

The Haunted Swamps of Heuristics



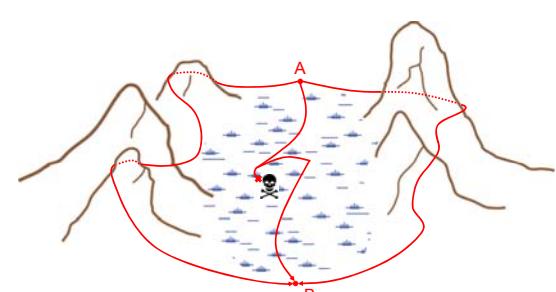
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Problem Solving ↔ Path Finding

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High ground of theory ↔ Haunted swamps of heuristics

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Heuristics

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- Heuristics
 - ◆ Greek: "Εύπίσκω", "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]

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Objects of Desire in Science

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- Focus objects of scientific interest
 - ◆ Data
 - ◆ Artefacts, fossils, mummies
 - ◆ Algorithms

Multipath CPR [Roos et al., 2007]

Ötzi the Iceman [Wikipedia, 2011]

Our community is really fond of algorithms

Dual Energy CT [Heinzl et al., 2009]

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Objects of Desire – Algorithms

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- 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

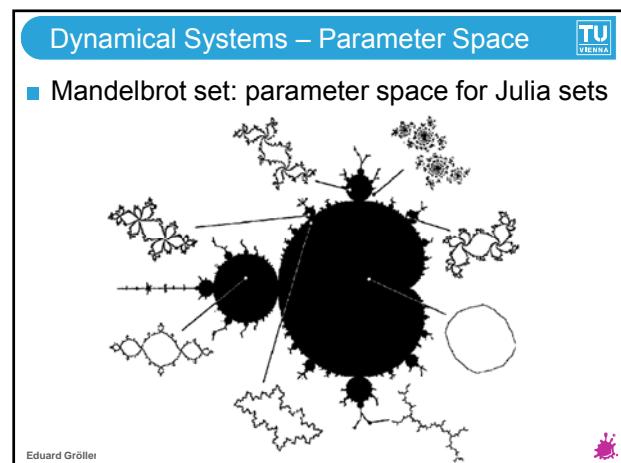
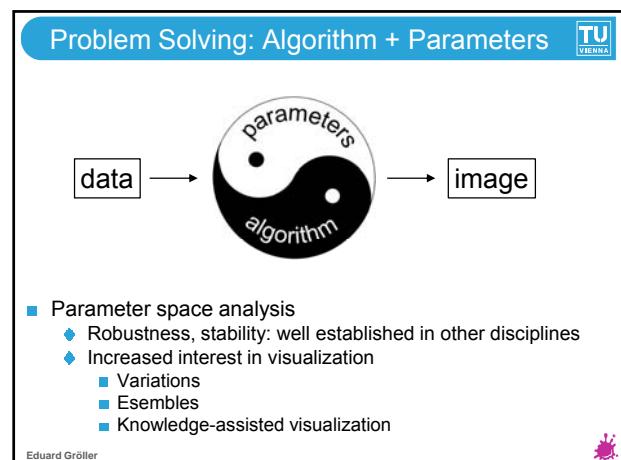
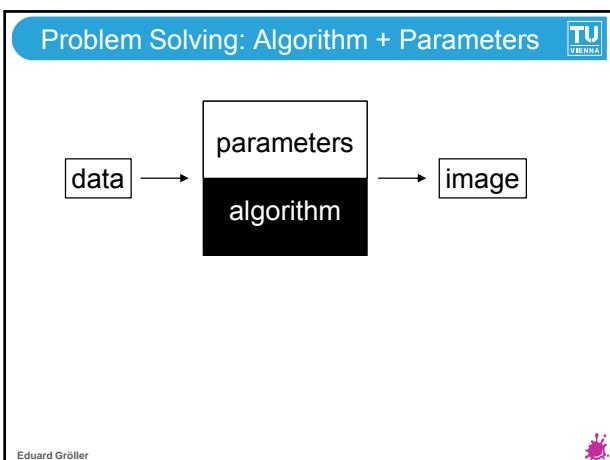
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Problem Solving: Algorithm + Parameters

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Parameter Space Analysis in Visualization (1)

Uncertainty-Aware Exploration of Continuous Parameter Spaces Using Multivariate Prediction

W. Berger¹, H. Piringer¹, P. Filzmoser², E. Gröller³

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Parameter Space Analysis in Visualization (2)

■ World Lines [Waser et al., 2010]

World Lines

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

Video

Parameter Space Analysis in Visualization (2)

World Lines

- Fluent connectivity assistance
- Testing branch closure procedures
- Other multi-scale simulation techniques
- Test data
- Analysis

Dobrev et al., 2010

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

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Problem Solving: Algorithm + Parameters

Examples

- Exploration of Continuous Parameter Spaces
- World Lines
- Parameter variation for computational steering

Visualization algorithms??

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Problem Solving: Algorithm + Parameters

Algorithms and parameters closely intertwined

algorithm + parameters \Rightarrow „solution cloud“

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Problem Solving: Algorithm + Parameters

Algorithms and parameters closely intertwined

Parameters deserve much more attention

Heuristics ok, but do sensitivity analysis

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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
- ...

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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

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

[Balabanian 2010]

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Side-by-side view

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```

graph TD
    Brain[Brain] --> Hemispheres[Hemispheres]
    Hemispheres --> SubCortical[Sub-cortical areas]
    Hemispheres --> Cortex[Cortex]
    SubCortical --> Cerebellum[Cerebellum]
    Cortex --> Lobe[Lobe]
    Lobe --> Gyrus[Gyrus]
  
```

Volume Rendering

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Hierarchical Layout

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Balloon layout

Integrated View

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Head, Skeleton, Spine and Cervix

Video

Integrated Visualization and Interaction

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	Abstract	Integrated	Spatial
Interaction	4.1 Graph Layout Node Rendering	4.3 Colored Edges & Styled Structures Pruning	
Abstract	4.2 Scatterplots	Occluded Structures	Selection Outline
Integrated	4.6 Property Labeling	4.5 Hierarchical Lifcharts	4.8 Hierarchical Visual Style
Spatial	4.4 Picked-Structure Path	4.2 Slice Intersection	4.1 Volume Rendering + Slicing

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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.

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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

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Comparative Slice View

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

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Comparative Slice View

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

Stokking et al. [2003]

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Comparative Slice View

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

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Visualization (Multi-image View)

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- Each slice shows part of each dataset

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Comparative Slice View (Multi-image View)

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- Direct density visualization
- Relative density visualization

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Comparative Slice View (Multi-image View)

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- Direct density visualization
- Relative density visualization

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Video: Comparative Visualization - Interaction

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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

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if principal curvature is not positive then contours are blueish

Semantic Layers for Illustrative Volume Rendering

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- 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

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if penetration depth is low and distance to focus is low
then skin-style is transparent white

if penetration depth is high or distance to focus is high
then skin-style is pink

if distance to plane is low
then skin-style is transparent blueish and glossy green is low

if distance to plane is high
then skin-style is opaque pink and glossy green is transparent

video1
video2
video3

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

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- 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

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

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- 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

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

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- 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

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Problem Solving ↔ Path Finding

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

A

B

Heuristics are great, BUT, Handle with care

High ground of theory ↔ Haunted swamps of heuristics

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