The Haunted Swamps of Heuristics

Eduard Gröller
Institute of Computer Graphics and Algorithms
Vienna University of Technology

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

Problem Solving ↔ Path Finding

High ground of theory ↔ Haunted swamps of heuristics

Objects of Desire in Science
- Focus objects of scientific interest
  - Data
  - Artefacts, fossils, mummies
  - 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

- Data → Parameters → Image

- 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)

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

Parameter Space Analysis in Visualization (2)
Parameter Space Analysis in Visualization (2)

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

[Waser et al., 2010]

Eduard Gröller

Video Sketching Uncertainty into Simulations [Ribicic et al., 2012]

Problem Solving: Algorithm + Parameters

- Examples
  - Exploration of Continuous Parameter Spaces
  - World Lines
  - Parameter variation for computational steering
- Visualization algorithms??

Problem Solving: Algorithm + Parameters

- Algorithms and parameters closely intertwined

algorithm + parameters \(\Rightarrow\) „solution cloud”

Problem Solving: Algorithm + Parameters

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

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
  - …

Integrated Views

Views - Linked Views - Integrated Views

- Separate views
  - + Remove overload
  - - Loss of context

- Linked views
  - + Re-establish context
  - - Scalability??

- Integrated views

Side-by-side view

Linked views

Eduard Gröller

Balabanian 2010

Volume Rendering

Hierarchical Layout

Brain
Hemispheres
Sub-cortical areas
Cerebellum
Cerebrum
Lobe
Gyrus

Integrated View

Integrated Visualization and Interaction

Eduard Gröller
**Comparative Visualization**


### Dataset Series

<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>9.88 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>

### Comparative Slice View

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

*Stoikking 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

Video: Comparative Visualization - Interaction

Fuzzy Visualization


Curvature Based Selective Application

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

Semantic Layers for Illustrative Volume Rendering

If principal curvature is not positive then contours are blueish
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

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

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

Problem Solving ↔ Path Finding

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

Heuristics are great, BUT, Handle with care

High ground of theory ↔ Haunted swamps of heuristics.