INTRODUCERE

In cursul de astazi

- Procesarea imaginii (definitii si exemple)
- Scopul procesarii imaginii
- Imaginea digitala
- Sistemul vizual uman
- Digitizare (frecventa Nyquist, alias, convolutie, functia de distributie a punctului)
- Cuantificare
- Modele de culori

Generalitati

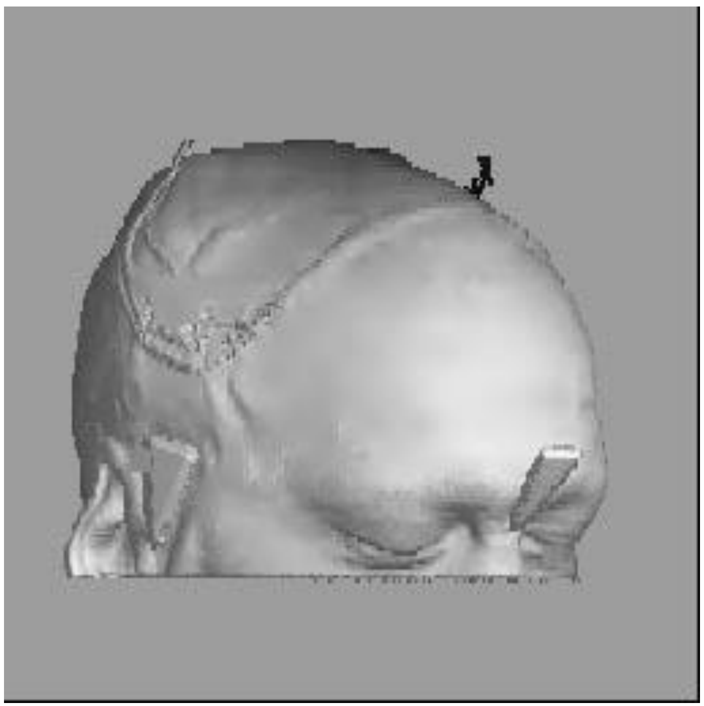
- procesarea imaginilor = manipularea si analiza informatiilor continute in imagini
- exemple simple:
  - utilizarea ochelarilor si a lentilelor;
  - controlul contrastului, luminozitatii, etc. televizorului, monitorului;
  - reflexia peisajului in apa, “fata morgana”, etc.
  - luarea unei fotografii cu o camera digitala

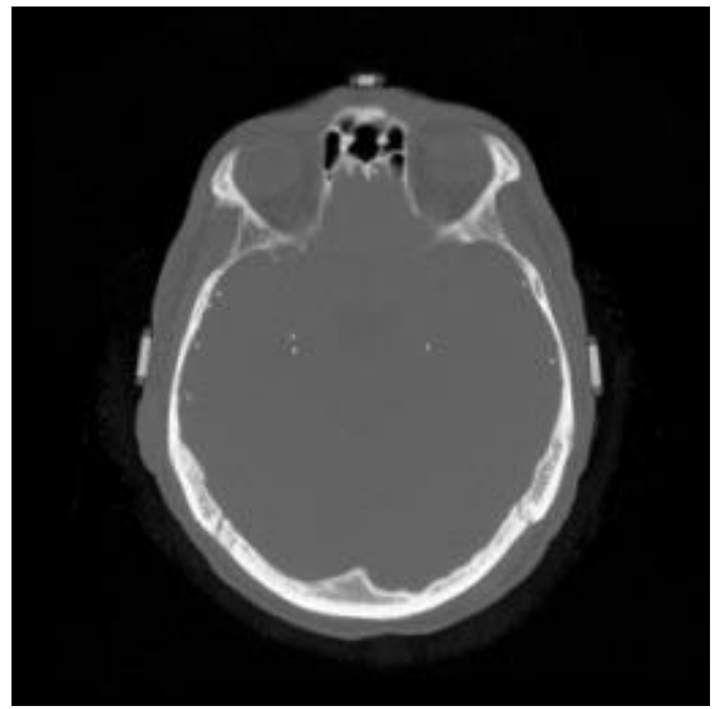
Utilizari

- industrie (verificarea pieselor,aplicatii CAD/CAM, etc.)
- procesarea informatiilor (recunoasterea caracterelor)
- astronomie
- criminologie (recunoasterea fetelor, amprentelor, etc.)
- etc.

Utilizari in domeniul medical (1)

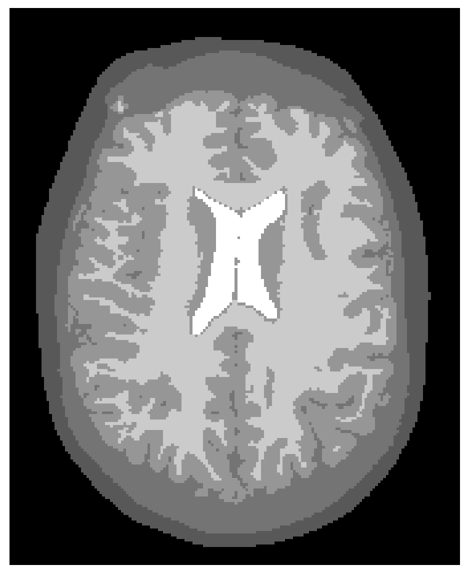
- Vizualizare





Utilizari in domeniul medical (2)

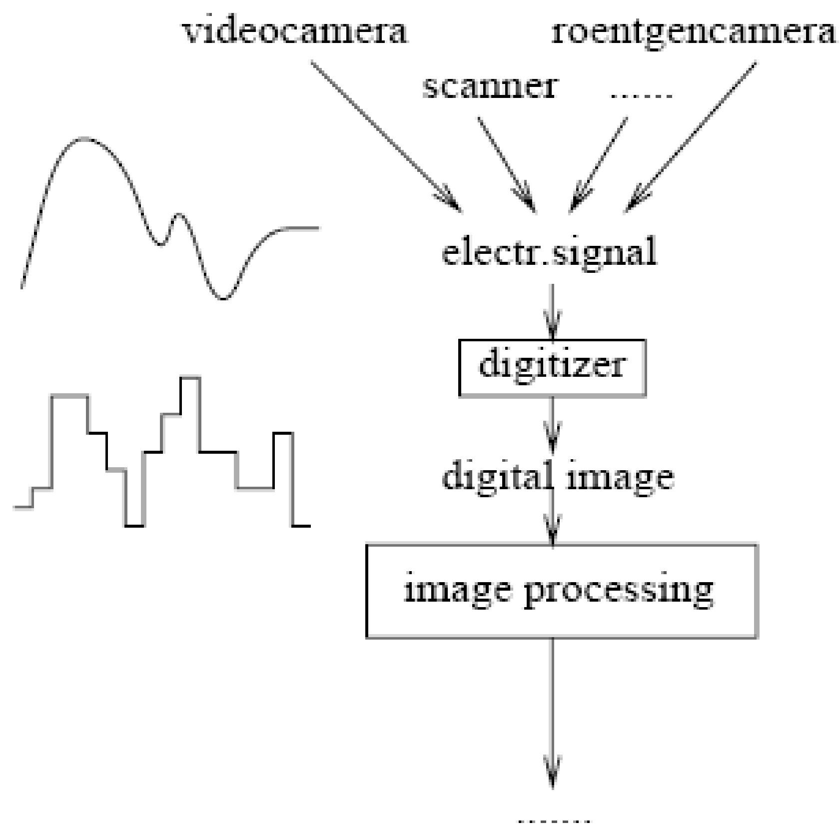
- Diagnosticare asistata de calculator
- Registrarea imaginilor (potrivirea imaginilor)
- Segmentarea imaginilor

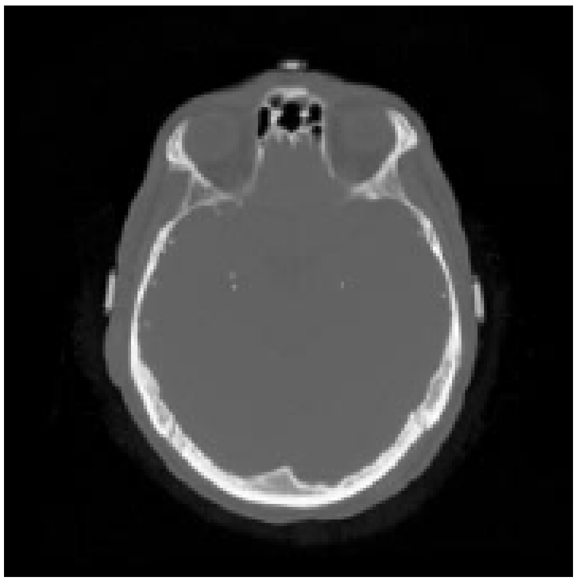
Scopul procesarii imaginilor

- imbunatatirea imaginilor
- recunoasterea formelor (forma si textura)
- reducerea datelor la informatii mai usor de utilizat
- sinteza imaginii (2D -> 3D)
- combinarea imaginilor
- compresia datelor

Obtinerea imaginilor digitale

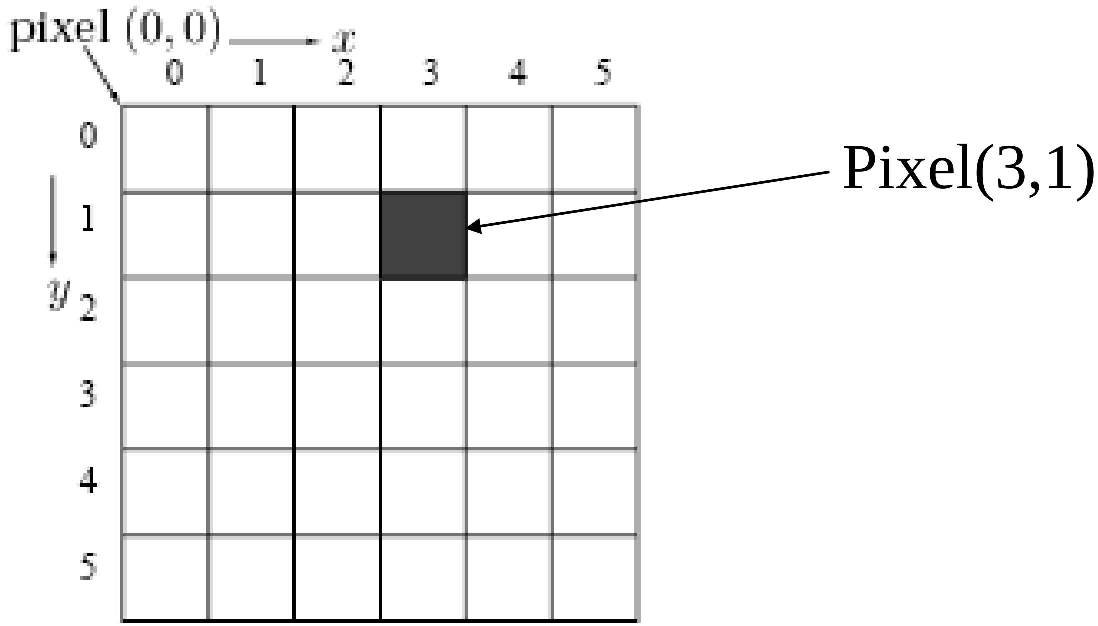


Esantionare si cuantificare



00	00	01	01	01	03	01	00
01	00	46	4a	45	7f	01	01
00	00	4a	5b	4c	63	00	01
00	04	4c	4c	4c	4c	4d	00
00	3d	4c	4c	4b	4c	49	00
00	0a	4d	4c	4d	4d	17	00
00	00	48	50	4d	57	01	00
00	00	01	02	10	00	01	01

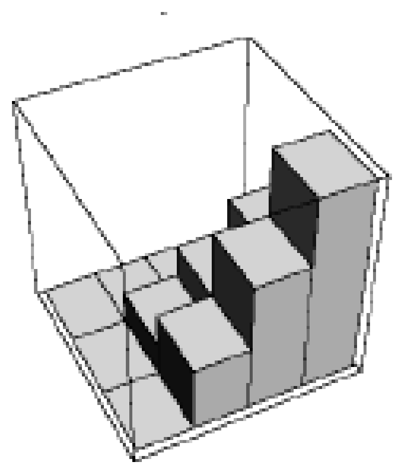
Conventia coordonatelor

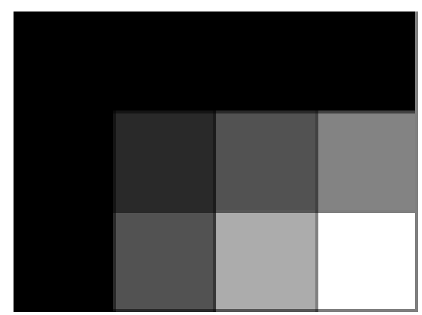


Reprezentare matematica

f(x,y) = xy pentru $(x,y) \in \{0,1,2,3\} \times \{0,1,2\}$

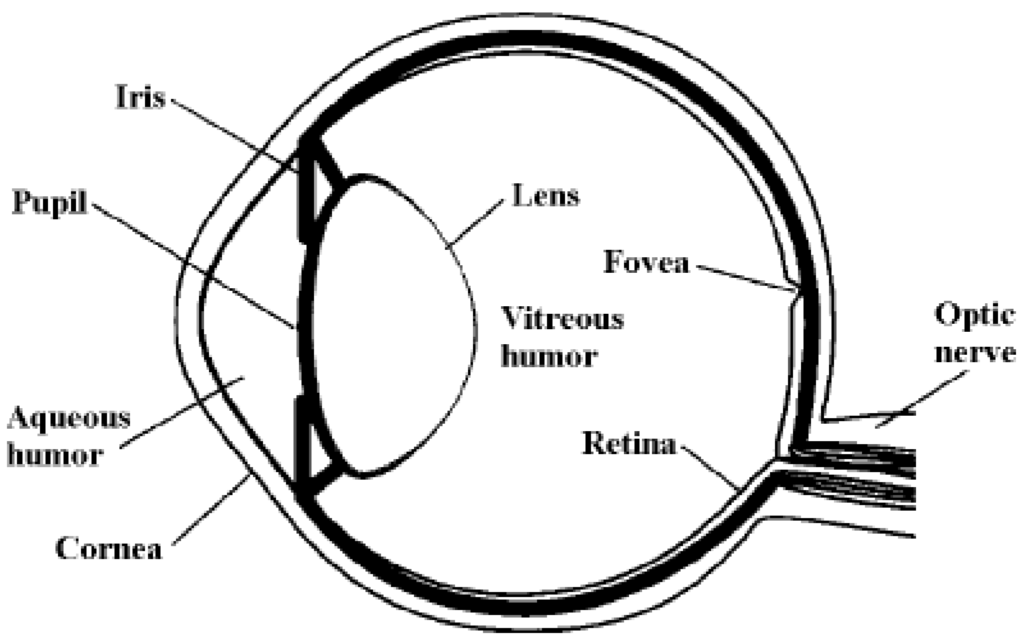
$$M = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 2 & 3 \\ 0 & 2 & 4 & 6 \end{pmatrix}$$





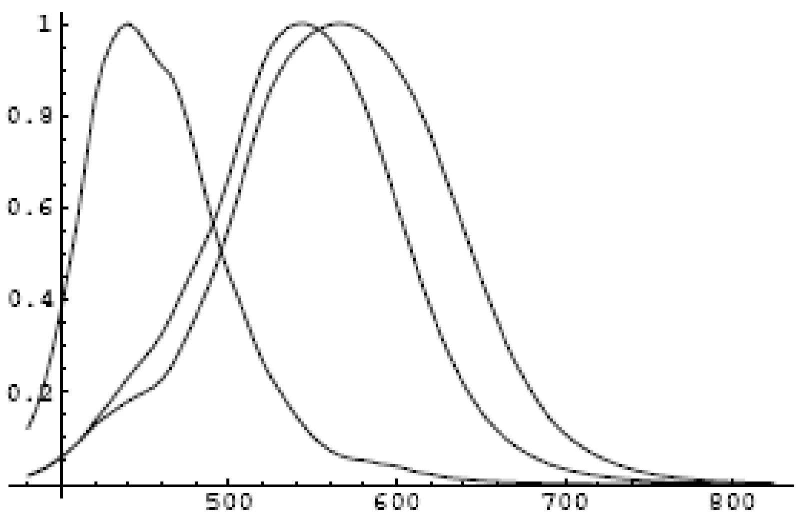
Sistemul vizual uman

Luminanta <-> luminozitate (stralucire)

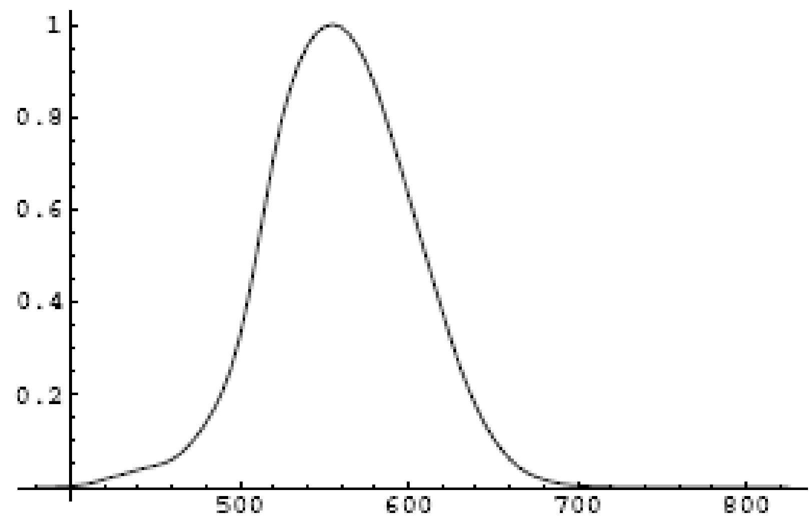


- *bastonase* (cca 100 mil.) – intensitatea luminoasa
- *conuri* (cca 7 mil.) – culorile si detaliile

Sistemul vizual uman (2)



Senzitivitatea relativa a celor trei tipuri de conuri



Functia de eficienta luminoasa

Luminanta versus luminozitate

Luminozitatea unui obiect:

$$I(\lambda) = \rho(\lambda)\, E(\lambda),$$

unde: $\rho(\lambda)$ este reflectivitatea obiectului, [0,1]

$E(\lambda)$ este energia razelor de lumina de unda λ.

Luminanta unui obiect:

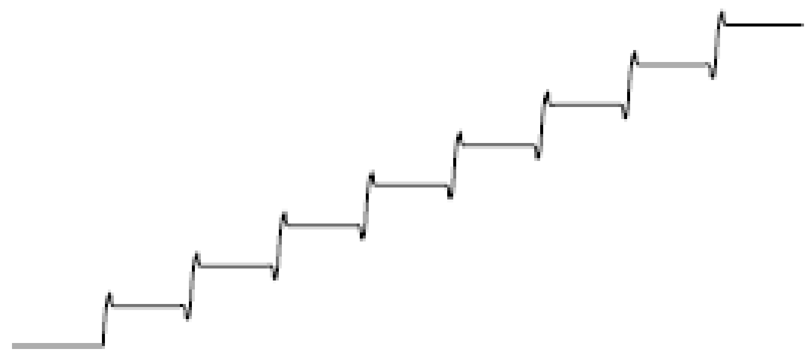
$$L = \int_0^\infty I(\lambda) V(\lambda)\, d\lambda,$$

unde $V(\lambda)$ este functia eficientei luminoase a sistemului vizual

Contrast

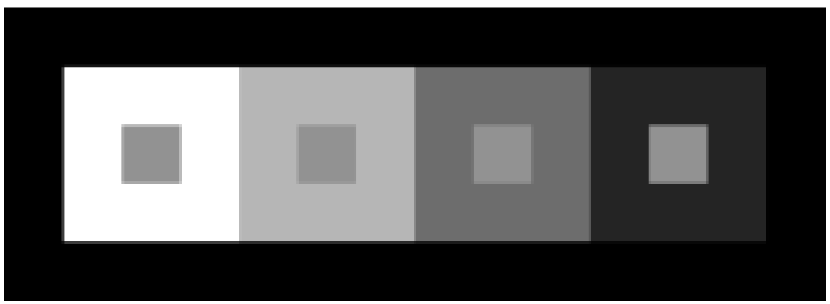
Contrast - perceptia luminozitatii unei zone in functie de intensitatea ariei inconjuratoare

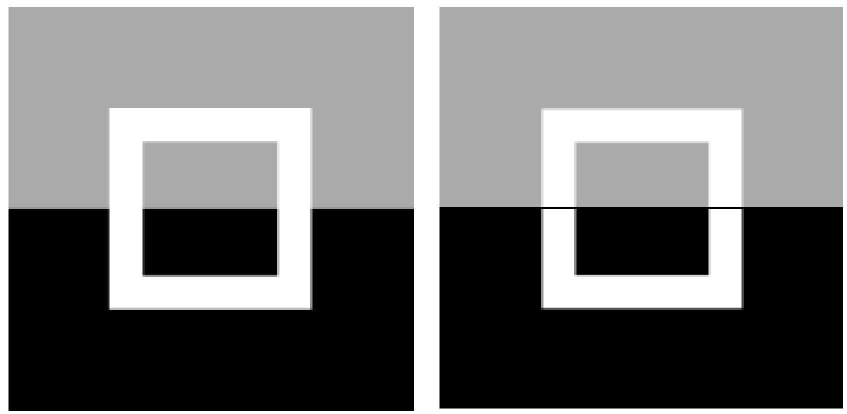
Efectul de banda Mach – accentuarea schimbarilor de intensitate



Contrast (2)

Efectul contrastului simultan

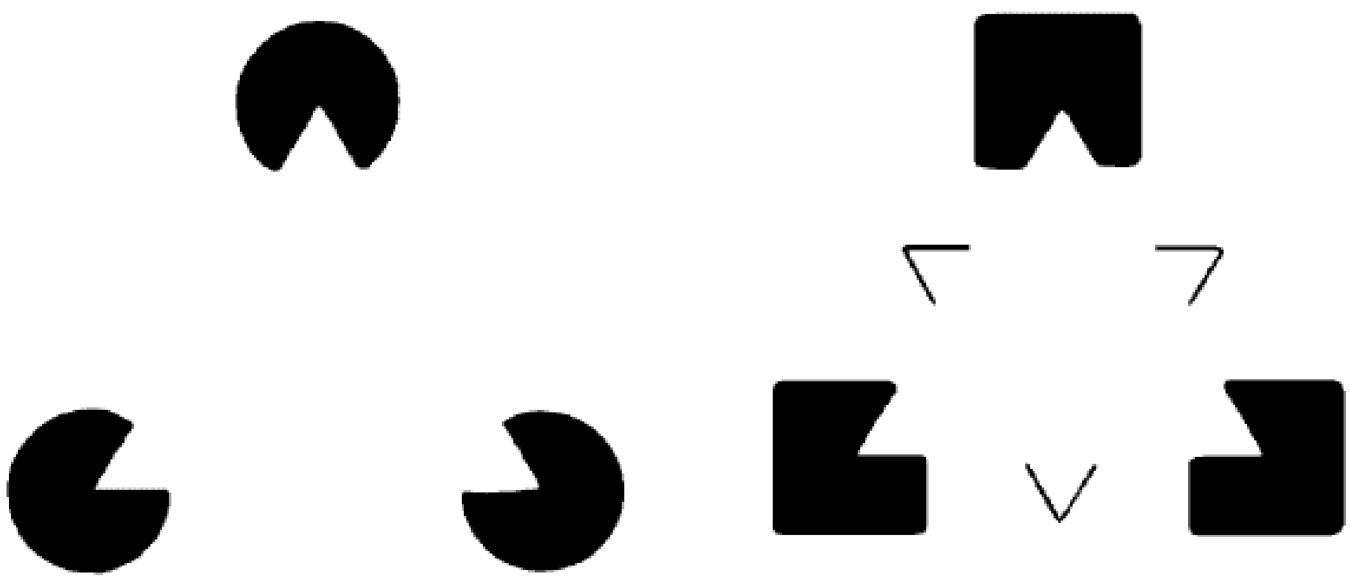




Inelul lui Benussi

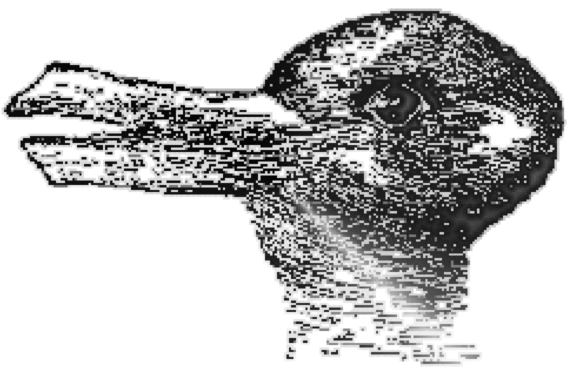
Contrast (3)

Fenomenul Gestalt



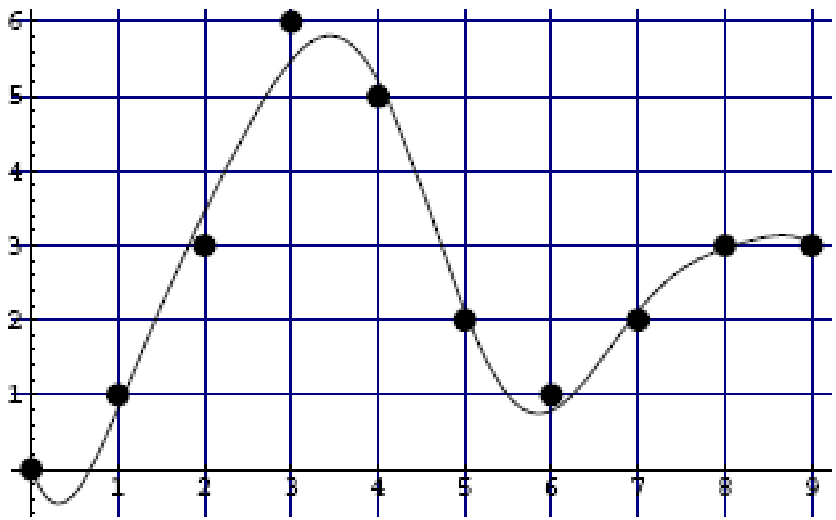
Contrast (4)

Fenomenul Gestalt

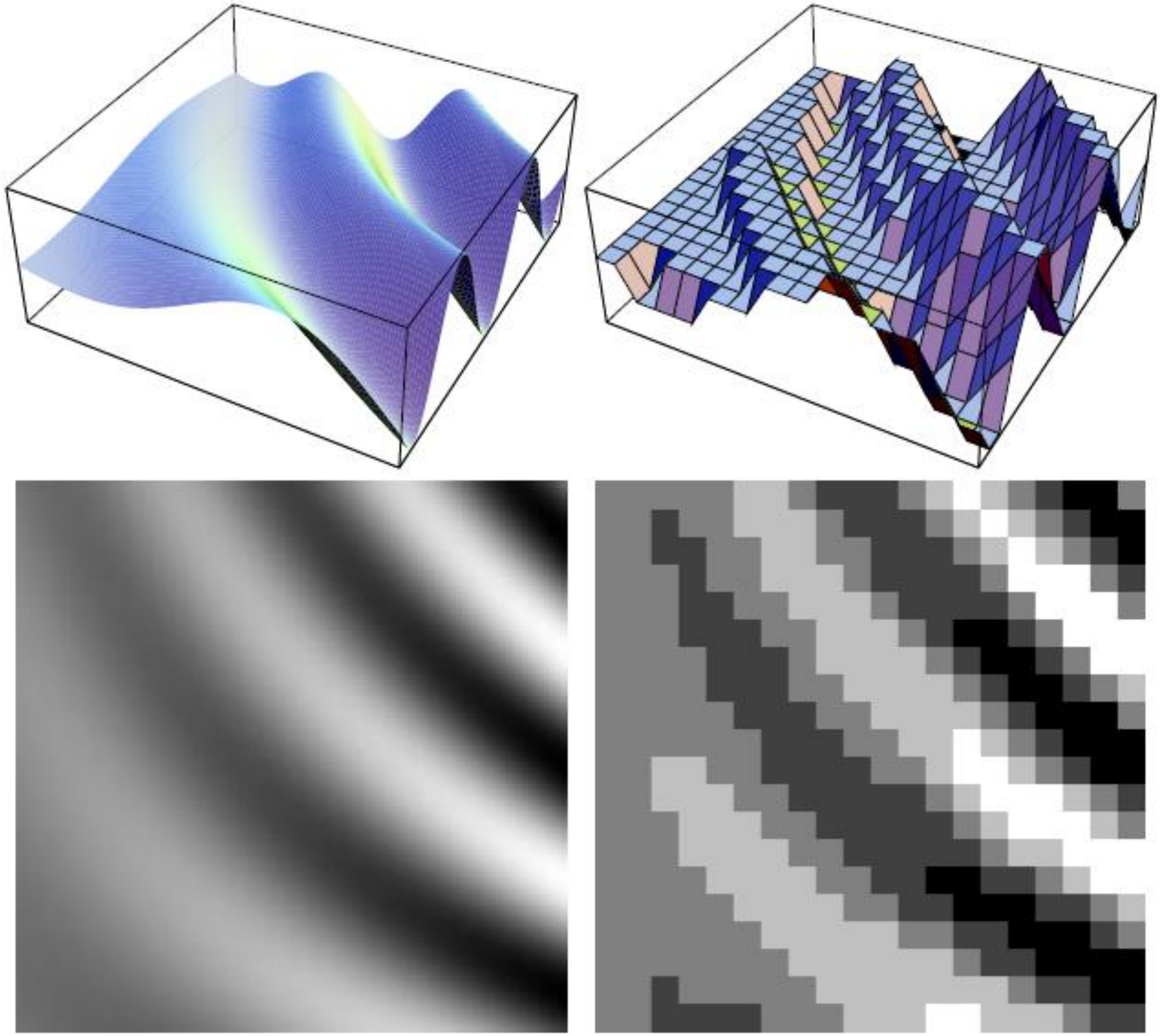


Achizitia imaginilor digitale

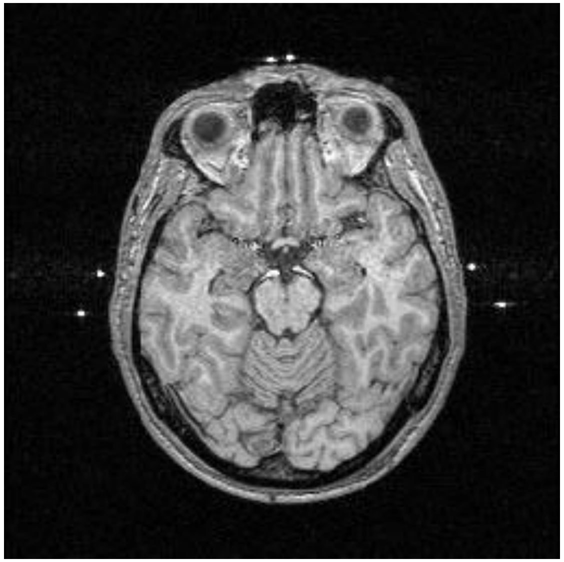
Esantionarea unui semnal 1D



Esantionarea unui semnal 2D

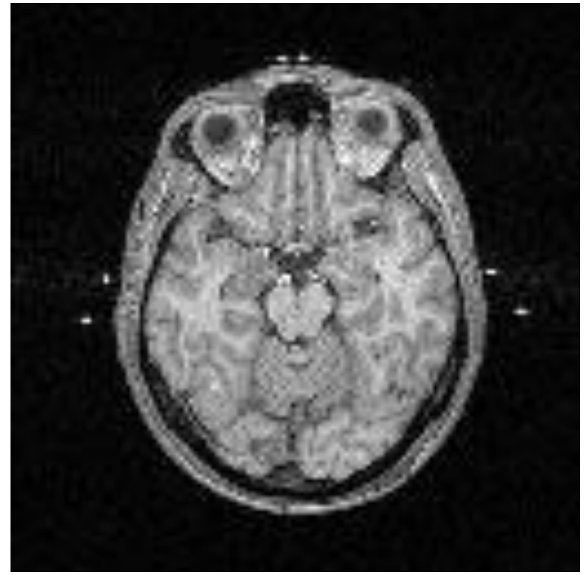


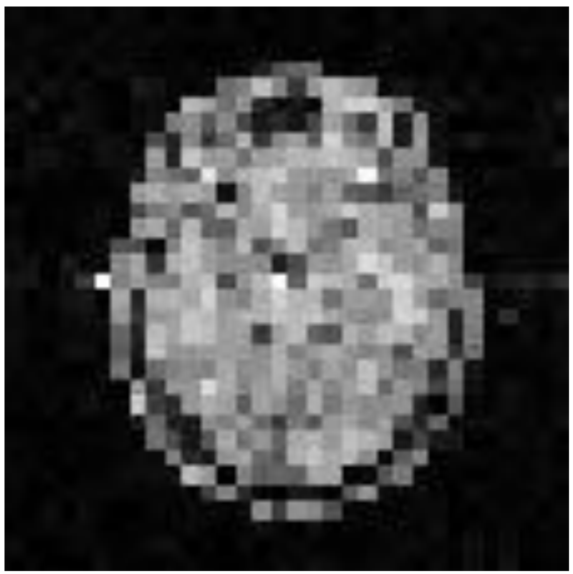
Rezolutia spatiala



← 256 x 256

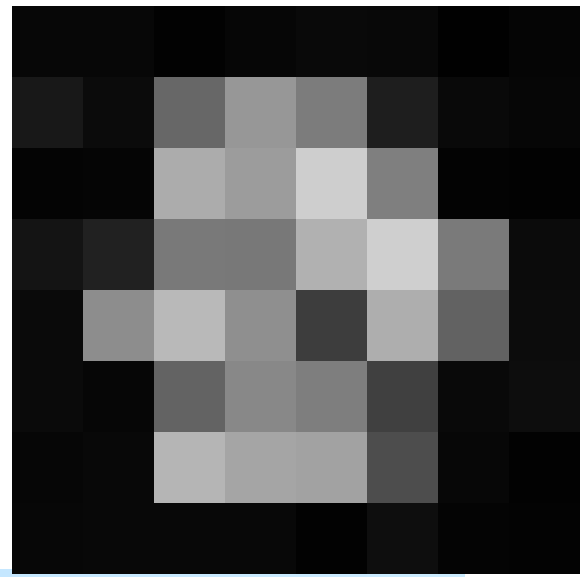
128 x 128 →



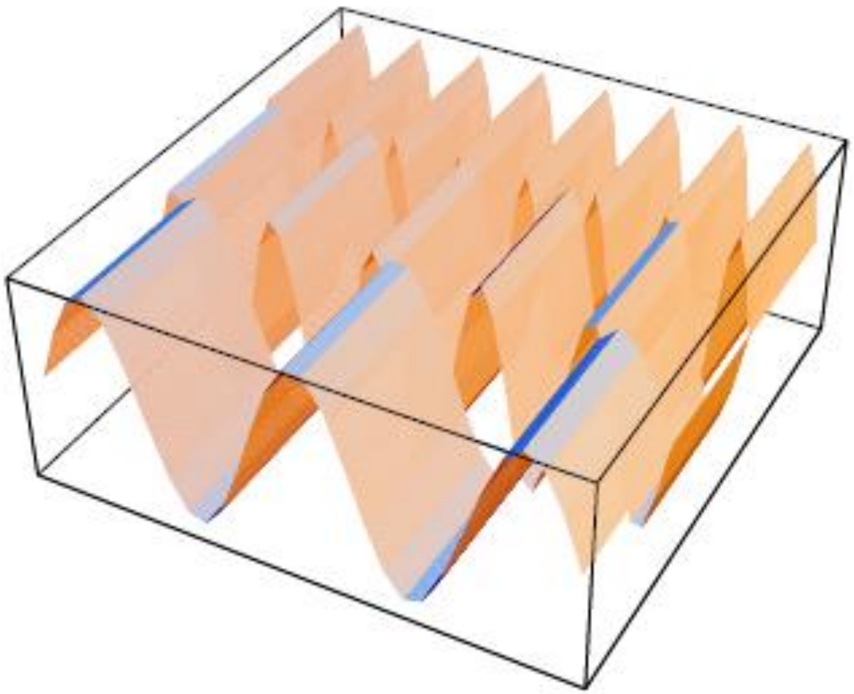


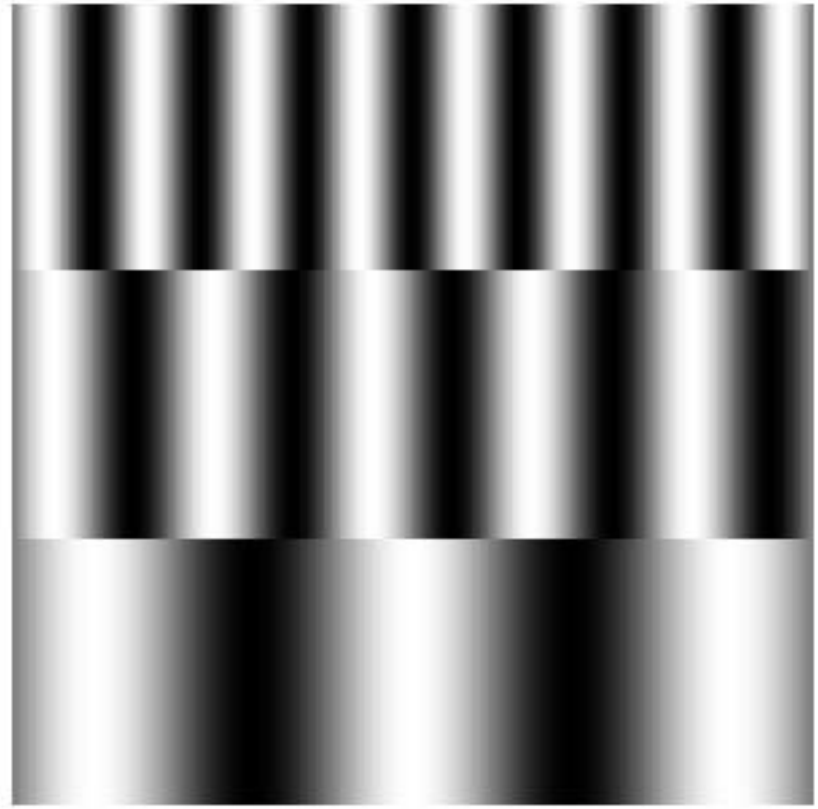
← 32 x 32

8 x 8 →



Frecventa spatiala





Frecventa

"Frecventa" = frecventa undei sinusoidale corespunzatoare

$f(x) = \sin(ax)$, unde $\nu = a/(2\pi)$ este frecventa (spatiala)

Frecventa cea mai joasa = 0 => imagine constanta

Rezolutia este limitata => detaliul cel mai fin este limitat =>
=> frecventa cea mai inalta este limitata

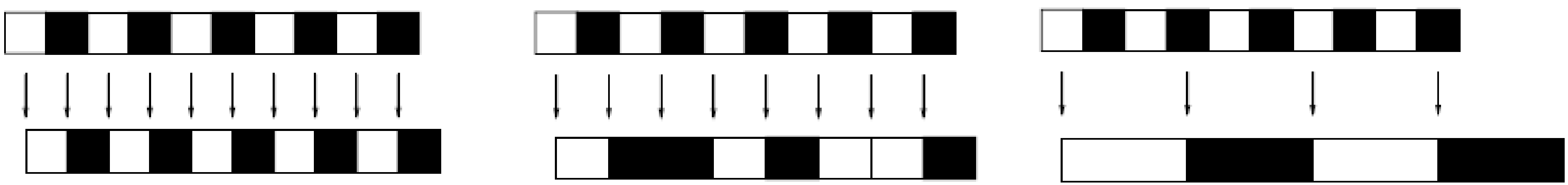
Teorema esantionarii

Pentru a capta cele mai mici detalii (cele mai inalte frecvente), frecventa de esantionare trebuie sa fie 2ξ sau mai mare, unde ξ reprezinta cea mai inalta frecventa din imaginea originala

Frecventa Nyquist = 2ξ

Alias (1)

ξ_n =1/2 per pixel ⇒ Frecventa Nyquist = 2·1/2=1

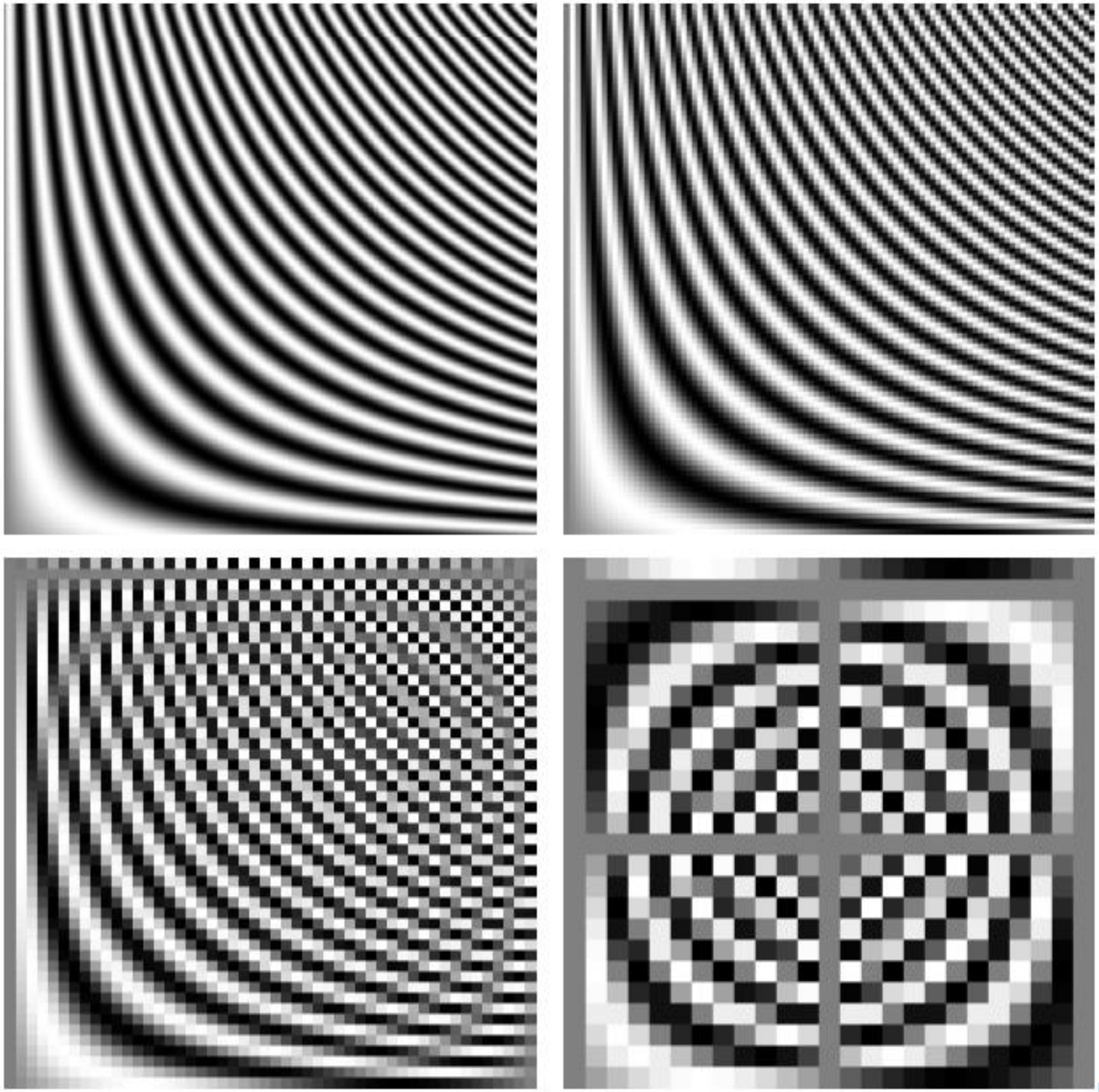


Esantionare cu
ν=1
⇒se obtine imaginea originala

Esantionare cu
ν=4/5
⇒pierderea unor detalii

Esantionare cu
ν=1/3
⇒un sablon care nu era prezent in imaginea originala

Alias (2)



Fie functia:

$f(x, y) = \sin(2\pi x(26-y))$

definita in domeniul:

$D_f=\{(x, y)\in[0, 1]\times[1,25]\}$

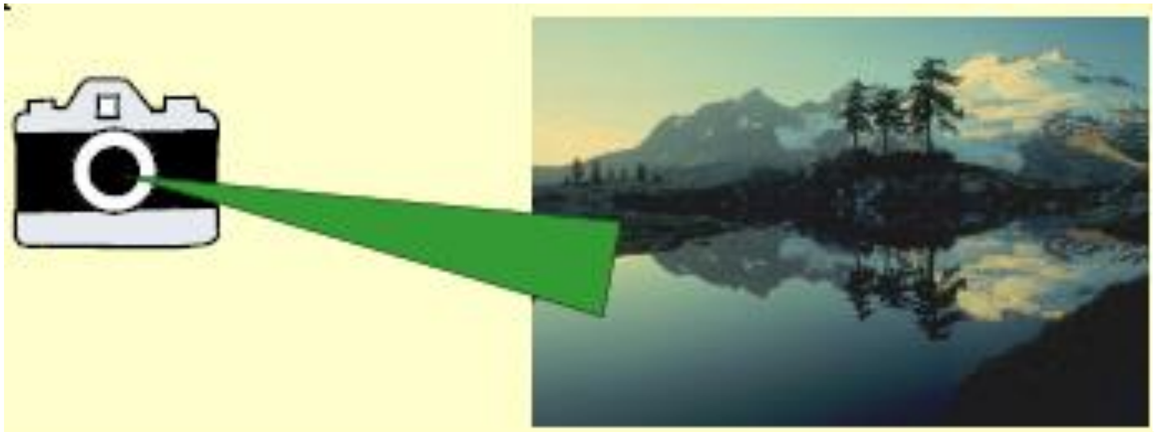
Observam ca:

ν = 25/linie sus

ν = 1/linie jos

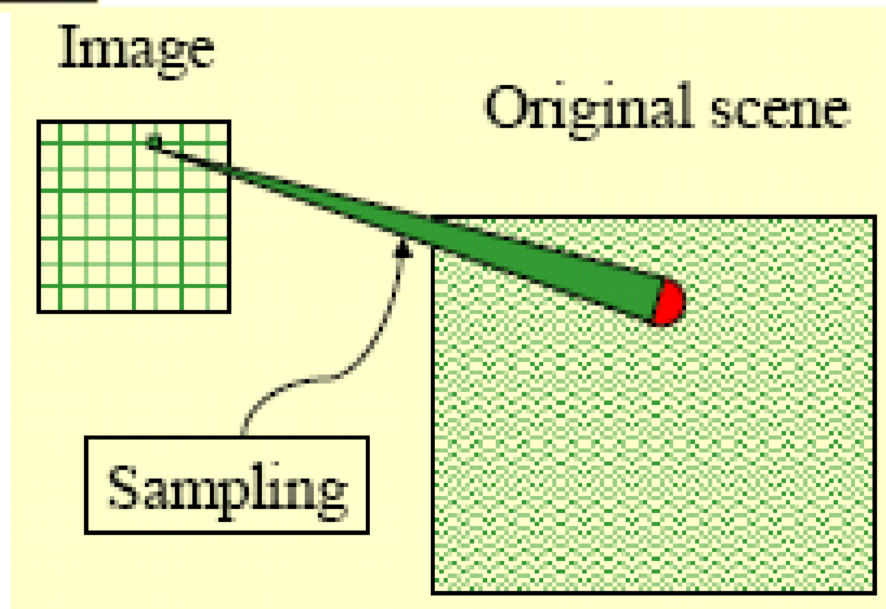
Esantionare la diferite frecvente: 400, 100, 50, 25

Esantionare



- esantionare cu precizia infinita = fals

- esantionarea ia in considerare o vecinatate



Esantionare si convolutie

- modelarea matematica = convolutia: f=imag orig., g=nucleul
- convolutia a doua functii integrabile $f,g:\mathbb{R}\rightarrow\mathbb{R}$ (im.esant.)

$$(f * g)(x) = \int_{-\infty}^{\infty} f(a)\, g(x-a)\, da$$

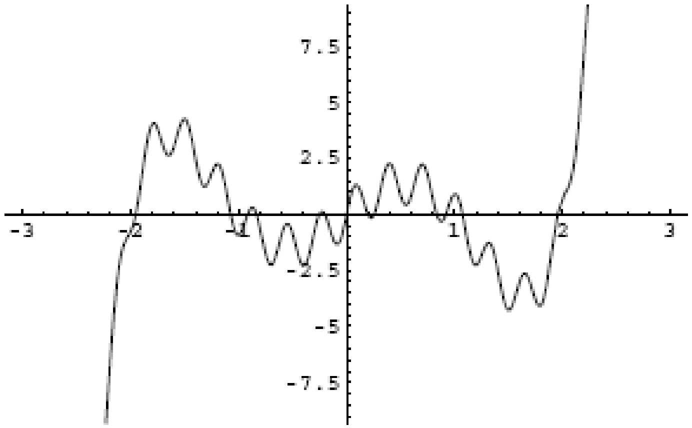
- convolutia a doua imagini *f* si *g* bidimensionale

$$(f * g)(x,y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(a,b)\, g(x-a, y-b)\, da\, db$$

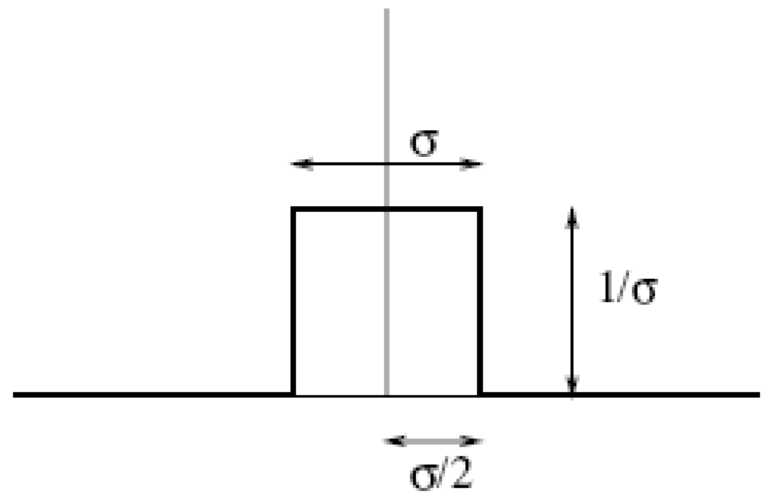
- convolutia este comutativa $f * g = g * f$

Convolutia unei functii unidimensionale

$f(x) =$

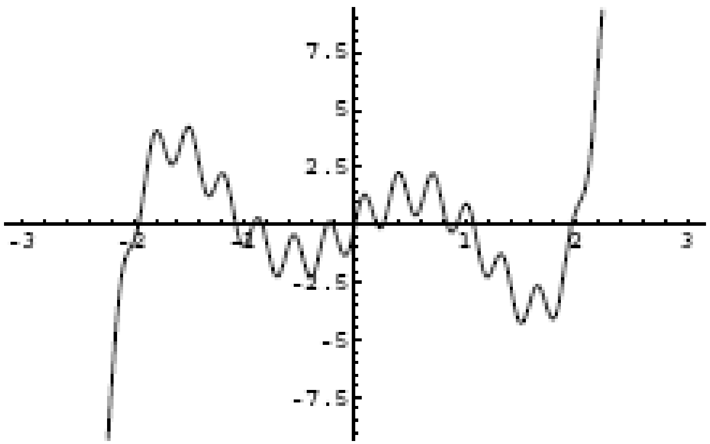


$$g(x) = \begin{cases} 1/\sigma & \text{if} \quad |x| \leqslant \sigma/2 \\ 0 & \text{if} \quad |x| > \sigma/2 \end{cases} =$$

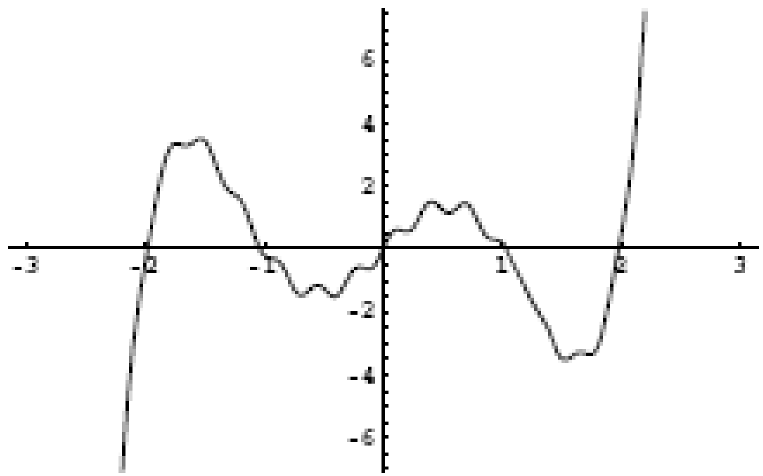


$$(g * f)(x) = \int_{-\infty}^{\infty} g(a)\, f(x-a)\, da = \frac{1}{\sigma} \int_{-\frac{\sigma}{2}}^{\frac{\sigma}{2}} f(x-a)\, da$$

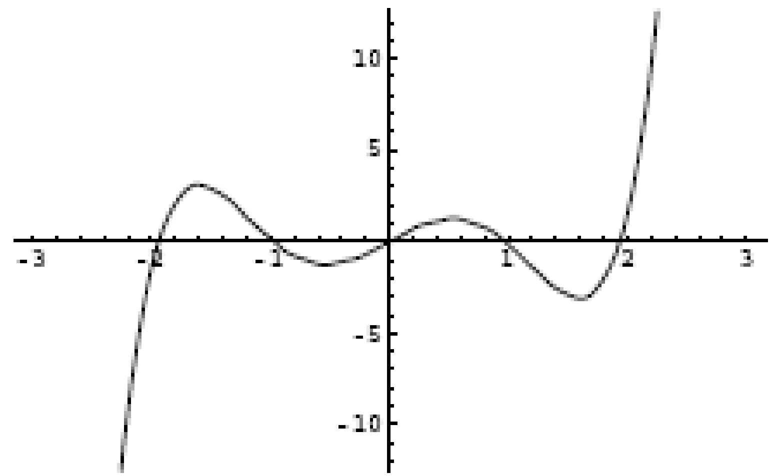
Convolutia unei functii unidimensionale



σ = 0,25



σ = 0,6



σ creste $\Rightarrow$ functia devine mai neteda, dispar detalii $\Rightarrow$ filtru trece jos

Nucleul ideal

- g = nucleul convolutiei
- daca σ tinde la zero ⇒ functia Dirac:

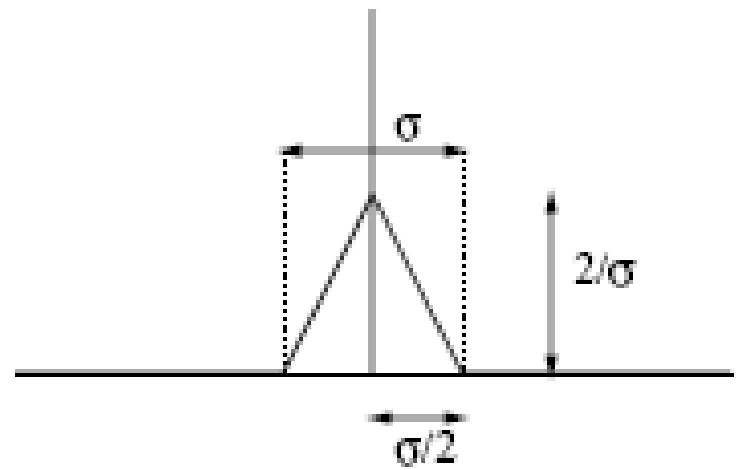
$$\begin{cases} \delta(x) = 0 & \forall x \in \mathbb{R} \setminus 0 \\ \int\limits_{-\infty}^{\infty} \delta(x)\, dx = 1. \end{cases}$$

- convolutia cu δ lasa functia neschimbata

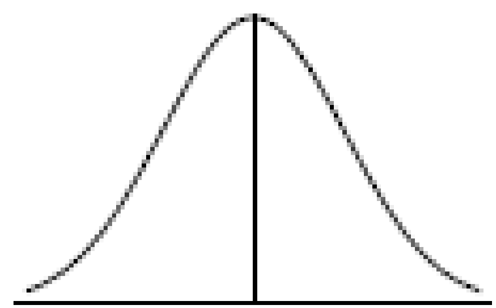
$$(\delta * f)(x) = \lim_{\sigma \to 0} \frac{1}{\sigma} \int_{-\frac{\sigma}{2}}^{\frac{\sigma}{2}} f(x-a)\, da = f(x)$$

Nuclee de convolutie 1D

$$\begin{cases} \frac{2}{\sigma} - \frac{4x^2}{\sigma^2|x|} & \text{if} \quad |x| \leqslant \sigma/2 \\ 0 & \text{if} \quad |x| > \sigma/2 \end{cases}$$



$$\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2}$$



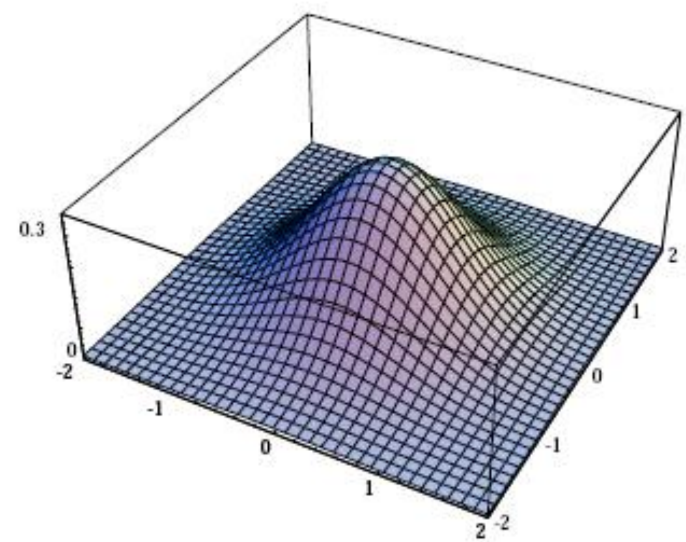
Nuclee de convolutie 2D

- functia dreptunghiulara

$$g(x,y) = \begin{cases} 1/\sigma^2 & \text{if } |x| \leqslant \sigma/2 \text{ and } |y| \leqslant \sigma/2 \\ 0 & \text{otherwise} \end{cases}$$

- functia lui Gauss

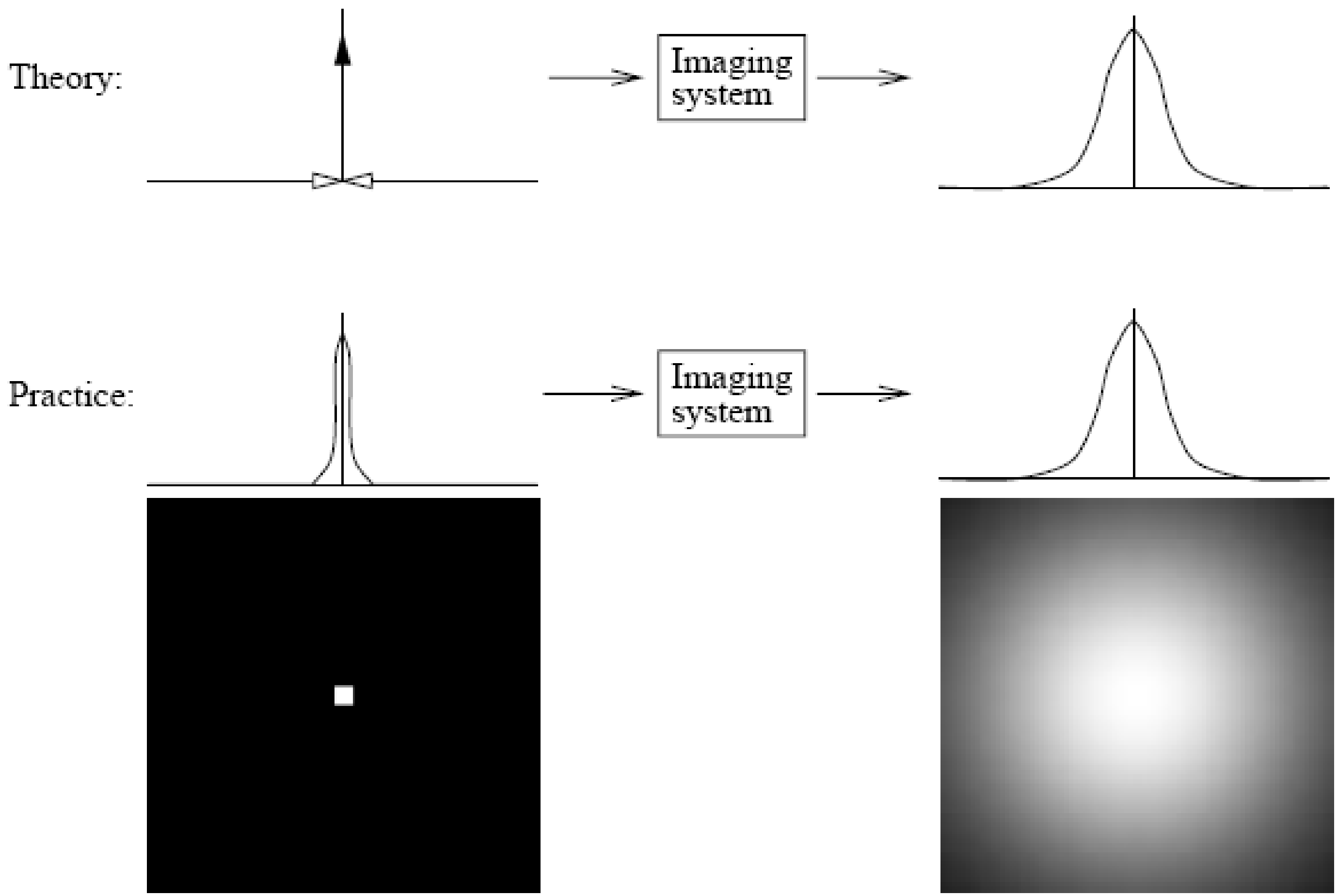
$$g(x,y) = \frac{1}{\sigma^2 2\pi} e^{-\frac{1}{2}\frac{x^2+y^2}{\sigma^2}}$$



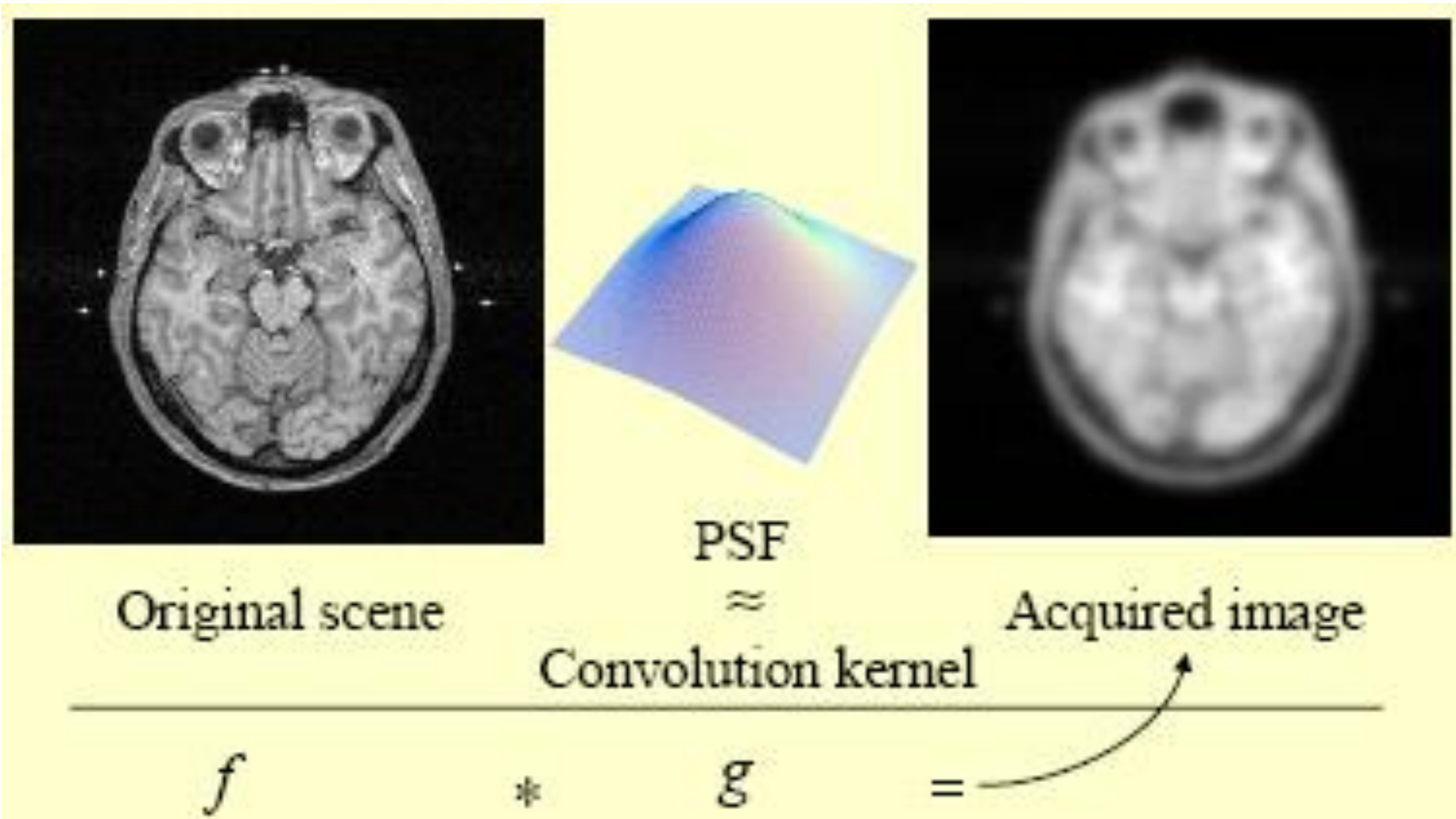
Volumul de sub nucleu este 1

$$\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} g(x,y)\,dx dy = 1$$

Functia de distributie a punctului

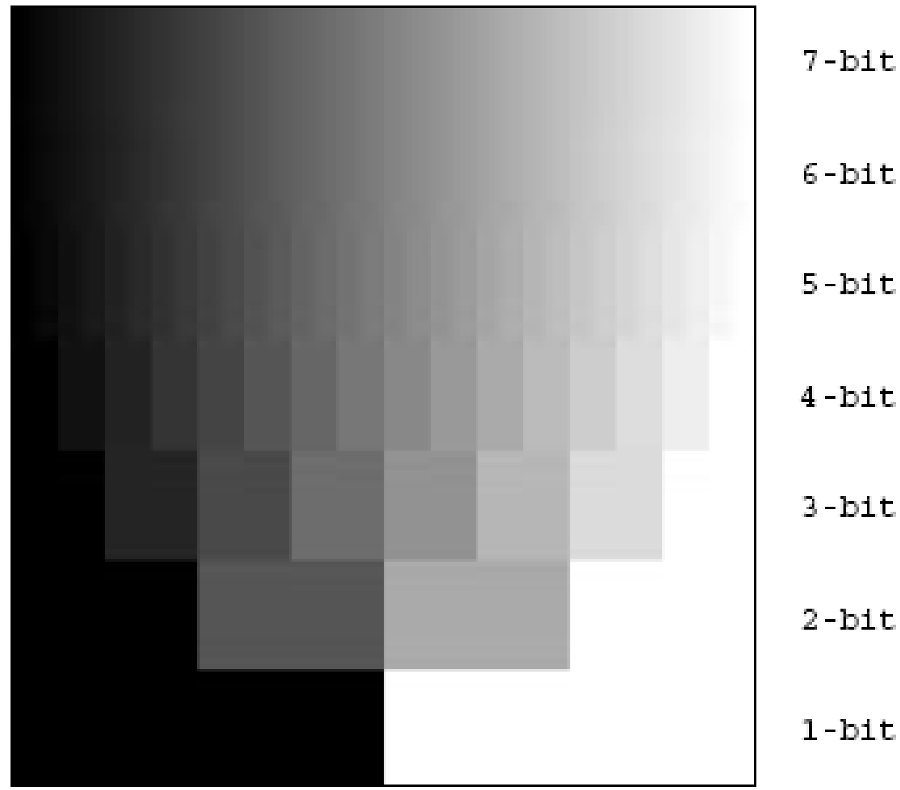


Exemplu



Cuantificare

- val. de gri sunt cuantificate la un numar finit de valori de gri
- n biti ⇒ 2^n nuante de gri
- pe 8 biti ⇒ 0 ÷ 255
- pe 32 biti ⇒ 0 ÷ 2^{32}-1
- intregi, intregi fara semn sau nr.reale (float)

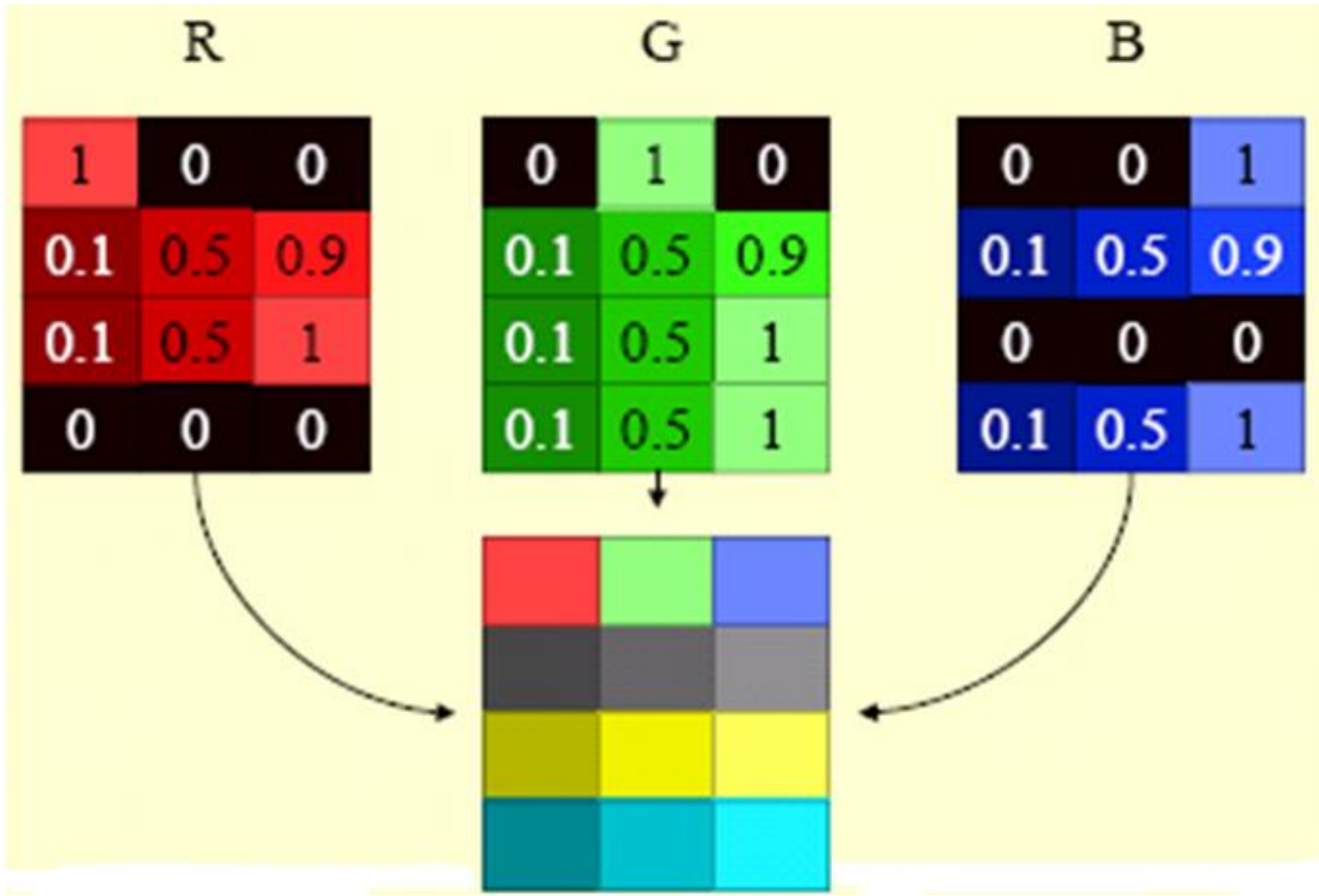


Modelul color

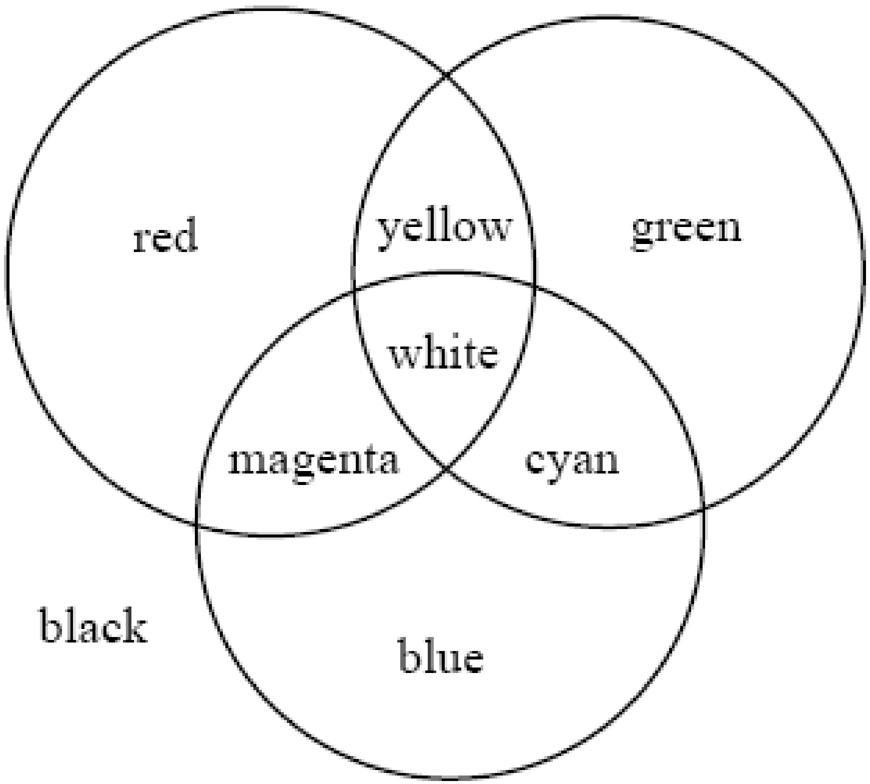
- modelul RGB (aditiv, emisiv)
- modelul CMY (substractiv, reflectant)
- modelul CMYK
- modelul HSV
- etc.

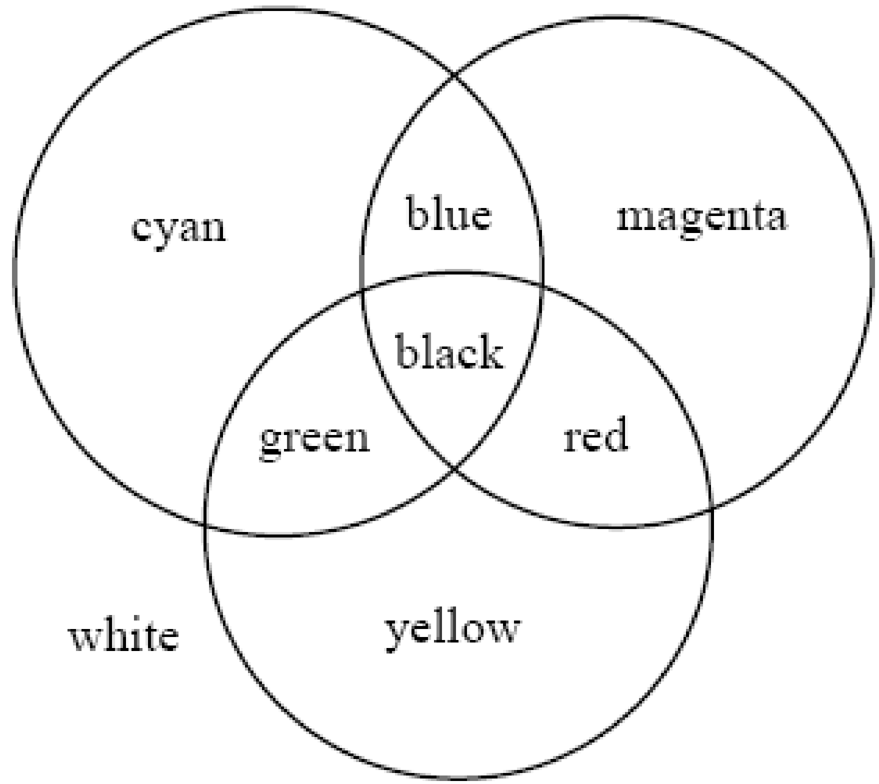
Modelul RGB

Red (700 nm), Green (546,1 nm), Blue (435,8 nm)



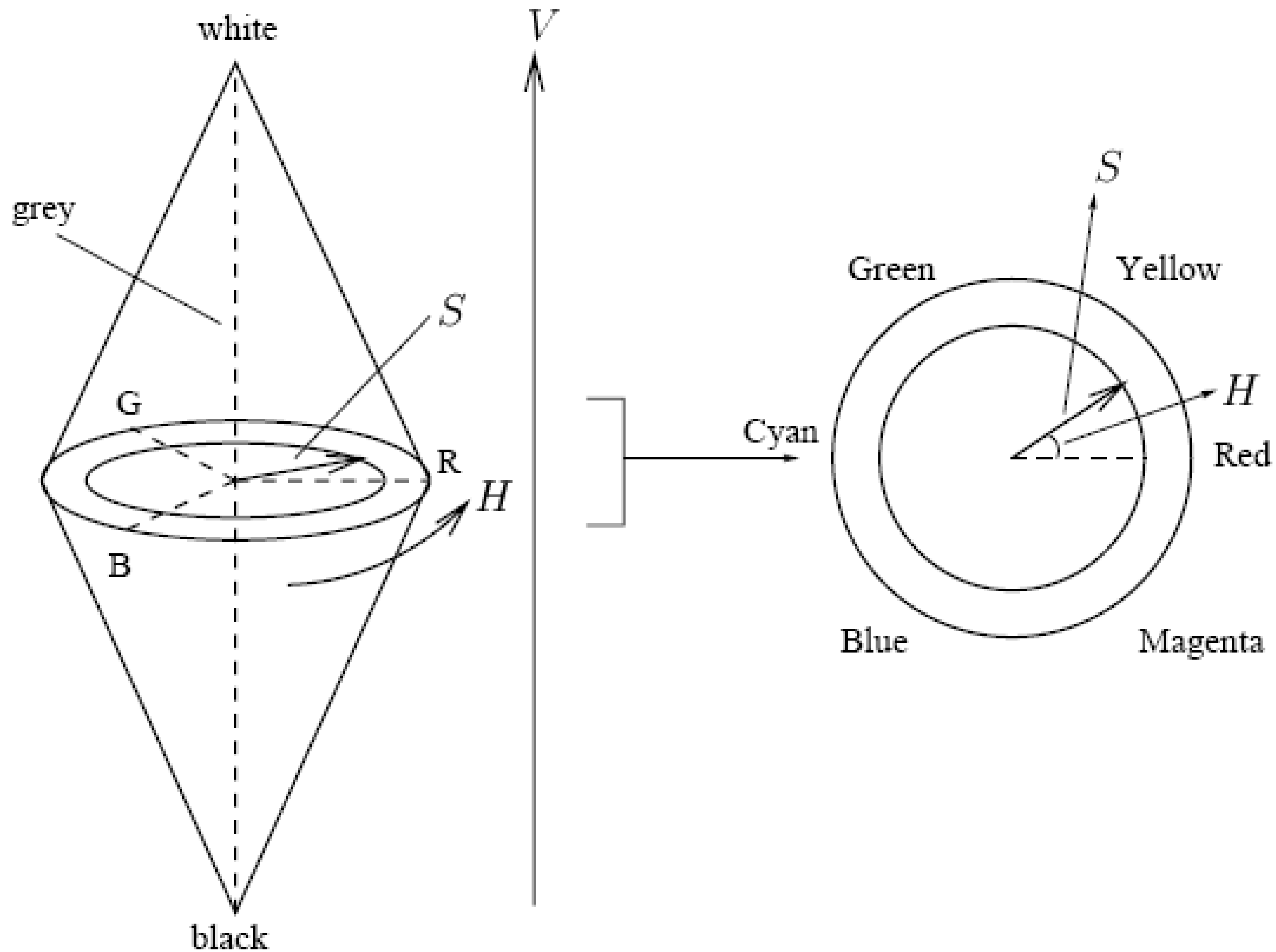
Modelul RGB si CMY





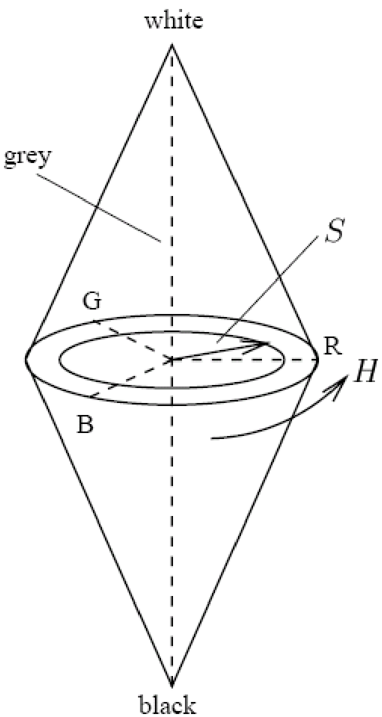
RGB (aditiv, emisiv) CMY (substractiv, reflectant)

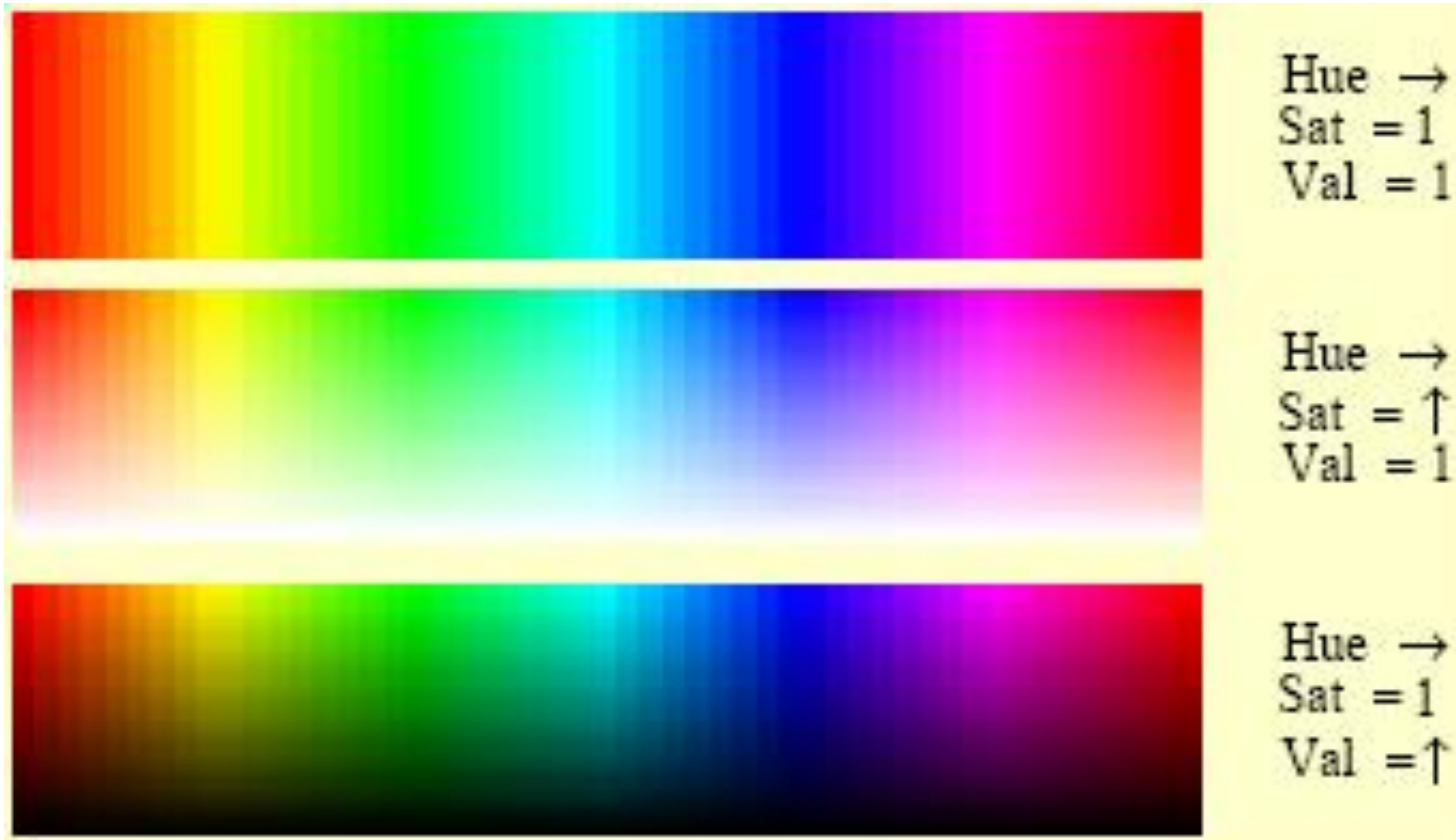
Modelul HSV



white
V
grey
S
G
R
H
B
black
S
Green
Yellow
H
Cyan
Red
Blue
Magenta

Modelul HSV


white
grey
S
G
R
H
B
black


Hue →
Sat = 1
Val = 1
Hue →
Sat = ↑
Val = 1
Hue →
Sat = 1
Val = ↑