Lecture 7: Multiples/Interaction

Information Visualization
CPSC 533C, Fall 2009

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Readings Covered

Ware, Chap 10: Interacting with Visualizations. first half, p 317-324

Tufte, Chap 4: Small Multiples

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

The Visual Design and Control of Trellis Display. R. A. Becker, W. S. Cleveland, and M. J. Shyu Journal of Computational and Statistical Graphics, 5:123-155. (1996).

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

Further Readings

Toolglass and magic lenses: the see-through interface. Eric A. Bier, Maureen C. Stone, Ken Pier, William Buxton, and Tony D. DeRose. Proc. SIGGRAPH'93, pp. 73-76.

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

The cognitive coprocessor architecture for interactive user interfaces George Robertson, Stuart K. Card, and Jock D. Mackinlay, Proc. UIST '89, pp 10-18.

Excentric Labeling: Dynamic Neighborhood Labeling for Data Visualization. Jean-Daniel Fekete and Catherine Plaisant. Proc. CHI'99, pages 512-519.

Ware Interaction: Data Manipulation

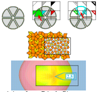
- low-level control loops
  - choice reaction time
    - depends on number of choices
  - selection time: Fitts' Law
    - depends on distance, target size
  - path tracing
    - depends on width
  - learning: power law of practice
    - also subtask chunking

Ware Interaction

- low-level control loops
  - two-handed interaction: Guiard's theory
    - coarse vs. fine control e.g. paper vs. pen positioning

Two-Handed Interaction Example

- toolglass: semi-transparent click-through tool
- magic lens: see-through tool



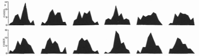
[Toolglass and magic lenses: the see-through interface. Eric A. Bier, Maureen C. Stone, Ken Pier, William Buxton, and Tony D. DeRose. Proc. SIGGRAPH'93, pp. 73-76.]

Ware Interaction

- low-level control loops
  - two-handed interaction: Guiard's theory
    - coarse vs. fine control e.g. paper vs. pen positioning
  - vigilance
    - difficult, erodes with fatigue
  - control compatability
    - learning/transfer: adaption time depends
  - hover/mouseover/tooltip
    - faster than explicit click

Small Multiples

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

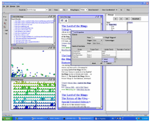


[Edward Tufte. The Visual Display of Quantitative Information, p 172]

Coordinated Multiple Views (CMV)

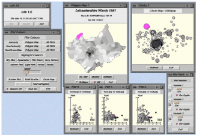
- more general than small multiples
- multiple views
  - multiform
    - different visual encodings of same data
  - overview+detail
    - different resolutions of same encoding/data
  - small multiples
    - same visual encodings of different data
- power of linking
  - linked highlighting (brushing)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

CMV Example: Visual Search Engine



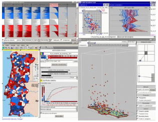
[VSE from Boukhelfia, Roberts, and Rodgers, Figure 3 of State of the Art: Coordinated & Multiple Views in Exploratory Visualization. Roberts, Proc. CMV 2007]

CMV Example: cdv



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

CMV Example: CommonGIS



[CommonGIS from Andrienko and Andrienko, Figure 4 of State of the Art: Coordinated & Multiple Views in Exploratory Visualization. Roberts, Proc. CMV 2007]

Replace, Replicate, Overlay

- when to do which
- design tradeoffs
  - always replace: too much reliance on memory
  - always replicate: too many windows
  - always overlay: too much clutter in single window

Architectural Issues

- must play nicely with other views
  - rendering, preprocessing, responding to commands
- most issues also true for scalability of single view
  - guaranteed response time independent of dataset size
- loose confederation
  - multithreaded, each component can work in background
- tighter confederation: return control to master regularly (TJ,H3)
  - divide work into pieces, enqueue
  - continue serving queue when control is returned

Animated Transitions

- animated transitions vs. jump cuts
  - object constancy
  - guaranteed frame rate avoids slowdown with large data
- early PARC architectural solution: Cognitive Co-Processor
  - split work into small chunks
  - animation vs. idle states
  - governor controls frame rate

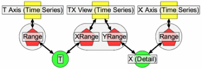
[The cognitive coprocessor architecture for interactive user interfaces. George Robertson, Stuart K. Card, and Jock D. Mackinlay, Proc. UIST '89, pp 10-18.]

Improvise

- tightly integrated coordination approach
  - components with many external control capabilities
- live properties
  - value slots, ports
  - change in response to user action
  - naive approaches fall into cycles
- coordinated queries
  - filters, projections

Coordinating Axes

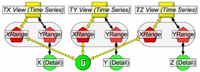
- scatterplot from components



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

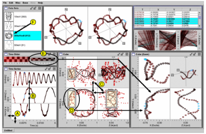
Coordinating Multiple Scatterplots

- sync horizontal but not vertical scrolling



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

Example: Complex Application



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

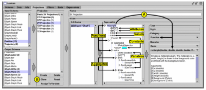
Selection

- selection decoupled from data
- selection-dependent loading, filtering, projection
- highlighting: user-customizeable differentiation of selected vs. unselected items
- video

Critique

Critique

- sophisticated and powerful approach to coordination
- but very large learning curve to build new apps



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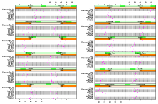
Automatic Dotplot Ordering: Trellis

alphabetical site,variety — use group median



[The Visual Design and Control of Trellis Display. Becker, Cleveland, and Shyu. JCSG 5:123-155 1996]

Trellis Structure

- conditioning/trellising: choose structure
  - pick how to subdivide into panels
  - pick x/y axes for indiv panels
  - explore space with different choices
    - multiple conditioning
- ordering
  - large-scale: between panels
  - small-scale: within panels
  - main-effects: sort by group median
    - derived space, from categorical to ordered

Confirming Hypothesis

- dataset error with Morris switched?
- old trellis: yield against variety given year/site
- new trellis: yield against site and year given variety
  - exploration suggested by previous main-effects ordering

[The Visual Design and Control of Trellis Display. Becker, Cleveland, and Shyu. JCSG 5:123-155 1996]

Partial Residuals

- fixed dataset, Morris data switched
- explicitly show differences
  - take means into account
  - line is 10% trimmed mean (toss outliers)

[The Visual Design and Control of Trellis Display. Becker, Cleveland, and Shyu. JCSG 5:123-155 1996]

Critique

Critique

- careful attention to statistics and perception
- finding signals in noisy data
  - trends, outliers
- exploratory data analysis (EDA)
  - Tukey work fundamental, Cleveland continues

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.]

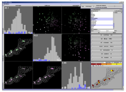
Multiform Bivariate Small Multiple

- 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

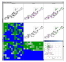
- scatterplots/maps, histograms along diagonal
  - per-column vars: mortality, early detection, recent screening
- univariate map var: screening facility availability



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

Spacefill Form

- linked highlight of low doctor ratio counties from scatterplot
- spacefill shows it's roughly half the items



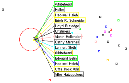
[Exploring High-D Spaces with Multiform Matrices and Small Multiples. MacEachren et al, Proc. InfoVis 2003.]

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

Excentric Labels

- show labels around mouseover region
- demo



[Excentric Labeling: Dynamic Neighborhood Labeling for Data Visualization. Jean-Daniel Fekete and Catherine Plaisant. Proc. CHI'99, pages 512-519.] [http://www.cs.umd.edu/hcil/excentric/]

Critique

Critique

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