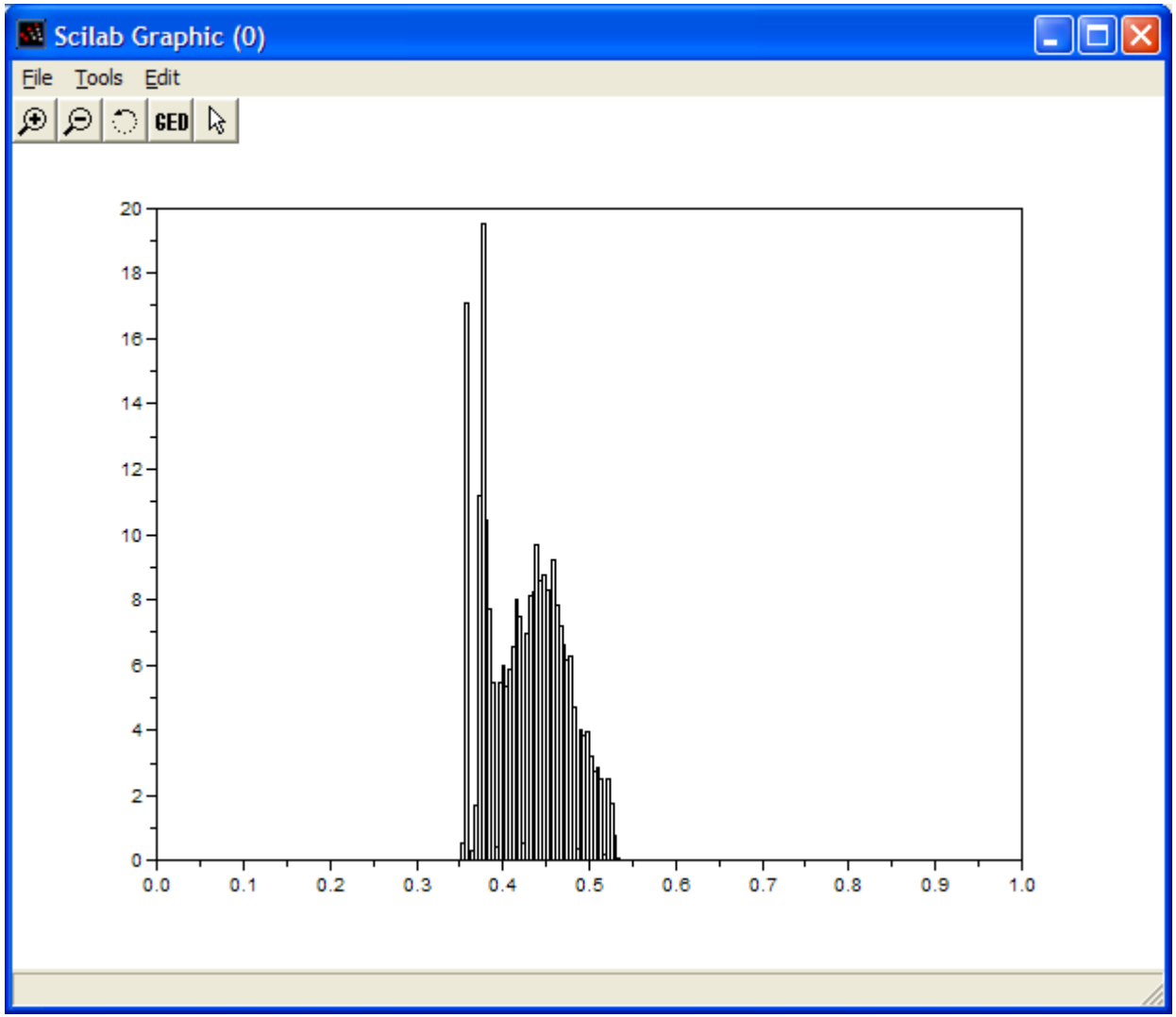
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Examples (cont…)



Histogram Examples (cont…)

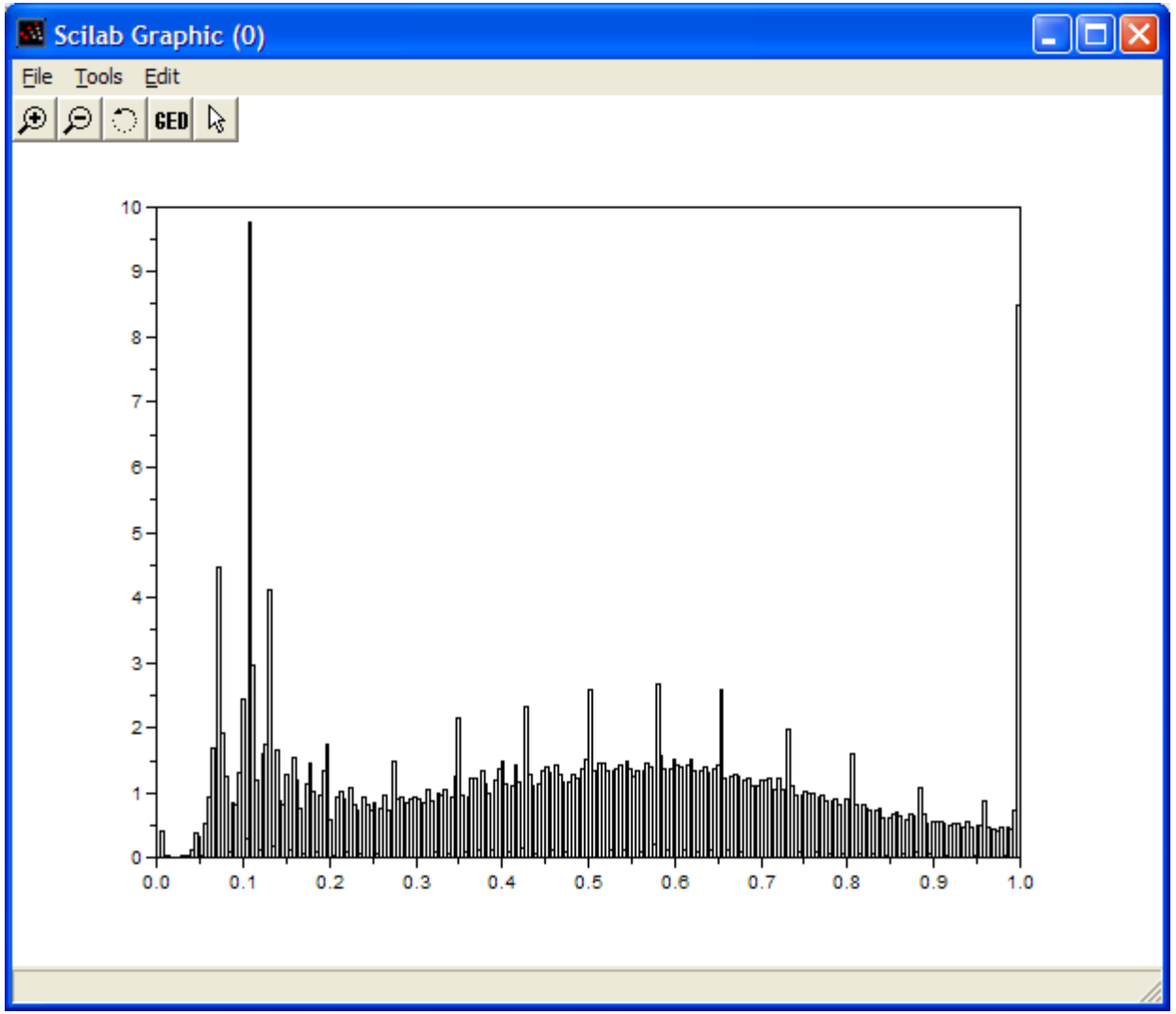




Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Examples (cont…)

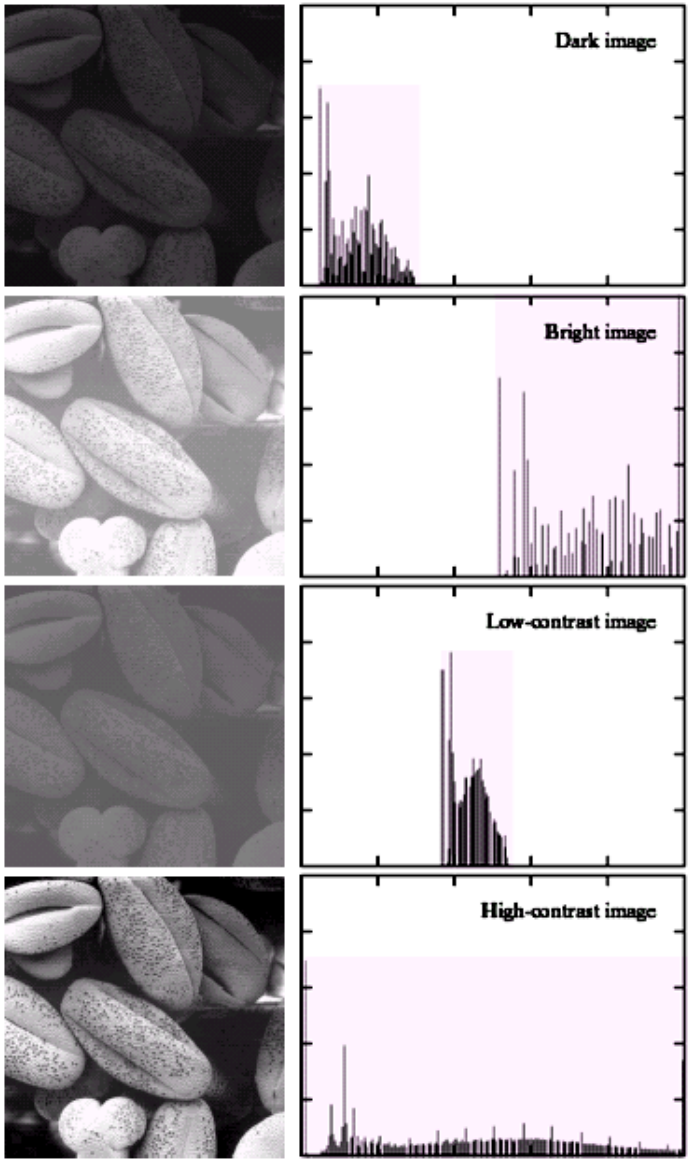
Histogram Examples (cont…)



Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Examples (cont…)

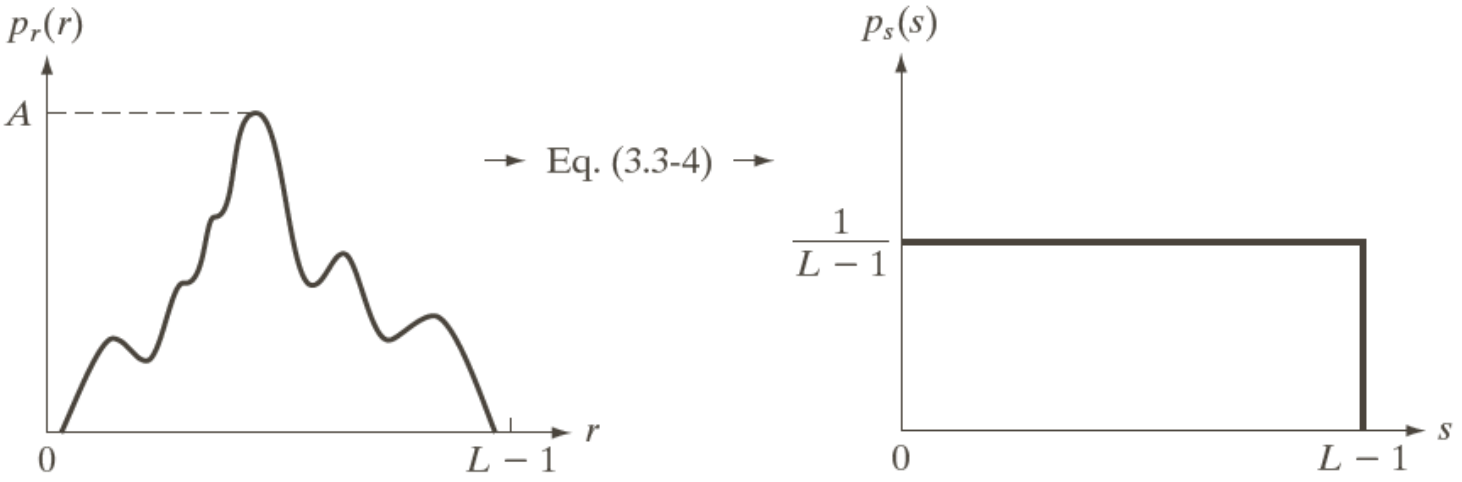
- A selection of images and their histograms
- Notice the relationships between the images and their histograms
- Note that the high contrast image has the most evenly spaced histogram



Contrast Stretching

- Spreading out the frequencies in an image (or equalising the image) is a simple way to improve dark or washed out images
- We can fix images that have poor contrast by applying a pretty simple contrast specification
- The interesting part is how do we decide on this transformation function?

Histogram Equalisation



a b

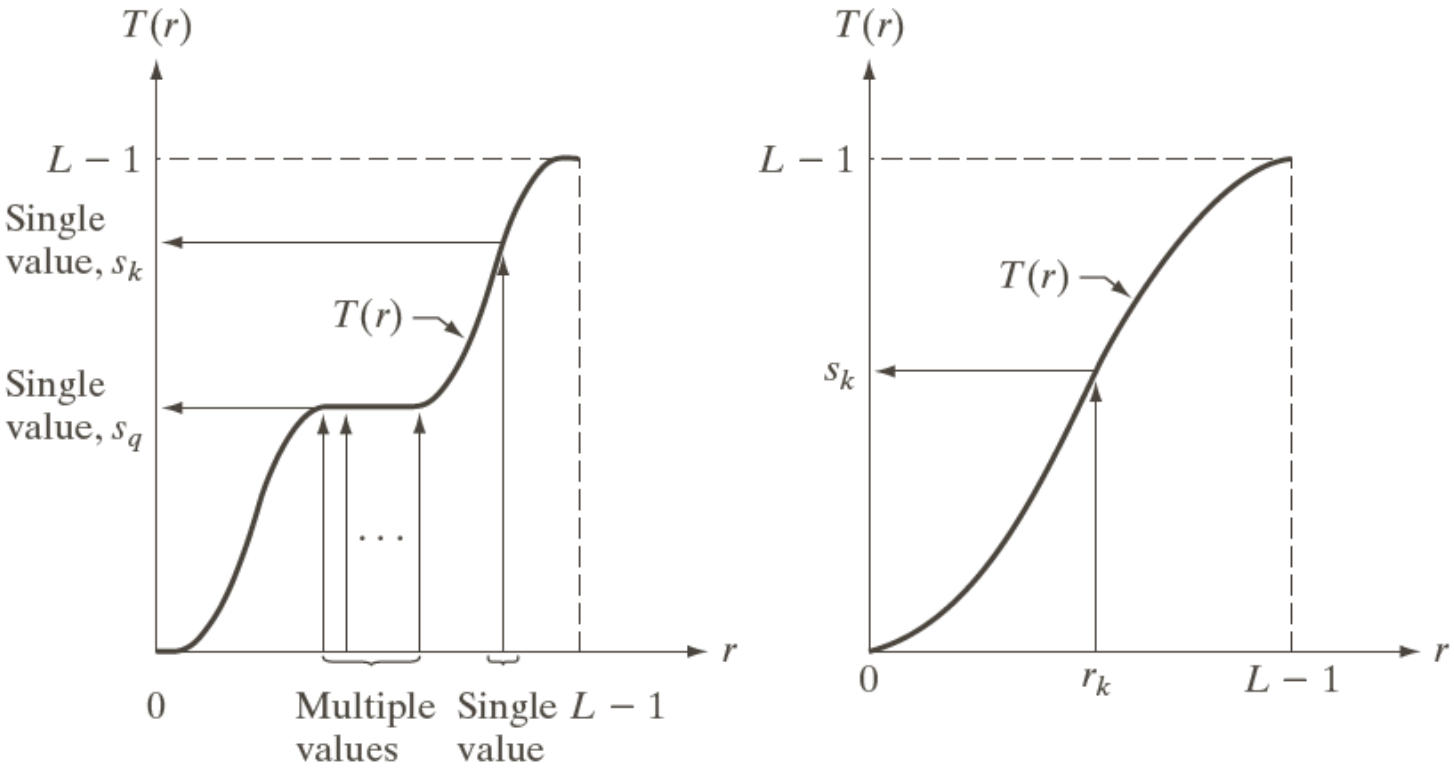
FIGURE 3.18 (a) An arbitrary PDF. (b) Result of applying the transformation in Eq. (3.3-4) to all intensity levels, r. The resulting intensities, s, have a uniform PDF, independently of the form of the PDF of the r's.

Histogram Equalisation

The transformation function should be:

1) Monotonically increasing

2) 0 <= T(r) <= L-1



a b

FIGURE 3.17 (a) Monotonically increasing function, showing how multiple values can map to a single value. (b) Strictly monotonically increasing function. This is a one-to-one mapping, both ways.

Histogram Equalisation

The formula for histogram equalisation for discrete values is given where

- r_k: input intensity
- s_k: processed intensity
- k: the intensity range (e.g 0.0 – 1.0)
- n_j: the frequency of intensity j
- MN: Total pixels

$$s_k = T(r_k)$$

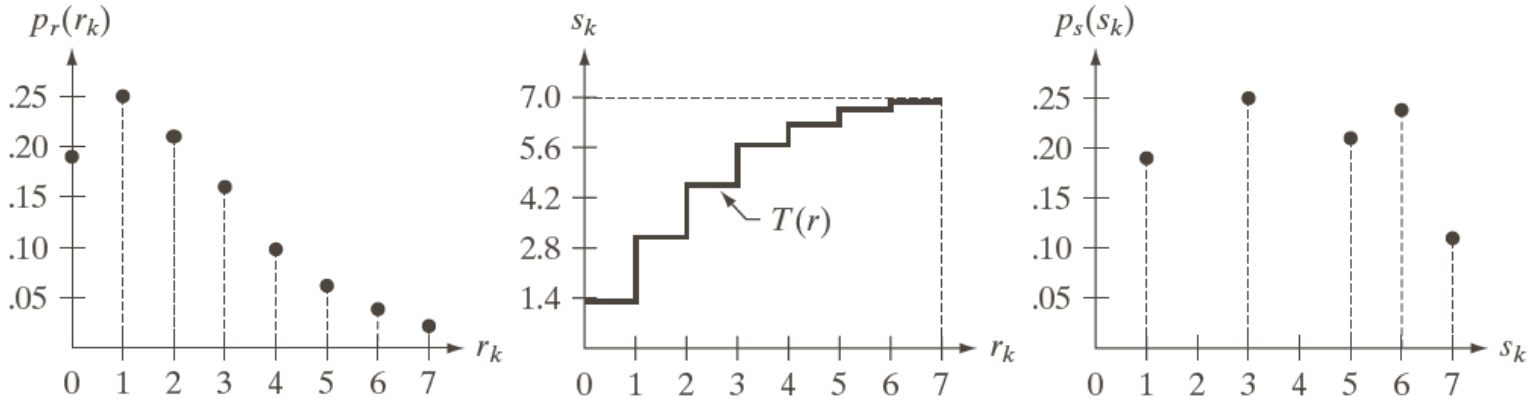
$$= (L-1)\sum_{j=0}^{k} p_r(r_j)$$

$$= \frac{(L-1)}{MN}\sum_{j=0}^{k} n_j$$

Equalisation Examples

r_k	n_k	$p_r(r_k) = n_k/MN$
$r_0 = 0$	790	0.19
$r_1 = 1$	1023	0.25
$r_2 = 2$	850	0.21
$r_3 = 3$	656	0.16
$r_4 = 4$	329	0.08
$r_5 = 5$	245	0.06
$r_6 = 6$	122	0.03
$r_7 = 7$	81	0.02

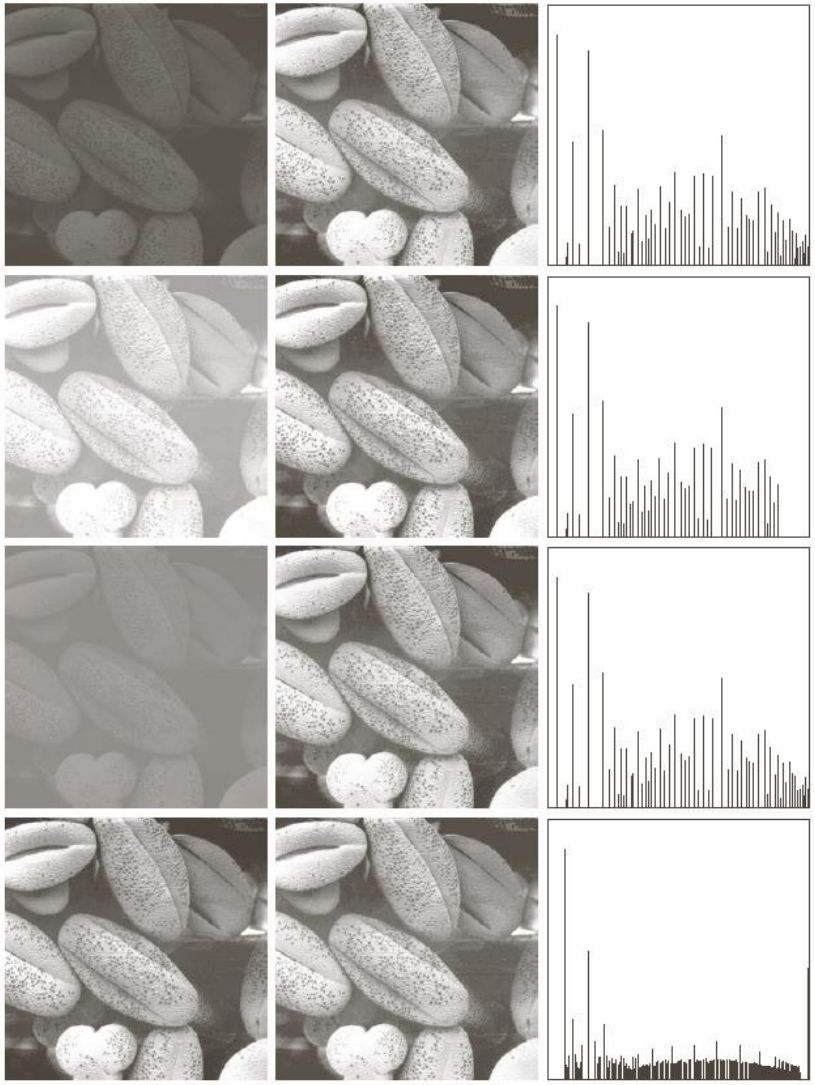
TABLE 3.1
Intensity distribution and histogram values for a 3-bit, 64 × 64 digital image.

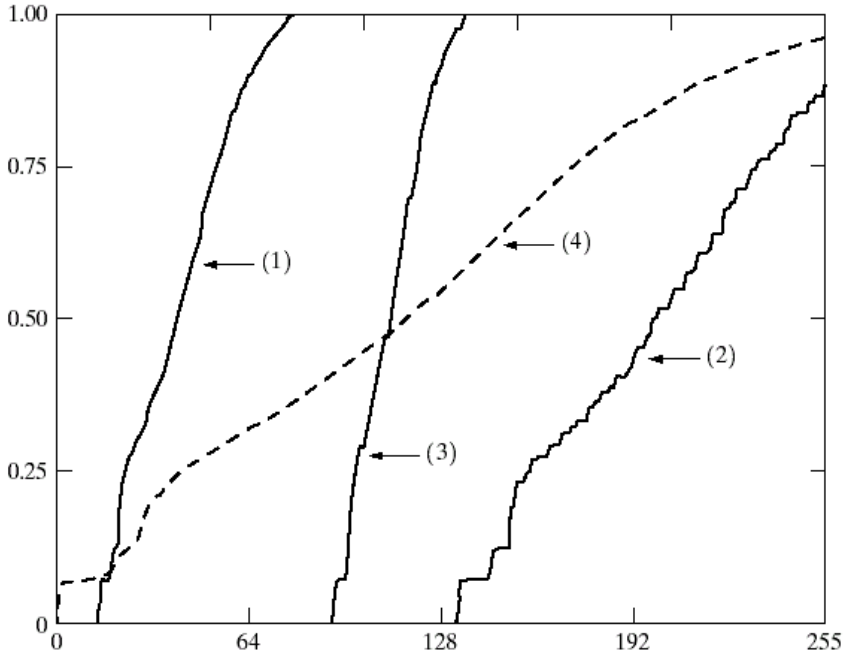


a b c

FIGURE 3.19 Illustration of histogram equalization of a 3-bit (8 intensity levels) image. (a) Original histogram. (b) Transformation function. (c) Equalized histogram.

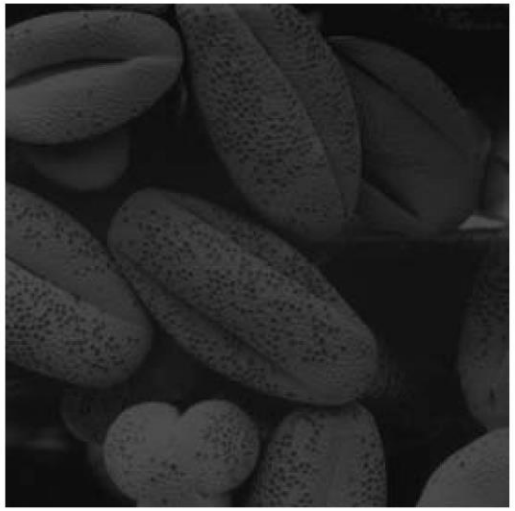
Equalisation Examples

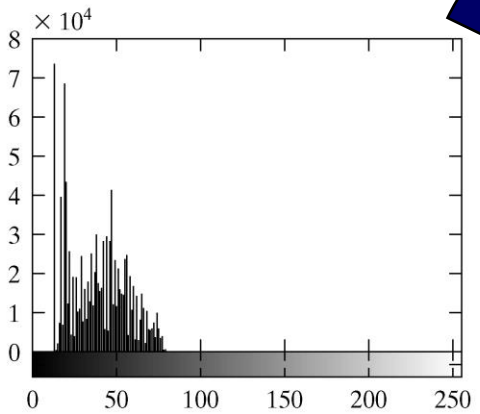


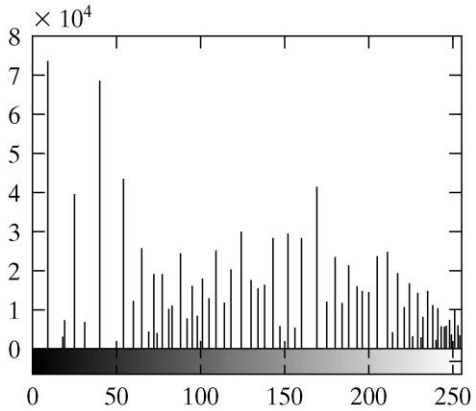


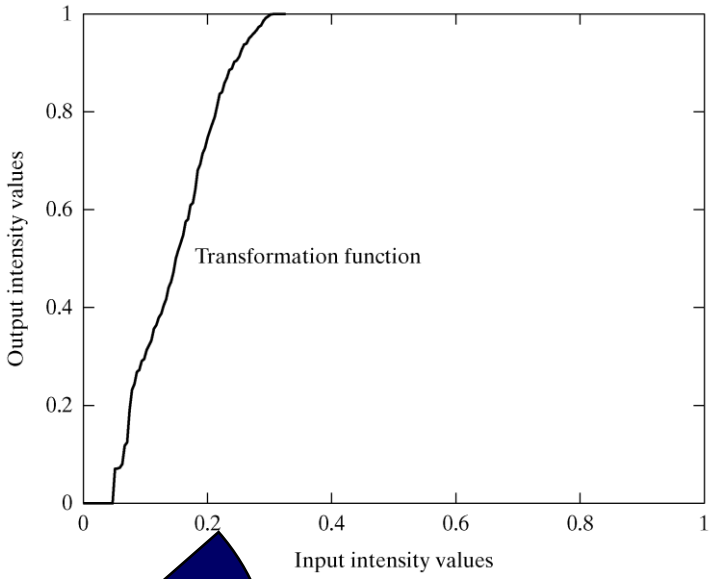
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Equalisation Transformation Function



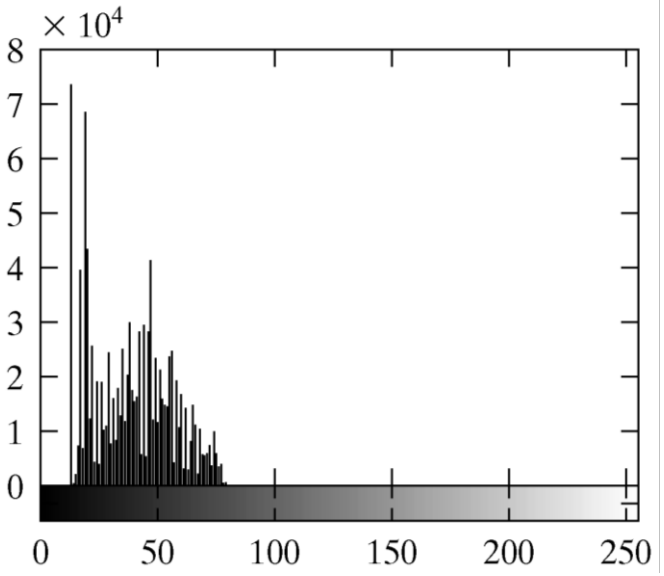


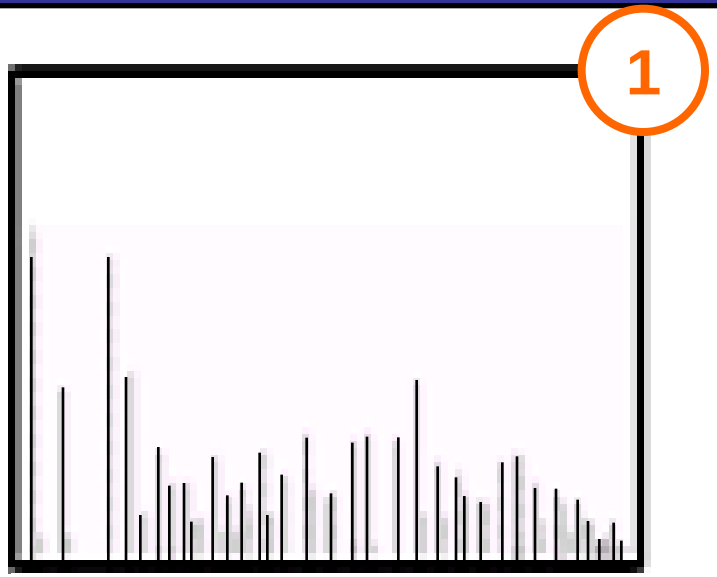


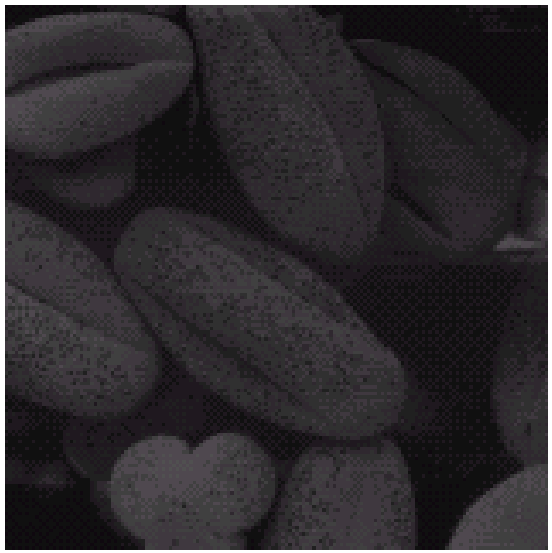


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

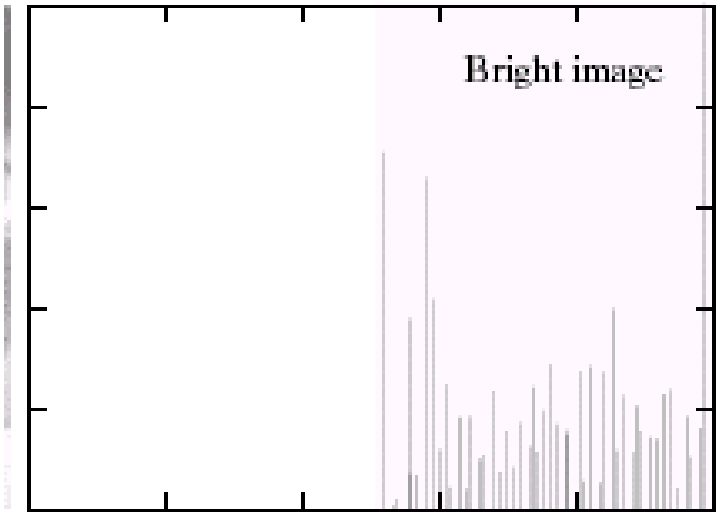
Equalisation Examples

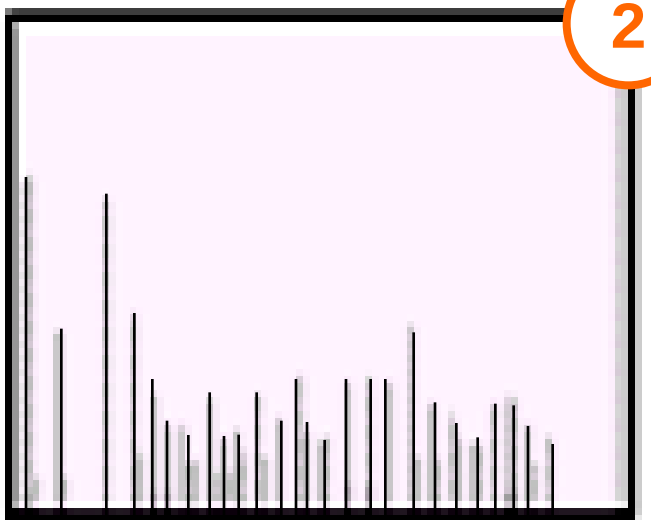




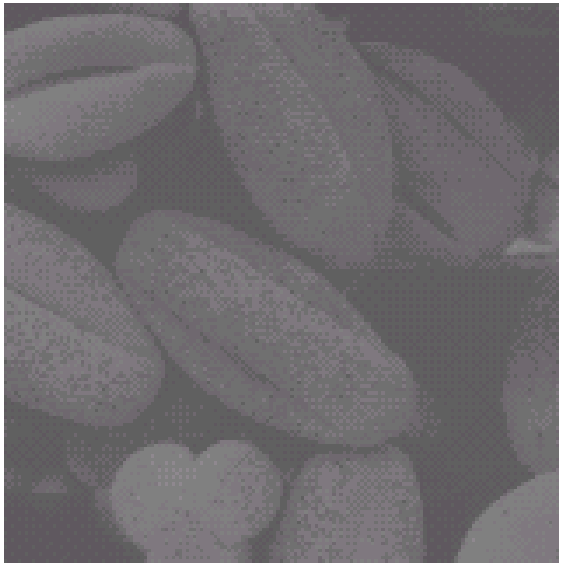


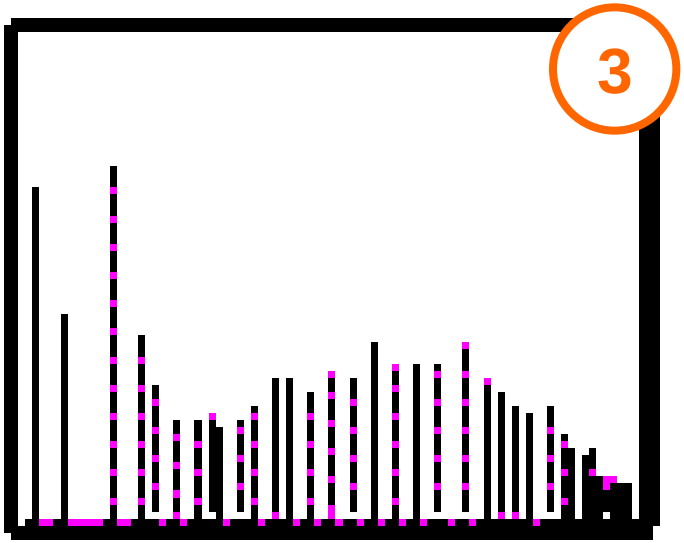
Equalisation Examples

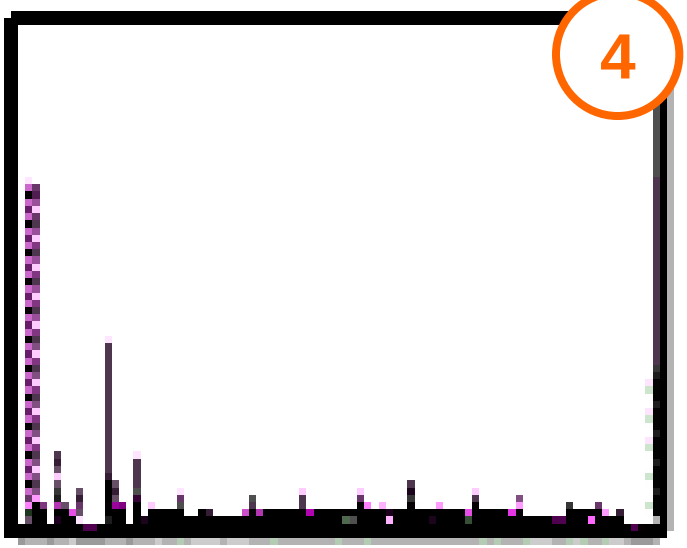




Equalisation Examples (cont…)

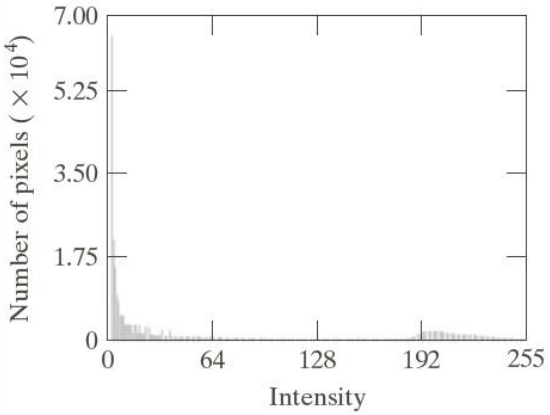


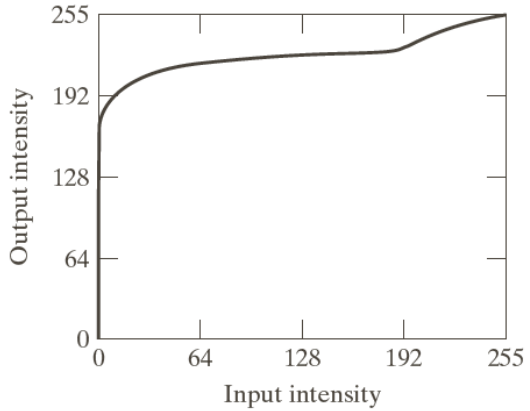


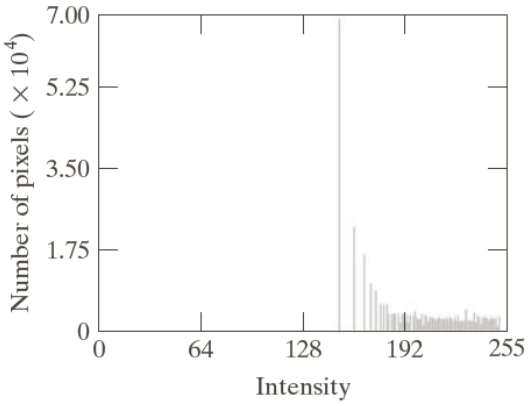


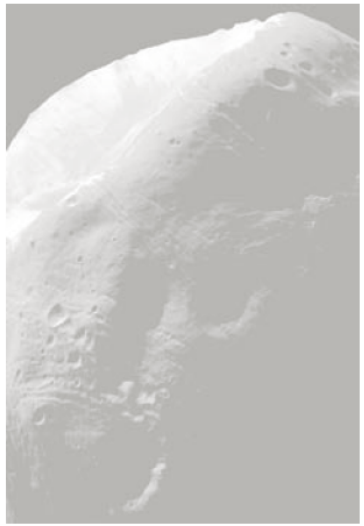
Histogram Matching (Specification)

- For some applications, enhancing based on uniform histogram is not best approach







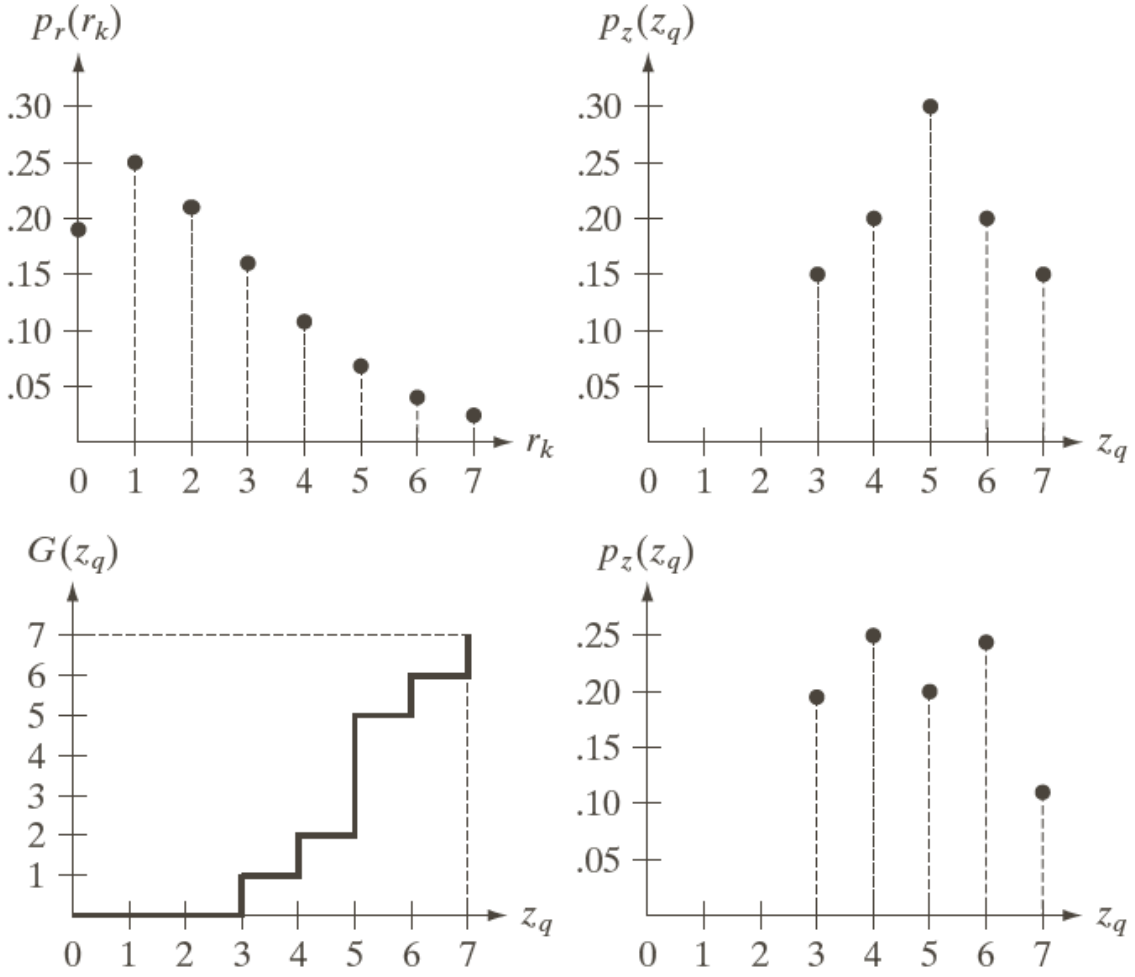


Histogram Matching (Specification)

- Useful to be able to specify the shape of the histogram that we wish (guess!) the processed image to have

- Method to generate a processed image that has a specified histogram is called ***Histogram Matching or Histogram Specification***

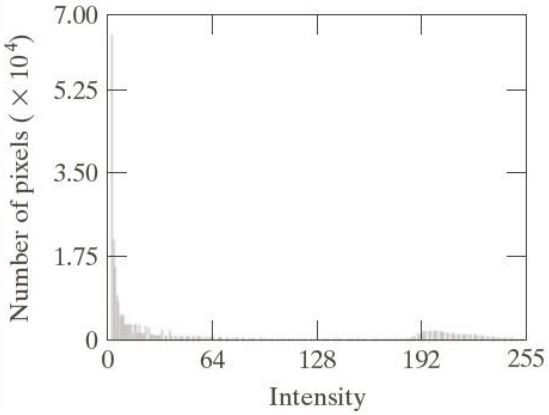
Histogram Matching (Specification)

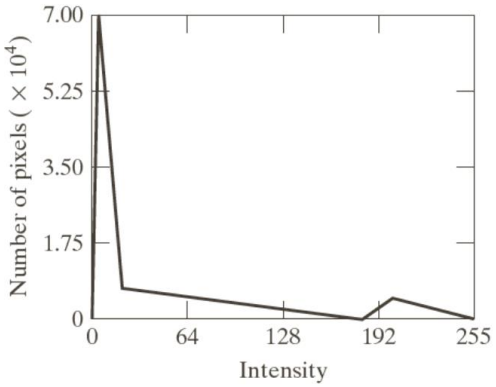


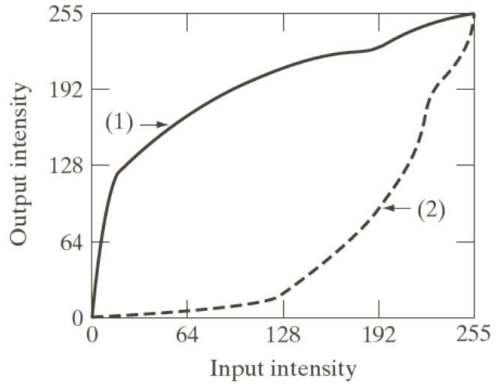
a b
c d

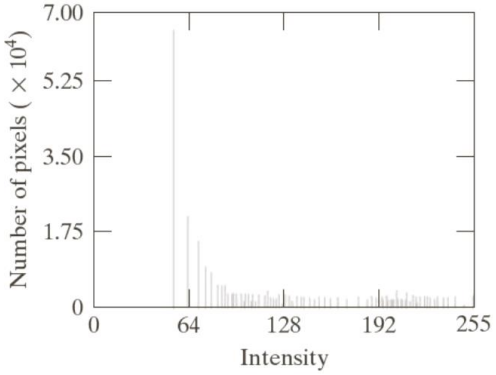
FIGURE 3.22
(a) Histogram of a 3-bit image. (b) Specified histogram. (c) Transformation function obtained from the specified histogram. (d) Result of performing histogram specification. Compare (b) and (d).

Histogram Matching (Specification)





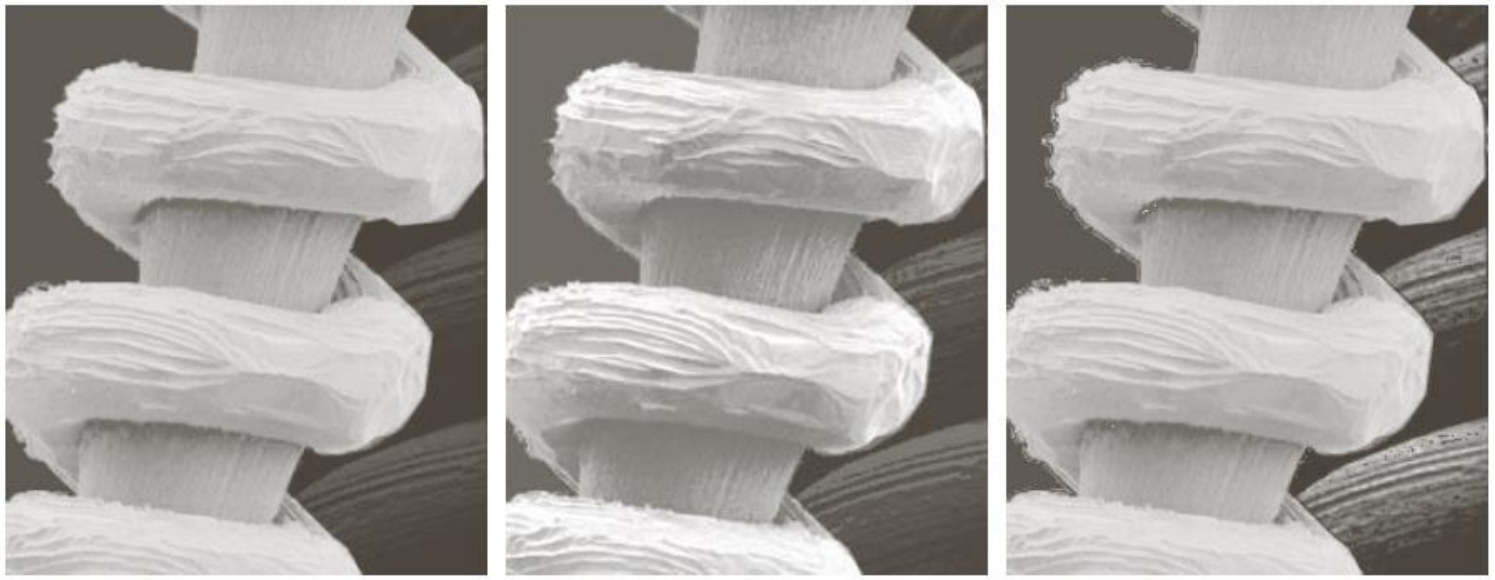




a c
b
d

FIGURE 3.25
(a) Specified histogram.
(b) Transformations.
(c) Enhanced image using mappings from curve (2).
(d) Histogram of (c).

Local Histogram processing



a b c

FIGURE 3.27 (a) SEM image of a tungsten filament magnified approximately 130×. (b) Result of global histogram equalization. (c) Image enhanced using local histogram statistics. (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)

Summary

We have looked at:

- Different kinds of image enhancement
- Histograms
- Histogram equalisation
- Histogram matching

Next time we will start to look at point processing and some neighbourhood operations