Medical Image Visualization

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M2 MIA / GICAO (P+R)

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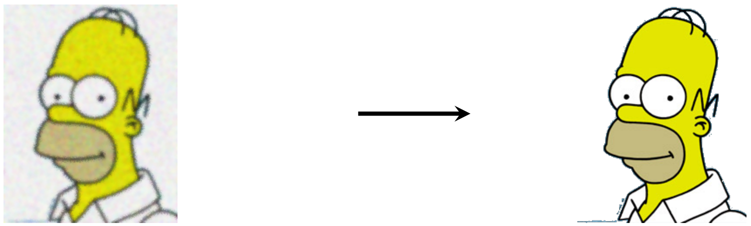
Image Processing/Analysis

- Image Processing

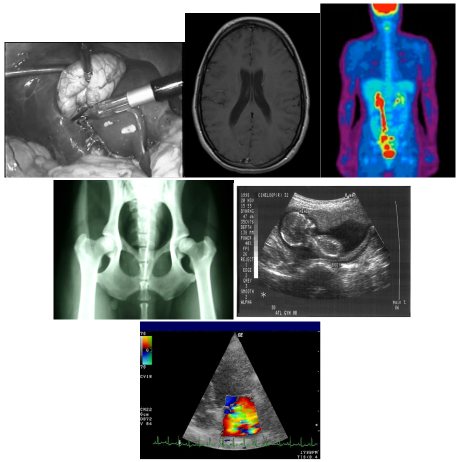


- Analysis

- Yellow skin
- Small ears
- Eyes : $5cm$ of diameter
- ...

Recall: What Do Medical Images Show ?

- Intensity
- Magnetic Field Measures
- Concentrations
- Absorption Coefficients
- Distances to interfaces
- Speeds
- Coefficients of elasticity
- ...



Recal: Use of Medical Images ?

- Knowledge of Human Organs
  - Shape
  - Composition
  - How they work
- Representation of the parameters of a model
  - Elasticity
  - Speed
- Diagnosis
- Therapy
  - Planing
  - Computer Assisted Medical Intervention
  - Patient care

Why a numerical analysis of images ?

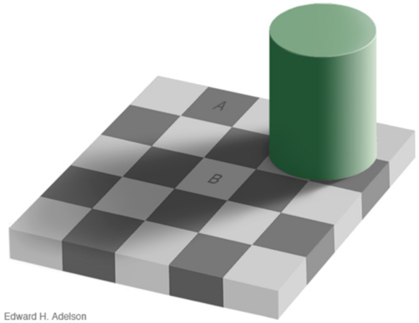
Why a numerical analysis of images ?

Human Being

- Identification
- A Priori Knowledge
- Interpretation

Ordinateur

- Quantitative
- Objective
- Reproducible



Edward H. Adelson

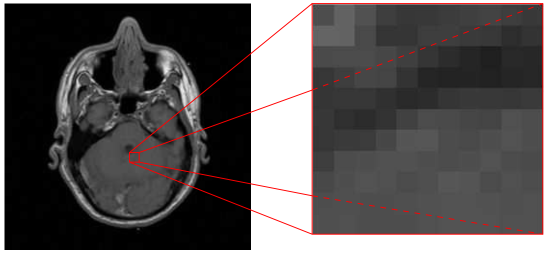
Numerical Image

Analogical variable:

- continuous
- in $\mathbb{R}^n$

Numerical variable:

- discrete/countable
- in $\mathbb{Z}^n$



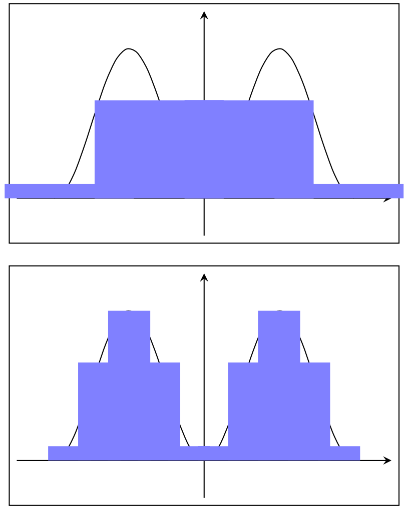
78	99	81	62	55	56	60	64	67	61	57
100	99	73	52	53	61	62	58	56	45	51
74	75	75	71	63	53	44	37	31	40	39
54	62	70	68	51	37	35	36	33	37	38
53	54	54	48	42	44	53	57	56	55	58
55	47	44	51	65	75	74	70	68	80	77
54	58	59	71	85	86	76	73	78	82	78
61	76	78	81	81	78	76	78	82	76	74
72	78	82	80	75	79	86	84	75	80	77
78	79	78	78	79	81	82	82	81	79	80
79	80	78	77	78	80	82	82	82	80	80

Image Discretization

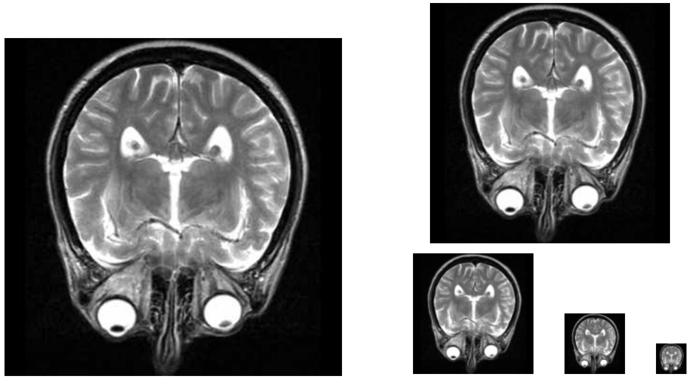
$$\begin{array}{rlcl} F_{continuous}: & \mathbb{R}^n & \longmapsto & \mathbb{R} \\ I_{discrete} & :G = [0,...,l] \times ... \times [0,...,m] & \longmapsto & A = [0,...255] \end{array}$$

- Spatial Discretization ($\mathbb{R}^n \Rightarrow G$) : sampling
  - Shannon Theorem
    To what extend may the high frequencies of a signal be reconstructed with respect to the sampling resolution ?
- Grey Level discretization : ($\mathbb{R} \Rightarrow A$): quantization

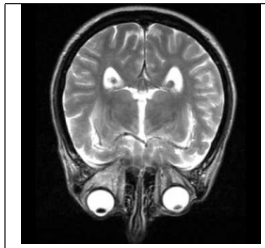
Recall: Shannon Theorem



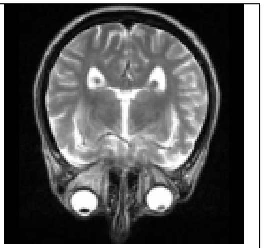
Spatial Sampling



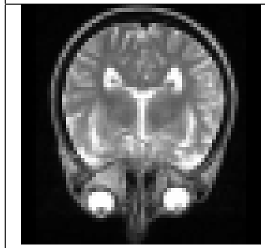
Spatial Sampling



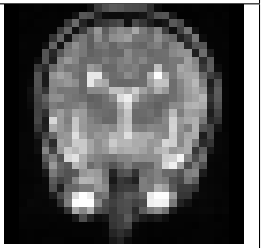
255 × 255 pixels



128 × 128 pixels

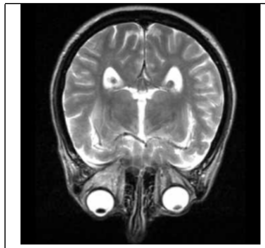


64 × 64 pixels

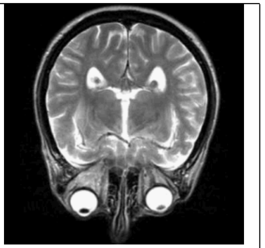


32 × 32 pixels

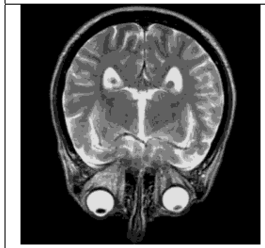
Quantization



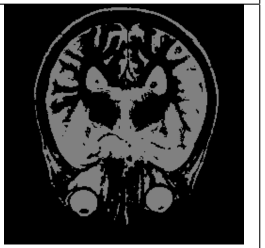
256 grey levels



32 grey levels



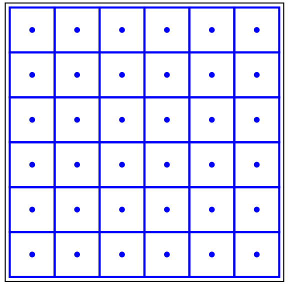
8 grey levels



2 grey levels

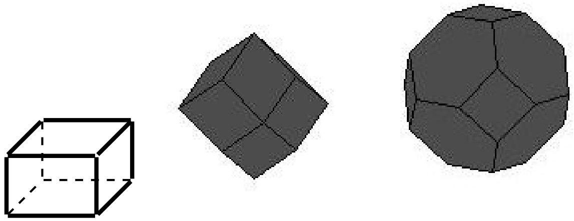
Spatial Sampling: 2D grids

- 2D square grid



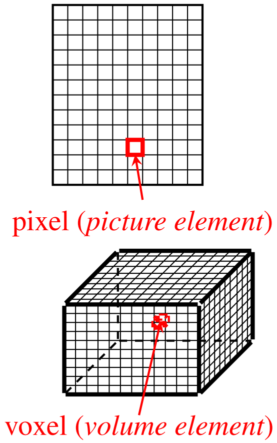
Spatial Sampling: 3D Grids

- 3D
  - cubic/parallelepiped grid
  - Face Centred Cubic grid
  - Body Centred Cubic grid



Medical Image Dimensionality

- 2D Images
  - Image 2D by nature (ex: endoscopy)
  - Projections (ex: radiography)
  - Slices (ex: MRI or X-Scan slices)
- 3D Volumes
  - Tomography
  - MRI
- 4D Images
  - 3D Volumes + Time

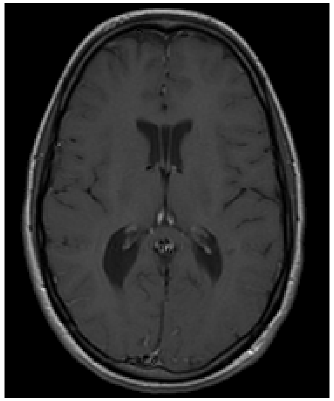


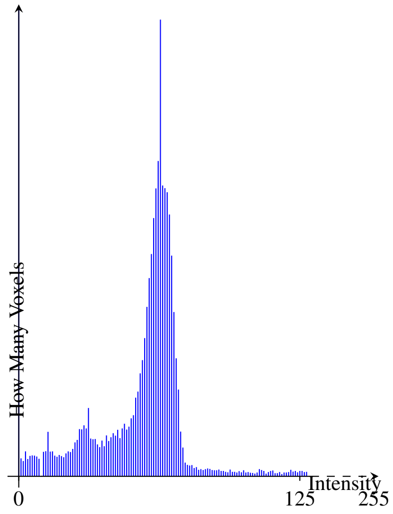
pixel (*picture element*)

voxel (*volume element*)

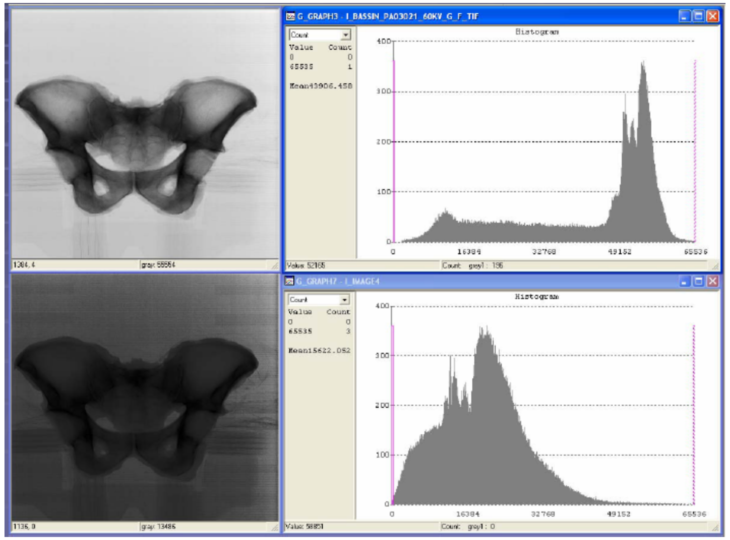
Resolution : size of a pixel / voxel

Histogram





Several types of histogram



1204, 4 gray: 55554

G_GRAPH3 - I_BASSIN_PA03021_60KV_G_F_TIF

Count

Value	Count
0	0
65535	1

Mean43906.458

Value: 52165 Count: grey1 : 196

1136, 0 gray: 13486

G_GRAPH7 - I_IMAGE4

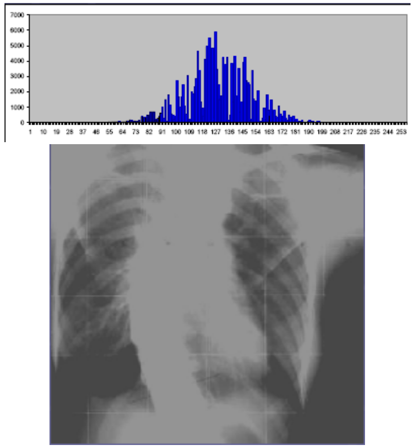
Count

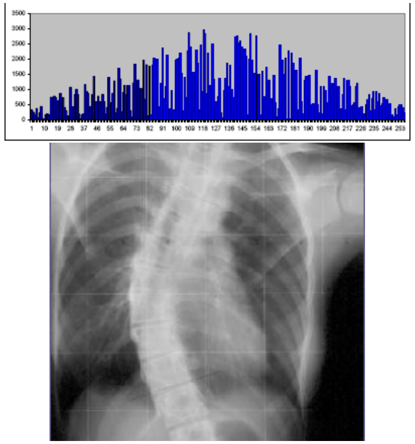
Value	Count
0	0
65535	3

Mean15622.052

Value: 58851 Count: grey1 : 0

Several types of histogram





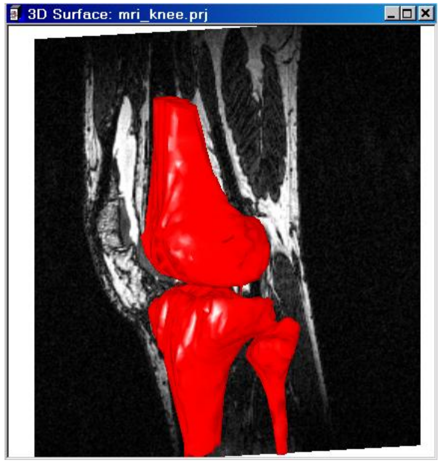
Problem: 3D data, 2D display

- Stereo visualization

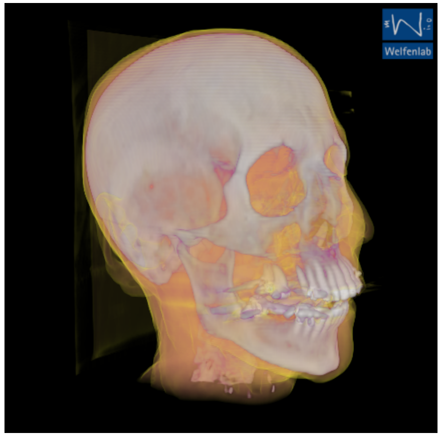
Problem: pseudo 3D reconstruction made by the brain → fatigue during long interventions.

Problem: 3D data, 2D display

- 3D Visualization on 2D screens



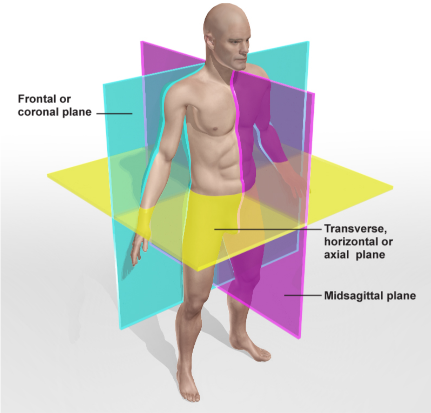
Surface extraction

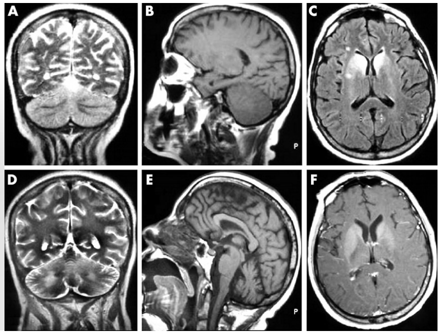


Volume rendering

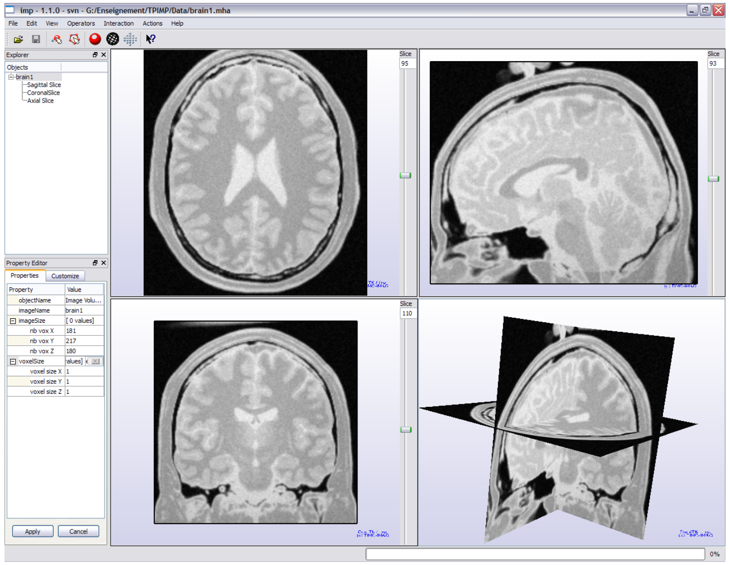
Problem: 3D data, 2D display

Medical images planes





Planes of Medical Images


imp - 1.1.0 - svn - G:/Enseignement/TPIMP/Data/brain1.mha

Property	Value
objectName	Image Volu...
imageName	brain1
imageSize	[0 values]
nb vox X	181
nb vox Y	217
nb vox Z	180
voxelSize	alues]
voxel size X	1
voxel size Y	1
voxel size Z	1

Vtk

What is Vtk ?

- Vtk = Visualization Tool Kit
- C++ library
- Open Source, Free, produced by Kitware
- Object-Oriented (interfaced with C++, Tcl/Tk, Pyton and Java)
- Allows visualization of
  - scalar data
  - vector data
  - tensor data
- Contains data rendering methods
  - Surface rendering
  - Volume rendering (ray tracing, 2D and 3D texture mapping, etc.)
- Contains some algorithms of image processing

Visualization System

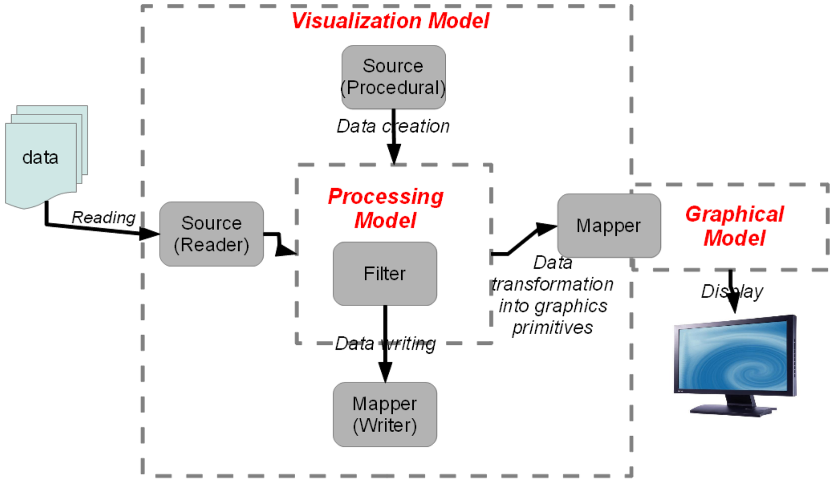
Reading, Processing and Displaying data as images

2 Steps

- Converts data in graphics primitives (points, lignes, triangles, etc.)
- Converts graphical data in images

Vtk Objects are organized in 3 models:

- Visualization Model
  Step 1: Geometrical representation of data
- Graphical Model
  Step 2: Geometrical representation rendering
- Processing Model
  Step 3: image processing



Visualization Model

Objectif

- Transform data into graphics primitives
- Build a geometrical represnetation of objects to be displaied

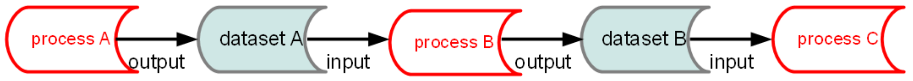
Based on *Pipeline*

- Data transformation is decomposed into modules
- Each module performes one operation on data
- Modules are interconnected to build a nettwork or pipeline
- Data ar going through the pipeline going from one module to the other.

Visualization Model

2 Object types

- *Data* objects
  - data going through the pipeline
  - called datasets
- *Process* objects
  - Algorithm module or component of the pipeline



Process Objects

Source

Start the pipeline

- Reading output data (images)
- New data generation
- No input
- One or more output(s)

Filter

Process data objects

- Receives one or more input(s)
- Generates one or more output(s)

Mapper

Ends the pipeline

- Generates graphic primitives

- Transmits the graphical model to the visualization pipeline