Comparative Visualization

Eduard Gröller

Institute of Computer Graphics and Algorithms
Vienna University of Technology
"The use of computer-supported, interactive, visual representations of (abstract) data to amplify cognition"

- Data is increasing in complexity and variability
Comparative Vis.: Where does if fit in?

# Items

- single
- many

Data

- simple
- complex

28,162
Comparative Vis.: Where does it fit in?

- **# Items**
  - single
  - many

- **Data**
  - simple
  - complex

Eduard Gröller
Comparative Vis.: Where does it fit in?

# Items

Data

simple complex

single many

Eduard Gröller
Comparative Vis.:: Where does it fit in?

- # Items:
  - single
  - many

- Data:
  - simple
  - complex

Eduard Gröller
Comparative Vis.: Where does it fit in?

- # Items
  - many
  - single

- Data
  - simple
  - complex

- Information Visualization
- No Visualization
- Scientific Visualization
- Comparative Visualization
Early Examples

Eduard Gröller
On Growth and Form – D‘Arcy Thompson

Human Skull
Skull of Chimpanzee
Skull of Baboon

Polyprion
Pseudopriacanthus alt.
Scorpaena sp.
Antigonia capros
Approaches
### Comparative Visualization: Approaches

<table>
<thead>
<tr>
<th>Juxtaposition</th>
<th>Superposition</th>
<th>Explicit Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Juxtaposition Image" /></td>
<td><img src="image2" alt="Superposition Image" /></td>
<td><img src="image3" alt="Explicit Encoding Image" /></td>
</tr>
</tbody>
</table>

[Gleicher et al.]

Eduard Gröller, Johanna Schmidt
Parameter Studies of Dataset Series

### Dataset Series inComputed Tomography

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Dataset Resolution</th>
<th>No of Datasets</th>
<th>Series Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>1000 * 1000 * 882</td>
<td>4</td>
<td>8.21 GB</td>
</tr>
<tr>
<td>No of Projections</td>
<td>1000 * 1000 * 882</td>
<td>6</td>
<td>9.86 GB</td>
</tr>
<tr>
<td>Current</td>
<td>856 * 856 * 882</td>
<td>6</td>
<td>7.22 GB</td>
</tr>
<tr>
<td>Integration Time</td>
<td>800 * 800 * 882</td>
<td>5</td>
<td>5.26 GB</td>
</tr>
<tr>
<td>Pre- and Post Filter Plates</td>
<td>848 * 848 * 882</td>
<td>15</td>
<td>17.72 GB</td>
</tr>
<tr>
<td>Mean Value Measurement</td>
<td>1000 * 1000 * 882</td>
<td>3</td>
<td>4.93 GB</td>
</tr>
<tr>
<td>Orientation</td>
<td>1000 * 1000 * 882</td>
<td>5</td>
<td>8.21 GB</td>
</tr>
</tbody>
</table>

**Orientation 0 degrees**

**Orientation 90 degrees**
Comparative Slice View

- Viewing two datasets on a single screen
- Viewing multiple datasets on a single screen

Stokking et al. [2003]
Visualization (Multi-image View)

- Each slice shows part of each dataset
Comparative Slice View (Multi-image View)

- Direct density visualization
- Relative density visualization
Analysis of Image Set Differences

- Input
- Difference Calculation
- Clustering
- Visual Analysis
VAICO

Visual Analysis for Image Comparison

Johanna Schmidt
Vienna University of Technology, Austria

M. Eduard Gröller
Vienna University of Technology, Austria

Stefan Bruckner
University of Bergen, Norway
Comparative Visualization: Quo Vadis? (1)

- What to compare? How to compare?

- Scatterplot to illustrate nD point sets
  - Use points as primitives
  - Eliminate most dimensions
  - Visualize distances in 2D

- MObjects to illustrate pores in XCT of CFRP
  - Use pores as primitives
  - Eliminate spatial location
  - Visualize pore orientations

Eduard Gröller
Mean Object (MObject)

Many pores
(shape variation not visible)

[Reh et al.]
MObject Calculation

Individual Objects

MObject

[Reh et al.]
„Similarity is in the eye of the beholder“ –
Task dependency to visualize
- Similarities/dissimilarities
- Outliers
- Trends
- Clusters
- Deviations
- Same/different items
- Larger/smaller items

Complex data lead to complex metrics: How to compare?
- Curves (e.g., Profile Flags)
- Surfaces (e.g., Maximum Similarity Isosurfaces)
- Volumes, flows, tensors
- Trees, graphs
Comparative Vis. of Cartilage Profiles (1)

Profile flags

[Mlejnek et al.]
Maximum Similarity Isosurfaces (1)

Multimodal Similarity Map (MSM)

[Haidacher et al.]
Maximum Similarity Isosurfaces (2)

most similar isovalue

same isovalue

The top views show corresponding surfaces, while the bottom views show different structures.
Visualization of sets ↔ statistical visualization

- Localize analysis in space and/or time
- Requires/allows interactive exploration
Explicit encoding: How to emphasize subtle differences?

Differences visualized through
- Color
- Cut-outs, cut-aways
- Ghosting
- Exploded views
- Focus+context
- Distortion (e.g., Caricaturistic Visualization)
Extrapolate the differences between
- Two individual items
- Individual item and average

[Rautek et al.]
Further topics/issues

- Parameter space analysis
- Uncertainty
- Variability, robustness
- Mapping complex objects onto each other (e.g., gene sequences, molecules, surfaces with varying topology)
- Scalability with respect to
  - # Items
  - Data complexity
Thank You for Your Attention

Questions ? Comments?

Acknowledgments

Wolfgang Berger
Stefan Bruckner
Raphael Fuchs
Michael Gleicher
Martin Haidacher
Christoph Heinzl
M. Muddassir Malik
Matej Mlejnek
Harald Piringer
Peter Rautek
Andreas Reh
Hrvoje Ribičić
Johanna Schmidt
Anna Vilanova
Ivan Viola
Jürgen Waser
…
Comparative Visualization

Visualization uses computer-supported, interactive, visual representations of (abstract) data to amplify cognition. In recent years data complexity and variability has increased considerably. This is due to new data sources as well as the availability of uncertainty, error and tolerance information. Instead of individual objects entire sets, collections, and ensembles are visually investigated. This raises the need for effective comparative visualization approaches. Visual data science and computational sciences provide vast amounts of digital variations of a phenomenon which can be explored through superposition, juxtaposition and explicit difference encoding. A few examples of comparative approaches coming from the various areas of visualization, i.e., scientific visualization, information visualization and visual analytics will be treated in more detail.

Comparison and visualization techniques are helpful to carry out parameter studies for the special application area of non-destructive testing using 3D X-ray computed tomography (3DCT). We discuss multi-image views and an edge explorer for comparing and visualizing gray value slices and edges of several datasets simultaneously.

Visual steering supports decision making in the presence of alternative scenarios. Multiple, related simulation runs are explored through branching operations. To account for uncertain knowledge about the input parameters, visual reasoning employs entire parameter distributions. This can lead to an uncertainty-aware exploration of (continuous) parameter spaces.

VAICo, i.e., Visual Analysis for Image Comparison, depicts differences and similarities in large sets of images. It preserves contextual information, but also allows the user a detailed analysis of subtle variations. The approach identifies local changes and applies cluster analysis techniques to embed them in a hierarchy. The results of this comparison process are then presented in an interactive web application which enables users to rapidly explore the space of differences and drill-down on particular features.

Given the amplified data variability, comparative visualization techniques are likely to gain in importance in the future. Research challenges, directions, and issues concerning this innovative area are sketched at the end of the talk.
References


References