Mario Negri Institute

Departments

Bioengineering
Cardiovascular Research
Environmental Health Sciences
Epidemiology
Molecular Biochemistry and Pharmacology
Molecular Medicine
Neuroscience
Oncology
Public Health
Renal Medicine
Imaging and quantification of kidney physiopathology

Hemodynamics and vascular disease
Hemodynamics and vascular disease

Hemodynamics involved in several vascular pathological processes

atherosclerosis

cerebral aneurysms

extra-cerebral aneurysms (AAA, ...)

intimal hyperplasia (grafts, bypasses, vascular access for HD, ...)

through the action of pressure, wall shear stress...

Image-based computational hemodynamics
Important to get the geometry right.

Streamlined tools needed for the generation of unstructured grids from images, for the numerical approximation of Navier-Stokes equations (using finite elements, finite volumes, ...).

At the present stage, large-scale studies are needed.

Robust characterization of geometry is the key for large-scale studies.

Data analysis on populations requires advanced post-processing.

Effort: providing a set of free widely available tools for

- image segmentation
- mesh generation
- analysis of vascular geometry
- CFD
- post-processing for CFD simulations
The Vascular Modeling Toolkit

www.vmtk.org

Luca Antiga, Mario Negri Institute
David Steinman, University of Toronto
based on VTK, ITK
BSD license
The Vascular Modeling Toolkit

www.vmtk.org

PypeS
Python pipeable
scripts framework

vmtkScripts
High-level Python scripts

vtkVmtk
C++ algorithms

VTK
Visualization Toolkit

ITK
Insight Segmentation
and Registration Toolkit

Tetgen
Quality Tetrahedral
Mesh Generator

command line

GUI?
The Vascular Modeling Toolkit

Features:

- Level-set and deformable model segmentation
- Smart branch initialization and small-vessel level-set segmentation
- Image processing and vessel enhancement
- Surface processing (decimation, smoothing, healing, capping, ...)
- Surface remeshing
- Volume meshing (Tetgen)
- Centerline computation
- Geometric analysis of vessels, shapes, bifurcations
- CFD pre-processing (flow extensions, boundary layers)
- Finite element framework for surface mapping and CFD post-processing
- Surface mapping and patching for population studies
Aneurisk project

Third largest database of cerebral aneurysmal geometries.

With Marina Piccinelli, Alessandro Veneziani, MathCS, Emory University
vmtk Slicer integration

NA-MIC
National Alliance for Medical Image Computing
Summary of past and ongoing projects at project weeks

vmtk Slicer integration

- automated generation of command line modules for non-interactive vmtk tasks (done)
- vmtk C++ code in Slicer as a library (done)
- interactive Slicer modules for segmentation, etc. (with Daniel Haehn) (in progress)
- vmtk Slicer as a NITRC project (to do)
Summary of past and ongoing projects at project weeks

Engineering core:

- Python interface and modules (with Dan Blezek) (done)
- Reference system issues for orientation-unaware command-line modules (done)
- Breakout sessions: AHM 2008, AHM 2009

```python
>>> from Slicer import slicer
>>> scene = slicer.MRMLScene
>>> node = scene.GetNodeByID('vtkMRMLScalarVolumeNode1')
>>> arr = node.GetImageData().ToArray()
>>> type(arr)
<type 'numpy.ndarray'>
>>> arr.max()
367
>>> arr[arr>200] = 200
>>> node.Modified()
```
With Roberto Foroni, University of Verona:

Pre-operative planning and intra-operative visualization platform for minimally-invasive neurosurgery

- Registration (affine, diffeomorphic demons), segmentation (EM), vessel extraction (enhancement, EM, level sets)
- Integrated visualization
- Slicer layout customization
- Workflows
Image quantification in autosomal dominant polycystic kidney disease (ADPKD)

- ADPKD: responsible for the majority of ESRD among hereditary kidney diseases, currently no treatment available
- currently at the Mario Negri Institute: 3 clinical trials on treatment with imaging endpoints (MR and CT)
- identified imaging evidence for key components for functional loss (Antiga et al, CJASN 2006; Caroli, ASN 2008)

Ongoing projects back home
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Mario Negri Institute:

• Slicer as a platform for image quantification in autosomal dominant polycystic kidney disease (ADPKD)

• Image analysis methodology has been developed (ITK)

• A complete set of Slicer modules will be created during the next months
Last slide: Meshing module!