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

H. Jacinto\(^1,3\), R. Kéchichian\(^1\), M. Desvignes\(^2\), R. Prost\(^1\), S. Valette\(^1\)

1 : CREATIS
2 : GIPSA-Lab
3 : OneFit Medical SAS
Some of our previous works

1998: 3D progressive transmission

- html
- Netscape plugin (c++)
- Cosmo Player
2011 : Google Body
Zygote Body

utf8 mesh encoder

→ Pure js is OK

65K limit
Input:
Imaging data: MRI, CT Scanners
Large Volumetric Data

Output:
Rendering
Processing (segmentation, detection, ...)

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

utf8, x3d are a possibility,
But no web format is the end-goal
Interactive Segmentation
Graph cuts

[Boykov & Jolly 2001]
Graph cuts

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

Segmentation:
Minimal cut

Multiple labels:
\(\alpha\)-expansion
Dealing with complexity

[Kéchichian et al. 2011]

Pixels → Clusters → Segmentation
$$E = \sum_{i=1}^{N} \int_{V_i} \rho(x) \cdot d(x, \bar{p}_i)^2 \, dx$$
Anatomical priors

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

\[ \gamma_{\text{hard}} > \gamma_{\text{soft}} \]

\[ \gamma_{\text{hard}} = 2 \cdot \gamma_{\text{soft}} \]
Results
Meshing

Marching Cubes: Too many triangles
Meshing

Approximated Centroidal Voronoi Diagrams
[Valette & Chassery 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
Some results
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