Avizo 9.2.0

3D Analysis Software for Scientific and Industrial Data

Dear Avizo User,

With this document we would like to inform you about the most important new features, improvements, and changes in this version. Please read these Release Notes carefully. We would appreciate your feedback regarding this version. If you encounter problems, but also if you have suggestions for improvement, please report them to fei-sw-support@fei.com. We would like to thank you in advance for your efforts.

July 2016, the Avizo team

CONTENTS

OVERVIEW

The Avizo 9.2 release includes important new features, enhancements, performance improvements, and issue fixes.

For major changes introduced in Avizo 9.1, please refer to the *Avizo 9.1.1 Release Notes* document.

PROPERTIES AREA ENHANCEMENTS

Avizo 9.2 comes with an improved properties area. It was redesigned with a focus on ergonomics and intuitiveness. For more details on each module's enhanced ports, please refer to its documentation.

ADDITIONAL DATA PROPERTIES

Additional information was added to the *Properties Area* of a data object when it is selected in the *Project View*:

- *Memory size* displays the memory usage in mega bytes of the data,
- *Physical size* represents the physical extent from the lower left corner on the zmin Z coordinate of the data,
- *Preview* displays a preview of the data (the size of the preview is configurable through the preferences),
- *Histogram* shows the data histogram.
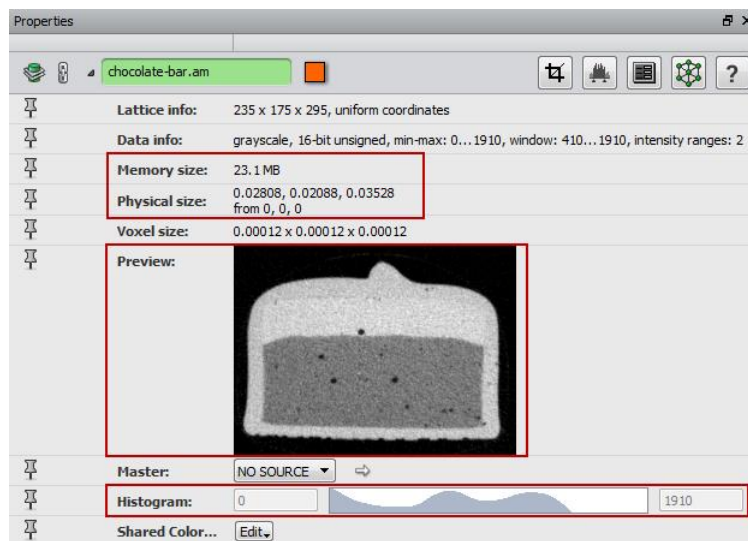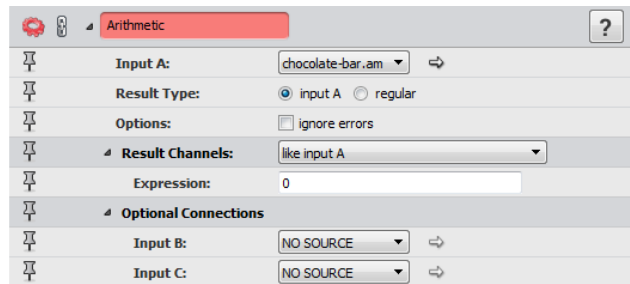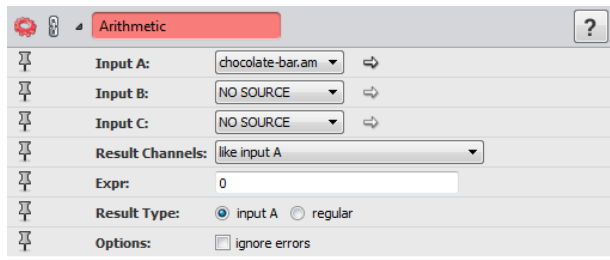

Note that this preview is also displayed in the data tooltip in the *Project View*.
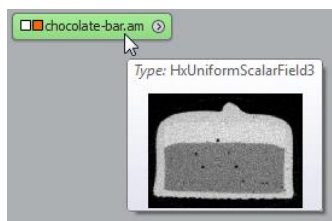
GROUPS OF PORTS

In order to simplify the view of all the ports of a module, groups have been added. By default, the ports without a group are all displayed, whereas the other are hidden within their own group. A click on the arrow on the group's left displays or hides the group ports.

ON/OFF PORTS

When checkboxes were used to display/hide some ports and to enter a specific configuration for the module, they have been replaced with a new type of **On/Off** port group. The ports are displayed when the **On/Off** port is turned on, and they are hidden when it's turned off.
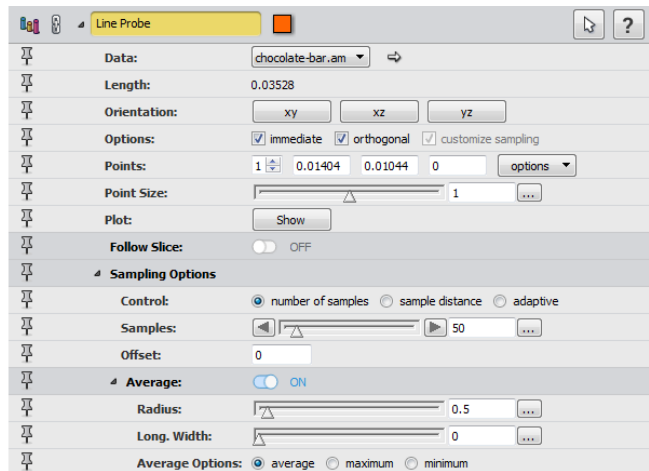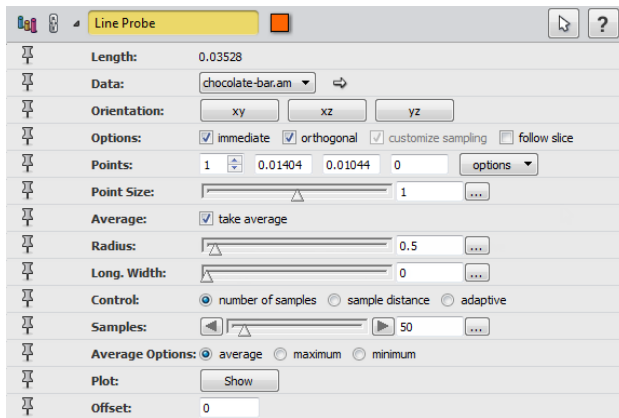
ADVANCED MODE

An **Advanced** mode is now available for displaying/hiding some ports or groups of ports for advanced usage. This button is displayed at the top of a module's properties. The ports or group of ports are displayed when the **Advanced** button is turned on, and they are hidden when it's turned off.

5
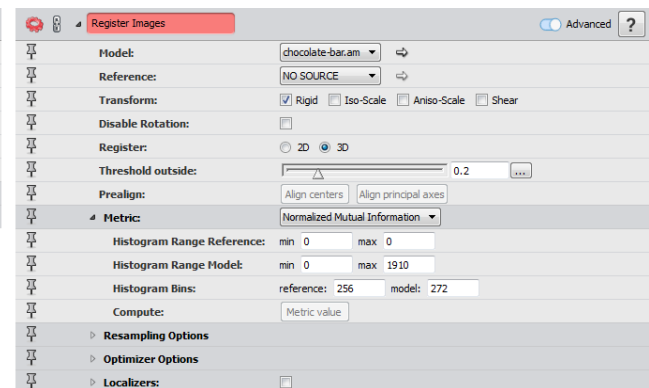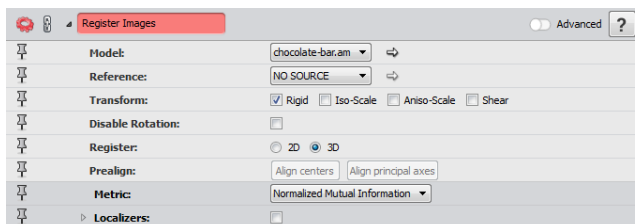
NEW MODULE

Distribution Analysis computes the cumulated value of a given property against another one. It takes a spreadsheet as input and can be used for instance in:

- Pore size distribution (X: pore size, Y: cumulated volume fraction);
- Fiber length distribution (X: fiber length, Y: cumulated volume fraction).

NEW READER

The REK reader adds support for Fraunhofer EZRT 3D image format for X-Ray CT, also used by Werth Messtechnik GmbH and ProCon X-Ray GmbH.

NEW PYTHON SCRIPTING

Avizo now integrates a ready-to-use **Python** distribution from FEI including the most frequently used scientific packages from the **Python** ecosystem. With its newly developed memo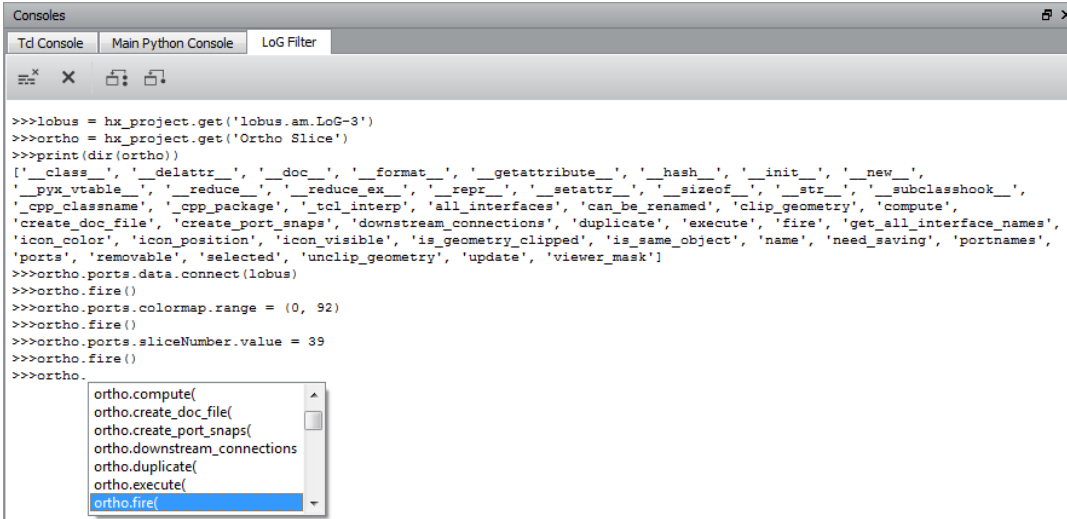ry sharing technology between **Python** and Avizo, this unique distribution allows direct access of data loaded by Avizo through **Python** utilities, e.g., *NumPy* arrays. This has the advantage that data does not need to be duplicated in memory, as is common for more traditional **Python** bridges.

With its true pythonic scripting API, this integration allows access to Avizo modules from **Python** scripts that is fully compliant with **Python** scripting conventions. The comprehensive and user-friendly integrated **Python** console interface allows convenient script generation and execution with easy switching between **Python** and **Tcl**. The **Python** console also offers convenient integration of the API documentation. This allows seamless creation of script objects using **Python** that can later be attached to data objects using the graphical user interface in Avizo.

Advantages of the integration of **FEI Python** are:

- Intuitive, popular and modern scripting language
- Access to hundreds of freely available scientific algorithm in the **Python** ecosystem
- Ultra-efficient memory management
- Direct access to Avizo data objects from **Python** scripts
- Fully compliant with **Python** scripting conventions

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- Convenient and full-featured **Python** console interface
  - Auto-completion for known attributes and functions
  - Full integration of API documentation
  - Easy switching between **Tcl** and **Python**
  - Convenience buttons to trigger most important scripting features, e.g., *Clear Console*, *Remove Python Data Objects*, etc.

FEI Python is based on **Python 2.7.11** and includes the most popular scientific packages such as *numpy* and *scipy*. *Numpy* is an extension for handling multi-dimensional arrays, which allows for elementwise operations, comparisons, logical operations and statistics among others. *Scipy* is an extension which provides a toolbox for scientific computing such as interpolation, integration, image processing, linear algebra, signal processing, and statistics. Creating additional windows for viewing plots is not currently supported.

Here is a complete list of **Python** packages already included in **FEI Python**:

- enstaller 4.8.11-1
- alabaster 0.7.7-1
- babel 2.2.0-1
- backports_abc 0.4-1
- certifi 2015.11.20.1-1
- configobj 5.0.6-1
- cycler 0.9.0-2
- cython 0.23.4-1
- decorator 4.0.6-1
- distribute_remove 1.0.0-3
- docutils 0.12-1
- freetype 2.5.3-4
- h5py 2.5.0-4
- hdf5 1.8.15.1-1
- jdcal 1.2-1
- jinja2 2.8-1
- libjpeg 7.0-3
- libopenjpeg 2.1.0-2
- libpng 1.6.12-3
- libxml2 2.9.2-2
- libxslt 1.1.28-3
- lxml 3.5.0-1
- markupsafe 0.23-1
- matplotlib 1.5.1-1
- mkl 10.3-2
- networkx 1.10-3
- numexpr 2.4.0-3

- numpy 1.9.2-2
- numpydoc 0.5-7
- openpyxl 2.3.1-3
- pandas 0.17.1-7
- patsy 0.4.1-1
- pil_remove 1.0.0-2
- pillow 3.1.0-1
- pydicom 0.9.9-1
- pygments 2.1-1
- pyparsing 2.0.3-1
- pytables 3.2.2-2
- python_dateutil 2.4.2-2
- pytz 2015.7-1
- scikit_learn 0.17-1
- scikits.image 0.11.3-12
- scipy 0.16.1-1
- seaborn 0.6.0-6
- setuptools 19.4-1
- singledispatch 3.4.0.3-1
- six 1.10.0-1
- snowballstemmer 1.2.1-1
- sphinx 1.3.5-1
- sphinx_rtd_theme 0.1.9-1
- ssl_match_hostname 3.4.0.2-1
- statsmodels 0.6.1-13
- tornado 4.3-1
- xlwt 1.0.0-1

ENHANCED FEATURES

A Memory Usage monitor is part of the status bar, with the memory value in percent is displayed using a progress bar. Its color changes when the consumed value exceeds a particular value:

- For workstations with less than 40 GB of memory, the progress bar becomes red if there is less than 4 GB left.
- For workstations with more than 40 GB of memory, the progress bar becomes red if there is less than 10% of the memory left.
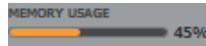
The snapping method of the measurement tools available in the viewer window and the associated Measurement module is now disabled by default on scalar fields, instead of being set to the maximum gradient magnitude intensity (*max gradient*).

The Colormap Legend module can now be connected to display modules with a *Colormap* port. The min/max values and the histogram of the module are updated according to the current colormap or display module local range.

Three new columns are available in the Spatial Graph Statistics module spreadsheet output:

- *Curved-Length*: curved segment length, with units the same as the bounding box;
- *Chord-Length*: distance between start and end point of the segment, with units the same as the bounding box;
- *Tortuosity*: tortuosity of the segment which is equal to *Chord-Length*/*Curved-Length*.

Spatial Graph to Volume is renamed to Convert Geometry To Label.

AVIZO – ENHANCEMENTS AND NEW FEATURES

NEW MODULES

Ring Artifact Removal (Windows and Linux only) removes rings from the tomogram by comparing the means of the voxel values between the thresholds in each ring and the means of the values between the thresholds of the whole sample. Adjustments are then made to all the voxel values of each ring.

Beam Hardening Correction (Windows and Linux only) performs a simple correction for beam hardening that only really works for homogeneous cylindrical objects. Beam hardening shows as a radial increase in the attenuation coefficient. From a defined rotation axis, the average radial intensity profile is first computed. This profile can then be smoothed with a Gaussian filter, and is then normalized. Then all the intensities will be divided by this smoothed profile to give a more or less radial averaging.

Cylindrical Intensity Profile (Windows and Linux only) computes a cylindrical intensity profile that consists of the average intensity at a distance *r* from a given rotation axis. The output is a 2-column spreadsheet with those radii and average intensity values. Only unsigned 16-bit and float scalar images are supported.

Radial Autocorrelation (Windows and Linux only) computes radial autocorrelation of a tomographic image. For grayscale images, it calculates the radial autocorrelation function (2-point correlation function) of the tomographic image. For segmented images, each phase can be treated separately, or they can be treated as a micro-porosity image.

Vector To RGB creates an RGB image from a vector field. The output data is an *unsigned char* data object.

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IMPROVED IMAGE PROCESSING ENGINE

The new version of our image processing engine brings important performance improvements for all the Erode, Dilate, Close, and Open modules; the support of *double* and *int64* outputs of the Volume Fraction module; and two new measures for the *Breadth3d* measurement (*BreadthOrientPhi* and *BreadthOrientTheta* which provide the orientation of the associated axis).

XFIBER EXTENSION – ENHANCEMENTS AND NEW FEATURES
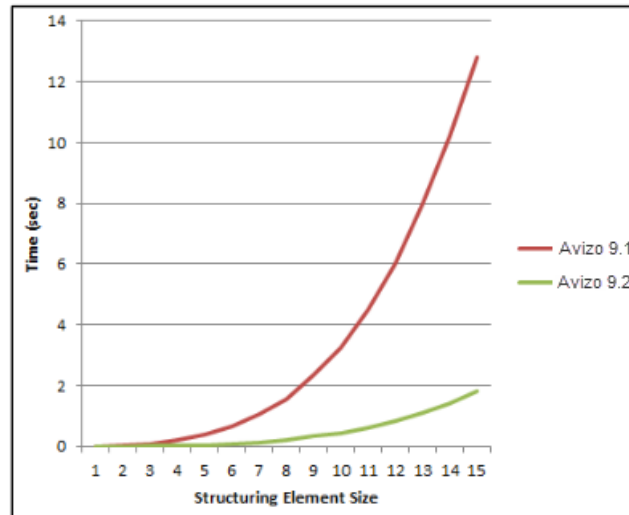
ENHANCED FEATURES

CYLINDER CORRELATION

A visual cylinder template can be displayed to easily set cylinder parameters. The cylinder *Length* and the cylinder *Radius* are synchronized with their corresponding ports when it is created. Different mouse interactions allow setting the radius and the length.
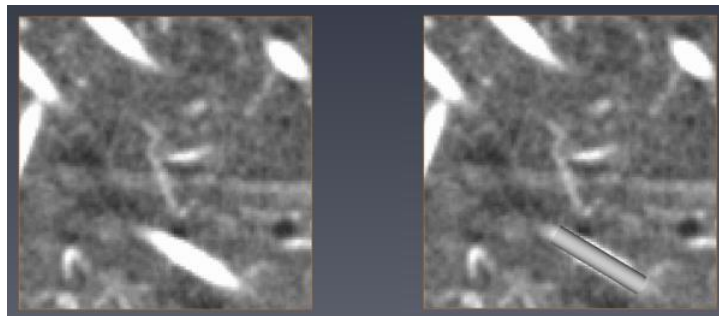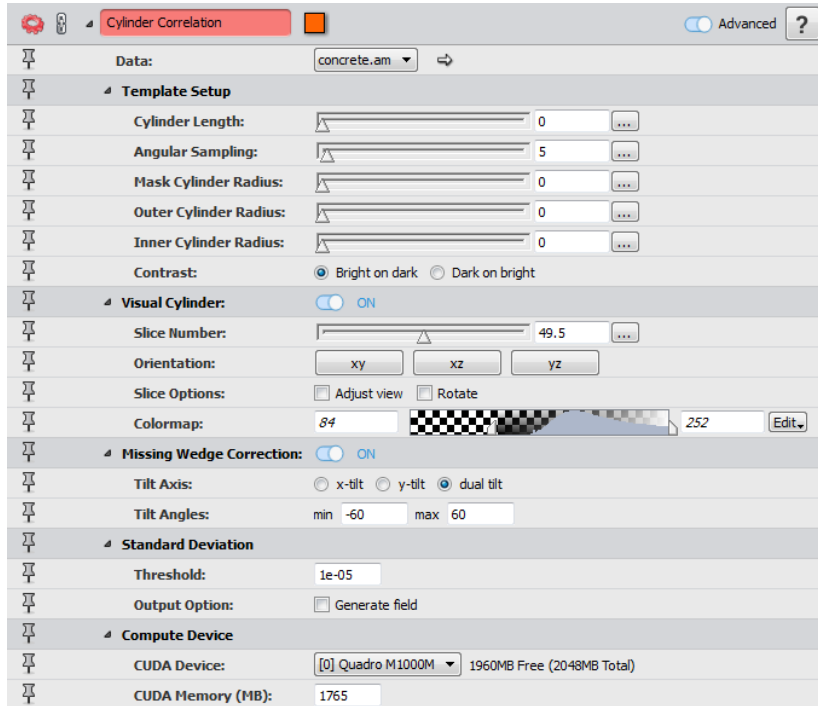
The cylinder parameters are now saved into the parameters bundle of the correlation field output.

Some default port settings have changed: the *Correct Missing Wedge* is set to *no*, and the *Contrast* is set to *Bright on dark*.

The memory footprint has been reduced significantly.

TRACE CORRELATION LINES

The correlation field input data can now be of *8-bit unsigned* type. The orientation field input data must be of type *16-bit unsigned* if the correlation field input is of *32-bit floating* type, or if the correlation field input is of *8-bit unsigned* type.

The Trace Correlation Lines module now uses the cylinder parameters from the correlation field input to automatically set the min line distance, the min line length, and the search cone. These parameters are used as default values; each value is still editable by the user.

By default, a Spatial Graph output of this module automatically contains statistics such as the length and the orientation of each centerline stored as attributes. These statistics are the same as obtained using a Spatial Graph Statistics module.

NEW MODULES

Spatial Graph Local Statistics quantifies statistics according to the density of the spatial graph in subdomains. It computes local statistics related to the volume fraction, surface area, and orientation tensors for materials with recurrent objects (fibers, neurons, molecules, etc.). The statistics are computed within subdomains, positioned according to a regular lattice. The primary input is a spatial graph representing the centerlines of the studied object.

Filter Spatial Graph By BBox Contact removes all segments touching the bounding box of the spatial graph. All nodes which have no incident edges after this step are also removed.

Plot 3D Orientation plots 3D orientations on a half sphere or on a sphere. The orientations are represented as a set of 3D columns. Properties of the input data can be mapped on height or color. The property may also be weighted to scale the contribution of each sample to the height.
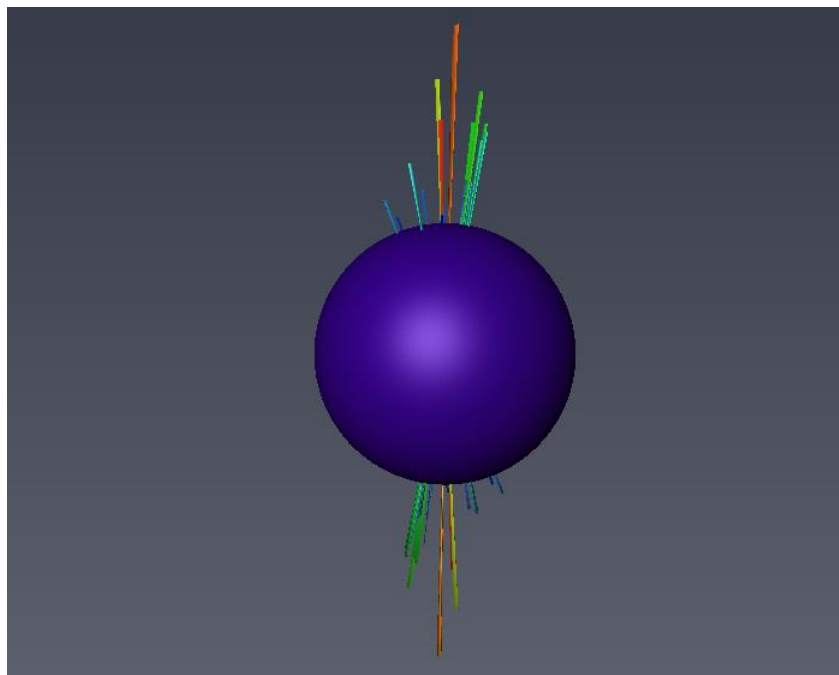
Spatial Graph Filter filters a spatial graph based on a user-defined formula using the listed properties. It will remove all the elements whose value does not fulfill this filter formula. Only one type of element, *Nodes* or *Segments*, can be filtered at a time. This module generates a new spatial graph containing only the nodes and segments resulting from this filtering.

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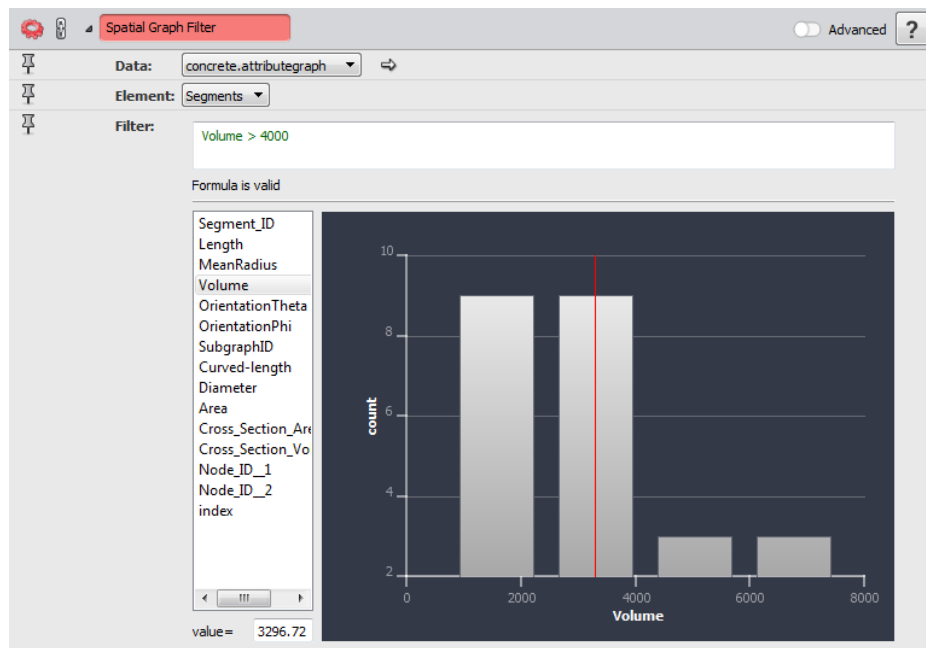
Fiber Shape Statistics internally reconstructs a labeled fiber data object from a grayscale image and a mask by converting the input spatial graph to a binarized representation (using the module Convert Geometry To Label) and growing it within the mask. This representation is then used to calculate the volume fraction of each fiber and deduce various statistics. The fiber shape statistics are the following:

- *FiberID*: the ID of the studied fiber
- *Curved Length*: the length of the studied fiber
- *Diameter*: the average diameter of the studied fiber (diameter=2*sqrt(volume3d/PI*length)
- *Cross Section Area*: this value is equal to fiber volume divided by fiber length
- *Cross Section Perimeter*: this value is equal to fiber area divided by fiber length

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NEW XPORENETWORKMODELING EXTENSION

The new Pore Network Modeling extension allows accessing different statistics from a labeled and separated pore space 3D image. The statistics include distribution of the following parameters:

- Pore volume
- Pore area
- Pore equivalent radius
- Pore center of gravity
- Pore coordination number (number of connected neighbors)
- Intersection percentage between pore network model and original pore space
- Throat area
- Throat equivalent radius
- Throat channel length
- Throat connection (id of pore 1, id of pore 2)

The extension also allows reading pore network code from the *Pore Network Node-Link* data format.

From a labeled image representing a separated pore space, a pore network can be generated. It contains the network code and can be used with several dedicated modules for visualization, filtering, etc.

NEW SEPARATION METHOD DEDICATED TO ARBITRARY PORE SPACE

A pore space can be separated into a set of connected and labeled pores using the Separate Objects module. The Pore Network Modeling extension provides an optimized mode for arbitrary pore shapes (*Skeleton – Aggressive*). Spherical pores can still be well separated using the default mode (*Chamfer – Conservative*).
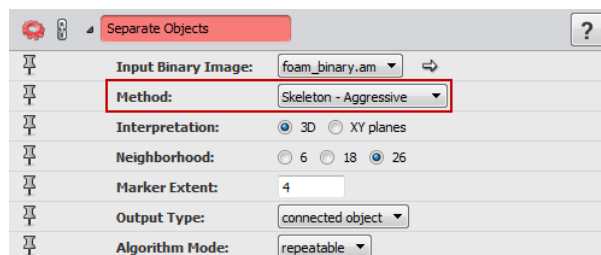
This method generates a label field using a separation algorithm based on watershedding and skeletonization, which carefully separates pores at throat centers.
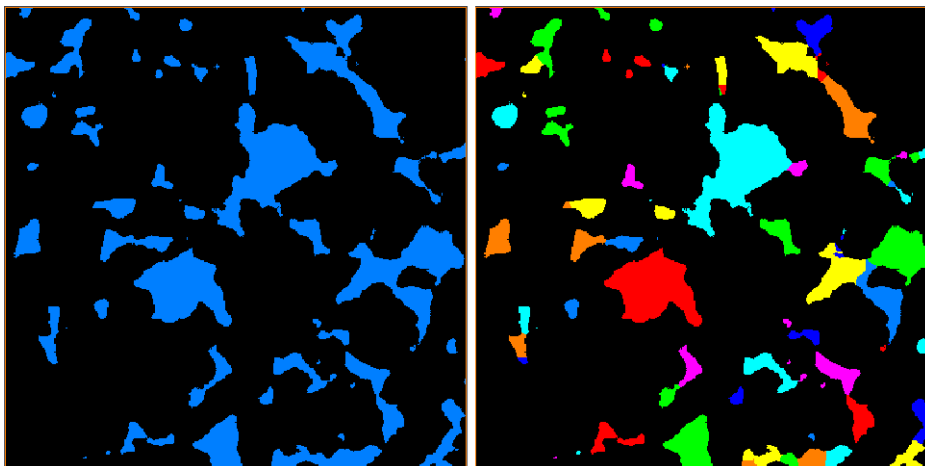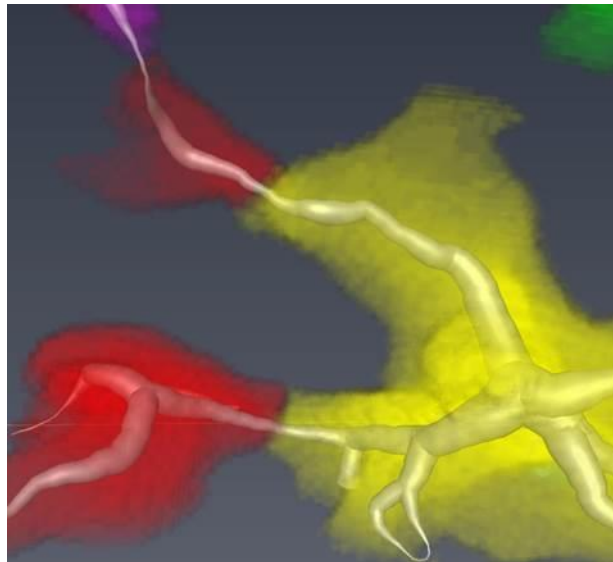
GENERATION OF A PORE NETWORK MODEL

The Generate Pore Network Model module generates a pore network model from a separated and labeled pore space. The extracted pore network model contains the following statistics:

- Number of nodes
- Number of throats
- Coordination number
- Throat equivalent radius
- Throat channel length (defined as distance from pore to pore centers)
- Pore volume
- Pore equivalent radius

	Pore ID	Volume	Area	EqRadius	LabelID	X Coord	Y Coord	Z Coord	Coordination Number
1	0	6182	1943.84	11.3854	1	12.1655	6.9264	10.3928	2
2	1	32004	5852.38	19.6957	2	46.5946	18.0579	13.7421	5
3	2	4506	1554.4	10.2463	3	76.9585	8.97847	5.62406	4
4	3	12638	3338.99	14.4498	4	105.767	10.6916	12.1898	4
5	4	79	146.159	2.66183	5	124.57	1.12658	4.63291	0
6	5	5807	2522.17	11.1503	6	12.5557	30.1362	4.74514	4
7	6	30558	6072.47	19.3945	7	83.2811	42.305	12.6139	10

Pores | Throats

VISUALIZATION

The Pore Network Model View module is a visualization module for a pore network model. *Pores* are displayed using spheres, and *Throats* are displayed using cylinders. Each of them may be colored or scaled according to their attributes.

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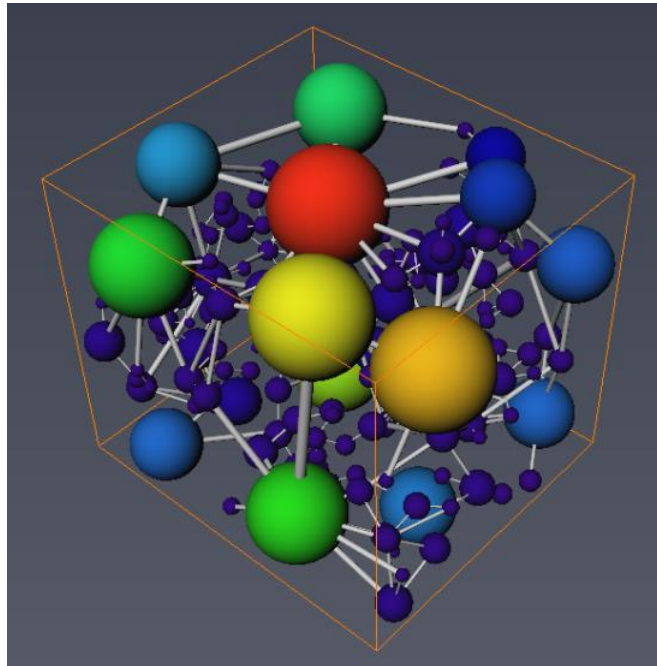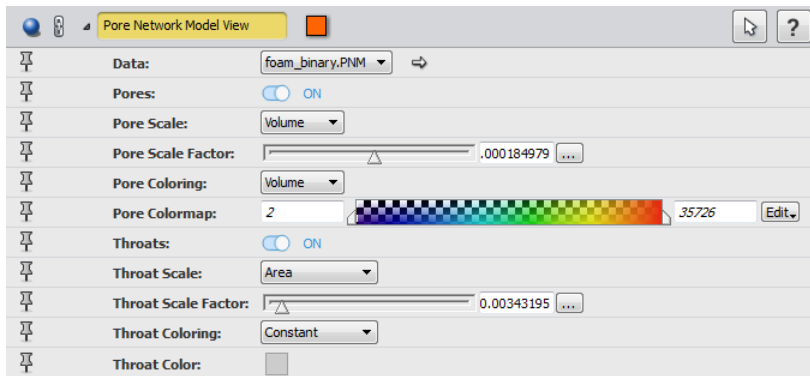
The network code can be displayed as a spreadsheet in the Tables panel. This spreadsheet has two tabs, one for pores and one for the throats. *Pores* and *Throats* can be highlighted by selecting them in the pore network model inner spreadsheet.

	Pore ID	Volume	Area	EqRadius	
1	0	0.0780831	1.22915	0.265149	
2	1	0.36192	3.39577	0.442087	
3	2	0.137864	1.8568	0.32047	
4	3	0.00497395	0.150073	0.105894	
5	4	0.00123118	0.0697584	0.0664881	
6	5	0.227976	2.9301	0.378966	
7	6	0.0134125	0.870604	0.147392	
8	7	0.540863	4.71242	0.505436	
9	8	0.00509241	0.146202	0.106728	
10	9	0.392019	3.23963	0.454018	
11	10	0.00184343	0.109115	0.0760641	
12	11	0.702889	4.64731	0.551568	
13	12	0.0356069	0.616192	0.204087	
14	13	0.00127244	0.0578862	0.0672227	
15	14	0.0140966	0.950393	0.149856	
16	15	0.000537724	0.0350506	0.0504456	
17	16	0.00379867	0.121044	0.0967939	
18	17	0.00159853	0.0676121	0.0725344	

PORE NETWORK MODEL FILTERING

The Pore Network Model Filter module filters a pore network model based on an user-specified formula. It will remove all the elements whose value does not fulfill this filter formula. Only one type of element, *Pores* or *Throats*, can be filtered at a time.
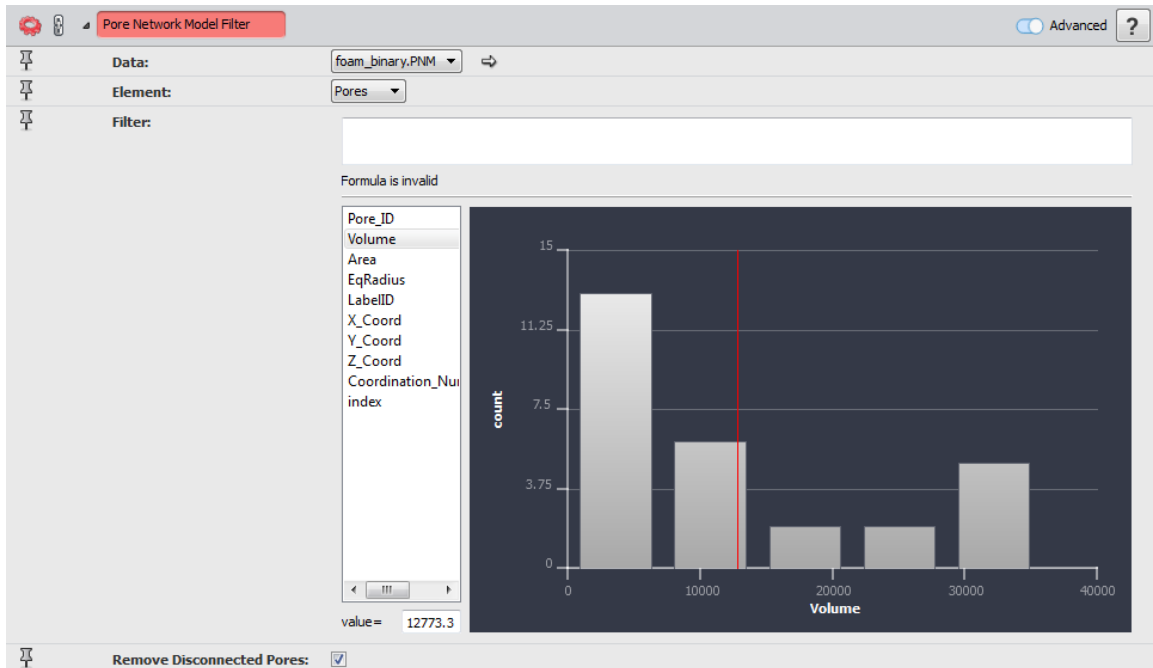
This module generates a new pore network model containing only the pores and throats resulting from this filtering. An option allows removal of all the disconnected pores in a second process.
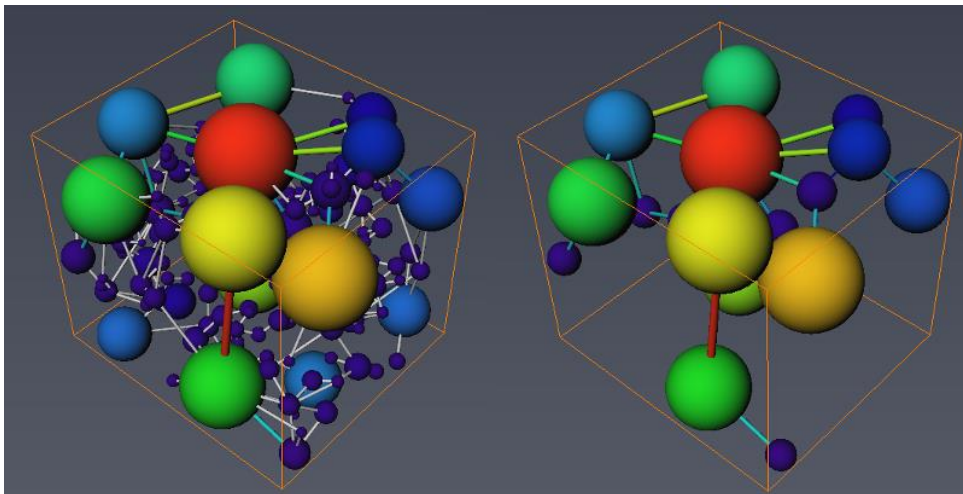
INTERSECTION PERCENTAGE COMPUTING

The Pore Intersection module compares a pore network model with a binary image in order to compute an intersection percentage for each sphere representing the pores and their representation in the binary image. The *Volume* of the pore network model attribute is automatically used for the intersection computation.
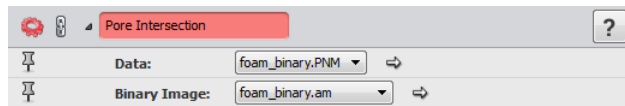
A copy of the pore network model is generated as a result. The intersection percentages computed are added in a new *Pores* attribute.

Tables

foam_binary-Intersection

	Pore ID	Volume	Area	EqRadius	LabelID	Intersection	X Coord	Y Coord	Z Coord	Coordination Number
1	0	6182	1943.84	11.3854	1	68.2789	12.1655	6.9264	10.3928	2
2	1	32004	5852.38	19.6957	2	77.1997	46.5946	18.0579	13.7421	5
3	2	4506	1554.4	10.2463	3	63.4044	76.9585	8.97847	5.62406	4

OPERATING SYSTEMS

Avizo 9.2 runs on:

- Microsoft Windows 7/8/10 (64-bit). 32-bit is no longer supported.
- Linux x86 64 (64-bit). Supported 64-bit architecture is Intel64/AMD64 architecture. Supported Linux distribution is Red Hat Enterprise Linux 6 and Red Hat Enterprise Linux 7.
- Mac OS X 10.7, 10.8, and 10.9 (64-bit).

In order to add custom extensions to Avizo with Avizo **XPand**, you will need:

- Microsoft Visual Studio 2013 (VC12) Update 4 on Windows.
- gcc 4.4.x on Red Hat Enterprise Linux 6 and Red Hat Enterprise Linux 7.
- gcc 4.2.x, provided by the standard Xcode development environment on Mac OS X.

Avizo 9.2 provides many enhancements and solutions to known problems, including the following:

Analysis Filter	42976	The histogram was displaying values based on the working unit instead of the display unit. This has been fixed.
Anisotropic Diffusion	40955	The partition size was erroneously set to 100% on Tesla graphic cards. This has been fixed.
Batch Job	43509 36852	Batch job with Deconvolution module could not be submitted. This has been fixed.
Convert Geometry To Label	44286 44287	Only supported data types (Spatial Graph, Surface, Cluster, Line Set, Landmark Set) can now be connected and used in this module.
Deconvolution	27433	Data sizes up to 536,870,911 voxels (including border voxels) are now supported.
Export To VRML	45192	A VRML file is now correctly exported by this module.
Extract Subvolume	45221	Extracting a volume from a large image works correctly now.
Filament Editor	35971	The Graph Info spreadsheet was not updated properly when the input graph was changed. This has been fixed.
	44906	When no data is connected to the Filament Editor, the warning message about the padding offset is no longer displayed in the Console at start-up.
Generate Surface	44908	Since Avizo 9, Generate Surface internally reorganizes the input label field materials using their id (from bundle parameters). Materials without an id in the input label field are appended to the rest of materials with a new id. This can cause compatibility issues with projects saved with previous versions of Avizo. Use the command removeMaterialsIds to restore the previous behavior where materials were considered in their storage order parameters, regardless of their id.
Isosurface	42084	A new action has been added to the Threshold port options menu in order to disable the auto adjust range, which is on by default.
Label Analysis	46070	Duplicating a Label Analysis data object no longer causes an error.
LDA	42959	On Linux platform, the video memory amount was abnormally limited to 4096 MB regardless of the graphic card. This has been fixed.
License Activation System	45823	XFiber license is no longer automatically checked out at Avizo startup.
Match Contrast	36936	32-bit float data type was not supported. This has been fixed.
Material Statistics	39828	The resulting spreadsheet export to "Amira mesh" format was not working properly. This has been fixed.
Measurement	23258	Decimal tuning was using the working unit instead of the display unit. This has been fixed.
Range Partitioning	41690	Performance issues when the range partitioning is enabled are now fixed.
Resample	35810	When a new data object is connected, the Resolution port values are now updated according to the resolution of the input.
Resample Transformed Image	44186	When connected to a binary data object, the output was not a binary image. This has been fixed.
Script Object	44190	A check is now made on allowed data types according to the declared primary data type in the resource file of Script Objects.
Segmentation Workroom	44713 44714	The TopHat and Watershed segmentation tools were abnormally available in Avizo Lite despite requiring an Avizo license. This has been fixed.
	44755 45725	The performance on the range modification of the Magic Wand has been improved.
	44867	When performing an interpolation between slices, the interpolation process would consider successive slices with selection as a stop and not interpolate the whole selection. This has been fixed.
	44918 44919	Since Avizo 9.1, no display modules configured in the Project Workroom will be shown in this viewer. You can change this by right-clicking into the 3D viewer

		and choosing a particular display module from *Object visibility in viewer 15/Visible objects* context menu. Due to compatibility issues with previous versions of Avizo, modules that were hidden might now be displayed in the 3D viewer at project reloading. Use the same *Object visibility in viewer 15/Visible objects* context menu to hide the objects.
TIFF Writer	39434	When saving a 2D TIFF, the "offset" information is now saved and can be reloaded correctly.
Volume Fraction	33839	Precision of computed values was wrong for large data. This has been fixed.
Voxelized Rendering	44799	If a label field was connected to this module, the Gamma port was displayed, but should not have been. This has been fixed.

Our team is continually focused on solving as many issues as possible to make your experience of Avizo as satisfactory as possible. To this purpose, we would appreciate your feedback regarding this version. If you encounter problems, or if you have suggestions for improvement, please report them to fei-sw-support@fei.com.