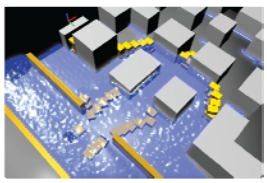


Trends in Visual Computing

Eduard Gröller

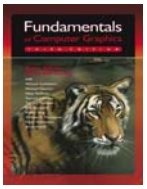
Institute of Computer Graphics and Algorithms
Vienna University of Technology

Vienna University of Technology (VUT)

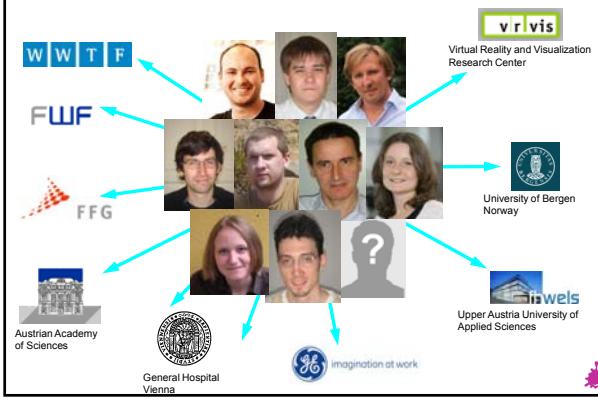
- VUT consists of 8 faculties
  - Scientific staff: ≈ 3.600
  - Students: ≈ 27.000 students
  - Graduates: 1.790 + 169 Ph.D. (2011)
- Faculty of Informatics
- Seven computer science institutes
- Institute of Computer Graphics and Algorithms (ICGA)
- Computer Graphics at ICGA (Purgathofer)
  - Rendering group (RVR): Wimmer
  - Visualization group (vis-group): Gröller

Teaching at ICGA

- Bachelor Studies: Media Informatics und Visual Computing
- Master Studies: Visual Computing
- Lectures (examples):
  - Introduction to Visual Computing
  - Computer Graphics
  - Rendering
  - Real-time Graphics
  - Introduction to Colour Science
  - Virtual Reality
  - Computeranimation
  - Visualization 1+2
  - Information Visualization
  - Medical Visualization 1+2
  - Augmented Reality on Mobile Devices

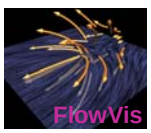


Vis-Group and Funding and Projects



(Data) Visualization (1)

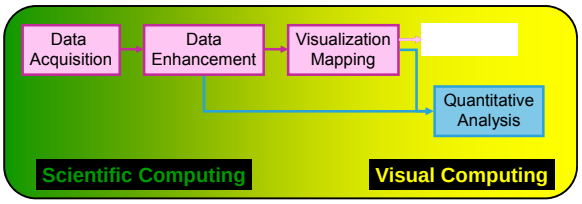
"The use of computer-supported, interactive, visual representations of (abstract) data to amplify cognition"



- Data is increasing in complexity and variability

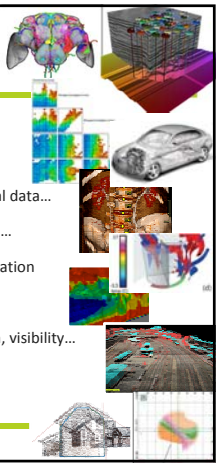
Visualization - Visual Computing

Visualization Pipeline



- Visualization is part of Visual Computing
- Visual Computing is acquistion, representation, processing, analysis, synthesis, and usage of visual information

Visual Computing is a Lot…

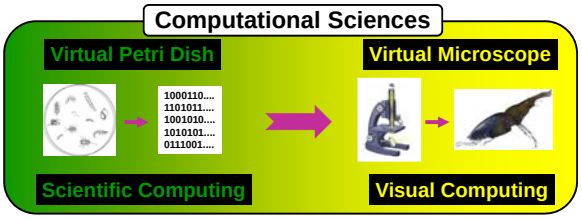


- **Computer Graphics**
  graphical user interfaces, animations …
- **Computer Vision /Pattern Recognition**
  modeling human vision…
- **Visualization**
  displaying volume- and other high-dimensional data…
- **Interactive Visual Analysis**
  presenting multidimensional data for analysis…
- **Visual Sensors**
  recording methods for obtaining visual information
- **Modeling**
  digital models from data/images
- **Rendering**
  real-time visualization, illumination simulation, visibility…
- **Virtual/Augmented Reality**
  combining real and virtual environments
- **Human-Computer-Interaction**
  the interface between users and computers

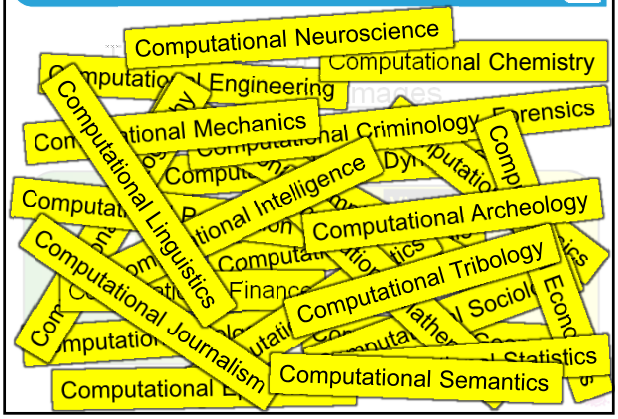
GS/WP

Visual Computing embedded in Science

The purpose of visual computing is insight, not images



Visual Computing embedded in Science



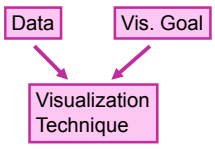
Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities

Eduard Gröller

New Data Sources - Novel Imaging Modalities

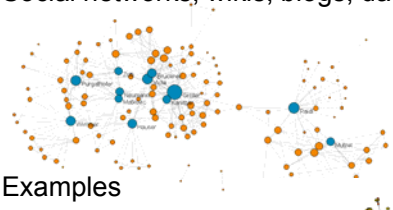
- Challenges
  - Very large (abstract) data sets
  - High-dimensional, multi-valued, multi-modal, heterogeneous
  - Time varying
    - Spatially sparse/dense, temporally sparse/dense
    - Need for registration
    - Need for feature extraction
- Examples
  - Web 2.0
  - Sonar Explorer



Eduard Gröller

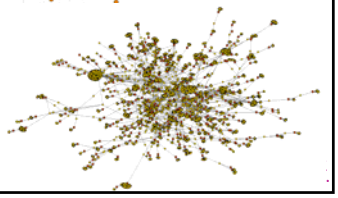
New Data Sources – Web 2.0

- Social networks, wikis, blogs, data warehouses



[Pfeffer 2007]

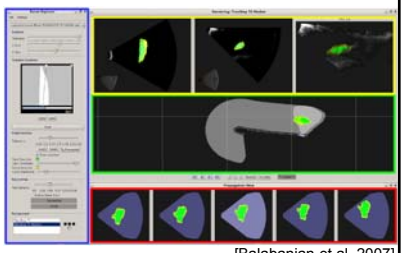
- Examples
  - Facebook
  - Twitter
  - LinkedIn
  - YouTube



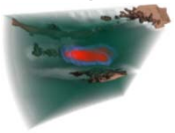
Eduard Gröller

Novel Imaging Modalities – 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

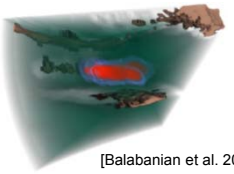


[Balabanian et al. 2007]

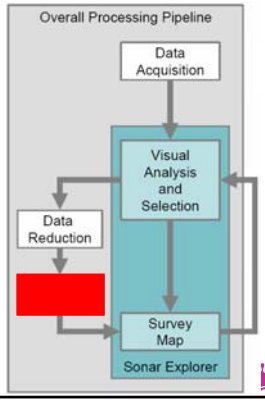


Novel Imaging Modalities – Sonar Explorer (2)

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

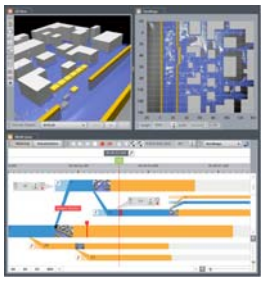


[Balabanian et al. 2007]



Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities
- Ensembles, Uncertainty, Parameter Spaces



Visual Steering to Support Decision Making in Visdom

J. Waser, R. Fuchs, H. Ribičić, Ch. Hirsch,
B. Schindler, G. Blöschl, E. Gröller

Visdom

vr vis

Flood emergency assistance

- **New Orleans 2005: 17th canal levee breach**

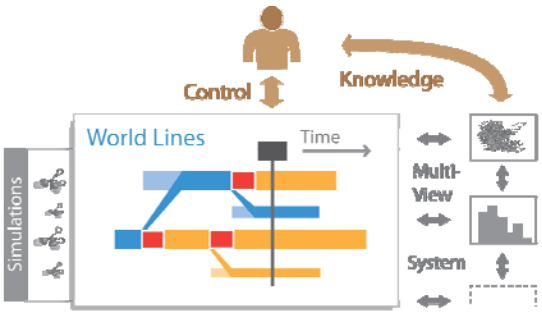
Image courtesy of USACE, US Army Corps of Engineers

Flood emergency assistance

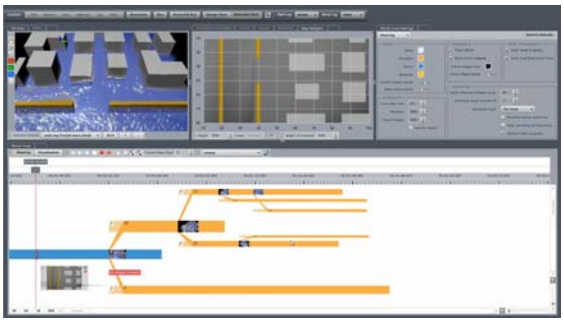
- **Evaluation of breach-closure techniques in a laboratory model**

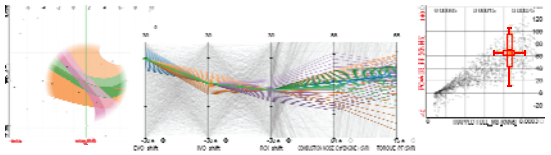
A. Sattar, A. Kassem, and M. Chaudhry. 17th street canal breach closure procedures. Journal of Hydraulic Engineering, 134(11):1547–1558, 2008.

Computational Steering: World Lines



Video: World Lines - Features





Uncertainty-Aware Exploration of Continuous Parameter Spaces Using Multivariate Prediction

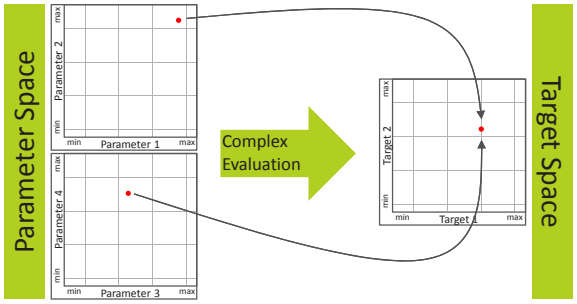
W. Berger[1], H. Piringer[1], P. Filzmoser[2], E. Gröller[3]

[1] VRVis Research Center, Vienna, Austria

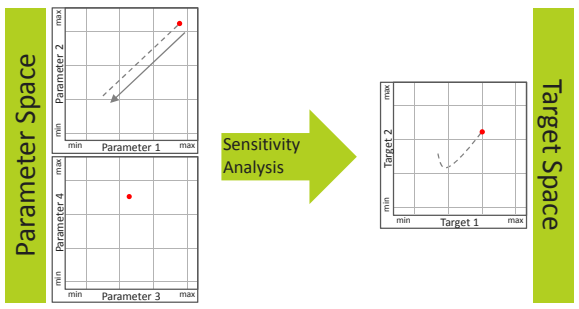
[2] Department of Statistics and Probability Theory, Vienna UT, Austria

[3] Institute of Computer Graphics and Algorithms, Vienna UT, Austria

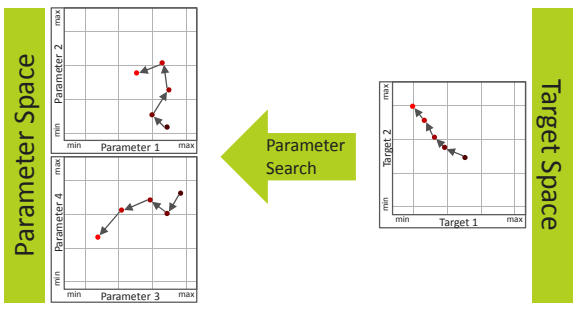
Motivation



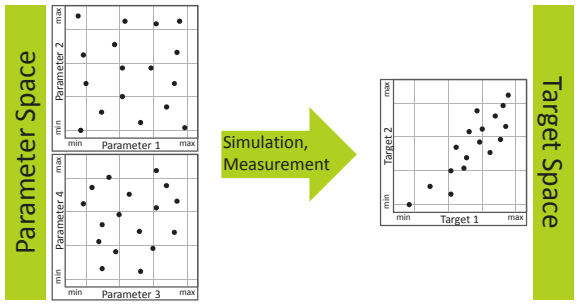
Motivation



Motivation



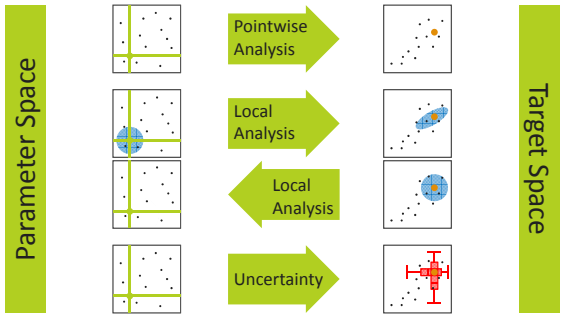
Motivation



Wolfgang Berger

v r vis

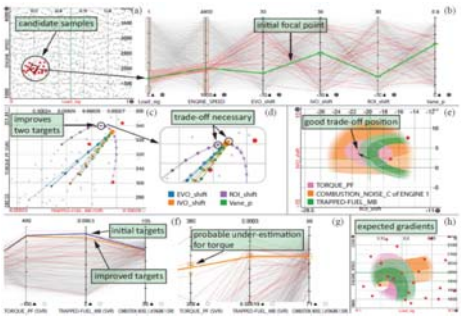
Contribution



Wolfgang Berger

v r vis

Application Example: Car Engine Design



Eduard Gröller

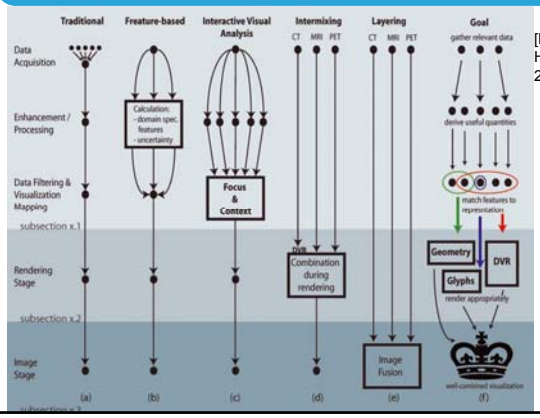
v r vis

Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities
- Ensembles, Uncertainty, Parameter Spaces
- Multivariate, Heterogeneous Data

Eduard Gröller

Visualization of Multi-Variate Scientific Data



[Fuchs& Hauser 2009]

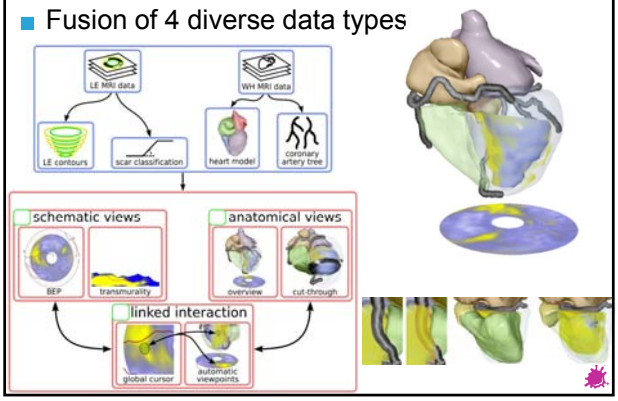
Coping with Complexity and Variability

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

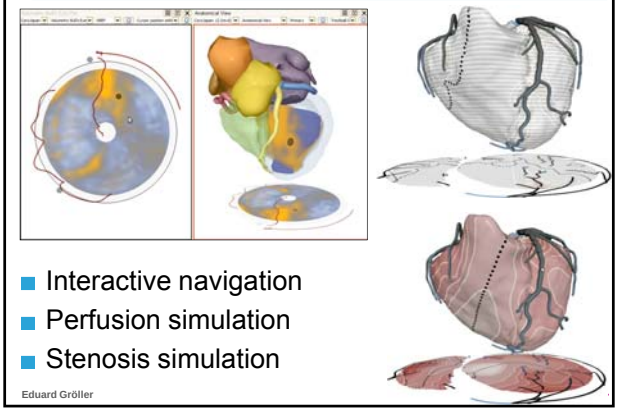
Eduard Gröller

Cardiac Data Visualization [Termeer et al.]

- Fusion of 4 diverse data types



Cardiac Data Visualization - Examples



- Interactive navigation
- Perfusion simulation
- Stenosis simulation

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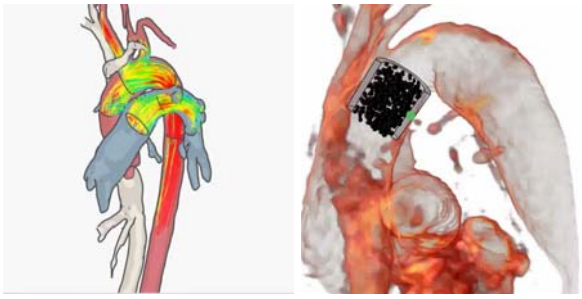
4D MRI Blood Flow [van Pelt et al.]



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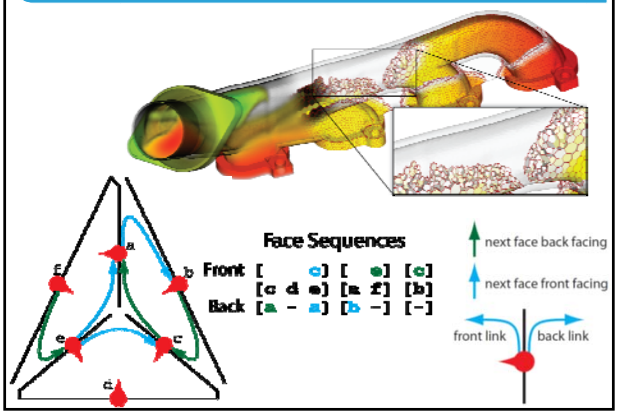
Generalized Polyhedral Grids [Muigg, Doleisch et al.]



Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities
- Ensembles, Uncertainty, Parameter Spaces
- Multivariate, Heterogeneous Data
- Visual Analytics (↔ SciVis ↔ InfoVis)

Eduard Gröller

Visual Analytics (↔ SciVis ↔ InfoVis)

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

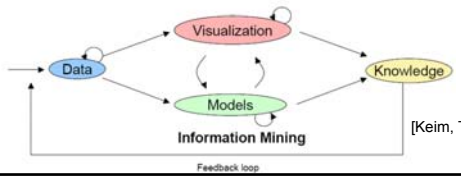
What do we have?

- 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

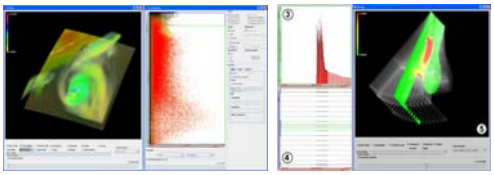
Visual Data-Exploration



[Keim, Thomas 2007]

Edua

SimVis: Interactive Visual Analysis of Large & Complex Simulation Data



Helmut Doleisch et al.

Challenges in Visual Computing

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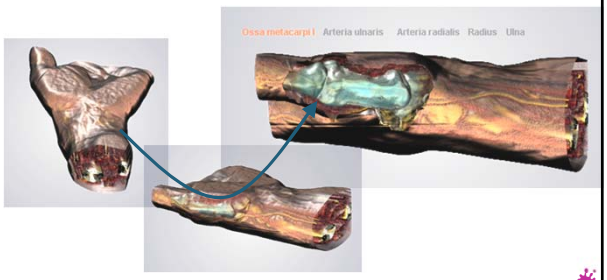
- Visual Analytics (↔ SciVis ↔ InfoVis)
- Interaction (Knowledge-assisted, User-centric)
-
-

Eduard Gröller

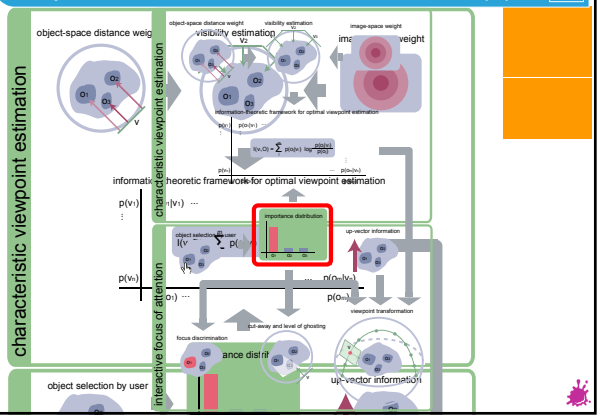
Importance-Driven Focus of Attention (1)

- Guided navigation between characteristic views

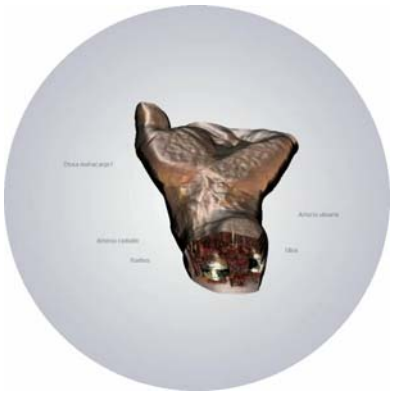
[Viola et al. 2006]



Importance-Driven Focus of Attention (2)

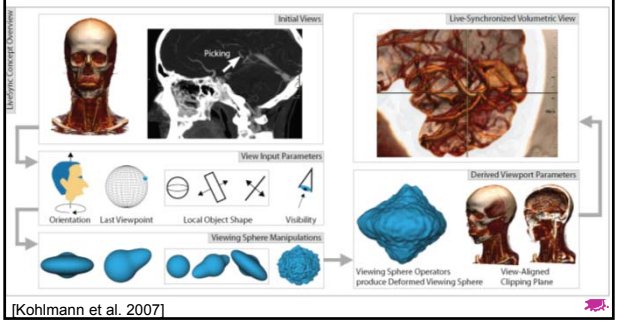


Importance-Driven Focus of Attention (3)



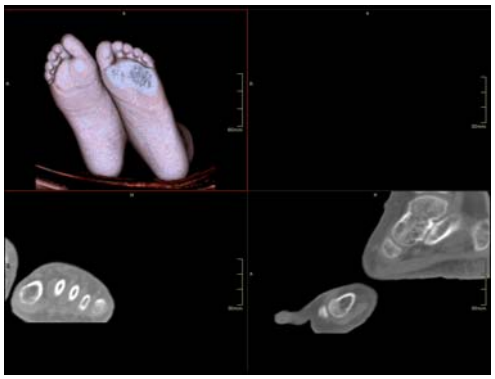
Knowledge-Based Navigation (1)

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



[Kohlmann et al. 2007]

Knowledge-Based Navigation (2)



[Kohlmann et al. 2007]

Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities
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- Visual Analytics (↔ SciVis ↔ InfoVis)
- Interaction (Knowledge-assisted, User-centric)
- 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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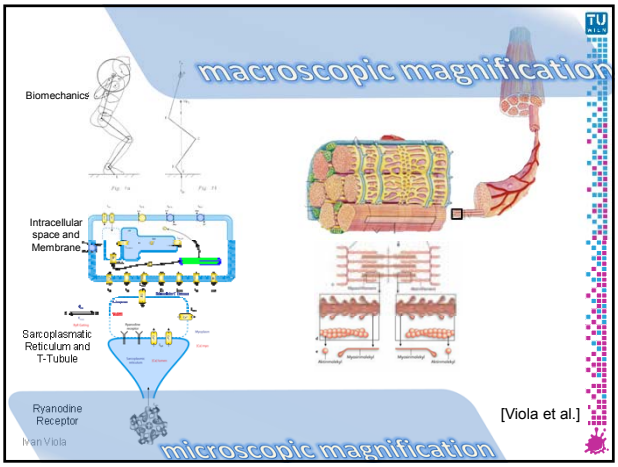


[Viola et al.]

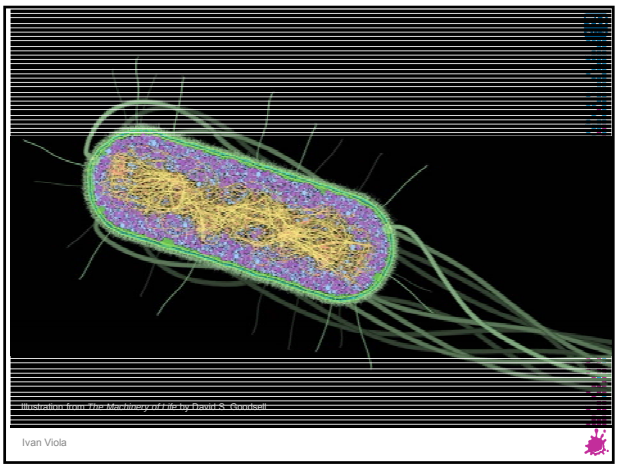
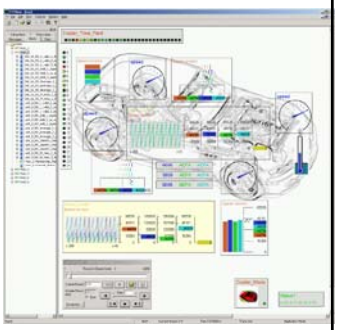


Illustration from The Machinery of Life by David S. Goodsell

Ivan Viola

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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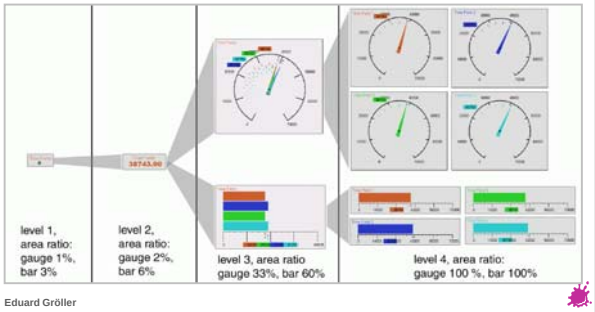
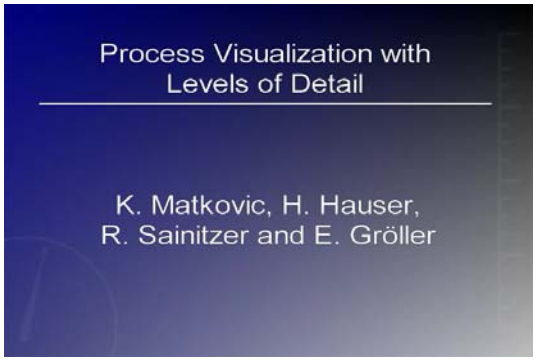
Scalability - Process Visualization (2)

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



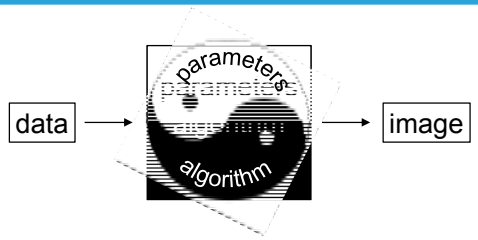
Scalability - Process Visualization (3)



Challenges in Visual Computing

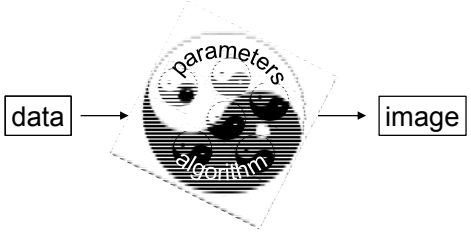
- New Data Sources - Novel Imaging Modalities
- Ensembles, Uncertainty, Parameter Spaces
- Multivariate, Heterogeneous Data
- Visual Analytics (↔ SciVis ↔ InfoVis)
- Interaction (Knowledge-assisted, User-centric)
- Scalability
- Visual Computing in the Cloud

Problem Solving: Algorithm + Parameters

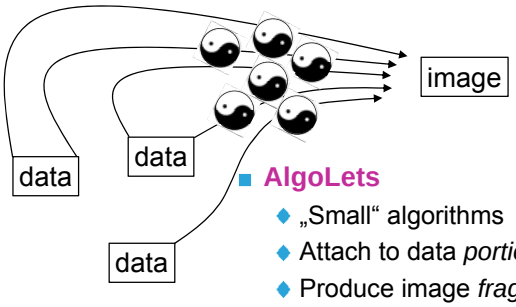


- Parameter space analysis
  - Robustness, stability: well established in other disciplines
  - Increased interest in visualization
    - Variations
    - Esembles
    - Knowledge-assisted visualization

AlgoLets: The Next Generation

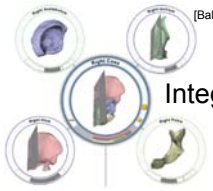


AlgoLets: The Next Generation



- **AlgoLets**
  - „Small“ algorithms
  - Attach to data *portions*
  - Produce image *fragments*
- Integration of fragments

Visual Computing: Topics for the Future ?

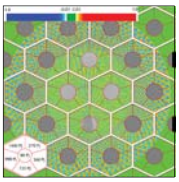


[Balabanian et al., 2010]

Integrated Views

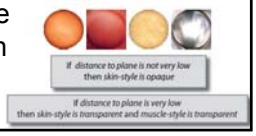
Fuzzy Visualization

[Rautek et al., 2007]



Comparative Visualization

[Malik et al., 2010]

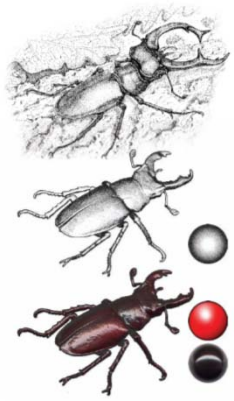


Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities
- Ensembles, Uncertainty, Parameter Spaces
- Multivariate, Heterogeneous Data
- Visual Analytics (↔ SciVis ↔ InfoVis)
- Interaction (Knowledge-assisted, User-centric)
- Scalability
- Visual Computing in the Cloud

Bring **visual computing** into the workflow of users!!

Thank You for Your Attention



Questions ?
Comments?

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Roy van Pelt
Anna Vilanova
Ivan Viola
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...

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