Image Enhancement

Cristina P Santos
cristina@dei.uminho.pt

03/10/2019

Visão por Computador

Contents

This lecture will cover:

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

Note about Grey Levels

- **Grey level values** are in the range [0, 255]
  Where 0 is black and 255 is white

- There is no reason why we have to use this range
  The range [0,255] stems from display technologies

- For many of the image processing operations in this lecture grey levels are assumed to be given in the range [0.0, 1.0] => **Normalization**

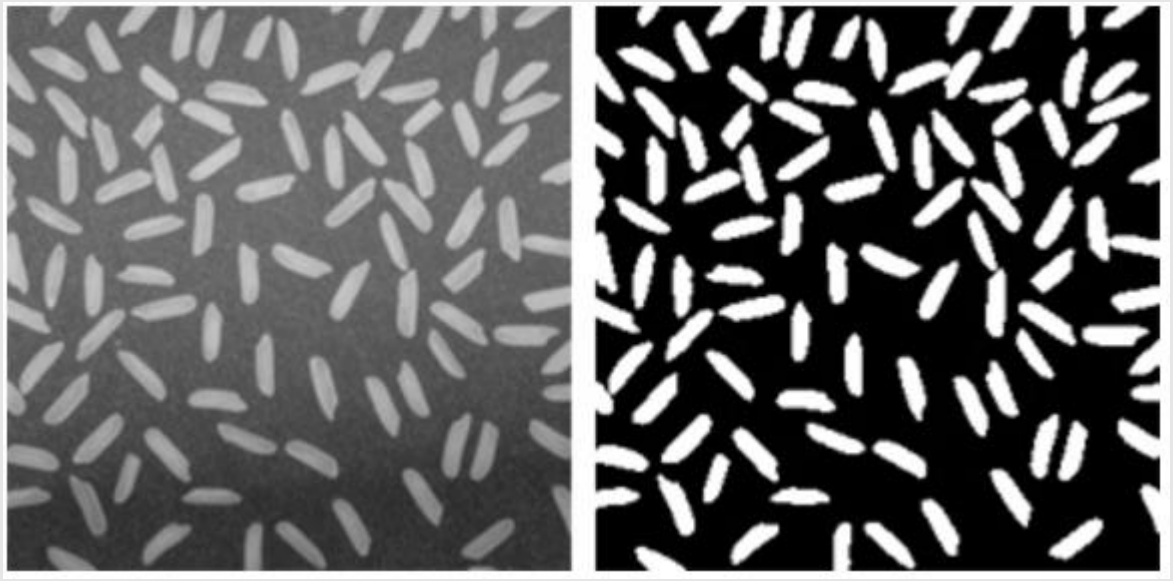
- **Binary image** can take only two value (0 or 255)

What is Image Enhancement?

- **Image enhancement** is the process of adjusting digital images so that the results are more suitable than the original image;

- The reasons for doing this include:
  - Highlighting interesting detail in images
  - Removing noise from images
  - Making images more visually appealing

Image Enhancement Examples



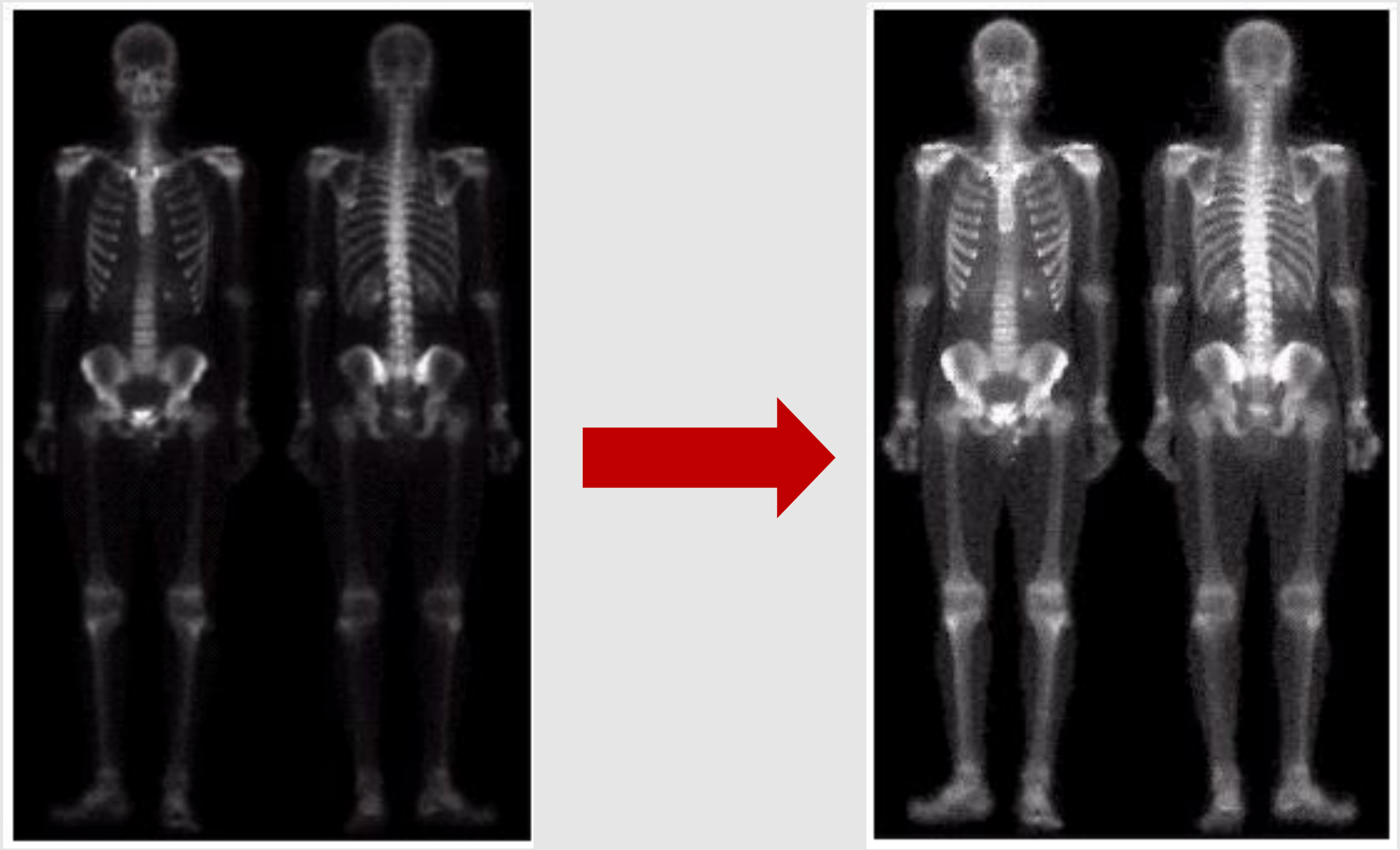
Correcting nonuniform illumination with **morphological operator**

Enhancing grayscale images with **histogram equalization**

Image Enhancement Examples

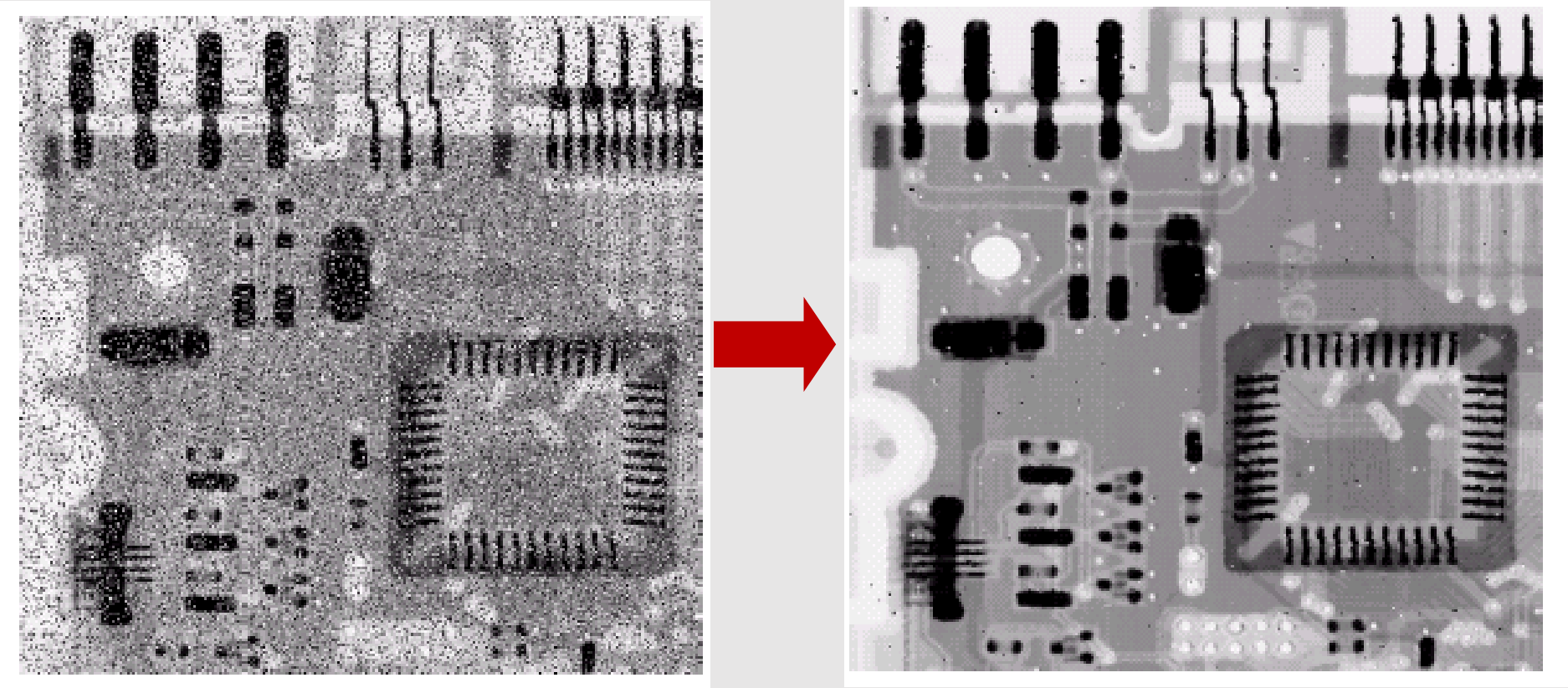
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Image Enhancement Examples



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

Image Enhancement Examples



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

Image Enhancement

The **image enhancement techniques** can be divided into two broad categories:

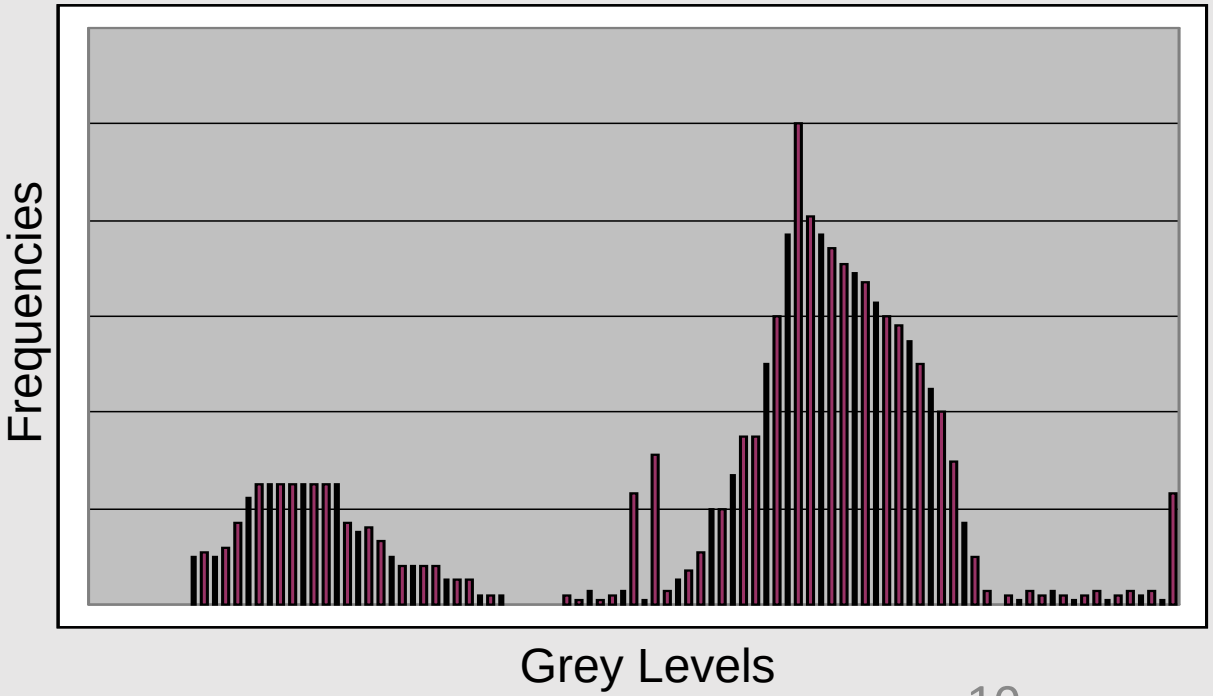
- **Spatial domain methods**: direct manipulation of image pixels;
- **Frequency domain methods**: manipulation of Fourier transform or wavelet transform of an image;

Image Histogram

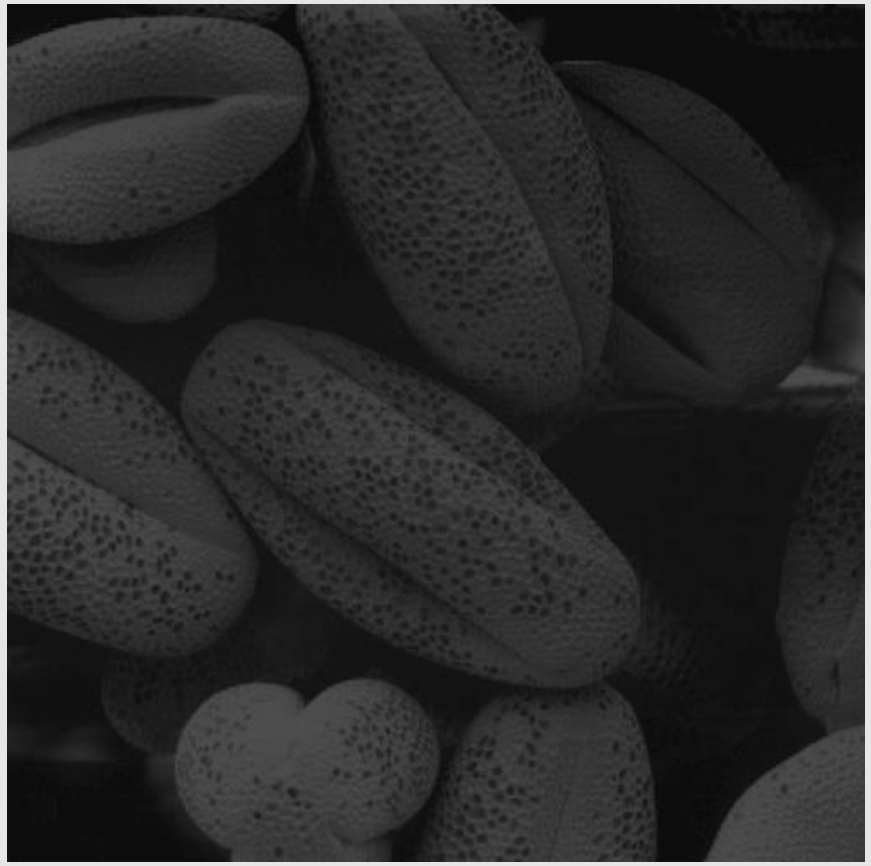
- The histogram of an image shows us the distribution of grey levels in the image, i.e., indicate us the number of pixels for each intensity of grey level;

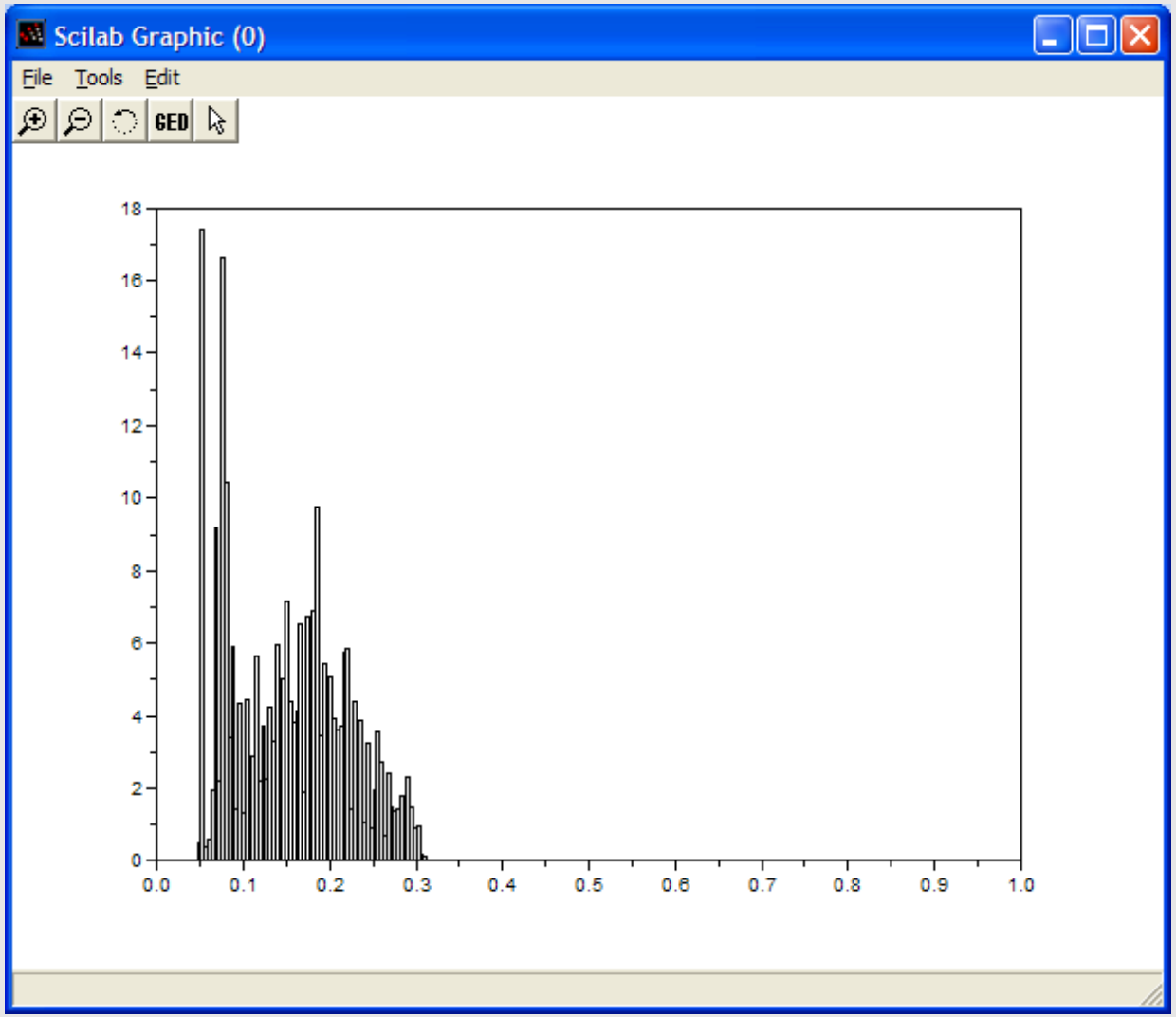
- By viewing the image's histogram, we can analyze the frequency of appearance of the different grey levels contained in the image.

- A good histogram is that which covers all the possible values in the grey scale used => suggests that the image has good contrast and that details in the image may be observed more easily.



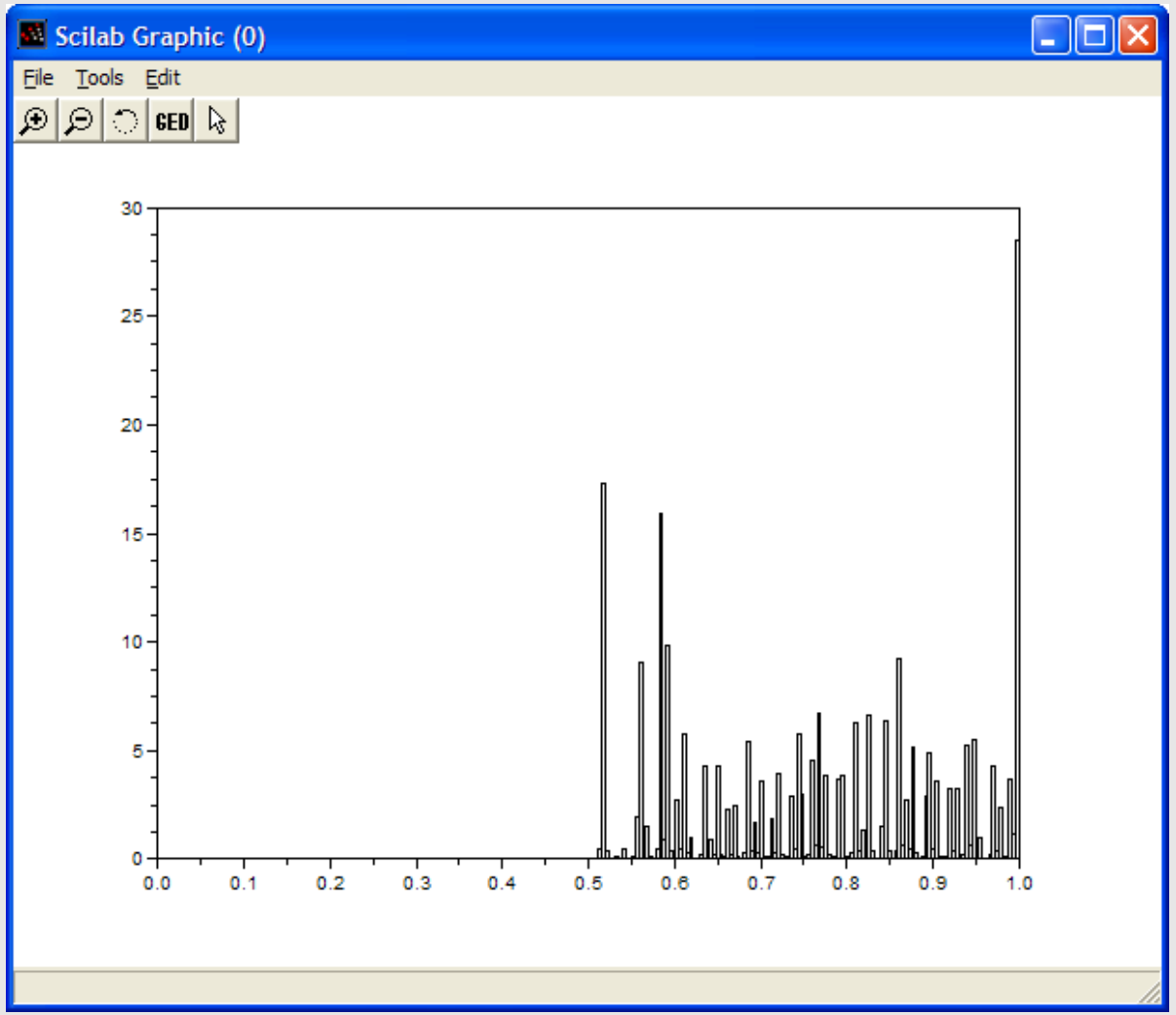
Histogram Examples





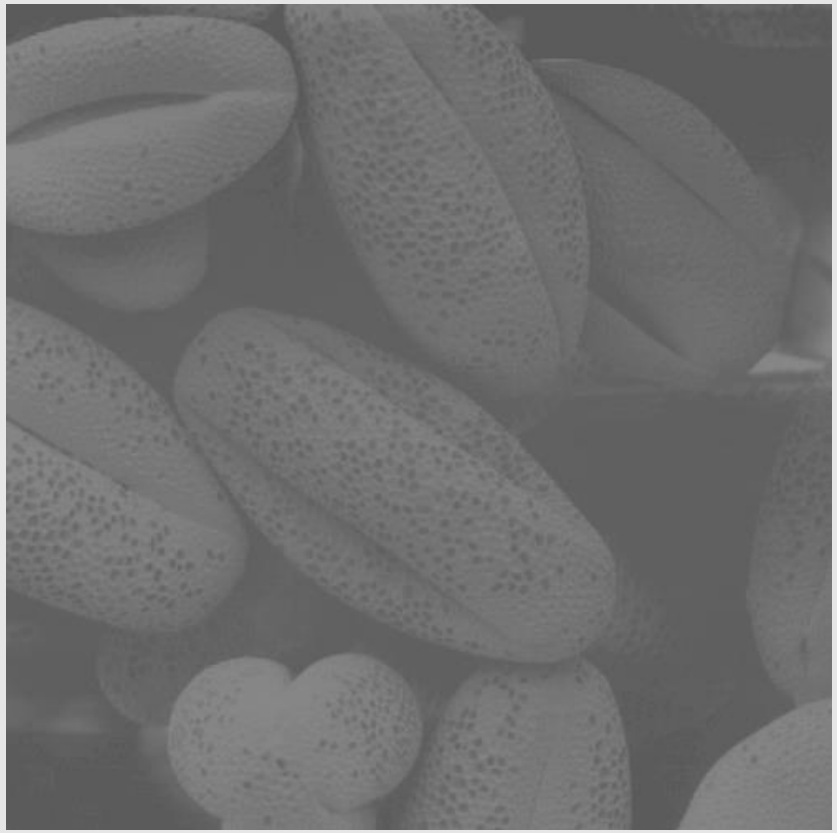
Images taken from Gonzalez & Woods, Digital Image Processing (2002)

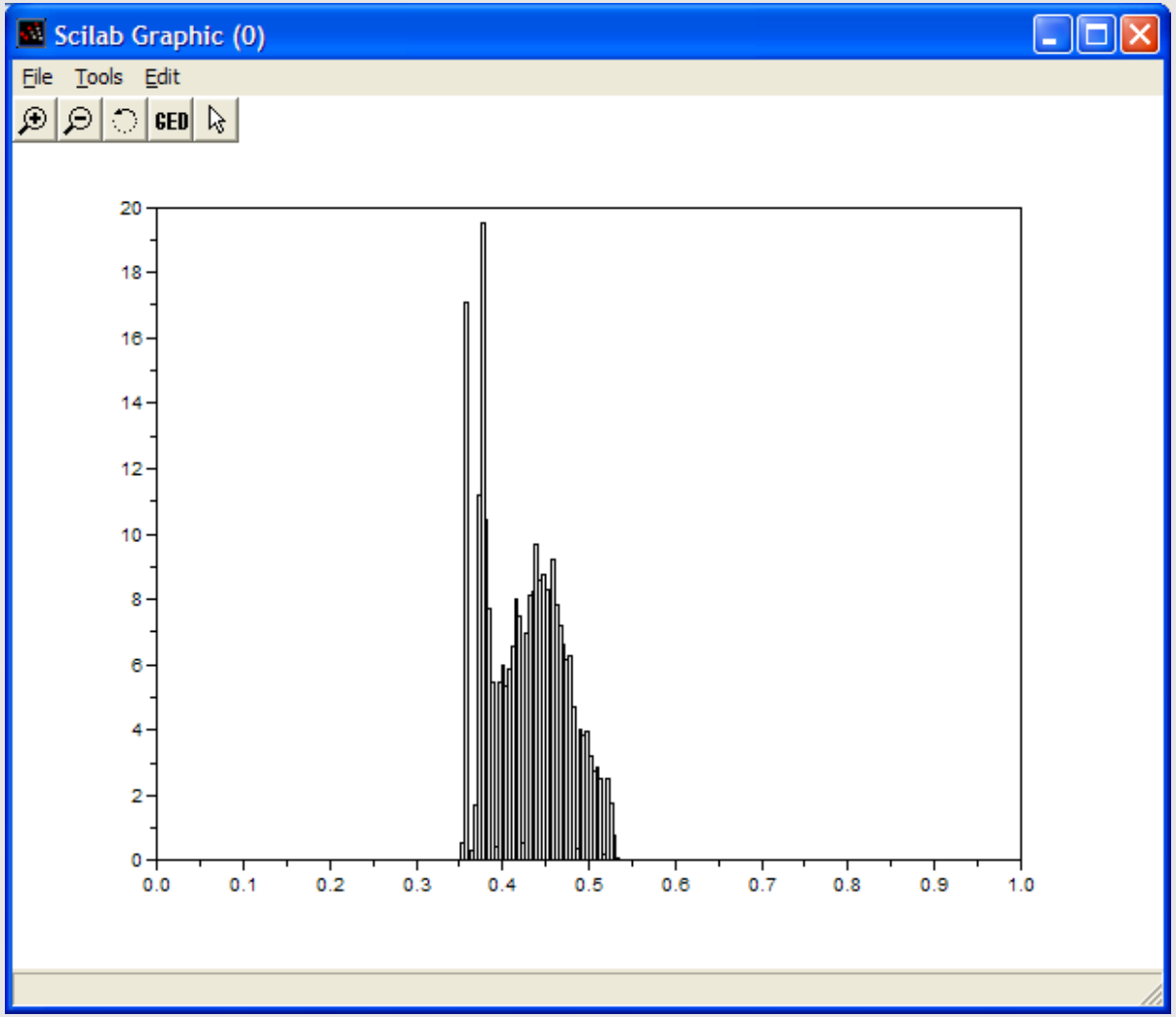
Histogram Examples



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

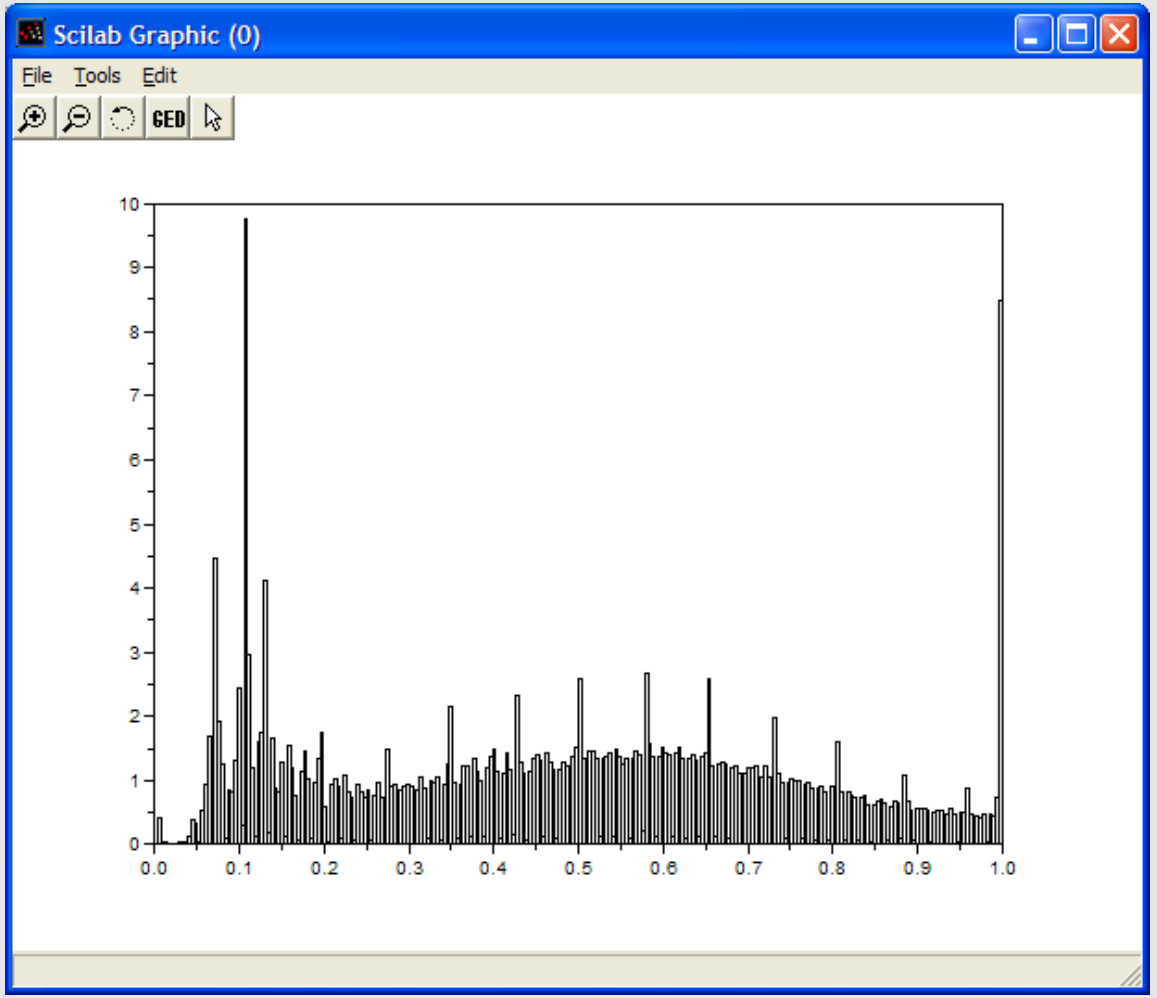
Histogram Examples





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

Histogram Examples

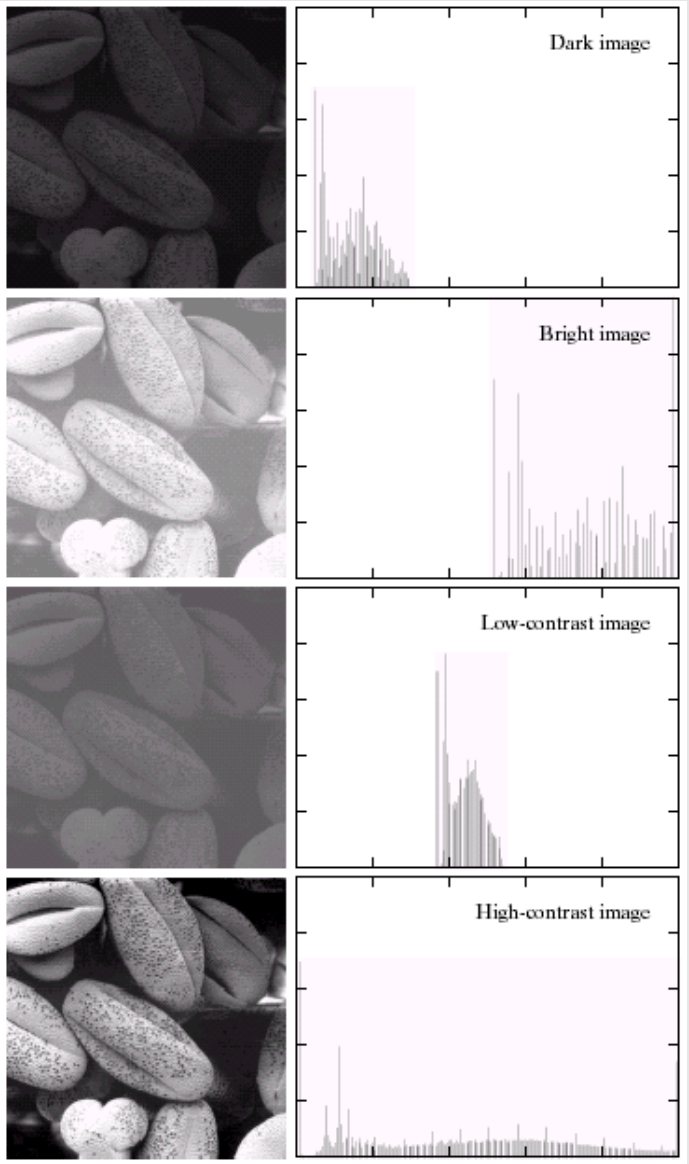


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Examples

- 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 => Better quality

We can fix images that have poor contrast by applying a pretty simple contrast specification



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

Histogram Equalisation

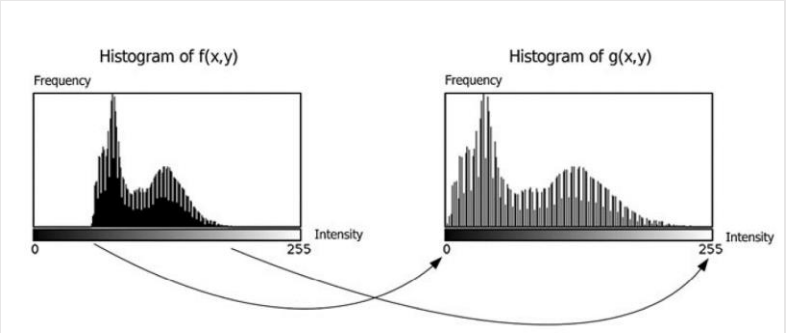
- Spreading out the frequencies in an image (or equalising the image) in the attempt to enhance the contrast;
  => Proper distribution of the image for the available grey levels

- **Histogram equalization** involves **transforming the intensity values** so that the histogram of the resulting image is equalized to become a constant;

- This technique can be used on a whole image or just on a part of an image;

Note

During histogram equalization the overall shape of the histogram changes, where as in histogram stretching the overall shape of histogram remains same



Histogram stretching

Histogram Equalisation

- The formula for histogram equalisation is

$$s_k = T(r_k) = \sum_{j=1}^{k} p_r(r_j) = \sum_{j=1}^{k} \frac{n_j}{n}$$

k: the intensity range (e.g 0-255)

r_k: input intensity

s_k: processed intensity = image's histogram for pixel value *k* normalized to [0,1].

n_j: the frequency of intensity *j*

n: the sum of all frequencies

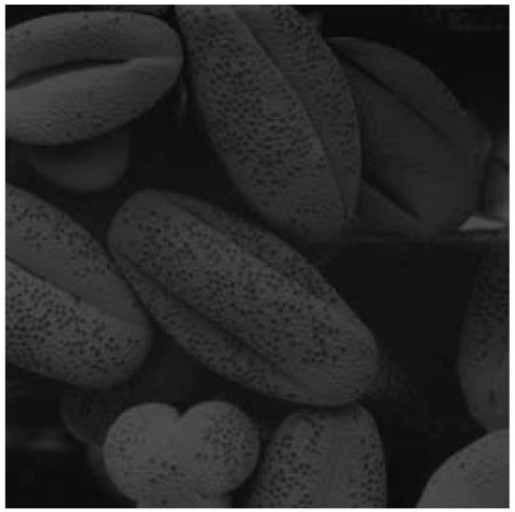
T: transformation of pixel intensities

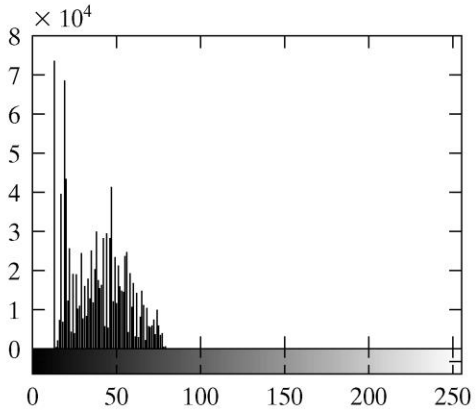
Methods for Histogram Equalisation

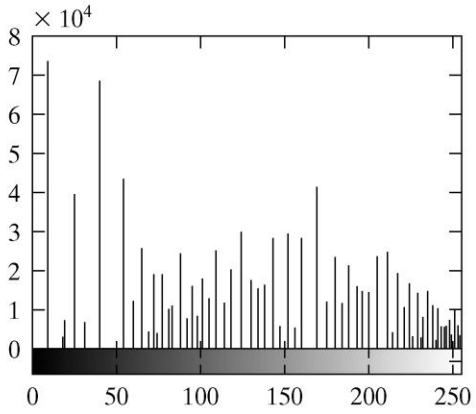
Method	Advantage	Disadvantage
Histogram expansion	Simple and enhance contrasts of an image.	If there are gray values that are physically far apart from each other in the image, then this method fails.
LAHE	Offers an excellent enhancement of image contrast.	Computationally very slow, requires a high number of operations per pixel.
Cumulative histogram equalization	Has good performance in histogram equalization.	Requires a few more operations because it is necessary to create the cumulative histogram.
Par sectioning	Easy to implement.	Better suited to hardware implementation.
Odd sectioning	Offers good image contrast.	Has problems with histograms which cover almost the full gray scale.

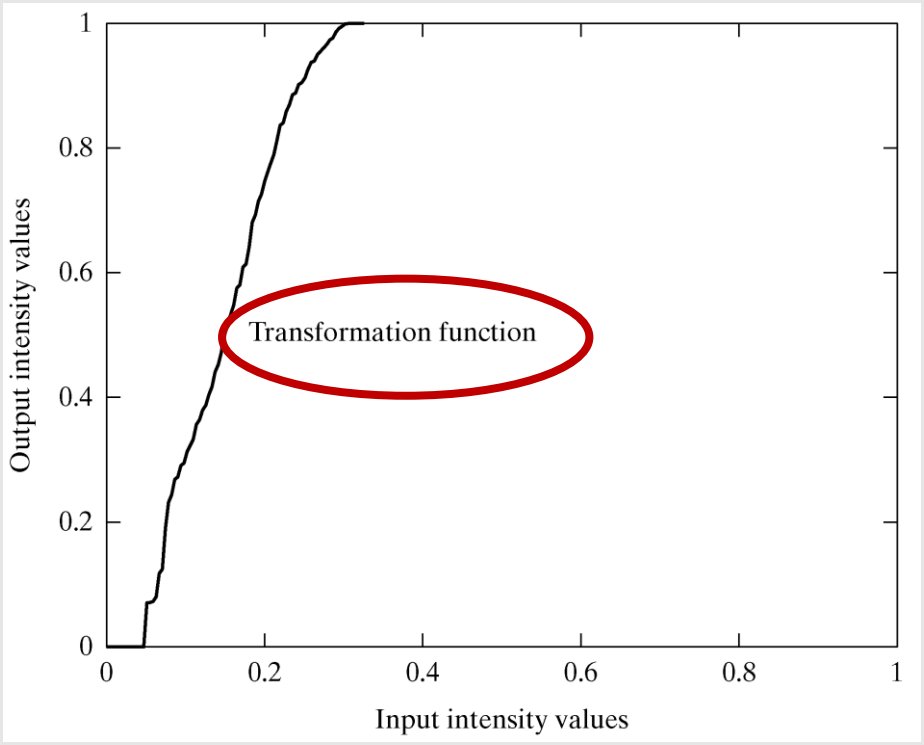
Cumulative histograma equalisation algorithm is usually selected due to its good performance and easy implementation ✓

Histogram Equalisation Examples



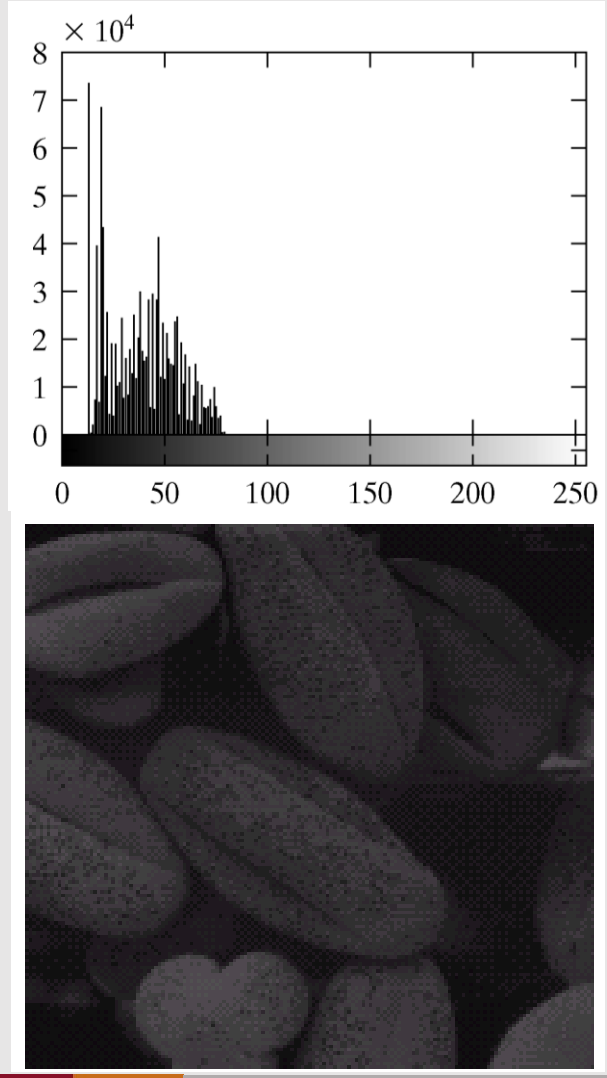


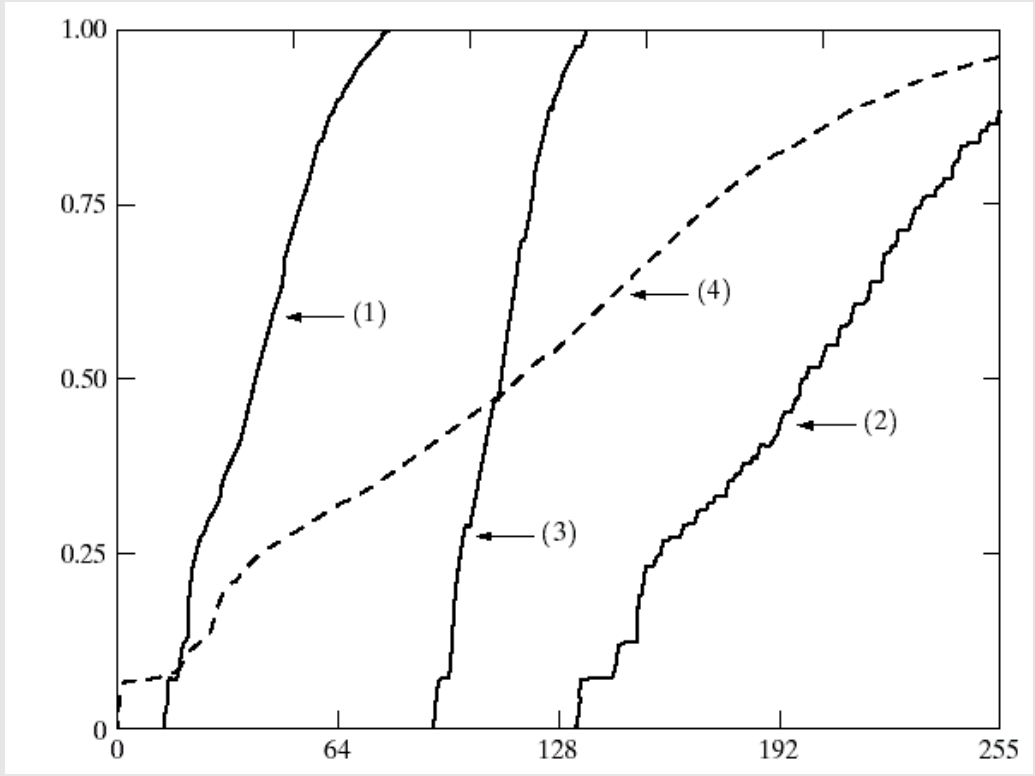


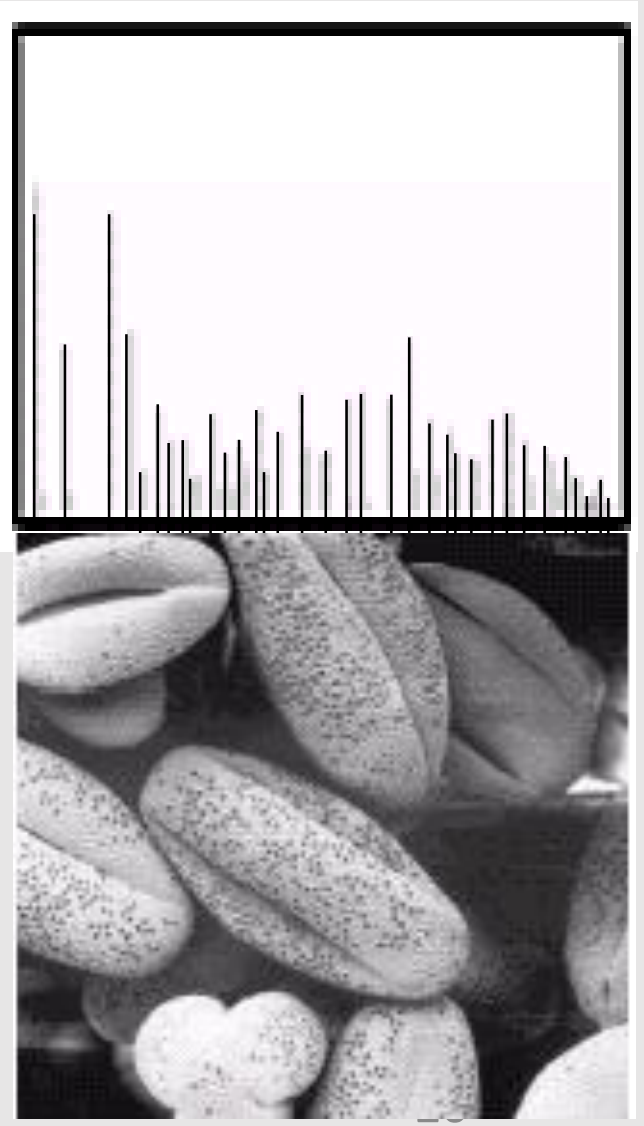


Images taken from Gonzalez & Woods, Digital Image Processing (2002)

Histogram Equalisation Examples

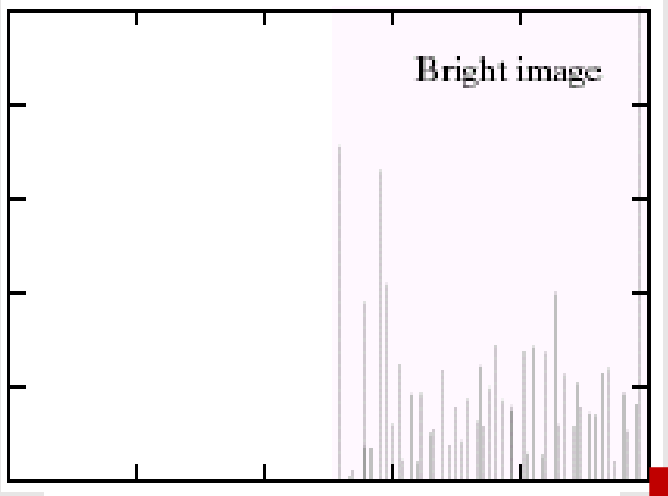


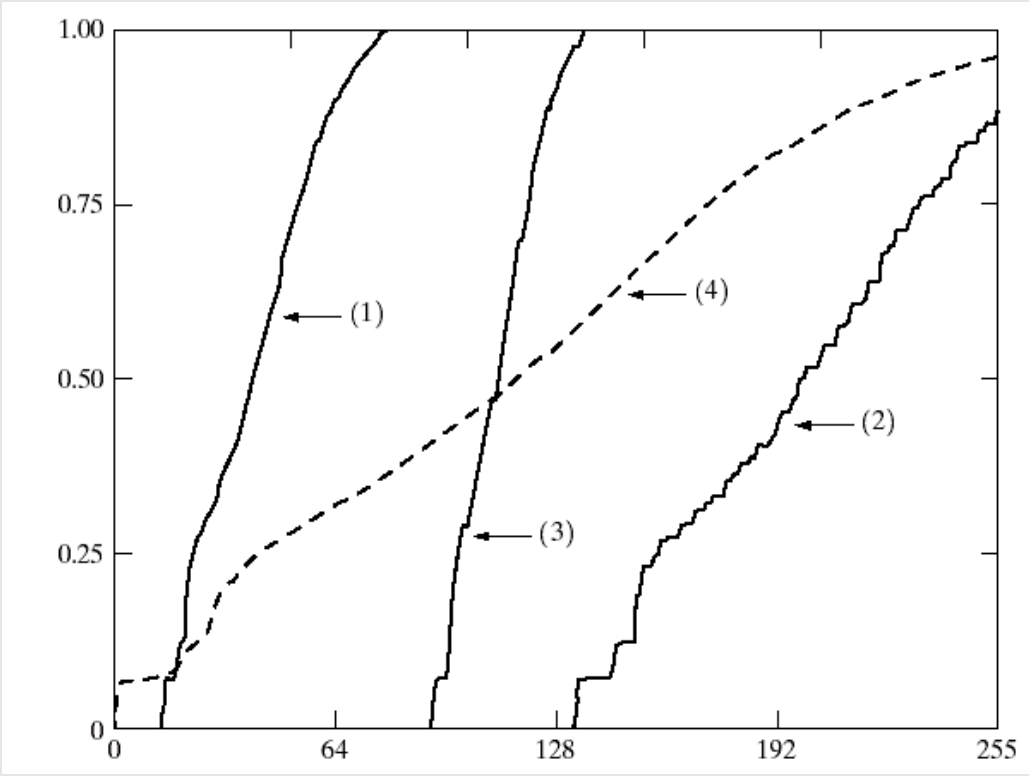




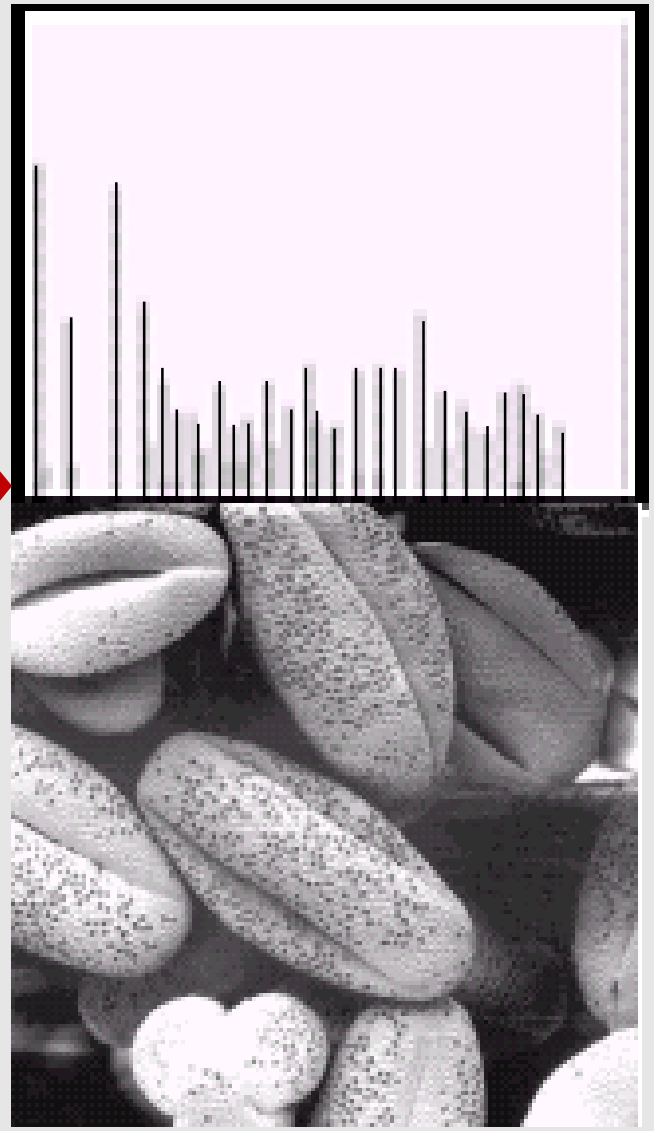
The function 1 was used to equalise the dark image

Histogram Equalisation Examples

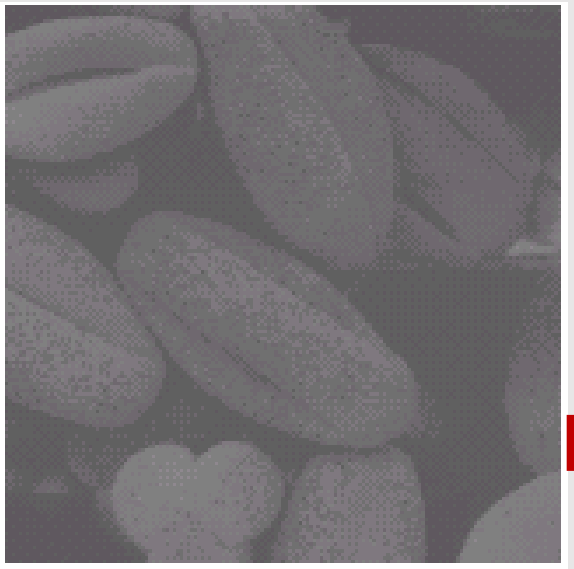


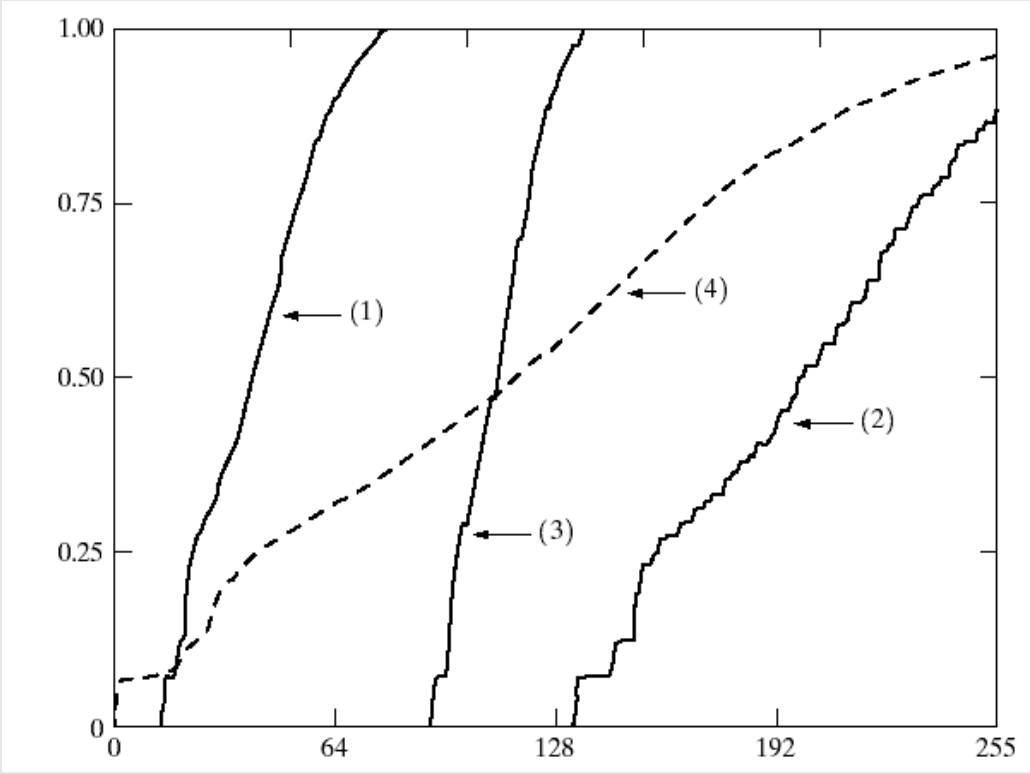


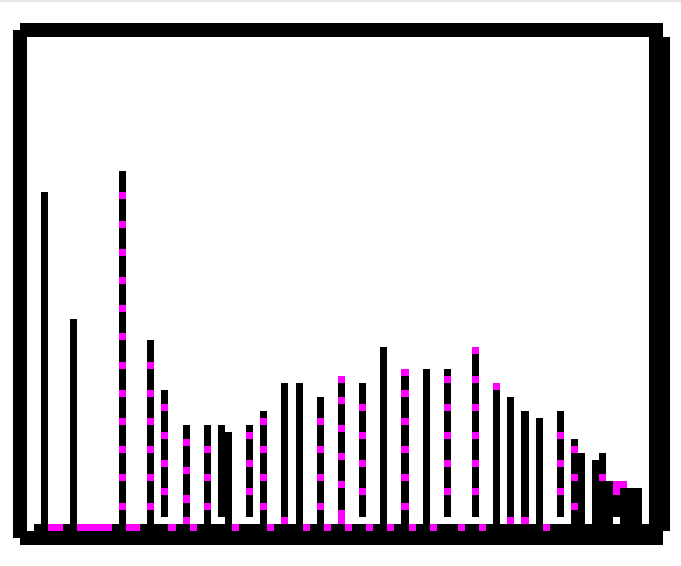
The function 2 was used to equalise the bright image



Histogram Equalisation Examples

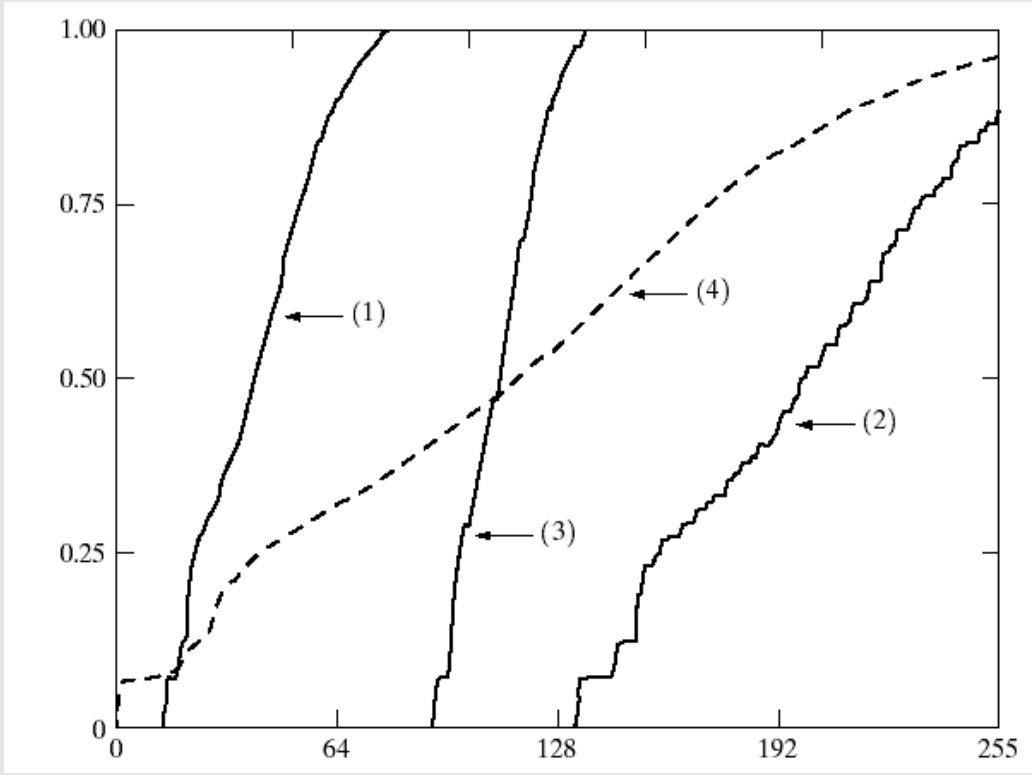






The function 3 was used to equalise the image

Histogram Equalisation Examples



The function 4 was used to equalise the image

Summary

We have looked at:

- Different kinds of image enhancement
- Histograms
- Histogram equalisation

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

Suggestions

Now you should:

- Play in different images
- Do Histograms of images
- Do Histogram equalisation