Leibniz Universität Hannover

Mensch-Computer-Interaktion 2

Visualization

(based on slides by Marti Hearst and Jeff Heer)

Human-Computer Interaction Group

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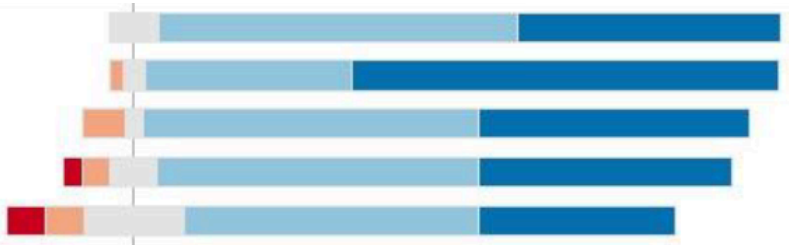
Lectures

Session	Date	Topic	
1	6.4.	Introduction	
2	13.4.	Interaction elements	GUI toolkits, interaction techniques
3	20.4.	Event handling	
4	27.4.	Scene graphs	
5	4.5.	Interaction techniques	
	11.5.	no class (CHI)	
	18.5.	no class (spring break)	
6	25.5.	Experiments	design and analysis of experiments
7	1.6.	Data Analysis	
8	8.6.	Data Analysis	
9	15.6.	Visualization	
10	22.6.	Visualization	current topics beyond-desktop UIs
11	29.6.	Modeling interaction	
12	6.7.	Computer vision for interaction	
13	13.7.	Computer vision for interaction	

Klausur:
28.7.2016
8-11 Uhr
HG E214

Review

- What is information visualization?
- What principle does the London Underground Map use?
- Two primary aims of visualization?
- What is a Treemap?
- How to improve Treemaps?
- Information visualization reference model?
- Differences in accuracy of perception of visual properties?
- Plotting Likert scales?



Preview

- Dynamic Queries
- Brushing and Linking
- Comparison of Information Visualization Systems (Study)
- Zooming
- Focus + Context
- Distortion

Dynamic Queries

Selecting value ranges of variables via controls with real time feedback in the display

Principles:

- Visual presentation of query's components
- Visual presentation of results
- Rapid, incremental, and reversible control
- Selection by pointing, not typing
- Immediate and continuous feedback
- Support browsing
- Details on demand

Slide adapted from Sarah Waterson

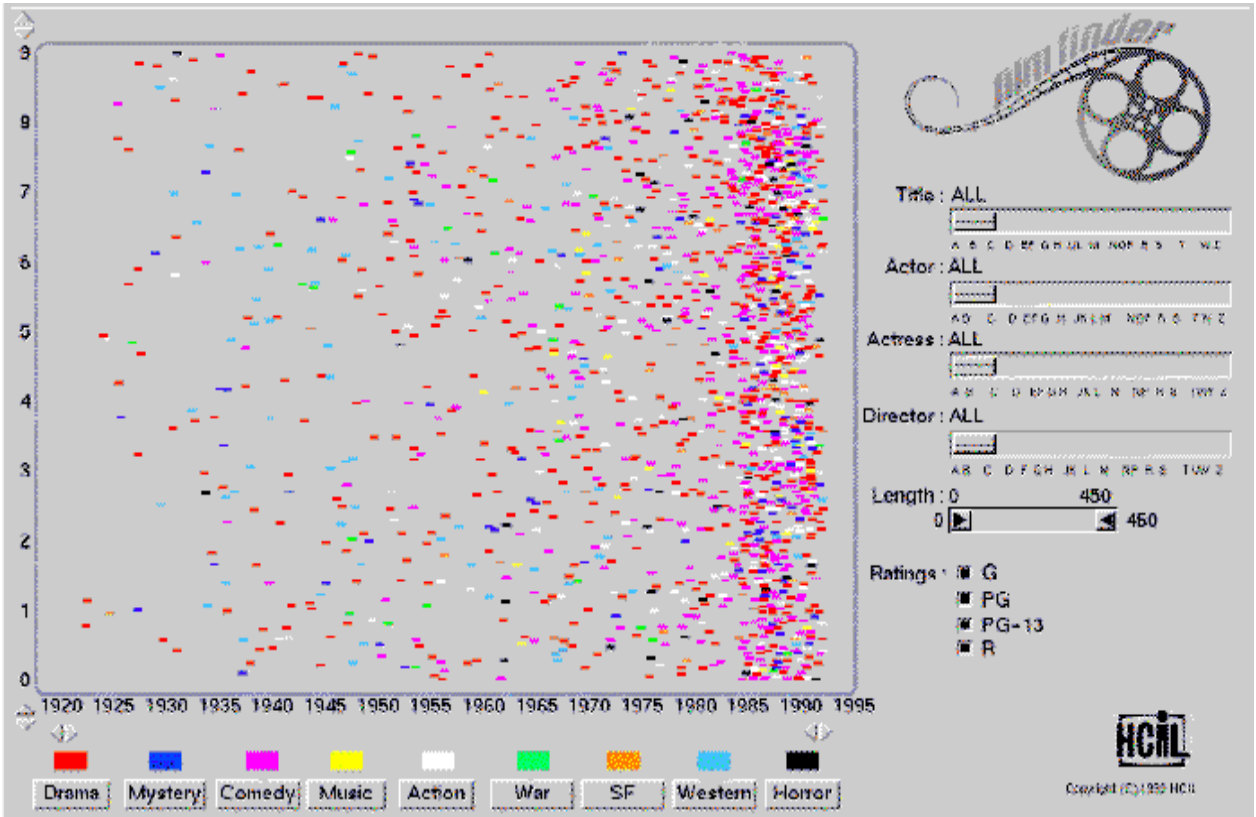
Dynamic Queries

- Tight coupling
  - Query components are interrelated in ways that preserve display invariants, reveal state of system
  - Output of queries can be easily used as input to produce other queries. Eliminate distinction between commands/queries/input and results/tables/ output

- Example: Interactive Scatterplots

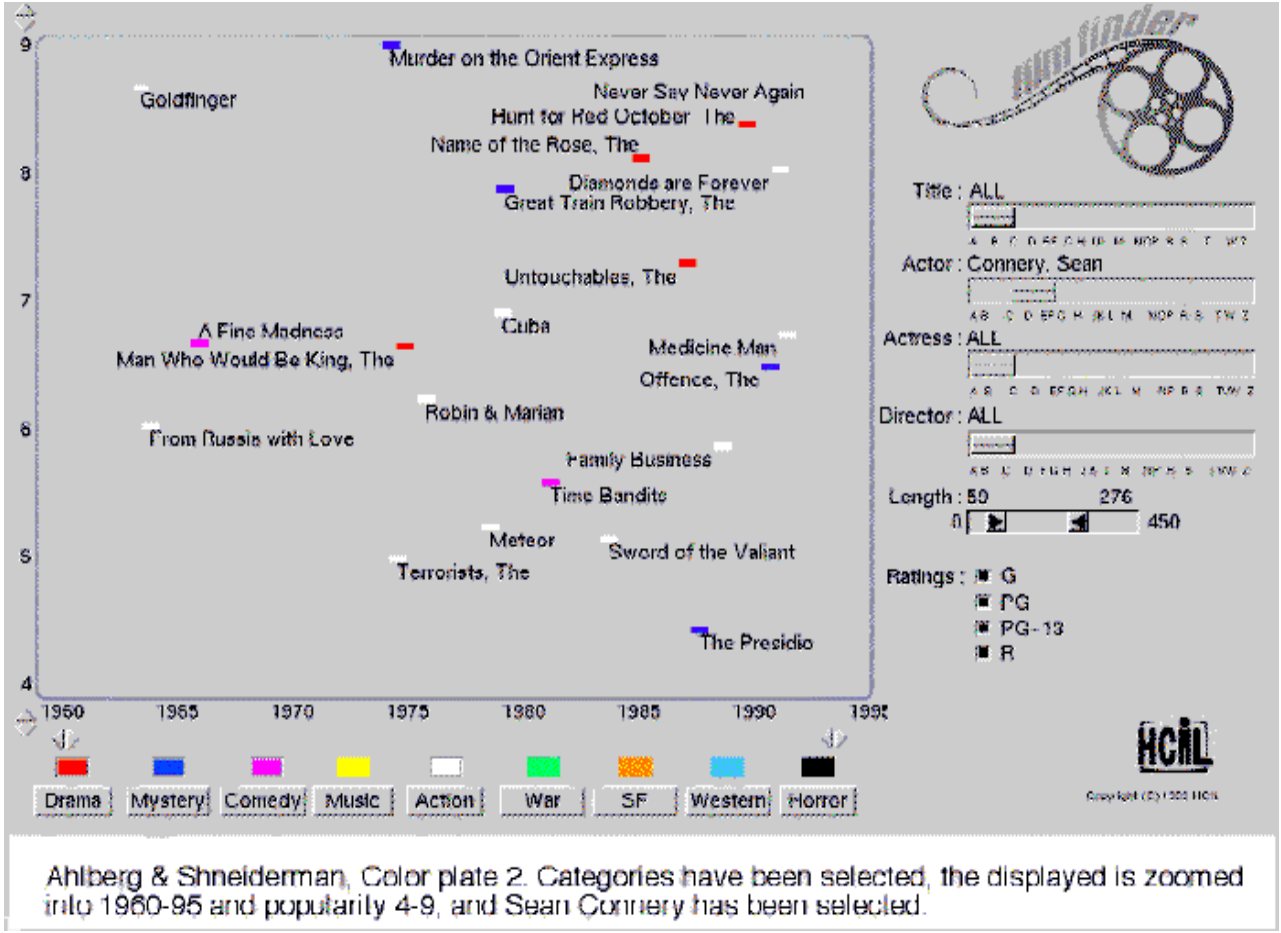
Slide adapted from Sarah Waterson

Interaction with Scatterplots



Ahlberg & Shneiderman, Color plate 1. The FilmFinder.

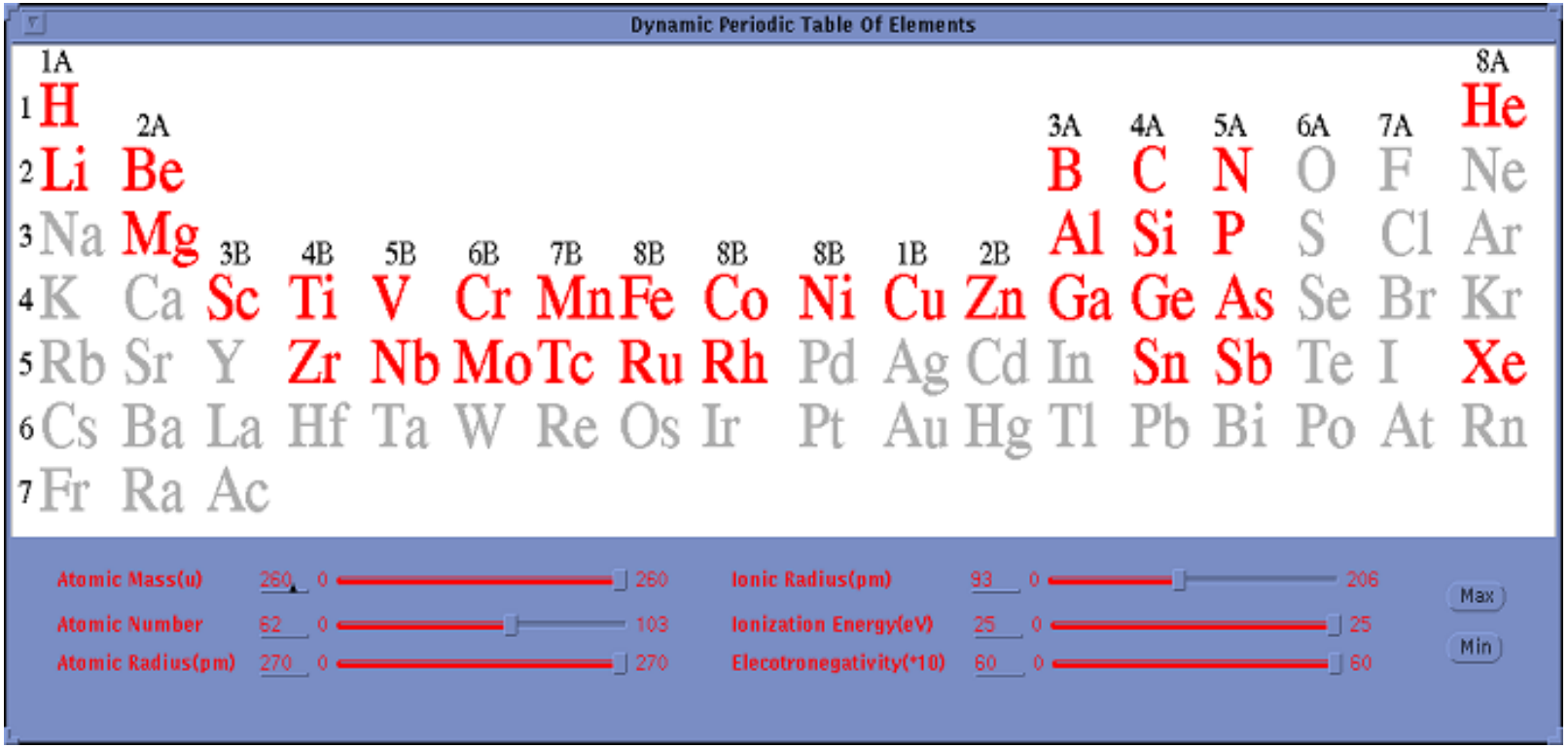
Interaction with Scatterplots



Ahlberg & Shneiderman, Color plate 2. Categories have been selected, the displayed is zoomed into 1960-95 and popularity 4-9, and Sean Connery has been selected.

Dynamic Query Example

Periodic Table of the Elements: Adjust properties to highlight matching elements. (Ahlberg,Williamson, Shneiderman '92)



Slide adapted from Sarah Waterson

Brushing and Linking

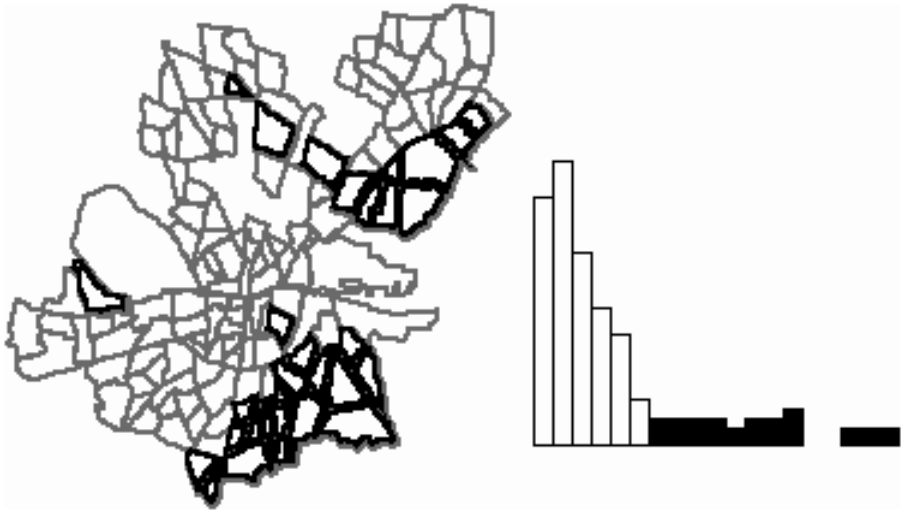
- Linking: Visually indicating which parts of one data display correspond to that of another
- Brushing: Selecting subsets of data by marking (brushing) items in a single view
- Usability issues: Selection, de-selection, setting values, appropriate widgets

Brushing and Linking

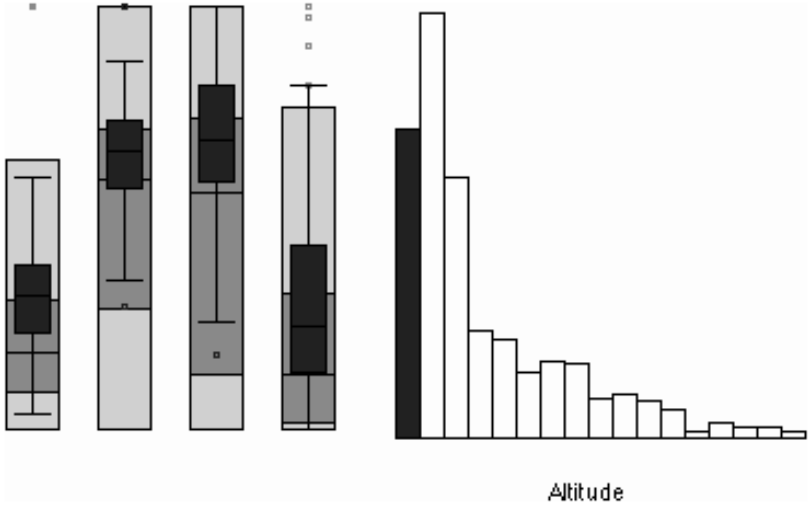
- At least two things must be linked together to allow for brushing
  - Select a subset of points
  - See the role played by this subset of points in one or more other views
- Highlighting is key

More Brushing and Linking Example

Districts of the city of Dublin showing areas with high levels of average income

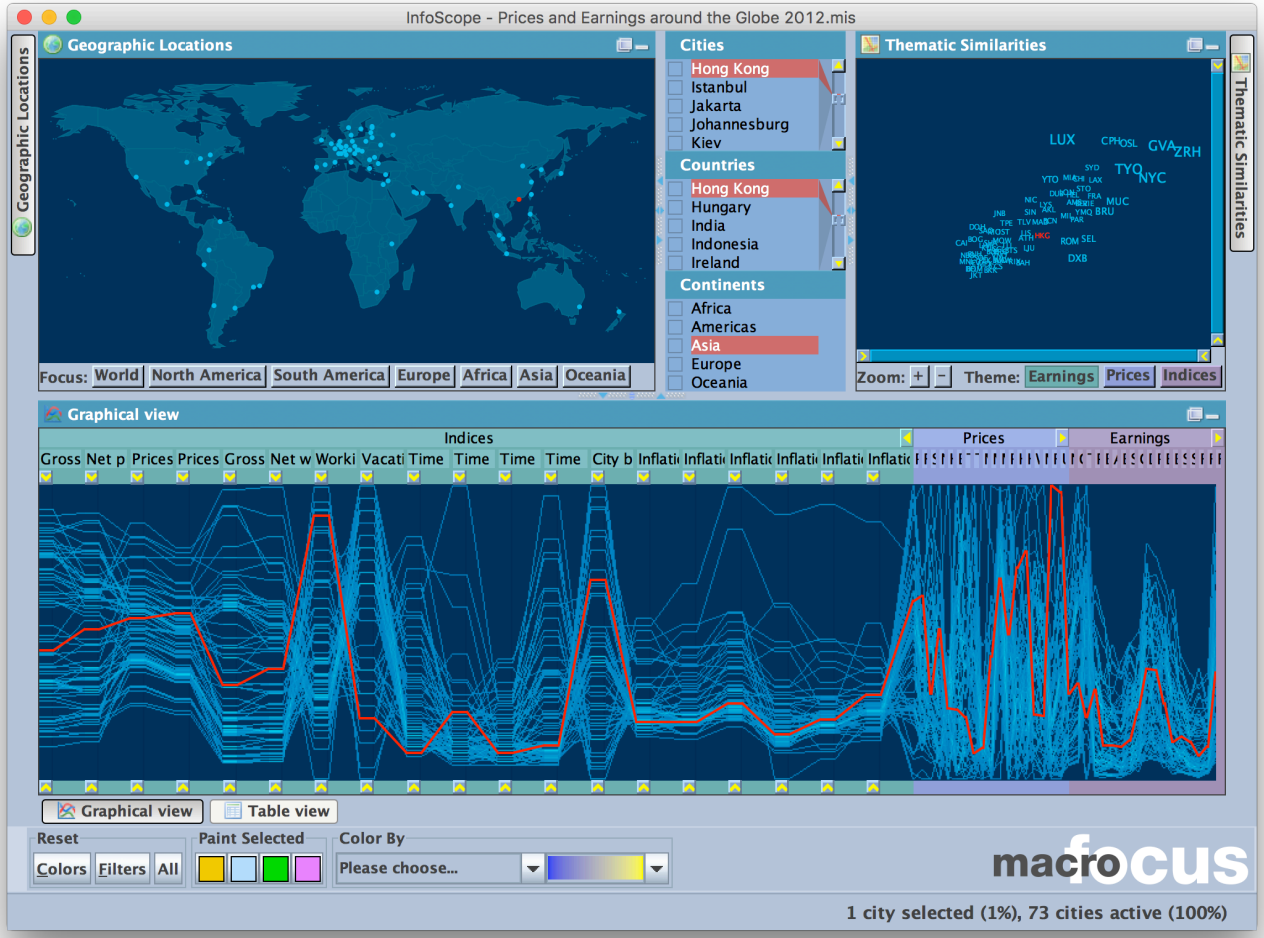


Linking altitude to grass and grain types in Scottish Districts



Slide adapted from Sarah Waterson

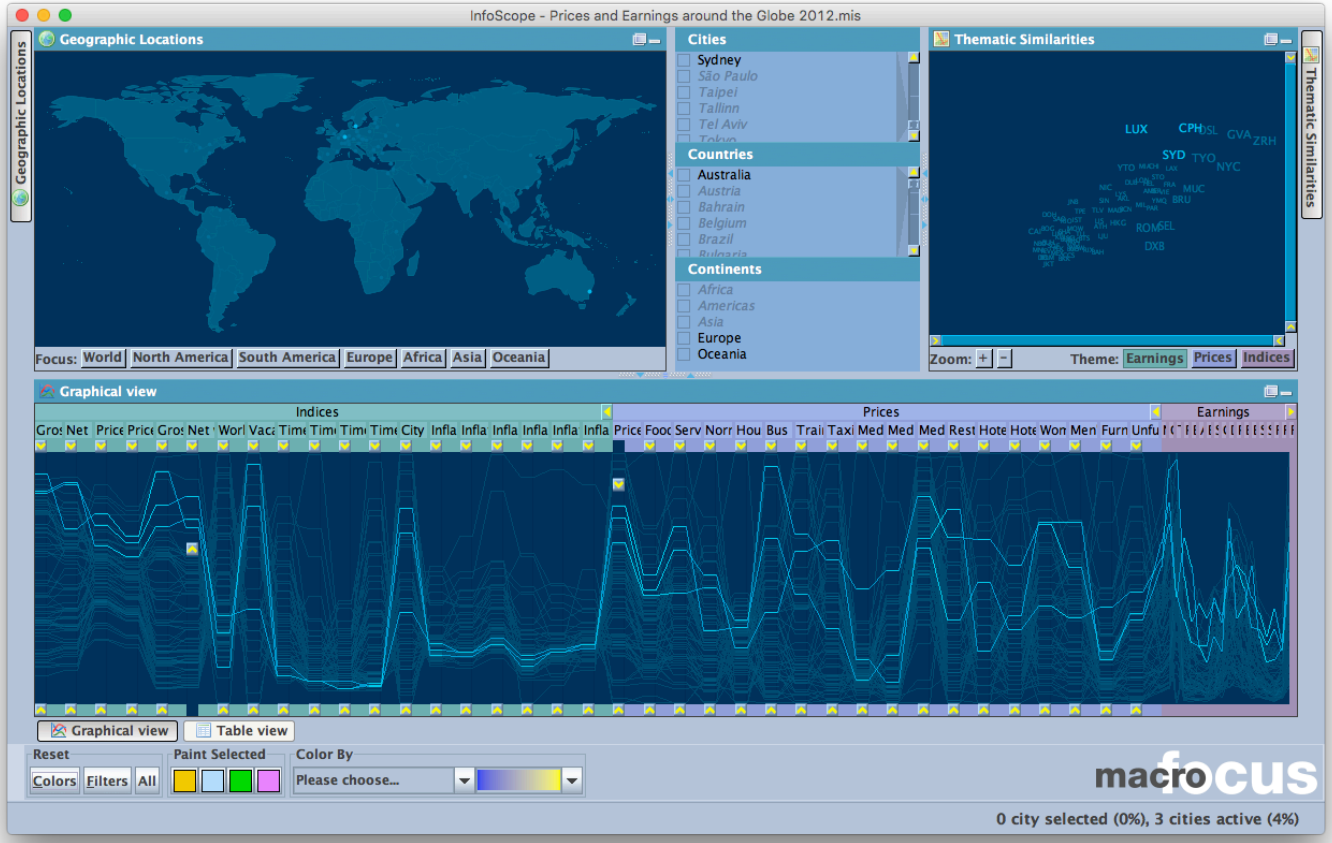
Brushing and Linking Example: InfoScope



http://www.macrofocus.com/public/products/infoscope/

Brushing and Linking Example: Parallel Coordinates in InfoScope

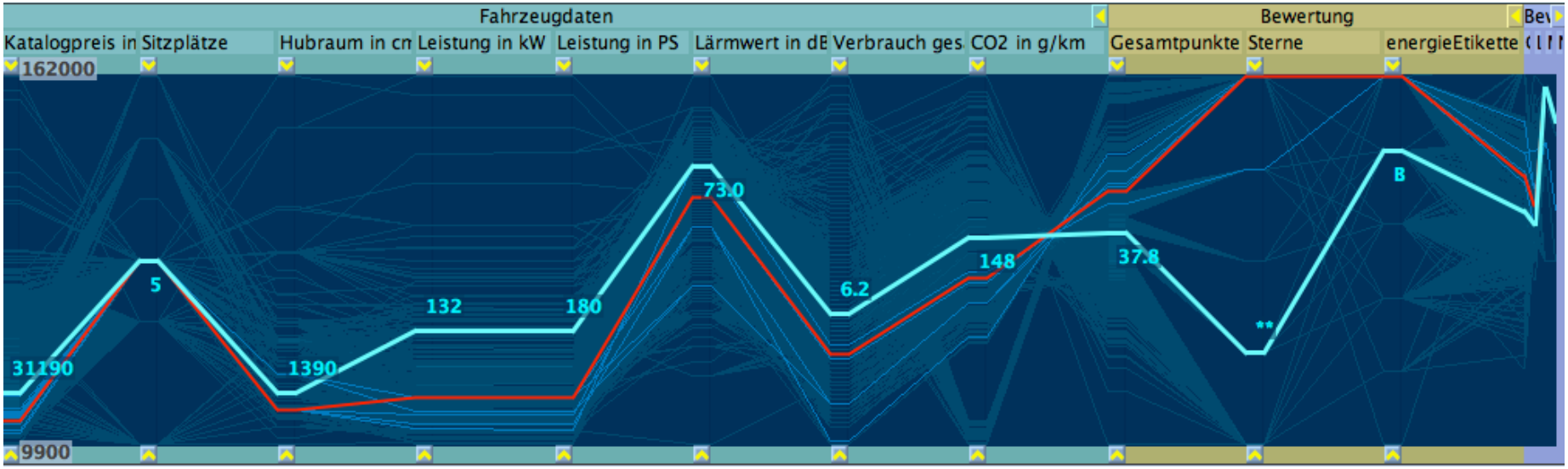
Example task: Find cities with high wages, small prices, and many paid holidays



Screenshot: InfoScope

Parallel Coordinate Axes

- Idea: Visualize multi-dimensional data by putting the coordinate axes parallel to each other
- A. Inselberg: Multidimensional Detective, InfoVis 1997

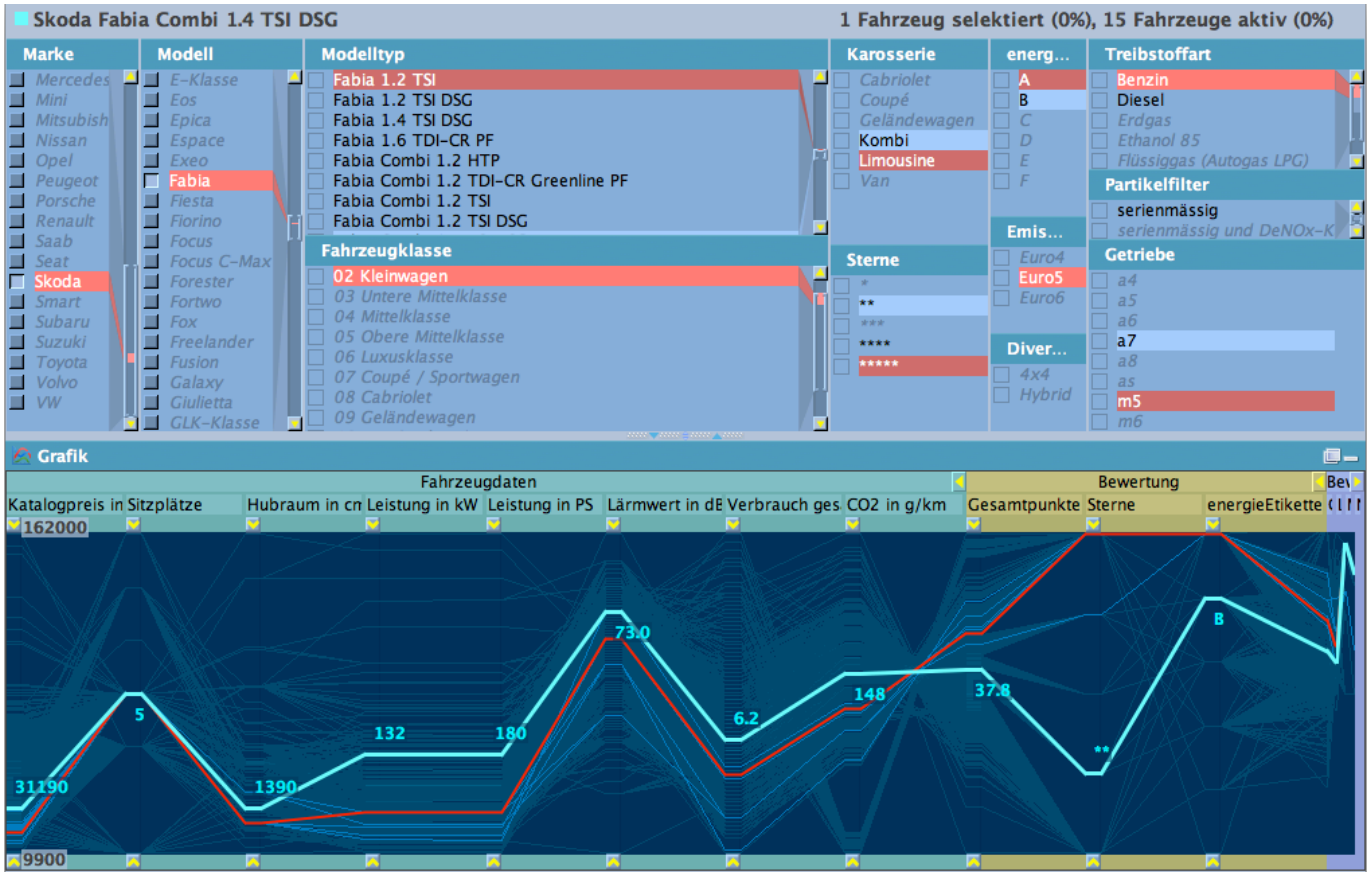


- Limitations: Each axis has at most two neighboring axes

Screenshot: InfoScope

Parallel Coordinate Axes

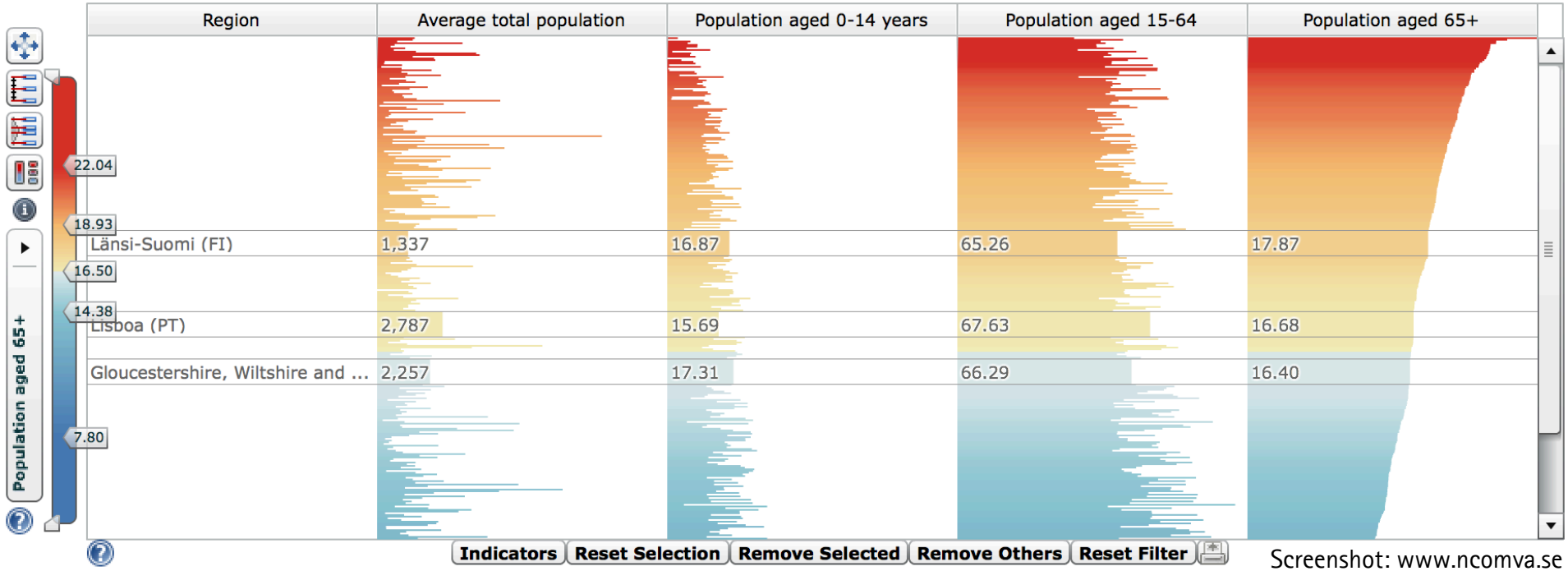
- Need for rearrangement, filtering, selection of axes



Screenshot: InfoScope

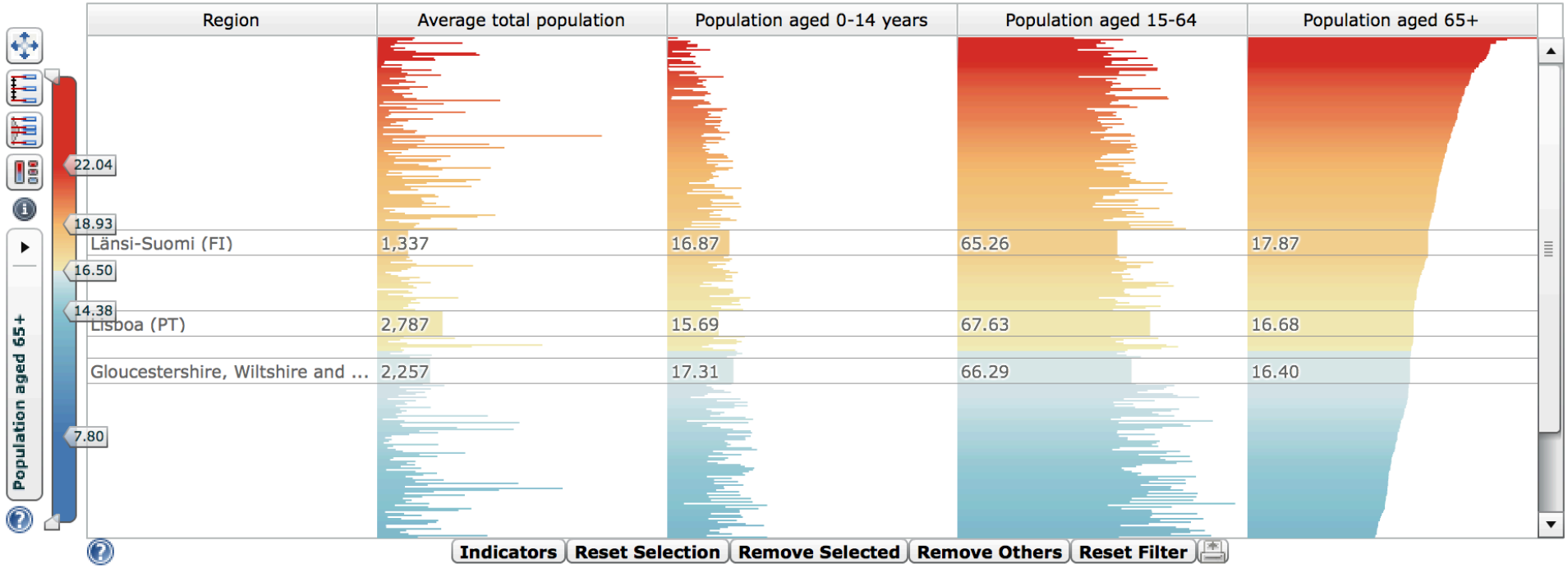
Table Lens

- Super Spreadsheets
  - Combines overview + details in an integrated view
  - Focus + Context allows for compressed representation
  - Sorting multiple columns allows patterns to emerge



Screenshot: www.ncomva.se

Table Lens Screenshot



http://www.ncomva.se/guide/?chapter=Visualizations&section=Table%20Lens#_General

Comparing 3 Information Visualization Systems

Alfred Kobsa: An Empirical Comparison of Three Commercial Information Visualization Systems, INFOVIS'01

Figure 1a. A screenshot from Eureka that shows how a user might solve the question "Did males cheat more on their girlfriends than females on their boyfriends?" (an actual question used in the experiment). After grouping the attribute "Gender" and sorting the column "Did you cheat?," a user can compare the number of "Yes" entries and thus find that more females than males indicated having cheated. (One male and one female gave no answers.)

Eureka (Table Lens)

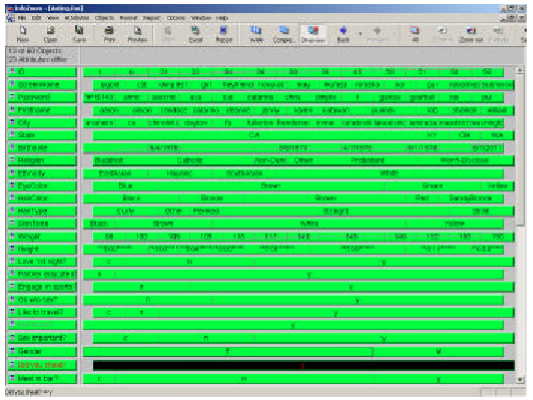


Figure 1b. This screenshot shows one possible way for solving the same problem in InfoZoom, specifically in its overview mode. After clicking at, and thereby zooming into, the "Yes" entries in the attribute "Did you cheat?", users can see from the length of the bars in the Gender category that females indicated more frequently having cheated than males.

InfoZoom

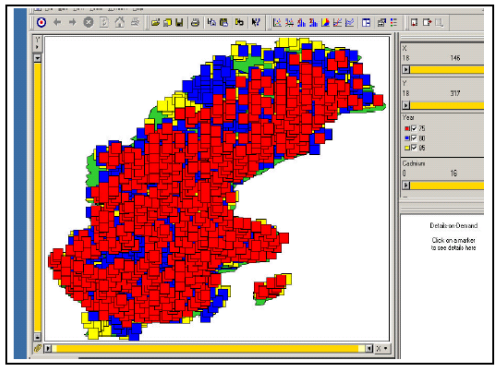


Figure 2. Spotfire's geographical representation of heavy metal concentrations through a scatterplot diagram.

Spotfire

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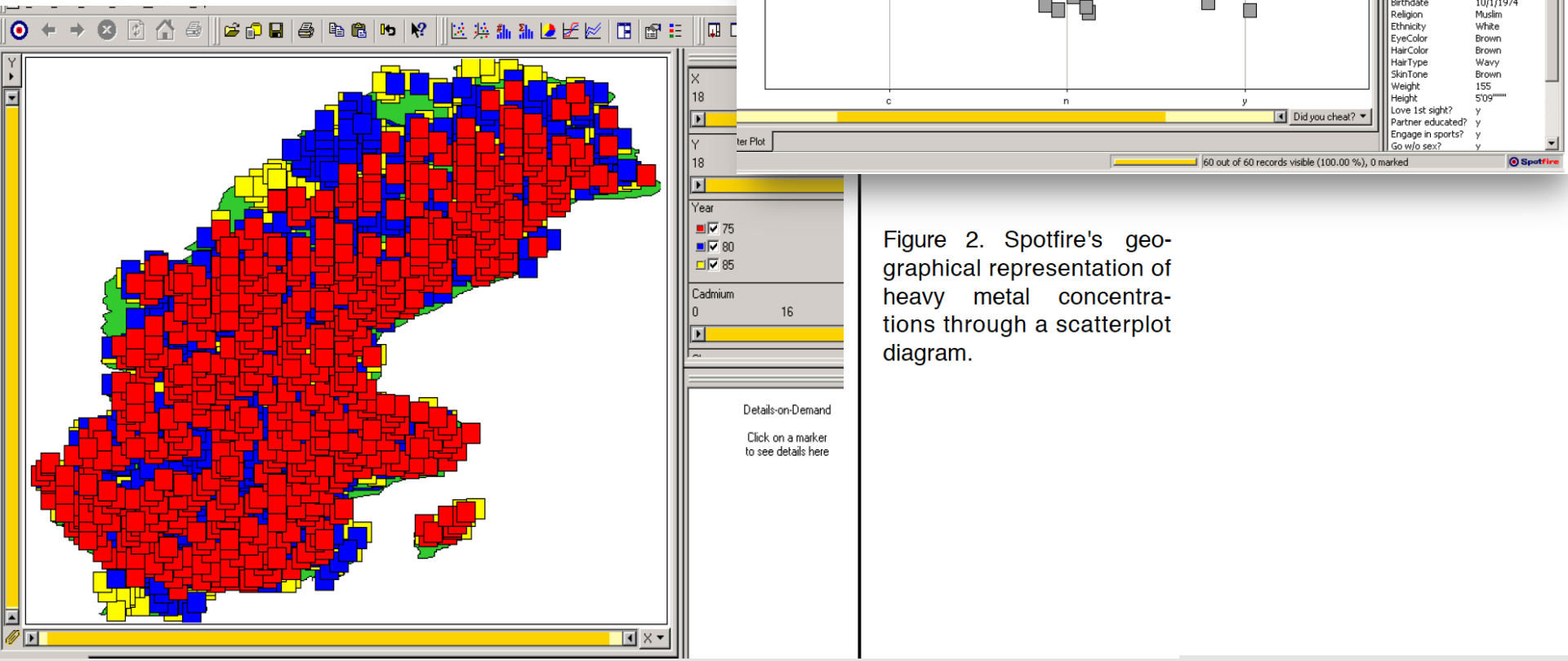
Spotfire



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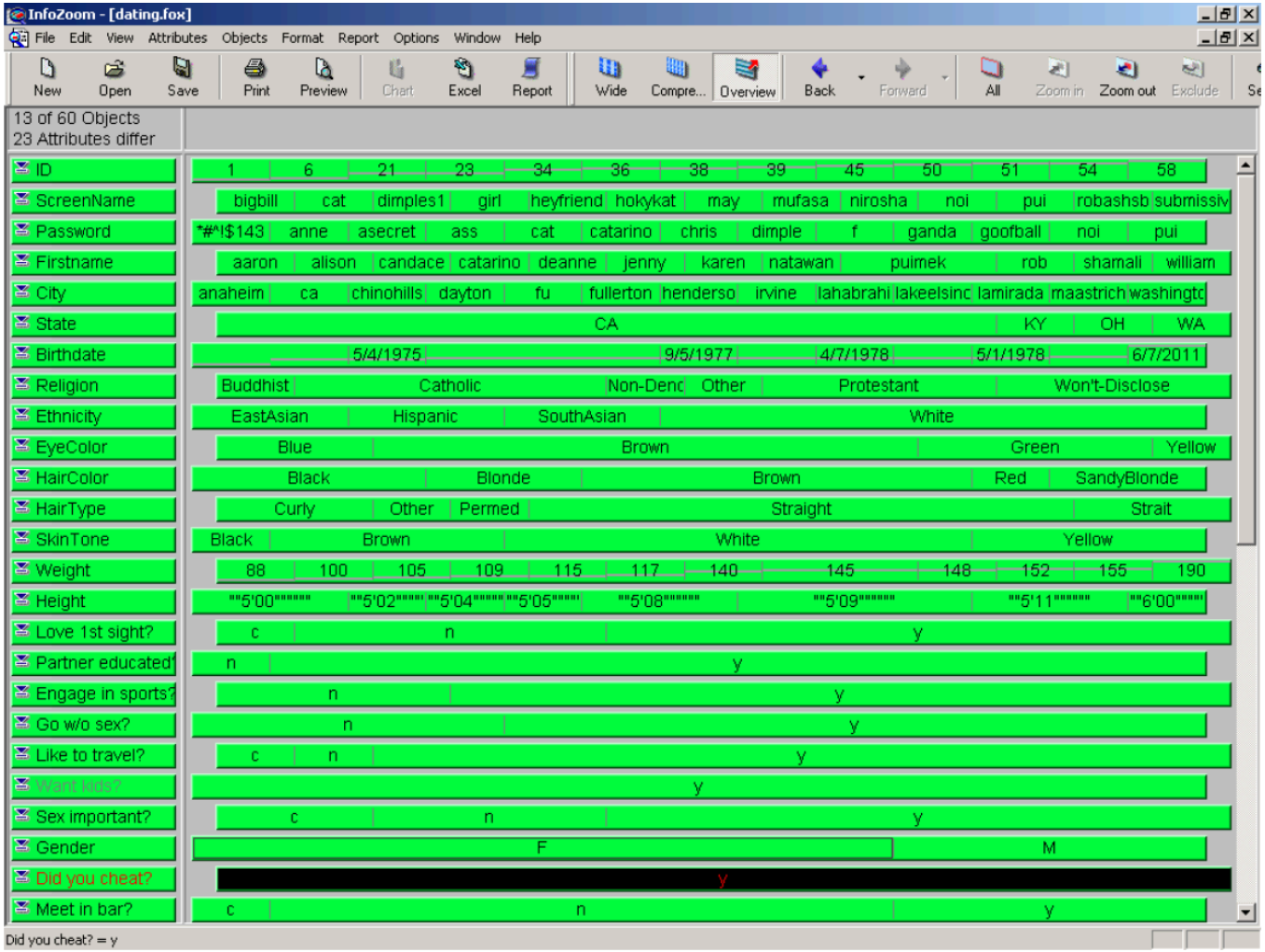
InfoZoom



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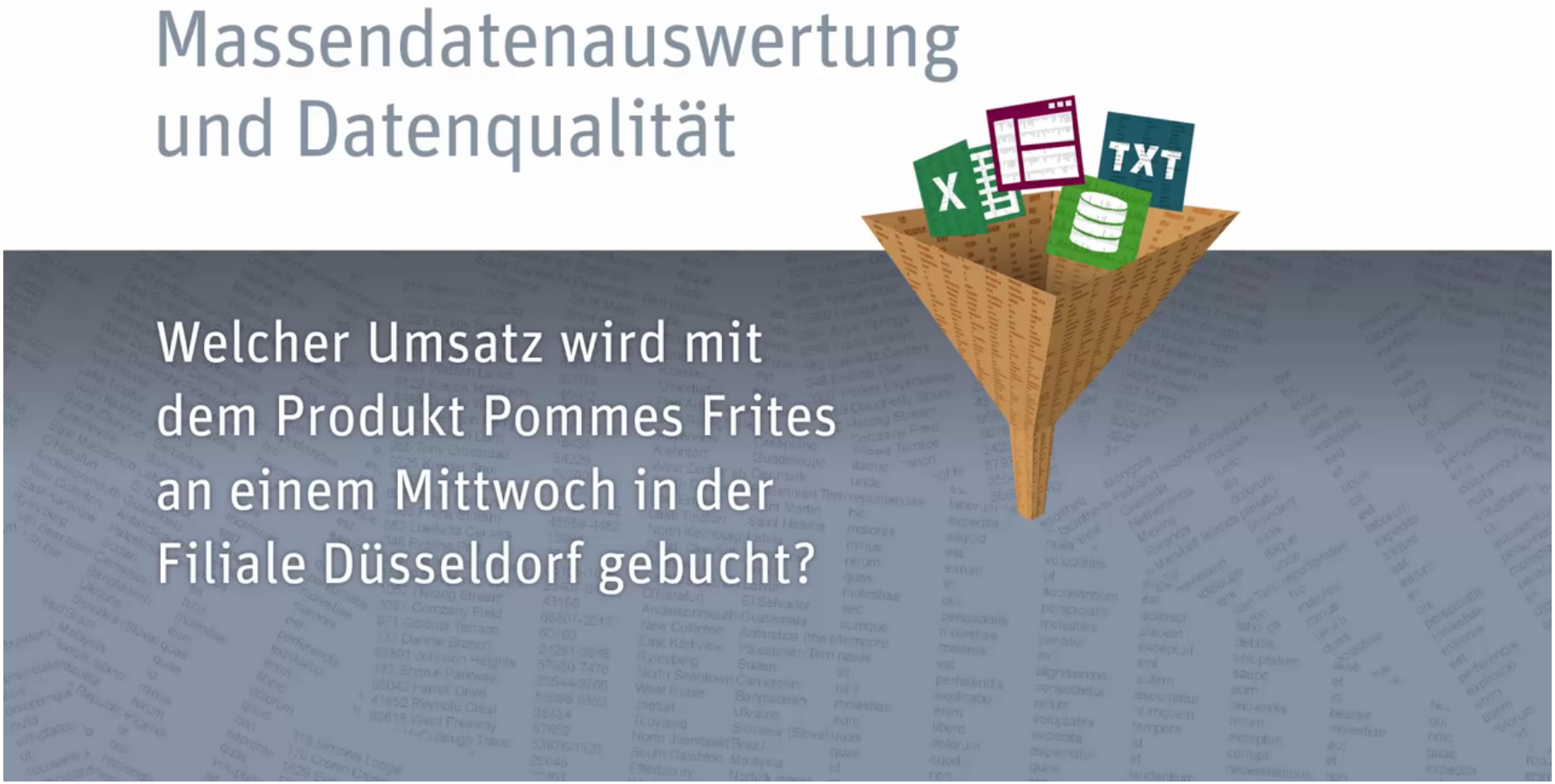
InfoZoom Video

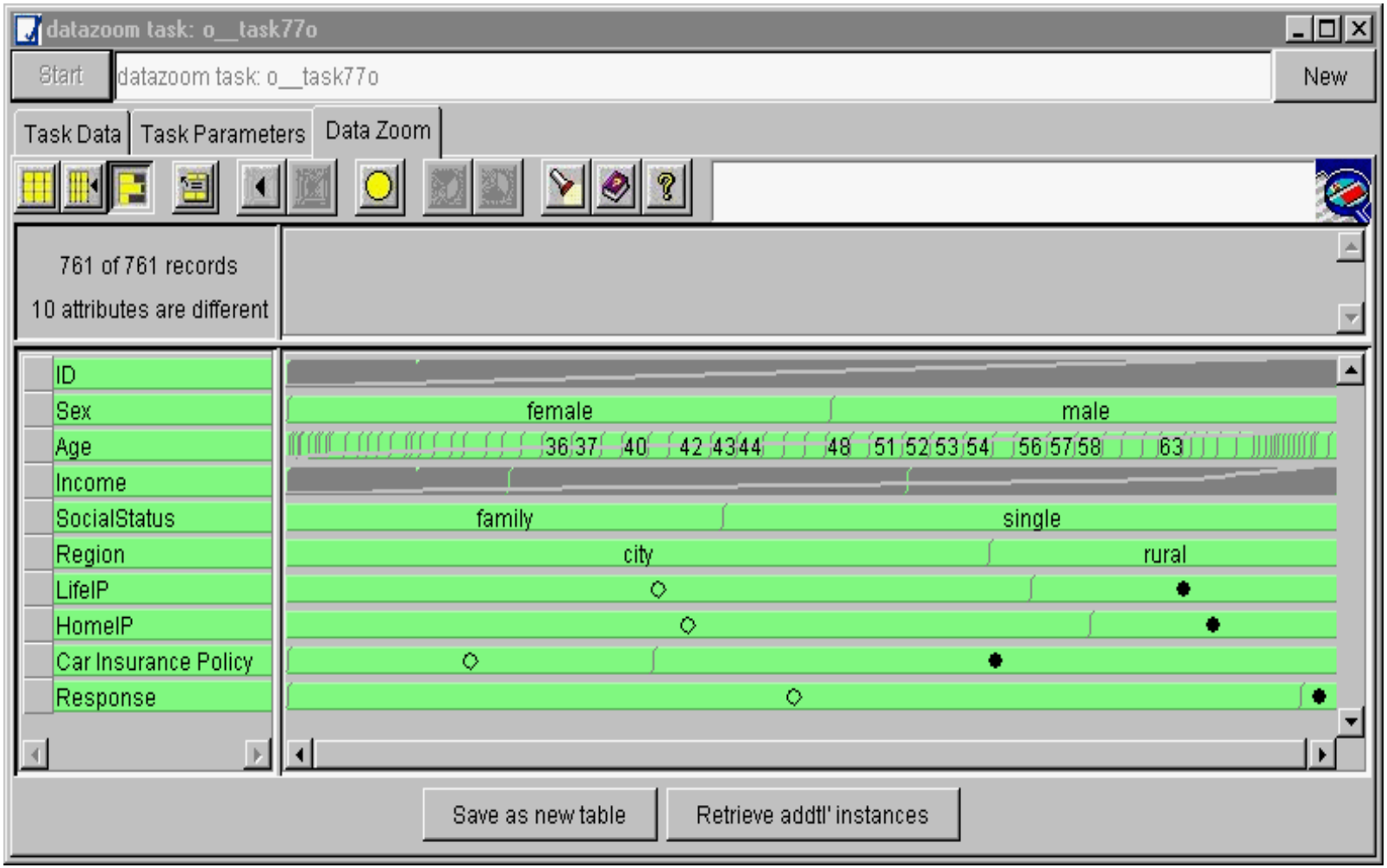


https://www.youtube.com/watch?v=Eib7vUZSX1Y

InfoZoom

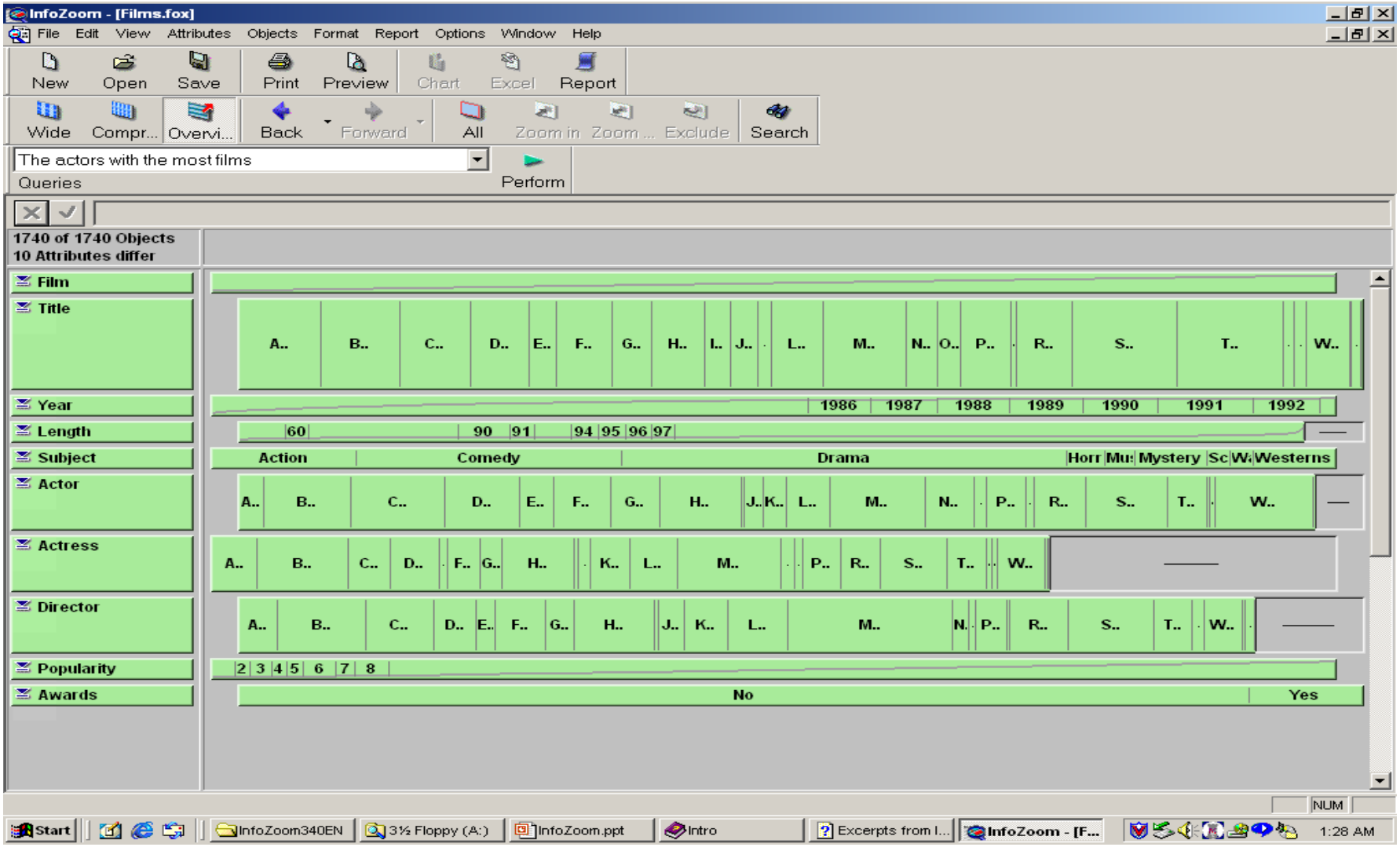
- Presents data in three different views
  - Overview mode has all attributes in ascending or descending order and independent of each other
    - Best for data exploration
  - Wide view shows data set in a table format
    - A column represents a data item
    - Like a conventional spreadsheet
  - Compressed view packs the data set horizontally to fit the window width
    - A column represents a data item
    - Zoomed-out view like Table Lens

InfoZoom Overview View

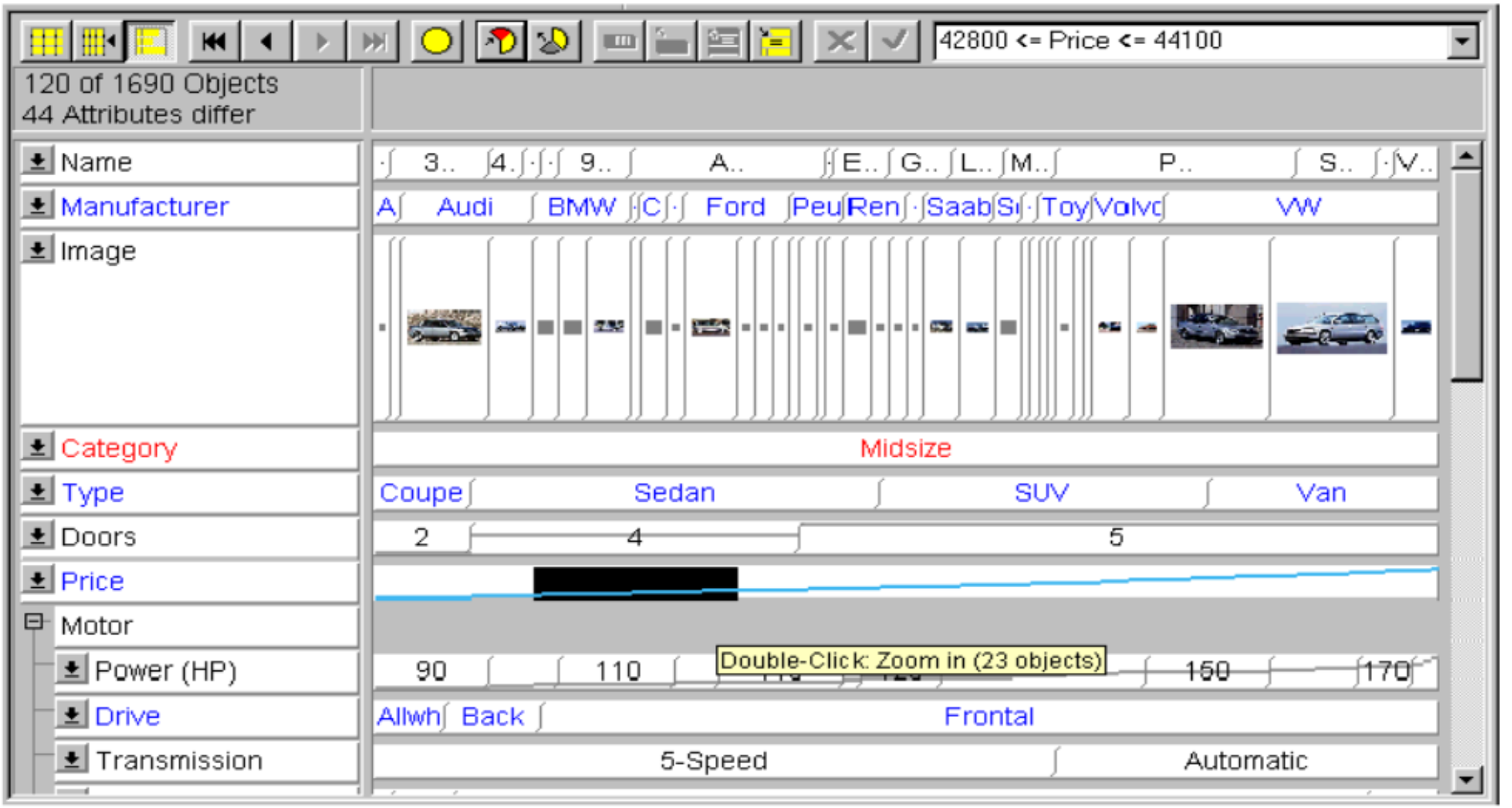


Slide by Alfred Kobsa

InfoZoom Overview View



InfoZoom Overview View (with hierarchy)

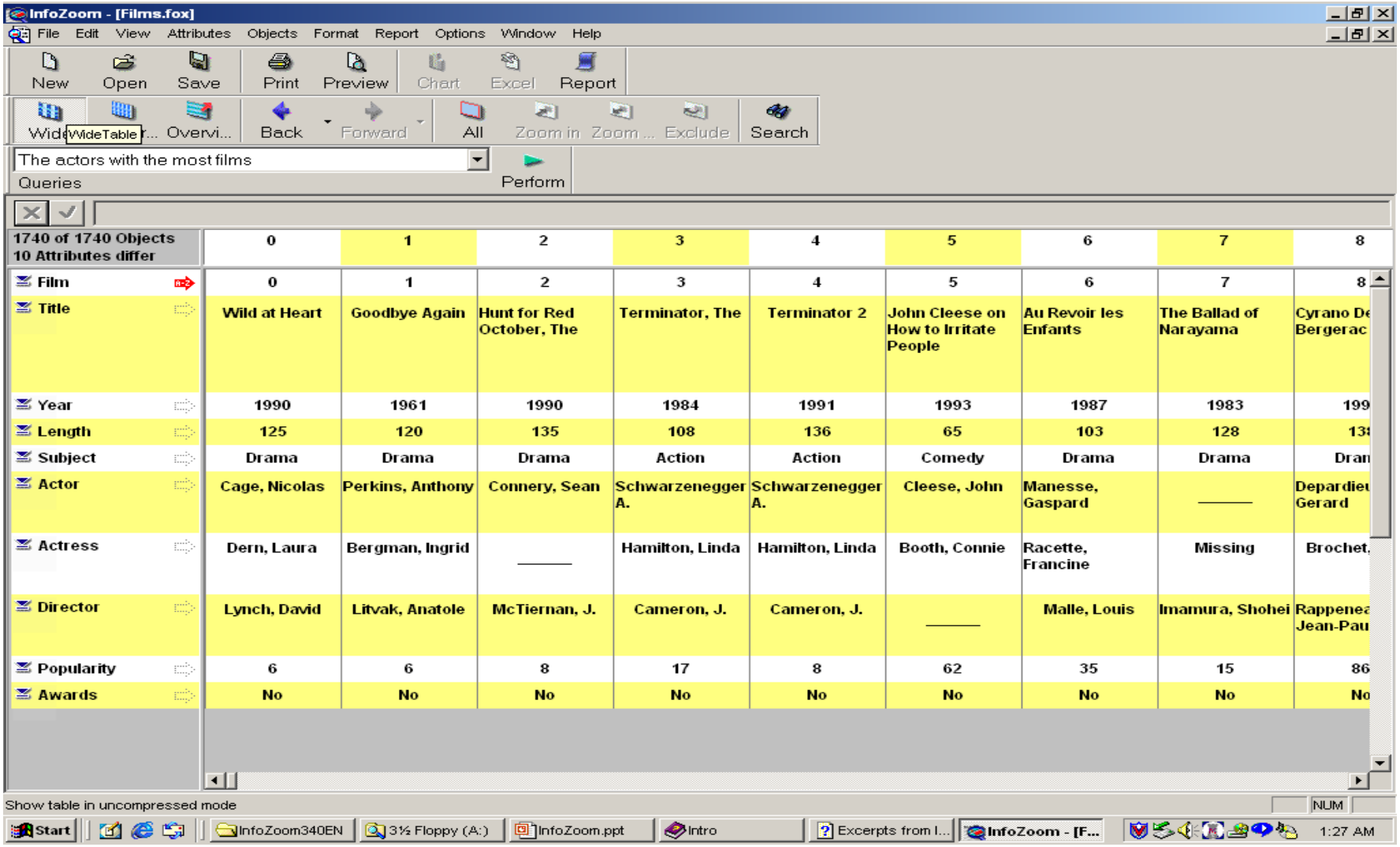


Slide by Alfred Kobsa

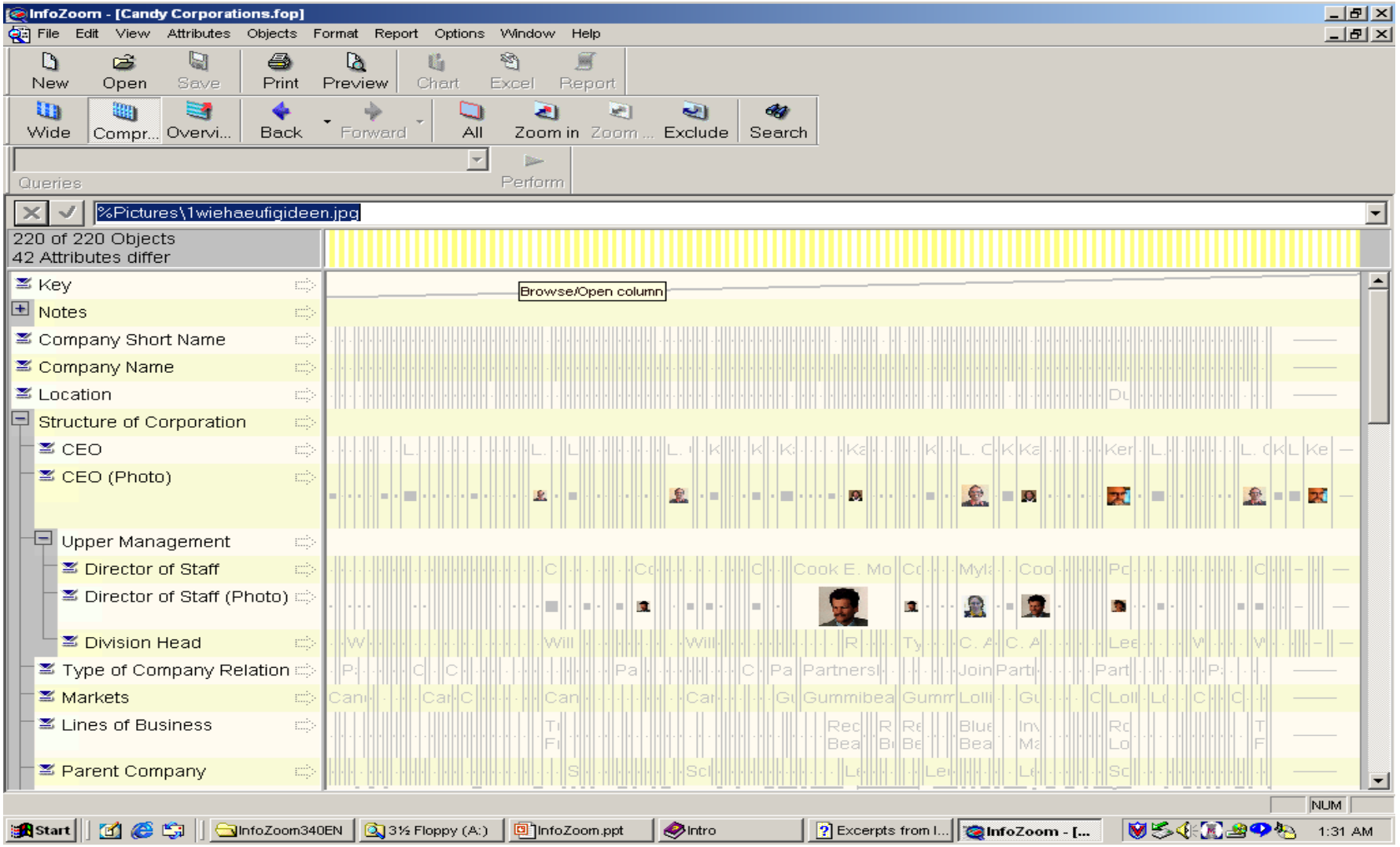
InfoZoom Wide Table View

4 of 1690 Objects 36 Attributes differ	Galaxy 1.9 TDI Autom. 110 PS	Espace 2.0 Autom.	Picnic 2.0 Autom.	Sharan 2.0 Autom.
Manufacturer	Ford	Renault	Toyota	VW
Image				
Category	Midsize			
Type	Van			
Price	465UU	47?3U	4435U	475UU
Beschleunigung [sek.]	17.8	13.7	11.7	17.2
Höchstgeschwindigkeit [	167	175	180	172
Gas	Diesel	Super		
Consumption				
Highway	5,2	7,9	7,8	8,5
City	8,5	12,8	13	16,1
Mix	6.5	9.7		11.3

InfoZoom Wide Table View



InfoZoom Compressed Table View



Datasets for Study

- Multidimensional data: three databases were used

- Anonymized data from a web based dating service
  - (60 records, 27 variables)
- Technical data of cars sold in 1970 – 82
  - (406 records, 10 variables)
- Data on the concentration of heavy metals in Sweden
  - (2298 records, 14 variables)

Slide by Kunal Garach

Brainstormed Questions/Tasks

- Questions/tasks generated in a brainstorming process without knowledge of the visualization systems
  - Aimed at high external validity
- Dating database
  - Do more women than men want their partners to have a higher education?
  - What proportion of the men live in California?
  - Do all people who think the bar is a good place to meet a mate also believe in love at first site?
- Car database
  - Do heavier cars have more horsepower?
  - Which manufacturer produced the most cars in 1980?
  - Is there a relationship between the displacement and acceleration of a vehicle?

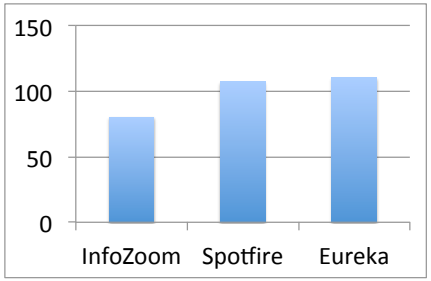
Experiment Design

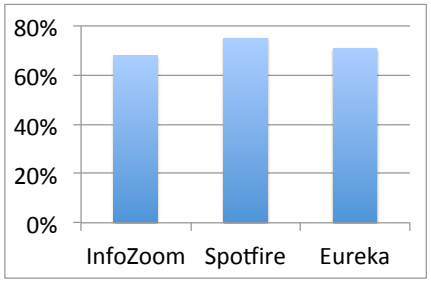
- 26 tasks (sum for the three data sets)
- 83 participants
- Between-subjects design
- Each was given one visualization system and all three data sets
- Independent variable: Visualization system
- 30 min instruction
- 30 min practice tasks
- 2 x 30 min to solve the tasks of each data set
  - (26 tasks in 90 min)

Slide adapted from Kunal Garach

Overall Results

- Mean task completion times
  - InfoZoom users: 80 secs
  - Spotfire users: 107 secs
  - Eureka users: 110 secs
- Answer correctness
  - InfoZoom users: 68%
  - Spotfire users: 75%
  - Eureka users: 71%
- Not a time-error tradeoff
  - Dominated by a few tasks
  - Spotfire more accurate on only 6 questions

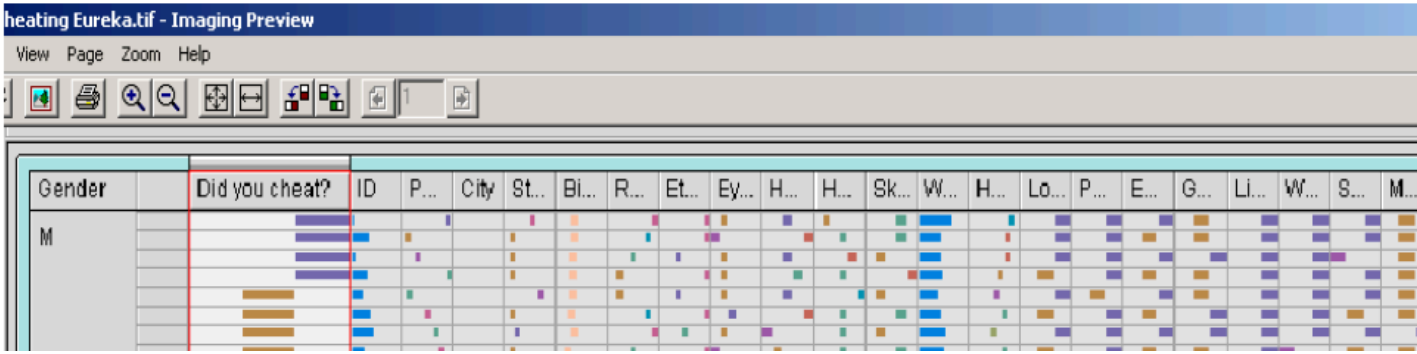




Slide by Kunal Garach

Eureka – Problems

- Hidden labels: Labels are vertically aligned, max 20 dimensions
- Problems with queries involving 3 or more attributes
- Correlation problems: Some participants had trouble answering questions correctly that involved correlations between two attributes.

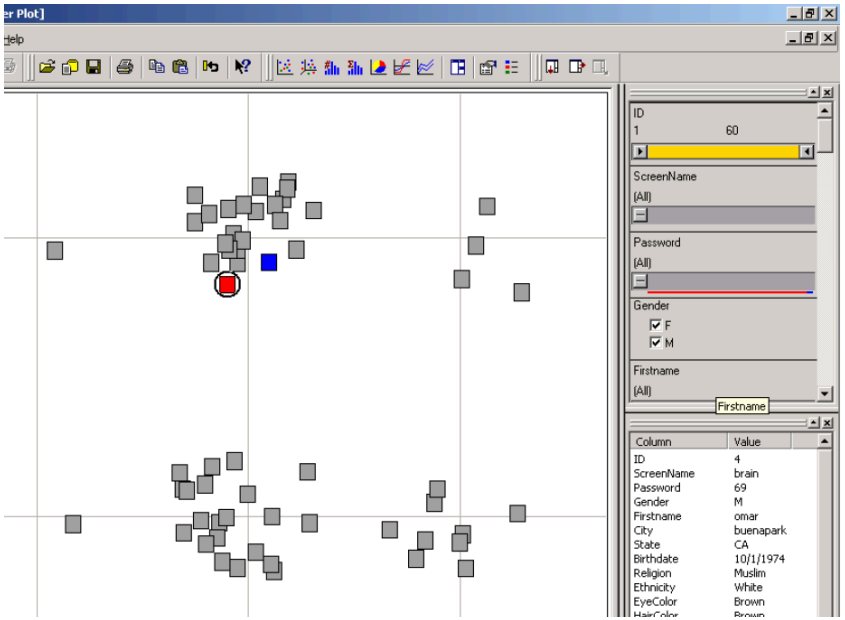


Slide by Kunal Garach

Spotfire – Problems

- Cognitive setup costs: Takes participants considerable time to decide on the right representation and to correctly set the coordinates and parameters

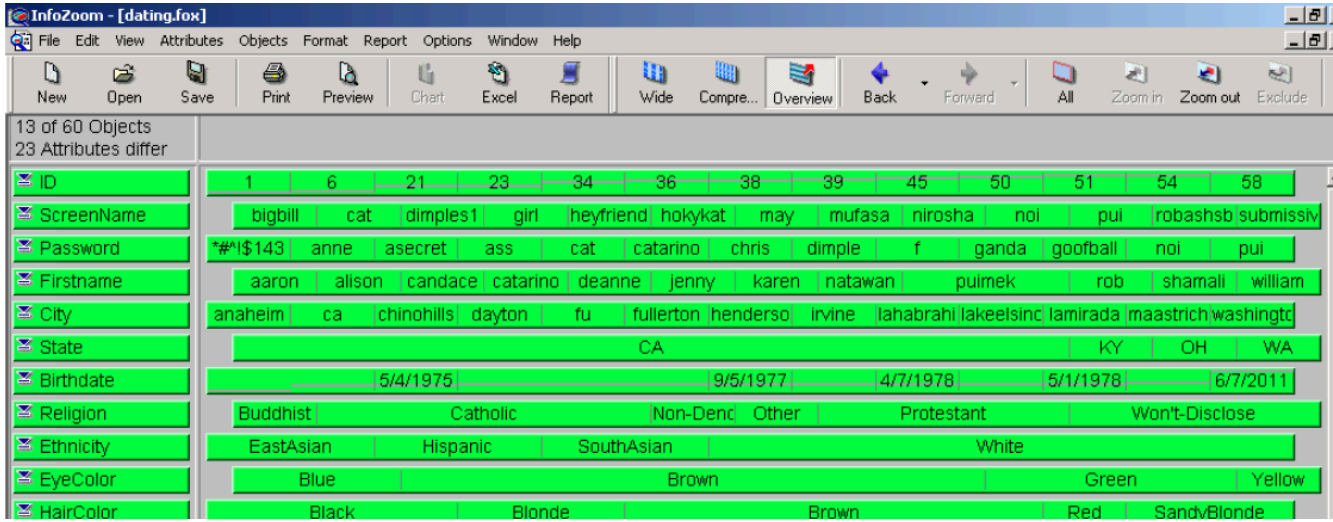
- Biased by scatterplot default: Though powerful, many problems cannot be solved (well) with it



Slide by Kunal Garach

InfoZoom – Problems

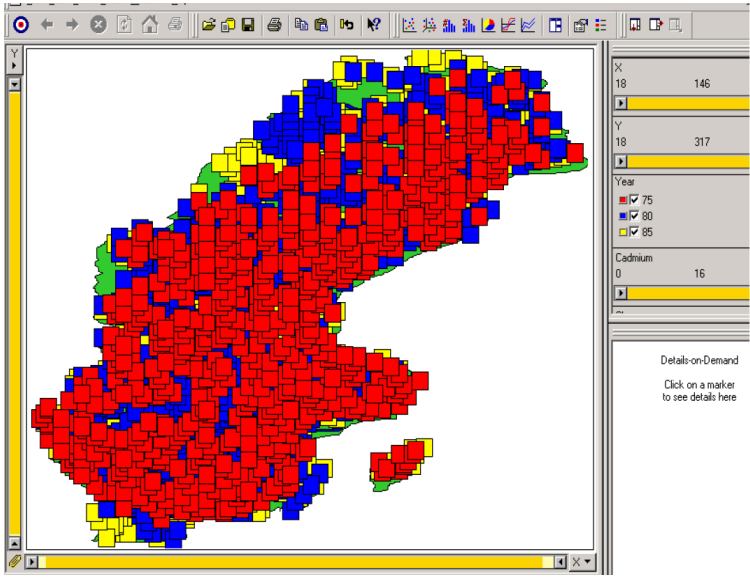
- Erroneous Correlations
  - People forget/don't realize that overview mode has all attributes sorted independent of each other
  - Narrow row height in compressed view
  - Participants did not use row expansion and scatterplot charting function which shows correlations more accurately



Slide by Kunal Garach

Geographic Questions

- Spotfire should have done better on these
  - Which part of the country has the most copper
  - Is there a relationship between the concentrations of vanadium and zinc?
  - Is there a low-level chrome area that is high in vanadium?
- Spotfire was only better only for the last question
  - (out of 6 geographic ones)



Discussion

- Many studies of this kind use relatively simple tasks that mirror the strengths of the system
  - Find the one object with the maximum value for a property
  - Count how many of certain attributes there are
- This study looked at more complex, realistic, and varied questions

Discussion

- Success of a visualization system depends on many factors
  - Properties supplied
    - Spotfire doesn't visualize as many dimensions simultaneously
  - Operations
    - Zooming easy in InfoZoom; allows for drill-down as well
    - Zooming in Eureka causes context to be lost
    - Column view in Eureka makes labels hard to see

Zooming, Focus + Context, Distortion

- Large amount of data in small space
- Maximize use of screen real estate
- Allow examination of a local area in detail within context of the whole data set

- Today's tools use one, two or all three of these techniques
  - (Zooming, Focus + Context, Distortion)

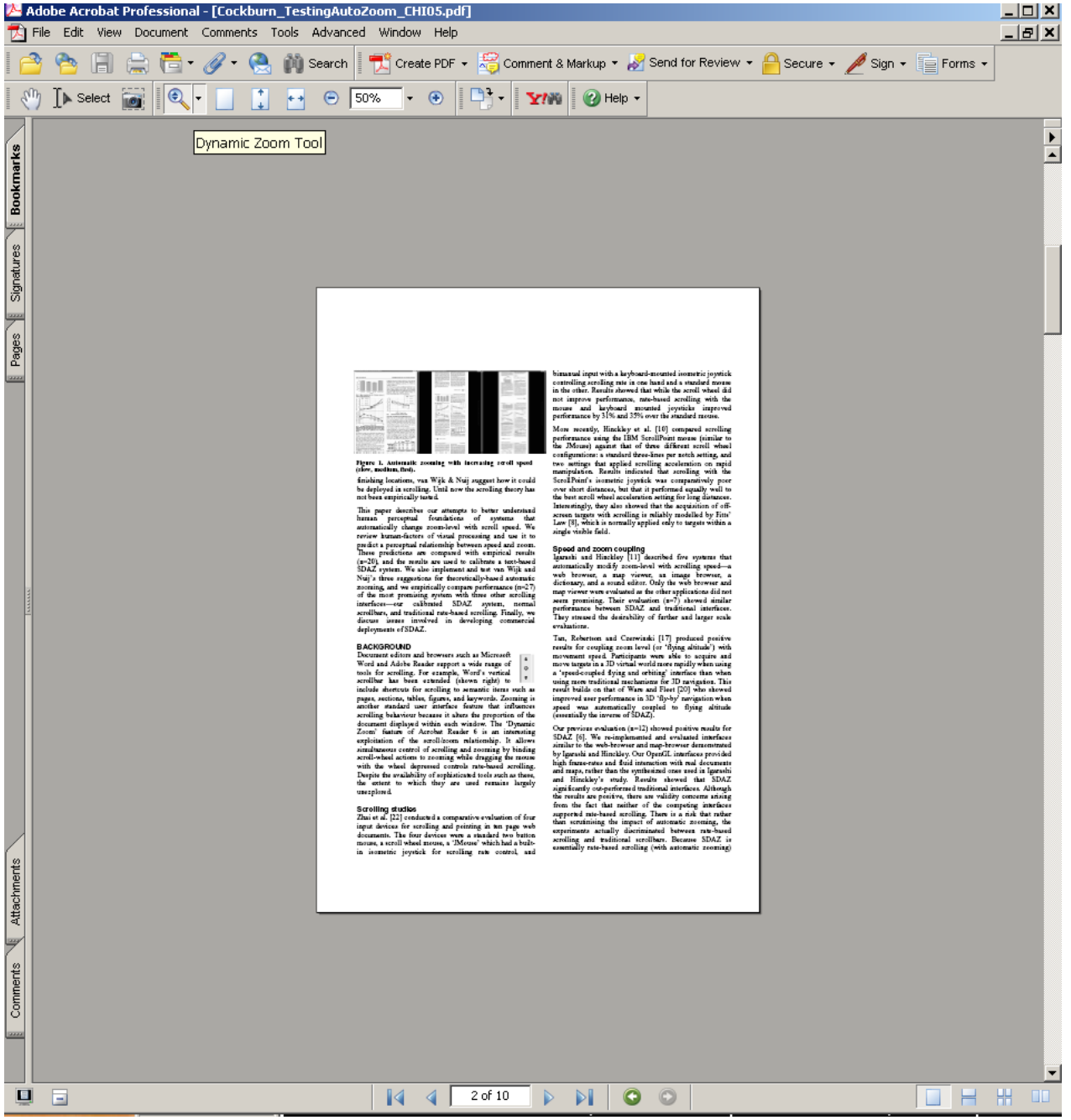
Slide adapted from Hornung & Zagreus

Zooming

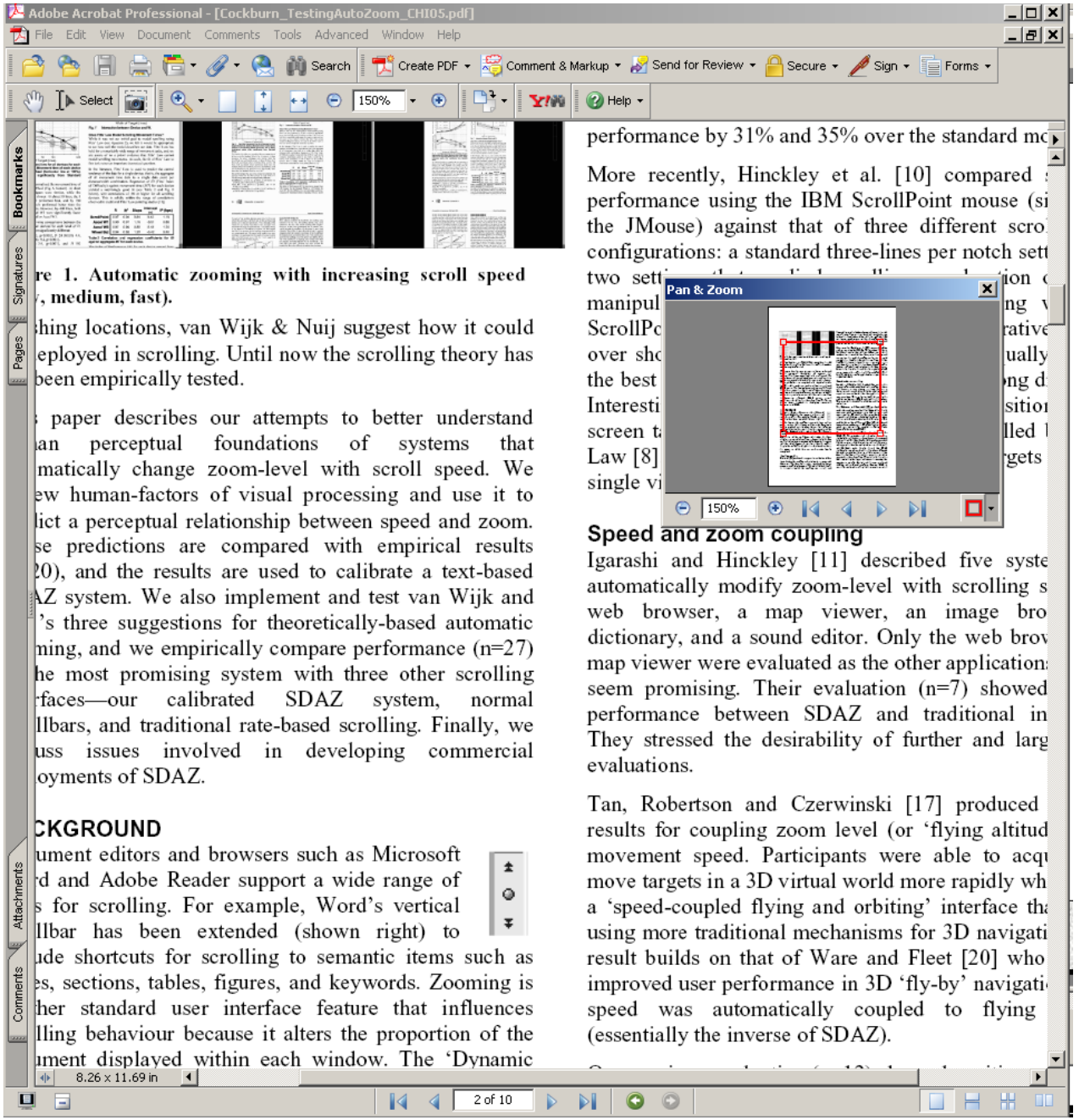
- Zoom in: Ability to see a portion in detail
  while seeing less of the overall picture
- Zoom out: See more of overall picture, but in less detail
- Animation clarifies relation between zoom levels
- Zooming vs. Overview + Detail

Slide adapted from Hornung & Zagreus

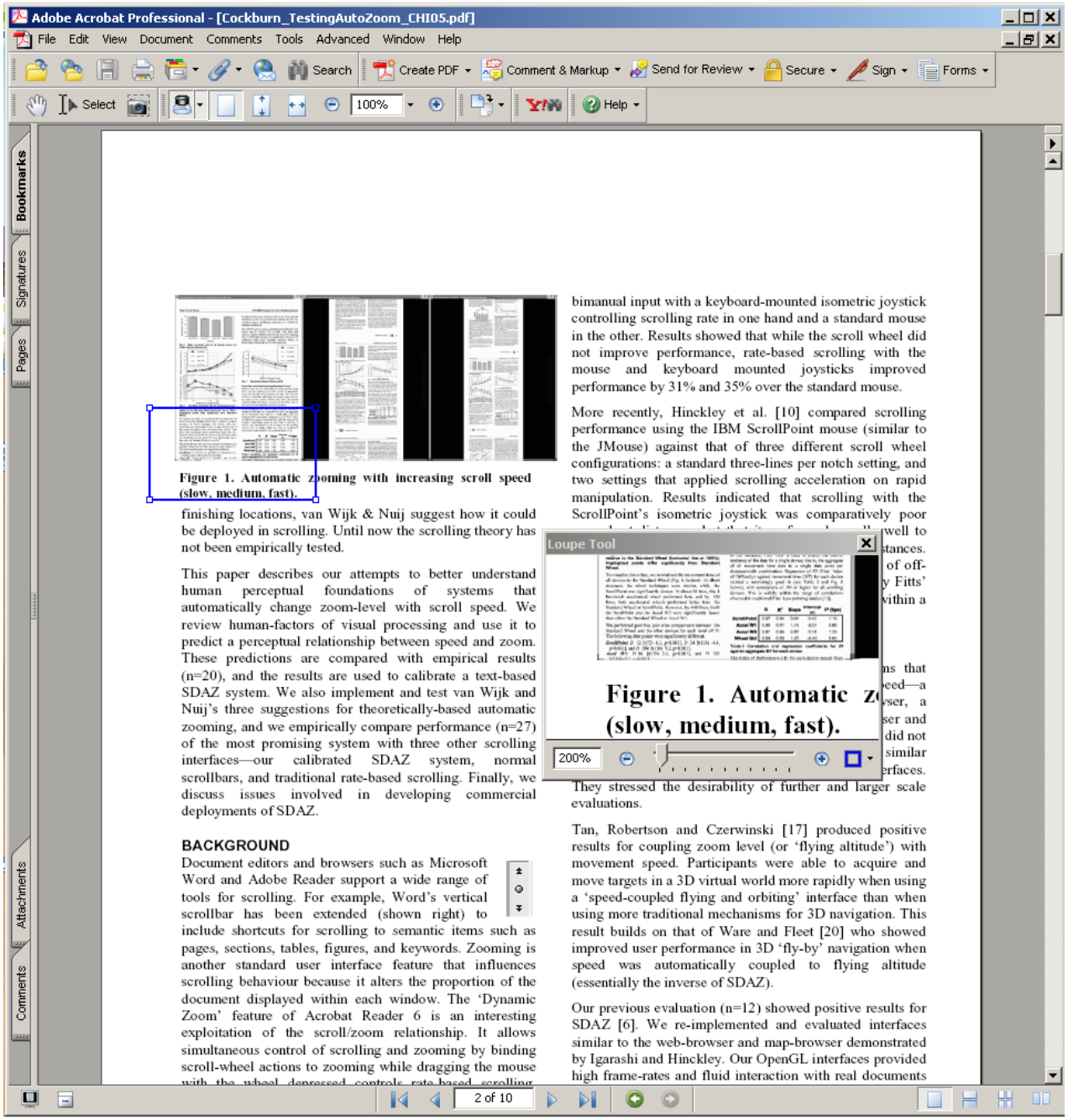
Dynamic Zoom Tool (Adobe PDF Reader)



Overview + Detail (Adobe PDF Reader)



Loupe (Adobe PDF Reader)

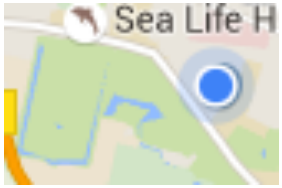


Semantic Zooming

- Geometric (standard) zooming
  - The view depends on the physical properties of what is being viewed
- Semantic zooming
  - When zooming away, instead of seeing a scaled-down version of an object, see a different representation
  - The representation shown depends on the meaning to be imparted

Examples of Semantic Zoom

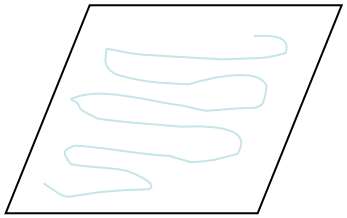
- Standard zoom
  - Image of a painting
  - Zoom in, see pixels
- Infinitely scalable painting program
  - Close in, see flecks of paint
  - Farther away, see paint strokes
  - Farther still, see the holistic impression of the painting

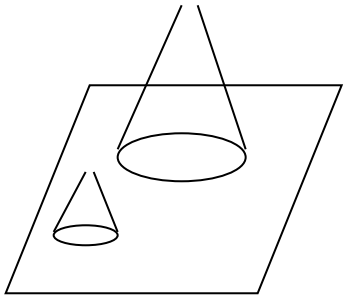


zoom in

Pad++ (1998)

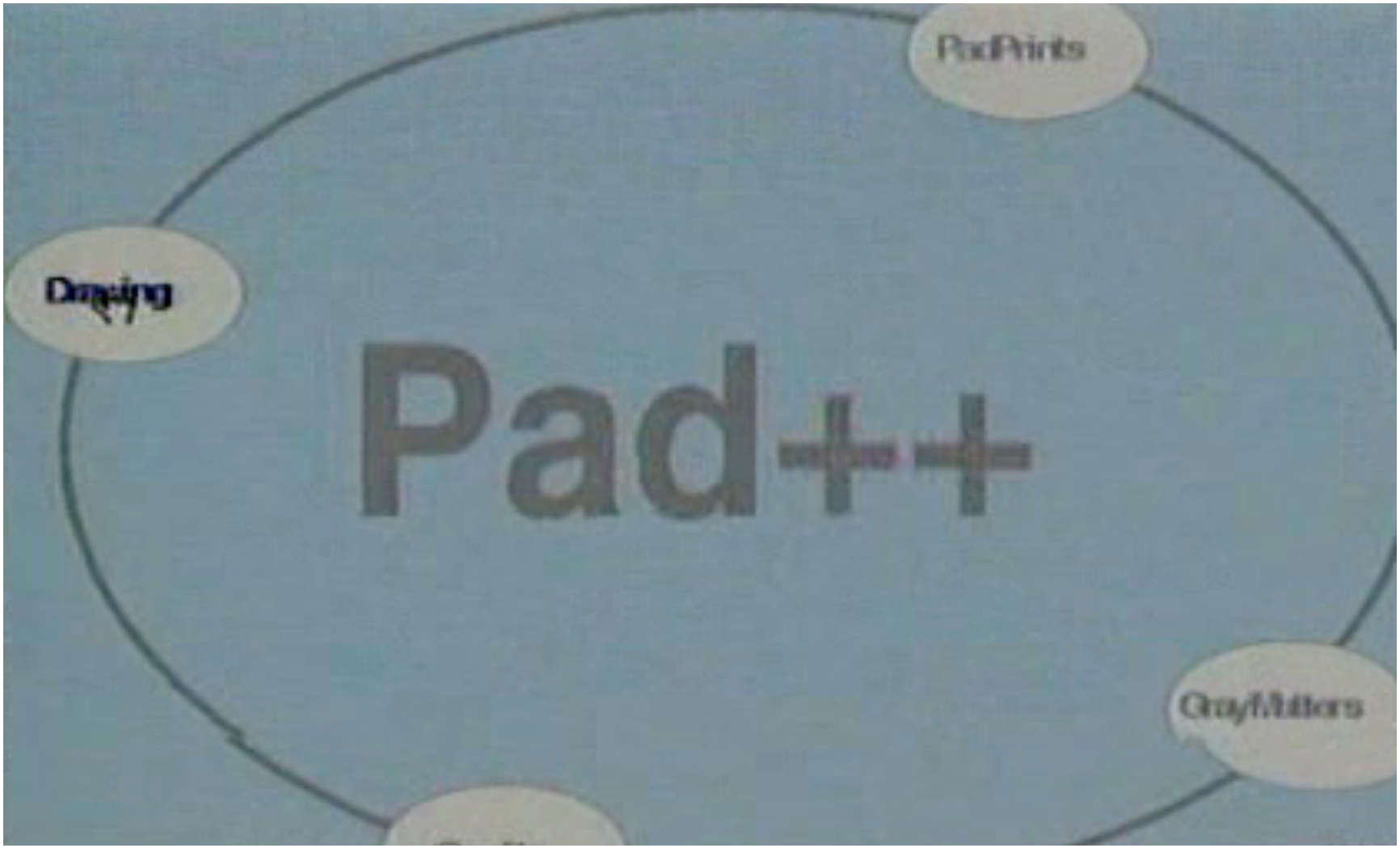
- A toolkit
- An infinite 2D plane
- Can get infinitely close to the surface too
- Navigate by panning and zooming
- Pan
  - Move around on the plane
- Zoom
  - Move closer to and farther from the plane





- Can do all this with JavaFX easily

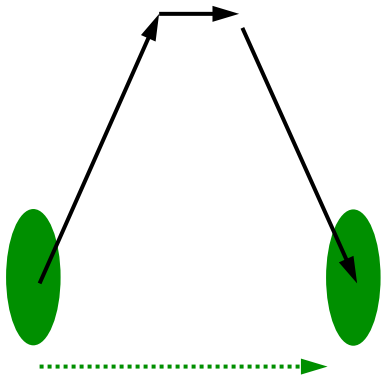
Pad++ Video



http://hcil.cs.umd.edu/video/1998/1998_pad.mpg

Navigation in Pad++

- How to keep from getting lost?
- Animated “hyperlinks” for traversal from one object to another
  - If the target is more than one screen away, zoom out, pan over, and zoom back in
- Goal: Help user maintain context



Speed-Dependent Zooming

- Navigation technique that integrates rate-based scrolling with automatic zooming
  - Igarashi & Hinckley, UIST 2000; Cockburn et al., CHI 2005
- Adjust zoom level automatically to prevent "extreme visual flow"
  - Automatically zoom out when going fast, zoom in when slowing down
  - Uses semantic zooming to provide context

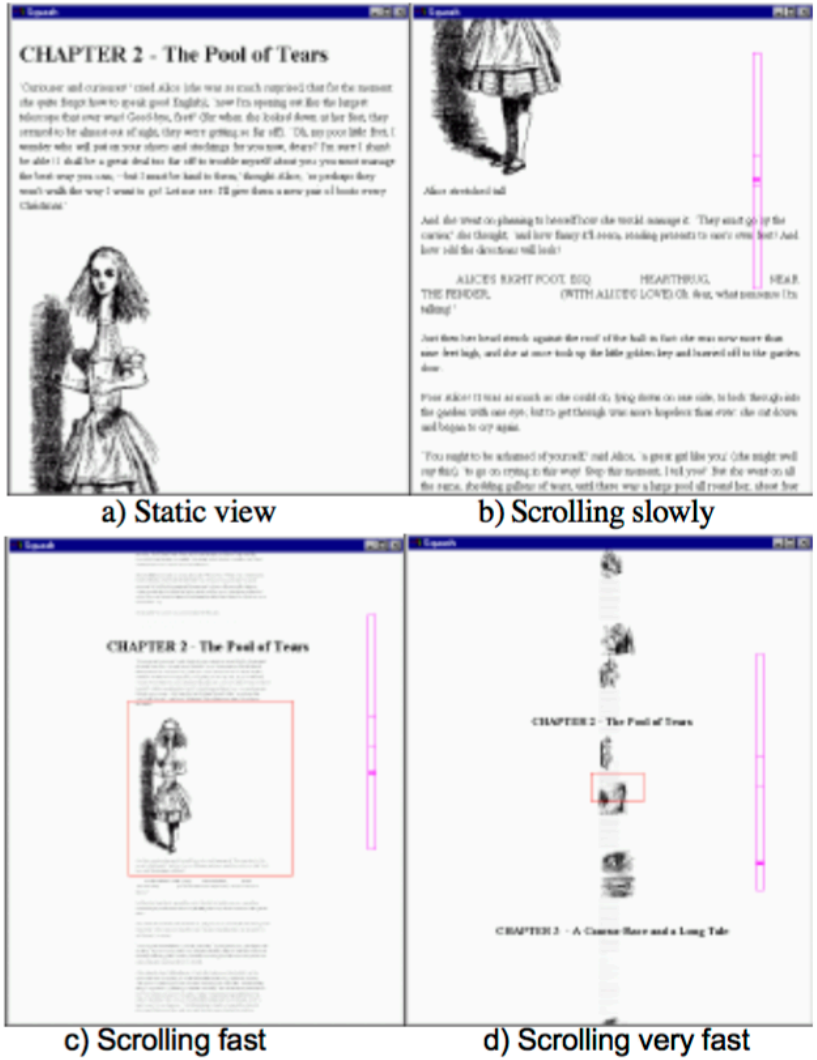


Figure: Igarashi & Hinckley: Speed-dependent Automatic Zooming for Browsing Large Documents, UIST 2000.

Speed-Dependent Zooming

- Applied to
  - Large Documents
    - (successful in a small study)
  - Image Collection
    - (not successful)
  - Maps
    - (mixed, needs work)
  - Dictionary
    - (not successful)
  - Sound Editor
    - (not successful)

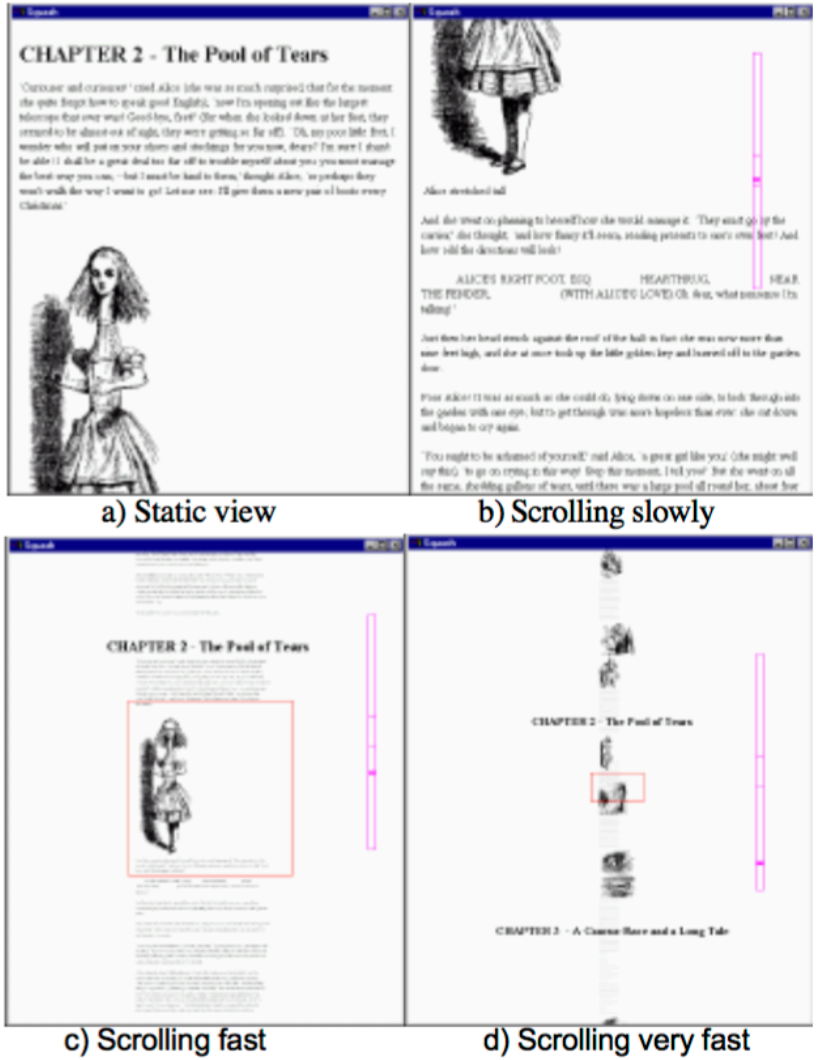
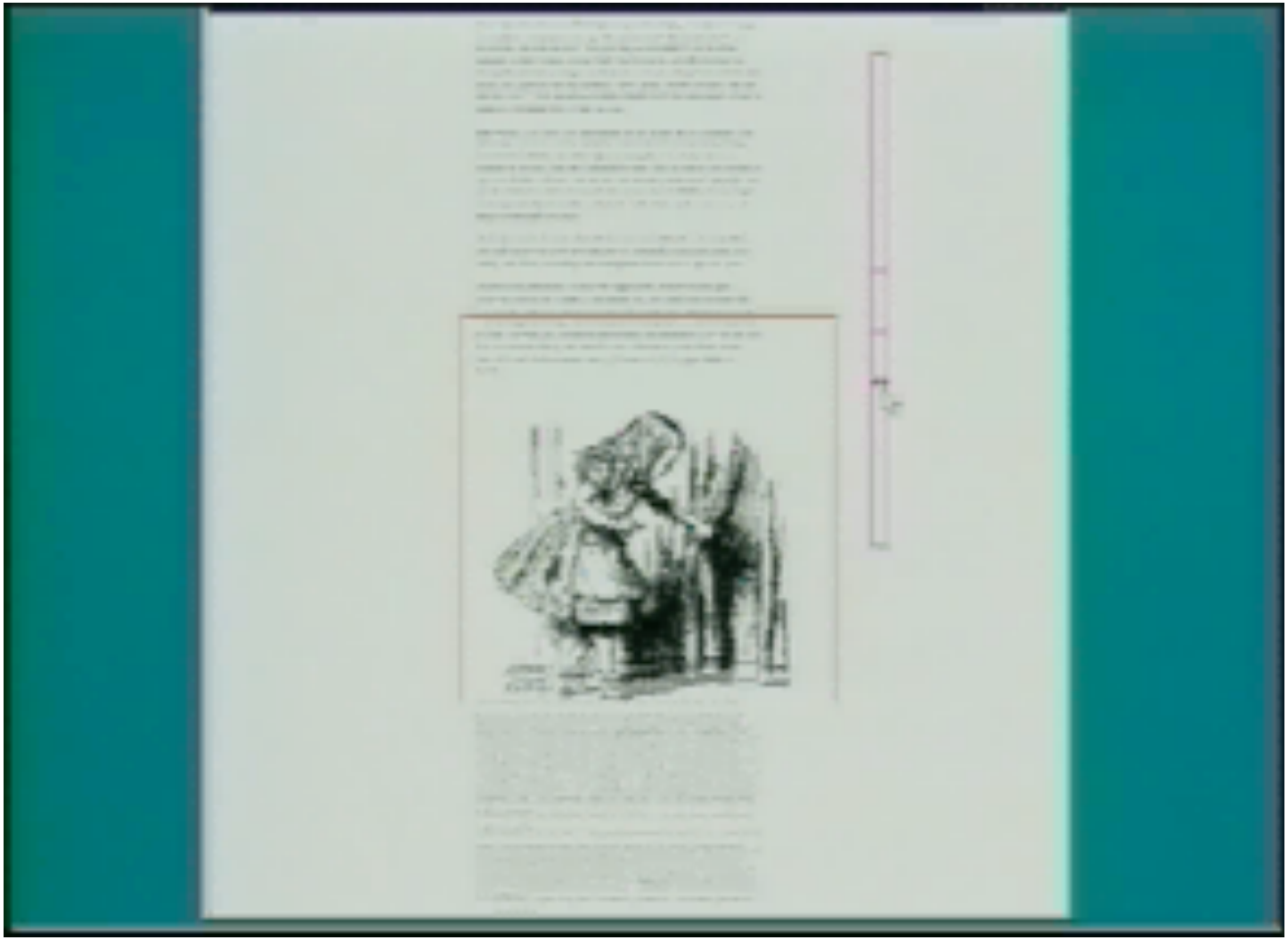


Figure: Igarashi & Hinckley: Speed-dependent Automatic Zooming for Browsing Large Documents, UIST 2000.

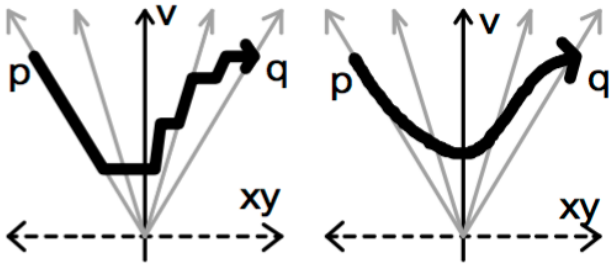
Speed-Dependent Zooming



http://www-ui.is.s.u-tokyo.ac.jp/~takeo/research/autozoom/autozoom.htm

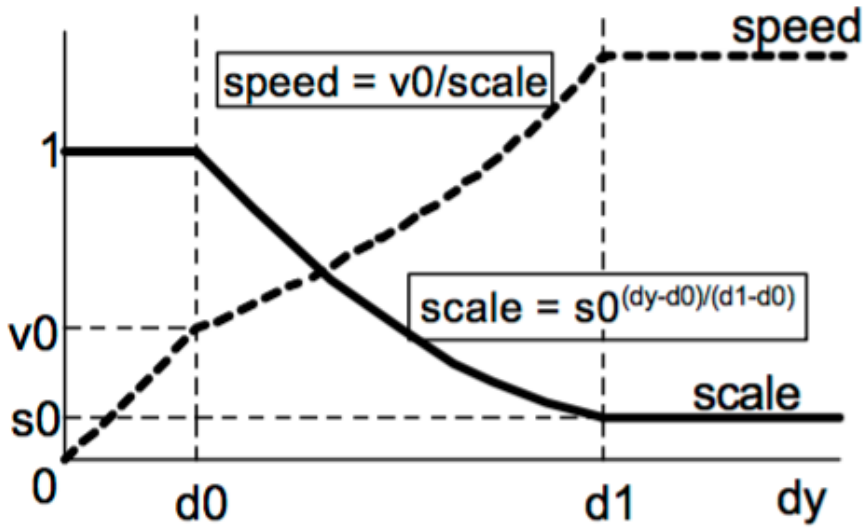
Speed-Dependent Zooming

- scale = $s_0^{\frac{d_y - d_0}{d_1 - d_0}}$
  - d_y: mouse speed (with $d_0 \leq d_y \leq d_1$)
  - s_0: minimum scale
  - d_0: mouse speed at which zooming starts
  - d_1: maximum mouse speed
- speed = v_0 / scale
- delay to avoid sudden zoom change



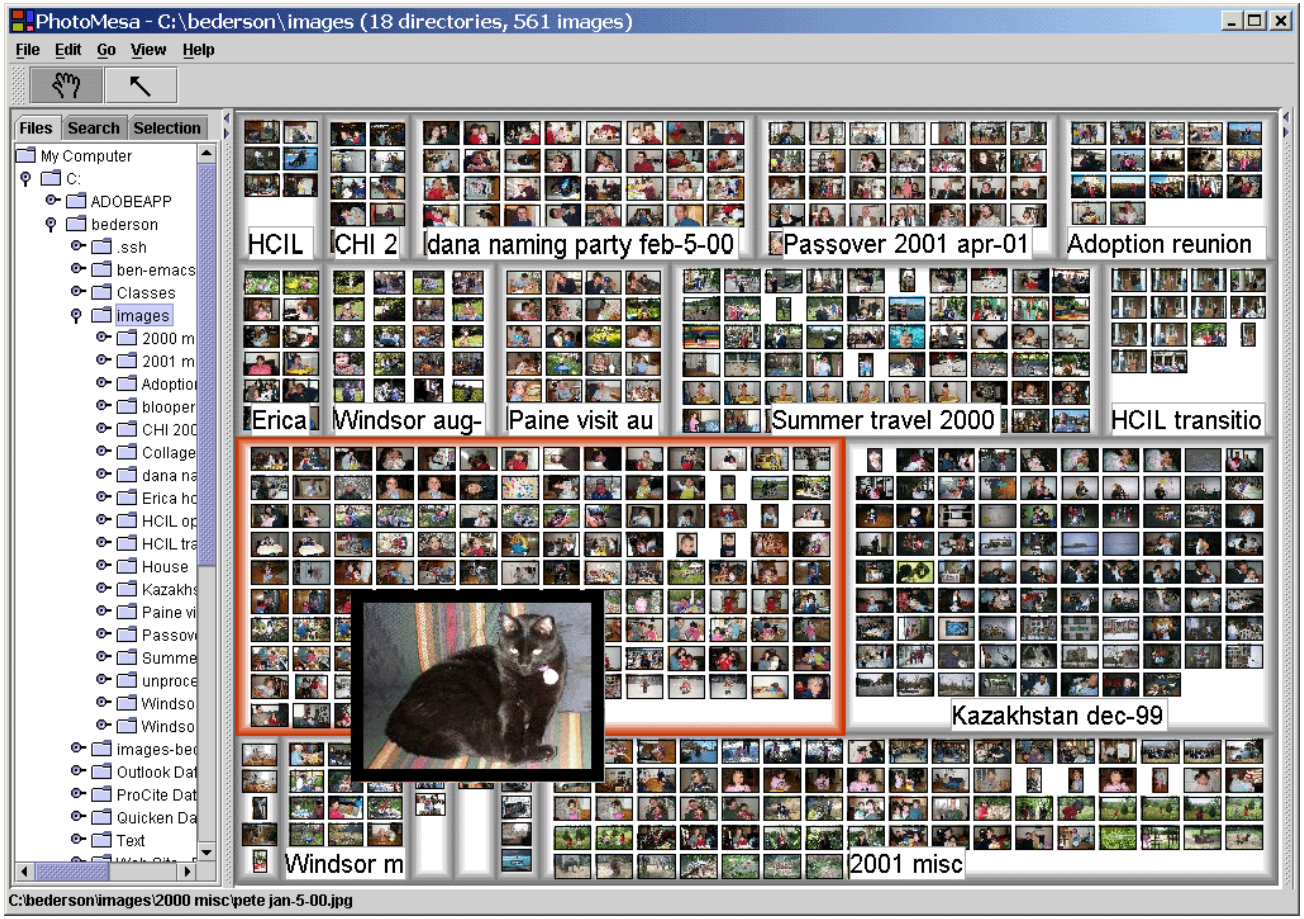
a) Manual zooming/panning. b) Automatic zooming.

Figure 2: Space-scale diagram [8] of the pan-zoom trajectory. An efficient pan-zoom trajectory results from speed dependent automatic zooming. (v=scale, xy=space, p=initial position, q=target position)



Figures: Igarashi & Hinckley: Speed-dependent Automatic Zooming for Browsing Large Documents, UIST 2000.

PhotoMesa: Zoomable Image Browser Using Quantum Treemaps and Bubblemaps



http://www.cs.umd.edu/hcil/photomesa

Slide adapted from Hornung & Zagreus

PhotoMesa Interface

PhotoMesa: A Zoomable Image Browser Using Quantum Treemaps and Bubblemaps, B. Bederson, UCM UIST 2001

- Zooming is primary presentation mechanism
- Zoom in, zoom out on levels of thumbnails
- Quickly drill down to individual picture (at full resolution)
- Outline shows area of next zoom level
- History of views
- Thumbnail zooms up when hover with cursor
- Export images
- Cluster by filename

Slide adapted from Hornung & Zagreus

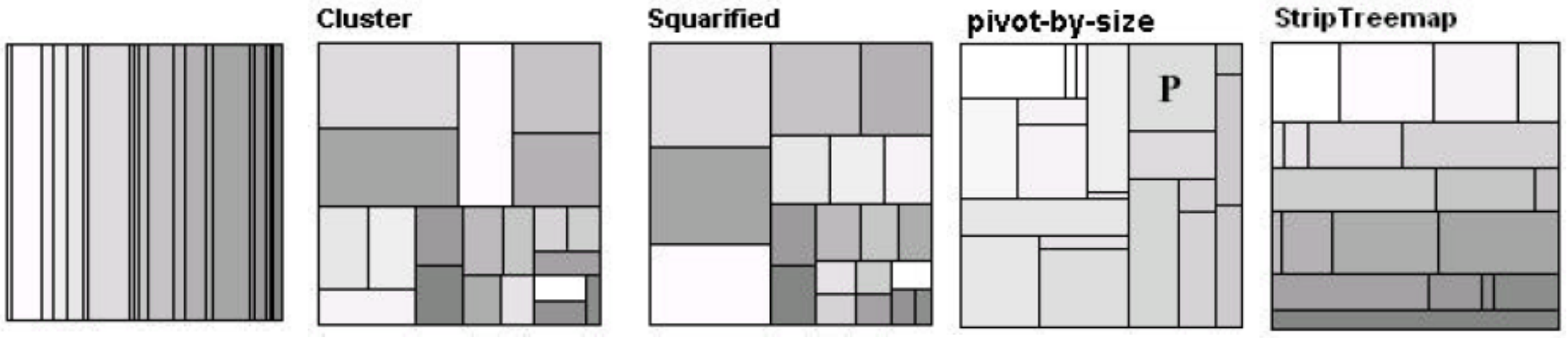
PhotoMesa Goals

- Automatically lay out images
- Use immediately – little setup time
- Large set of images in context
- Default groupings are by directory, time, or filename
- Can add metadata

Slide adapted from Hornung & Zagreus

Quantum Treemaps

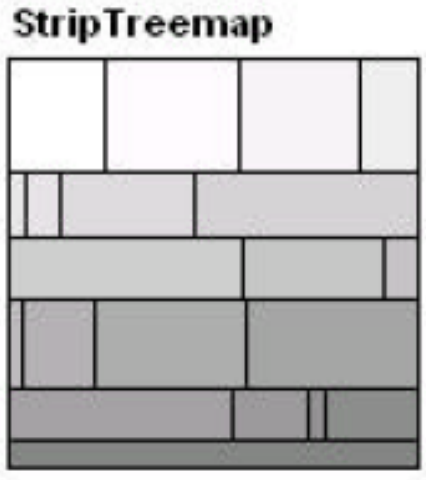
- Conventional treepmaps do not preserve order
  - Instability on updates
  - Less suitable for quantum-sized objects, like images
- Quantum treemaps
  - Aim to preserve order
  - Rectangles are integral multiples of an input object size
  - Improves readability



Figures: Bederson, Shneiderman: Ordered and Quantum Treemaps: Making Effective Use of 2D Space to Display Hierarchies

Strip Treemap Algorithm (Bederson and Shneiderman)

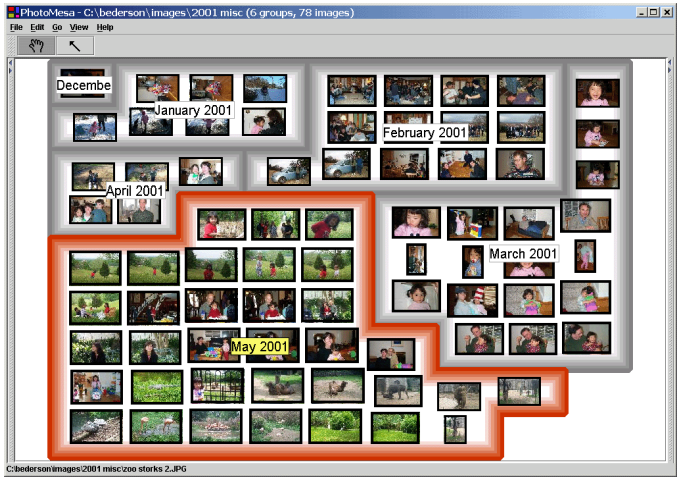
1. Scale the area of all the rectangles so that the total area of the input rectangles equals that of the layout rectangle.
2. Create a new empty strip, the current strip.
3. Add the next rectangle to the current strip, recomputing the height of the strip based on the area of all the rectangles within the strip, and then recomputing the width of each rectangle.
4. If the average aspect ratio of the current strip has increased as a result of adding the rectangle in step 3, remove the rectangle pushing it back onto the list of rectangles to process and go to step 2.
5. If all the rectangles have been processed, stop. Else, go to step 3.



Bederson, Shneiderman: Ordered and Quantum Treemaps: Making Effective Use of 2D Space to Display Hierarchies

Bubblemaps

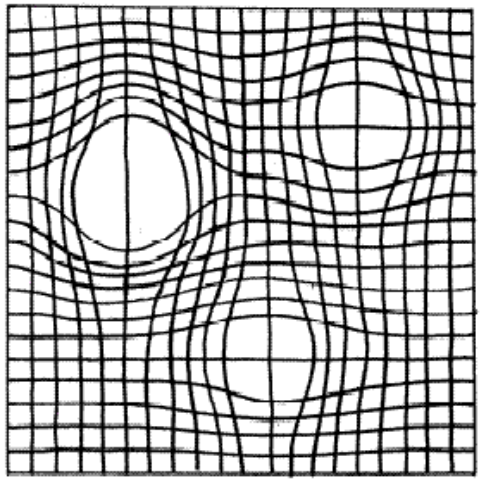
- Like Quantum Treemaps, elements guaranteed to be same size
- Arbitrary shapes
- No wasted space
- May be harder to visually parse than Quantum Treemaps



Slide adapted from Hornung & Zagreus

Distortion-Based Views

- (The following slides are based on the classic paper by Leung & Apperly '94.)
- How to show large amounts of information in a static space?
- Non-distortion-oriented approaches
  - Displaying a portion of the information at a time
  - Scrolling or paging access
  - Providing hierarchical access
  - Structure-specific presentation



Slide adapted from Fengdong Du

Distortion-Based Views

- Distortion-oriented Approaches
  - Distort an image of a large amount of information so that it fits on screen
  - Allow the user to examine a local area in detail
  - At the same time, present a global view of the information space
  - Provide navigation mechanism

Slide adapted from Fengdong Du

Idea of Distortion-Based Techniques

- Co-existence of local details with global context at reduced magnification
- A focus region to display detailed information
- Demagnified view of the peripheral areas is presented around the focus area

Slide adapted from Fengdong Du

Distortion-Based Views

- Treat the displayed information as it was printed on a stretchable rubber sheet with rigid frame
- Any stretching in one part of the sheet results in an equivalent amount of shrinkage in other areas.
- The consequence of the stretching and the shrinking of the sheet is an overall distorted view.

Slide adapted from Fengdong Du

Stretchable Rubber Sheet

- Treat the displayed information as if it was printed on a stretchable rubber sheet with rigid frame
- Any stretching in one part of the sheet results in an equivalent amount of shrinkage in other areas
- The consequence of the stretching and the shrinking of the sheet is an overall distorted view.

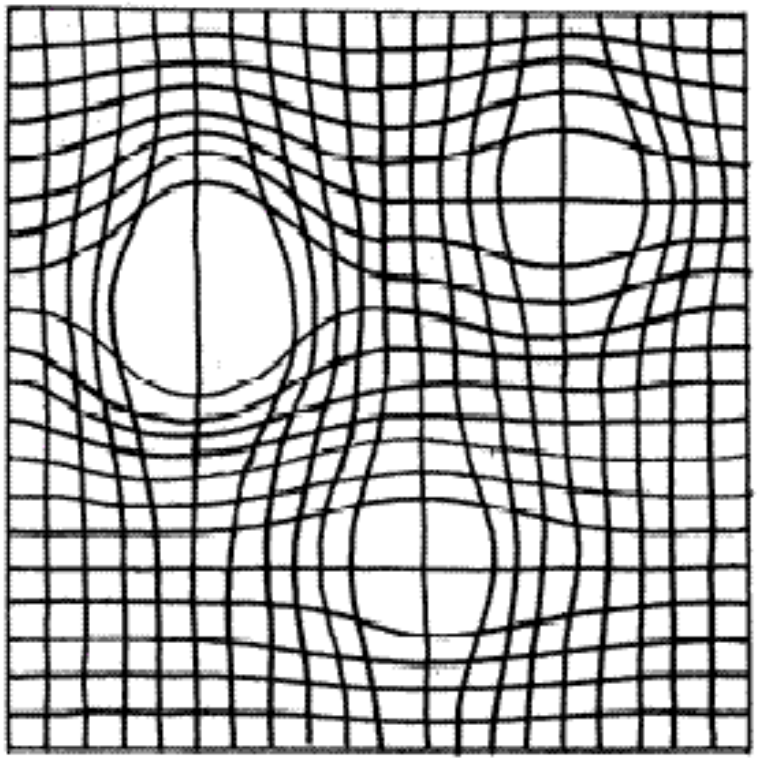


Image from Leung & Apperly 1994

Slide adapted from Fengdong Du

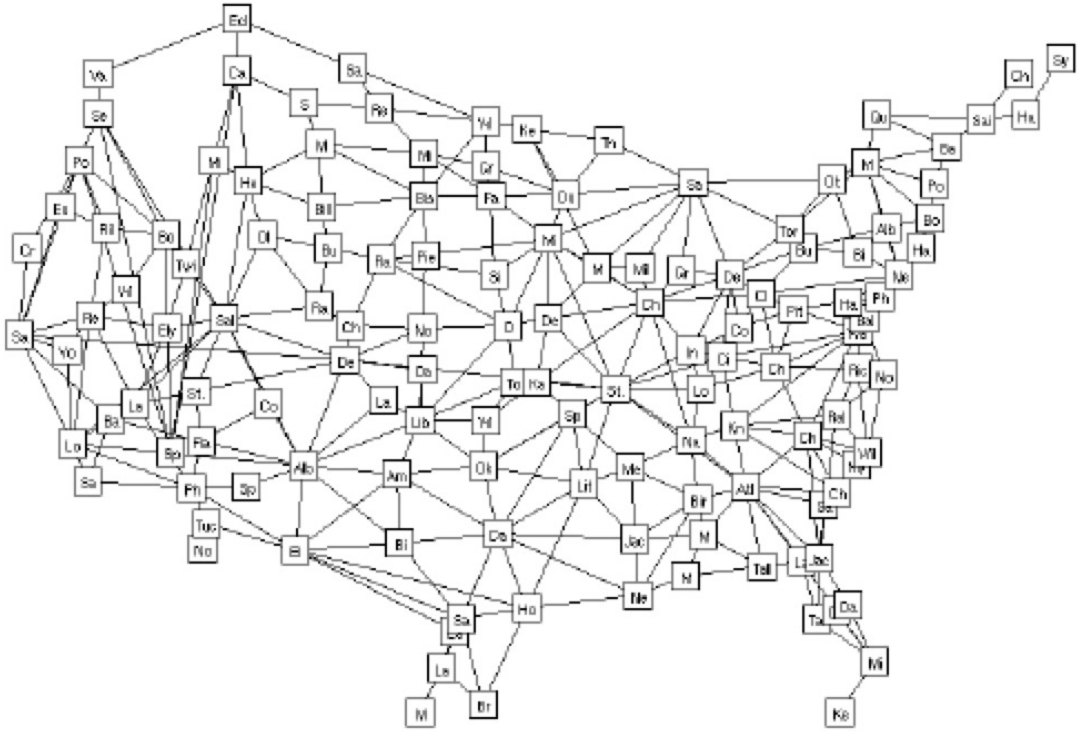


Figure 1: A graph with 134 vertices and 338 edges. The vertices represent major cities in the United States, and the edges represent paths between neighboring cities. (Typically, the edges would be annotated with the distance and driving time between the cities.) The *a priori importance* value assigned to each vertex is proportional to the population of the corresponding city. Fisheye views of this graph appear in Figures 2–6

Slide adapted from Fengdong Du

Image from Sarkar & Brown 1992

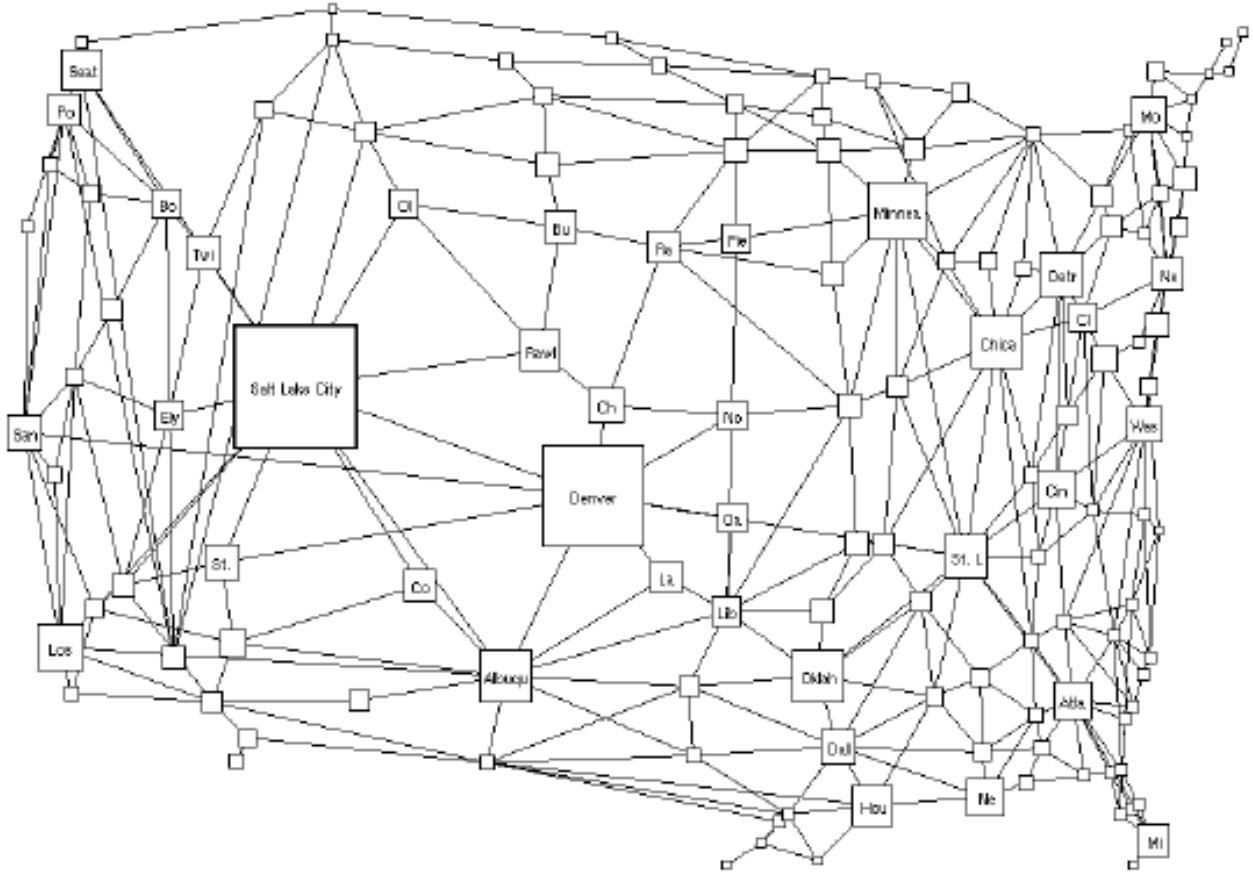


Figure 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City. The level of distortion is the same as in Figure 3; only the location of the focus has changed. The values of the fisheye parameters are $d = 2, c = 0.5, e = 0.5, VWcutoff = 0$.

Slide adapted from Fengdong Du

Image from Sarkar & Brown 1992

Fisheye Menu

- Distortion Function
  - Maximum font size
  - Focus length (number of items at full size)
    - Together these control the trade-off between the number of items at full size and the size of the smallest item
      - Focus length ↑ small items ↓ distortion ↑
- Alphabetic Index
  - Indexes can decrease search time
  - Index is positioned so that if cursor is aligned with it, the item will be the first one for that letter
    - Initial design had current position, but this was confusing because it moved

Slide adapted from Hornung & Zagreus

Fisheye Menu

- Bederson: Fisheye Menus, UIST 2000.

- Dynamically change the size of a menu item to provide a focus area around the mouse pointer, while allowing all menu items to remain on screen
- All elements are visible but items near cursor are full-size, further away are smaller
- "Bubble" of readable items move with cursor

Slide adapted from Hornung & Zagreus

http://www.cs.umd.edu/hcil/fisheyemenu/fisheyemenu-demo.shtml