Part 3: Multiples, Navigation, Focus+Context

Information Visualization Mini-Course
TECS Week 2008

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10 January 2008

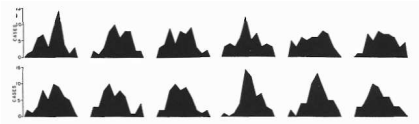
Mini-Course Outline

- Part 1: Monday morning
  - Intro
  - Design Studies
  - Models
  - Perception and Memory
- Part 2: Monday afternoon
  - Color
  - Space, Layers, and Ordering
  - Statistical Graphics
- Part 3: Thursday afternoon
  - Multiples and Interaction
  - Navigation and Zooming
  - Focus+Context
- Part 4: Friday morning
  - High Dimensional Data
  - Graphs and Trees
  - User Studies

Small Multiples

Edward Tufte. Envisioning Information. Chap 4: Small Multiples. Graphics Press, 1990.

- several small windows with
  - same visual encoding
  - different data
  - shown side by side

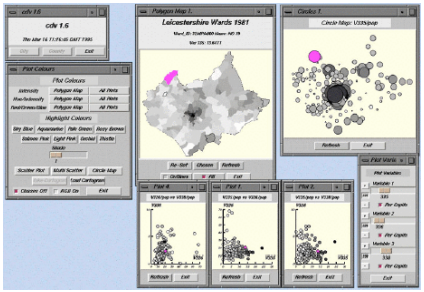


[Edward Tufte. The Visual Display of Quantitative Information, p 172]

Coordinated Multiple Views (CMV)

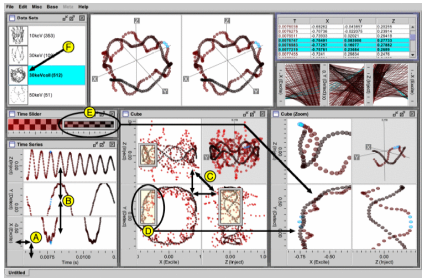
- more general than small multiples
- multiple views
  - multiform: different visual encodings of same data
  - different resolutions of same encoding
    - overview+detail
- power of linking
  - linked highlighting (brushing)
  - linked navigation
  - linked parameter changes

CMV Example: cdv



[cdv from Dykes, Figure 2 of State of the Art: Coordinated & Multiple Views in Exploratory Visualization. Roberts, Proc. CMV 2007]

Example: Complex Application



[Building Highly-Coordinated Visualizations In Improvise. Chris Weaver. Proc. InfoVis 2004]

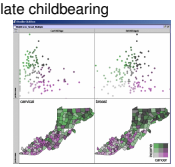
Multiform Matrices and Small Multiples

- matrices for bivariate exploration (SPLOM and other)
  - vs. small multiples for univariate
- uniform vs. multiform multiples
- techniques
  - juxtaposition
  - sorting/ordering
  - manipulation
  - linking multiple bivariate views

[Exploring High-D Spaces with Multiform Matrices and Small Multiples. Alan MacEachren, Xiping Dai, Frank Hardisty, Diansheng Guo, and Gene Lengerich. Proc InfoVis 2003.]

Multiform Bivariate Small Multiple

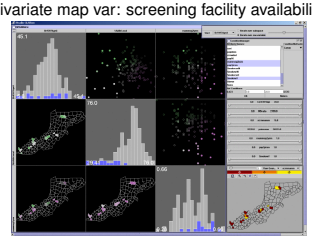
- common variable: per capita income
- per-column variables: type of cancer mortality
- per-row forms: scatterplot, choropleth/thematic map
- left bright green: high income, low cervical cancer
  - hypoth: not screened
- right dark green: low income, high breast cancer
  - hypoth: late childbearing



[Exploring High-D Spaces with Multiform Matrices and Small Multiples. MacEachren et al, Proc. InfoVis 2003.]

Multiform Bivariate Matrix

- scatterplots/maps, histograms along diagonal
  - per-column vars: mortality, early detection, recent screening
- univariate map var: screening facility availability



[Exploring High-D Spaces with Multiform Matrices and Small Multiples. MacEachren et al, Proc. InfoVis 2003.]

Sorting and Linking

- sorting
  - manual: direct manipulation from user
  - automatic: conditional entropy metric
  - automatic: hierarchical clustering to find interesting
- linking
  - highlighting
  - many others
    - background color, subspce, conditioning, ...
  - conditioning: filter in/out of given range on another var
- video

Critique

- great previous work taxonomy
- great explanation of how vis techniques used with specific data can lead to hypothesis generation
- careful use of color

Multiples: Readings

Tufte, Chap 4: Small Multiples

State of the Art: Coordinated & Multiple Views in Exploratory Visualization. Jonathan C. Roberts. Proc. Conference on Coordinated & Multiple Views in Exploratory Visualization (CMV) 2007.

Building Highly-Coordinated Visualizations In Improvise. Chris Weaver. Proc. InfoVis 2004

Exploring High-D Spaces with Multiform Matrices and Small Multiples. Alan MacEachren, Xiping Dai, Frank Hardisty, Diansheng Guo, and Gene Lengerich. Proc InfoVis 2003.

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What Kind of Motion?

- rigid
  - rotate/pan/zoom
  - easy to understand
  - object shape static, positions change
- morph/change/distort
  - object evolves
    - beating heart, thunderstorm, walking person
  - multiscale/ZUI
    - object appearance changes by viewpoint
  - focus+context
    - carefully chosen distortion

Spatial Navigation

- real navigation only partially understood
  - compared to low-level perception, JNDs
- spatial memory / environmental cognition
  - city: landmark/path/whole
- implicit logic
  - evolved to deal with reality
  - so we'll learn from synthetic worlds
  - but we can't fly in 3D...
- how much applies to synthetic environments?
  - even perception not always the same!

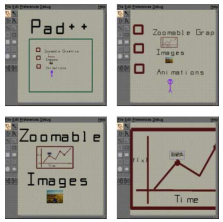
Macro/Micro

- classic example: map
  - arms-length vs. up-close
- paper vs. computer screen
  - 300-600 dpi vs. 72 dpi (legally blind)
  - finally changing

[Tufte, Envisioning Information. Chapter 2: Macro/Micro.]

Pad++

- "infinitely" zoomable user interface (ZUI) [video]



[Pad++: A Zooming Graphical Interface for Exploring Alternate Interface Physics Bederson and Hollan, Proc UIST 94]

Space-Scale Diagrams

- reasoning about navigation and trajectories

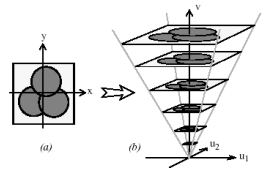
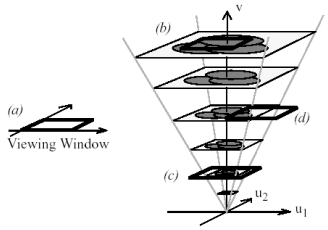


Figure 1. *The basic construction of a Space-Scale diagram from a 2D picture.*

Space-Scale Diagrams: Understanding Multiscale Interfaces
George Furnas and Ben Bederson, Proc SIGCHI '95.
www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf

Viewing Window



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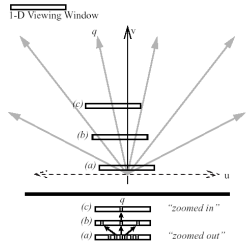
1D Version



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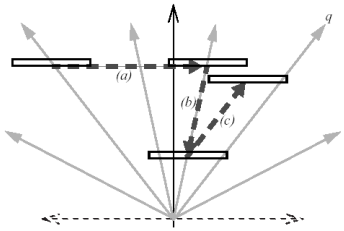
Pan-Zoom Trajectories



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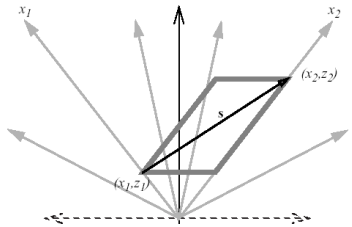
Joint Pan-Zoom Problem



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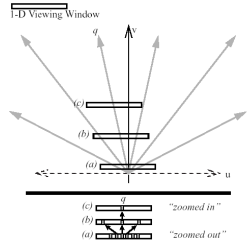
Shortest Path?



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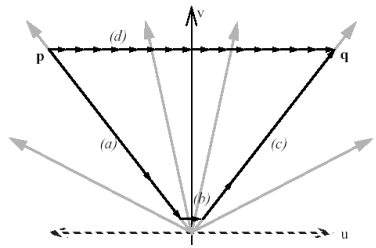
www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf

Shortest Path



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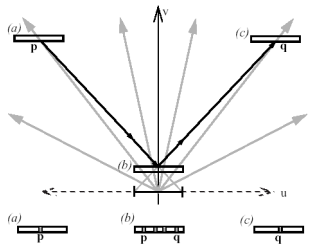
www.cs.umd.edu/hcil/pad++/papers/chi-95-spacescale/chi-95-spacescale.pdf

Shortest Path, Details



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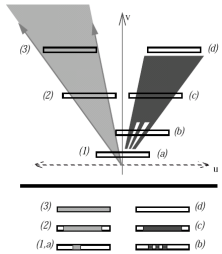
Semantic Zooming



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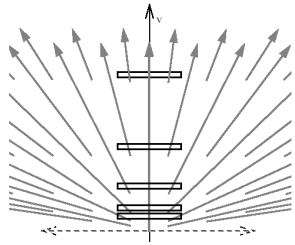
Multiscale Display



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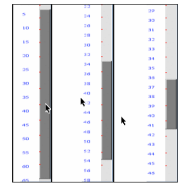
OrthoZoom

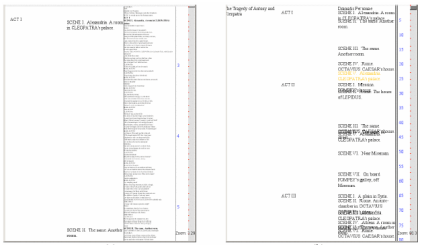
- scale/zoom ratio target: 32 bits, 1:3B
  - index of difficulty: ID = $\log(1 + D/W)$
  - D = target distance, W = target size
- control area larger than graphical representation
  - zoom factor is orthogonal cursor-slider distance



[OrthoZoom Scroller: 1D Multi-Scale Navigation. Catherine Appert and Jean-Daniel Fekete. Proc. SIGCHI 06, pp 21-30.]

OrthoZoom

- multi-scale table of contents (video)



[OrthoZoom Scroller: 1D Multi-Scale Navigation. Catherine Appert and Jean-Daniel Fekete. Proc. SIGCHI 06, pp 21-30.]

Navigation: Readings

Envisioning Information. Chapter 2: Macro/Micro. Edward Tufte, Graphics Press 1990.

Pad++: A Zooming Graphical Interface for Exploring Alternate Interface Physics Ben Bederson, and James D Hollan, Proc UIST 94.

Space-Scale Diagrams: Understanding Multiscale Interfaces George Furnas and Ben Bederson, Proc SIGCHI 95.

OrthoZoom Scroller: 1D Multi-Scale Navigation. Catherine Appert and Jean-Daniel Fekete. Proc. SIGCHI 06, pp 21-30.

Nav: Further Reading

Smooth and Efficient Zooming and Panning. Jack J. van Wijk and Wim A.A. Nuij, Proc. InfoVis 2003, p. 15-22

Speed-Dependent Automatic Zooming for Browsing Large Documents Takeo Igarashi and Ken Hinckley, Proc. UIST 00, pp. 139-148.

Rapid Controlled Movement Through a Virtual 3D Workspace Jock Mackinlay, Stuart Card, and George Robertson. Proc SIGGRAPH '90, pp 171-176.

Effective View Navigation, George W. Furnas, Proc. SIGCHI 97, pp. 367-374

Critical Zones in Desert Fog: Aids to Multiscale Navigation, Susanne Jul and George W. Furnas, Proc. UIST 98

Design Guidelines for Landmarks to Support Navigation in Virtual Environments Norman G. Vinson, Proc. SIGCHI 99.

Tuning and testing scrolling interfaces that automatically zoom Andy Cockburn, Joshua Savage, Andrew Wallace. Proc CHI 05.

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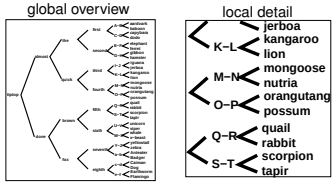
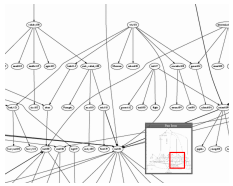
Avoiding Disorientation

- problem
  - maintain user orientation when showing detail
  - hard for big datasets
- example: trees exponential in depth
  - node count, space needed



Overview and Detail

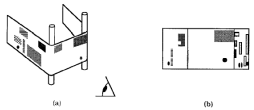
- one approach: use two windows for linked overview
  - cognitive load to correlate?



- another approach:
  - merge overview, detail
  - focus+context

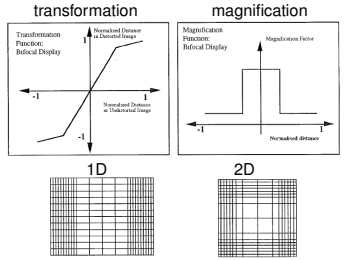
Focus+Context Intuition

- move part of surface closer to eye

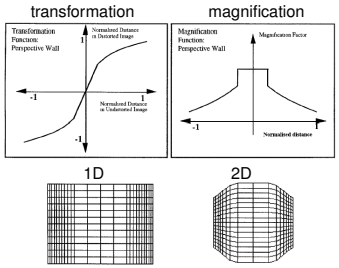


- stretchable rubber sheet
- borders tacked down
- merge overview and detail into combined view
  - geometric distortion: often, but not always

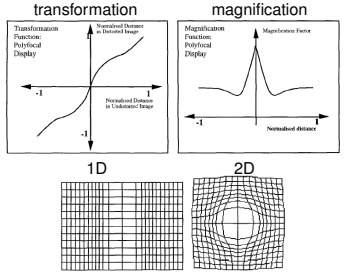
Bifocal Display



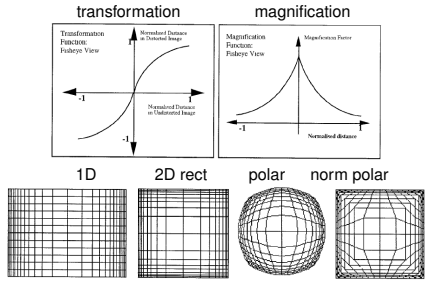
Perspective Wall



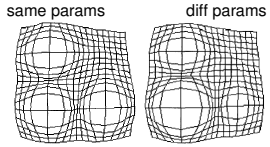
Polyfocal: Continuous Magnification



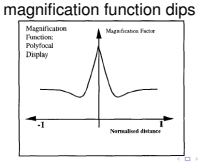
Fisheye Views: Continuous Mag



Multiple Foci

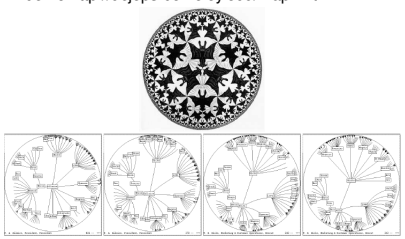


polyfocal magnification function dips allow this



2D Hyperbolic Trees

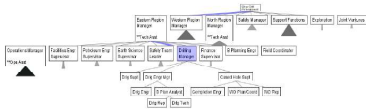
- fisheye effect from hyperbolic geometry
- demo http://ucjeps.berkeley.edu/map2.html



[Lamping and Rao. The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. Proc SIGCHI '95. http://citeseer.nj.nec.com/lamping95focuscontext.html]

SpaceTree

- focus+context tree: filtering, not geometric distortion
  - animated transitions



- semantic zooming

- demo

F+C: Readings

A Review and Taxonomy of Distortion-Oriented Presentation Techniques. Y.K. Leung and M.D. Apperley, ACM Transactions on Computer-Human Interaction, Vol. 1, No. 2, June 1994, pp. 126-160. [http://www.ai.mit.edu/people/jimmylin/papers/Leung94.pdf]

The Hyperbolic Browser: A Focus + Context Technique for Visualizing Large Hierarchies. John Lamping and Ramana Rao, Proc SIGCHI '95. [http://citeseer.nj.nec.com/lamping95focuscontext.html]

SpaceTree: Supporting Exploration in Large Node Link Tree, Design Evolution and Empirical Evaluation. Catherine Plaisant, Jesse Grosjean, and Ben B. Bederson. Proc. InfoVis 2002. ftp://ftp.cs.umd.edu/pub/hcil/Reports-Abstracts-Bibliography/2002-05html/2002-05.pdf

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Munzner, Guimbretiere, Tasiran, Zhang, and Zhou. SIGGRAPH 2003. [http://www.cs.ubc.ca/~tmm/papers/tj/]

F+C: Further Reading

A Fisheye Follow-up: Further Reflection on Focus + Context. George W. Furnas. SIGCHI 2006.

H3: Laying Out Large Directed Graphs in 3D Hyperbolic Space Tamara Munzner, Proc InfoVis 97.

Nonlinear Magnification Fields. Alan Keahey, Proc InfoVis 1997

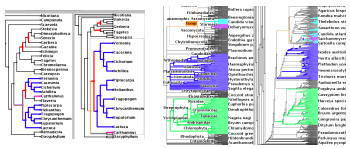
Effects of 2D Geometric Transformations on Visual Memory. Heidi Lam, Ronald A. Rensink, and Tamara Munzner. Proc. Applied Perception in Graphics and Visualization (APGV 2006), 119-126, 2006

Overview Use in Multiple Visual Information Resolution Interfaces. Heidi Lam, Tamara Munzner, and Robert Kincaid. IEEE TVCG 13(6):1278–1285 (Proc. InfoVis 07), 2007.

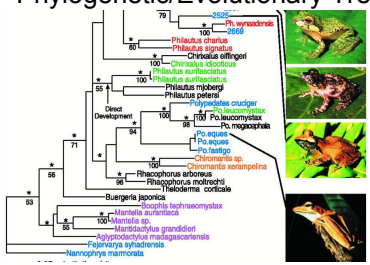
TreeJuxtaposer

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility. Tamara Munzner, Francois Guimbretiere, Serdar Tasiran, Li Zhang, and Yunhong Zhou. Proc SIGGRAPH 2003, p 453-472

- side by side comparison of evolutionary trees

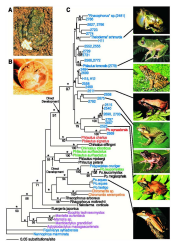


Phylogenetic/Evolutionary Tree



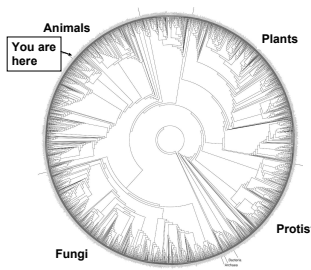
M Meegaskumbura et al., Science 298:379 (2002)

Common Dataset Size Today



M Meegaskumbura et al., Science 298:379 (2002)

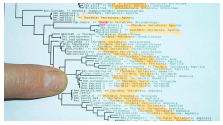
Future Goal: 10M node Tree of Life



David Hillis, Science 300:1687 (2003)

Paper Comparison: Multiple Trees

focus



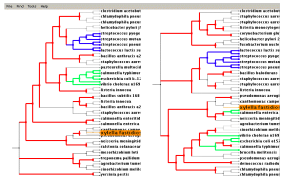
context

Accordion Drawing

- rubber-sheet navigation
  - stretch out part of surface, the rest squishes
  - borders nailed down
  - Focus+Context technique
    - integrated overview, details
  - old idea
    - [Sarkar et al 93], [Robertson et al 91]
- guaranteed visibility
  - marks always visible
  - important for scalability
  - new idea
    - [Munzner et al 03]

Guaranteed Visibility

- marks are always visible
- easy with small datasets



Guaranteed Visibility Challenges

- hard with larger datasets
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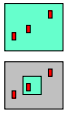
    - AD solution: constrained navigation



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    - AD solution: constrained navigation
  - underneath other marks
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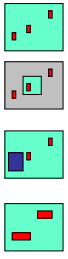
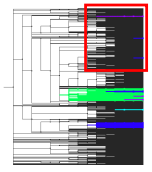
Guaranteed Visibility Challenges

- hard with larger datasets
- reasons a mark could be invisible
  - outside the window
    - AD solution: constrained navigation
  - underneath other marks
    - AD solution: avoid 3D
  - smaller than a pixel
    - AD solution: smart culling

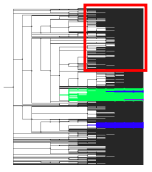


Guaranteed Visibility: Small Items

- Naïve culling may not draw all marked items



Guaranteed visibility of marks



No guaranteed visibility

Guaranteed Visibility: Small Items

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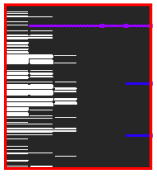

Guaranteed visibility of marks

No guaranteed visibility

TreeJuxtaposer

- video, software from olduvai.sourceforge.net/tj