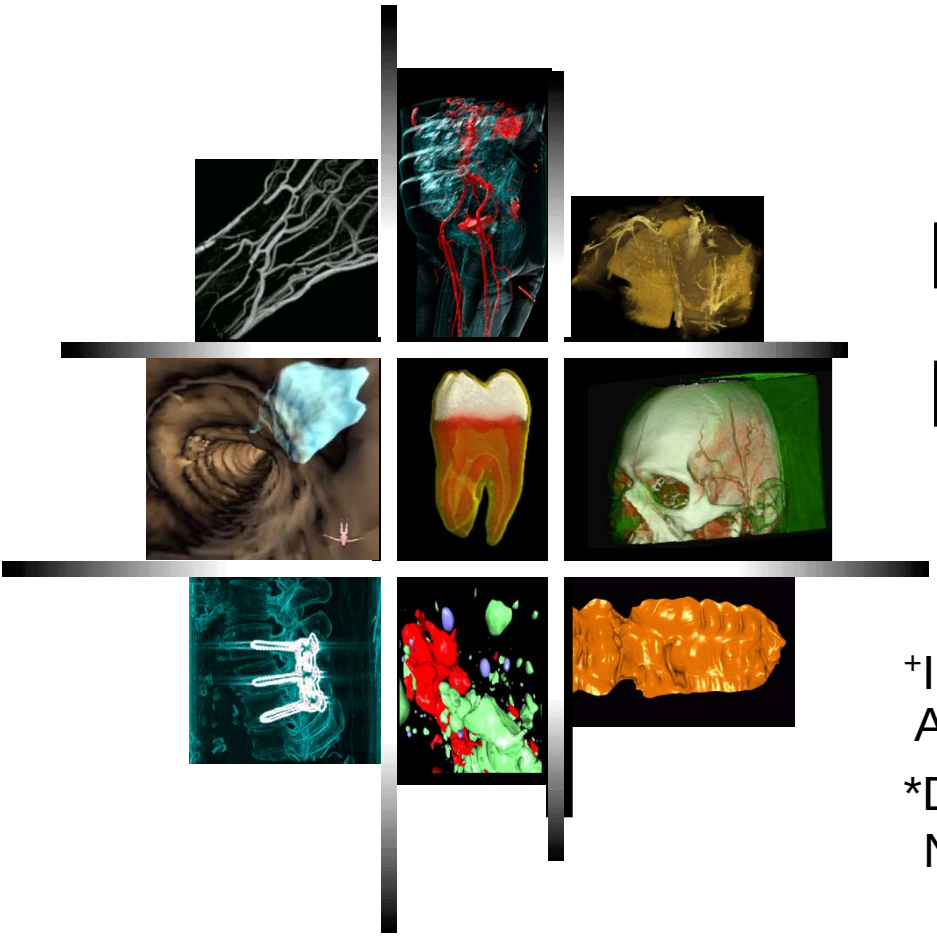
Visualisierung



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Helwig Hauser*

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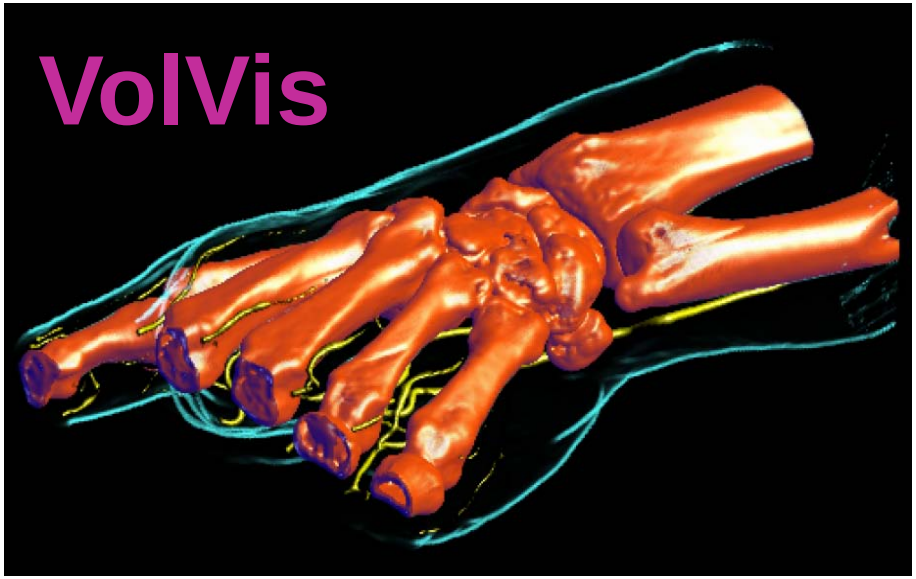
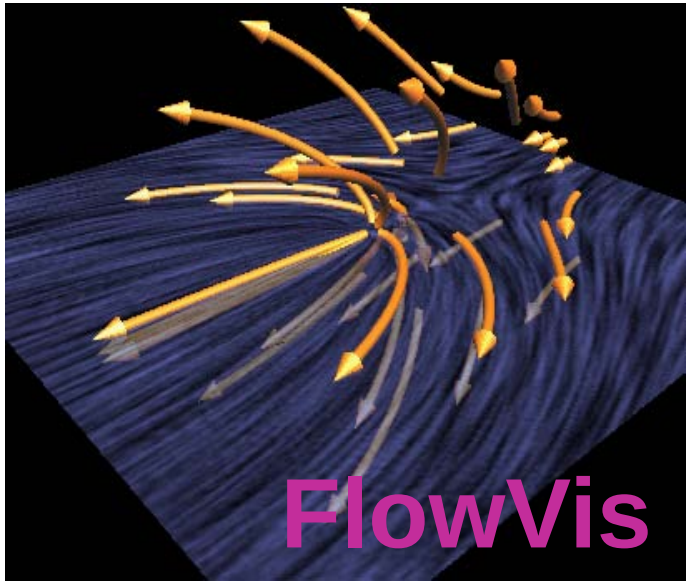
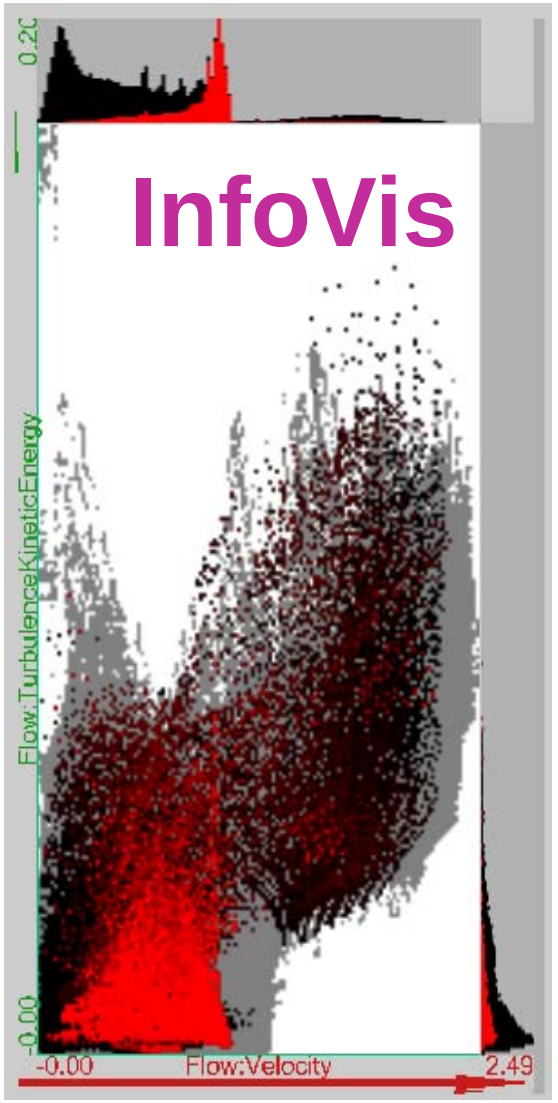
Organizational Details

- 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 Illcik, 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/

Visualization Examples



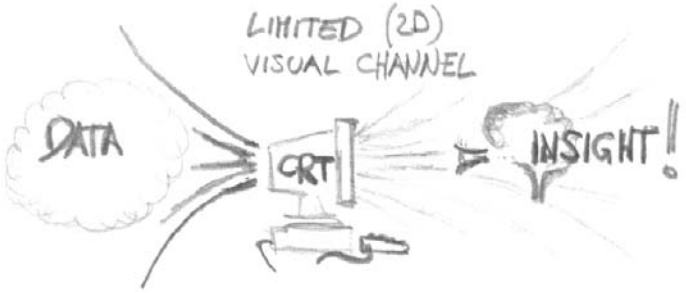




Visualization – Definition

The purpose of computing
is insight, not numbers

[R. Hamming, 1962]



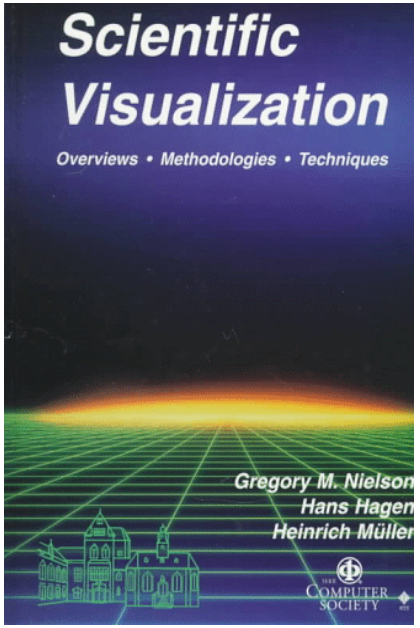
- Visualization:
  - Tool to enable a User insight into Data
  - to form a mental vision, image, or picture of (something not visible or present to the sight, or of an abstraction); to make visible to the mind or imagination

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

Visualization – Background

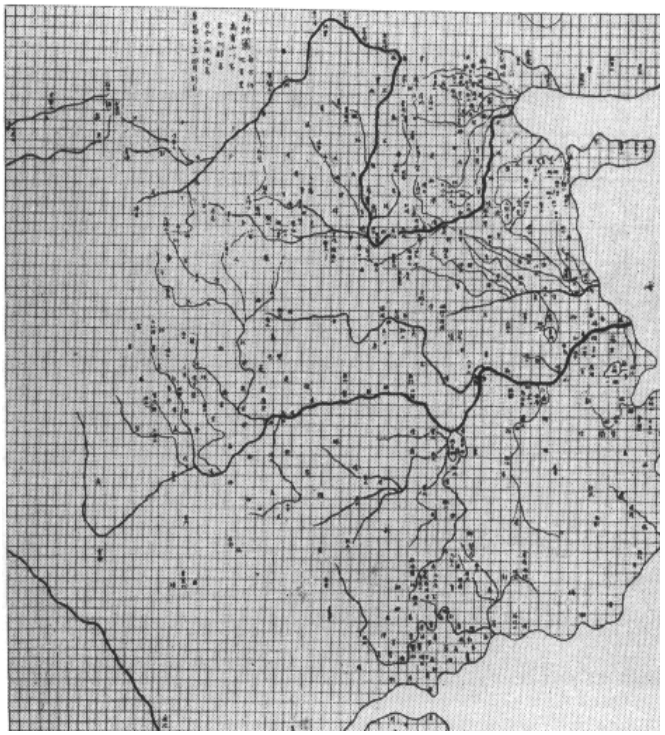
- Background:
  - Visualization = rather old
  - Often an intuitive step: graphical illustration
  - Data in ever increasing sizes ⇒ graphical approach necessary
  - Simple approaches known from business graphics (Excel, etc.)
  - Visualization = own scientific discipline since 20 years
  - First dedicated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

L. da Vinci (1452-1519)



1997

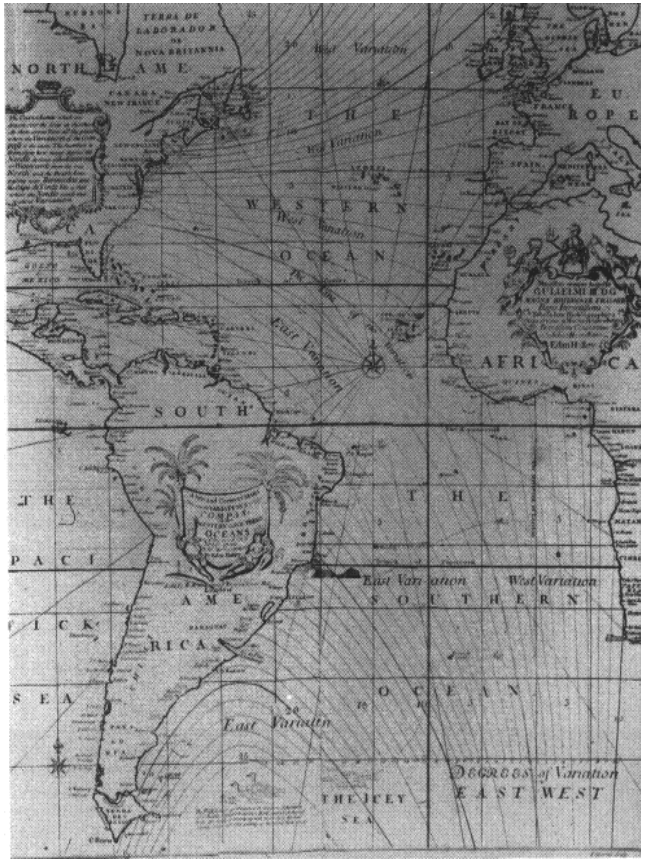
Travelling Routes of Yu the Great



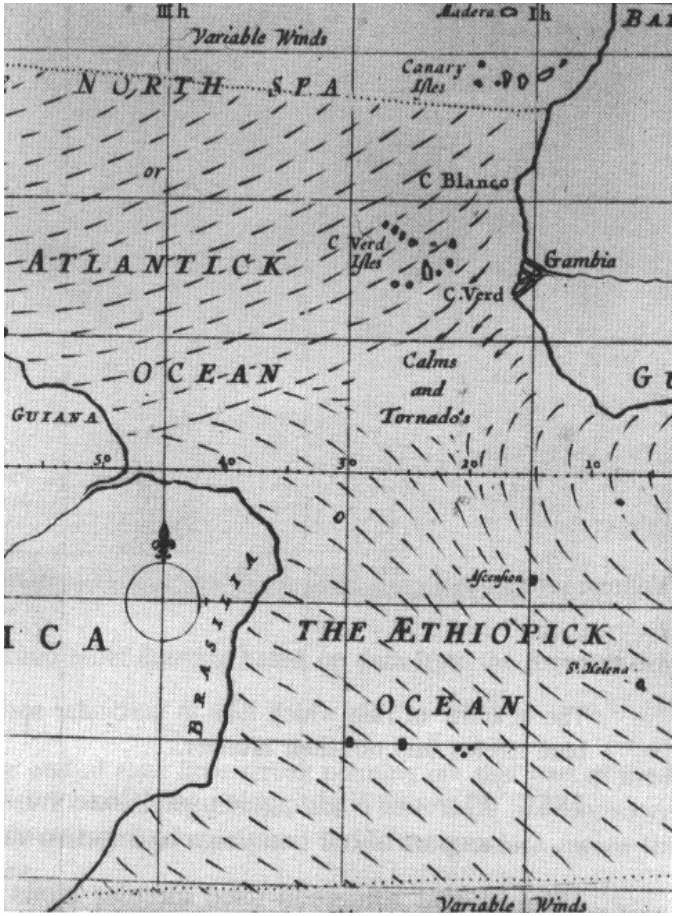
China, 1137

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

Cartography

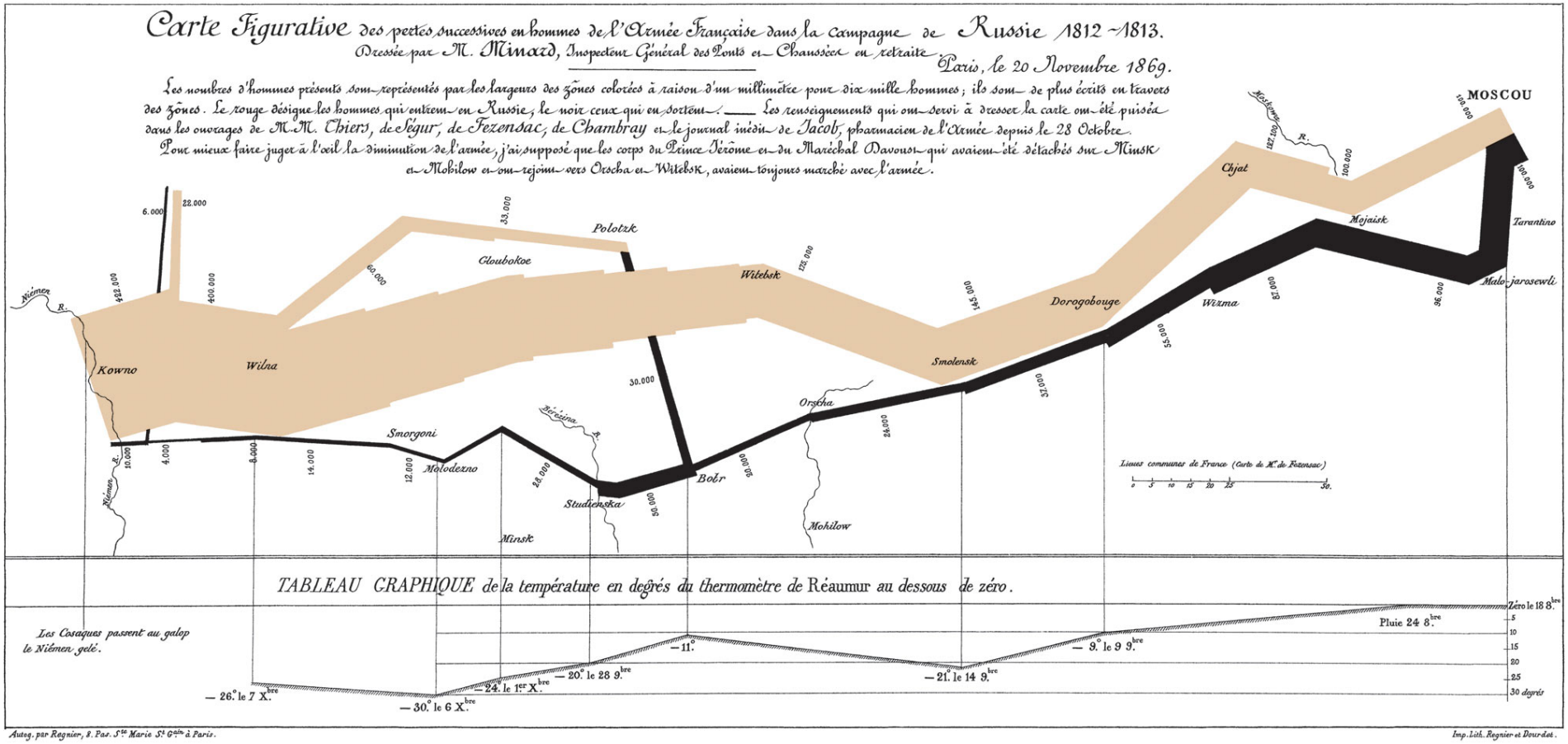


Isolines to visualize compass deviations



Wind flow visualization

Military Campaign of Napoleon

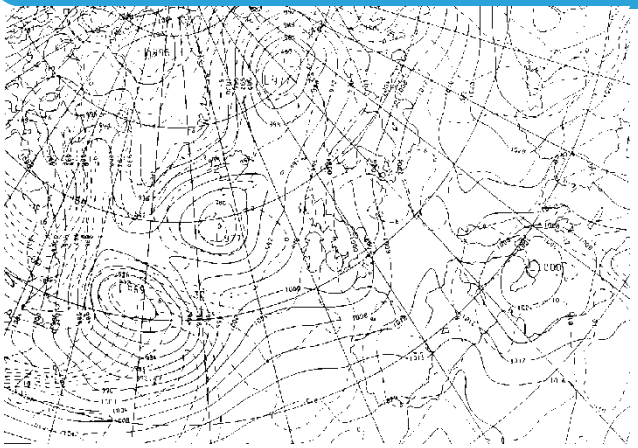


- Line thickness encodes troop strength

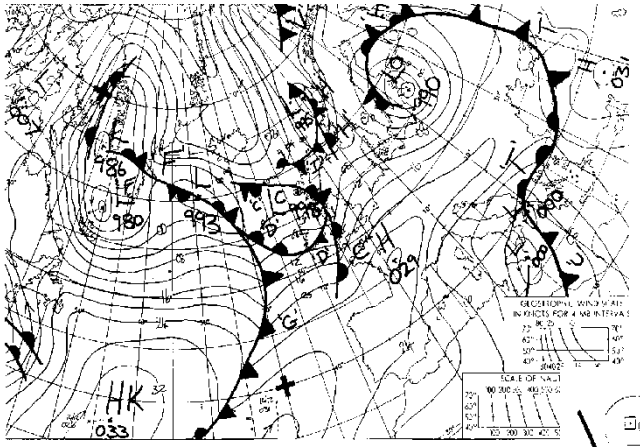
Cholera Epidemic in London

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

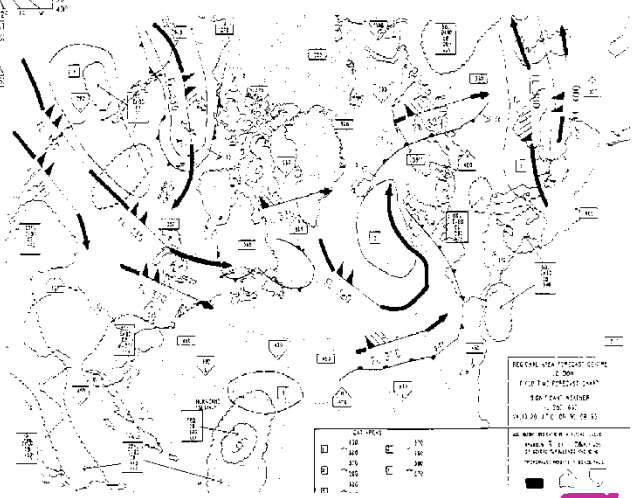
Weather Maps in Meteorology



Map with iso-pressure lines



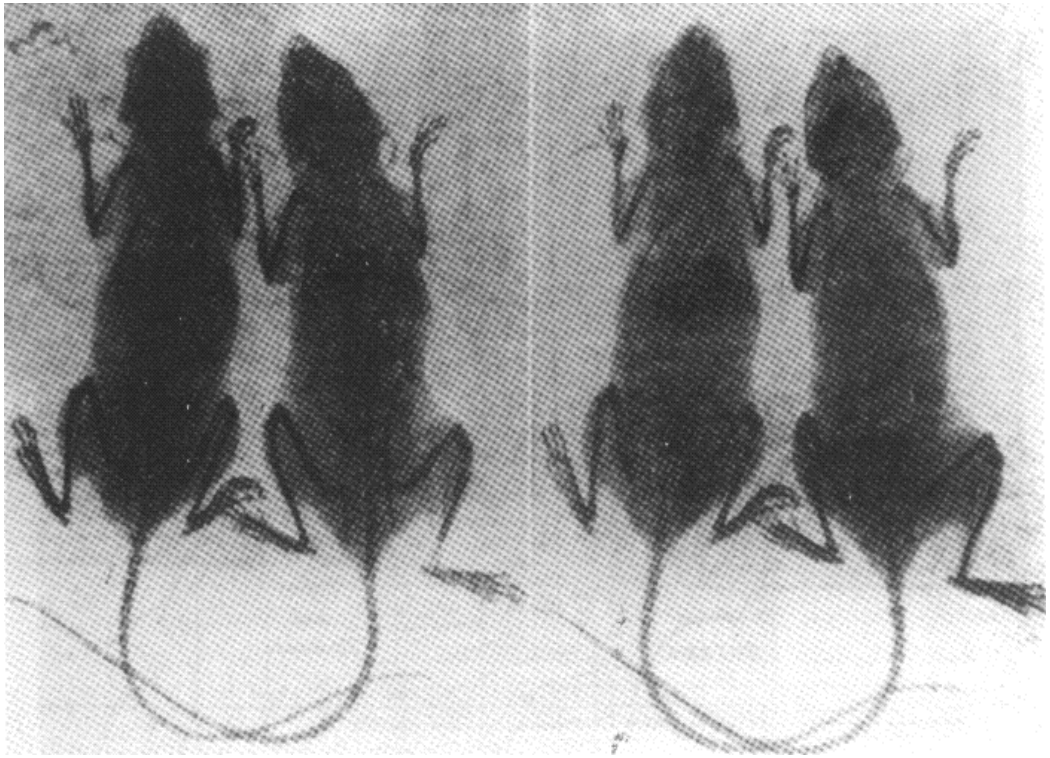
Weather fronts



Map for pilots

Visualization in Medicine

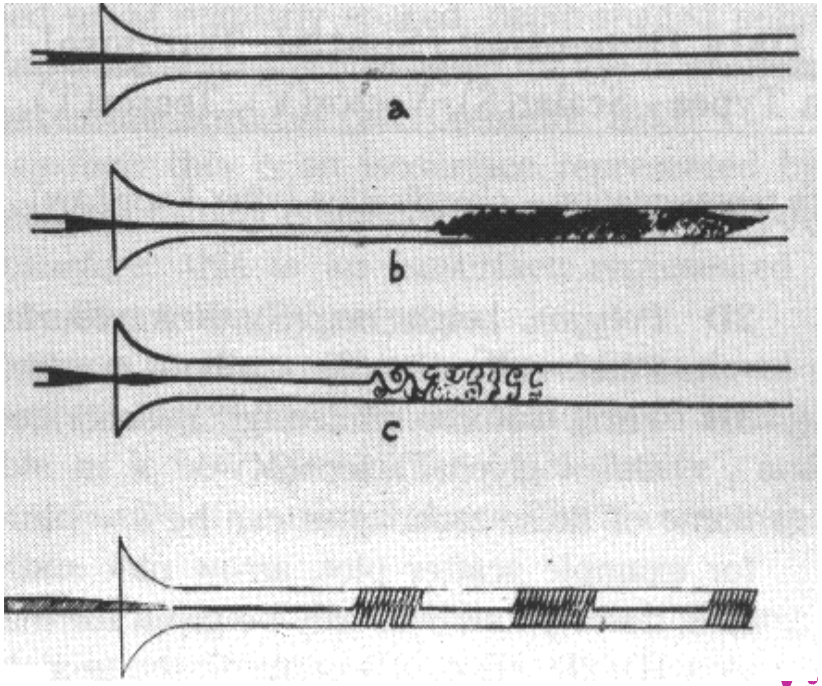
- X-rays (Wilhelm Röntgen, 1895)
- Stereo X-ray images (1896)



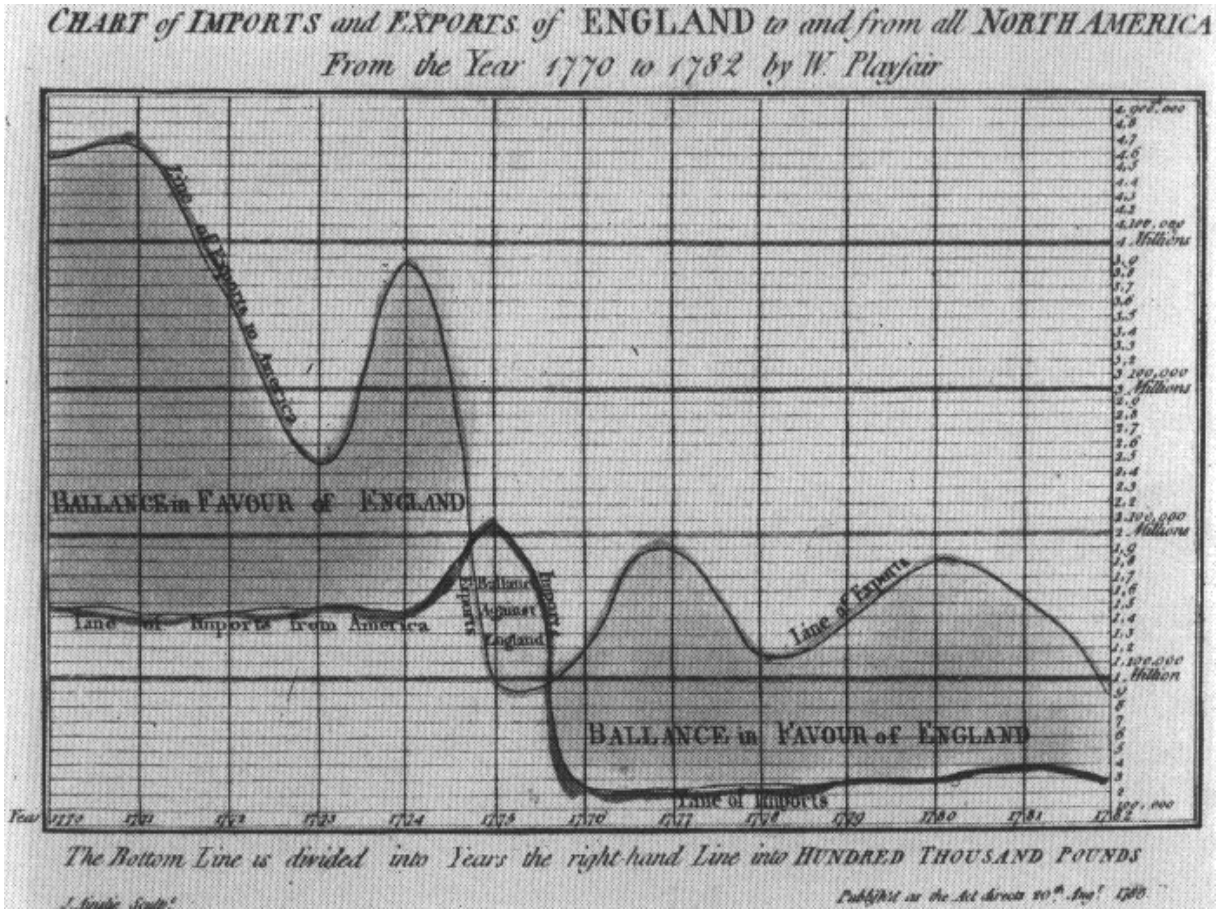
- X-ray tomography

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)

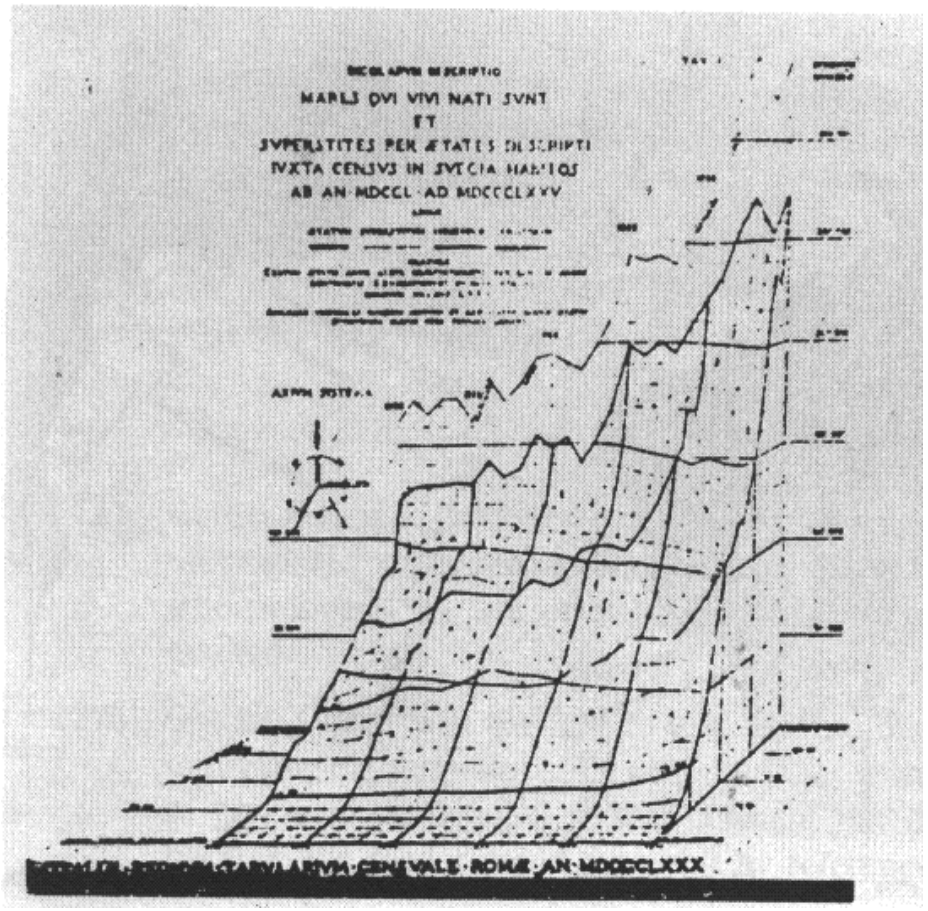


Business Graphics



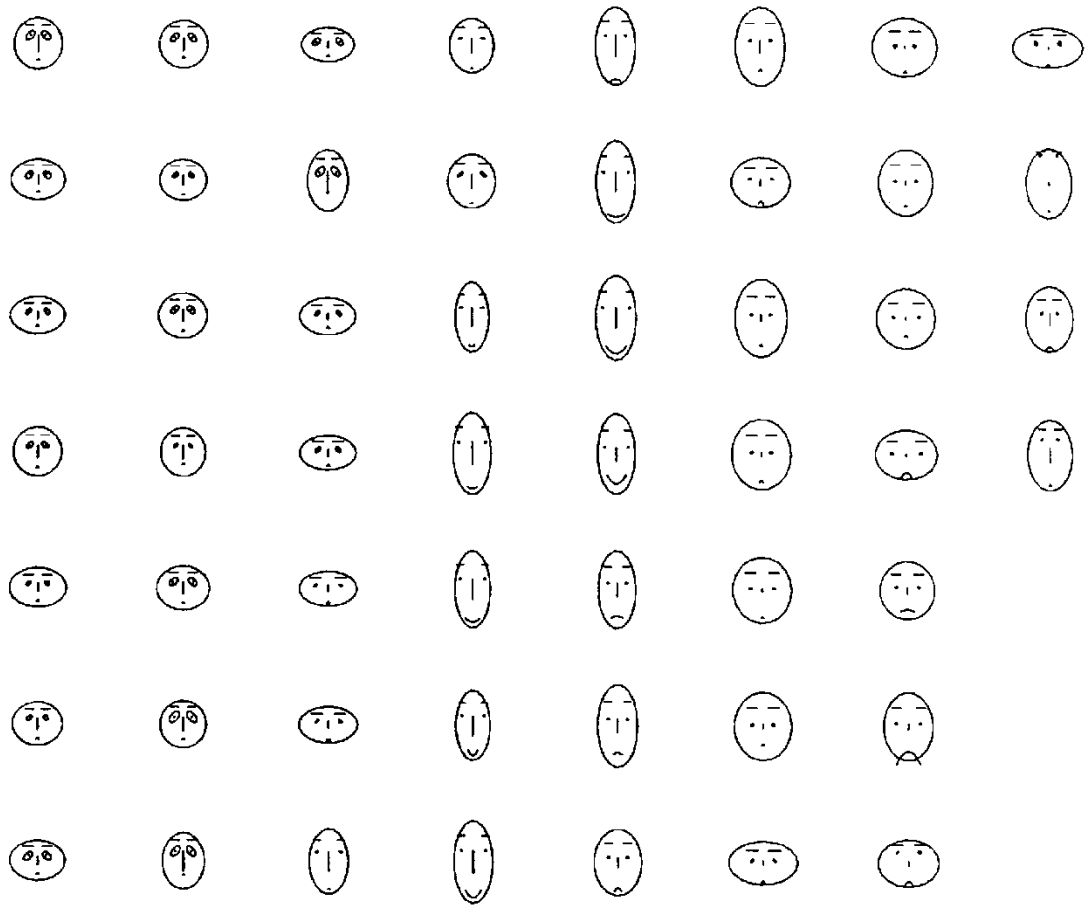
- W. Playfair, engl. econometrist, 1785
- Imports/Exports USA-England 1770-1782

Population Development



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

Icons

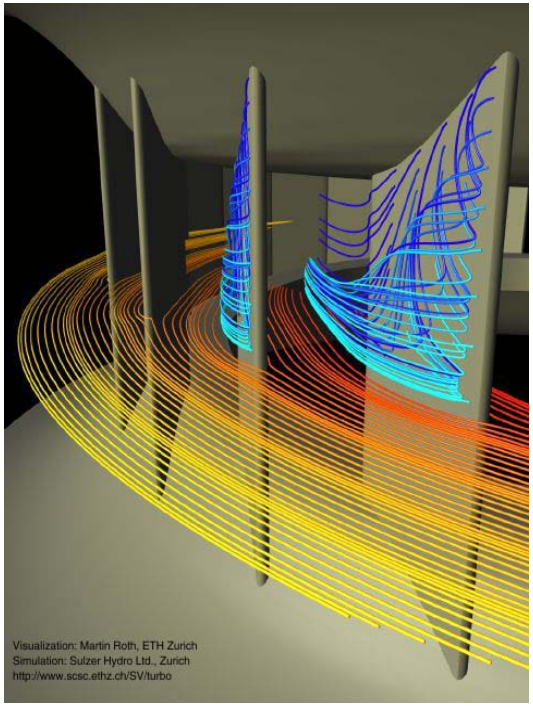


- H. Chernoff, 1973, 2D scatterplot
- Data characteristics encoded in geometric face features

Visualization – Sub Topics

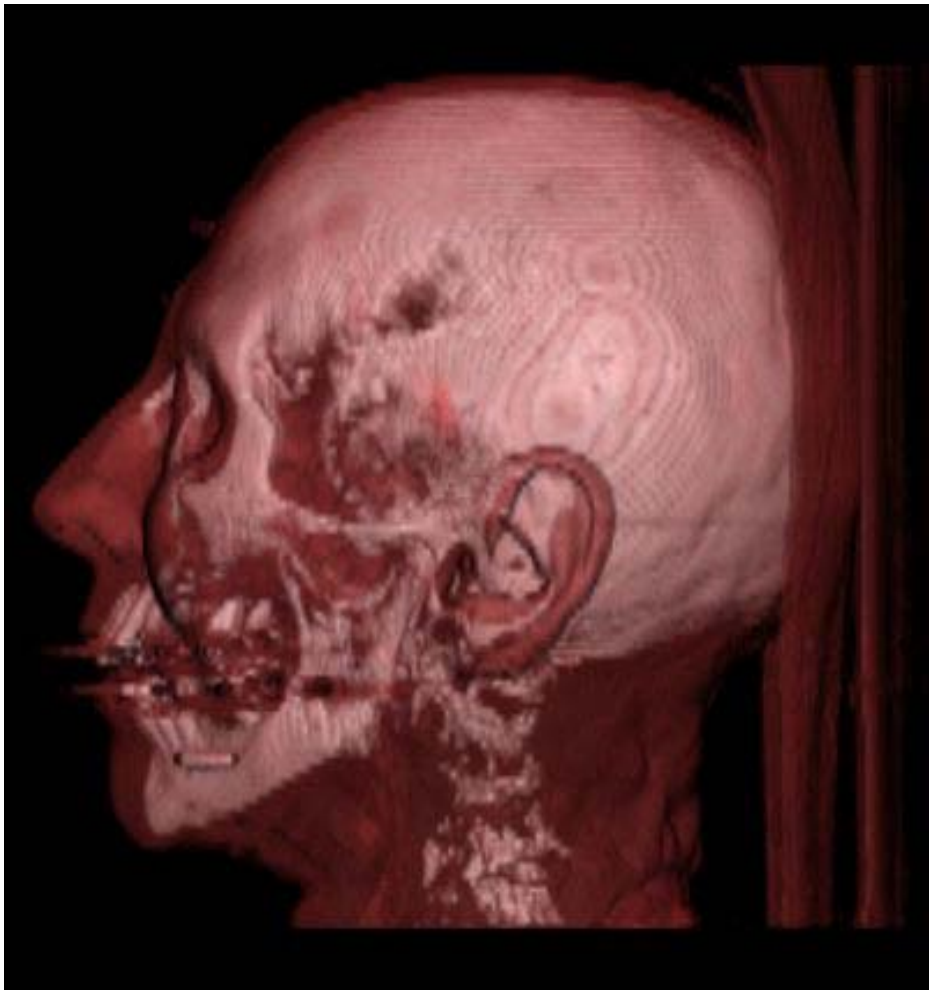
- Visualization of …
  - Medical data ⇒ VolVis!
  - Flow data ⇒ FlowVis!
  - Abstract data ⇒ InfoVis!
  - GIS data
  - Historical data (archeologist)
  - Microscopic data (molecular physics), Macroscopic data (astrononomy)
  - Extrem large data sets

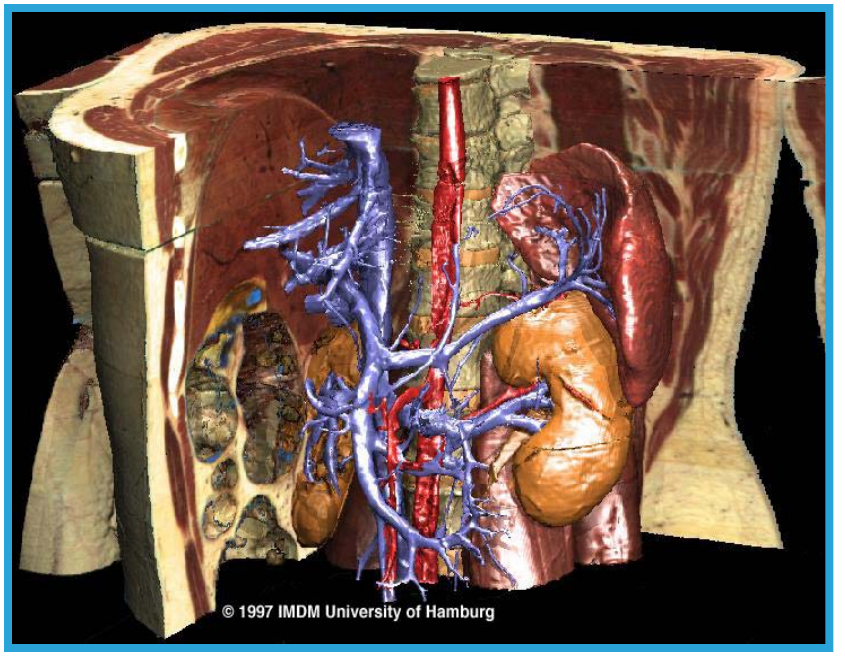
  etc. …

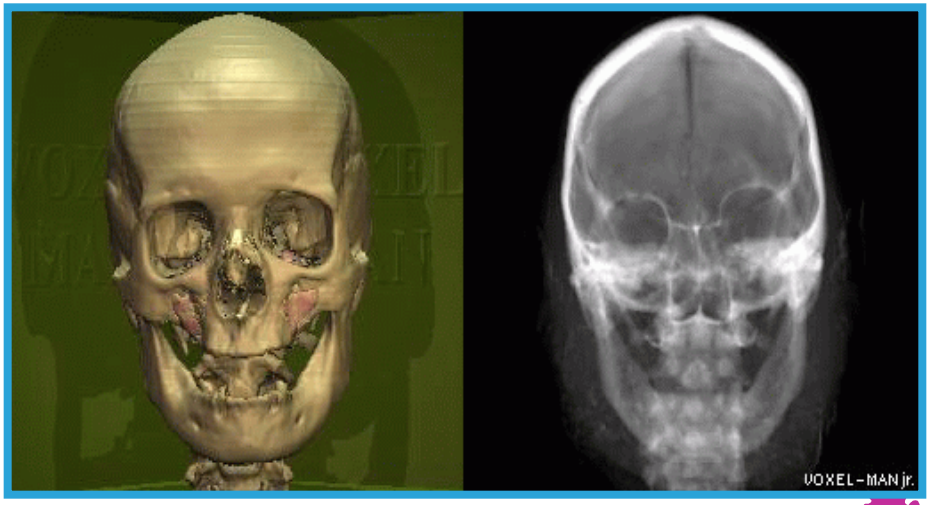


Visualization – Examples

- Medical data

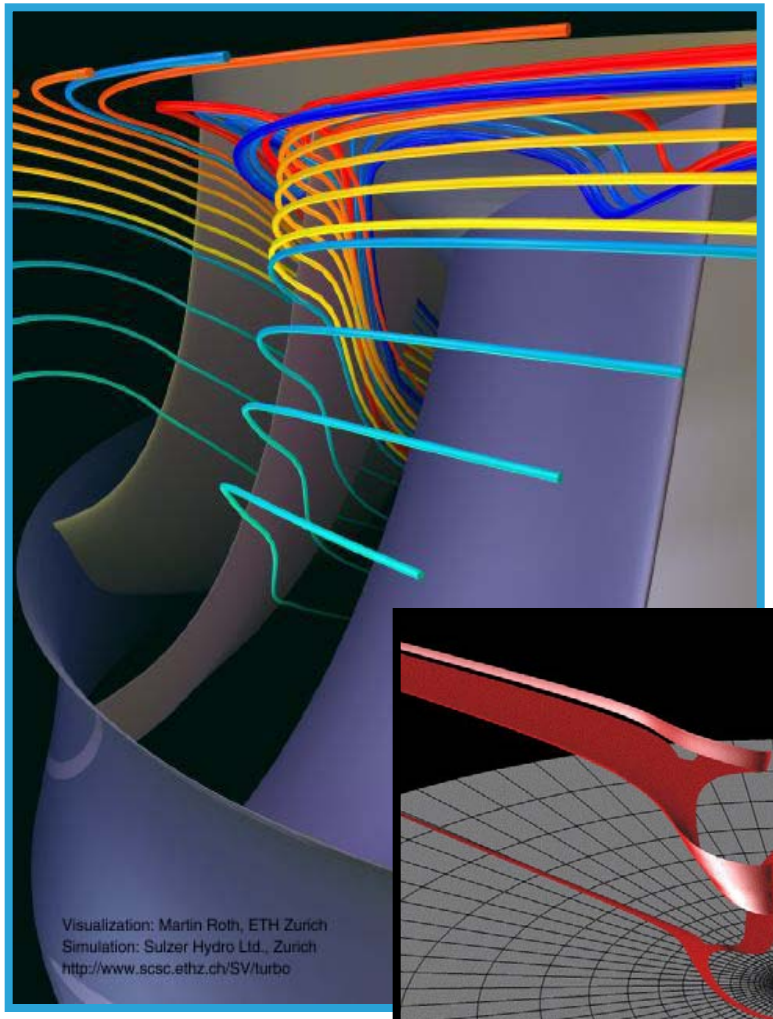


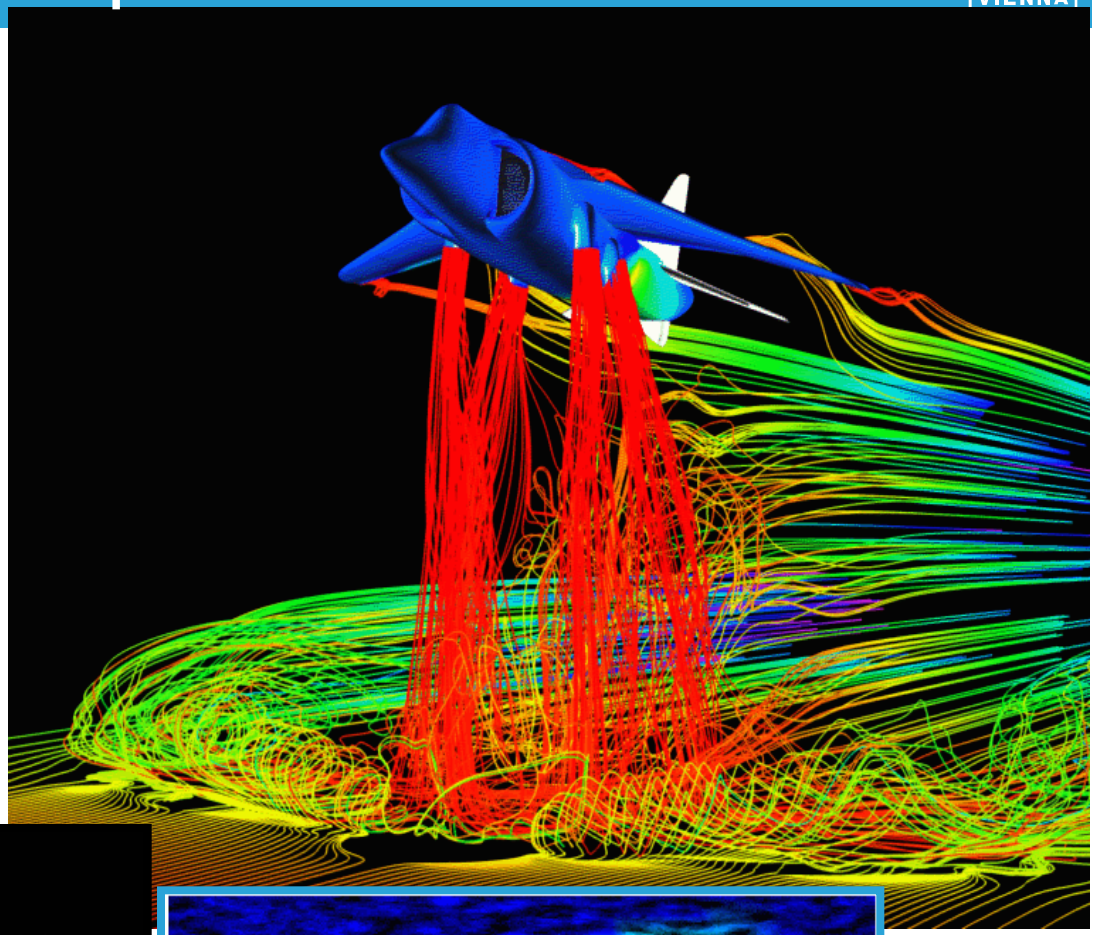


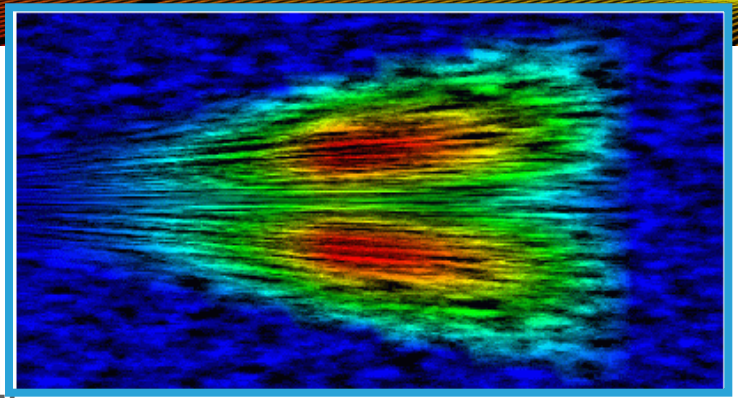


Visualization – Examples

- Flow data

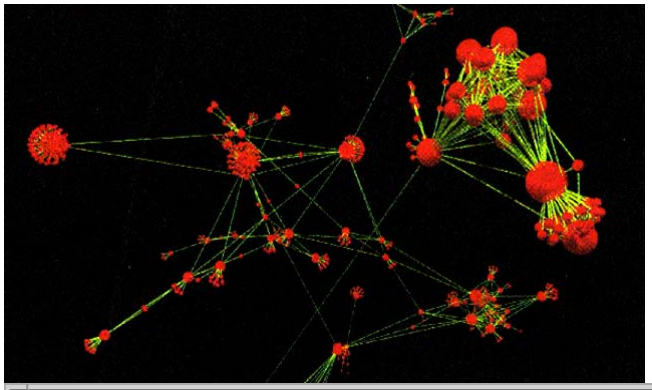


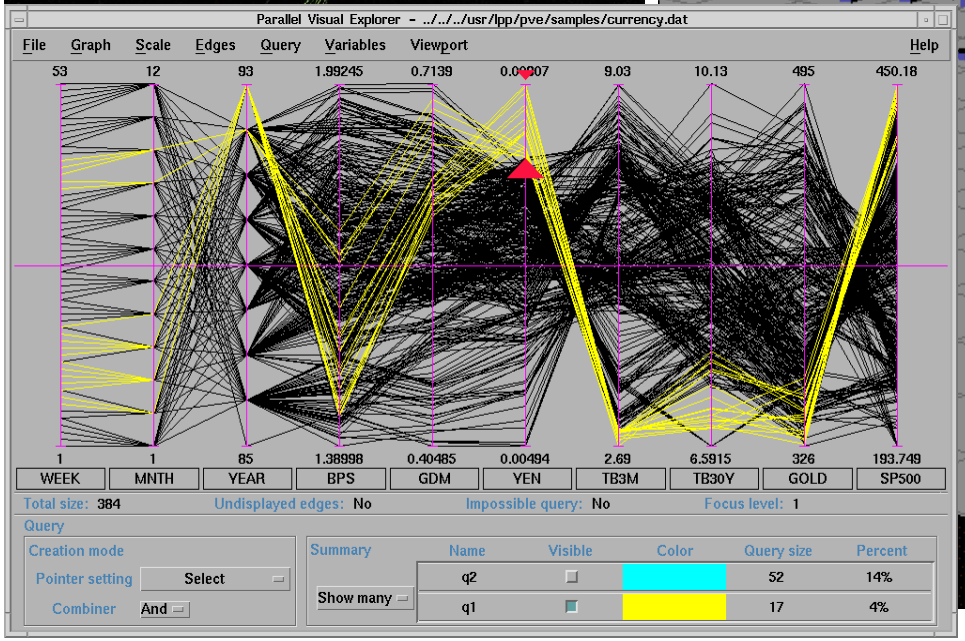


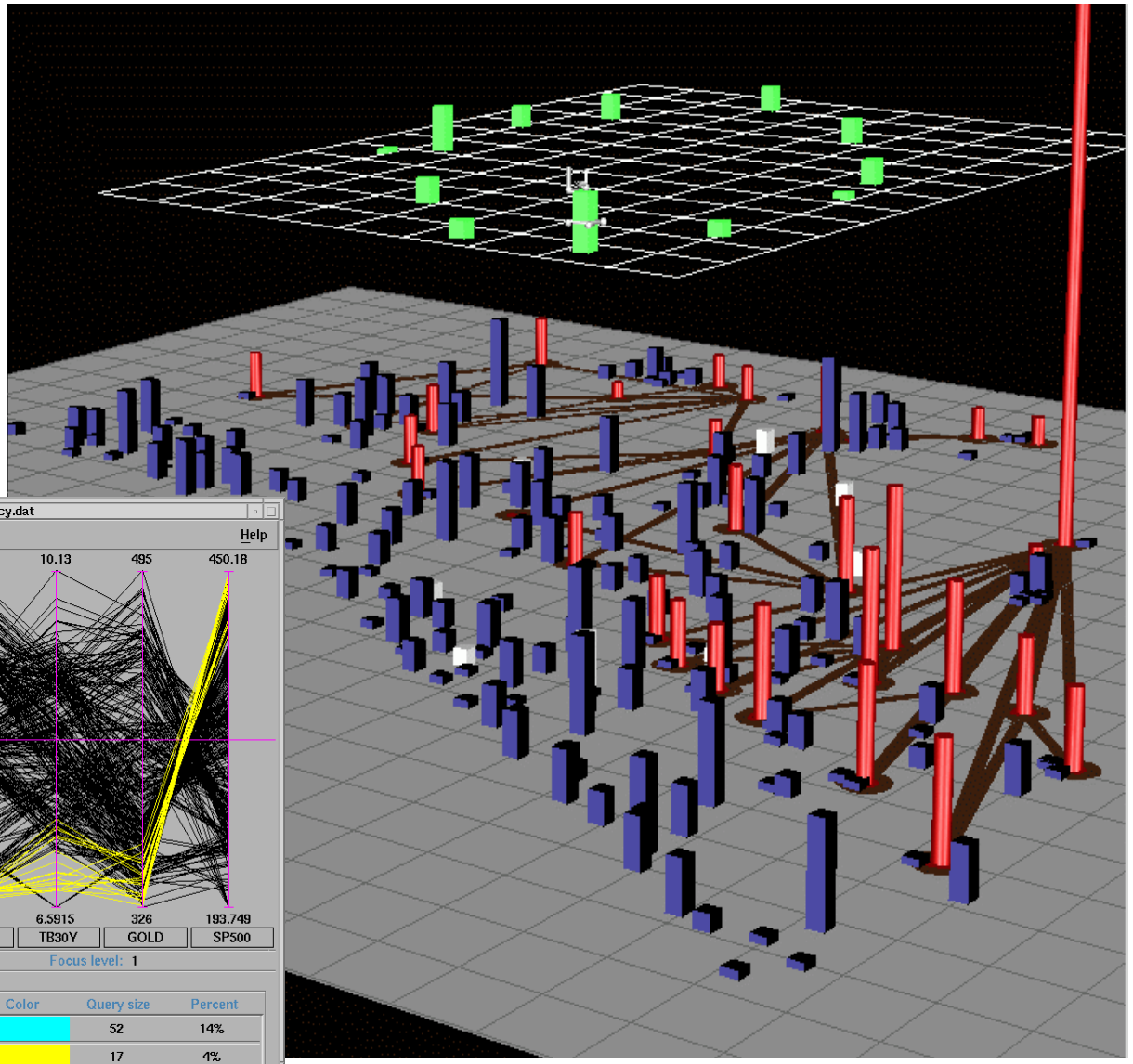


Visualization – Examples

- 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

Inherent spatial reference

3D

---

nD

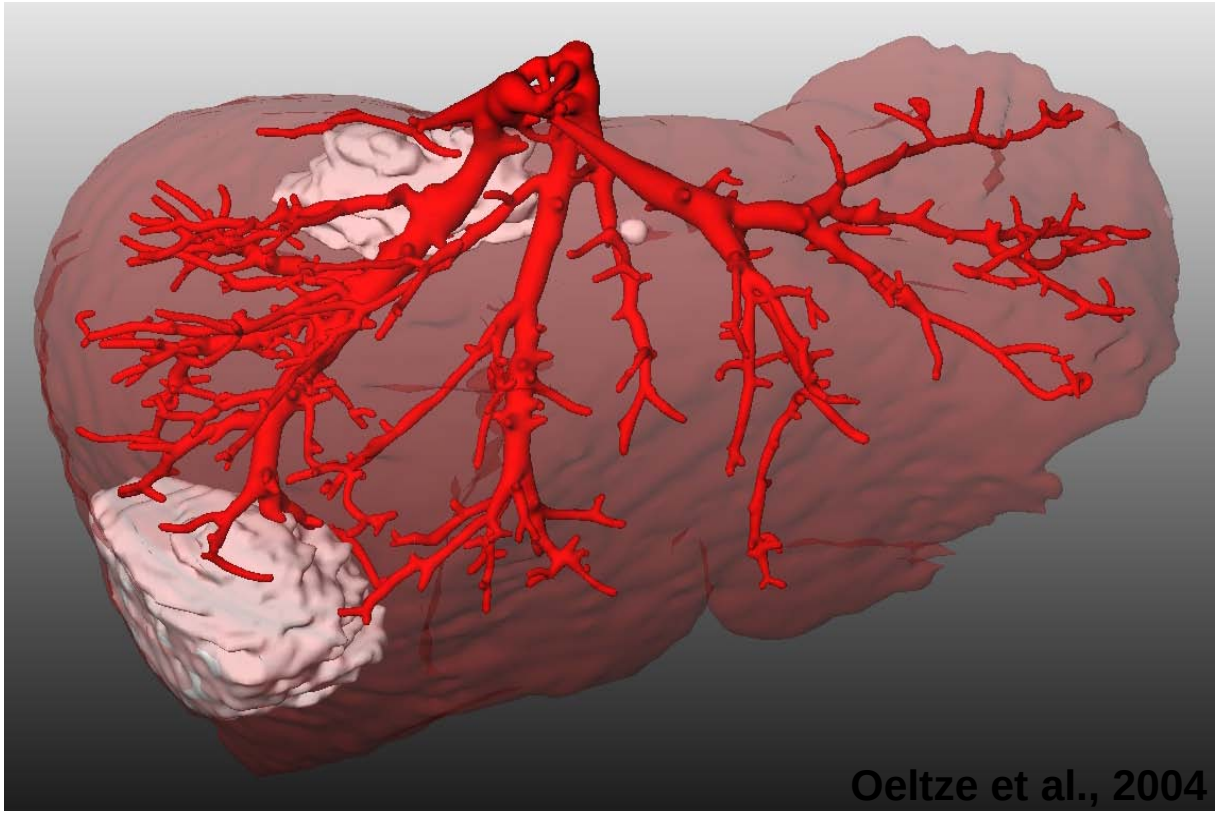
  - Information Visualization

Usually no spatial reference

VolVis - Example

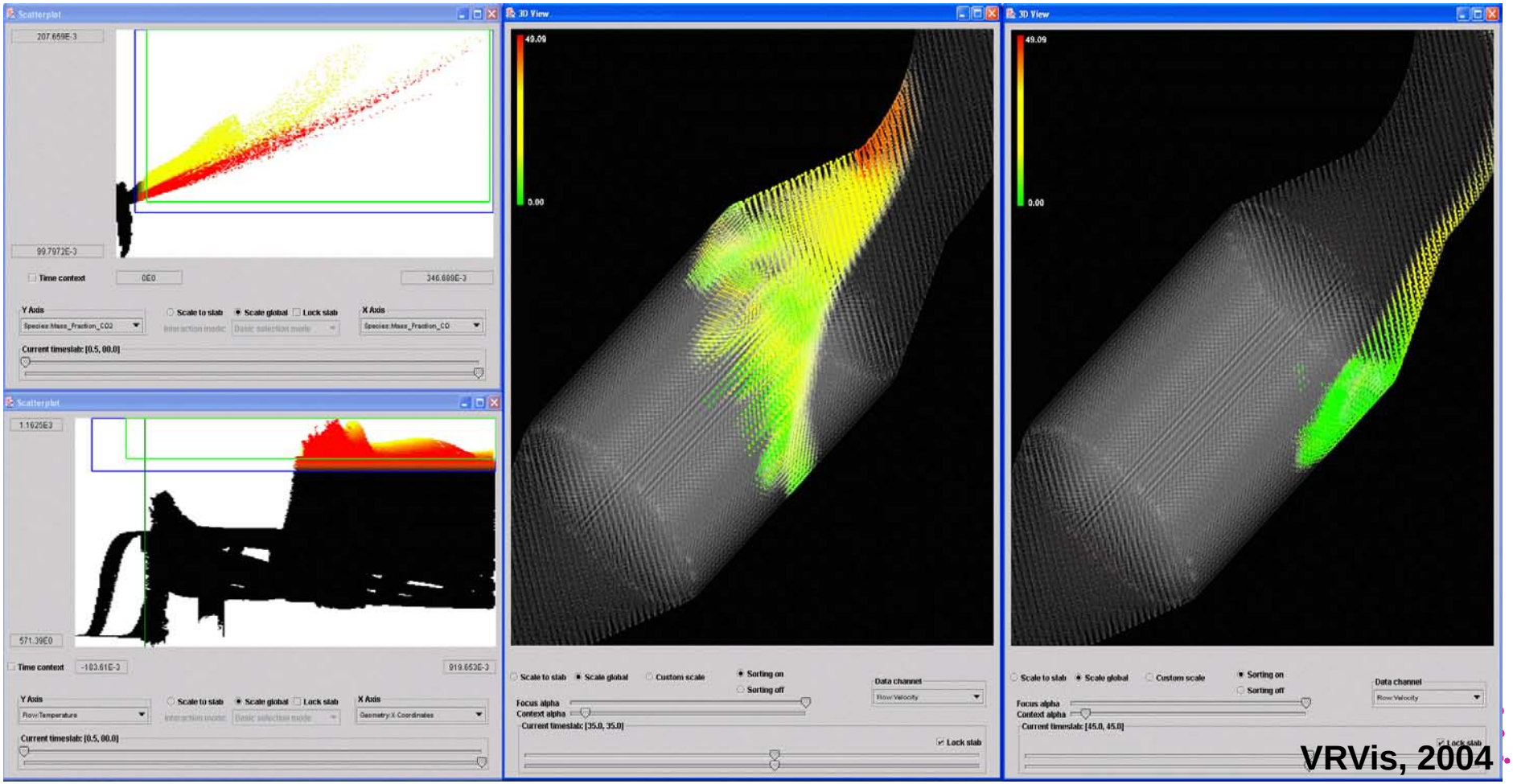
- Medical Visualization in **Surgery Planning**

- Image:
  Liver
  (blood vessels, tumors)



FlowVis - Example

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



InfoVis - Example

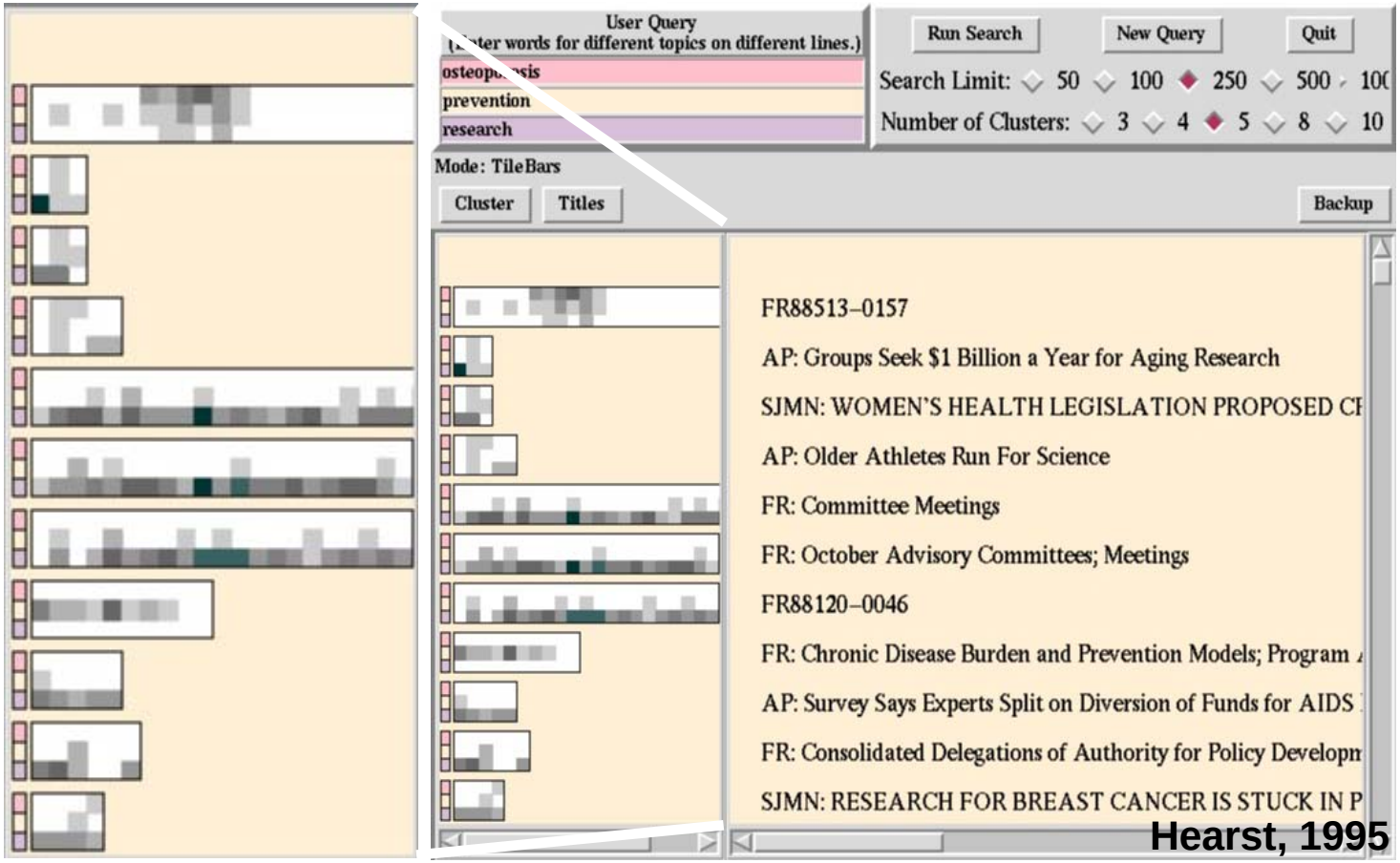
- Visualization of **Search-Results**

- Image:

  document lengths

  frequencies

  etc.

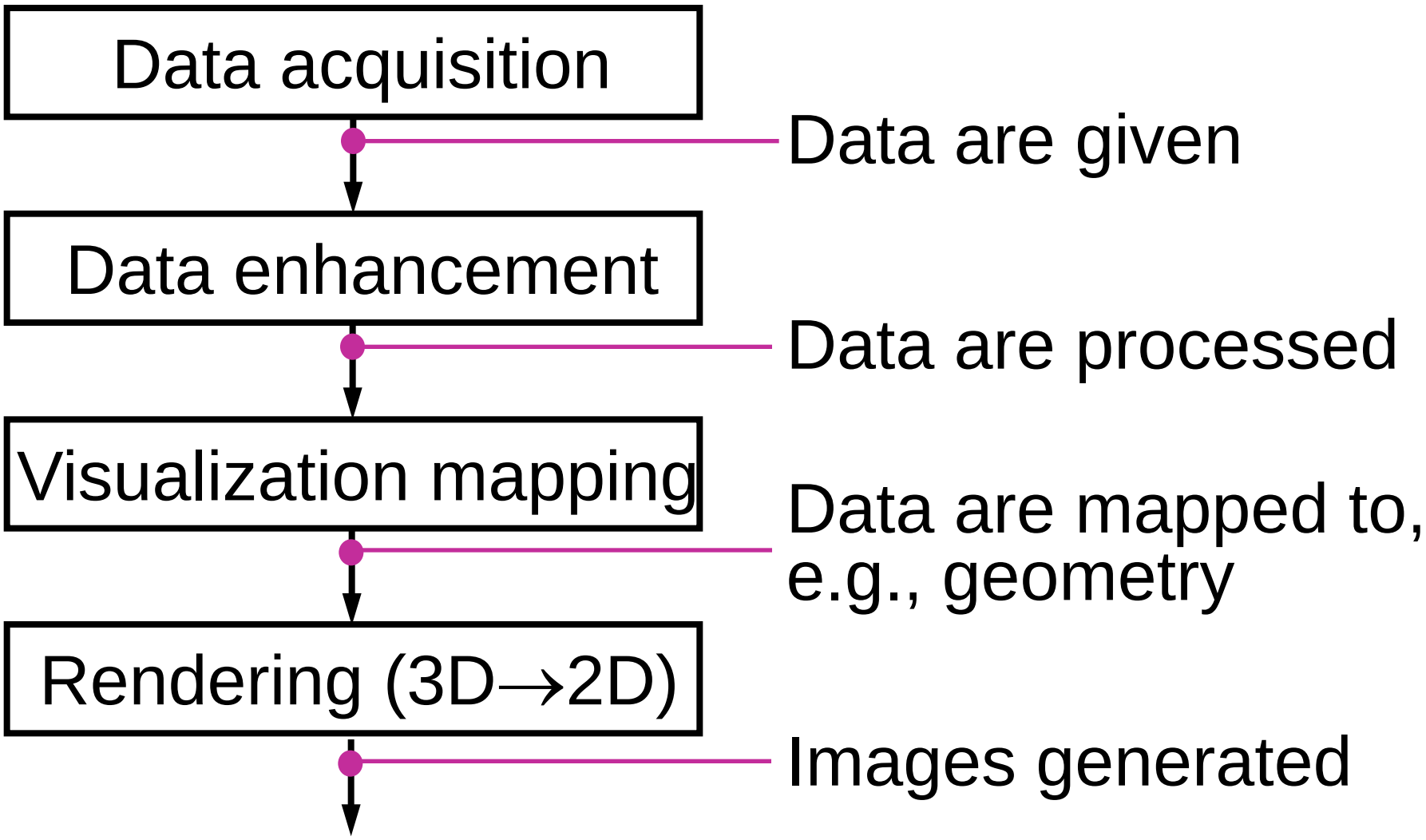


Hearst, 1995

Visualization Pipeline

Typical steps in the visualization process

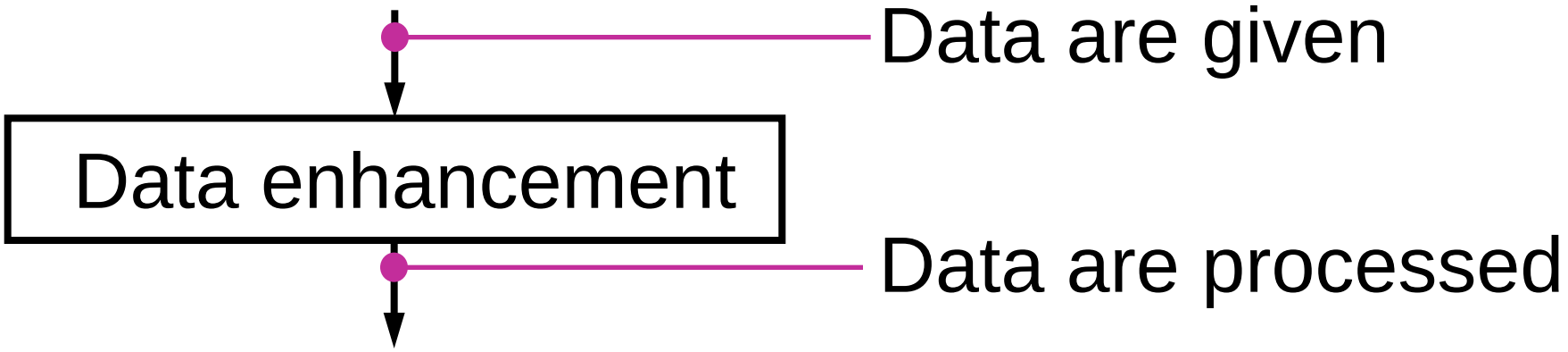
Visualization-Pipeline – Overview



Visualization-Pipeline – 1. Step

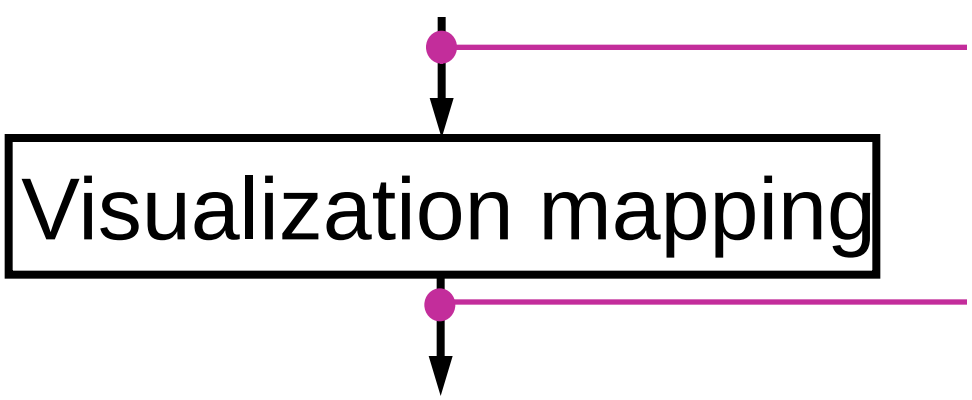
- Data acquisition
  - Measurements, e.g., CT/MRI
  - Simulation, e.g., flow simulation
  - Modelling, e.g., game theory

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, …

Visualization-Pipeline – 3. Step

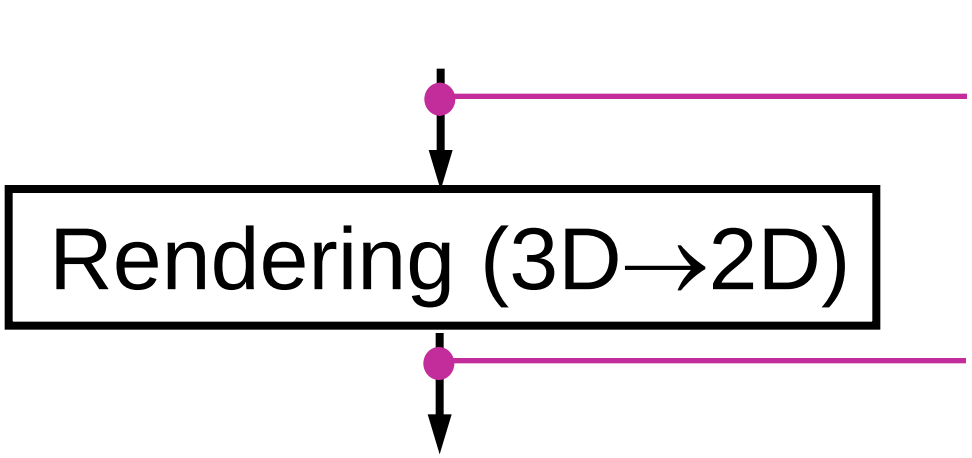


Data are processed

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, …

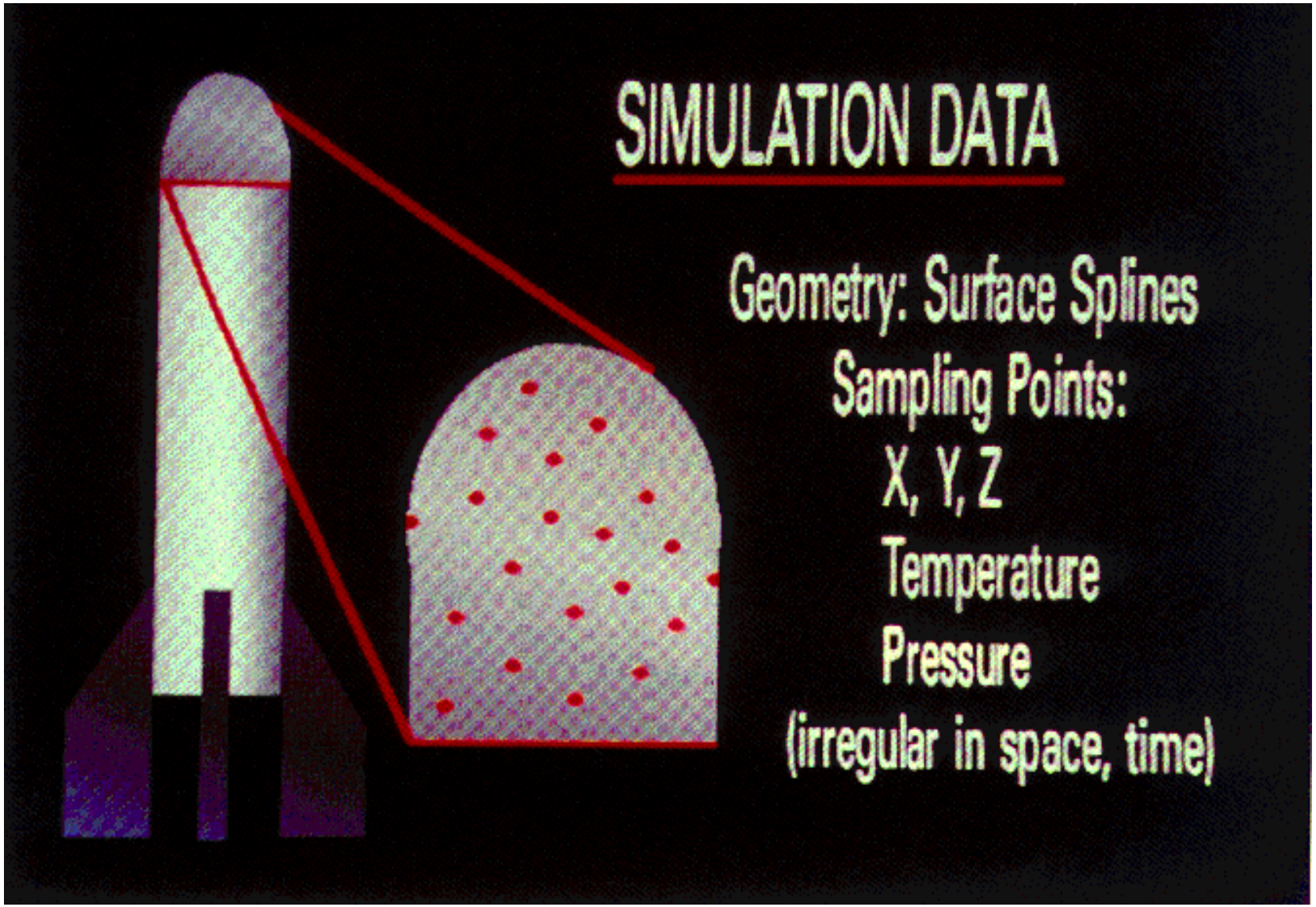
Visualization-Pipeline – 4. Step

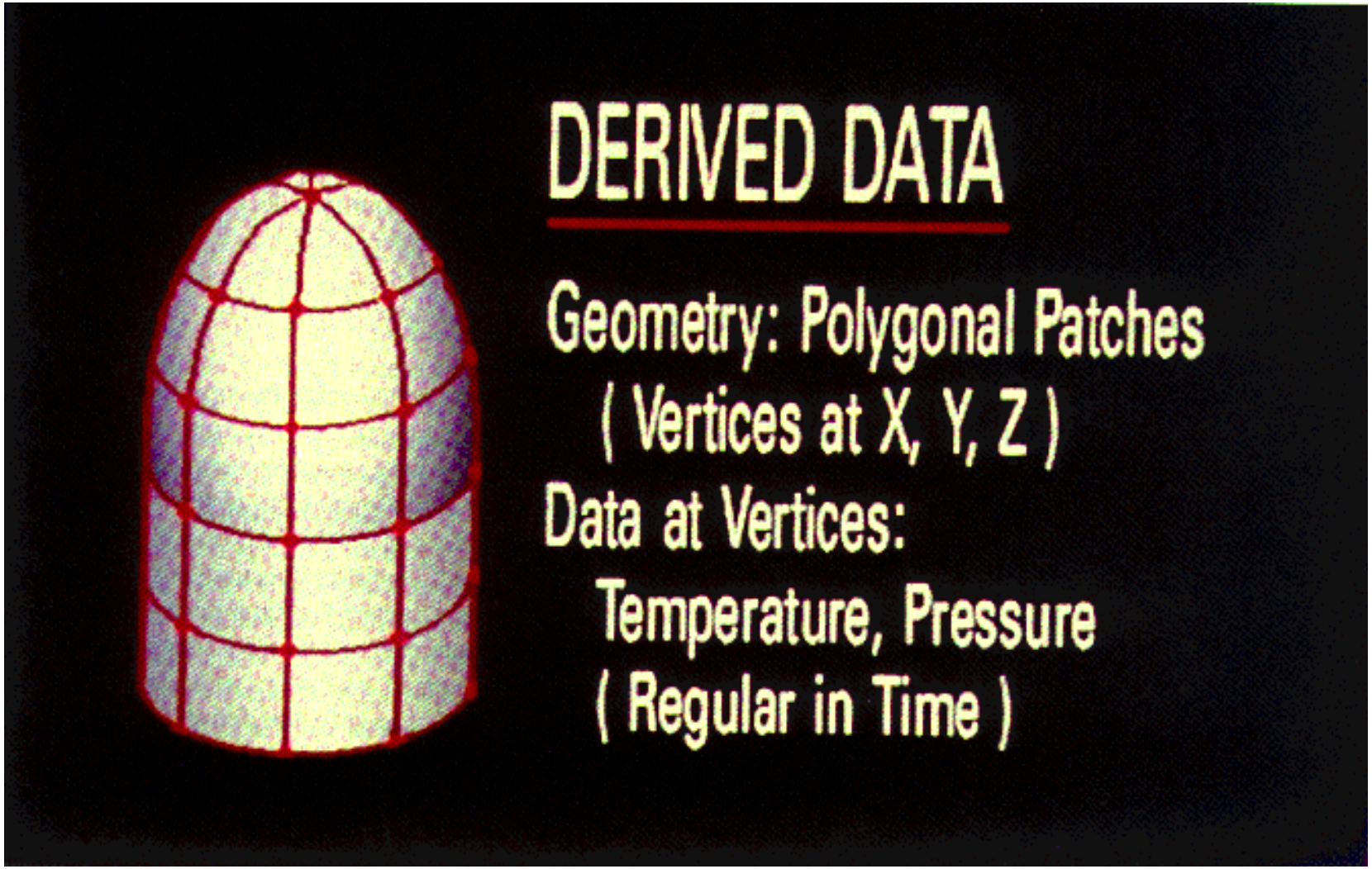


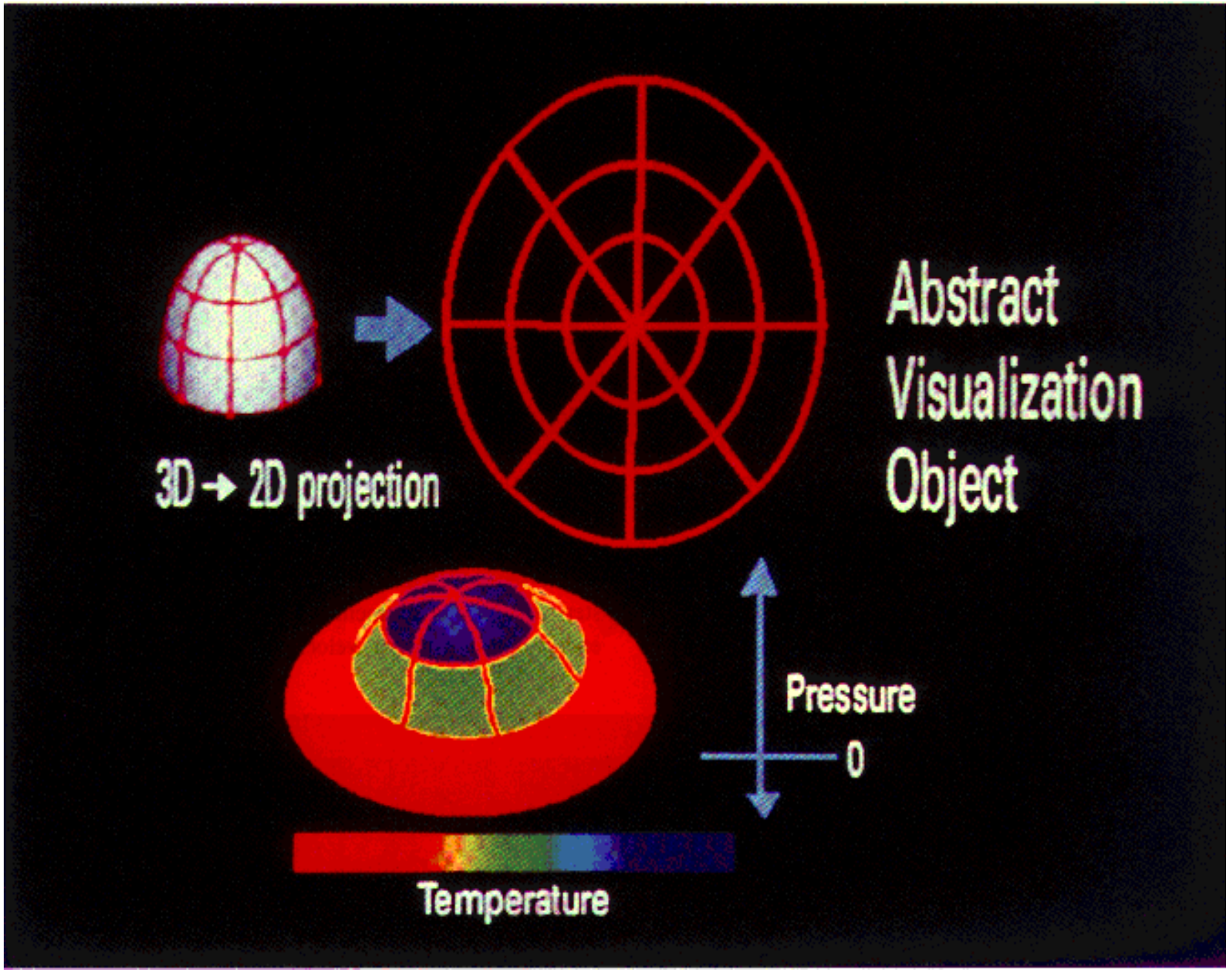
Data are mapped to, e.g., geometry

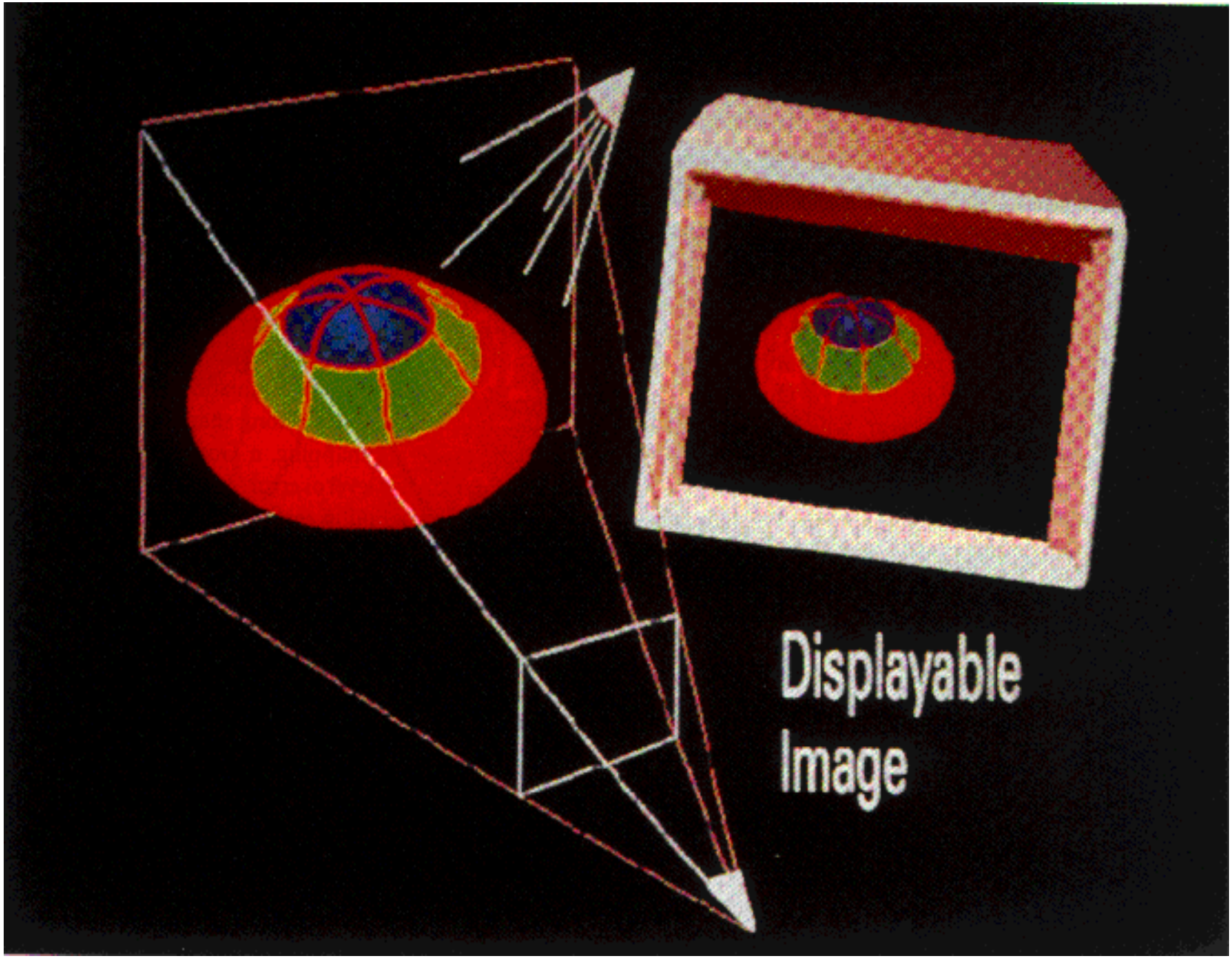
Images generated

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

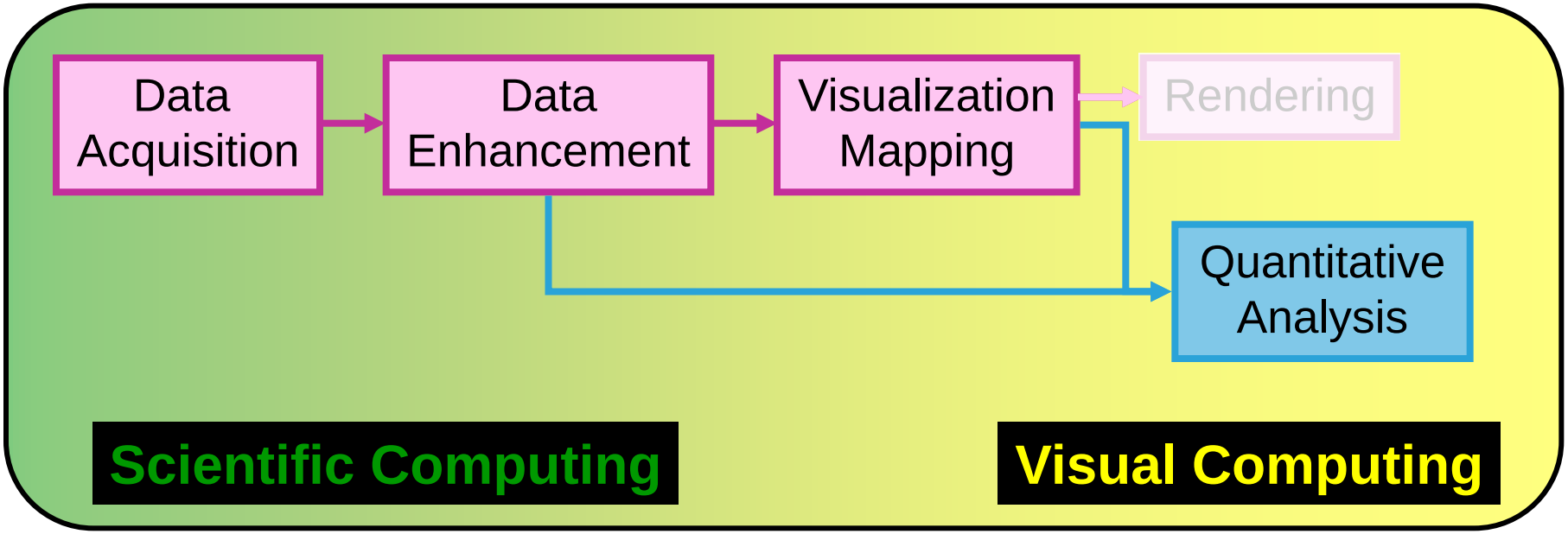

SIMULATION DATA
Geometry: Surface Splines
Sampling Points:
X, Y, Z
Temperature
Pressure
(irregular in space, time)


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


3D → 2D projection
Abstract
Visualization
Object
Pressure
0
Temperature


Displayable
Image

Computational Sciences



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