Local and Remote Visualisation Techniques

UvA HPC cursus

Robert Belleman, UvA/Ivl
Paul Melis, SURFsara
Tijs de Kler, SURFsara
Program for today

- 13:00 – 13:30: Introduction to visualization
- 13:30 – 14:30: Visualization at SURFsara, Introduction to ParaView
- 14:30 – 16:30: Hands-on: scientific visualization with ParaView
- 16:30 – 17:00: Remote Visualization
Introduction to 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 SARA

• 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, …
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A  B  C  D

\begin{align*}
\mu_x &= 9.00, \quad \sigma_x = 3.32 \\
\mu_y &= 7.50, \quad \sigma_y = 2.03 \\
\text{linear regression: } y &= \frac{1}{2}x + 3
\end{align*}

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.

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.

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

Charles Minard, 1869

CARTE FIGURATIVE des pertes successives en hommes de l’Armée Française dans la campagne de Russie 1812-1813.

Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.

TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro

Xbre = December

9bre = November

8bre = October
Software: Tableau

Napoleon's March to Moscow (and back)

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 quoi.

Napoleon's March 1812
The losses of French army during the Russian campaign, 1812-1813.
Software: Spotfire
DIY Software: D3.js
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

CSVReader → TableToPoints → streamtracer → tube → Render

- table
- pointdata
- lines
- polygons
- image
- glyphs
Example: visualizing flow data with streamlines

CSVReader → TableToPoints → streamtracer → tube → Render

Table: pointdata, lines, polygons, image

Glyphs, Outline
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

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- 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.vtk.org/)
Robert G. Belleman, PhD
Informatics Institute
Universiteit van Amsterdam

Science Park 904
1098 XH Amsterdam

Email: R.G.Belleman@uva.nl