Visualisierung

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Organizational Details

- **186.004 Visualisierung, VO**
  - 3.0 ECTS, 2 hours
  - Eduard Gröller, Helwig Hauser
  - BDS/W, BMIb/W, BZI/W, MCG/P
  - [http://www.cg.tuwien.ac.at/courses/Visualisierung/VO.html](http://www.cg.tuwien.ac.at/courses/Visualisierung/VO.html)

- **186.703 Visualisierung Übung, LU**
  - 3.0 ECTS, 2 hours
  - Peter Rautek, Martin Illcik, Wolfgang Knecht, Eduard Gröller
  - BDS/W, BMIb/W, BZI/W, MCG/W
  - [http://www.cg.tuwien.ac.at/courses/Visualisierung/LU.html](http://www.cg.tuwien.ac.at/courses/Visualisierung/LU.html)

- **Exams:**
  - oral
  - registration: [http://www.cg.tuwien.ac.at/courses/anmeldung/](http://www.cg.tuwien.ac.at/courses/anmeldung/)
Visualization Examples

VolVis

FlowVis

InfoVis
The purpose of computing is insight, not numbers

[R. Hamming, 1962]

Visualization:

- **Tool** to enable a **User** insight into **Data**
- to form a **mental vision, image, or picture of** (something not visible or present to the sight, or of an abstraction); to make **visible to the mind or imagination**


- **Computer Graphics**, but not photorealistic rendering
Background:

- Visualization = rather old
- Often an intuitive step: graphical illustration
- Data in ever increasing sizes ⇒ graphical approach necessary
- Simple approaches known from business graphics (Excel, etc.)
- Visualization = own scientific discipline since 20 years
- First dedicated conferences: 1990

L. da Vinci (1452-1519)
Travelling Routes of Yu the Great

Geographical Map using cartesian coordinates

Grid with longitudinal and latitudinal lines

China, 1137
Cartography

Isolines to visualize compass deviations

Wind flow visualization
Military Campaign of Napoleon

Line thickness encodes troop strength

Eduard Gröller, Helwig Hauser
Cholera Epidemic in London

- Cartographic visualization
- Correlation between water supply and disease incidents detected
Weather Maps in Meteorology

Map with iso-pressure lines

Weather fronts

Map for pilots
Visualization in Medicine

- X-rays (Wilhelm Röntgen, 1895)
- Stereo X-ray images (1896)

- X-ray tomography
Experimental Flow Investigation

- Fixation of tufts, ribbons on
  - Aircraft in wind tunnels
  - Ship hull in fluid tanks

- Introduction of smoke particles (in wind tunnel)
- Introduction of dye (in fluids)
W. Playfair, engl. econometrist, 1785

Imports/Exports USA-England 1770-1782
Population Development

- Population size Schweden 1750-1785
- Population as function of year and age group
Icons

- H. Chernoff, 1973, 2D scatterplot
- Data characteristics encoded in geometric face features
Visualization – Sub Topics

- Visualization of …
  - Medical data ⇒ VolVis!
  - Flow data ⇒ FlowVis!
  - Abstract data ⇒ InfoVis!
  - GIS data
  - Historical data (archeologist)
  - Microscopic data (molecular physics), Macroscopic data (astronomy)
  - Extrem large data sets
  - etc. …
Medical data
Flow data
Visualization – Examples

- Abstract data
Visualization – Three Types of Goals

- Visualization, …
  - … to explore
    - Nothing is known, Vis. used for data exploration
  - … to analyze
    - There are hypotheses, Vis. used for Verification or Falsification
  - … to present
    - “everything” known about the data, Vis. used for Communication of Results
Visualization – Three Major Areas

Three major areas

- Volume Visualization
- Flow Visualization
- Information Visualization

Scientific Visualization

Inherent spatial reference

3D

nD

Usually no spatial reference
Medical Visualization in **Surgery Planning**

- Image: **Liver** (blood vessels, tumors)

Oeltze et al., 2004
FlowVis - Example

For **DPF-Analysis**
(DPF: Diesel Particle Filter)
InfoVis - Example

- Visualization of **Search-Results**

- Image:
  - document lengths
  - frequencies
  - etc.

Hearst, 1995
Visualization Pipeline

Typical steps in the visualization process
Visualization-Pipeline – 1. Step

Data acquisition

- Measurements, e.g., CT/MRI
- Simulation, e.g., flow simulation
- Modelling, e.g., game theory

Data are given
Visualization-Pipeline – 2. Step

Data enhancement

Data are given

Data are processed

- Data enhancement
  - Filtering, e.g., smoothing (noise suppression)
  - Resampling, e.g., on a different-resolution grid
  - Data Derivation, e.g., gradients, curvature
  - Data interpolation, e.g., linear, cubic, …
Visualization-Pipeline – 3. Step

- Visualization mapping
- Data are processed
- Data are mapped to, e.g., geometry

- Visualization mapping = data is renderable
  - Iso-surface calculation
  - Glyphs, Icons determination
  - Graph-Layout calculation
  - Voxel attributes: color, transparency, …
Visualization-Pipeline – 4. Step

Rendering (3D→2D)

- Data are mapped to, e.g., geometry
- Images generated

- Rendering = image generation with Computer Graphics
  - Visibility calculation
  - Illumination
  - Compositing (combine transparent objects, …)
  - Animation
SIMULATION DATA

Geometry: Surface Splines
Sampling Points:
X, Y, Z
Temperature
Pressure
(irregular in space, time)
DERIVED DATA

Geometry: Polygonal Patches
( Vertices at X, Y, Z )

Data at Vertices:
Temperature, Pressure
( Regular in Time )
3D → 2D projection

Abstract Visualization Object

Temperature

Pressure 0
Computational Sciences - Visual Computing

Computational Sciences

Data Acquisition → Data Enhancement → Visualization Mapping → Rendering

Scientific Computing

Visual Computing

- Scientific visualization
- Computer vision
- Human computer interaction