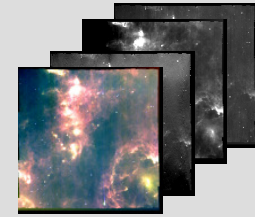


1.0 The Need for Visualization

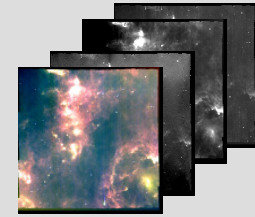
- "Like good writing, good graphical displays of data communicate ideas with clarity, precision, and efficiency."
- "Like poor writing, bad graphical displays distort or obscure the data, making it harder to understand or compare."

(Michael Friendly, Statistical Consulting Service and Psychology Department, York University, <http://www.math.yorku.ca/SCS/Gallery/> [Oct. 99]).



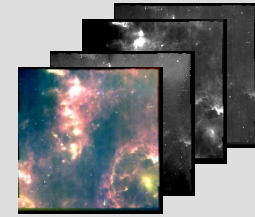
1.1 History

- visualization finds ancestry in pictograms
 - e.g. travel, Da Vinci's airplanes, architecture - human generated
- computer-generated since late 40's
 - Large tables expressed as plots, statistical data for exploration
- mid 80's: need and opportunity grow
 - increased data rates from
 - measuring devices: e.g. space missions, medical instruments ("fire hose")
 - scientific computing: e.g. start of national supercomputer centers, computational sciences (CFD or Molecular Modeling)
 - mature and cheap technology: powerful graphical workstations, color, sufficient memory and storage



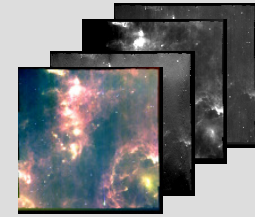
1.1 History (cont.)

- Committee on “Graphics, Image Processing, and Workstations” (1986)
 - sponsored by NSF / Division of Advanced Scientific Computing
- Goal of committee
 - recommendations to HW/SW builders to improve scientific productivity
- Result of committee
 - recommendations to research communities to develop new concepts/techniques for “Visualization in Scientific Computing (ViSC)”
- Solidifying goals
 - workshop on “Visualization in Scientific Computing”
- Governmental support: e.g. NSF and NASA
- Yearly conferences by IEEE (e.g. Visualization ‘99)



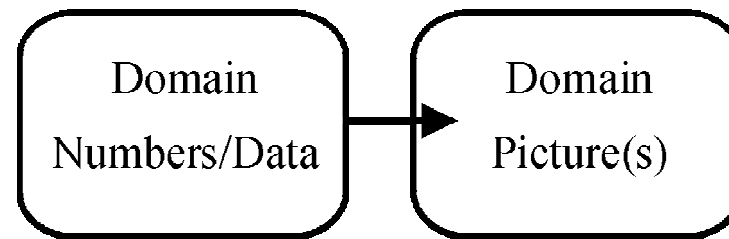
1.2 Definitions

- “to visualize”: form a mental vision, image, or picture of (something not visible or present to sight, or of an abstraction); to make visible to the mind or imagination [The Oxford English Dictionary, 1989]
- here: “a computer generated image or collection of images, possibly ordered, using a computer representation of data as its primary source and a human as its primary target”
- **“computer-generated visualizations meant to be viewed by a human” (ACM SIGGRAPH Education Committee, 1997) includes various flavors of visualization:**
 - Data visualization
 - Scientific Visualization
 - Information Visualization
 - Software Visualization

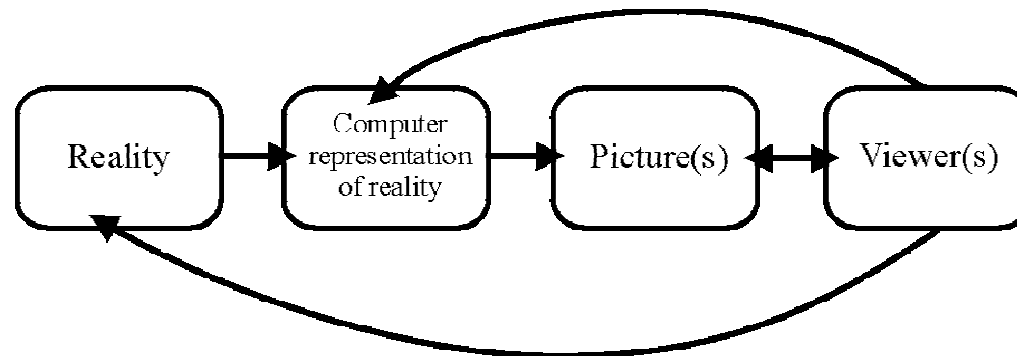


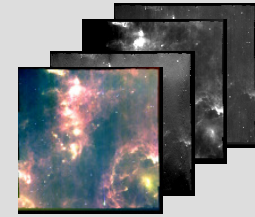
1.2 Definitions (cont.)

Mapping Process



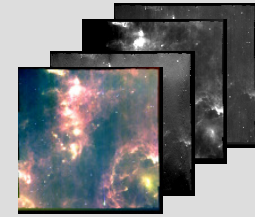
- Mapping from computer representations to perceptual (visual) representations, choosing encoding techniques to maximize human understanding and communication





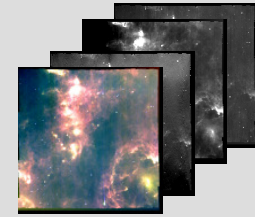
1.2.1 Sample Definitions

- “The purpose of computing is insight not numbers” (Richard Hamming)
- “Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualization offers a method for seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields it is already revolutionizing the way scientists do science.” [MCC87]
- “Scientific visualization is a new, exciting field of computational science spurred on in large measure by the rapid growth in computer technology, particular in graphics workstation hardware and computer graphics software. [Visualization tools] are beginning to impact our daily lives through usage in arts, particularly film animation, and they hold great promise for scientific research and education. When computer graphics is applied to scientific data for purposes of gaining insight, testing hypothesis, and general elucidation, we speak of scientific visualization.” [ARE94]



1.2.1 Sample Definitions (cont.)

- “A useful definition of visualization might be the binding (or mapping) of data to a representation that can be perceived. The types of binding could be visual, auditory, tactile, etc. or a combination of these.” [FOL94]
- “Visualization is more than a method of computing. Visualization is the process of transforming information into a visual form, enabling users to observe the information. The resulting visual display enables the scientist or engineer to perceive visually features which are hidden in the data but nevertheless are needed for data exploration and analysis.” [GER94]
- “Scientific data visualization supports scientists and relations, prove or disprove hypotheses, and discover new phenomena using graphical techniques... The primary objective in data visualization is to gain insight into an information space by mapping data onto graphical primitives.”[SEN94]
- “Visualization is analytic graphics.” Carol Hunter, LLNL

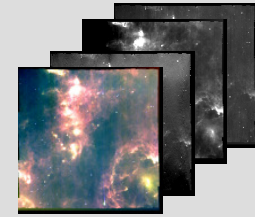


1.2.1 Sample Definitions (cont.)

“Underlying the concept of visualization is the idea that an observer can build a mental model, the visual attributes of which represent data attributes in a definable manner. This raises several questions:

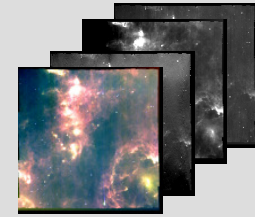
- What mental models most effectively carry various kinds of informations ?
- Which definable and recognizable visual attributes of these models are most useful for conveying specific information either independently or in conjunction with other attributes ?
- How can we most effectively induce chosen mental models in the mind of an observer ?
- How can we provide guidance on choosing appropriate models and their attributes to a human or automated display designer ?

Choosing the appropriate representation can provide the key to critical and comprehensive appreciation of the data, thus benefiting subsequent analysis, processing, or decision making. [ROB91]“



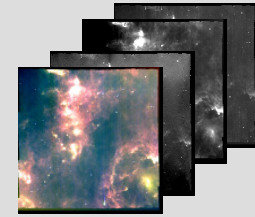
1.2.2 Visualization and adjacent Disciplines

- Computer Graphics: Efficiency of algorithms (CG) versus effectiveness of use (V).
- Computer Vision: Mapping from pictures to abstract description (CV) versus mapping from abstract description to pictures (V).
- Image Processing: Mapping from data domain to data domain (IP) versus mapping from data domain to picture domain (V).
- (Visual) Perception: General and scientific explanation of human abilities and limitations (VP) versus goal oriented use of visual perception in complex information representation.
- Art and Design: Aesthetics and style (AD) versus expressiveness and effectiveness of data (V) .



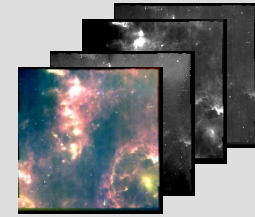
1.2.2 Visualization and adjacent Disciplines (cont.)

Haber and McNabb define Visualization as the “use of computer imaging technology as a tool for comprehending data obtained by simulation or physical measurement.” In their understanding Visualization technology depends on the integration of older technologies, including computer graphics, image processing, computer vision, computer-aided design, geometric modeling, approximation theory, perceptual psychology, and user interface studies.[HAB90]



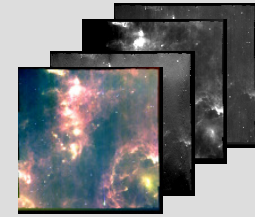
1.2.3 Examples of Goals in Visualization

- exploration/exploitation of data and information
- enhancing understanding of concepts and processes
- gaining new (unexpected, profound) insights
- making invisible visible
- effective presentation of significant features
- quality control of simulations, measurements
- increasing scientific productivity
- medium of communication/collaboration

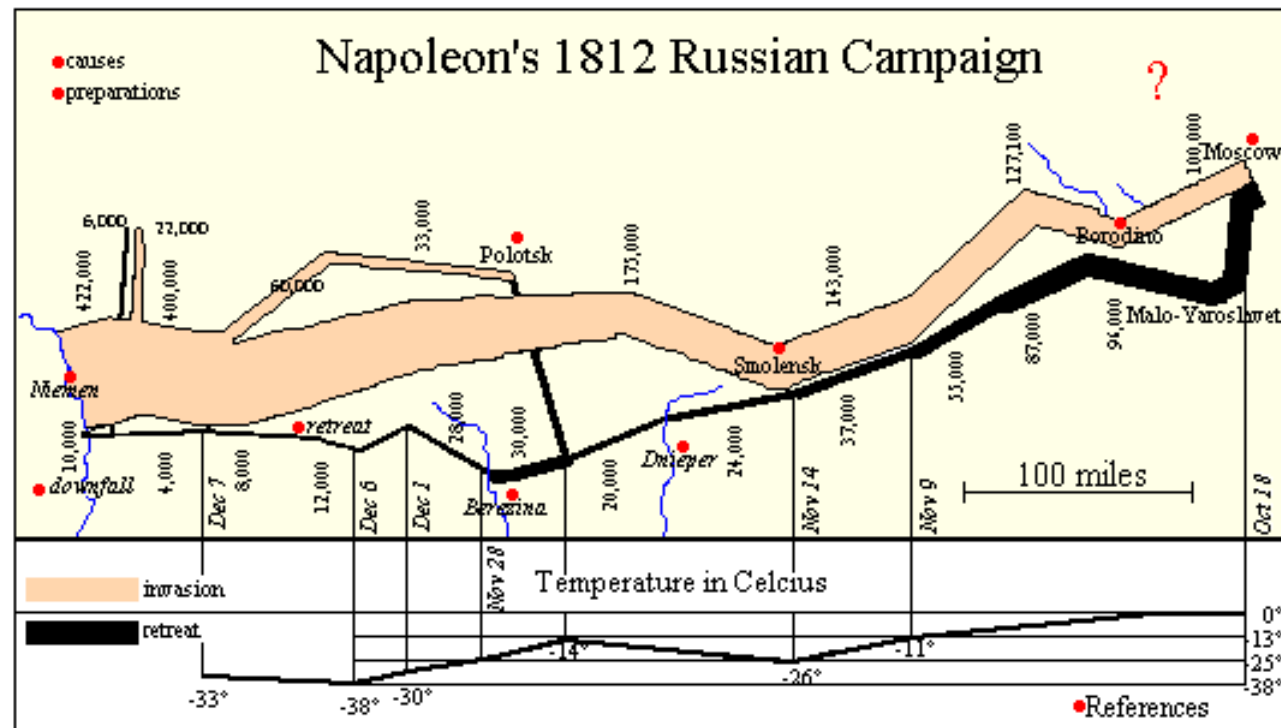


1.3 Sample Applications

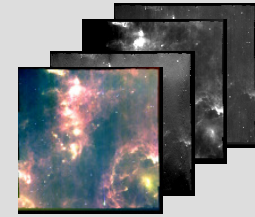
- Geophysics, e.g. “The Visualization of a Storm”
- Biochemistry, e.g. the visualization of DNA, molecules, or crystals
- Engineering and Physics, e.g. the visualization of a helicopter turbine, of a wind tunnel, of the Big Bang, of Finite Elements Analysis computations
- Sociology and Politics, e.g. the visualization of census data, of vote distributions or the spread of aids
- Mathematics, e.g. the visualization of splines
- Information Technology, e.g. the visualization of the web, the visualization of retrieved documents from a query



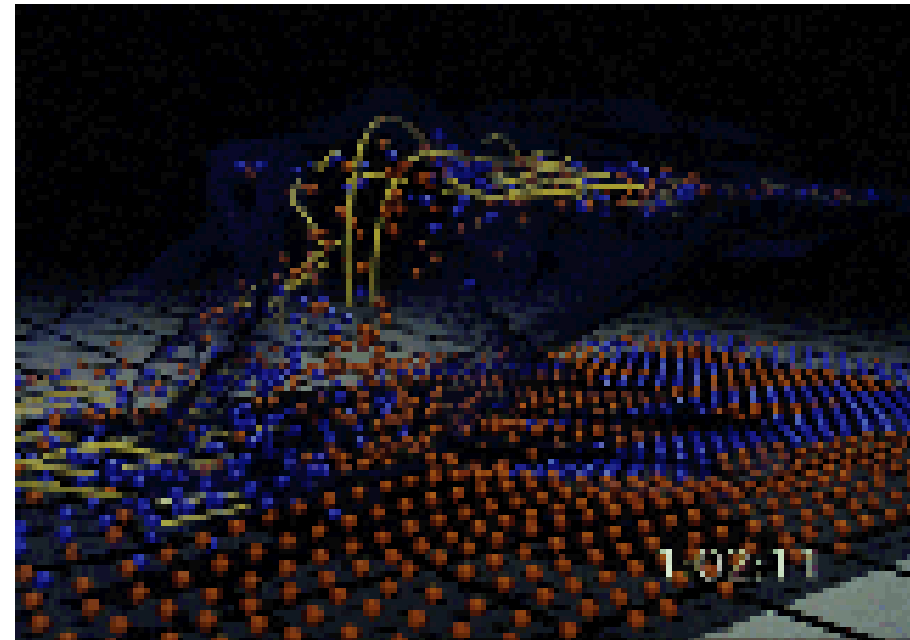
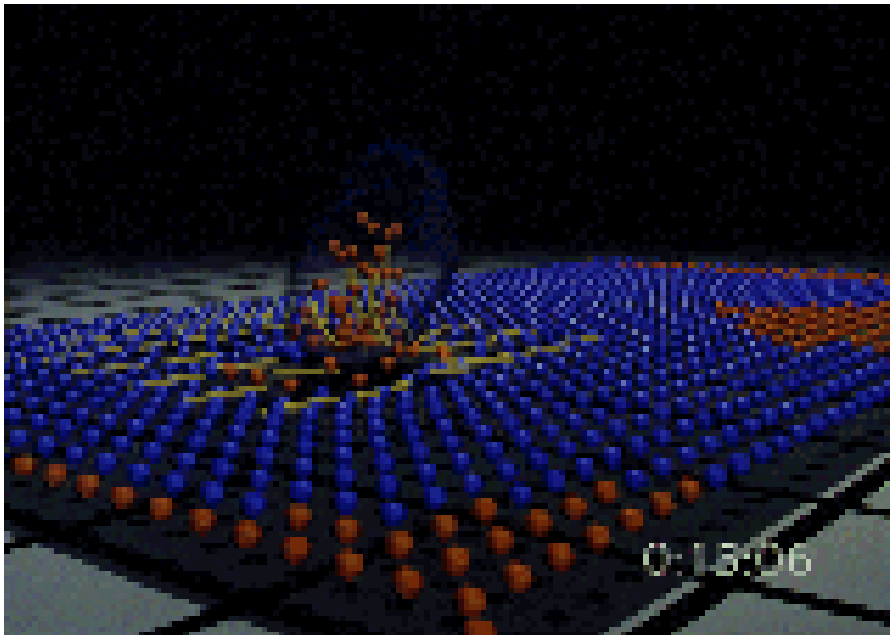
Examples of Visualization



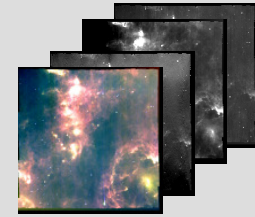
This graphic is an adaptation of M. Charles Joseph Minard's „March of the Napoleon Army“ by Sunny McClendon, as part of an Information Design Class at the University of Texas at Austin.



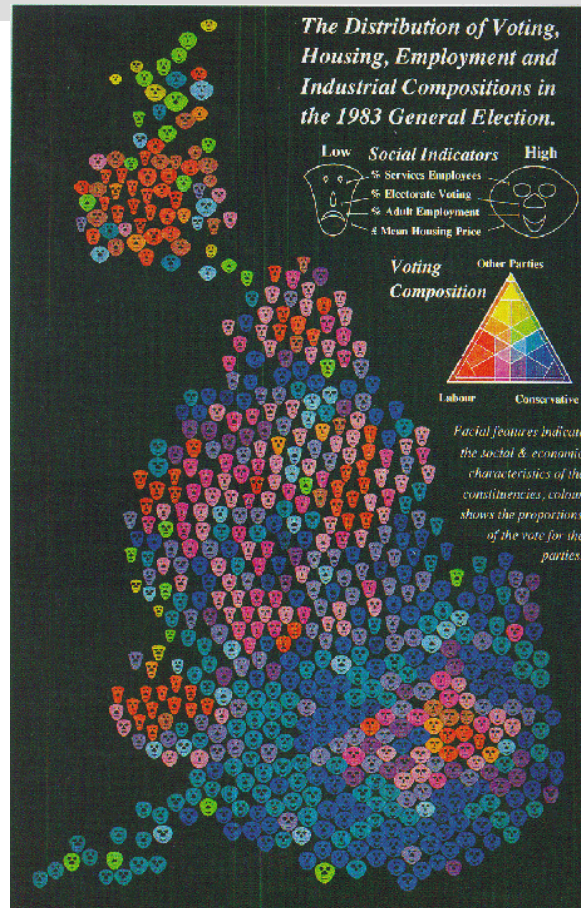
Examples of Visualization



„Study of a Numerically Modeled Severe Storm“, Video by Wilhelmson, Robert et al.
(Department of Atmospheric Studies and NCSA).



Examples of Visualization



From: Visualization in Geographical Information Systems,
Plate 10. Edited by H. M. Hearnshaw and D.J. Unwin, Wiley

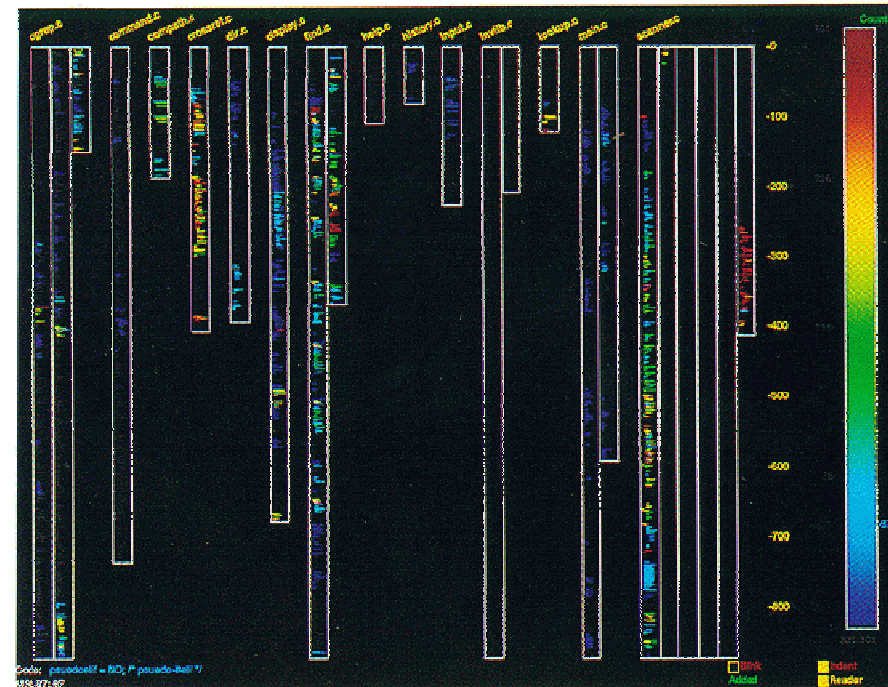
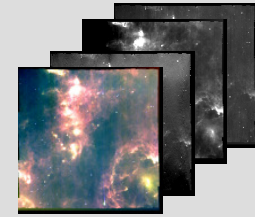
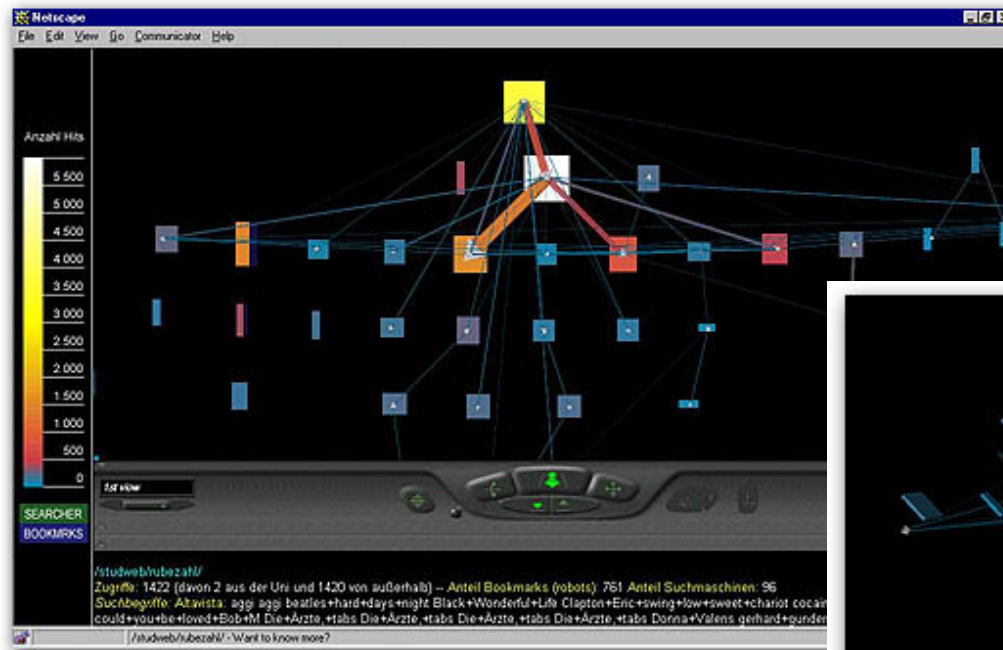


Figure 1: Seesoft profile display.

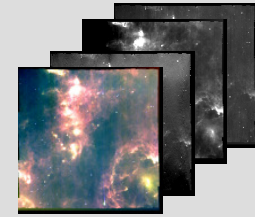
From: S.G. Eick and J.L. Steffen,
Proc. Vis'92, IEEE Comp. Soc. Press



Examples of Visualization

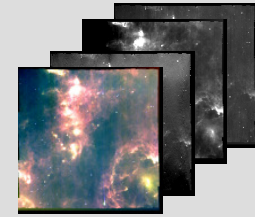


Bauch, Kaiser, Steinkamp. Visualization of Internet Access at the University of Paderborn. Project Work.



1.4 Impact of Future Technology

- Next generation PCs
- Next generation storage systems
- Next generation display technologies
- Next generation communication systems
- Next generation analytic tools
- Limitation of human capacity
- Improved understanding of psychological and perceptual issues



1.5 Journals and Conferences

- IEEE Visualization Conference since 1990
- IEEE Transaction on Visualization and Computer Graphics
- IEEE Computer Graphics and Applications
- ACM SIGGRAPH Conference
- ACM SIGGRAPH Computer Graphics