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 Illek, 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
- InfoVis
- FlowVis
Visualization – Definition

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

Visualization – Background

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

Travelling Routes of Yu the Great

China, 1137

Geographical Map using cartesian coordinates
- Grid with longitudinal and latitudinal lines
Cartography

Isolines to visualize compass deviations

Wind flow visualization

Military Campaign of Napoleon

- Line thickness encodes troop strength

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)
Business Graphics

- 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 (archaeologist)
  - Microscopic data (molecular physics), Macroscopic data (astronomy)
  - Extrem large data sets
  - etc. …

Visualization – Examples

- Medical data

Visualization – Examples

- 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
  \{ Scientific Visualization \}
- Information Visualization

Inherent spatial reference
Scientific Visualization
3D
nD
Usually no spatial reference
**VolVis - Example**

Medical Visualization in **Surgery Planning**

- Image: Liver (blood vessels, tumors)

**FlowVis - Example**

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

**InfoVis - Example**

Visualization of **Search-Results**

- Image: document lengths, frequencies etc.
Visualization Pipeline

Typical steps in the visualization process

Visualization-Pipeline – Overview

Data acquisition

Data enhancement

Visualization mapping

Rendering (3D→2D)

Data are given

Data are processed

Data are mapped to, e.g., geometry

Images generated

Visualization-Pipeline – 1. Step

Data acquisition

Data acquisition

- Measurements, e.g., CT/MRI
- Simulation, e.g., flow simulation
- Modelling, e.g., game theory
Visualization-Pipeline – 2. Step

- 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

- Data are processed
- Visualization mapping
- 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)
- 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

Pressure
0
Temperature
Computational Sciences - Visual Computing

**Computational Sciences**

- Data Acquisition
- Data Enhancement
- Visualization Mapping
- Quantitative Analysis

**Scientific Computing**

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