

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

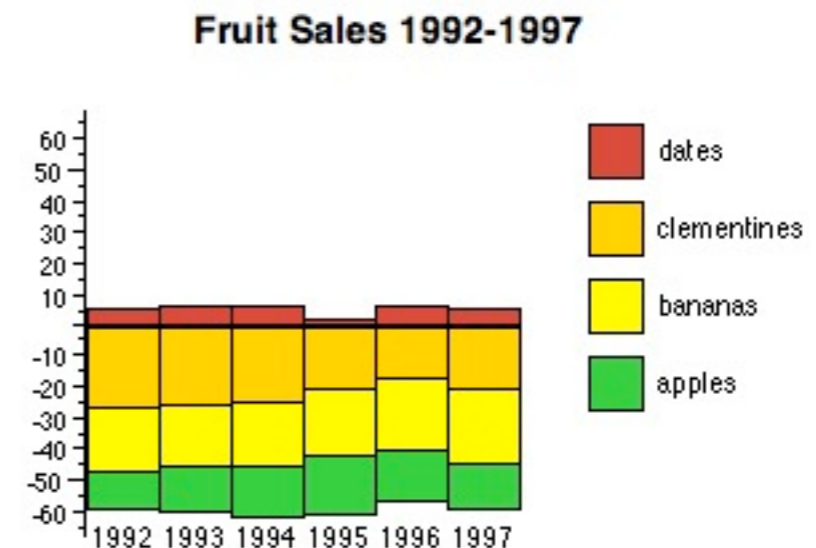
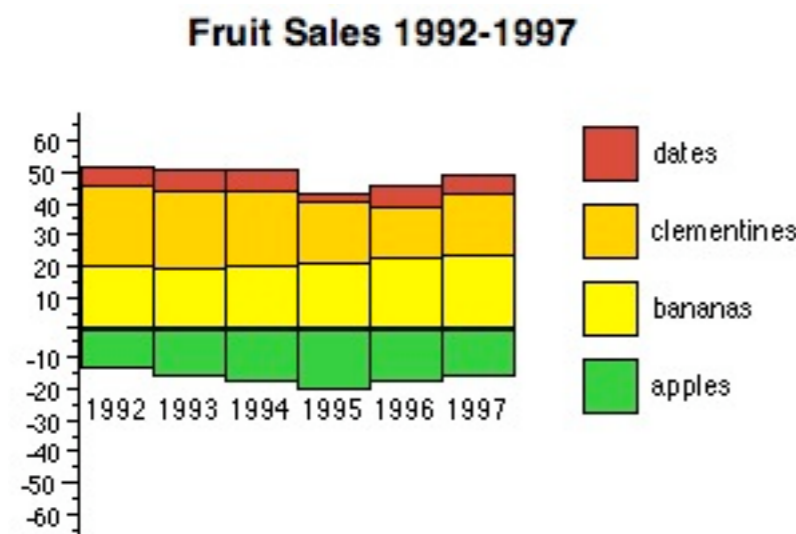
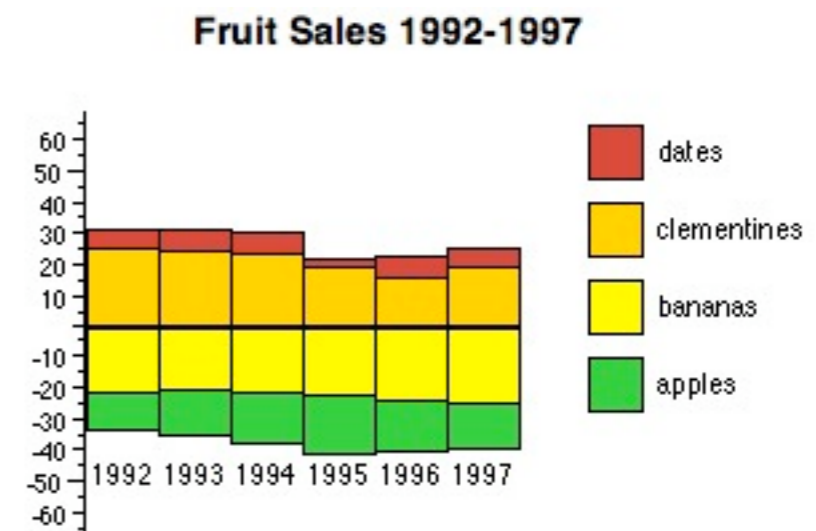
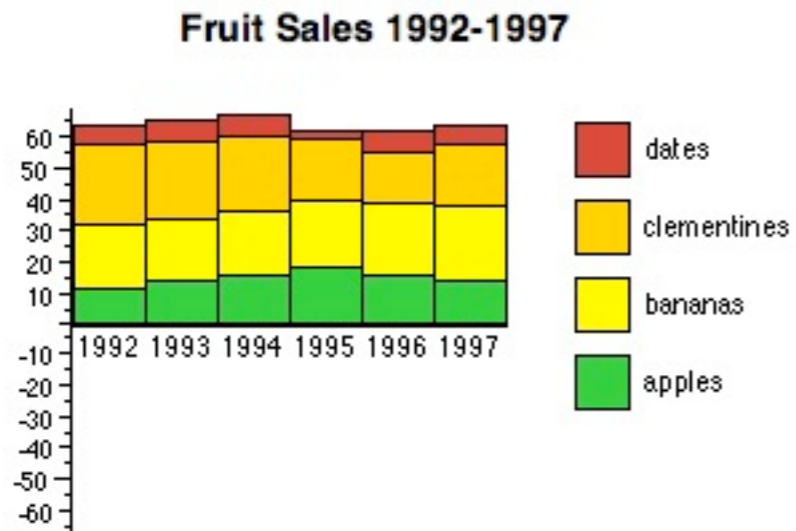
InfoVis & Interaction

- 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 InfoVis 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)

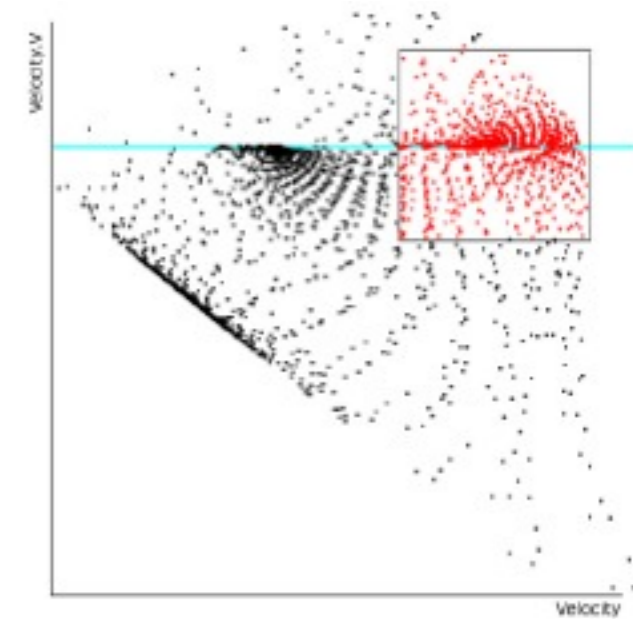
- Shneiderman 1982
- DM features
 - Visibility of all objects of interest
 - Incremental actions with rapid feedback on all actions
 - Reversibility of all actions, so that users are encouraged to explore without penalties
 - Syntactic correctness of all actions, so that every user action is a legal operation
- DM does not only make interaction easier for novice users but fundamentally extends visualization capabilities

Common Interaction Techniques

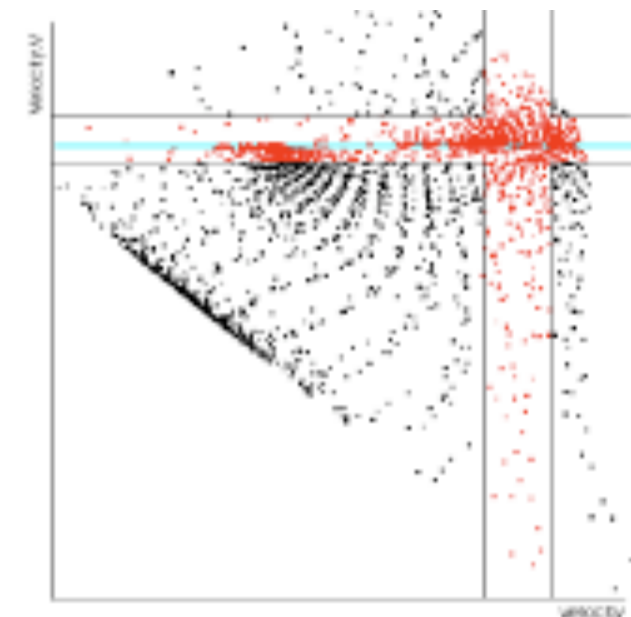
- Details-on-demand
 - Provides improved scalability by displaying information about data case(s) on demand to the user
 - View may move from aggregation of objects to the elements contained
- Direct Walk
 - Linkage between cases
 - Exploring one case may lead to another (e.g. hyperlinks on news page)
- 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



AND-brush

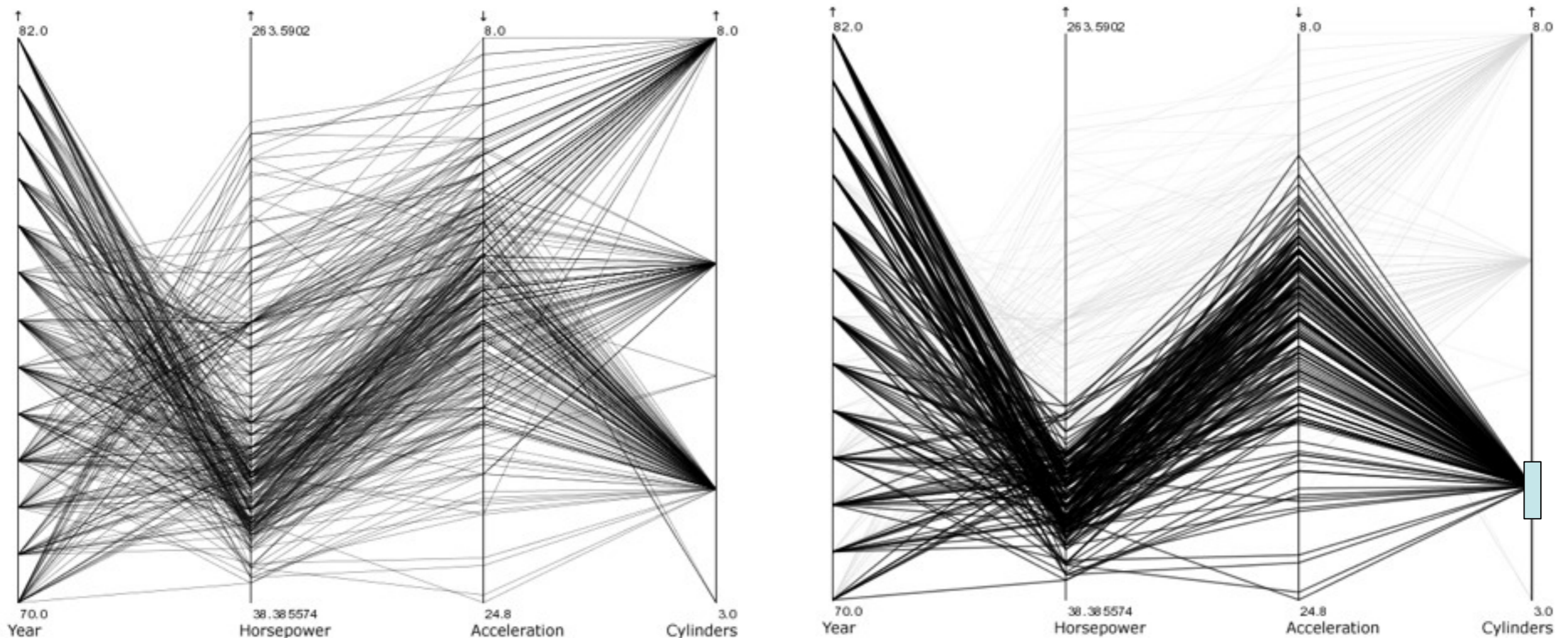


OR-brush

Composite scatterplot brushes - Hauser et al. 2002

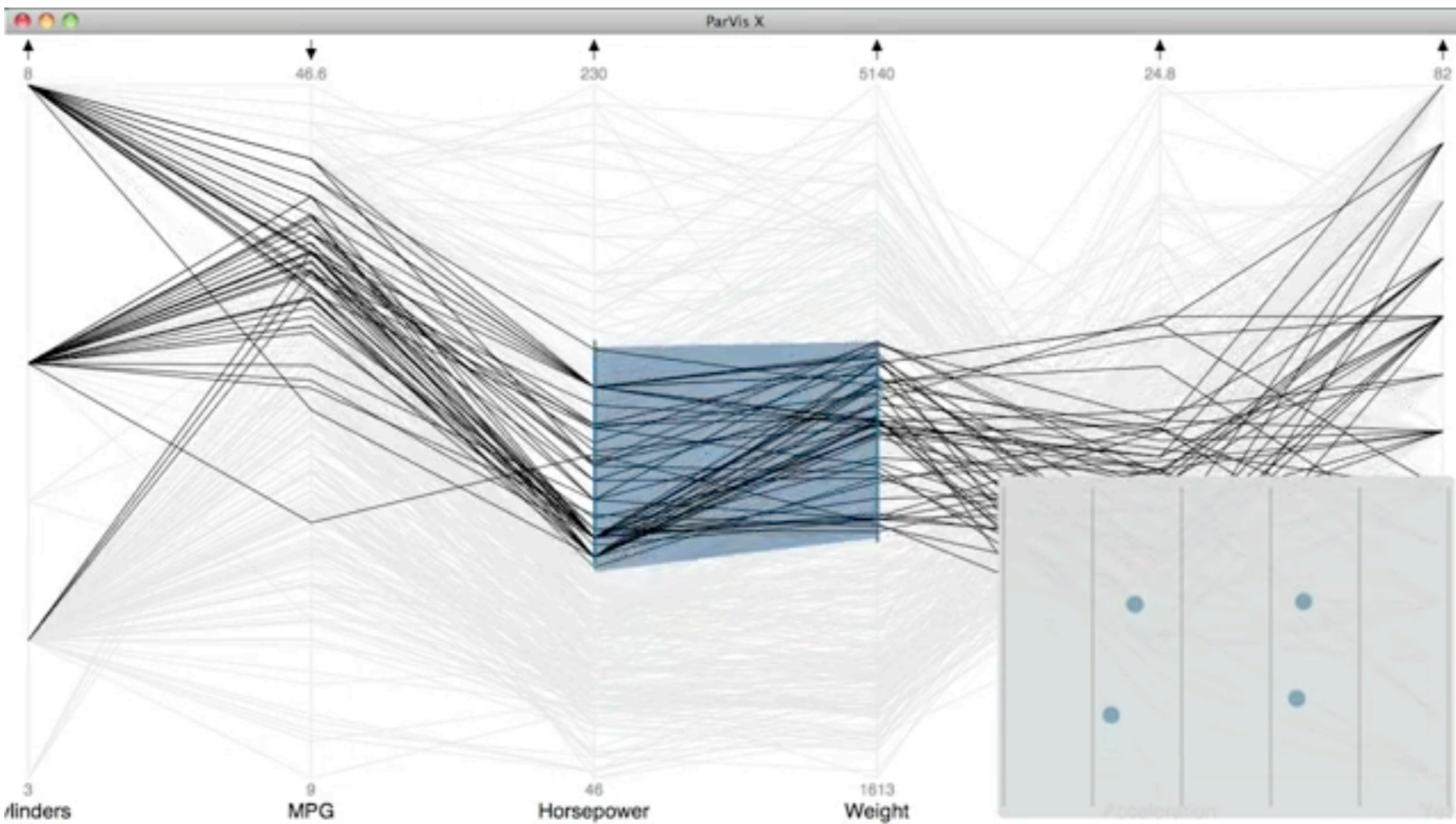
Brushing Example

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



Hauser et al. 2002

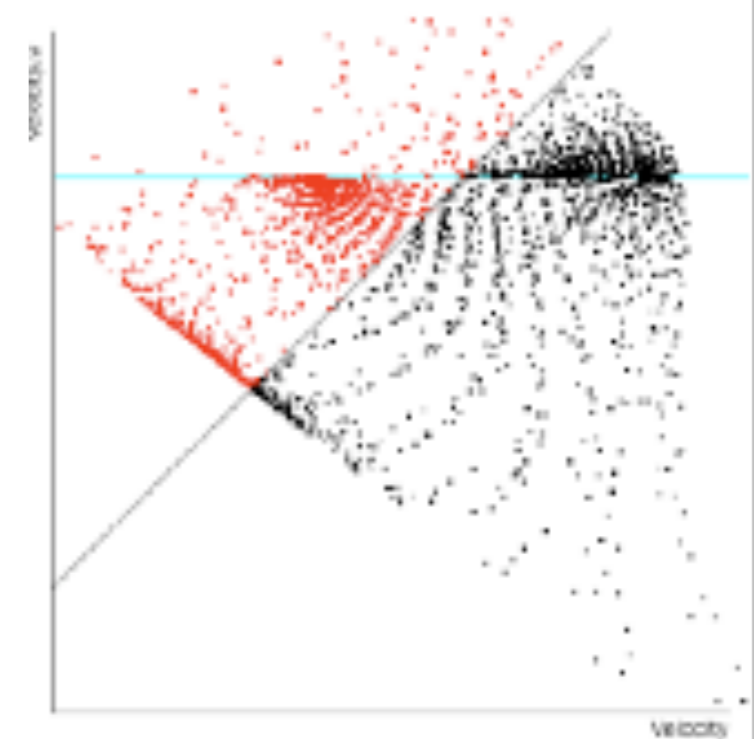
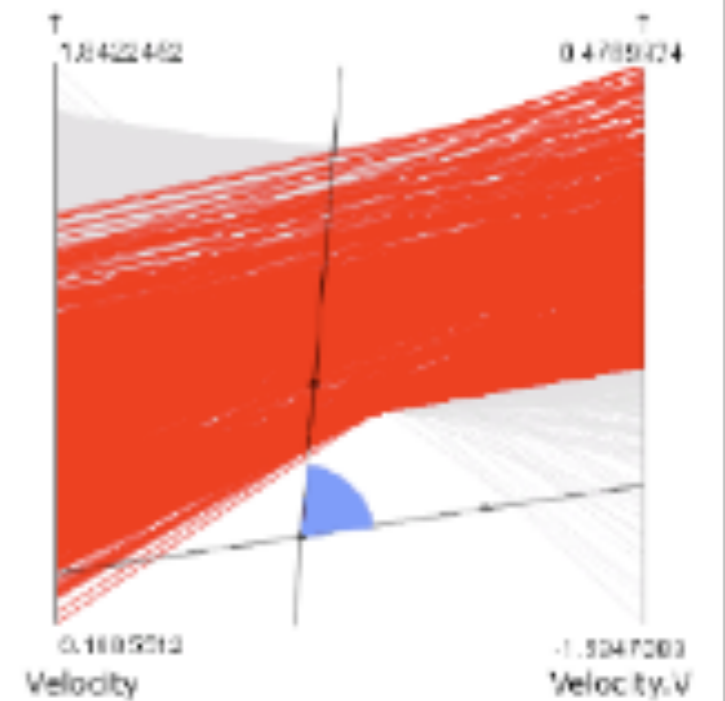
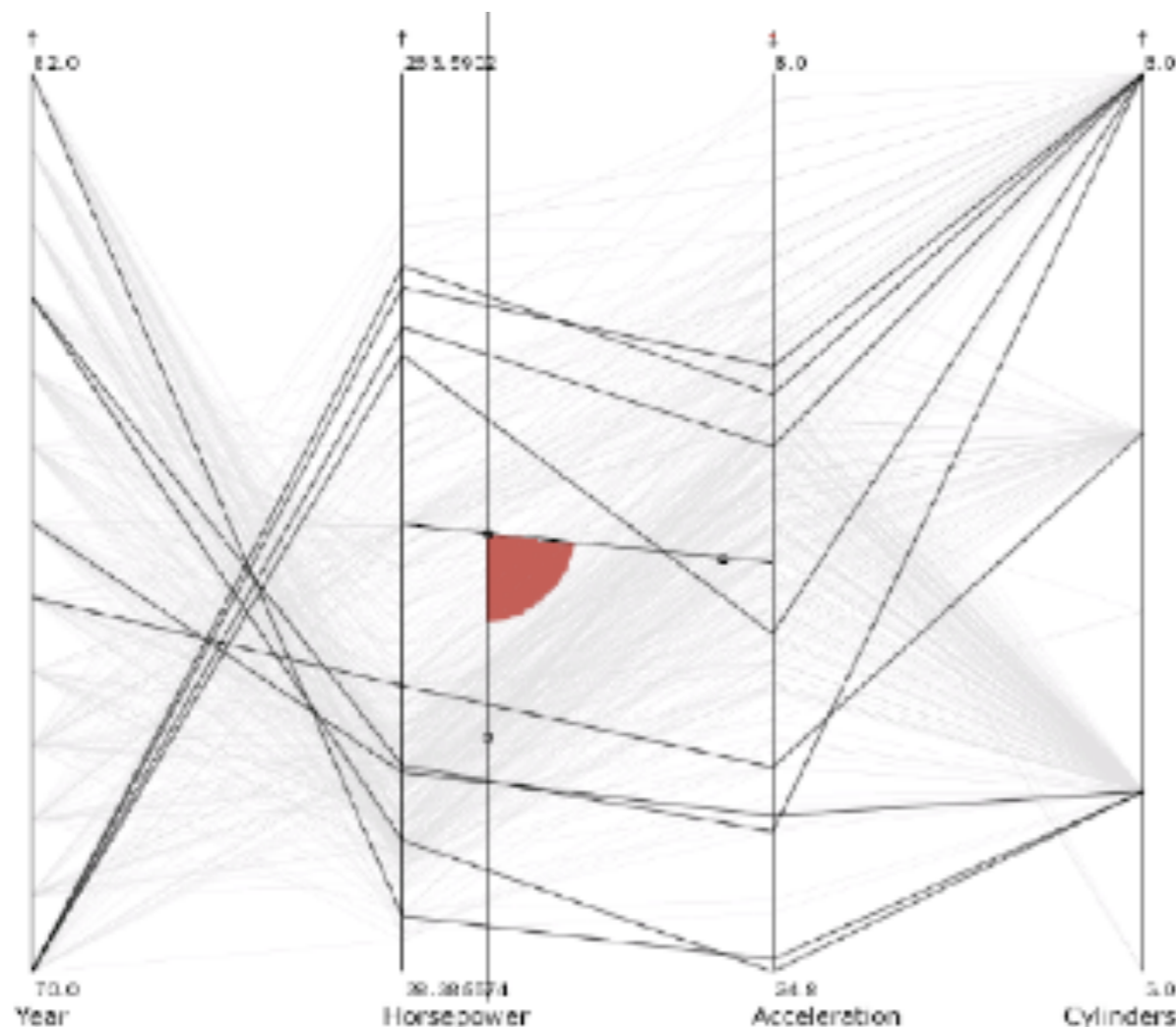
Brushing a parallel coordinate plot



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

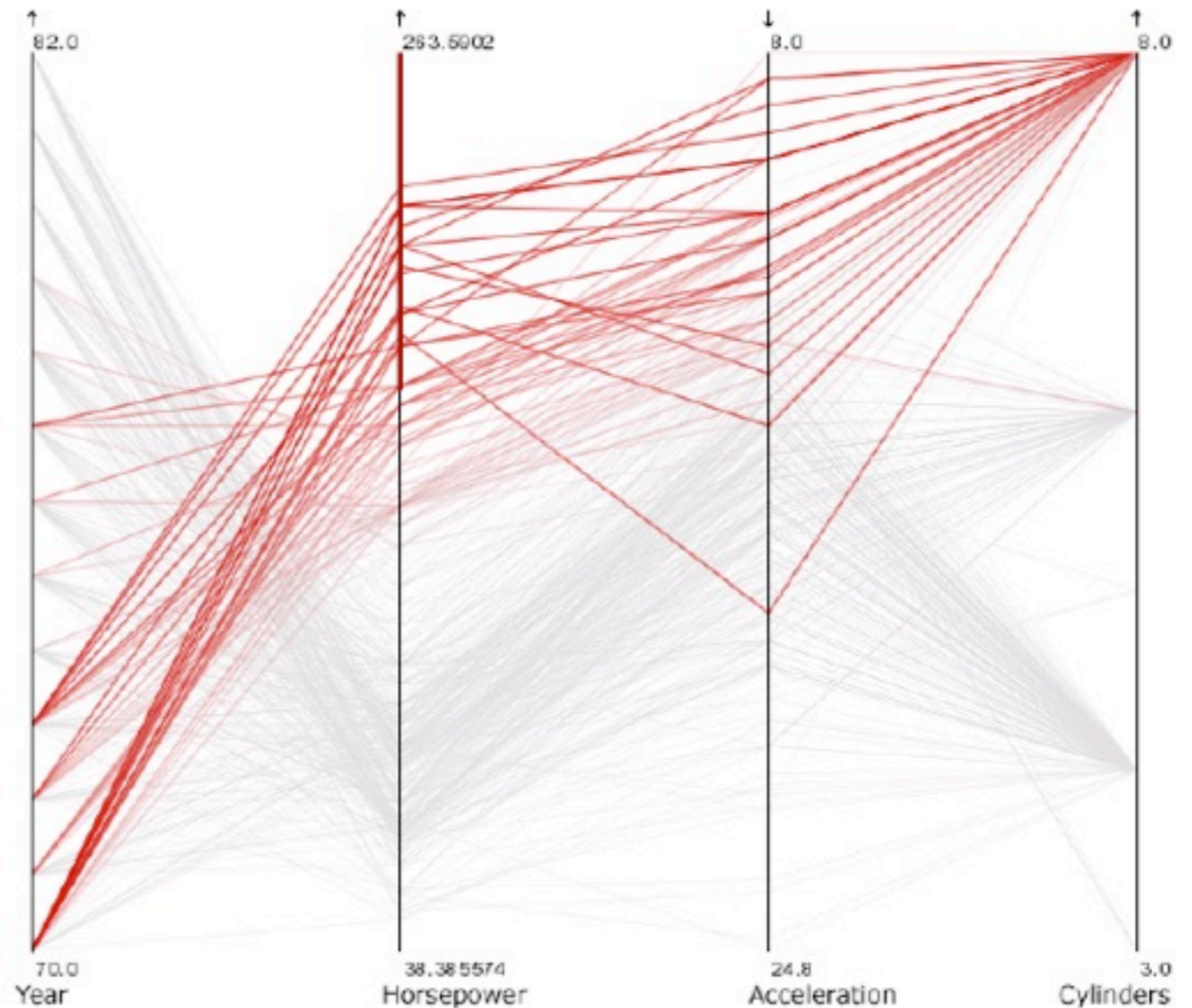


angular brush

Hauser et al. 2002

Smooth Brush

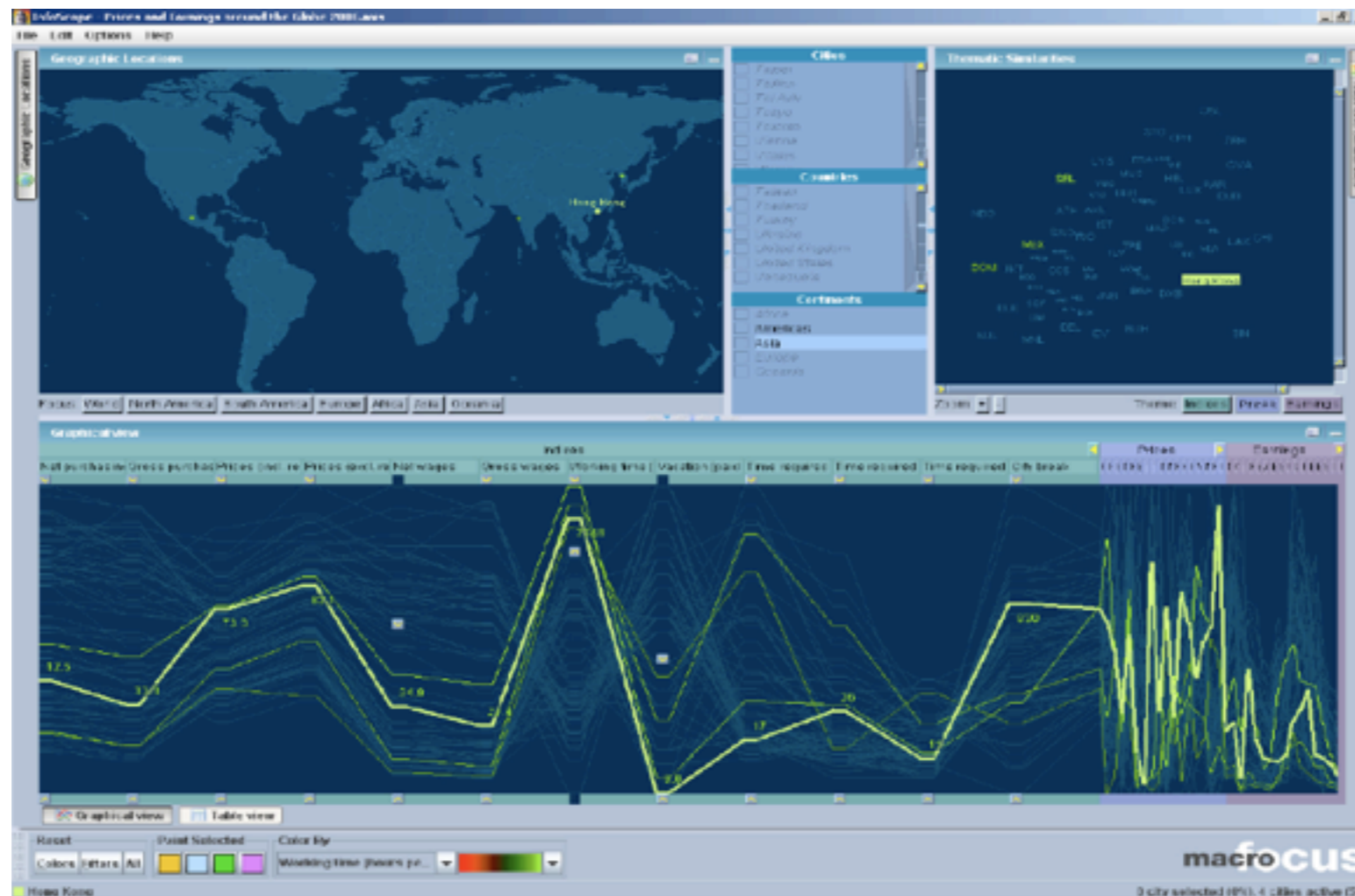
- Non-binary brushing
- Degree-of-interest defined by distance to brushed range
- Decreasing degree is mapped to decreasing drawing intensity



Hauser et al.
2002

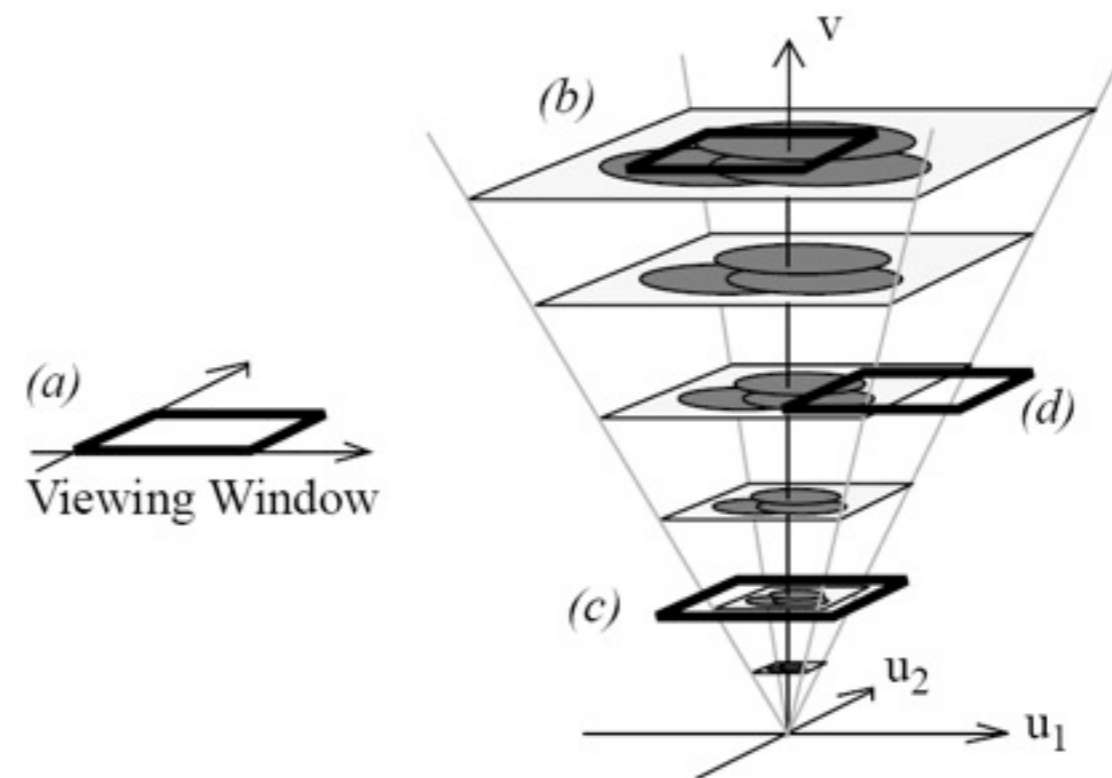
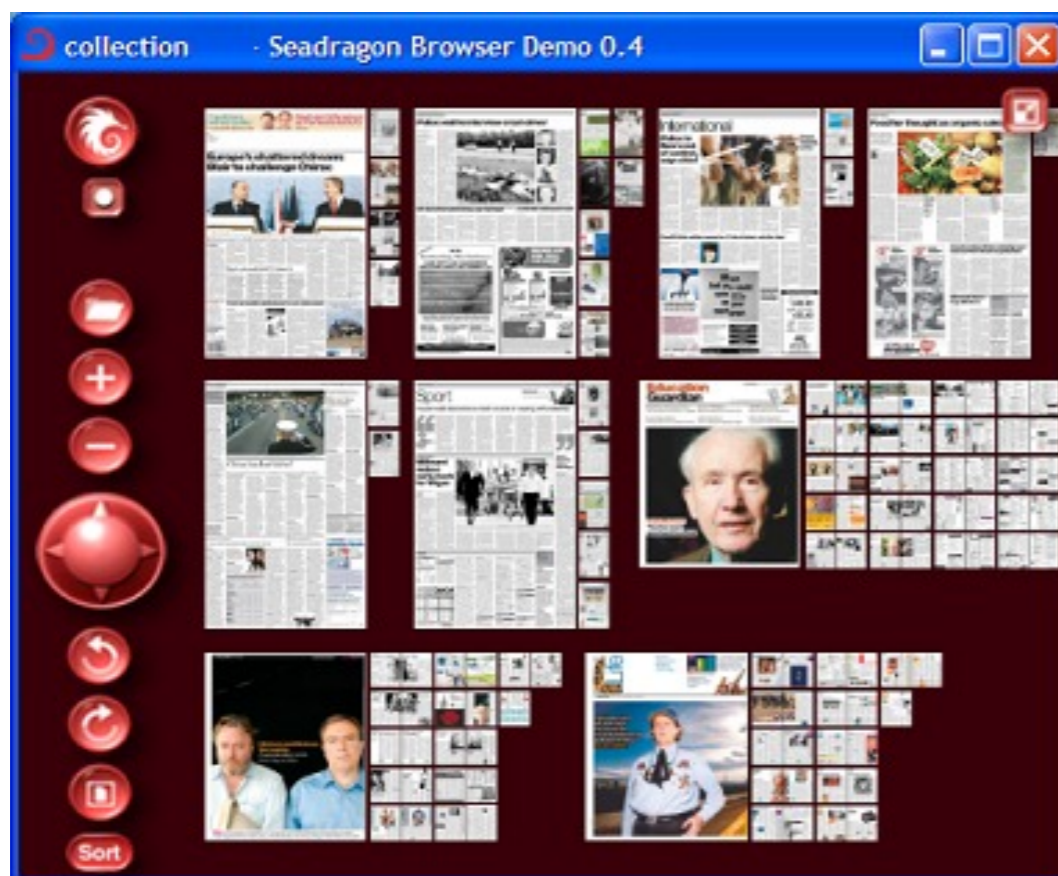
Another Brushing Example

- 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

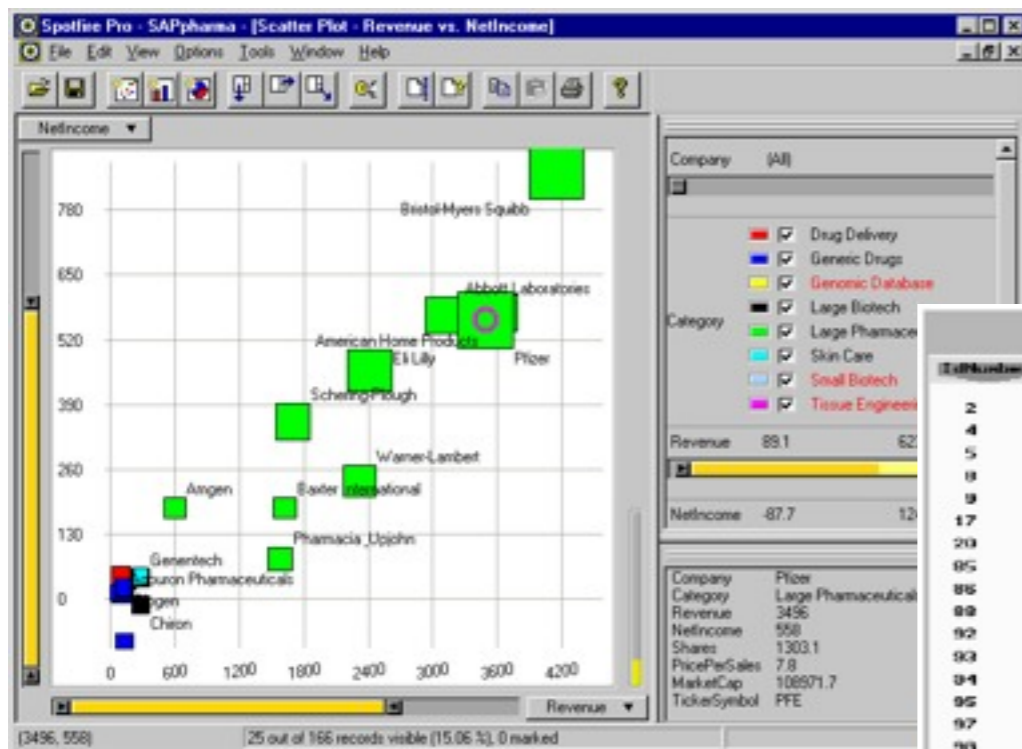
- Shneiderman 1994
- Explore and search databases
- SQL example: `SELECT customer_id, customer_name, COUNT(order_id) as total FROM customers INNER JOIN orders ON customers.customer_id = orders.customer_id GROUP BY customer_id, customer_name HAVING COUNT(order_id) > 5 ORDER BY COUNT(order_id) DESC`
- 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

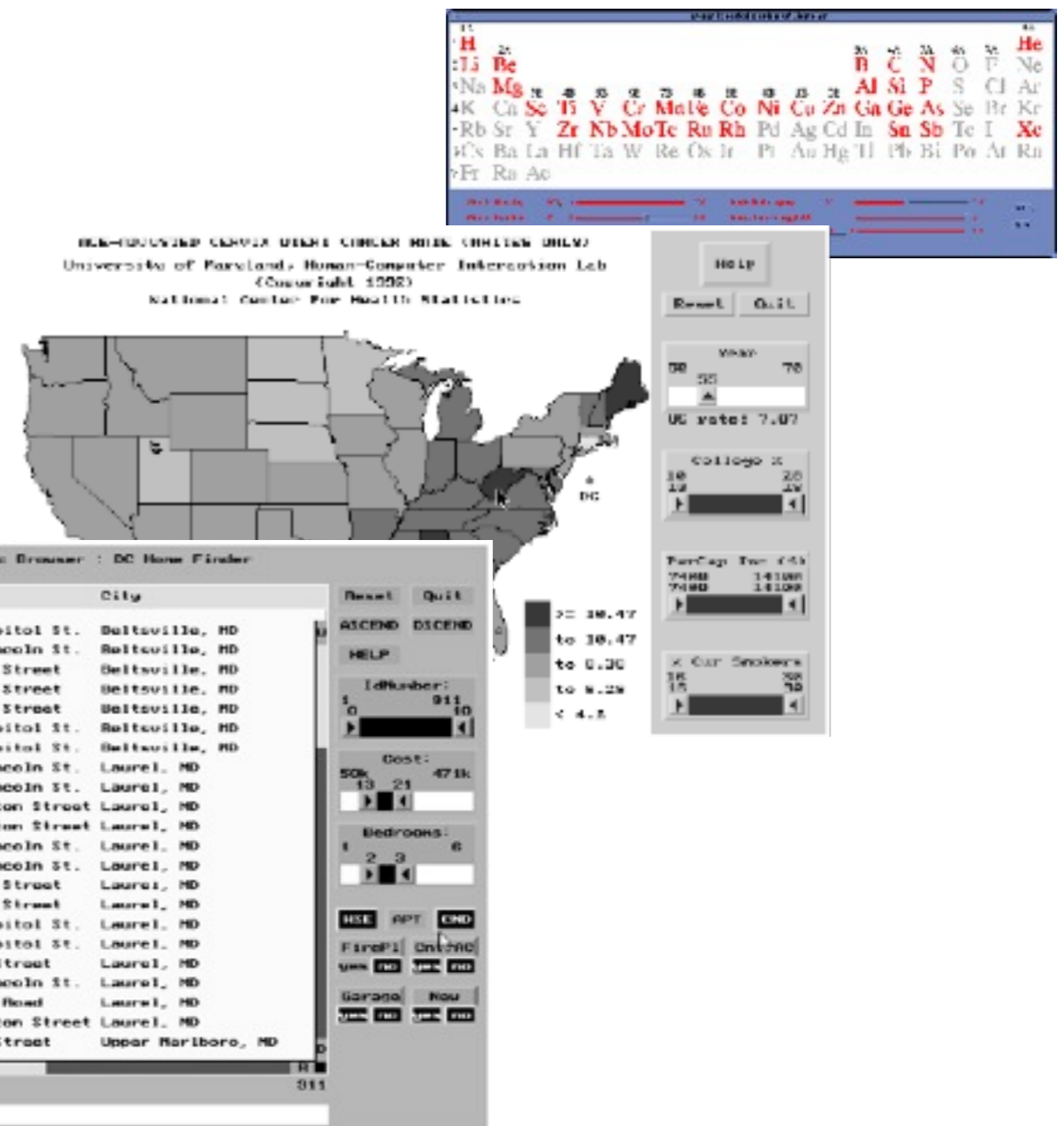
- Based on Direct Manipulation (DM)
- DM principles with regard to Dynamic Queries
 - Visual presentation of the query's components
 - Visual presentation of results
 - Rapid, incremental, and reversible control of the query
 - Selection by pointing, not typing
 - Immediate, continuous feedback
- Implementation 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(!)

The yellow dots above are homes in the DC area for sale. You may get more information on a home by selecting it. You may drag the 'A' and 'B' distance markers to your office or any other location you want to live near. Select distances, bedrooms, and cost ranges by dragging the corresponding slider boxes on the right. Select specific home types and services by pressing the labeled buttons on the right.

Dynamic HomeFinder

Reset Quit

Save Print

Dist to A:
1 30
19

Dist to B:
1 30
6

Bedrooms:
1 7
2 4

Cost:
\$50k \$500k
16 38

Look at:
Hse TH Cnd

Features:
Grg Fp1
CAC New



This graph shows the network structure. The nodes are represented by small white dots. The edges are represented by thin lines. The red diamond shape highlights a specific cluster of nodes. The blue structure within the diamond represents a specific network component or flow.

Dynamic Network

Reset | Back

Zoom | Fit

Scale: 100%

Scale: 100%

Zoom: 100%

Scale: 100%

Zoom: 100%

Reset | Back

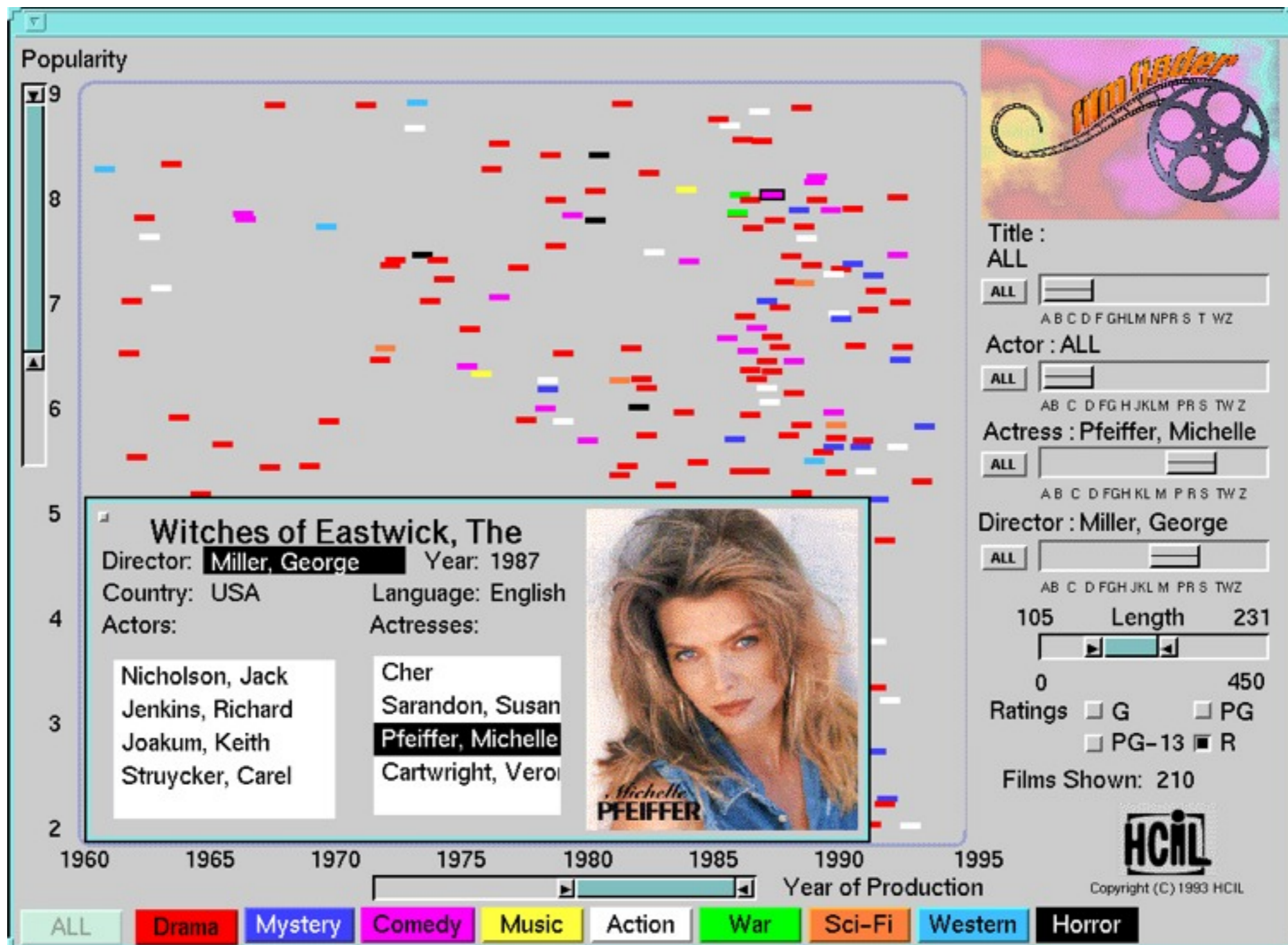
Zoom | Fit

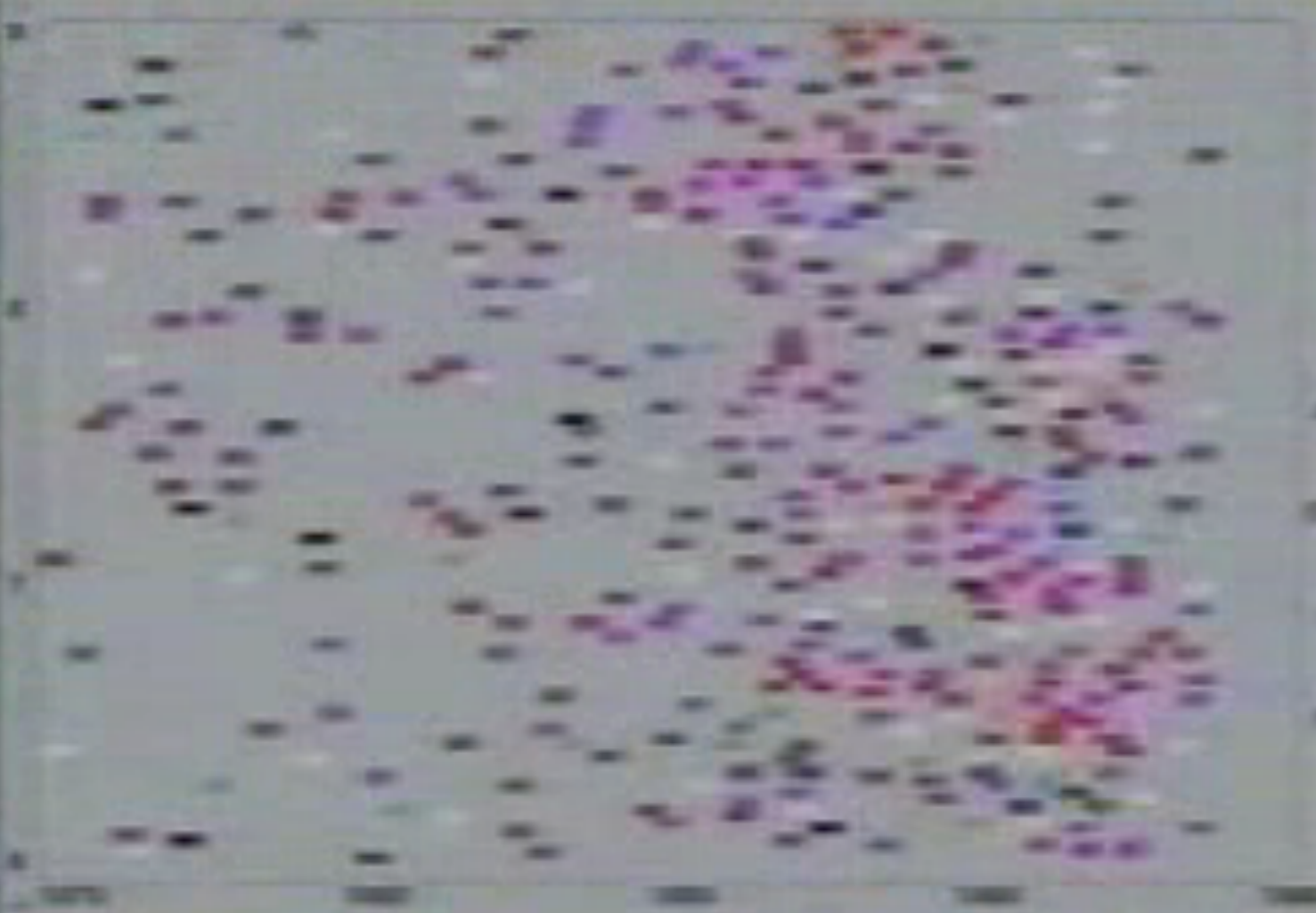


Year	U.S.	U.S. (without Alaska and Hawaii)
1950	10.5	9.5
1960	11.5	10.5
1970	12.5	11.5
1980	13.5	12.5
1990	14.5	13.5
2000	15.5	14.5
2010	16.5	15.5
2020	17.5	16.5
2030	18.5	17.5
2040	19.5	18.5
2050	20.5	19.5

FilmFinder

- Ahlberg & Shneiderman 1994

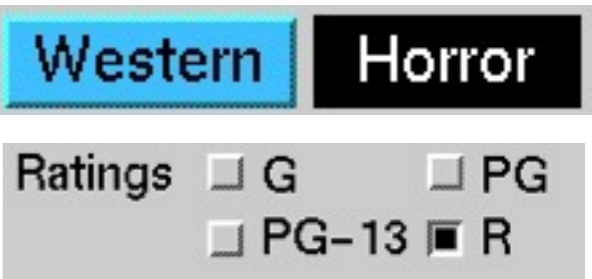




Title _____
 Director _____
 Year _____
 Genre _____
 Rating _____
 Length _____
 Budget _____
 Box Office _____
 Cast _____
 Crew _____

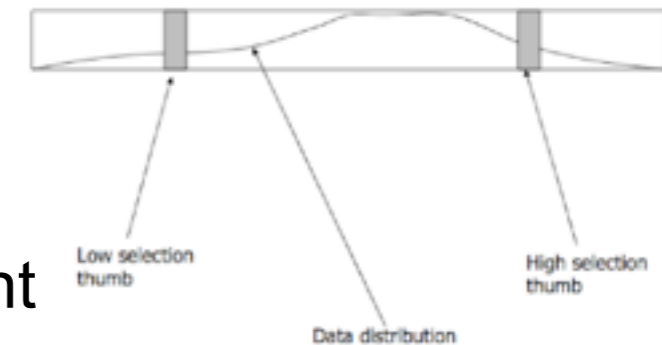
1990
 1995
 2000
 2005
 2010
 2015
 2020

Dynamic Query Controls



- Check boxes and buttons (Nominal with low cardinality)
- Sliders and range slider (ordinal and quantitative data)
- Alphasliders (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 Alphalider for PDAs / MP3 player - movie
- Extend data sliders with data visualization (Eick 1994)

Finde:

Input field

Input field

ABC DE FGHI LM P RS T W

start found not found

Ende

Dynamic Queries Online

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

The screenshot shows the 'immo.search.ch' website interface. At the top, there are navigation links and a search bar. Below the search bar, there are filters for 'Wohnung' (Apartment), 'Preis' (Price) set to 200,000 CHF, and 'Zimmer' (Rooms) set to 2-3. A list of property listings is shown on the left, with columns for 'ID', 'Preis', 'Zimmer', 'Fläche', and 'm²'. A map view is visible on the right side of the page.

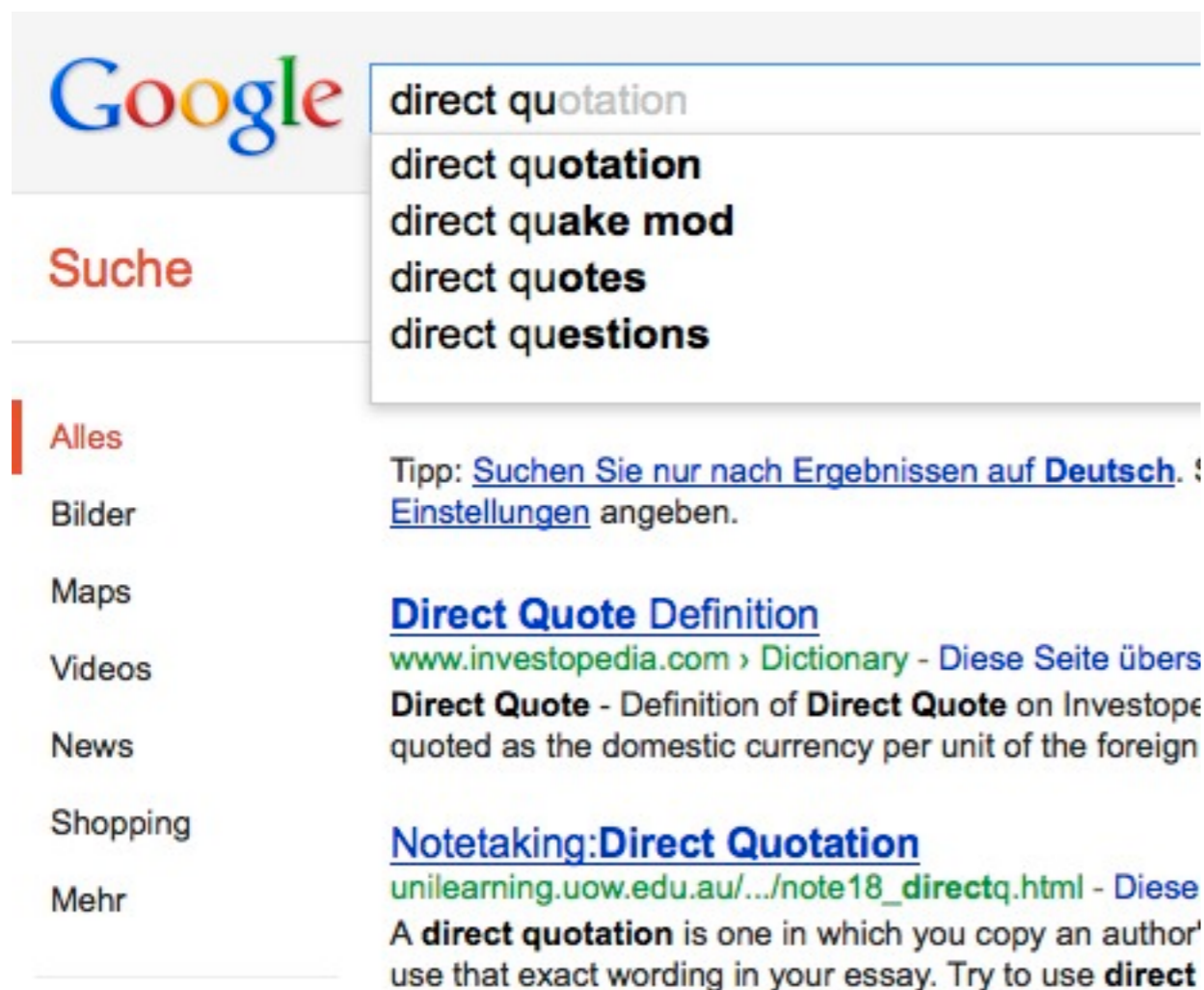
The screenshot shows the 'Search for Diamonds' interface. It features a 'Refine Search Criteria' section with sliders for Shape, Carat, Cut, Color, and Clarity. The 'Need Help?' and 'Customize Search' sections are also visible.

Your Search Results: 2,821 Diamonds

Compare	Shape	Carat	Cut	Color	Clarity	Polish	Symmetry	Report	Price	Details
<input type="checkbox"/>	Round	0.72	Very Good	G	VS1	VG	VG	GIA	\$2,872	view details
<input type="checkbox"/>	Round	0.75	Very Good	H	VS1	EX	VG	GIA	\$2,873	view details
<input type="checkbox"/>	Round	0.77	Very Good	E	S11	VG	EX	GIA	\$2,874	view details
<input type="checkbox"/>	Round	0.79	Very Good	F	VS2	EX	ID	AQBL	\$2,874	view details
<input type="checkbox"/>	Round	0.79	Very Good	F	VS2	EX	ID	AQSL	\$2,874	view details
<input type="checkbox"/>	Round	0.79	Good	D	VS2	EX	VG	GIA	\$2,876	view details
<input type="checkbox"/>	Oval	0.71	Very Good	F	VS2	G	G	GIA	\$2,877	view details
<input type="checkbox"/>	Round	0.88	Very Good	G	S12	EX	VG	GIA	\$2,877	view details
<input type="checkbox"/>	Round	0.78	Very Good	H	VS1	G	VG	AQBL	\$2,878	view details
<input type="checkbox"/>	Round	0.80	Good	H	VS1	VG	EX	GIA	\$2,879	view details
<input type="checkbox"/>	Round	0.53	Very Good	D	VVS1	EX	EX	AQBL	\$2,879	view details
<input type="checkbox"/>	Oval	0.80	Good	F	S12	G	G	GIA	\$2,879	view details
<input type="checkbox"/>	Round	0.75	Very Good	F	S11	EX	VG	GIA	\$2,879	view details
<input type="checkbox"/>	Oval	0.93	Good	H	S12	VG	G	GIA	\$2,880	view details
<input type="checkbox"/>	Oval	0.91	Very Good	I	S11	G	G	GIA	\$2,882	view details
<input type="checkbox"/>	Oval	0.92	Fair	I	S11	G	G	GIA	\$2,882	view details

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



Google

Suche

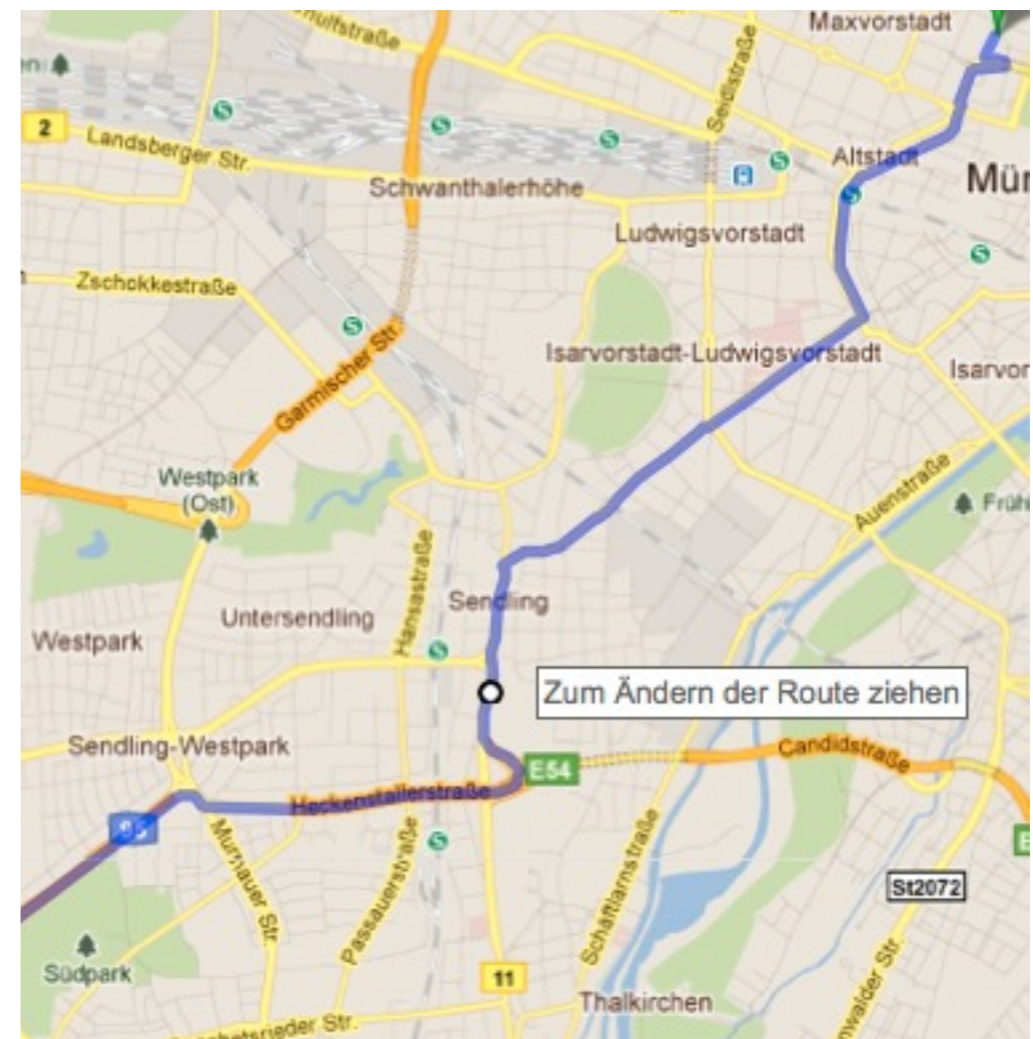
Alles
Bilder
Maps
Videos
News
Shopping
Mehr

direct quotation
direct quotation
direct quake mod
direct quotes
direct questions

Tipp: [Suchen Sie nur nach Ergebnissen auf Deutsch.](#) [Einstellungen](#) angeben.

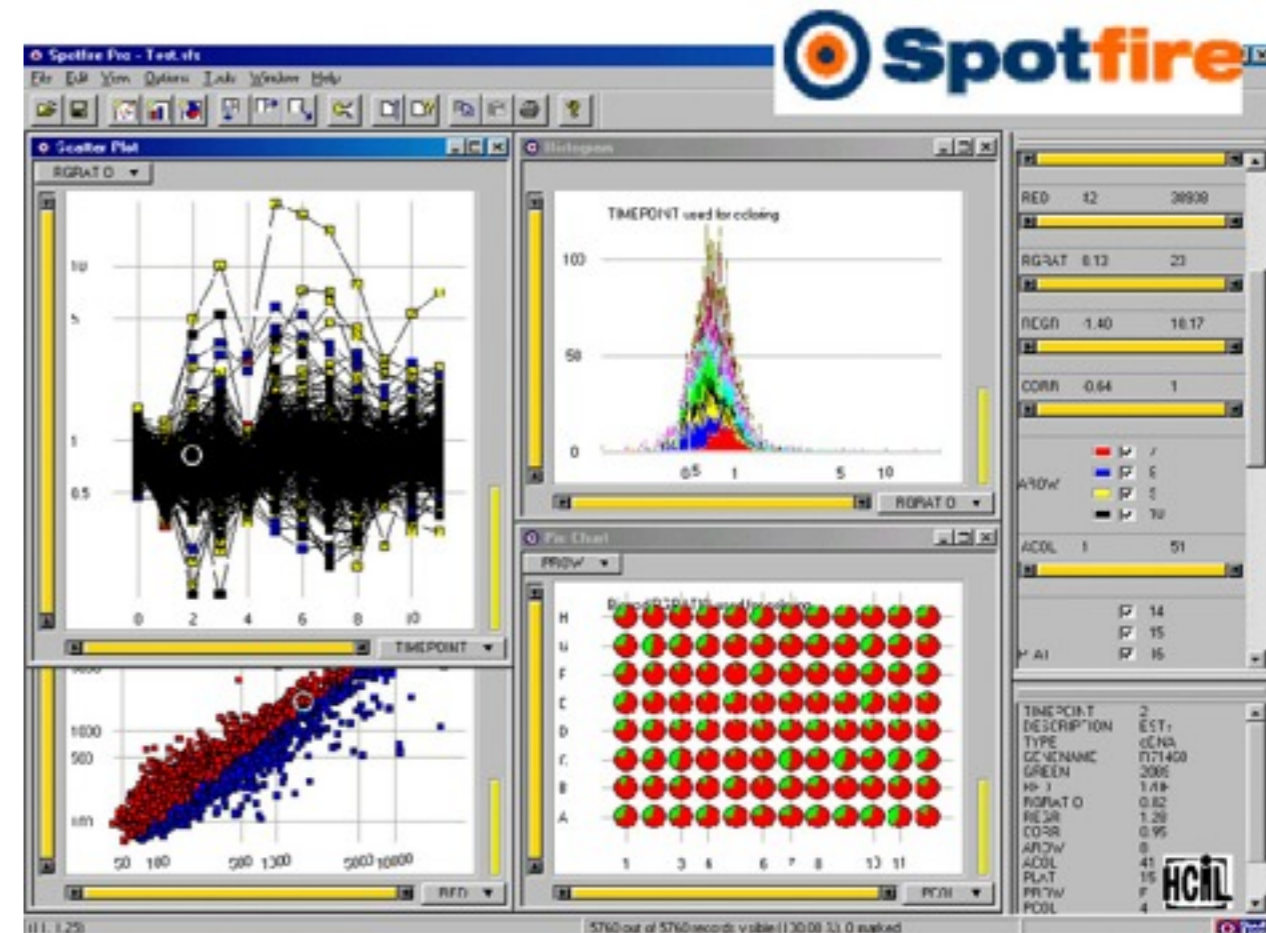
[Direct Quote Definition](#)
[www.investopedia.com > Dictionary](#) - Diese Seite übers **Direct Quote** - Definition of **Direct Quote** on Investop
quoted as the domestic currency per unit of the foreign

[Notetaking:Direct Quotation](#)
[unlearning.uow.edu.au/.../note18_directq.html](#) - Diese
A **direct quotation** is one in which you copy an author's
use that exact wording in your essay. Try to use **direct**



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

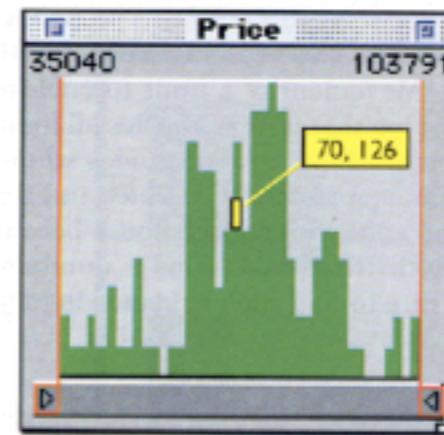


FIGURE 3.55 A histogram representing the prices of a collection of houses. The contribution of one house is shown in yellow

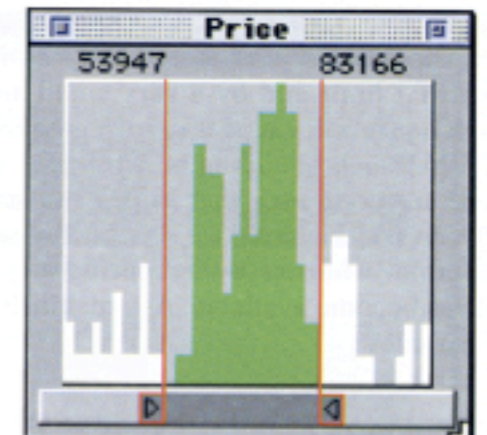
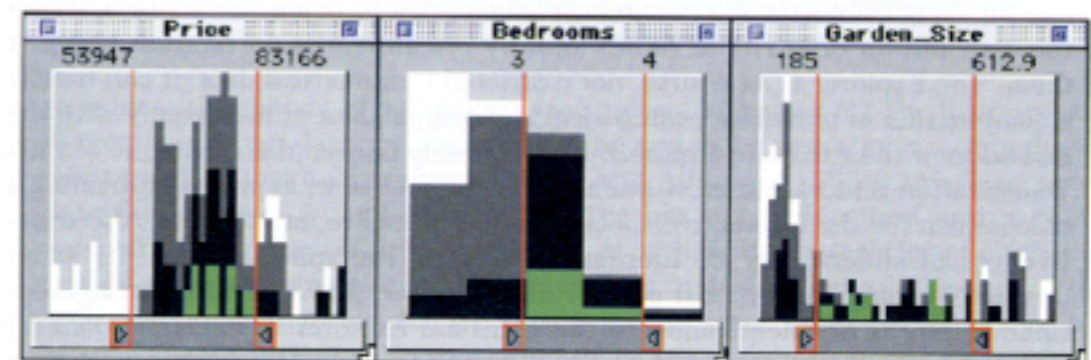


FIGURE 3.56 Limits on Price identify a subset of houses, coded green

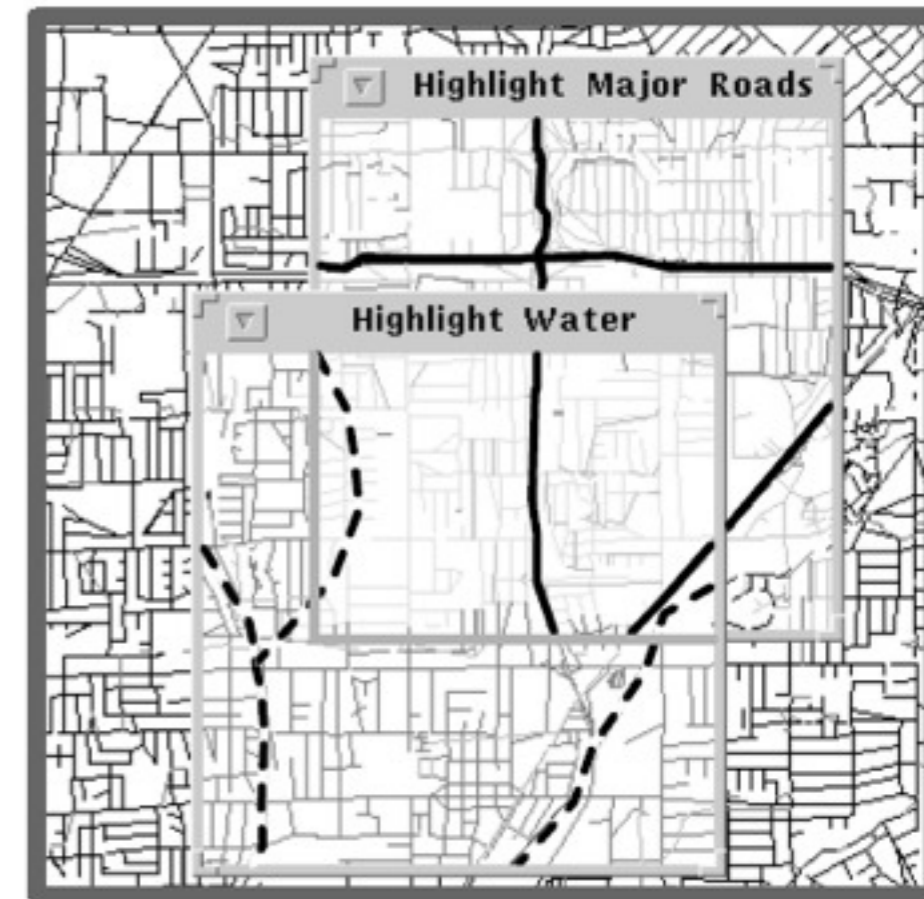


Spence 2004

- 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

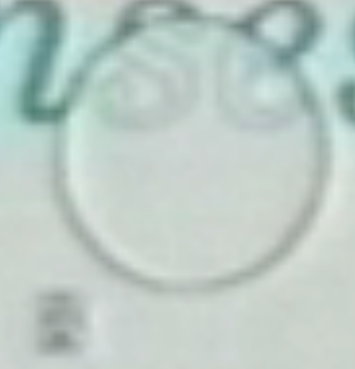
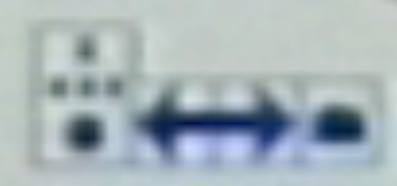


Stone et al. 1994



Magnify Circle

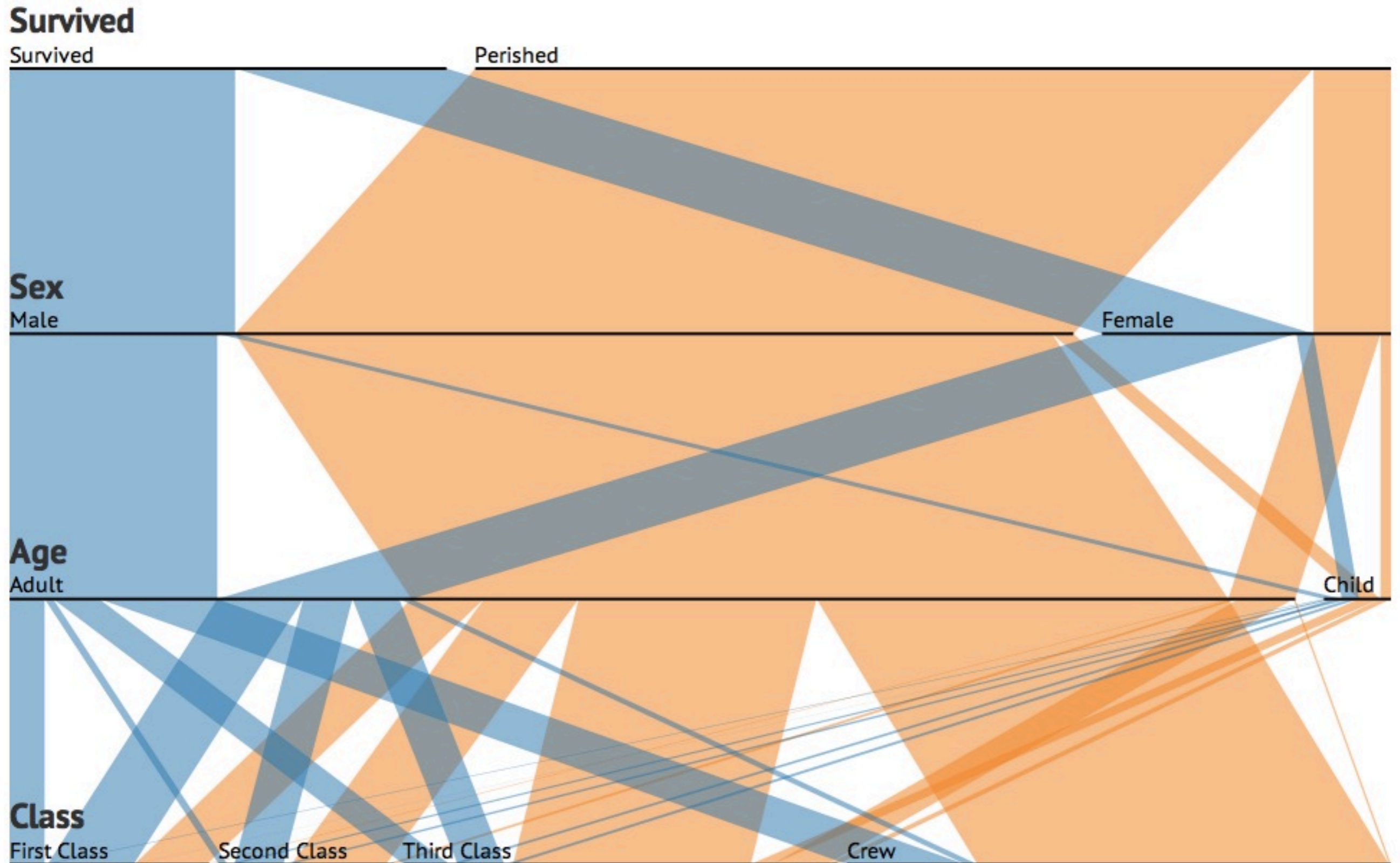
M *MC* *Lenses*



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



Curves?

Data: [Robert J. MacG. Dawson.](#)

Additional Sources

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

