

Advanced visualization with VisNow platform

Visualization and Visual Analysis



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VISNOW

<http://visnow.icm.edu.pl>



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Data visualization and visual analysis

Data

- Result of observations and experiments
- Physical or computer simulated

Problem

- Extract information hidden in data...
- ... for experiment understanding
- ... for simulation algorithm verification
- ... for presentation

Scope of visualization

Visual Analysis

Application of algorithms, processing methods and visual presentation for data analysis and extraction of information hidden inside

Visual Modelling

Application of visual analysis for creation of computational and experimental models

Visual presentation



Statistics vs. visualization

Statistics

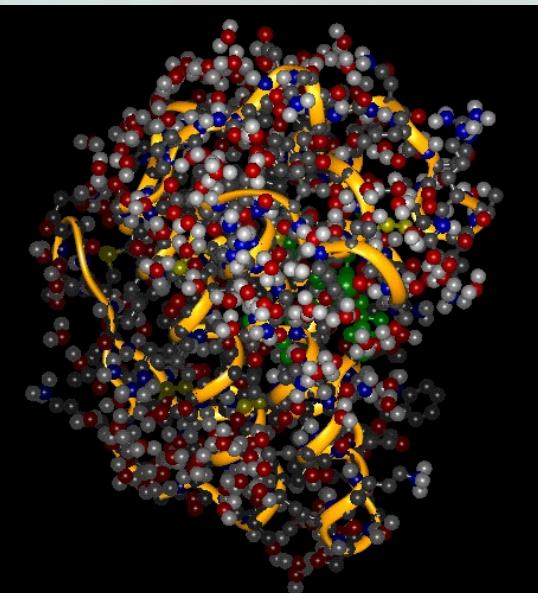
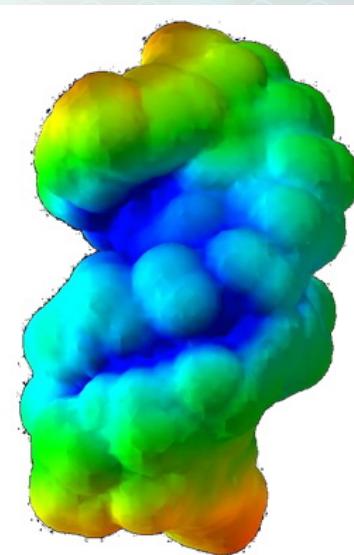
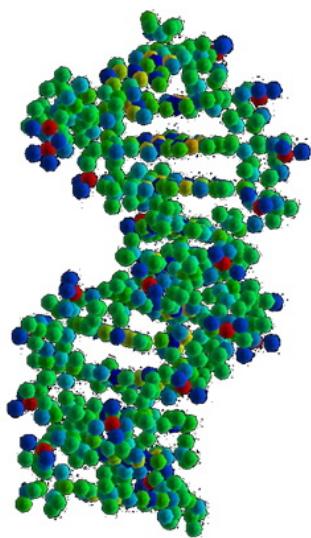
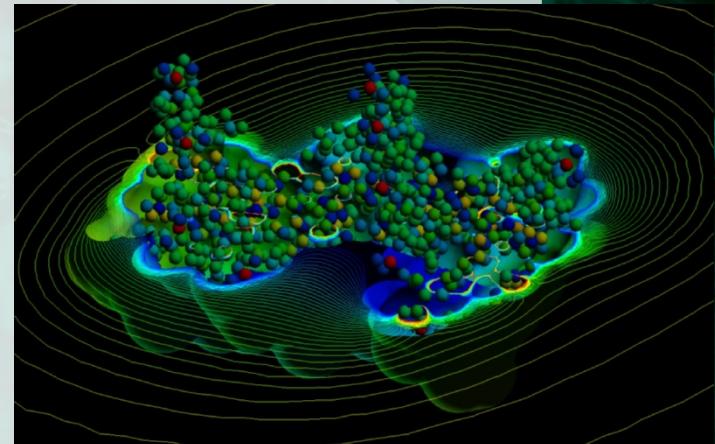
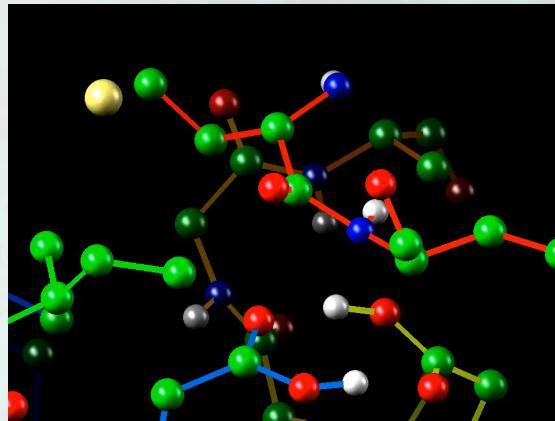
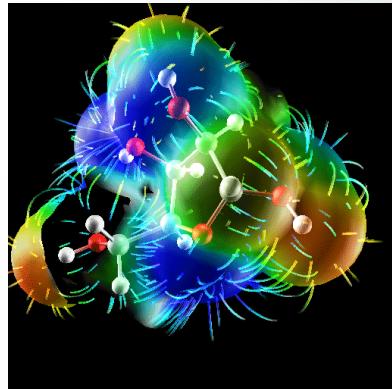
- Mathematically based
- Provides simple and easily comparable results
- Provides answers to asked questions

Visualization

- Presents images, animations, movies or interactive worlds
- Presents more information in parallel and in easily interpreted form
- **Reveals the unexpected!**
- **Induces formulating new questions and stating hypotheses**

Application areas

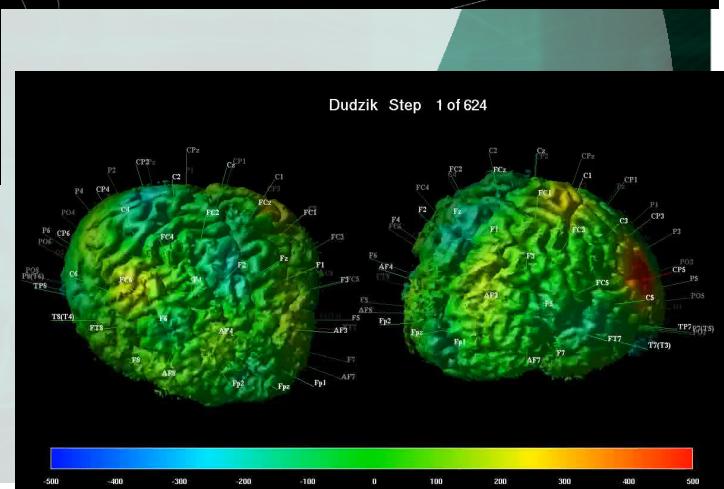
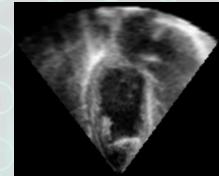
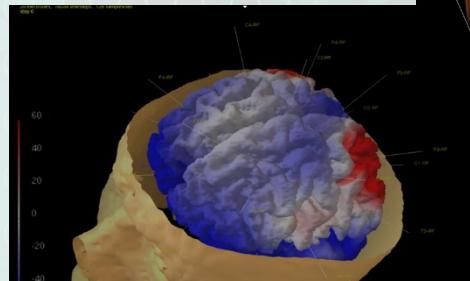
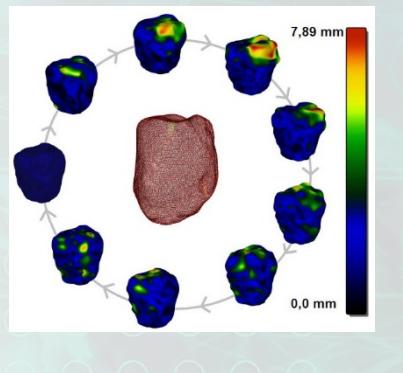
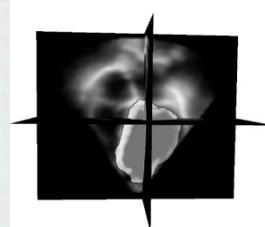
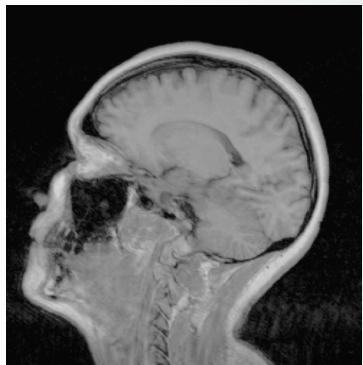
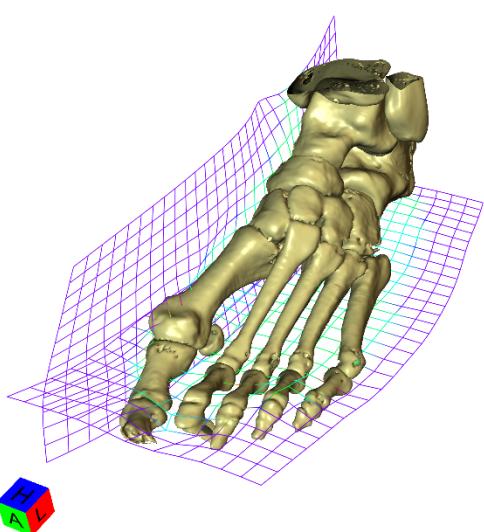
Molecular simulations



natical

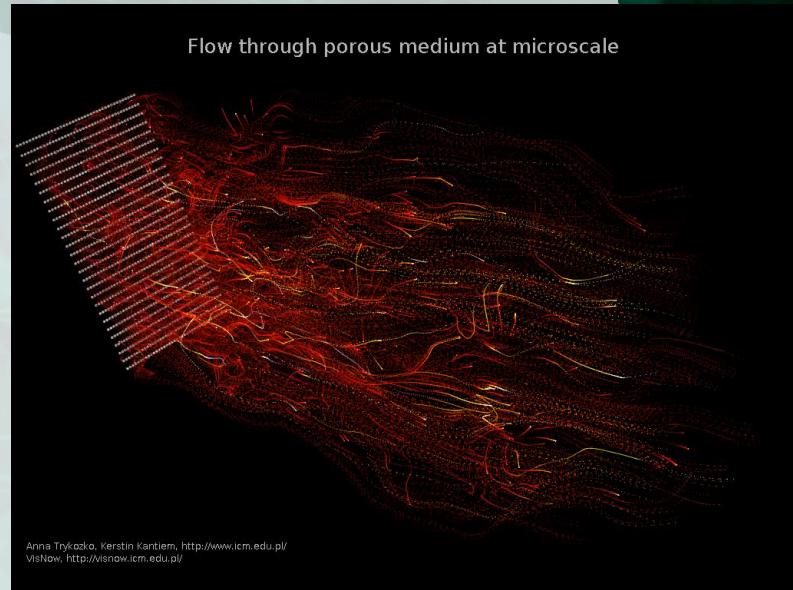
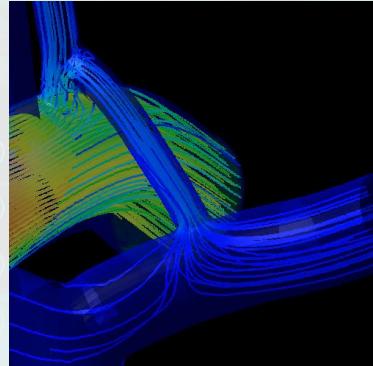
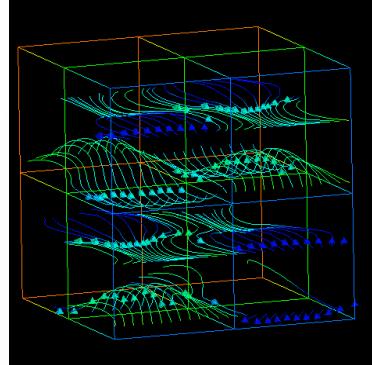
Application areas

Medical imaging

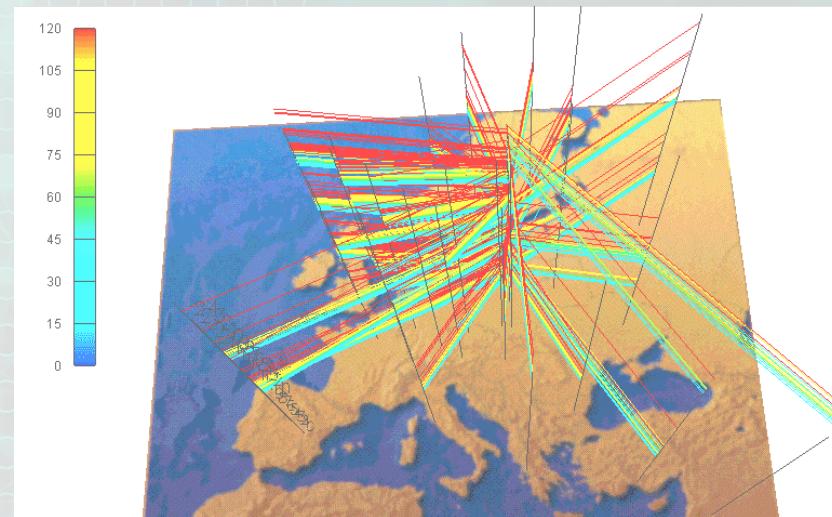


Application areas

Flow modelling

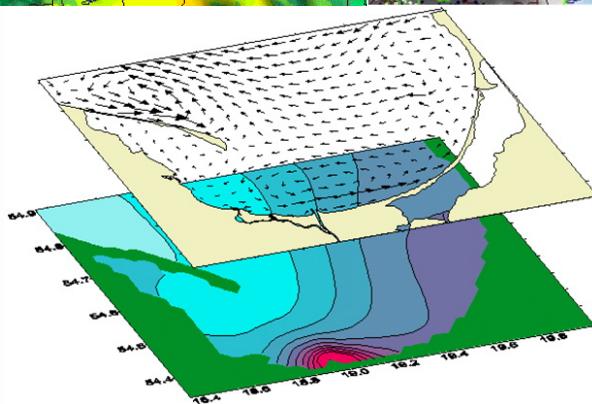
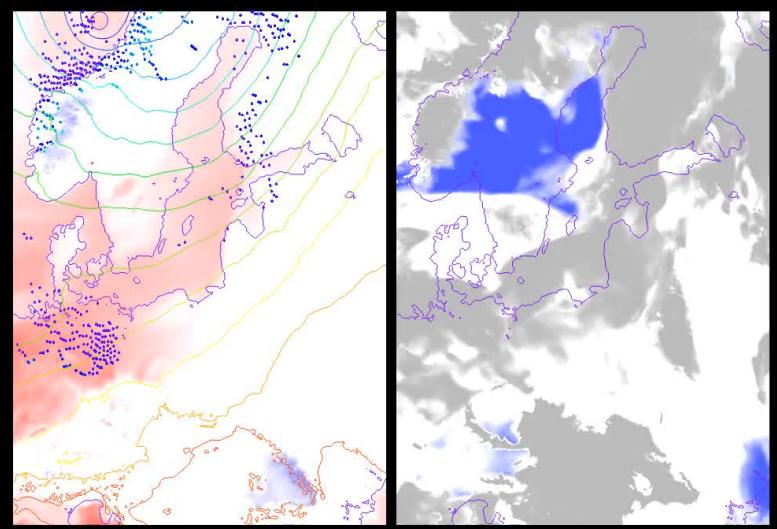
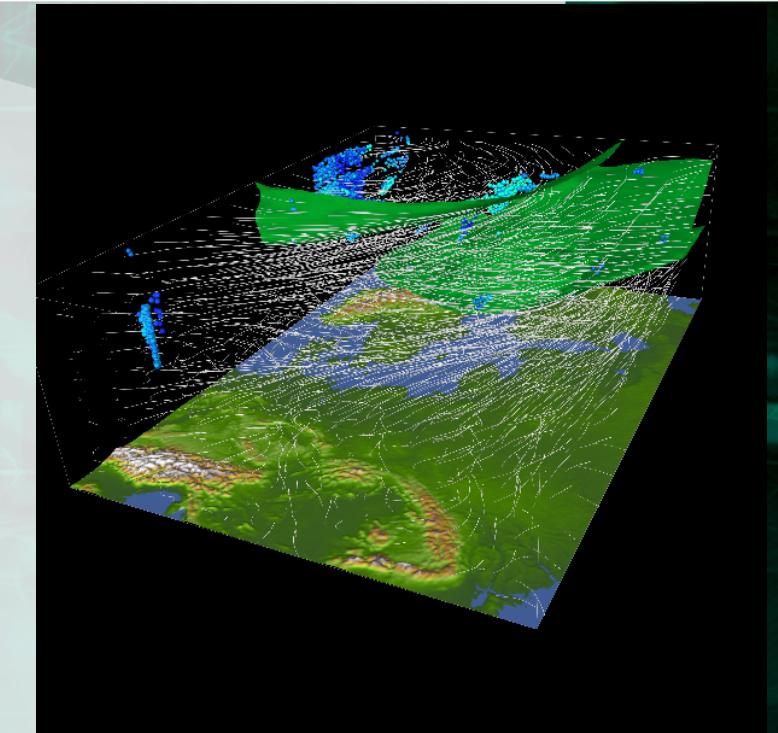
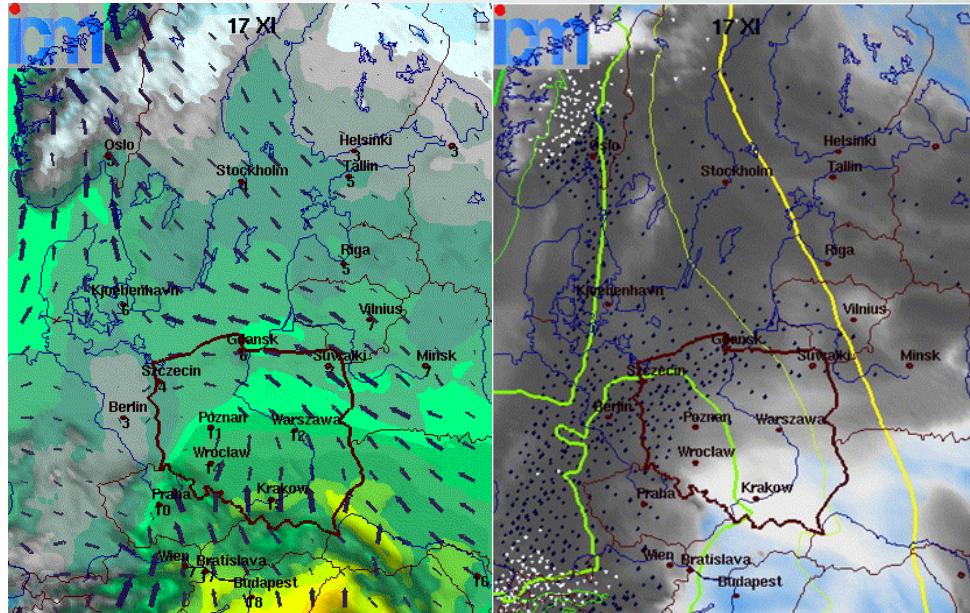


Airline operations



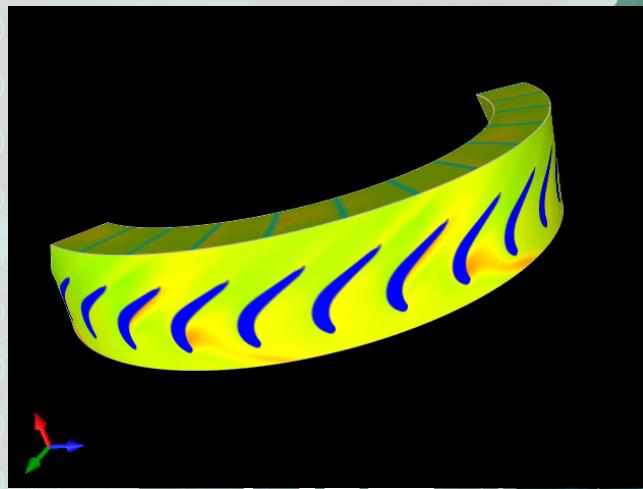
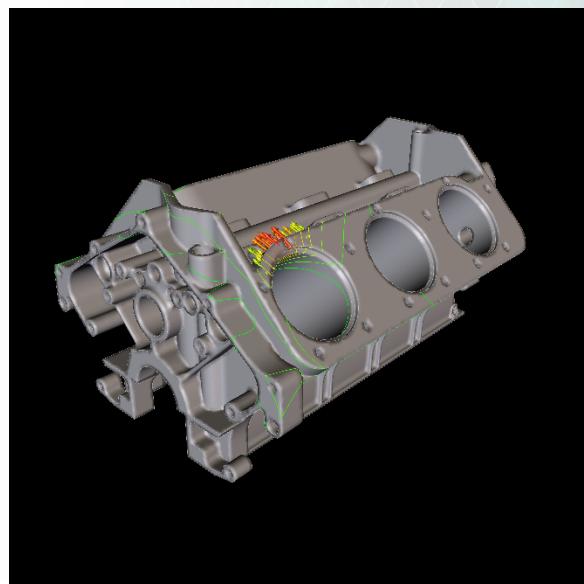
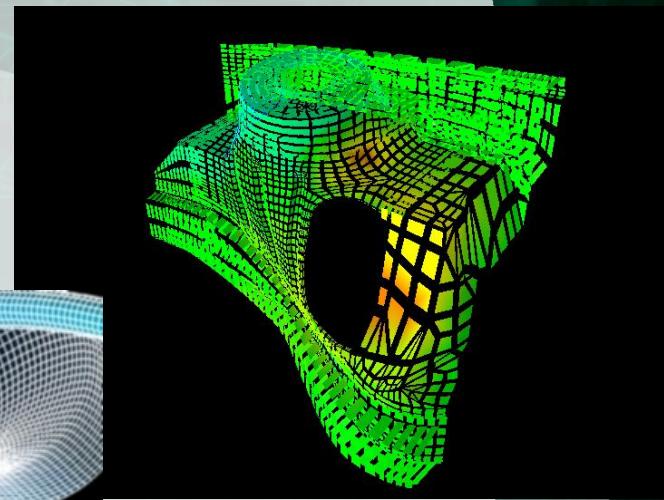
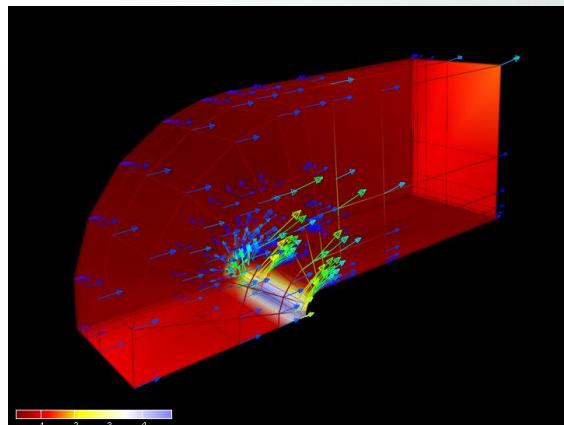
Application areas

Numerical weather forecasting



Application areas

Mechanics



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ntre for Mathematical

Advanced visualization with VisNow platform

Visualization systems and paradigms



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Visualization software

Assumptions

- Computer software for visualization and visual analysis
- Translates data to images
- Enables data processing
- Provides user interaction

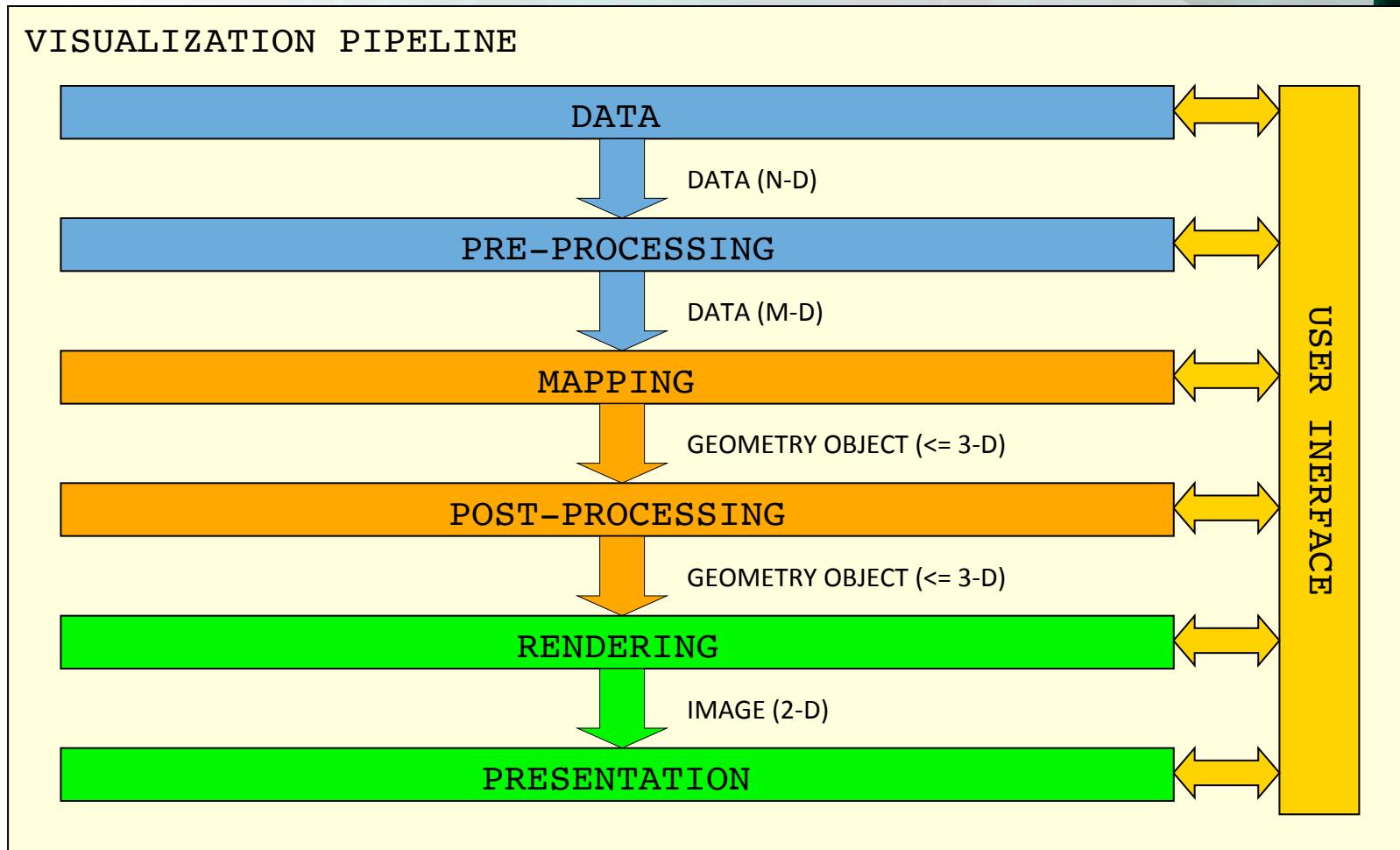
Base components

- Visualization pipeline
- Paradigm
- Data
- Functionality



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Pipeline



Paradigms

Visualization pipeline

- Basis for all visualization tools
- Different client-server distribution
- Two main paradigmes

Data centered paradigm

- Dataset is central
- Dataset is processed
- Dataset is presented
- Example software:
 - ParaView
 - ImageJ/Fiji

Data flow driven paradigm

- Processing network is central
- Network nodes = processing blocks
- Network connections = data flow
- Example software:
 - AVS/Express
 - MeVisLab
 - VisNow v1.x

- Novel dual paradigm in VisNow v2.0



Data for visualization

Geometry

- N-dimensional point coordinates ($N=1,2,3$)
 - Location in space
 - Naturally given or calculated on the basis of structure or values
 - Explicit or easily calculable

Structure

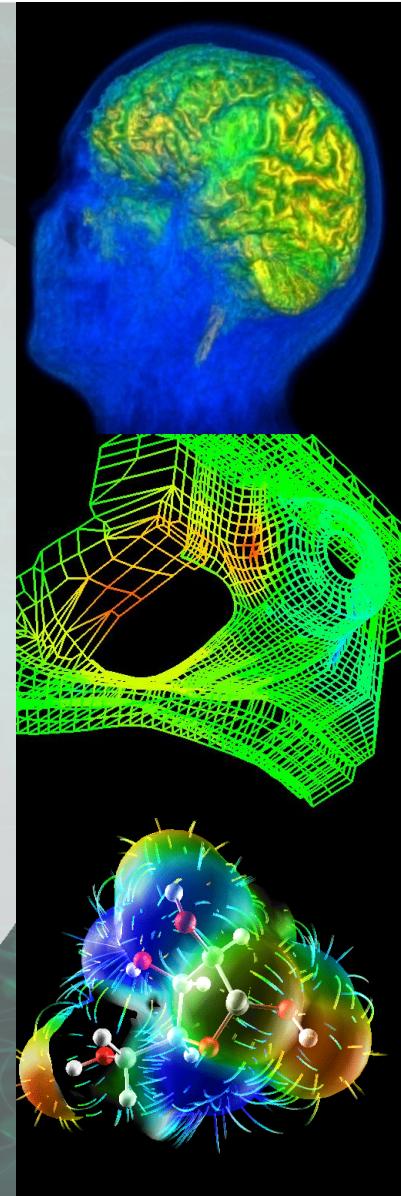
- Logical relations between points
- Usually imposes possible interpolations
- Problem dependant

Values

- Scalar, vector, tensor, symbolic, etc.

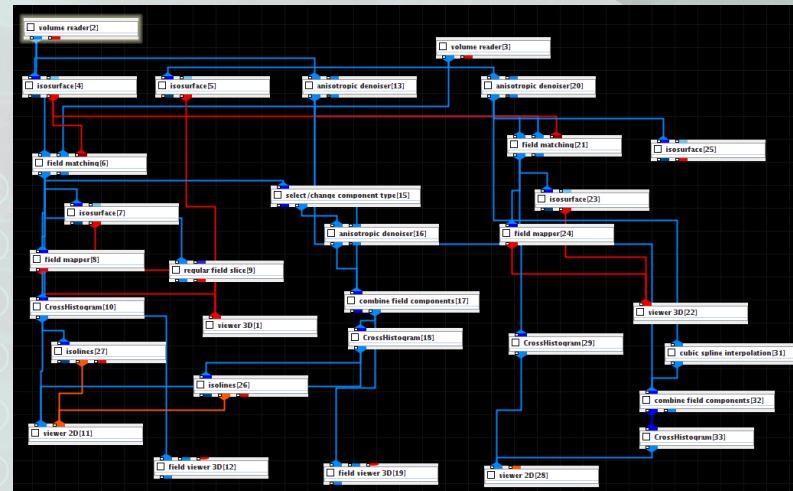
Generic data type

- **FIELD = geometry + structure + values**



Solution – modular systems

- Framework
 - Data flow steering
 - Synchronization
- Canonical data types
 - Generic type – data field
- Module template
 - Interface with framework
 - Calculations core
 - Parameters
 - User interface
- Language and UI for network construction
- Presentation layer (viewers)
- Interaction schemas



VisNow – motivation and design principles

High-level modules

- Complex **modules with broad functionality** – e.g. flow visualization
- Contrary to majority of visualization systems with fine-grained technical modules
- Ease of network creation and **more legible network**

Read-and-watch

- **Instant automatic visualization** of data fields on each processing level
- Visual representation incorporated in modules
- Each mapping controlled independently

Reasonable default parameters

- Automated intelligent preparation of **default parameters**
- Supports instant visualization



VisNow – functionality

Generic representation of data („field”) based on JSciC library:

- Geometry + structure + multivariate scalar or vector data components
- Time dependency
- Physical units support
- Regular and Irregular (unstructured) field sub-types
- Up to 2^{63} data elements (on regular grids)

Data access:

- VNF – VisNow field (own format based on JSciC library),
- VTK, AVS fields, UCD, images, DICOM, OBJ, STL, EnSight, CSV, ANSYS Fluent, GADGET-2, ...
- Generic metadata format (VNF header) to binary or ASCII data files

Processing:

- Remeshing, differential operations, transforms (e.g. FFT, Radon), interpolation, denoising
- Data arithmetic with physical units support
- Segmentation, skeletonization

VisNow – functionality

Mapping:

- Colormapping, transparency mapping, texturing
- Slicing, volume rendering, isosurfaces, isolines, glyph representations, flow visualization (streamlines), 2D/3D graphs
- Correlation analysis, parallel coordinates

Presentation:

- 2D/3D viewer, 3D regular field viewer (orthoslices + 3D), engineering viewer

Output:

- Various data formats for field writing
- Images and animations from viewer modules

Plugins:

- Bio-Formats reader (~140 microscopy image formats)
- ImageJ/Fiji integration (work in progress)
- Experimental
- Extensible – write your own plugin



VisNow – roadmap

Current work – VisNow v1.3

- v1.3-RC1 available now (March 2018)
- v1.3 available by May 2018

Side work – libraries

- JLargeArrays library
- JSciC library

Future work – VisNow v2.0

- New GUI
- New data flow engine
- Batch processing
- Parallel and distributed execution
- Client-server mode



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VisNow v1.3 – what's new?

- More support for large datasets
- Physical units support (incl. unit-aware calculations)
- Automated data-parallelism for component calculations
- Various image formats for reading and writing
- **Clipboard** module
- New VNF binary serialization data format
- Constant arrays support in components
- **Spatial crop** module
- **Line probe** module
- New 1D graphs
- Integrated VTK data reading
- **Stationary flow visualization** module
- Bugfixes



VisNow availability

Open source project

- Open access to Java source code
-  GitLab: <https://gitlab.com/ICM-VisLab/VisNow>
- Cooperation possible

Platform independent

- Java >= 1.7
- Windows, Linux, Mac OS X



Current version

- v1.3-RC1

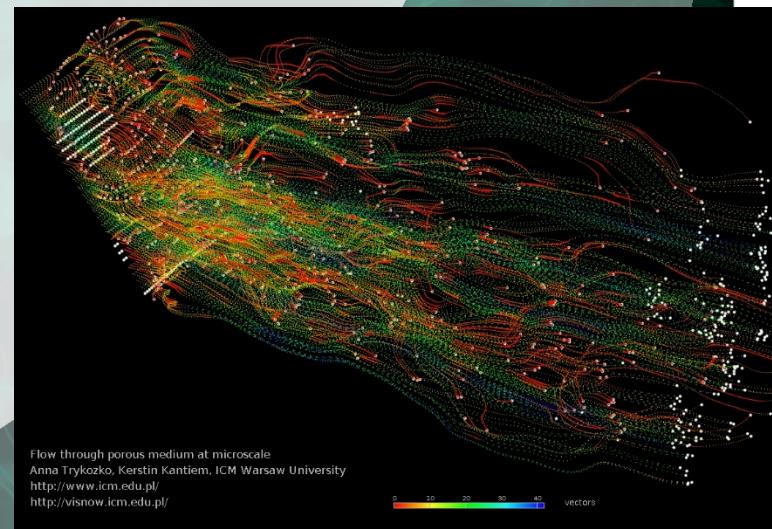
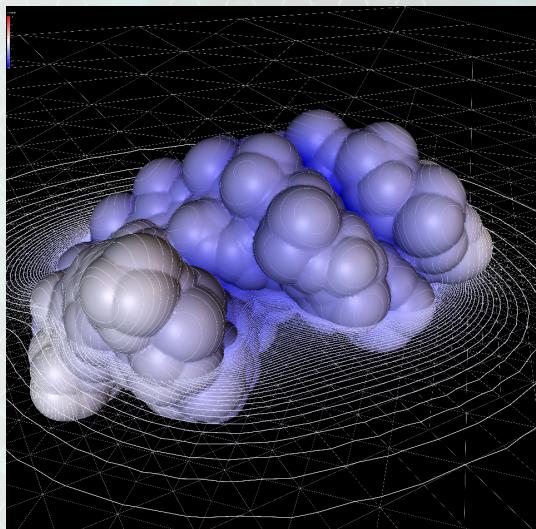
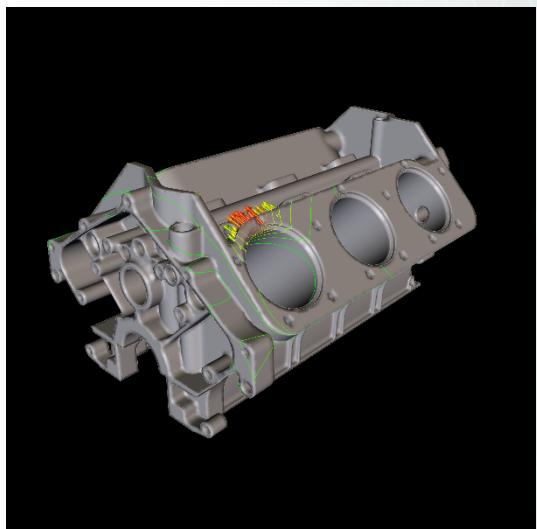
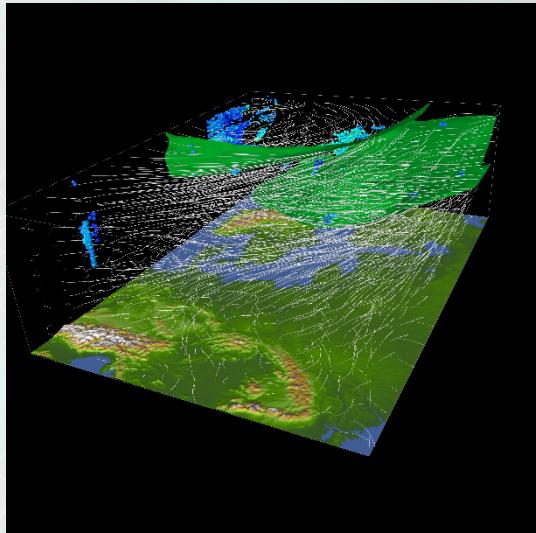
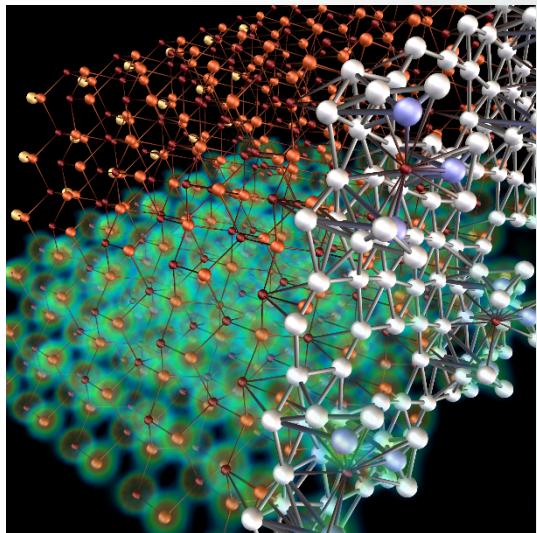
<http://visnow.icm.edu.pl>



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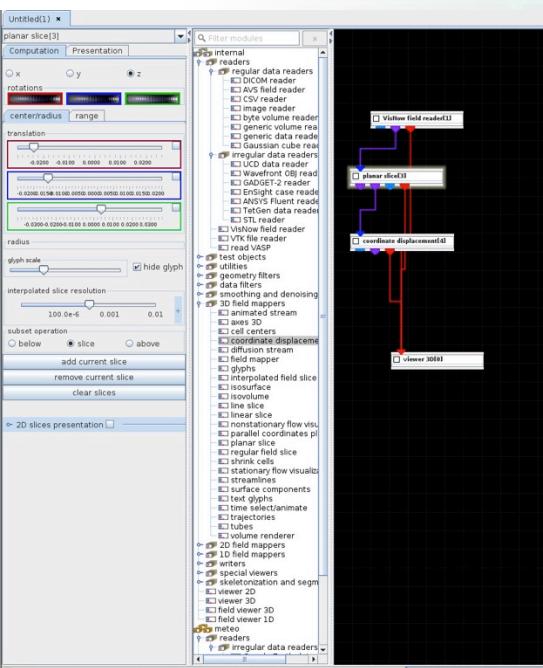
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Flow through porous medium at microscale
Anna Trykozko, Kerstin Kantiem, ICM Warsaw University
<http://www.icm.edu.pl/>
<http://visnow.icm.edu.pl/>



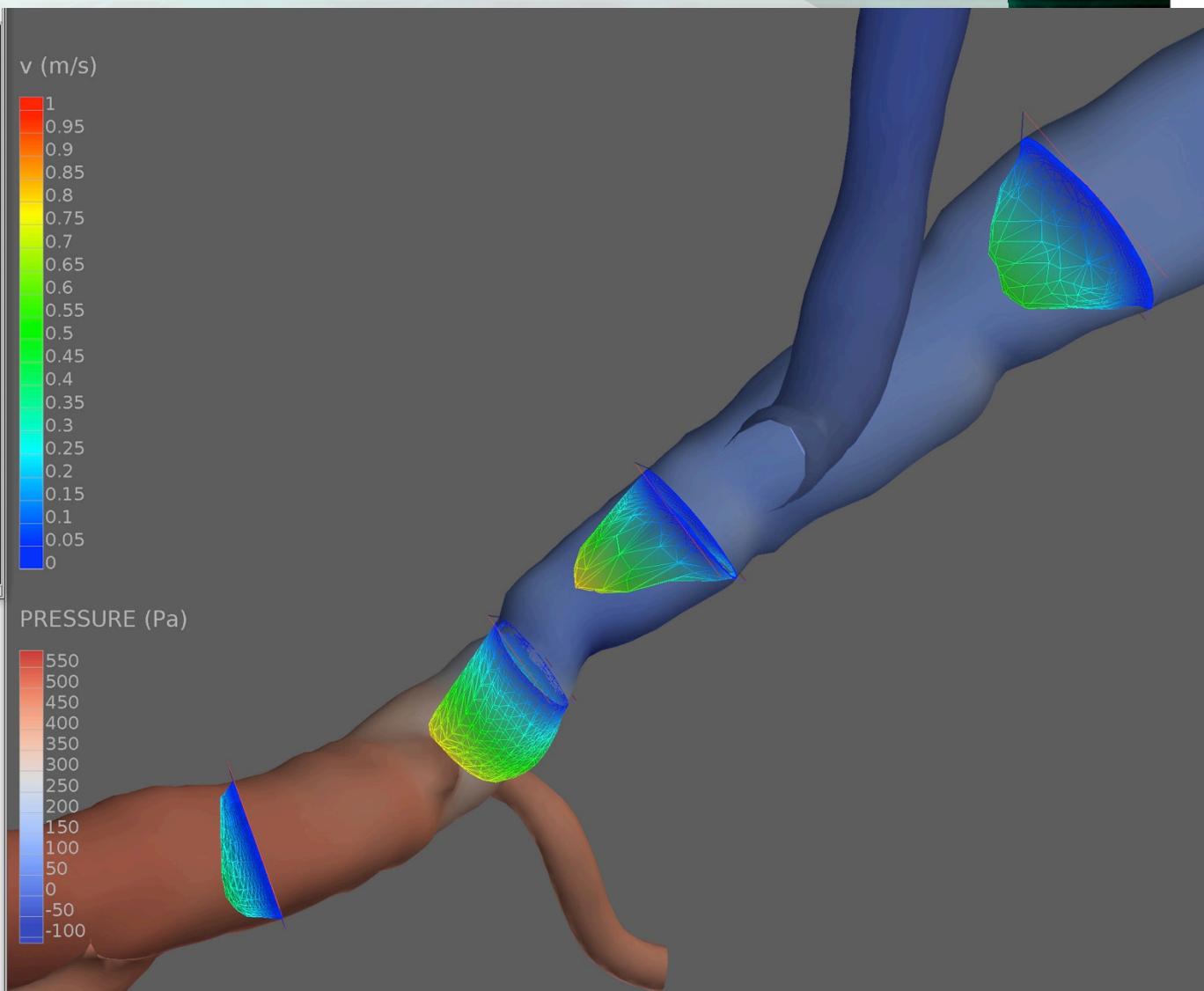
VISNOW



Fragment of coronary artery
computational flow model visualization:

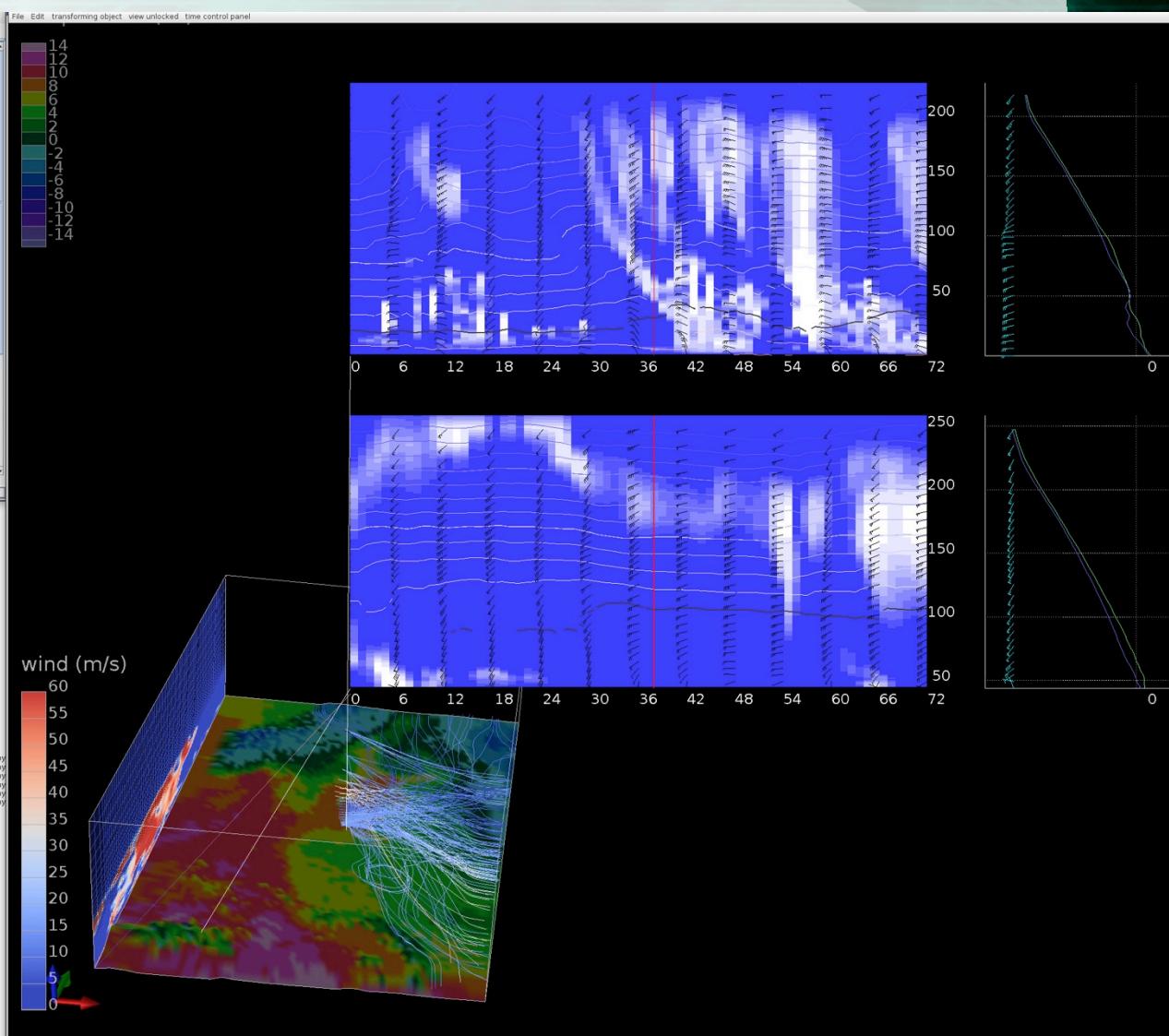
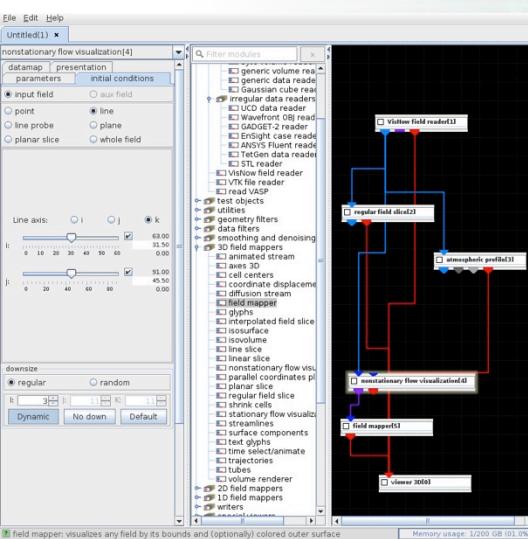
Internal view of artery walls colored by pressure,
Velocity profiles at selected slices colored by flow velocity
Only 4 modules in the network
- the "planar slice" module has built-in capability of accumulation
of multiple slices,
- the 'coordinate displacement module creates profiles as properly
oriented 3D graphs

PRESSURE (Pa)





VISNOW



3D+time data from a numerical weather forecast:

a vertical slice at the boundary colored by cloud cover at model levels;

the ground surface is colored by temperature (note discretized colormap)

vertical profiles show clouds, isotherm and wind barbs (the model time as the horizontal axis, model height ASL in hectometers as the vertical axis);

wind trajectories starting from selected points at a vertical line probe are computed with an experimental nonstationary flow visualization module.

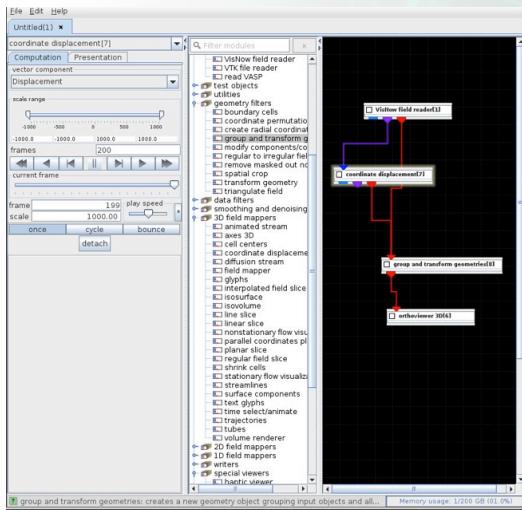
Multicomponent, time dependent data are read in with the following .vnf file:

```
#visflow regular field
field "forecast_europe_small_3d_model_levels_2015111500", dims 43 91 70, coords
component bulk_cloud_fraction float, unit "%", min 0.0, max 1.0, phys_min 0.0, phy
component pressure float, unit "hPa", min 0, max 105000.0, phys_min 0.0, phy
component temperature float, unit "C", min -53.16, max 53.16, phys_min -0.0, phy
component visibility float, unit "km", min 0.0, max 100000.0, phys_min 0.0, phy
component wbt_bulb_temp float, unit "C", min 193.16, max 293.16, phys_min -80.0, phy
component lambda float, unit "m", min 0.0, max 60.0, phys_min 0.0, phy
component phi float, unit "N"
component lambda_model float, unit "E"
component phi_model float, unit "N"
component height float, unit "m"
file "europe_small_3d_model_levels_stretched.vnd" binary
timestep 0.0
coords
bulk_cloud_fraction
pressure
lambda
phi
lambda_model
phi_model
height
end
timestep 1.0 1.0
bulk_cloud_fraction
pressure
temperature
visibility
wbt_bulb_temp
wind
repeat 71
```

Note automatic conversion of units for the first 6 components



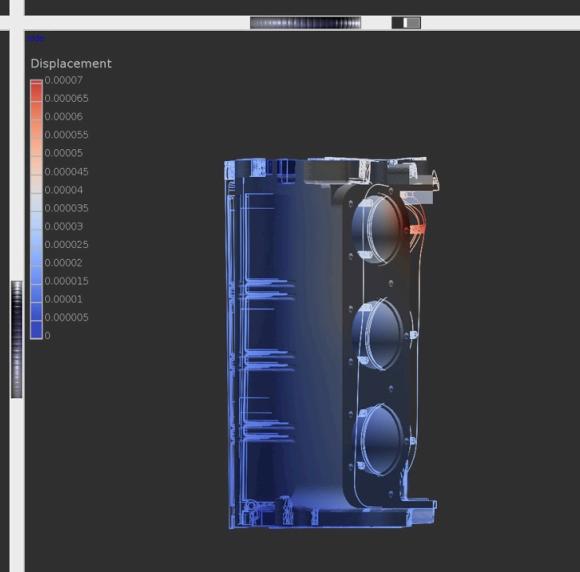
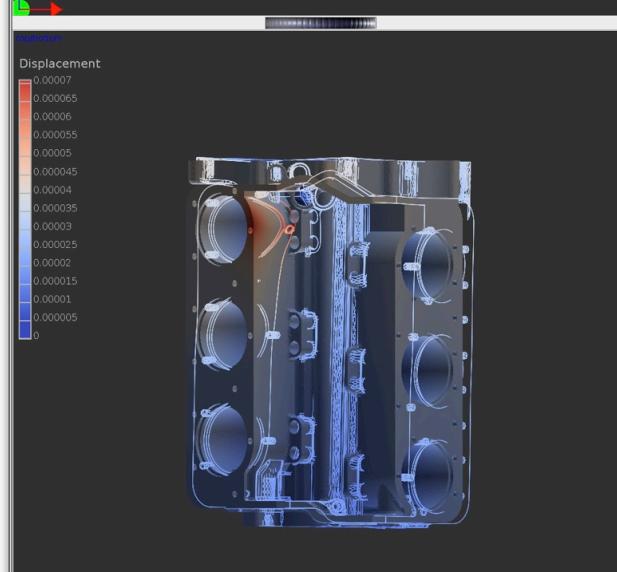
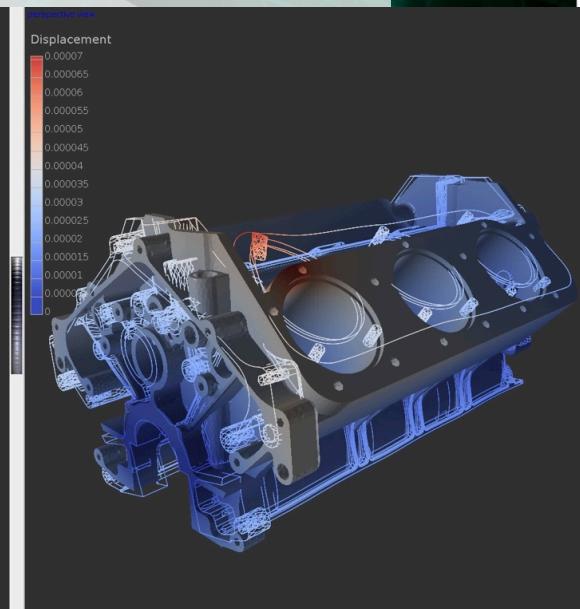
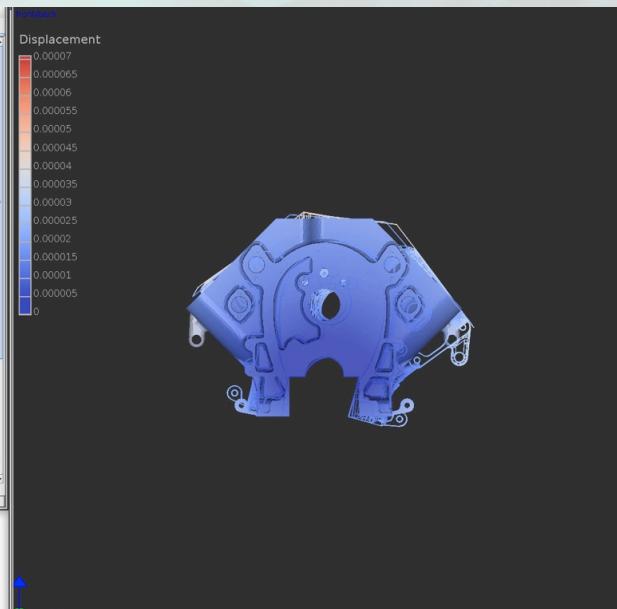
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Displacement of the engine frame under test point load

Original (not displaced) field shown as flat shaded surfaces

Displacement multiplied by 1000 shown as lines with the feature angle exceeding 10 degrees



Advanced visualization with VisNow platform

Data structures



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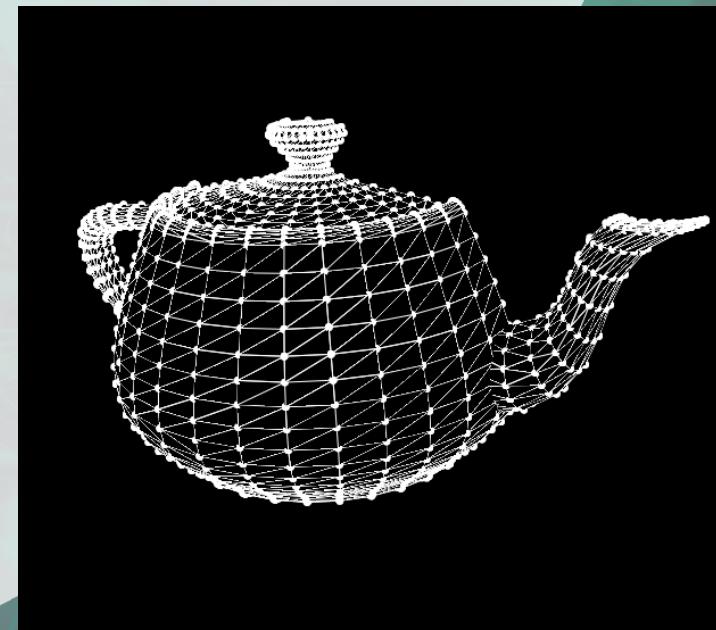
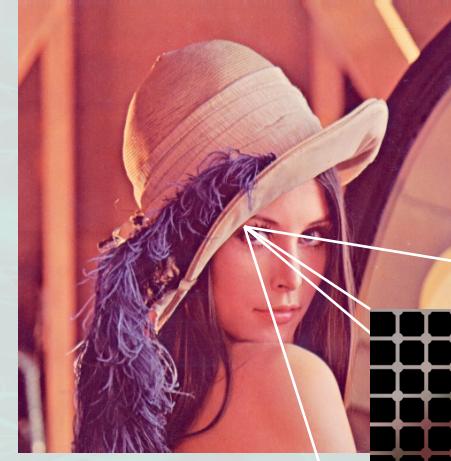


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VisNow fields

Regular Field

- Structured grid of neighbouring nodes
- 1/2/3-dimensional grid
- Values defined on nodes
- Simple example: image data



Irregular Field

- Unstructured nodes
- Cells defined over nodes
- Cell sets defined over cells form a grid
- 0/1/2/3-dimensional cells
- Values defined on nodes or cells
- Simple example: scanned 3D surface

Regular Fields



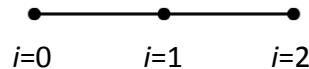
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Regular Field structure

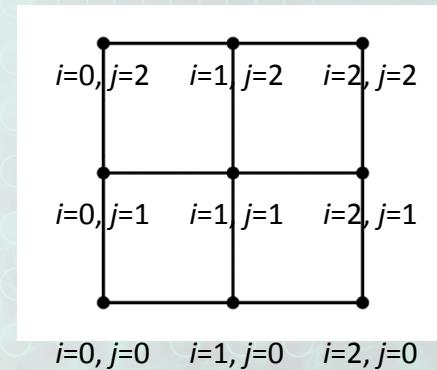
Structure

- Array based
- Indexed as i, j, k

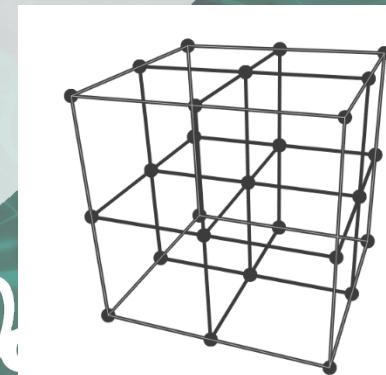
1D



2D



3D

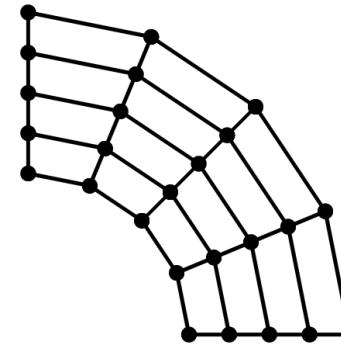


Mathematical

Regular Field geometry

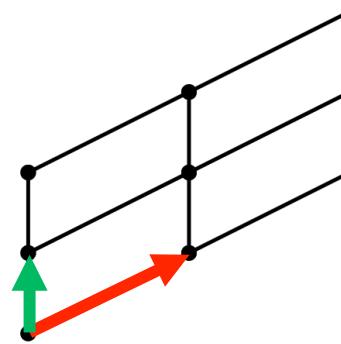
Explicit/curvilinear/arbitrary

- Geometry described explicitly by x, y, z coordinates for each node



Affine/linear

- Geometry described implicitly by base
- N base vectors for N -dimensional field
- Node coordinates calculated from position in structure (i, j, k) , basis vectors and origin point



Irregular Fields



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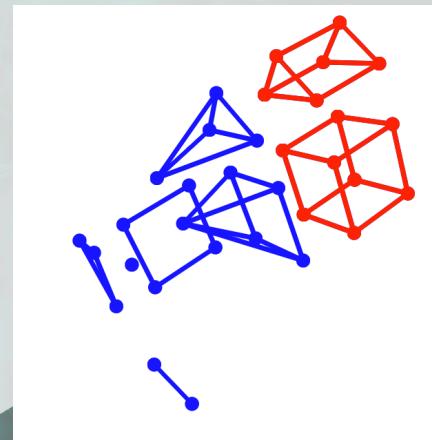
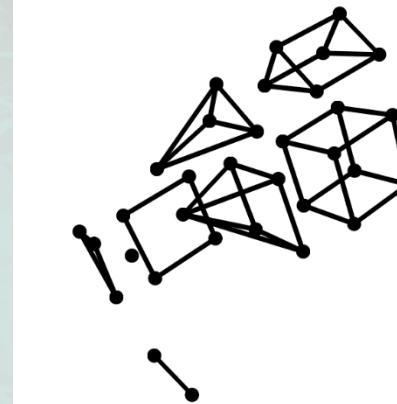
Irregular Field structure and geometry

Explicit geometry

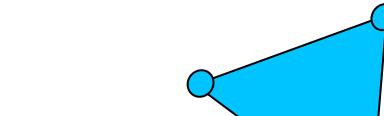
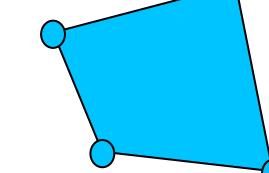
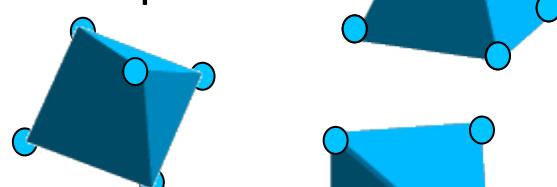
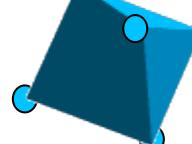
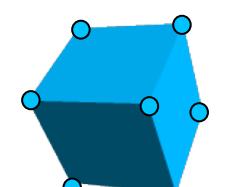
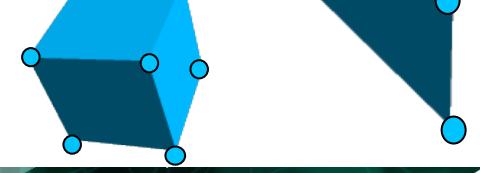
- Geometry described explicitly by x,y,z coordinates for each node

Structure

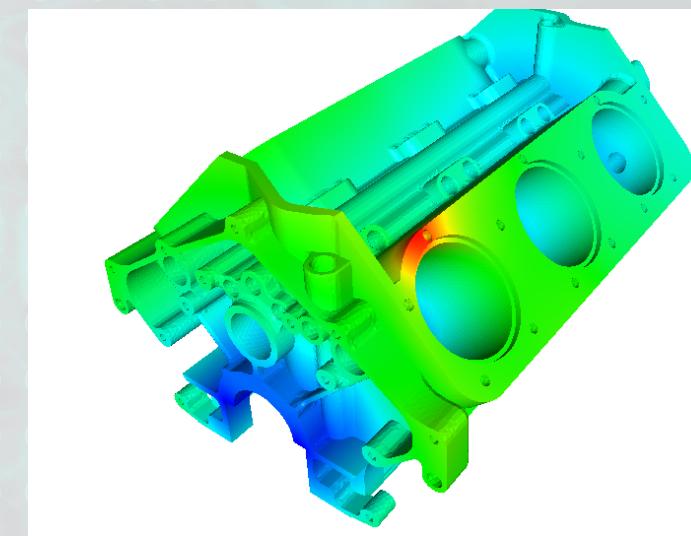
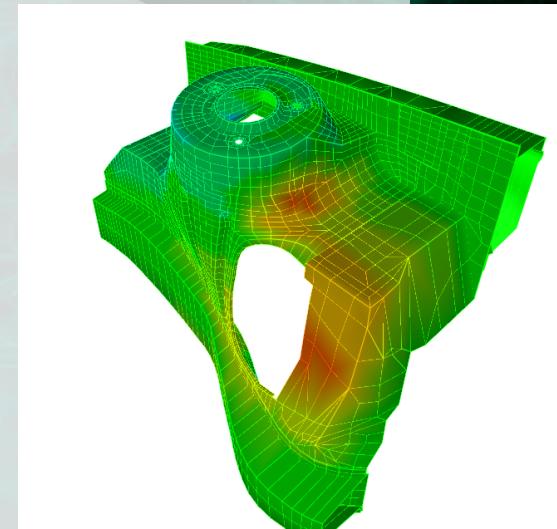
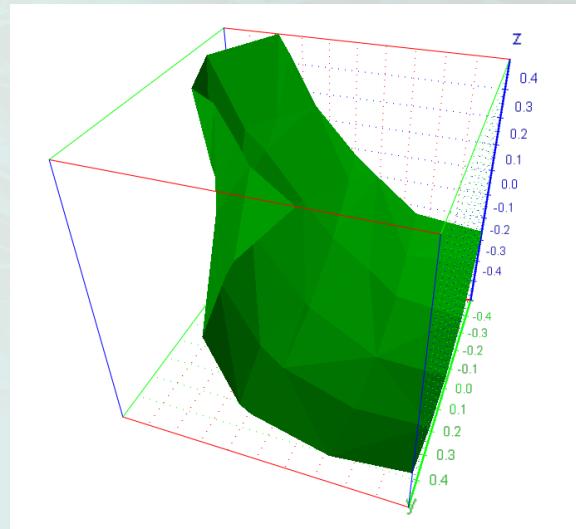
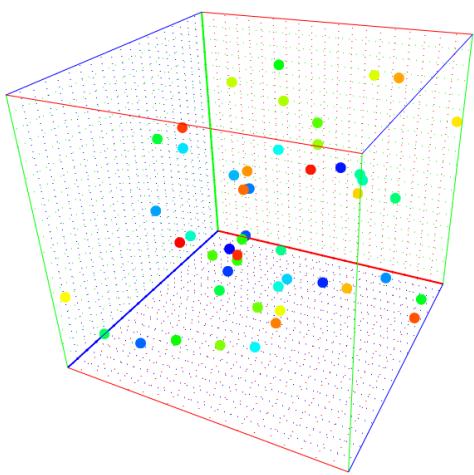
- Nodes indexed as i
- Cell
 - 0D/1D/2D/3D
 - Given by list of vertices/node indices
 - Limited to declared types
- Cellset
 - Group of cells of any types
 - Additionally group of boundary cells
- Irregular Field
 - Can contain any number of cellsets
 - Cellsets can overlap



Irregular Field cells

0D Cells	1D Cells	2D Cells	3D Cells	Vertices	Example
Point				1	
Segment				2	
Triangle				3	
Quadrilateral				4	
Terahedron				4	
Pyramid				5	
Prism				6	
Hexahedron				8	

Irregular Field examples



Values



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Regular Field values

Node data

- Value assigned to node
- Interpolated on walls and edges
- Global for field

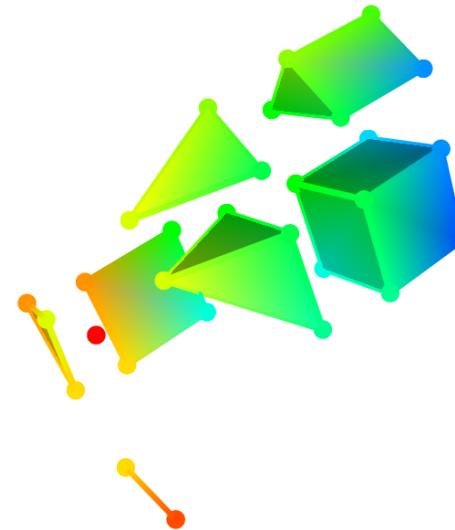


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Irregular Field values

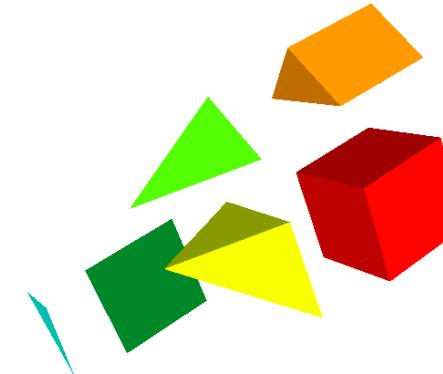
Node data

- Value assigned to node
- Interpolated on walls and edges
- Global for field



Cell data

- Value assigned to whole cell
- Local for cellset



Data components

- Each field or cellset can have several values assigned
- Consistent piece of information, declared over all nodes (node data) or all cells in cellset (cell data) is called data component
- E.g. numerical weather forecast simulation calculates several values in each grid node: pressure, temperature, wind direction and velocity, etc. Each such measurement is stored as a single data component.
- Values stored in components can be numbers, texts or other objects (e.g. atom) and can be scalar or vector

Component

- **Name** – used for component identification and description
- **Type** – defines data type of this component
- **Vector length** – 1 for scalar data, >1 for vector data
- **Range** – range of numerical values
- **Physical range** – range of linearly mapped physical values
- **Unit** – unit for physical range

Data types

Byte

- Unsigned single byte
- Values 0 - 255

Short

- Signed short (two bytes)
- Values -32768 - 32768

Int

- Signed integer (four bytes)
- Values $-2^{31}-1 - 2^{31}-1$

Float

- Single precision floating numbers (four bytes)

Double

- Double precision floating numbers (eight bytes)

Logic

- Binary true/false

String

- Text data

Complex

- Complex numbers
- Single precision (float)

Object

- Any Java object
- Requires additional support in modules

Other field parameters

Mask

- Binary information on node validity
- Invalid nodes are not displayed

Time

- Time dependent geometry
- Time dependent data
- Time dependent mask

Advanced visualization with VisNow platform

User interface

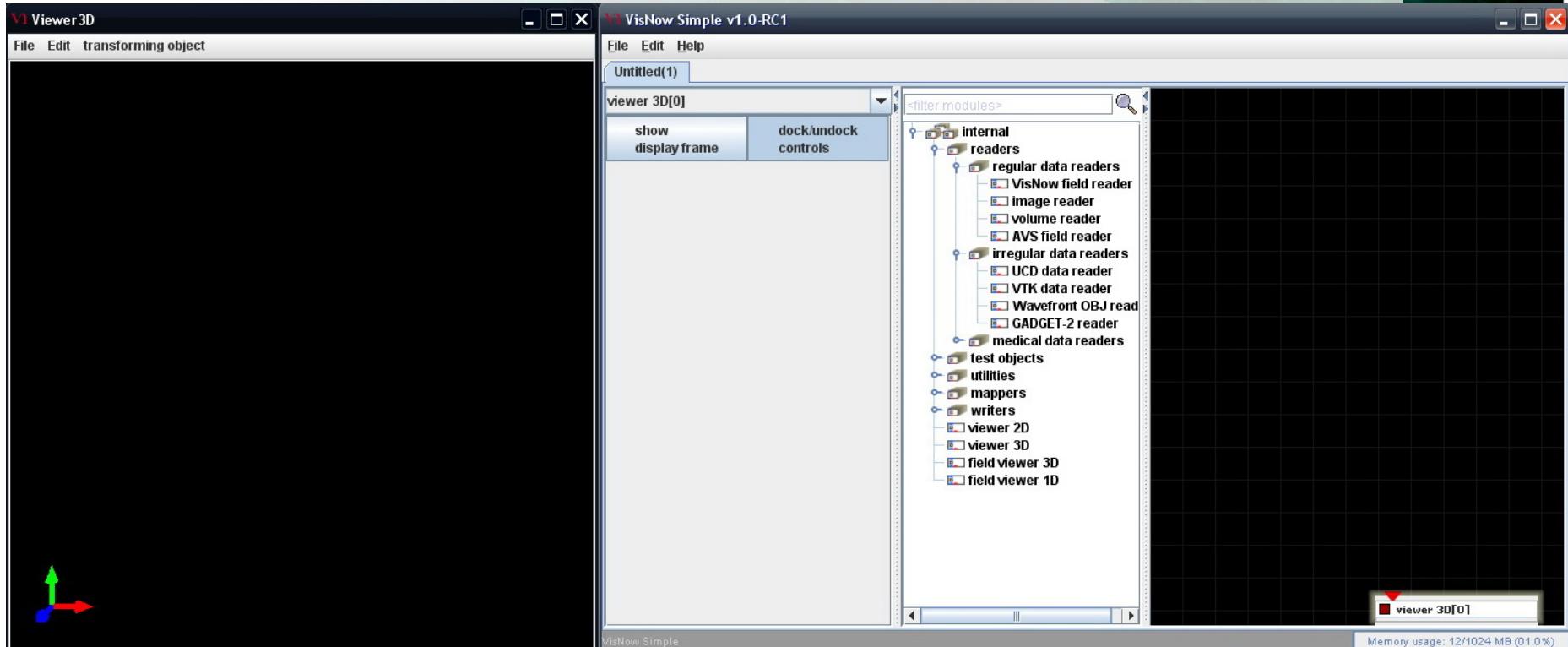


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[Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.](https://creativecommons.org/licenses/by-nc-nd/4.0/)



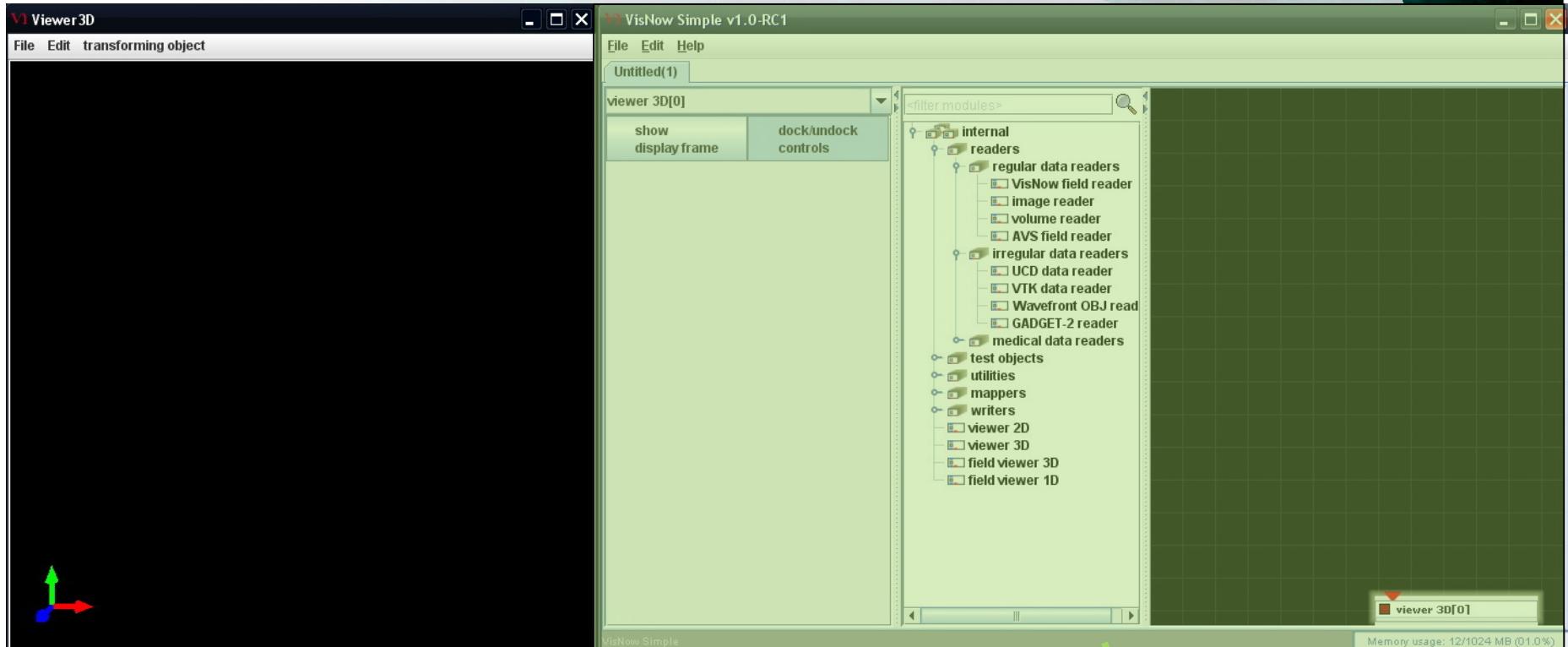
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VisNow – user interface



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VisNow – user interface

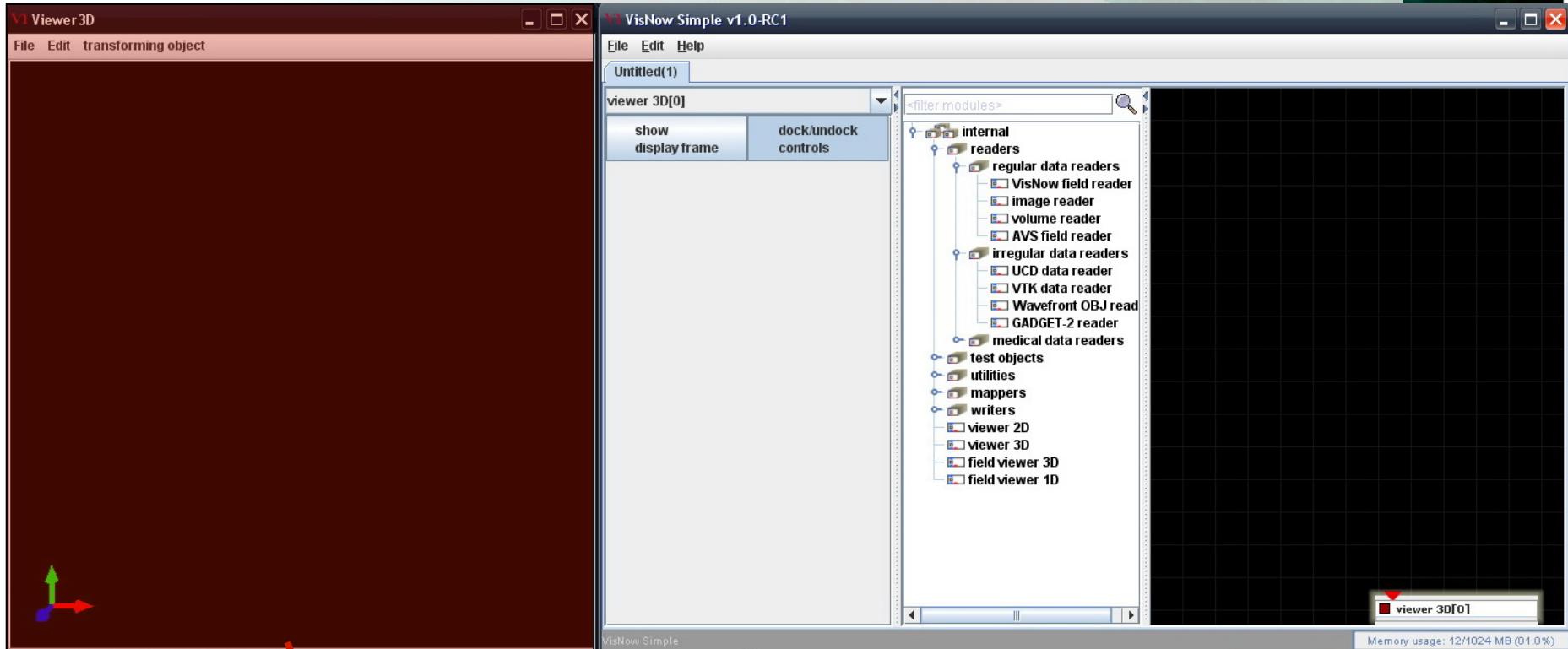


Main window



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VisNow – user interface

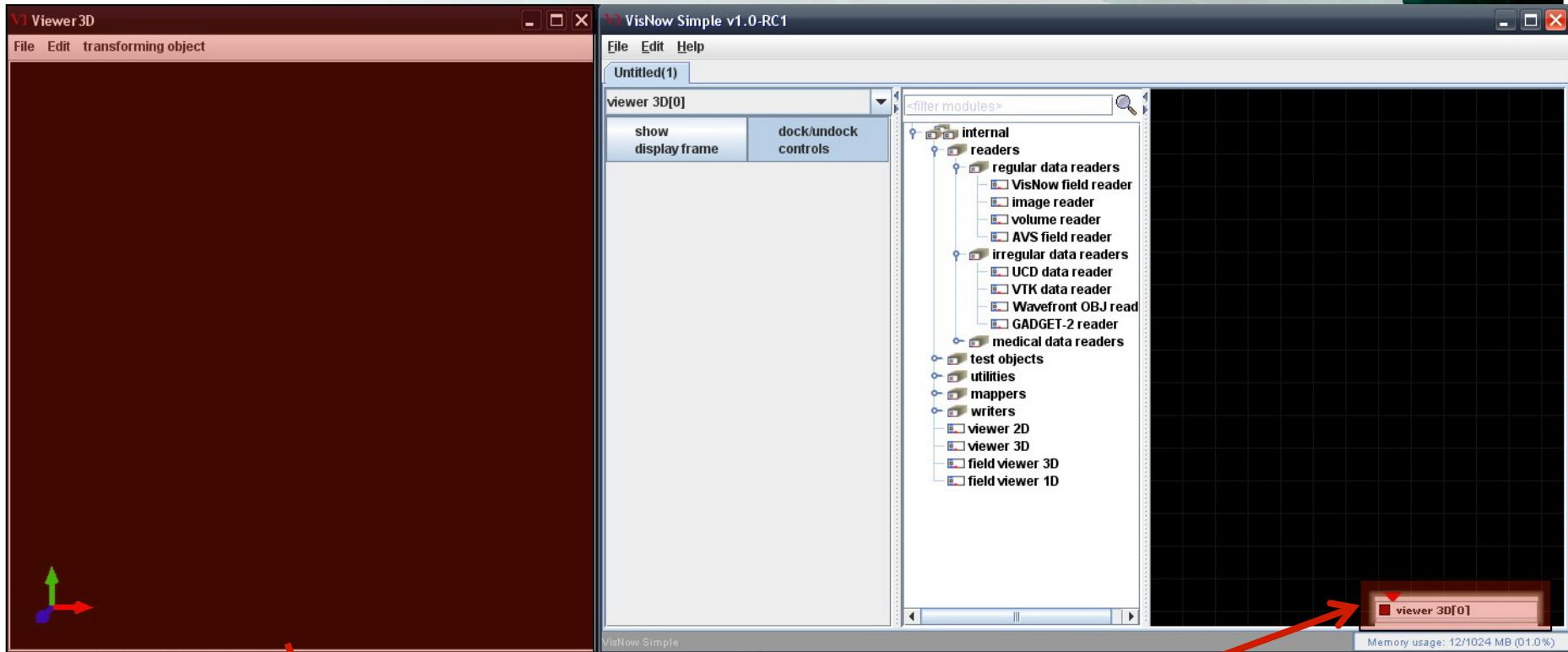


Graphical window



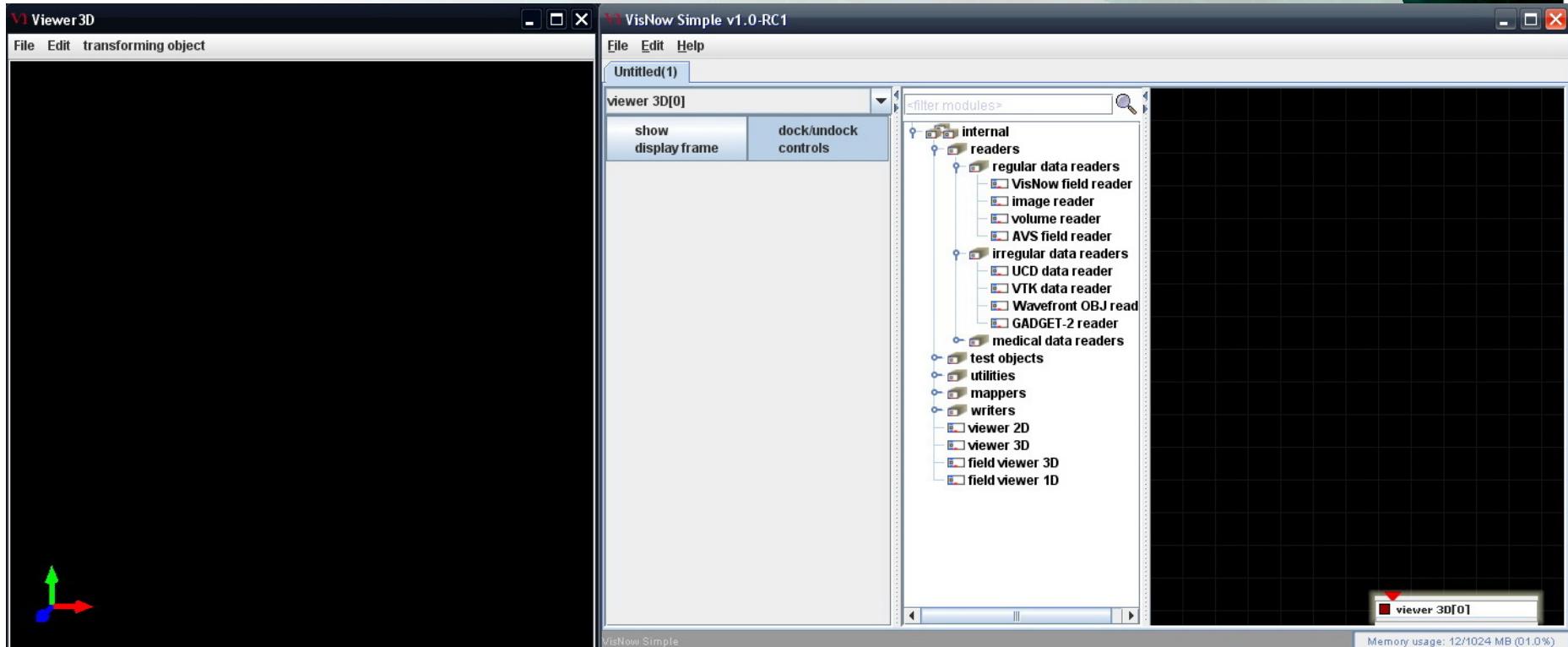
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VisNow – user interface



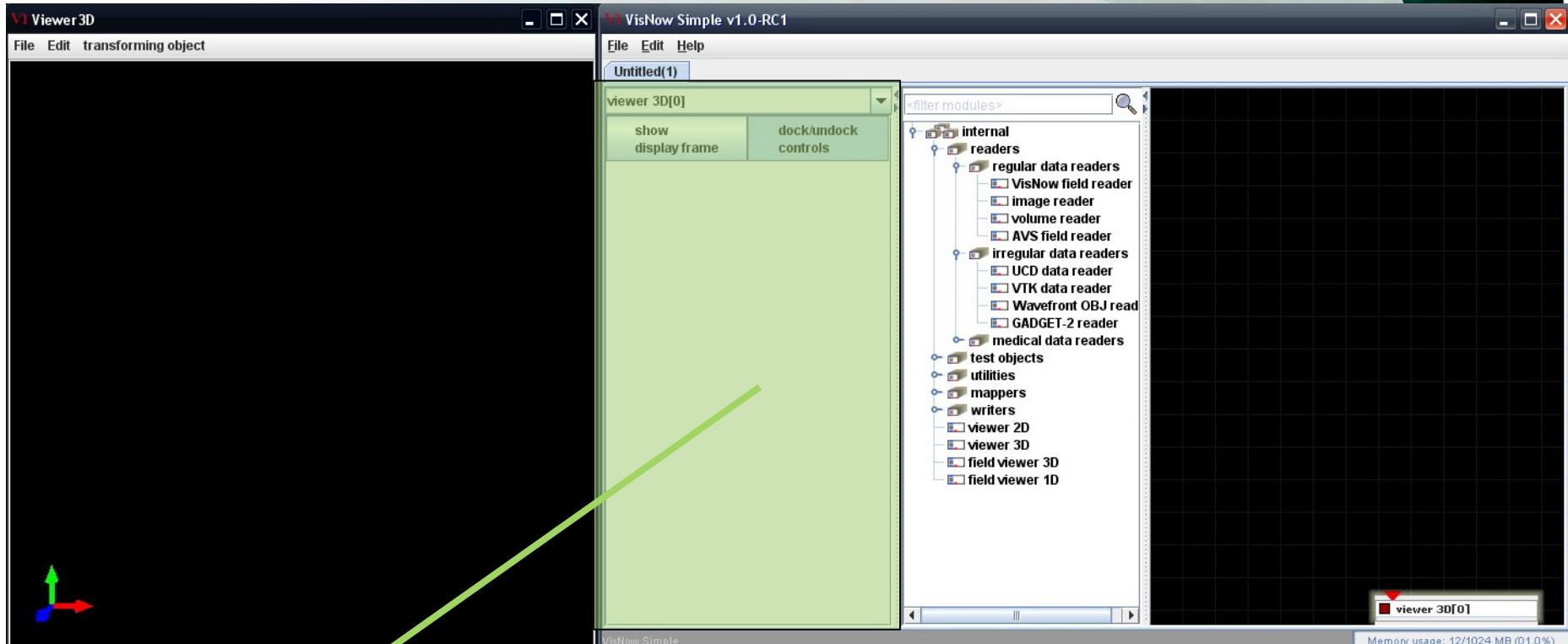
Graphical window
related to **viewer 3D**
module

VisNow – user interface



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VisNow – user interface

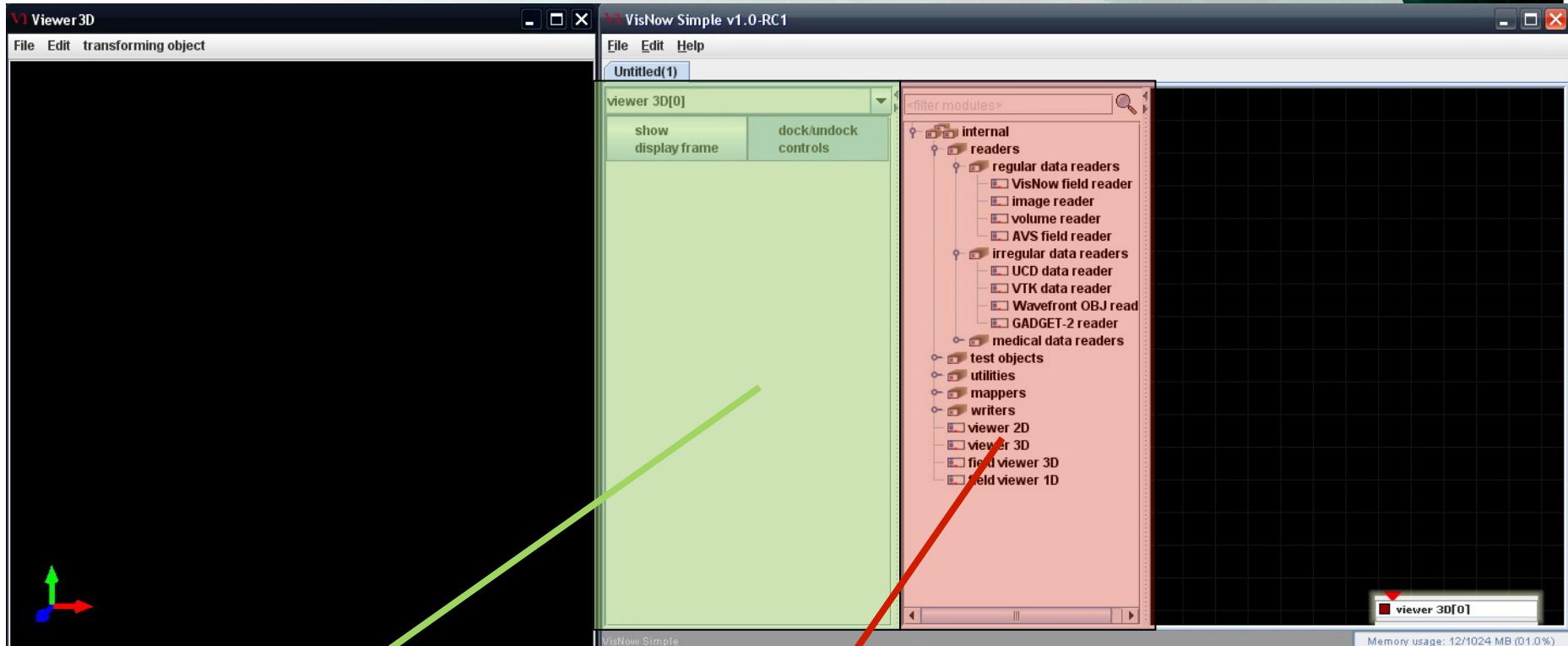


User interface of a
module



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VisNow – user interface



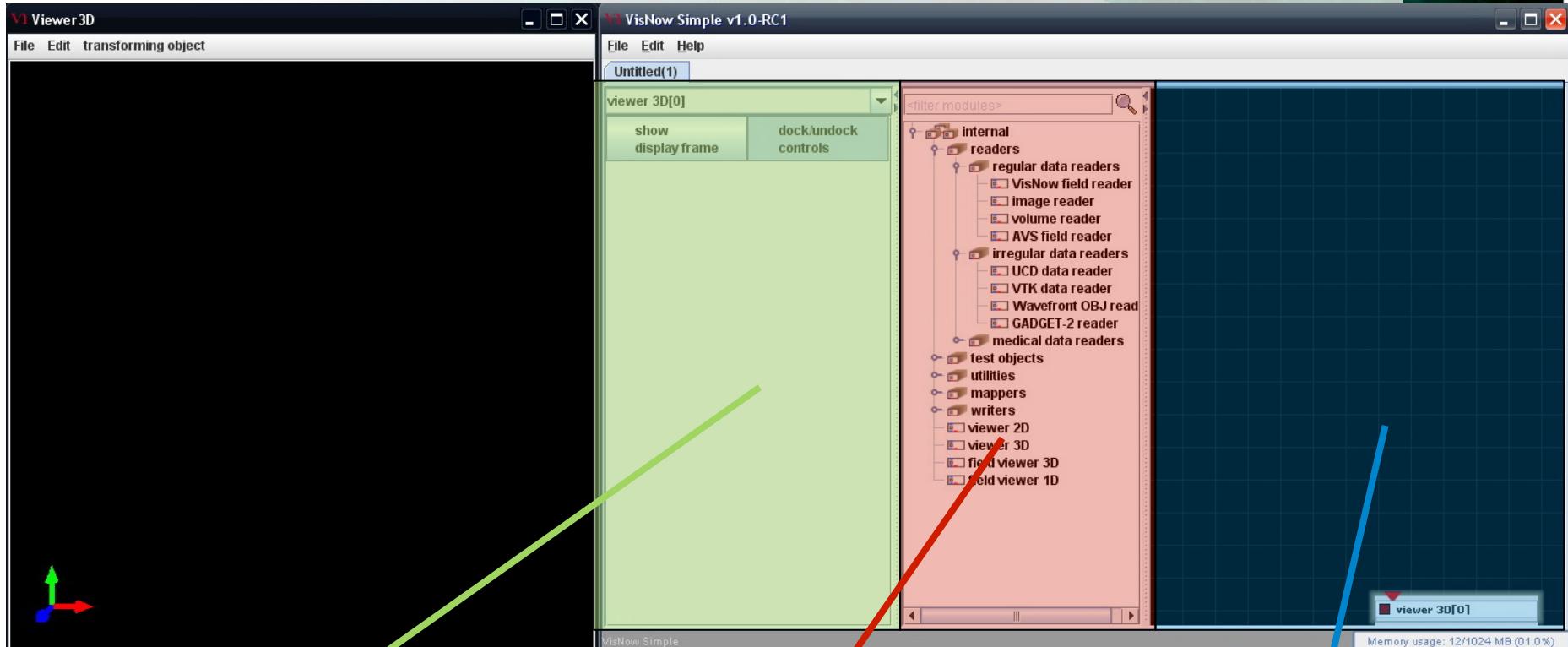
User interface of a
module

Modules library



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VisNow – user interface

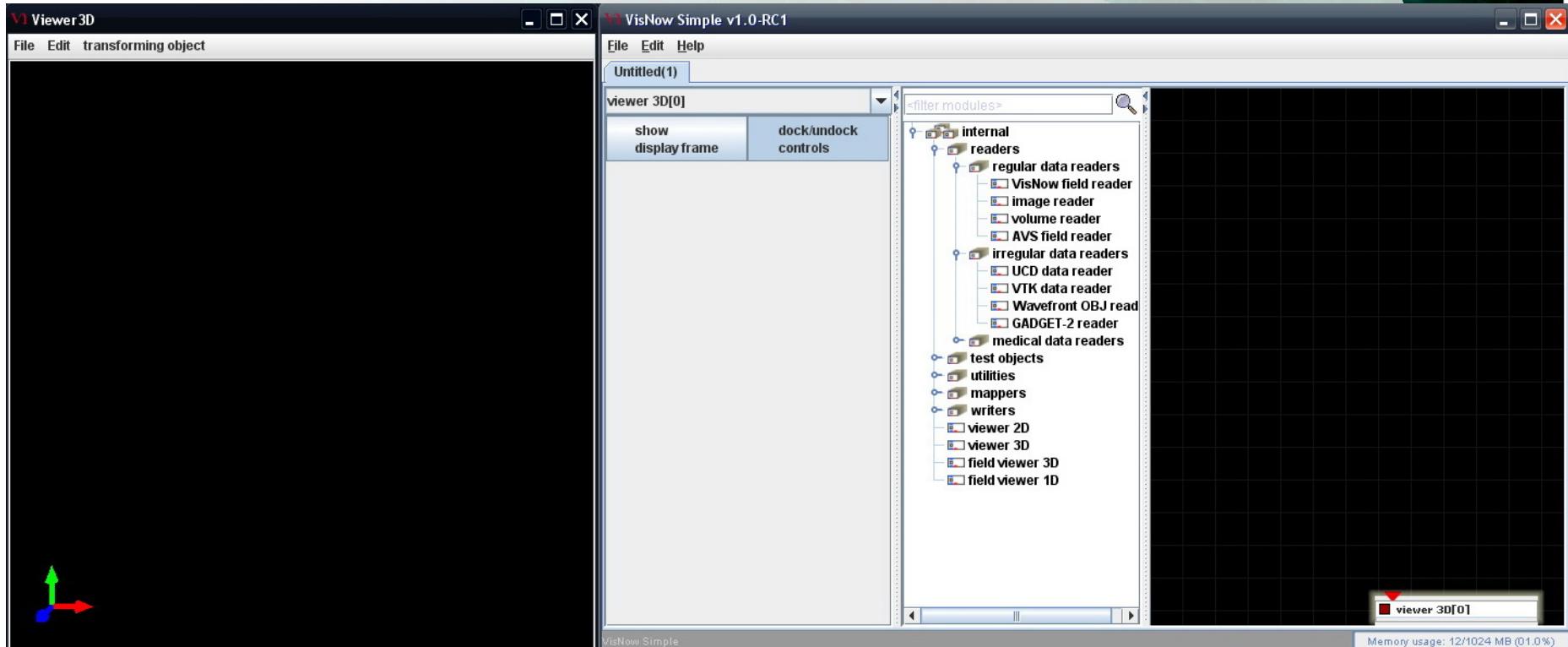


User interface of a
module

Modules library

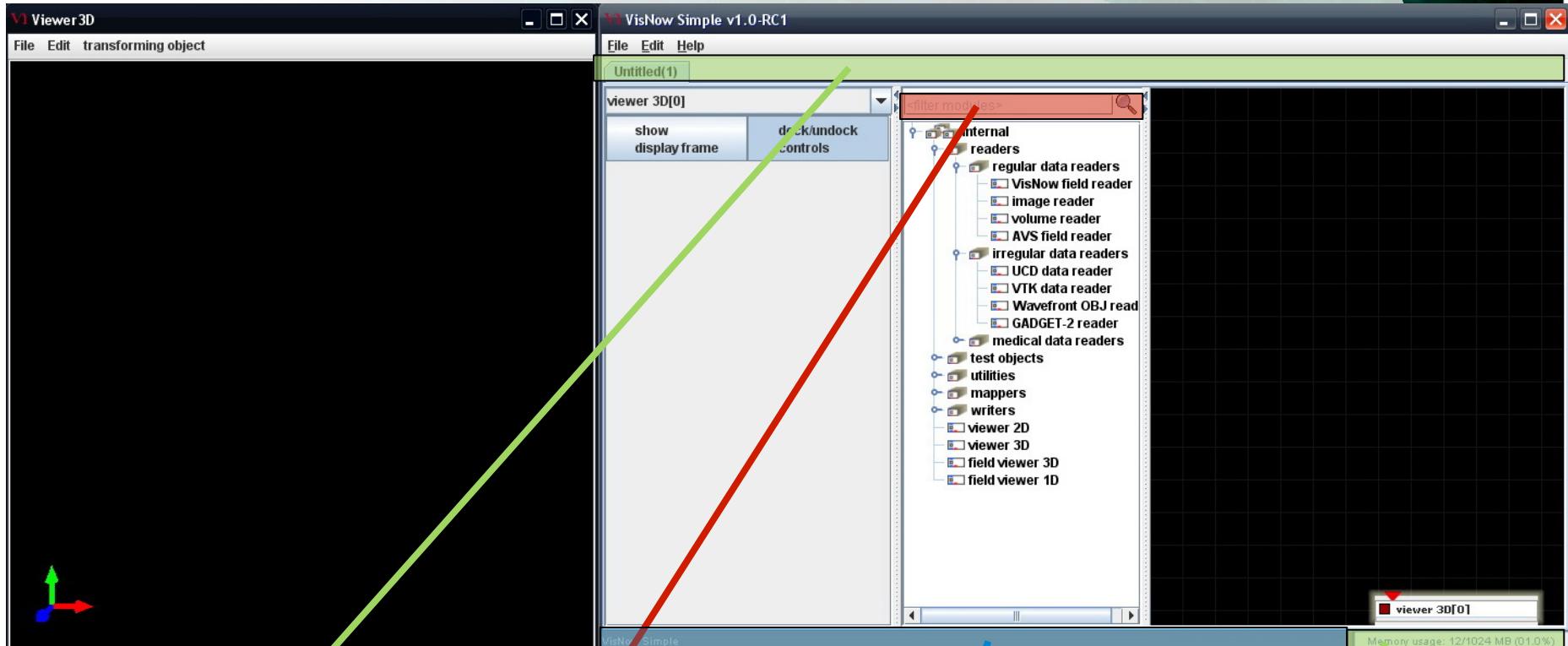
Workspace

VisNow – user interface



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VisNow – user interface



Application tabs

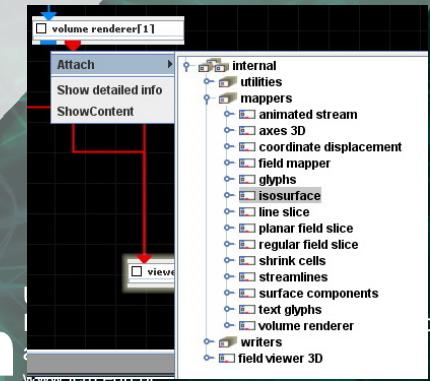
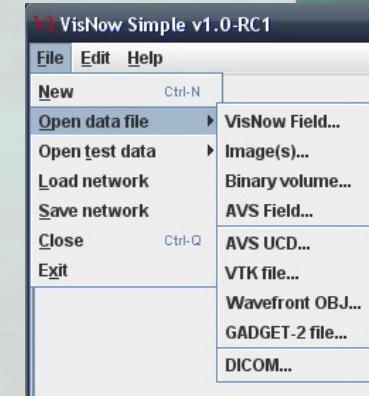
Module search engine

Message bar

Memory monitor

VisNow – user interface

- How to create a module?
 - Drag-and-drop from modules library tree to the workspace
- Main menu
 - ‘File – Open data file’
 - ‘File – Open test data’
- Right click on workspace
 - menu ‘Open data file’
 - menu ‘Open test file’
 - menu ‘New module’
- Output port wizard
 - menu ‘Attach’



VisNow – user interface

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- Module components?

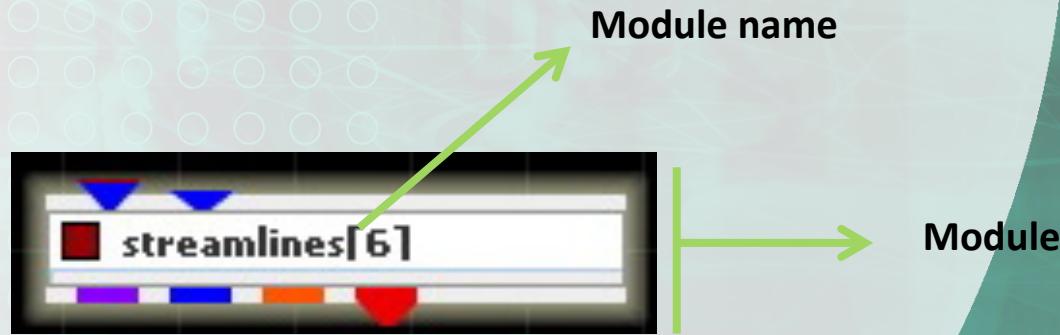


Module

VisNow – user interface

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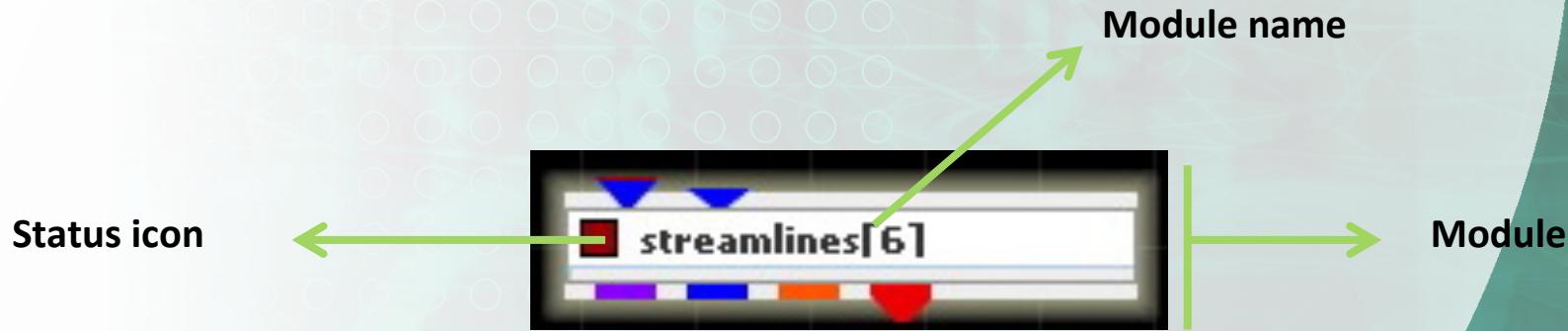
- **Module components?**



VisNow – user interface

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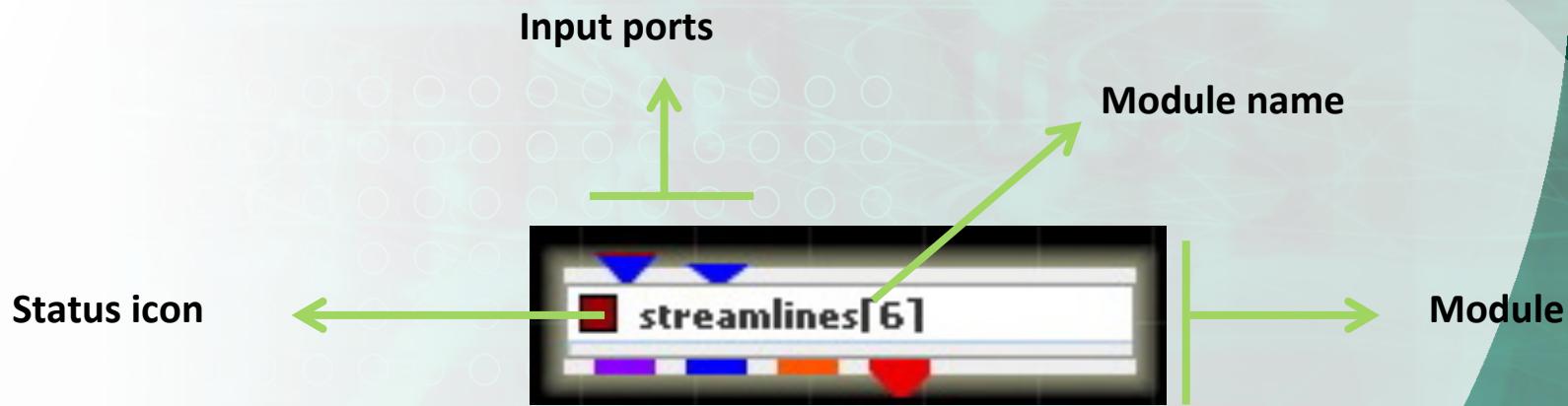
- **Module components?**



VisNow – user interface

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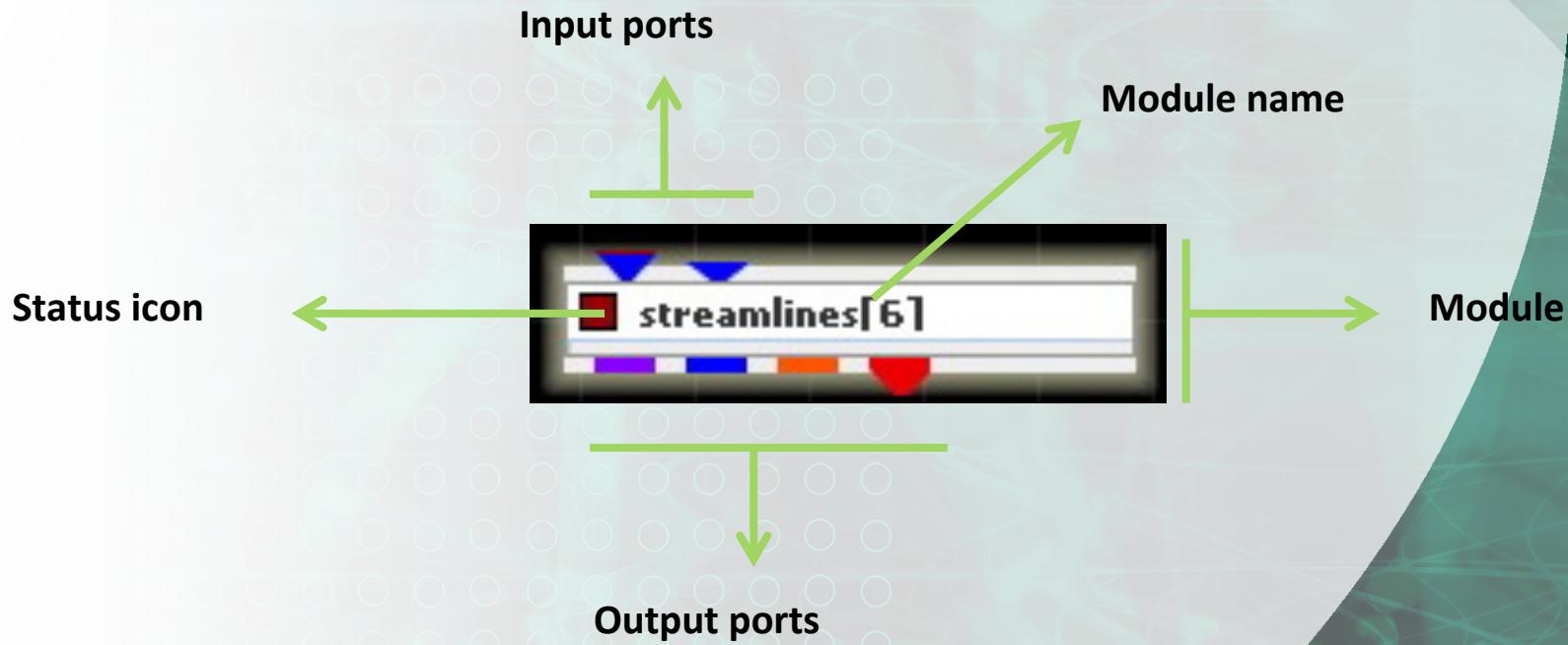
- **Module components?**



VisNow – user interface

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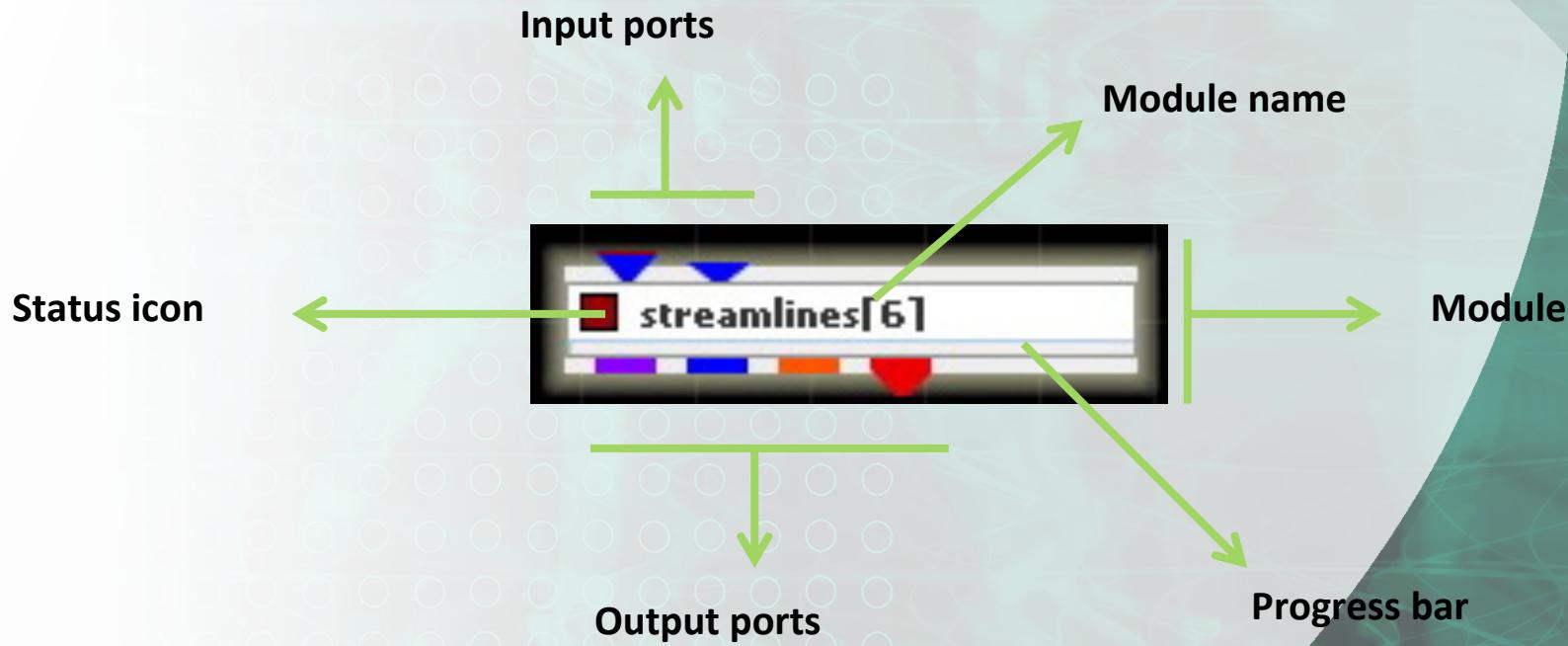
- **Module components?**



VisNow – user interface

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- **Module components?**



VisNow – user interface

- **Module status**

- Status icon colour



- Not connected (on required ports)



- No data (on required ports)



- Wrong data



- Correct

- Other

- Progress bar



VisNow – user interface

- Port representations?

- Port colour = data type

- Field

- Regular Field

- Irregular Field

- Geometry object

- Input port shape



- Required port



- Optional port

- Output port shape



- No data



- Data ready

VisNow – user interface

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- **How to connect modules?**

- **Connection mouse dragging**

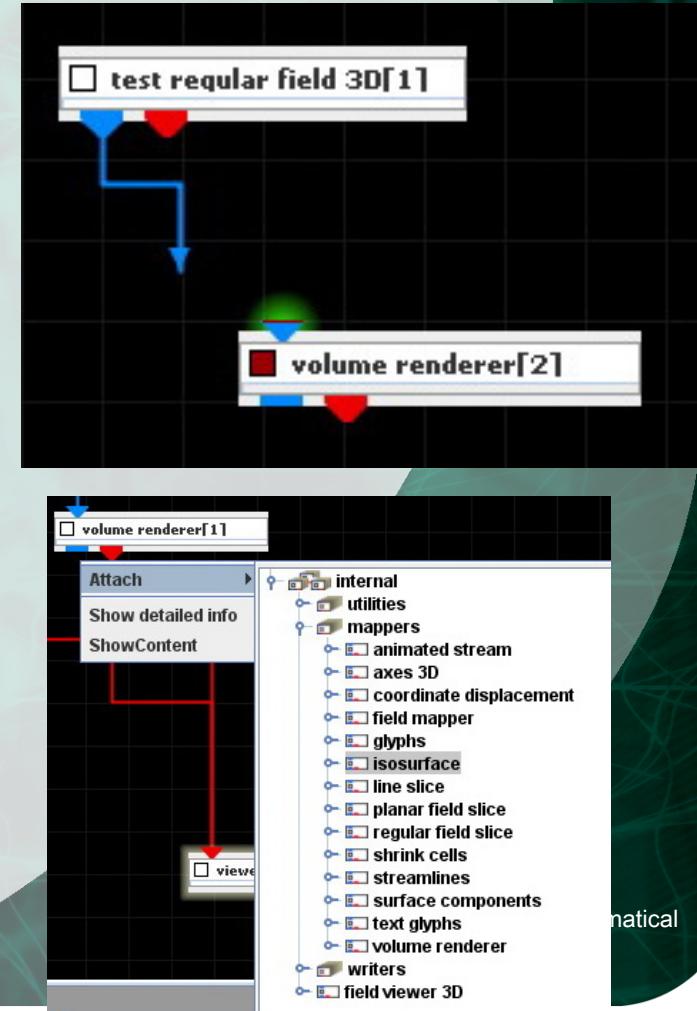
- Press and hold LMB on output port
- Drag the connection
- Release LMB on input port

- **Output port wizard**

- menu ‘Attach’

- **Automatic Viewer connection**

- Configurable option
- To the most recent Viewer



VisNow – user interface

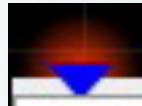
- **How to connect modules properly?**

- **Output port wizard**

- Always suggests only correct modules

- **Connection mouse dragging**

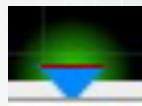
- Ports that match the dragged data are highlighted:



- Connection **impossible** (data not compatible)



- Connection **conditional** (no data on output to decide)



- Connection **correct** (data compatible)

VisNow – user interface

- **How to select and move?**

- **Module**

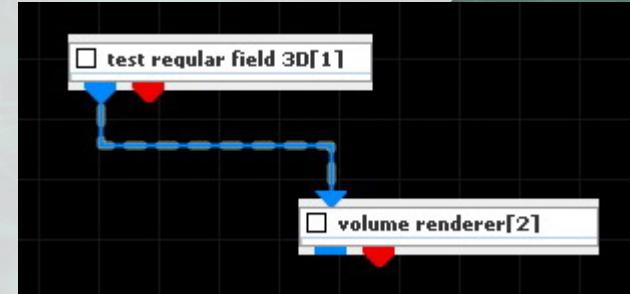
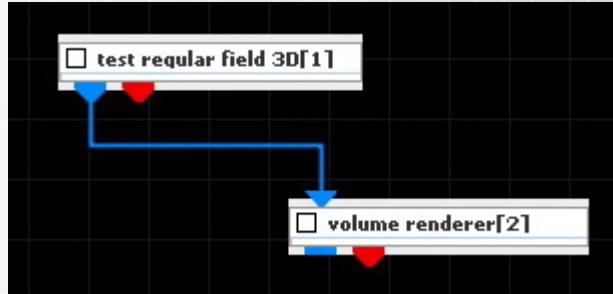
- LMB click selects a module (module is highlighted)



- LMB dragging moves module on workspace

- **Connection**

- LMB click selects a connection (connection is highlighted)



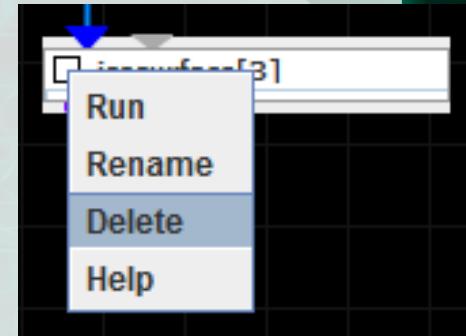
VisNow – user interface

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- **How to delete?**

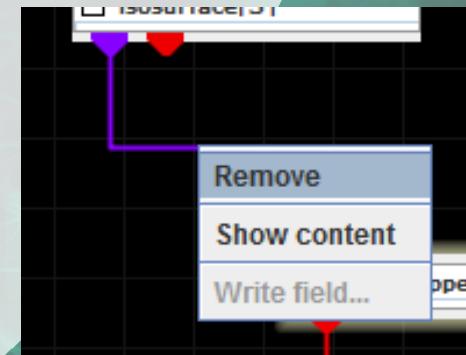
- **Module**

- Select a module
- Press '**Delete**' on the keyboard...
- ...or click RMB on the module and select '**Delete**'



- **Connection**

- Select connection
- Press '**Delete**' on the keyboard...
- ...or click RMB on the connection and select '**Remove**'

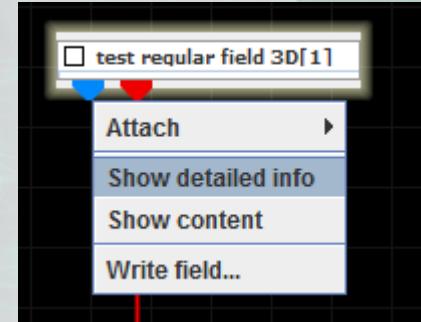


VisNow – user interface

- Port information

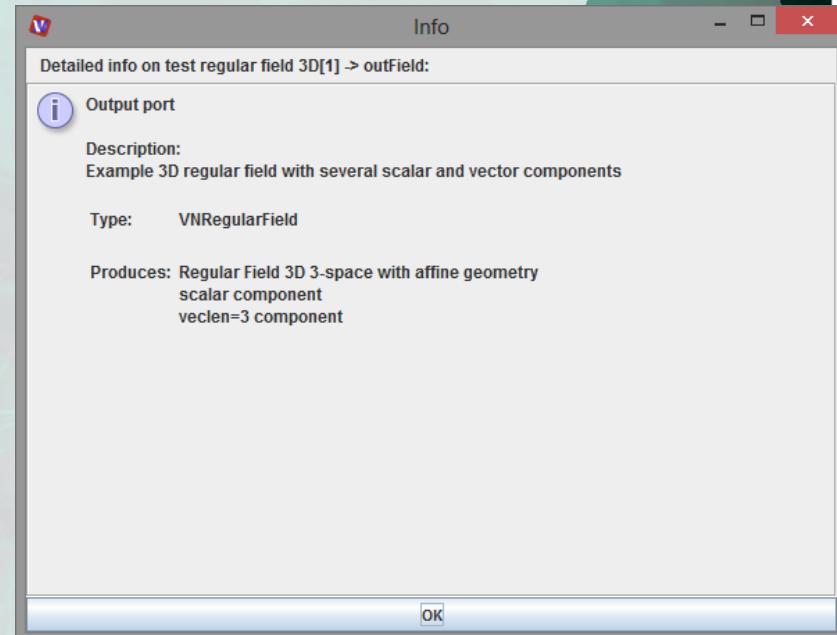
- Port context menu

- Click RMB on the port and select '*Show detailed info*'
- Port description window



- Port description

- Description
- Data type
- Produces / Requires



VisNow – user interface

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- **Connection acceptance**

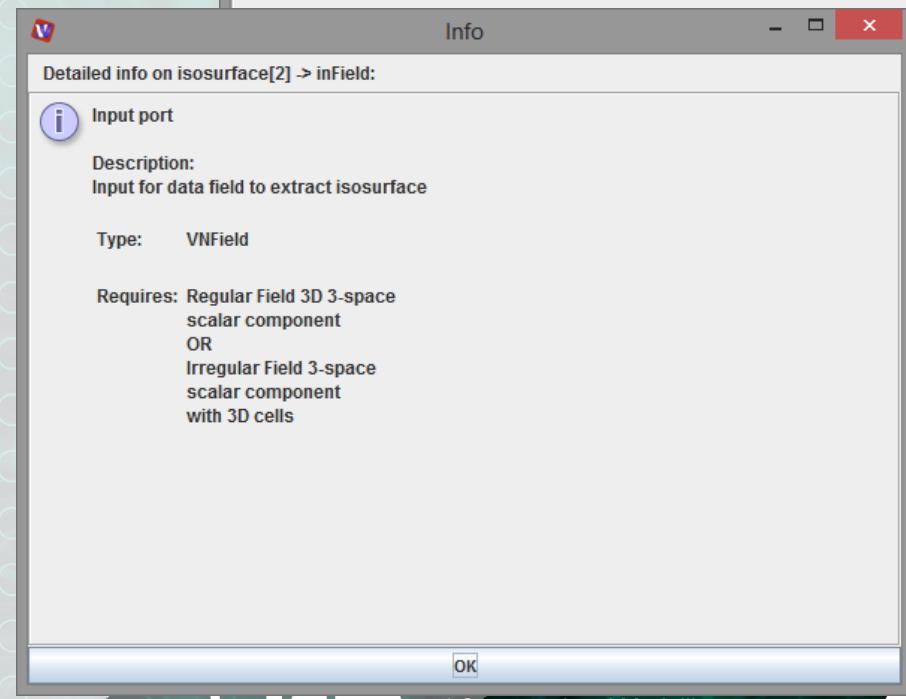
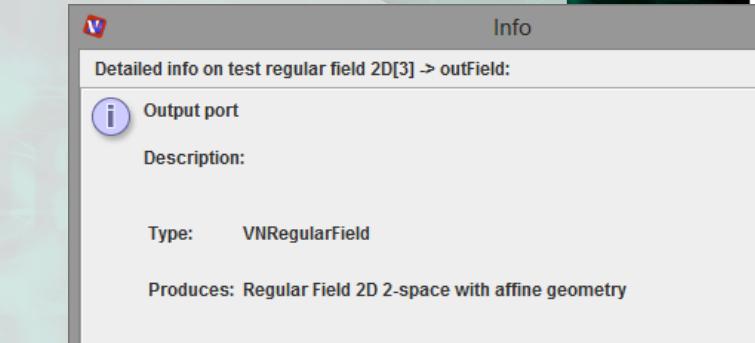
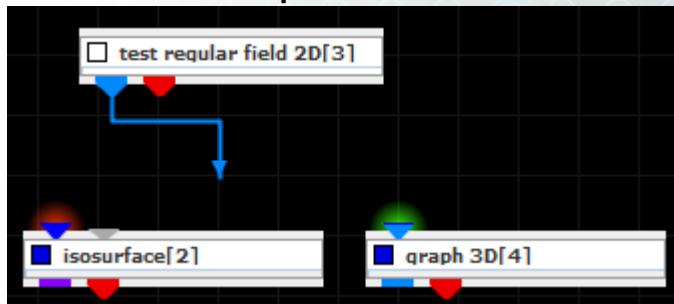
- **Port highlighting – connection correctness**

- **Output ports description**

- Produces

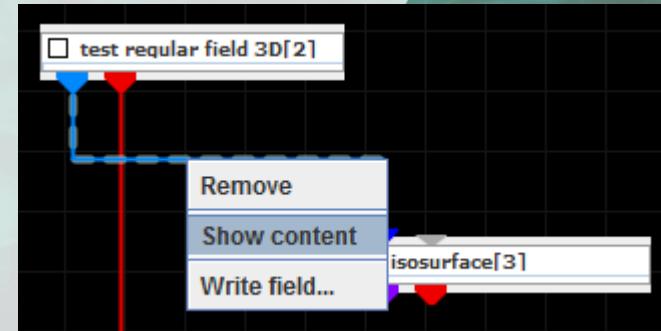
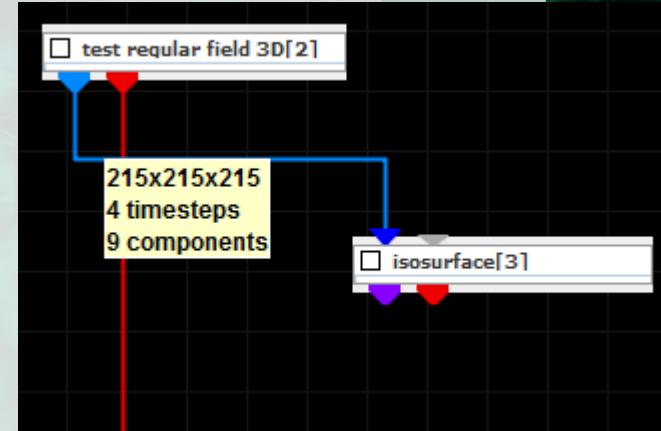
- **Input ports description**

- Requires



- **Data information**

- **Port or connection tooltip**
 - Visible after moving mouse cursor over port or connection
 - Short content description
- **Port or connection context menu**
 - Click RMB and select '*Show content*' or double-click LMB
 - Dialog window with detailed content description



VisNow – user interface

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- **Data information**

- **Show content**

- Dedicated SINGLE information window
- Updated
- Detailed data description
 - Type
 - Structure
 - Geometry
 - Data components

The screenshot shows a Windows-style dialog box titled "Info" with the sub-titre "Contents of test regular field 2D[3] -> outField:". The window contains two sections: a detailed description of the field's properties and a table of data components.

Detailed Description:

- Regular Field 2D 2-space, true 2-dim
- dimensions = {50x50}
- geometric extents
- x: [-0.500, 0.500]
- y: [-0.500, 0.500]
- physical extents
- x: [-0.500, 0.500]
- y: [-0.500, 0.500]
- origin at (-0.500, -0.500, 0.000)
- cell vectors:
(0.020, 0.000, 0.000)
(0.000, 0.020, 0.000)

Data Components:

Component	vlen	type	st.	min	max	physMin	physMax
gaussians	1	float	1	0.367	14.015	0.367	14.015
gaussians1	1	float	1	0.199	7.239	0.199	7.239
gaussians2	1	float	1	0.157	6.726	0.157	6.726
gaussians_gradient	2	float	1	0.162	37.015	0.162	37.015
byte_gaussians	1	byte	1	20.000	147.000	0.300	0.700
short_gaussians	1	short	1	0.000	14.000	0.000	14.000
int_gaussians	1	int	1	0.000	14.000	0.000	14.000
complex_gaussians	1	complex	1	2.910	2.910	2.910	2.910
string_gaussians	1	string	1	6.000	12.000	6.000	12.000
logic_gaussians	1	logic	1	0.000	1.000	0.000	1.000

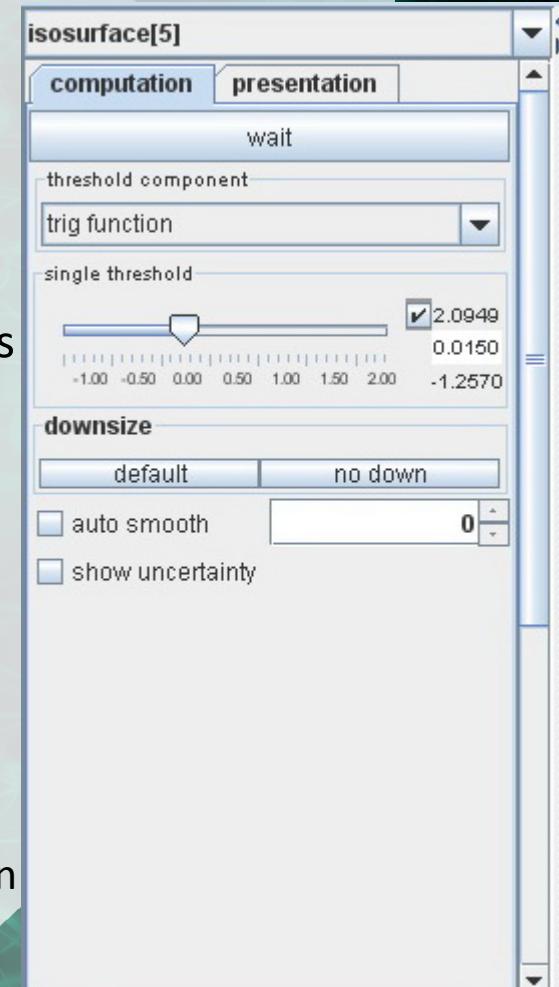
OK

VisNow – user interface

- **Module steering**

- **Module interface**

- Select a module...
- ...or choose from a drop-down menu on the top of module GUI panel
- If a module has no correct data the interface is hidden
- Module steering parameters
- ‘computation’ tab
 - Calculations parameters
- ‘presentation’ tab
 - Visualization parameters
 - Only for ‘geometry output’ port in visualization module



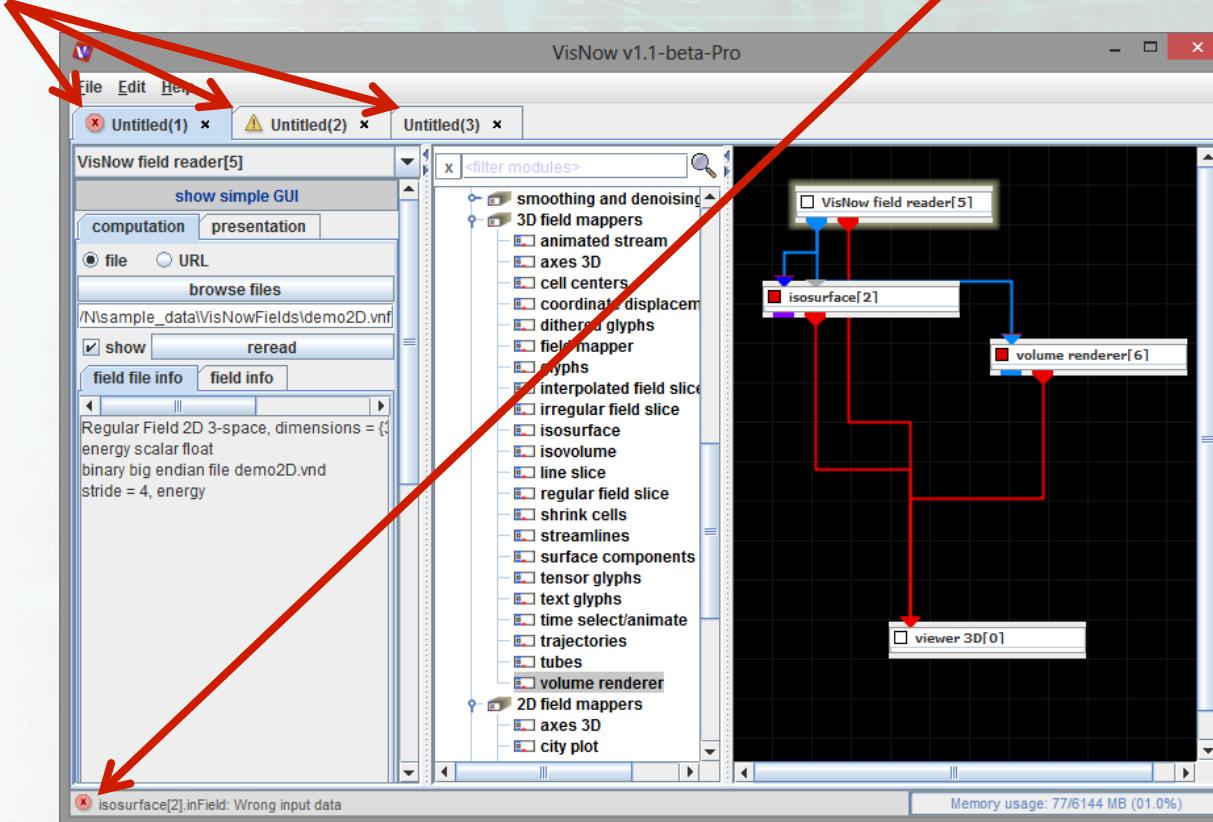
VisNow – user interface

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- **Messagess**



- **Application status**



- **Message bar**

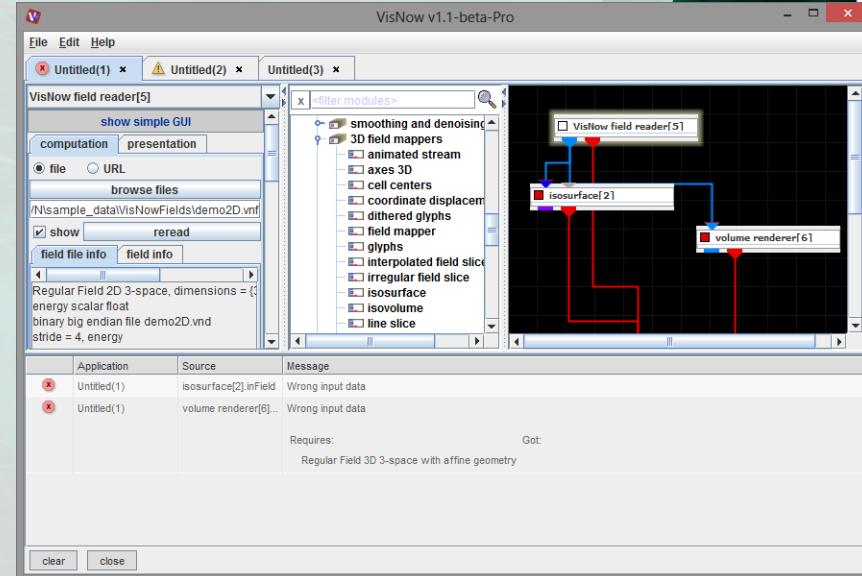
VisNow – user interface

- **Messages**



- **Message bar**

- Opens on click
- Contains a list of recent messages
 - Icon – error / warning / information
 - Application – name of source application
 - Source – source name (e.g. module)
 - Message – message text



	Application	Source	Message
✖	Untitled(1)	isosurface[2].inField	Wrong input data
✖	Untitled(1)	volume renderer[6]...	Wrong input data

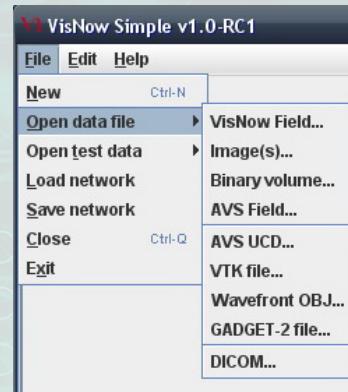
Requires:
Regular Field 3D 3-space with affine geometry

VisNow – user interface

- Main menu

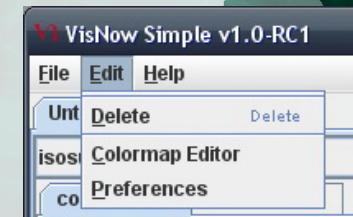
- *File*

- Input data
- Network save/load
- Program exit



- *Edit*

- Colour maps editor
- User preferences



- *Help*

- Help with technical description of modules
- Show log – VisNow logging view

VisNow - Help

Module: Volume Renderer

volume renderer [0]

Maps volumetric data using volume rendering algorithm.

input port	type	description	data acceptors
inField	VNRegularField	Input for volume data to render	Regular Field 3D 3-space with affine geometry at least one scalar component
output port	type	description	data schemas
croppedField	VNRegularField	Output of cropped field	Regular Field 3D 3-space with affine geometry
outObj	VNGeometryObject	Output of geometry object for 3D rendered volume	

Table of Contents Search

- VisNow
 - Modules
 - readers
 - test objects
 - utilities
 - mappers
 - Field Mapper
 - Shrink Cells
 - Cell Centers
 - Axes 3D
 - Glyphs
 - Text Glyphs
 - Isosurface
 - Line Slice
 - Surface Components
 - Volume Renderer
 - Regular Field Slice
 - Planar Field Slice
 - Coordinate Displacement
 - Streamlines
 - Animated Stream
 - Isolines
 - Graph 3D
 - Ribbon Plot
 - Graph 1D Object

VisNow – user interface

- **User preferences**

- Main menu -> Edit -> Preferences
- Properties tab

- **Hardware performance**

- Computer performance vs. dynamic sliders refreshing

- **Multithreading**

- Number of maximum CPU threads for calculations

- **Startup viewers**

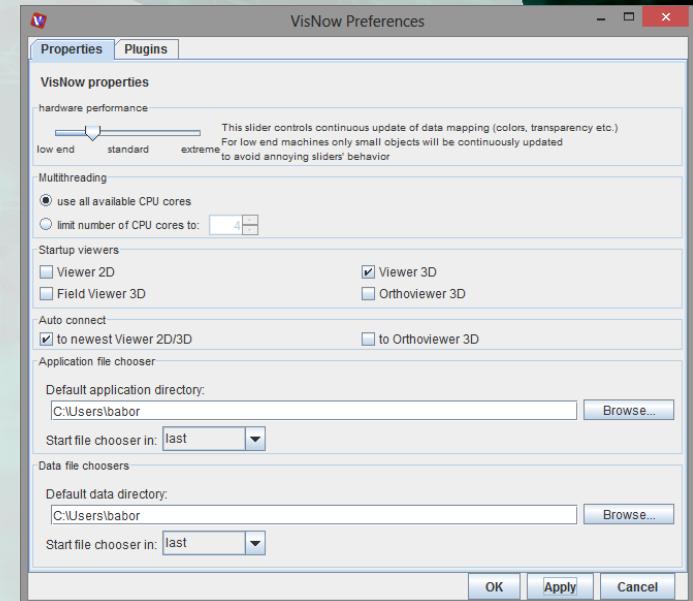
- Choice of viewers automatically created on application startup

- **Auto connect**

- Setup of automatic viewer connecting

- **Default directories**

- Default directories for application VNA files and data files



VisNow – user interface

- **Plugins**

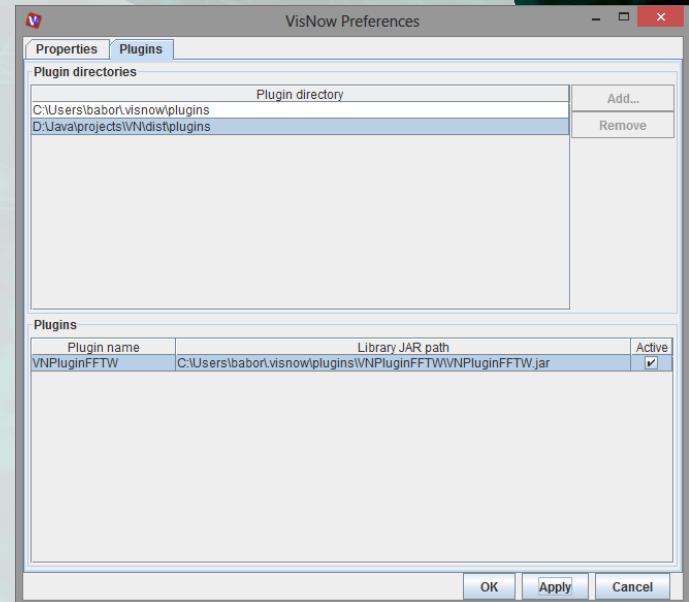
- Main menu -> Edit -> Preferences
- Plugins tab

- **Plugins mechanism**

- VisNow can read external module libraries
- May be published on other licences
- Plugins are automatically loaded as selected

- **Plugin availability?**

- Create your own plugin
- Available on VisNow web site soon
- Community!!!

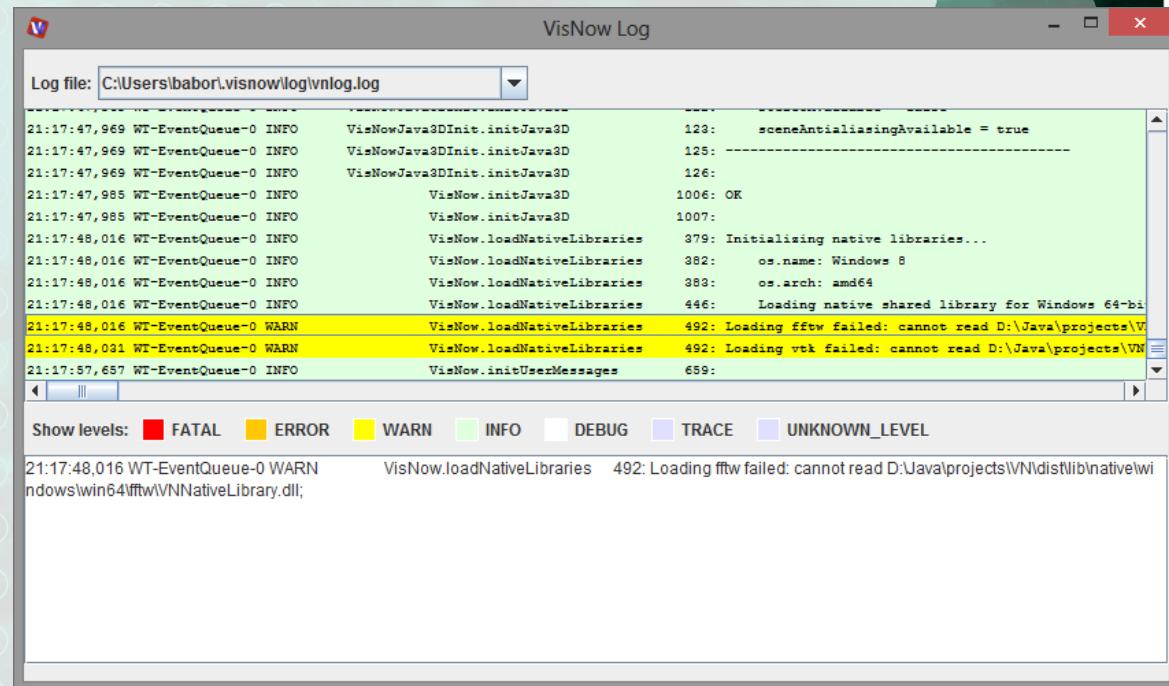


VisNow – user interface

- **Logs**

- **Logging view**

- Main menu -> Help -> Show log
- Contain VisNow system logs



The screenshot shows the "VisNow Log" window. At the top, there is a dropdown menu labeled "Log file: C:\Users\babor\visnow\log\vnlog.log". The main area displays a list of log entries. Some entries are highlighted in yellow, indicating specific events or errors. The log entries include:

```
21:17:47,969 WT-EventQueue-0 INFO VisNowJava3DInit.initJava3D 123: sceneAntialiasingAvailable = true
21:17:47,969 WT-EventQueue-0 INFO VisNowJava3DInit.initJava3D 125: -----
21:17:47,969 WT-EventQueue-0 INFO VisNowJava3DInit.initJava3D 126: 
21:17:47,985 WT-EventQueue-0 INFO VisNow.initJava3D 1006: OK
21:17:47,985 WT-EventQueue-0 INFO VisNow.initJava3D 1007: 
21:17:48,016 WT-EventQueue-0 INFO VisNow.loadNativeLibraries 379: Initializing native libraries...
21:17:48,016 WT-EventQueue-0 INFO VisNow.loadNativeLibraries 382: os.name: Windows 8
21:17:48,016 WT-EventQueue-0 INFO VisNow.loadNativeLibraries 383: os.arch: amd64
21:17:48,016 WT-EventQueue-0 INFO VisNow.loadNativeLibraries 446: Loading native shared library for Windows 64-bit
21:17:48,016 WT-EventQueue-0 WARN VisNow.loadNativeLibraries 492: Loading fftw failed: cannot read D:\Java\projects\VN
21:17:48,031 WT-EventQueue-0 WARN VisNow.loadNativeLibraries 492: Loading vtk failed: cannot read D:\Java\projects\VN
21:17:57,657 WT-EventQueue-0 INFO VisNow.initUserMessages 659: 
```

Below the log entries, there is a legend for "Show levels": FATAL (red), ERROR (yellow), WARN (light green), INFO (light blue), DEBUG (light purple), TRACE (medium purple), and UNKNOWN_LEVEL (light pink).



VISNOW

visnow.icm.edu.pl

Contact:

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Bartosz Borucki, Krzysztof Nowiński



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