Scientific Visualization and Virtual Reality

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Structure of this course

- Lectures
- Paper presentation (P)
- Visualization project (V)

norm = $^1/_2(P + V)$
where $(P \geq 5.5) \wedge (V \geq 5.5)$

Blackboard

- Papers to read for this course
- Papers to read for student presentations
- Lecture sheets
  - available after each lecture
- Visualization project documentation
- Announcements

Lectures

- Lecturers:

  Robert Belleman + you!

- Location and time:
  - Mondays: 09:00-10:45, A1.06
  - Wednesdays: 09:00-10:45, B0.203 / A1.06

Preliminary lecture program

- Introduction to Scientific Visualization
- Scientific Visualization I
- Scientific Visualization II
- Visualization of (Bio-)medical data
- Virtual/Augmented Reality Environments
- Student lectures

Visualization project

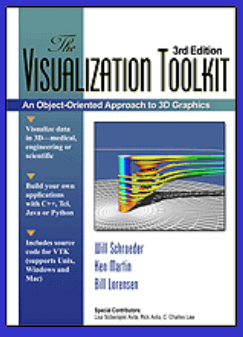
- Scheduled computer labs:
  - Wednesdays: 11:00-13:00, G0.10 / B1.24FG
  - Fridays: 13:00-15:00, A1.16A / G0.10
- Start with ParaView tutorial: see Blackboard
  - and if you're done with that, do the VTK tutorial
- More information during next lecture.

Course material

- The visualization Toolkit: An Object-Oriented Approach to 3D Graphics.
  W. Schroeder, K. Martin and B. Lorensen,
  Kitware Inc. publishers

  http://www.kitware.com/products/vtkbook.html

- Papers on Blackboard



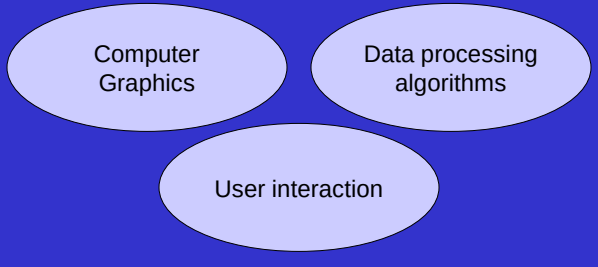
Scientific Visualization: an introduction

Overview

- Visualization of information and scientific data
- Applications
- Visualization architectures

Visualization

- Visual presentation of information
  - A (good) picture speaks a thousand words
  - “The purpose of computing is insight, not numbers” (R.W. Hamming)



X	Y	X	Y	X	Y	X	Y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
14,00	9,96	14,00	8,10	14,00	8,84	8,00	7,04
6,00	7,24	6,00	6,13	6,00	6,08	8,00	5,25
4,00	4,26	4,00	3,10	4,00	5,39	19,00	12,50
12,00	10,84	12,00	9,11	12,00	8,15	8,00	5,56
7,00	4,82	7,00	7,26	7,00	6,42	8,00	7,91
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

A B C D

"Anscombe's quartet", F.J. Anscombe, "Graphs in Statistical Analysis", American Statistician, 27 (February 1973), 17-21.

X	Y	X	Y	X	Y	X	Y
10,00	8,04	10,00	9,14	10,00	7,46	8,00	6,58
8,00	6,95	8,00	8,14	8,00	6,77	8,00	5,76
13,00	7,58	13,00	8,74	13,00	12,74	8,00	7,71
9,00	8,81	9,00	8,77	9,00	7,11	8,00	8,84
11,00	8,33	11,00	9,26	11,00	7,81	8,00	8,47
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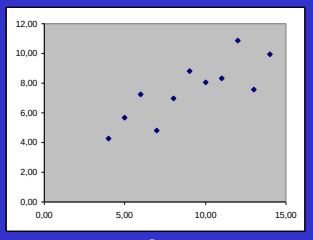
5,00	5,68	5,00	4,74	5,00	5,73	8,00	6,89

A B C D

$\mu_x = 9.00$, $\sigma_x = 3.32$
$\mu_y = 7.50$, $\sigma_y = 2.03$
linear regression: $y = ½x + 3$

"Anscombe's quartet", F.J. Anscombe, "Graphs in Statistical Analysis", American Statistician, 27 (February 1973), 17-21.



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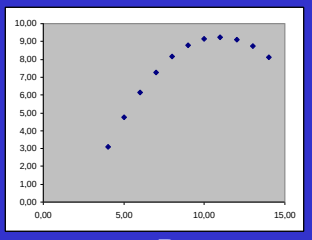

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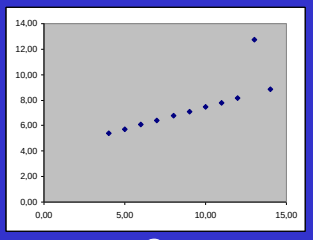
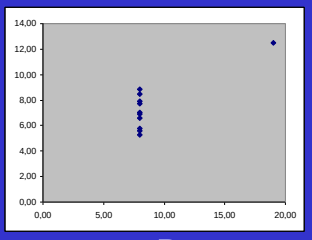


C

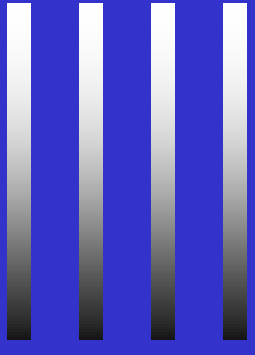


D

"Anscombe's quartet", F.J. Anscombe, "Graphs in Statistical Analysis", American Statistician, 27 (February 1973), 17-21.

Visualization …

- … helps researchers see patterns in data
- … a balance between science and art
- … done incorrectly, it can hurt understanding



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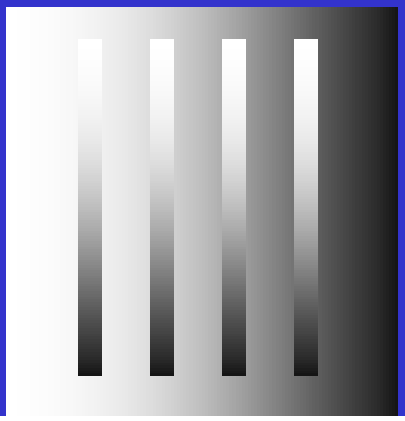

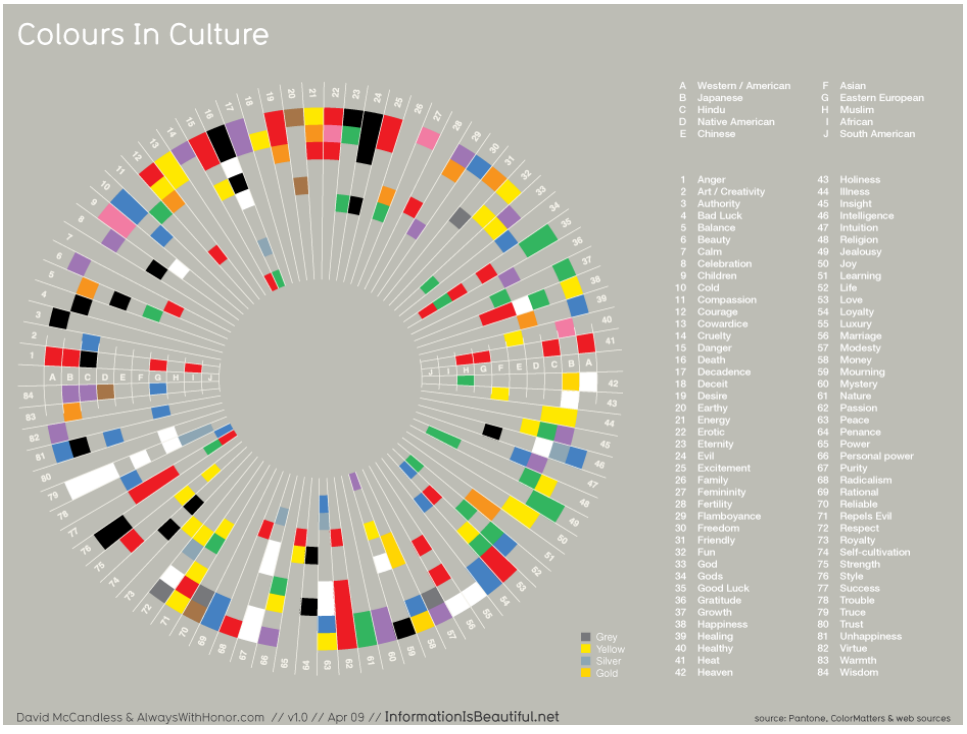

The Semiology of Graphics

Jacques Bertin (1918-2010)

- Semiology: the study of symbol systems

"graphics is a set of signs that allow you to transcribe the existing relations of difference, order or proportionality amongst qualitative or quantitative data"

Sémiologie Graphique. Les diagrammes, les réseaux, les cartes. With Marc Barbut [et al.]. Paris : Gauthier-Villars, 1967. (Translation 1983. *Semiology of Graphics* by William J. Berg.)

The Semiology of Graphics

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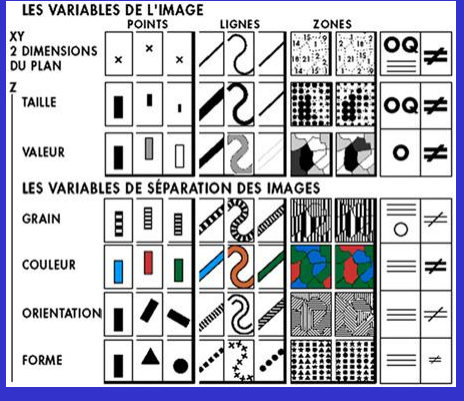
8 visual variables:

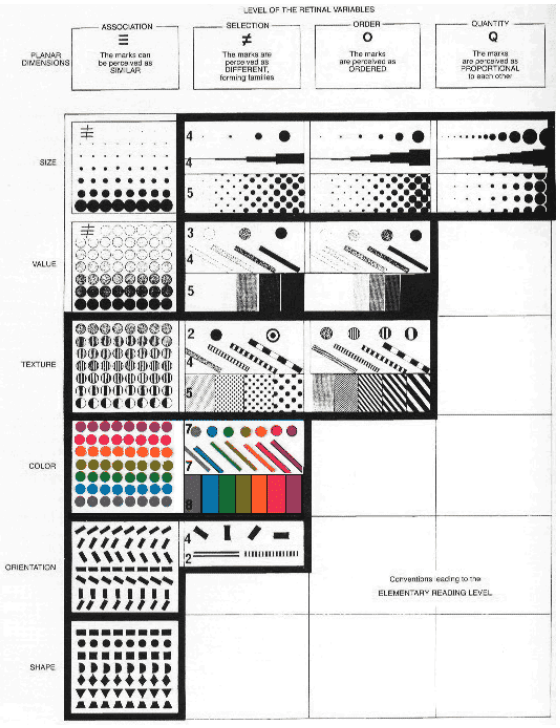
- (x,y) position
- Size
- Value
- Texture
- Colour
- Orientation
- Shape



Bertin's "Level of Organization"

- Association
- Selection
- Order
- Quantity

Note that Bertin disregards 3D and animation.



Remember this

- All representations of information are subjective interpretations of the information, not the information itself.
- The challenge in visualization is to find a representation that is both efficient and appropriate.
- The purpose of visualization is to inform, not to misinform.
- Any visualization is limited in its interpretation.

Seeing is hard

"Selective attention test", Simons and Chabris (1999)

Seeing is hard

Visualization taxonomy

- Scientific visualization (“scivis” or “datavis”)
  - Data with an implicit or explicit geometric structure
    - Measurements, results from simulations or experiments
- Information visualization (“infovis” or “infographics”)
  - Data with an abstract structure
    - Relations, data structures, databases
- Visual analytics
  - Interactive environments for the detection of the expected and discovery of the unexpected

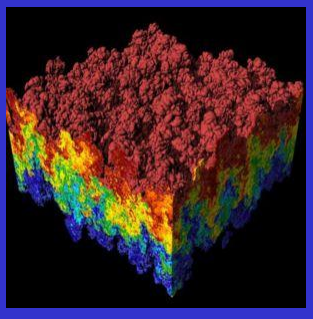
Scientific visualization

- Scientific visualization deals with all aspects that are connected with the visual representation of data sets from scientific experiments or simulations to achieve a deeper understanding or a simpler representation of complex phenomena.

Martin Rotard, Daniel Weiskopf, and Thomas Ertl, *Curriculum for a Course on Scientific Visualization*, Eurographics / ACM SIGGRAPH Workshop on Computer Graphics Education (2004)

Scientific visualization

Scientific visualization is concerned with exploring data and information visually to gain understanding and insight.



A scientific visualization of an extremely large simulation of a Raleigh-Taylor instability caused by two mixing fluids.

"Using the computer to display real-world objects that cannot normally be seen, such as the shapes of molecules, air and fluid dynamics and weather patterns. Scientific visualization requires enormous computing resources, and the supercomputer centers and national laboratories throughout the world are always at the forefront of such activity."

Computer Desktop Encyclopedia

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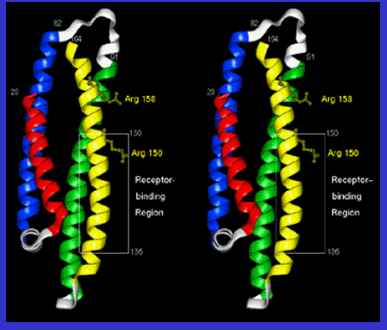
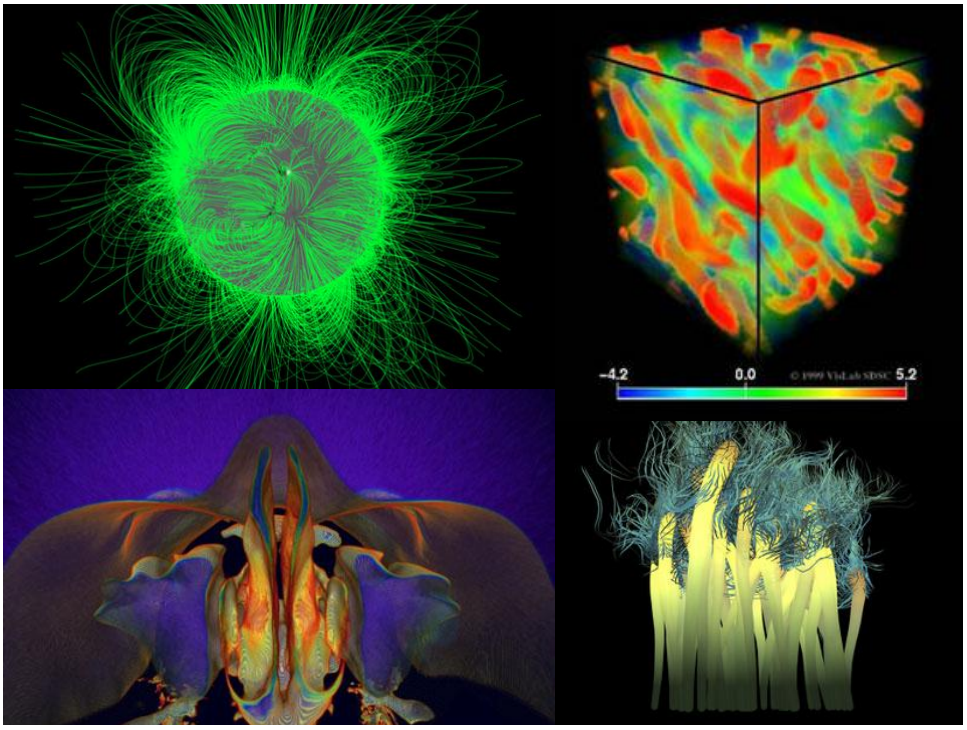


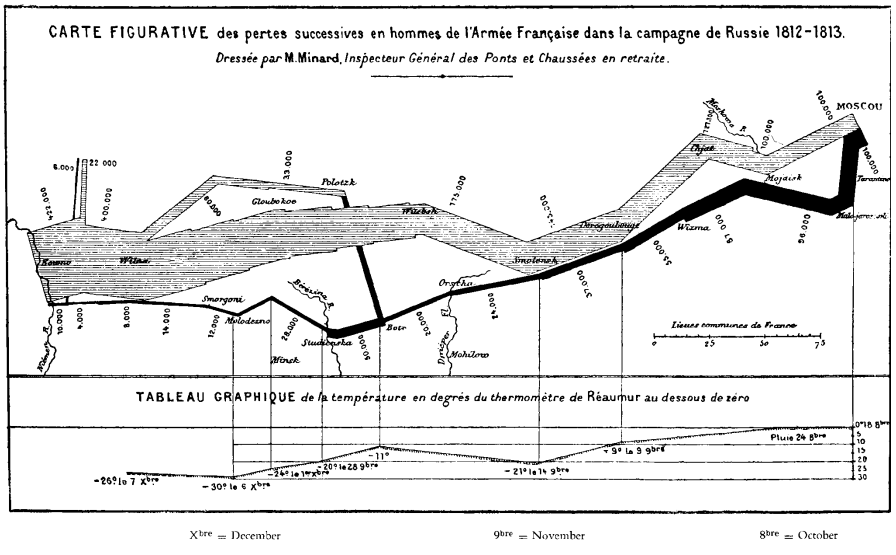
3D four-helix bundle structure of the molecule is represented as a ribbon model. The 3D image of this molecule helps researchers better understand it and its interaction with other molecules.

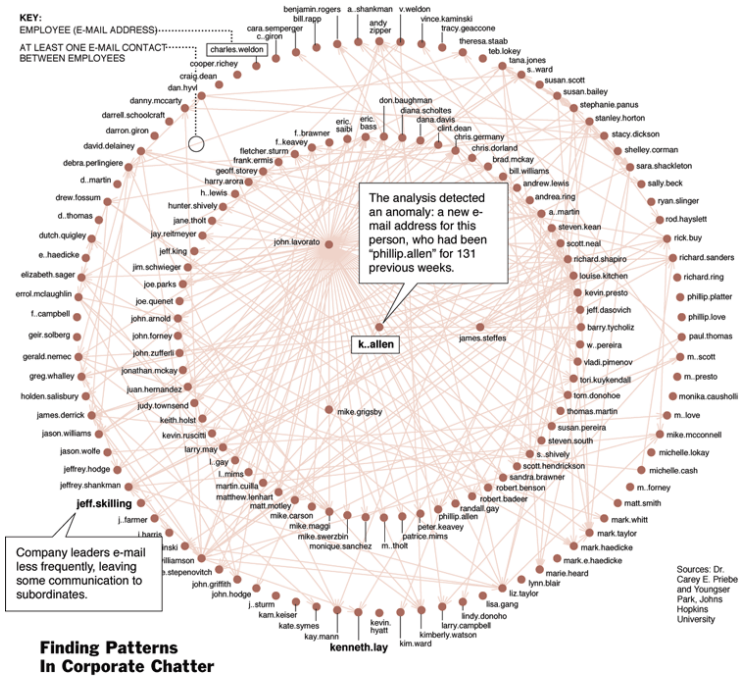
"Process of graphically displaying real or simulated scientific data. It is a vital procedure in the creative realization of scientific ideas, particularly in computer science. Basic visualization techniques include surface rendering, volume rendering, and animation. High-performance workstations or supercomputers are used to show simulations, and high-level programming languages are being developed to support visualization programming. Scientific visualization has applications in biology, business, chemistry, computer science, education, engineering, and medicine."

Britannica Concise Encyclopedia



Information visualization

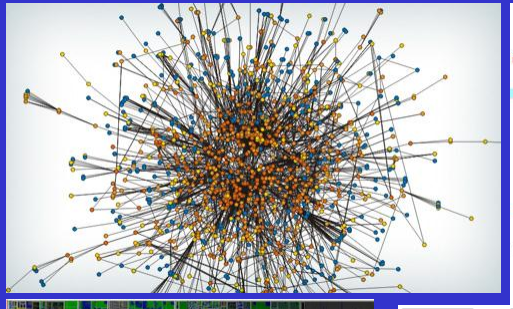


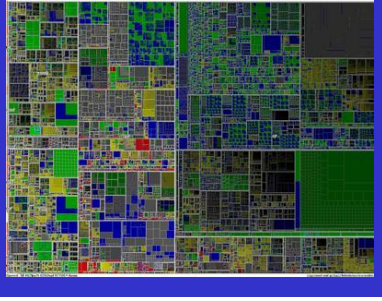


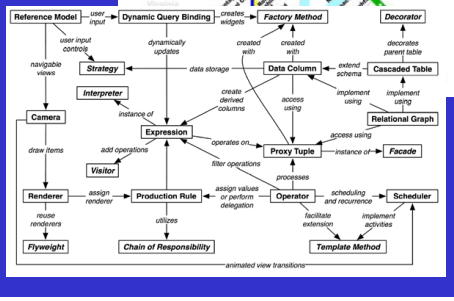
Finding Patterns In Corporate Chatter

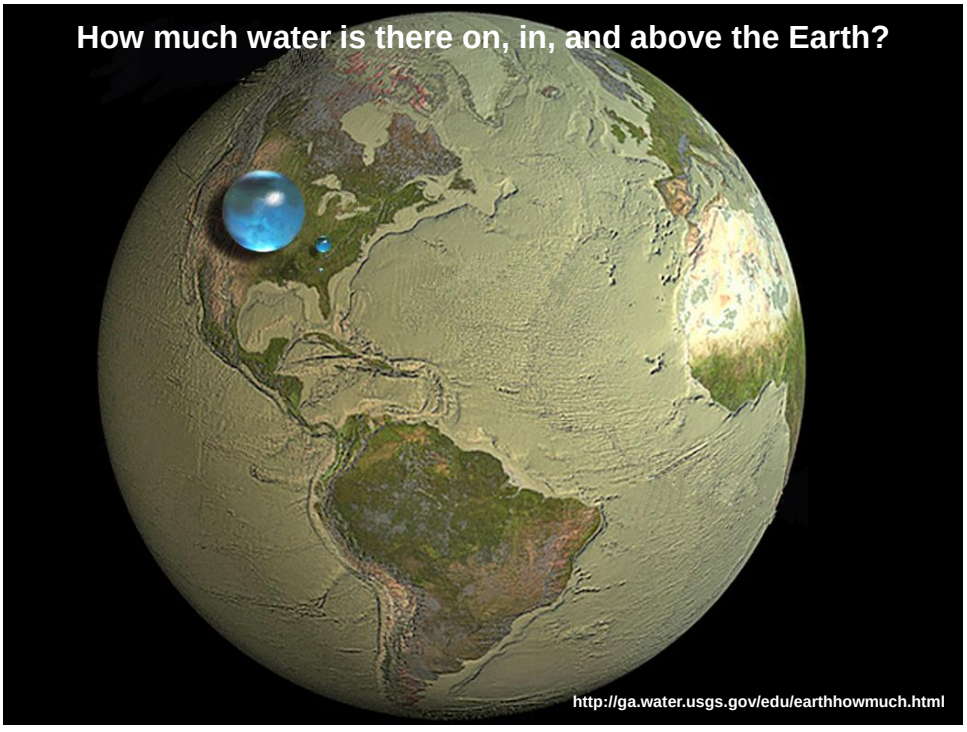
Computer scientists are analyzing about a half million Enron e-mails. Here is a map of a week's e-mail patterns in May 2001, when a new name suddenly appeared. Scientists found that this week's pattern differed greatly from others, suggesting different conversations were taking place that might interest investigators. Next step: word analysis of these messages.

Information visualization

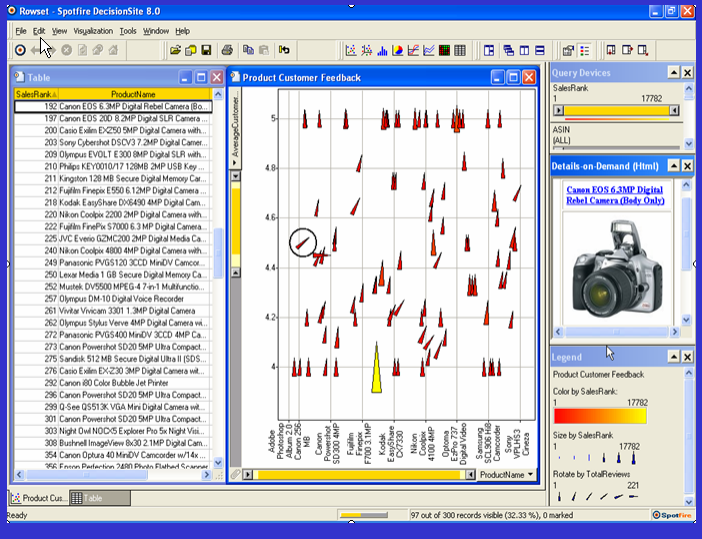




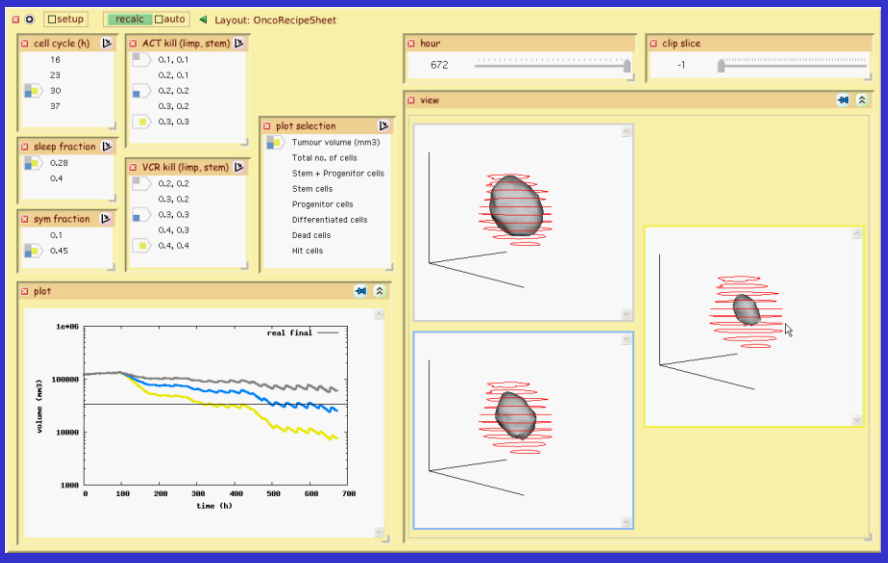




Visual analytics



Visual analytics



Assignment

- Find an appealing visualization, e.g. from
  - http://www.visualcomplexity.com/
  - http://www.sci.utah.edu/vissuccess/
  - http://vis.ncsa.illinois.edu/gallery.html
  - http://www.math.yorku.ca/SCS/Gallery/
  - http://prefuse.org/gallery/
  - http://manyeyes.alphaworks.ibm.com/manyeyes/visualizations
  - http://www.bewitched.com/
  - http://visual-analytics.org/
  - http://www.informationisbeautiful.net/
  - …
- For next week's session prepare 1 or 2 PPT/PDF slides with:
  - The image (duh…)
  - Your name
  - Background - what does the visualization represent?
  - Effectiveness - how useful is the visualization ?
  - Esthetics - why is the visualization appealing?
  - Methods - how do you think the visualization was achieved?
- Email to me: R.G.Belleman@uva.nl
  - Deadline: Tuesday, Sept 4th, 18:00
- Be prepared to present it in ~10 minutes during next session.