Lecture 6: Statistical Graphics

Information Visualization
CPSC 533C, Fall 2009

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UBC Computer Science

Mon, 28 September 2009

Readings Covered

Multi-Scale Banking to 45 Degrees. Jeffrey Heer, Maneesh Agrawala. IEEE TVCG 12(5) (Proc. InfoVis 2006), Sep/Oct 2006, pages 701-708.

Animated Transitions in Statistical Data Graphics. Jeffrey Heer and George G. Robertson. IEEE TVCG (Proc. InfoVis 2007) 13(6): 1240-1247, 2007.

Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Wesley Willett, Jeffrey Heer, and Maneesh Agrawala. IEEE TVCG (Proc InfoVis 2007) 13(6):1129-1136.

Graph-Theoretic Scagnostics. Leland Wilkinson, Anushka Anand, and Robert Grossman. Proc InfoVis 05

Additional Readings

Visual information seeking: Tight coupling of dynamic query filters with starfield displays. Chris Ahlberg and Ben Shneiderman, Proc SIGCHI '94, pages 313-317

Metric-Based Network Exploration and Multiscale Scatterplot. Yves Chiricota, Fabien Jourdan, Guy Melancon. Proc. InfoVis 04, pages 135-142.

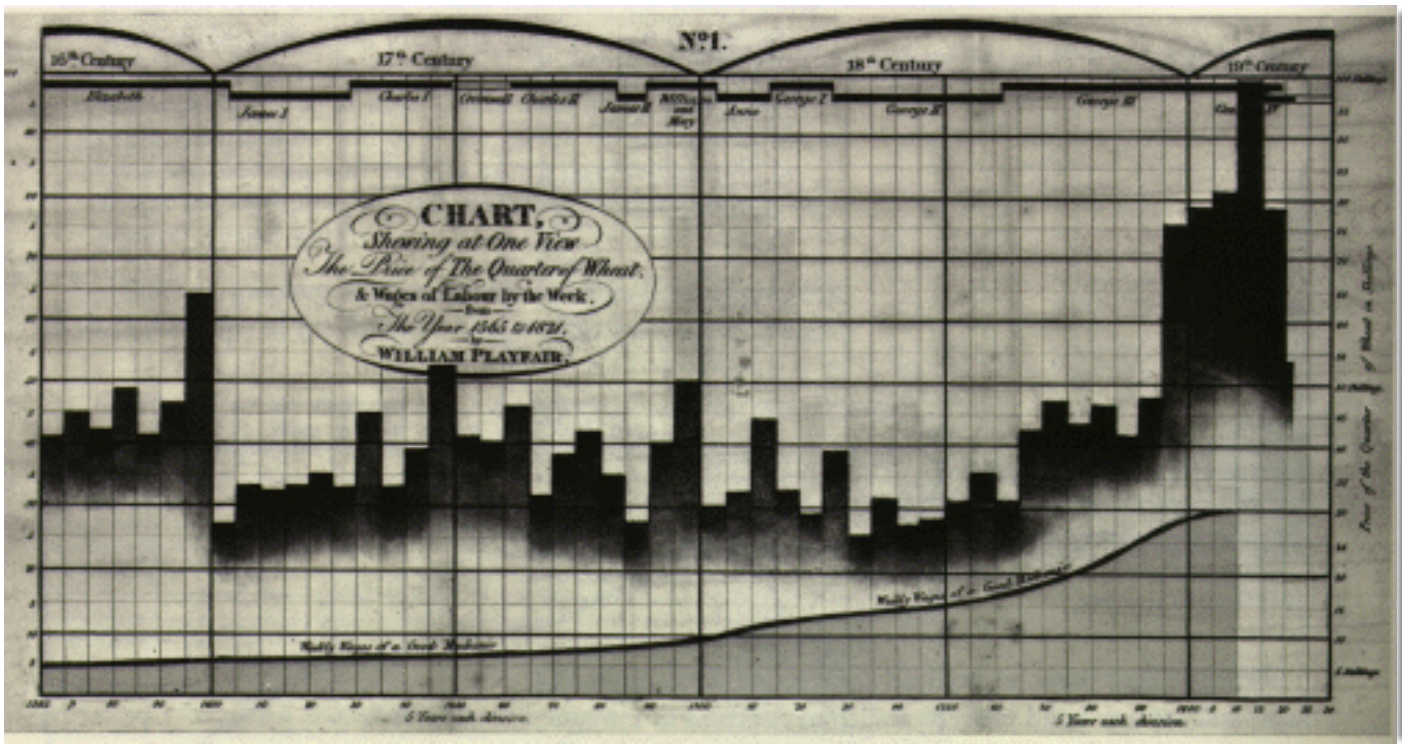
The Elements of Graphing Data, William S. Cleveland, Hobart Press 1994.

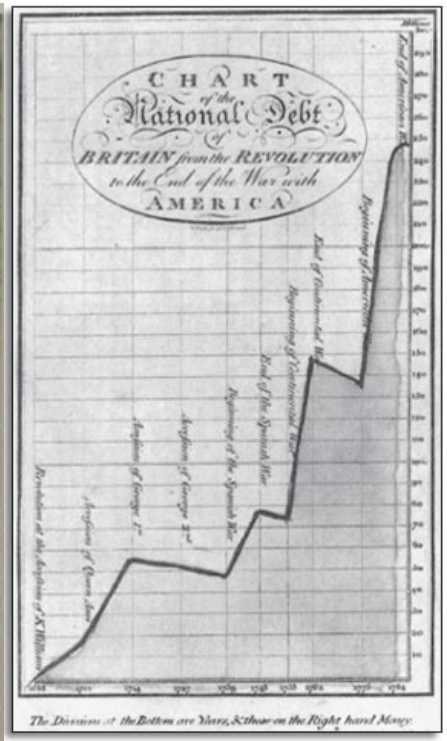
Statistical Graphics

- long history for paper-based views of data
  - springboard for infovis
  - http://www.math.yorku.ca/SCS/Gallery/milestone/
- improving line charts
- improving scatterplots
  - interactive dynamic queries
  - multiscale structure
  - matrix of scatterplots, level of indirection
- improving statistical graphics
  - animated transitions between graphics
  - making widgets more information-dense

Line Charts

- invented by William Playfair (1759-1823)
  - also bar charts, pie charts, ...

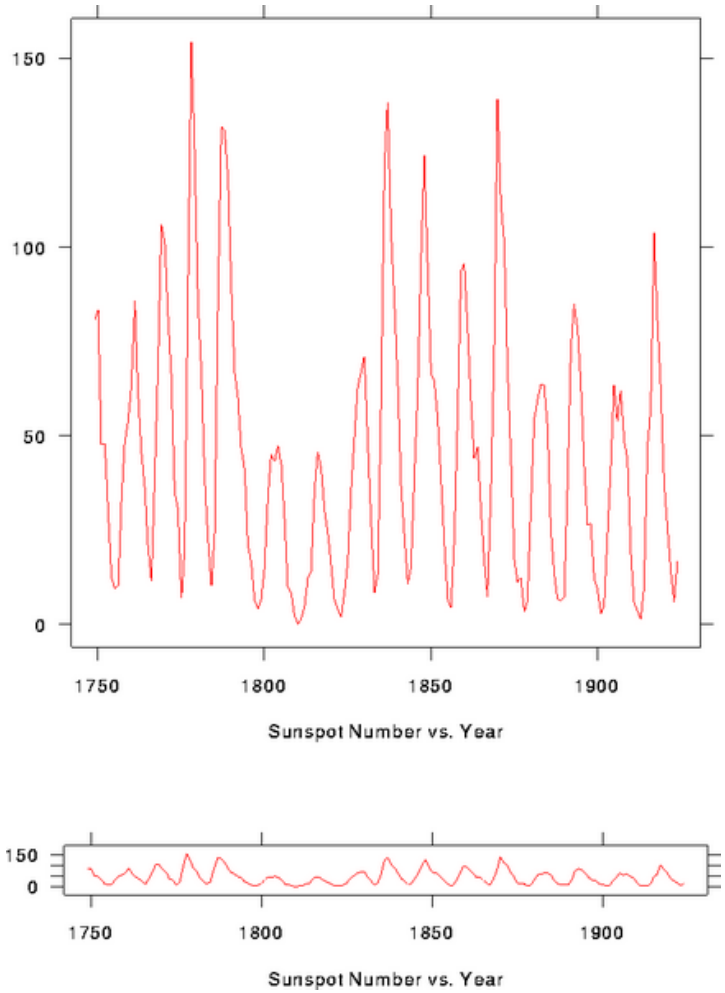




http://labspace.open.ac.uk/file.php/1872/Mu120_3_021i.jpg
http://www.math.yorku.ca/SCS/Gallery/images/playfair-wheat1.gif

Banking to 45 Degrees

- previous work by Cleveland
- perceptual principle: most accurate angle judgement at 45 degrees
- pick line graph aspect ratio (height/width) accordingly



[www.research.att.com/∼rab/trellis/sunspot.html]

Multiscale Banking to 45

- frequency domain analysis
- find interesting regions at multiple scales

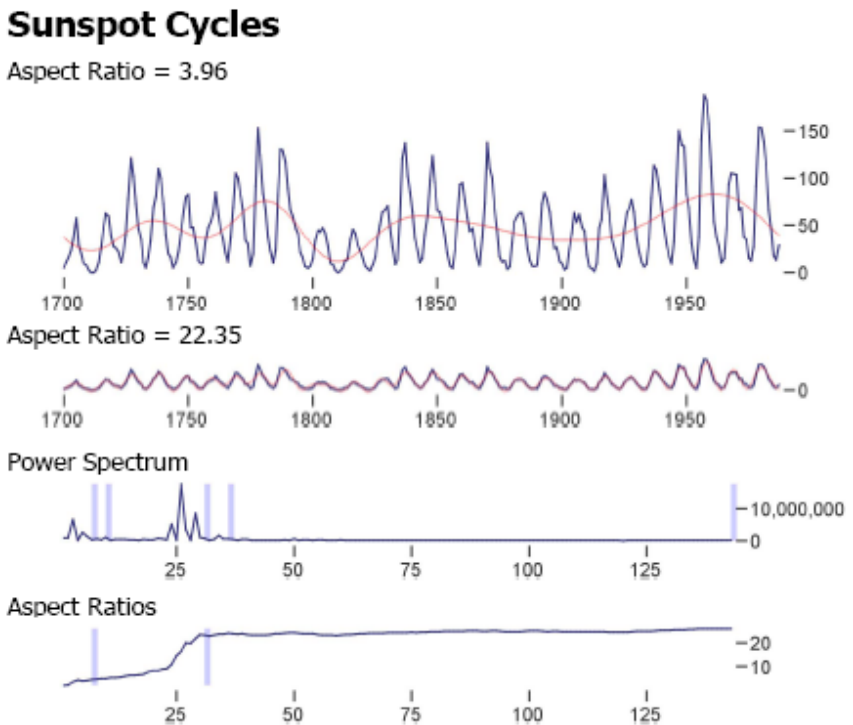
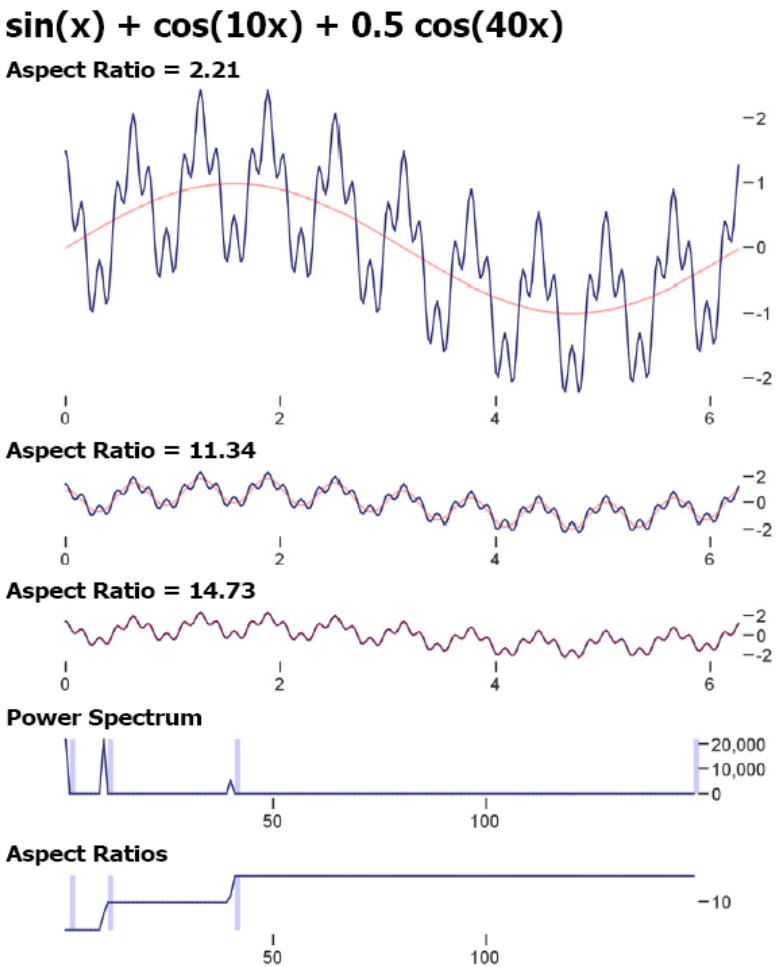


Figure 5. Sunspot observations, 1700-1987. The first plot shows low-frequency oscillations in the maximum values of sunspot cycles. The second plot brings the individual cycles into greater relief.

[Multi-Scale Banking to 45 Degrees. Heer and Agrawala, Proc InfoVis 2006 vis.berkeley.edu/papers/banking]

Choosing Aspect Ratios

- FFT the data, smooth by convolve with Gaussian
- find interesting spikes/ranges in power spectrum
- cull nearby regions if too similar, ensure overview shown
- create trend curves for each aspect ratio



Multiscale Banking to 45

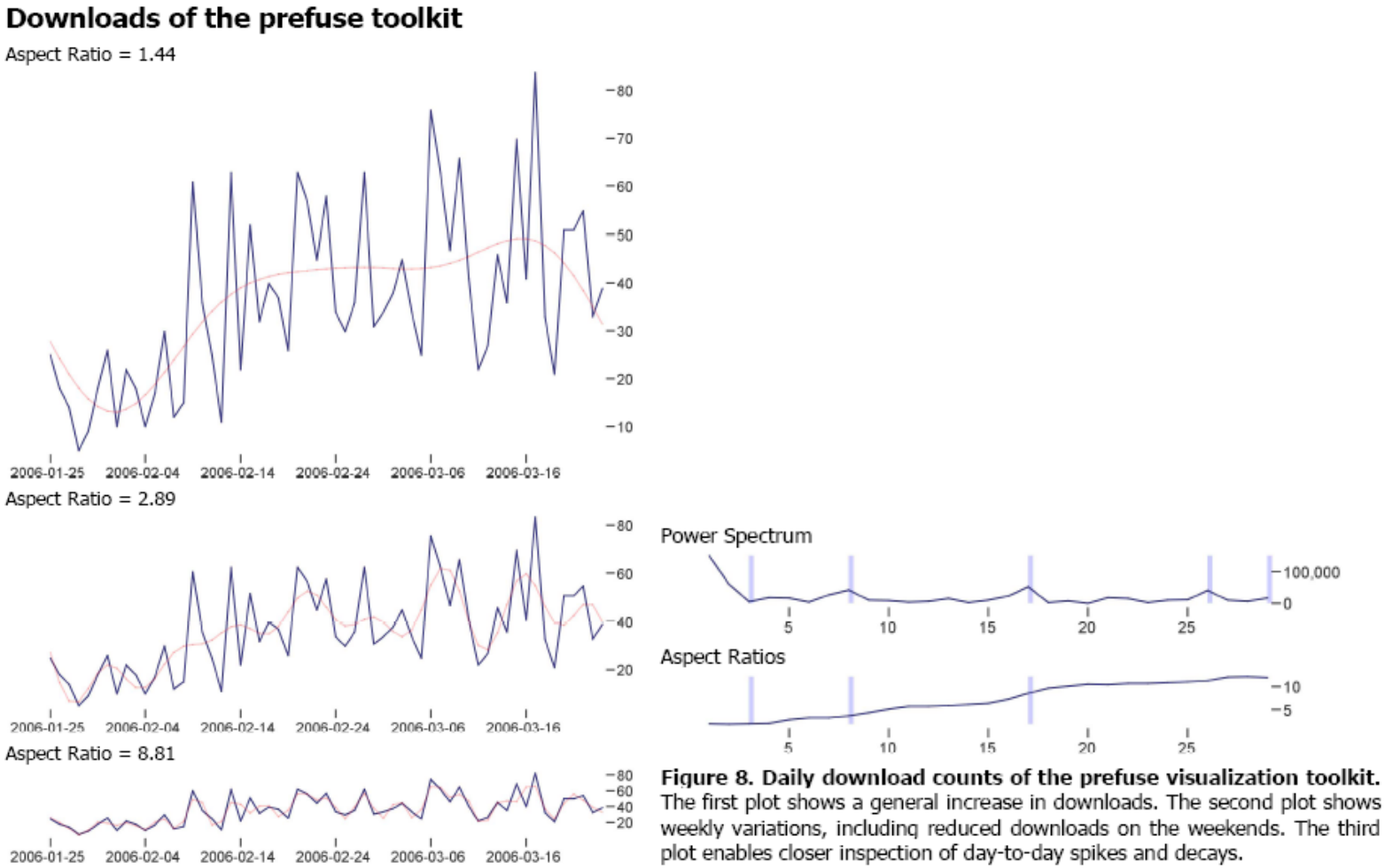


Figure 8. Daily download counts of the prefuse visualization toolkit. The first plot shows a general increase in downloads. The second plot shows weekly variations, including reduced downloads on the weekends. The third plot enables closer inspection of day-to-day spikes and decays.

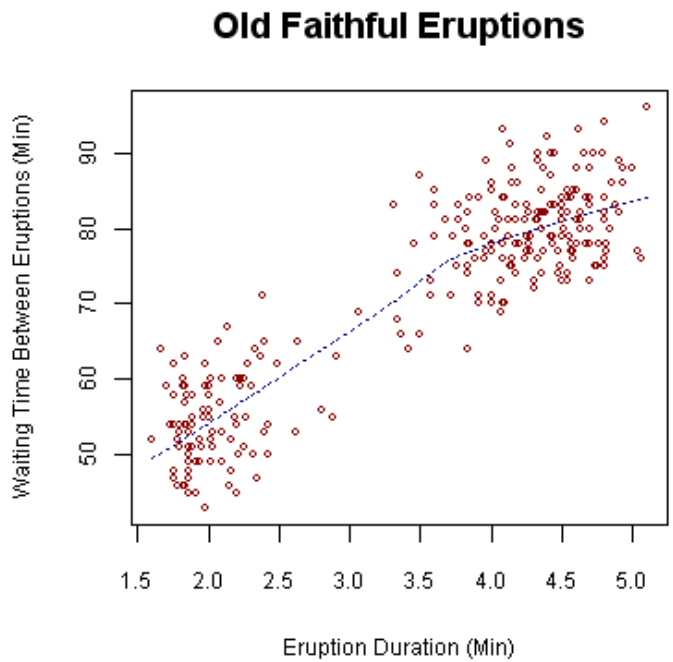
[Multi-Scale Banking to 45 Degrees. Heer and Agrawala, Proc InfoVis 2006 vis.berkeley.edu/papers/banking]

Critique

- very nice generalization of old idea
- does not require interactivity to reap benefits

Scatterplots

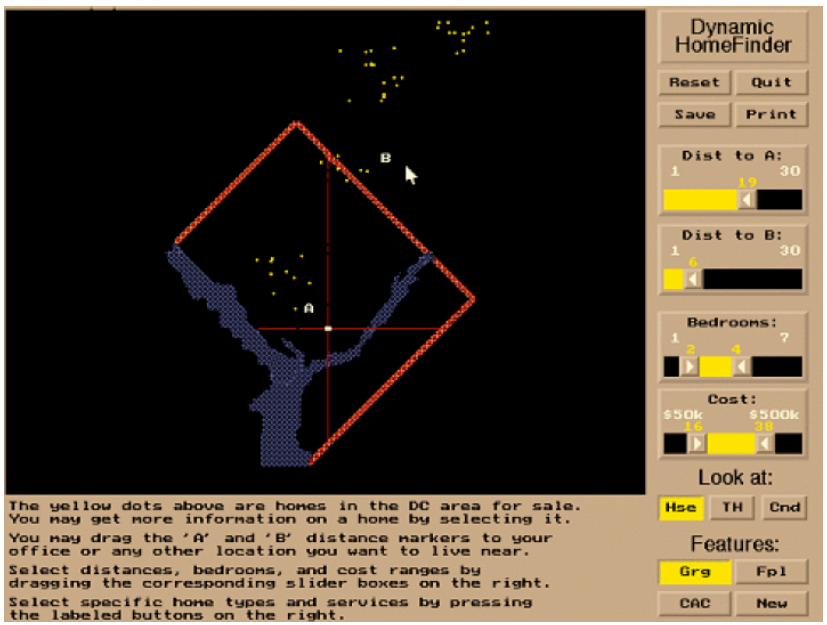
- encode two input variables with spatial position
- show positive/negative/no correllation between variables



[http://upload.wikimedia.org/wikipedia/commons/0/0f/Oldfaithful3.png]

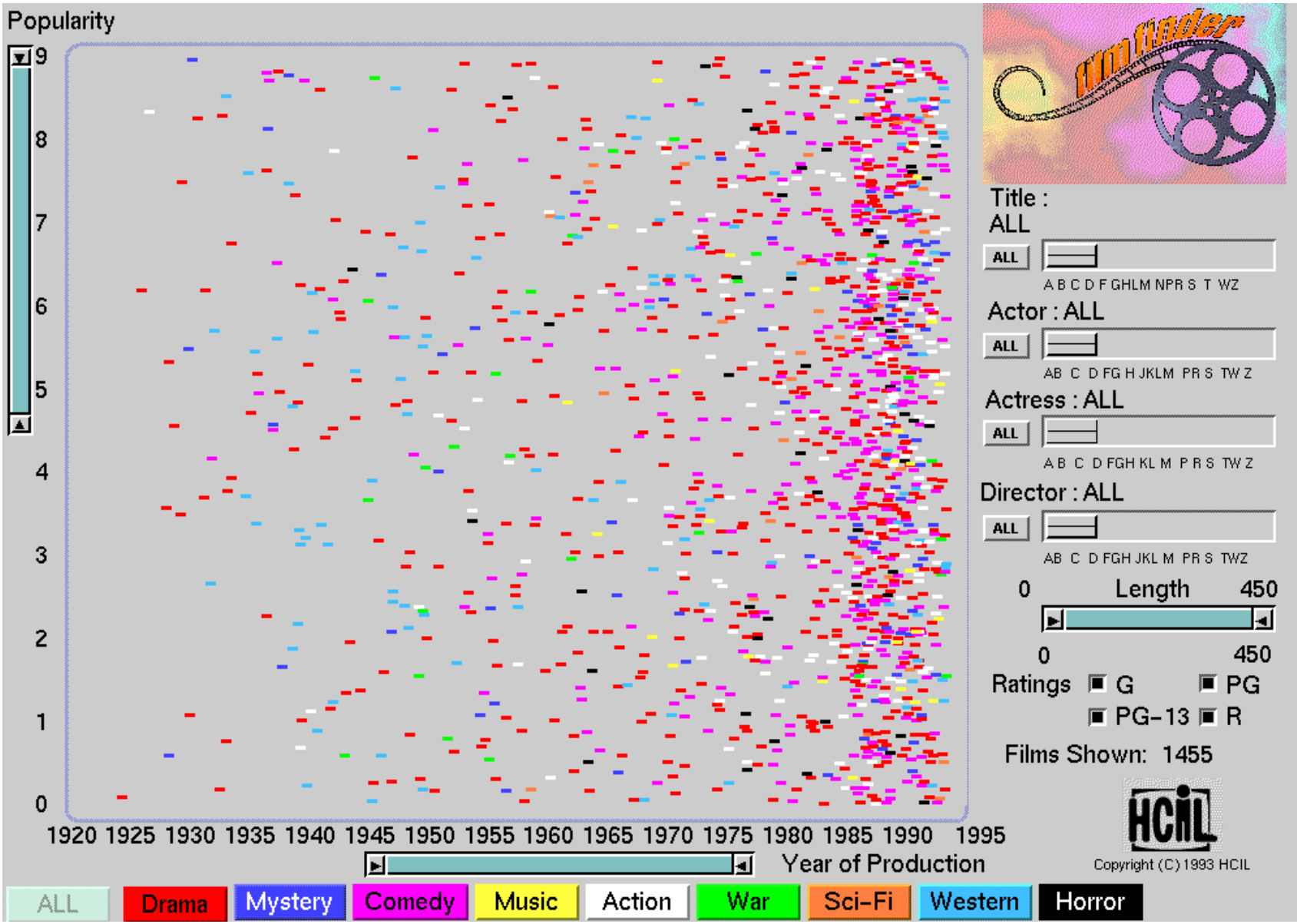
Interactive Scatterplots: Dynamic Queries

- tight coupling: immediate feedback after action
- fast, lightweight visual exploration
  - vs. composing SQL query



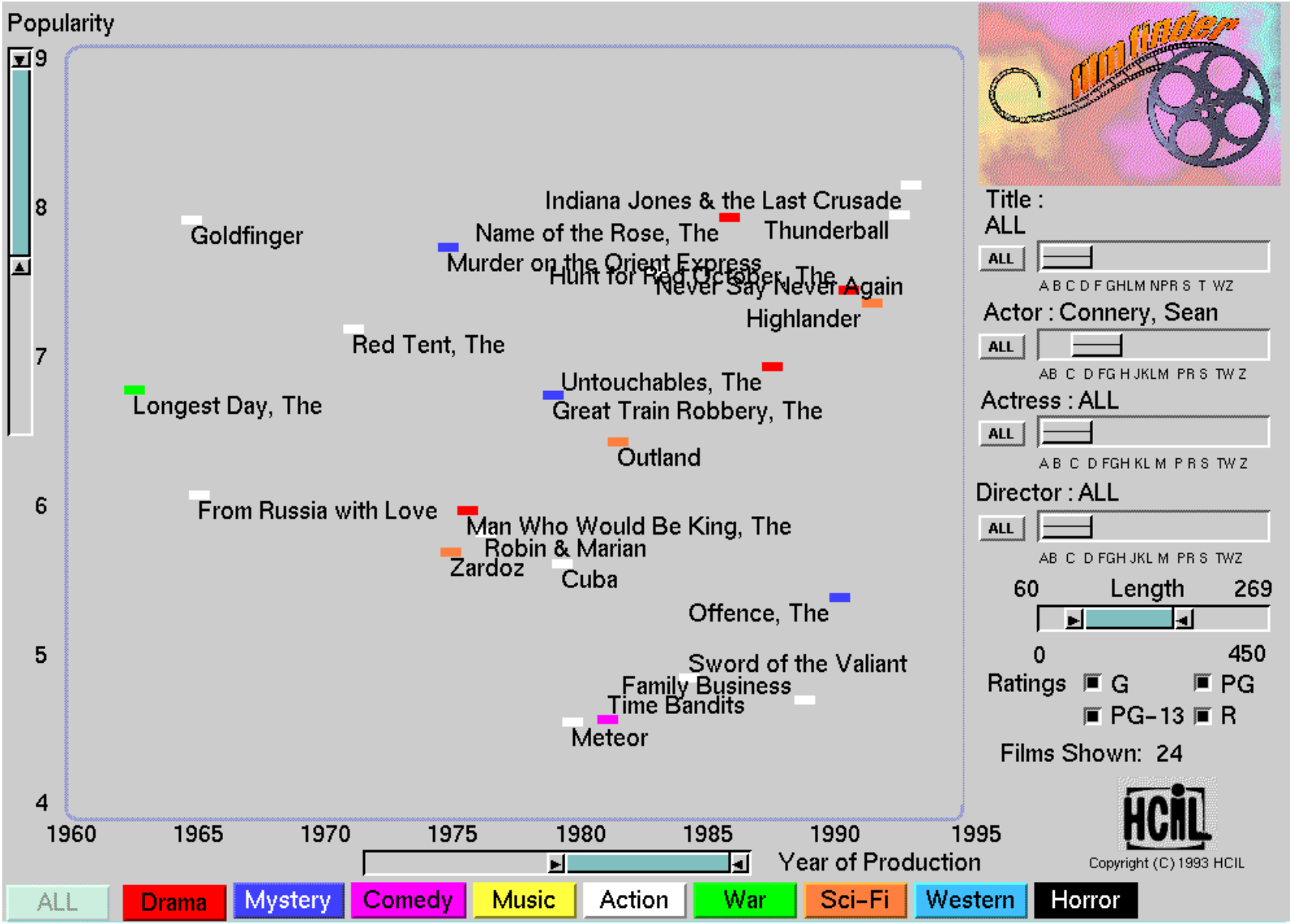
[Visual information seeking: Tight coupling of dynamic query filters with starfield displays. Chris Ahlberg and Ben Shneiderman, Proc SIGCHI '94, p 313-317]
[http://www.cs.umd.edu/hcil/pubs/screenshots/FilmFinder/]

FilmFinder



[Visual information seeking: Tight coupling of dynamic query filters with starfield

FilmFinder



[Visual information seeking: Tight coupling of dynamic query filters with starfield

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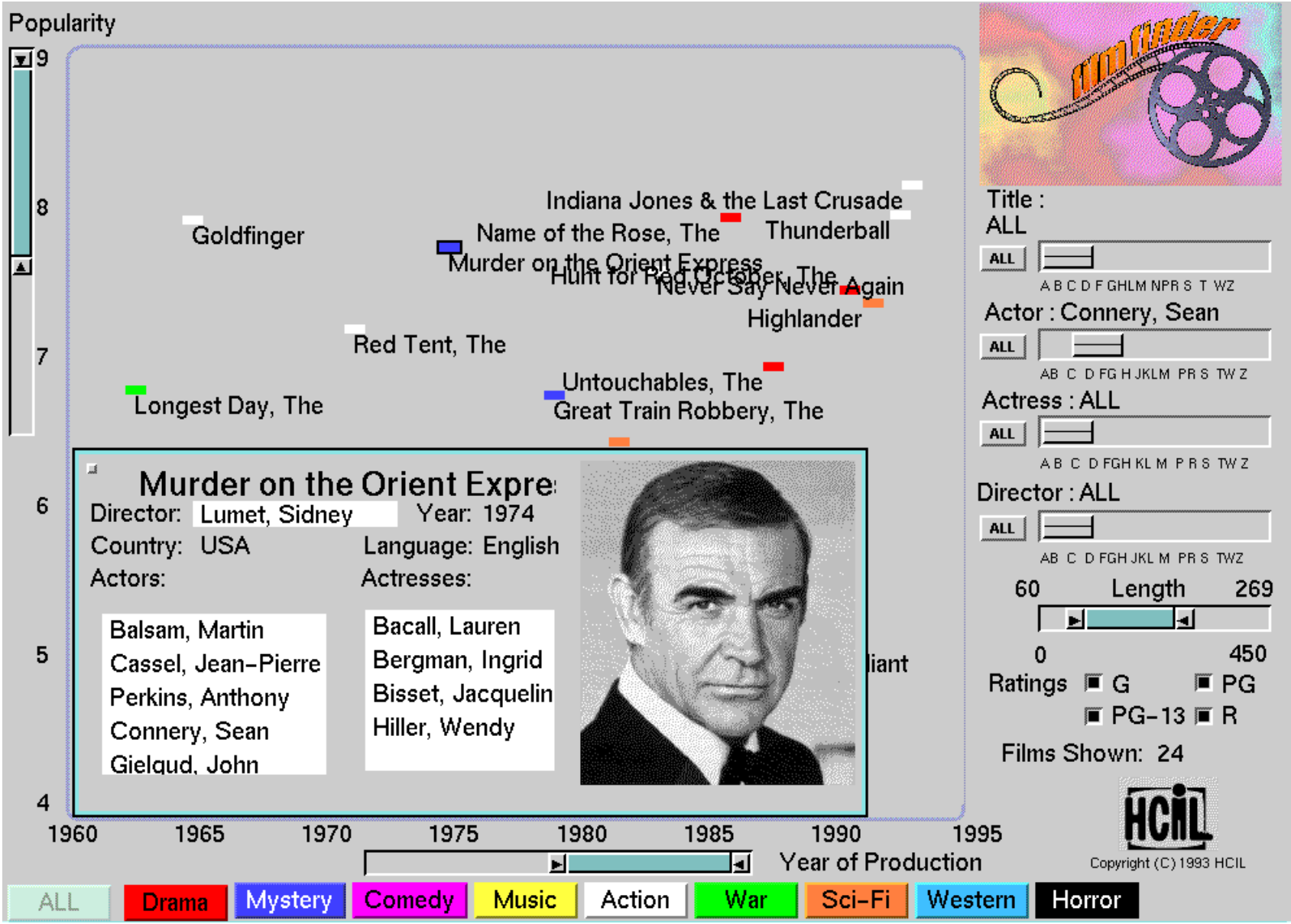
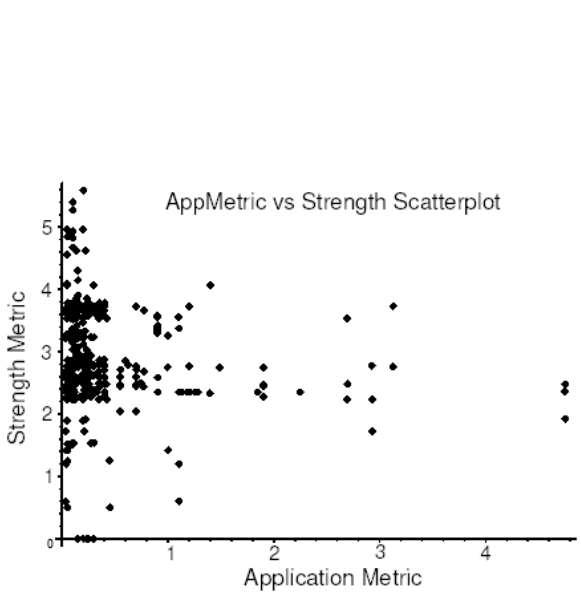
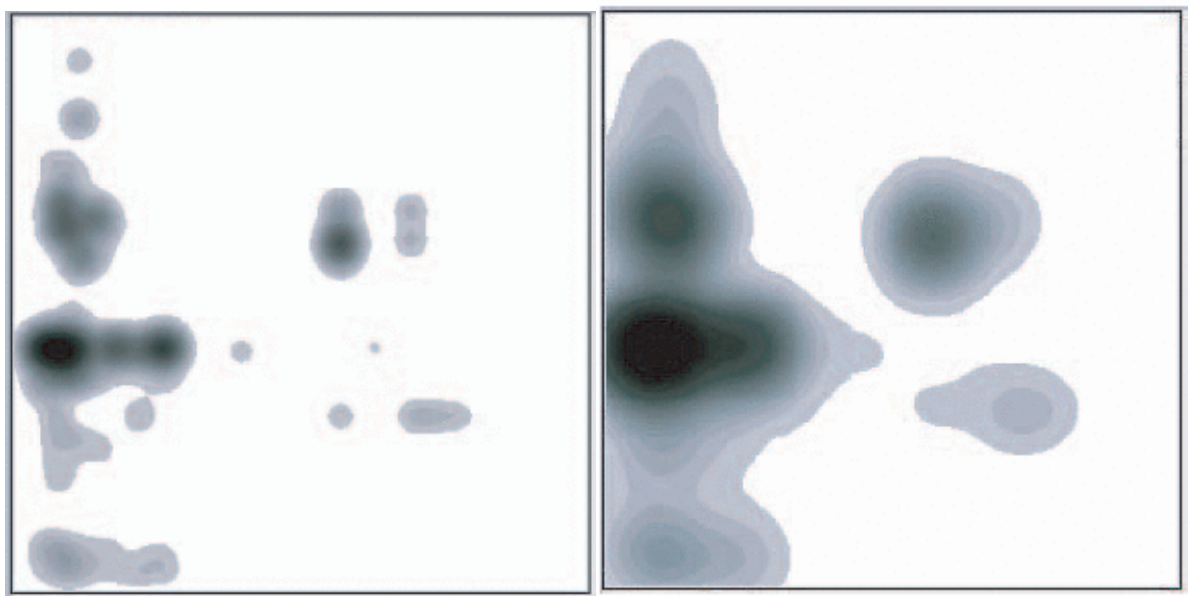


[Visual information seeking: Tight coupling of dynamic query filters with starfield

Multiscale Scatterplots

- blur shows structure at multiple scales
  - convolve with Gaussian
  - slider to control scale parameter interactively
- easily selectable regions in quantized image





[Metric-Based Network Exploration and Multiscale Scatterplot. Yves Chiricota, Fabien Jourdan, Guy Melancon. Proc. InfoVis 04]

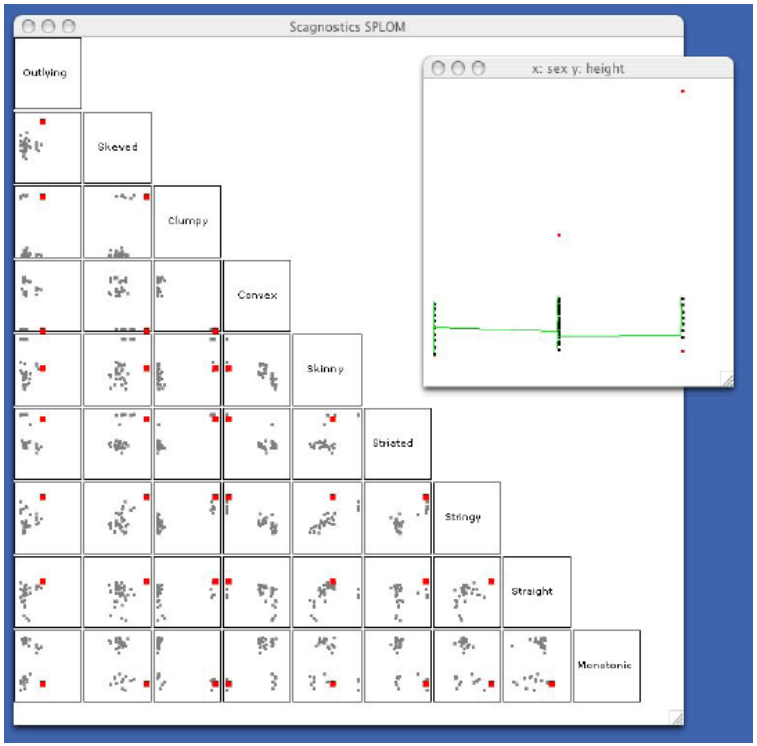
SPLOM: Scatterplot Matrix

- show all pairwise variable combos side by side
  - matrix size grows quadratically with variable count

[Graph-Theoretic Scagnostics. Wilkinson, Anand, and Grossman. Proc InfoVis 05.]

Graph-Theoretic Scagnostics

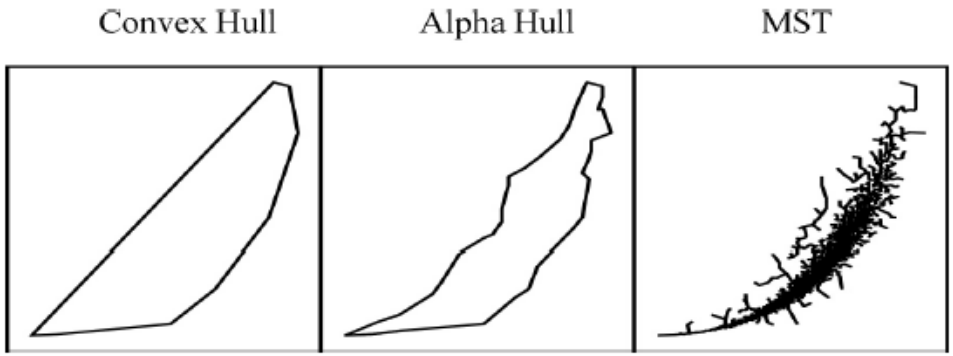
- reduce problem to constant size
  - overview matrix of 9 geometric metrics
- meta-SPLOM: each point represents scatterplot
  - detail on demand to see individual scatterplots



Graph-Theoretic Scagnostics. Leland Wilkinson, Anushka Anand, and Robert Grossman. Proc InfoVis 05.

Measuring Scatterplots

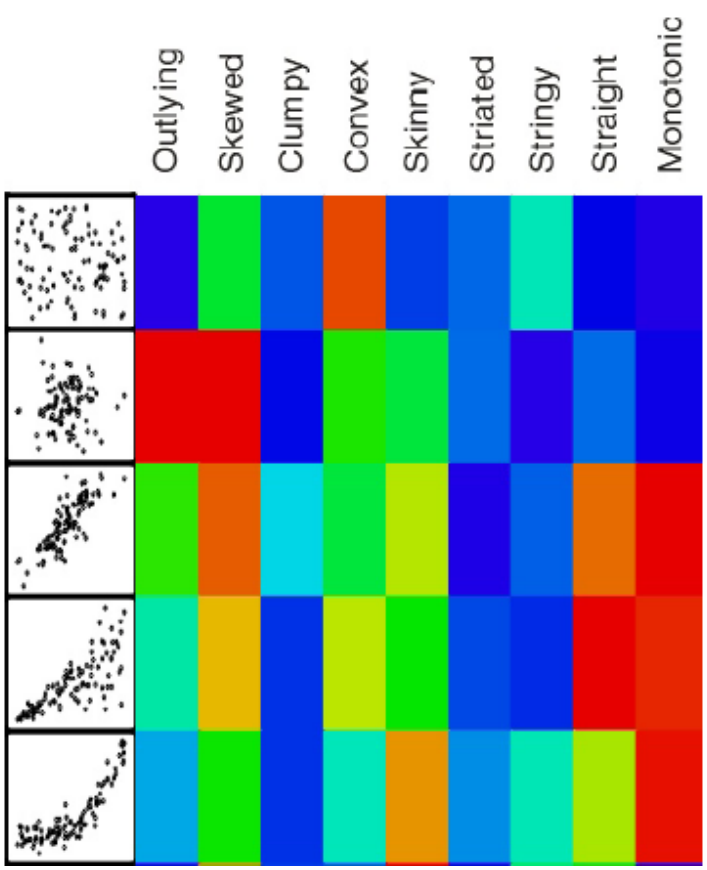
- aspects and measures
  - outliers: outlying
  - shape: convex, skinny, stringy, straight
    - computed with convex hull, alpha hull, min span tree

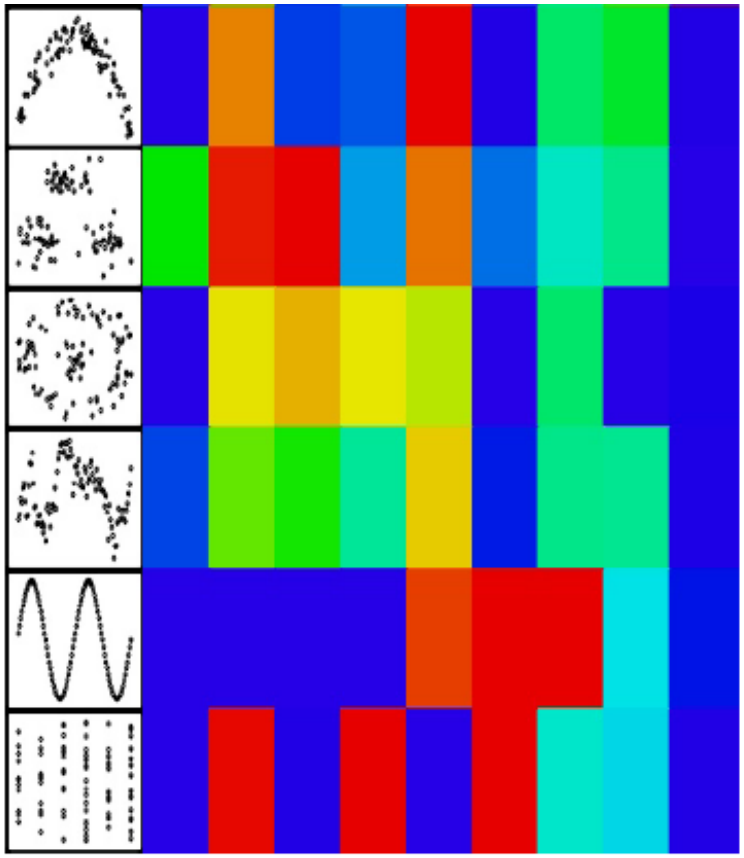


  - trend: monotonic
  - density: skewed, clumpy
  - coherence: striated

[Graph-Theoretic Scagnostics. Wilkinson, Anand, and Grossman. Proc InfoVis 05.]

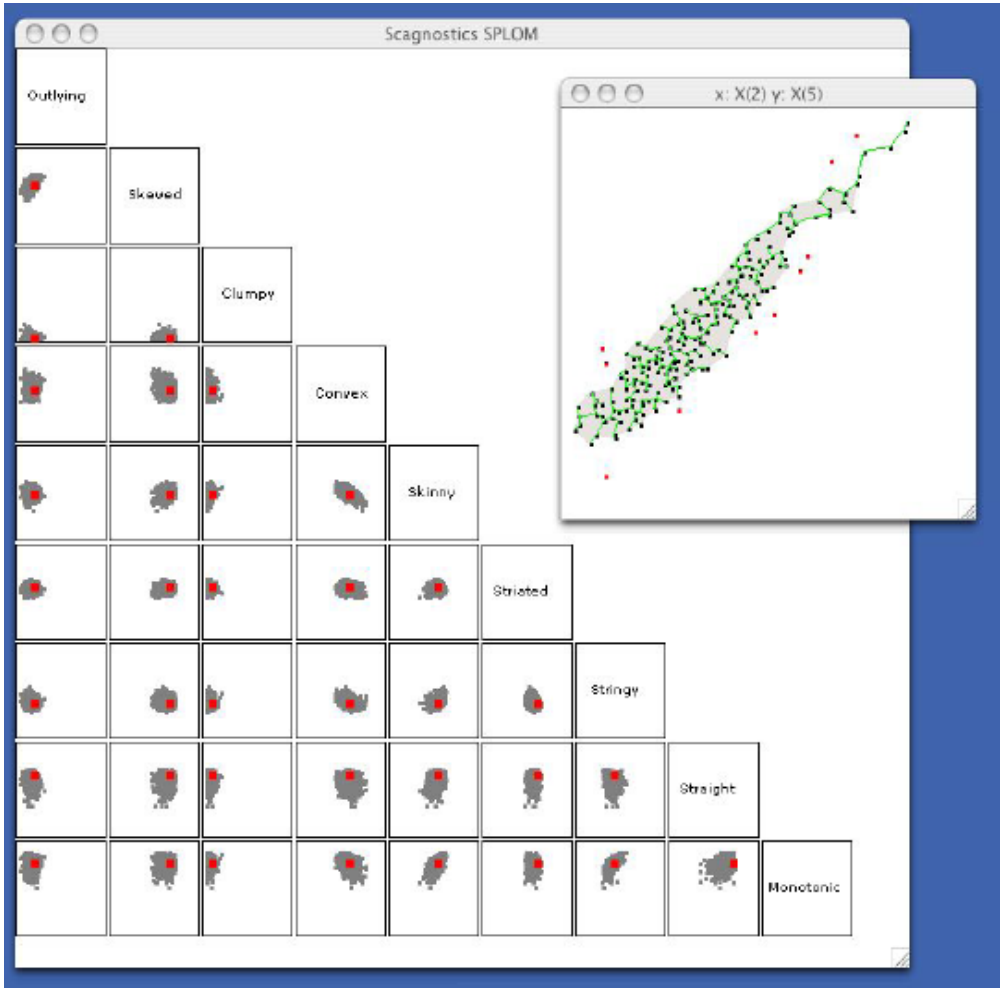
Measuring Scatterplots





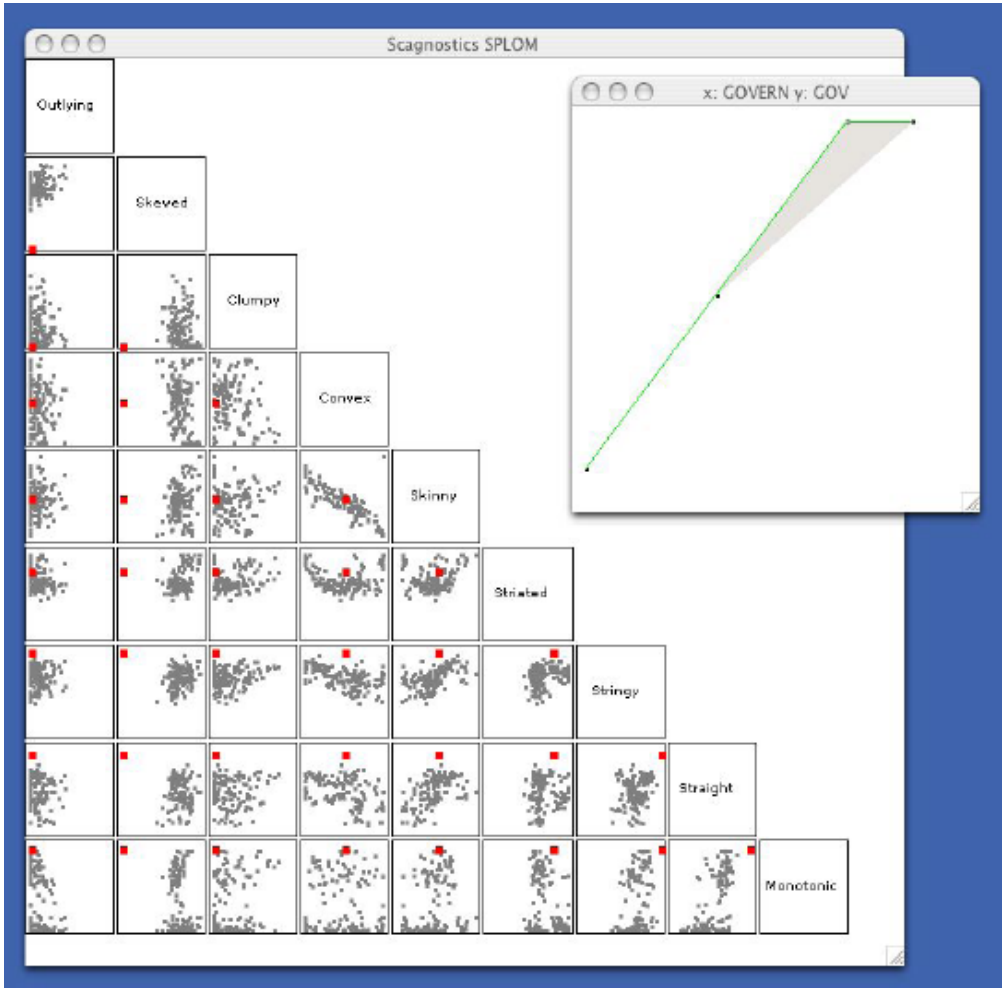
[Graph-Theoretic Scagnostics. Wilkinson, Anand, and Grossman. Proc InfoVis 05.]

Results



[Graph-Theoretic Scagnostics. Wilkinson, Anand, and Grossman. Proc InfoVis 05.]

Results



[Graph-Theoretic Scagnostics. Wilkinson, Anand, and Grossman. Proc InfoVis 05.]

Critique

- powerful and elegant method
  - curse of dimensionality is hard problem
- abstraction level clearly appropriate for experts
  - unsuitable for novices
- presentation problem: color use in paper itself

Animated Transitions

- general and powerful idea
  - transitions, not motion as visual encoding
- benefits
  - attracts attention
  - facilitates object constancy
  - implies causality
  - emotionally engaging
- this paper: statistical graphics
  - design principles
  - controlled experiments

[Animated Transitions in Statistical Data Graphics. Jeffrey Heer and George G. Robertson. IEEE TVCG (Proc. InfoVis 2007) 13(6): 1240-1247, 2007.]

Transition Taxonomy

- change viewpoint
- change spatial substrate
- filter
- reorder
- change time
- change visual mapping
- change data schema

Congruence Principles

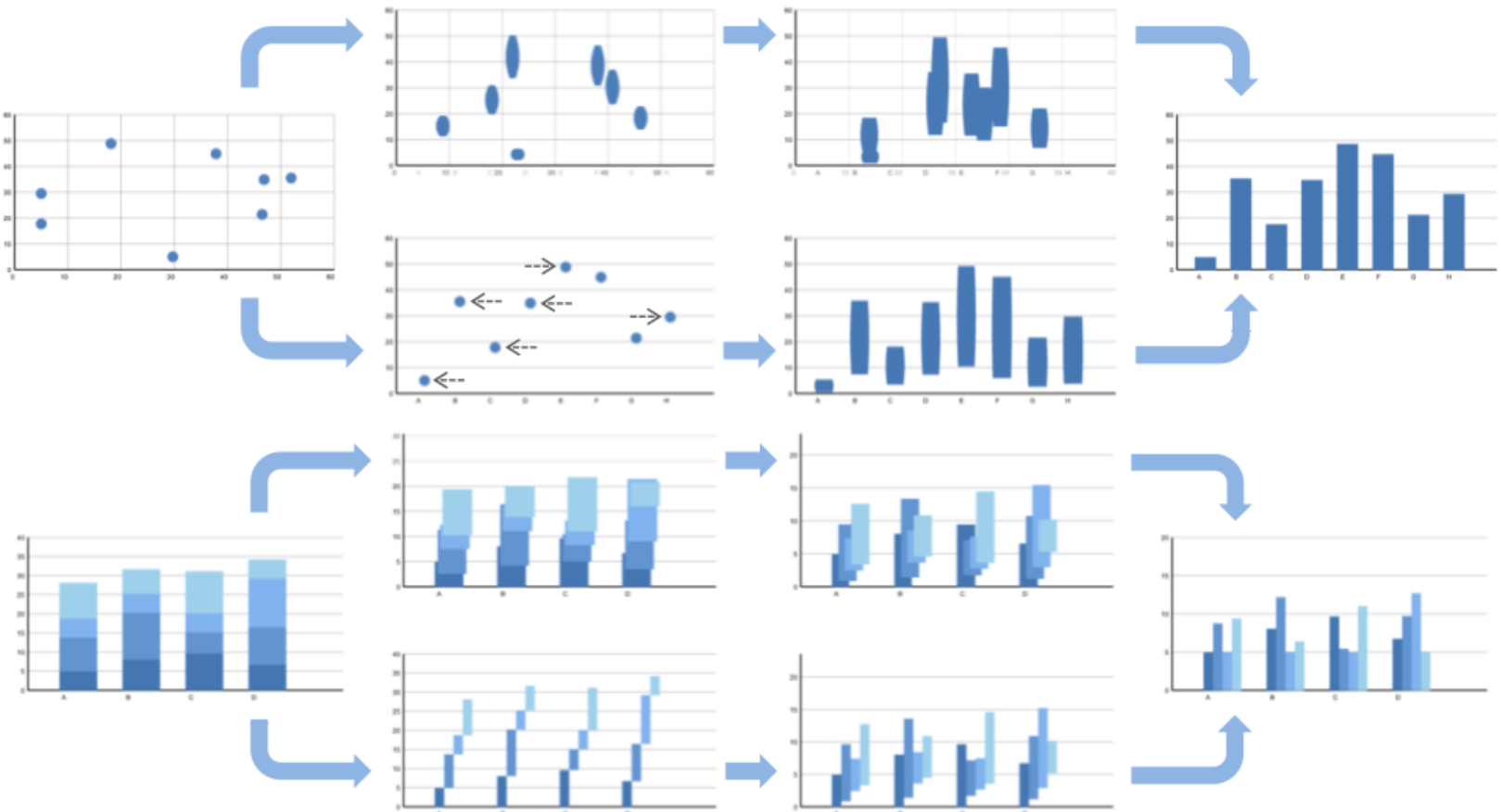
- internal and external representations should match
  - both structure and content
- principles
  - maintain valid data graphics during transitions
  - use consistent mappings (semantic-syntactic)
  - respect semantic correspondences
  - avoid ambiguity

Apprehension Principles

- external representation structure and content should be readily and accurately perceived and comprehended

- principles
  - group similar transitions
    - gestalt common fate
  - minimize occlusion
  - maximize predictability
    - slow-in, slow-out
  - use simple transitions
  - use staging for complex transitions
  - make transitions as long as needed, but no longer

Staging



[Animated Transitions in Statistical Data Graphics. Jeffrey Heer and George G. Robertson. IEEE TVCG (Proc. InfoVis 2007) 13(6): 1240-1247, 2007.]

Experiments

- study 1: object location tracking
  - animation always helped
  - staged animation almost always helped
- study 2: value change estimation
  - animation helps in some cases
  - staging not significant help
- preference: staged anim mostly, anim always
- guideline: avoid overly complex multi-staging

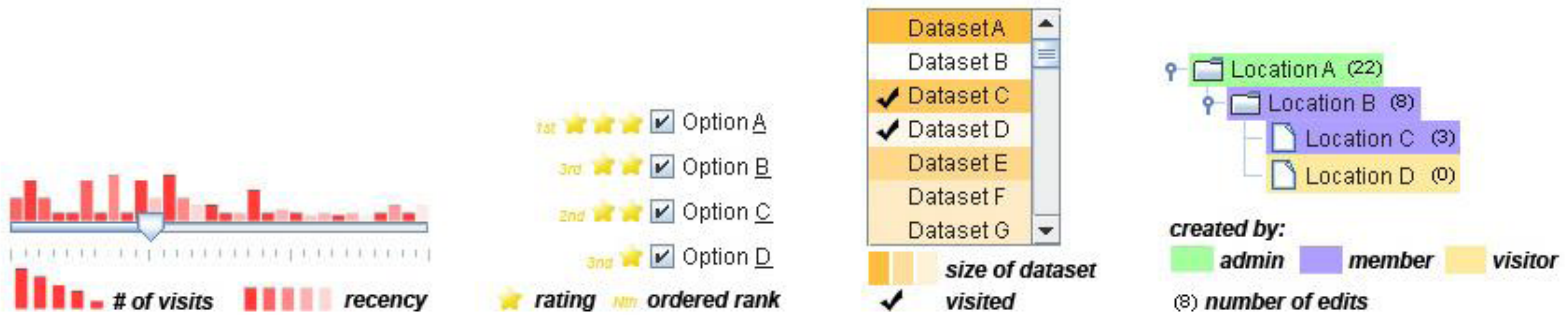
Critique

Critique

- thorough investigation,
  - goes beyond anecdotal evidence

Scented Widgets

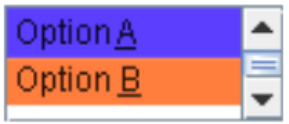
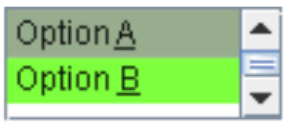
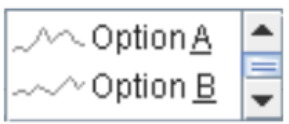
- embedded visualizations for standard UI elements
  - graphically compact/terse
  - information scent cues for navigating info spaces



[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE TVCG (Proc InfoVis 2007) 13(6):1129-1136.]

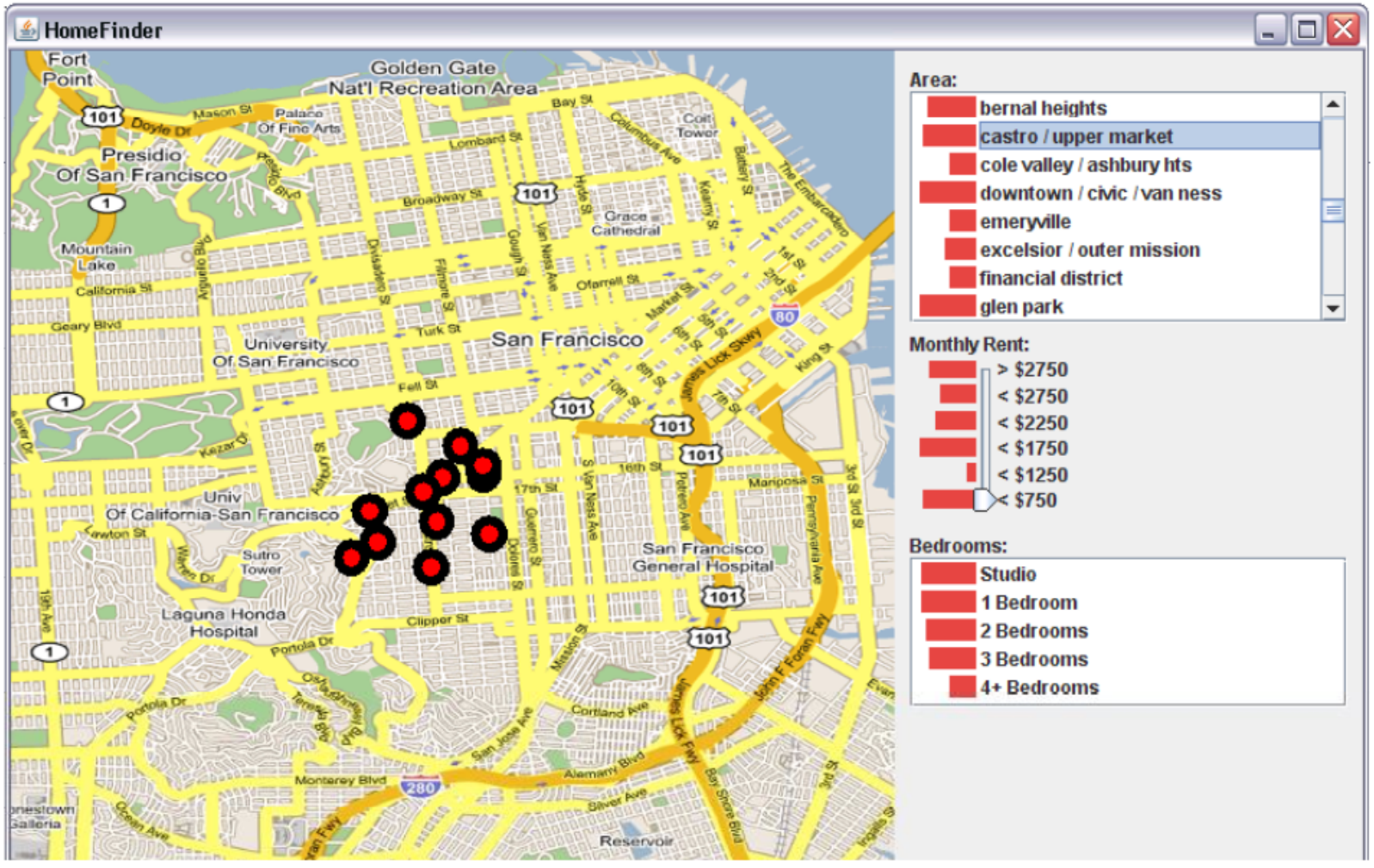
Implemented Scent Types

Table 1. Scent encodings supported by scented widgets

Name	Description	Example
Hue	Varies the hue of the widget (or of a visualization embedded in it)	
Saturation	Varies the saturation of the widget (or of a visualization embedded in it)	
Opacity	Varies the saturation of the widget (or of a visualization embedded in it)	
Text	Inserts one or more small text figures into the widget	
Icon	Inserts one or more small icons into the widget.	
Bar Chart	Inserts one or more small bar chart visualizations into the widget	
Line Chart	Inserts one or more small line chart visualizations into the widget	

[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE TVCG (Proc InfoVis 2007) 13(6):1129-1136.]

Example Application



[Scented Widgets: Improving Navigation Cues with Embedded Visualizations. Willett, Heer, and Agrawala. IEEE TVCG (Proc InfoVis 2007) 13(6):1129-1136.]

Experiments

- more unique discoveries at first
  - but effect faded over time
- significant preference
- no impairment from clutter

Critique

Critique

- information-dense annotation successful
- good discussion of toolkit issues
- user study solidifies contribution

Reading for Next Time

- Ware, Chapter 10: Interacting with Visualizations: first half, p 317-324
- Tufte, Chapter 4: Small Multiples
- Exploring High-D Spaces with Multiform Matrices and Small Multiples. Alan MacEachren, Xiping Dai, Frank Hardisty, Diansheng Guo, and Gene Lengerich. Proc InfoVis 2003, p 31-38.
- 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 (1996). Journal of Computational and Statistical Graphics, 5:123-155.