

U2.2 Image Enhancement

SJK002 Computer Vision

Master in Intelligent Sytems



- Gray level changes
- Enhancement
- Histograms
- Histogram changes:
 - Adaptive equalization (window-based)
- LUTs – Look Up Tables
- Examples of enhancement and LUT transformations

Gray level changes

Image contrast change:

Objective: better image visualization

- Make image darker/clearer
- Bring image gray levels to a more convenient range

Most usual functions:

(m: original gray level, p: new gray level)

- Invert: $p = 255 - m$
- Make darker: $p = \frac{m^2}{255}$ $p = \frac{m^3}{255^2}$
- Make clearer: $p = \sqrt{255m}$ $p = \sqrt[3]{255^2 m}$

Gray level changes



Original



Inverted



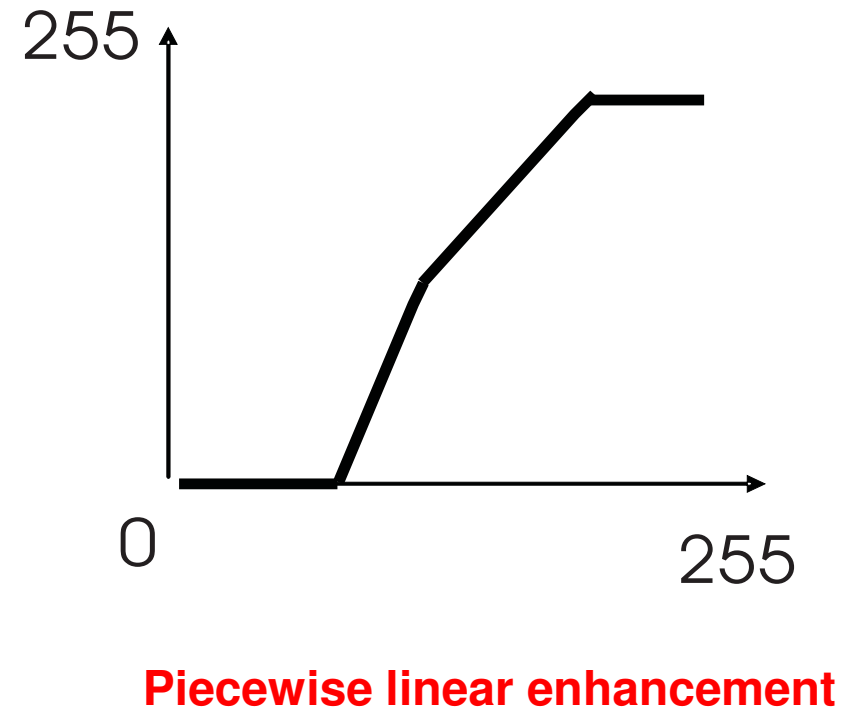
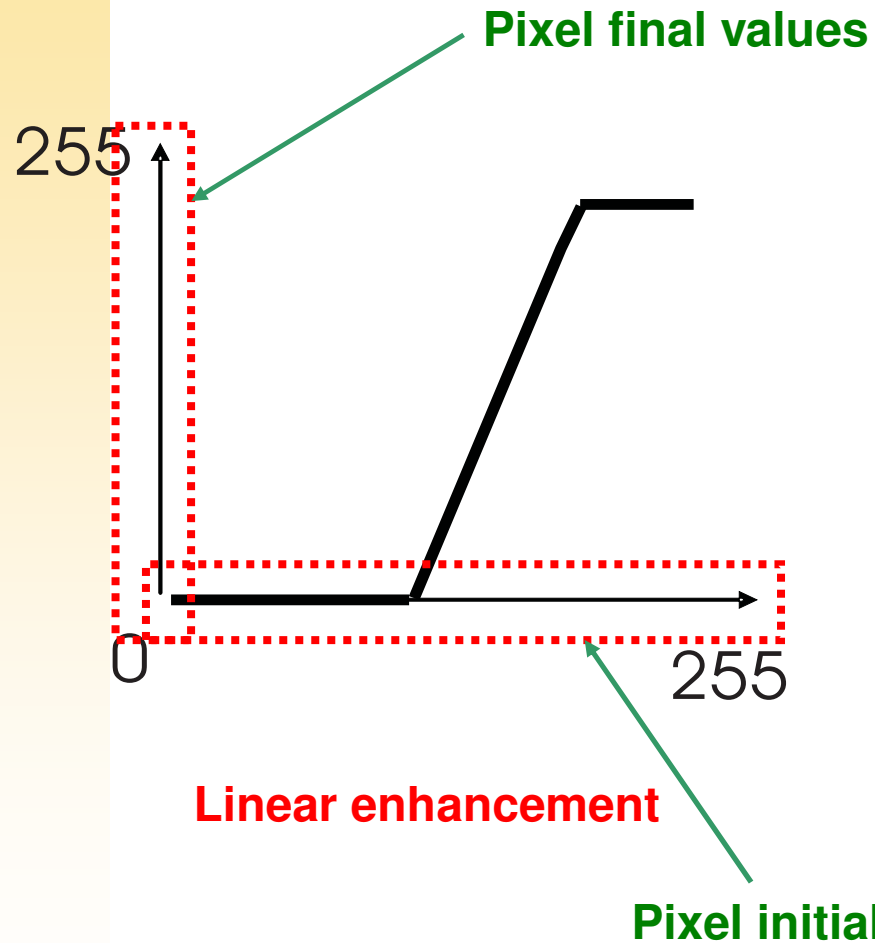
Darker



Clearer

$$p = \sqrt{255m}$$

Enhancement



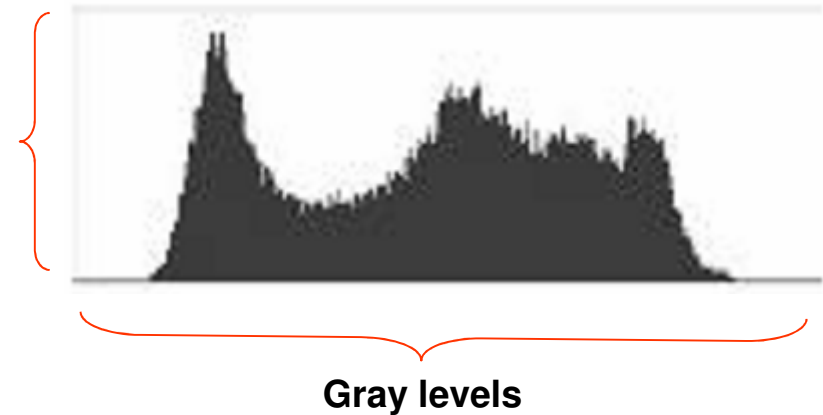
Histogram

Histogram: number of occurrences of each gray level in the image

- Allows to analyze the image **gray level distribution**.
- **Probability density function** of gray levels.

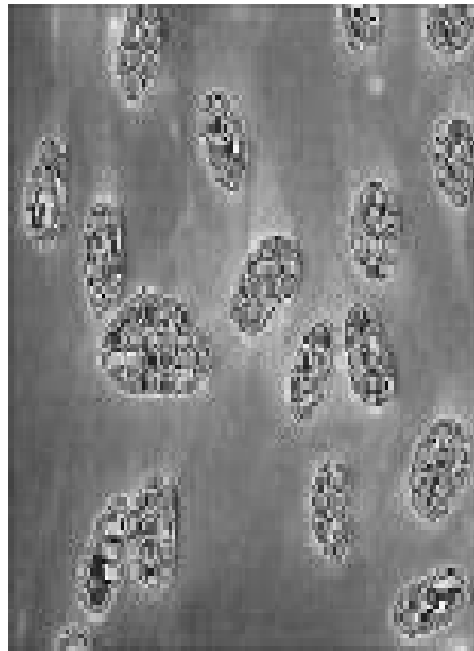


Number of pixels of each gray level

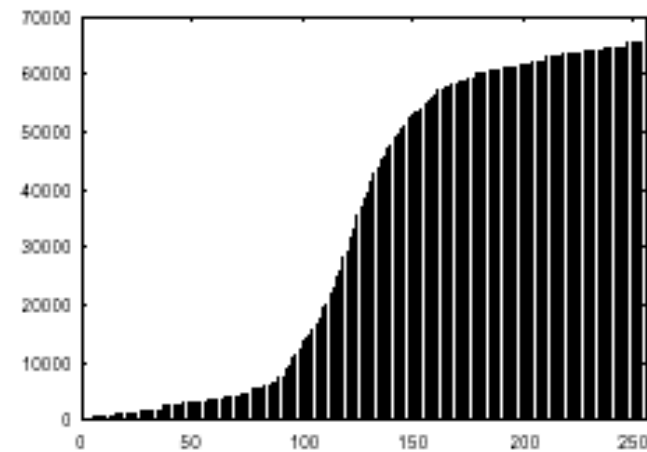
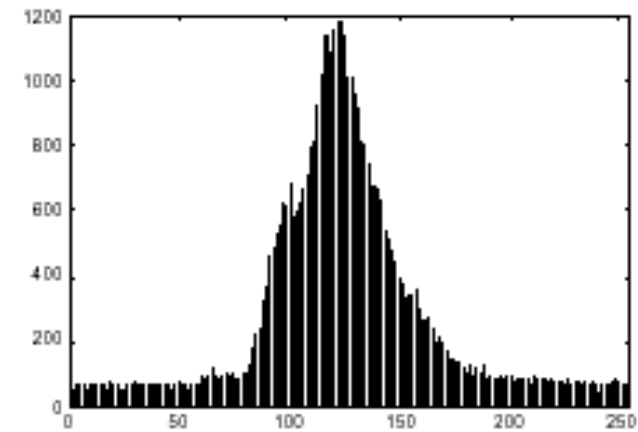


Cummulated histogram

Image



Histogram



Cummulated histogram

Histogram equalization

Objective: Distribute the existing gray levels in the whole available gray level range.

Idea: Approximate the image histogram by flat histogram. That is, the cummulated histogram is approximately a straight line.

Sustitution:

$$factor = \frac{NM}{G} \quad p = integer\ part \left\{ \frac{H(m)-1}{factor} \right\}$$

m: original gray level

p: new gray level

H(m): cummulated histogram

G: Niveles de gris en la image gray levels

N, M: image size

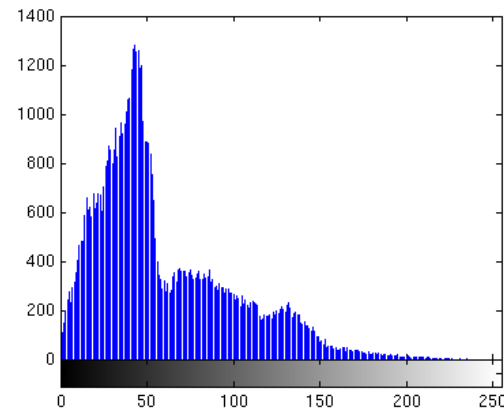
Histogram equalization



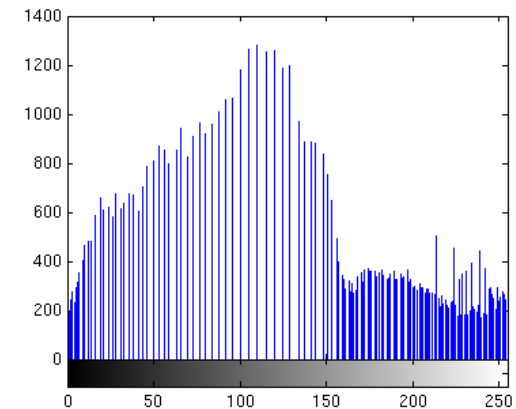
Original



Equalized



Original
histogram



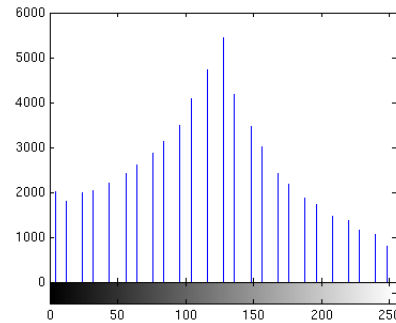
Equalized
histogram

Histogram equalization

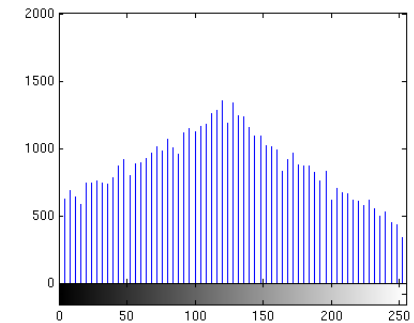
- Adaptive equalization (window-based)



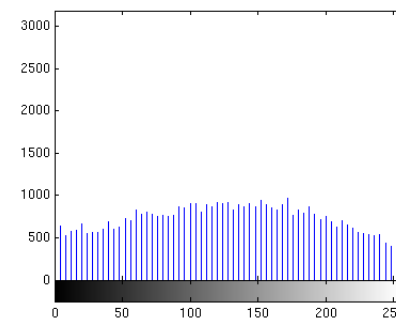
5x5



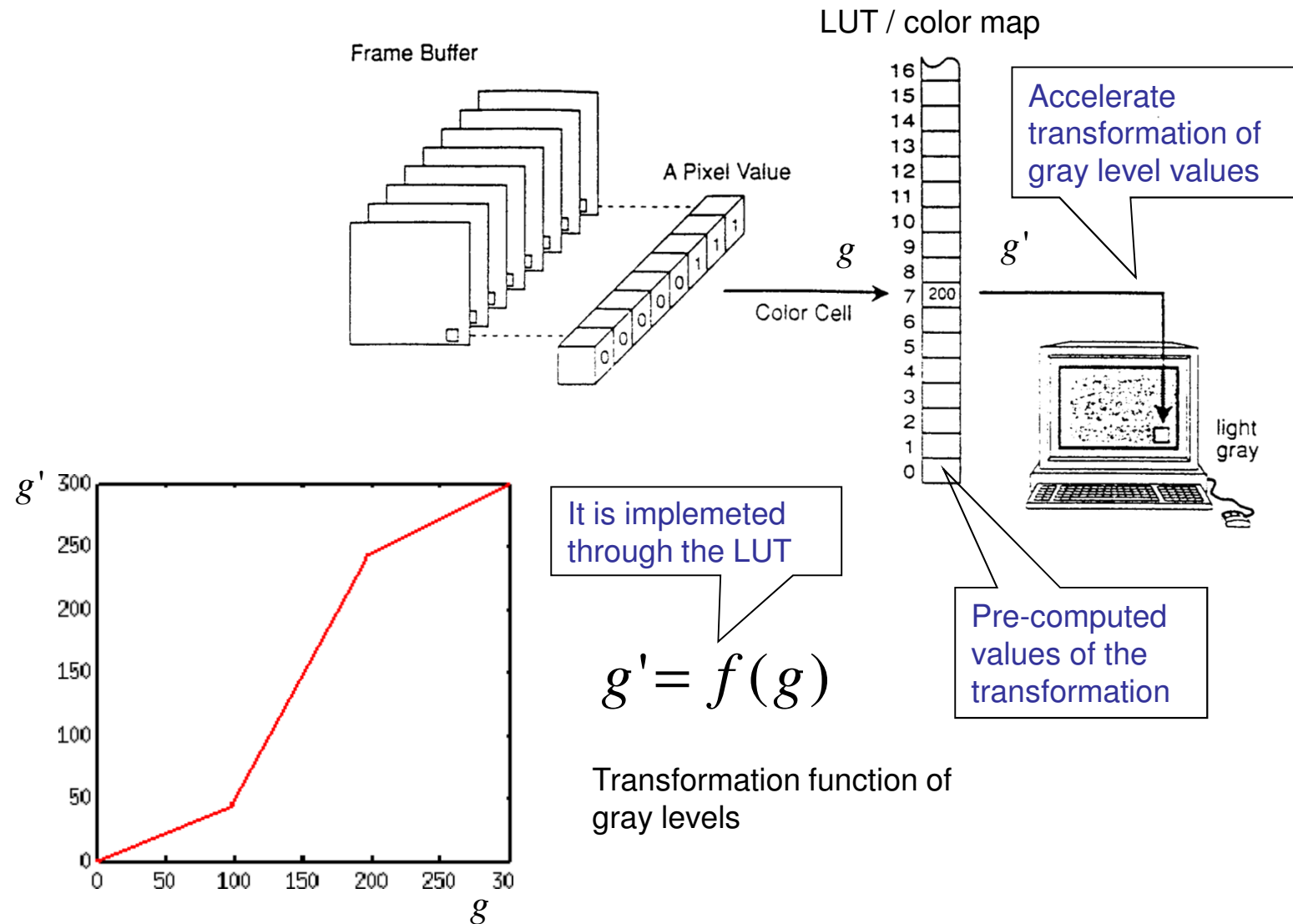
21x21



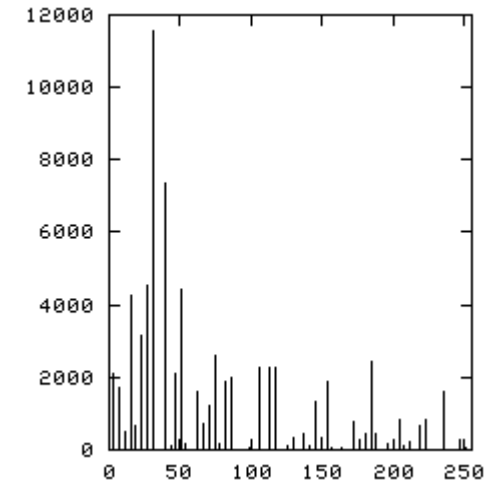
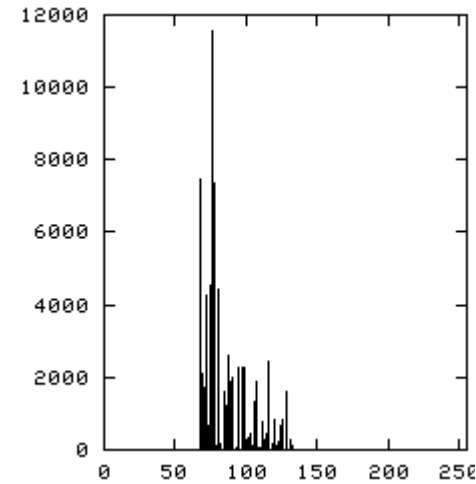
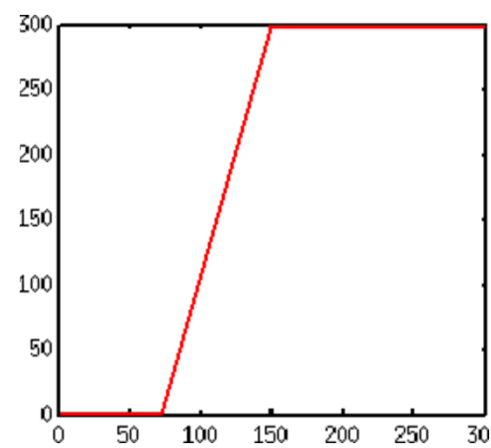
41x41



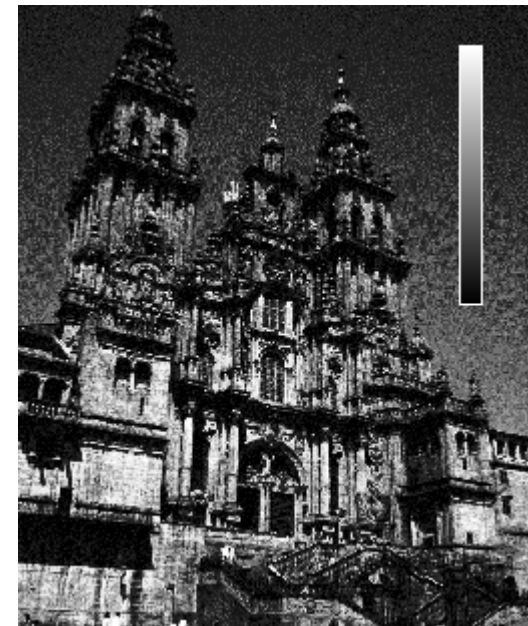
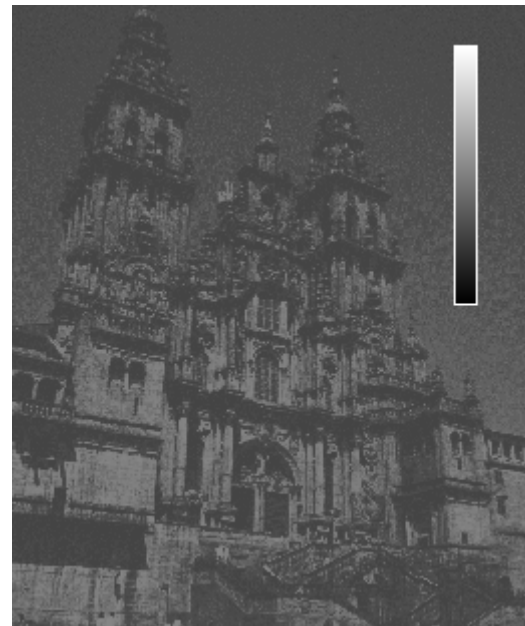
LUTs – Look Up Tables



Contrast enhancement

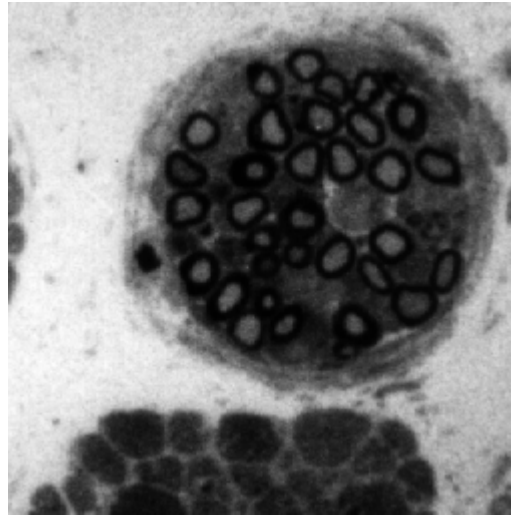


Original
image

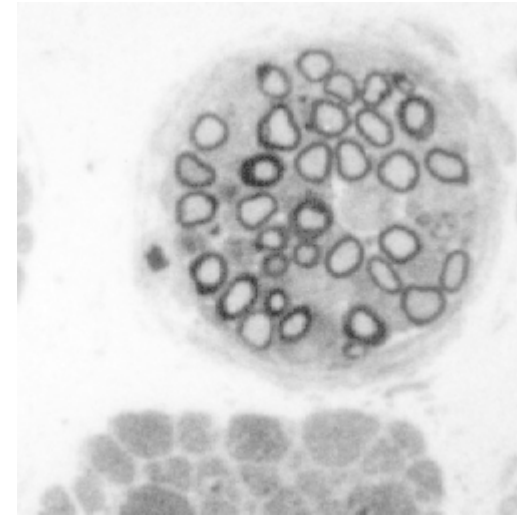


Enhanced
image

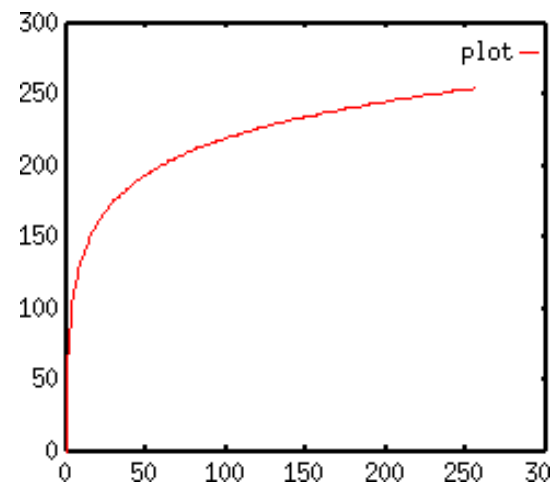
Logarithmic enhancement



Original image

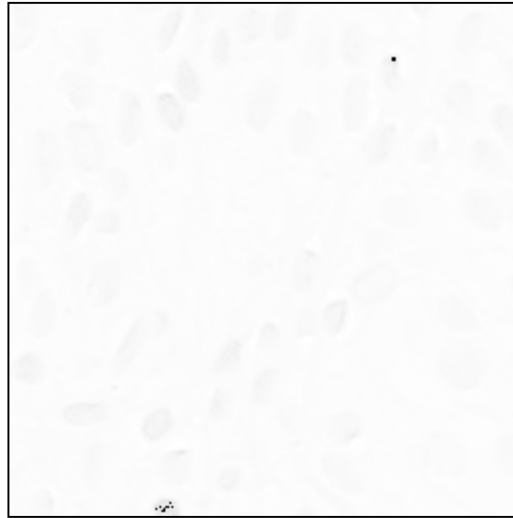


Enhanced image

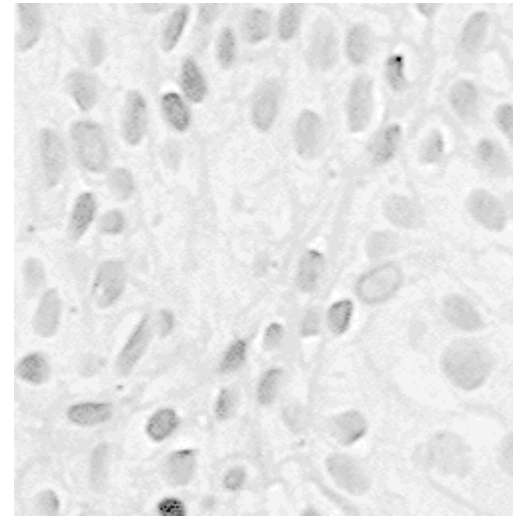


Logarithmic
transformation of
gray levels

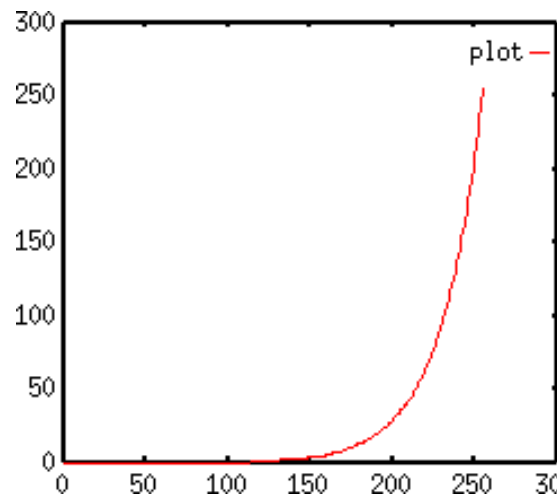
Exponential transformation



Original image

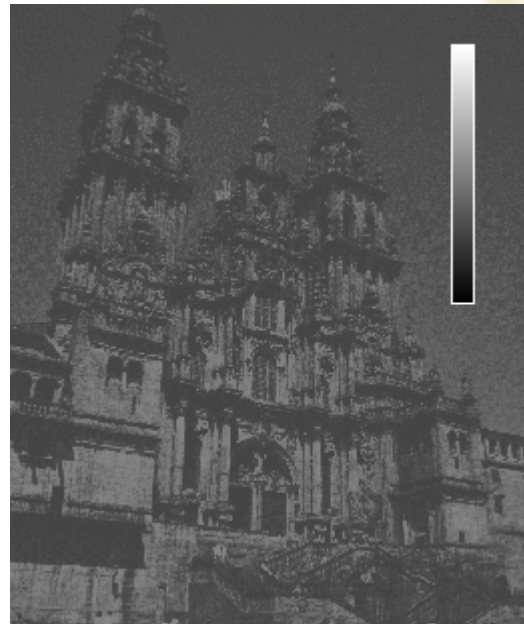


Enhanced image

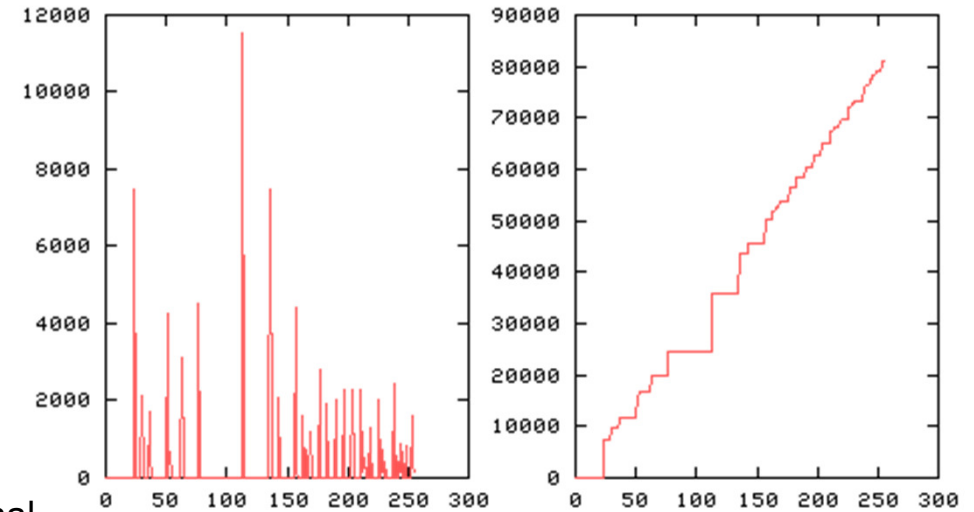


Exponential
transformation of
gray levels

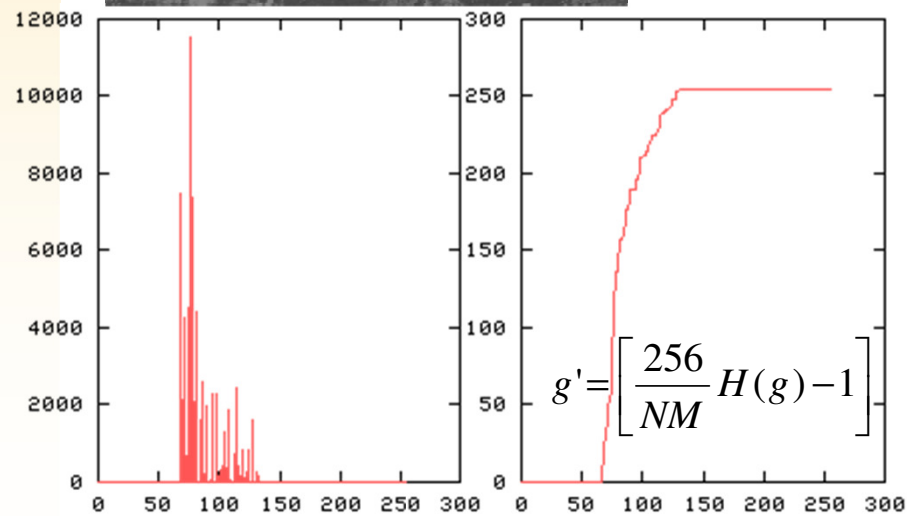
Histogram equalization



Original image



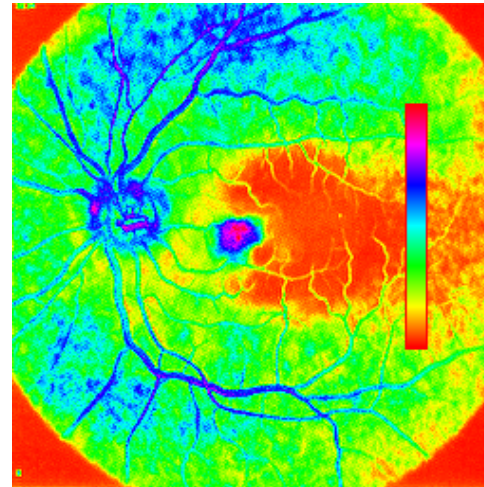
Enhanced image



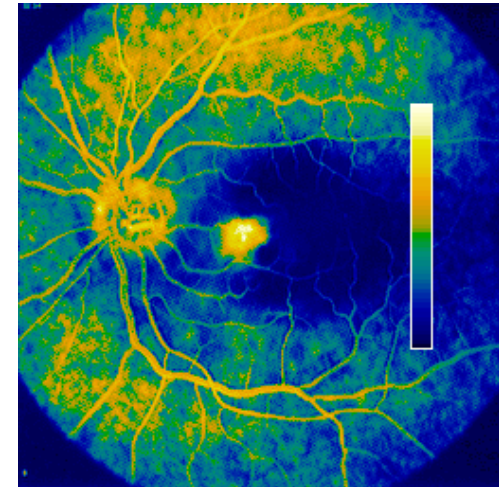
Pseudocolor



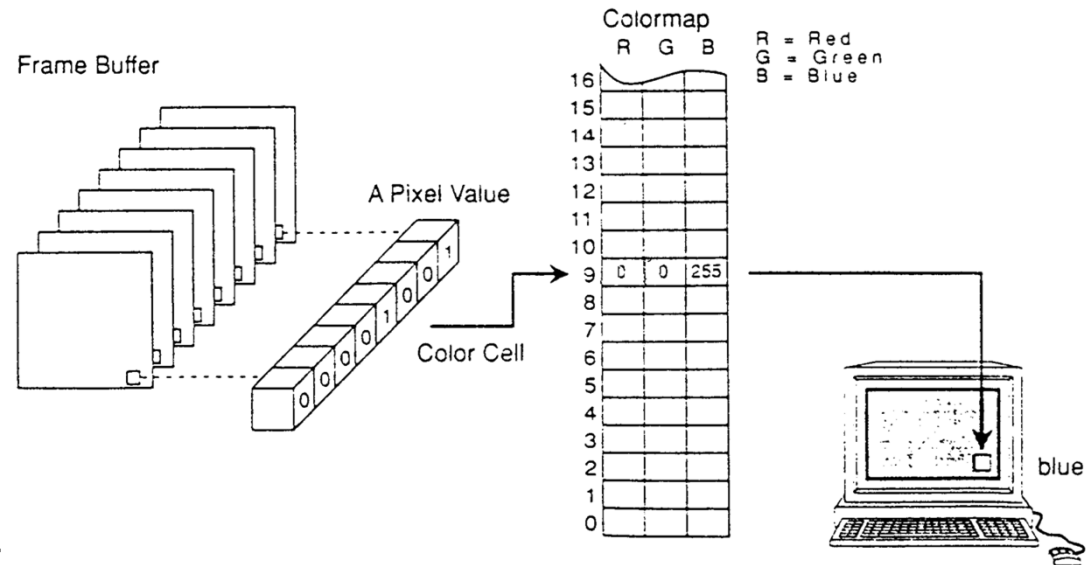
Gray level original image



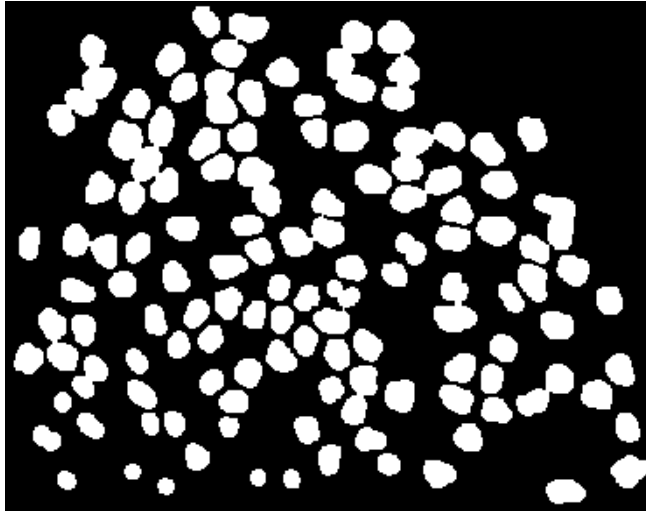
Pseudocolor image



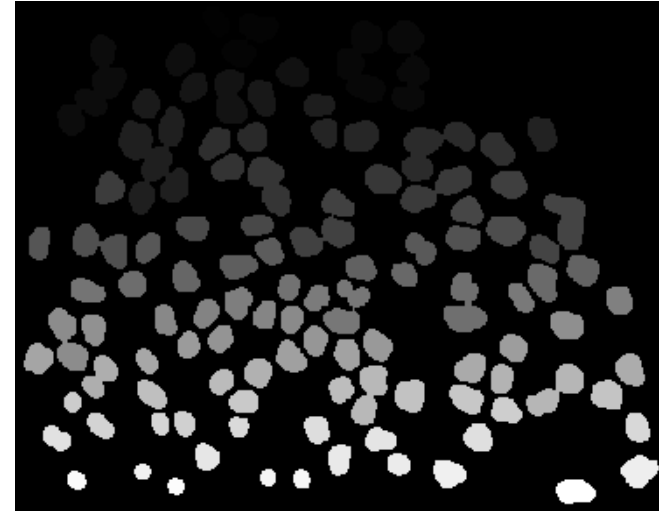
Pseudocolor image



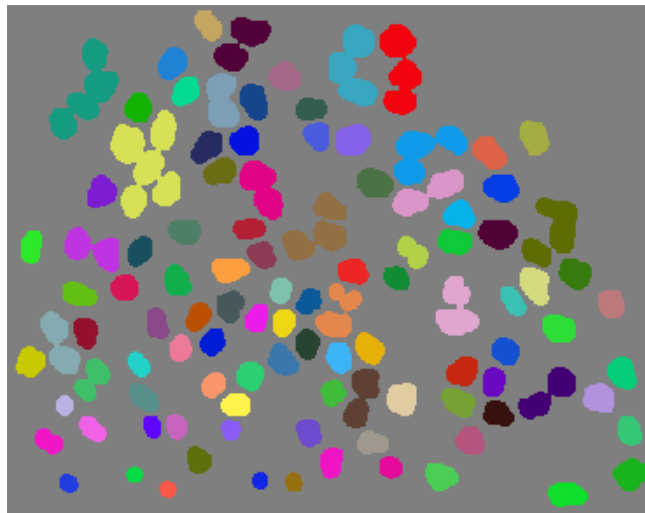
Features visualization



Binary image



Connected
components in
gray levels



LUT with color map to
differentiate among
connected components.

Bibliography

- Visión por Computador, fundamentos y métodos. Arturo de la Escalera, Prentice-Hall, 2001. Capítulo 5.
- Image Processing. The Fundamentals. Maria Petrou and Panagiota Bosdogianni. Wiley, 1999. Capítulo 4.