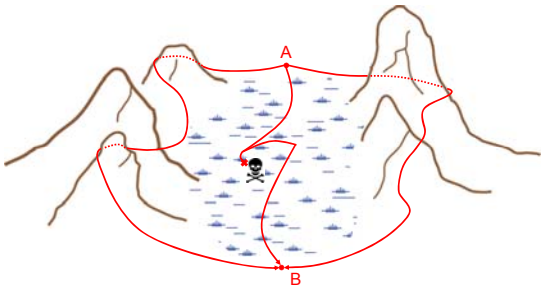
The Haunted Swamps of Heuristics

Eduard Gröller

Institute of Computer Graphics and Algorithms

Vienna University of Technology

Problem Solving ↔ Path Finding



High ground of theory ↔ Haunted swamps of heuristics

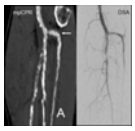
Heuristics

- Heuristics
  - Greek: "Εὑρίσκω", "find" or "discover“
  - Experience-based techniques for problem solving, learning, and discovery
  - Finding a good enough solution
- Examples
  - Trial and Error
  - Draw a picture
  - Assume a solution and work backward
  - Abstract problem → examine concrete example
  - Solve a more general problem first

[Wikipedia, 2011]

Objects of Desire in Science

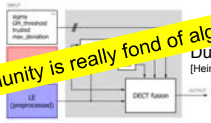
- Focus objects of scientific interest
  - Data



Multipath CPR
[Roos et al., 2007]

Ötzi the Iceman
[Wikipedia, 2011]

  - Artefacts, fossils, mummies
  - Algorithms



Dual Energy CT
[Heinzl et al., 2009]

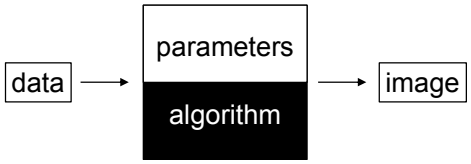
Our community is really fond of algorithms

Objects of Desire – Algorithms

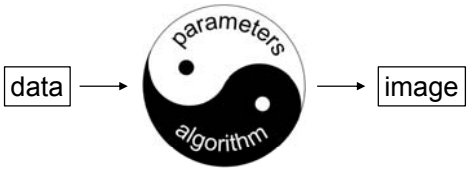
- Algorithm: set of instructions + constants + variables
- And then there are: parameters
- Parameters: auxiliary measures (greek)
- Constraints, boundary conditions, approximations, calibrations ⇒ encoded in parameters
- Whatever does not work ⇒ encoded in parameters
- Parameters often specified heuristically
- Problem solving: algorithm + parameters

Problem Solving: Algorithm + Parameters

Problem Solving: Algorithm + Parameters



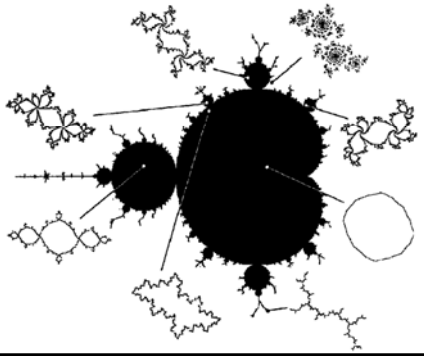
Problem Solving: Algorithm + Parameters



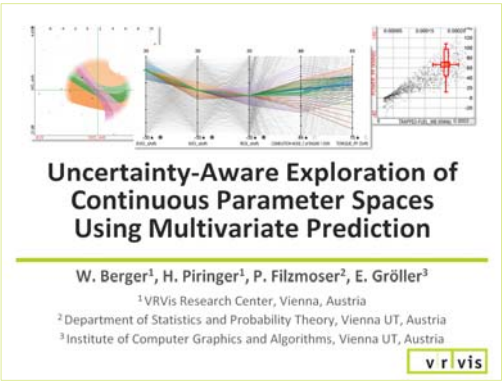
- Parameter space analysis
  - Robustness, stability: well established in other disciplines
  - Increased interest in visualization
    - Variations
    - Esembles
    - Knowledge-assisted visualization

Dynamical Systems – Parameter Space

- Mandelbrot set: parameter space for Julia sets



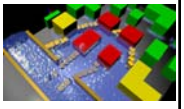
Parameter Space Analysis in Visualization (1)

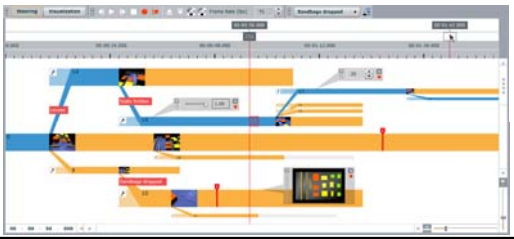


Parameter Space Analysis in Visualization (2)

- World Lines
  - Flood emergency assistance
  - Testing breach closure procedures
  - Steer multiple, related simulation runs
  - Test alternative decisions
  - Analyze and compare multi-runs

[Waser et al., 2010]





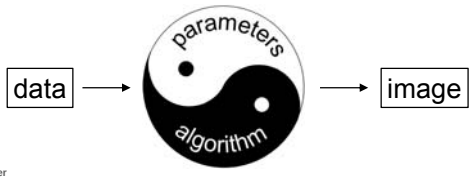
Video

Parameter Space Analysis in Visualization (2)

Problem Solving: Algorithm + Parameters

- Examples
  - Exploration of Continuous Parameter Spaces
  - World Lines

  ⇒ Parameter variation for computational steering
- Visualization algorithms??



Eduard Gröller

Problem Solving: Algorithm + Parameters

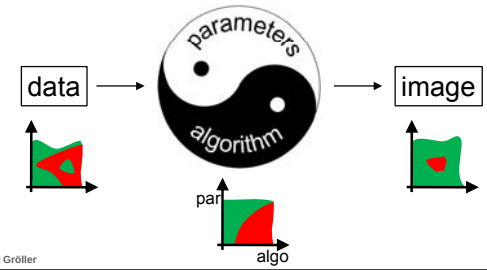
- Algorithms and parameters closely intertwined

algorithm + parameters ⇒ „solution cloud“

Eduard Gröller

Problem Solving: Algorithm + Parameters

- Algorithms and parameters closely intertwined
- Parameters deserve much more attention
- Heuristics ok, but do sensitivity analysis

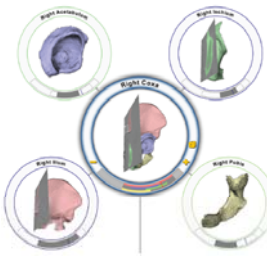


Eduard Gröller

Coping with Complexity and Variability

- Reducing data complexity well established
  - Sub-setting
  - Slicing
  - Projection
  - Dimension reduction
  - Clustering
- Reducing visual complexity ??
  - Integrated views
  - Comparative visualization
  - Fuzzy visualization
  - …

Eduard Gröller

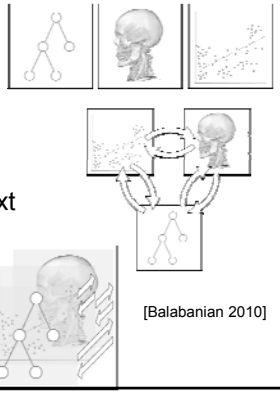


Integrated Views

Balabanian, J-P., Viola, I., Gröller, E.: **Interactive Illustrative Visualization of Hierarchical Volume Data**. Proceedings of Graphics Interface 2010, May 31st–June 2nd, 2010, Ottawa, Ontario, Canada, pp . 137–144

Views - Linked Views - Integrated Views

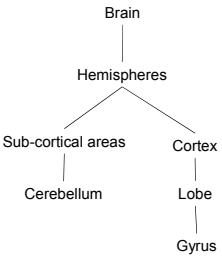
- Separate views
  - \+ Remove overload
  - − Loss of context
- Linked views
  - \+ Re-establish context
  - − Scalability??
- Integrated views



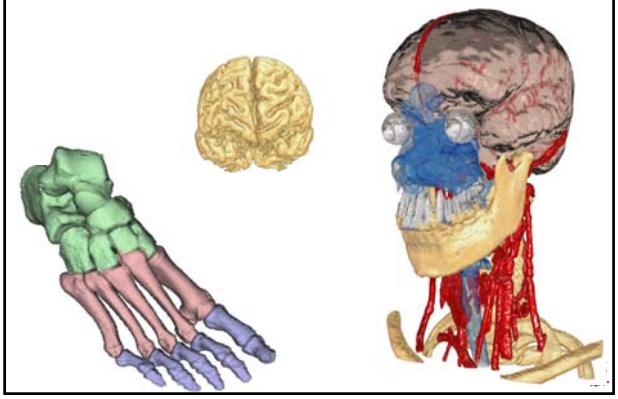
[Balabanian 2010]

Eduard Gröller

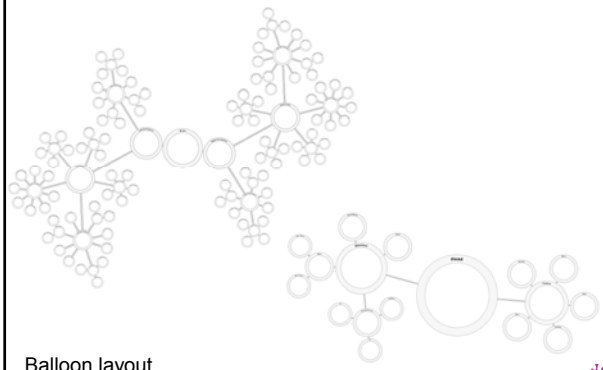
Side-by-side view



Volume Rendering

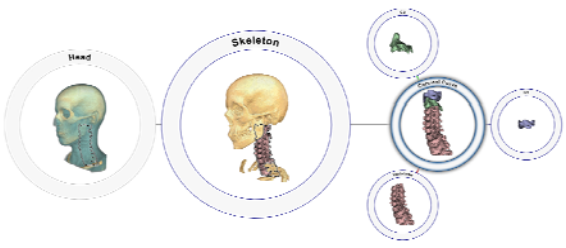


Hierarchical Layout



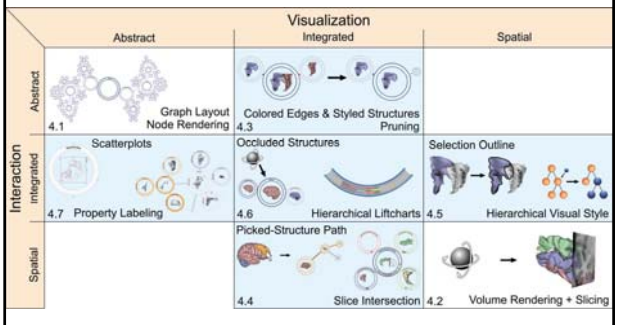
Balloon layout

Integrated View

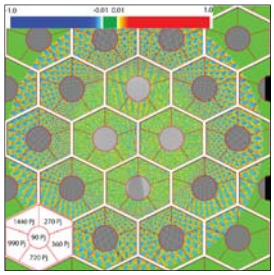


Video

Integrated Visualization and Interaction



Eduard Gröller



Comparative Visualization

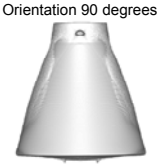
Malik, M.M., Heinzl, Ch.; Gröller, E.: **Comparative Visualization for Parameter Studies of Dataset Series**. IEEE Transactions on Visualization and Computer Graphics, 16(5):829–840, 2010.

Dataset Series

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

Orientation 0 degrees

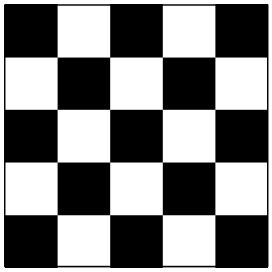
Orientation 90 degrees



Muhammad Muddassir Malik, Eduard Gröller

Comparative Slice View

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



Muhammad Muddassir Malik, Eduard Gröller

Comparative Slice View

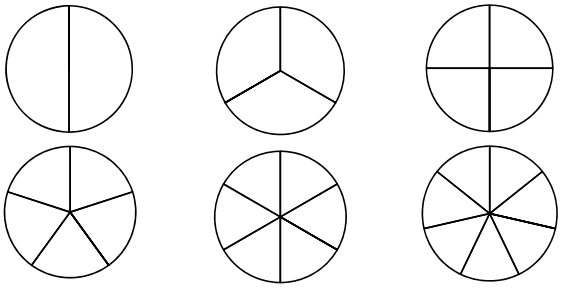
- Viewing two datasets on a single screen
- Viewing multiple datasets on a single screen

Stokking et al. [2003]

Muhammad Muddassir Malik, Eduard Gröller

Comparative Slice View

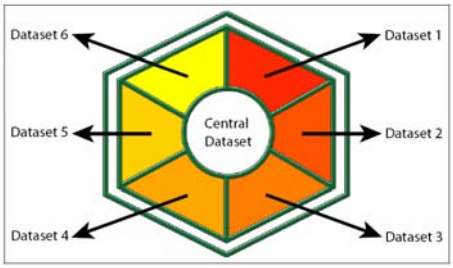
- Viewing two datasets on a single screen
- Viewing multiple datasets on a single screen



Muhammad Muddassir Malik, Eduard Gröller

Visualization (Multi-image View)

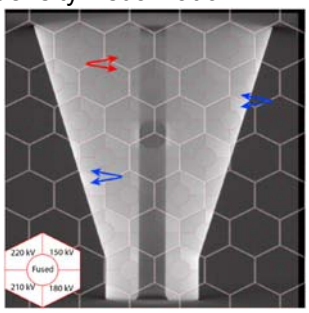
- Each slice shows part of each dataset



Muhammad Muddassir Malik

Comparative Slice View (Multi-image View)

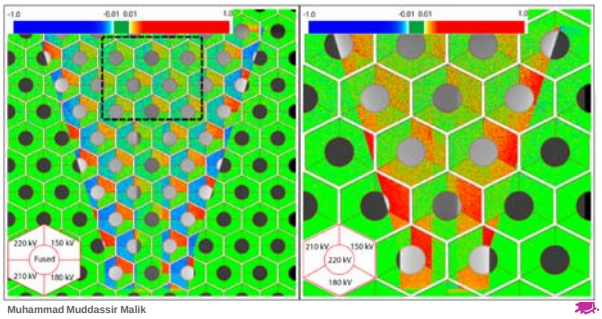
- Direct density visualization
- Relative density visualization



Muhammad Muddassir Malik

Comparative Slice View (Multi-image View)

- Direct density visualization
- Relative density visualization



Muhammad Muddassir Malik

Video: Comparative Visualization - Interaction

Muhammad Muddassir Malik, Eduard Gröller

Fuzzy Visualization

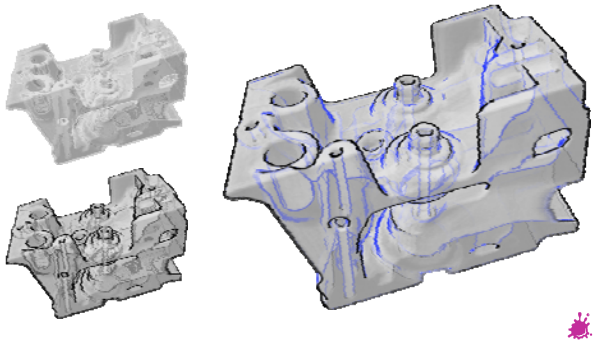
Rautek, P., Bruckner, S., Gröller, E.: **Semantic Layers for Illustrative Volume Rendering**. IEEE Transactions on Visualization and Computer Graphics (Proc. Visualization 2007), 13(6):1336-1343, 2007

if distance to plane is not very low then skin-style is opaque

if distance to plane is very low then skin-style is transparent and muscle-style is transparent

Curvature Based Selective Application

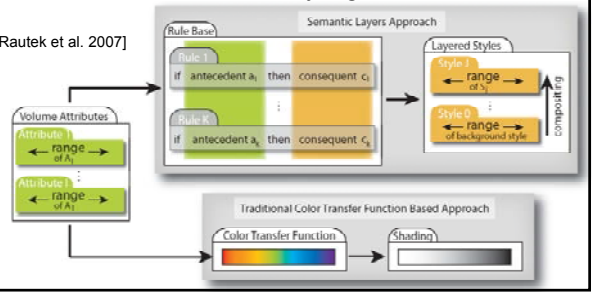
if principal curvature is not positive then contours are blueish



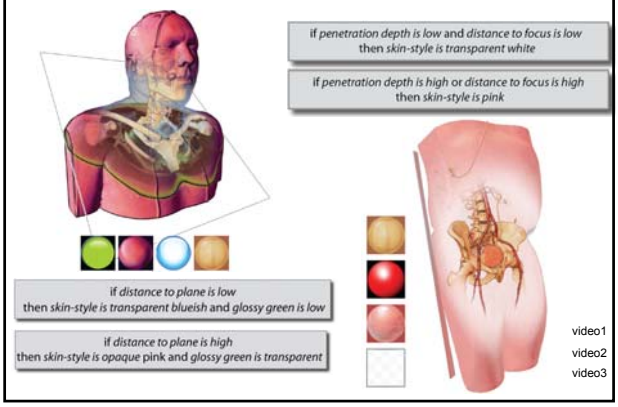
Semantic Layers for Illustrative Volume Rendering

- Mapping volumetric attributes to visual styles
- Use natural language of domain expert (rules)
- Rules evaluated with fuzzy logic arithmetics

[Rautek et al. 2007]



Semantics Driven Illustrative Rendering



Algo., Parms., Heuristics – Quo Vadis? (1)

- Image collections : comput. photography → large data collections: comput. vis. ???
- Integrated views/interaction
- Comparative visualization
- Comparative navigation
- Difference visualization
- Contradictory visualization
- Information theory → fuzzy visualization
- Sparsification of visual representations

Eduard Gröller

Algo., Parms., Heuristics – Quo Vadis? (2)

- Parameter space analysis
  - Local (stability), global (boundaries, basins)
  - Topology of parameter spaces
  - Automatic parameter tuning
- Interaction sensitivity
- Interval arithmetics → distribution arithmetics in visualization (uncertainty visualization)
- Algorithmic centric → data/image centric
- Imperative → declarative approaches

Eduard Gröller

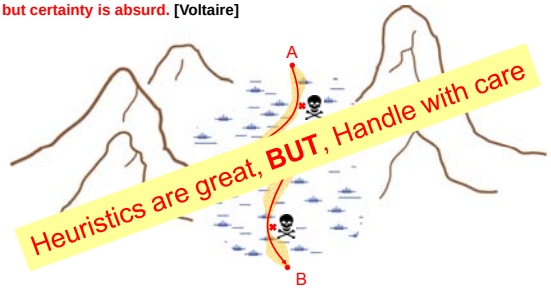
Algo., Parms., Heuristics – Quo Vadis? (3)

- Frameless rendering → algorithmless rendering
- Program verification → image verification
  - Algorithms on demand
  - Each pixel/voxel gets its own algorithm
- Publishing in visualization
  - More stability/robustness analyses in future?
  - Executable Paper Grand Challenge

Eduard Gröller

Problem Solving ↔ Path Finding

Doubt is not a pleasant condition, but certainty is absurd. [Voltaire]



High ground of theory ↔ Haunted swamps of heuristics

Eduard Gröller