A Web Interface for 3D Visualization and Interactive Segmentation of Medical Images

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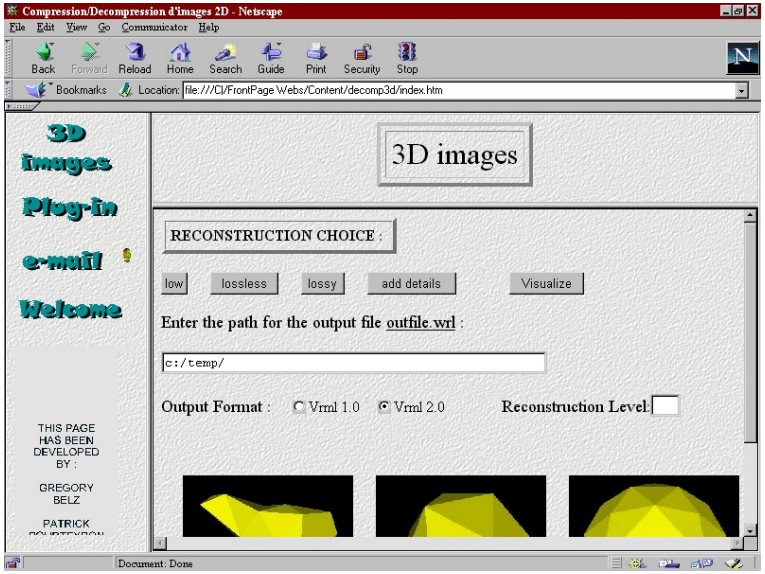
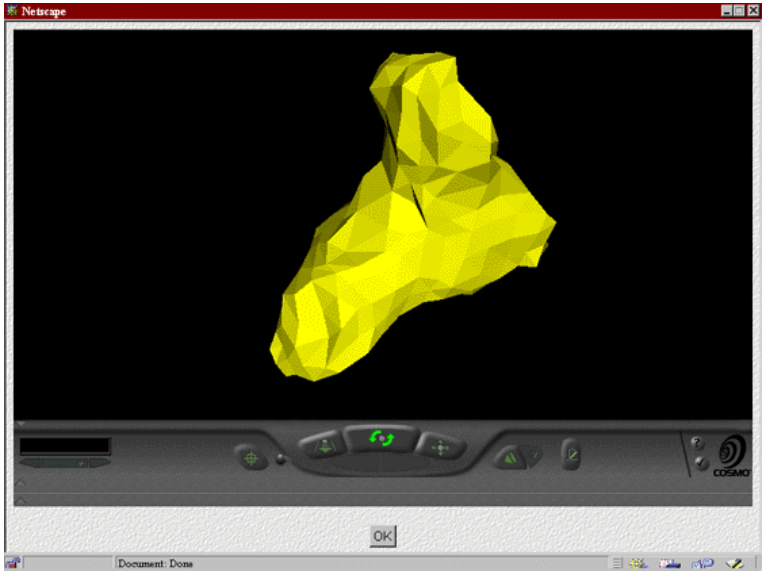
1 : CREATIS
2 : GIPSA-Lab
3 : OneFit Medical SAS

Some of our previous works

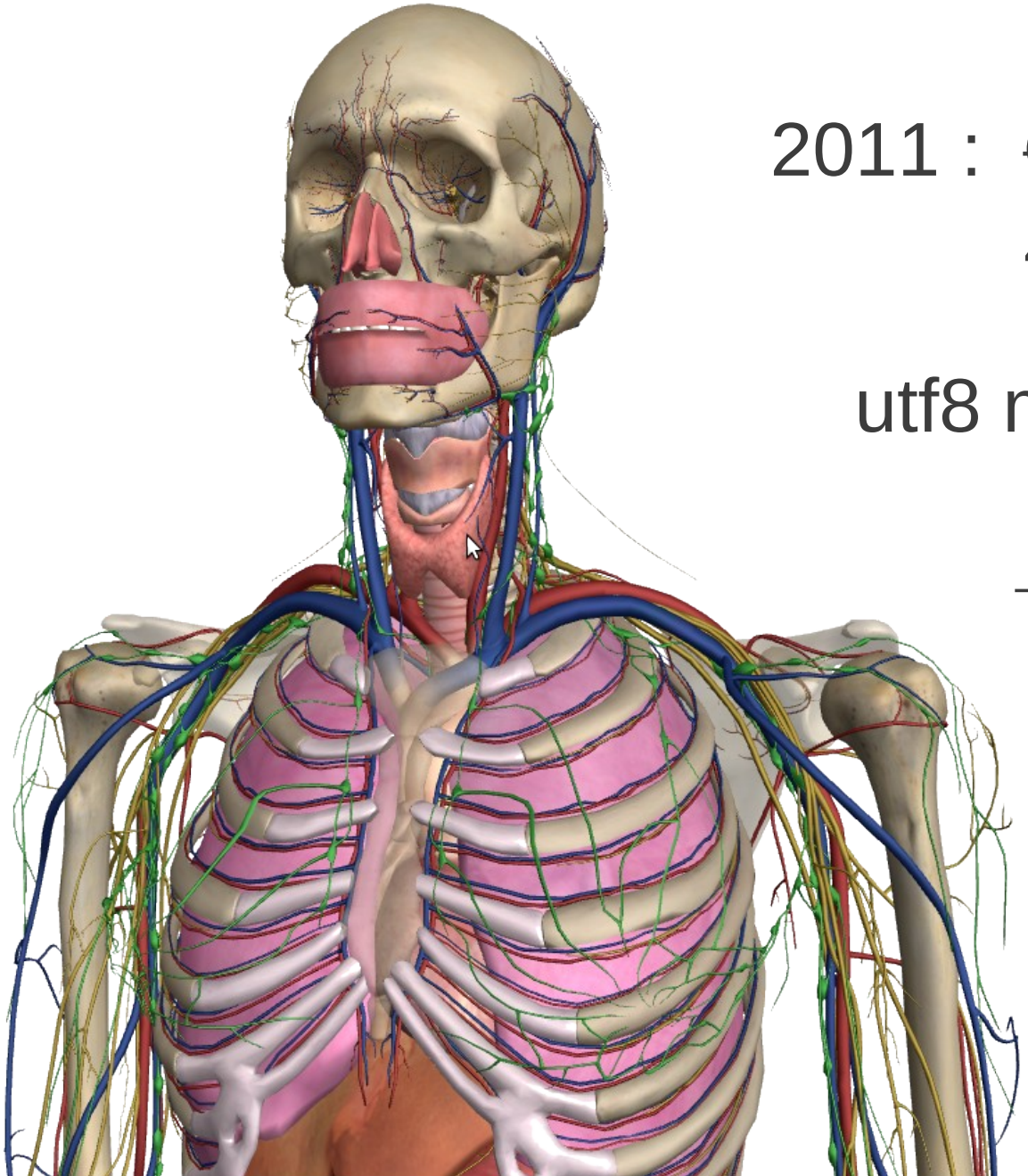
1998 : 3D progressive transmission





- html
- Netscape plugin (c++)
- Cosmo Player

WebGL



2011 : ~~Google Body~~
Zygote Body

utf8 mesh encoder

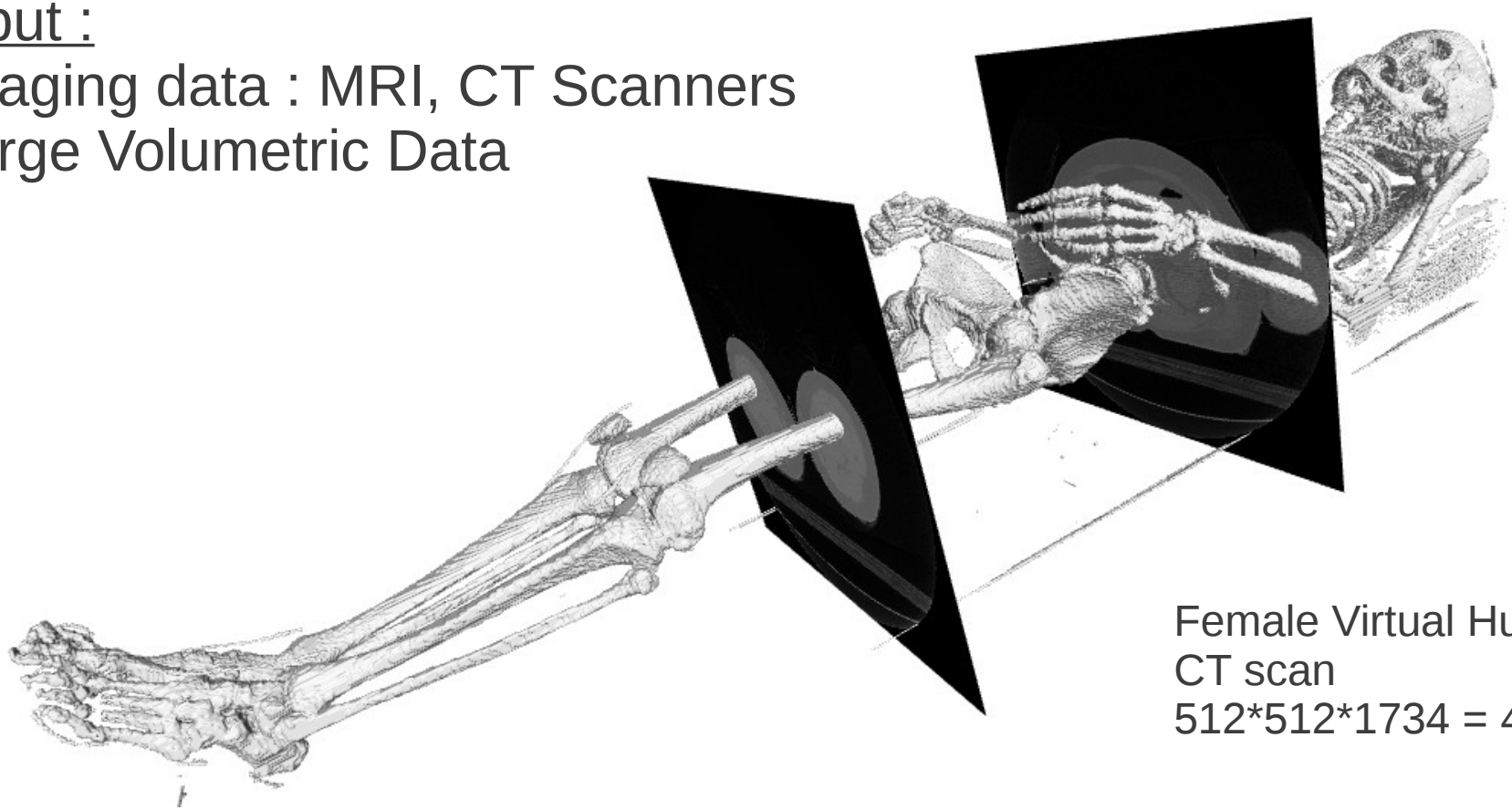
→ Pure js is OK

65K limit

Creatis

Context

<u>Input :</u>
Imaging data : MRI, CT Scanners
Large Volumetric Data



Female Virtual Human
CT scan
512*512*1734 = 455 MB

<u>Output :</u>
Rendering
Processing (segmentation, detection, ...)

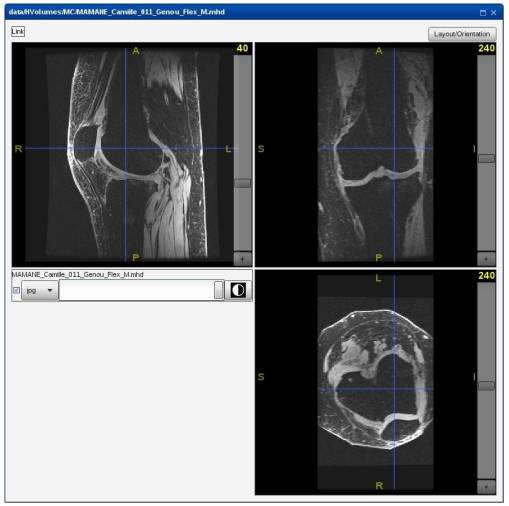
Medical visualization

MPR
- What physicians want

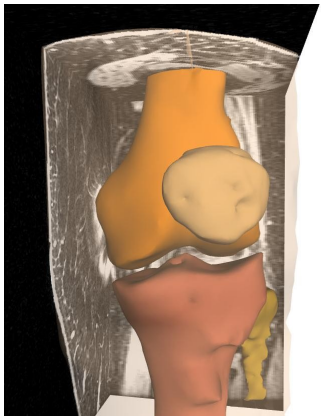
3D Meshes
- Medium Bandwidth

Remote Volume Rendering
- e.g. : ParaviewWeb
- High bandwidth
- High server load

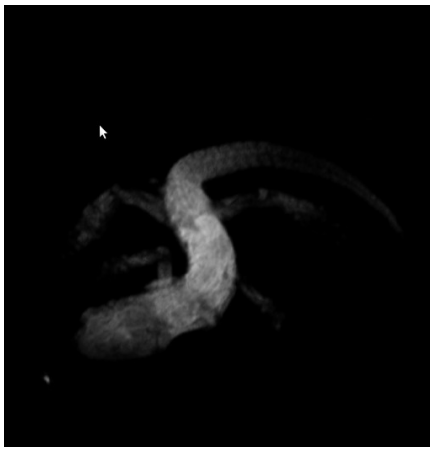
Volume Rendering
- High bandwidth
- High client load



MPR



Meshes

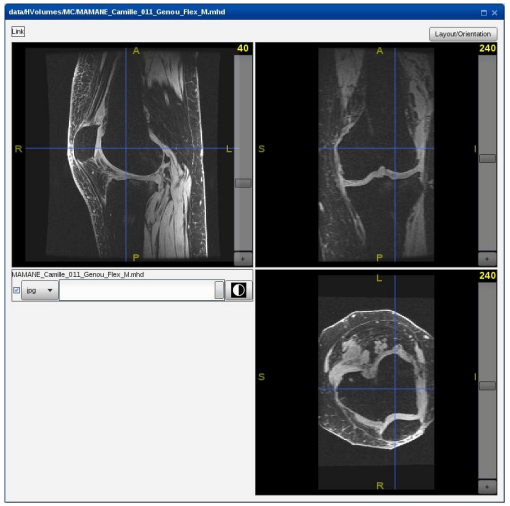


Volume Rendering

MPR

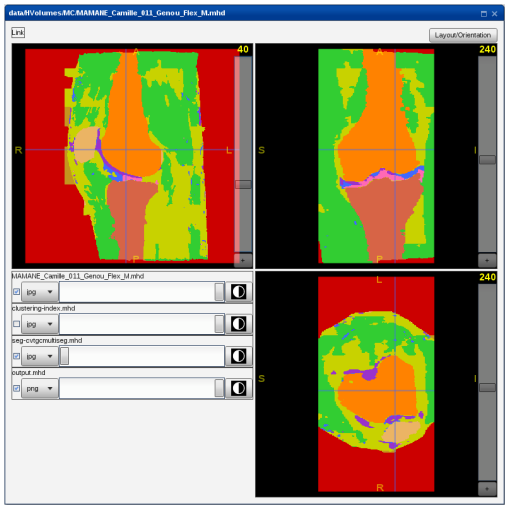
Server-side : Precompute 2D slices

- In-core
- about 1:1 RAM → DISK trade
- slicing delay (fixable)



Client-side : WebGL (three.js)

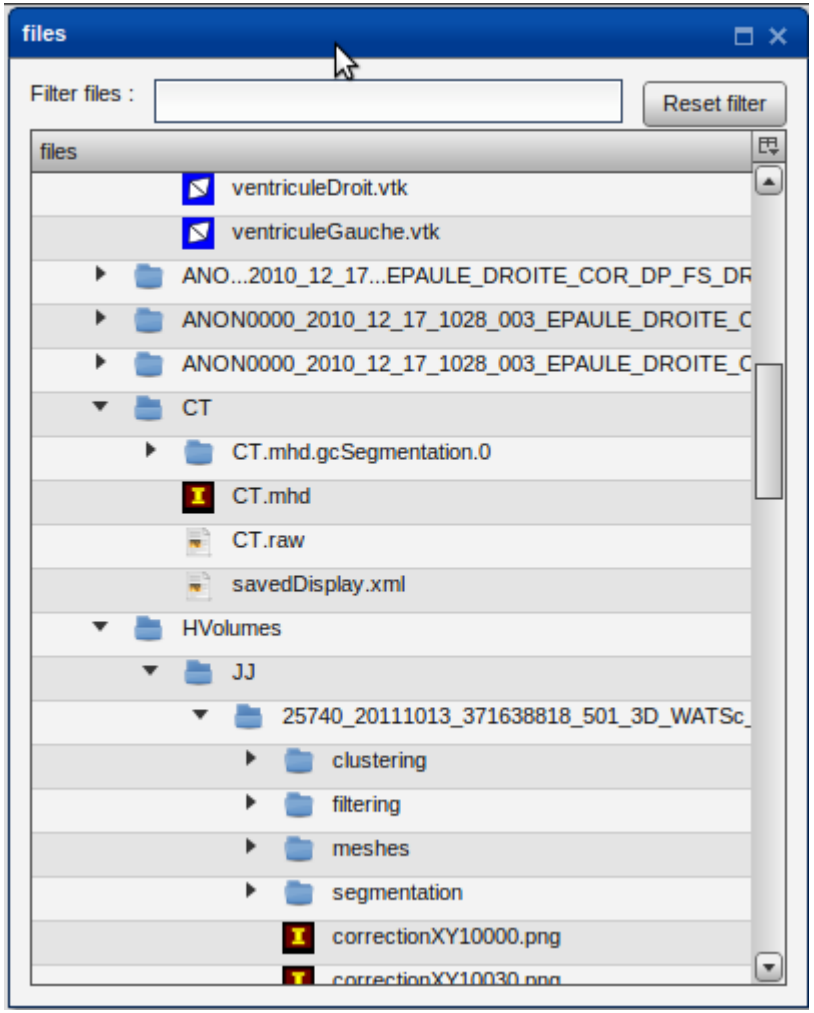
- <img> → texture
- shaders provide:
  - Contrast/brightness
  - HDR
  - Lookup Tables



Under the hood

Server-side processing :

- Generic RPC framework
- Bare filesystem as storage
- RPC Caching



Data Formats

Voxel Data:

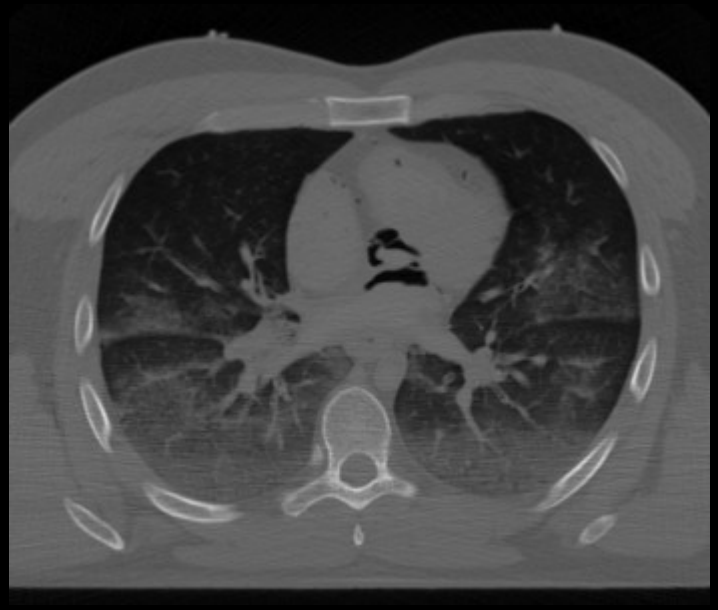
DICOM → RAW/ZRAW → Slices

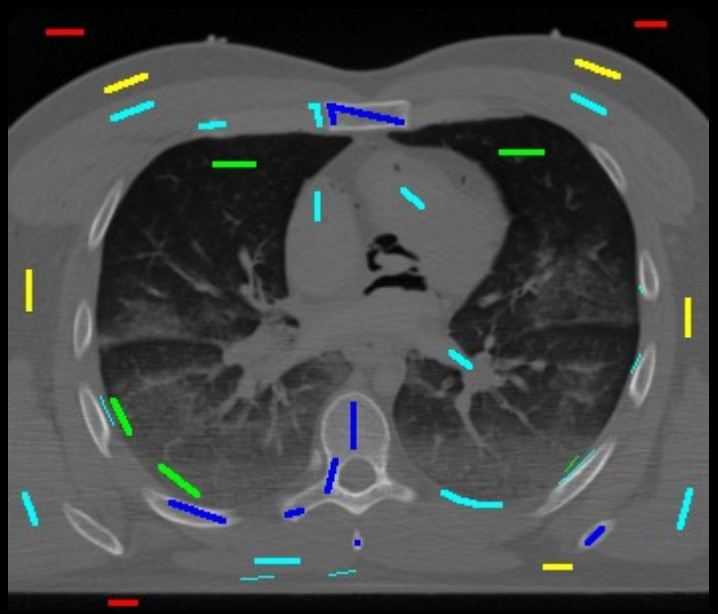
Surfaces :

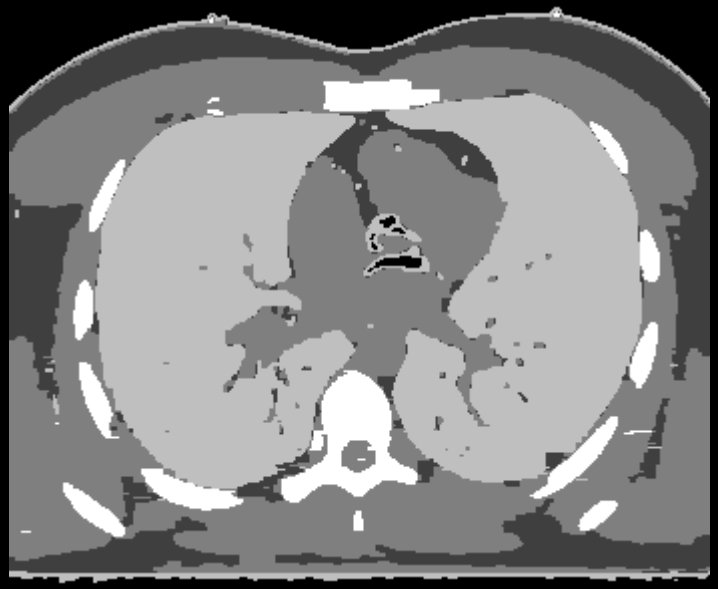
.vtk, .ply, .stl → OpenCTM (just works^{tm})

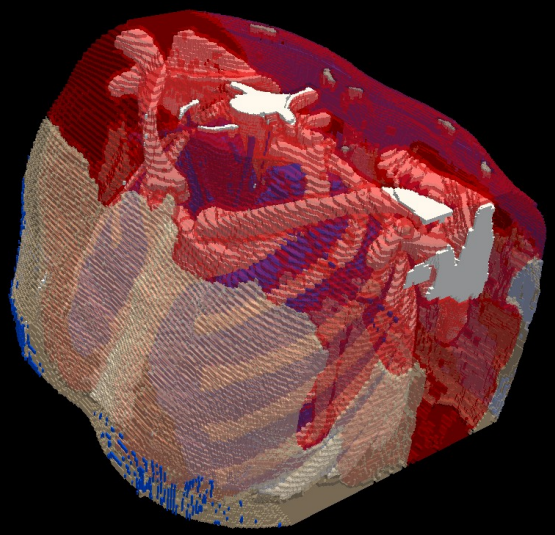
utf8, x3d are a possibility,
But no web format is the end-goal

Interactive Segmentation





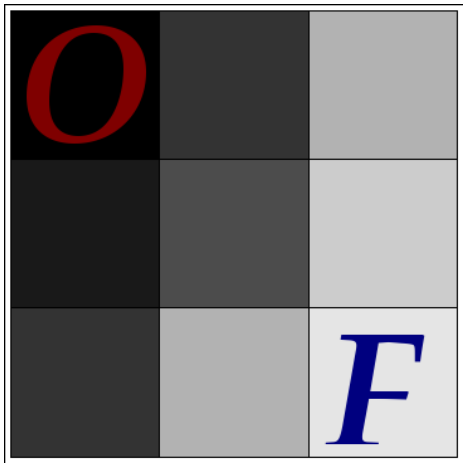


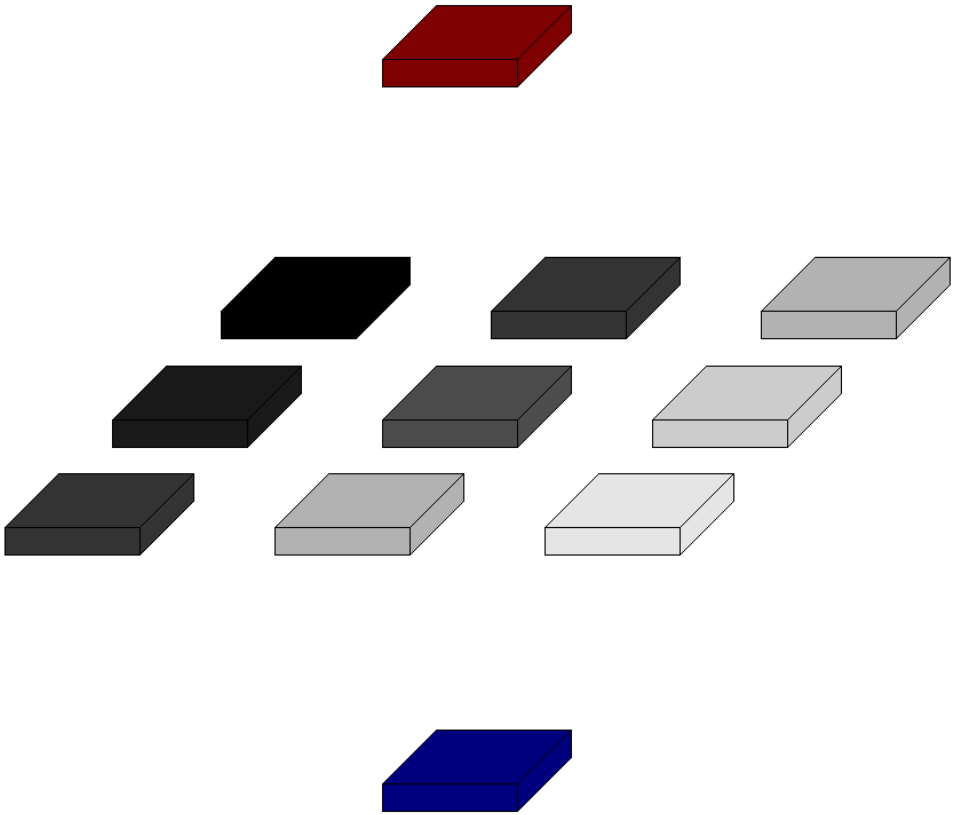


Creatis

Graph cuts

[Boykov & Jolly 2001]



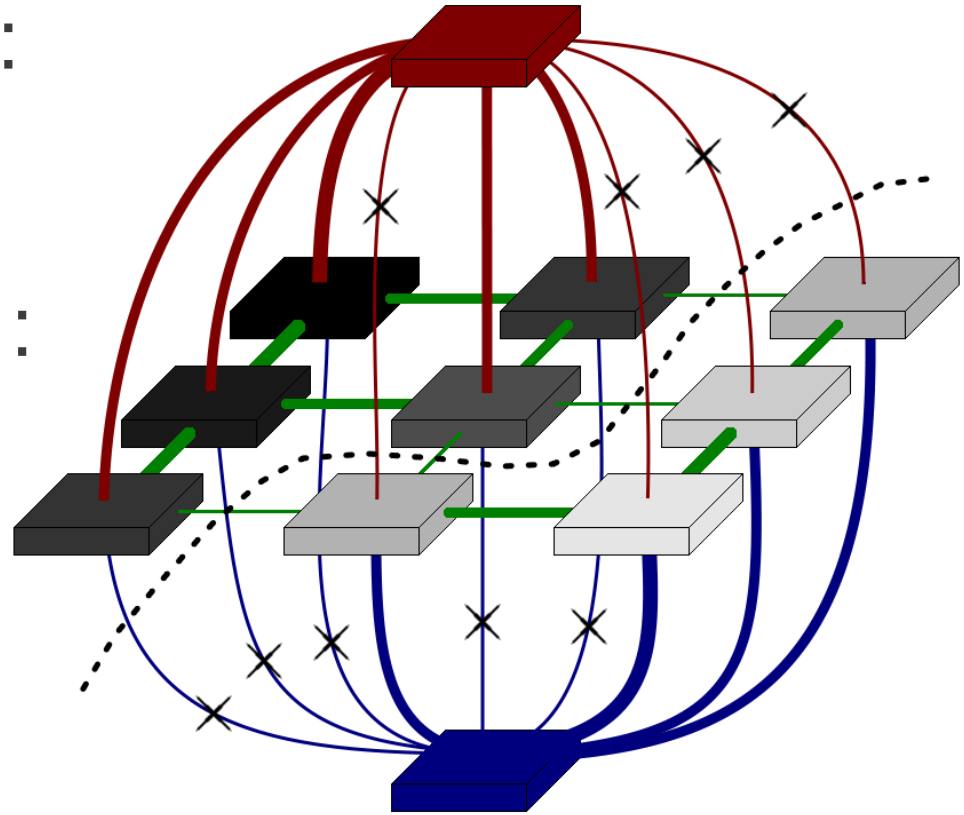


Graph cuts

$$E(\ell) = \lambda \sum_{u \in C(\mathcal{I})} D(\ell_u) + \sum_{\{u,v\} \in N} V_{u,v}(\ell_u, \ell_v)$$

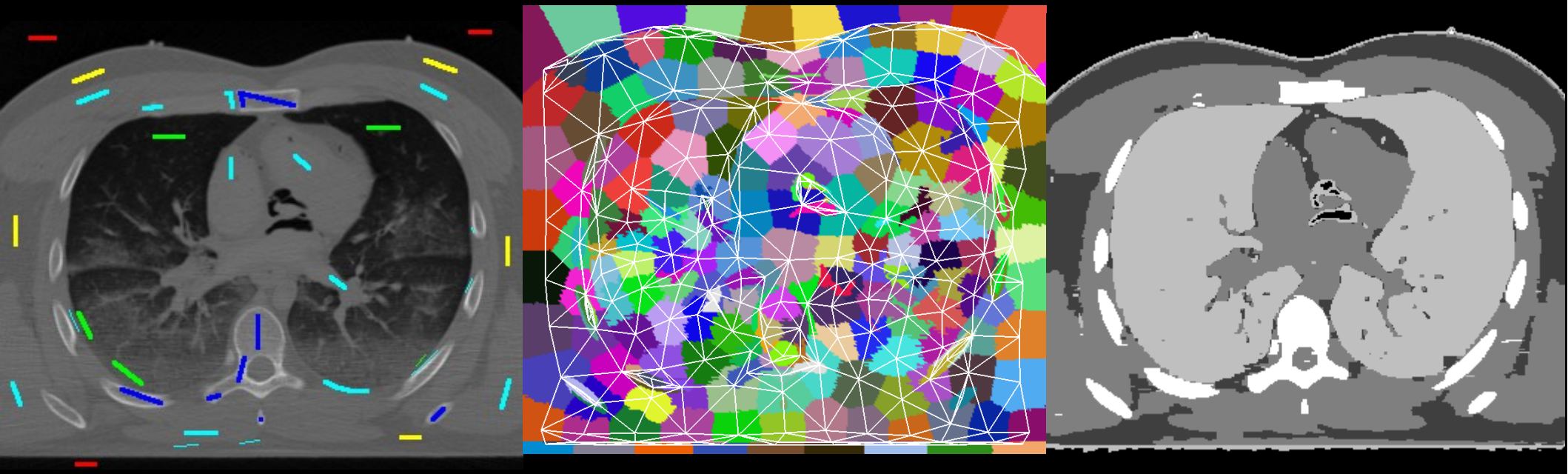
Segmentation :
Minimal cut

Multiple labels :
α-expansion



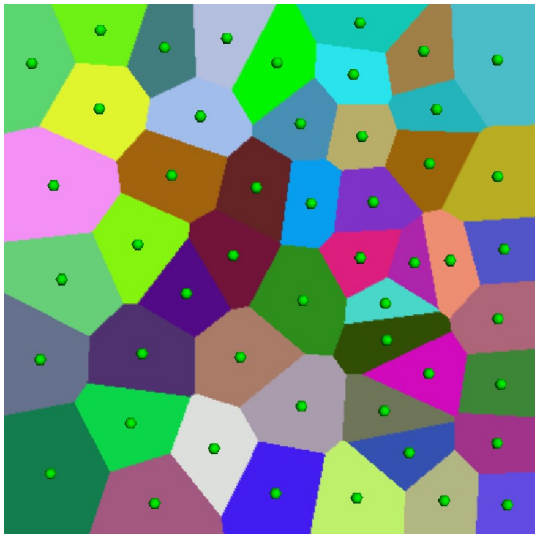
Dealing with complexity

[Kéchichian et al. 2011]

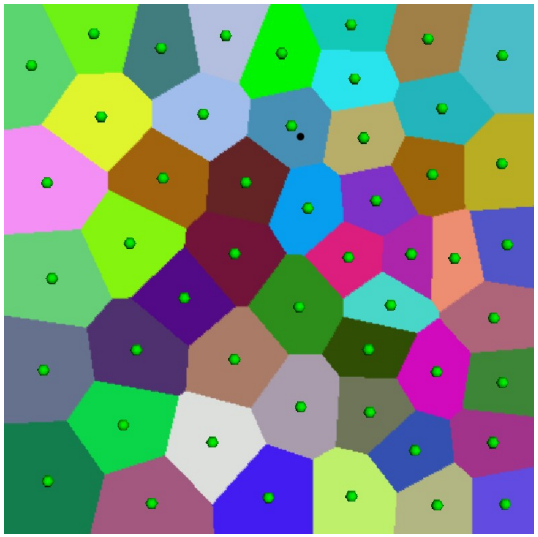


Pixels → Clusters → Segmentation

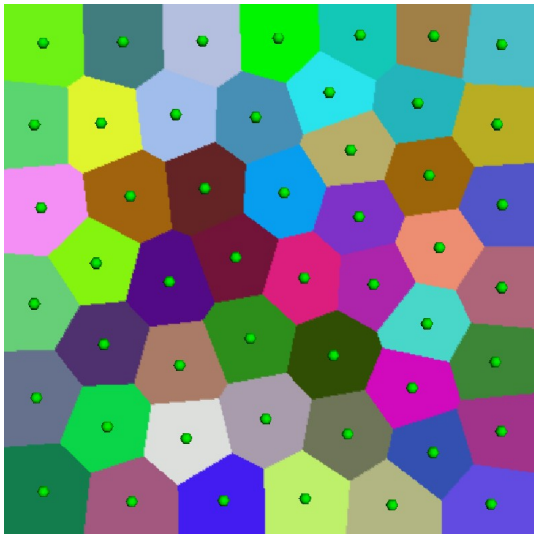
Voronoi/Delaunay/Lloyd



Initial



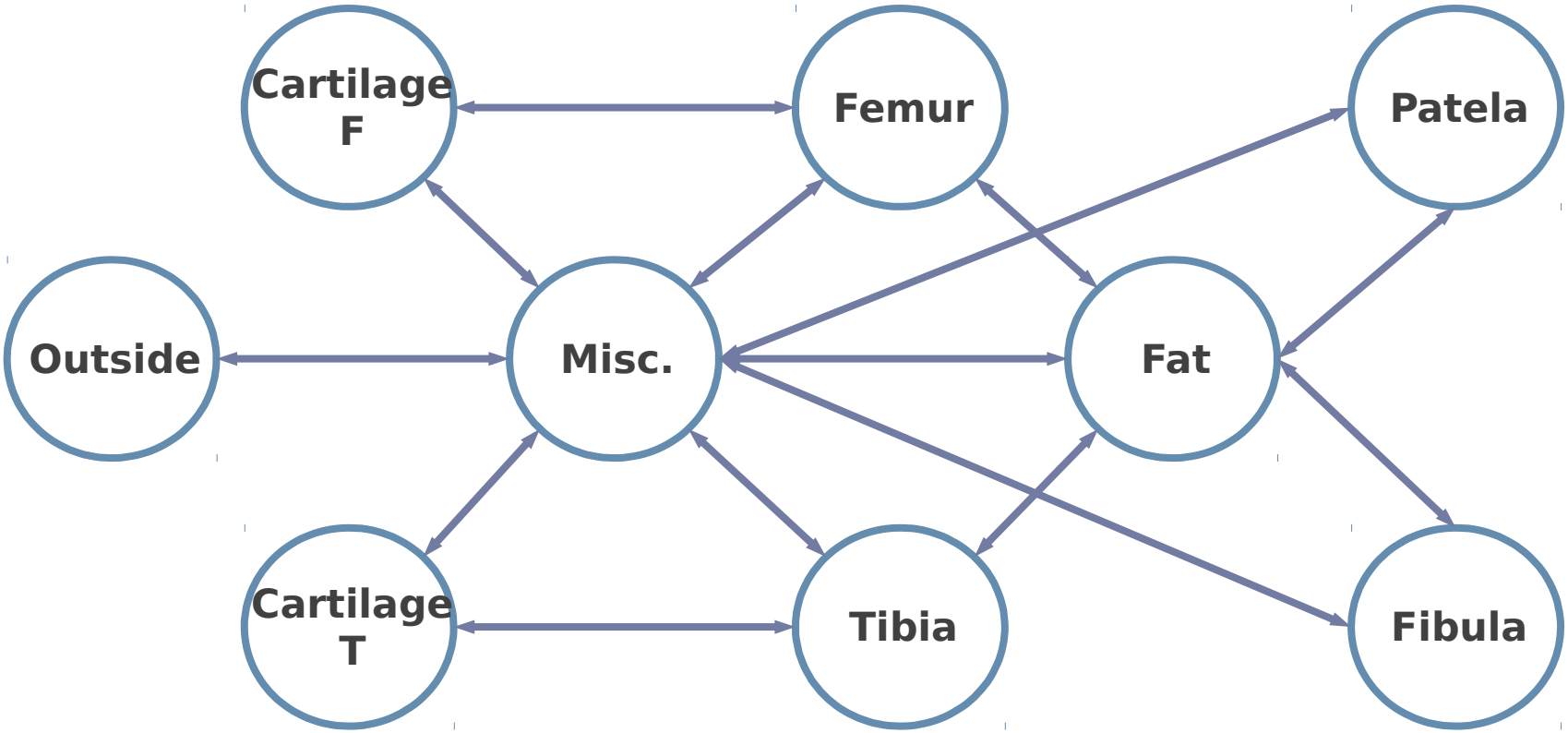
2 iterations



50 iterations

$$E = \sum_{i=1}^{N} \int_{V_i} \rho(x).d(x, \overline{p_i})^2 dx$$

Anatomical priors

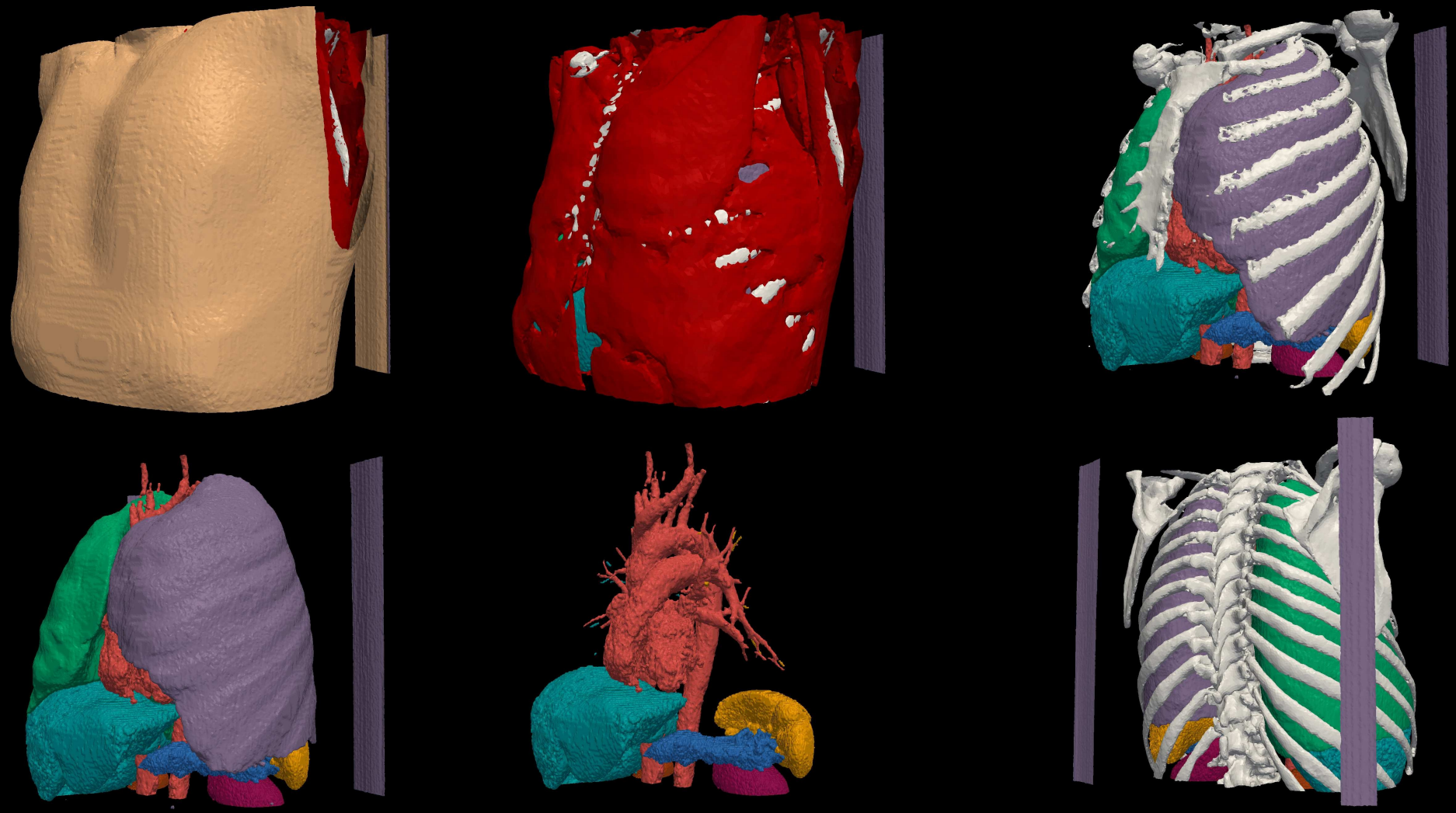


$$V_{u,v}(\ell_u, \ell_v) = \begin{cases} 0 & \ell_u = \ell_v \\ \gamma_{soft} & \exists \pi \in \Pi, \pi(\ell_u, \ell_v) \\ \gamma_{hard} & otherwise \end{cases}$$

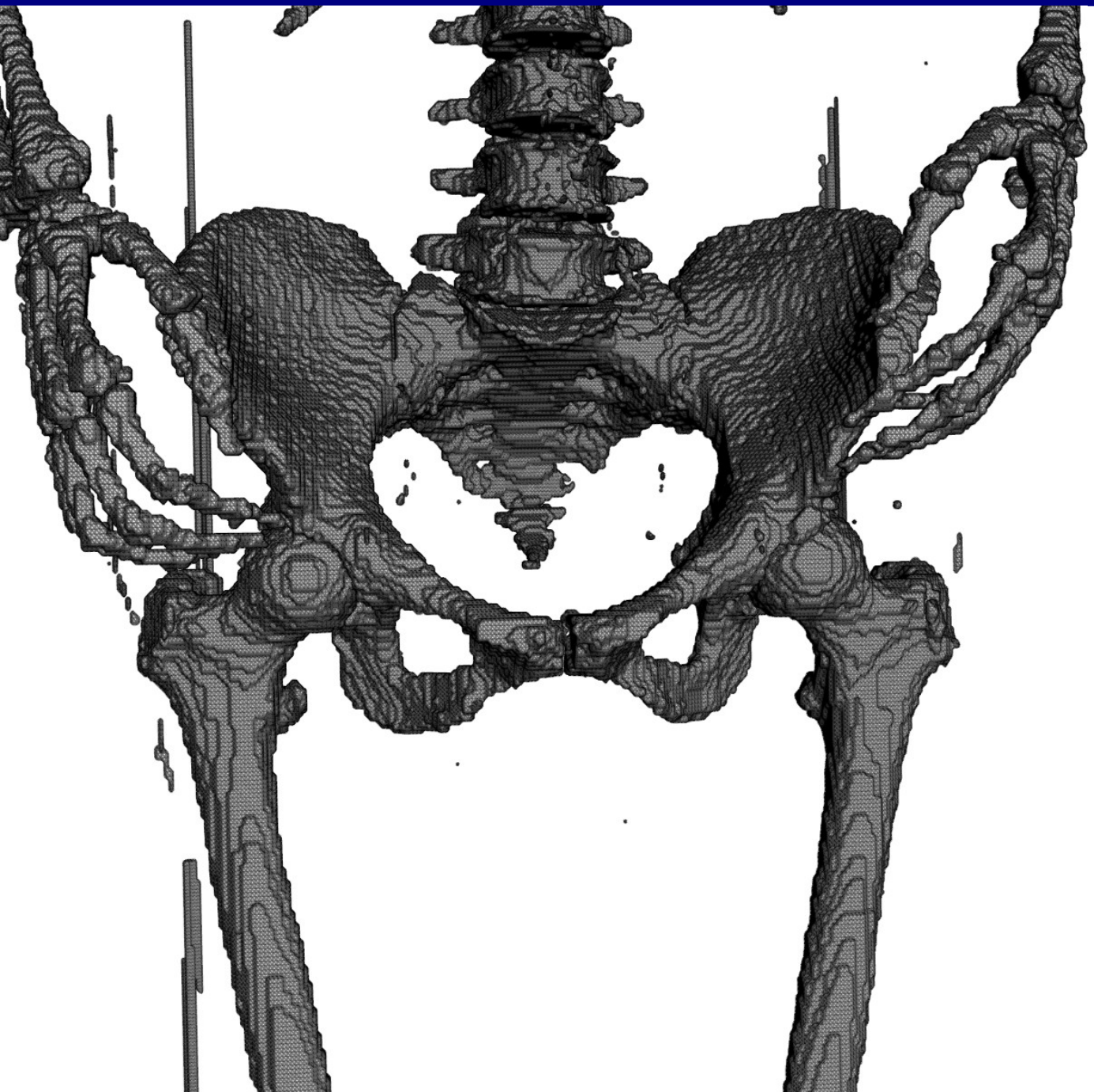
$$\gamma_{hard} > \gamma_{soft}$$

$$\gamma_{hard} = 2\,\gamma_{soft}$$

Results

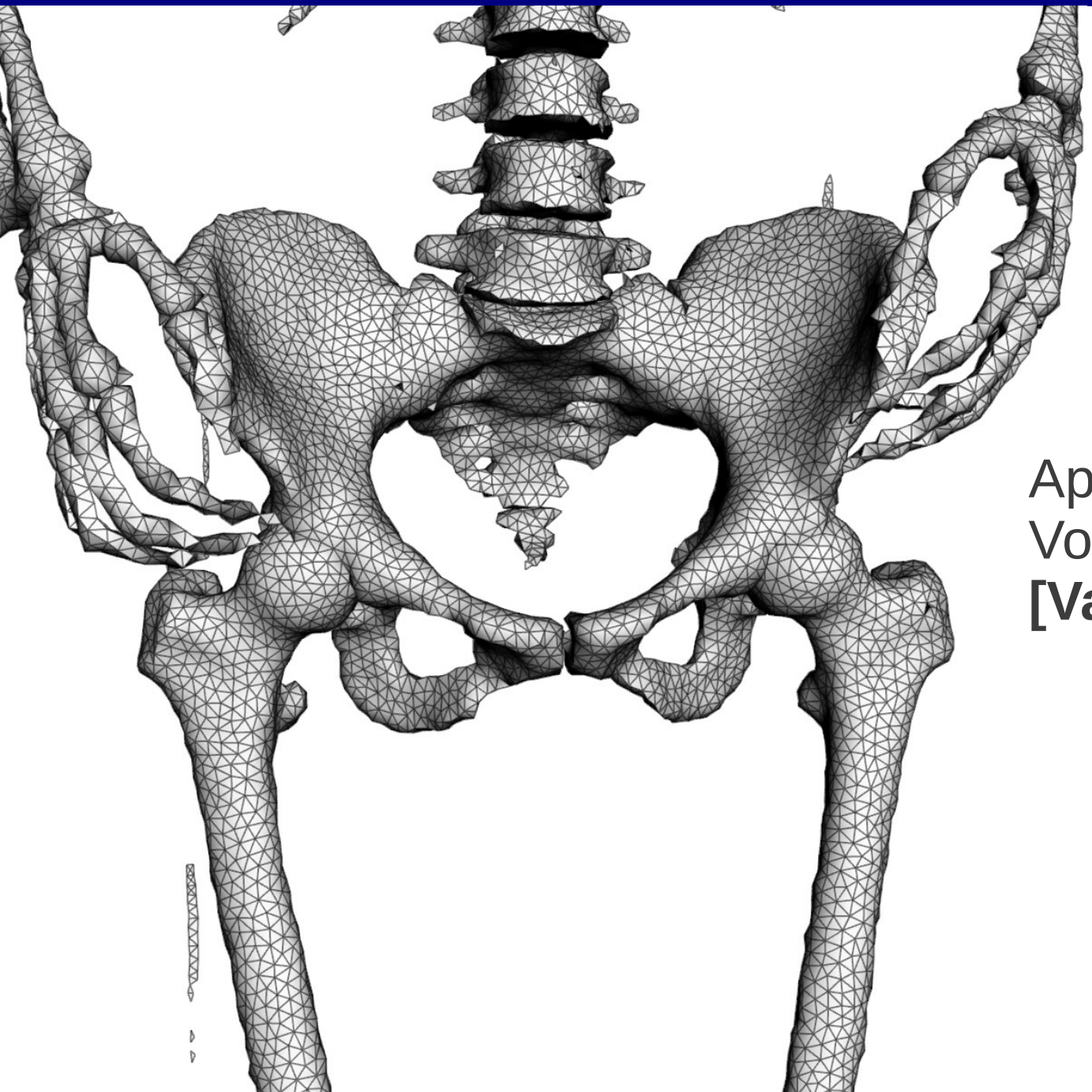


Meshing



Marching Cubes :
Too many triangles

Meshing



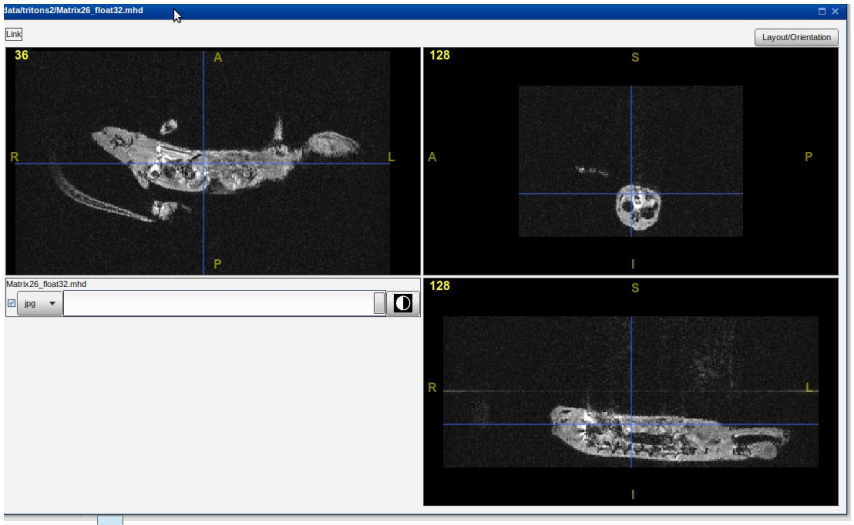
Approximated Centroidal Voronoi Diagrams
[Valette & Chasserry 04]

Experiments on tritons/newts

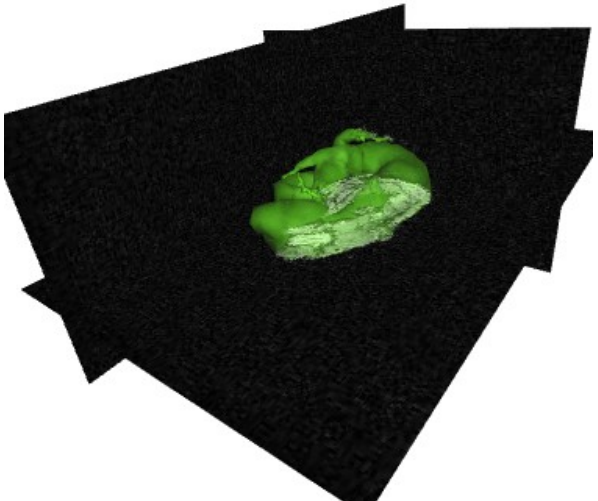
Collaboration with T. Wardziak (U. Lyon)

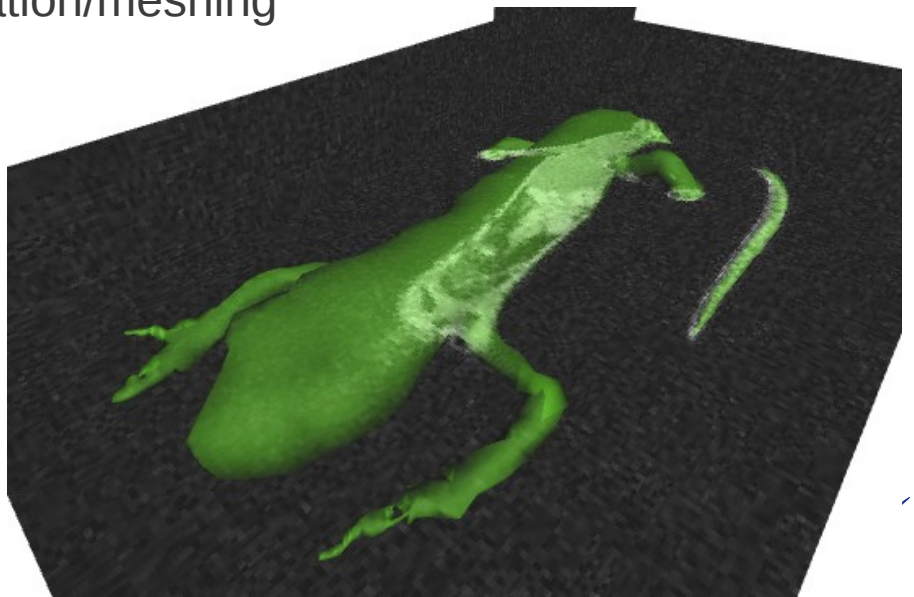
- 20 individuals
- 2 postures 'I' and 'S'

MRI

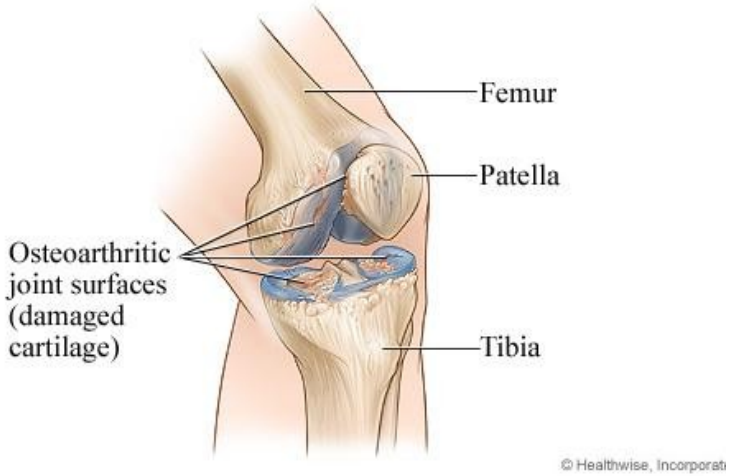


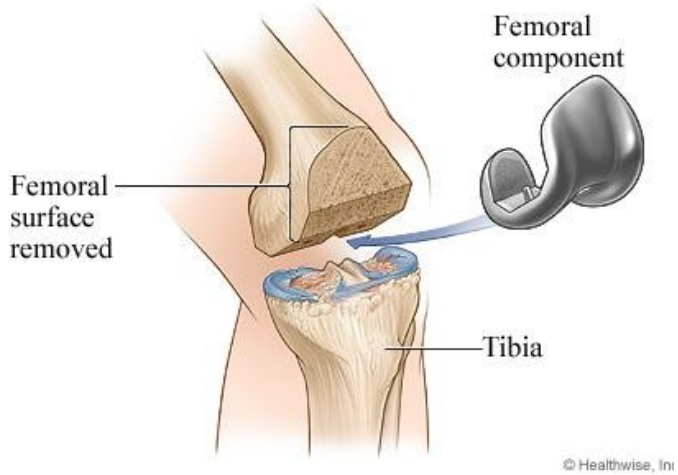
Segmentation/meshing

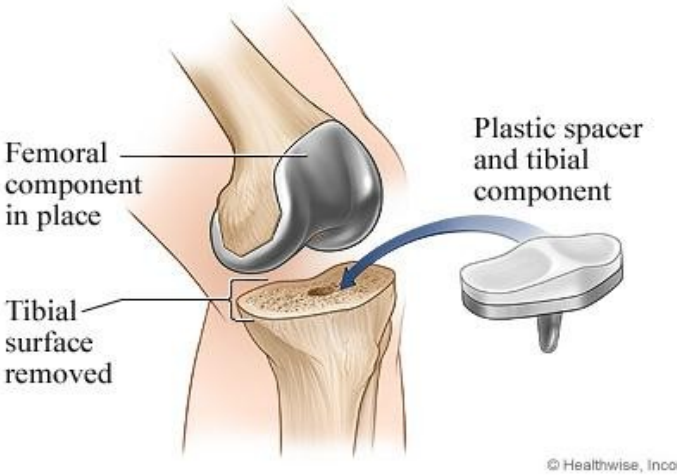


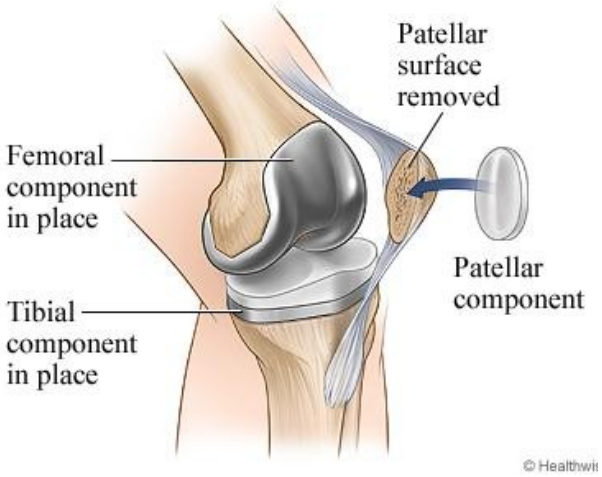


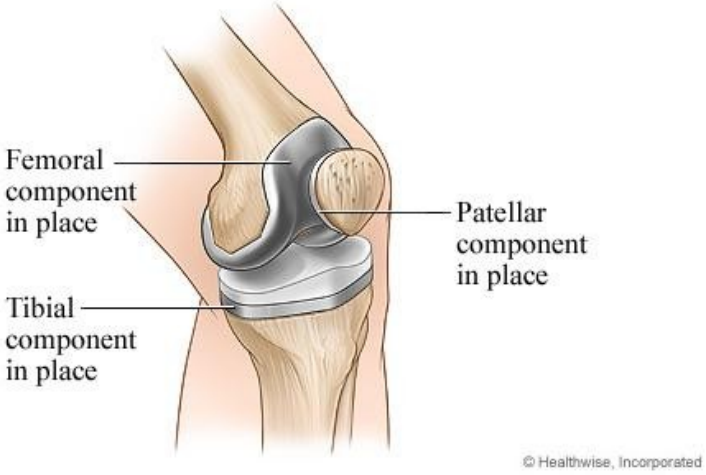
Arthroplasty



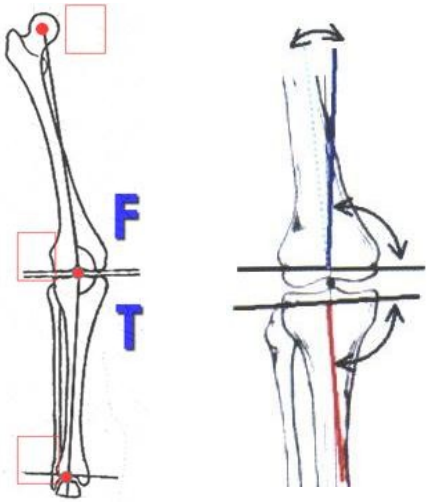






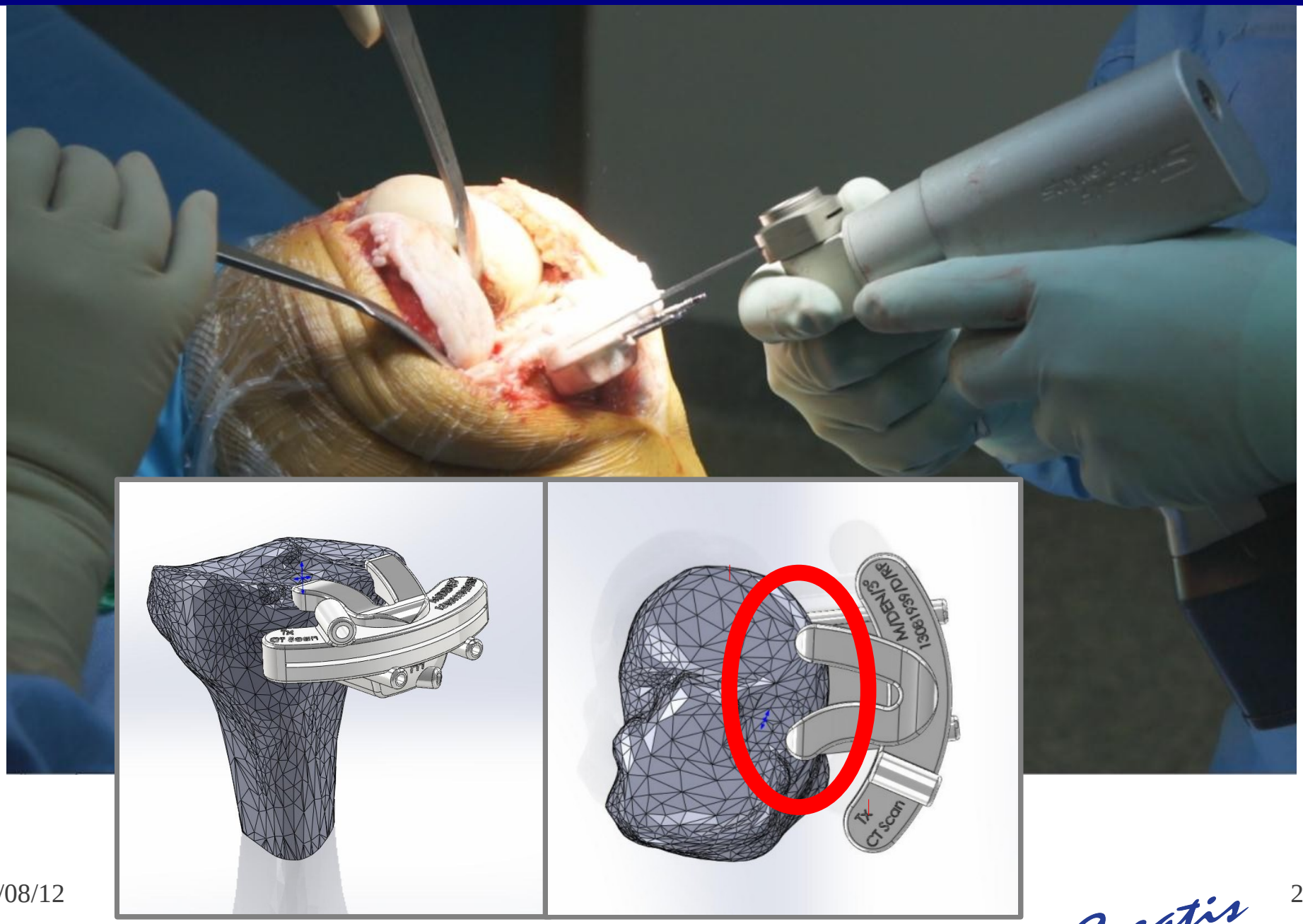


Orthopedics :
The good angles

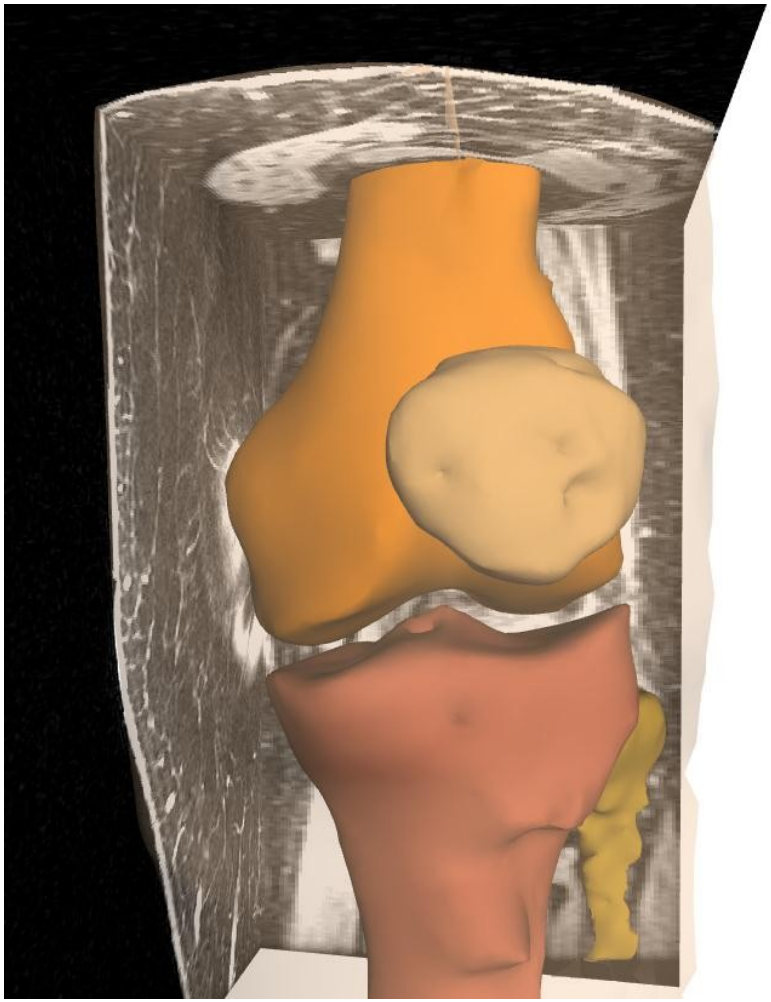


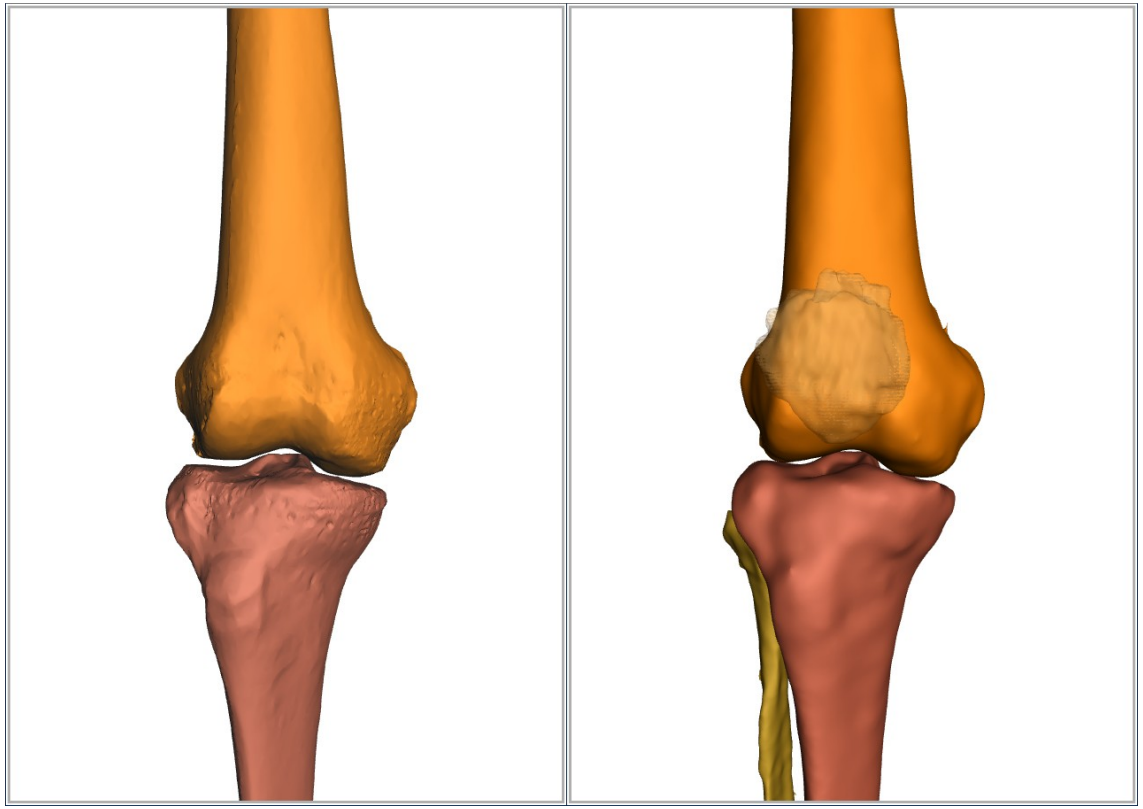
Creatis

One Fit adapters



Some results





Reference Ours

Source code

Client

Js (8 kLOC) + qooxdoo + three.js

Server

.php (1 kLOC) OR .js (1 kloc) + node.js

RPC (c++)

- slicing/meshing :
  - github.com/valette/ACVD
  - VTK
  - OpenCTM
  - GDCM
- segmentation : proprietary license

Thank you