Visualisierung – Aktuelle Themen und Trends

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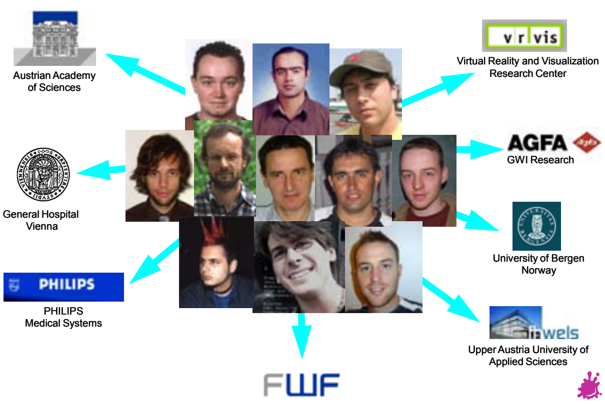
Outline

- Vis-group at Vienna University of Technology
- Brief Comments on Visualization
- Challenges in Visualization

The vis-group



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Scientific Visualization - Information Visualization

"The use of computer-supported, interactive, visual representations of (abstract) data to amplify cognition"

- computer-based - new medium
- interactive - direct manipulation & animation
- visual representations - use human perception
- data - task specific
- amplify cognition - helping people to think

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Visualization – Three Major Areas

- Three major areas
  - Volume Visualization
  - Flow Visualization

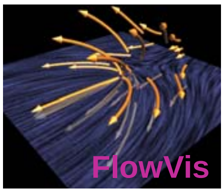
  Scientific Visualization — Inherent spatial reference — 3D

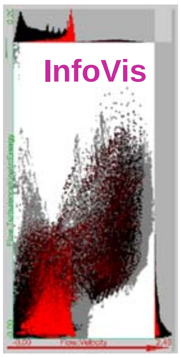
  - **Information Visualization**

  nD — Usually no spatial reference

Eduard Gröller, Helwig Hauser

Visualization Examples





InfoViz vs. SciViz

InfoViz

- Abstract data
- n-dimensional
- Very important:
  - Visual metaphor
  - User interaction
  - **Exploration**, Analysis, Presentation

SciViz

- Concrete Data
- 2- oder 3-dimensional, time related?
- Very important:
  - 3D-rendering
  - Fast rendering
  - **Analysis**, Exploration, Presentation

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Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
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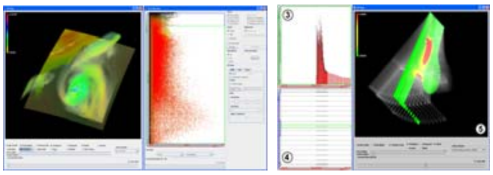
SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

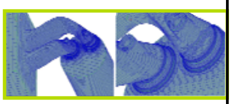


Dr. Helmut Doleisch
VRVis Research Center

http://www.VRVis.at/

The Beginning: CFD Data

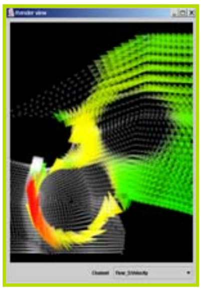
- computational fluid dynamics simulation
- data resulting from CFD:
  - grid-based geometry
  - scalar and vector data per grid element (cell or vertex)
  - time-dependent results
  - time-varying grid geometries
- data characteristics:
  - multi-dimensional data
  - large data sets (#cells * #timesteps * #dim.)
  - data ranges differ by many magnitudes



Helmut Doleisch
http://www.simvis.at/
SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

Motivation

- large data sets from simulation
- **goal**: support **exploration** and **analysis** of results
  - analyze n-dim. data interactively
  - use 3D visualization
  - overview, zoom and filter, detail on demand (Shneidermans' information seeking mantra)
- challenge:
  - occlusion
  - interactive data handling



Interactive Data Handling

- sample data set size:
  - 540 million data items
  - currently working to expand to billions

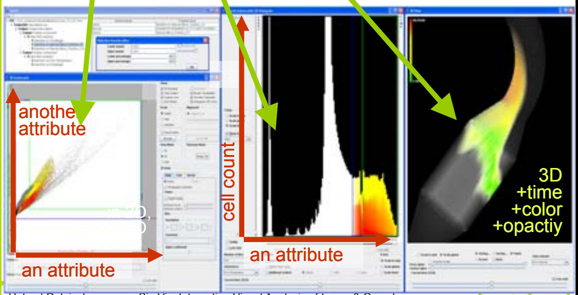
cells	timesteps	attributes	cells * timesteps	cells * timesteps * attributes
704.900	20	16	14.098.000	225.568.000
150.124	600	6	90.074.400	540.446.400
7.680.000	288	15	2.211.840.000	33.177.600.000

SimVis

- VRVis´ solution for these challenges
- Feature-based visualization framework
- SimVis key features:
  - Multiple, linked views
  - Interactive feature specification
  - Focus+Context visualization
  - Smooth feature boundaries
  - Explicit feature representation
  - On-the-fly attribute derivation

SimVis: Multiple Views

- Scatterplots, histogram, 3D(4D) view, etc.



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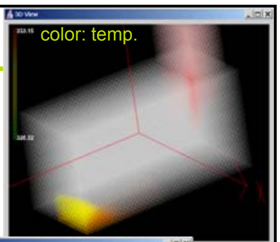
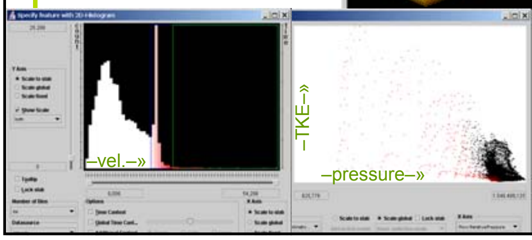
SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

Brushing

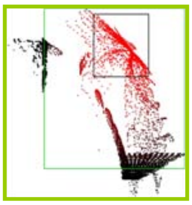
- Move/alter/extend brush interactively
- Update linked F+C views in real-time

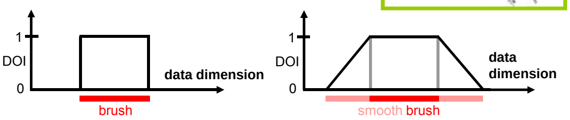




Brushing extensions: smooth brushing

- simulation data is often rather smoothly distributed ➔
  - we use smooth brushing, resulting in continuous mapping to the [0,1] range





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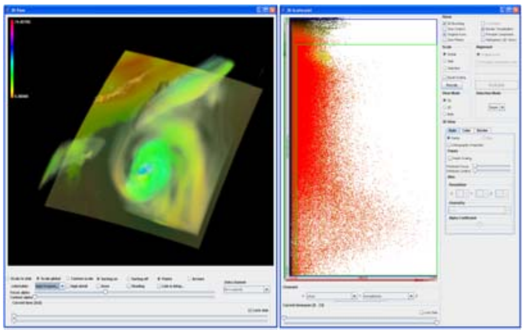

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SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
- New Data Sources - Novel Imaging Modalities

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New Data Sources - Novel Imaging Modalities

- Challenges
  - Very large (abstract) data sets
  - High-dimensional, multi-valued, multi-modal, heterogeneous
  - Time varying
    - Spatially sparse/dense, temporally sparse/dense
    - Need for registration
    - Need for feature extraction
- Examples
  - Web 2.0
  - Dual energy CT

Data → Visualization Technique ← Vis. Goal

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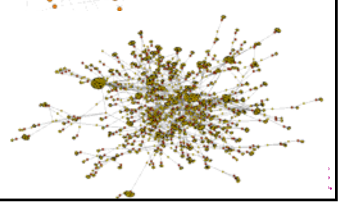
New Data Sources – Web 2.0

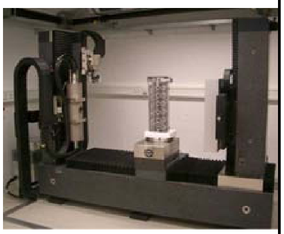
- Social networks, wikis, blogs, data warehouses

[Pfeffer 2007]

- Examples
  - MySpace
  - LinkedIn
  - Flickr
  - YouTube



Novel Imaging Modalities – Dual Energy CT



- Micro CT – Industrial CT
- Two X-ray sources
- Metrology and dimensional measurement
- Multi-materials
- Res: 508x523x61
- Voxelsize (μm) 200
- Data have complimentary strengths and weaknesses

[Heinzl et al. 2007]

Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
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- Visual Analytics - Visual Computing – Knowledge Assisted Visualization
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Visual Analytics

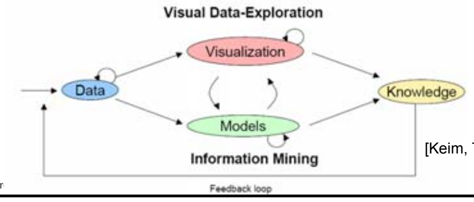
"Visual Analytics is the science of analytical reasoning facilitated by interactive visual interfaces"

What do we have?

- Automatic Knowledge Discovery & Information Mining
- Interactive Visual Data-Exploration

What do we need?

Tight Integration of Visual and Automatic Data Analysis Methods with Database Technology for a Scalable Interactive Decision Support



[Keim, Thomas 2007]

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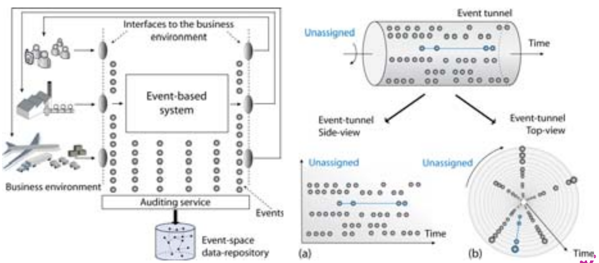
Visual Analytics – The Event Tunnel (1)

- Interactive Visualization of Complex Event Streams for Business Process Pattern Analysis

[Suntinger et al. 2008]



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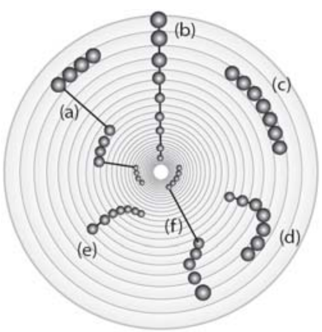
Visual Analytics – The Event Tunnel (2)



(a) Stair pattern
Process with several idle times

(b) Non-interfering chain
Process with regular steps

(c) Parallel chain
Fast process without idle times

(d) Acceleration worm
Process execution accelerated continously

(e) Deceleration worm
Process execution decelerated continously

(f) Rattlesnake
Process with one extreme idle time

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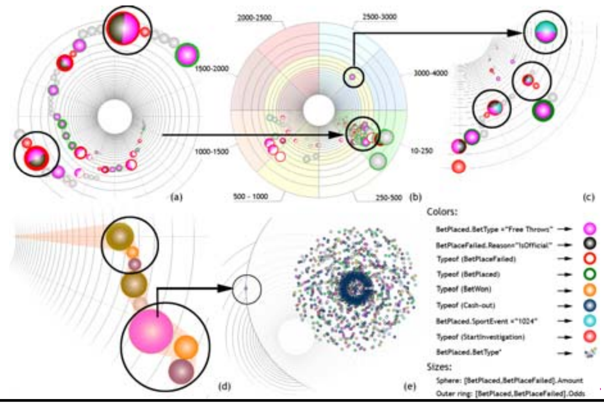
Visual Analytics – The Event Tunnel (3)



Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
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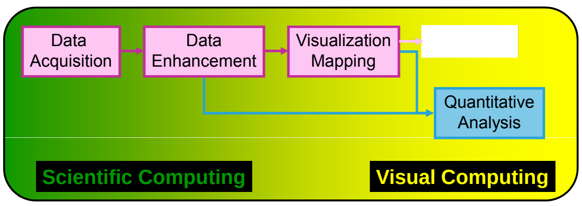
Visual Computing - Computational Sciences

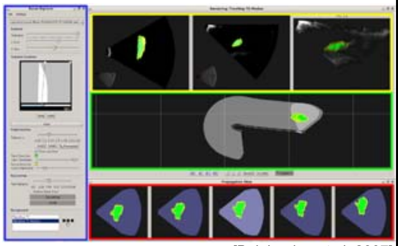
Computational Sciences



- Visual Computing
  - Scientific visualization
  - Computer vision
  - Human computer interaction

Visual Computing – Sonar Explorer (1)

- 4D sonar data
- Cones with res: 25x20x1319
- Ping rate 1 Hz
- 2 GB/ping
- Time steps overlapping
- Highly anisotropic
- Noisy
- Signal strength reduced with spreading and absorption



[Balabanian et al. 2007]

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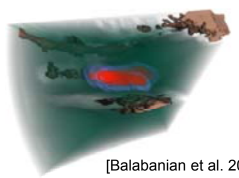
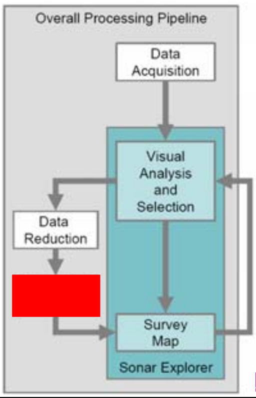
Visual Computing – Sonar Explorer (2)

- Fish school monitoring
  - Size of school
  - Center of gravity
  - Shape parameters
  - Motion characteristics



[Balabanian et al. 2007]



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Knowledge Assisted Visualization (KAV)

"Utilize knowledge and information derived from the process of scientific visualization or from abstract data analysis"

- Challenges
  - Metadata visualization
  - Visualization enabled by
    - topological information of the data
    - statistical information of the data
    - geometric information of the data
    - semantic information of the data
  - Visualization via learning
  - Visualization via shared knowledge in a collaborative setting
  - Knowledge representation for visualization
- Example
  - Automatic view point selection
  - Automatic reporting

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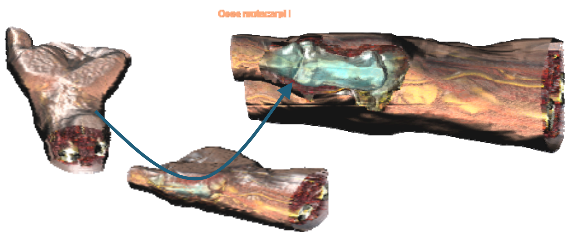
KAV - Importance-Driven Focus of Attention (1)

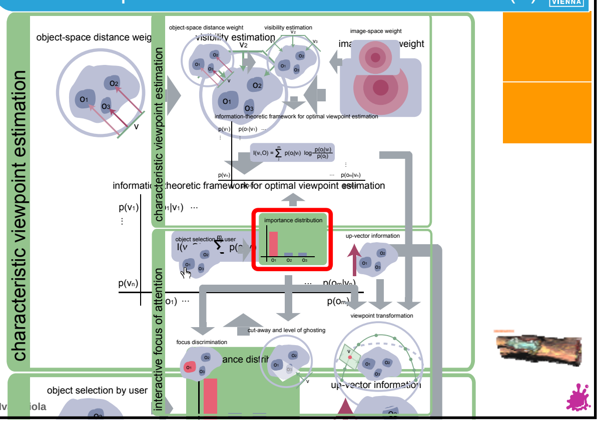
- Guided navigation between characteristic views

[Viola et al. 2006]



Eduard Gröller, Ivan Viola

KAV - Importance-Driven Focus of Attention (2)



Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
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- Scalability
-
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Scalability

- Challenges [Keim, Thomas 2007]
  - amount of data and dimensionality
  - numbers of data sources and heterogeneity
  - data quality and data resolution
  - dynamicity and novelty
  - data representation and visual resolution
- Examples
  - Focus+Context
  - Aggregation
  - Abstraction and Illustration

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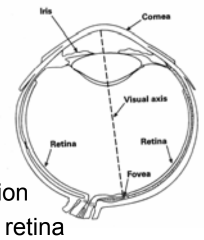
Scalability - Focus+Context Principle

Basic idea of Focus+Context Visualization:

- Important regions in great detail (focus)
- Global view with reduced detail (context)
- Dynamic integration



Rationale

- Zooming hides the context
- Two separate displays split attention
- Human vision has both fovea and retina

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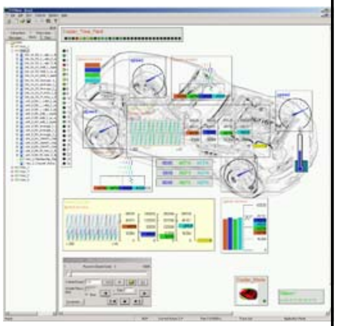
Scalability - Process Visualization (1)

- Improving singular instruments
  - History encoding
  - Multi-instruments
  - Levels of detail (LOD)
- Improving the monitoring system
  - Focus+Context (F+C) rendering
  - Collision avoidance



[Matković et al. 2002]

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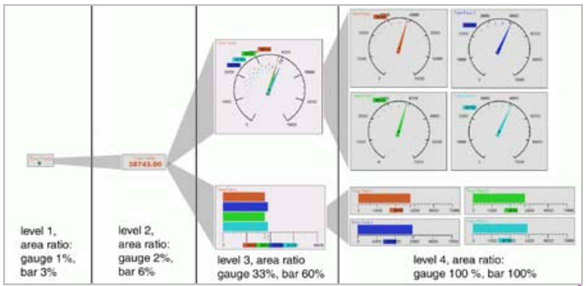
Scalability - Process Visualization (2)

- Various instruments can be used to construct Levels of Detail (LODs)



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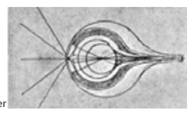
Scalability - Illustration

- An illustration is a picture with a communicative intent
- Conveys complex structures or procedures in an easily understandable way
- Uses abstraction to prevent visual overload – allows to focus on the essential parts
- Abstraction is visualized through distinct stylistic choices



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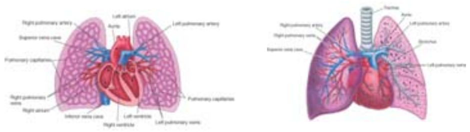
Scalability - Abstraction

- Fundamental for creating an expressive illustration
- Introduces a distortion between visualization and underlying model
- Different degrees of abstraction introduced at different levels
- Task of an illustrator: find the necessary abstraction for the intent of the illustration



„As detailed as necessary - as simple as possible“

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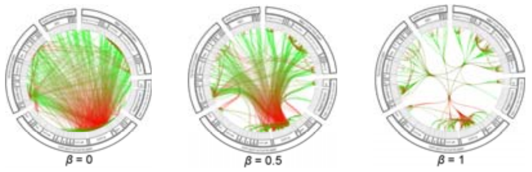
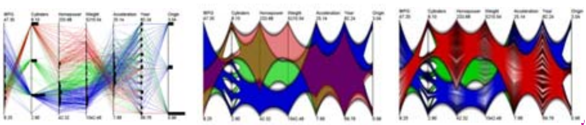
Scalability – Illustration Examples

- Hierarchical Edge Bundles

[Holten 2006]



- Illustrative Parallel Coordinates



[McDonnell, Mueller 2008]

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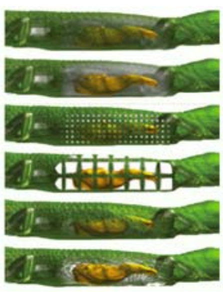
Scalability – Smart Visibility (1)

- Importance-driven feature enhancement

[Viola et al. 2004, 2005]



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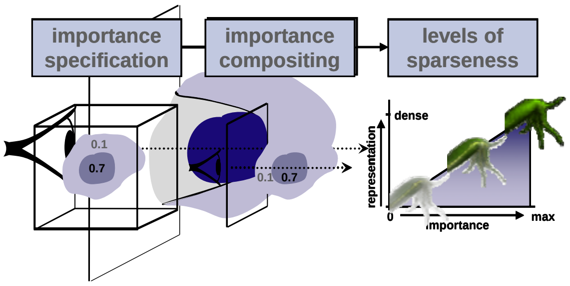
Scalability – Smart Visibility (2)

[Viola et al. ‘04 ‘05]



importance-driven feature enhancement

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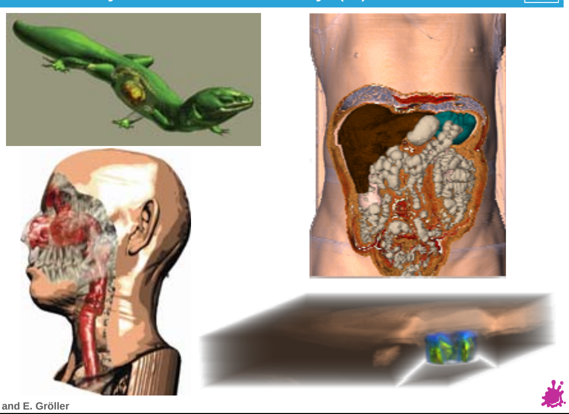
Scalability – Smart Visibility (3)



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Scalability

Do not fight complexity with complexity

Challenges in Visualization

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- Scalability
- Visualization Yes ! – Interaction No ?
-

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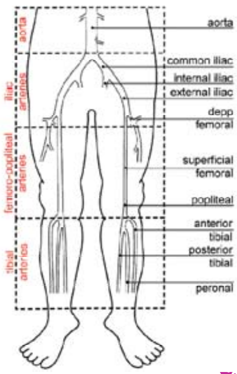
Visualization Yes ! – Interaction No ?

- Problems
  - Interaction is very time-consuming
  - Interaction prevents comparisons
  - Interaction hampers reporting
- Challenges
  - Provide standardized views
  - Algorithms highly parameterized – provide sensible default settings
  - Support automatic parameter tuning
  - Provide navigational aids
- Examples
  - Automatic view point selection
  - Focus of attention
  - Automatic light placement (inconsistent lighting)
  - Automatic reporting
  - Dynamic poster - automatic storytelling



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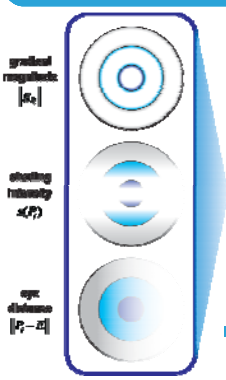
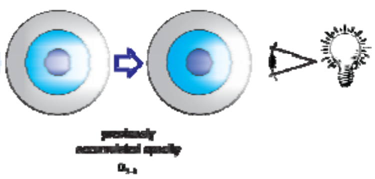
Context-Preserving Rendering (1)

[Bruckner et al. 2006]

$$m(P_i) = \|g_{P_i}\|^{(\kappa_t \cdot s(P_i)(1-\|P_i - E\|)(1-\alpha_{i-1}))^{\kappa_s}}$$

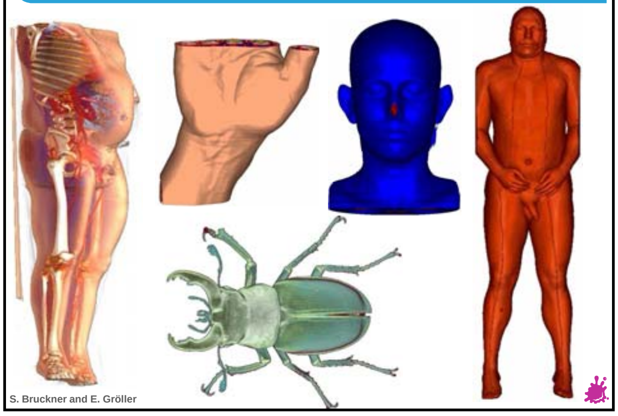




- Integrate various focus+context approaches with only few parameters

S. Bruckner and E. Gröller

Context-Preserving Rendering (2)



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Visualization Yes ! – Interaction No ?

Provide the user with the flexibility he/she can cope with –
avoid the terror of unconstrained liberty

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- Interaction Yes ! – BUT User centric !

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Interaction Yes ! – BUT User Centric !

- Problems
  - Medical doctors do not (want to) know transfer functions
  - Complex 3D interaction is complex
- Challenges
  - Include user model (novice, experienced, expert)
  - Include motifs
  - Include user preferences
  - 2D+ navigation (instead of 3D navigation)
- Examples
  - Semantic layers for illustrative volume rendering
  - Knowledge-based navigation

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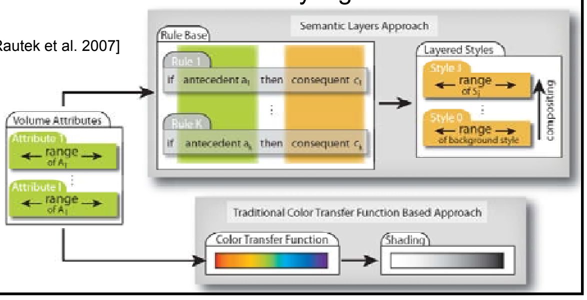
Semantic Layers for Illustrative Volume Rendering (1)

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

[Rautek et al. 2007]



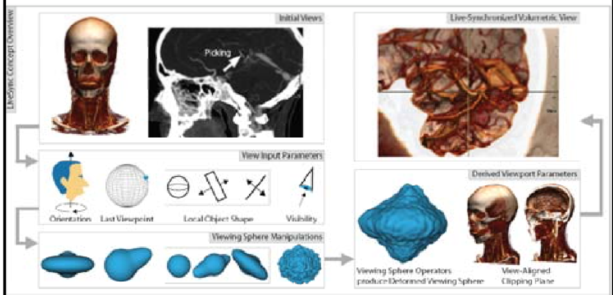
Semantic Layers for Illustrative Volume Rendering (2)

Die Grenzen meiner Sprache bedeuten die Grenzen meiner Welt

[Ludwig Wittgenstein]

Knowledge-Based Navigation

- Interaction with 2D slices
- Automatic generation of expressive 3D views



[Kohlmann et al. 2007] Video

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Bring **visualization** into the workflow of users!!

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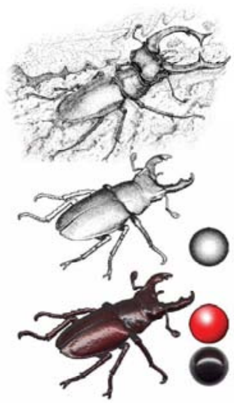
Thank You for Your Attention



Questions ?
Comments?

Acknowledgments

Jean-Paul Balabanian
Stefan Bruckner
Helmut Doleisch
Helwig Hauser
Christoph Heinzl
Krešimir Matković
Hannes Obweger
Peter Rautek
Martin Suntinger,
Ivan Viola
...