Introduction to Visualization

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Course outline

Day 1

- Presentation and introduction.
- Introduction to Computer Graphics.
- GLSL programming.
- **Hands on session:** Shader programming with GLSL.

Day 2

- Data visualization techniques: scalar, vector and tensor fields, graphs
- Volume rendering.
- **Hands on session:** GPU-based ray-casting volume rendering.

Course outline

Day 3

- Parallel rendering.
- Equalizer.
- **Hands on session:** Sort-first and sort-last parallel rendering.

Day 4

- Visualization frameworks.
- The roadmap to exa-scale Visualization.
- **Hands on session:** Stream line visualization and introduction to VTK programming.

What is Visualization?

Motivation

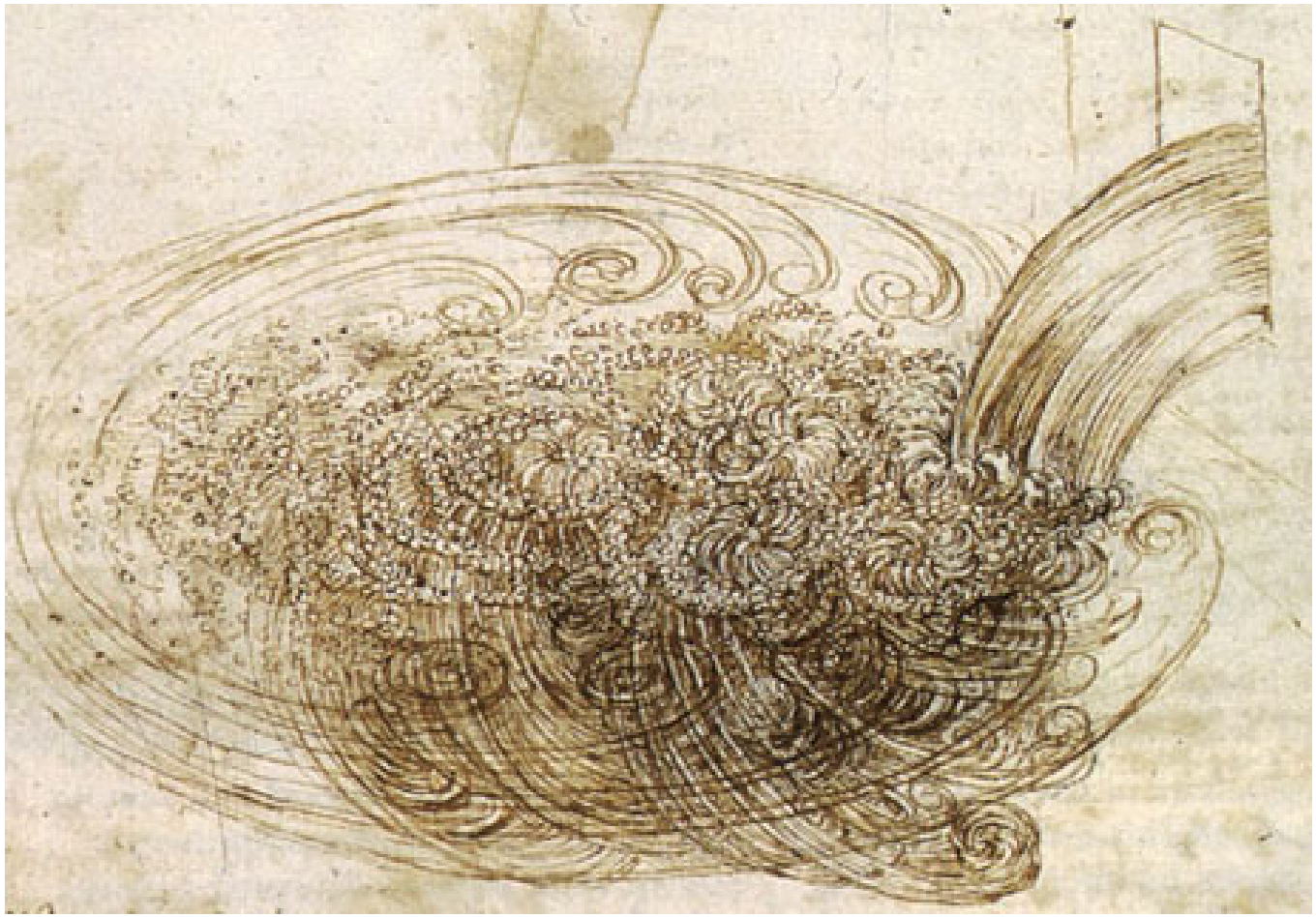
- Available data sets are ever growing and analysis has become the bottleneck long time ago.
- The human visual system if a very powerful information processing system:
  - The transmission bandwidth of the human retina has been approximated as 8 Gbps.
  - The 50% of the cortical area of the macaque monkey is devoted to visual processing.

Definition

"Visualization studies the computing methods to transform symbolic and numerical information into visual representations that humans can observe to gain understanding and insight about the underlying data."

Notable historical examples of visualizations

Turbulent water flow drawings, Leonardo da Vinci, circa 1500

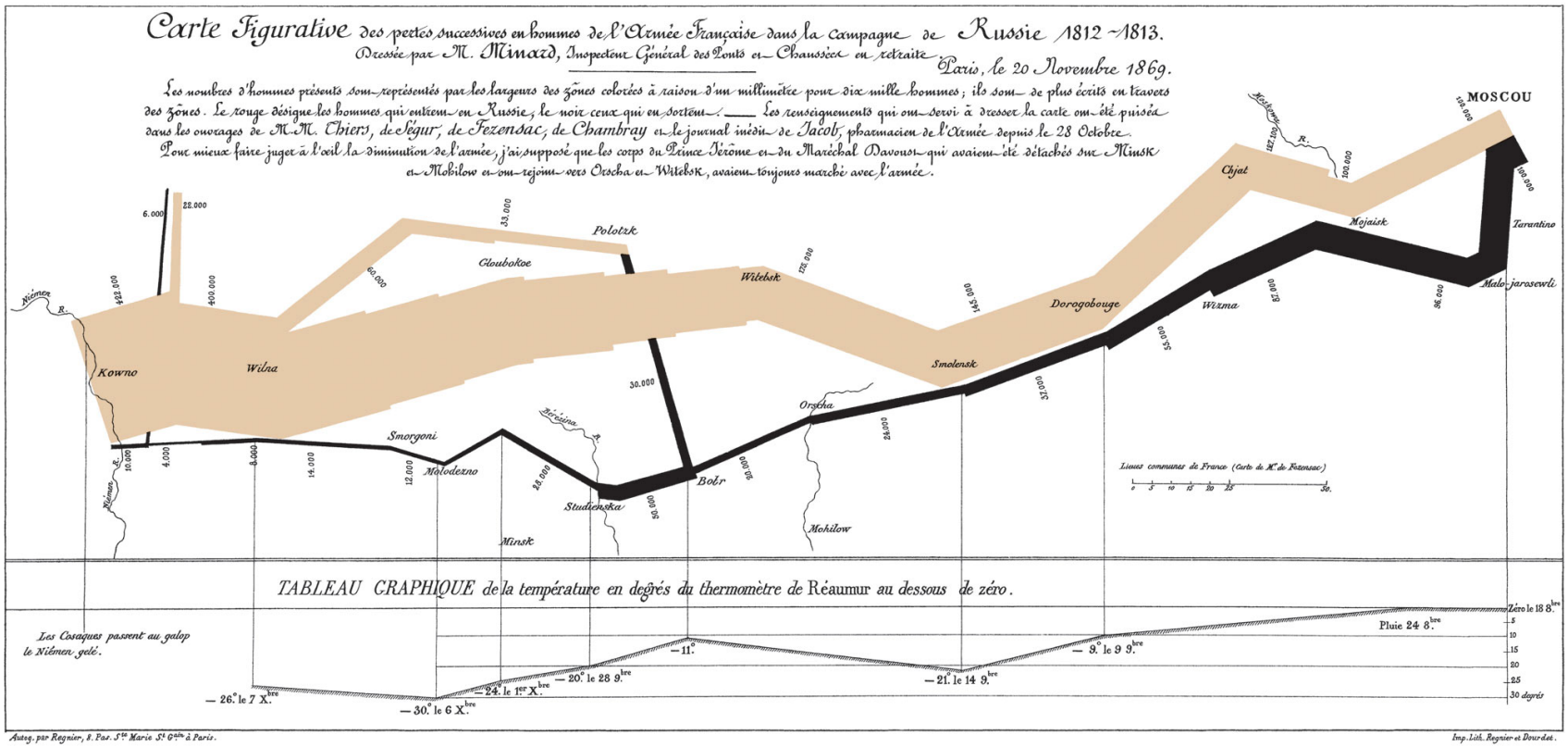


Notable historical examples of visualizations

Broad Street cholera outbreak in London, John Snow, 1845

Notable historical examples of visualizations

Flow map of Napoleon's Russia campaign by Charles Joseph Minard, 1869 (Edward Tufte's redesign)



The birth of Visualization

McCormick et al presented in 1987 a report encouraging US government to fund research in an new computing field named Scientific Visualization Computing.

- In this report the term Scientific Visualization appears for the first time.
- Most of the research lines mentioned are still valid (only with larger numbers).
- And the analysis was also extensible to a broader vision of data sources.

Data sources of human knowledge

Everyday TB of data are produced, in some cases just to be there until someone can analyze them.

- Supercomputers
- Internet
- Medical scanners
- -omics
- High-Energy Physics
- Satellites
- Sensor netwoks

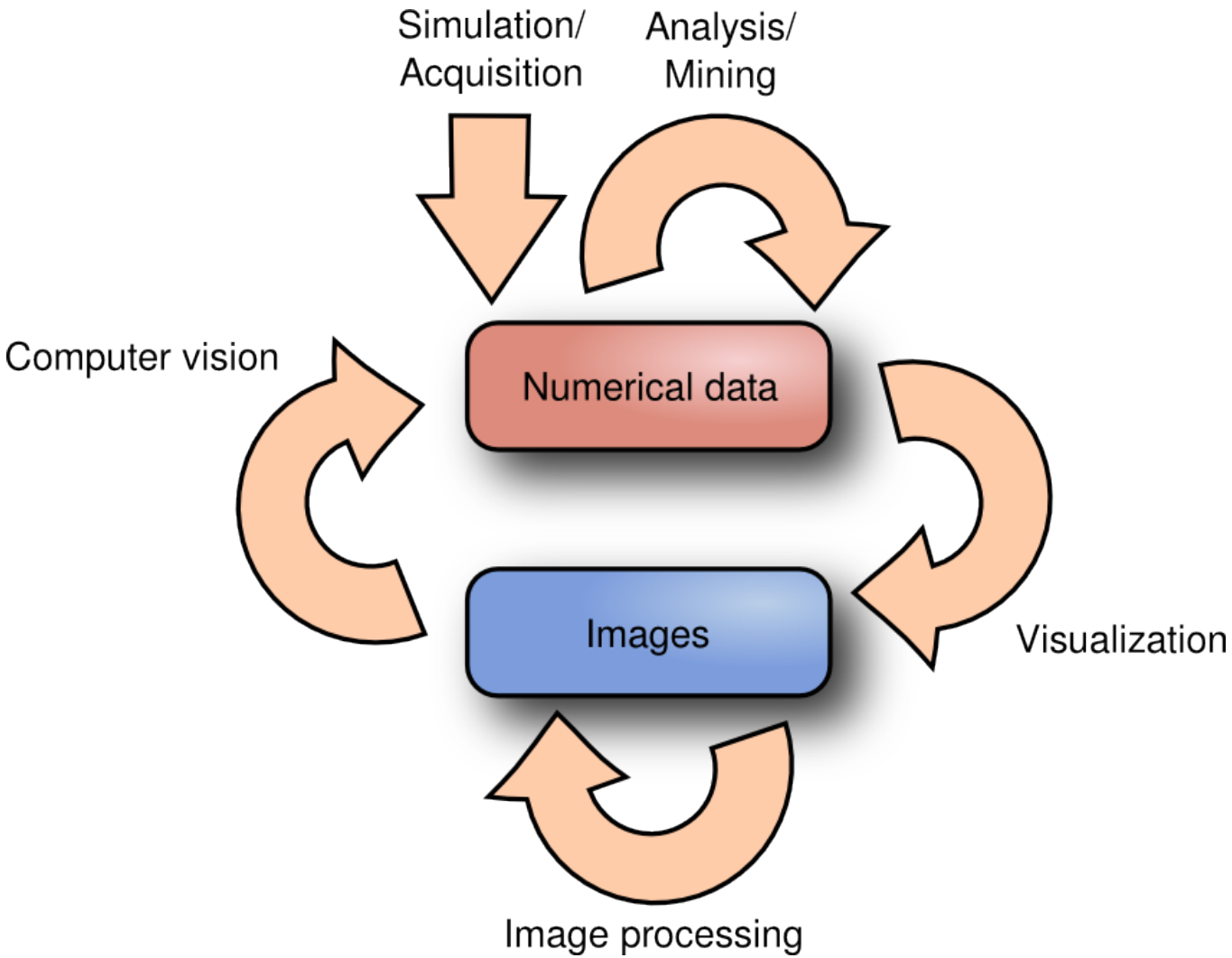
Goals of visualization

The 3 D's of visualization

- **Debug**: Help data producers validate their code or instruments.
- **Discover**: Enable exploration, query and analysis of the data to find new insight.
- **Disseminate**: Produce media for communication of discoveries and results to other people.

- Visualization is a enabling technology.
- In HPC facilities, Visualization should be one of the services offered to the users ("Here I have my TB of simulation results, now what?")

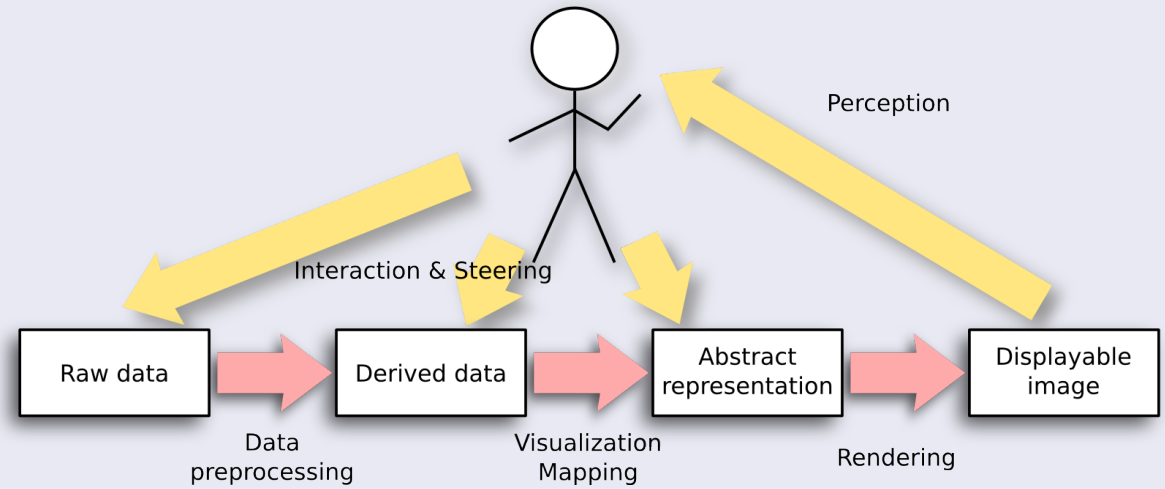
Visual Computing



Data processing models

The data flow model

The most common way of describing the logical operations of a visualization pipeline. Proposed by Haber and McNabb in 1990.



Object-oriented models

A generalization of the previous one.

- Directed acyclic graphs.
- Push or pull execution models.

Types of Visualization

According to: the nature of the data

- Scientific Visualization
- Information Visualization

. . . simultaneity and locality of data generation process

- Post-processing
- Co-processing
- In-situ

. . . human-computer interaction latency

Batch – Interactive – Real-time

. . . other criteria

Collaborative, Steerable, remote, ...