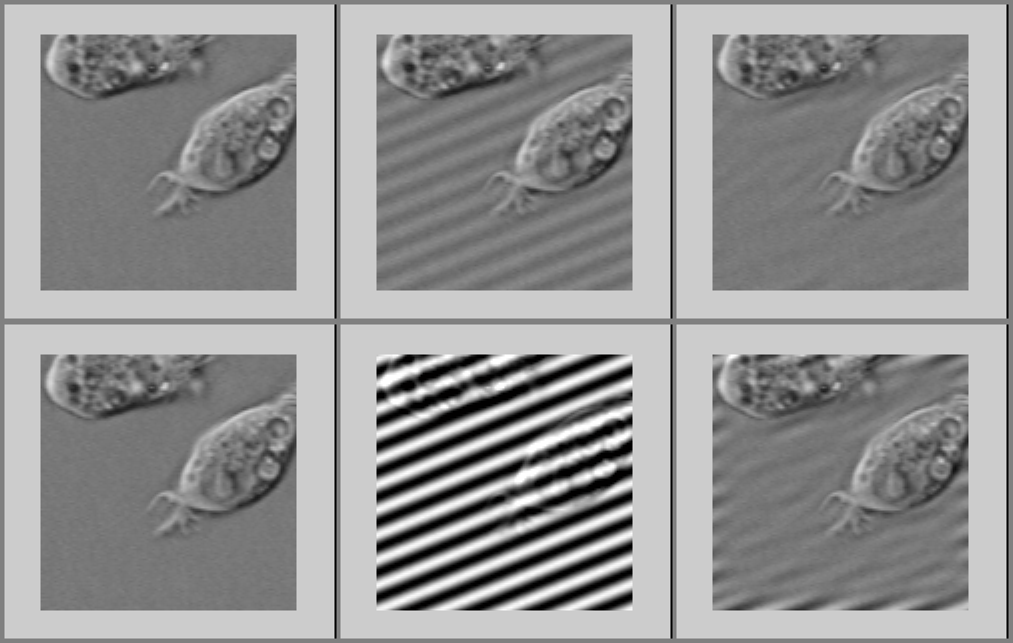
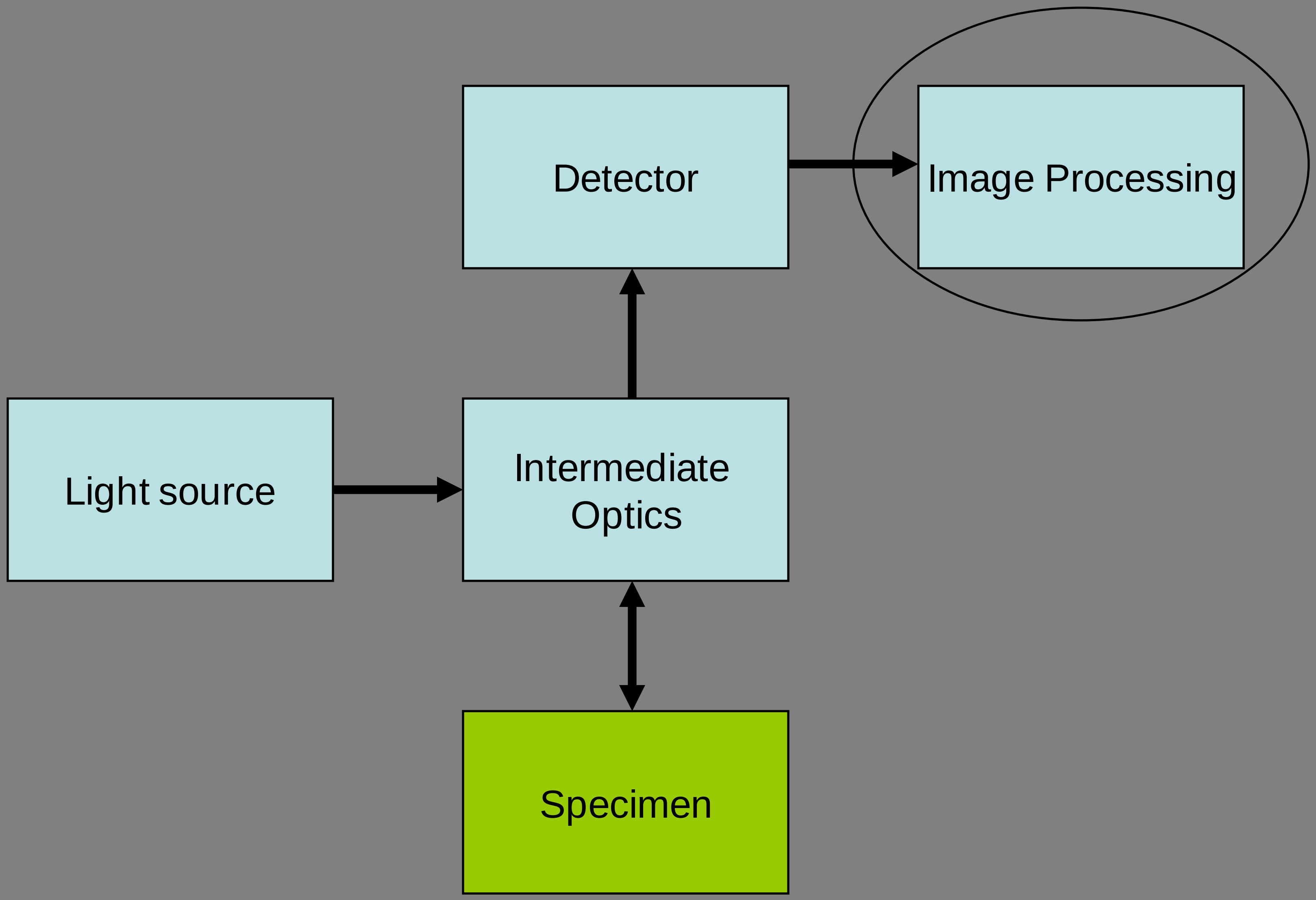
Image Processing and Analysis I



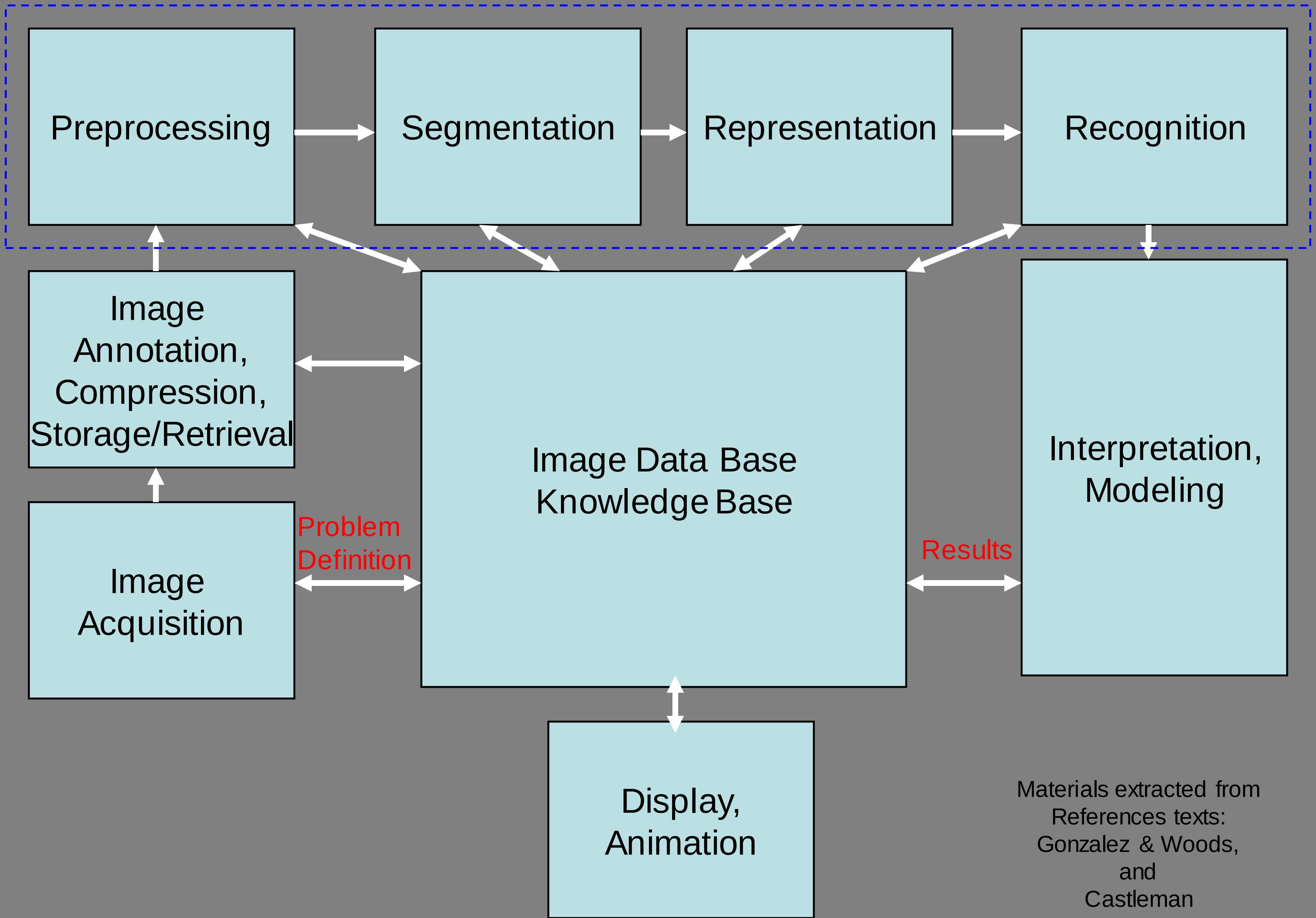
Materials extracted from Gonzalez & Wood
and Castleman

A typical biomedical optics experiment



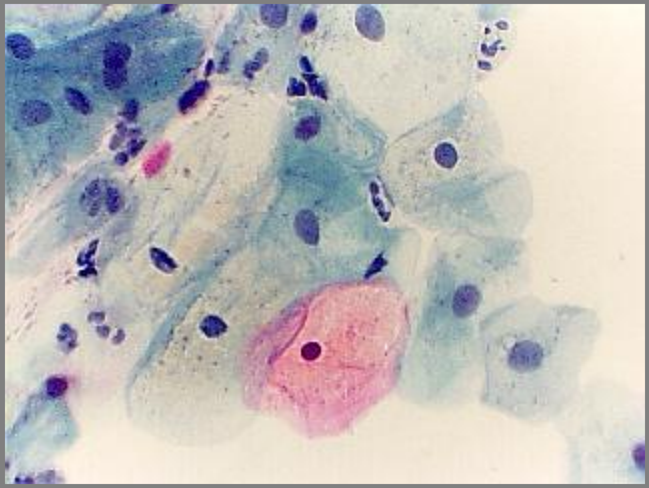
Digital Image Processing

A process to extract information from image data

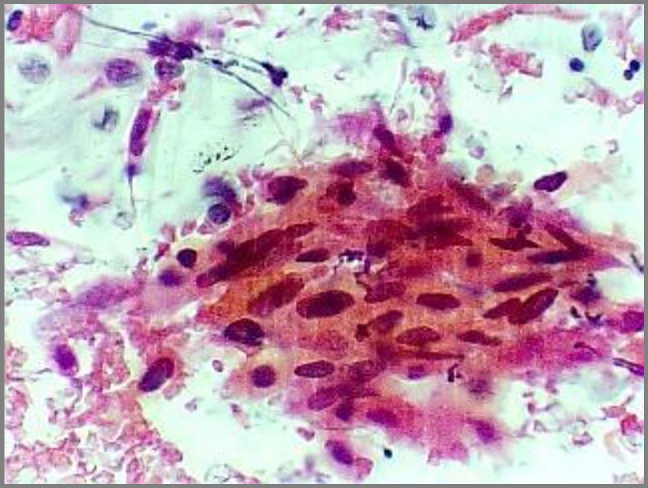


Materials extracted from References texts: Gonzalez & Woods, and Castleman

Image Processing Example 1 – Pap Smear



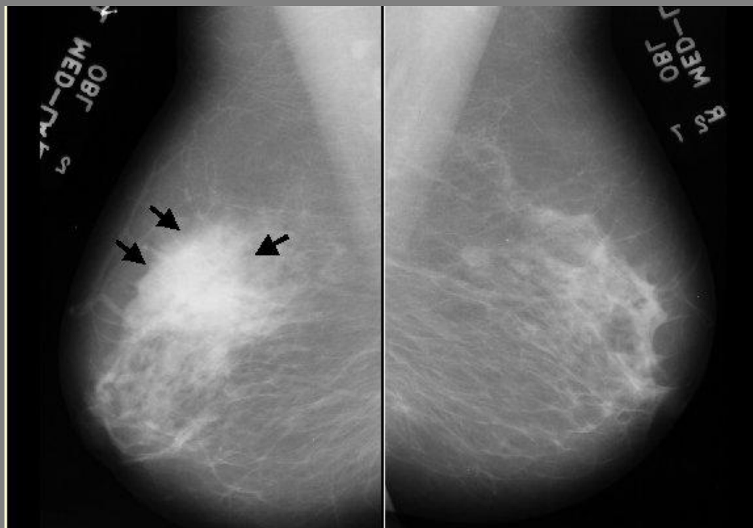
Benign Squamous Cells

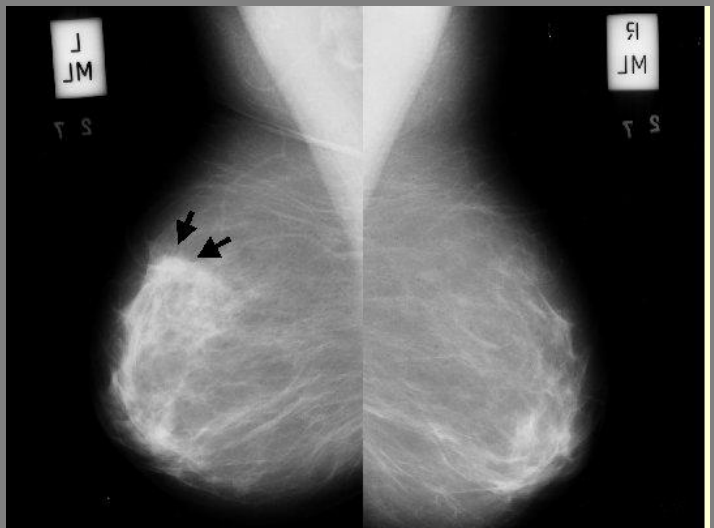


Squamous Cell Carcinoma

One of the few histopathological tasks
where image recognition system is becoming commercial

Image Processing Example 2 – Breast X-Ray





The distinction between benign and malignant can be difficult for breast x-ray
Radiologist are highly trained in image recognition

Most biomedical imaging today does not address underlying
molecular and cellular based mechanisms

Image Data Base – Format and Data Base

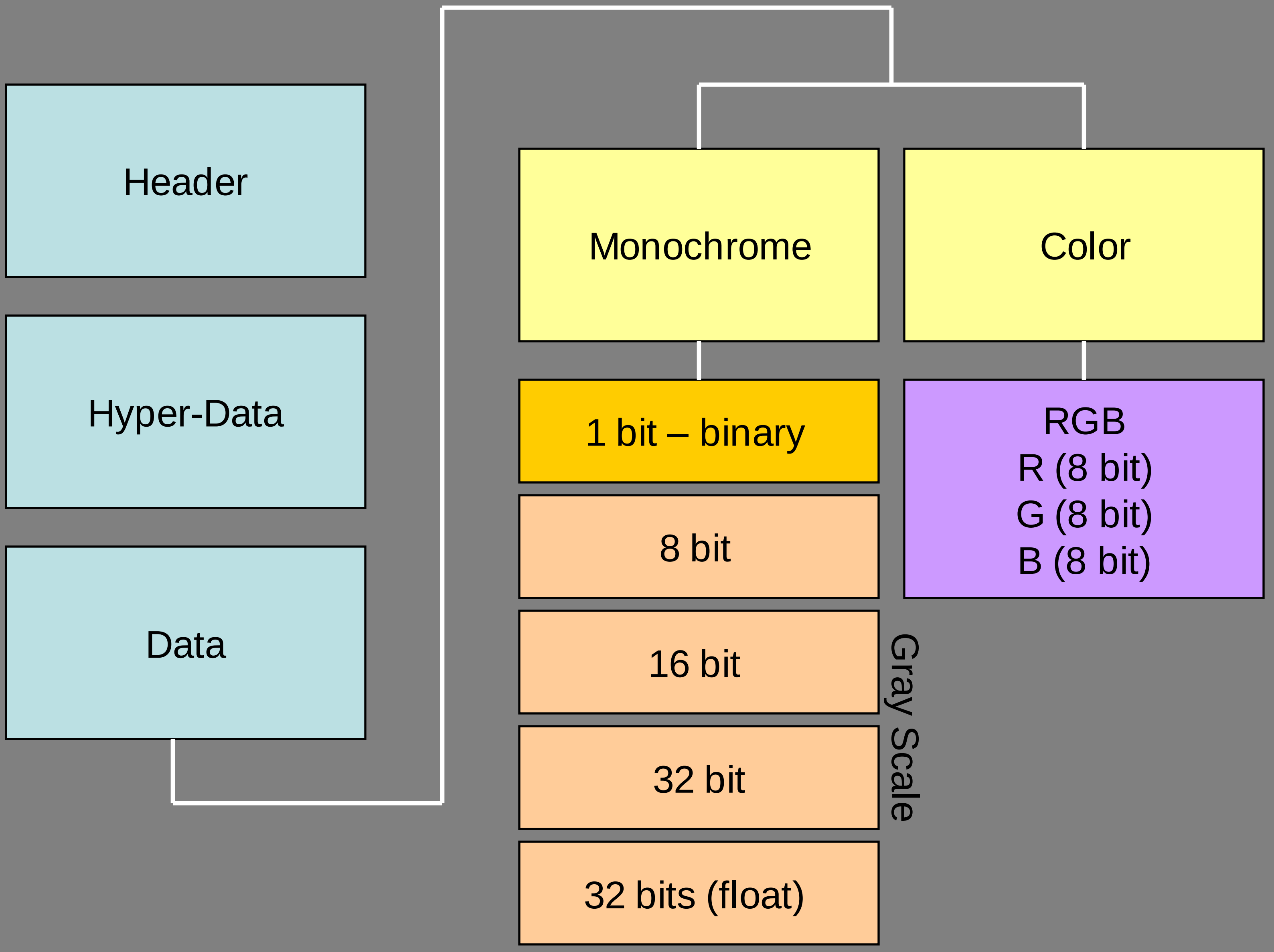
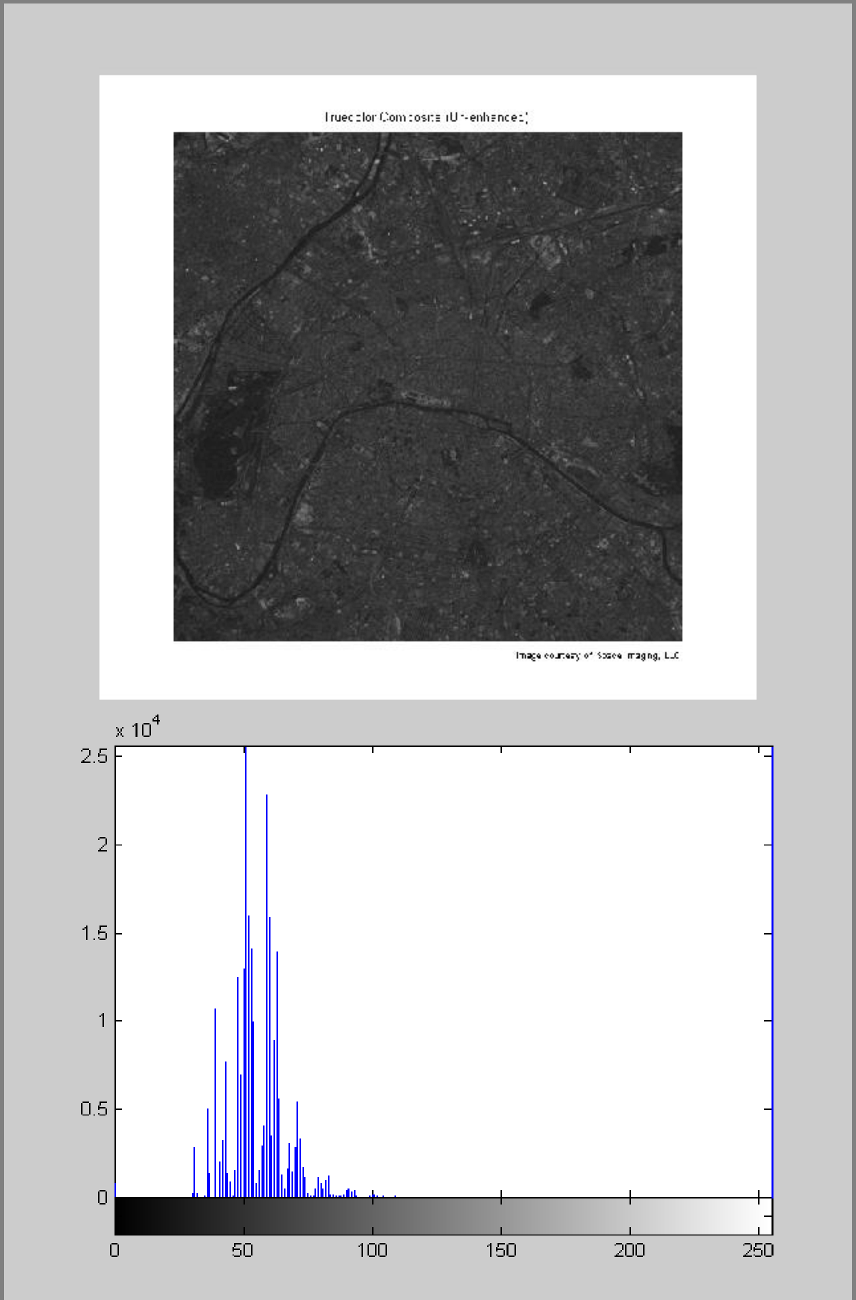


Image Preprocessing – histogram and contrast



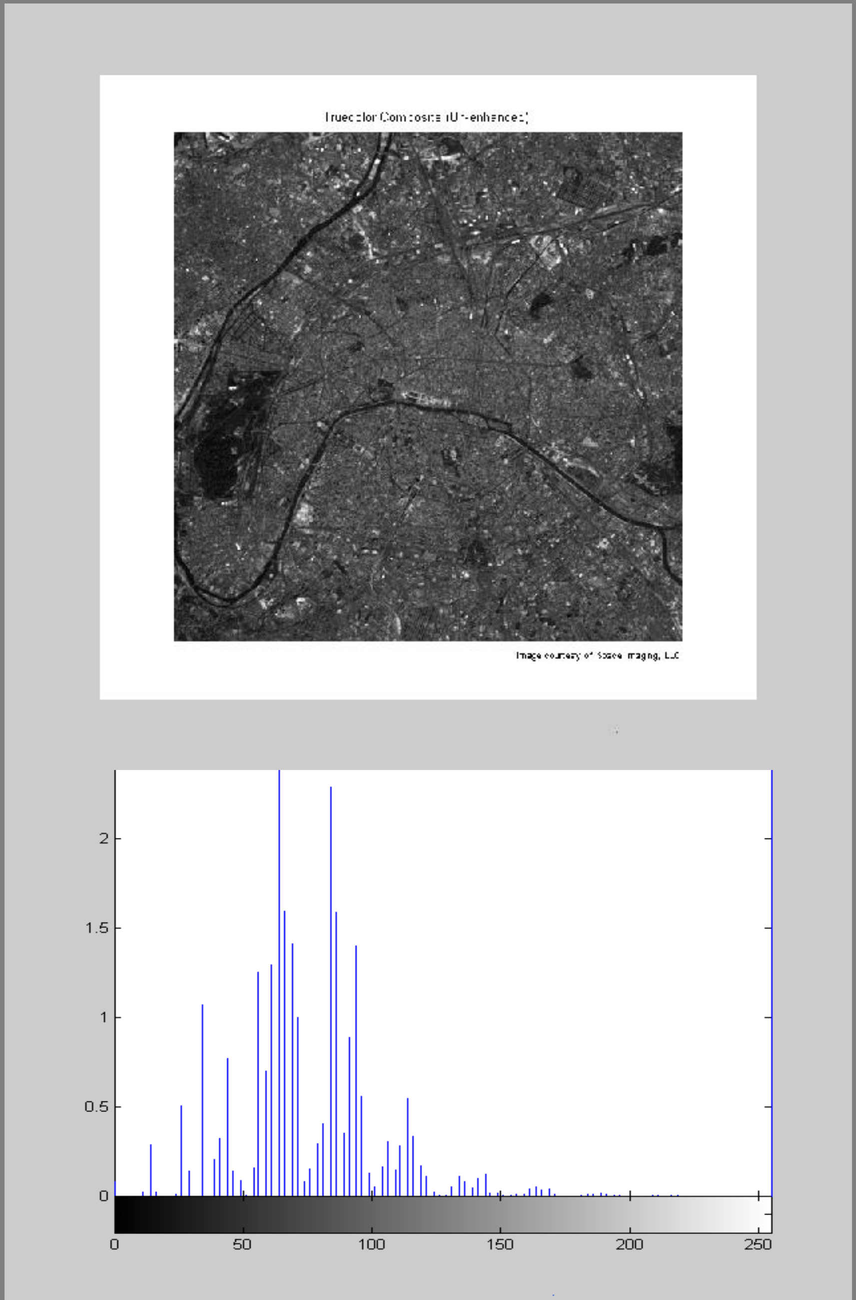


Image Preprocessing – histogram equalization

Let r be the gray level value of a pixel in the image.

$r \in [0,1]$; Map each gray level value r to a new value s: $s = T(r)$

The histogram distribution of the original image is: $P_r(r)$

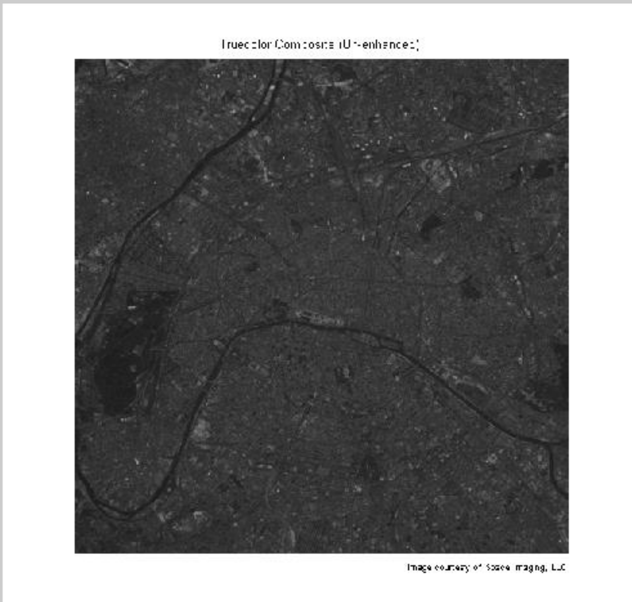
The histogram distribution of the new image is: $P_s(s)$

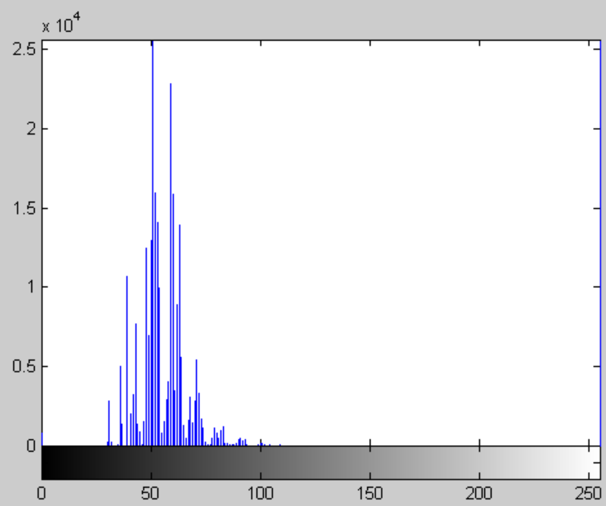
In general: $P_s(s) = [p_r(r)\frac{dr}{ds}]_{r=T^{-1}(s)}$

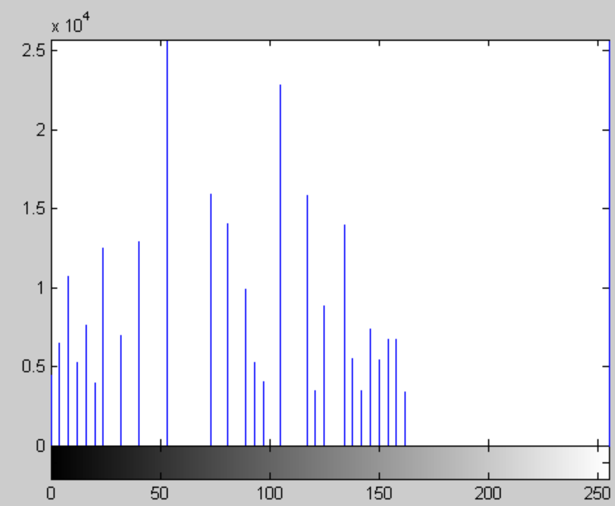
Histogram equalization is defined as the transform: $s = T(r) = \int_0^r p_r(w)dw$

Since $\frac{ds}{dr} = P_r(r)$, $P_s(s) = 1$ for histogram equalization

Image Preprocessing – histogram and contrast





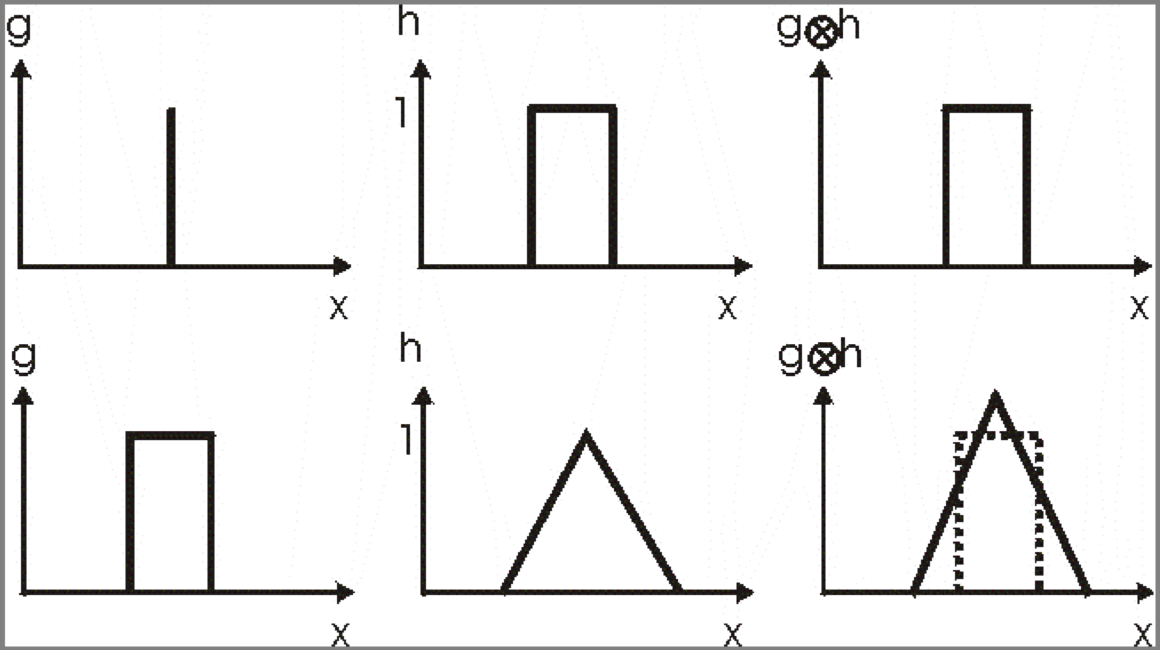


Convolution and Image Processing

Recall the definition of convolution:

$$g(t) \otimes h(t) = \int_{-\infty}^{\infty} g(\tau) h(t-\tau) d\tau$$

Graphical explanation of convolution:



Convolution Theorem

$$\Im(g \otimes h)(f) = \tilde{g}(f)\tilde{h}(f)$$

$$\int_{-\infty}^{\infty} g \otimes h(t) e^{-i2\pi ft} dt = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} g(\tau) h(t-\tau) d\tau e^{-i2\pi ft} dt$$

$$= \int_{-\infty}^{\infty} d\tau g(\tau) e^{-i2\pi f\tau} \left(\int_{-\infty}^{\infty} dt h(t-\tau) e^{-i2\pi f(t-\tau)} \right)$$

$$= \int_{-\infty}^{\infty} d\tau g(\tau) e^{-i2\pi f\tau} \left(\int_{-\infty}^{\infty} dt' h(t') e^{-i2\pi f(t')} \right)$$

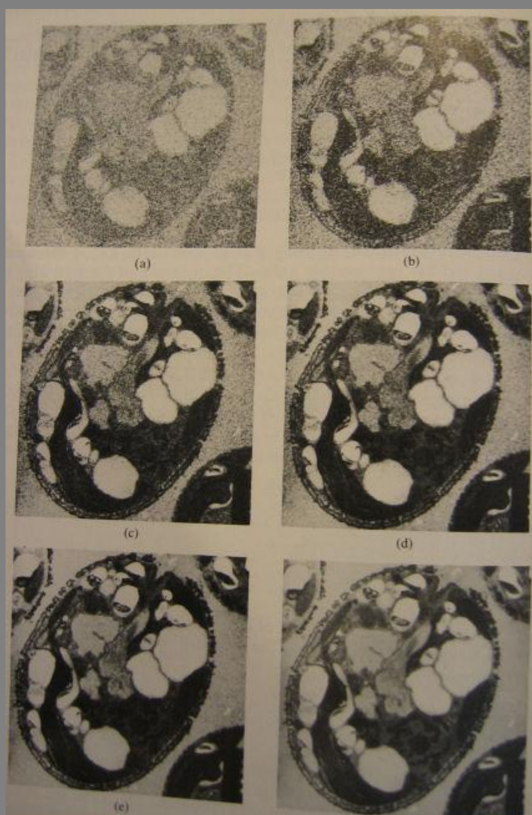
$$= \tilde{g}(f)\tilde{h}(f)$$

where $t' = t - \tau \quad dt' = dt$

Image Preprocessing –
Noise Reduction, averaging, low pass filter, median filter

Averaging M images reduce noise by sqrt(M)

$$\sigma_M = \frac{1}{\sqrt{M}}\sigma_1$$



Avg by 2,8,16,32,128

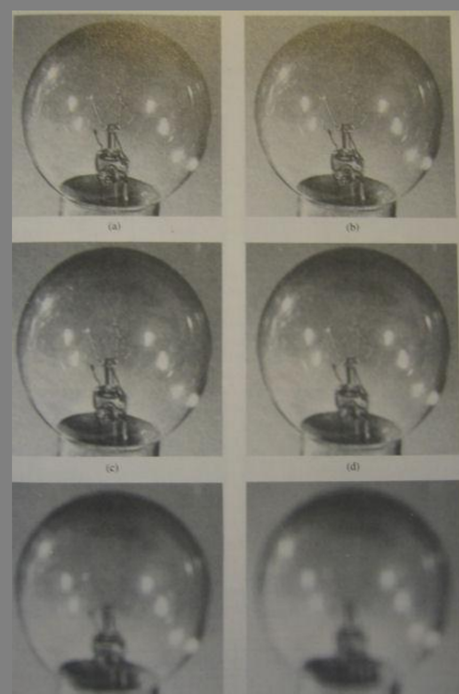
Low Pass Filter

3x3 kernel

$$\frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$$

5x5 kernel

$$\frac{1}{25}\begin{bmatrix}1 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 1\\ 1 & 1 & 1 & 1 & 1\end{bmatrix}$$



Kernel 3,5,7,15,25

Median Filter

Replace center pixel value by the median value from a nxn pixel neighorhood

$$\begin{bmatrix}7 & 12 & 10\\ 6 & 9 & 12\\ 8 & 10 & 200\end{bmatrix}$$

Avg = 30; Median =10

5x5 low pass vs median