FDI Spring 2008
Visualization & Successful Grants

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

Session Overview

• Visualization & Graphical Communication
• VT Visualization Resources
  – People, facilities, training (faculty & students)
• Integrating Visualization components into proposals
• Grant ‘Boilerplate’ information
Visualization & Graphical Communication

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

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)
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

Visualization Overview

![Processing in a typical visualization pipeline (from Card et al, 1999)](image)

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

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:

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Edward Tufte

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

<table>
<thead>
<tr>
<th>State</th>
<th>College Degree %</th>
<th>Per Capita Income</th>
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<tbody>
<tr>
<td>Minnesota</td>
<td>12.4%</td>
<td>38,499</td>
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<td>37,601</td>
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<td>13.5%</td>
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<td>Wisconsin</td>
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<tr>
<td>Wyoming</td>
<td>35.4%</td>
<td>39,251</td>
</tr>
</tbody>
</table>

*Mark Monmonier, How to Lie with Maps (Chicago, 1996), pp. 142–143.*
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/blink, 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 accuracy)
- Red / Green channel
- Yellow / Blue channel

The rainbow spectrum is not a perceptually linear sequence (not pre-attentive)!
(Keller 1993; Ware, 2000)
Color:
- Pop-out or Categorical variables OK;
- Ordinal is poor with Rainbow scale
- Quantitative reading is poor in general;

Design Gotchas
Which network is easier to understand?

See Graph Vis!
Context Required

Nearly all the important questions are left unanswered by this display:

Before stricter enforcement

After stricter enforcement

Conclusions:
- Traffic deaths decrease after stricter enforcement.

Production Gotchas
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://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)

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
Stereo Walls

TORG (active)  Andrews (passive)

3-4 additional in labs around campus
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

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
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

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!
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
• …

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
NSF / NIH Visualization Report

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

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


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

**NAE Grand Challenges**

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


**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 Research

• 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

Provide Vis Expertise/Tools

- Molecular Dynamics Simulation (NIH)
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!

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

Some key results…
Faster User Task Performance

Key Results

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

Users were ~8 times faster with 8 times more screen space

p=0.01

Larger display size →
Basic Research

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

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

Key Results

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

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

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)
Digital Copies at:

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

Discussion

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

• Nicholas Polys - npolys@vt.edu
• Chris North – north@vt.edu