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

Visualization – Three Major Areas

- Three major areas
  - Volume Visualization
  - Flow Visualization
  - Information Visualization

Scientific Visualization

Inherent spatial reference

3D

nD

Usually no spatial reference
Visualization Examples

VolVis

FlowVis

InfoVis

InfoViz vs. SciViz

- Abstract data
- n-dimensional

- Very important:
  - Visual metaphor
  - User interaction
  - Exploration, Analysis, Presentation

- 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

New Data Sources - Novel Imaging Modalities

Visual Analytics - Visual Computing –

Knowledge Assisted Visualization

Scalability

Visualization Yes ! – Interaction No ?

Interaction Yes ! – BUT User centric !

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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

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 (Shneiderman's information seeking mantra)
- challenge:
  - occlusion
  - interactive data handling

SimVis: Interactive Visual Analysis of Large & Complex Simulation Data

Interactive Data Handling

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

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<th>attributes</th>
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<td></td>
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</tbody>
</table>
```

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.

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
Brushing extensions: smooth brushing

Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
- 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
  - Dual energy CT

New Data Sources - Novel Imaging Modalities

Visualization Technique
New Data Sources – Web 2.0

- Social networks, wikis, blogs, data warehouses

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
- Voxel size (μm) 200
- Data have complimentary strengths and weaknesses

Challenges in Visualization

- Scientific Visualization ↔ Information Visualization
- New Data Sources - Novel Imaging Modalities
- Visual Analytics - Visual Computing – Knowledge Assisted Visualization
"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

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### Visual Analytics – The Event Tunnel (1)
Interactive Visualization of Complex Event Streams for Business Process Pattern Analysis

**Stair pattern**
Process with several idle times

**Non-interfering chain**
Process with regular steps

**Parallel chain**
Fast process without idle times

**Acceleration worm**
Process execution accelerated continuously

**Deceleration worm**
Process execution decelerated continuously

**Rattlesnake**
Process with one extreme idle time
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Visual Computing - Computational Sciences

- Data Acquisition
  - Scientific visualization
  - Computer vision
  - Human computer interaction
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

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

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[Balabanian et al. 2007]
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
  - semantic information of the data
- Visualization via learning
- Visualization via shared knowledge in a collaborative setting
- Knowledge representation for visualization

Example
- Automatic viewpoint selection
- Automatic reporting

KAV - Importance-Driven Focus of Attention (1)

Guided navigation between characteristic views

[Viola et al. 2006]

KAV - Importance-Driven Focus of Attention (2)
Challenges in Visualization

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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

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
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

[Marković 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

[Bruckner et al. 2004]
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]
Scalability – Smart Visibility (2)

[Viola et al. ’04 ’05]

Importance specification → Importance compositing → Levels of sparseness

Importance-driven feature enhancement

Scalability – Smart Visibility (3)

Challenges [Keim Thomas 2007]
- Amount of data and dimensionality
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Do not fight complexity with complexity
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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

Context-Preserving Rendering (1)
- Integrate various focus+context approaches with only few parameters
Context-Preserving Rendering (2)

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S. Bruckner and E. Gröller

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Challenges
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Algorithms highly parameterized – provide sensible default settings
Support automatic parameter tuning
Provide navigational aids

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**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

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

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

[Image: Kohlmann et al. 2007]

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Bring visualization into the workflow of users!!

Thank You for Your Attention

Questions ?
Comments?

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[Image: Eduard Gröller 58]