



Avizo[®] **amira[®]**

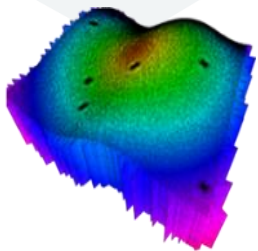
SFU Viz-day: 3D Image Processing Workbench

Ming Lei, Ph.D. Application Engineer

mlei@fei.com



Solving Visualization and Analysis challenges since 1986



Open Inventor[®] 3D Development Toolkit

- Oil & Gas, Geosciences, Mining
- Medical and Life Sciences
- Engineering and Simulation



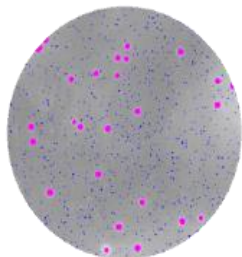
Amira[®] 3D Analysis Software

- Life Sciences
- Biomedical Research
- Pharmaceutical Industry

Visilog

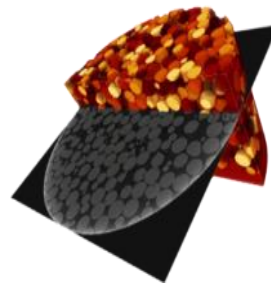
2D & Image Processing

- Biology
- Pharmaceutical
- Materials Research



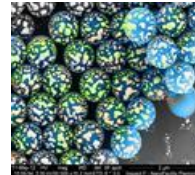
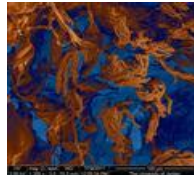
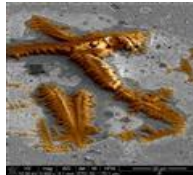
Avizo[®] 3D Analysis Software

- Materials and Geoscience
- Industrial Inspection
- Engineering & Simulation



FEI

- FEI is a leading scientific instruments manufacturer
- Delivers 2D and 3D microscopy solutions for:
 - Life science
 - Materials science
 - Oil & Gas/Geosciences
 - Electronics
- Employs approximately 2300 people in more than 50 countries worldwide



- VSG joined FEI in August 2012
- Goal: develop high-end visualization and analysis solutions for advanced electron microscopy and multi-modality applications
- VSG is now the FEI Visualization Sciences Group

Customers examples

Oil & Gas



Design & Engineering



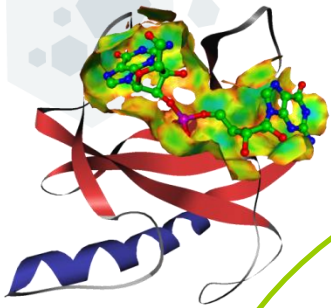
Medical, Food & Scientific



Academic / Gov.



A researcher's digital workbench: **Workflow**



Import and Export

- Standard formats
- Microscopy and medical formats
- Finite element modeling
- Geometric modeling and CAD
- Flexible raw data import

Present

- Live animations
- Movie generation
- 3D stereo vision
- Virtual reality navigation
- Single and tiled screen display
- Support for tracked devices

Process

- 2D and 3D image filtering
- Surface generation
- FEM grid generation
- Interactive/automatic segmentation
- Interactive/automatic alignment
- Registration and morphing
- Simulation of porous material properties

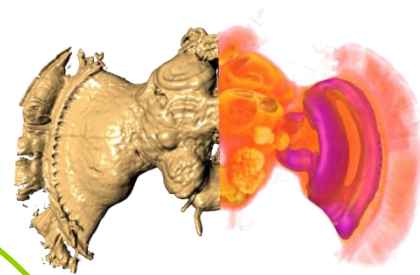
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Visualize

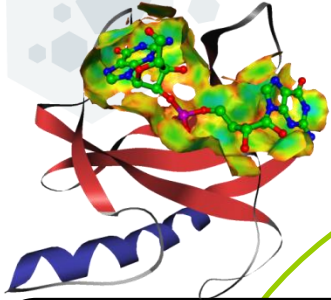
- Orthogonal and oblique slicing
- Volume rendering
- Surface rendering
- Isolines and isosurfaces
- Multichannel imaging
- Image fusion

Analyze

- Measurement tools
- Densitometry (gray value statistics)
- Arithmetic operations on images
- Direct integration of Matlab[®]
- Simulation result post-processing



A researcher's digital workbench: **Import & Export**

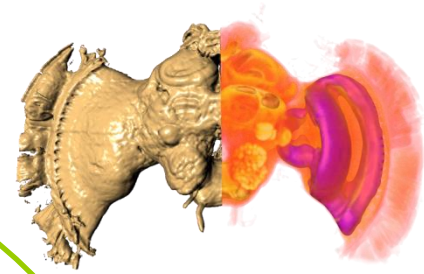


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Analyze

- Measurement tools
- Densitometry (gray value statistics)
- Co-localization analysis
- Arithmetic operations on images
- Direct integration of Matlab®

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Material, scale and size do not matter

Open Data...

- Biomedical
- Electronics
- Micro-devices
- Composite materials
- Metallic foams
- Polymers, plastics
- Diamonds
- Food and seeds
- Wood and paper
- Building materials
- Geology
- Microfossils
- Space



Imaging Data

- Electron microscopy
 - S/TEM tomography
 - TEM serial sectioning
 - FIB-SEM Nanotomography
- Light microscopy
 - Confocal
 - Polish and view 3D (e.g. Robo-MET)
- X-ray/synchrotron tomography
 - Industrial
 - Material sciences (micro and nano)
- MRI
- Ultrasound
- GPR
- LIDAR
- Remote Sensing Satellite Imagery

Any Material, Any Scale, Any Size.

Federating different data sources

Modeling and Experiment Formats

- 3D imaging (MRI, CT, FIB-SEM)
 - TIFF, JPG, PNG, BMP, RAW Binary, DICOM...
- 3D Scene/Geometry and CAD Formats
 - VRML, Open Inventor (.iv), DXF, IGES, STEP CATIA...
- Microscopy Formats
 - Leica, Zeiss, Bio-Rad, FEI, MRC, STK...
- Surface Scanner Formats
 - PLY, PSI

Customized formats with modern programming/scripting

- C++
- TCL
- Matlab
- LabVIEW

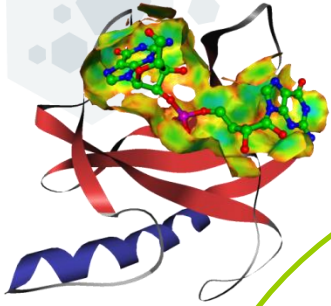
Simulation Formats

- FEA formats
 - Abaqus, Ansys, Nastran
- CFD formats
 - Fluent, Star-CCM+
- Multiphysics formats
 - Comsol, Ansys multiphysics
- Crash simulation format
 - Madymo, Radioss
- Scientific Data Formats
 - Matlab, Tecplot, AVS
- Climate simulation formats
 - NetCDF
- Molecular simulation formats
 - PDB, AMBER, CHARMM, PHI, TRIPOS

N Dimensional data formats

- Time varying (transient)
- Design parameter space
- Real time

A researcher's digital workbench: **Process**



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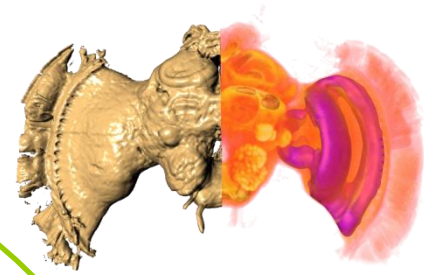
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Visualize

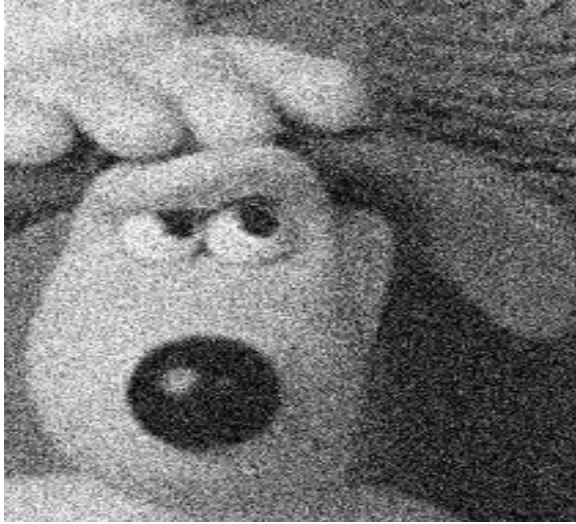
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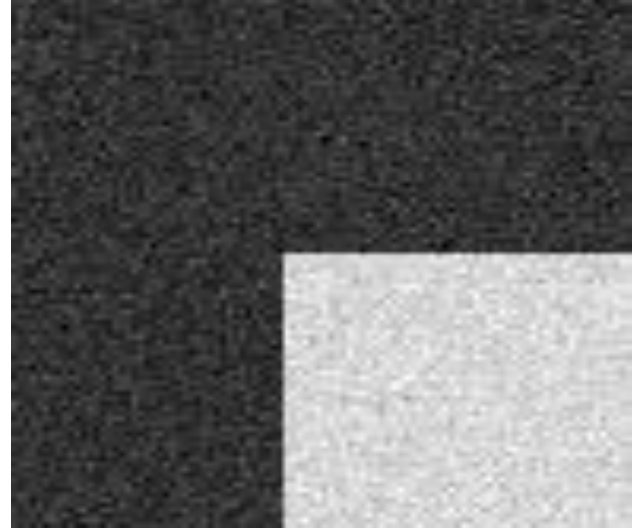
Filtering



White noise



Salt and Pepper noise



White noise in two phases

Filtering

3 filter families

- Linear filter: boxfilter

$$O(n,m) = \frac{1}{K} \sum_{i=-p}^p \sum_{j=-q}^q I(n-i, m-j)$$

- None linear filter : medianfilter

All pixels of the neighbourhood are sorted by greylevel.
Median value is used for the output pixel

- adaptive: bilinearfilter, nagaofilter, snnfilter,...

Edge preserving smoothing filter

$$O(i,j) = \frac{1}{K(i,j)} \sum_{l=-\frac{n_x}{2}}^{\frac{n_x}{2}} \sum_{m=-\frac{n_y}{2}}^{\frac{n_y}{2}} e^{-\frac{(I(i,j)-I(l,m))^2}{k^2}} I(l,m)$$

Slice alignment

Manual alignment

Support for automatic alignment methods

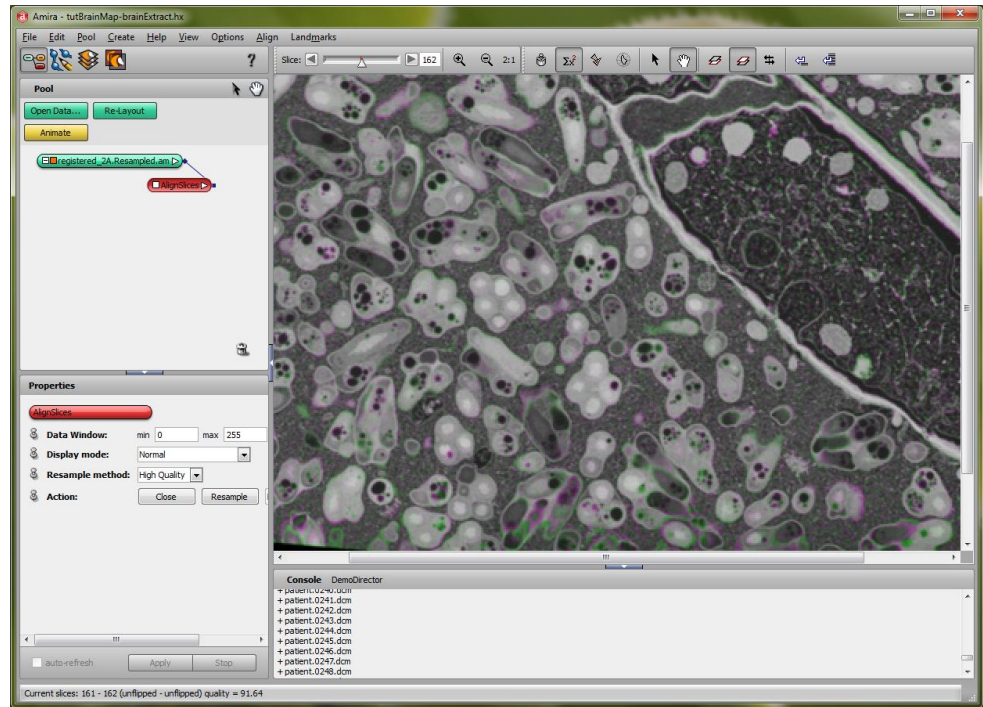
- Centers of gravity / principle axis
- Euclidean distance (least square of gray values)
- Landmarks
- Edge detection

Masking

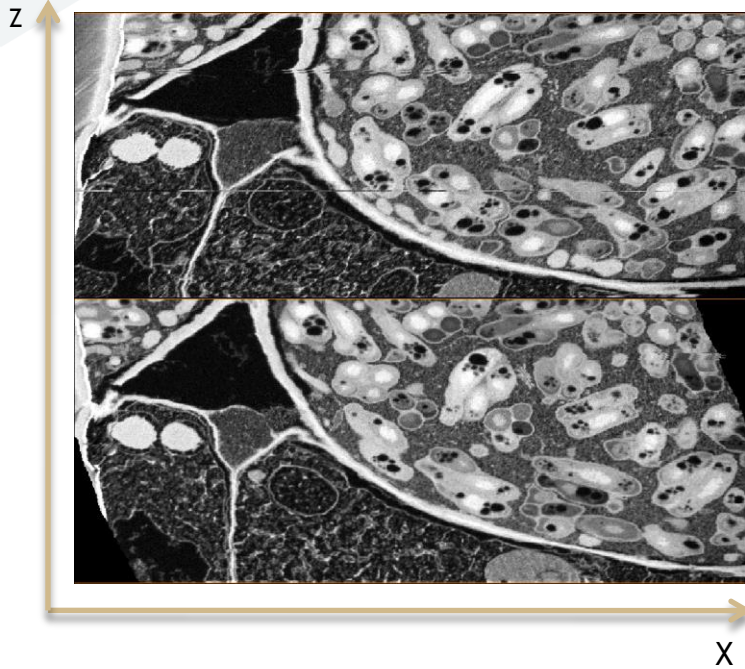
- Set a label field to restrict alignment to a region of interest

Label Field

- Co-align an associated label field



Slice alignment



Pre-processing of FIB-SEM data

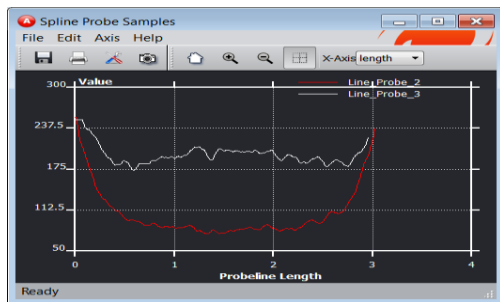
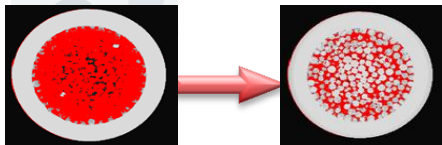
BEFORE



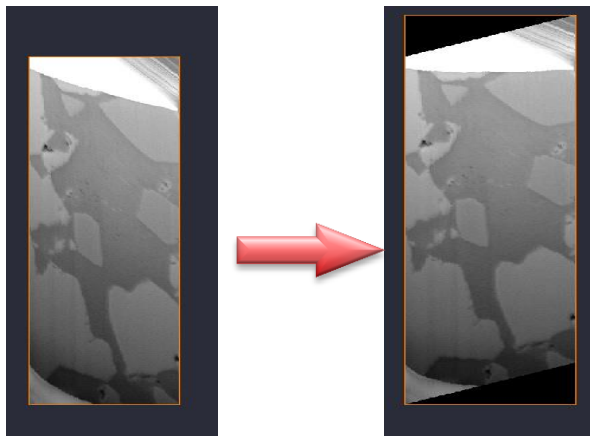
AFTER

Alignment of classical serial sections

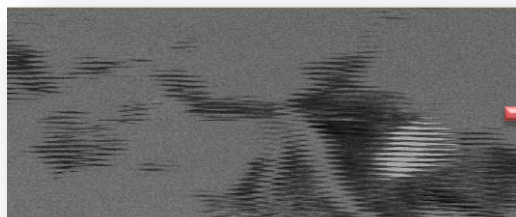
Correcting artifacts



Beam hardening



Shearing



Mis-alignment



Light Microscopy
Z-drop
Non-uniform illumination

CT
Beam hardening

FIB-SEM
Shadowing
Mis-alignment
Shearing

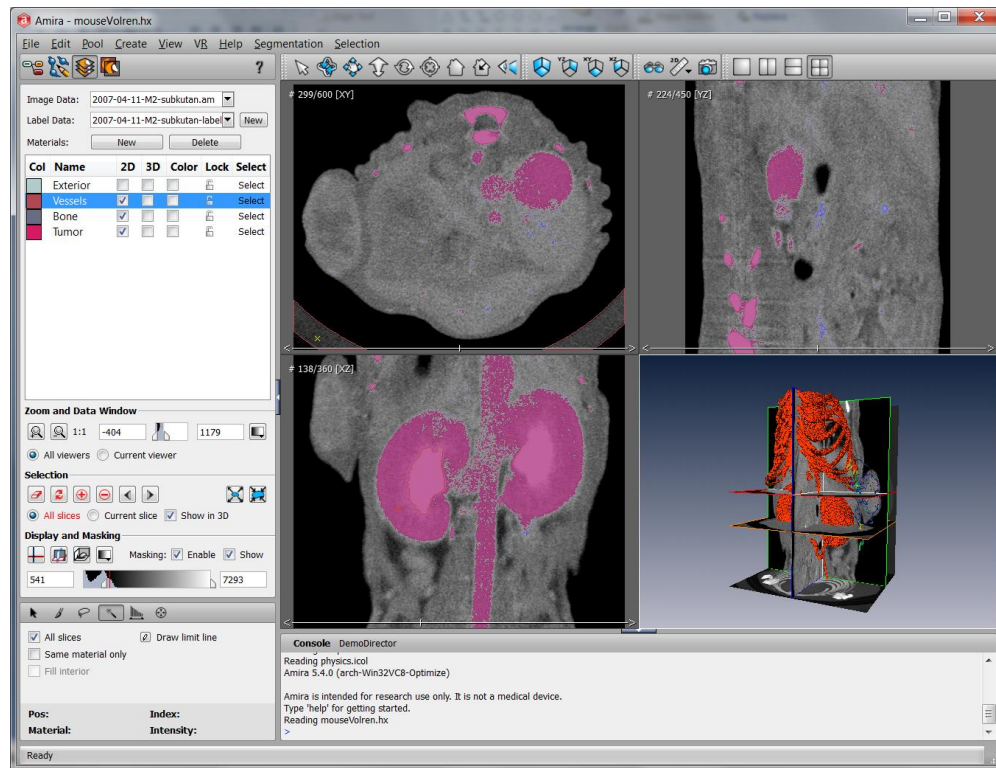
3D Image Segmentation Editor

Interface

- Slice centered
- 3D overview

Segmentation Tools

- Brushing, contouring
- Interpolation
- Wrapping
- Intelligent scissors
- Region growing
- Active contours
- Masking
- Morphologic operators



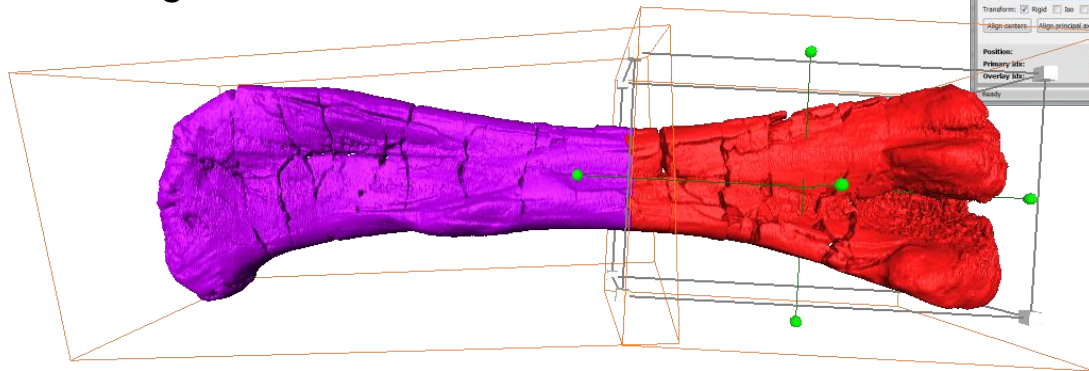
3D image registration

Multivolume Visualization

- 3D e.g., with volume rendering
- 2D fusion on ortho and oblique slices, 3D+2D

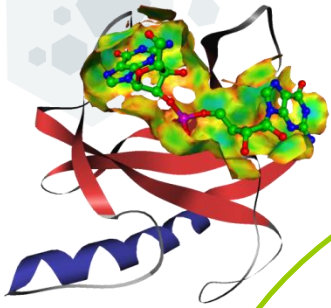
Registration

- Manual registration through interactive manipulators
- Multi-modal (CT,PET,MR...) automatic registration



Diplodocus Carnegie
Transformation of one data
set to fit another

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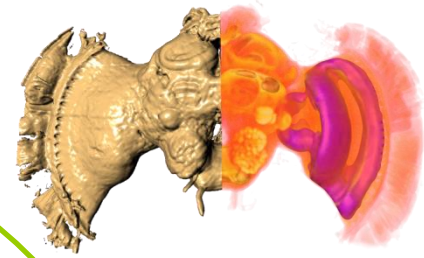
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- Co-localization analysis
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Measurement

- Fast length and angle measurements in the viewer
- Volume, surface area of segmentation results
- Densitometry (gray value statistics) of segmentation results
- Plot intensity along lines or curves
- Surface thickness approximation

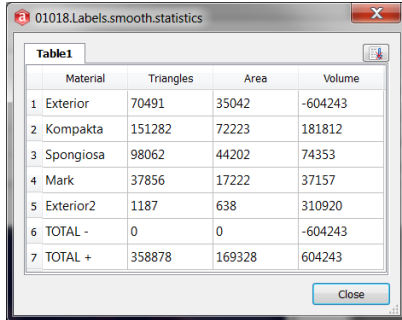


Table1				
	Material	Triangles	Area	Volume
1	Exterior	70491	35042	-604243
2	Kompakta	151282	72223	181812
3	Spongiosa	98062	44202	74353
4	Mark	37856	17222	37157
5	Exterior2	1187	638	310920
6	TOTAL -	0	0	-604243
7	TOTAL +	358878	169328	604243

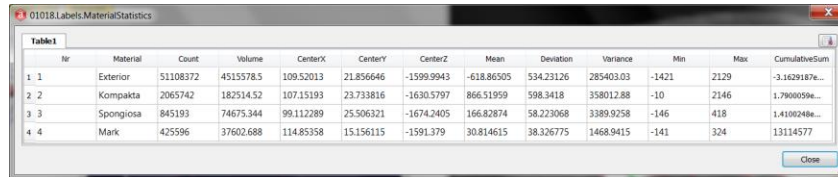
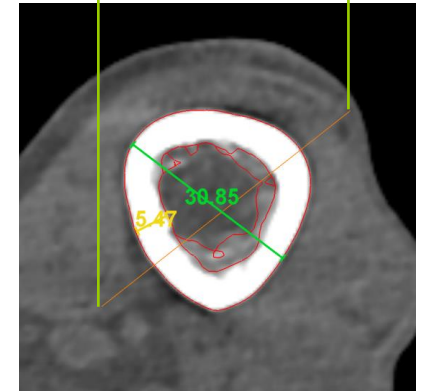
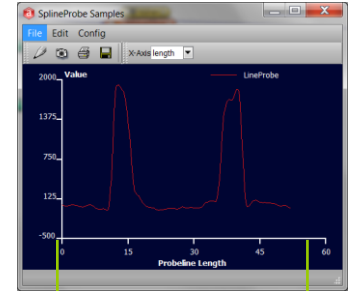
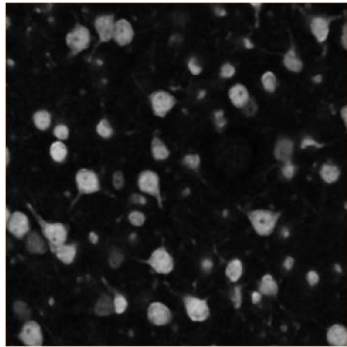
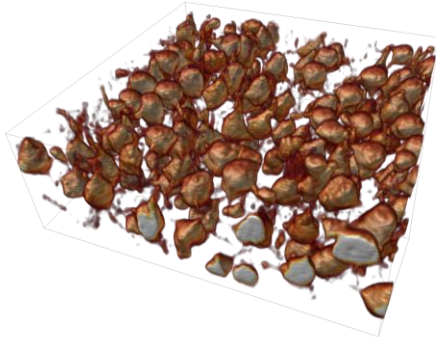


Table1													
Nr	Material	Count	Volume	CenterX	CenterY	CenterZ	Mean	Deviation	Variance	Min	Max	CumulativeSum	
1	1	Exterior	51108372	4515578.5	109.52013	21.856646	-1599.9943	-618.86505	534.23126	285403.03	-1421	2129	-3.1629187e...
2	2	Kompakta	2065742	182514.52	107.15193	23.733816	-1630.5797	866.51959	598.34818	358012.88	-10	2146	1.79009059e...
3	3	Spongiosa	845193	74675.344	99.112289	25.506321	-1674.2405	166.82874	58.223068	3389.9258	-146	418	1.4100248e...
4	4	Mark	425596	37602.688	114.85358	15.156115	-1591.379	30.814615	38.326775	1468.9415	-141	324	13114577



Individual Quantification: Segmentation of individual particles

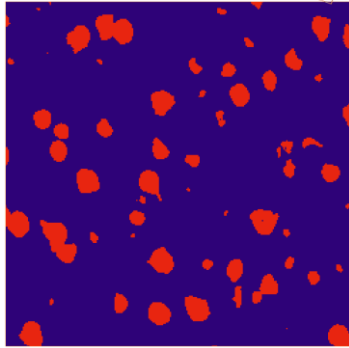
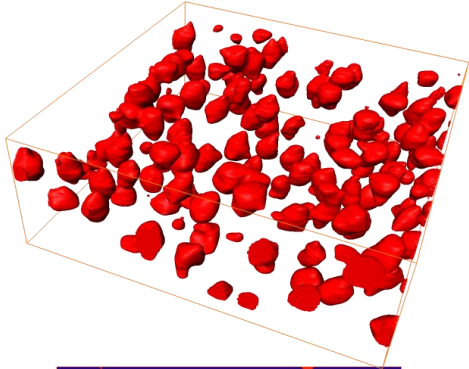


Confocal image stack

Analysis of neuron cell bodies

- Confocal microscopy imaging
- Binarization using a local threshold
- Separation of clustering cells and labeling using watershed segmentation

Individual Quantification: Segmentation of individual neurons

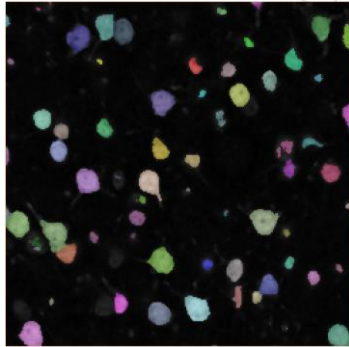
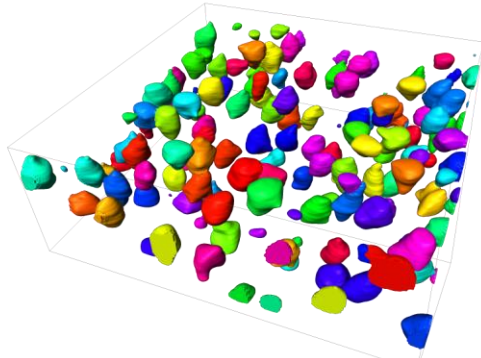


Binary image

Analysis of neuron cell bodies

- Confocal microscopy imaging
- **Binarization using a local threshold**
- Separation of clustering cells and labeling using watershed segmentation

Individual Quantification: Segmentation of individual neurons



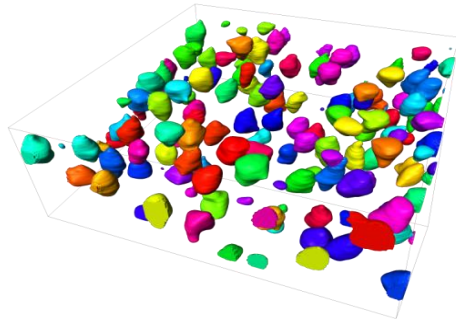
Labeled objects

Analysis of neuron cell bodies

- Confocal microscopy imaging
- Binarization using a local threshold
- Separation of clustering cells and labeling using watershed segmentation

Individual Quantification:

Quantitative analysis of the identified cells

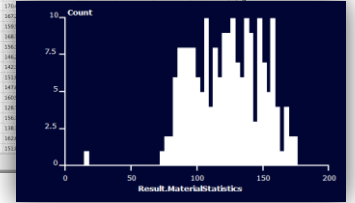


Surface reconstruction of the identified objects

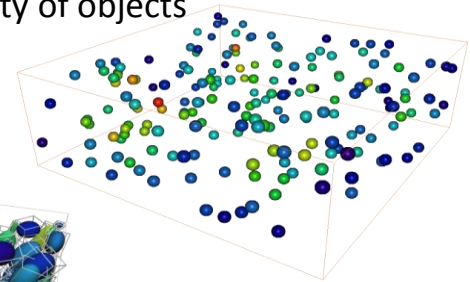
Compute and Plot standard volumetric quantities: size, position, densitometry (gray value statistics)

Analyze & Visualize

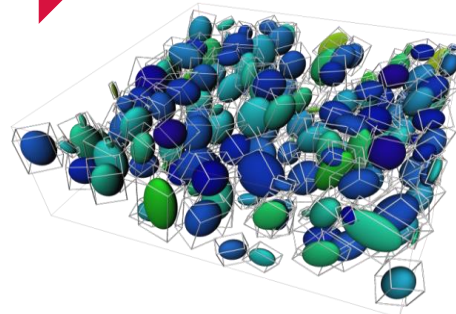
Index	Material	Count	Volume	Centers	Quality	Centroid	Mean	Standard	Variance	Min	Max	ExportStatistics
1	Material001	1472260	2128970	287.24887	184.61134	32.007098	14.479018	11.48897	133.69888	0	252	95701344
2	Material001	1747417	26124652	1376.0371	12.61612	130.77168	56.416807	244.8621	12	252	1618208	
3	Material002	1461	1462.7377	243.01015	11.348812	11.348814	46.105248	1418.8904	16	252	602815	
4	Material003	9808	1576.5962	164.75857	122.57455	10.593371	175.22826	98.201139	162.2899	61	252	942498
5	Material004	14625222	22179218	132.22494	12.144113	244.82062	66.870163	122.22898	46	242	712288	
6	Material005	1722	1220.4153	120.64643	140.46465	10.003007	176					
7	Material006	6269	2091.5371	178.82498	103.49492	11.021002	145					
8	Material007	4718	1561.112	261.96917	114.84918	11.367396	151					
9	Material008	1680	1796.85	124.13086	231.96469	11.082247	144					
10	Material009	1785	1368.0448	230.21095	247.96816	12.597044	156					
11	Material010	1296	1385.7192	235.5281	84.102602	12.598026	142					
12	Material011	110	167.2208	252.49484	65.91842	8.8847407	142					
13	Material012	4112	1361.4699	210.24602	107.788611	11.048404	151					
14	Material013	1047	1046.7112	184.01114	101.67147	14.821975	142					
15	Material014	2761	809.7124	125.98415	108.24613	9.9892187	140					
16	Material015	11916	1198.8845	268.70168	108.08111	11.217108	144					
17	Material016	1796	1244.6793	126.438	112.89343	10.264911	151					
18	Material017	2969	975.1223	231.25216	113.71914	9.9861186	138					
19	Material018	1912	1888.8812	228.26987	124.7194	14.41717	160					
20	Material019	4718	1546.996	176.22914	153.63886	14.221812	151					



Compute local density of objects

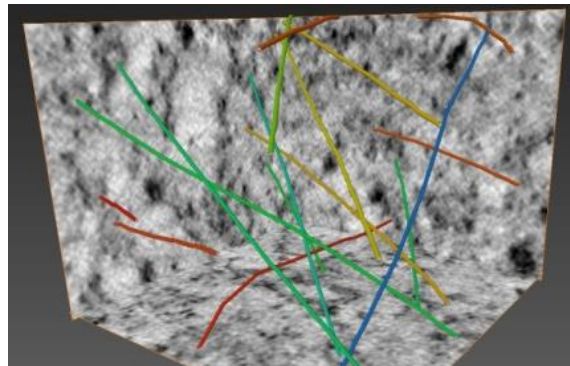
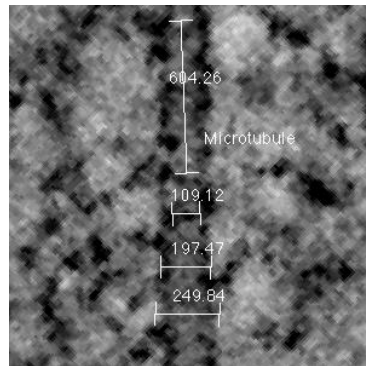


Compute shape parameters, visualize objects as ellipsoids or boxes



Filament detection & analysis

- Template creation and matching for filaments and micro-tubules
- Template correction for missing wedge artifact in TEM tilt series
- Tracing centerlines in correlation plots from template matching
- Enhanced spatial graph statistics including filament orientation

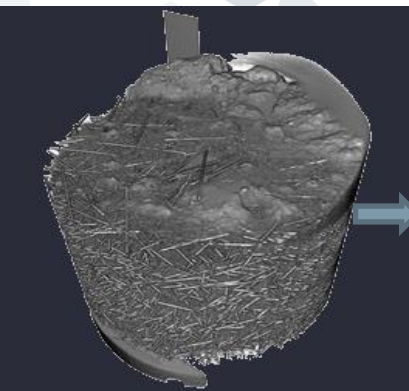


Tables
MicrotubuleExample.statistics

	Segment ID	Length	Mean Radius	Volume	Orientation Theta	Orientation Phi	Graph ID
1	0	2589.9316	0	0	56.389015	35.610855	Graph0
2	1	2741.7454	0	0	60.548882	339.41074	Graph1
3	2	2625.6311	0	0	47.378864	89.648483	Graph2
4	3	2277.5977	0	0	84.502151	90.612762	Graph3
5	4	1404.3077	0	0	66.729683	55.437469	Graph4

Graph Summary | Graph Statistics | Segment Statistics | Node Statistics

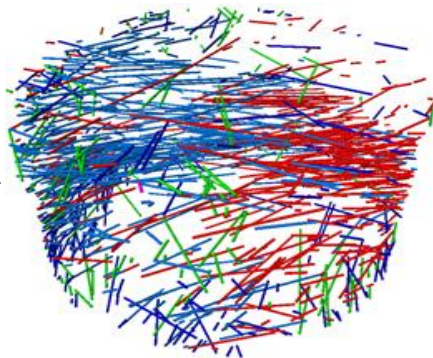
Case Study: MicroCT in Fibrous Composites



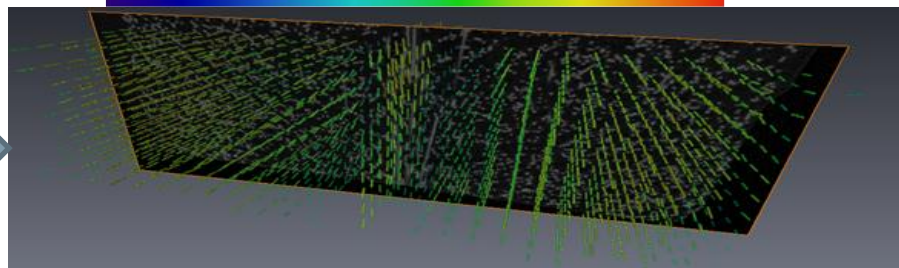
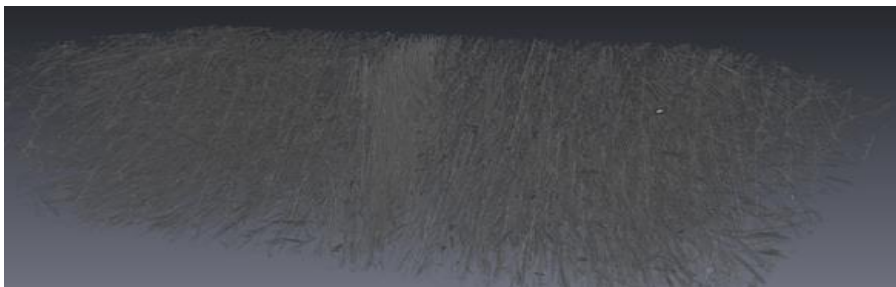
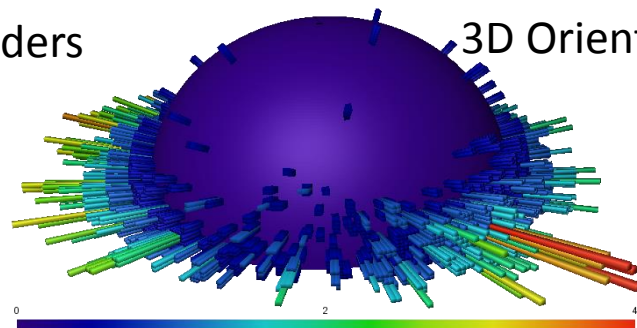
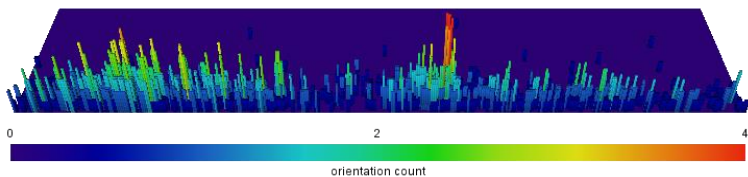
Segmentation



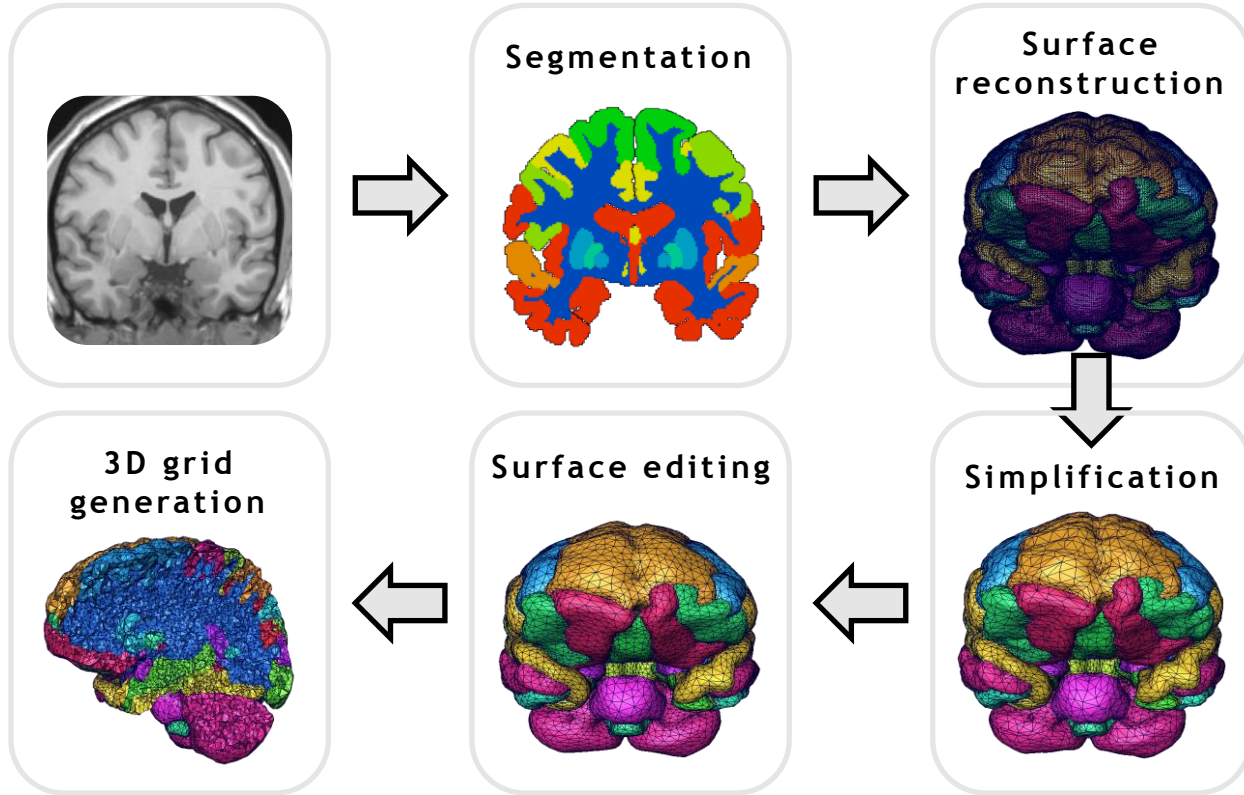
To cylinders



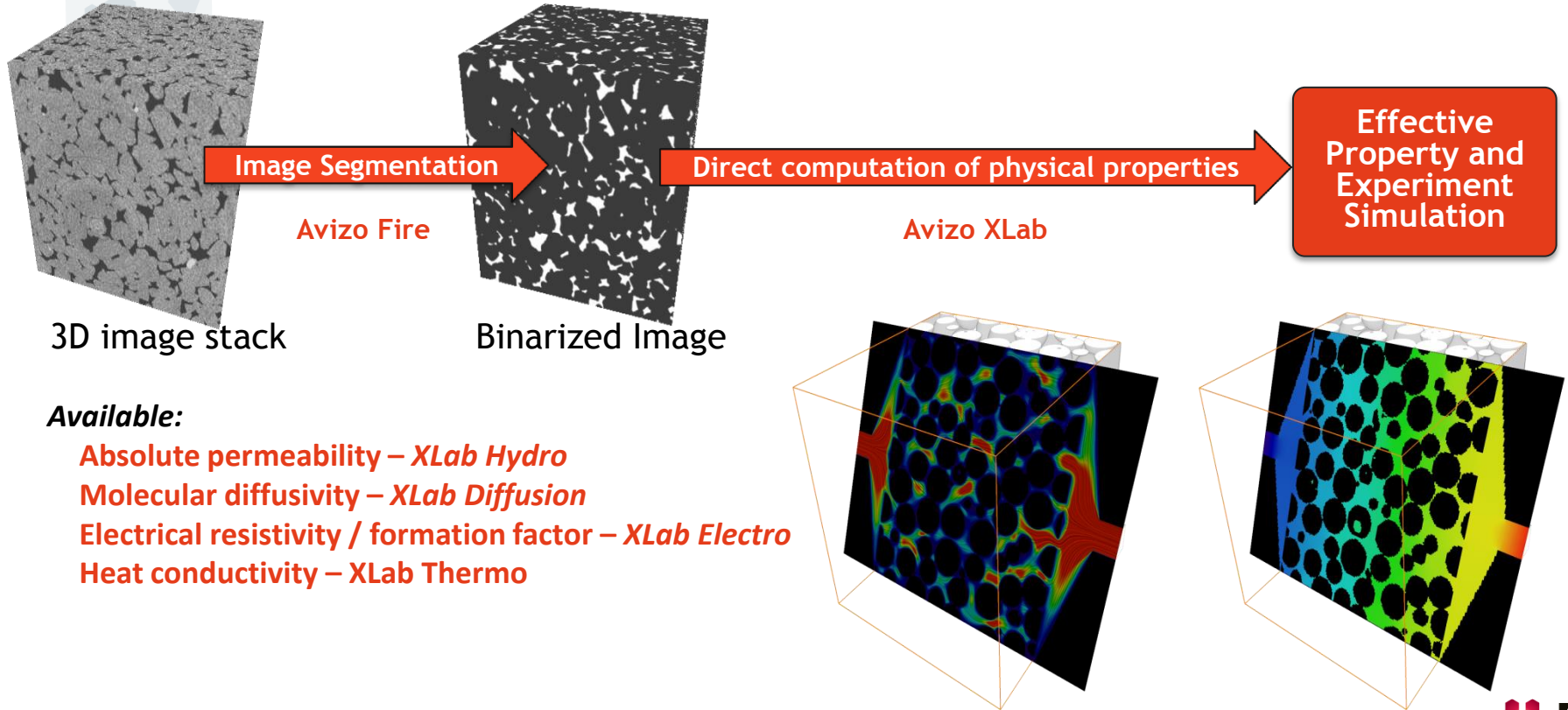
3D Oriented



From image to model: The geometry reconstruction pipeline



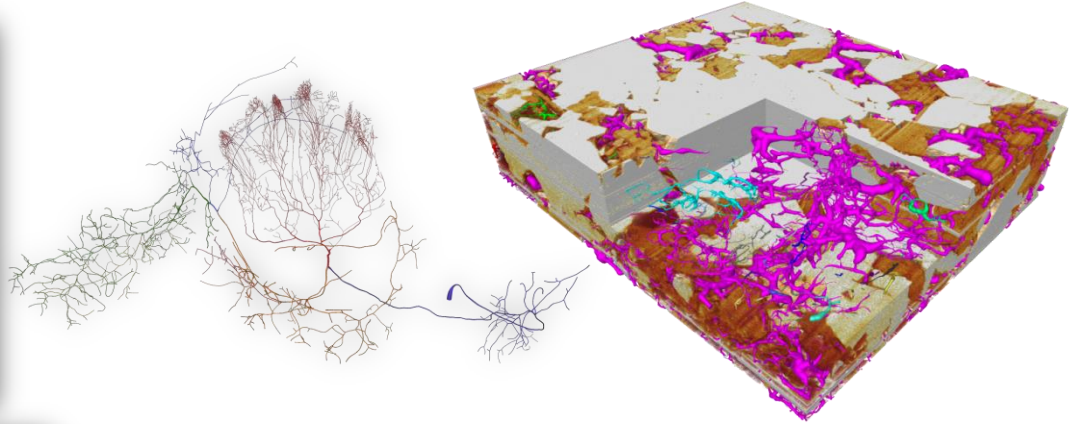
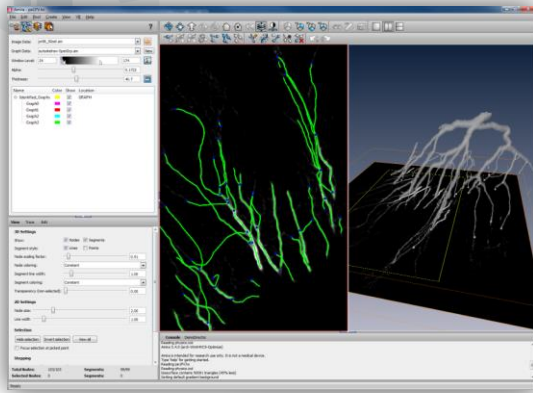
Xlab: Overview



Available:

- Absolute permeability – *XLab Hydro*
- Molecular diffusivity – *XLab Diffusion*
- Electrical resistivity / formation factor – *XLab Electro*
- Heat conductivity – *XLab Thermo*

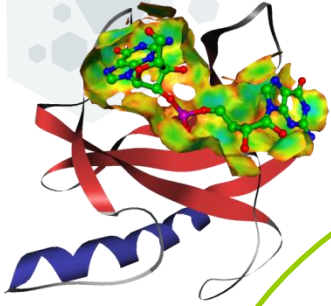
Skeletonization and filament editing



Segment Label	Name	Mean Length	Mean Radius	Total Length	Total Volume	Number of Segments
1	Graph0	222.68056	52.550838	205640.8	1.4008041e+10	6277
2	Graph1	222.08614	52.184565	24908.184	1.8036115e+09	118
3	Graph2	228.82153	31.809813	18163.018	7586032	83
4	Graph3	184.86362	23.769907	15109.362	34883768	78
5	Graph4	187.12189	15.818387	9599.094	398883.8	23
6	Graph5	268.88208	18.028216	28612.513	3889952.3	18
7	Graph6	261.52636	20.255239	1340.4687	3866615	16
8	Graph7	273.00577	36.387882	4095.9864	2872814	15
9	Graph8	264.80819	48.011866	2252.802	11370102	11
10	Graph9	153.02384	12.964817	1530.2183	1084853.6	10
11	Graph10	122.37282	14.577933	1223.7282	1405882.9	10
12	Graph11	127.13423	9.1841617	2134.268	937962.88	9
13	Graph12	263.08281	38.838397	2184.5034	17751482	8
14	Graph13	224.32266	21.607868	1345.8754	286847.2	6
15	Graph14	233.7894	5.4896459	1264.7863	128388.57	6
16	Graph15	258.80966	13.289548	1284.0482	1887791.1	5
17	Graph16	127.53725	8.8344235	637.68638	234088.27	5
18	Graph17	254.24267	18.455177	1273.2709	238089.9	5
19	Graph18	180.26388	25.262019	801.81238	1788121.8	5
20	Graph19	150.39665	43.888817	1461.5442	961624.8	5
21	Graph20	248.22882	14.795614	961.84236	813278.88	4
22	Graph21	281.52117	17.207474	1186.9816	258208.8	4

- Automatic extraction of centerlines with local thickness
- Flexible editor for manual editing of centerlines
- Interactive tracing of filaments
- Versatile label editor for functional and topological annotations
- Basic descriptive statistics (length, radius, volume per segment, branching level)

A researcher's digital workbench: Visualize



Import and Export

- Standard formats
- Microscopy and medical formats
- Finite element modeling
- Geometric modeling and CAD
- Flexible raw data import

Present

- Live animations
- Movie generation
- 3D stereo vision
- Virtual reality navigation
- Single and tiled screen display
- Support for tracked devices

Process

- 2D and 3D image filtering
- Surface generation
- FEM grid generation
- Interactive/automatic segmentation
- Interactive/automatic alignment
- Registration and morphing
- Deconvolution and Z-drop correction

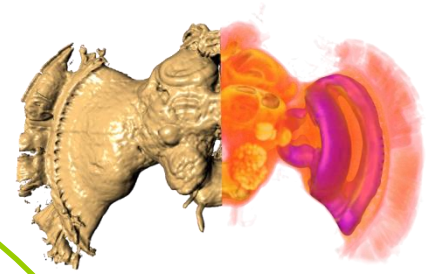
Avizo[®]
amira[®]

Visualize

- Orthogonal and oblique slicing
- Volume rendering
- Surface rendering
- Isolines and isosurfaces
- Multichannel imaging
- Image fusion

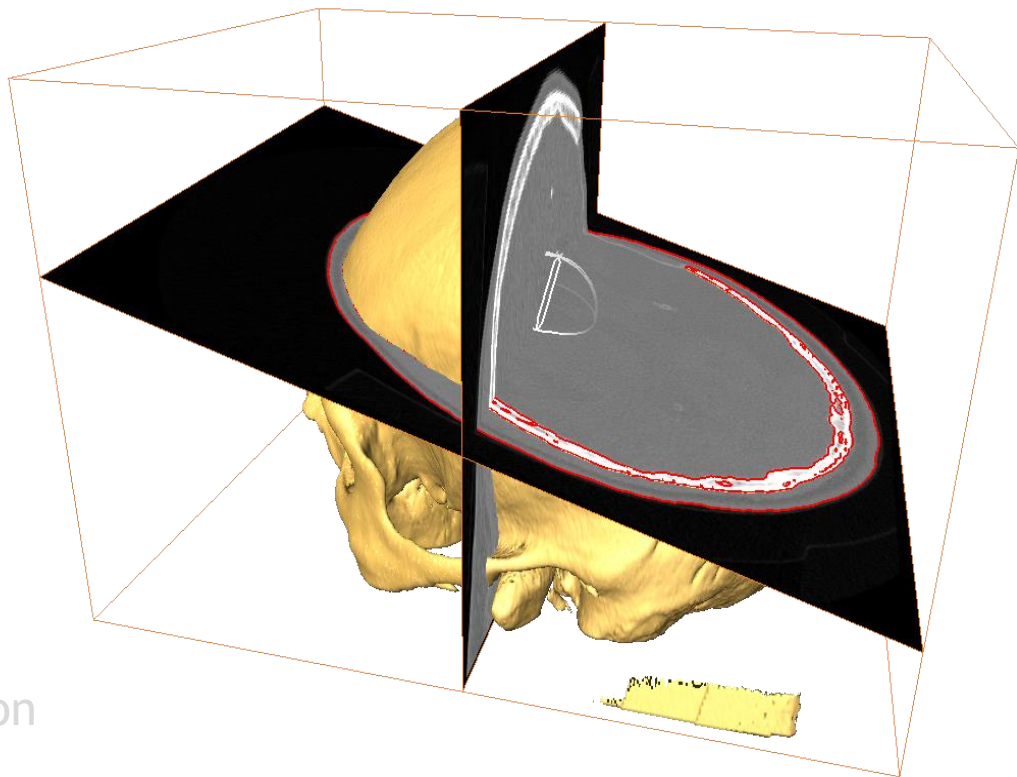
Analyze

- Measurement tools
- Densitometry (gray value statistics)
- Co-localization analysis
- Arithmetic operations on images
- Direct integration of Matlab[®]



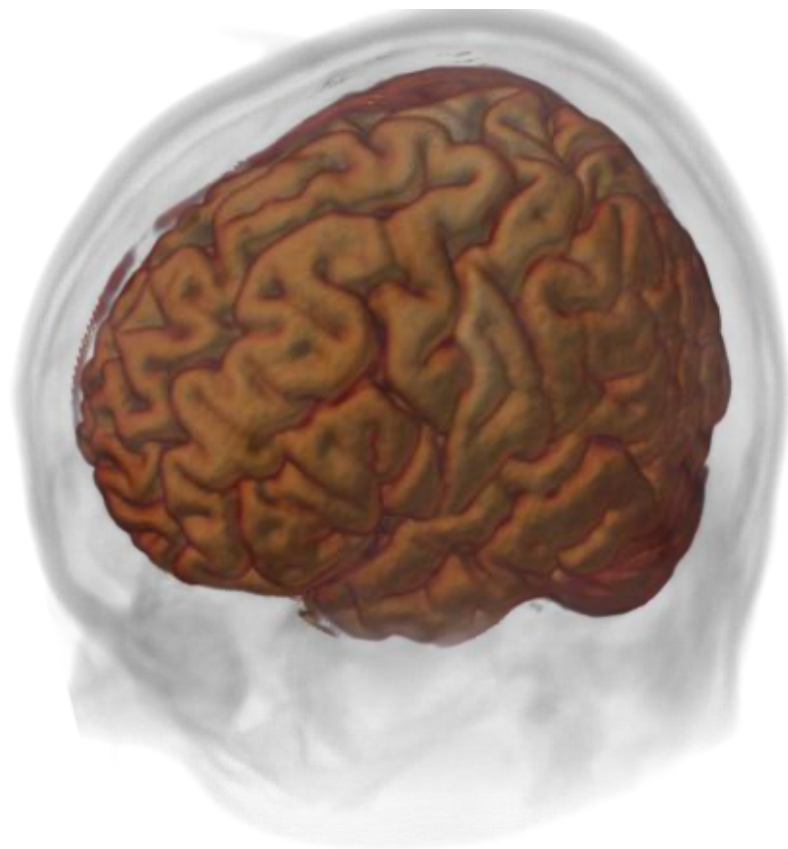
Visualize

- Orthogonal and oblique slicing
- Flexible volume rendering
- Surface rendering
- Isoline and Isosurface
- Multichannel visualization
- False-color mapping
- Advanced molecular visualization



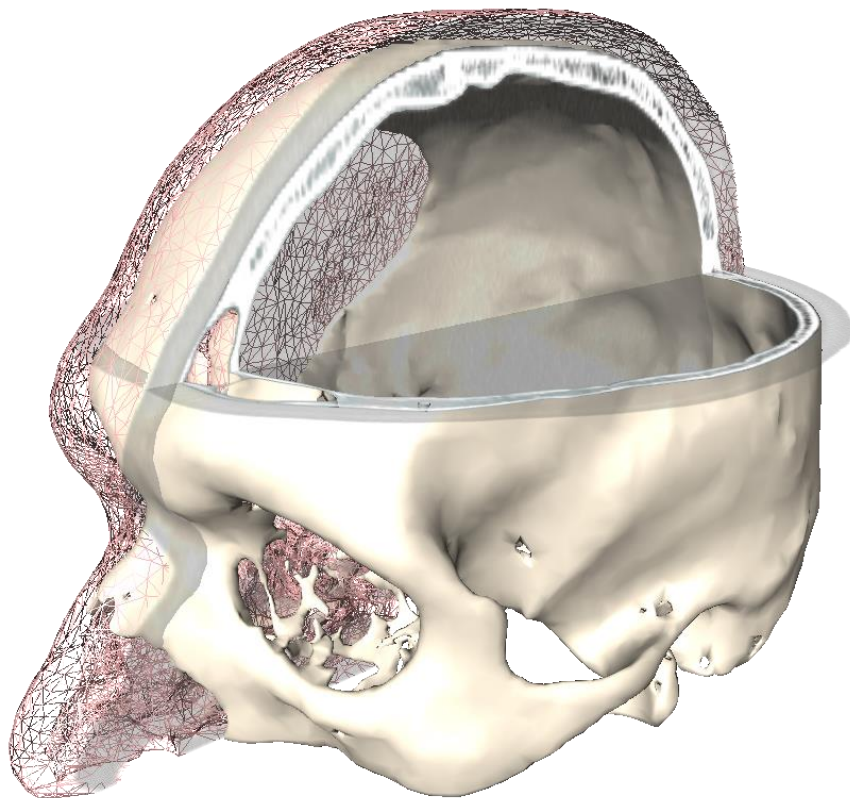
Visualize

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- **Flexible volume rendering**
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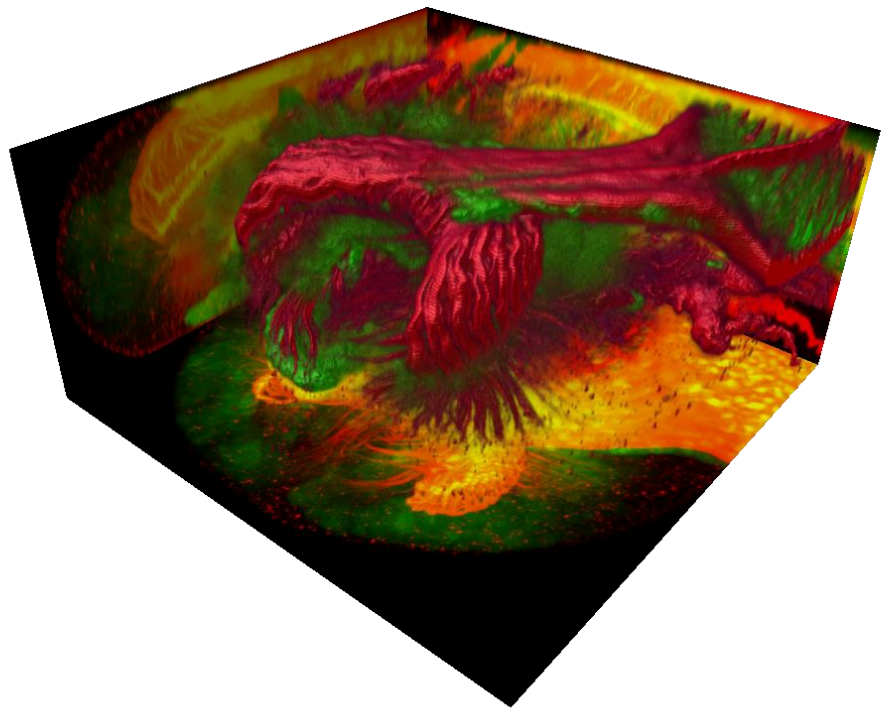
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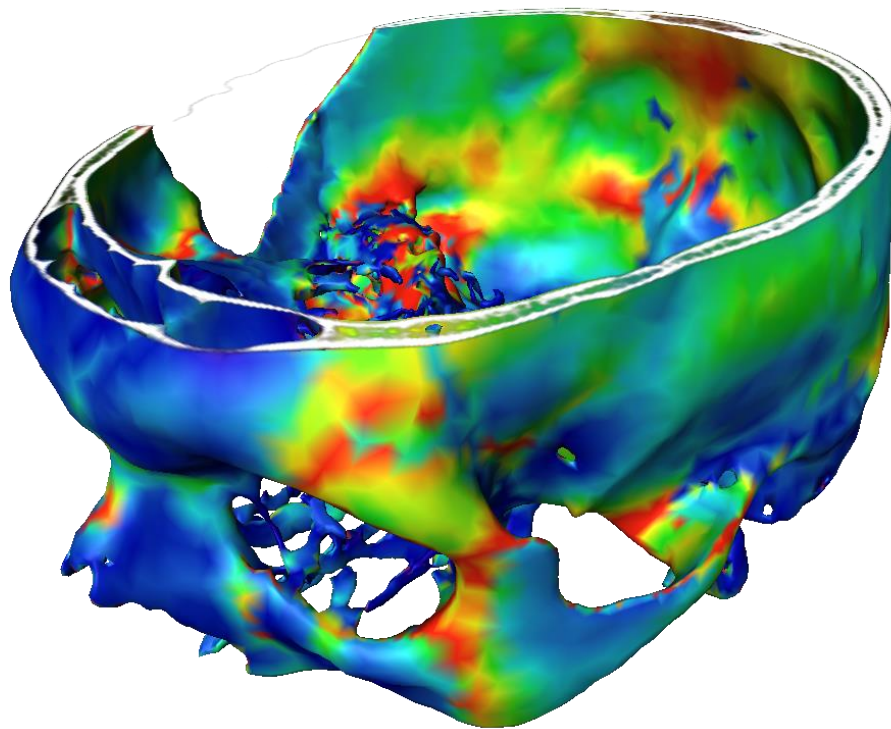
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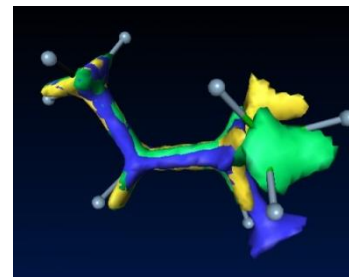
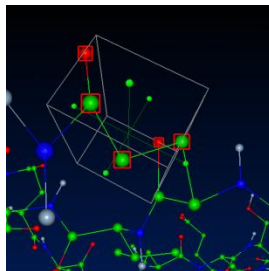
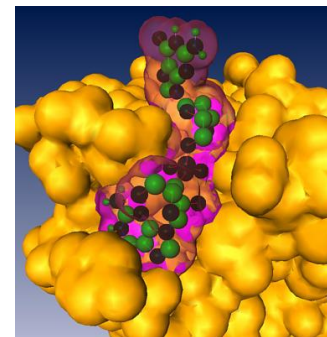
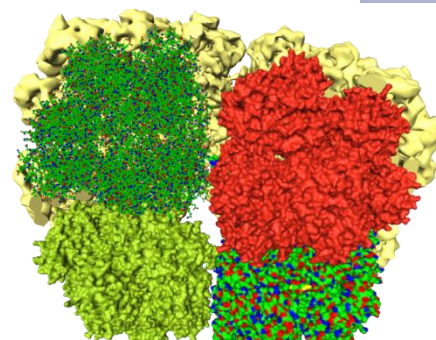
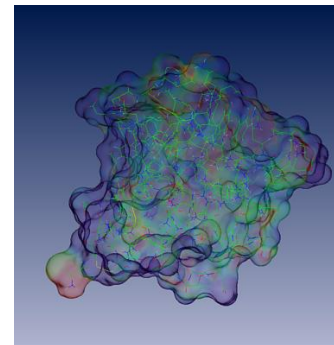
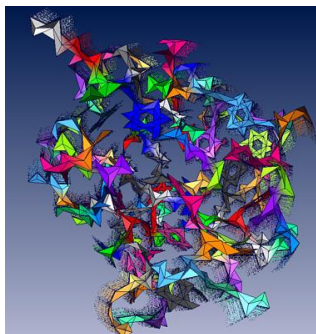
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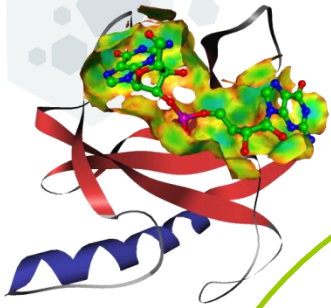


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A researcher's digital workbench: Present

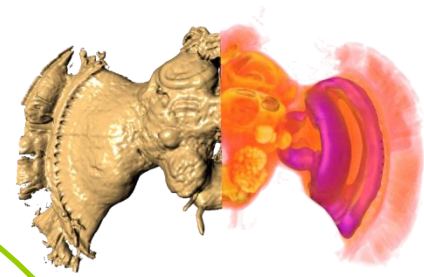


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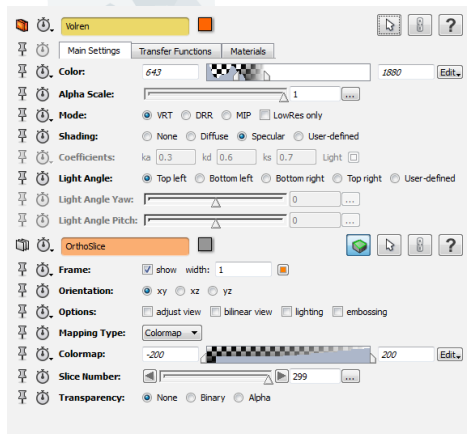
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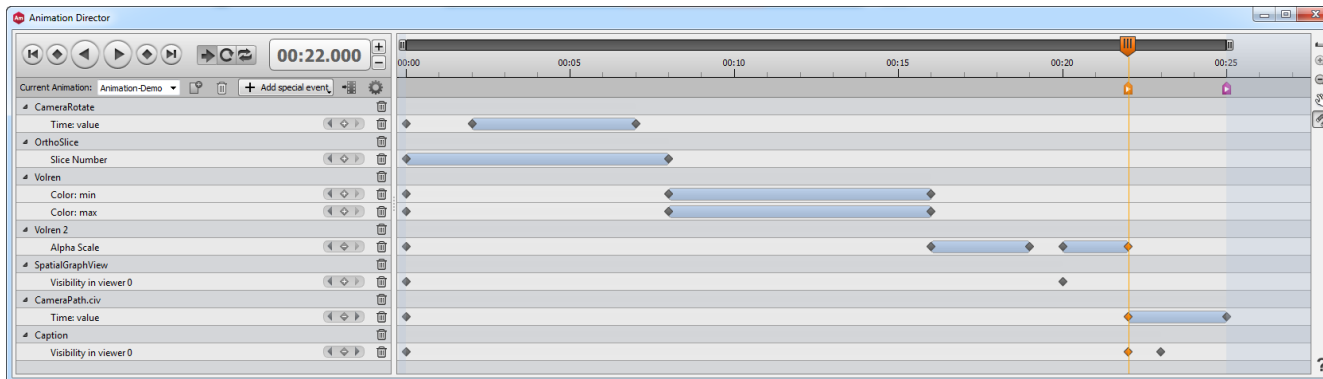
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Demo Director

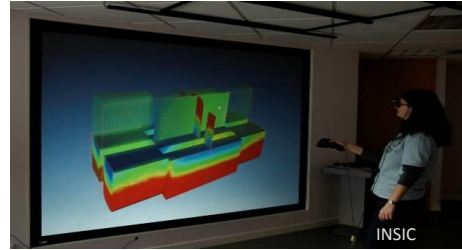
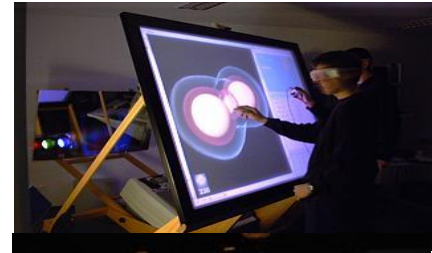
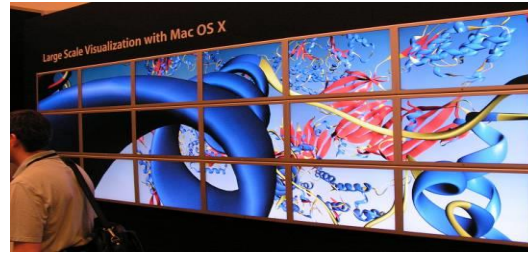
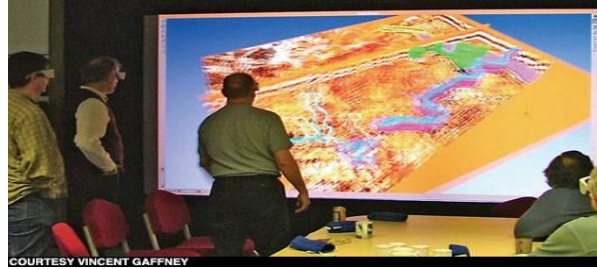


Visual animation authoring

- Graphical user interface for demo creation
- Integrated intuitive timeline window
- Easy creation of events through tree list of ports
- Exact synchronization by snapping

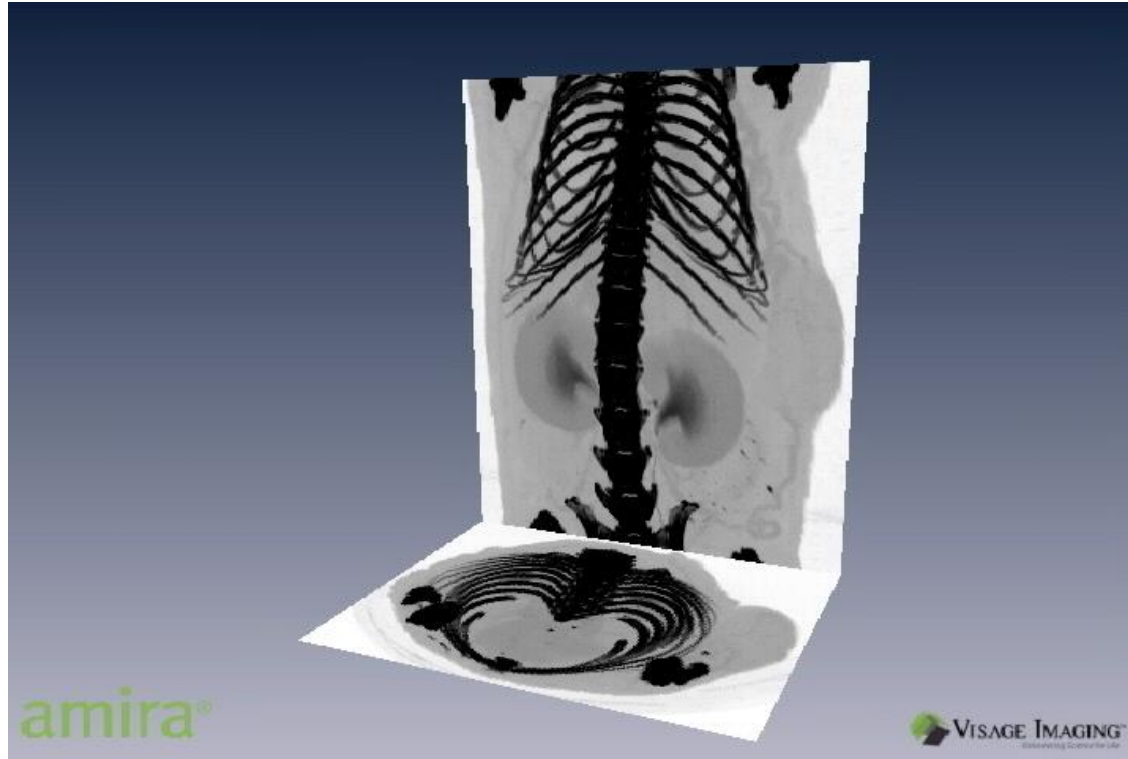


Avizo XScreen applied

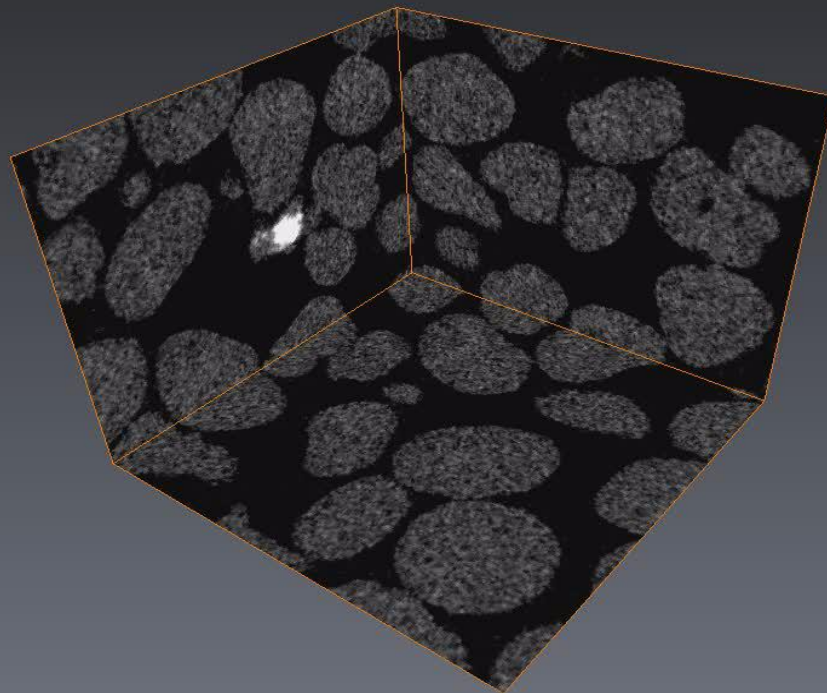


Explore. Discover. Resolve.

Rendering video clips from animations



Rendering video clips from animations



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vsg
Visualization Sciences Group

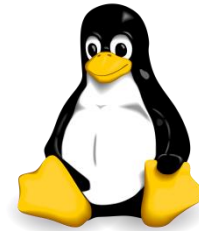
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Operating systems and hardware platforms

Available platforms:

- Windows XP/Vista/7/8 32 Bit, 64 Bit
- Linux 64 Bit
- Mac OS X 10.7, 10.8, 10.9 64Bit

Full data and network compatibility across all platforms



OS X

Thank you!

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www.vsg3d.com



One on one sessions

200 - 230

230 - 300

300 - 330

330 - 400

