5. Interaction with Visualizations
Dynamic linking, brushing and filtering in Information Visualization displays

Lecture „Informationsvisualisierung”

Prof. Dr. Andreas Butz, WS 2012/13

Concept and slides: Thorsten Büring,

3rd, revised edition

Outline

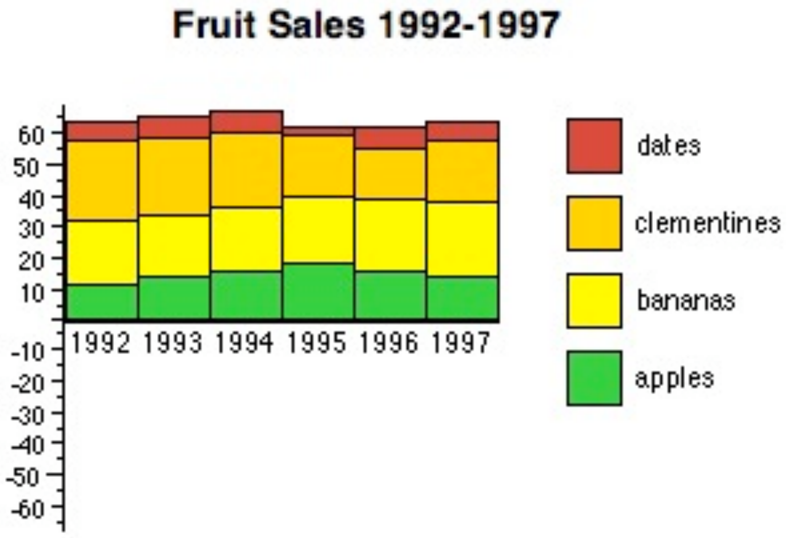
- InfoVis & Interaction
- Direct Manipulation (DM)
- Common Interaction Techniques
  - Brushing
  - Zooming & Panning
  - Dynamic Queries
- Attribute Explorer
- Dynamic Queries and Movable Filters

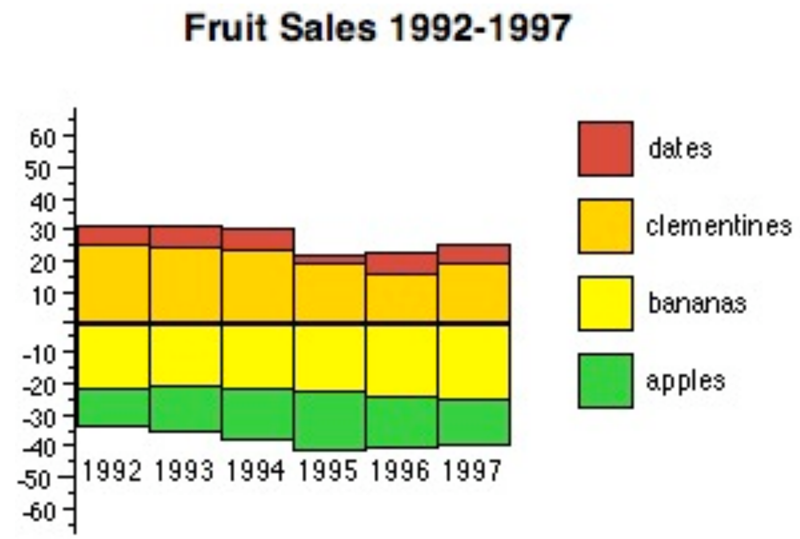
InfoVis & Interaction

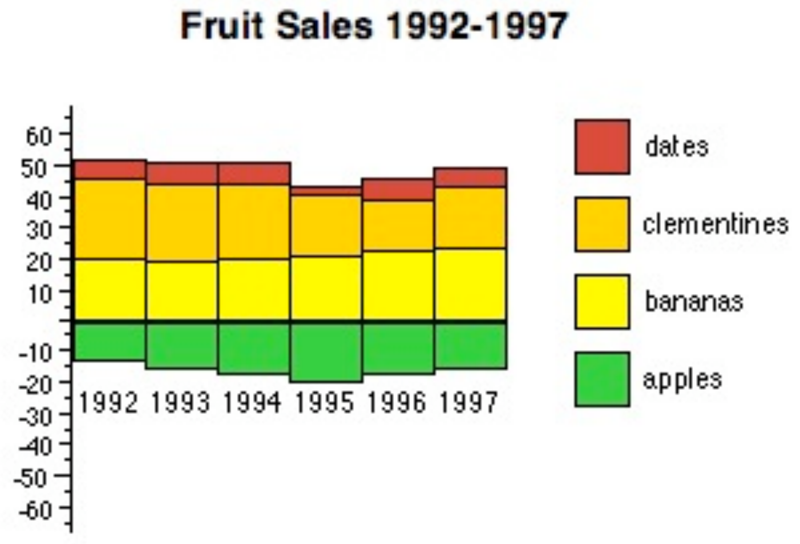
- Information Visualization research originally: focus on finding novel visual representations
- Increasing interest in interaction design, HCI models and evaluation as well as aesthetics in the IfoVis community
- HCI Interaction models help us to better understand the complex concepts of human-machine communication
- Norman's execution-evaluation cycle (Norman 1988)
  - 1. Establishing the goal
  - 2. Forming the intention
  - 3. Specifying the action sequence
  - 4. Executing the interaction
  - 5. Perceiving the system state
  - 6. Interpreting the system state
  - 7. Evaluating the system state with respect to the goals and intentions

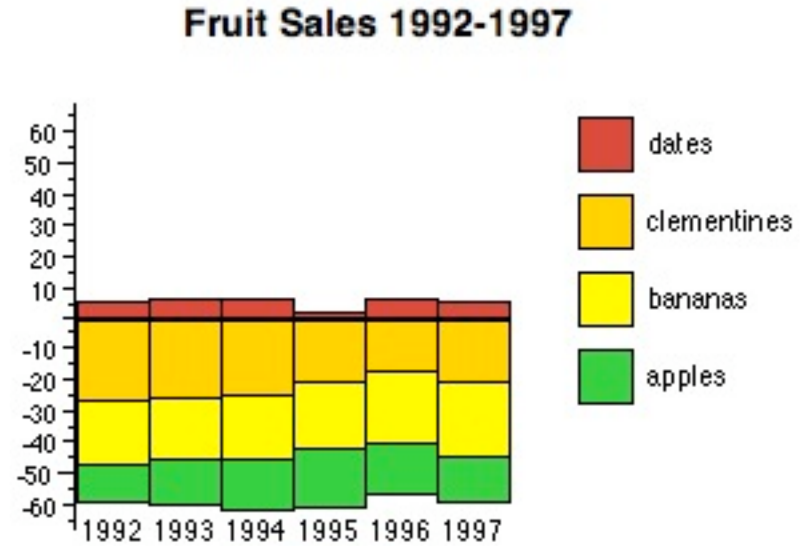
Simple Interaction Example

- Stacked histogram
  - how are the banana sales progressing???
  - http://www.hiraeth.com/alan/topics/vis/hist.html









Direct Manipulation (DM)

- Shneiderman 1982
- DM features
  - Visibility of all objects of interest
  - Incremental actions with rapid feedback on all actions
  - Reversibility of all actions, so that users are encouraged to explore without penalties
  - Syntactic correctness of all actions, so that every user action is a legal operation

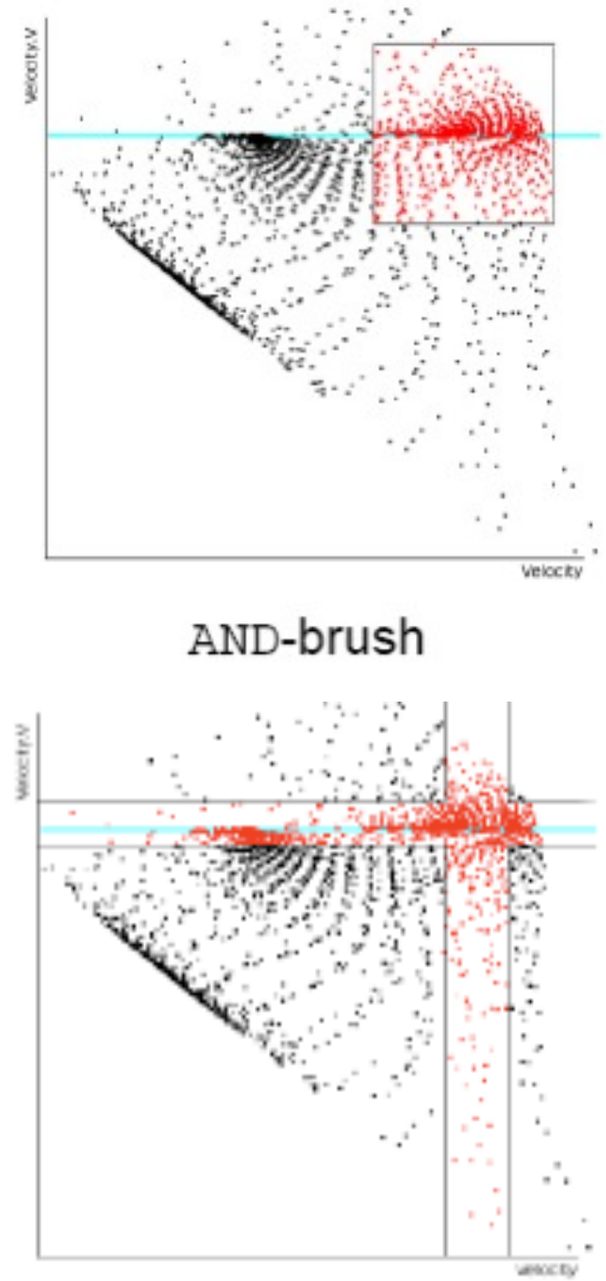
- DM does not only make interaction easier for novice users but fundamentally extends visualization capabilities

Common Interaction Techniques

- Details-on-demand
  - Provides improved scalability by displaying information about data case(s) on demand to the user
  - View may move from aggregation of objects to the elements contained
- Direct Walk
  - Linkage between cases
  - Exploring one case may lead to another (e.g. hyperlinks on news page)
- Manipulate View
  - Rearrange view (e.g. move view position, sorting items in a table)
  - Change representation (e.g. from histogram to scatterplot)
- Linking
  - Connection between multiple views of the same data space
  - Updating one view means updating all

Brushing

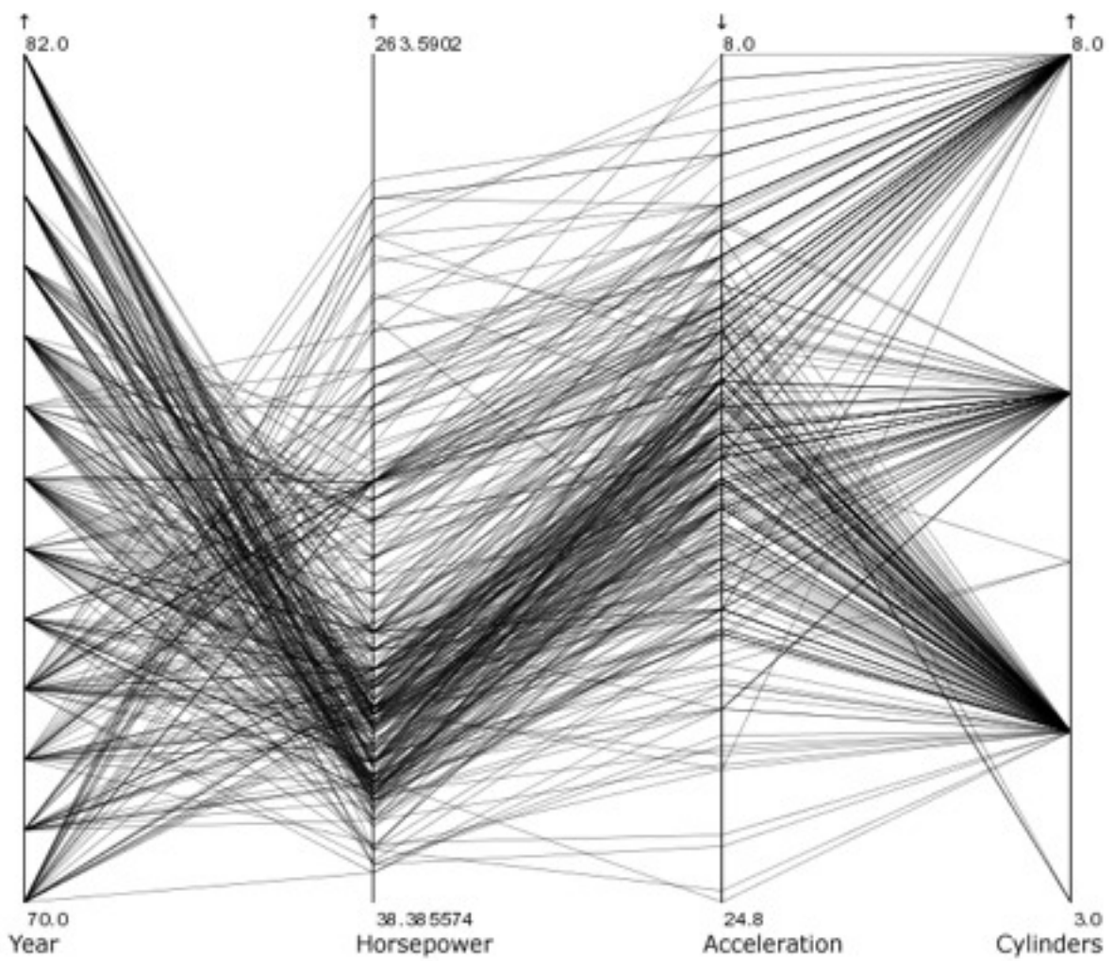
- Becker & Cleveland 1987
- A collection of dynamic methods for viewing multidimensional data
- Brush is an interactive interface tool to select / mark subsets of data in a single view, e.g. by sweeping a virtual brush across items of interest
- Given linked views (e.g. scatterplot matrix) the brushing can support the identification of correlations across multiple dimensions (brushing & linking)
- Usually used to visually filter data (via highlighting)
- Additional manipulation / operations may be performed on the subsets (masking, magnification, labeling etc.)
- Different types of brushes (Hauser et al. 2002))
  - Simple brush via sweeping
  - Composite brush: composed multiple single-axis brushes by the use of logical operators
  - Angular brush
  - Smooth brush

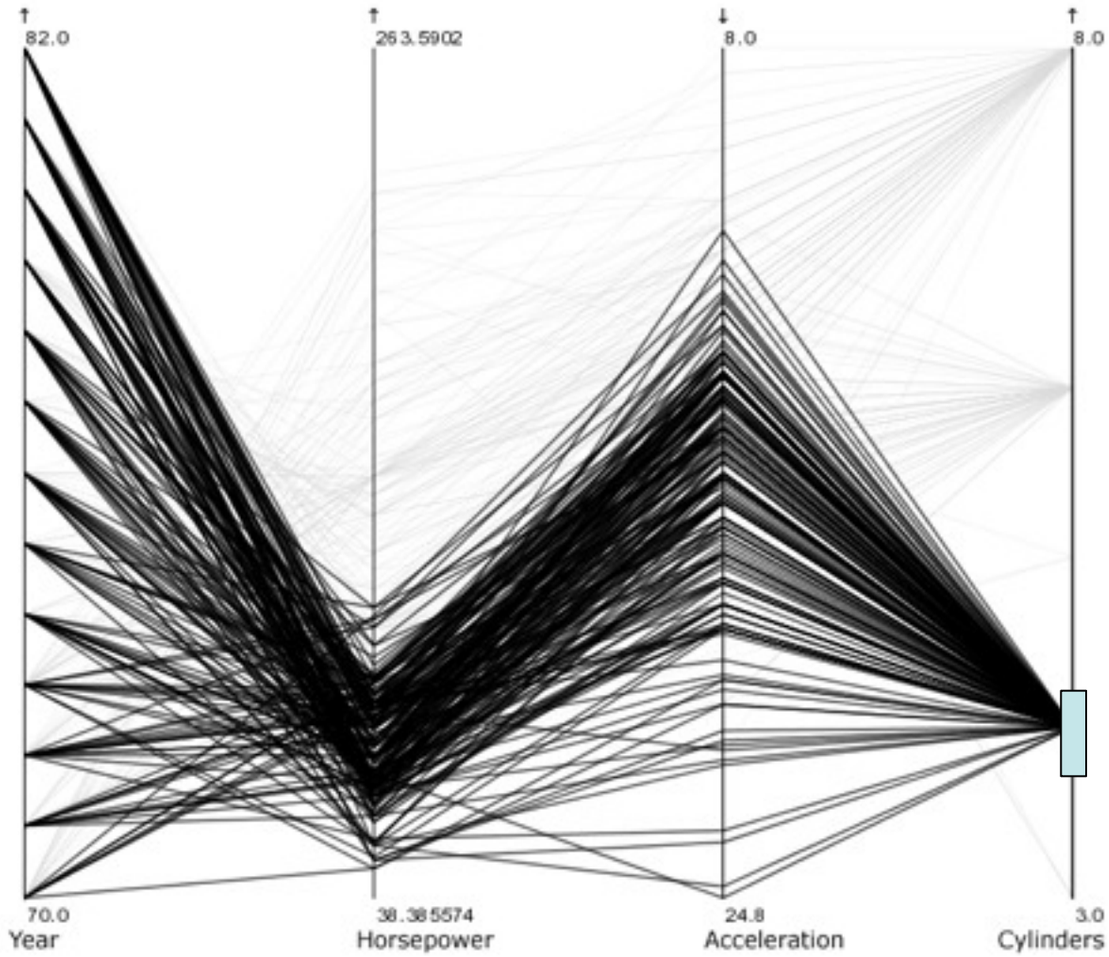


Composite scatterplot brushes - Hauser et al. 2002

Brushing Example

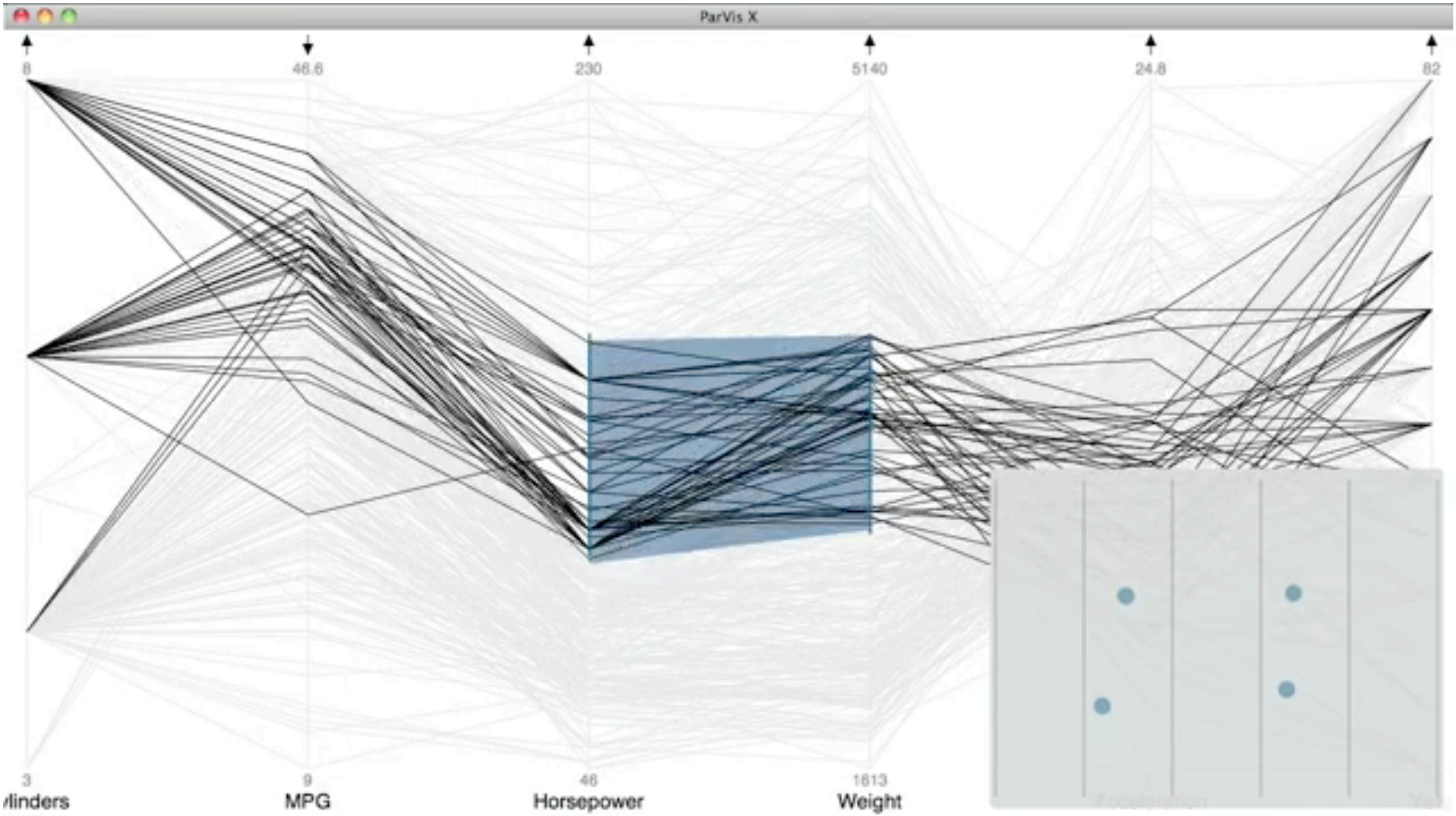
- Brushing one dimension in parallel coordinates to highlight car data objects with 4 cylinders





Hauser et al. 2002

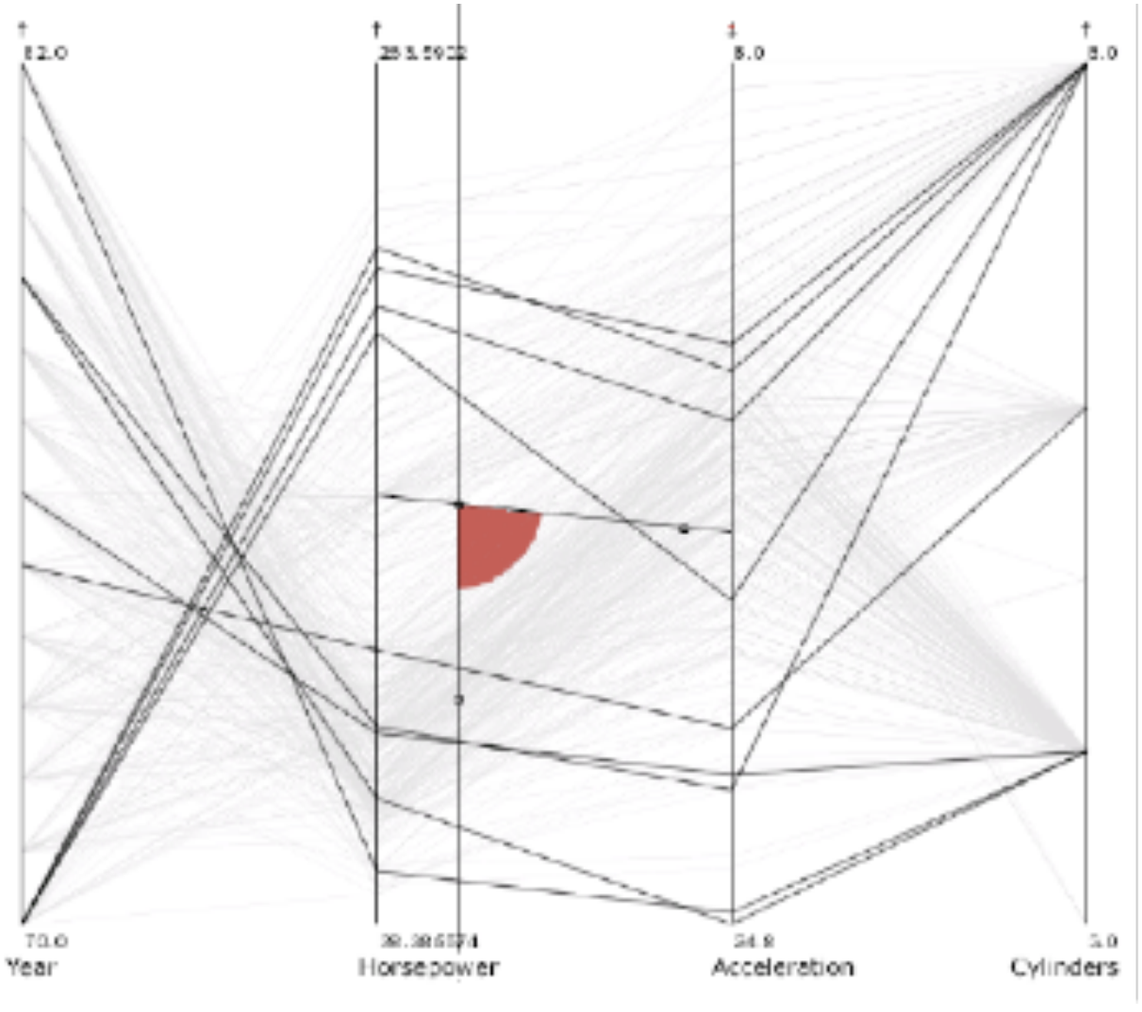
Brushing a parallel coordinate plot

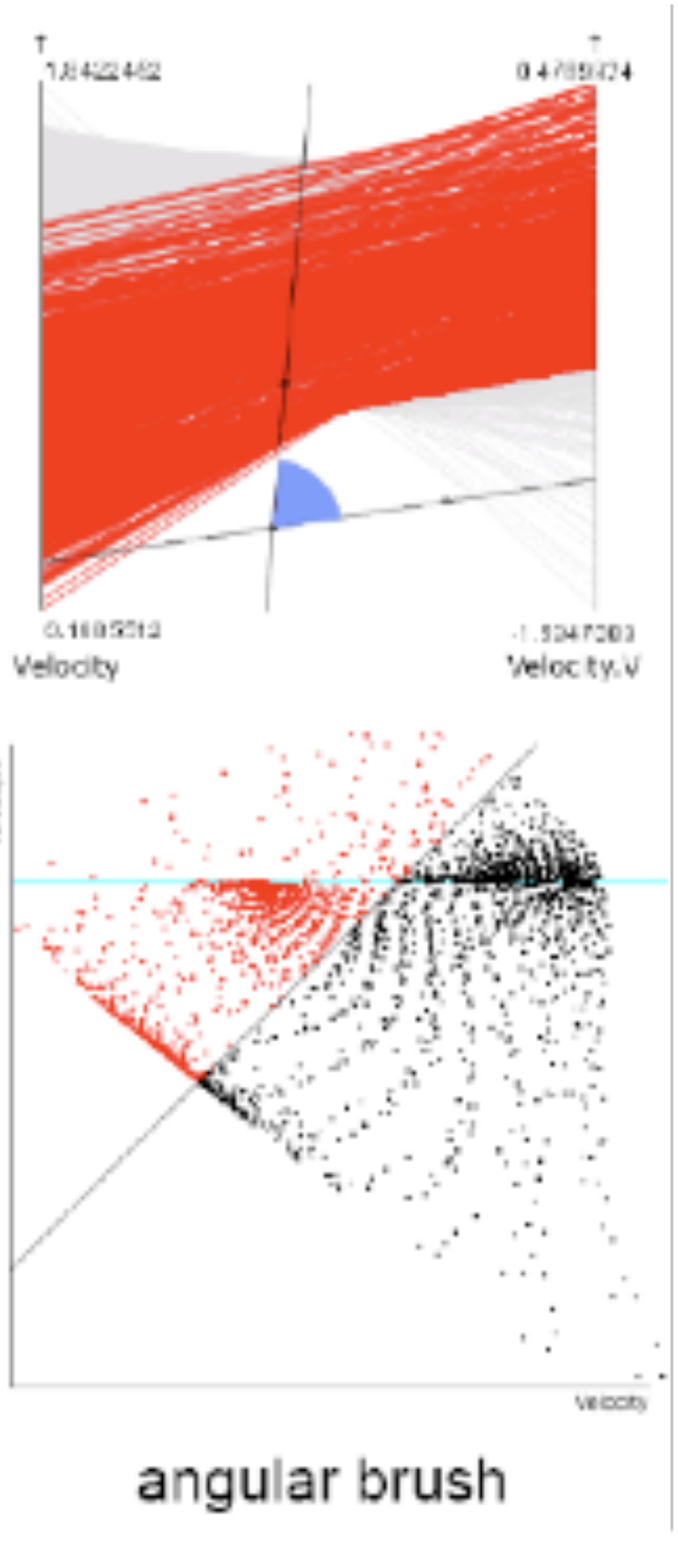


Robert Kosara, Poster: Indirect Multi-Touch Interaction for Brushing in Parallel Coordinates, IEEE Information Visualization Posters, 2010.

Angular Brush

- Angular brush: brushing by specifying a slope range – highlight correlation and outliers between two dimensions

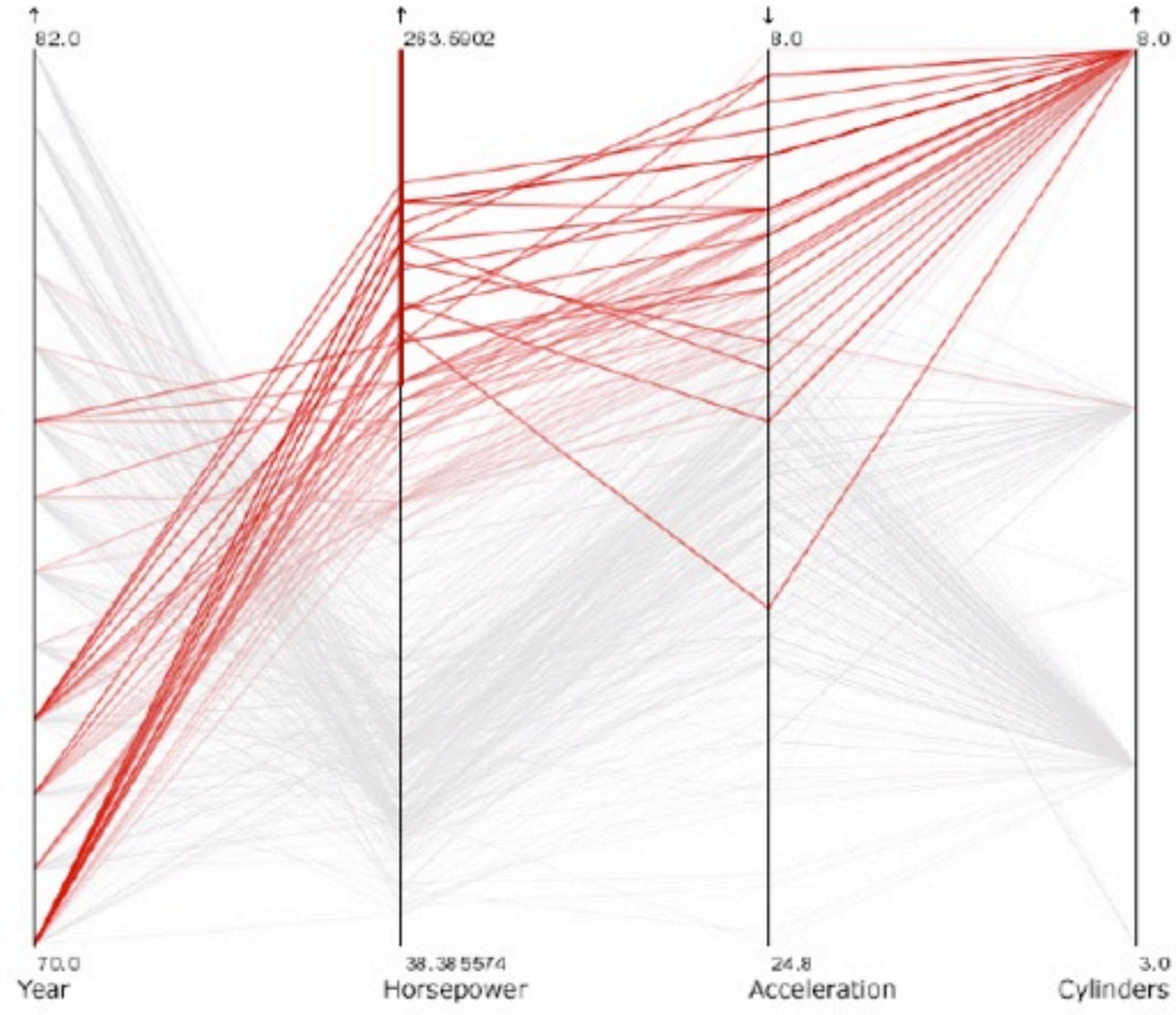




Hauser et al. 2002

Smooth Brush

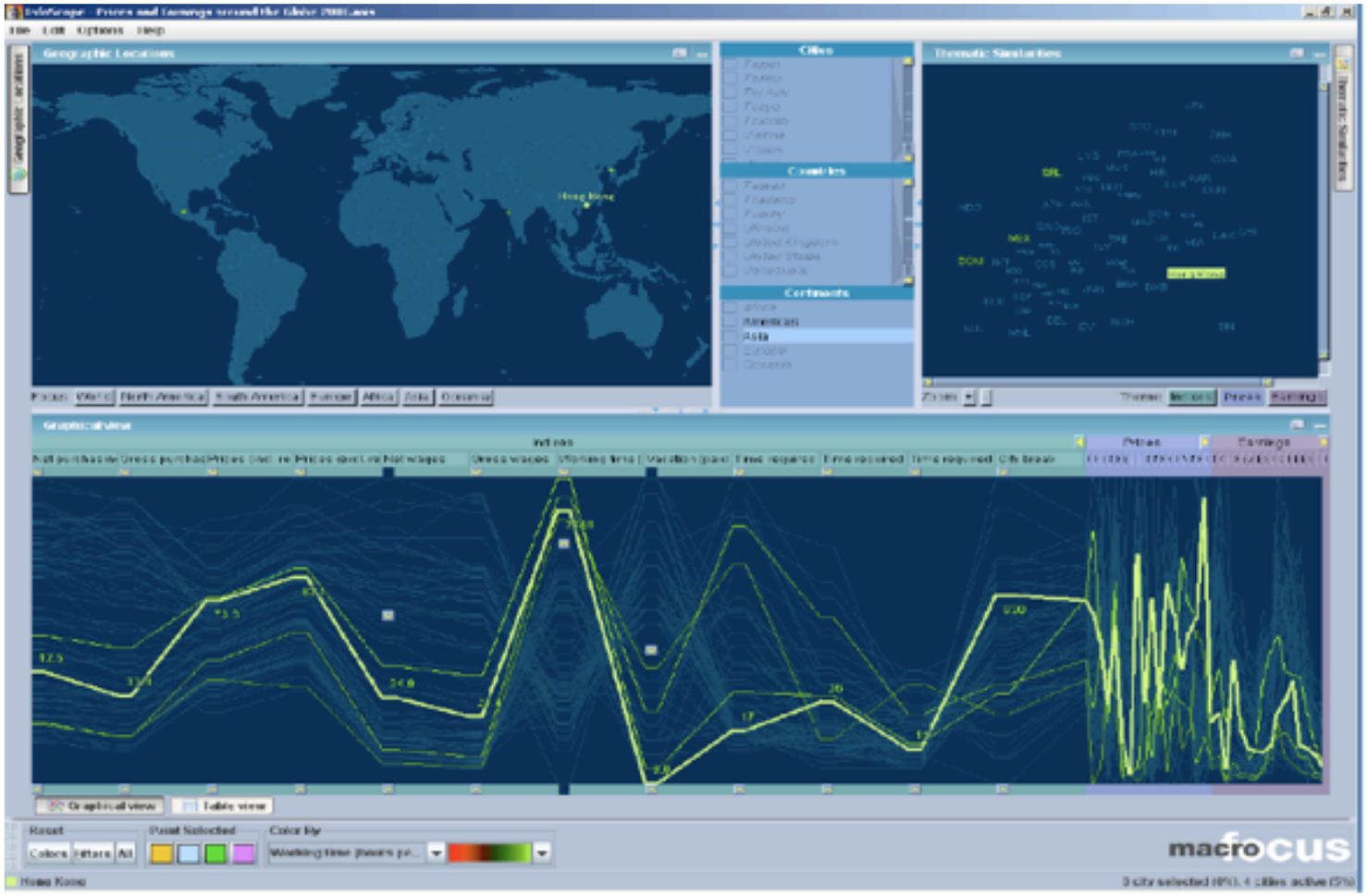
- Non-binary brushing
- Degree-of-interest defined by distance to brushed range
- Decreasing degree is mapped to decreasing drawing intensity



Hauser et al. 2002

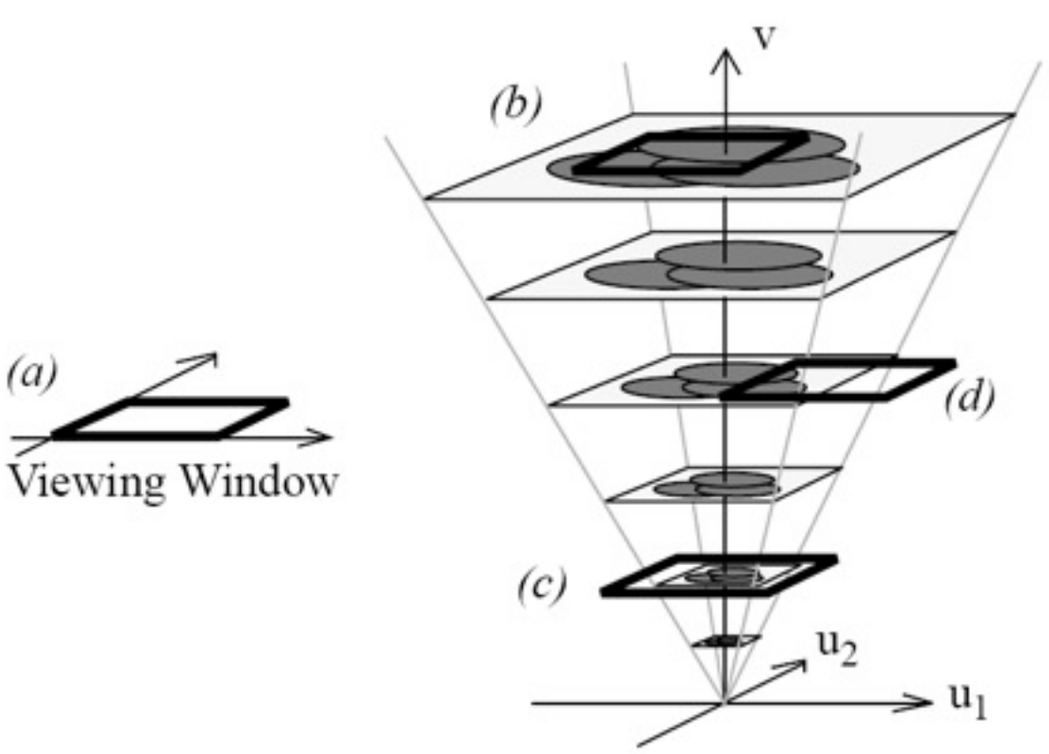
Another Brushing Example

- Example for composite (AND) brush in Parallel Coordinate Plot – find the cities with high wages, small prices and many paid holiday days
- Demo InfoScope: http://www.macrofocus.com/public/products/infoscope.html (free trial and applet)



Zooming & Panning

- Moving from overview to detail: another way to filter data / focus on a subset of data
- Scale and translation of the viewport
- Geometrical versus semantic zooming
- Topic of a lecture to come (lecture 10: presentation I)



Furnas & Bederson 1995

Dynamic Queries

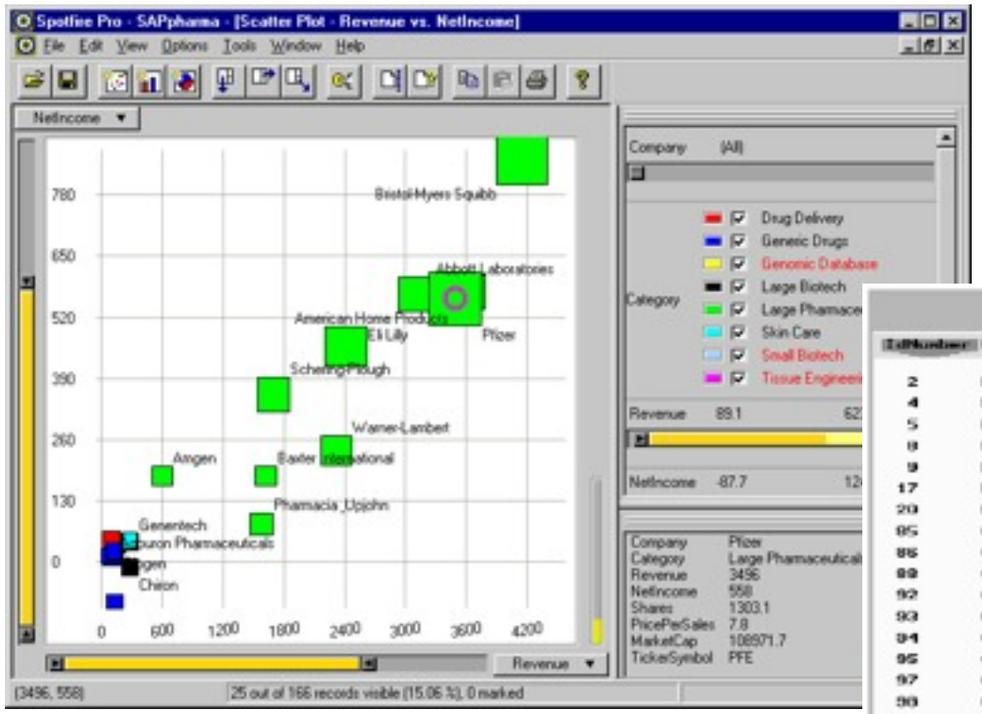
- Shneiderman 1994
- Explore and search databases
- SQL example: SELECT customer_id, customer_name, COUNT(order_id) as total FROM customers INNER JOIN orders ON customers.customer_id = orders.customer_id GROUP BY customer_id, customer_name HAVING COUNT(order_id) > 5 ORDER BY COUNT(order_id) DESC
- Problems
  - Takes time to learn
  - Takes time to formulate and reformulate
  - User must know what she is looking for – only exact matches
  - Lots of ways to fail
  - SQL error messages helpful?
  - Zero hits – what component is to be changed?

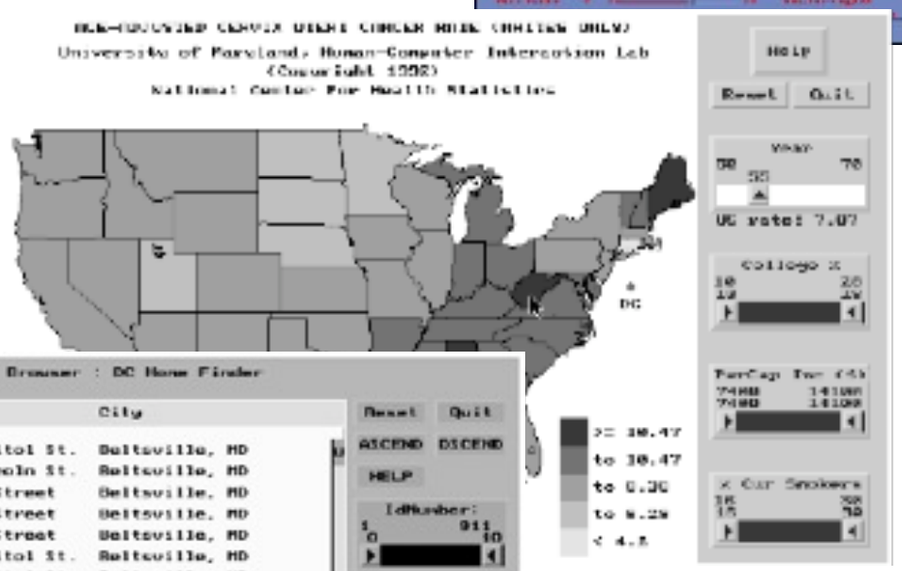
Dynamic Queries

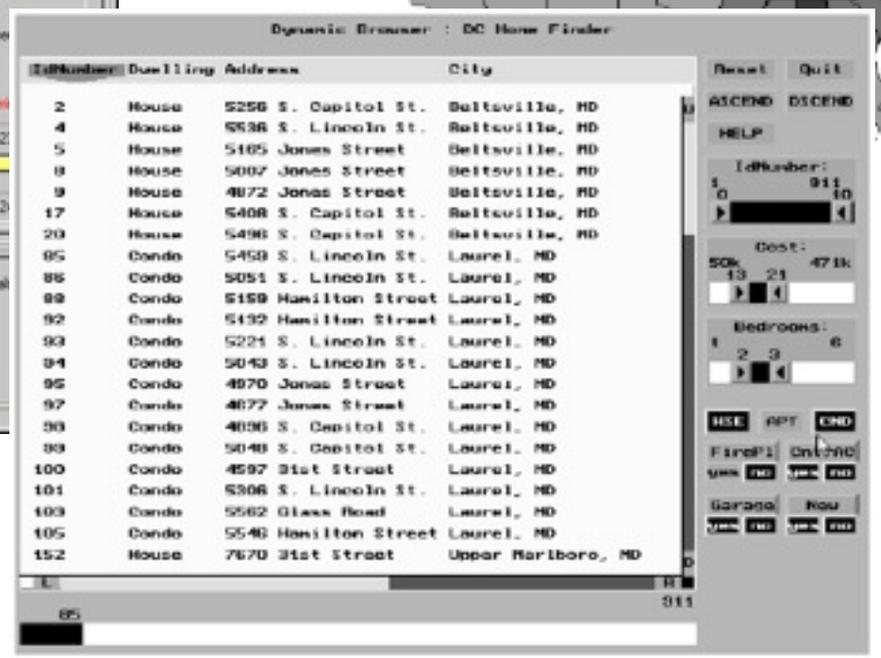
- Based on Direct Manipulation (DM)
- DM principles with regard to Dynamic Queries
  - Visual presentation of the query's components
  - Visual presentation of results
  - Rapid, incremental, and reversible control of the query
  - Selection by pointing, not typing
  - Immediate, continuous feedback
- Implementation approach
  - Graphical query formulation: Users formulate queries by adjusting sliders, pressing buttons, bounding box selection…
  - Search results displayed are continuously updated (< 100 ms)

Examples

- Visual representations of data to query?
- Some examples: geographic data, starfields, tables etc.



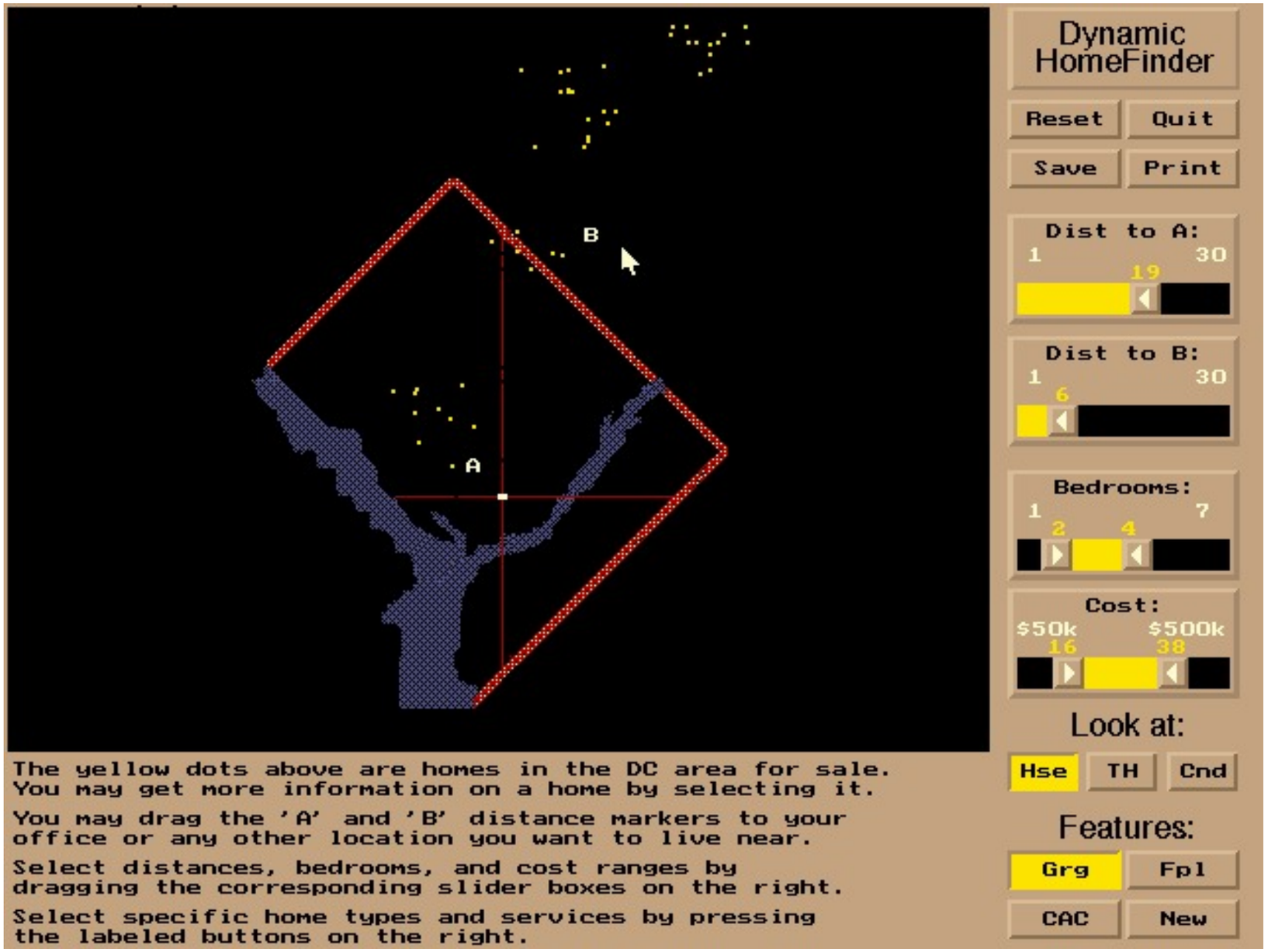




Shneiderman 1994

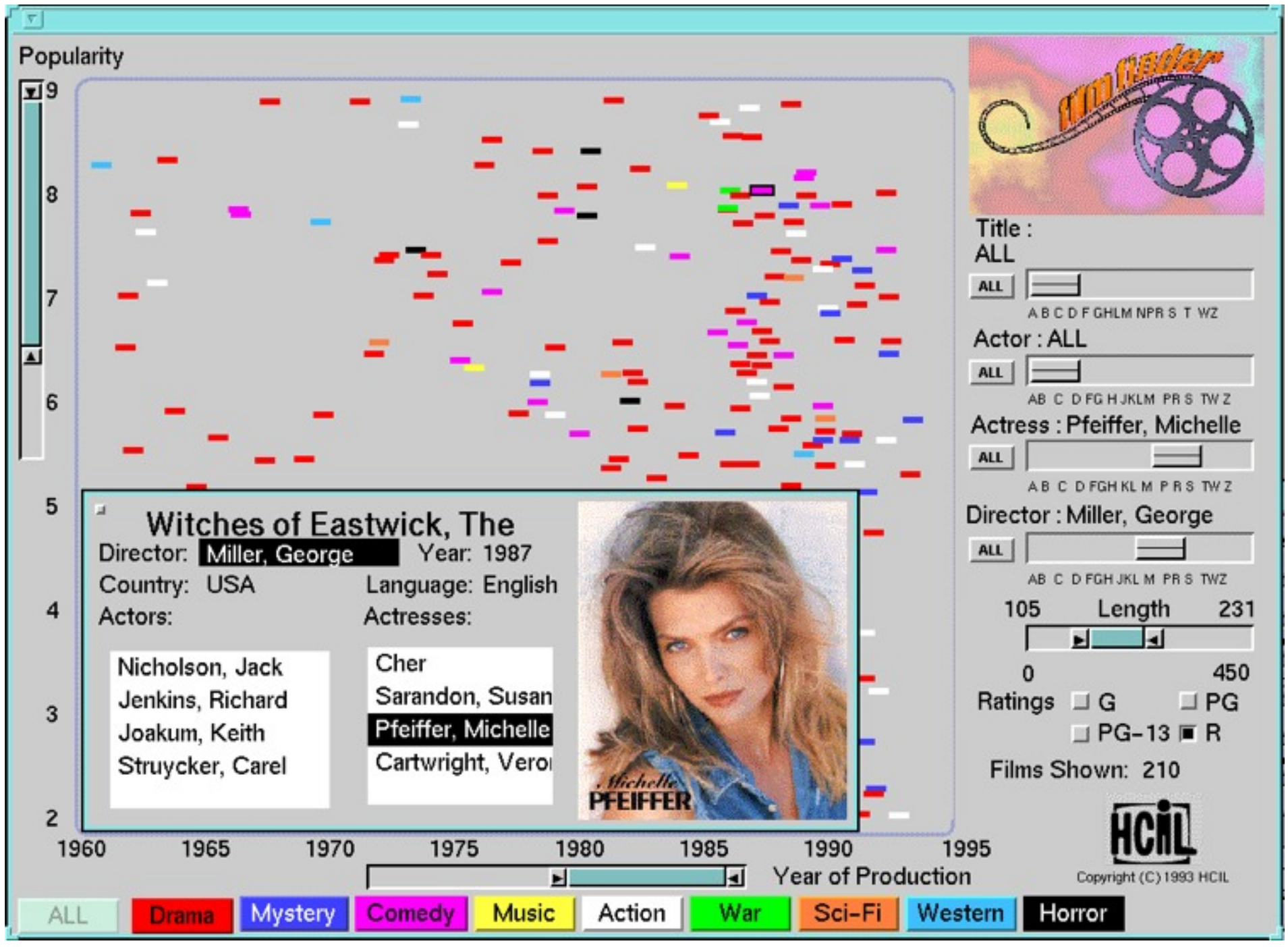
HomeFinder

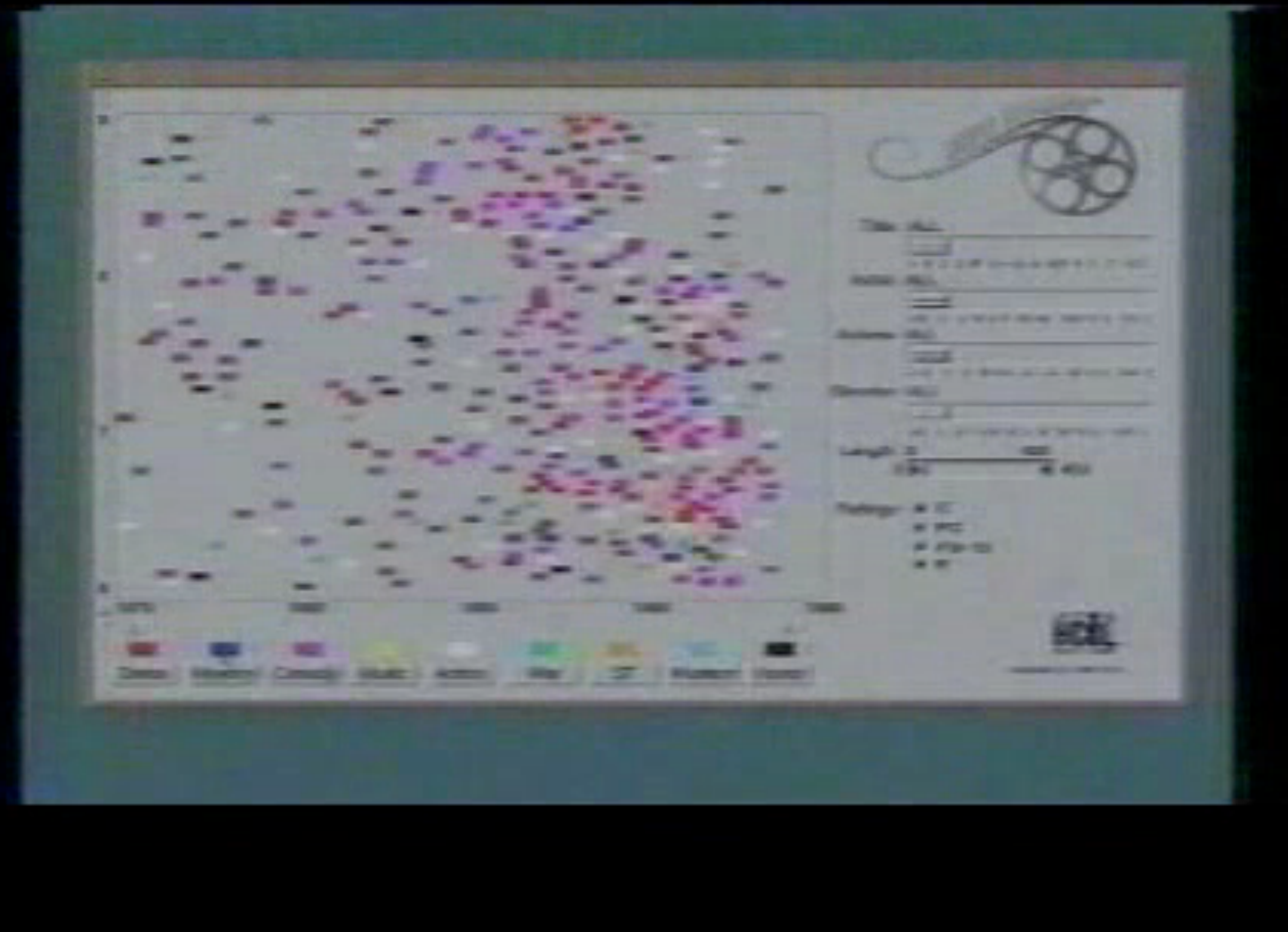
- One of the first DQ interfaces
- Williamson & Shneiderman 1983(!)



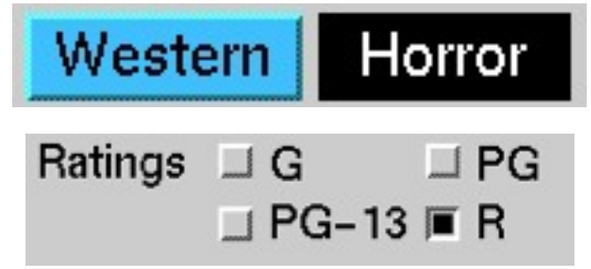
FilmFinder

- Ahlberg & Shneiderman 1994

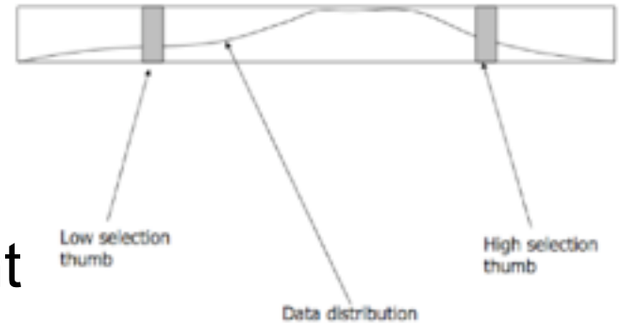


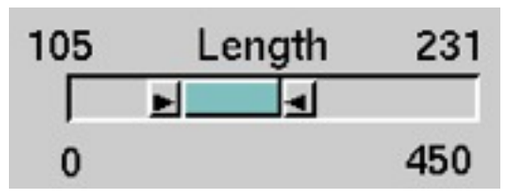


Dynamic Query Controls

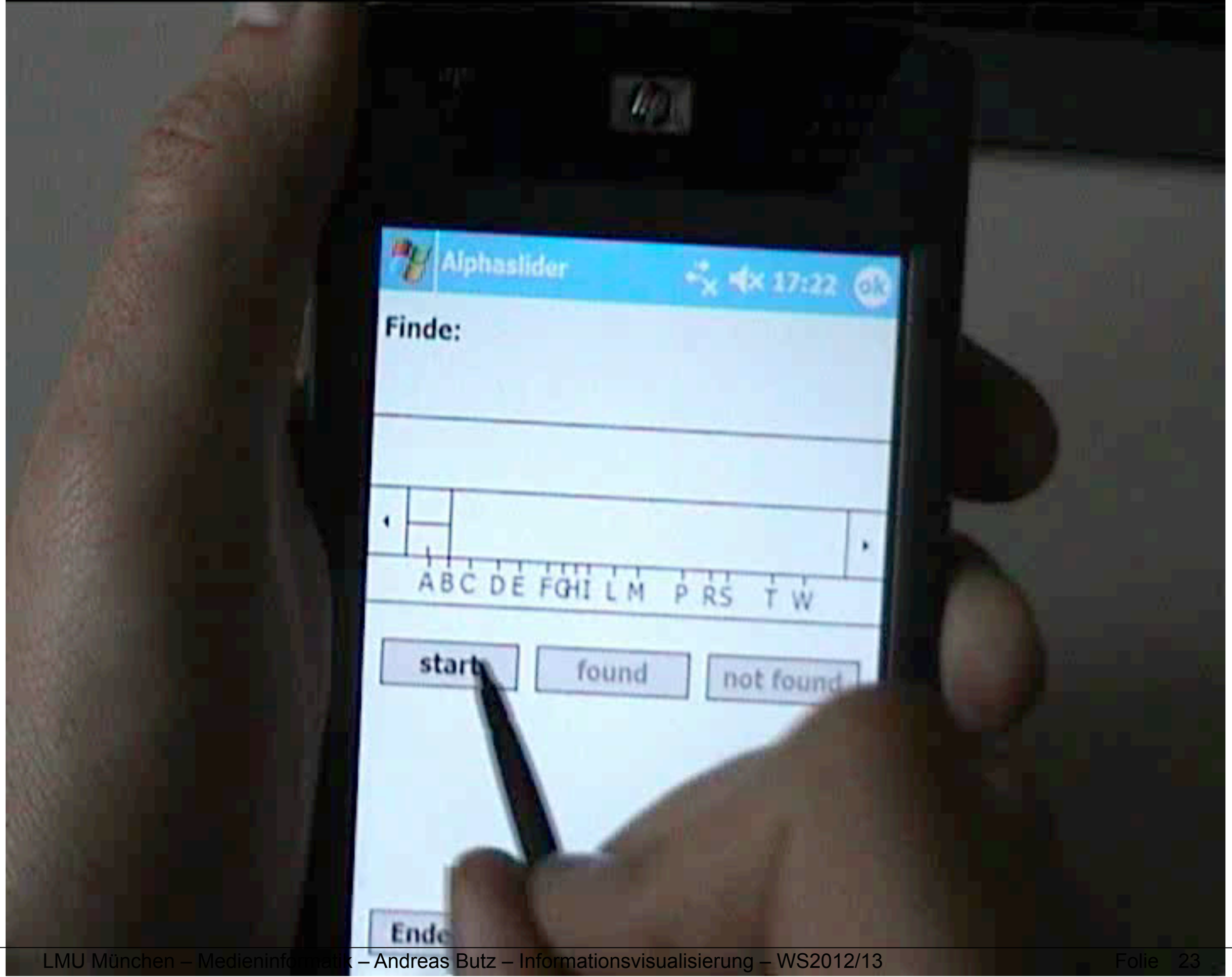


- Check boxes and buttons (Nominal with low cardinality)
- Sliders and range slider (ordinal and quantitative data)
- Alphaslider (ordinal data) (Ahlberg & Shneiderman 1994)
  - Small-sized widget to search sorted lists
  - Online-text output
  - Two-tiled slider thumb for dragging operations with different granularities
  - Letter index visualizing the distribution of initial letters – jump to a position in the slider
  - Locating an item out of 10,000 items ~ 28s for novice users
  - Pros and cons to text entry?



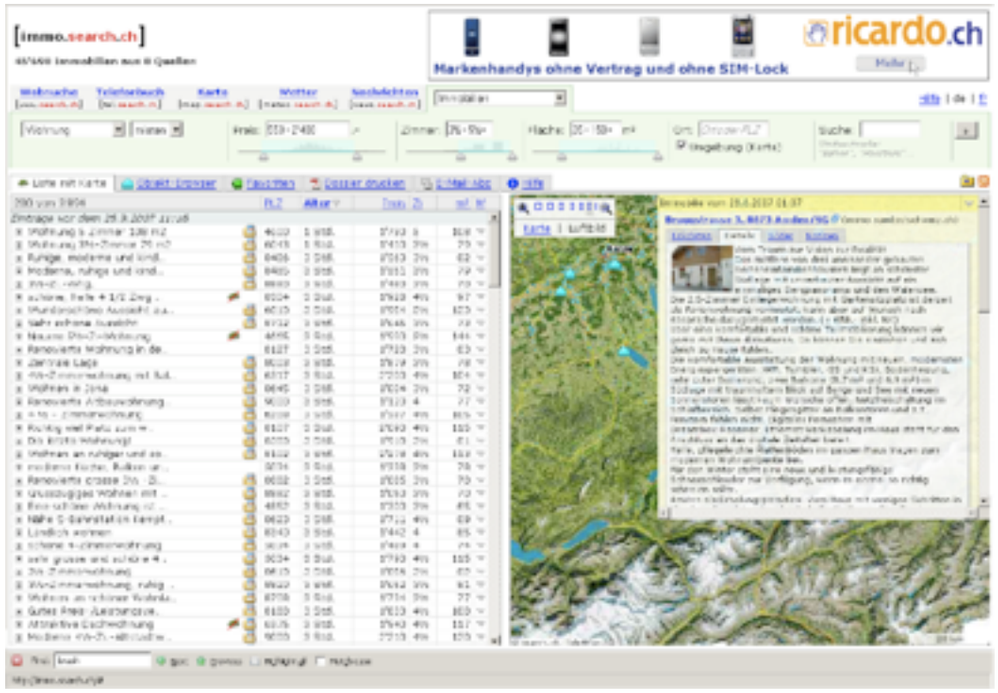


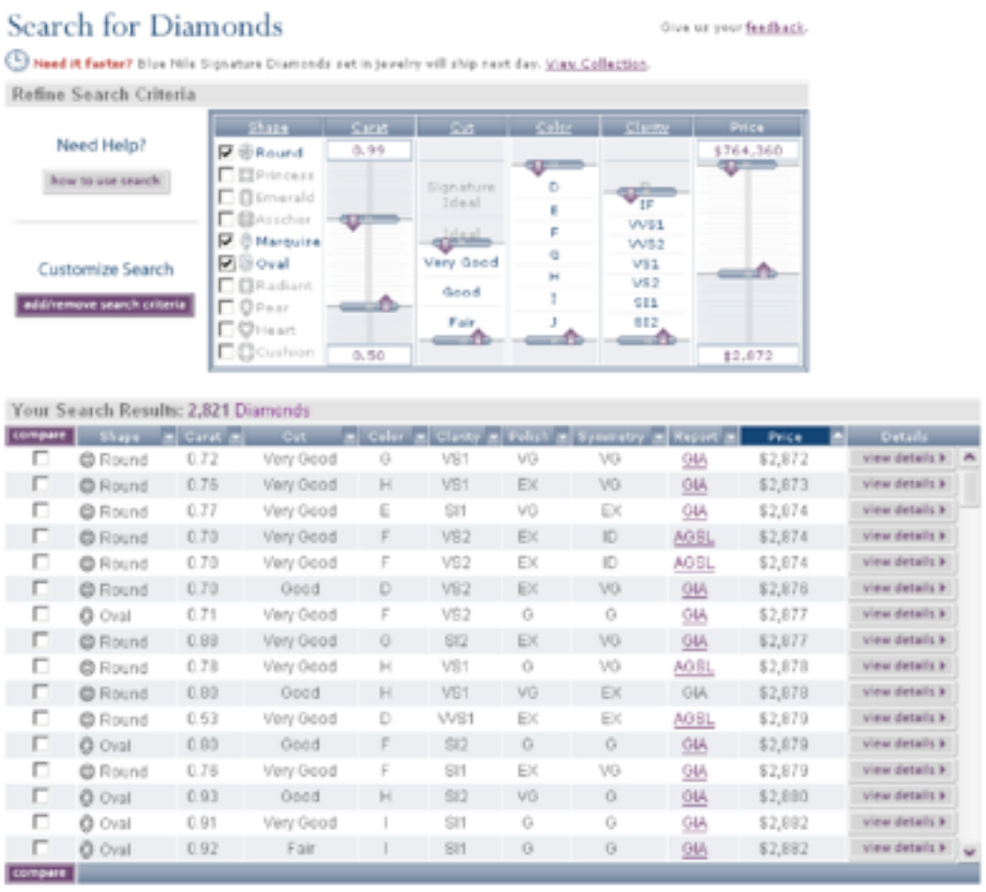
- Redesigned Alphaslider for PDAs / MP3 player - movie
- Extend data sliders with data visualization (Eick 1994)


Alphaslider
17:22
ok
Finde:
A B C D E F G H I L M P R S T W
start
found
not found

Dynamic Queries Online

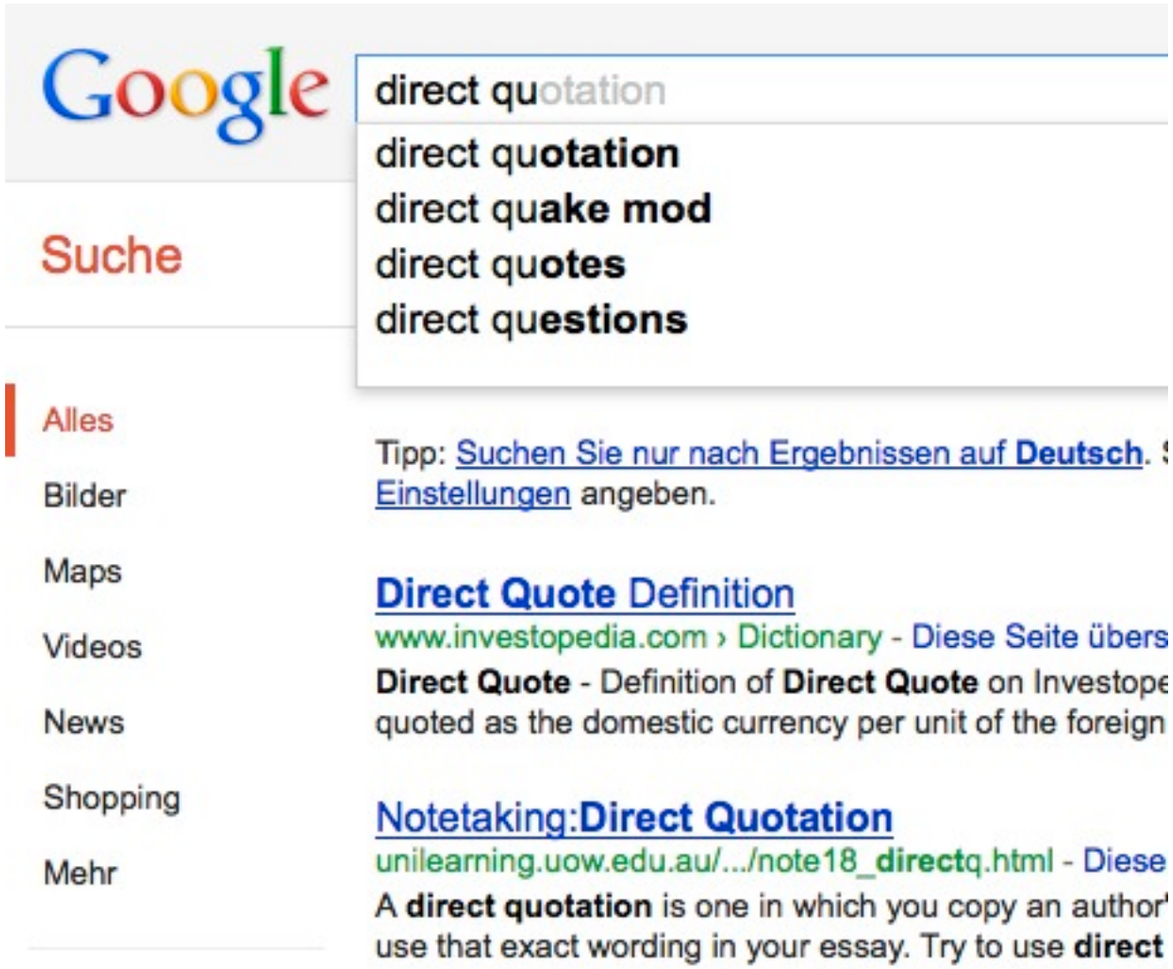
- Online examples: http://immo.search.ch and diamond search (http://www.bluenile.com)

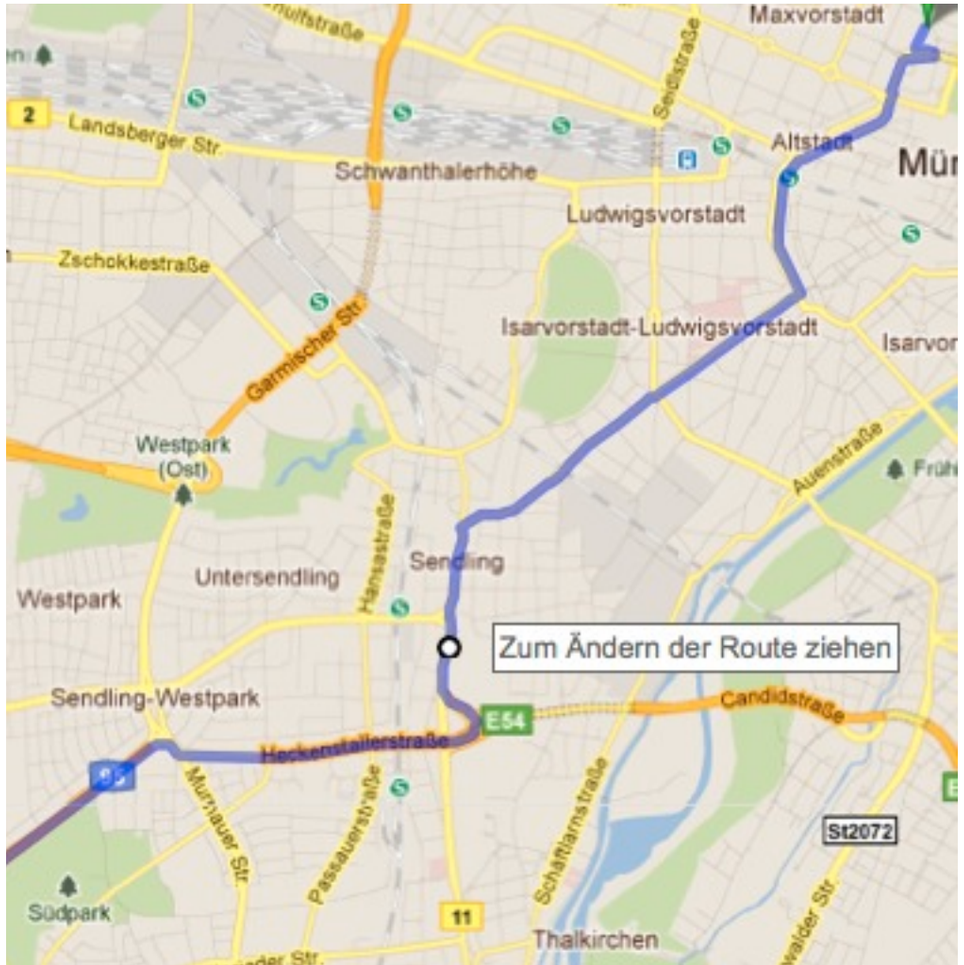




DQ in current search interfaces

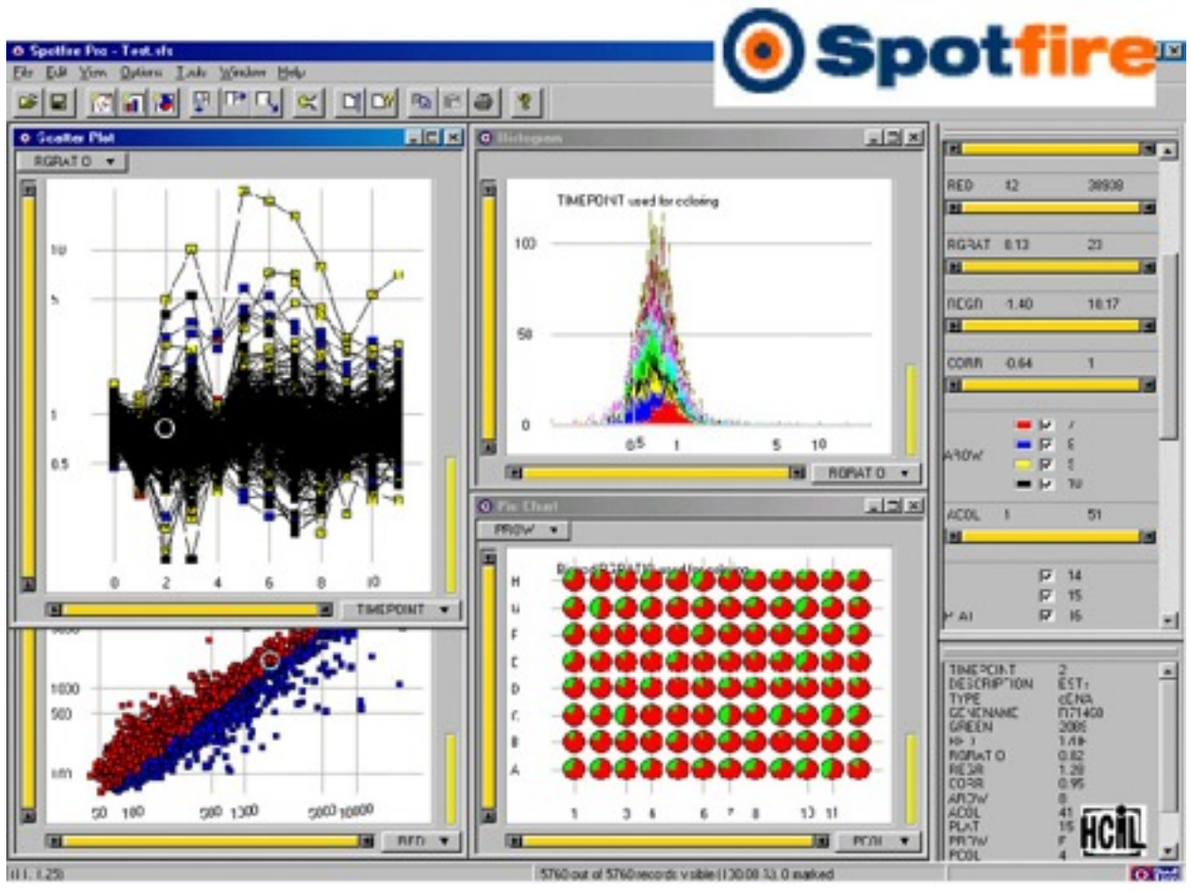
- DQ have become widespread with fast search algorithms and increased computing capacity
  - search happens while typing in search terms in google search
  - new routes are calculated while point is dragged in google maps





Making Money with Dynamic Queries

- Starfield displays and Dynamic Queries provided the basis for SpotFire
- Christopher Ahlberg
  - 1991: Visiting student from Sweden at the HCIL University of Maryland
  - 1996: Founder of SpotFire
  - 2007: SpotFire was sold for 195 Mio. $
- Well done!



Summary Dynamic Queries

- Users can rapidly, safely playfully explore a data space – no false input possible
  - Users can rapidly generate new queries based on incidental learning
  - Visual representation of data supports data exploration
  - Analysis by continuously developing and testing hypotheses (detect clusters, outliers, trends in multivariate data)
  - Provides straightforward undo and reversing of actions

Potential problems with DQ as implemented in the FilmFinder?
Limit of query complexity – filters are always conjunctive
Performance is limited for very large data sets and client / server applications
Controls require valuable display space
Information is pruned
Only single range queries and single selection in the alphaslider

Case Study: The Attribute Explorer

- Tweedie et al. 1994
- Example for DQ, brushing & linking and fuzzy search
- Linked histograms to search and explore multivariate data
- Filtering data via range sliders
- Color-coding to highlight and discriminate data cases across views
- Sensitivity information: visualizes how well data cases meet the filter requirements
- Particularly useful for zero-hits situations

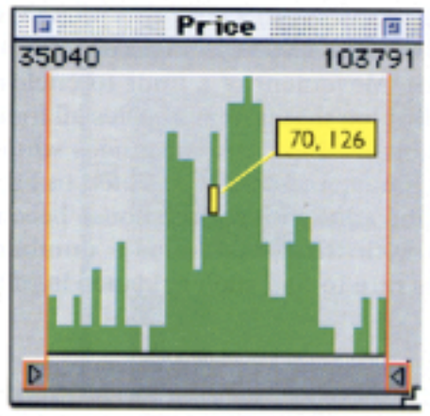


FIGURE 3.55 A histogram representing the prices of a collection of houses. The contribution of one house is shown in yellow

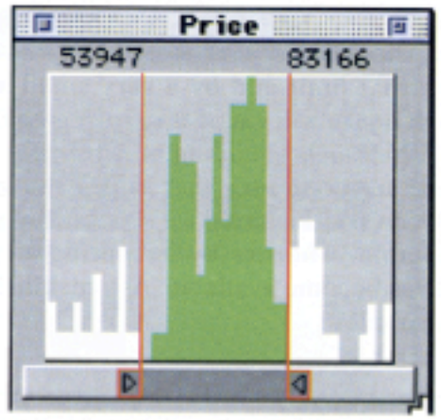
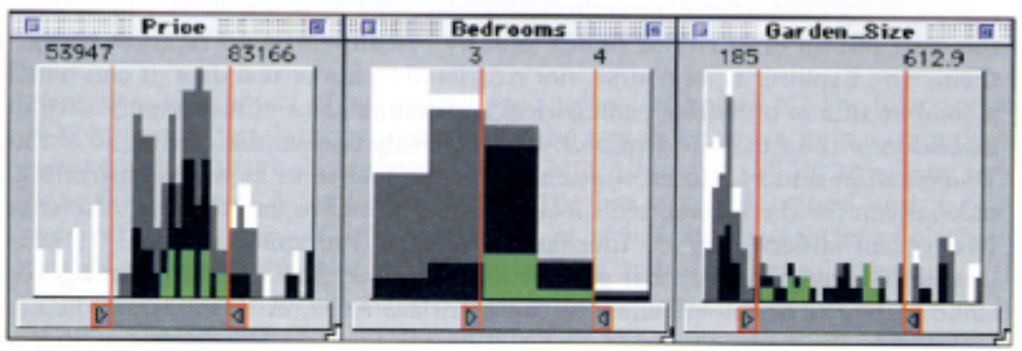


FIGURE 3.56 Limits on *Price* identify a subset of houses, coded green



Spence 2004

- The Attribute Explorer

Dynamic Queries and Movable Filters

- Fishkin and Stone 1995
- Dynamic Queries (DQ)
  - Disjunctive queries can only be performed by sequential querying
  - Effect of DQ is global – no way to limit filtering to only a portion of the data
  - Number of possible queries is fixed in advance
- Combine approach with magic lens filters
  - Arbitrarily-shaped region with an operator that manipulates the view of underlying objects
  - Filters are spatially bounded – global context is maintained
  - Filters that overlap compose their effects in the overlap region

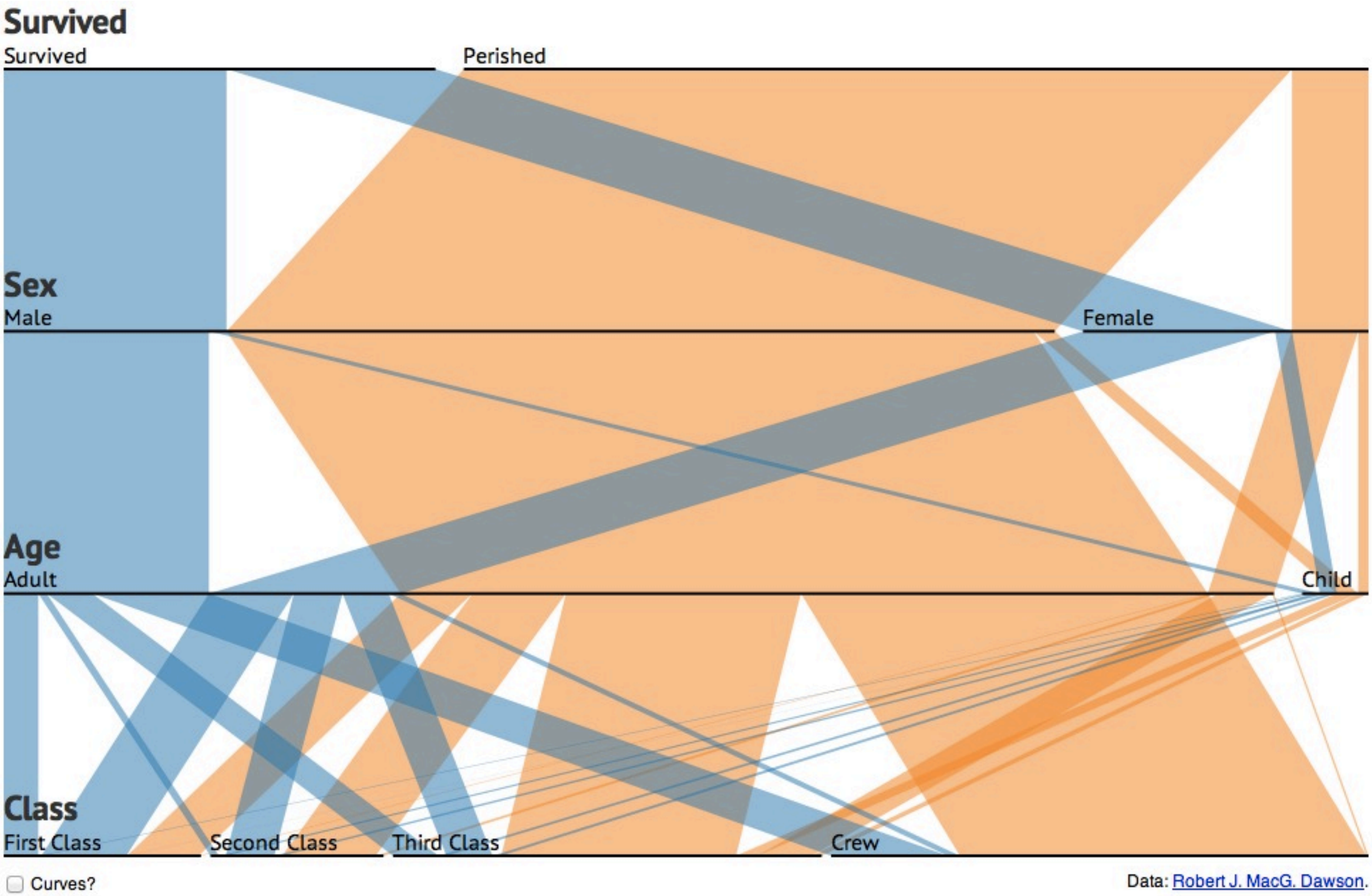
Stone et al. 1994

Magnify Circle

Idea & Implementation

- Each lens acts as a filter that screens on some attribute of the data
- Lens components
  - Filtering function (what to filter)
  - Composition mode (how to combine the filter result with lenses underneath, i.e. AND, OR, NOT)
- Composition modes are implemented as buttons on the lens
- Grouping: Replace a stack of lenses by a single compound lens, which also has a composition mode
- Compound lenses may contain other compound lenses
- Boolean queries and grouping allow queries of arbitrary complexity
- Multiple concurrent queries on different portions of the data space

Parallel sets: recent de.js implementation



Additional Sources

- Alan Dix et al.: Human Computer Interaction., 3. Auflage, 2003.
- Lecture material CS 7450 John Stasko, 2006