Local and Remote Visualisation Techniques

UvA High Performance Computing course

Robert Belleman, UvA/IvI
Paul Melis, SURFsara

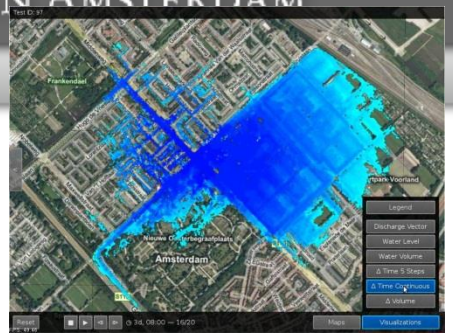
Program for today

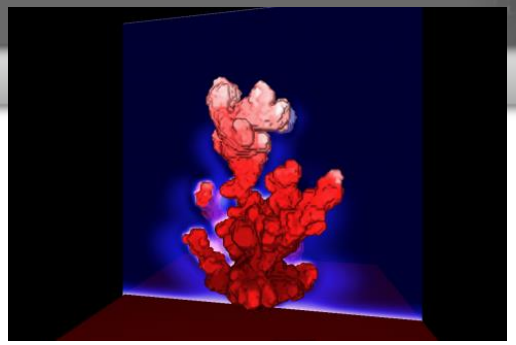
09:00 – 09:15	Who's who?
09:15 – 09:45	Introduction to Data Visualization (Robert Belleman)
09:45 – 10:45	Visualization at SURFsara and an Introduction to ParaView (Paul Melis)
10:45 – 11:45	Hands-on: Scientific Visualization with ParaView
11:45 – 12:15	Remote Visualization, the Collaboratorium (Paul Melis)
12:15 – 12:45	Information visualization with D3.js (Robert Belleman, Paul Melis)
12:45 – 13:00	Closing

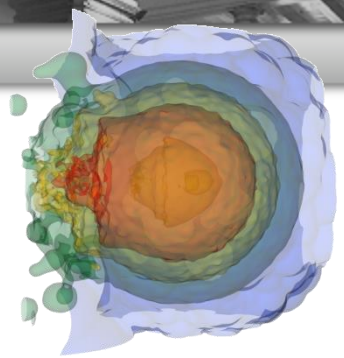
Introduction to Data Visualization

Robert G. Belleman, PhD
Informatics Institute
University of Amsterdam

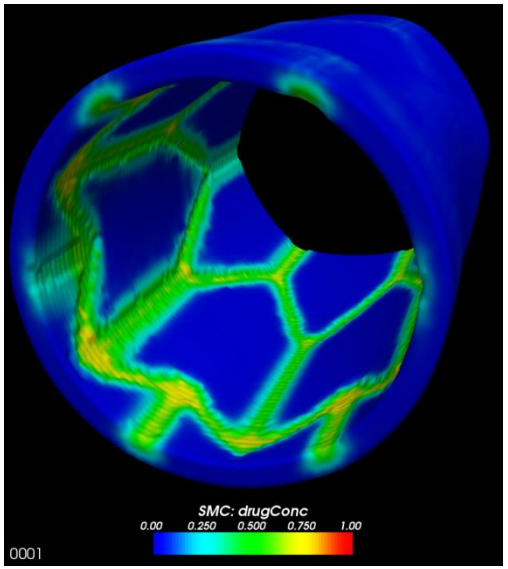
Email: R.G.Belleman@uva.nl

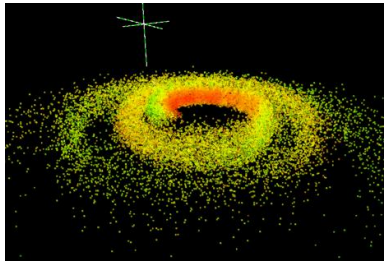


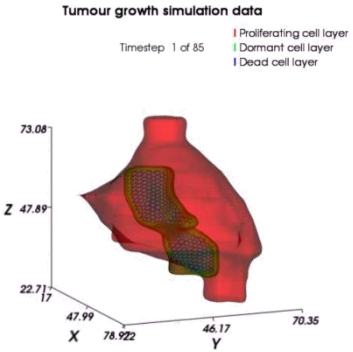


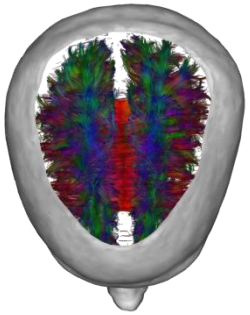


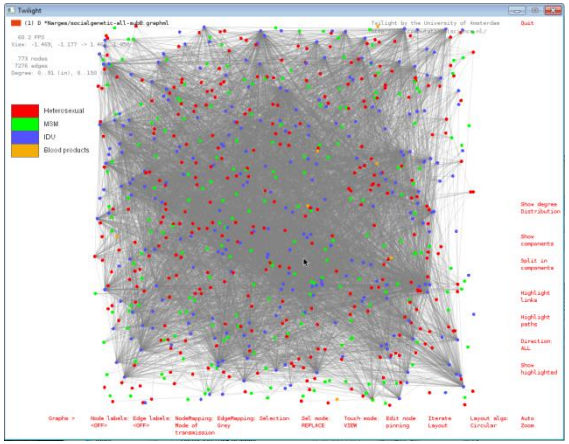
- **Scientific Visualization and Virtual Reality** team
  - part of *Computational Science* at UvA/IvI
  - close collaboration with SURFsara
- Research theme: **interactive visual exploration**
  - Software solutions and architectures, Problem Solving Environments, Interactive graphics devices
- Application areas: computational science
  - (astro)physics, medicine, biology, finance, architecture, computer science, …











X	Y	X	Y	X	Y	X	Y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
14,00	9,96	14,00	8,10	14,00	8,84	8,00	7,04
6,00	7,24	6,00	6,13	6,00	6,08	8,00	5,25
4,00	4,26	4,00	3,10	4,00	5,39	19,00	12,50
12,00	10,84	12,00	9,11	12,00	8,15	8,00	5,56
7,00	4,82	7,00	7,26	7,00	6,42	8,00	7,91
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

A B C D

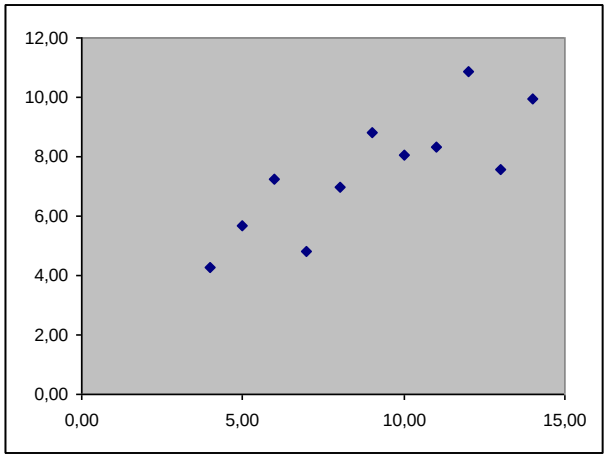
“Anscombe’s quartet”, F.J. Anscombe, “Graphs in Statistical Analysis”, American Statistician, 27 (February 1973), 17-21.

X	Y	X	Y	X	Y	X	Y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
14,00	9,96	14,00	8,10	14,00	8,84	8,00	7,04
6,00	7,24	6,00	6,13	6,00	6,08	8,00	5,25
4,00	4,26	4,00	3,10	4,00	5,39	19,00	12,50
12,00	10,84	12,00	9,11	12,00	8,15	8,00	5,56
7,00	4,82	7,00	7,26	7,00	6,42	8,00	7,91
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

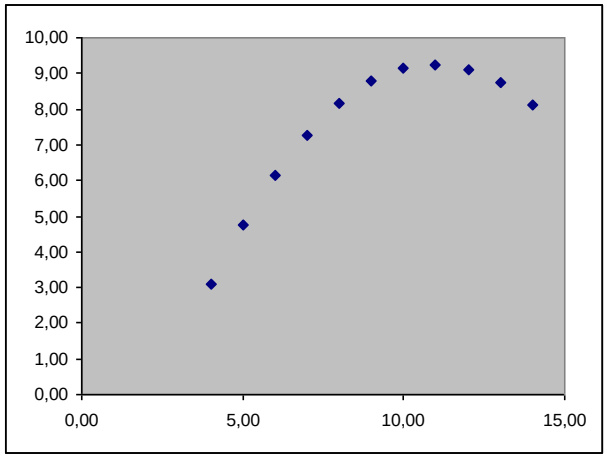
A **B** **C** **D**

$\mu_x = 9.00$, $\sigma_x = 3.32$
$\mu_y = 7.50$, $\sigma_y = 2.03$
linear regression: $y = \frac{1}{2}x + 3$

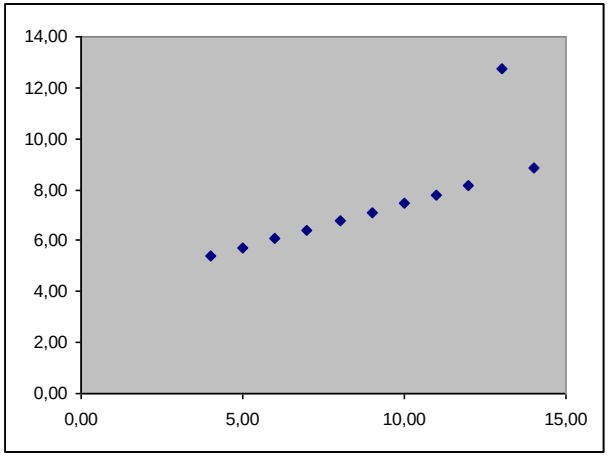
“Anscombe’s quartet”, F.J. Anscombe, “Graphs in Statistical Analysis”, American Statistician, 27 (February 1973), 17-21.



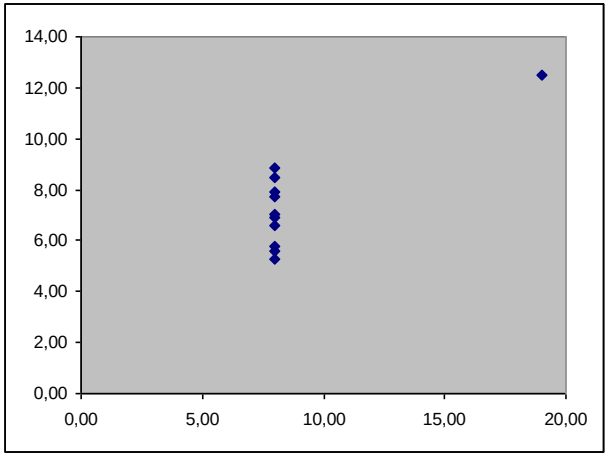
A



B



C



D

“Anscombe’s quartet”, F.J. Anscombe, “Graphs in Statistical Analysis”, American Statistician, 27 (February 1973), 17-21.

Visualization taxonomy

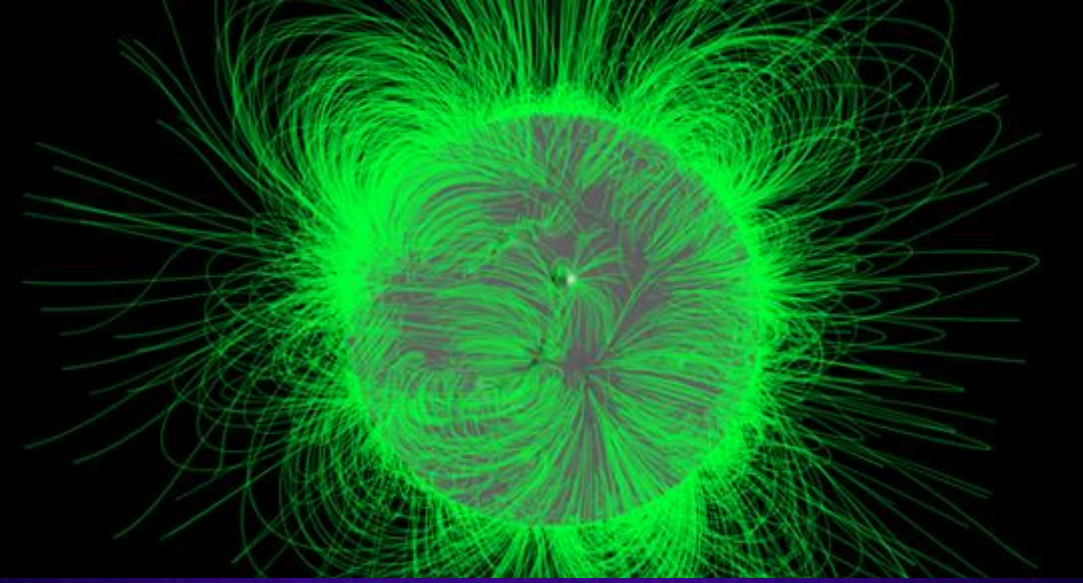
- Scientific visualization (“scivis” or “datavis”)
  - Data with an implicit or explicit geometric structure
    - Measurements, results from simulations or experiments
- Information visualization (“infovis” or “infographics”)
  - Data with an abstract structure
    - Relations, graphs and networks
- Visual analytics
  - Interactive environments for the detection of the expected and discovery of the unexpected

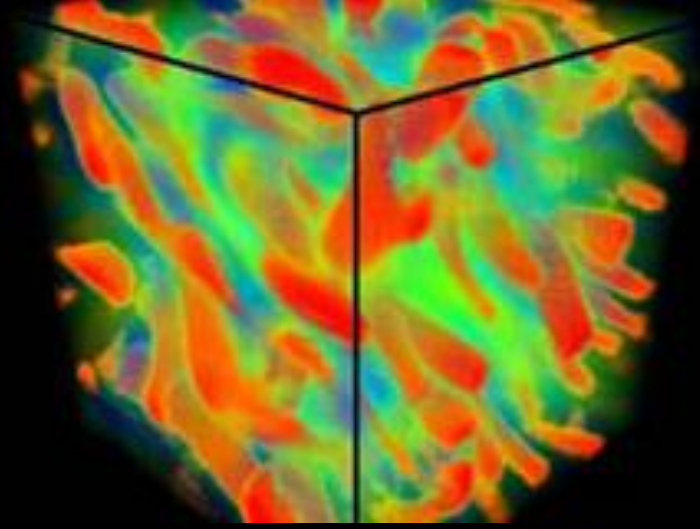
Scientific visualization

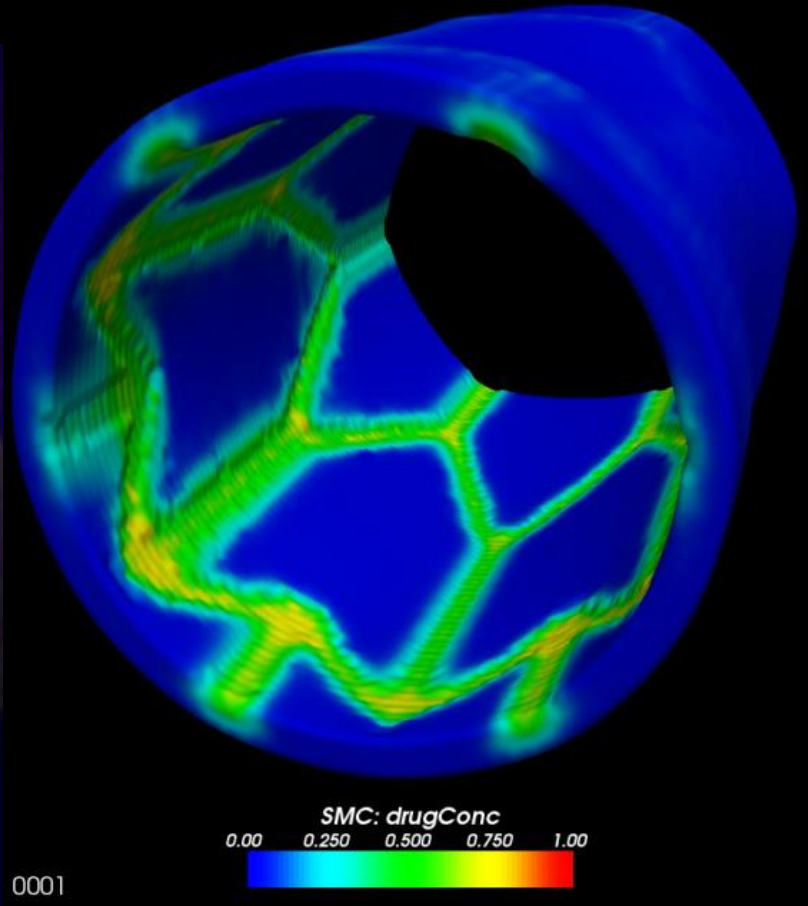
- "Scientific visualization deals with all aspects that are connected with the visual representation of data sets from scientific experiments or simulations to achieve a deeper understanding or a simpler representation of complex phenomena."

Martin Rotard, Daniel Weiskopf, and Thomas Ertl, *Curriculum for a Course on Scientific Visualization*, Eurographics / ACM SIGGRAPH Workshop on Computer Graphics Education (2004)

L






SMC: drugConc
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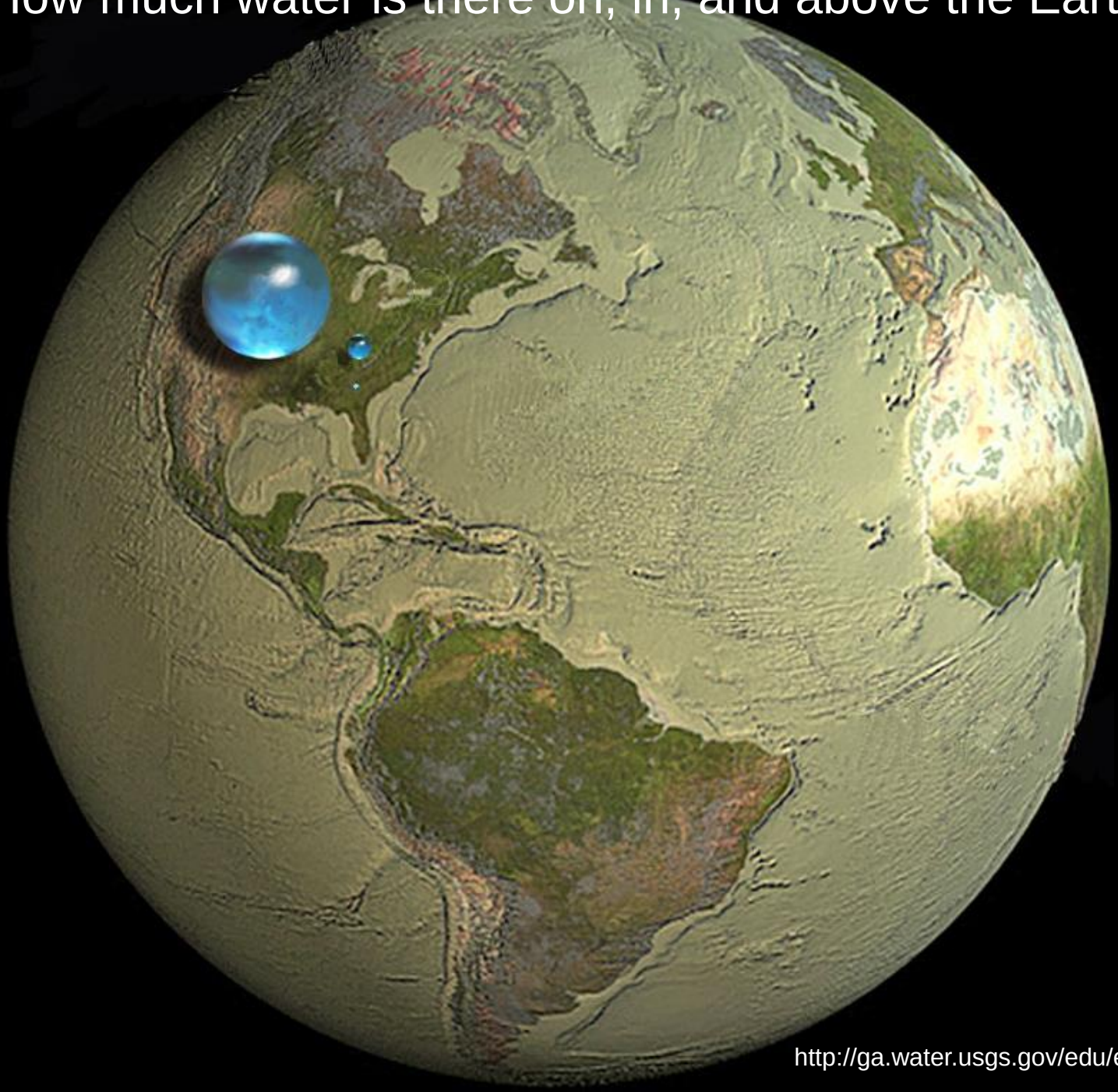
0001

Information visualization

- “In information visualization, the graphical models may represent abstract concepts and relationships that do not necessarily have a counterpart in the physical world.”

Maria Cristina Ferreira de Oliveira, Haim Levkowitz, [doi.ieeecomputersociety.org/10.1109/TVCG.2003.1207445 From Visual Data Exploration to Visual Data Mining: A Survey], IEEE Transactions on Visualization and Computer Graphics, vol. 9, no. 3, pp. 378-394, July-September, 2003.

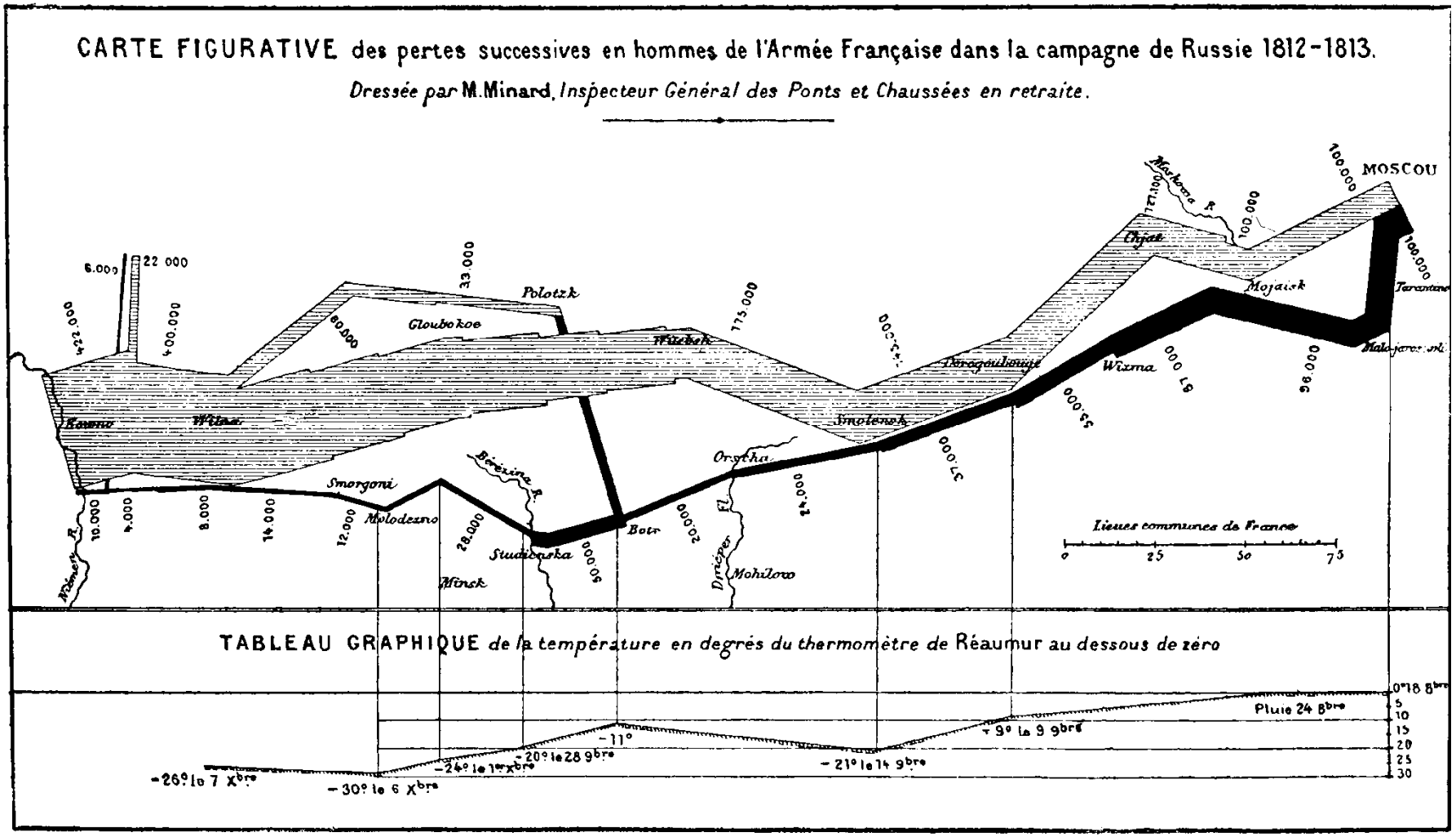
How much water is there on, in, and above the Earth?



http://ga.water.usgs.gov/edu/earthhowmuch.html

Information visualization

Charles Minard, 1869



Xbre = December 9bre = November 8bre = October

Software: Tableau

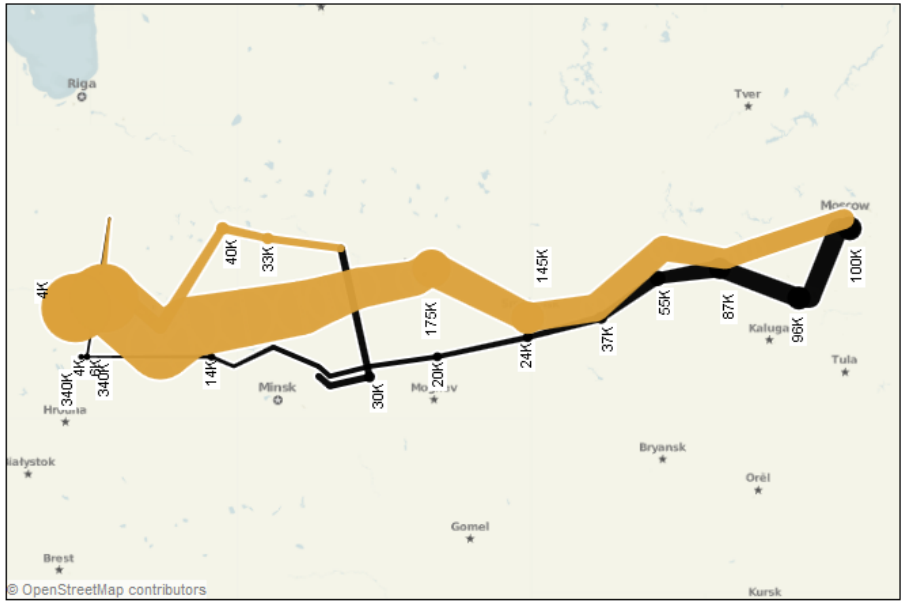
Napoleon's March to Moscow (and back)

Like 4 Tweet 10 by amorrison@table... - Jun. 23rd 2010

Some call this viz – created by Charles Minard in 1869 – the best ever because it displays so many different kinds of information so clearly. Kim Rees of Information Aesthetics recreated this viz and used it as a measuring stick in her review of social visualization tools. We like the review and we love the viz. While not original, it has a certain je ne sais qua.

Napoleon's March 1812

The losses of French army during the Russian campaign, 1812-1813.



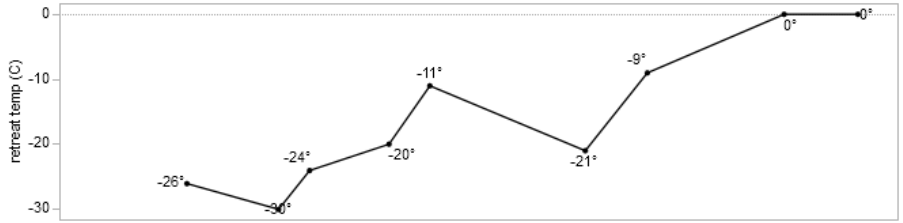


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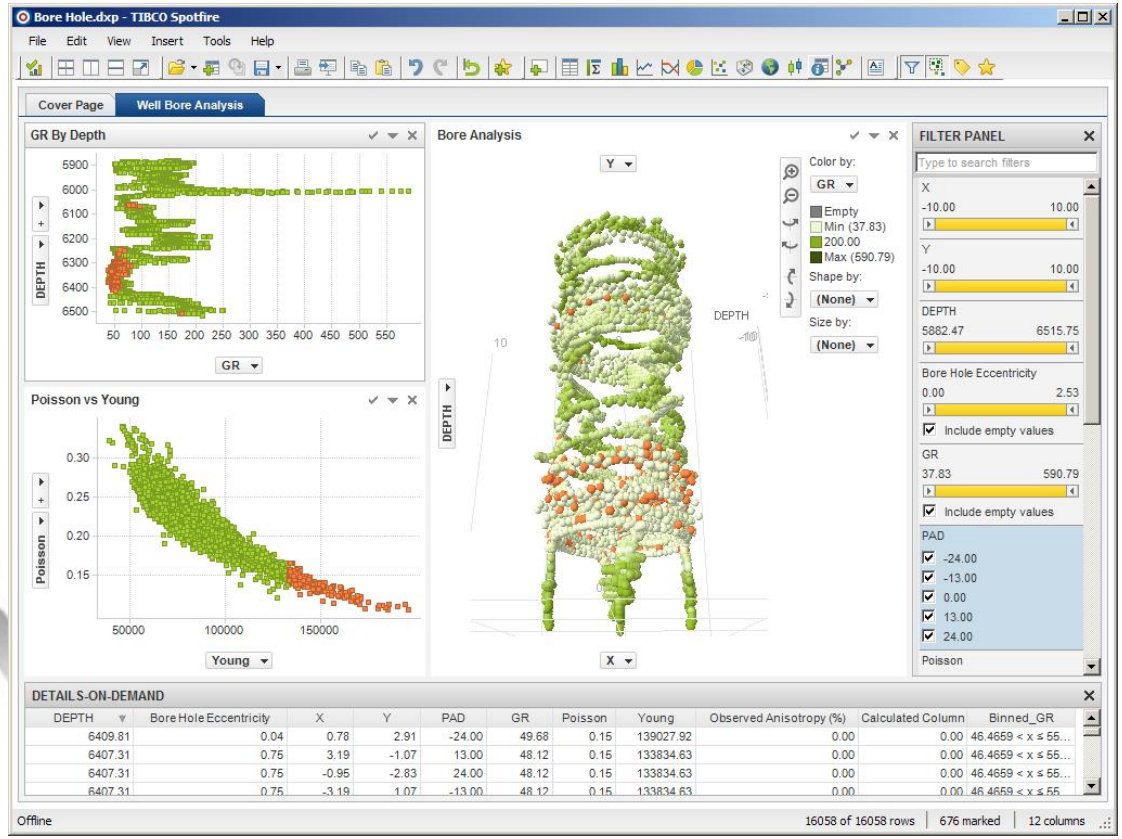
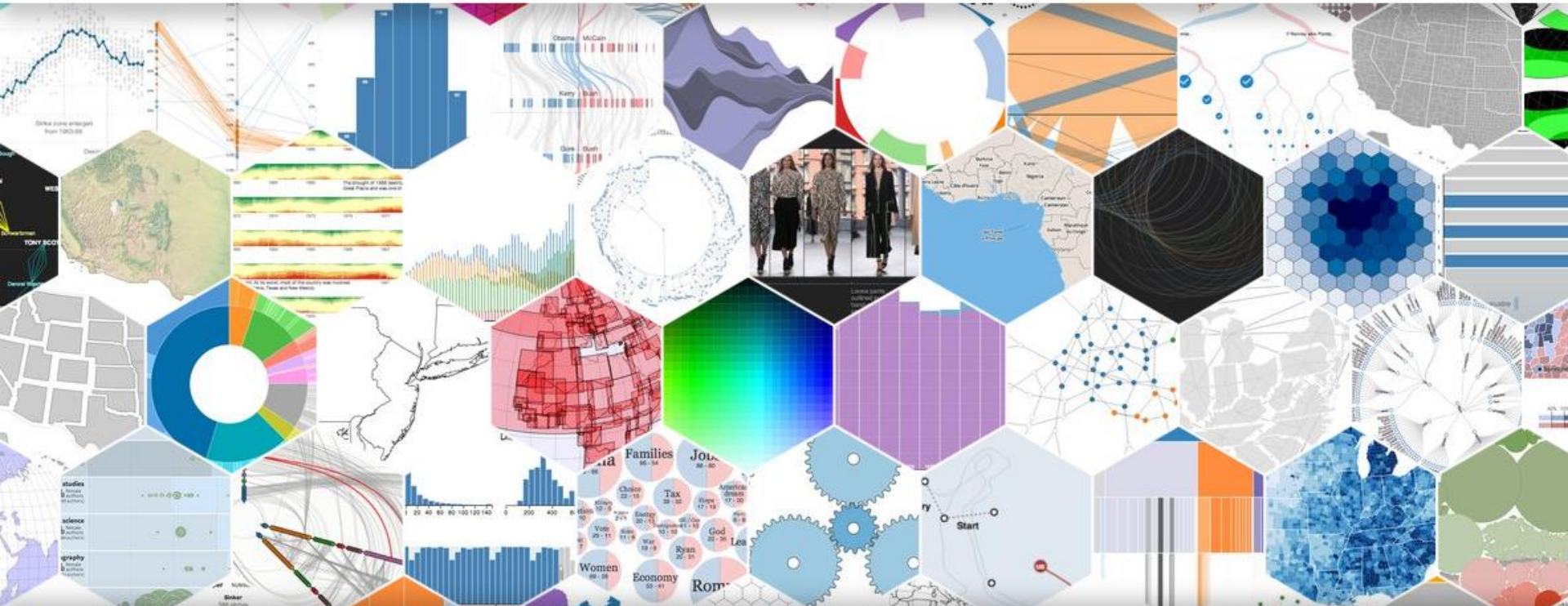
tableau

Software: Spotfire

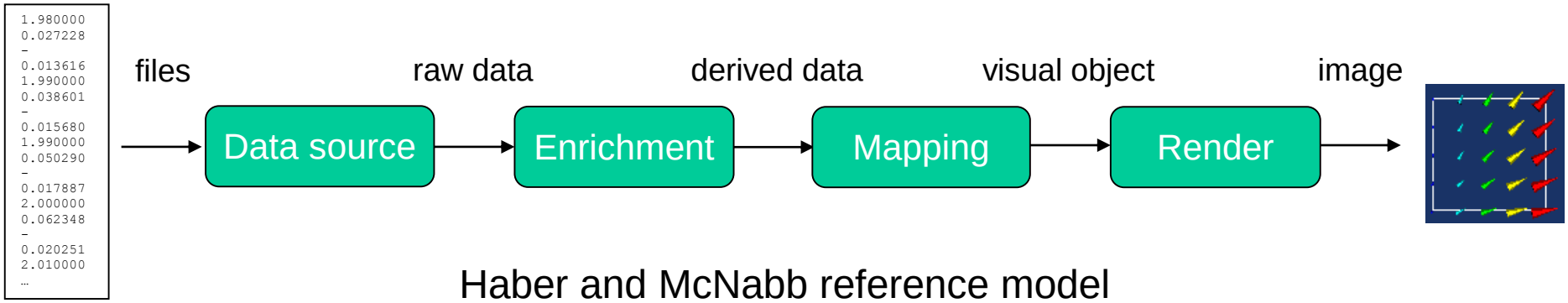


DIY Software: D3.js

Data-Driven Documents

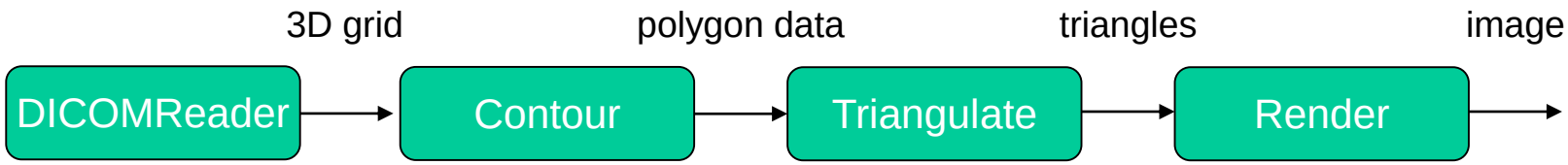


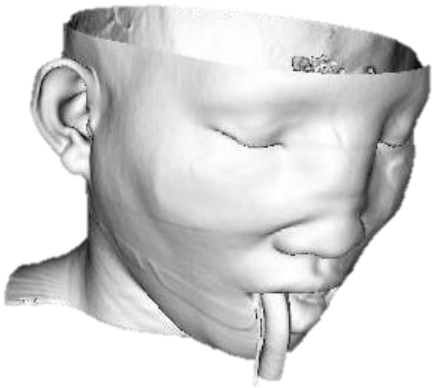
The scientific visualization pipeline



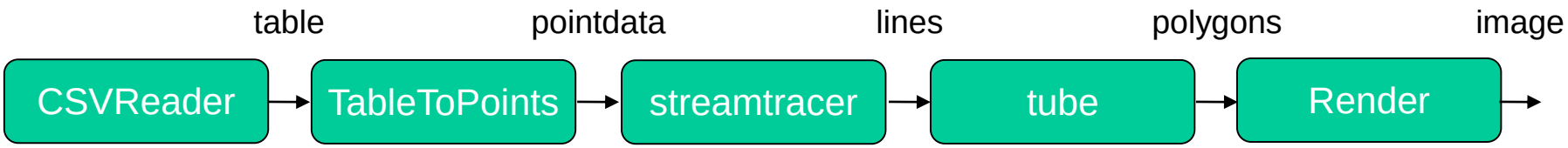
Haber and McNabb reference model

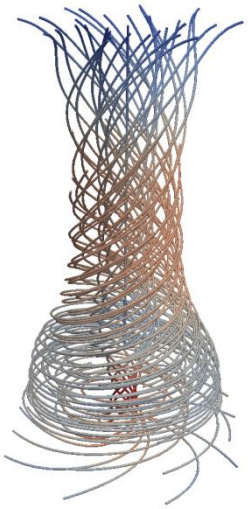
Example:
extracting a contour from medical data



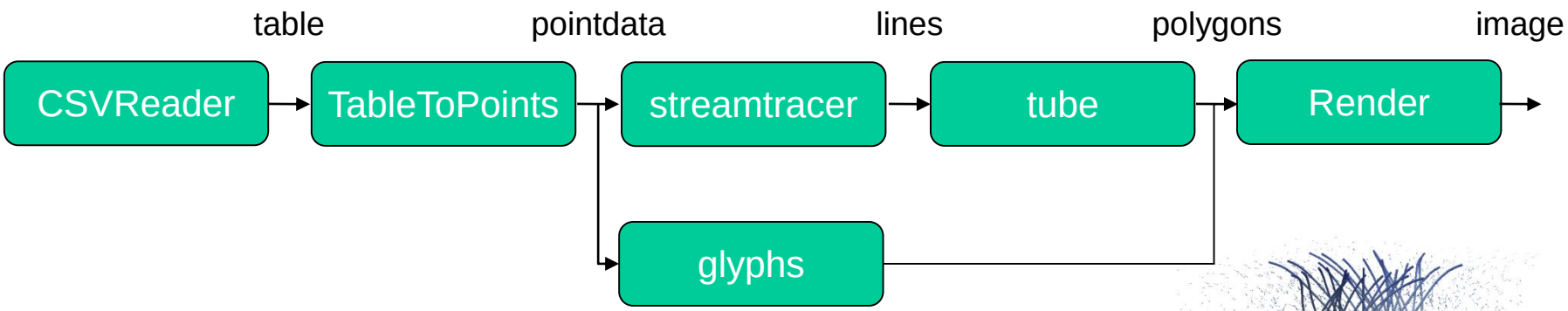


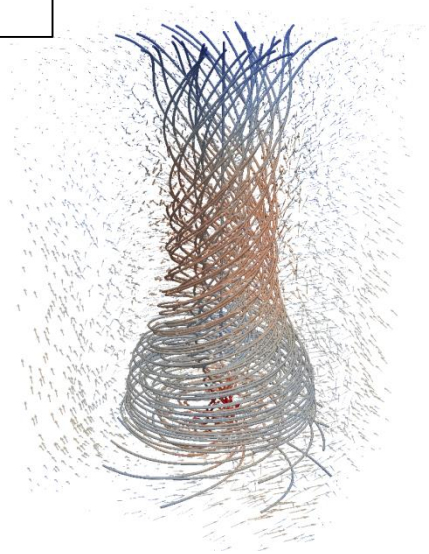
Example:
visualizing flow data with streamlines



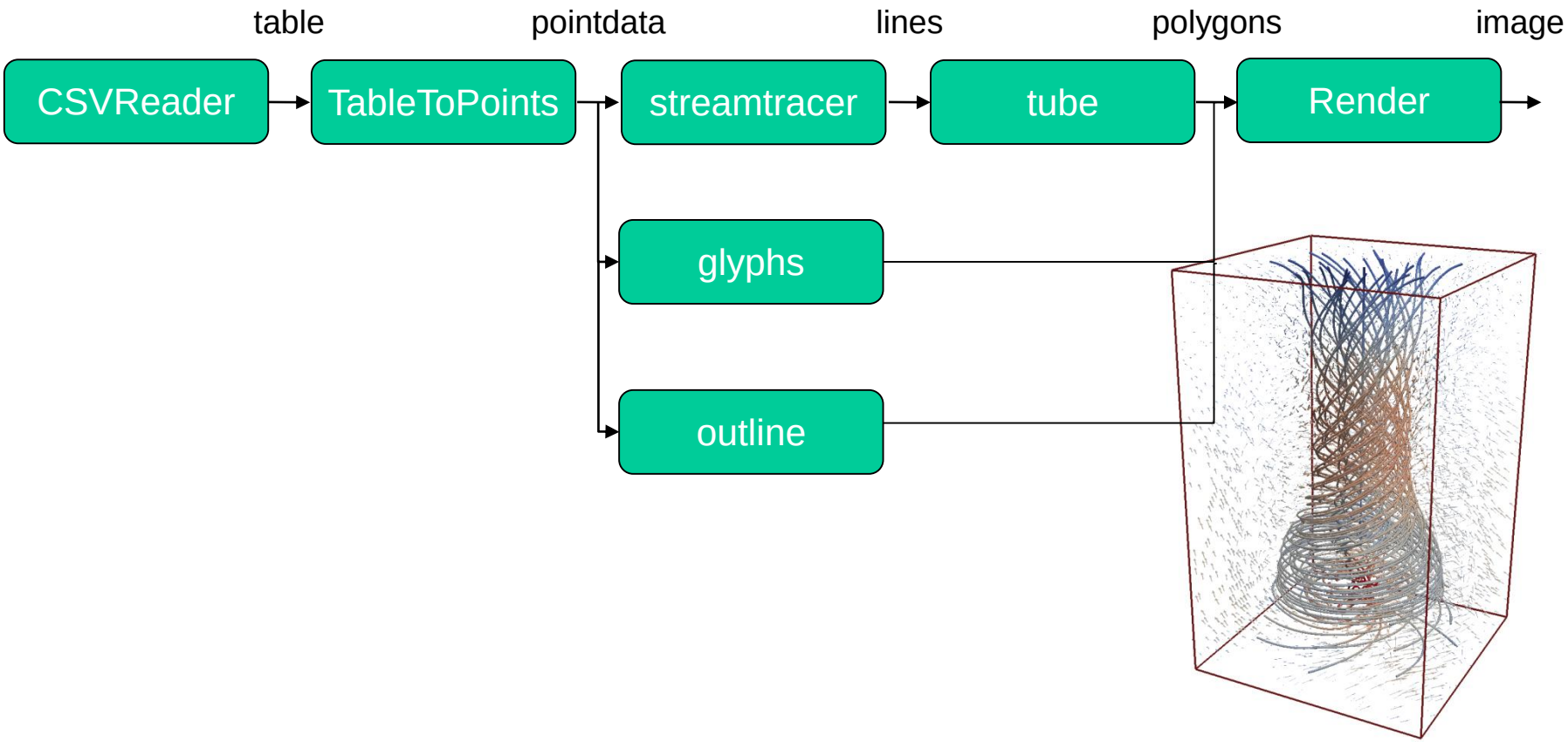


Example:
visualizing flow data with streamlines





Example:
visualizing flow data with streamlines



Pipeline creation

- Filters are connected together to form a “visualization pipeline” or “dataflow network”
- The input port of a filter may only be connected to the output port(s) of (an)other filter(s) if the port types are “similar"

Pipeline behaviour

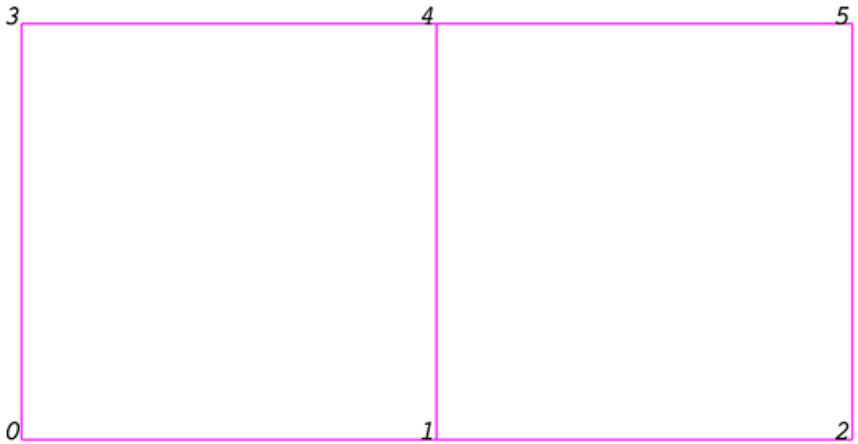
- Filters in a pipeline only execute when necessary
  - When data at the input has changed, or a parameter
- Data flows downstream, update checks go upstream

Data model

- Data sets are represented by a *mesh* and *attributes*

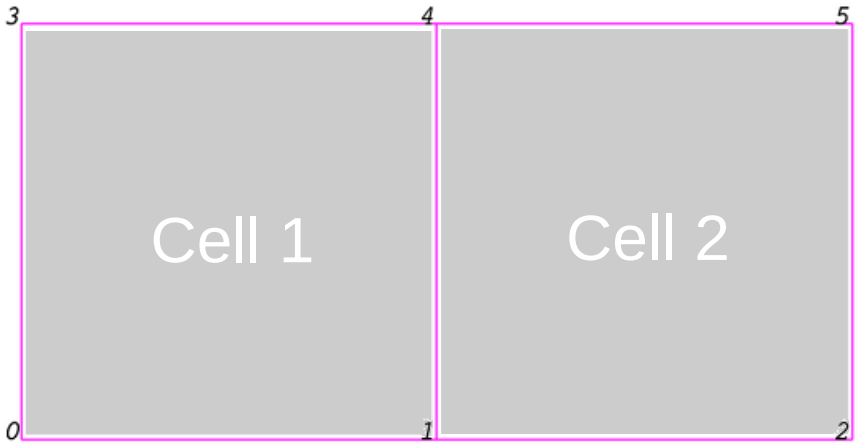
Data model

- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)



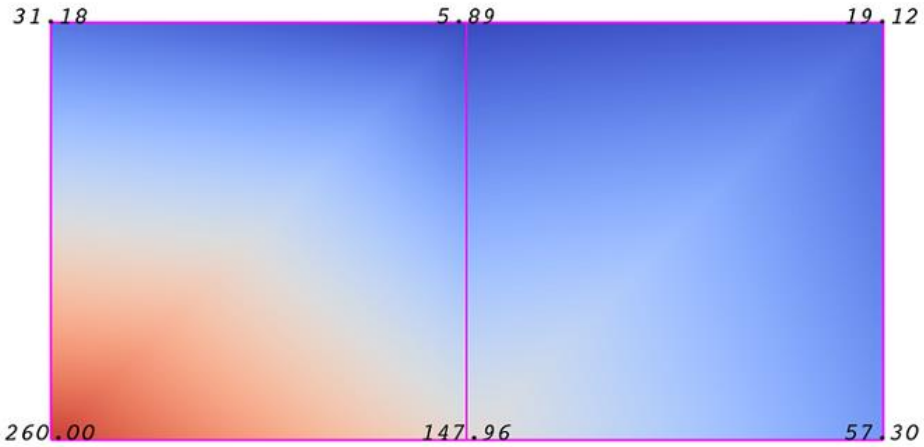
Data model

- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)
- Collections of vertices form cells (regions, zones)



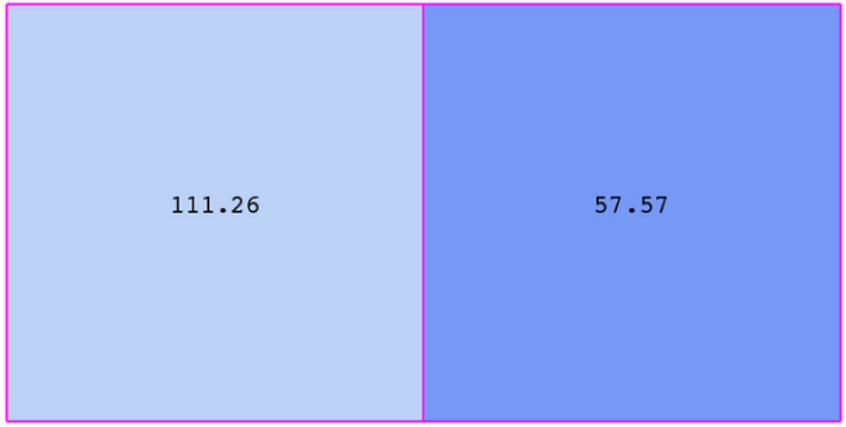
Data model

- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)
- Collections of vertices form cells (regions, zones)
- Vertices can have attributes

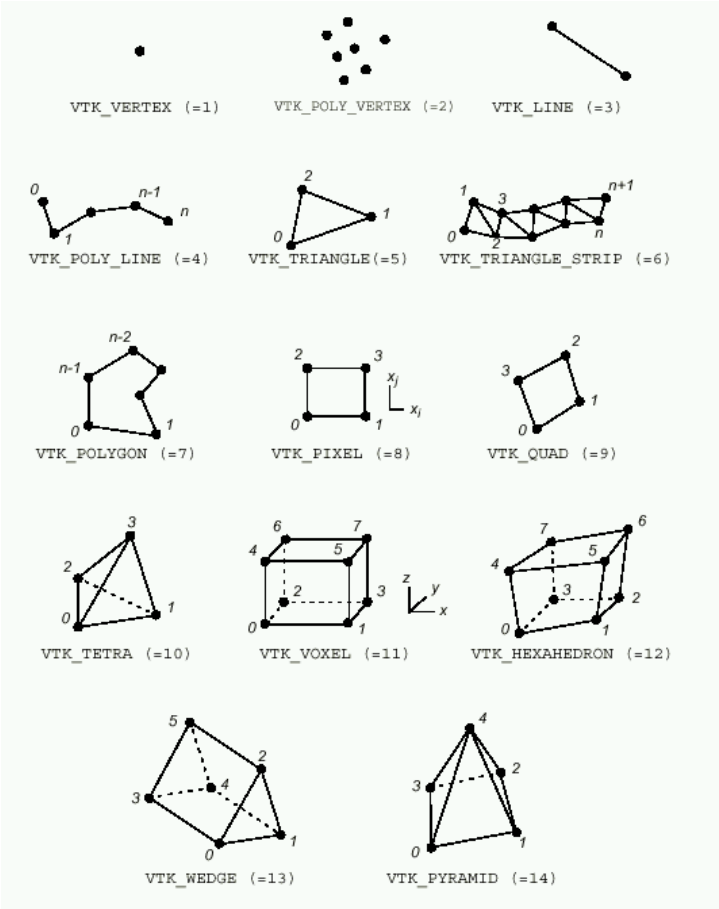


Data model

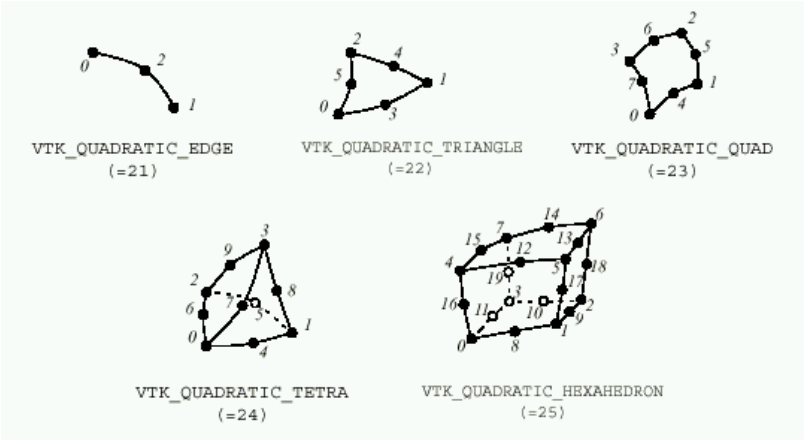
- Data sets are represented by a *mesh* and *attributes*
- A mesh consists of interconnected vertices (topology)
- Collections of vertices form cells (regions, zones)
- Vertices can have attributes
- Cells can have attributes



Cell types



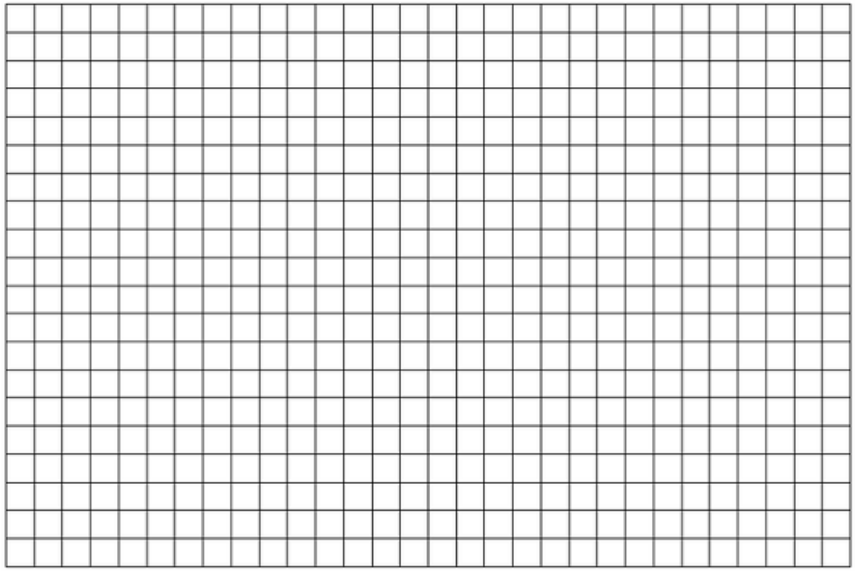
Linear cell types



Non-linear cell types

Uniform Rectilinear Grid (image data)

Implicit topology and point coordinates, all cells of same type.



Properties:

- Extent: min/max indices
- Origin
- Spacing

Examples:

- Images (JPEG, PNG, TIFF, etc)
- (Bio-)medical data (CT, MRI, CLSM, etc)

Rectilinear grid

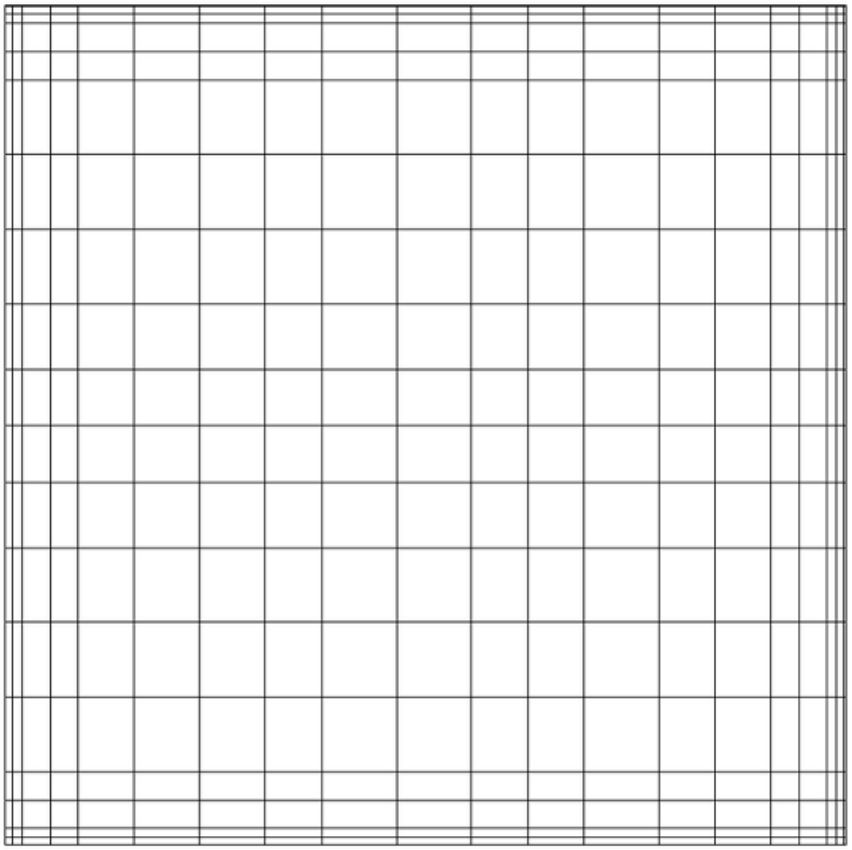
Implicit topology, semi-implicit point coordinates, all cells of same type.

Properties:

- Extent: min/max indices
- Vertex coordinates

Examples:

- Data structure in simulations with non-uniform density



Curvilinear Grid

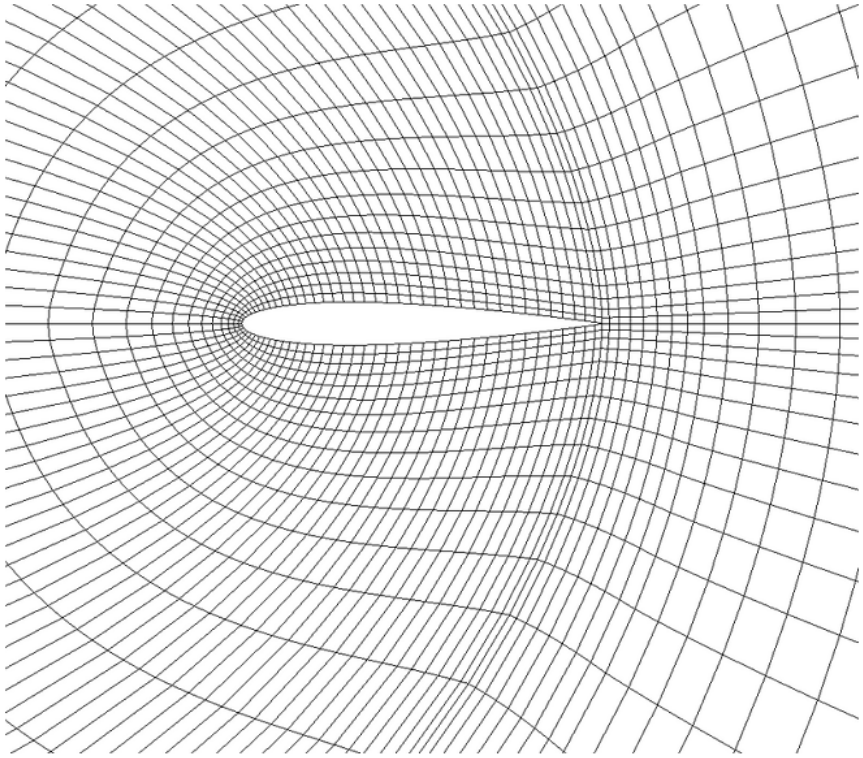
Implicit topology, explicit point coordinates, all cells of same type.

Properties:

- Extent: min/max indices
- Vertex coordinates

Examples:

- Data structure in simulations with non-uniform density on non-rectangular domain

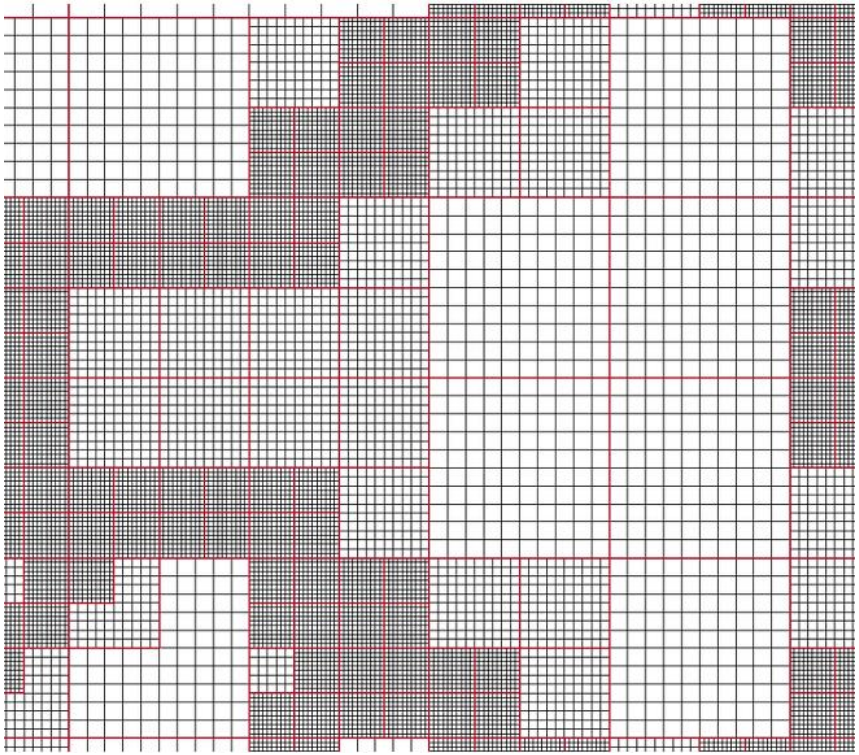


Adaptive Mesh Refinement (AMR)

Collection of non-uniform rectilinear grids (a.k.a. Berger-Oliger mesh).

Examples:

- Data structure in simulations with irregular non-uniform density

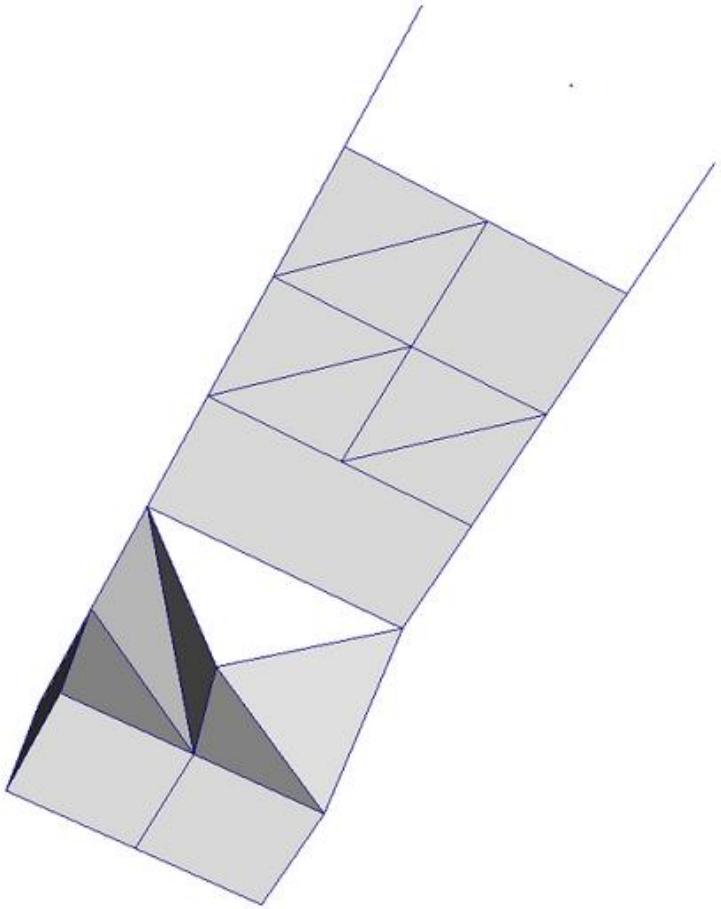


Unstructured grid

Explicit topology, explicit point coordinates, all possible cell types.

Examples:

- Finite Element/Volume Models
- CAD/CAM

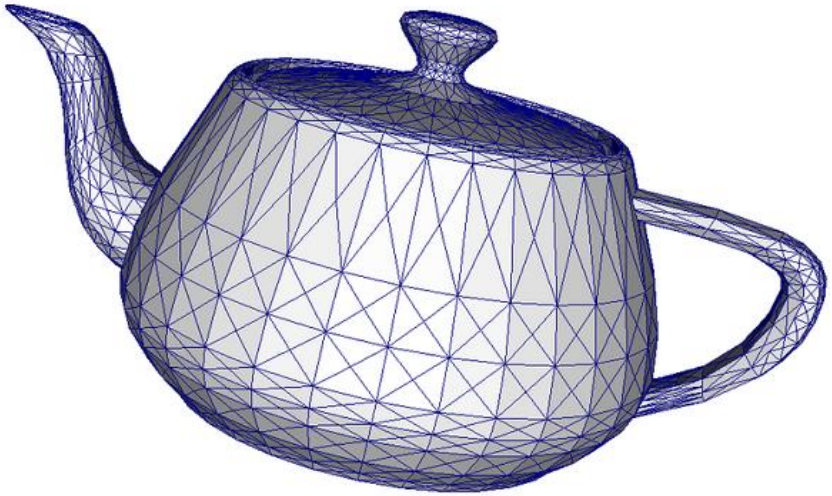


Polygon data

Explicit topology, explicit point coordinates, restricted cell types (vertices, lines, polygons).

Examples:

- Game models (OBJ, STL, PLY)
- Molecule models (PDB)



Software

- Often domain-specific
- Almost all based on visualization pipeline / dataflow concept

Commercial:

- AVS (Advanced Visual Systems)
- IRIS Explorer
- Amira
- Matlab, Mathematica, IDL
- Spotfire
- …

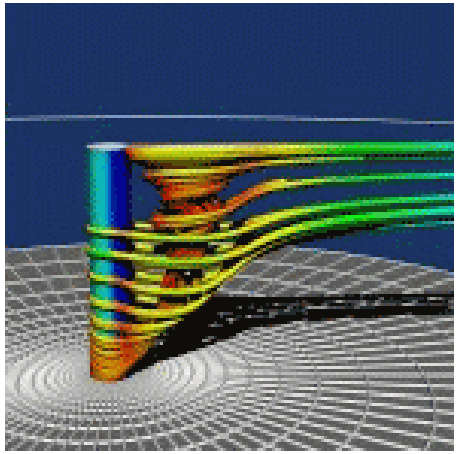
Public domain:

- VTK
- ParaView
- VolView
- VisIt
- DeVIDE
- MeVisLab
- SCIRun
- Gephi
- Cytoscape
- R
- …

The Visualization Toolkit (VTK)

VTK is:

- open source visualization library
  - C++ library with > 1500 classes
  - Language “bindings” to Java, Python, Tcl, Ruby
- works on Unix/Linux, Windows, MacOS
- object-oriented design



VTK provides:

- *Visualization* methods to turn data into geometry
- *Graphics* model to turn geometry into images (OpenGL)
- *Image processing* methods

The Visualization Toolkit (VTK)

VTK is *not*:

- VTK is *not* a programming language
- VTK is *not* an application
  - No drag-and-drop “visual program editor” as with AVS, Iris Explorer, OpenDX, etc.
  - You have to *program*

More info:

- http://www.vtk.org/
- http://www.paraview.org/

ParaView 3.8.1 64-bit

Time: 0 0

ImageFile | Surface

Pipeline Browser

- builtin:
- canyon_elev.raw
- ExtractSurface2
- Tetrahedralize3
- WarpByScalar3

Object Inspector

Properties | Display | Information

Color

- Interpolate Scalars
- Map Scalars

Apply Texture: None

Color by: ImageFile

Edit Color Map... | Rescale to Data Range

Slice

Slice Direction

Slice: 0

Annotation

Show cube axes | Edit

Style

Representation: Surface

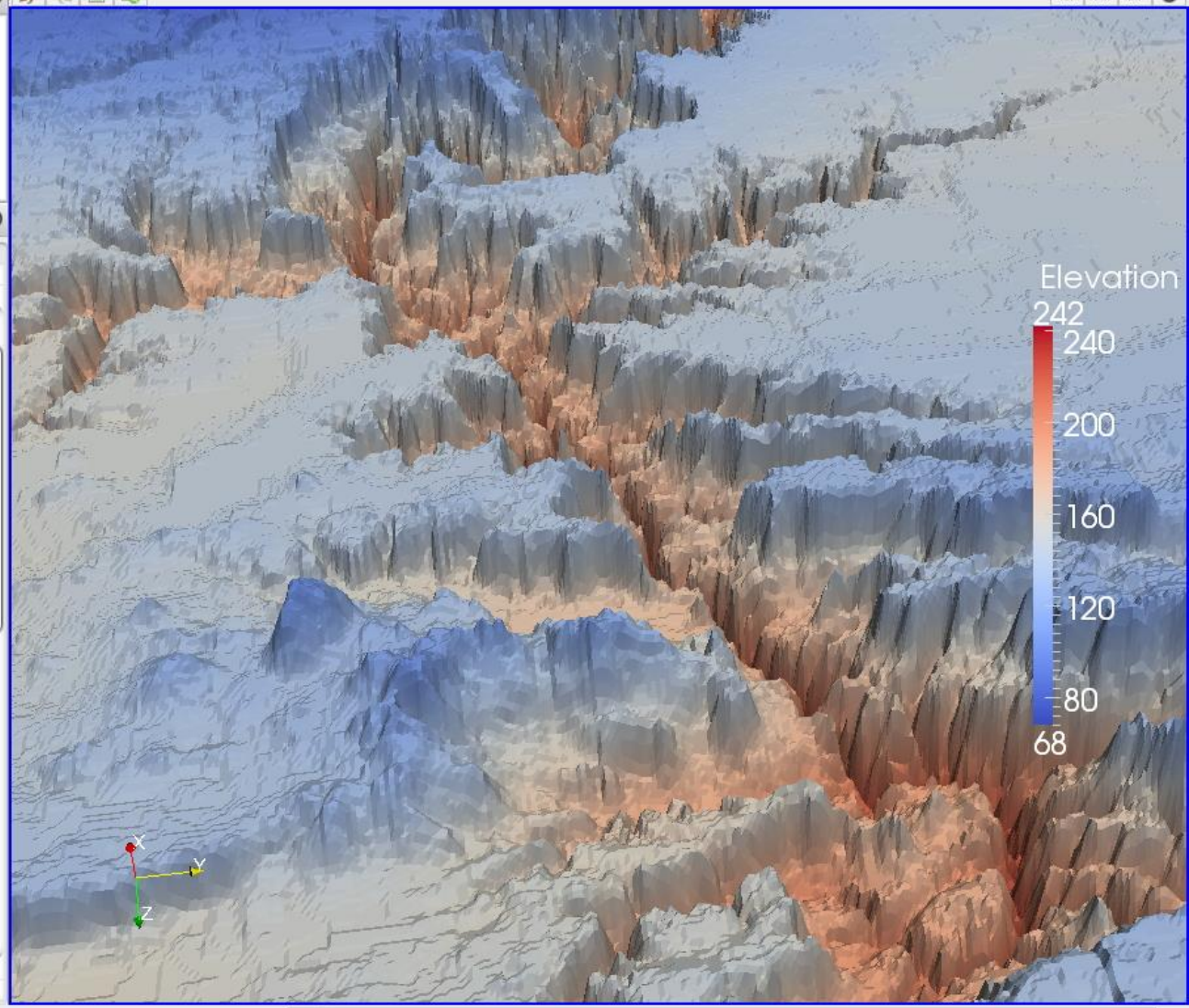
Interpolation: Flat

Material: None

Point size: 2.00

Line width: 1.00

Opacity: 1.00



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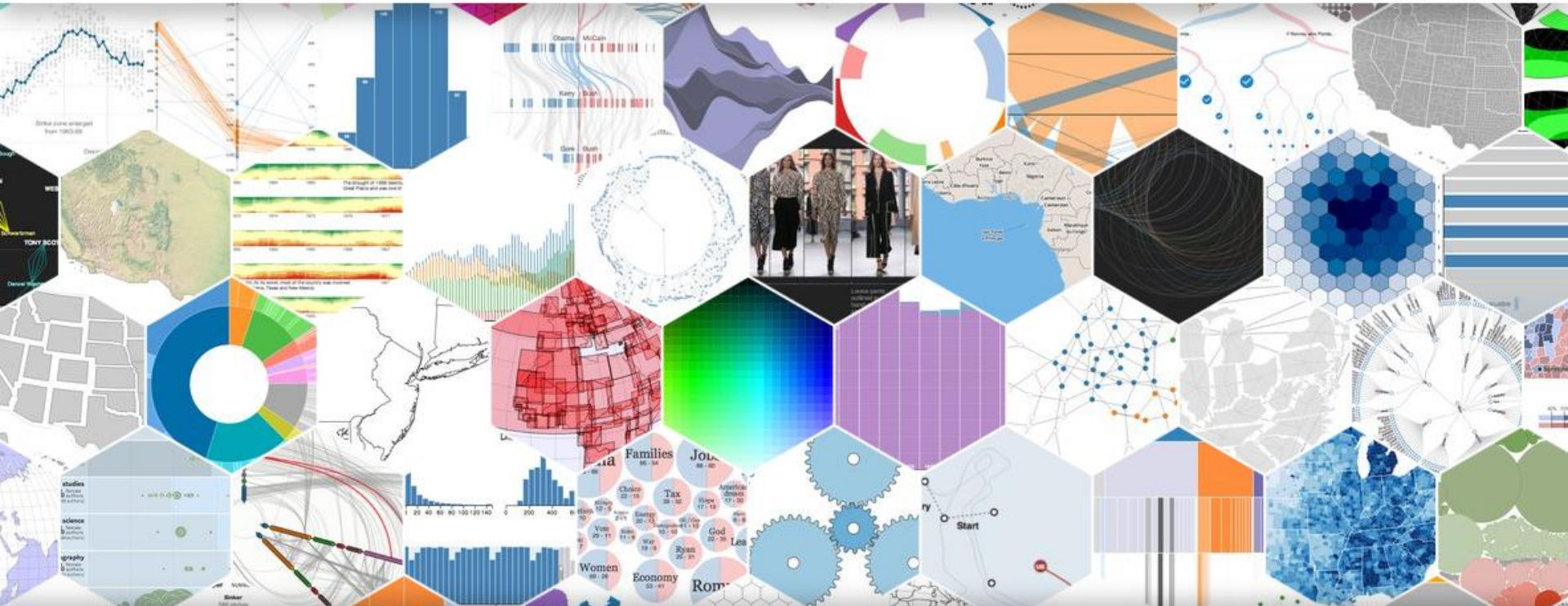
Email: R.G.Belleman@uva.nl

DIY Software: D3.js

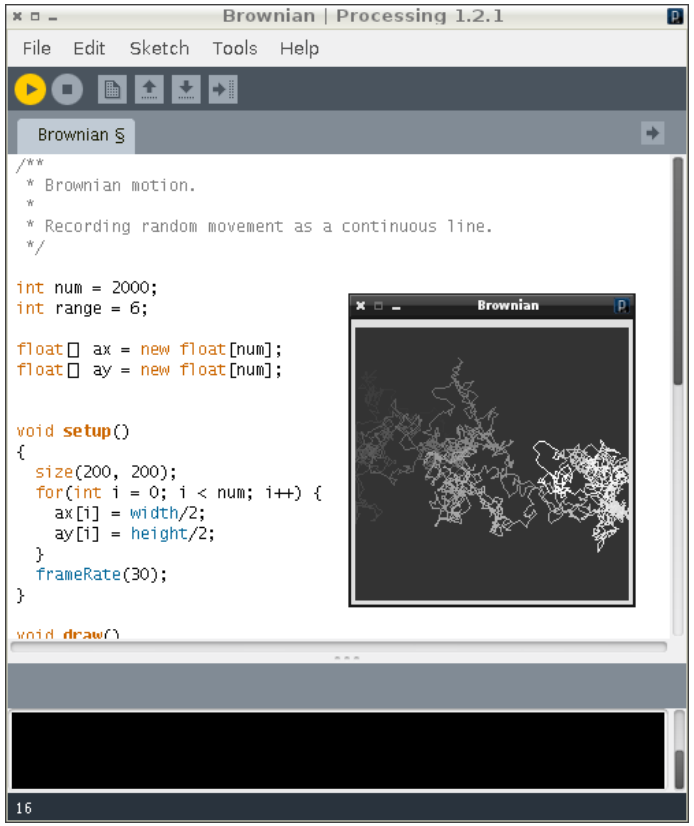
Data-Driven Documents



D3.js tutorial

- http://bost.ocks.org/mike/d3/workshop/#0

Processing


Brownian | Processing 1.2.1
File Edit Sketch Tools Help
Brownian §
/**
* Brownian motion.
*
* Recording random movement as a continuous line.
*/
int num = 2000;
int range = 6;
float[] ax = new float[num];
float[] ay = new float[num];
void setup()
{
size(200, 200);
for(int i = 0; i < num; i++) {
ax[i] = width/2;
ay[i] = height/2;
}
frameRate(30);
}
Brownian
16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login - sign up
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by Diana Lange
sketch
by Aris Bezas
Biomechanics
by Asher Salomon
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share your sketches with others
help and collaborate with the community
improve and polish your programming skills
follow classes around the world teaching processing
Processing is an open source
programming language and
Waiting for www.openprocessing.org...