

Mensch-Computer-Interaktion 2

Visualization

(based on slides by Marti Hearst and Jeff Heer)



Human-Computer
Interaction Group

Prof. Dr. Michael Rohs
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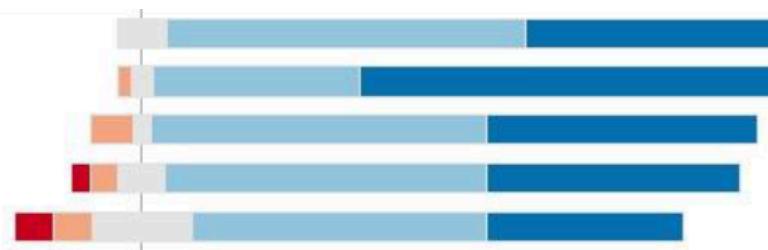
Lectures

Session	Date	Topic	
1	6.4.	Introduction	
2	13.4.	Interaction elements	
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	
7	1.6.	Data Analysis	
8	8.6.	Data Analysis	
9	15.6.	Visualization	
10	22.6.	Visualization	
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

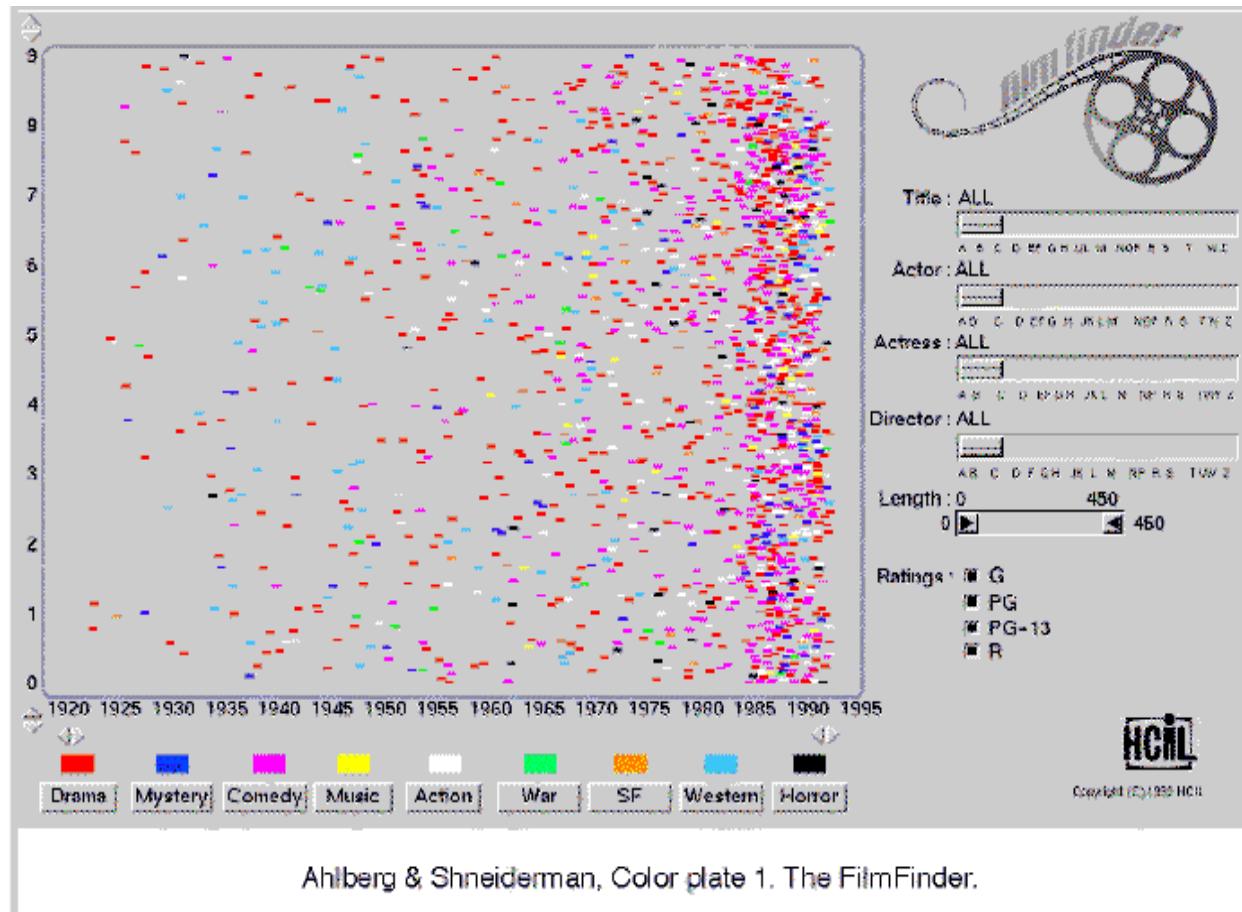
Principles:

- 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

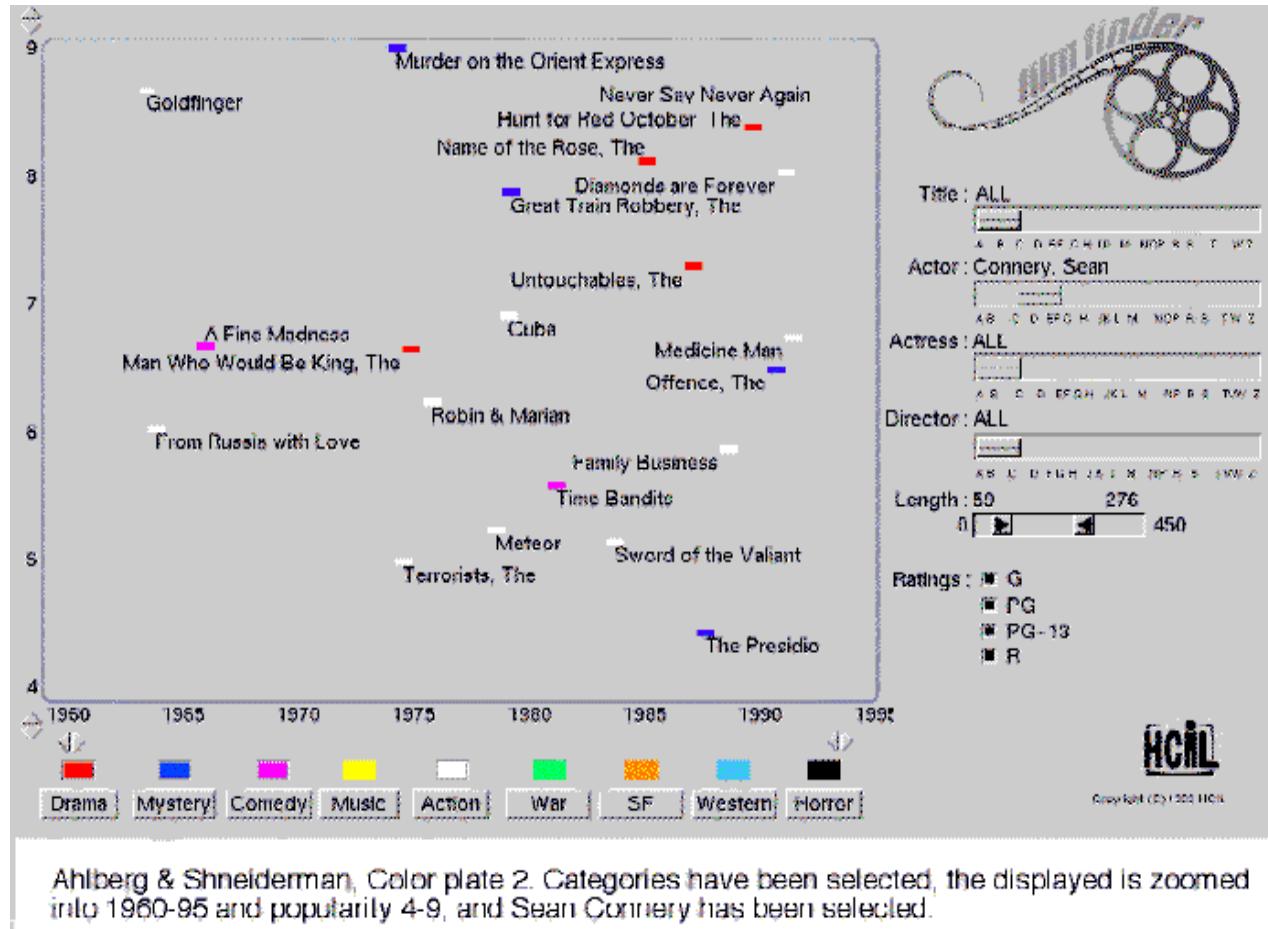
Dynamic Queries

- 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

Interaction with Scatterplots

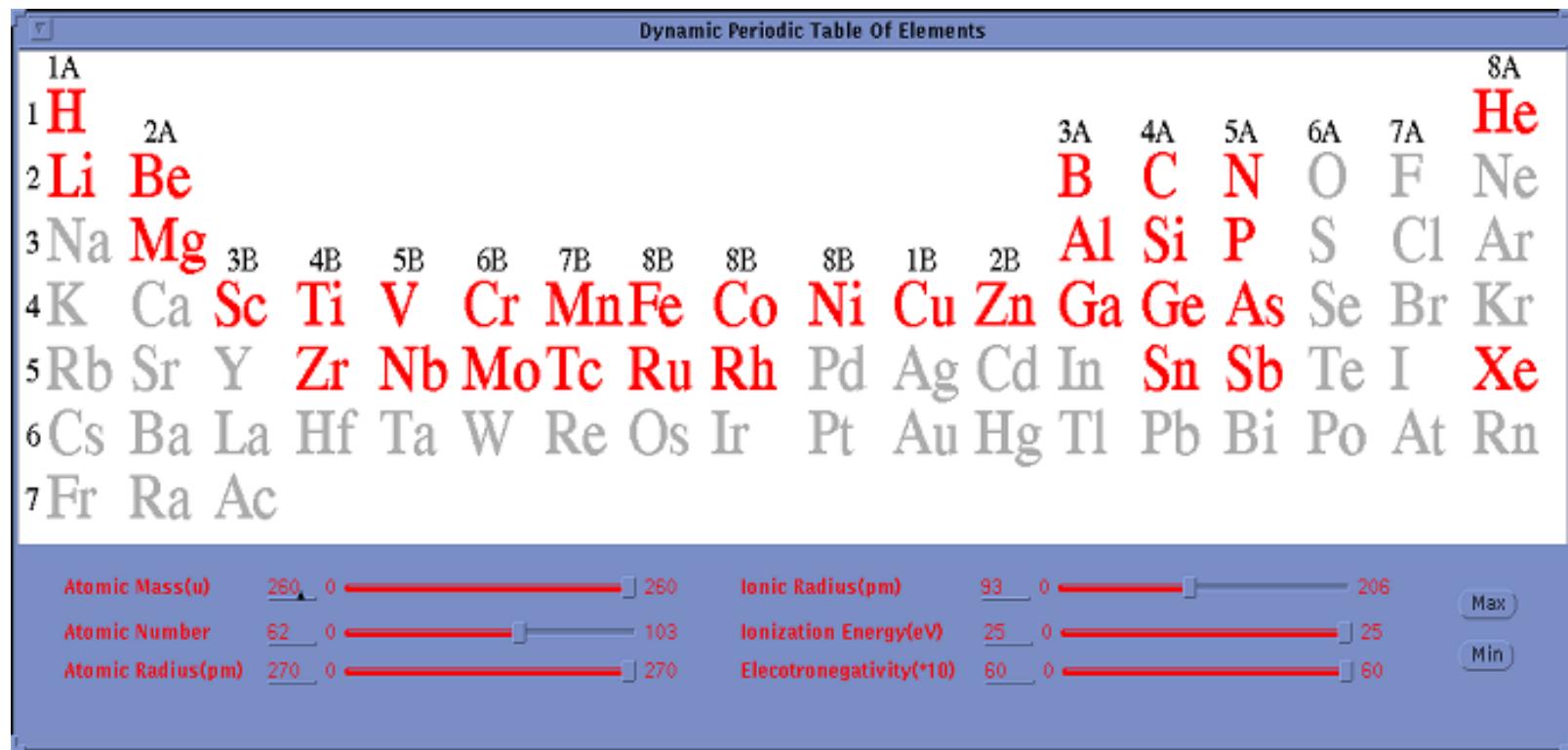


Interaction with Scatterplots



Dynamic Query Example

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



Slide adapted from Sarah Waterson

Brushing and Linking

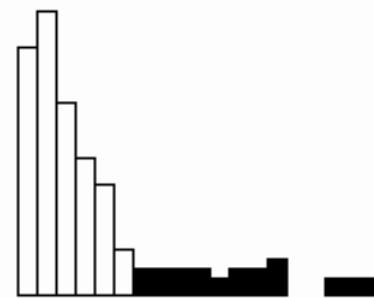
- Linking: Visually indicating which parts of one data display correspond to that of another
- Brushing: Selecting subsets of data by marking (brushing) items in a single view
- Usability issues: Selection, de-selection, setting values, appropriate widgets

Brushing and Linking

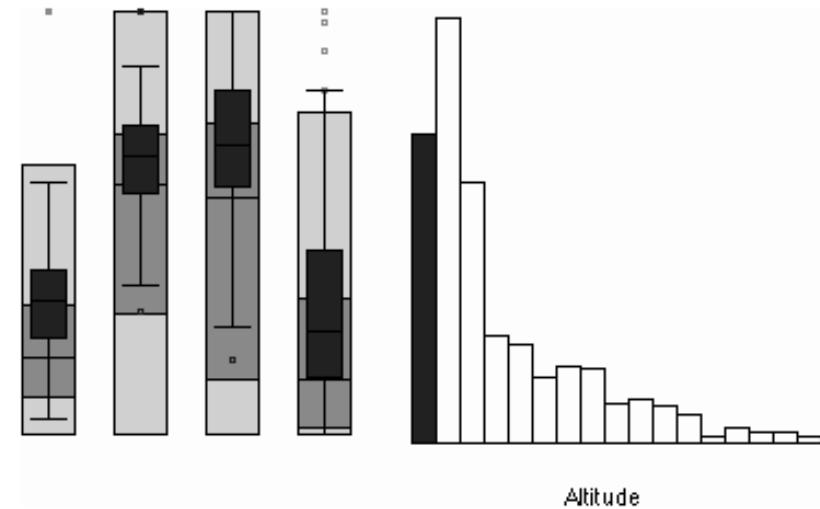
- At least two things must be linked together to allow for brushing
 - Select a subset of points
 - See the role played by this subset of points in one or more other views
- Highlighting is key

More Brushing and Linking Example

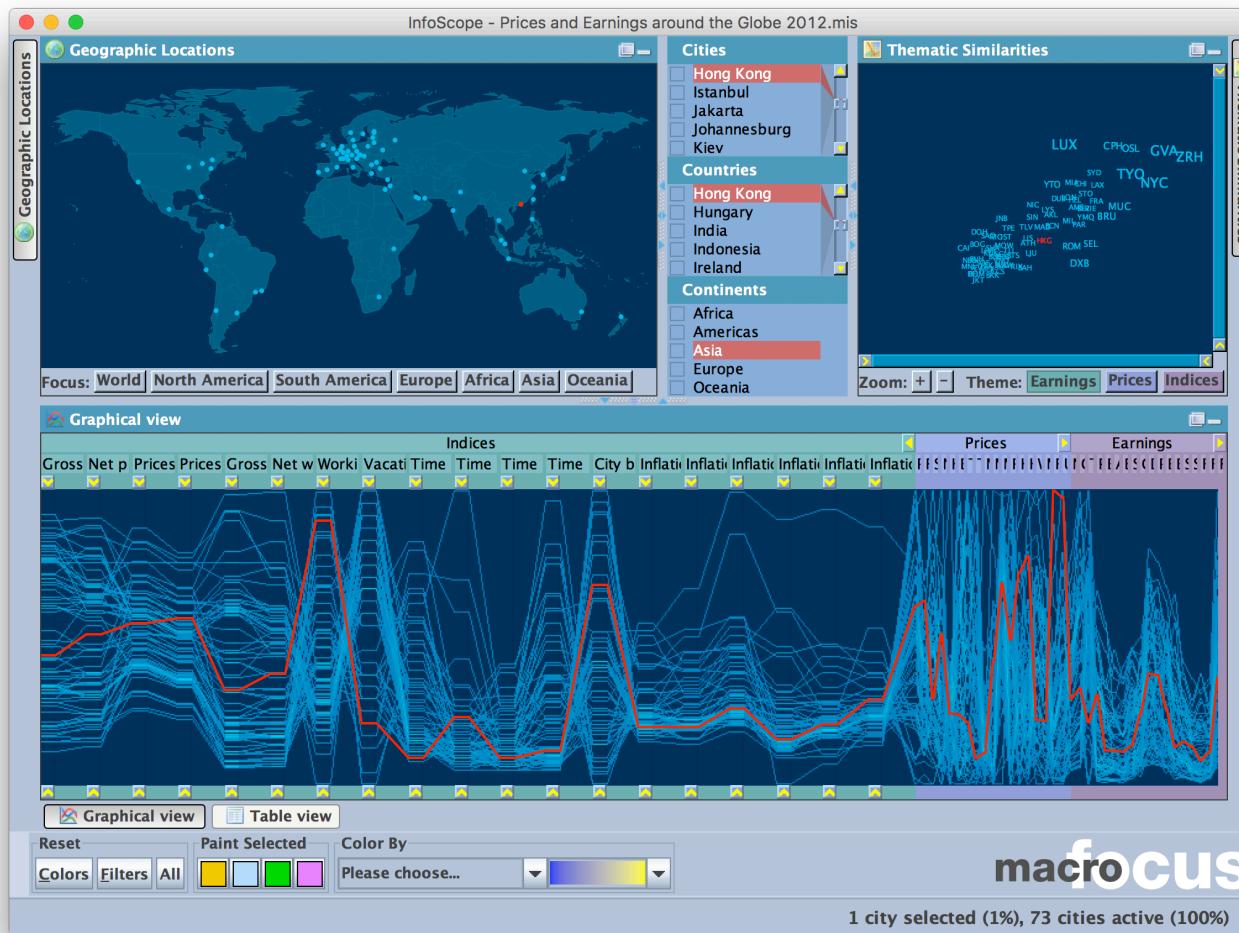
Districts of the city of Dublin showing areas with high levels of average income



Linking altitude to grass and grain types in Scottish Districts



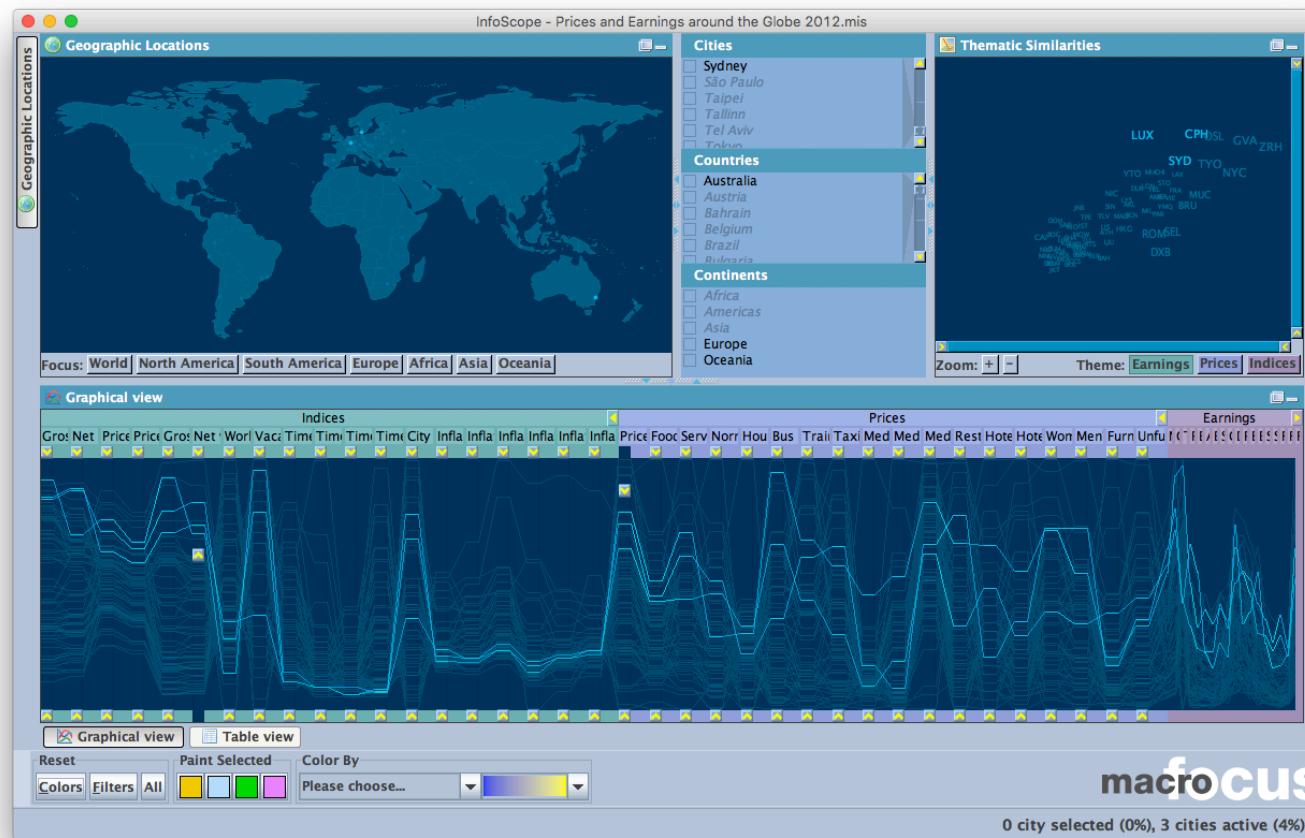
Brushing and Linking Example: InfoScope



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

Brushing and Linking Example: Parallel Coordinates in InfoScope

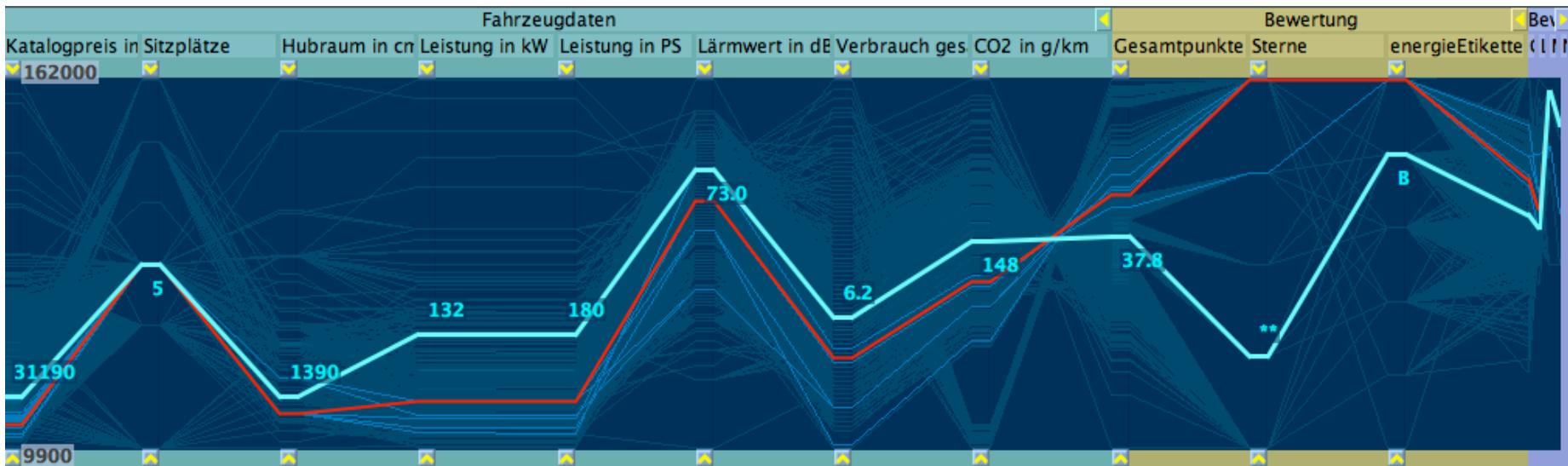
Example task: Find cities with high wages, small prices, and many paid holidays



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

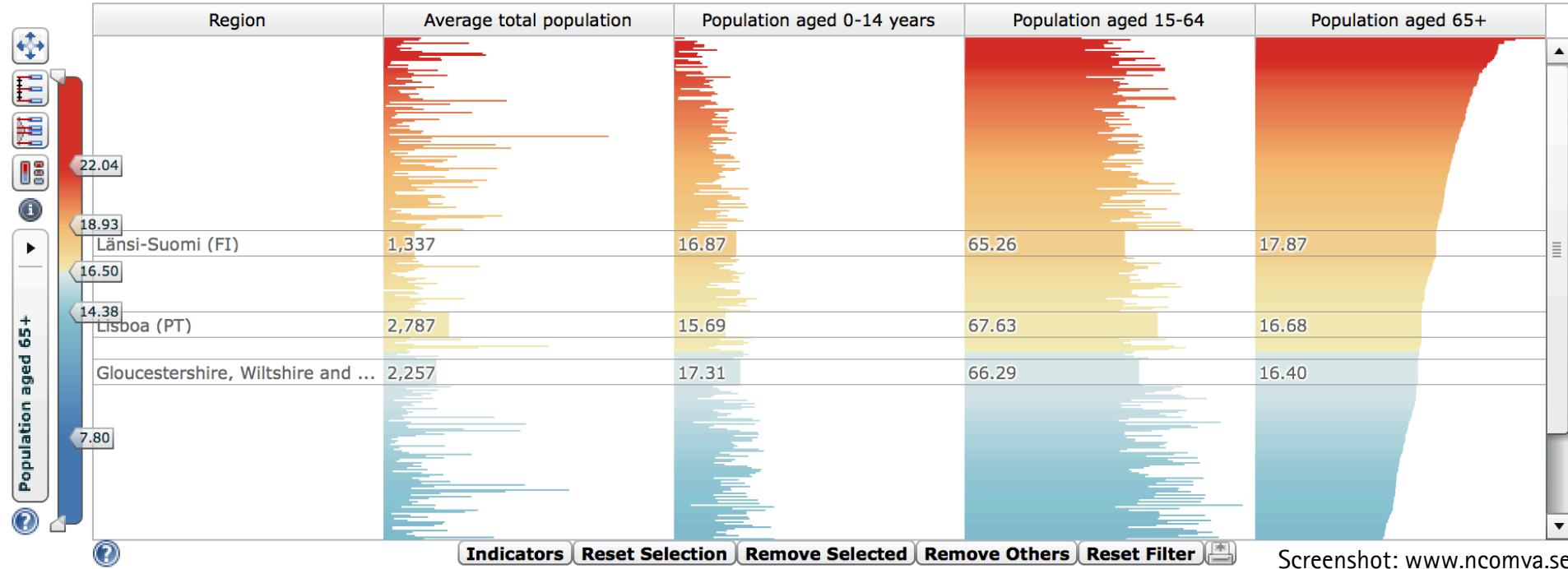
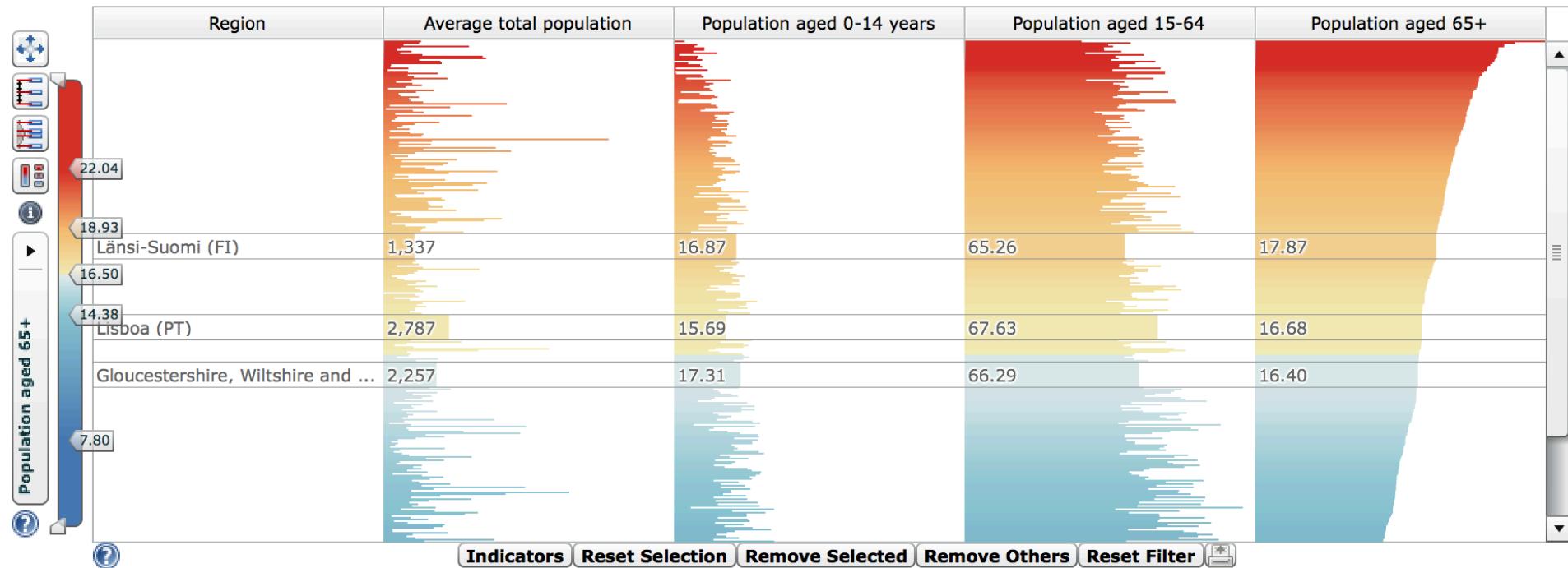


Table Lens Screenshot



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

Comparing 3 Information Visualization Systems

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

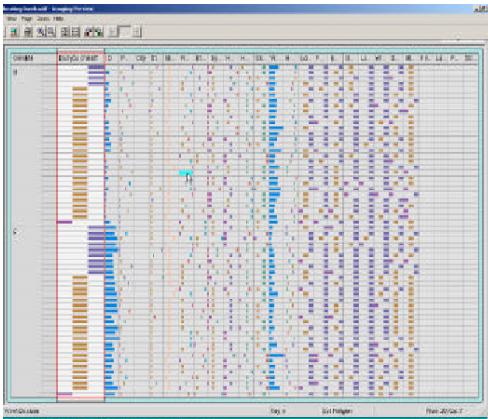


Figure 1a. A screenshot from Eureka that shows how a user might solve the question "Did males cheat more on their girlfriends than females on their boyfriends?" (an actual question used in the experiment). After grouping the attribute "Gender" and sorting the column "Did you cheat?," a user can compare 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

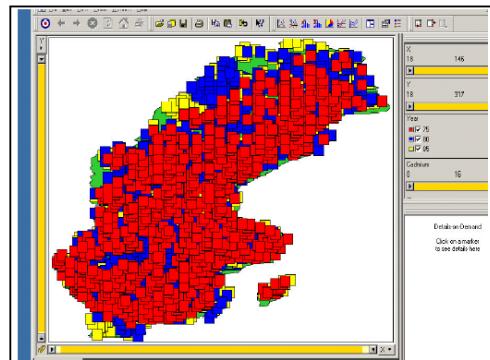


Figure 2. Spotfire's geographical representation of heavy metal concentrations through a scatterplot diagram.

Spotfire

Eureka (Table Lens)

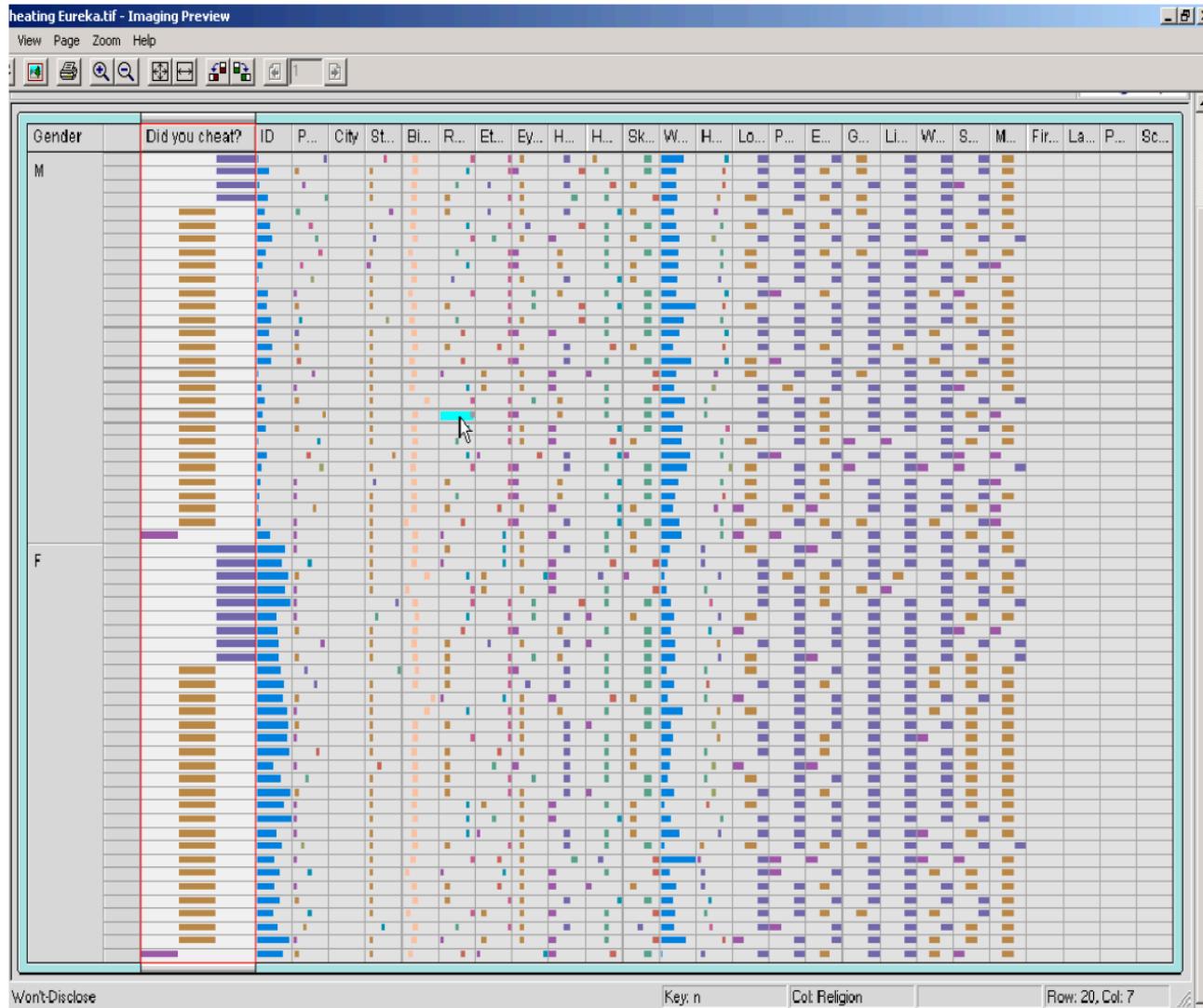


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Spotfire

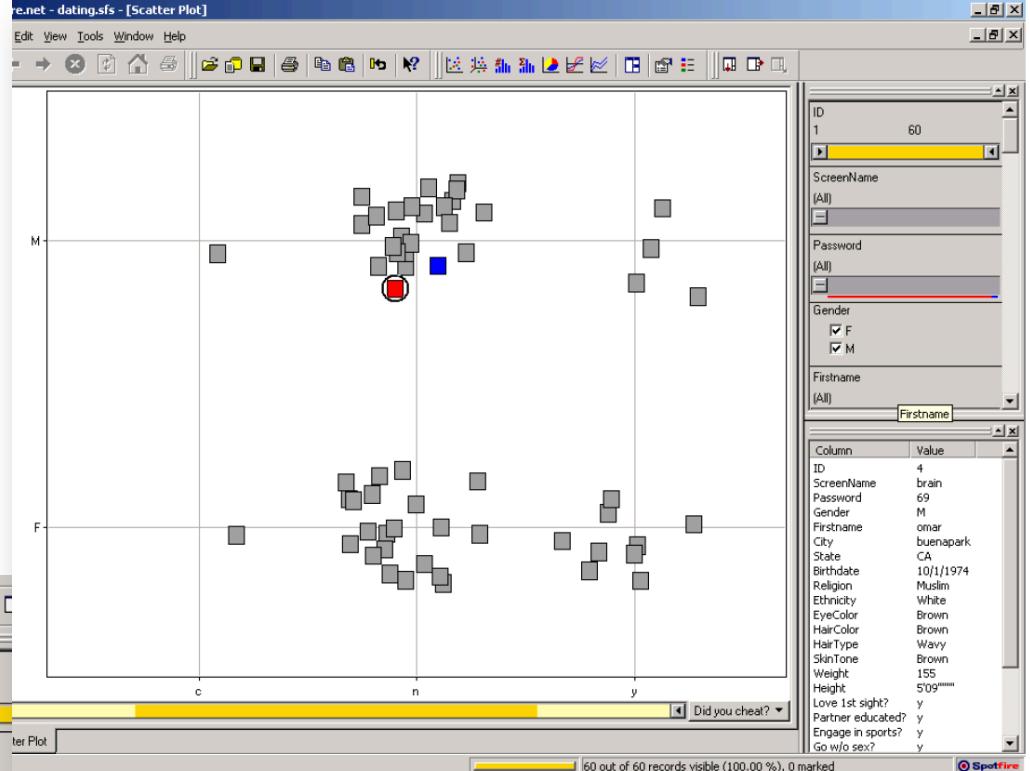
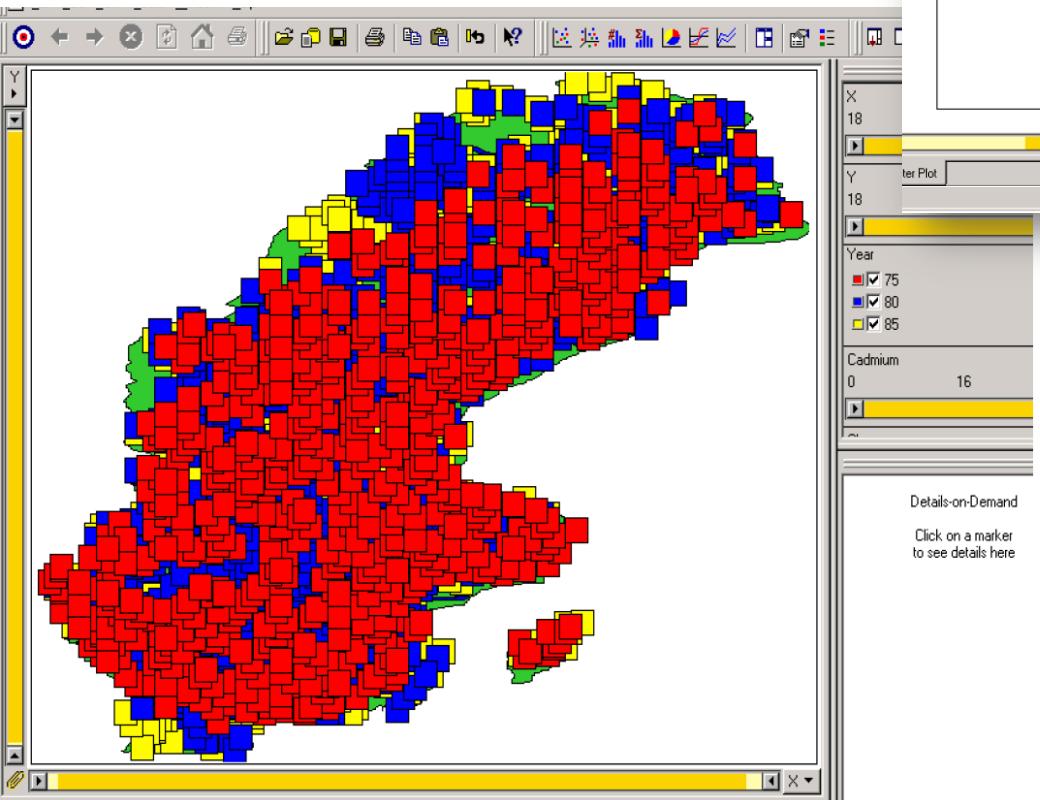


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InfoZoom

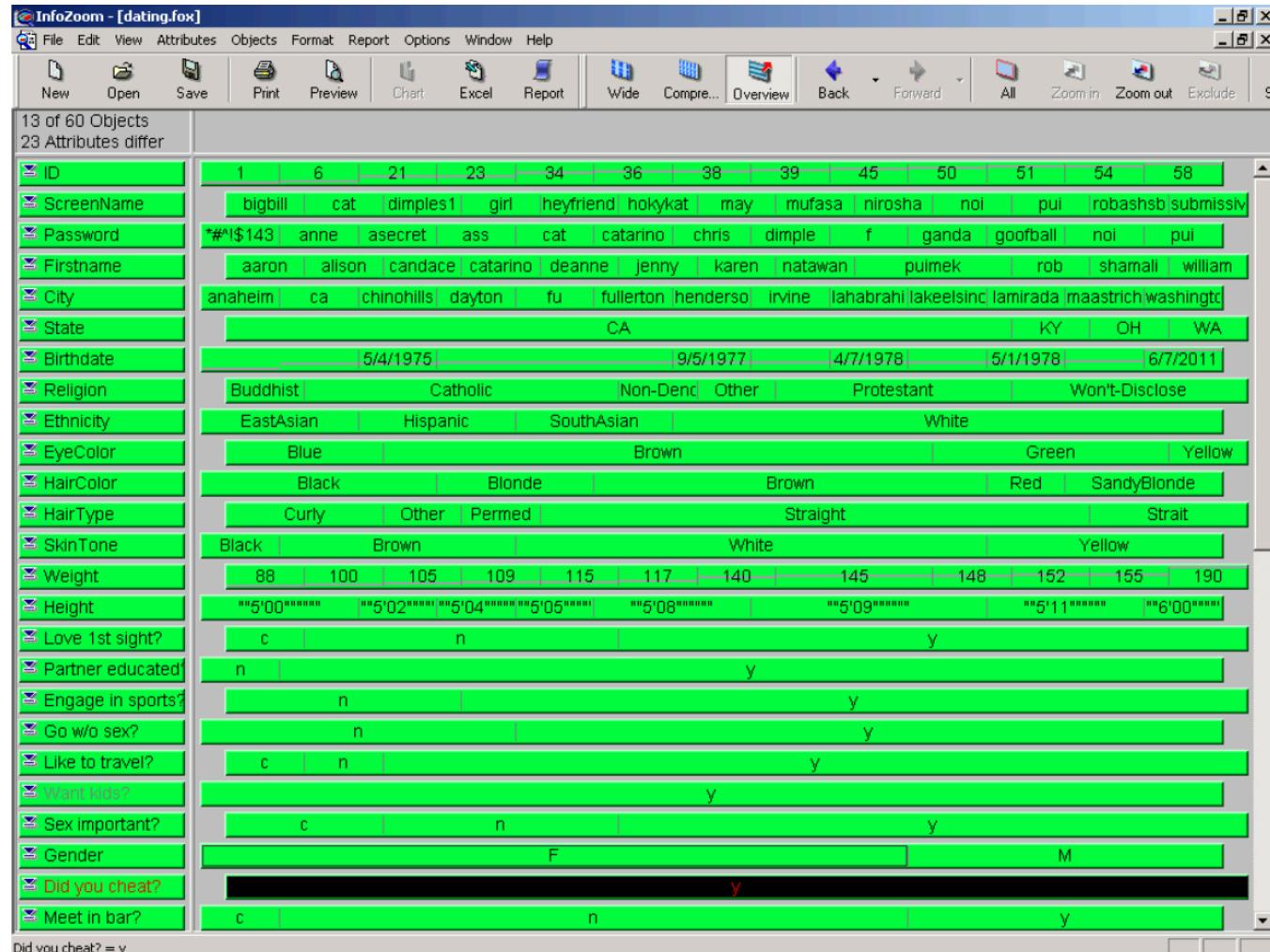
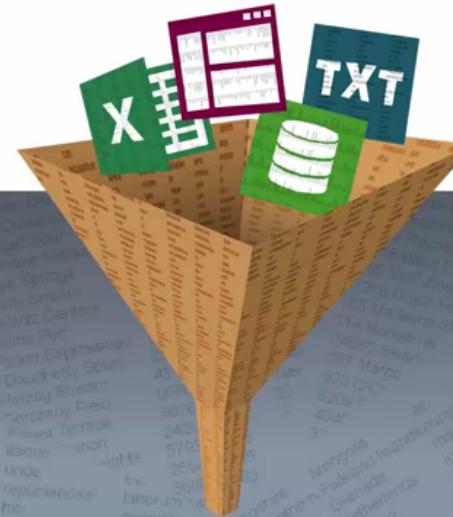


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InfoZoom Video

Massendatenauswertung und Datenqualität



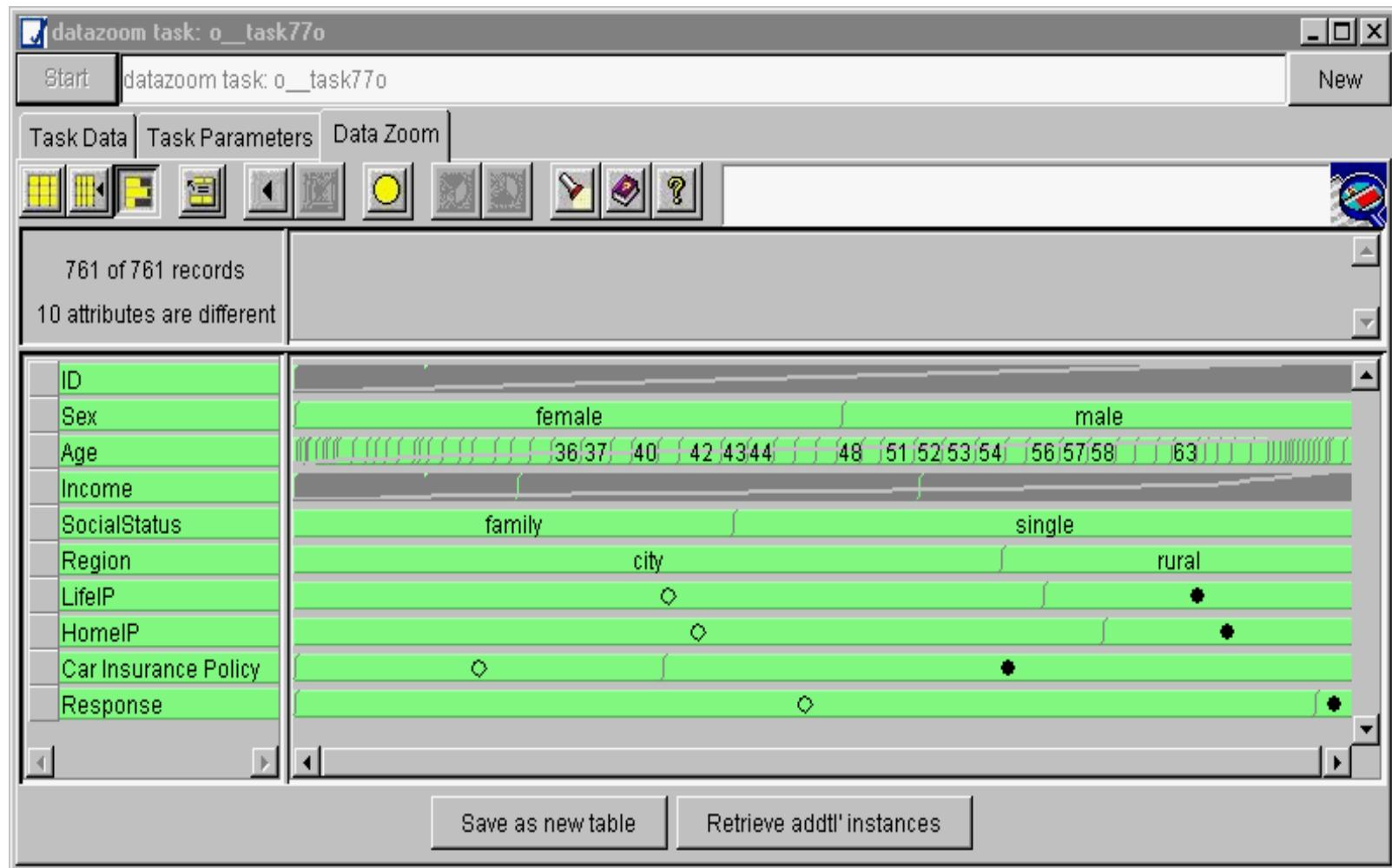
Welcher Umsatz wird mit
dem Produkt Pommes Frites
an einem Mittwoch in der
Filiale Düsseldorf gebucht?

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

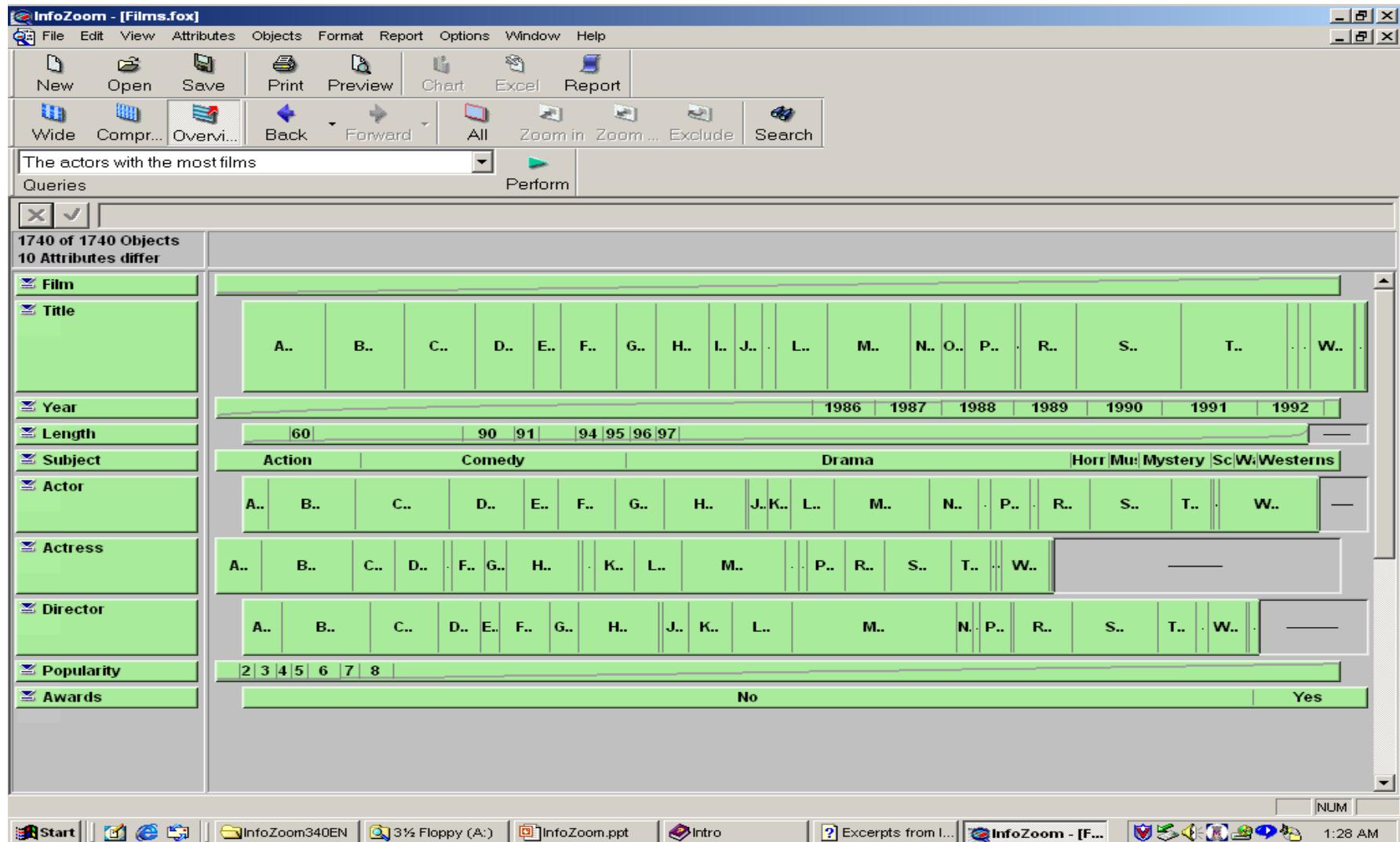
InfoZoom

- 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

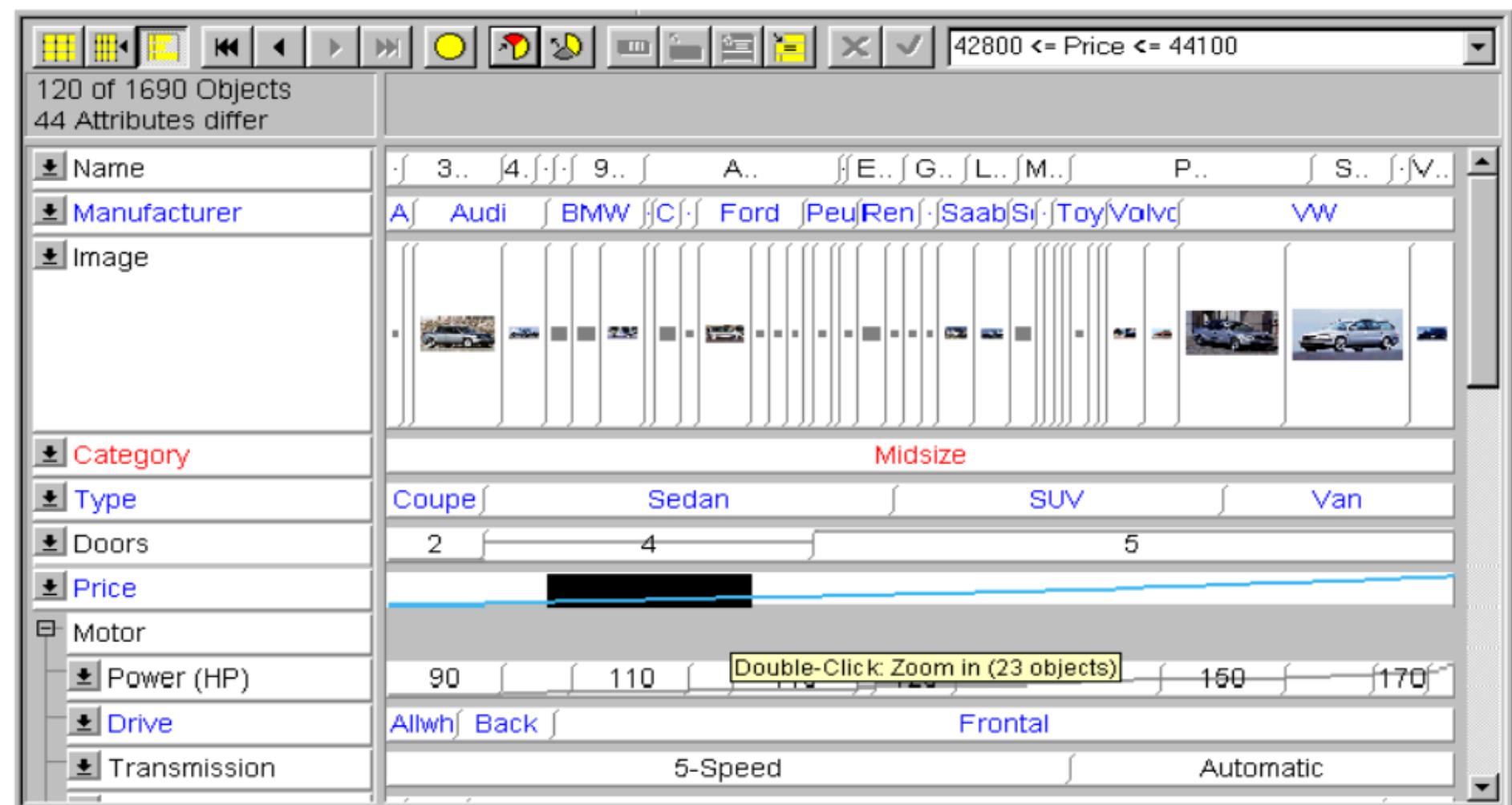
InfoZoom Overview View



InfoZoom Overview View



InfoZoom Overview View (with hierarchy)



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 46500

Beschleunigung [sek] 17.8

Höchstgeschwindigkeit 167

Gas Diesel Super

Consumption

Highway 5.2

City 8.5

Mix 6.5

7.9

12.8

9.7

7.8

13

16.1

11.3

InfoZoom Wide Table View

InfoZoom - [Films.fox]

File Edit View Attributes Objects Format Report Options Window Help

New Open Save Print Preview Chart Excel Report

WideTable... Overview Back Forward All Zoom in Zoom... Exclude Search

The actors with the most films

Queries Perform

1740 of 1740 Objects 10 Attributes differ	0	1	2	3	4	5	6	7	8
Film	0	1	2	3	4	5	6	7	8
Title	Wild at Heart	Goodbye Again	Hunt for Red October, The	Terminator, The	Terminator 2	John Cleese on How to Irritate People	Au Revoir les Enfants	The Ballad of Narayama	Cyrano De Bergerac
Year	1990	1961	1990	1984	1991	1993	1987	1983	199
Length	125	120	135	108	136	65	103	128	138
Subject	Drama	Drama	Drama	Action	Action	Comedy	Drama	Drama	Drama
Actor	Cage, Nicolas	Perkins, Anthony	Connery, Sean	Schwarzenegger A.	Schwarzenegger A.	Cleese, John	Manesse, Gaspard	—	Depardieu Gerard
Actress	Dern, Laura	Bergman, Ingrid	—	Hamilton, Linda	Hamilton, Linda	Booth, Connie	Racette, Francine	Missing	Brochet,
Director	Lynch, David	Litvak, Anatole	McTiernan, J.	Cameron, J.	Cameron, J.	—	Malle, Louis	Imamura, Shohei	Rappeneau Jean-Pau
Popularity	6	6	8	17	8	62	35	15	86
Awards	No	No	No	No	No	No	No	No	No

Show table in uncompressed mode

Start | InfoZoom340EN | 3½ Floppy (A:) | InfoZoom.ppt | Intro | Excerpts from I... | InfoZoom - [F...] | NUM | 1:27 AM

InfoZoom Compressed Table View

The screenshot shows the InfoZoom application interface. The title bar reads "InfoZoom - [Candy Corporations.fop]". The menu bar includes File, Edit, View, Attributes, Objects, Format, Report, Options, Window, and Help. The toolbar contains icons for New, Open, Save, Print, Preview, Chart, Excel, and Report, along with buttons for Wide, Compr..., Overvi..., Back, Forward, All, Zoom in, Zoom ..., Exclude, and Search. A dropdown menu under "View" is open, showing "Perform". The left sidebar displays a tree view of company attributes: Key, Notes, Company Short Name, Company Name, Location, Structure of Corporation (with CEO and CEO (Photo) expanded), Upper Management (with Director of Staff and Director of Staff (Photo) expanded), Division Head, Type of Company Relation, Markets, Lines of Business, and Parent Company. The main pane shows a compressed table view of 220 objects across 42 attributes. The table is color-coded in green and yellow. The first few columns show attribute names like "Key", "Notes", "Company Short Name", etc. Subsequent columns represent individual objects, each with a small thumbnail image. The table is highly compressed, with many columns sharing the same width and overlapping content.

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)

Brainstormed Questions/Tasks

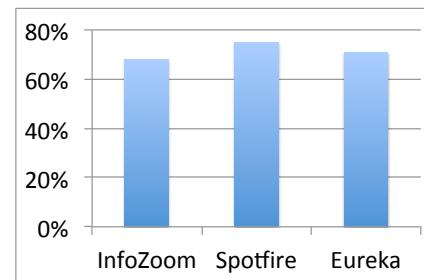
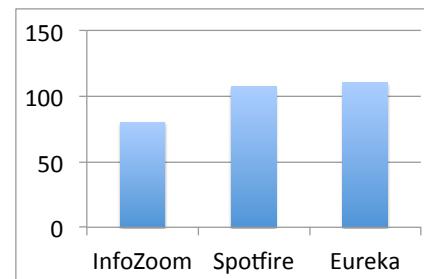
- Questions/tasks generated in a brainstorming process without knowledge of the visualization systems
 - Aimed at high external validity
- Dating database
 - Do more women than men want their partners to have a higher education?
 - What proportion of the men live in California?
 - Do all people who think 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)

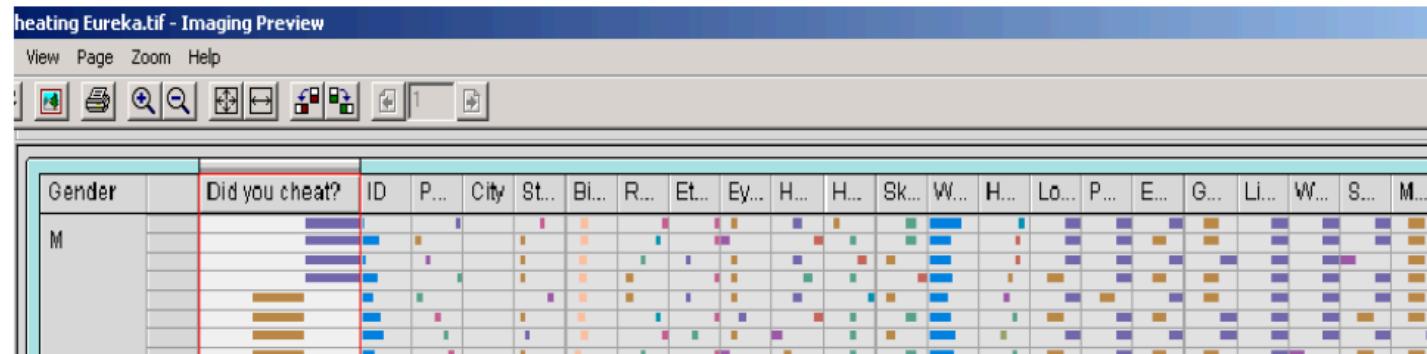
Overall Results

- 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



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.

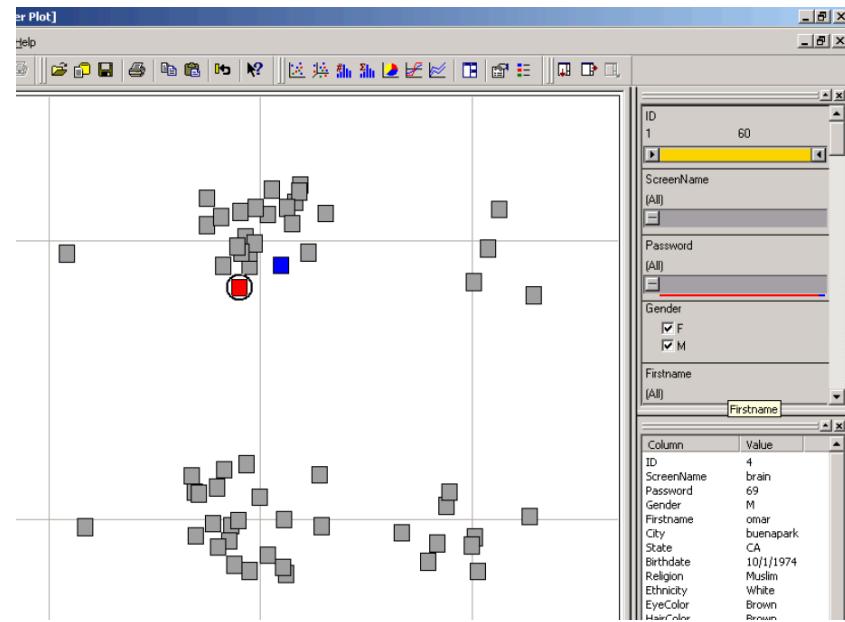


The screenshot shows a software interface titled "heating Eureka.tif - Imaging Preview". The window includes a menu bar with "View", "Page", "Zoom", and "Help", and a toolbar with various icons. Below the toolbar is a grid of colored cells representing survey data. The columns are labeled with abbreviations such as ID, P..., City, St..., Bl..., R..., Et..., Ey..., H..., H..., Sk..., W..., H..., Lo..., P..., E..., G..., Li..., W..., S..., M... . The first column is labeled "Gender" and contains the value "M". The second column is labeled "Did you cheat?" and contains several red highlighted cells. The rest of the grid contains a variety of colored cells (purple, blue, green, orange, yellow) representing different survey responses across the remaining columns.

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



InfoZoom – Problems

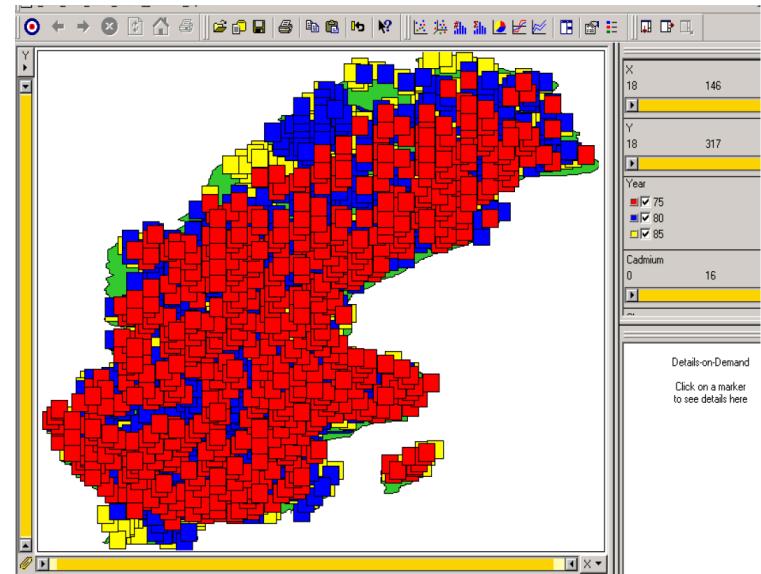
- Erroneous Correlations
 - People forget/don't realize that overview mode has all attributes sorted independent of each other
 - Narrow row height in compressed view
 - Participants did not use row expansion and scatterplot charting function which shows correlations more accurately

The screenshot shows the InfoZoom application window titled "InfoZoom - [dating.fox]". The menu bar includes File, Edit, View, Attributes, Objects, Format, Report, Options, Window, and Help. The toolbar contains icons for New, Open, Save, Print, Preview, Chart, Excel, Report, Wide, Compre..., Overview, Back, Forward, All, Zoom in, Zoom out, and Exclude. The main area displays a table with 13 columns and 13 rows of data. The first column lists attributes: ID, ScreenName, Password, Firsname, City, State, Birthdate, Religion, Ethnicity, EyeColor, and HairColor. The second column contains numerical values (1, 6, 21, 23, 34, 36, 38, 39, 45, 50, 51, 54, 58). Subsequent columns show various names and categorical values. Row 13 is partially visible at the bottom.

ID	1	6	21	23	34	36	38	39	45	50	51	54	58
ScreenName	bigbill	cat	dimples1	girl	heyfriend	holkykat	may	mufasa	nirosha	nol	pui	robashsb	submissiv
Password	*#!\$143	anne	asecret	ass	cat	catarino	chris	dimple	f	ganda	goofball	nol	pui
Firsname	aaron	alison	candace	catarino	deanne	jenny	karen	natawan	puimek	rob	sharnali	william	
City	anaheim	ca	chinohills	dayton	fu	fullerton	henderso	irvine	lahabrahilakeelsinc	lamirada	maastricht	washingto	
State									CA		KY	OH	WA
Birthdate					5/4/1975			9/5/1977		4/7/1978		5/1/1978	6/7/2011
Religion	Buddhist		Catholic		Non-Denc	Other		Protestant		Won't-Disclose			
Ethnicity	EastAsian		Hispanic		SouthAsian					White			
EyeColor	Blue				Brown					Green		Yellow	
HairColor	Black		Blonde		Brown					Red		SandyBlonde	

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)

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

Dynamic Zoom Tool (Adobe PDF Reader)

Adobe Acrobat Professional - [Cockburn_TestingAutoZoom_CHI05.pdf]

File Edit View Document Comments Tools Advanced Window Help

Search Create PDF Comment & Markup Send for Review Secure Sign Forms

Select Camera Magnifying glass Up Down Left Right Home Stop Refresh Help

50%

Dynamic Zoom Tool

Bookmarks

Pages Signatures

Attachments

Comments

Figure 1. Automatic zooming with increasing scroll speed (left) and decreasing scroll speed (right).

finishing location via Wijk & Nuij suggest how it could be deployed in scrolling. Until now the scrolling theory has not been empirically tested.

This paper describes our attempt to better understand human perception foundations of zooming systems—automatically change scroll speed with scroll speed. We review human-factors of visual processing and use it to predict a perceptual relationship between speed and zoom. This is followed by a brief description of the SDAZ system ($n=20$) and the results are used to calibrate a touch-based SDAZ system. We also implement and test van Wijk and Nuij's three suggestions for theoretically-based automatic zooming. Finally we compare our system to SDAZ ($n=27$) of the most promising system with three other scrolling interfaces—our calibrated SDAZ system, normal scrollwheel, and traditional raw-hand scrolling. Finally, we discuss areas involved in developing commercial deployments of SDAZ.

BACKGROUND

Document editors and browsers such as Microsoft Word and Adobe Reader support a wide range of tools for scrolling. For example, Word's vertical scroll wheel has four modes (labeled right, left, up, down) which include shortcuts for scrolling to semantic items such as pages, sections, tables, figures, and keywords. Zouncing is another standard feature of scrollwheel scrolling. Zouncing is a scrollwheel's tendency to overshoot when it reaches the edge of the document displayed within each window. The 'Dynamic Zoom' feature of Acrobat Reader is an interesting application of scrollwheel zooming. It allows simultaneous control of scrolling and zooming by holding scroll-wheel actions to zooming while dragging the mouse with the other hand. Despite the availability of sophisticated tools and techniques, the extent to which they are used remains largely unexplored.

Scrolling studies

Zhai et al. [22] conducted a comparative evaluation of four input devices for scrolling and panning in an open page web document. The four devices were a standard computer mouse, a scroll wheel mouse, a 'Mouse' which had a built-in isometric joystick for scrolling raw control, and bimanual input with a keyboard-mounted isometric joystick controlling scrolling rate in one hand and a standard mouse in the other. Results showed that while the scroll wheel did not improve performance much, scrollwheel with the mouse and a standard joystick improved performance by 31% and 35% over the standard mouse.

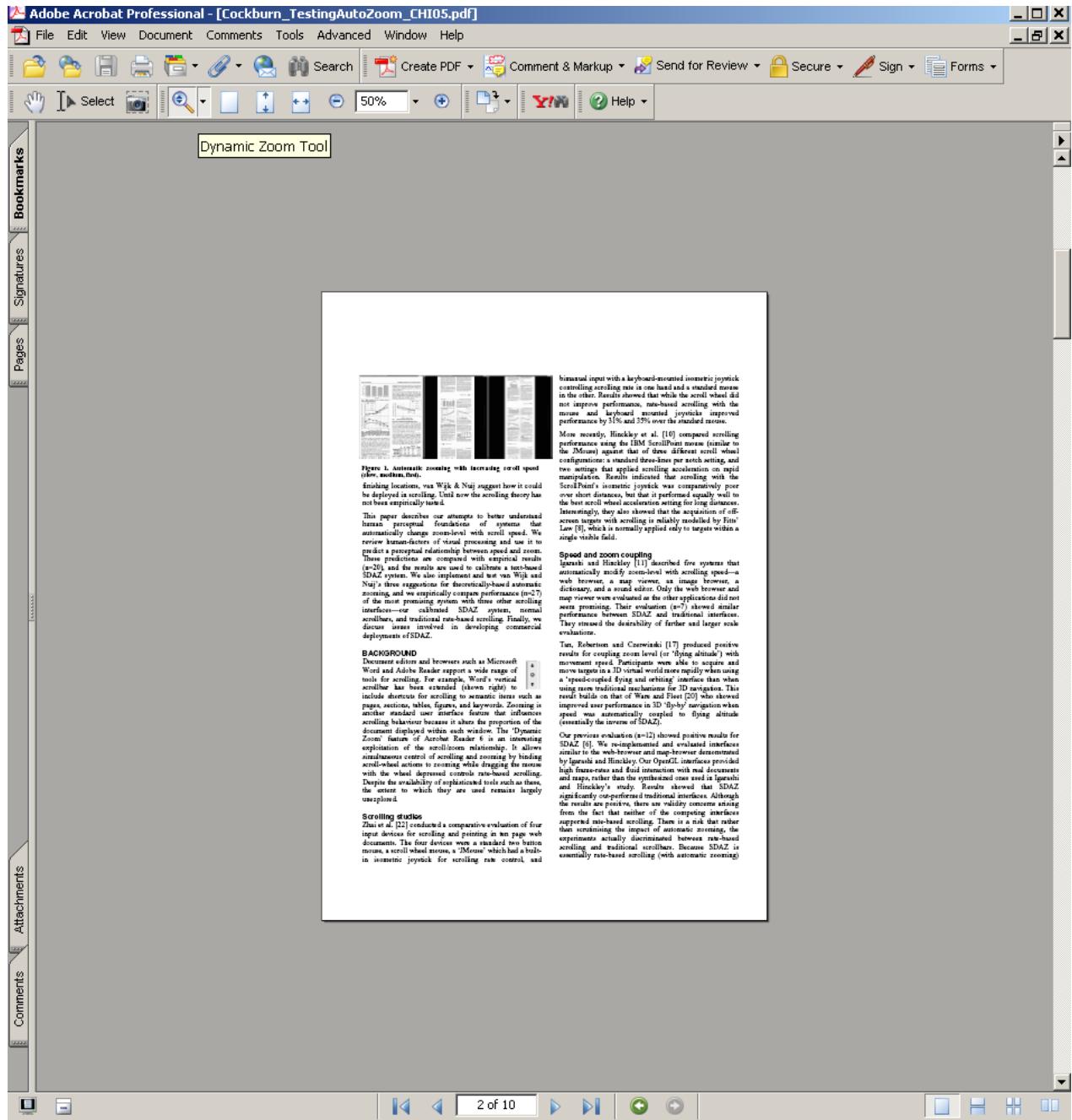
More recently, Hinckley et al. [16] compared scrolling performance measures for RMS scrollwheel mouse (unrelated to the scrollwheel input), a standard scrollwheel configuration, a standard three-lines per scroll setting, and two settings that applied scrolling acceleration on rapid translation. Results indicated that scrolling with the scrollwheel mouse type was comparable over short distances, but that it performed equally well to the best scroll wheel acceleration setting for long distances. Interestingly, they found that the acquired scrollwheel affords increased scroll speed that is roughly bounded by Fitts' Law [8], which is normally applied only to targets within a single visible field.

Speed and zoom coupling

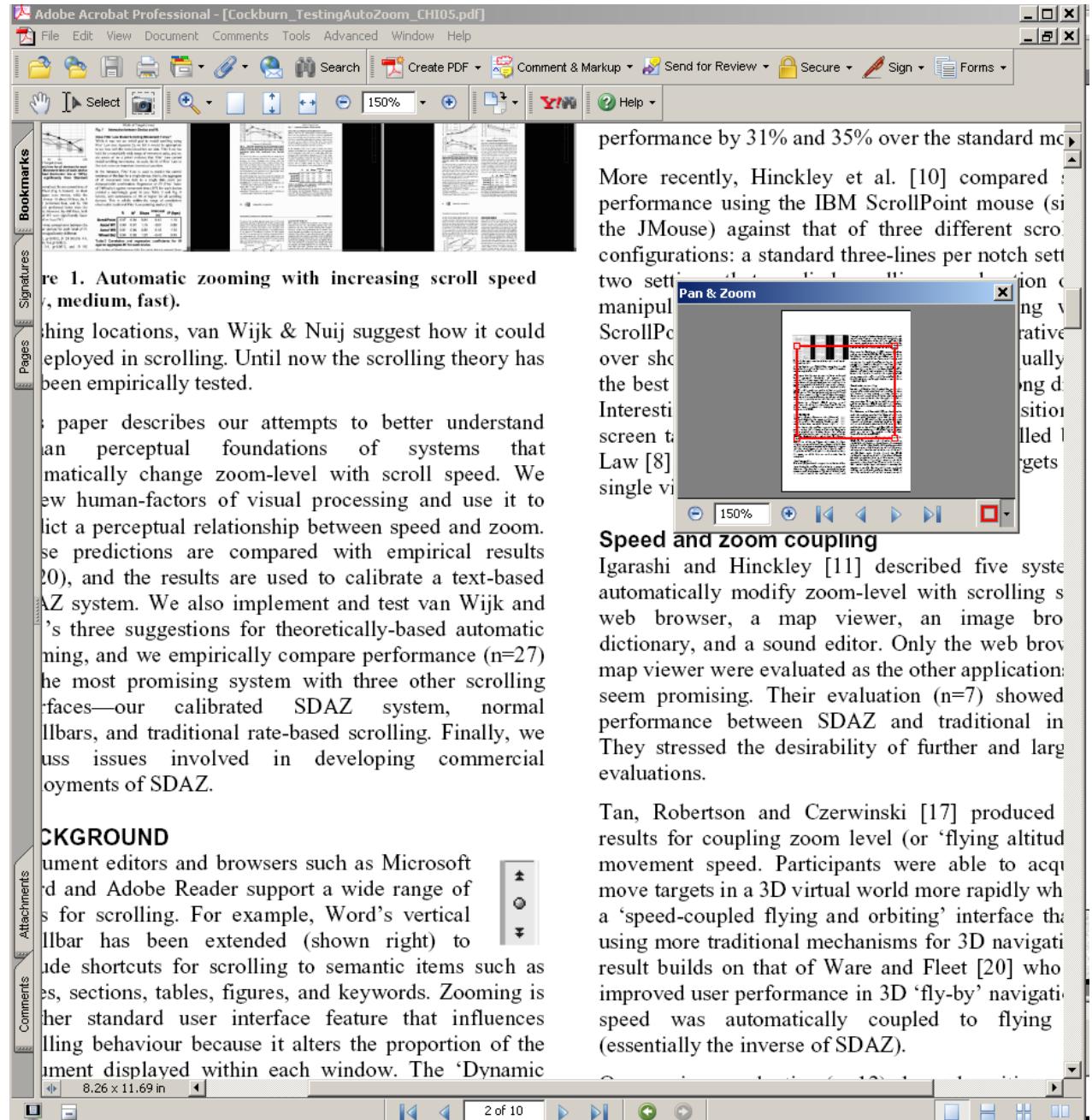
Igarashi and Hinckley [11] described five systems that automatically modify coupling with scrolling speed—a very broad category, ranging from a web browser, a dictionary, and a word editor. Only the web browser and map viewer were evaluated as the other applications did not seem promising. Their results showed similar performance between SDAZ and traditional interfaces. They stressed the desirability of further and larger scale evaluations.

Tan, Robertson, and Corlett [17] produced positive results for a scrollwheel-based scroll wheel ("the scrollit") with movement speed. Participants were able to acquire and move targets in a 3D virtual world more rapidly when using a 'speed-coupled flying and orbiting' interface than when using a 'standard scrollwheel' or a '3D mouse'. This result builds on that of Ware and Fleet [20] who showed improved user performance in 3D 'flyby' navigation when speed was coupled to scrollwheel movement, as opposed to the inverse of SDAZ.

Our previous evaluation ($n=12$) showed positive results for SDAZ [6]. We re-implemented and evaluated interfaces similar to the web-browsers and document viewers developed by Igarashi and Hinckley. Our OpenGL interface provided high frame-rates and fluid interaction with real documents and maps, rather than the synthesized ones used in Igarashi and Hinckley's study. Results showed that SDAZ is significantly faster than the standard scrollwheel. Although the results are positive, there are validity concerns arising from the fact that neither of the competing interfaces appeared to match the participants in a task that related to evaluating the impact of automatic zooming, the experiments actually discriminated between raw-based scrolling and traditional scrollbars. Because SDAZ is essentially raw-based scrolling (with automatic zooming)



Overview + Detail (Adobe PDF Reader)



The screenshot shows the Adobe Acrobat Professional interface. On the left, a sidebar lists 'Bookmarks', 'Signatures', 'Pages', 'Attachments', 'Comments', and 'Search'. The main area displays several pages of a technical document. A zoomed-in view of one page is shown in a separate window titled 'Pan & Zoom'.

Figure 1. Automatic zooming with increasing scroll speed (slow, medium, fast).

thing locations, van Wijk & Nuij suggest how it could be employed in scrolling. Until now the scrolling theory has been empirically tested.

This paper describes our attempts to better understand the perceptual foundations of systems that automatically change zoom-level with scroll speed. We review human-factors of visual processing and use it to predict a perceptual relationship between speed and zoom. These predictions are compared with empirical results [20], and the results are used to calibrate a text-based SDAZ system. We also implement and test van Wijk and Nuij's three suggestions for theoretically-based automatic zooming, and we empirically compare performance ($n=27$). The most promising system with three other scrolling interfaces—our calibrated SDAZ system, normal scrollbars, and traditional rate-based scrolling. Finally, we discuss issues involved in developing commercial implementations of SDAZ.

BACKGROUND

Document editors and browsers such as Microsoft Word and Adobe Reader support a wide range of methods for scrolling. For example, Word's vertical scrollbar has been extended (shown right) to include shortcuts for scrolling to semantic items such as pages, sections, tables, figures, and keywords. Zooming is another standard user interface feature that influences scrolling behaviour because it alters the proportion of the document displayed within each window. The 'Dynamic

performance by 31% and 35% over the standard mouse.

More recently, Hinckley et al. [10] compared performance using the IBM ScrollPoint mouse (similar to the JMouse) against that of three different scroll configurations: a standard three-lines per notch setting, two settings that automatically change zoom-level with scroll speed, and a zoomed-in view. The zoomed-in view was manipulated using a scrollwheel or a trackball. The ScrollPoint mouse showed the best performance, followed by the best zoomed-in view. Interestingly, the best zoomed-in view did not follow the Law [8] of screen target size and distance. It was the best zoomed-in view.

Speed and zoom coupling

Igarashi and Hinckley [11] described five systems that automatically modify zoom-level with scrolling speed in a web browser, a map viewer, an image browser, a dictionary, and a sound editor. Only the web browser and map viewer were evaluated as the other applications seem promising. Their evaluation ($n=7$) showed mixed performance between SDAZ and traditional scrolling. They stressed the desirability of further and larger evaluations.

Tan, Robertson and Czerwinski [17] produced mixed results for coupling zoom level (or 'flying altitude') with movement speed. Participants were able to acquire move targets in a 3D virtual world more rapidly when using a 'speed-coupled flying and orbiting' interface than using more traditional mechanisms for 3D navigation. This result builds on that of Ware and Fleet [20] who found improved user performance in 3D 'fly-by' navigation when speed was automatically coupled to flying (essentially the inverse of SDAZ).

Loupe (Adobe PDF Reader)

Adobe Acrobat Professional - [Cockburn_TestingAutoZoom_CHI05.pdf]

File Edit View Document Comments Tools Advanced Window Help

Search Create PDF Comment & Markup Send for Review Secure Sign Forms

Select

Bookmarks

Pages Signatures

Attachments

Comments

100%

100% 200% 300% 400% 500% 600% 700% 800% 900% 1000% 1100% 1200% 1300% 1400% 1500% 1600% 1700% 1800% 1900% 2000% 2100% 2200% 2300% 2400% 2500% 2600% 2700% 2800% 2900% 3000% 3100% 3200% 3300% 3400% 3500% 3600% 3700% 3800% 3900% 4000% 4100% 4200% 4300% 4400% 4500% 4600% 4700% 4800% 4900% 5000% 5100% 5200% 5300% 5400% 5500% 5600% 5700% 5800% 5900% 6000% 6100% 6200% 6300% 6400% 6500% 6600% 6700% 6800% 6900% 7000% 7100% 7200% 7300% 7400% 7500% 7600% 7700% 7800% 7900% 8000% 8100% 8200% 8300% 8400% 8500% 8600% 8700% 8800% 8900% 9000% 9100% 9200% 9300% 9400% 9500% 9600% 9700% 9800% 9900% 10000% 10100% 10200% 10300% 10400% 10500% 10600% 10700% 10800% 10900% 11000% 11100% 11200% 11300% 11400% 11500% 11600% 11700% 11800% 11900% 12000% 12100% 12200% 12300% 12400% 12500% 12600% 12700% 12800% 12900% 13000% 13100% 13200% 13300% 13400% 13500% 13600% 13700% 13800% 13900% 14000% 14100% 14200% 14300% 14400% 14500% 14600% 14700% 14800% 14900% 15000% 15100% 15200% 15300% 15400% 15500% 15600% 15700% 15800% 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98900% 98900% 99000% 99100% 99200% 99300% 99400% 99500% 99600% 99700% 99800% 99900% 99900% 100000%

Figure 1. Automatic zooming with increasing scroll speed (slow, medium, fast).

finishing locations, van Wijk & Nuij suggest how it could be deployed in scrolling. Until now the scrolling theory has not been empirically tested.

This paper describes our attempts to better understand human perceptual foundations of systems that automatically change zoom-level with scroll speed. We review human-factors of visual processing and use it to predict a perceptual relationship between speed and zoom. These predictions are compared with empirical results ($n=20$), and the results are used to calibrate a text-based SDAZ system. We also implement and test van Wijk and Nuij's three suggestions for theoretically-based automatic zooming, and we empirically compare performance ($n=27$) of the most promising system with three other scrolling interfaces—our calibrated SDAZ system, normal scrollbars, and traditional rate-based scrolling. Finally, we discuss issues involved in developing commercial deployments of SDAZ.

BACKGROUND

Document editors and browsers such as Microsoft Word and Adobe Reader support a wide range of tools for scrolling. For example, Word's vertical scrollbar has been extended (shown right) to include shortcuts for scrolling to semantic items such as pages, sections, tables, figures, and keywords. Zooming is another standard user interface feature that influences scrolling behaviour because it alters the proportion of the document displayed within each window. The 'Dynamic Zoom' feature of Acrobat Reader 6 is an interesting exploitation of the scroll/zoom relationship. It allows simultaneous control of scrolling and zooming by binding scroll-wheel actions to zooming while dragging the mouse with the wheel depressed, controls rate-based scrolling.

Figure 1 shows a screenshot of Adobe Acrobat Professional displaying a complex document with multiple panels. A blue rectangular selection box highlights a specific area of the document. The text in the figure caption indicates that the figure illustrates automatic zooming with increasing scroll speed (slow, medium, fast). The document contains various charts, graphs, and tables, typical of a research paper or technical report. The overall layout is professional and organized.

The Loupe Tool interface is shown in the bottom right corner of the screenshot. It includes a title bar, a toolbar with icons for zoom, search, and other functions, and a main panel displaying a table of data. The table has columns for 'Speed' and 'Zoom' (in %) and rows for different conditions. The data is as follows:

Speed	Zoom	Notes
Slow	100%	Standard scroll speed
Medium	150%	Intermediate scroll speed
Fast	200%	High scroll speed

The notes column indicates that the slow speed is standard scroll speed, medium speed is intermediate scroll speed, and fast speed is high scroll speed. The interface also includes a zoom slider and a status bar at the bottom showing '2 of 10'.

They stressed the desirability of further and larger scale evaluations.

Tan, Robertson and Czerwinski [17] produced positive results for coupling zoom level (or 'flying altitude') with movement speed. Participants were able to acquire and move targets in a 3D virtual world more rapidly when using a 'speed-coupled flying and orbiting' interface than when using more traditional mechanisms for 3D navigation. This result builds on that of Ware and Fleet [20] who showed improved user performance in 3D 'fly-by' navigation when speed was automatically coupled to flying altitude (essentially the inverse of SDAZ).

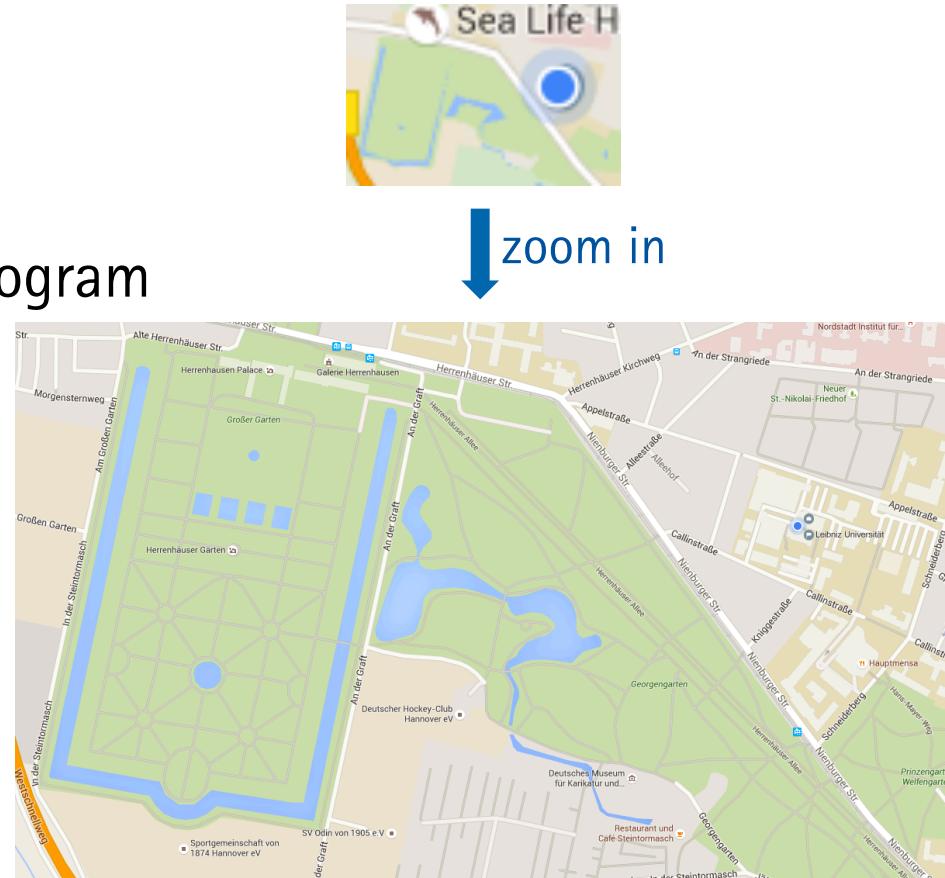
Our previous evaluation ($n=12$) showed positive results for SDAZ [6]. We re-implemented and evaluated interfaces similar to the web-browser and map-browser demonstrated by Igarashi and Hinckley. Our OpenGL interfaces provided high frame-rates and fluid interaction with real documents

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

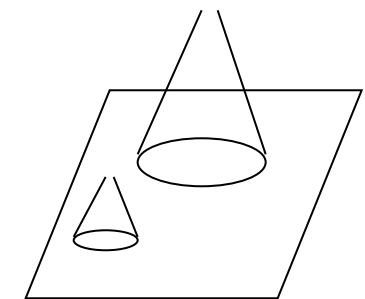
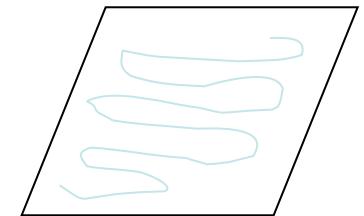
Examples of Semantic Zoom

- 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

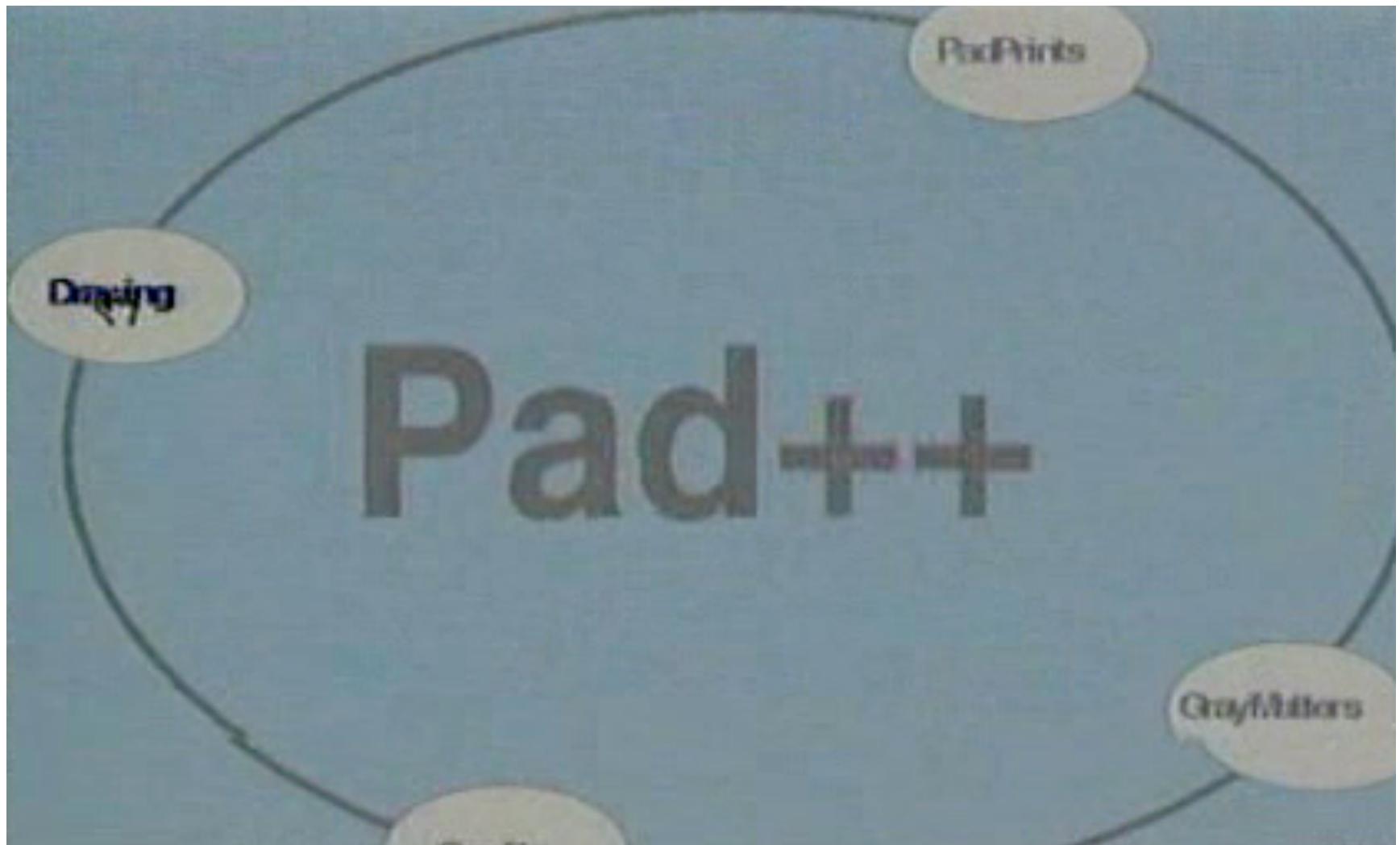


Pad++ (1998)

- 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



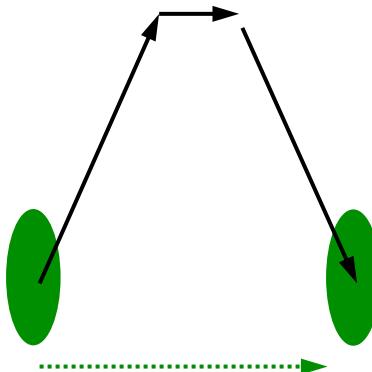
Pad++ Video



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

Navigation in Pad++

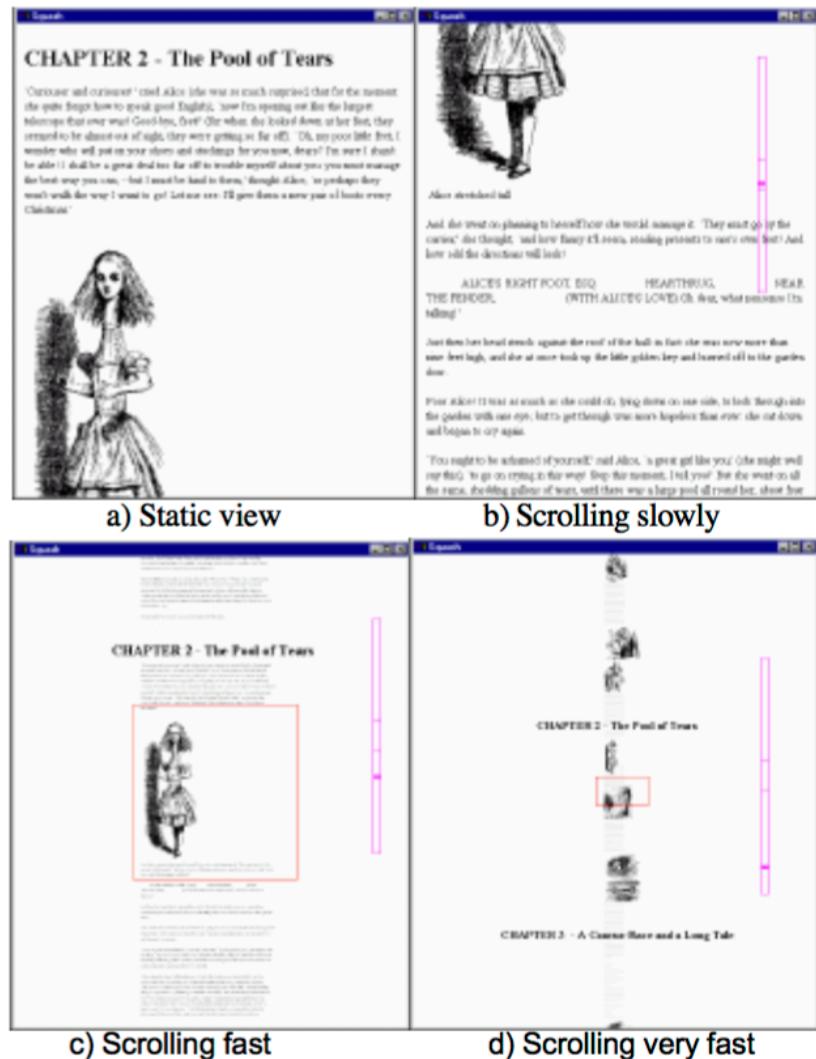
- How to keep from getting lost?
- Animated “hyperlinks” for traversal from one object to another
 - If the target is more than one screen away,
zoom out, pan over, and zoom back in
- Goal: Help user maintain context



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)

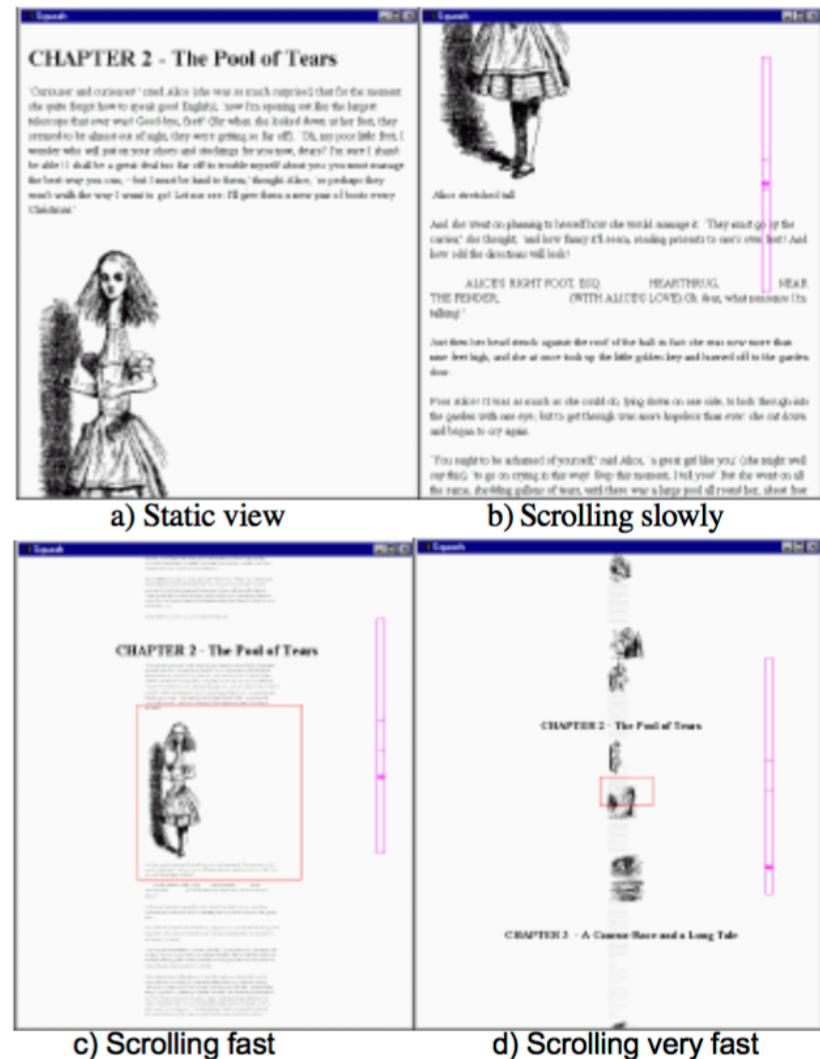
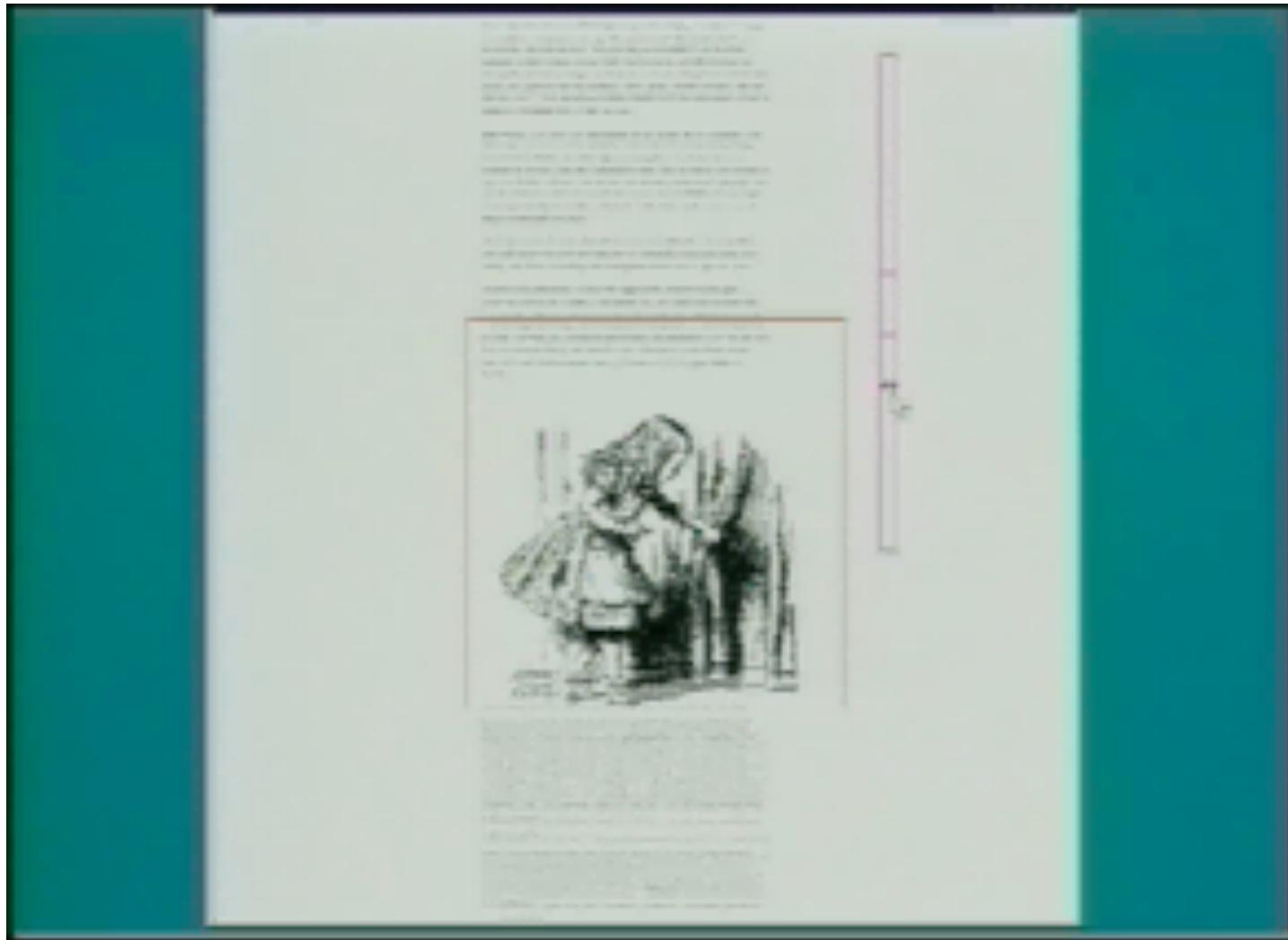


Figure: Igarashi & Hinckley: Speed-dependent Automatic Zooming for Browsing Large Documents, UIST 2000.

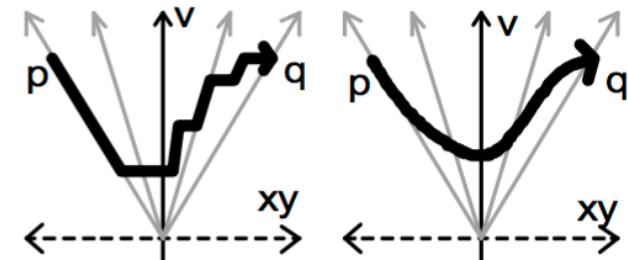
Speed-Dependent Zooming



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

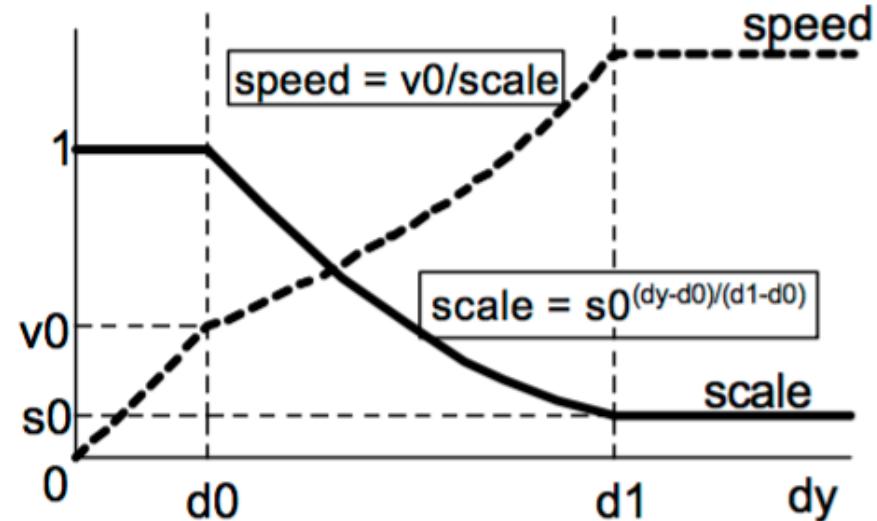
Speed-Dependent Zooming

- $\text{scale} = s_0 \frac{d_y - d_0}{d_1 - d_0}$
 - 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
- $\text{speed} = v_0 / \text{scale}$
- delay to avoid sudden zoom change



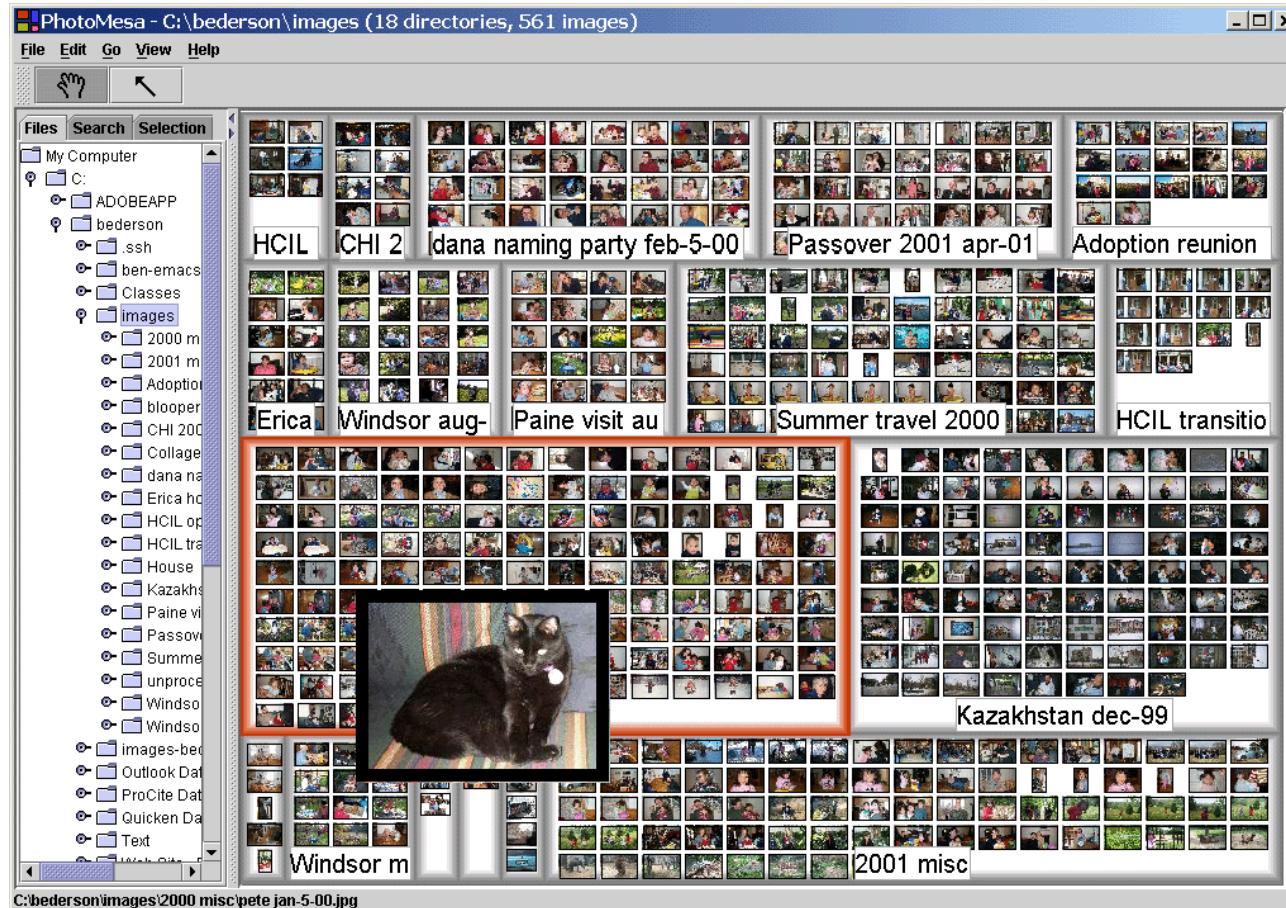
a) Manual zooming/panning. b) Automatic zooming.

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

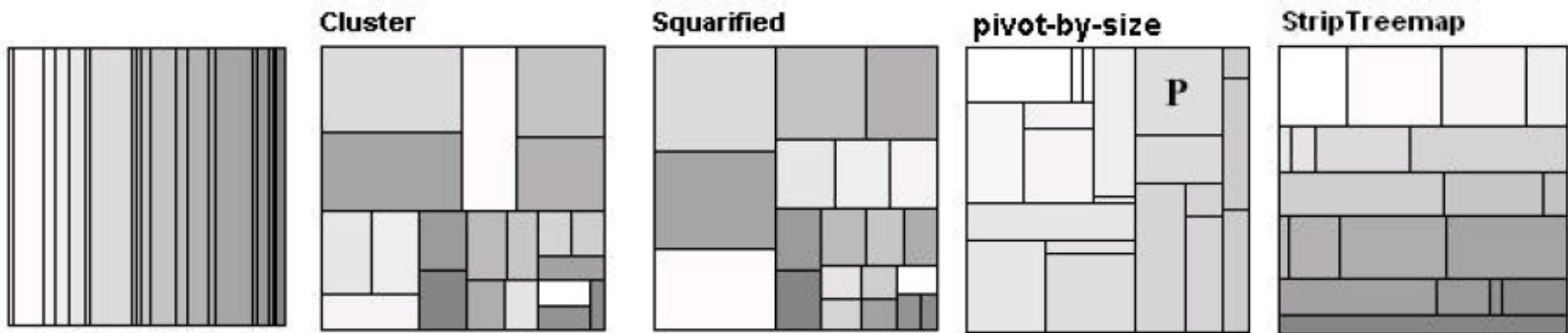
- Zooming is primary presentation mechanism
- Zoom in, zoom out on levels of thumbnails
- Quickly drill down to individual picture (at full resolution)
- Outline shows area of next zoom level
- History of views
- Thumbnail zooms up when hover with cursor
- Export images
- Cluster by filename

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

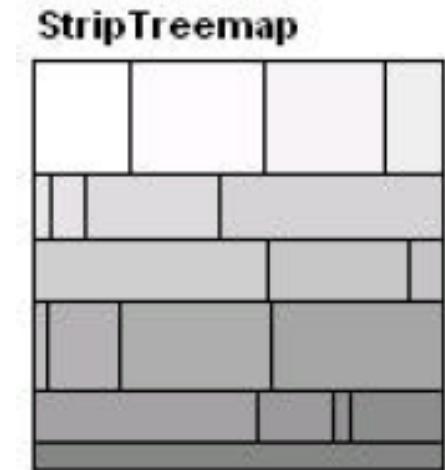
Quantum Treemaps

- Conventional treemaps 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



Strip Treemap Algorithm (Bederson and Shneiderman)

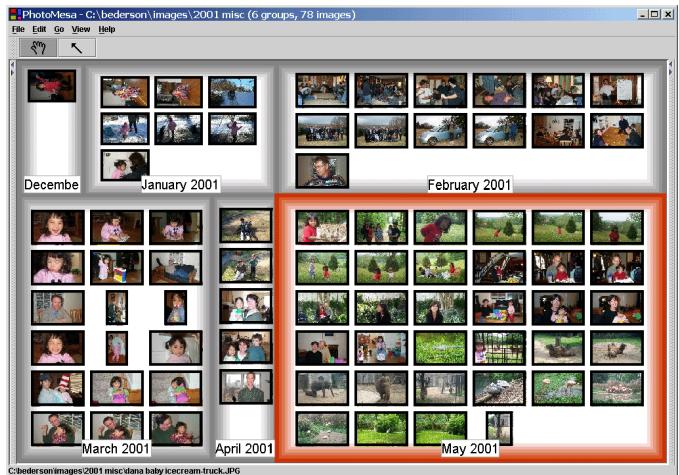
1. Scale the area of all the rectangles so that the total area of the input rectangles equals that of the layout rectangle.
2. Create a new empty strip, the current strip.
3. Add the next rectangle to the current strip, recomputing the height of the strip based on the area of all the rectangles within 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

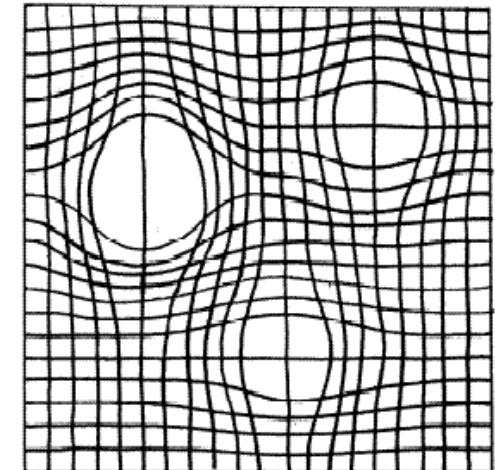
- Like Quantum Treemaps, elements guaranteed to be same size
- Arbitrary shapes
- No wasted space
- May be harder to visually parse than Quantum Treemaps



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

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

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.

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
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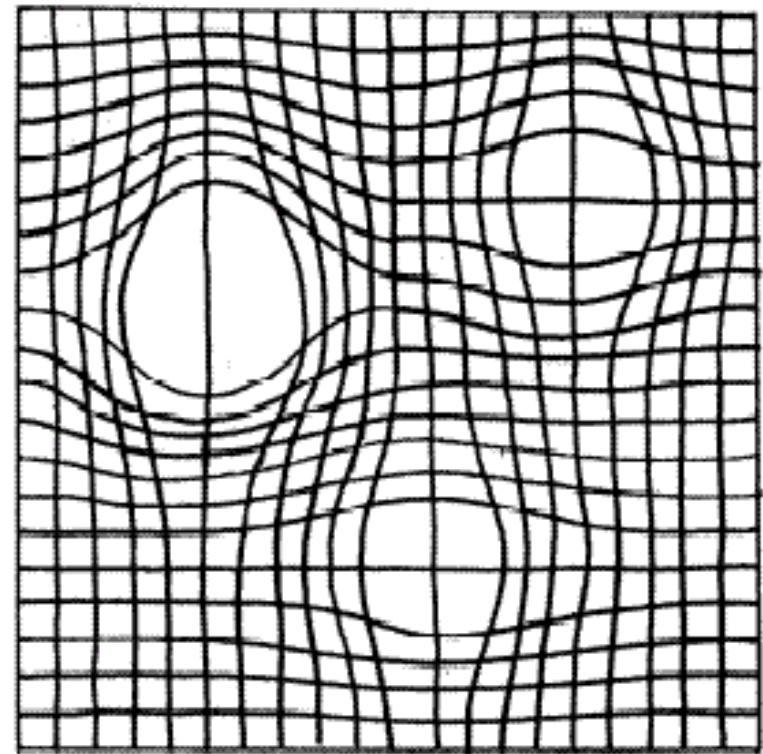


Image from Leung & Apperly 1994

Slide adapted from Fengdong Du

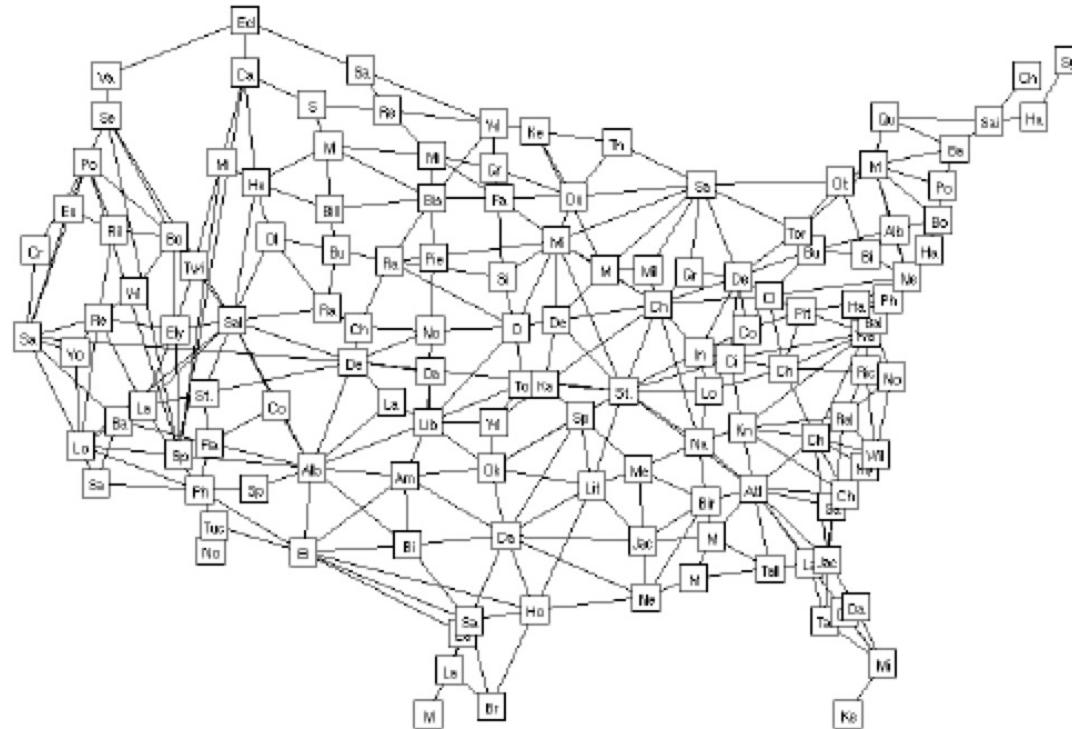


Figure 1: A graph with 134 vertices and 338 edges. The vertices represent major cities in the United States, and the edges represent paths between neighboring cities. (Typically, the edges would be annotated with the distance and driving time between the cities.) The *a priori importance* value assigned 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

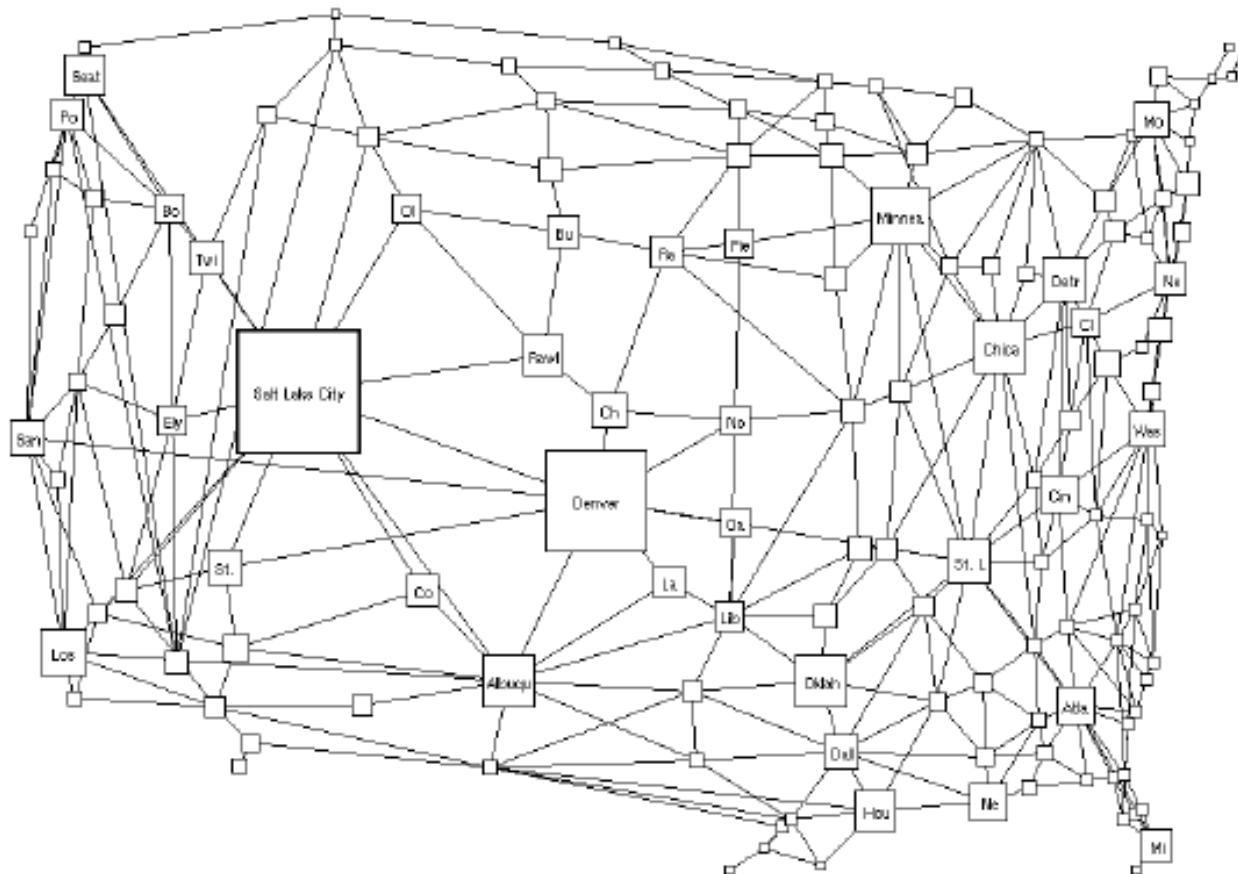


Figure 4: A fisheye view of the graph in Figure 1, with the focus on Salt Lake City. The level of distortion is the same as in Figure 3; only the location of the focus has changed. The values of the fisheye parameters are $d = 2$, $c = 0.5$, $e = 0.5$, $VWcutoff = 0$.

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

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

- Afghanistan
- Albania
- Algeria
- American Samoa
- Andorra
- Angola
- Anguilla
- Antarctica
- Antigua and Barbuda
- Arctic Ocean
- Argentina
- Armenia
- Aruba
- Ashmore and Cartier Islands
- Atlantic Ocean
- Australia
- Austria
- Azerbaijan
- Bahamas, The
- Bahrain
- Baker Island
- Bangladesh
- Barbados
- Bassas da India
- Belarus
- Belgium
- Belize
- Benin
- Bermuda
- Bhutan
- Bolivia
- Bosnia and Herzegovina
- Botswana
- Bouvet Island
- Brazil