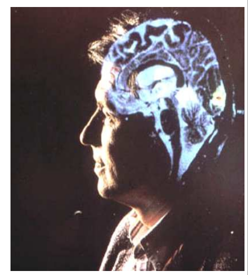
FDI Spring 2008
Visualization & Successful Grants

Nicholas Polys, Ph.D.
Chris North, Ph.D.



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Session Overview

- Visualization & Graphical Communication
- VT Visualization Resources
  - People, facilities, training (faculty & students)
- Integrating Visualization components into proposals
- Grant 'Boilerplate' information

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Visualization & Graphical Communication

- What is visualization?
- Examples
- Pop-out effects (pre-attention)
- Color usage
- Design Gotchas
- Production Gotchas

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Good Graphics

- Precision
- Clarity
- Maximize Data-to-ink ratio
  - Data Ink Ratio = (data ink) / (total ink in the plot)
- Minimize Lie factor
  - Lie factor = (size of graphic) / (size of data)

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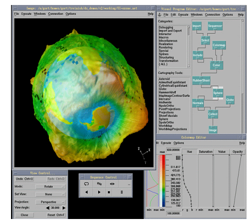
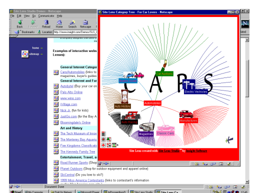
A definition

- Generally:
  – The use of computer-supported, interactive, visual representations of data to amplify cognition

  Card, McKinlay and Schneiderman

  – Scientific Visualization
  – Information Visualization
  – Virtual Environments





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Visualization Overview

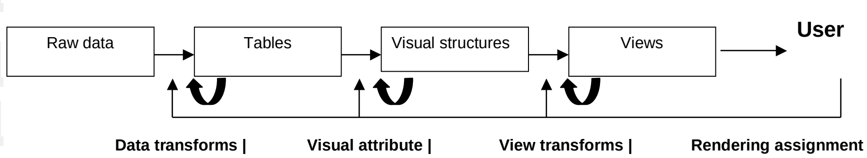

Figure 2.1: Processing in a typical visualization pipeline (from Card et al, 1999)

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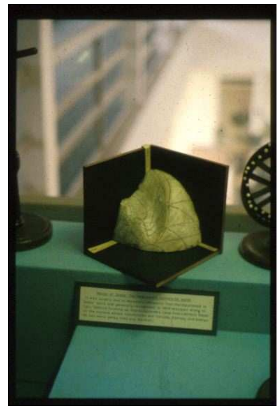
Visual Thinking

- Many of the great scientists were good at visual thinking:
  - Leonardo da Vinci
  - James Clerk Maxwell
  - Michael Faraday
  - Albert Einstein
- This was often at the expense of verbal skills
- Tom West : “In the Mind’s Eye”
  - See also
  - http://www.krasnow.gmu.edu/twest/maxwell_visual.html



Maxwell’s clay model now in
New Cavendish Laboratory, Cambridge
(picture by Tom West)

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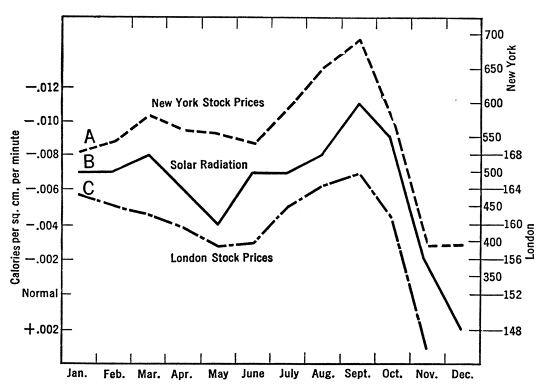
Of course, statistical graphics, just like statistical calculations, are only as good as what goes into them. An ill-specified or preposterous model or a puny data set cannot be rescued by a graphic (or by calculation), no matter how clever or fancy. A silly theory means a silly graphic:



SOLAR RADIATION AND STOCK PRICES

A. New York stock prices (Barron’s average). B. Solar Radiation, inverted, and C. London stock prices, all by months, 1929 (after Garcia-Mata and Shaffner).

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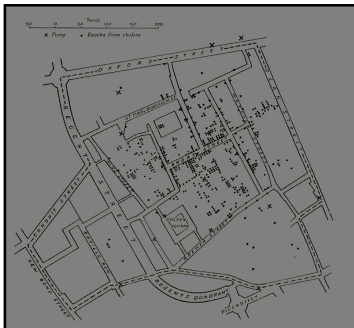
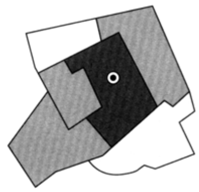
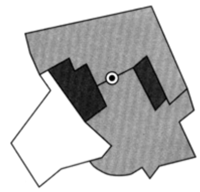


Edward Tufte

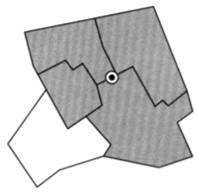


In this aggregation of individual deaths into six areas, the greatest number is concentrated at the Broad Street pump.



In this aggregation of the deaths, the two areas with the most deaths do not even include the infected pump!

[18] Mark Monmonier, *How to Lie with Maps* (Chicago, 1991), pp. 142–143.



Using different geographic subdivisions, the cholera numbers are nearly the same in four of the five areas.

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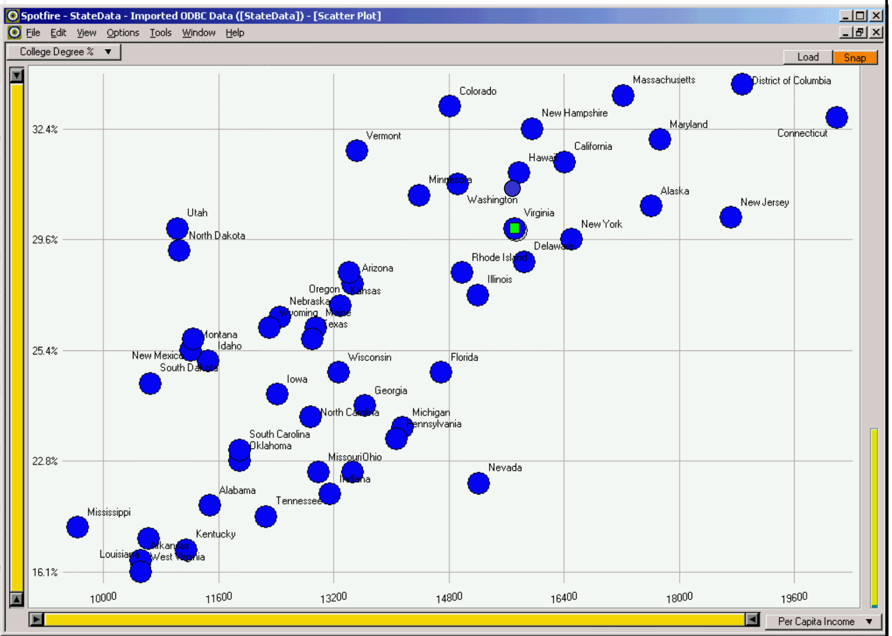
- Which state has highest income?
- Relationship between income and education?
- Outliers?

Table - StateData ()

Load Snap

State	College Degree %	Per Capita Income
Alabama	20.6%	11486
Alaska	30.3%	17610
Arizona	27.1%	13461
Arkansas	17.0%	10520
California	31.3%	16409
Colorado	33.9%	14821
Connecticut	33.8%	20189
Delaware	27.9%	15854
District of Columbia	36.4%	18881
Florida	24.9%	14698
Georgia	24.3%	13631
Hawaii	31.2%	15770
Idaho	25.2%	11457
Illinois	26.8%	15201
Indiana	20.9%	13149
Iowa	24.5%	12422
Kansas	26.5%	13300
Kentucky	17.7%	11153
Louisiana	19.4%	10635
Maine	25.7%	12957
Maryland	31.7%	17730
Massachusetts	34.5%	17224
Michigan	24.1%	14154
Minnesota	30.4%	14389
Mississippi	19.9%	9648
Missouri	22.3%	12989
Montana	25.4%	11213
Nebraska	26.0%	12452
Nevada	21.5%	15214
New Hampshire	32.4%	15959
New Jersey	30.1%	18714
New Mexico	25.5%	11246
New York	29.6%	16501
North Carolina	24.2%	12885
North Dakota	28.1%	11051
Ohio	22.3%	13461
Oklahoma	22.8%	11893
Oregon	27.5%	13418
Pennsylvania	23.2%	14068
Rhode Island	27.5%	14981
South Carolina	23.0%	11897
South Dakota	24.6%	10661
Tennessee	20.1%	12255
Texas	25.5%	12904
Utah	30.0%	11029
Vermont	31.5%	13527
Virginia	30.0%	15713
Washington	30.9%	14923
West Virginia	16.1%	10520
Wisconsin	24.9%	13276
Wyoming	25.7%	12311



College Degree %

Per Capita Income

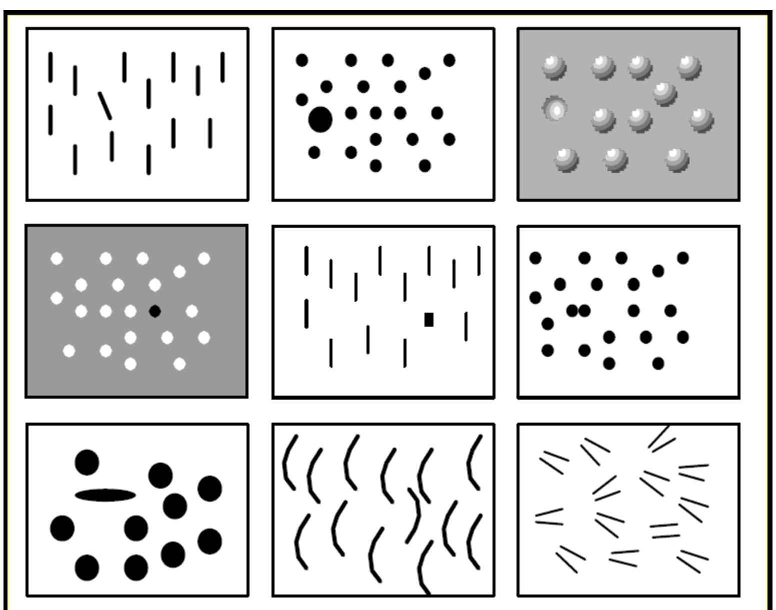
Pre-attentive Processing

- Involuntary, do not require conscious attention
- Parallel
- Efficient
- Resistant to instruction

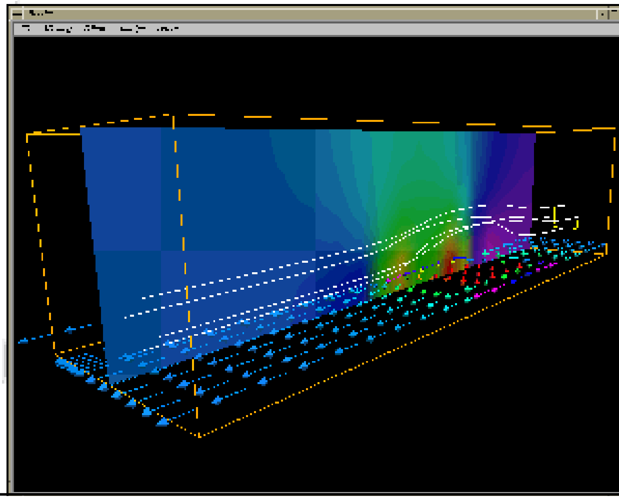
Attention

- Pop out effects 'stand out' in some simple dimension (conjunctions don't):
  - Rapid visual search
  - Form, color, simple motion/blinking, spatial stereo depth, shading, position

12987621909023748
59432908706548394
05602485954372890
09890509874632234



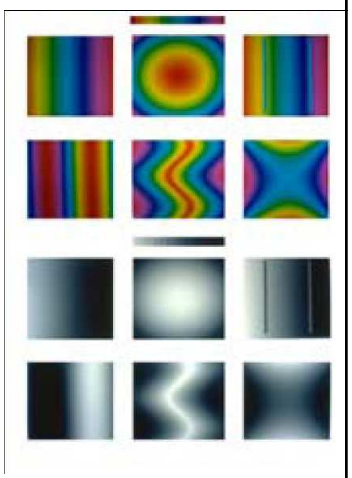
Representing multiple properties



- Flow of air around a car
  - Vectors and particle paths illustrate flow
  - Coloured slice indicates pressure

Features: Color

- Luminance channel (3x spatial accuity)
- Red / Green channel
- Yellow / Blue channel



The rainbow spectrum is not a perceptually linear sequence (not pre-attentive)!
(Keller 1993; Ware, 2000)

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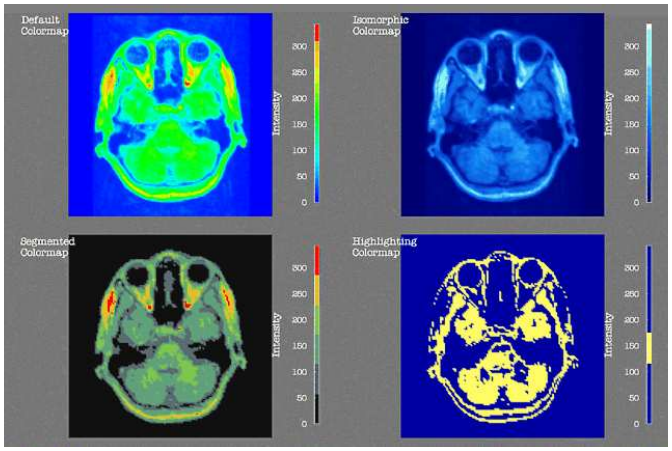

Color:

- Pop-out or Categorical variables OK;
- Ordinal is poor with Rainbow scale
- Quantitative reading is poor in general;

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Design Gotchas

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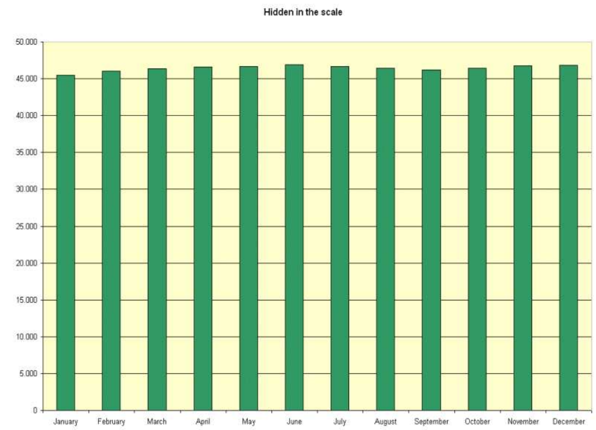
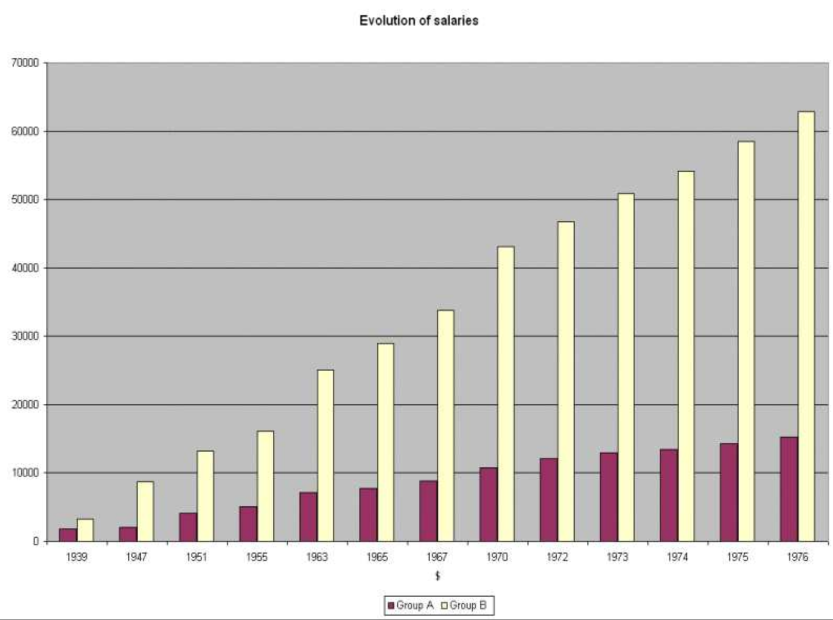
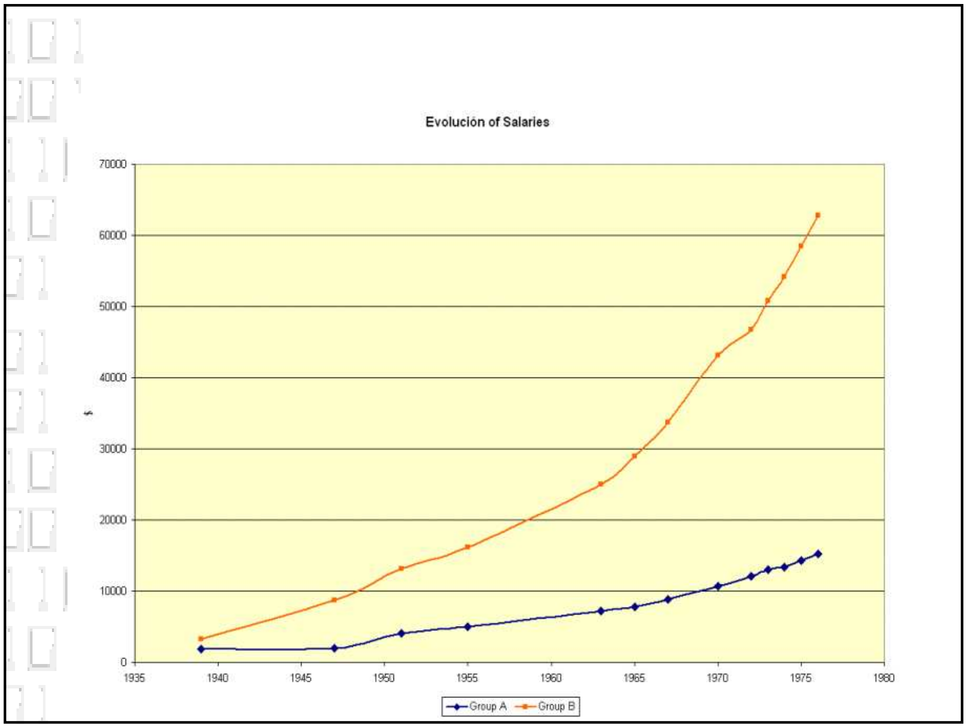
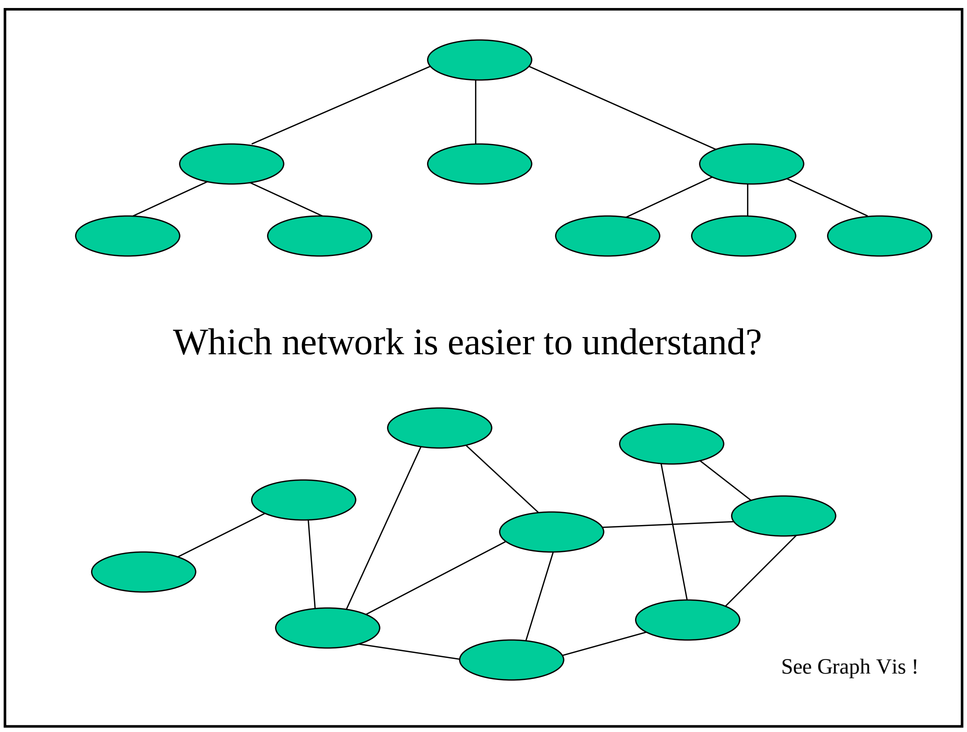
Scale

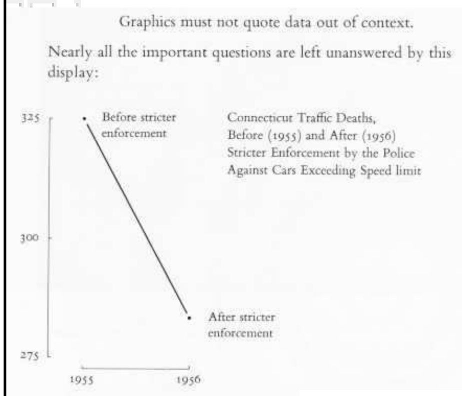

Hidden in the scale
50.000
45.000
40.000
35.000
30.000
25.000
20.000
15.000
10.000
5.000
0
January
February
March
April
May
June
July
August
September
October
November
December

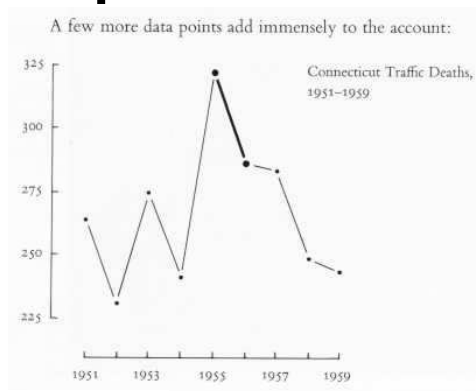

Evolution of salaries
70000
60000
50000
40000
30000
20000
10000
0
1939
1947
1951
1955
1963
1965
1967
1970
1972
1973
1974
1975
1976
$
Group A
Group B

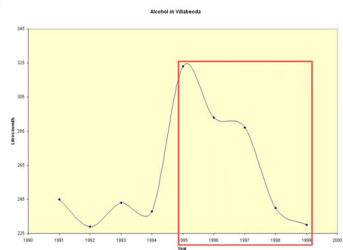

Evolución of Salaries
70000
60000
50000
40000
30000
20000
10000
0
$
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
Group A
Group B


Which network is easier to understand?
See Graph Vis !

Context Required







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Production Gotchas

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Image Production

Bad printouts reflect poor attention to detail!

- Screen images are at 72 dpi
- For print:
  - Color images look clear at 300 dpi
  - Grayscale images look clear at 600 dpi
- Bottom line: size and/or resolve your images accordingly (before using in doc / latex)

Movie Production

- Movie size, framerate, and color pallette determine movie size
- Watch out for flicker – incurs cognitive load!
- Watch out for interpolation vs sequencing – incurs erroneous assumptions!

Frame Rate

- Threshold for perceiving continuity:
  - flicker < 50 Hz
  - > 24 fps looks smooth & plenty interactive
- Flicker & Attention can lead to change blindness (Simmons, 2000)

Attention and blindness

- http://www.psych.ubc.ca/~rensink/flicker/
  - http://www.psych.ubc.ca/~rensink/flicker/download/index.html
- http://viscog.beckman.uiuc.edu/djs_lab/demos.html

Resources @ VT

VT Visualization Resources

- Infrastructure & Resources that makes VT uniquely capable of performing some research
- For research programs *and* educational purposes:
  - People & Groups
  - Facilities
  - Training
  - Collaboration

People

- VT Advanced Research Computing (ARC) www.arc.vt.edu
  - Nicholas F. Polys
  - Kevin Shinpaugh
  - John Burkhart
  - Bill Sydor
  - Bill Marmagas
  - Terry Herdman (Assoc. VP, ICAM)

Nicholas Polys

- Director of Visual Computing, Advanced Research Computing (arc.vt.edu)
  - Manage & develop data and delivery software systems for visualization
  - E.g. virtual environments for desktop, stereo wall, CAVE
- Affiliate Research Professor, Instructor Dept. of Computer Science

Facilities / Labs – VT ARC

- TORG 3050: Visual Computing Lab
  CAVE, stereo wall, lab machines
- Andrews: Parallel and shared-memory supercomputers, stereo wall, lab machines
- Other depts have stereo walls (architecture, art, civil engineering)

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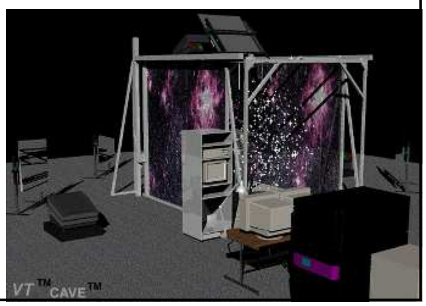
VT CAVE

Immersive visualization venue

- 3 wall + floor stereo projected surround
- Head & Input tracking
- Not a cost center! (Free use for faculty and student projects)
- www.cave.vt.edu



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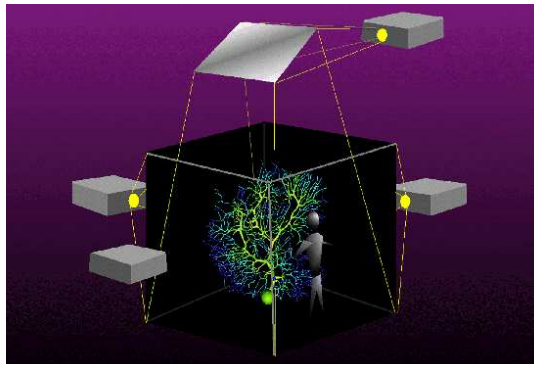
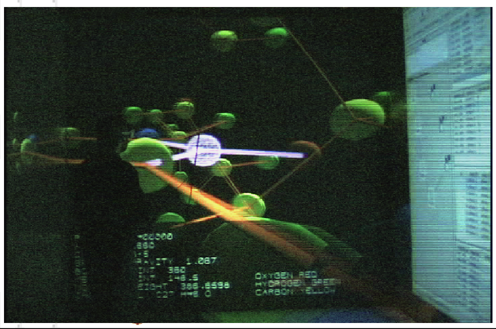
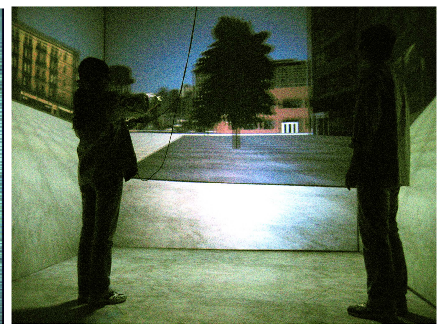
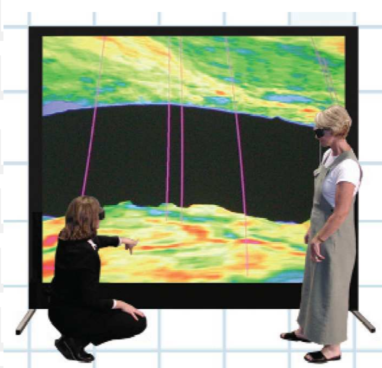


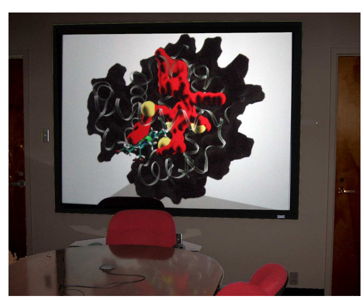




Stereo Walls



TORG (active)



Andrews (passive)

3-4 additional in labs around campus

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Software Stack

Support for many data & disciplines:

- CFD
- CAD
- Architecture
- Molecular Dynamics
- VRML/X3D
- DIVERSE VR (Win, Mac, Linux)
- … documentation available !

Faculty & Student Training

- FDI classes in Visualization Technology & production skills (7 session track) run in spring, fall, and summer

- CAVE & Stereo wall training
  - Operation of, development for
  - Documentation online
  - Free, open to faculty, grad, undergrad
  - by appointment

Chris North

- Associate Professor
- Dept of Computer Science
- Center for Human-Computer Interaction
- Laboratory for Information Visualization and Evaluation
- GigaPixel Display Laboratory

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People

CHCI **www.hci.vt.edu**

- Chris North: interactive data visualization, large displays
- Doug Bowman: VE, 3D interaction
- Yong Cao: graphics, animation, simulation
- Denis Gracanin: multi-user systems, quality-of-service

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VT GigaPixel Laboratory

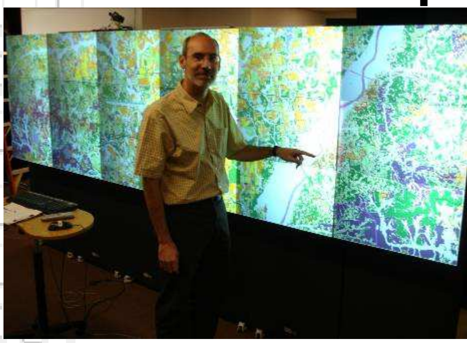
- ~200 Mpixels, scalable
- Reconfigurable
- Multiple display technologies
- Diverse input devices
- Link to AwareLab, VICON

Analyst Workspace Options

9 tiled LCD panels
Single CPU
MS Windows
Small cubicle
< $5,000

24 tiled LCD panels
Curved configuration
Multi-CPU
Large cubicle/office
~ $20,000

Collaborative Workspace Options



18 Rear-projection blocks
near-seamless
Multi-CPU
Large conference room
~ $150,000

50 tiled LCD panels
Touch-sensitive
Multi-CPU
Medium conference room
~ $120,000

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Student Training

- CS5764 Information Visualization
- CS5754 Virtual Environments
- CS5714/ISE Usability Engineering
- ESM4714 Scientific Visual Data Analysis

- Open to non-CS students-
  have your grad students contact us!

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Ways to collaborate

- Talk to us
- Write visualization components into grant proposals. We can help write these parts.
- Hire a CS visualization GRA
  - E.g. PathSim
- Send your students to our classes
  - E.g. VBI, CEE, …
- Reserve equipment time
- …

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Integrating Visualization into Proposals

Improved visualization support is a recognized challenge:

- NSF / NIH Report - 2006
- Visual Analytics Initiative - 2006
- Many other agencies are facing the same problem: making sense of large, heterogeneous data sets

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NSF / NIH Visualization Report

A renewed funding priority for basic research-transformative technology and techniques

http://tab.computer.org/vgtc/vrc/index.html

- C. Johnson, R. Moorhead., T. Munzner, H. Pfister, P. Rheingans, and T. S. Yoo, (Eds.): (2006). NIH-NSF Visualization Research Challenges Report, IEEE Press).

Visual Analytics R&D Agenda

A renewed initiative in visualization, recasting the problem to interactive analysis tools for large, complex data sets

http://nvac.pnl.gov/agenda.stm

- Thomas, J. J., and Cook, Kristin A. (2006). A Visual Analytics Agenda. IEEE Computer Graphics & Applications, 10-13.

NAE Grand Challenges

- National Academy of Engineering notes that improving Virtual Reality is a grand challenge (worthy of pursuit)!

http://www.engineeringchallenges.org/cms/8996/9140.aspx

Educational Technology

Horizon Report 2007– New Media Consortium

- Proprietary and open technology exists!
- Adoption timeline:
  - 1-2 years Virtual Worlds
  - 3-5 years Multi-User spaces

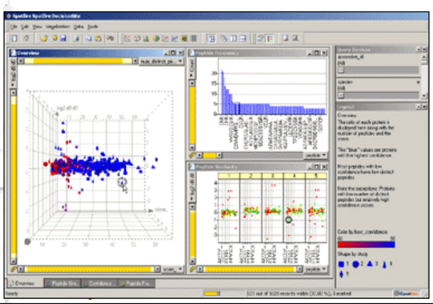
http://www.nmc.org/horizon/

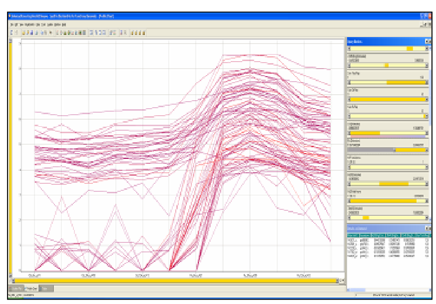
Integrating Visualization into your Reseach

- Applied
  1. Consulting & evaluation of existing software
  2. Development of tools for research
  3. Development of tools for production
- Basic
  4. Fundamental science

1. Provide Vis Expertise/Tools

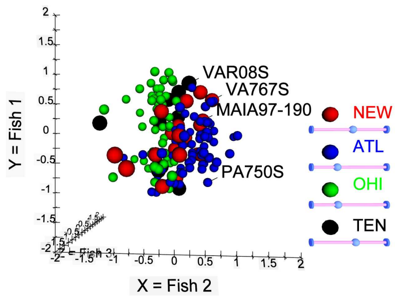
- Karen Duca, VBI
- Effect of smoking on Flu immune system?
- >3 million data values
- Spotfire™, …

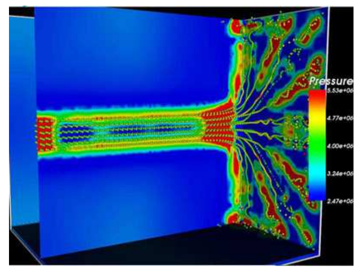




Provide Vis Expertise/Tools

- Fisheries & Wildlife Science
- Computational Fluid Dynamics





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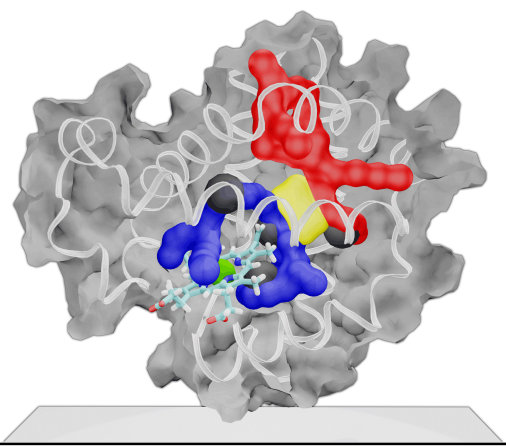
Provide Vis Expertise/Tools

- Molecular Dynamics Simulation (NIH)



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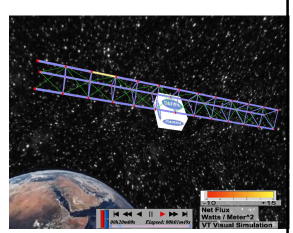
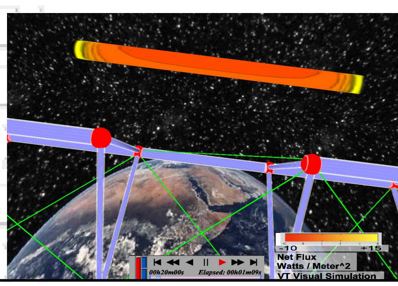
2. Develop New Vis Tools

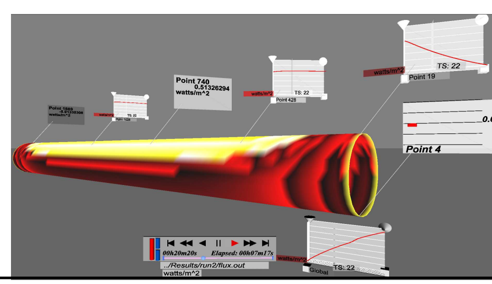
- NuTech, Inc. Geospatial agent-based reasoning
- Research tool
- Parallel processing
- Visualization front end

Develop New Vis Tools

- Server-side system (DARPA)
  - ICAM satellite flux modeling



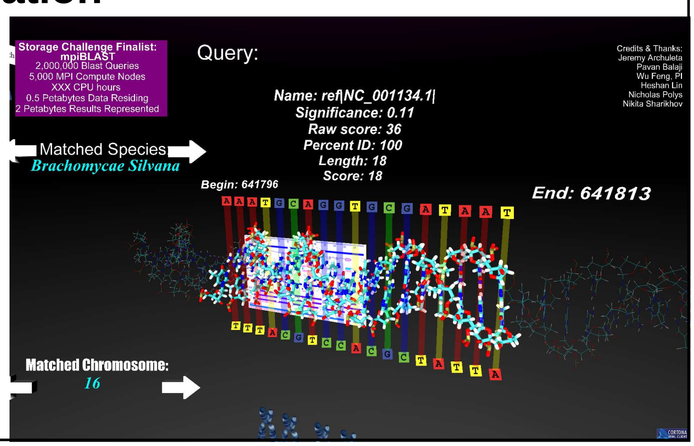




"Look Ma, no equations!"

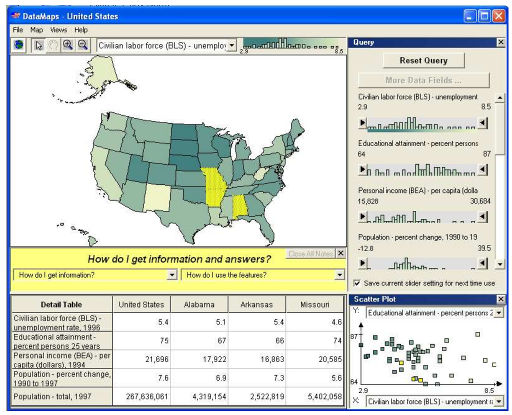
Develop New Vis Tools

- **mpiBLAST DNA matching visualization**



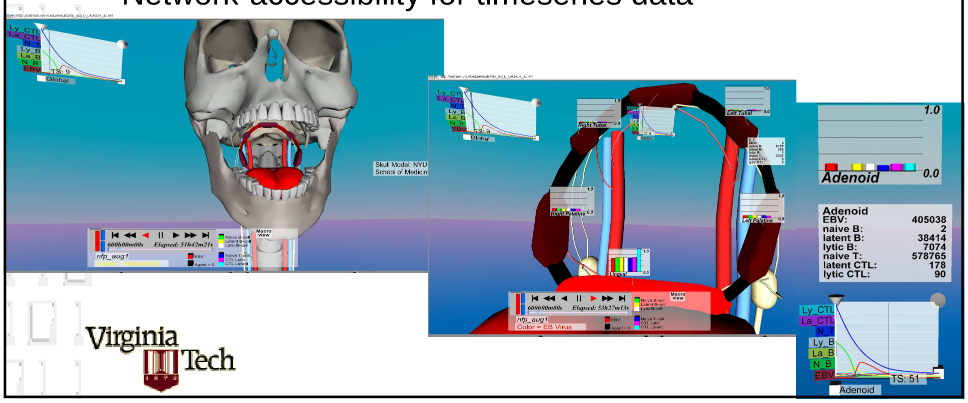
3. Engineer New Vis Products

- Census Bureau
- Emphasis on UE process, users/customers
- Distributable Tool
  - Counties USA CD-ROM

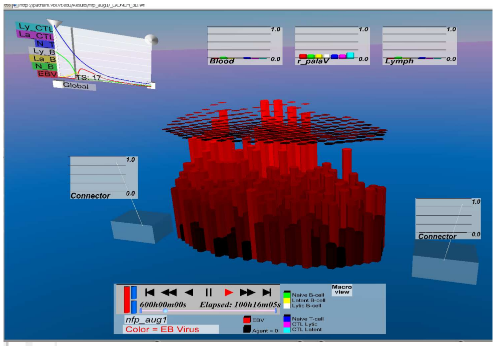


Engineer New Vis Products

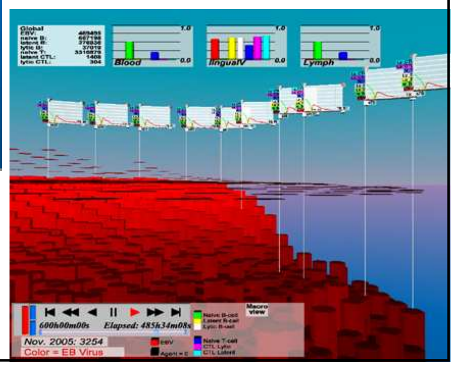
- PathSim (VBI- Duca, Laubenbacher, Tufts U)
- Agent-based immune system simulation + visual analysis environment
- Network-accessibility for timeseries data



PathSim



Web-based visualization & analytic services



upwards of 7 million agents whose state and location can be measured every 6 simulation minutes!

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4. Basic Research

- Bill Carstensen, Dept of Geography and CGIT
- How do large high-resolution displays & visualizations impact geospatial analysts?

Some key results…

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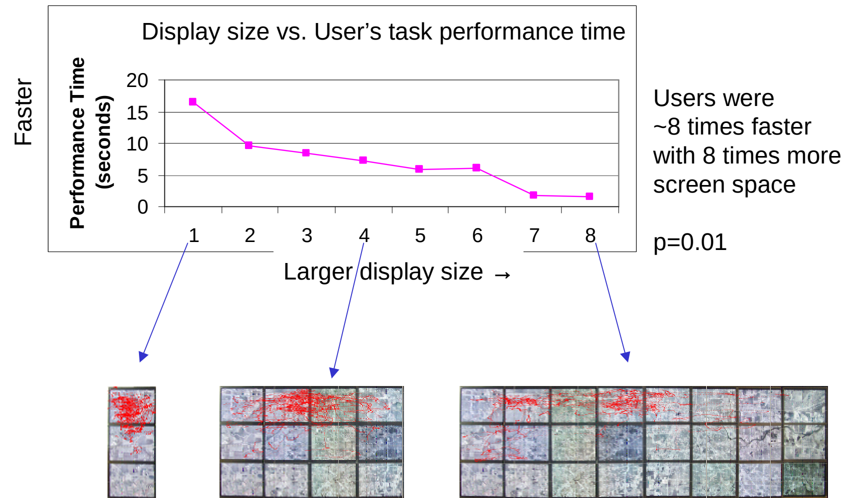
Faster User Task Performance



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Key Results

- ↑Display size →
  ↓Virtual navigation,
  ↑Physical navigation,
  ↓Performance time
- Up to 10x task performance boost
- Virtual Nav has more impact on performance
- Analysts prefered Physical Nav
  (100% when zooming choice)
- Differing search strategies/paths
- Tethered analyst → reduced benefit

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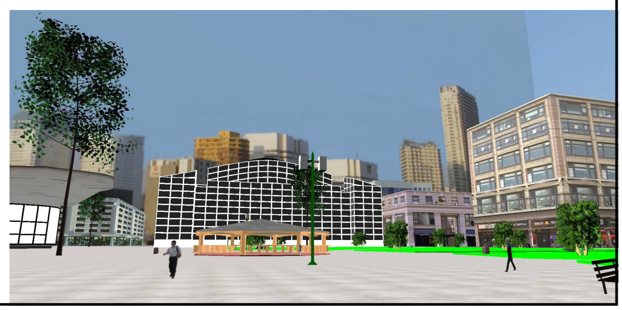
Basic Research

Carilion Biomedical – Karen Roberto, Center for Gerontology, UVA Medical

- Web + CAVE virtual worlds as assessment tools for Mild Cognitive Impairment



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Key Results

- Open standards enabled cross-platform testing
- Immersive technologies can provide powerful presence for users
- Safe and private assessment tool

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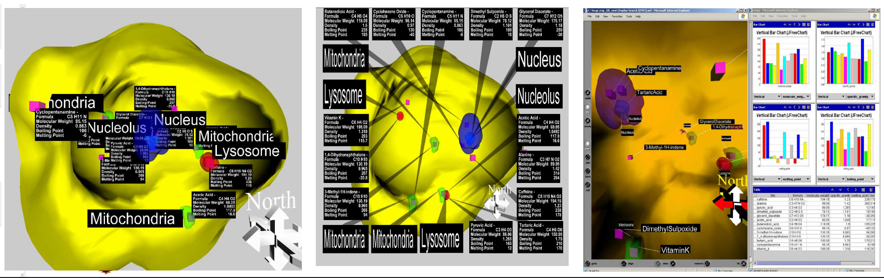
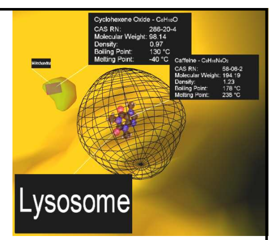
Basic Research

- Cell Biology & BioChemistry courseware
- Effects of information layout and display size on task performance



Key Results



- Different display techniques are advantageous for accuracy and speed depending on :
  - Task type (search, compare)
  - Information type of criteria or target (spatial or abstract)
  - Size of display (desktop, wall, CAVE)
- Users rely on different perceptual cues

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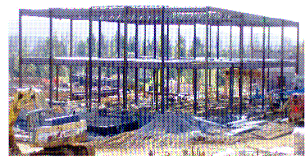
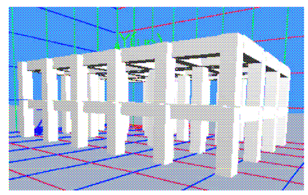
Other Examples

- Bowman & Setareh: Immersive environment for building structures for Earthquake simulation
- Bowman: Mine safety





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Boilerplate Information

Infrastructure & Resources that makes VT uniquely capable of performing some research:

- Visual Computing labs & staff (CAVE, etc)
- High-Performance Computing (Sys X, etc)
- Human Computer Interaction labs (Gigapixel, etc)

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Digital Copies at:

http://people.cs.vt.edu/~npolys/IT/FDI/fall07/grants/

Discussion

Thanks for your attention!
Please contact us to discuss your ideas!

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- Chris North – north@vt.edu