Trends in Visual Computing

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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"

Visualization is part of Visual Computing
Visual Computing is acquisition, 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

The purpose of visual computing is insight, not images.

- Visual Computing embedded in Science

- Challenges in Visual Computing

- New Data Sources - Novel Imaging Modalities
- 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

- New Data Sources – Web 2.0

- Social networks, wikis, blogs, data warehouses
  - Facebook
  - Twitter
  - LinkedIn
  - YouTube

[Gröller 2007]
Novel Imaging Modalities – Sonar Explorer (1)
- 4D sonar data
- Cones with resolution: 25x20x1319
- Ping rate 1 Hz
- 2 GB/ping
- Time steps overlapping
- Highly anisotropic
- Noisy
- Signal strength reduced with spreading and absorption

Novel Imaging Modalities – Sonar Explorer (2)
- Fish school monitoring
  - Size of school
  - Center of gravity
  - Shape parameters
  - Motion characteristics

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

Flood emergency assistance
- New Orleans 2005: 17th canal levee breach

Evaluation of breach-closure techniques in a laboratory model
Computational Steering: World Lines

Video: World Lines - Features

Uncertainty-Aware Exploration of Continuous Parameter Spaces Using Multivariate Prediction

Motivation

Sensitivity Analysis

Parameter Search
**Motivation**

Parameter Space → Target Space

Simulation, Measurement

**Contribution**

Parameter Space → Target Space

Pointwise Analysis

Local Analysis

Uncertainty

**Application Example: Car Engine Design**

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**Challenges in Visual Computing**

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

**Visualization of Multi-Variate Scientific Data**

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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
  - …
Cardiac Data Visualization
- Fusion of 4 diverse data types

Interactive navigation
- Perfusion simulation
- Stenosis simulation

4D MRI Blood Flow
- van Pet et al.

Generalized Polyhedral Grids
- Muigg, Doleisch et al.

Challenges in Visual Computing
- New Data Sources - Novel Imaging Modalities
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- Multivariate, Heterogeneous Data
- Visual Analytics (↔ SciVis ↔ InfoVis)

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
- Data
- Models
- Knowledge
- Information Mining
- [Keim, Thomas 2007]
SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

Helmut Doleisch et al.

Importance-Driven Focus of Attention (1)

- Guided navigation between characteristic views

[Viola et al. 2006]

Importance-Driven Focus of Attention (2)

Knowledge-Based Navigation (1)

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

[Kohmann et al. 2007]
**Knowledge-Based Navigation (2)**

![Image](image1.png)

[Kohlmann et al. 2007]

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**Challenges in Visual Computing**

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- Multivariate, Heterogeneous Data
- 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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**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

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[Viola et al.]
Scalability - Process Visualization (2)

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

Scalability - Process Visualization (3)

- Process Visualization with Levels of Detail

  K. Matkovic, H. Hauser, R. Sainitzer and E. Groller

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- 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
    - Ensembles
    - Knowledge-assisted visualization

AlgoLets: The Next Generation

- AlgoLets
  - „Small“ algorithms
  - Attach to data portions
  - Produce image fragments
- Integration of fragments
Thank You for Your Attention

Questions? Comments?

Acknowledgments

Wolfgang B Berger
Jean-Paul Babalablanian
Helmut Doleisch
Raphael Fuchs
Helwig Hauser
Armin Kantarai
Peter Koldmann
M. Maddassar Malik
Krasimir Markov
Philipp Mugg

Harald P Pringer
Werner Purgathofer
Peter Rauzer
Hugo Ribbiño
Georg Stonański
Maurice Terme
Roy van Pelt
Anna Wallnö
Ivan Voža
Jürgen Waser

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