Digital Image Processing – problems, methods and applications

Paweł Forczmański

Agenda

1. organization
2. bibliography
3. introduction to DIP
4. other

Bibliography

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R. C. Gonzalez, P. Wintz: *Digital Image Processing. Second Edition*. Addison Wesley Publ. Comp., Reading, MA., 1987.

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D. Ballard and C. Brown *Computer Vision*, Prentice-Hall, New York, 1982.

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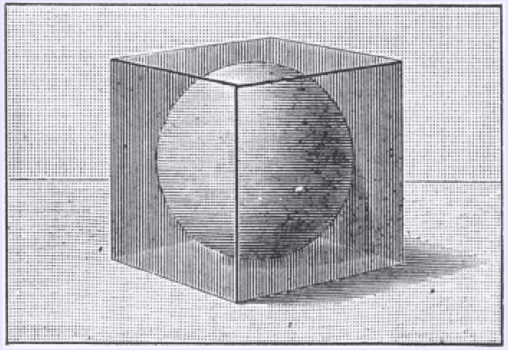
A.Bovik (ed.), *Handbook of Video & Image Processing*, Academic Press, London 2000

Lab

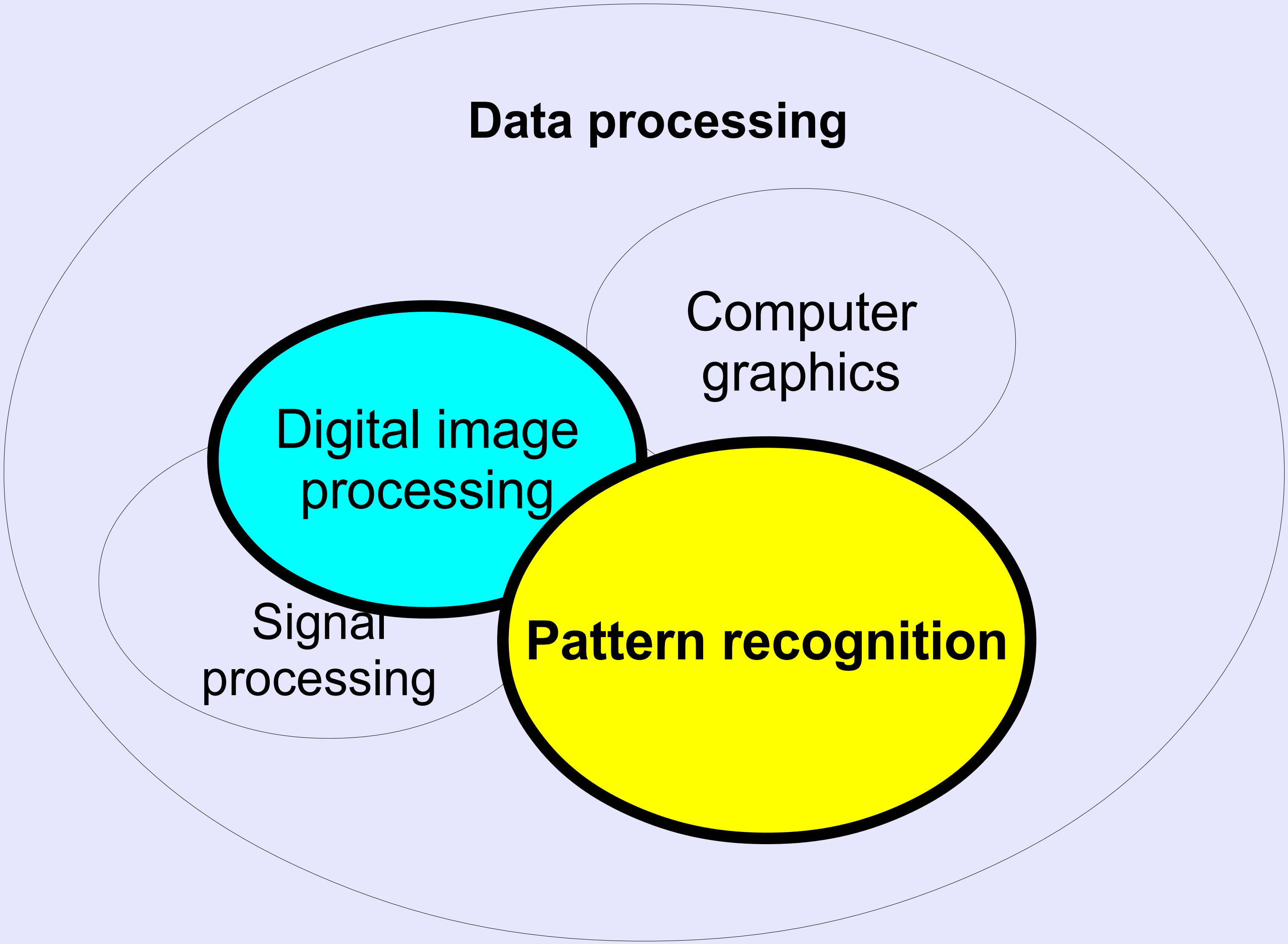
The main aim of Laboratory is to practise dip programming



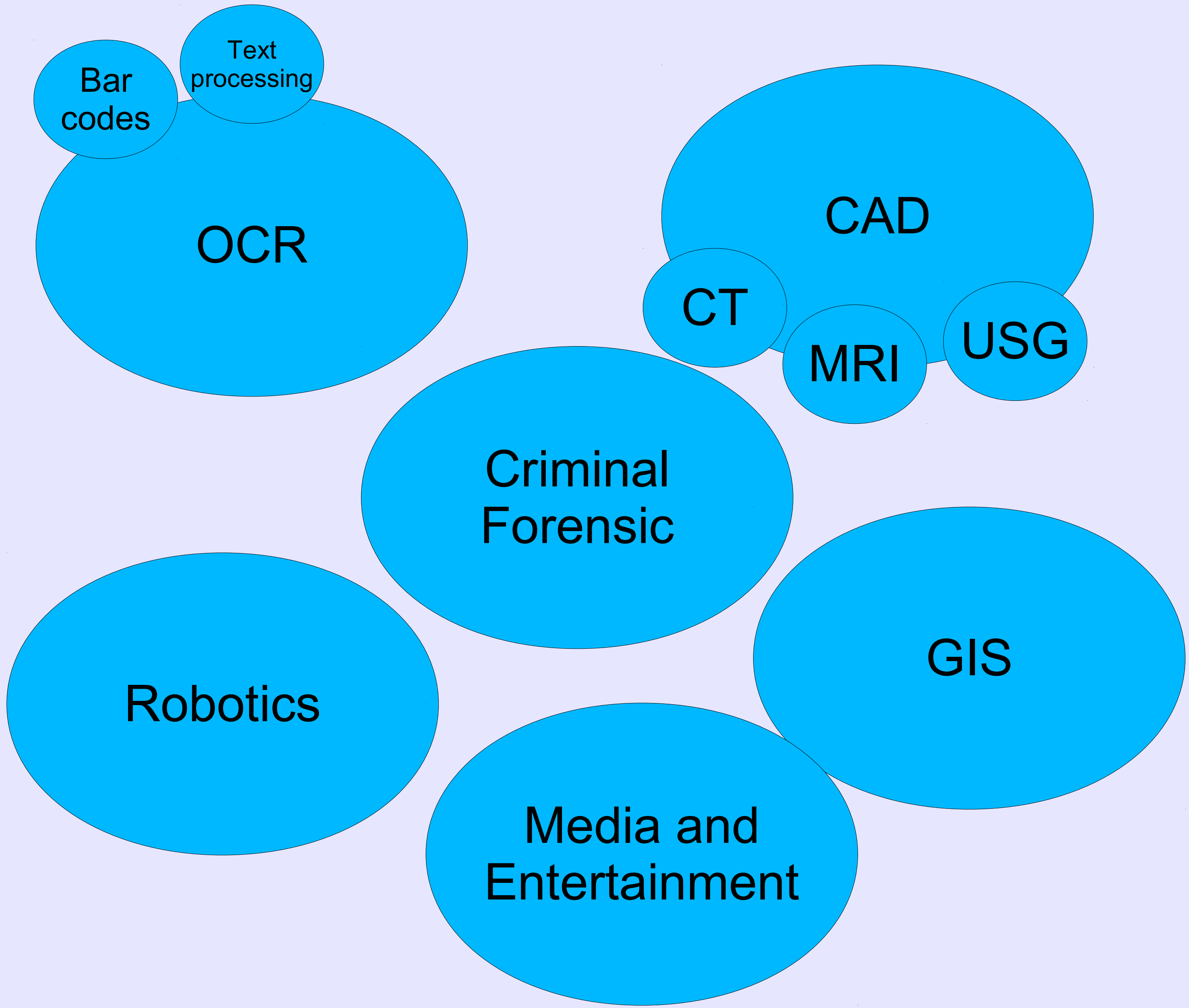
Contents:

- Introduction to Matlab
- Simple image characteristics
- Imaging and image pre-processing (demosaicing)
- Histogram
- Convolution
- Fourier spectrum and its applications

Introduction



Applications



Objectives

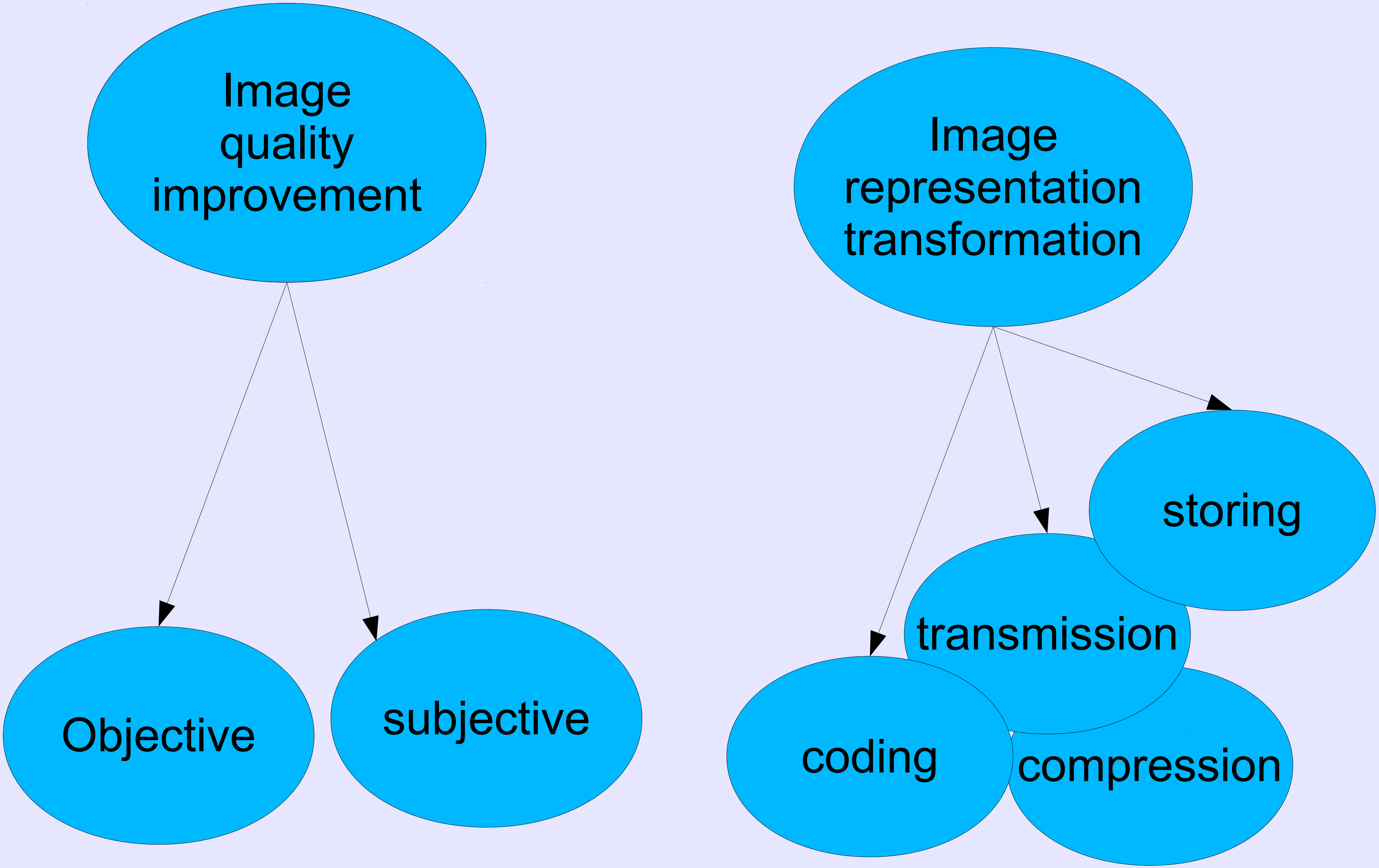


Image quality improvement
Objective
subjective
Image representation transformation
storing
transmission
coding
compression

DIP scheme

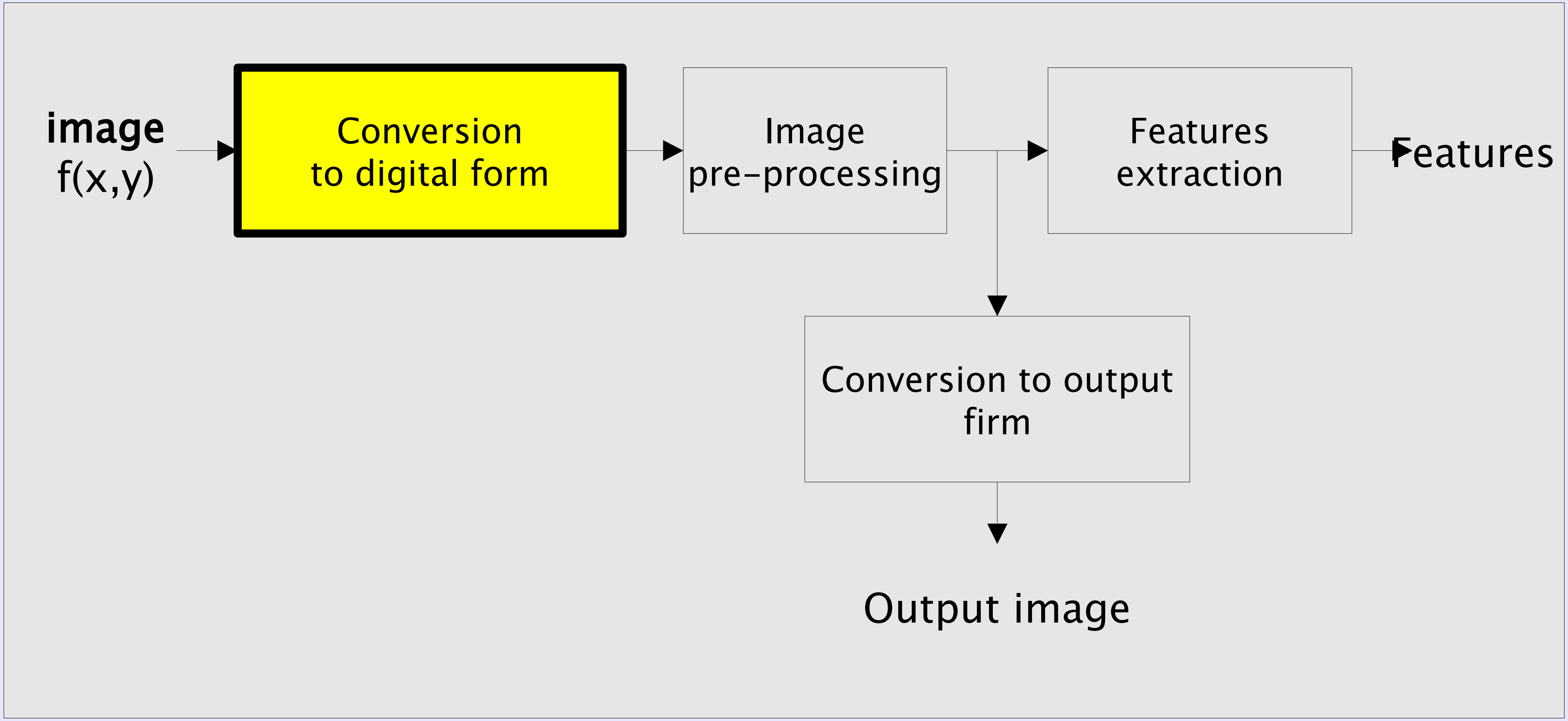
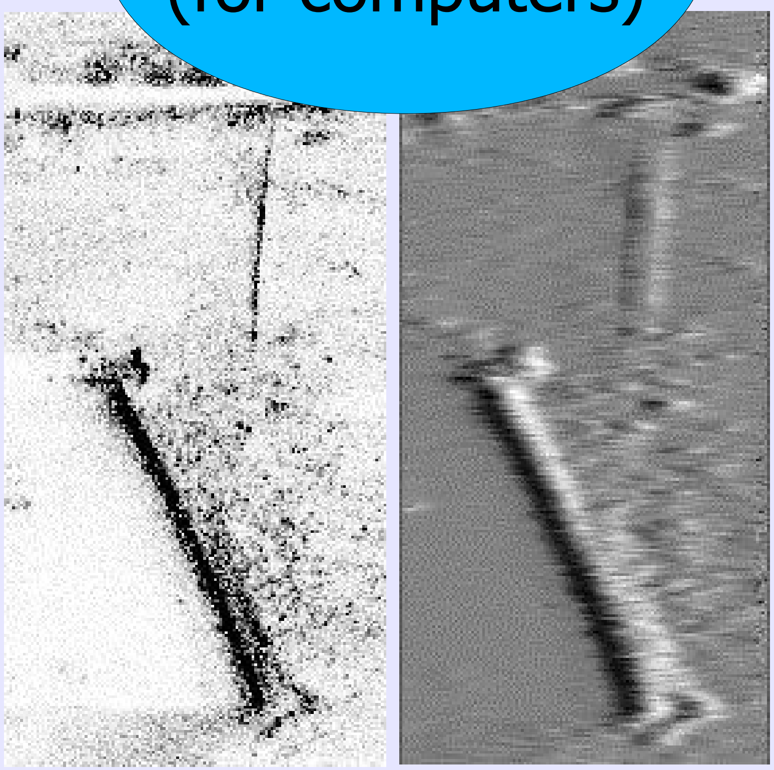


image
f(x,y)
Conversion
to digital form
Image
pre-processing
Features
extraction
Features
Conversion to output
firm
Output image

Quality improvement

Objective
(for computers)



subjective
(for humans)

Image features

Example of featrures extracted from images:

Intensity histogtogrtam,

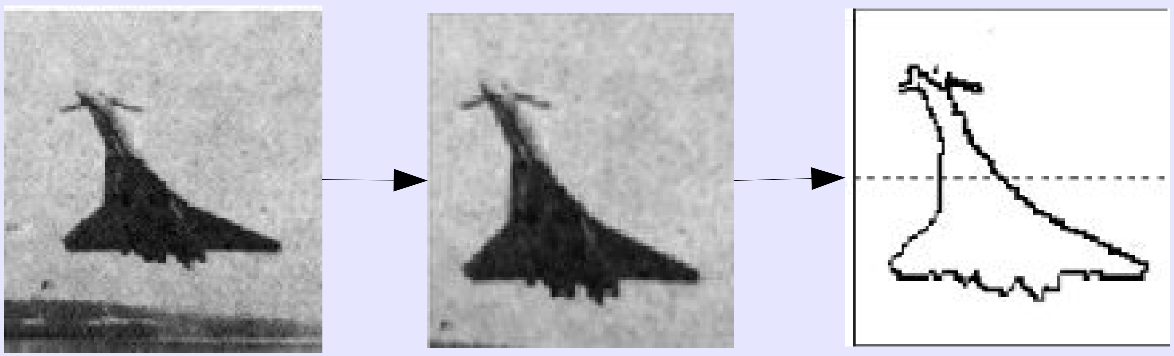
Statistical features (mean, dispersion),

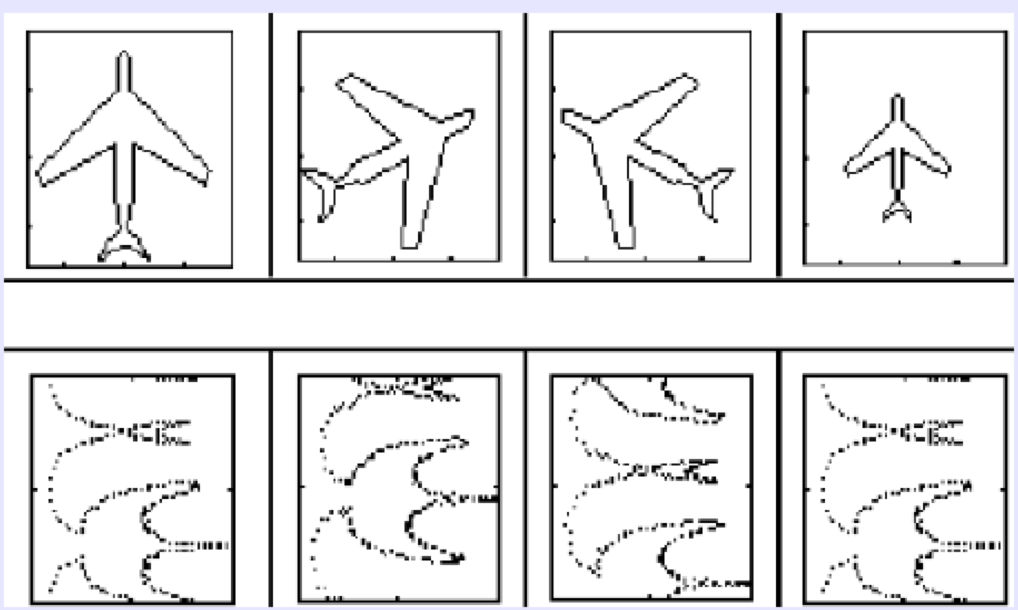
Spectrum (FFT),

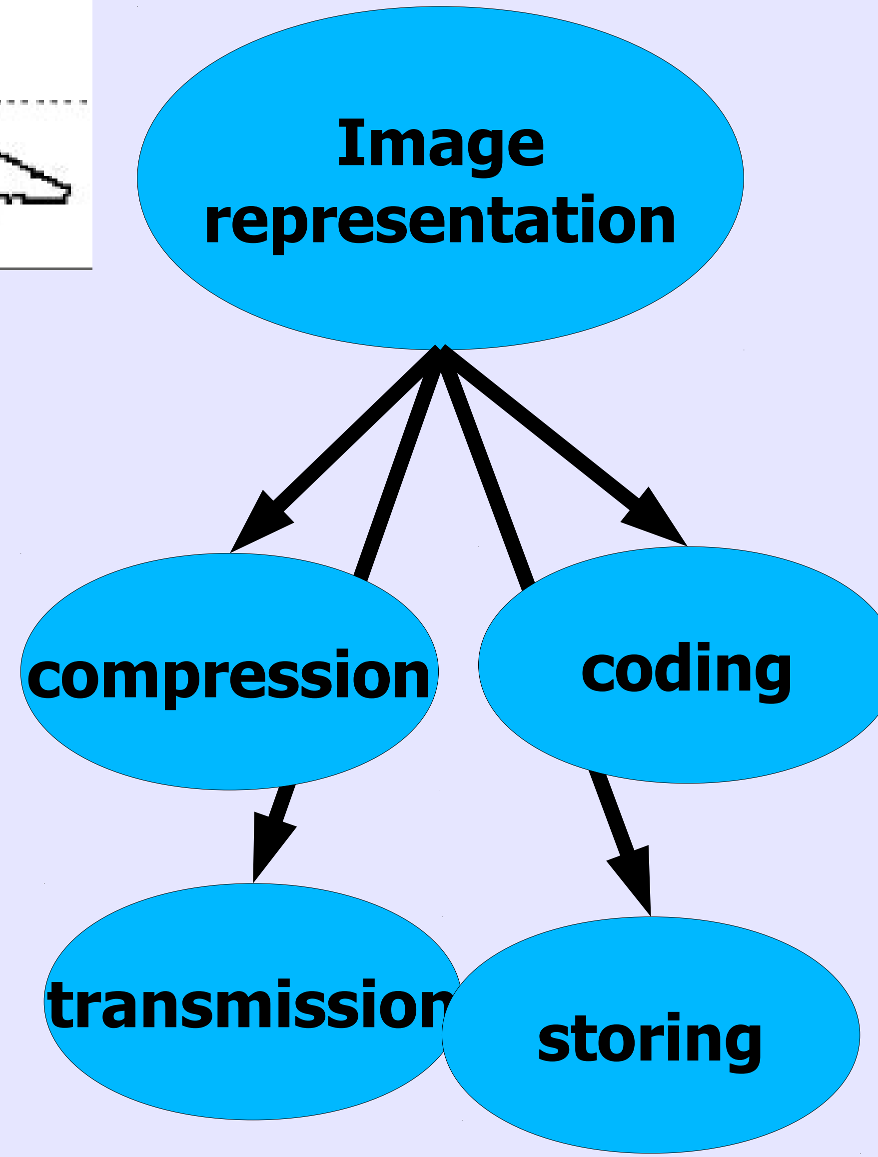
Wavelet transform coefficients

etc...

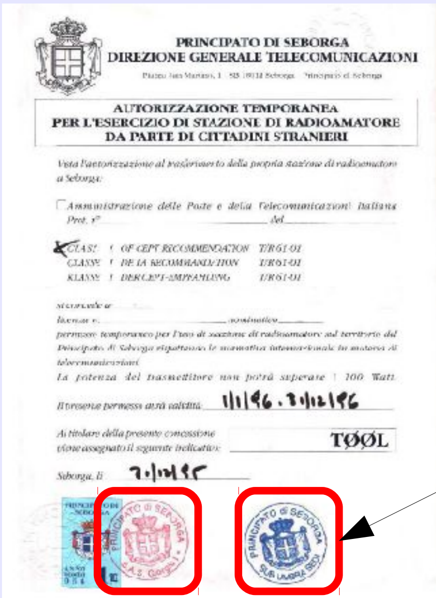
representation



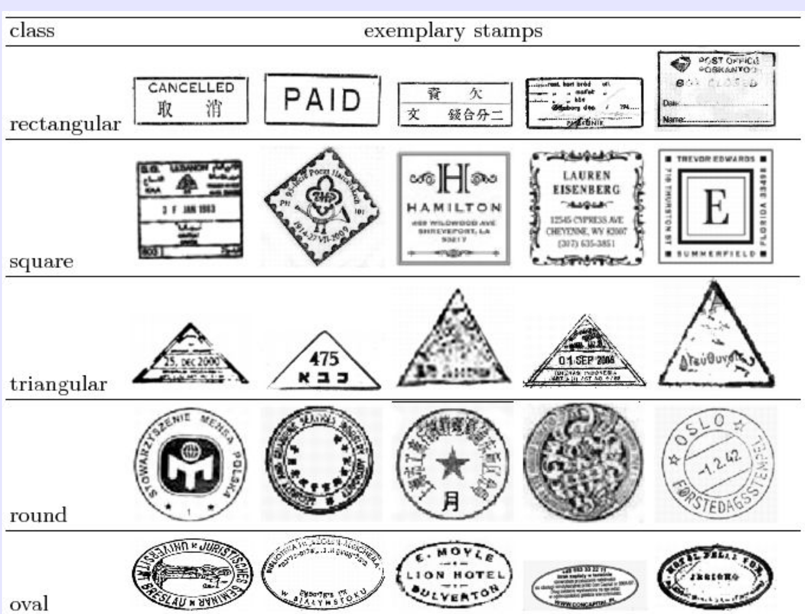


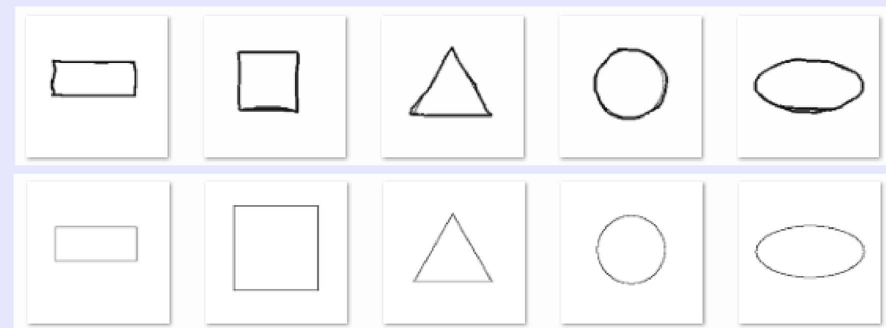


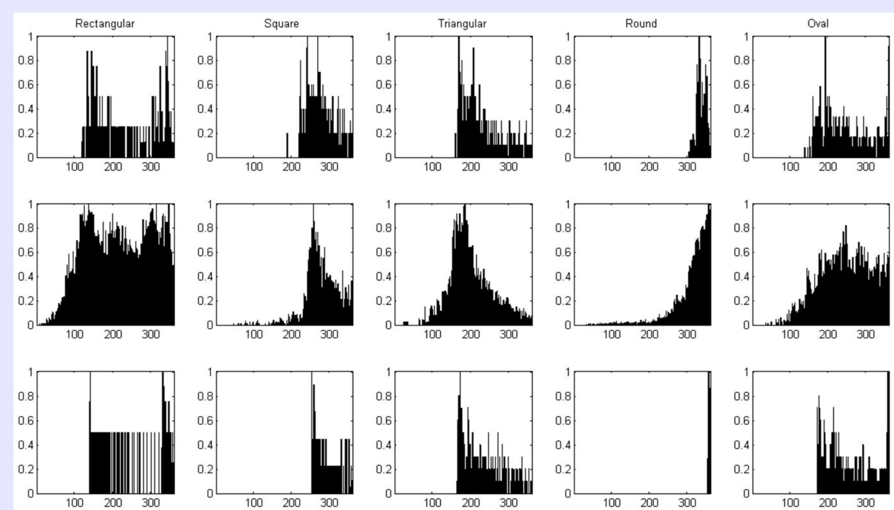
descriptors



Visual descriptors

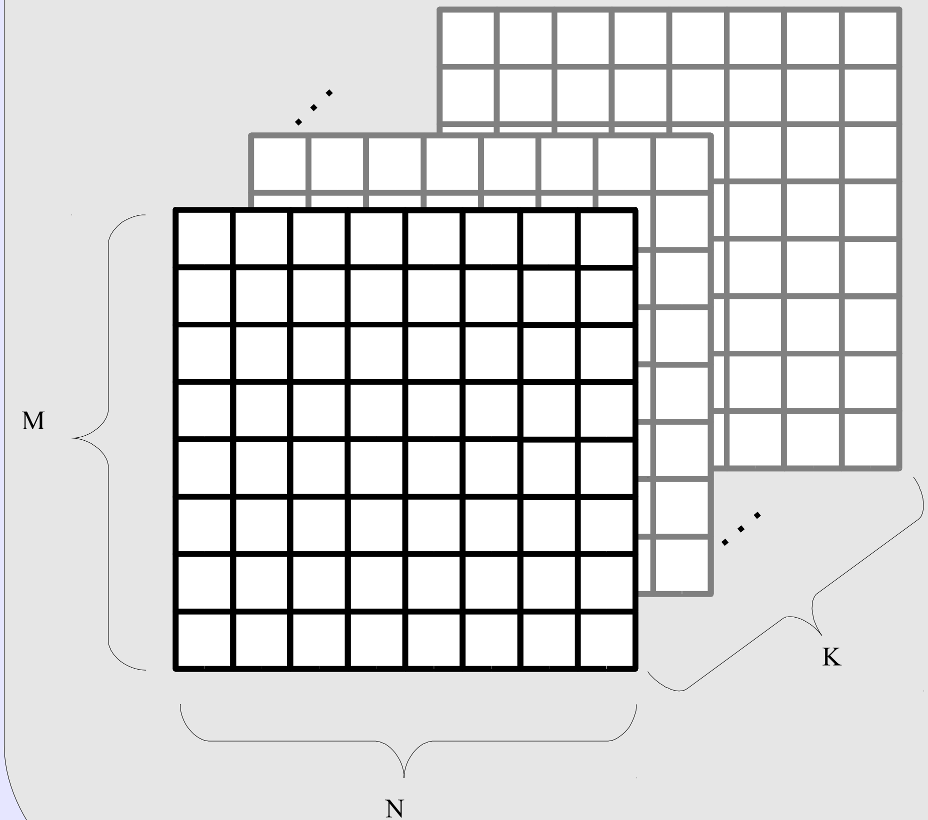


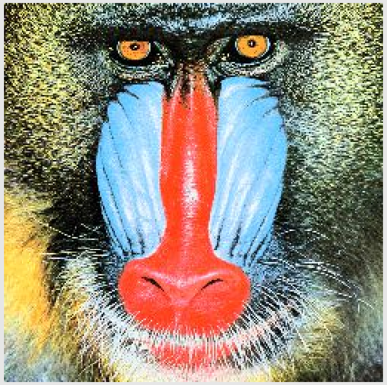




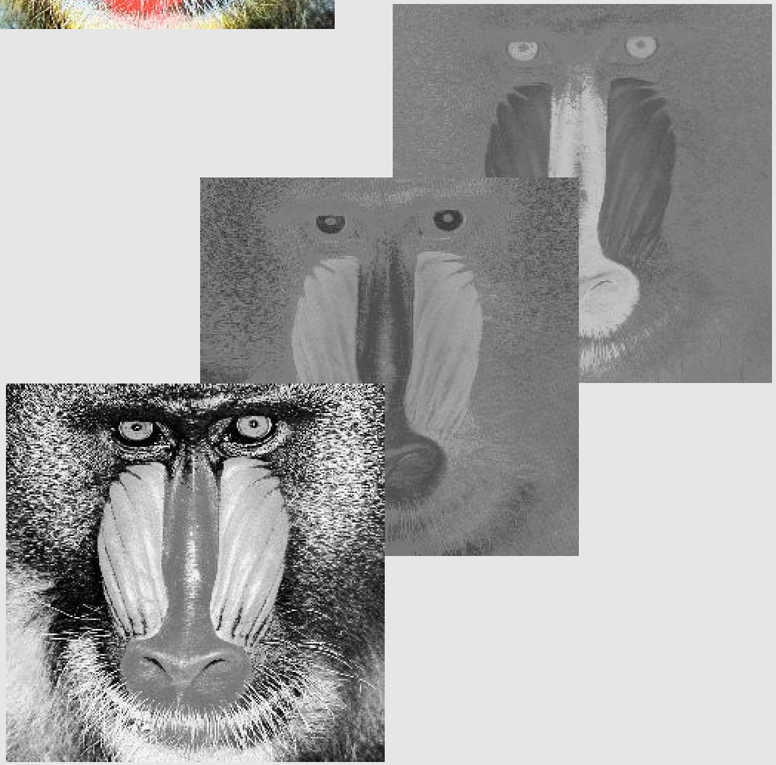
Data representation (1)

Tyical color image is in a raster form which has:
M columns
N rows
i **K** layers:

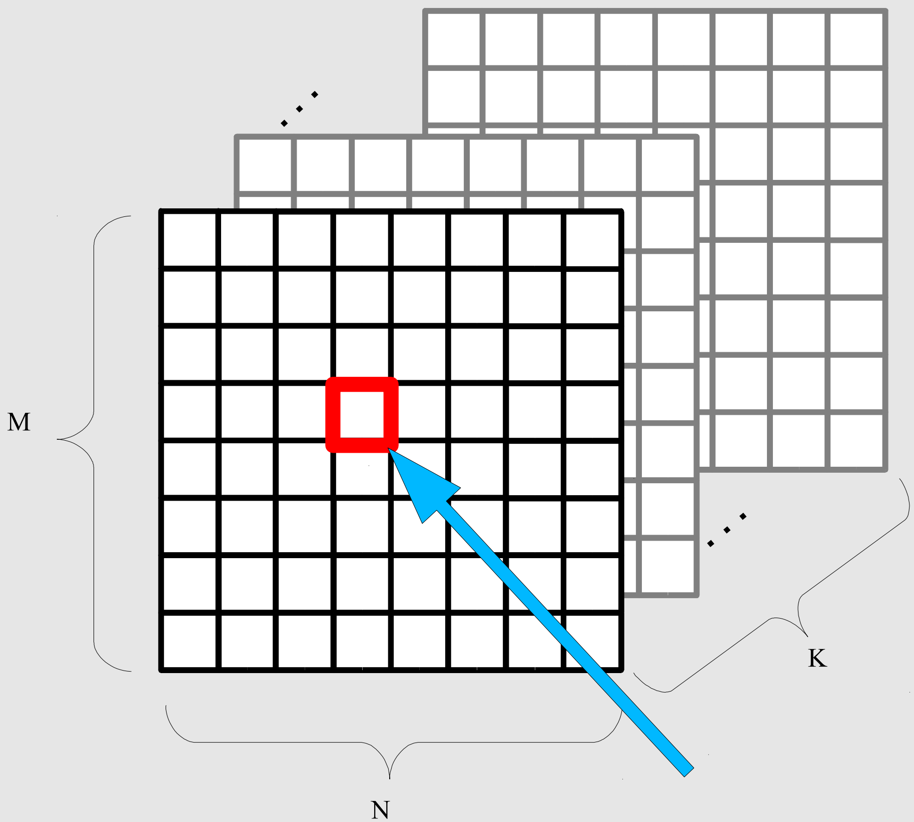




Sample image with **MxNx3** (YUV color-space)



Data representation (2)



$$\forall_{k \in K} X^{k}_{M \times N} = \begin{bmatrix} x_{1,1,k} & \cdots & x_{1,N,k} \\ \vdots & \ddots & \vdots \\ x_{M,1,k} & \cdots & x_{M,N,k} \end{bmatrix}$$

Data representation (3)

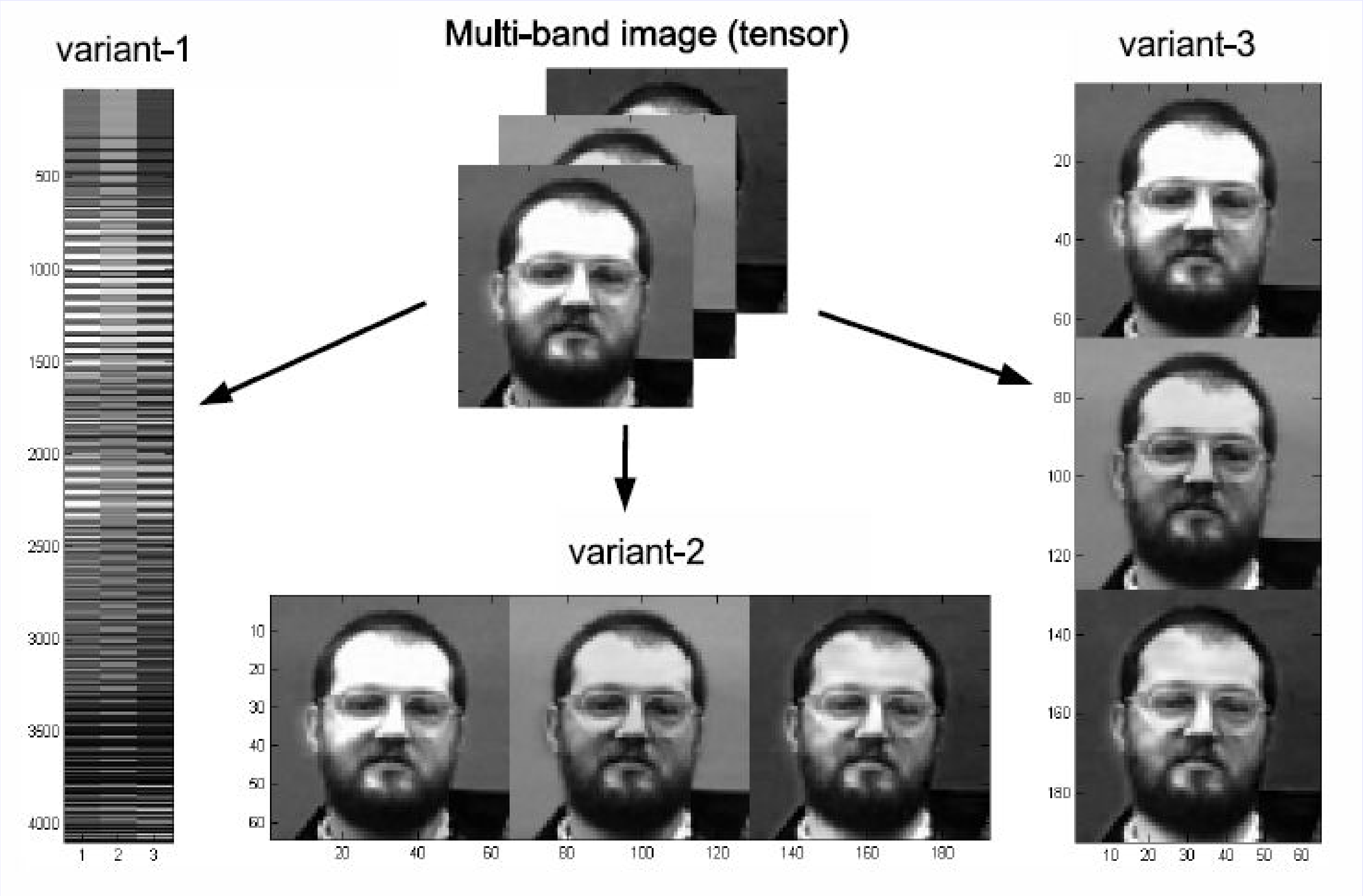


Image classes

Image classes

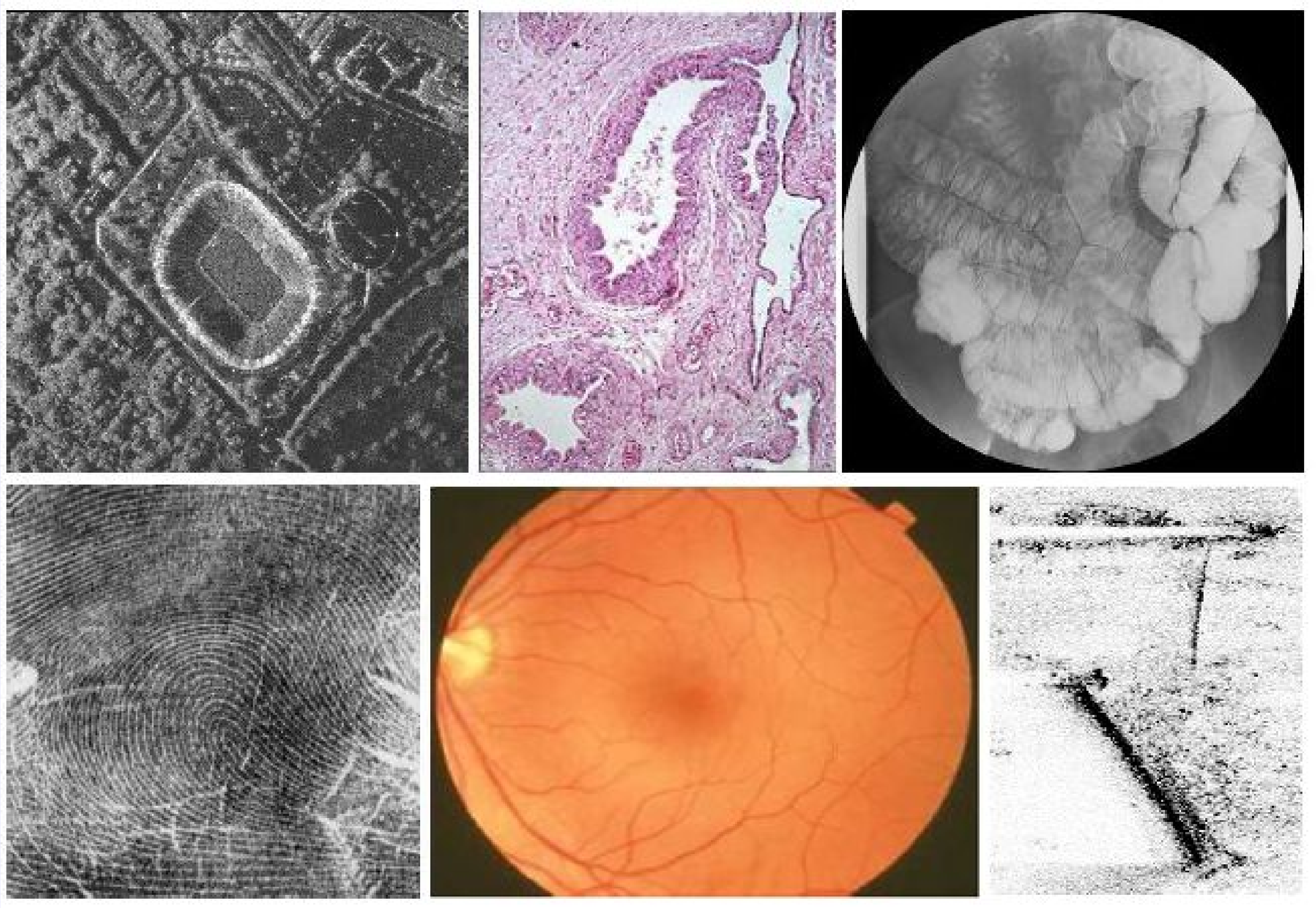
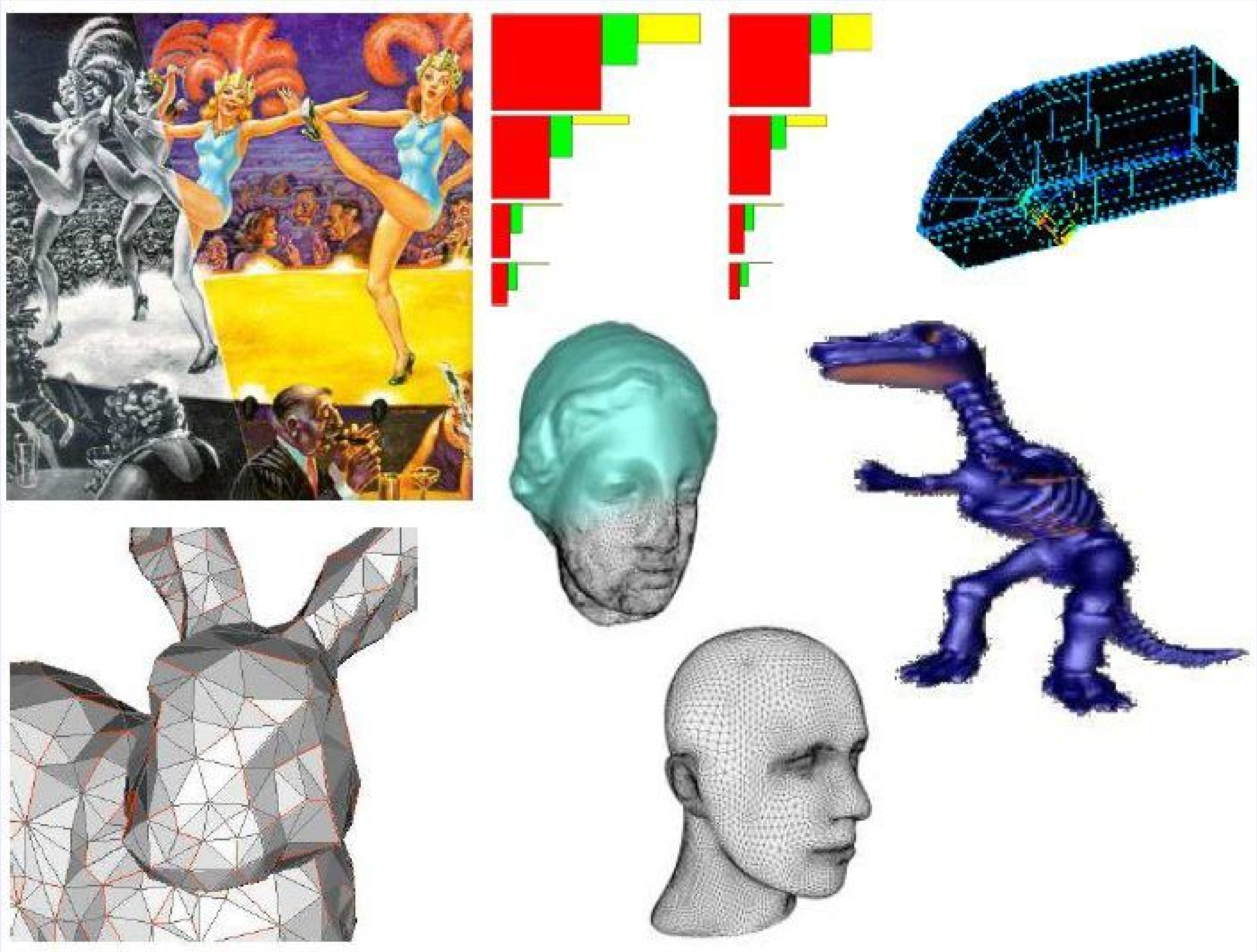
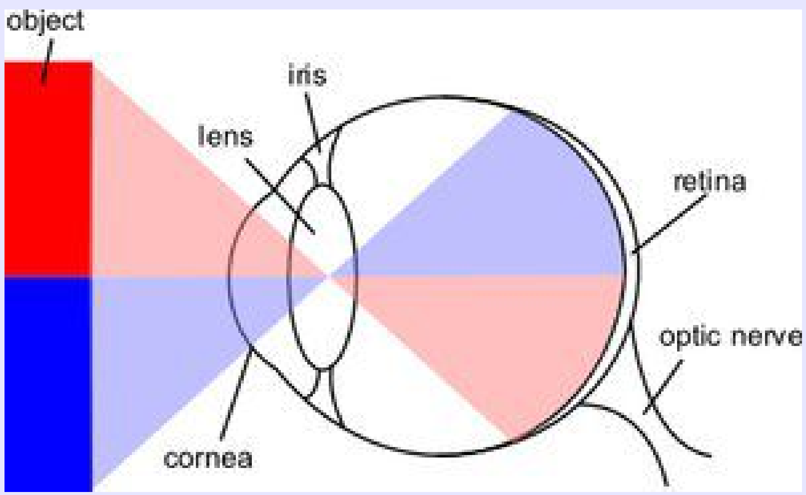


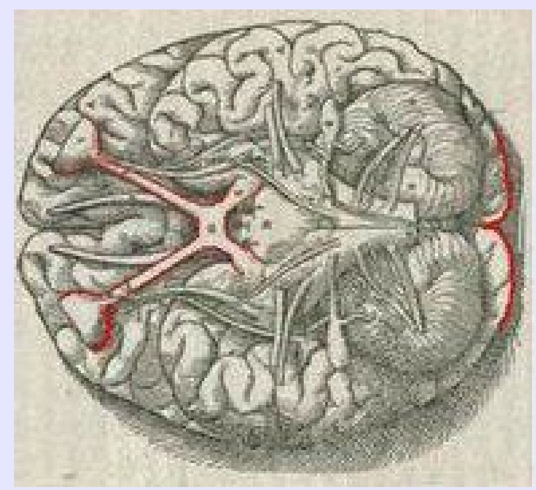
Image classes



Visual cortex

According to experiments performed at University of Pennsylvania (2006) human's retina bandwidth is ~ **8960** kbps, while small mammals ~ **875** kbps.





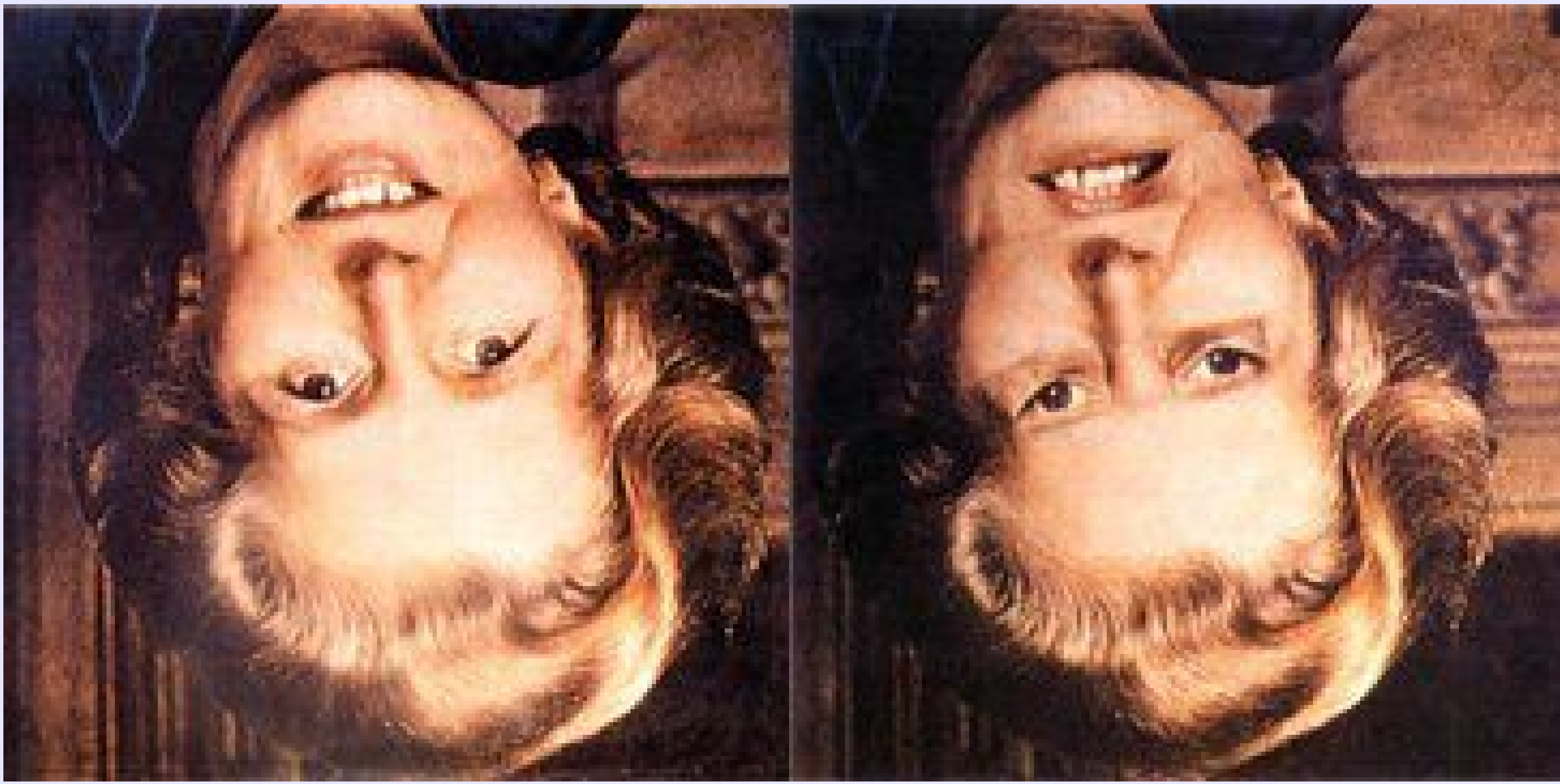
Mach bands

- low frequency characteristics of human vision

Bjoern Borg

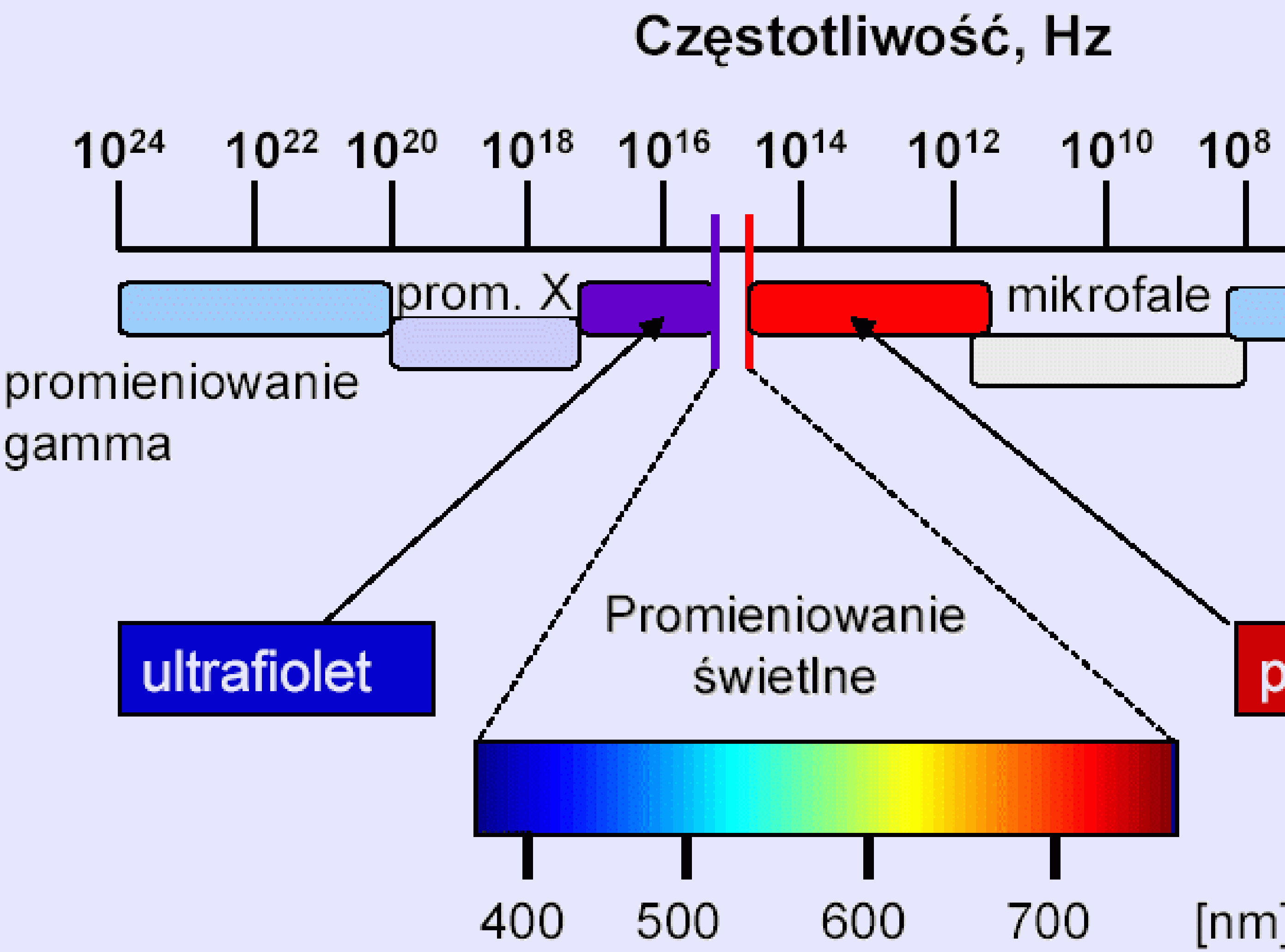
Bjoern Borg)

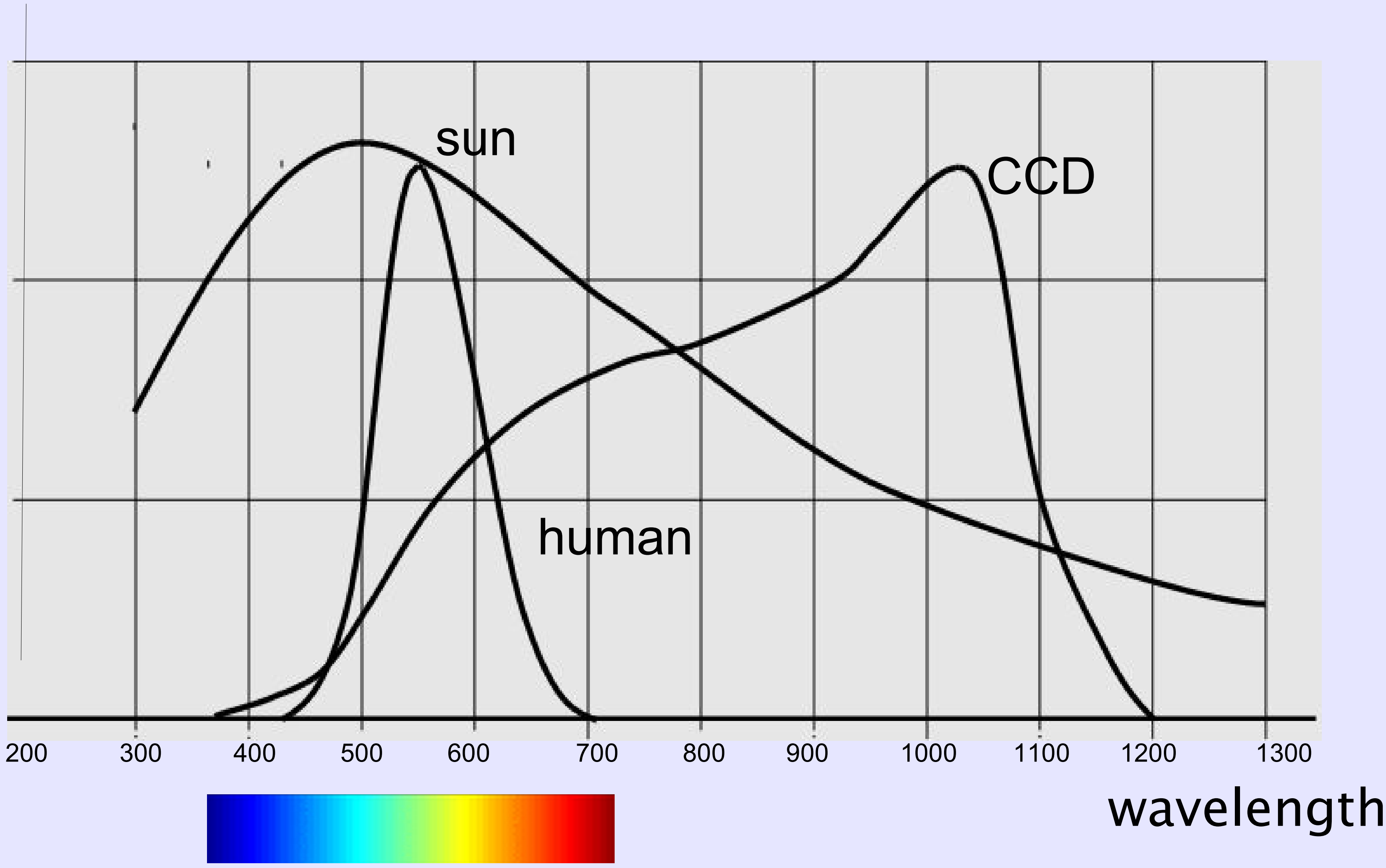
Margaret Thatcher



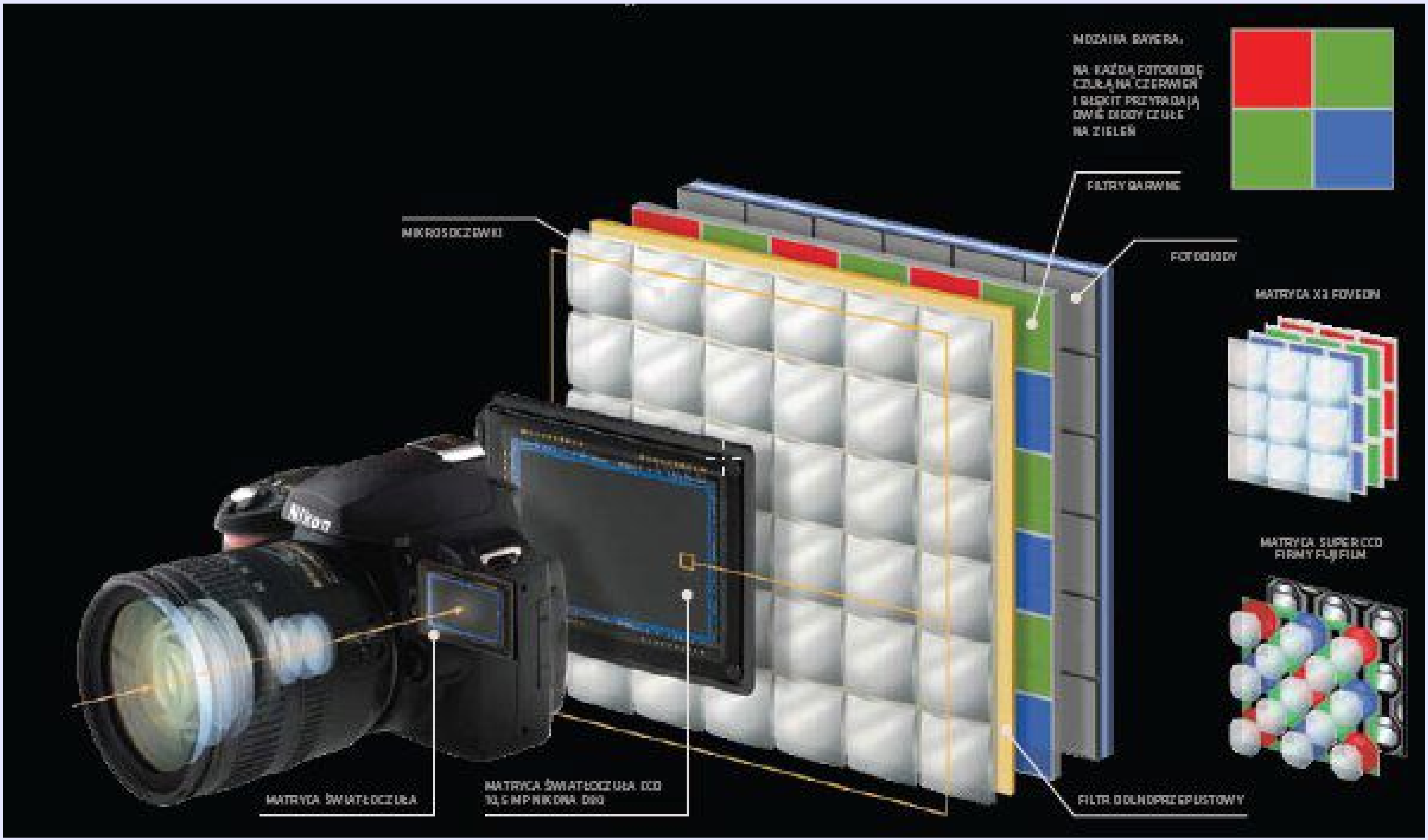
Margaret Thatcher

Lightwave


Częstotliwość, Hz
10^24
10^22
10^20
10^18
10^16
10^14
10^12
10^10
10^8
10^6
10^4
10^2
prom. X
mikrofale
promieniowanie gamma
fale radiowe
ultrafiolet
Promieniowanie świetlne
podczerwień
400
500
600
700
[nm]

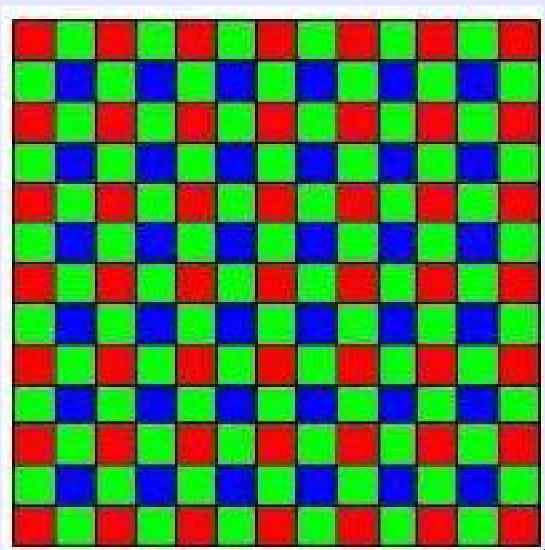

sun
CCD
human
200
300
400
500
600
700
800
900
1000
1100
1200
1300
wavelength

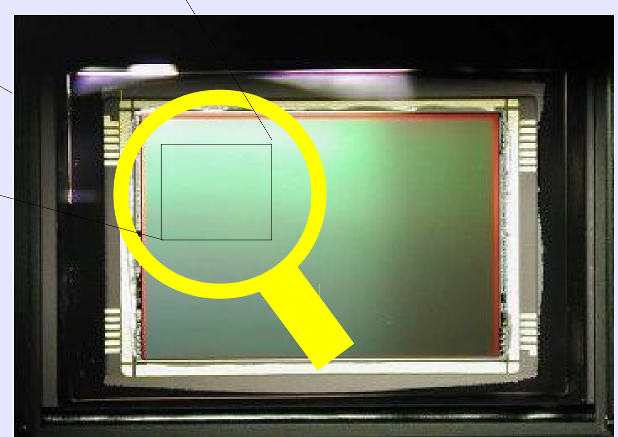
Digital camera

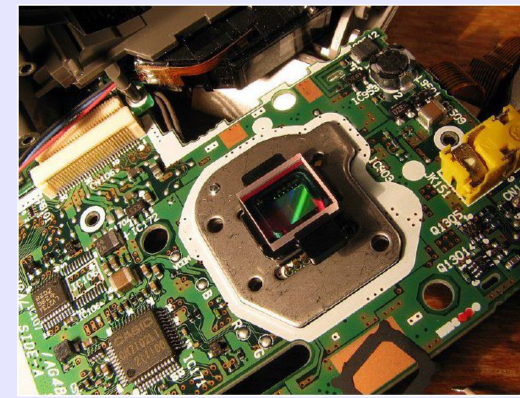


Light sensors matrix

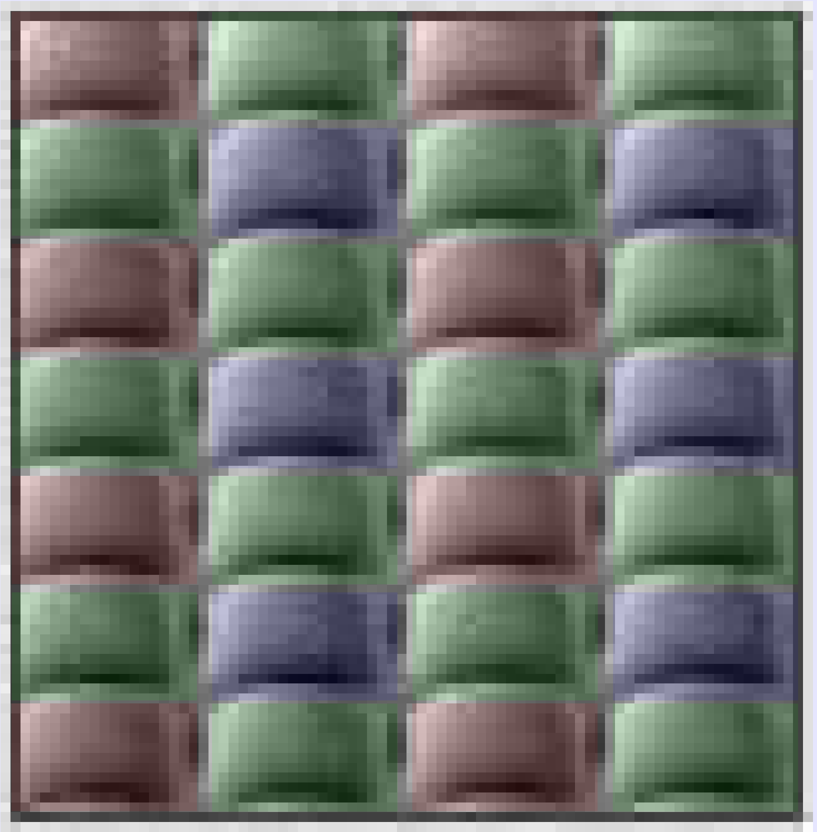
Przy pozyskiwaniu obrazów barwnych używa się elementów światłoczułych wyposażonych w sensory wrażliwe na trzy podstawowe barwy składowe : R, G, B.

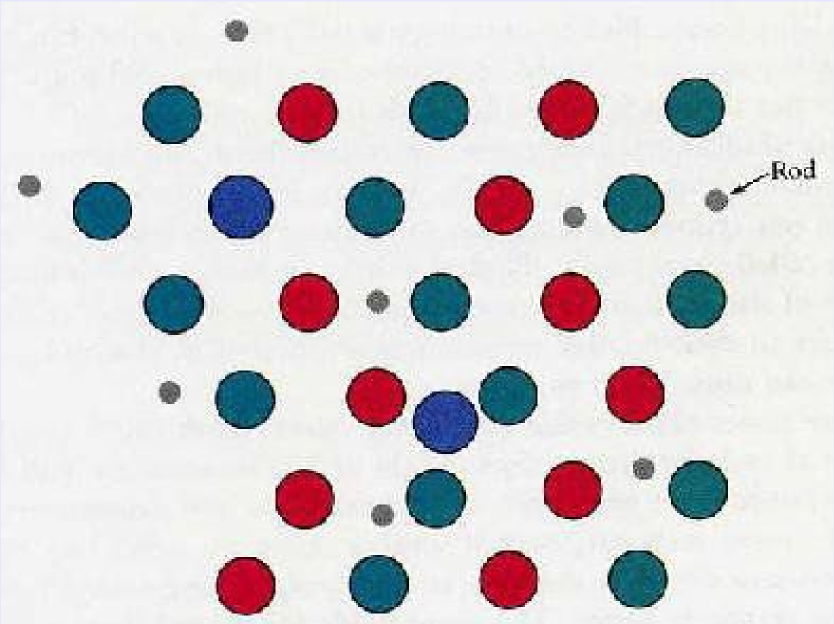






CCD vs eye





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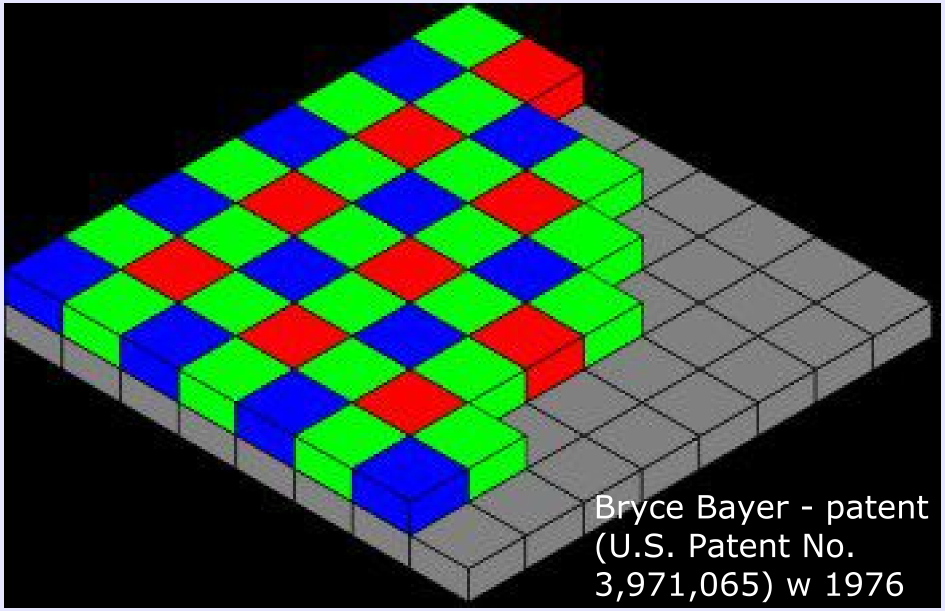
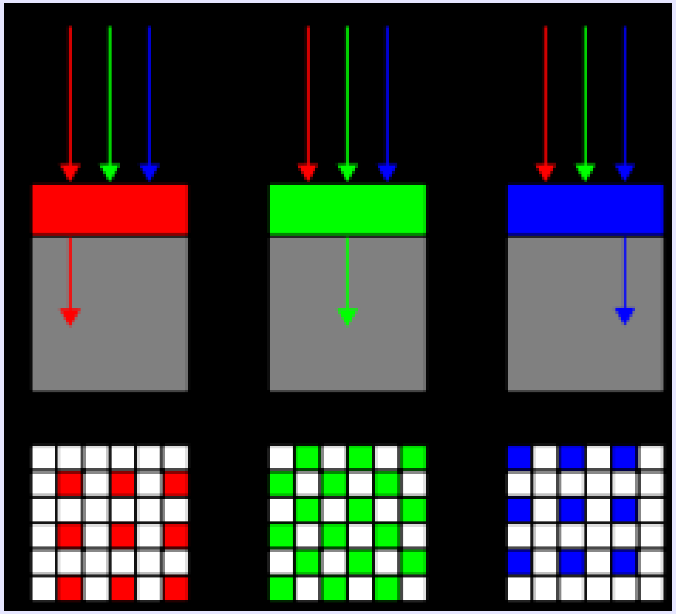
Zachodniopomorski Uniwersytet Technologiczny w Szczecinie

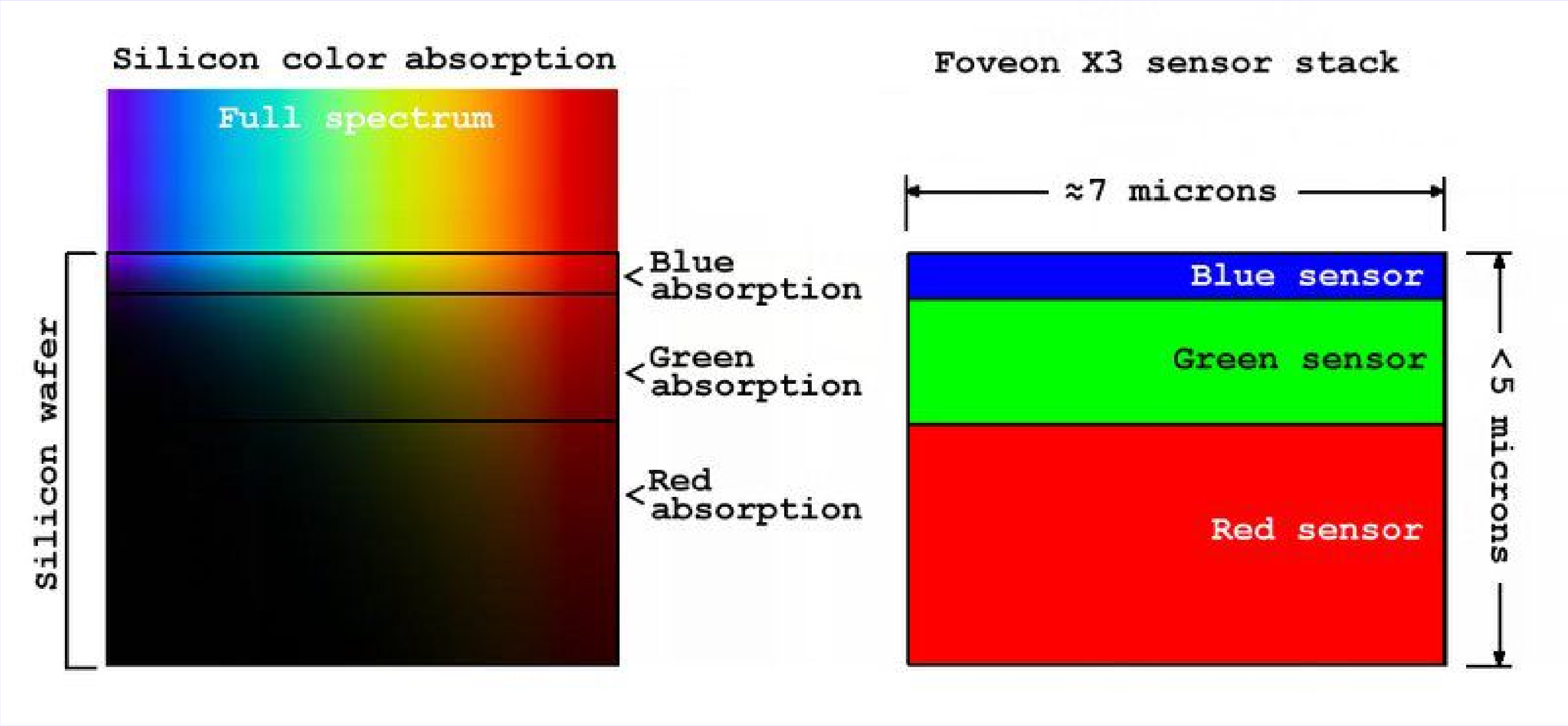
MegaPixels?



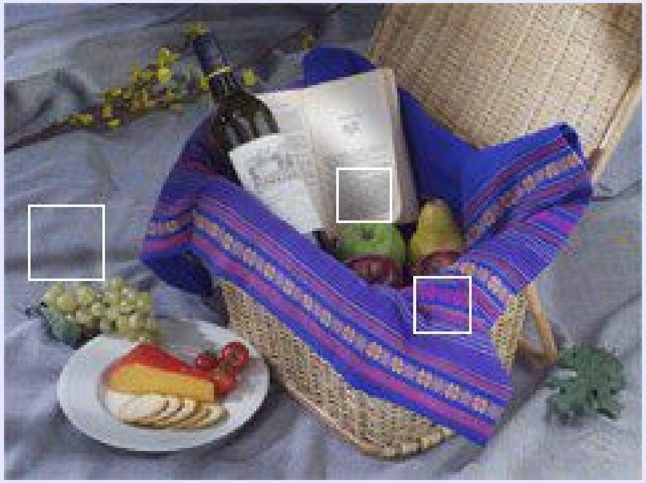
Bryce Bayer - patent (U.S. Patent No. 3,971,065) w 1976

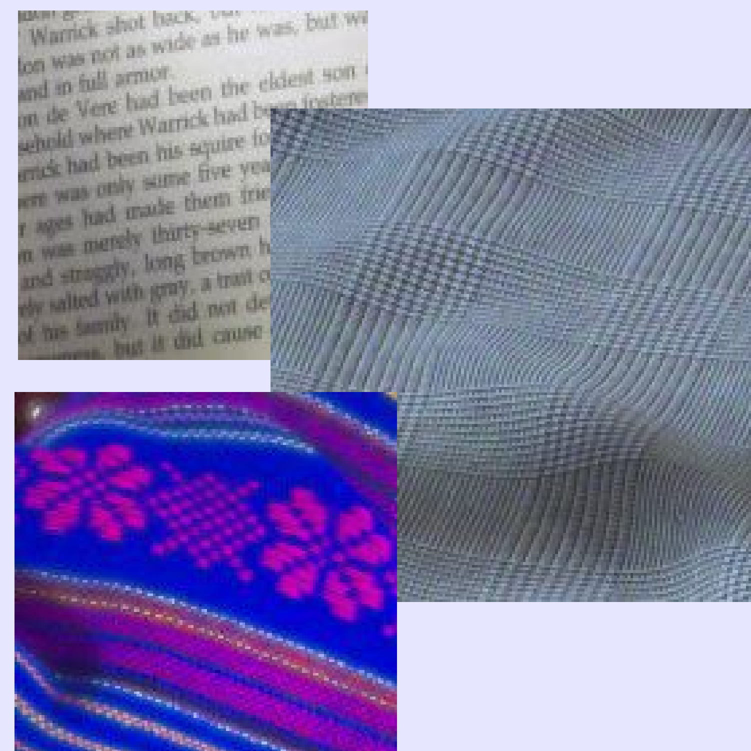


Foveon X3

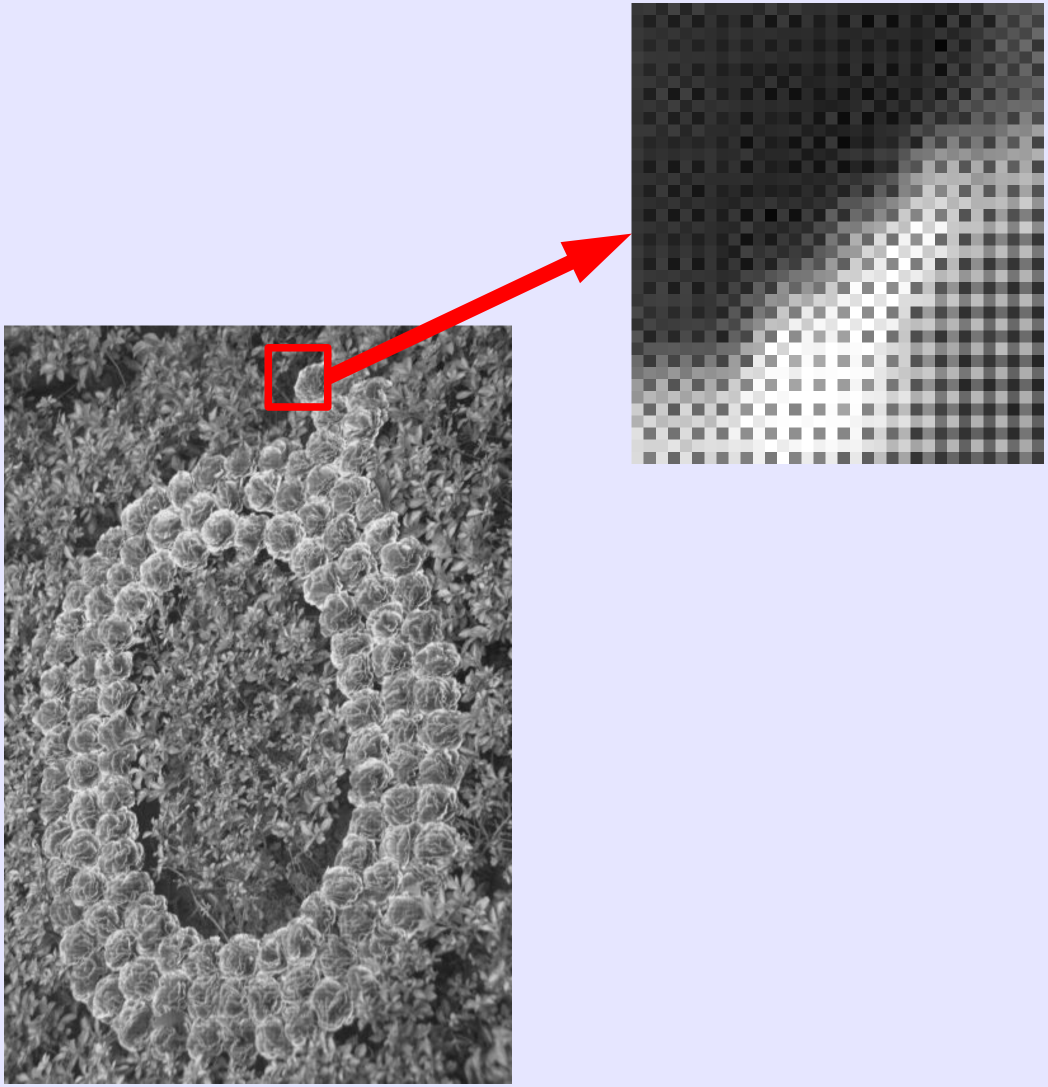

Silicon color absorption
Full spectrum
Silicon wafer
<Blue absorption
<Green absorption
<Red absorption
Foveon X3 sensor stack
≈7 microns
Blue sensor
Green sensor
Red sensor
<5 microns

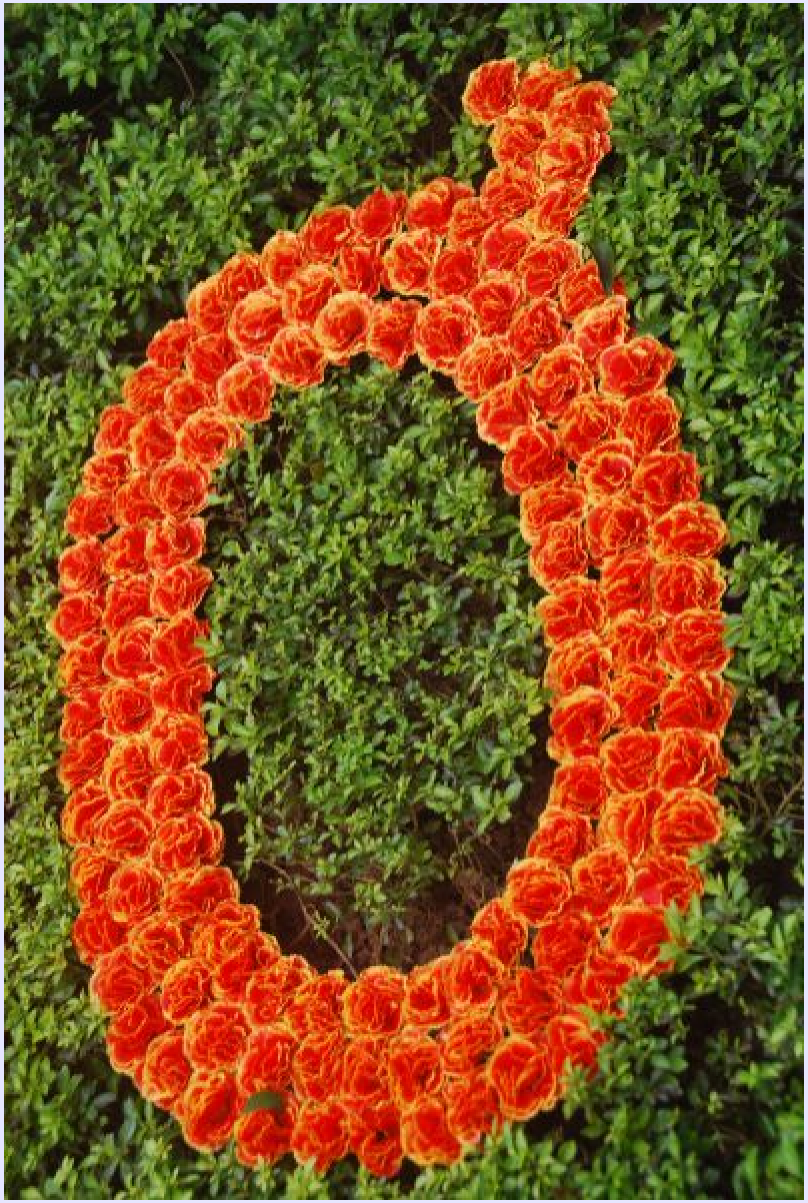
Bayer Matrix vs Foveon X3





Demosaicing





Demosaicing

http://en.wikipedia.org/wiki/Demosaicing

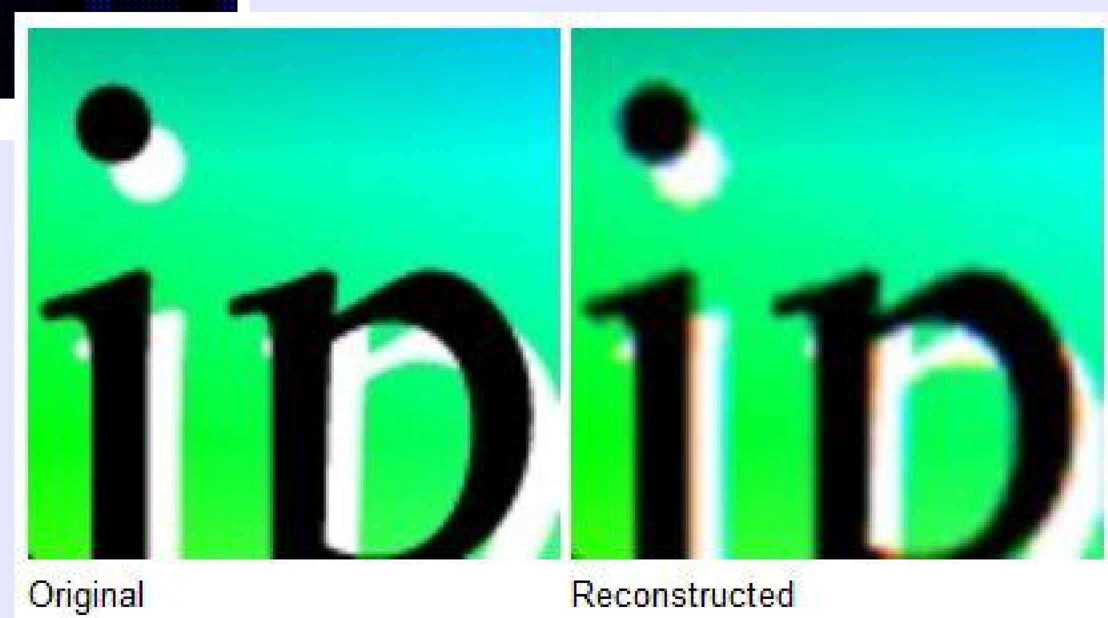
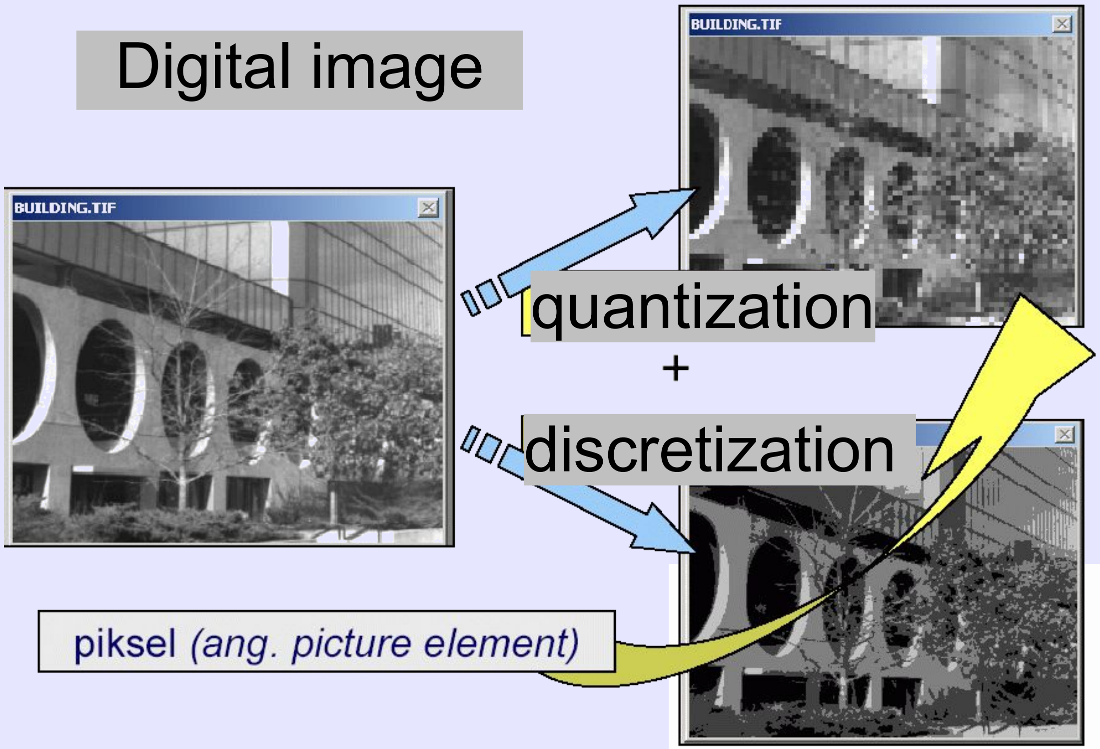


Image acquisition

Digital image

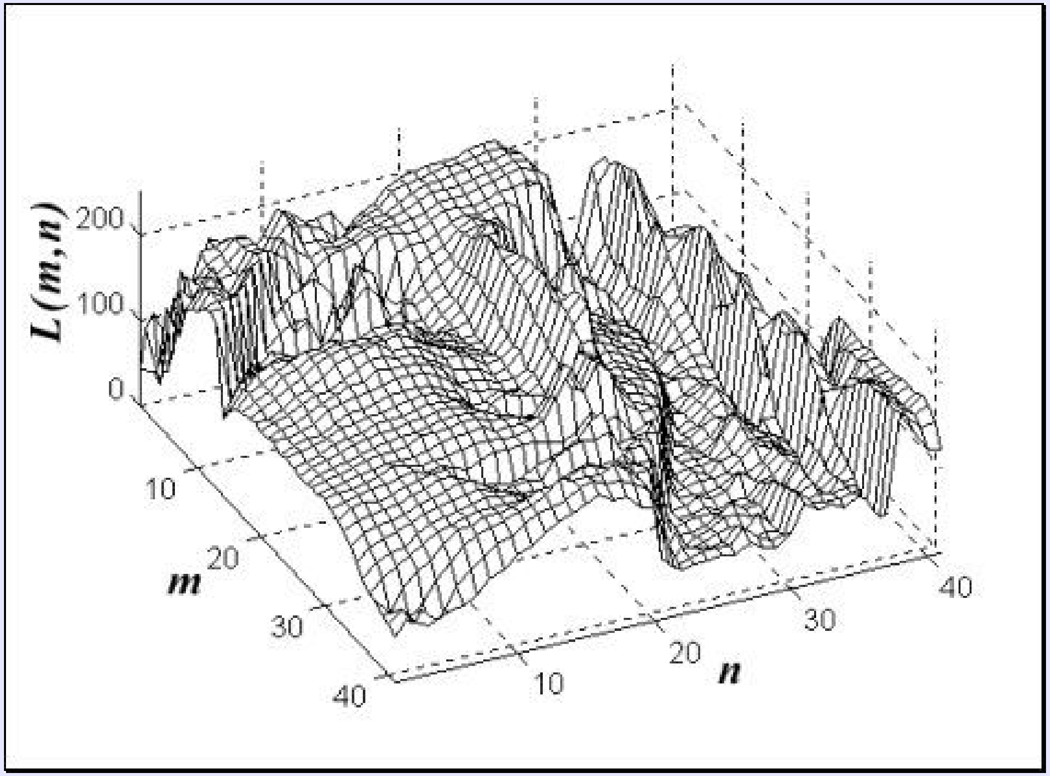


$$f : R \times R \to R$$

$$f : (x, y) \mapsto f(x, y)$$

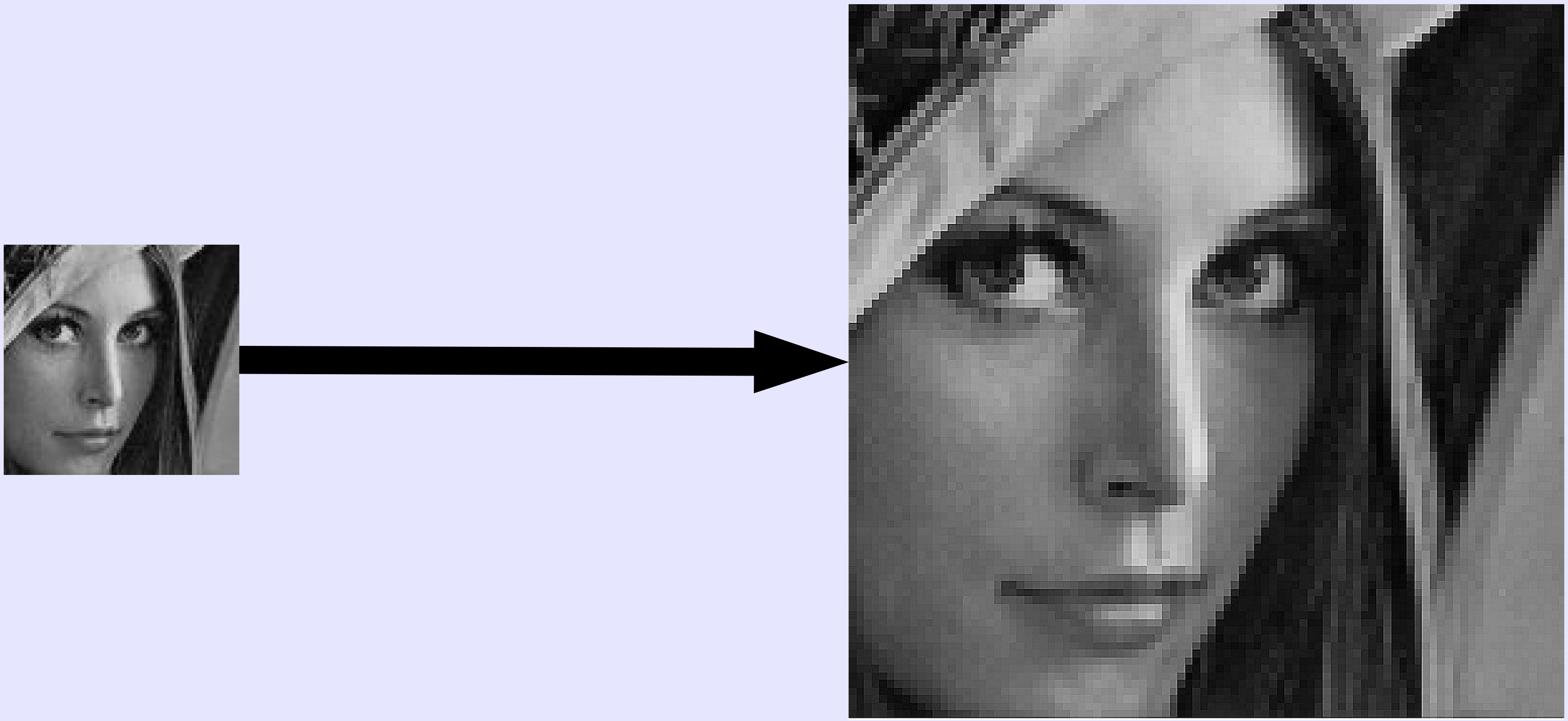
$$\begin{tikzcd}
f : R \times R \to R \arrow[r, "\text{discretization}"] \arrow[d, "\text{quantization}"] & f_d : I \times I \to R \arrow[d, "\text{quantization}"] \\
f_k : R \times R \to I \arrow[r, "\text{discretization}"] & g : I \times I \to I
\end{tikzcd}$$

Image form



Spatial resolution

Spatial resolution



interpolation

Nearest Neighbor

Linear (bi-, tri-) interpolation

Color (gray-level) resolution