

# Visualisierung



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Helwig Hauser\*

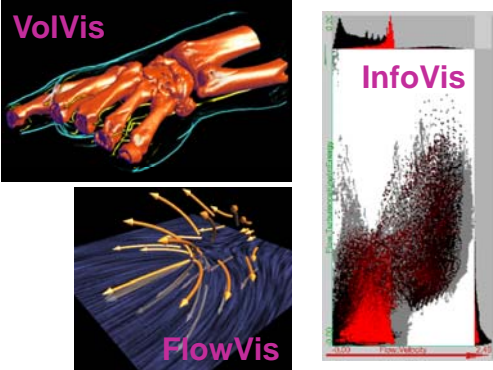
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## Organizational Details

- 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>
- 186.703 Visualisierung Übung, LU
  - 3.0 ECTS, 2 hours
  - Peter Rautek, Martin Ilcik, Wolfgang Knecht, Eduard Gröller
  - BDS/W, BMib/W, BZI/W, MCG/W
  - <http://www.cg.tuwien.ac.at/courses/Visualisierung/LU.html>
- Exams:
  - oral
  - registration: <http://www.cg.tuwien.ac.at/courses/anmeldung/>

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## Visualization Examples



VolVis


InfoVis

FlowVis

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## 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** [Oxford Engl. Dict., 1989]
  - Computer Graphics, but not photorealistic rendering

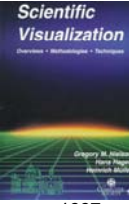
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## Visualization – Background

- Background:
  - Visualization = rather old
  - Often an intuitive step: graphical illustration
  - Data in ever increasing sizes  $\Rightarrow$  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)



Scientific Visualization  
1997

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## Travelling Routes of Yu the Great



China, 1137

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

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## Cartography



Isolines to visualize compass deviations

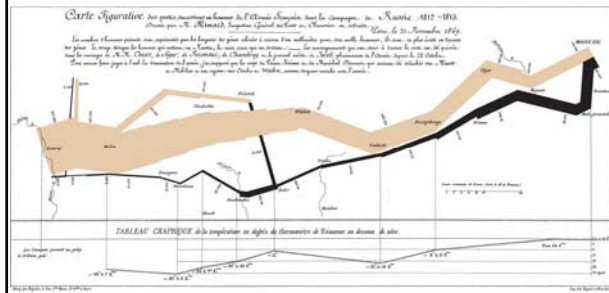


Wind flow visualization

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## Military Campaign of Napoleon



Line thickness encodes troop strength

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## Cholera Epidemic in London

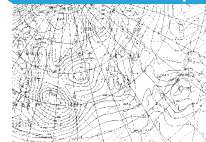


- Cartographic visualization
- Correlation between water supply and disease incidents detected

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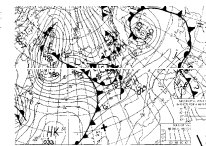
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## Weather Maps in Meteorology



Map with iso-pressure lines

Weather fronts



Map for pilots



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## Visualization in Medicine



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



- X-ray tomography

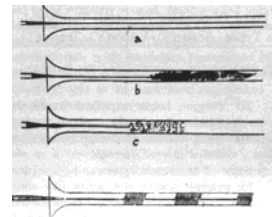
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## Experimental Flow Investigation



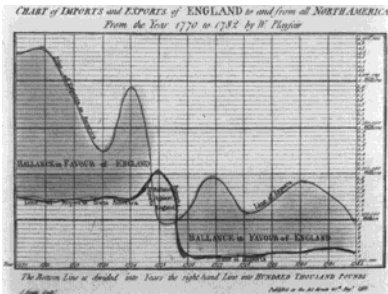
- Fixation of tufts, ribbons on
  - ◆ Aircraft in wind tunnels
  - ◆ Ship hull in fluid tanks
- Introduction of smoke particles (in wind tunnel)
- Introduction of dye (in fluids)



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## Business Graphics

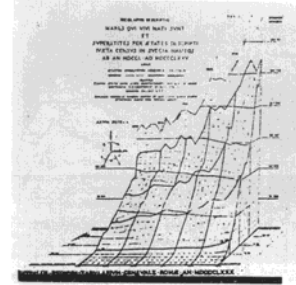


- W. Playfair, engl. econometrist, 1785
- Imports/Exports USA-England 1770-1782

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## Population Development

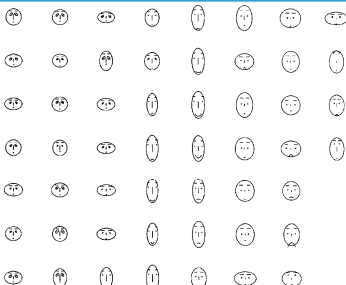


- Population size Schweden 1750-1785
- Population as function of year and age group

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## Icons



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

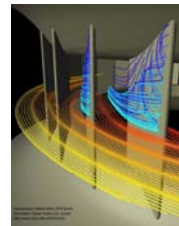
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## Visualization – Sub Topics



- 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. ...



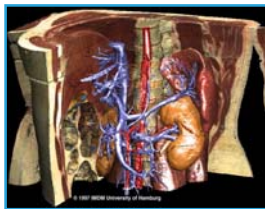
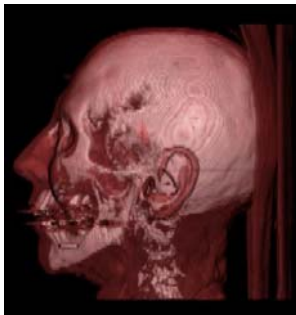
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## Visualization – Examples



- Medical data



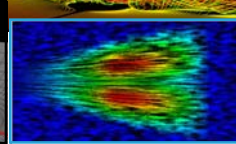
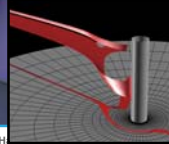
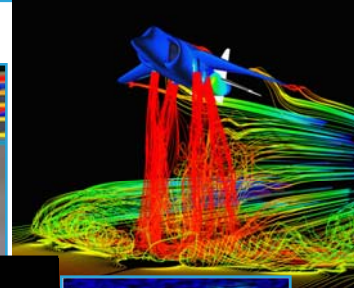
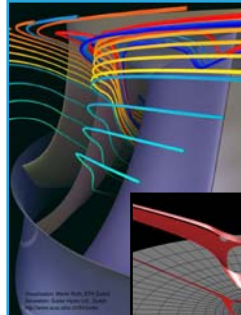
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## Visualization – Examples



- Flow data



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### Visualization – Examples

- Abstract data

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### Visualization – Three Types of Goals

- Visualization, ...
  - ... to **explore**
    - Nothing is known, Vis. used for **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**

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### Visualization – Three Major Areas

- Three major areas
  - Volume Visualization } Scientific Visualization } Inherent spatial reference
  - Flow Visualization } } 3D
  - Information Visualization } Usually no spatial reference

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### VolVis - Example

- Medical Visualization in **Surgery Planning**

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

Oeltze et al., 2004

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### FlowVis - Example

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

VRVis, 2004

### InfoVis - Example

- Visualization of **Search-Results**

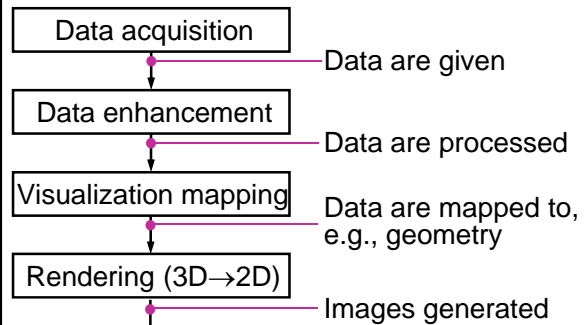
Image: document lengths, frequencies, etc.

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# Visualization Pipeline

Typical steps in the visualization process

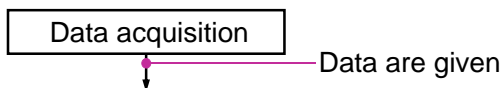
## Visualization-Pipeline – Overview



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## Visualization-Pipeline – 1. Step

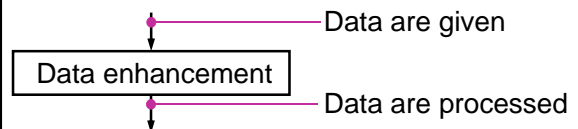


- Data acquisition
  - ◆ Measurements, e.g., CT/MRI
  - ◆ Simulation, e.g., flow simulation
  - ◆ Modelling, e.g., game theory

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## Visualization-Pipeline – 2. Step

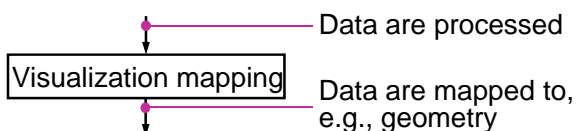


- Data enhancement
  - ◆ Filtering, e.g, smoothing (noise suppression)
  - ◆ Resampling, e.g., on a different-resolution grid
  - ◆ Data Derivation, e.g., gradients, curvature
  - ◆ Data interpolation, e.g., linear, cubic, ...

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## Visualization-Pipeline – 3. Step

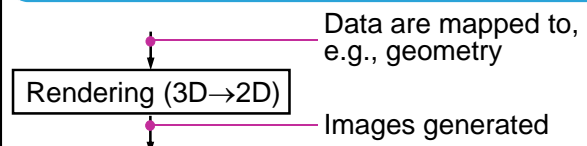


- Visualization mapping = data is renderable
  - ◆ Iso-surface calculation
  - ◆ Glyphs, Icons determination
  - ◆ Graph-Layout calculation
  - ◆ Voxel attributes: color, transparency, ...

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## Visualization-Pipeline – 4. Step



- Rendering = image generation with Computer Graphics
  - ◆ Visibility calculation
  - ◆ Illumination
  - ◆ Compositing (combine transparent objects, ...)
  - ◆ Animation

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### SIMULATION DATA

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

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### DERIVED DATA

Geometry: Polygonal Patches  
 ( Vertices at X, Y, Z )  
 Data at Vertices:  
 Temperature, Pressure  
 ( Regular in Time )

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3D → 2D projection

Abstract Visualization Object

Temperature

Pressure

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Displayable Image

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Computational Sciences - Visual Computing TU  
WIEN

### Computational Sciences

```

    graph LR
      A[Data Acquisition] --> B[Data Enhancement]
      B --> C[Visualization Mapping]
      C --> D[Quantitative Analysis]
      C --> E[ ]
      style E fill:none,stroke:none
      subgraph Scientific_Computing [Scientific Computing]
        A
        B
        C
      end
      subgraph Visual_Computing [Visual Computing]
        C
        D
      end
  
```

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

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