

CSC2537 / STA2555 - INFORMATION VISUALIZATION

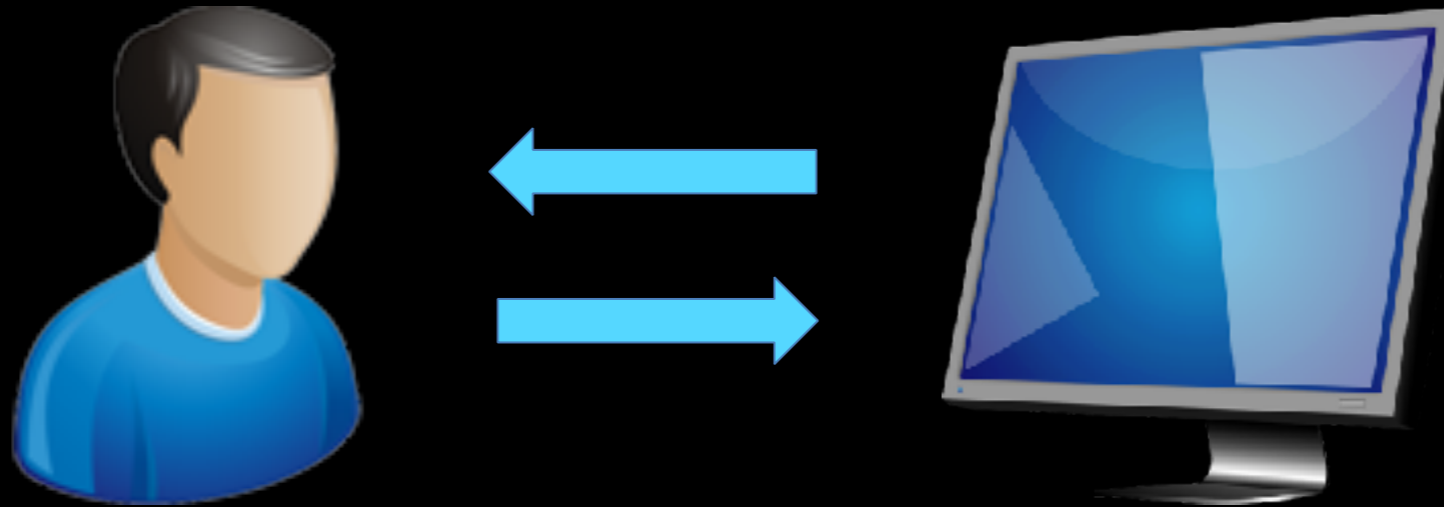
INTERACTION

Fanny CHEVALIER



This lecture is heavily inspired from slides by **Pierre Dragicevic**, **Jean-Daniel Fekete**, **Yvonne Jansen** and **John Stasko**. Thanks to all of them for sharing their material.

INTERACTION



HCI research mostly focuses on input

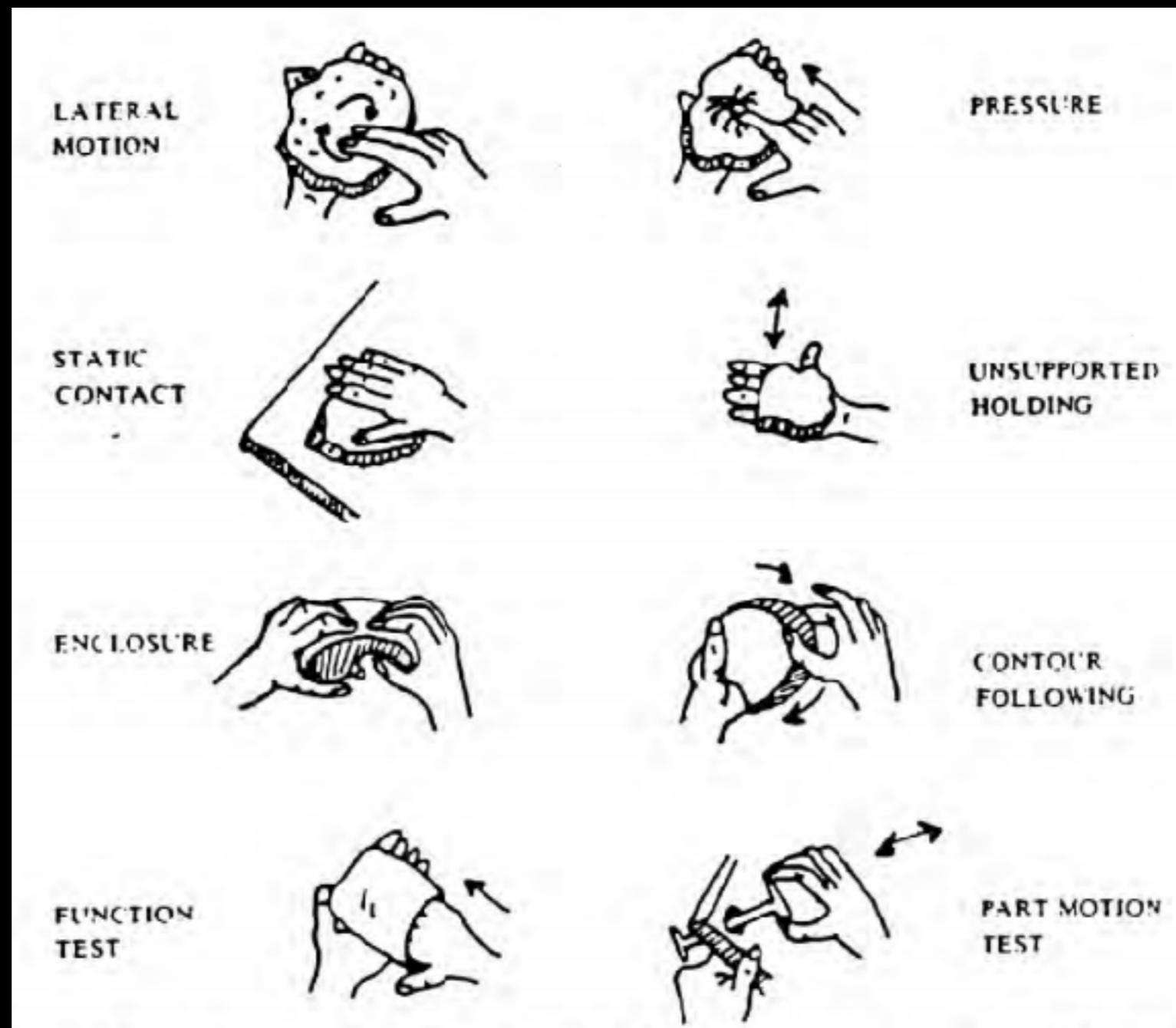
- output for affordances & feedback

Infovis research mostly focuses on output

- input for steering output

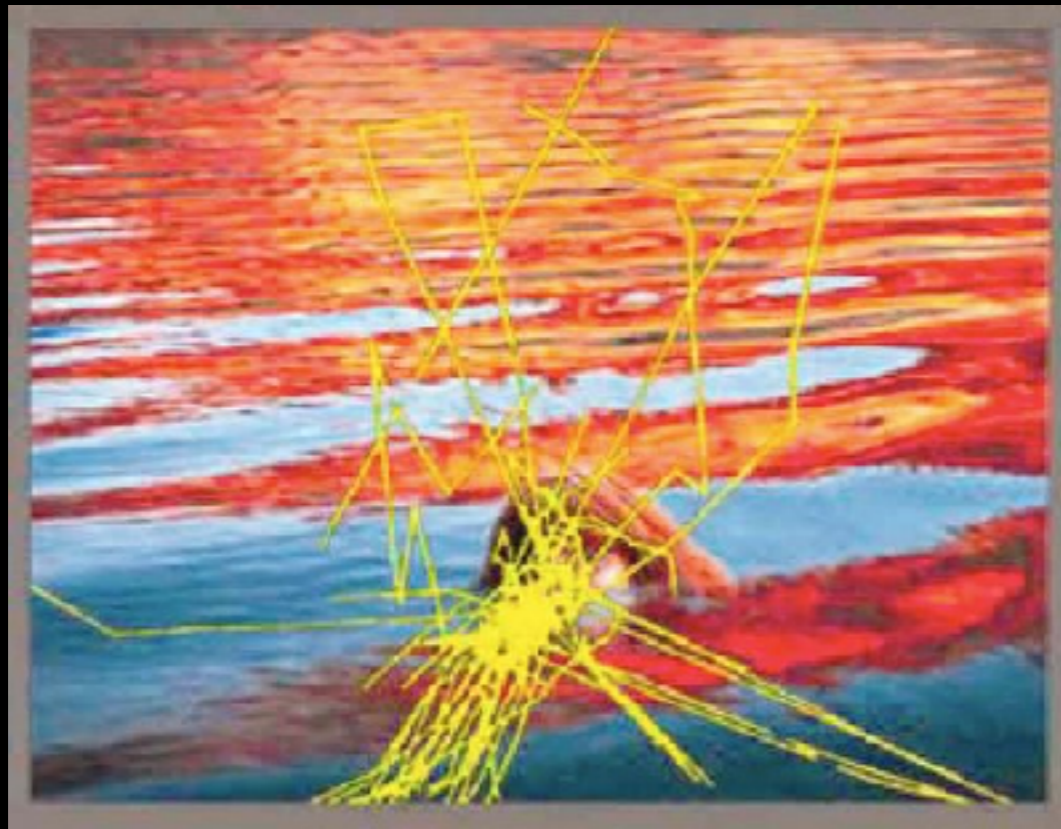
ACTIVE PERCEPTION

Perception requires action



ACTIVE PERCEPTION

Perception requires action



Eye movement of a layperson



Eye movement of an artist

ACTIVE PERCEPTION

Perception requires action



ACTIVE PERCEPTION

Perception requires action



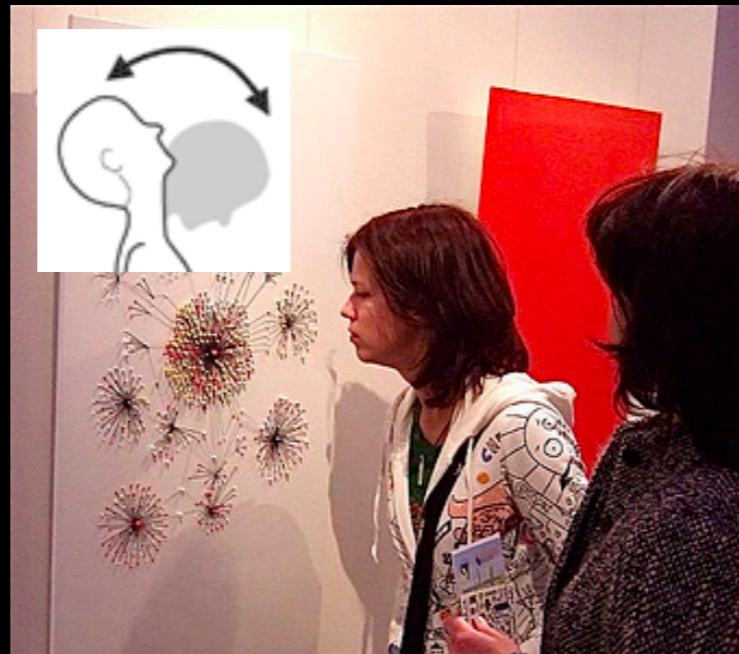
ACTIVE PERCEPTION

Perception requires action



ACTIVE PERCEPTION

Where is the person interacting?



A DEFINITION OF INTERACTION

Static content

Does not change

Dynamic content

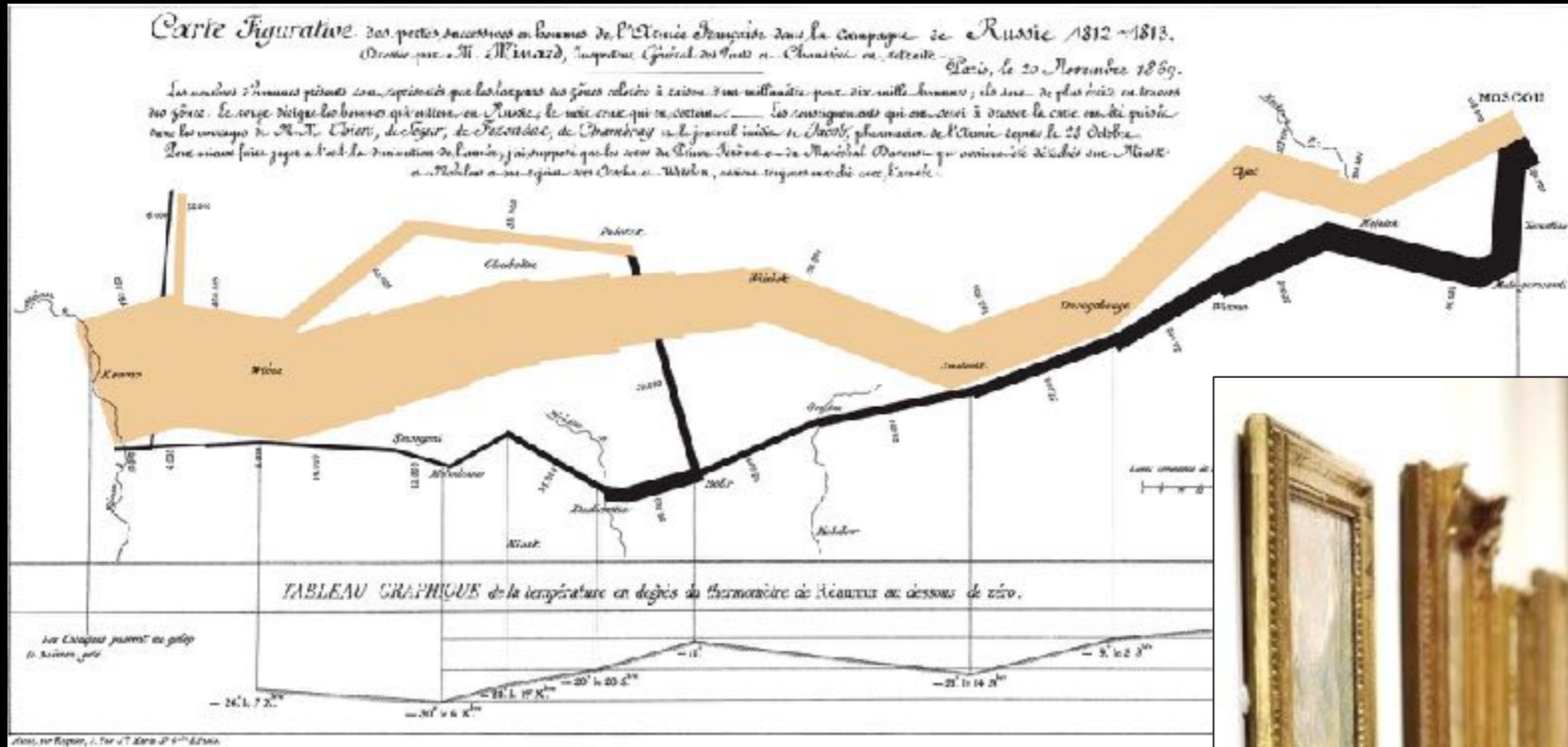
Animated content

Changes independently from the user

Interactive content

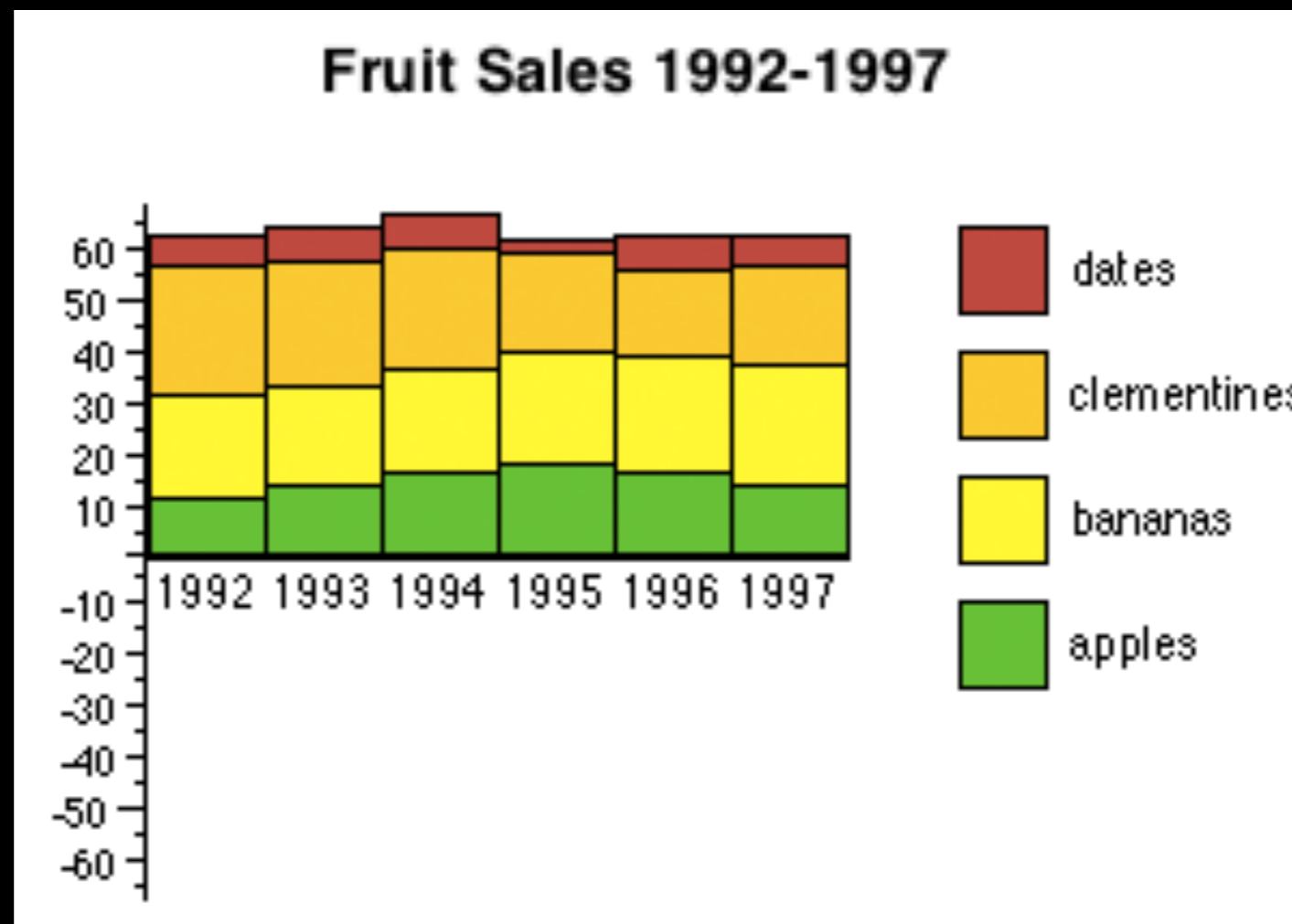
Changes as a result of user actions

WHY USE COMPUTER INTERACTION?



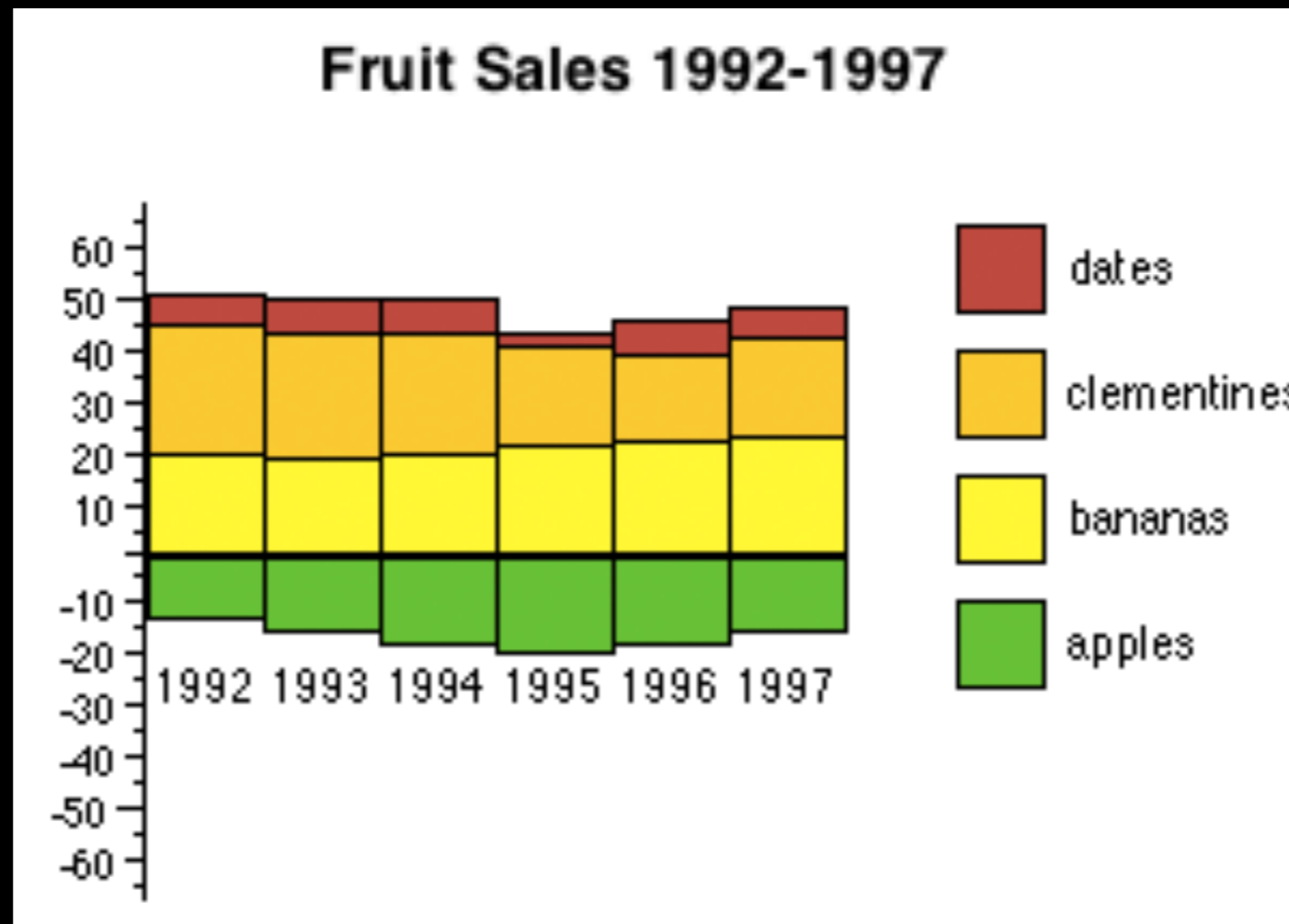
WHY USE COMPUTER INTERACTION?

Evolution of apple sales? Of bananas?



WHY USE COMPUTER INTERACTION?

Evolution of apple sales? Of bananas?



DAYS YOU CAN STAY FOR \$100

the most expensive ↓

↑ the cheapest

1.	Reykjavik, Iceland	0.69	9.62																		Goa, India	42.								
2.	Oslo, Norway	0.89				6.82																Hanoi, Vietnam	41.							
3.	Venice, Italy	0.93						4.7															Marrakech, Morocco	40.						
4.	Sydney, Australia	0.93								3.95														Manila, Philippines	39.					
5.	London, United Kingdom	1.02								3.92															Cairo, Egypt	38.				
6.	New York City, USA	1.06											3.35													Beijing, China	37.			
7.	Boston, USA	1.08											3.31														Kiev, Ukraine	36.		
8.	Rome, Italy	1.17												3.1													Mexico City, Mexico	35.		
9.	Dubai, UAE	1.21												3.05														Bangkok, Thailand	34.	
10.	Amsterdam, Netherlands	1.27													2.73													Denpasar, Bali	33.	
11.	Tokyo, Japan	1.3													2.62													Seoul, South Korea	32.	
12.	Barcelona, Spain	1.35													2.59													Hong Kong, China	31.	
13.	Paris, France	1.35													2.54													Singapore	30.	
14.	Dublin, Ireland	1.36													2.43														Prague, Czech Republic	29.
15.	Moscow, Russia	1.36													2.27														Kingston, Jamaica	28.
16.	Rio de Janeiro, Brazil	1.4													2.16														Buenos Aires, Argentina	27.
17.	Montreal, Canada	1.41													2.08														Istanbul, Turkey	26.
18.	San Francisco, USA	1.52													2														Santo Domingo, Dominican Republic	25.
19.	Chicago, USA	1.57													1.96														Kuala Lumpur, Malaysia	24.
20.	Los Angeles, USA	1.57													1.82														Cape Town, South Africa	23.
21.	Berlin, Germany	1.53													1.76														Jerusalem, Israel	22.

The cheapest



Goa

- Bed \$2.69
- Goa State Museum (free)
- Transport \$0.90
- Food \$6.74



Hanoi

- Bed \$4.80
- Ho Chi Minh Mausoleum (free)
- Transport \$1.20
- Food \$8.64



Marrakech

- Bed \$6.19
- El Bahia Palace \$1.13
- Transport \$1.69
- Food \$12.38

The most expensive



Reykjavik

- Bed \$26.71
- Blue Lagoon \$46.74
- Transport \$40.90
- Food \$30.05



Oslo

- Bed \$37.14
- Viking Ship Museum \$10.13
- Transport \$12.66
- Food \$52.33



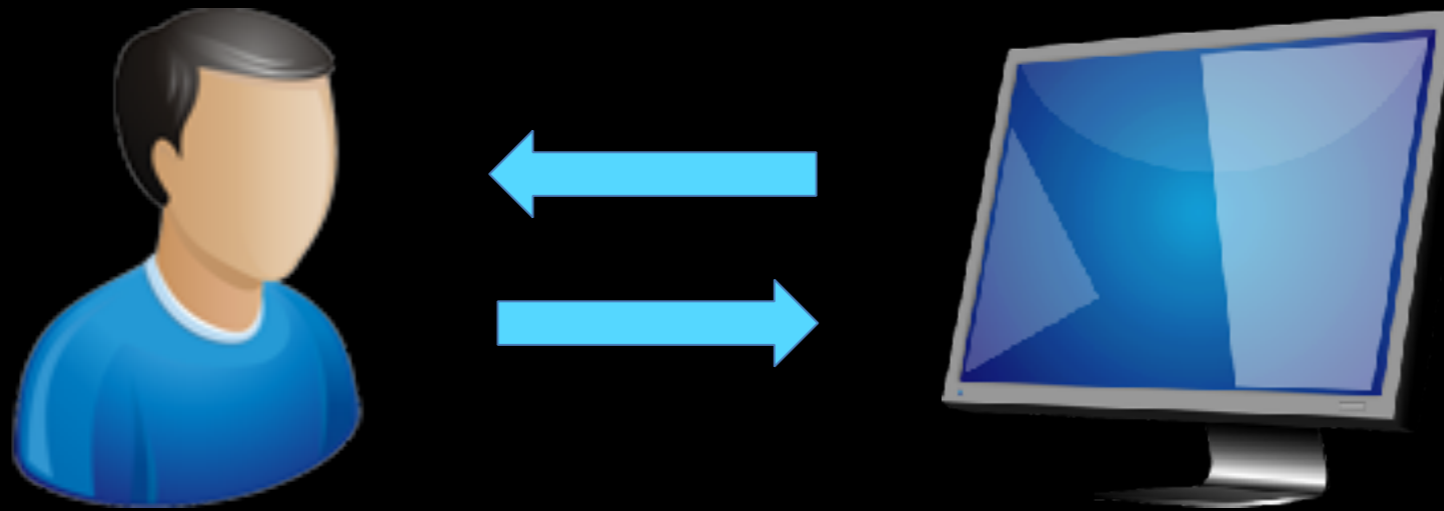
Venice

- Bed \$24.72
- Venice museum pass \$22.25
- Transport \$24.72
- Food \$30.90

HOW MANY DAYS FOR \$100



WHY USE COMPUTER INTERACTION?

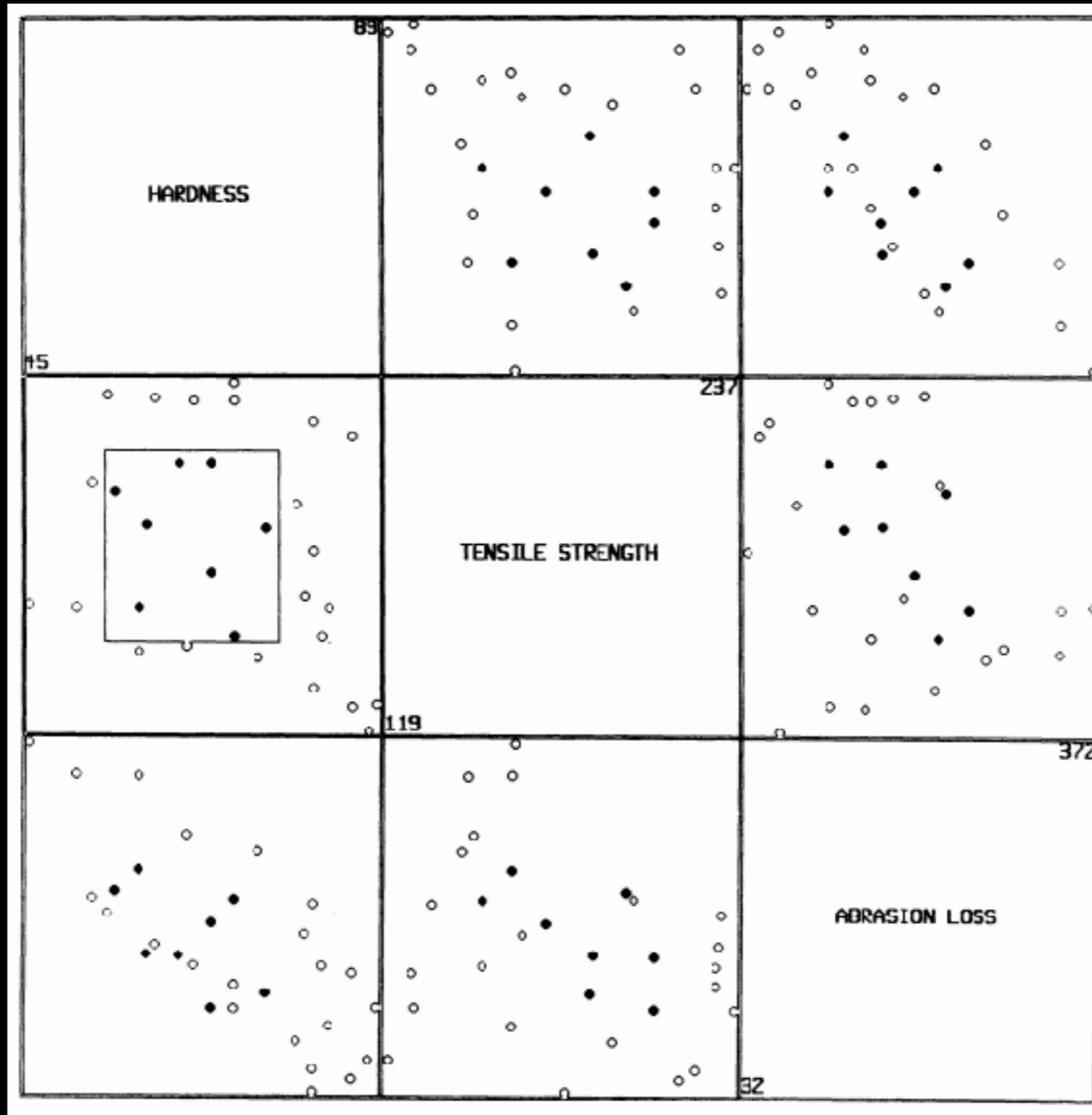


There is too much to be shown

There are many ways to show it

—> let the user dynamically control
what to show and **how**

EXAMPLE 1: BRUSHING

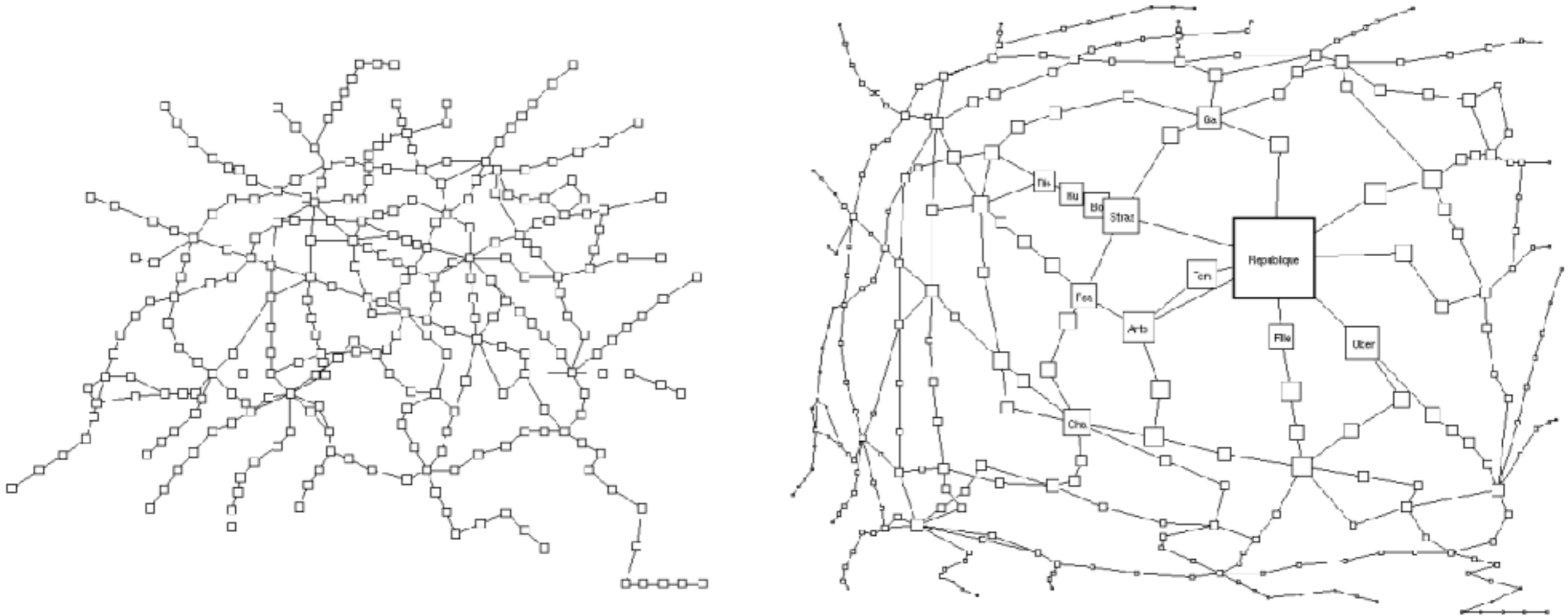


EXAMPLE 1: BRUSHING



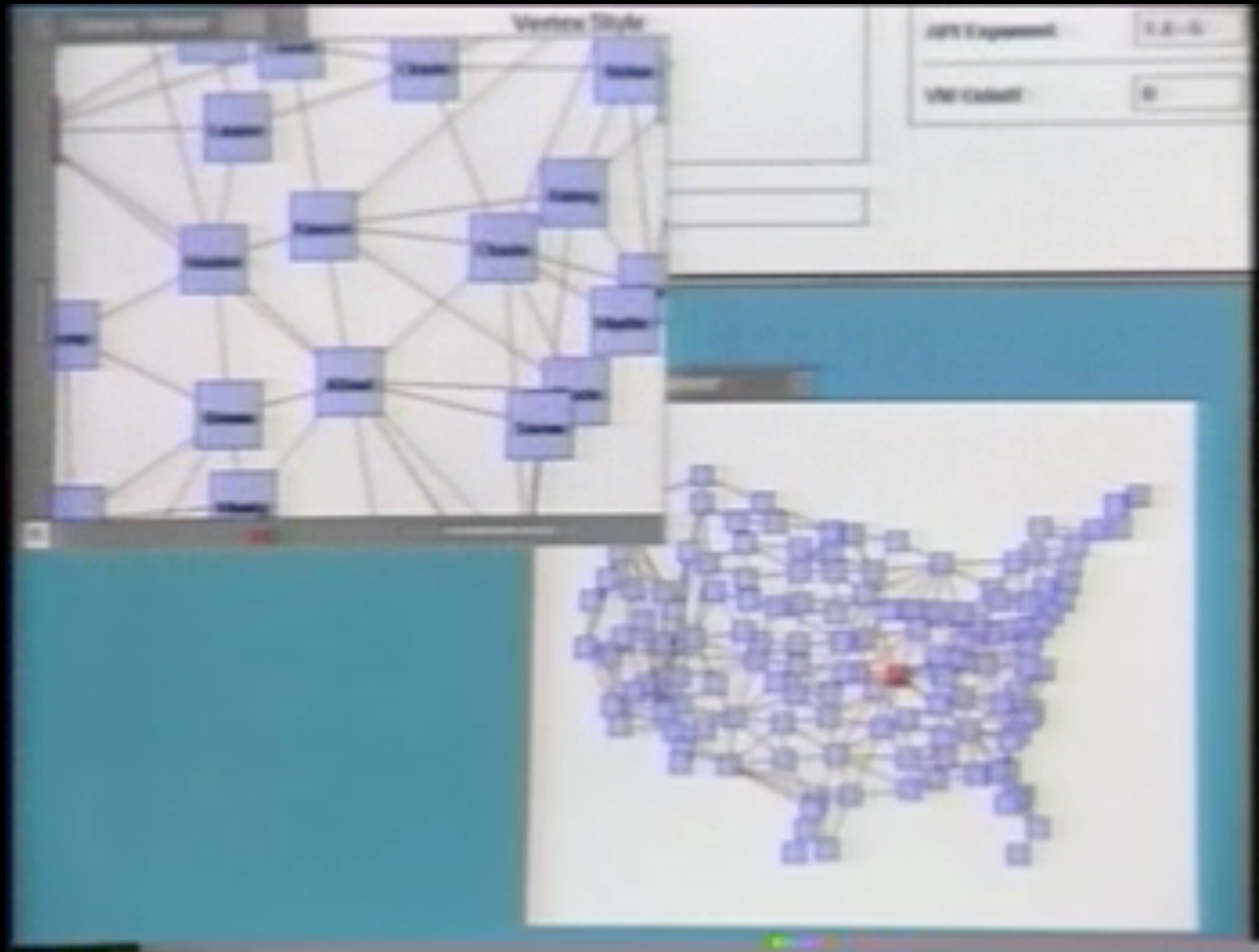
Beker and Cleveland, 1987

EXAMPLE 2: FISHEYE VIEWS



Sarkar and Brown, 1992 (see also Furnas, 1986)

EXAMPLE 2: FISHEYE VIEWS



Sarkar and Brown, 1992 (see also Furnas, 1986)

EXAMPLE 3: DYNAMIC QUERIES



EXAMPLE 3: DYNAMIC QUERIES

**Dynamic Queries Demos:
Revised HomeFinder
and Text Version
plus Health Statistics Atlas**

Ben Shneiderman

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1:29

MANY INTERACTION TECHNIQUES



TAXONOMIES OF INTERACTION

What?

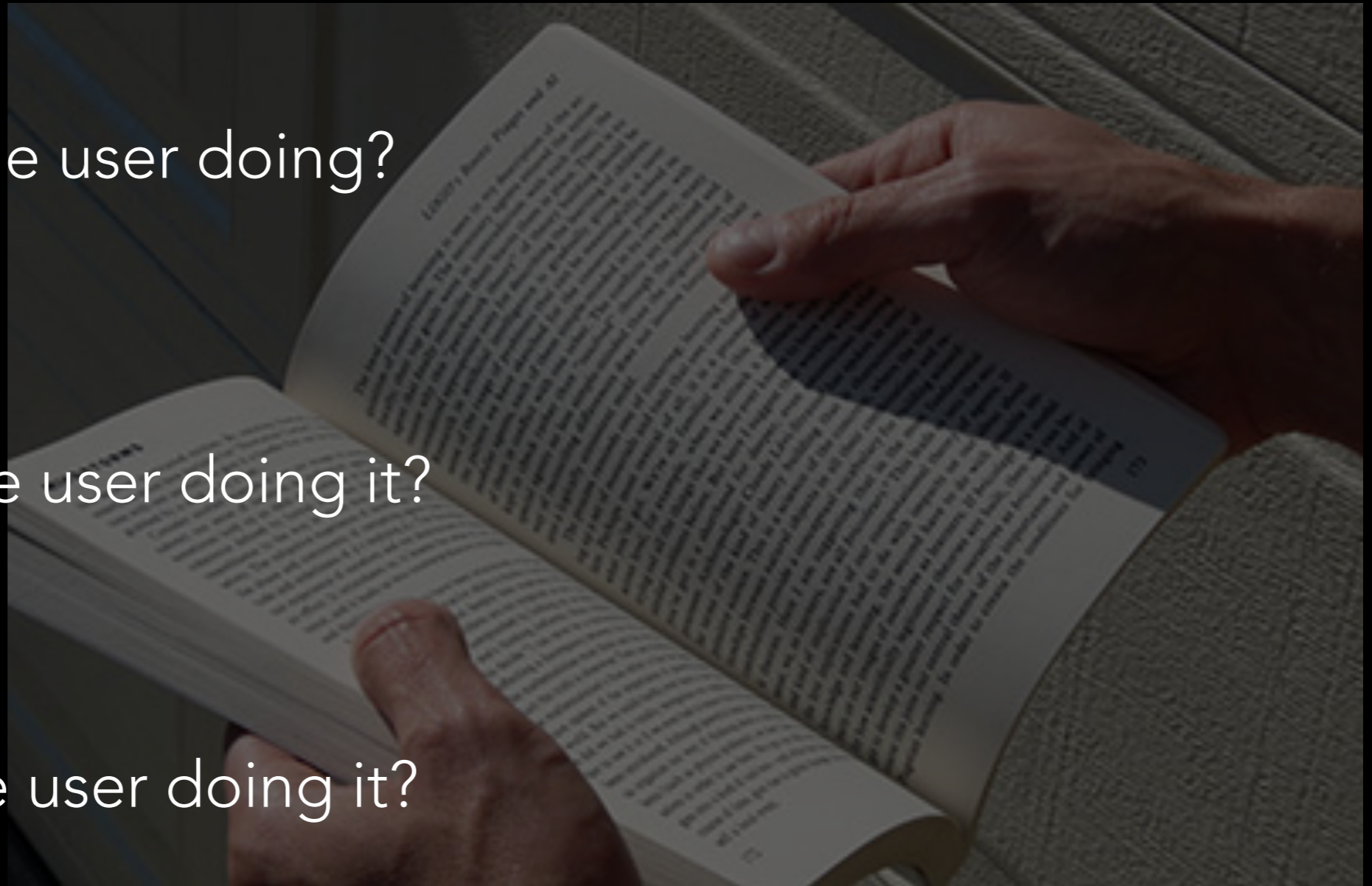
What is the user doing?

Why?

Why is the user doing it?

How?

How is the user doing it?



TAXONOMIES OF INTERACTION

What?

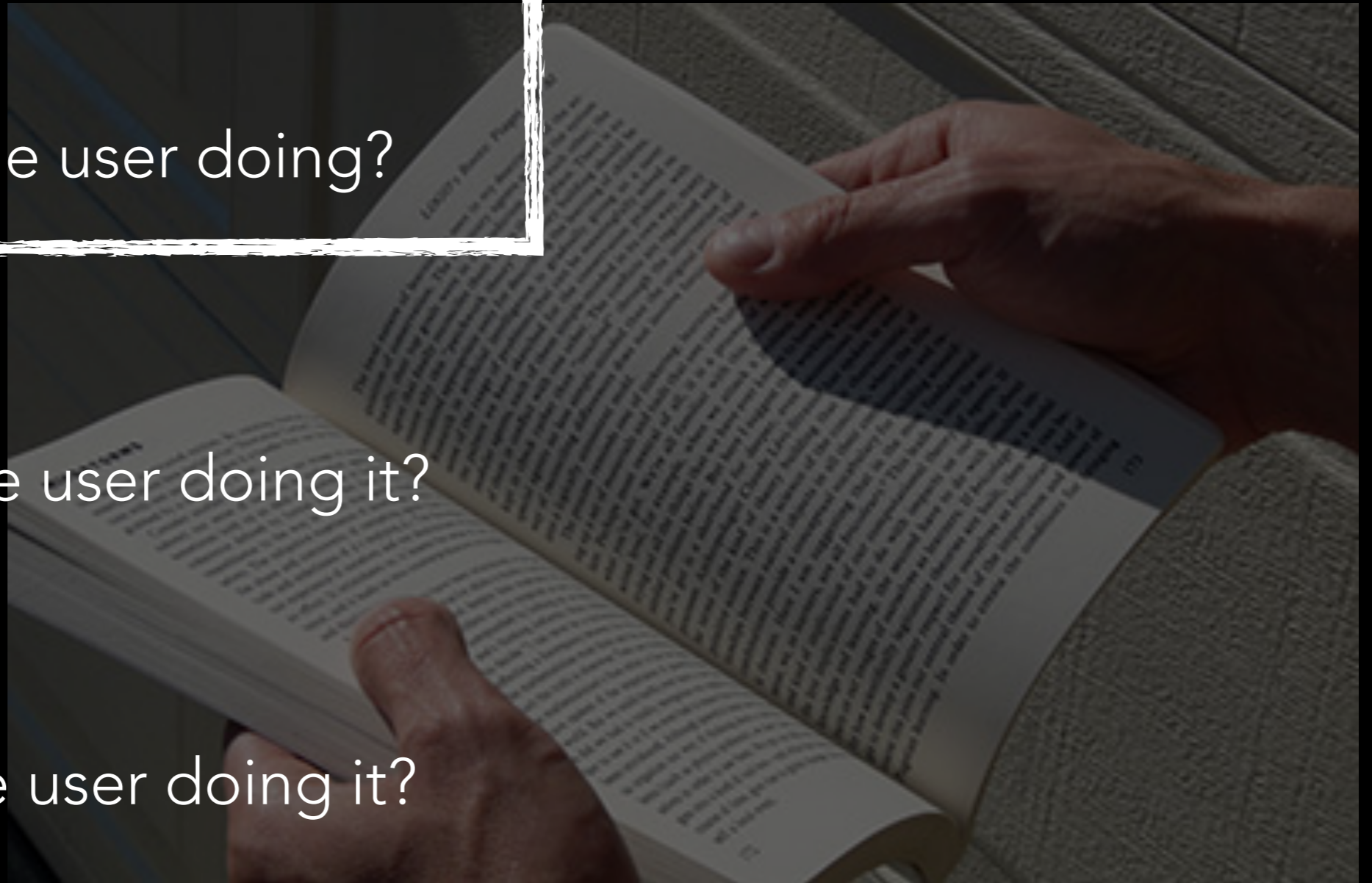
What is the user doing?

Why?

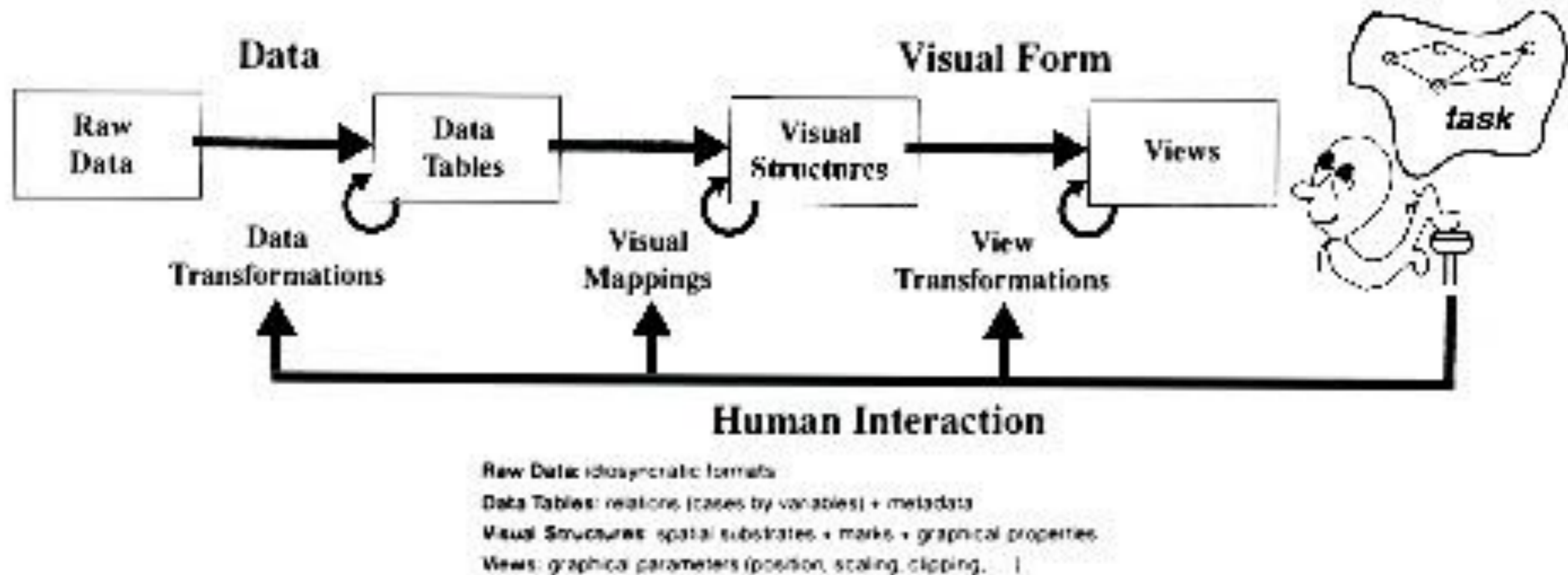
Why is the user doing it?

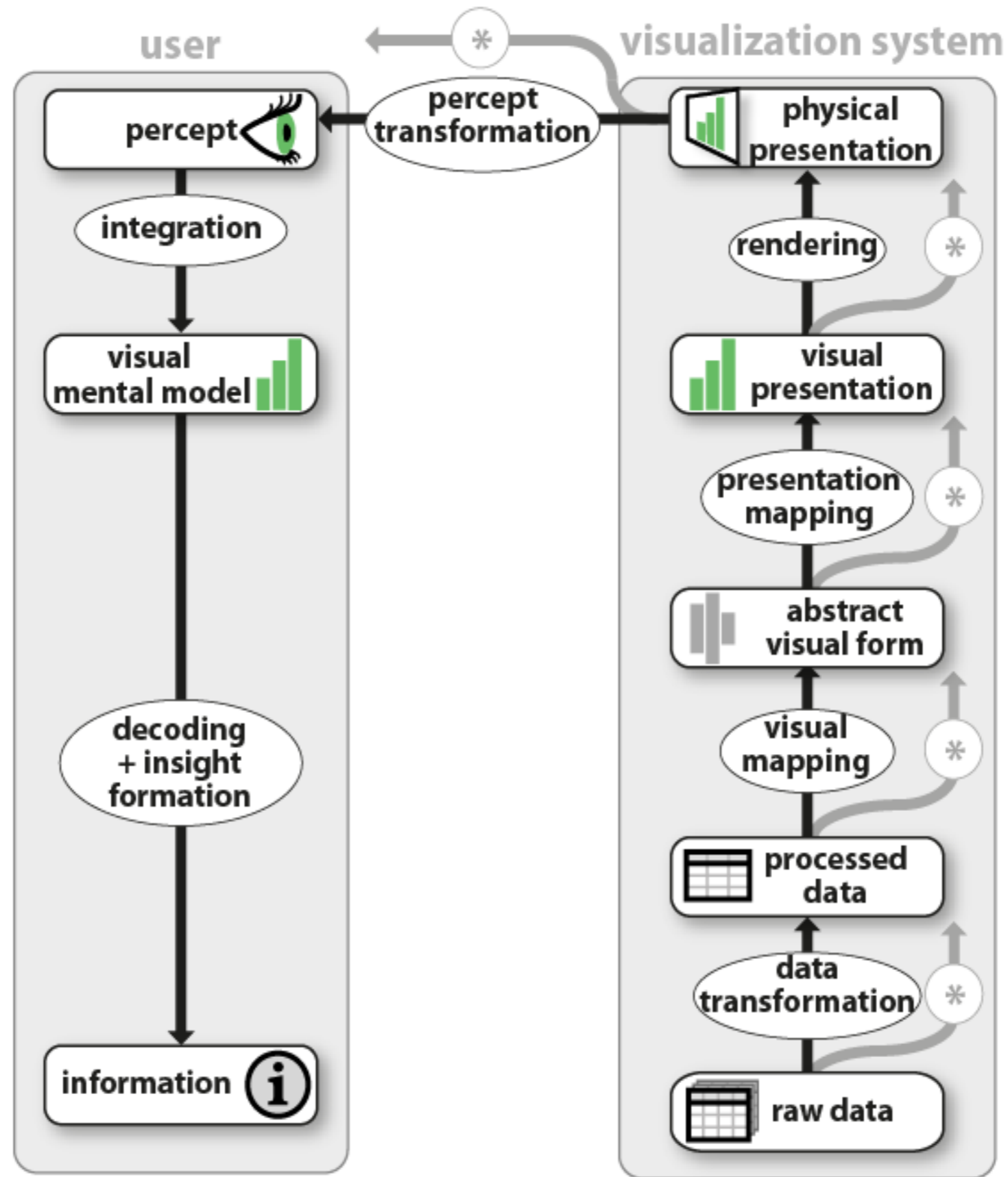
How?

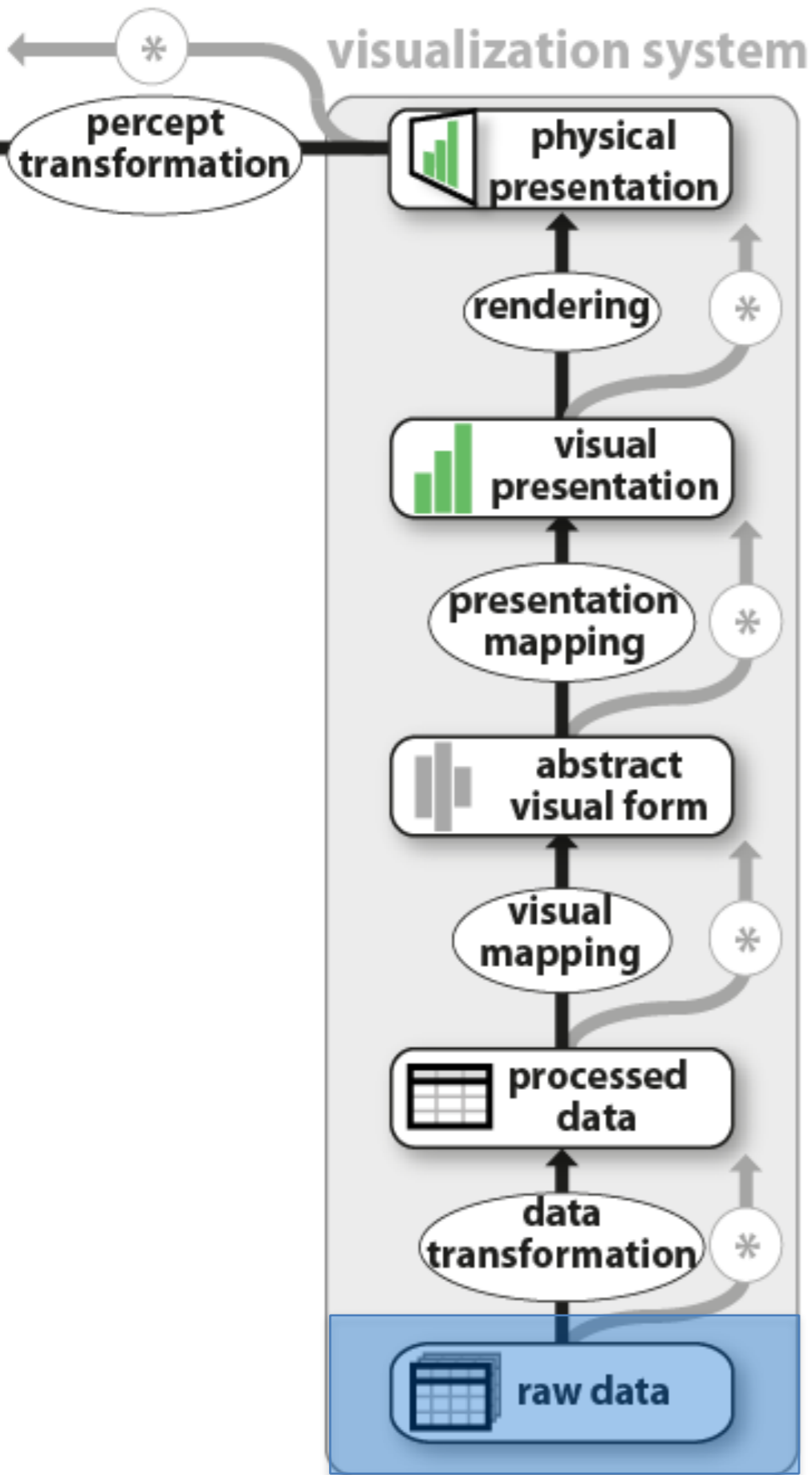
How is the user doing it?



THE VISUALIZATION PIPELINE



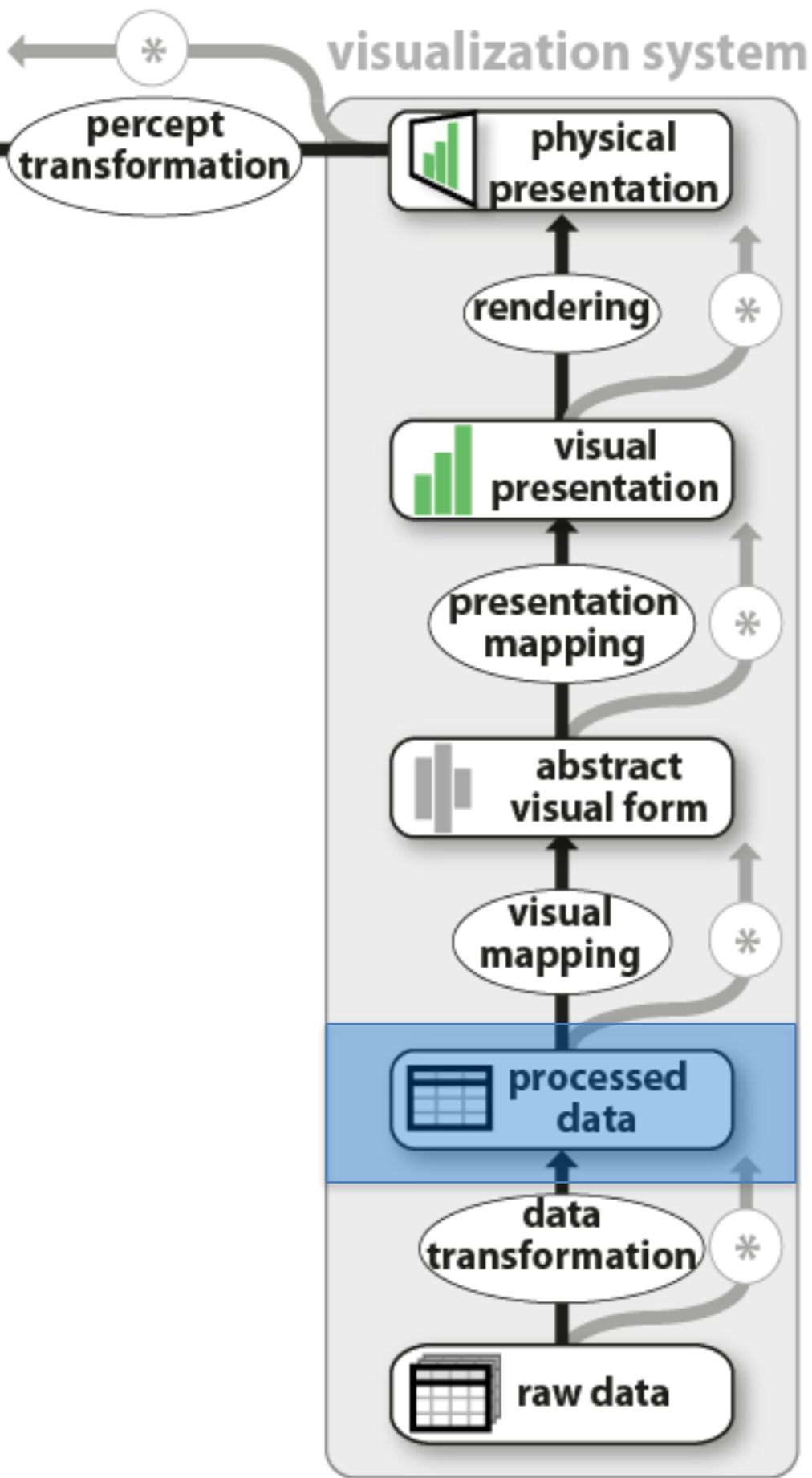




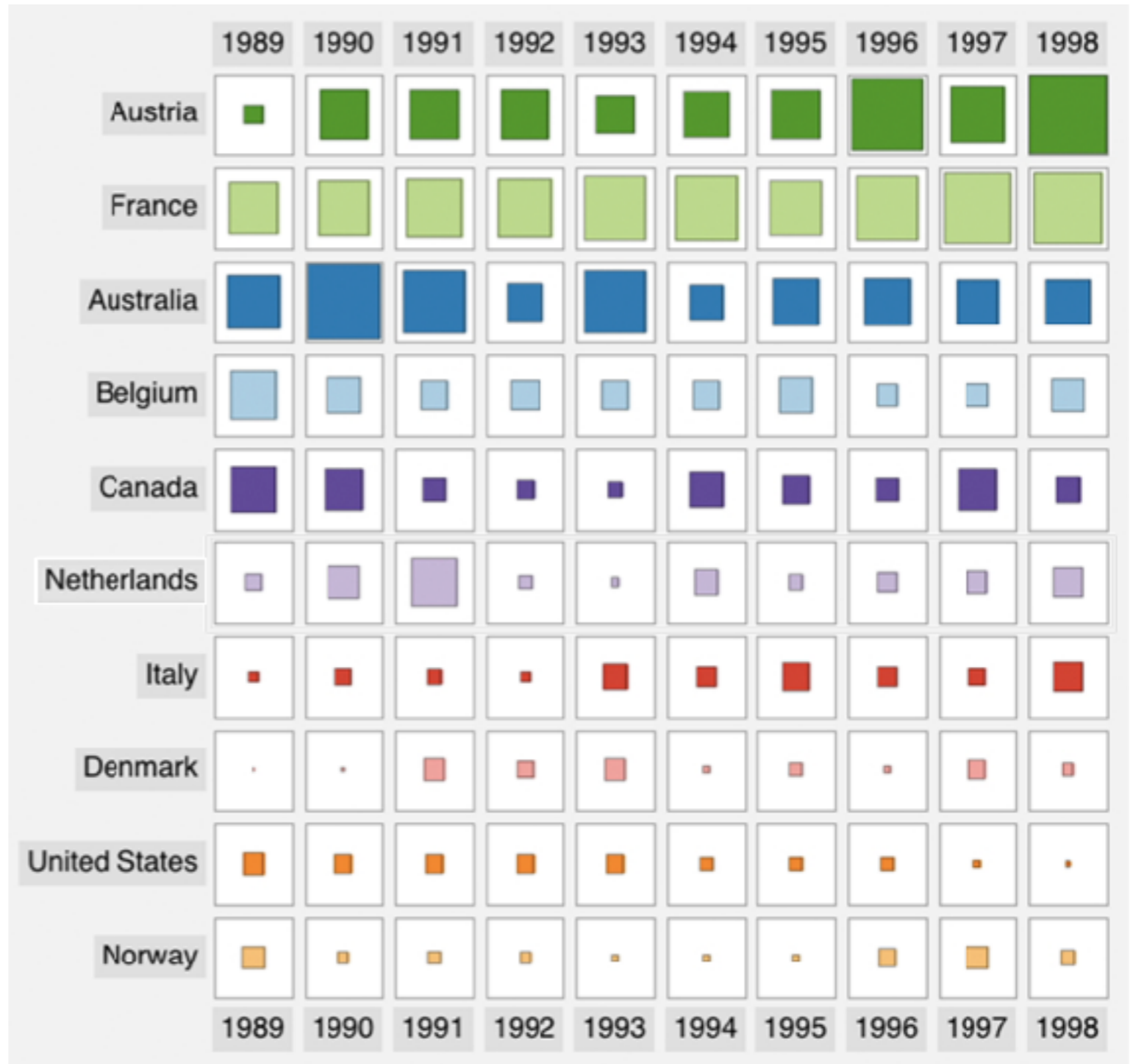
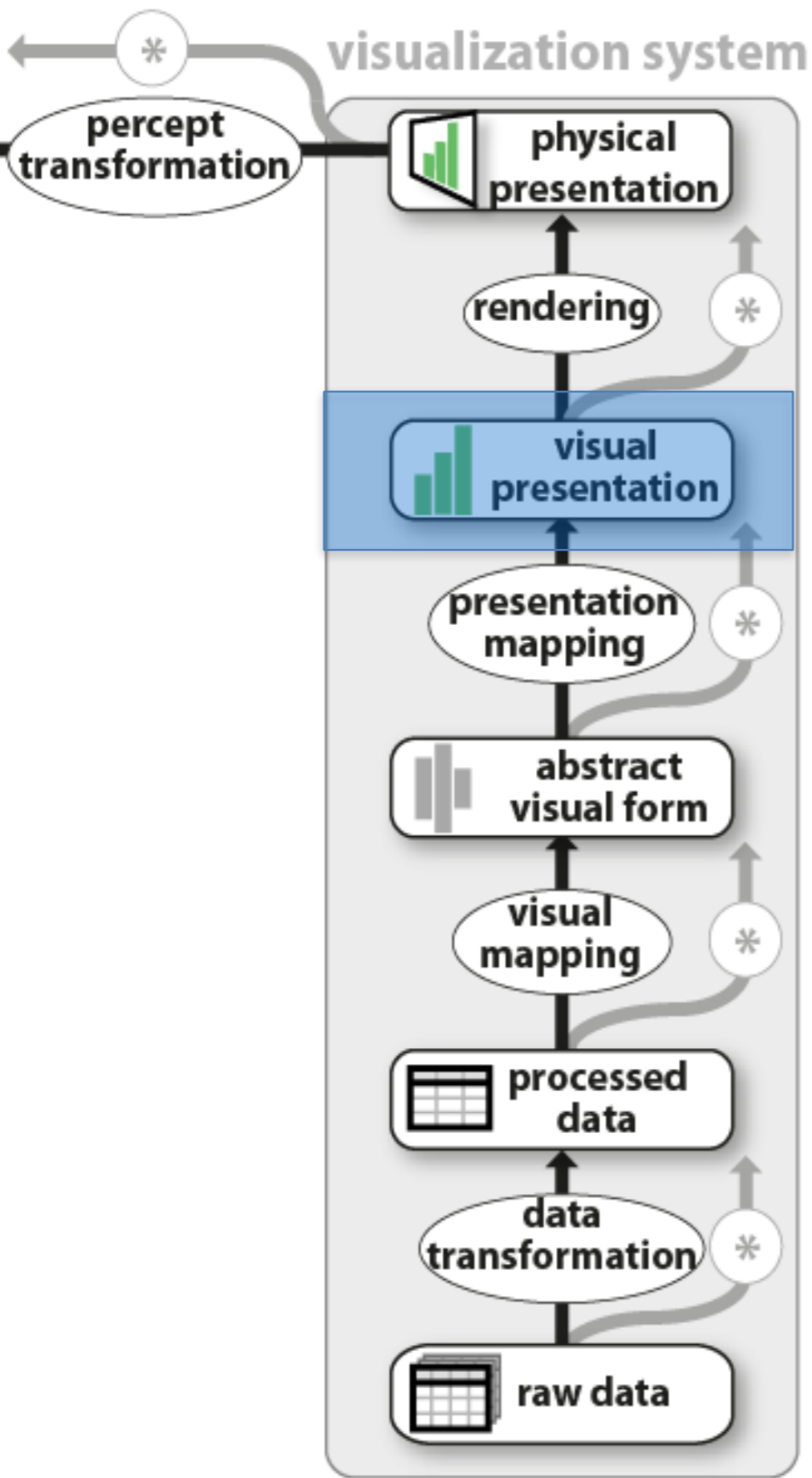
GAPMINDER for a fact-based world view

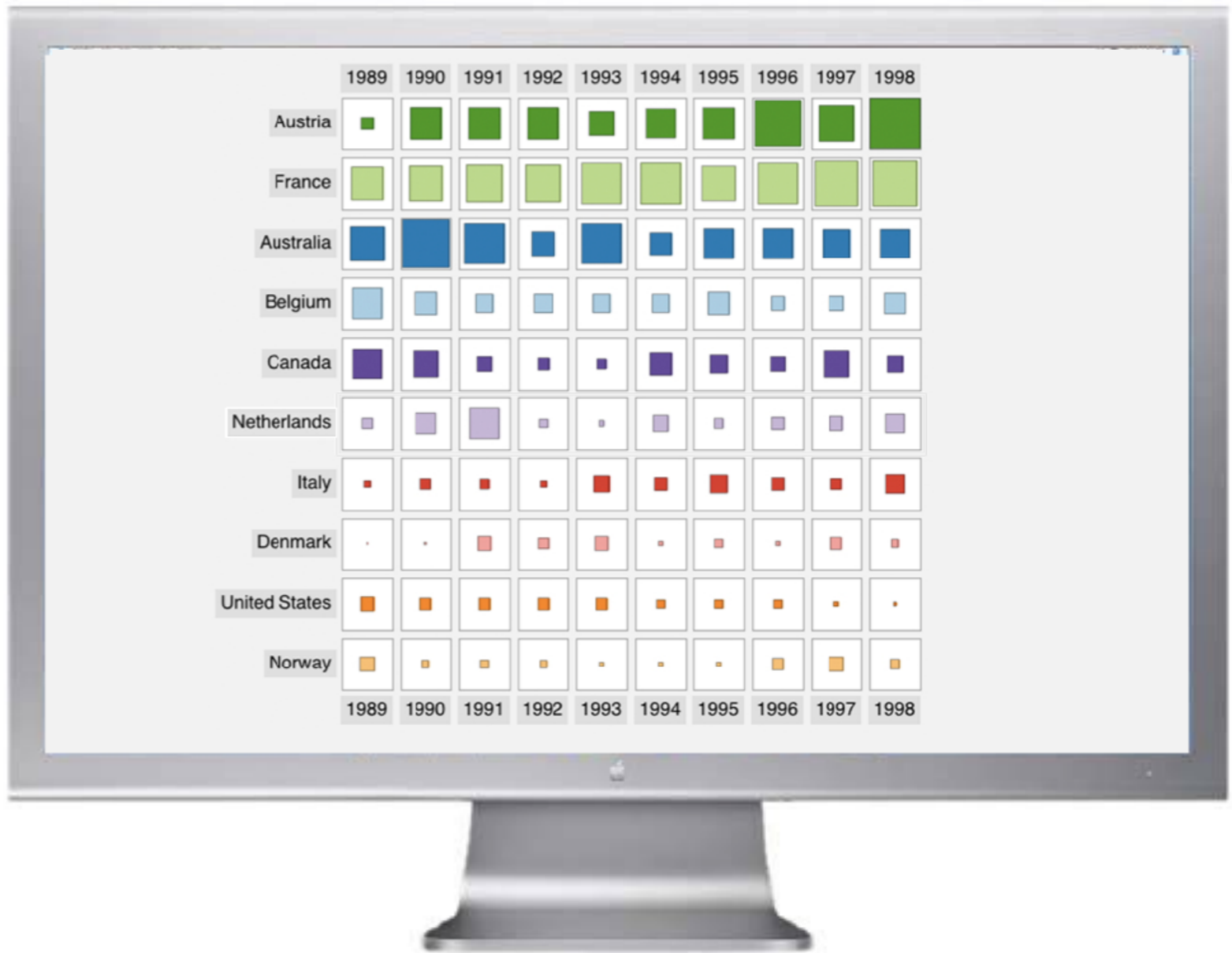
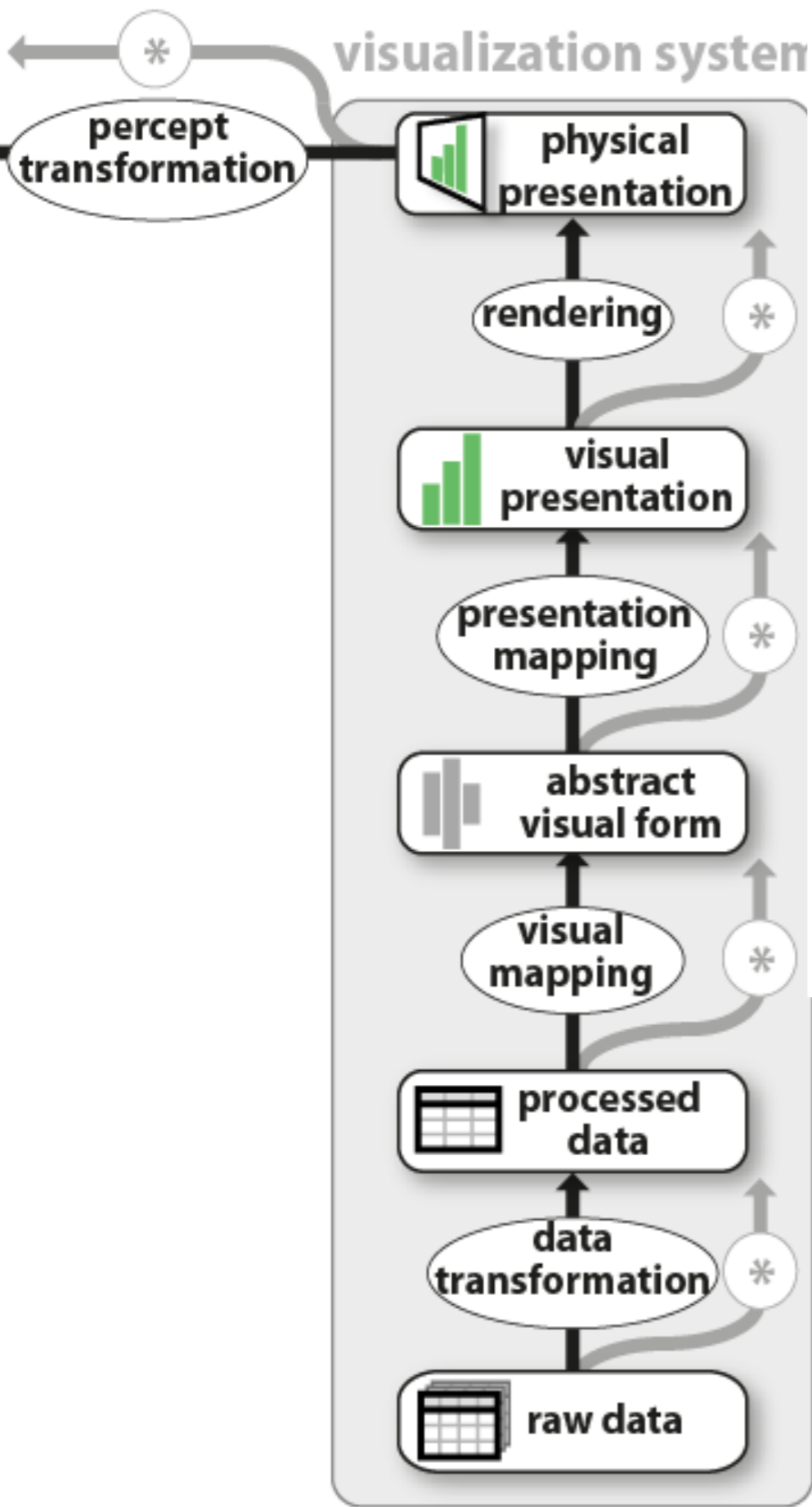
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ			
1	Education aid (% of total aid)	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020

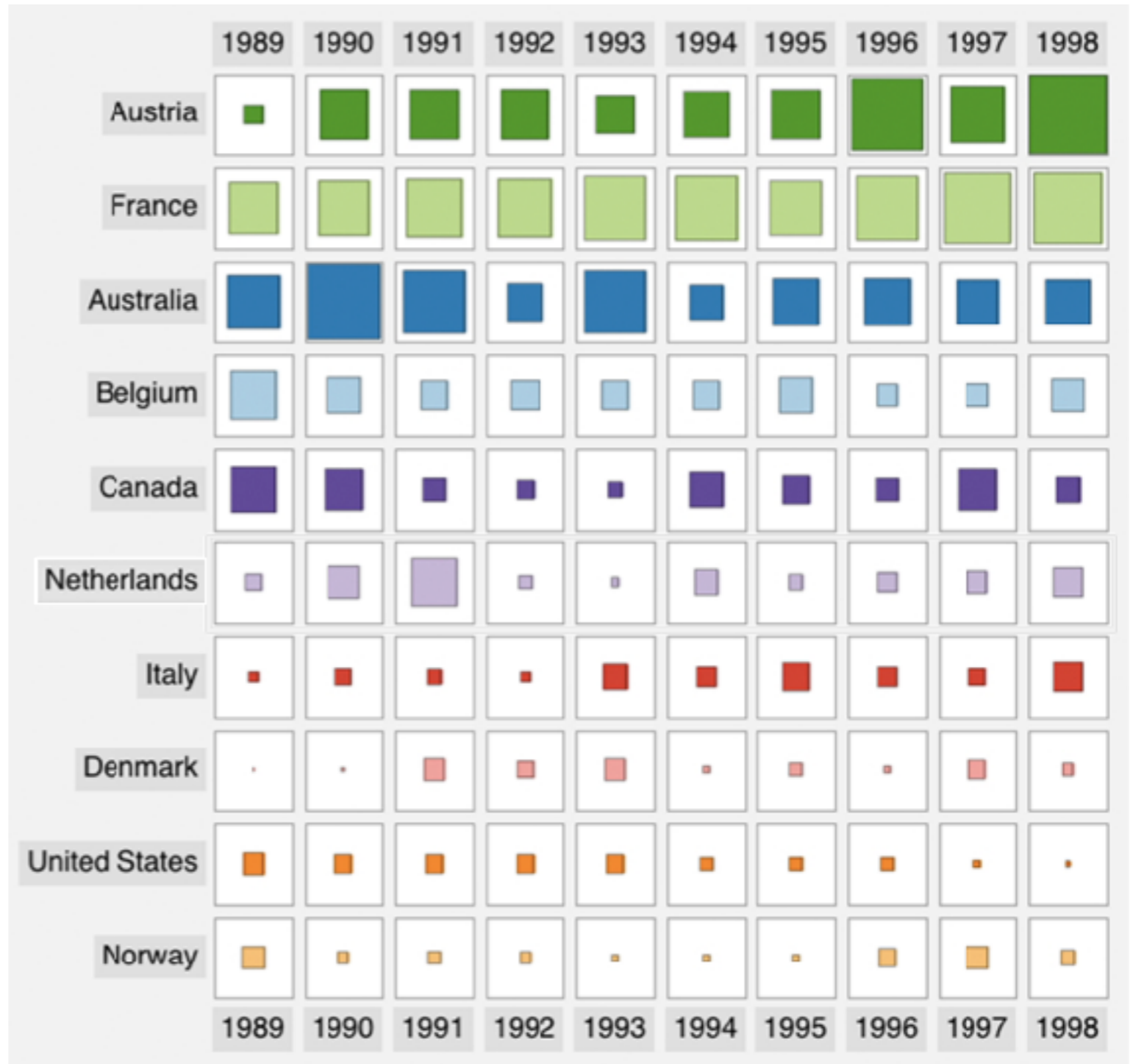
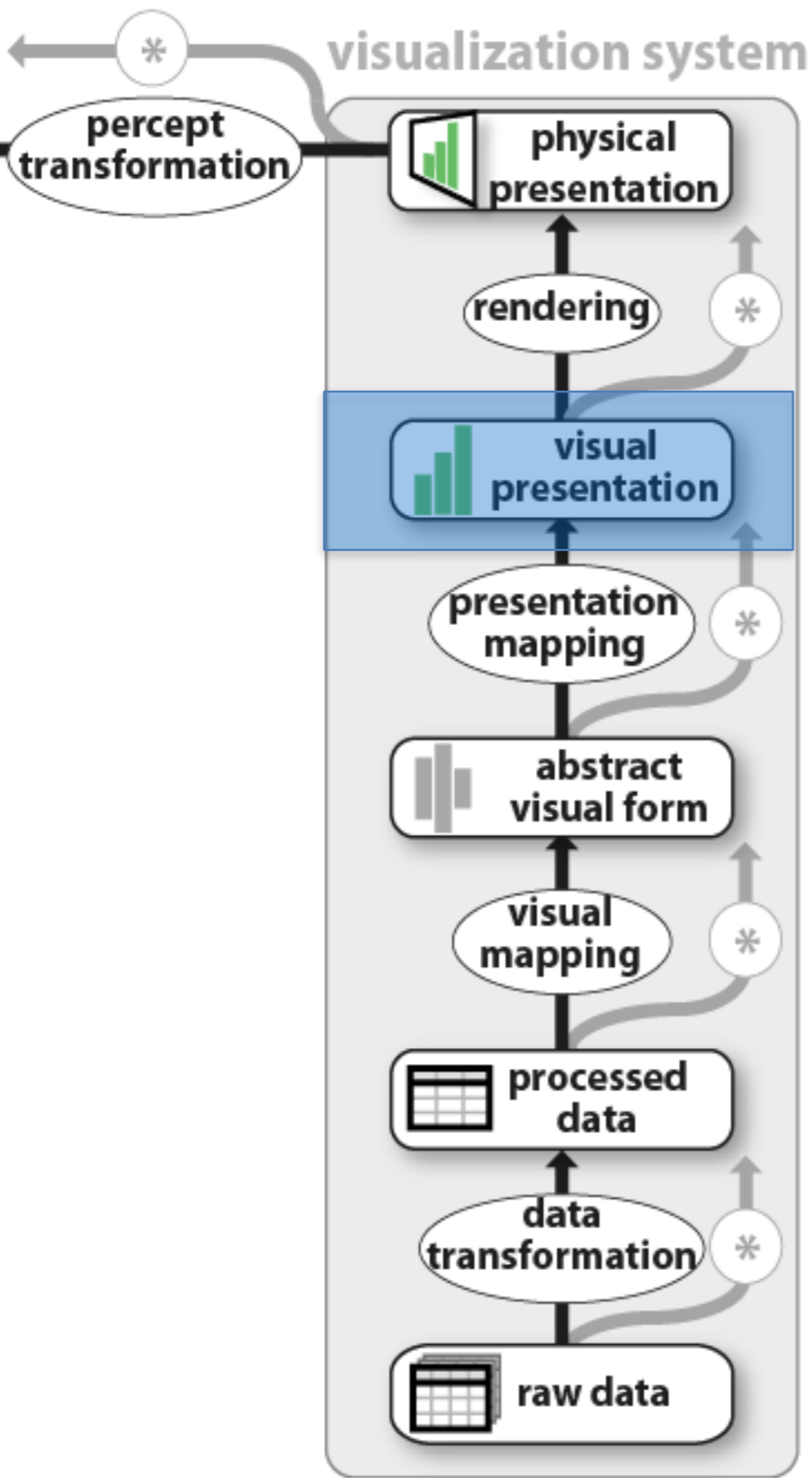
	A	B	C	D	E	F	G	H	I	J	K
1	Education aid (% of total aid)	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
2	Australia					4.75	33.2	19.7	23.7	26.3	30.1
3	Austria					24.7	42.3	13.5	2.52	15.9	4.8
4	Belgium					84.5	83.7	11	11.4	15.9	18.1
5	Canada					33.7	38.6	18	25.3	8.41	5.1
6	Denmark					100	100	13.7	19	5.6	15.1
7	Finland							29.6	13.5	14.1	20.1
8	France					62.9	63.7	46.8	33.4	38.2	38.1
9	Germany					54.6	54.8	21.7	18.8	23.6	18.1
10	Greece										
11	Ireland										
12	Italy					20.1	95.8			39.5	
13	Japan					12.6	12.3	2.92	1.08	2.15	2.5
14	Luxembourg										
15	Netherlands						42	32.6	12.4	15	1
16	New Zealand							19.5	20.9	5.15	8.8
17	Norway					54.7	48.8	32.4	9.71	5.74	7.0
18	Portugal										
19	Spain										
20	Sweden					32.6	23.4	15	13.7	20.7	18.1
21	Switzerland					47	46	12	15	8.7	11.1
22	United Kingdom					49.8	32.4	15.9	16.2	0.91	0.1
23	United States					69.3	64	9.97		7.76	6.1

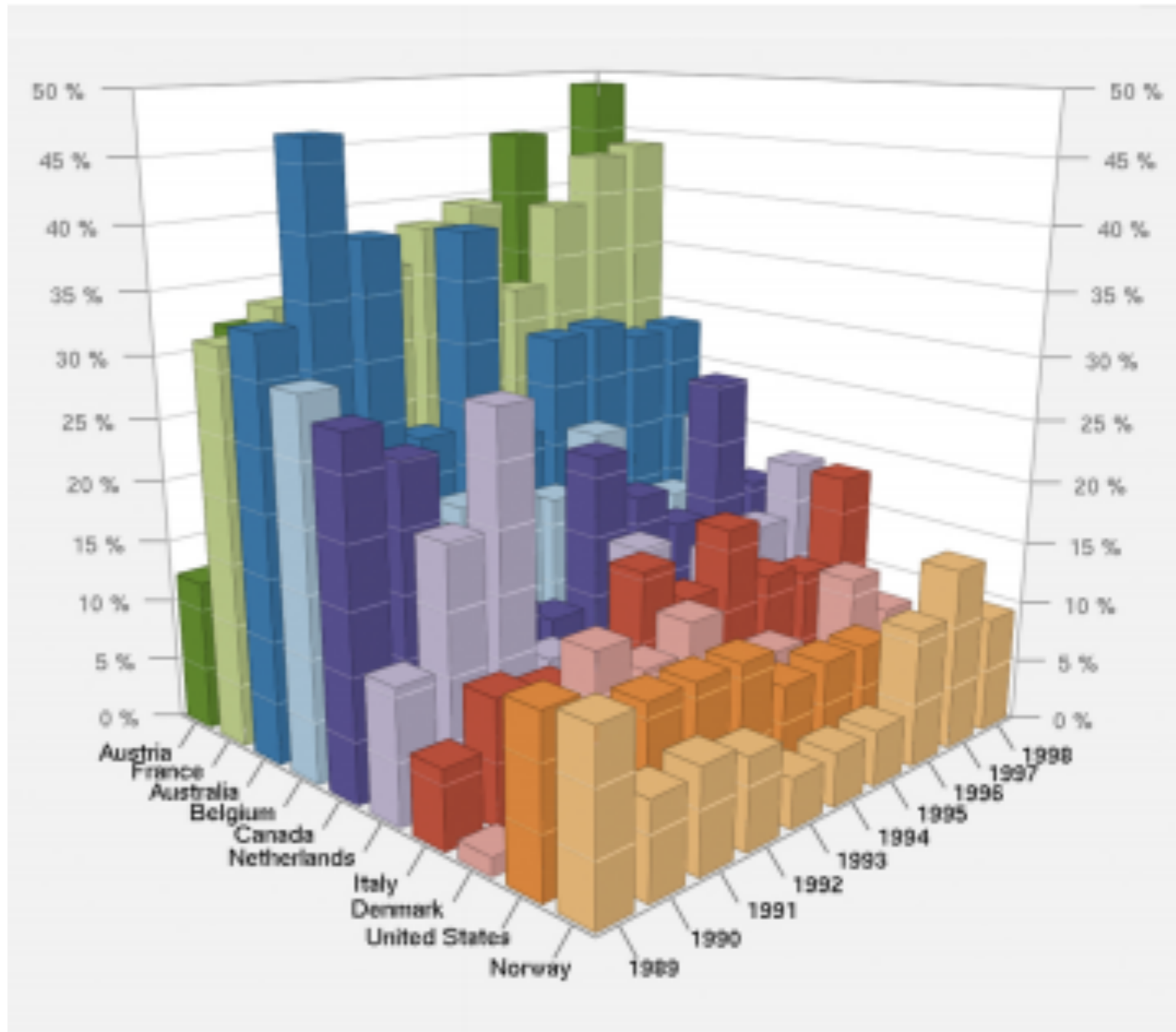
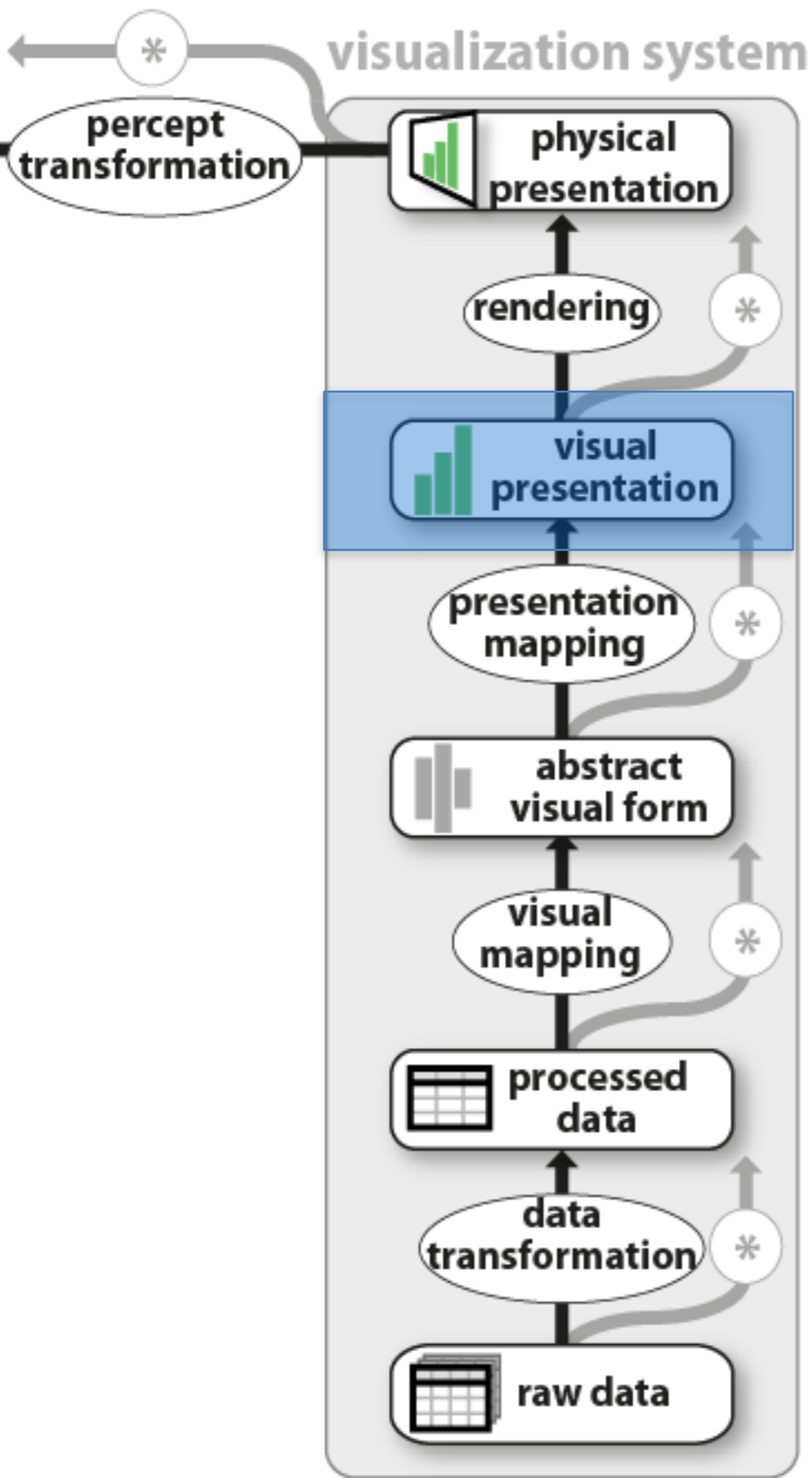


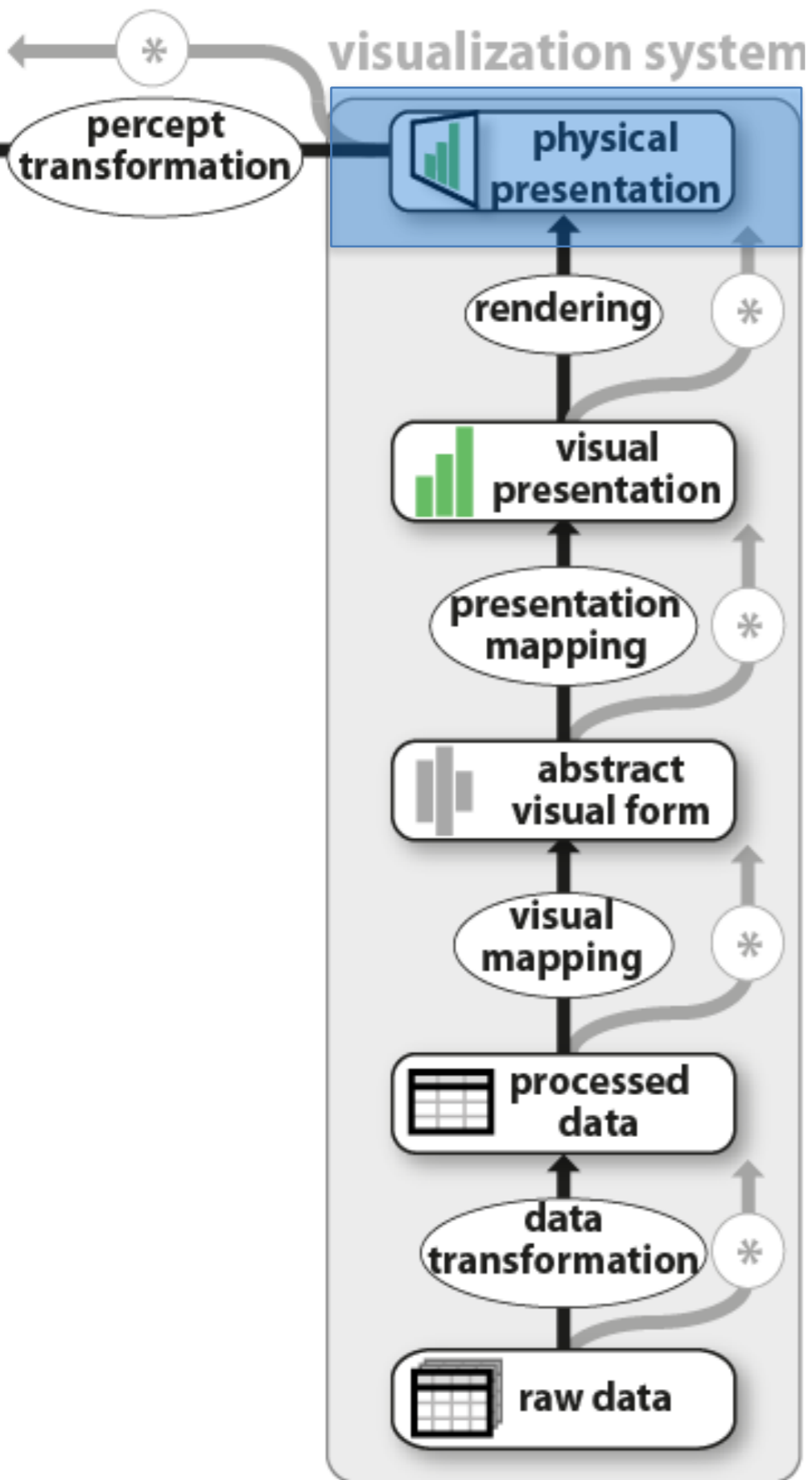
	A	B	C	D	E	F	G	H	I	J	K
1		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	Austria	12.23	31.86	31.07	31.57	24.02	28.61	30.52	44.99	35.41	48.95
3	France	31.87	34.18	35.95	36.06	38.78	40.18	32.68	39.26	43.15	43.9
4	Australia	33.57	46.93	39.24	23.18	38.94	21.38	29.1	29.43	27.97	28.32
5	Belgium	29.93	22.13	17.64	18.52	17.72	17.13	21.77	13.63	14.69	20.38
6	Canada	28.11	25.09	14.35	11.19	9.291	21.67	17.33	13.98	25.19	15.66
7	Netherlands	10.78	20.12	29.08	8.702	5.085	15.12	9.117	12.48	13.75	18.17
8	Italy	6.278	9.992	9.04	6.076	15.66	12.26	16.75	11.75	10.75	17.98
9	Denmark	1.485	1.933	13.52	10.71	13.01	4.193	7.937	4.303	11.42	7.581
10	United States	13.69	11.25	11.22	11.22	11.22	7.992	8.465	8.409	4.702	3.038
11	Norway	14.25	7.561	8.219	7.255	3.967	4.307	4.476	10.99	14.62	9.296

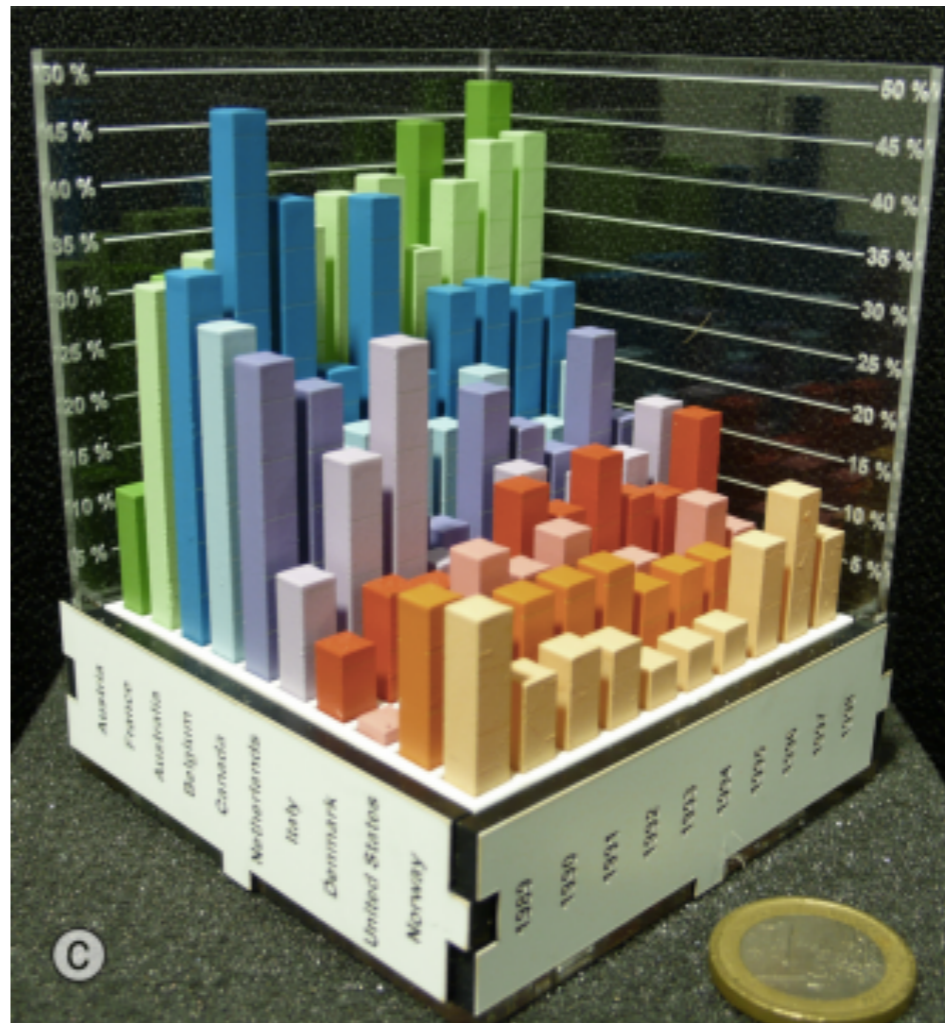
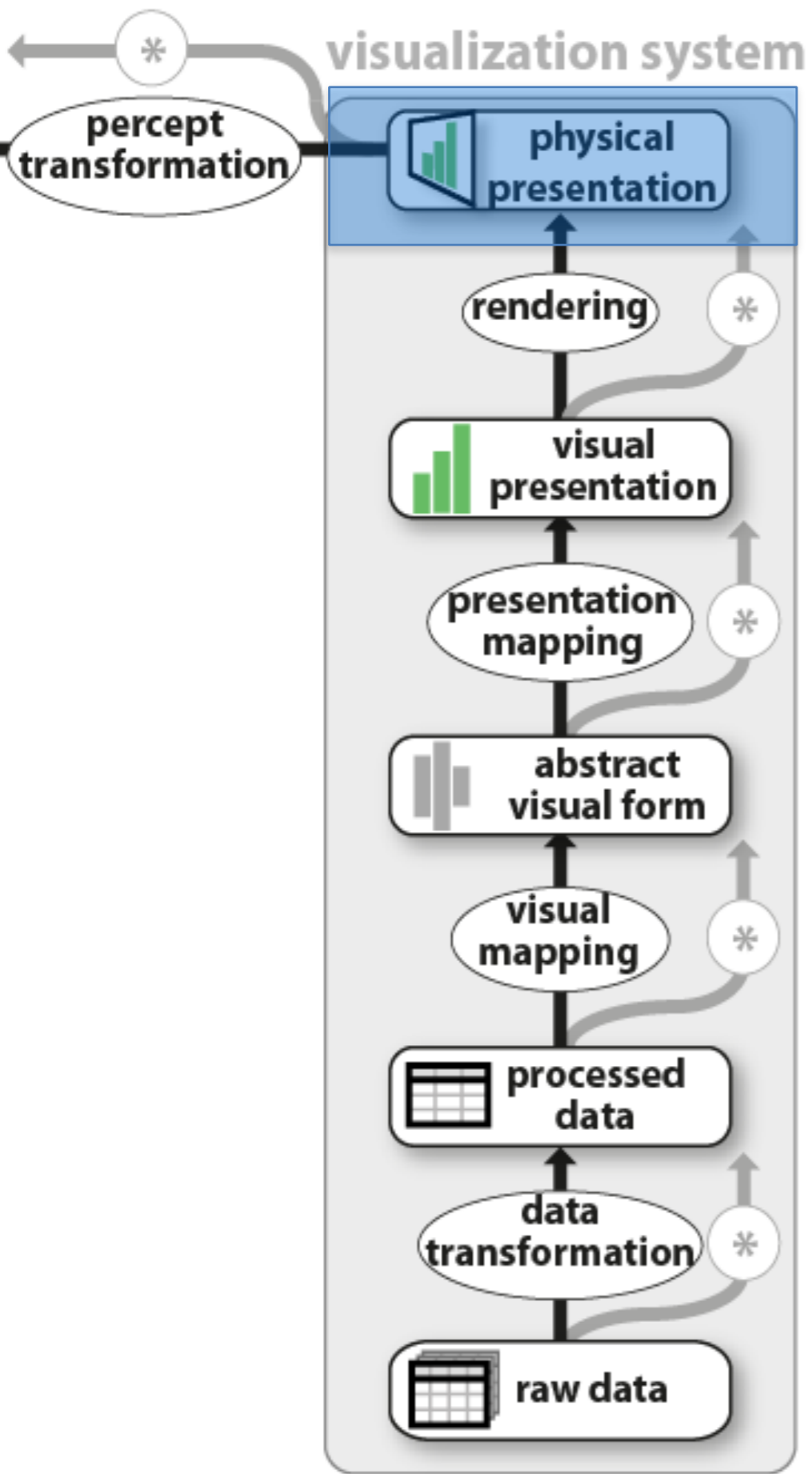












TAXONOMIES OF INTERACTION

What?

What is the user doing?

Why?

Why is the user doing it?

How?

How is the user doing it?

A photograph of a person's hands holding an open book, with the pages visible. The image is dimly lit and serves as a background for the text.

**Task
Taxonomies**

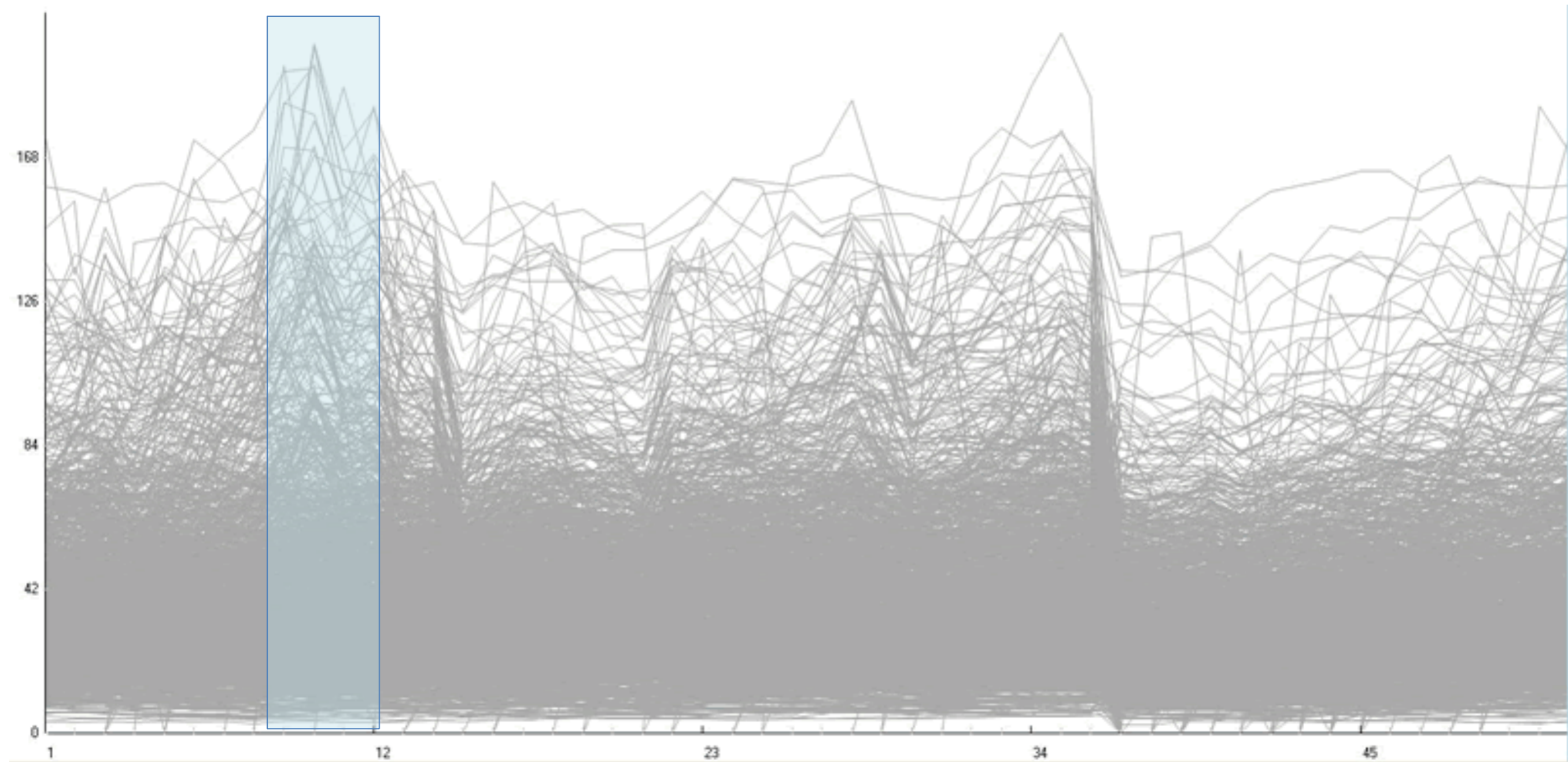
ANALYTICAL TASKS

Shneiderman, 1996

1. **Overview**: Gain an overview of the entire collection
2. **Zoom**: Zoom in on items of interest
3. **Filter**: Filter out uninteresting items
4. **Details-on-demand**: Select an item or group and get details when needed
5. **Relate**: View relationships among items
6. **History**: Keep a history of actions to support undo, replay, and progressive refinement
7. **Extract**: Allow extraction of sub-collections and of the query parameters

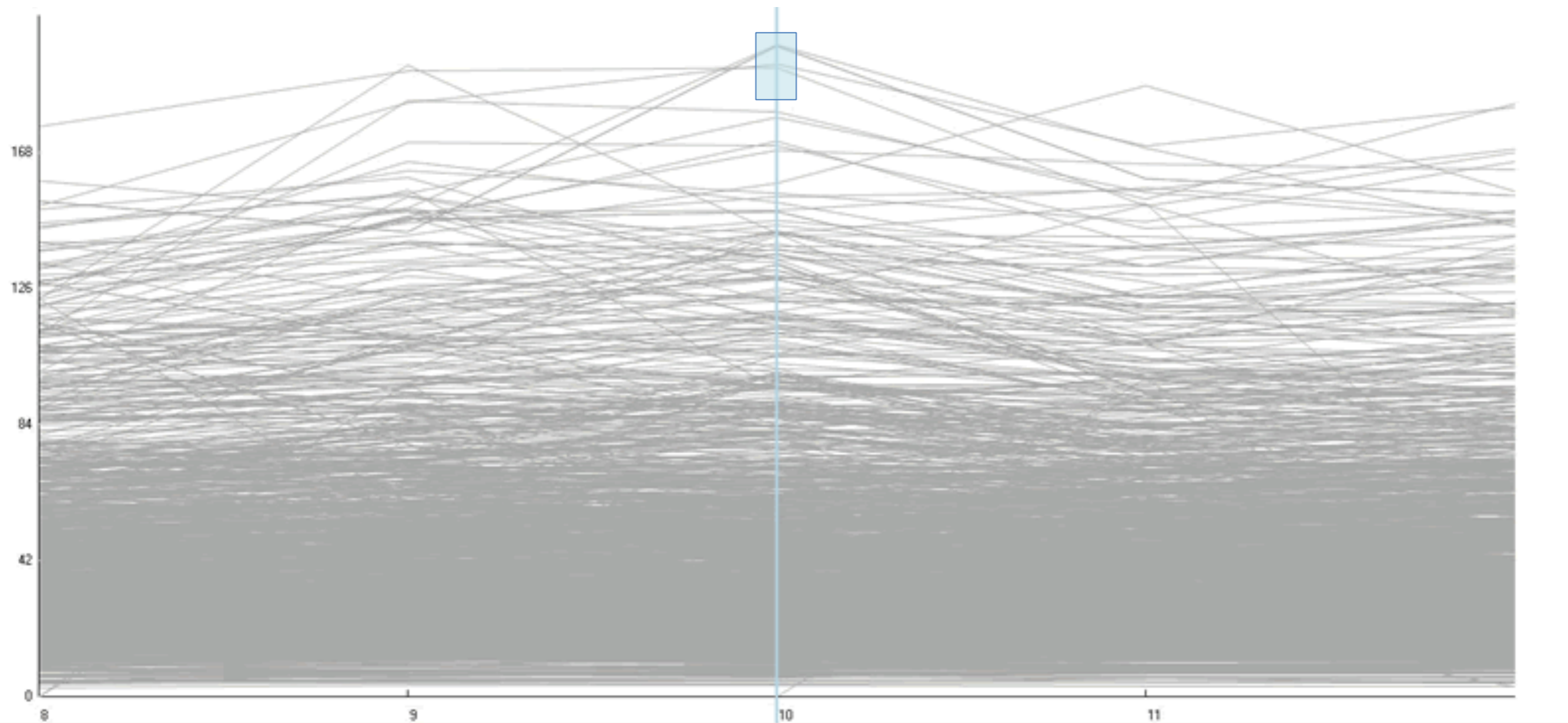
ANALYTICAL TASKS

1. Overview



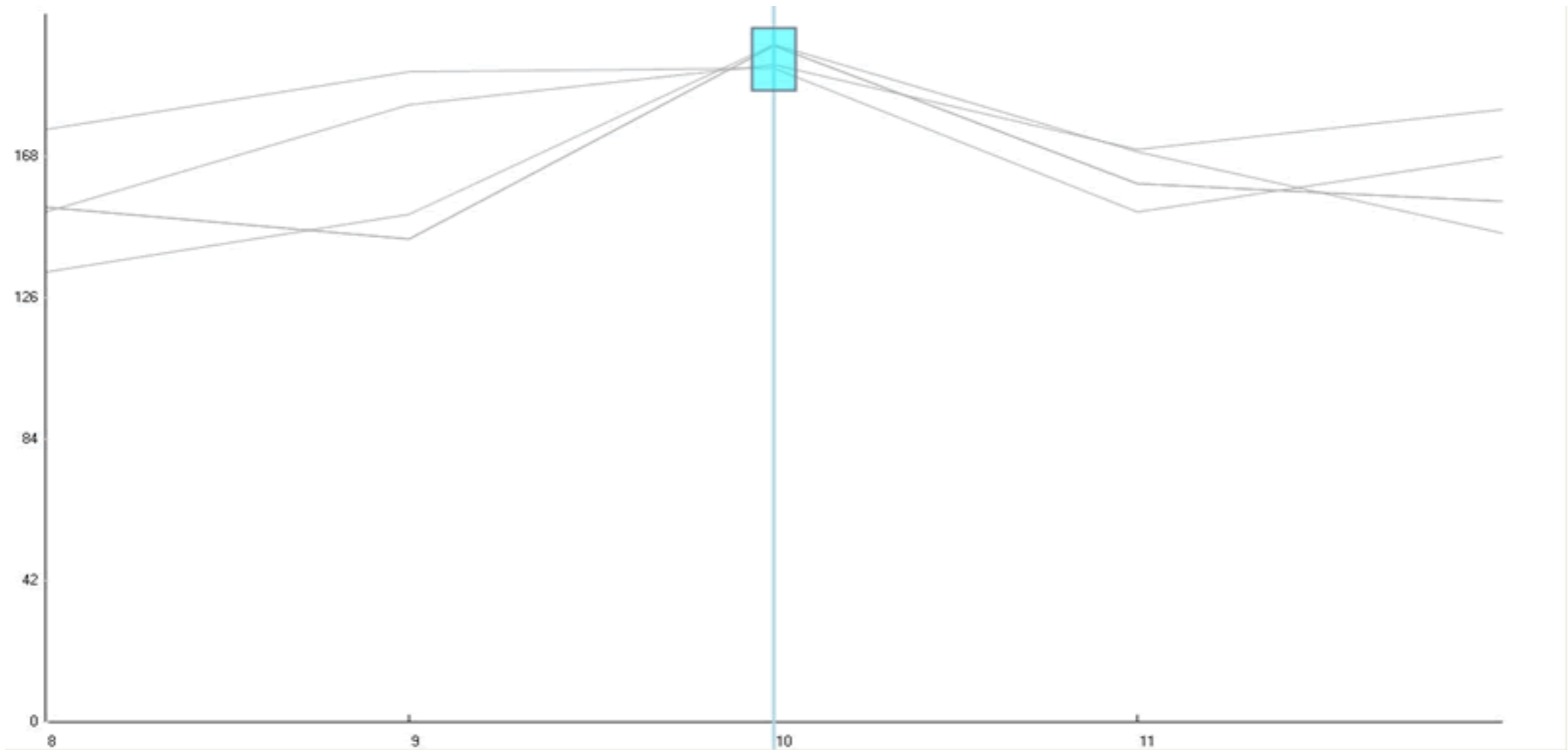
ANALYTICAL TASKS

2. Zoom



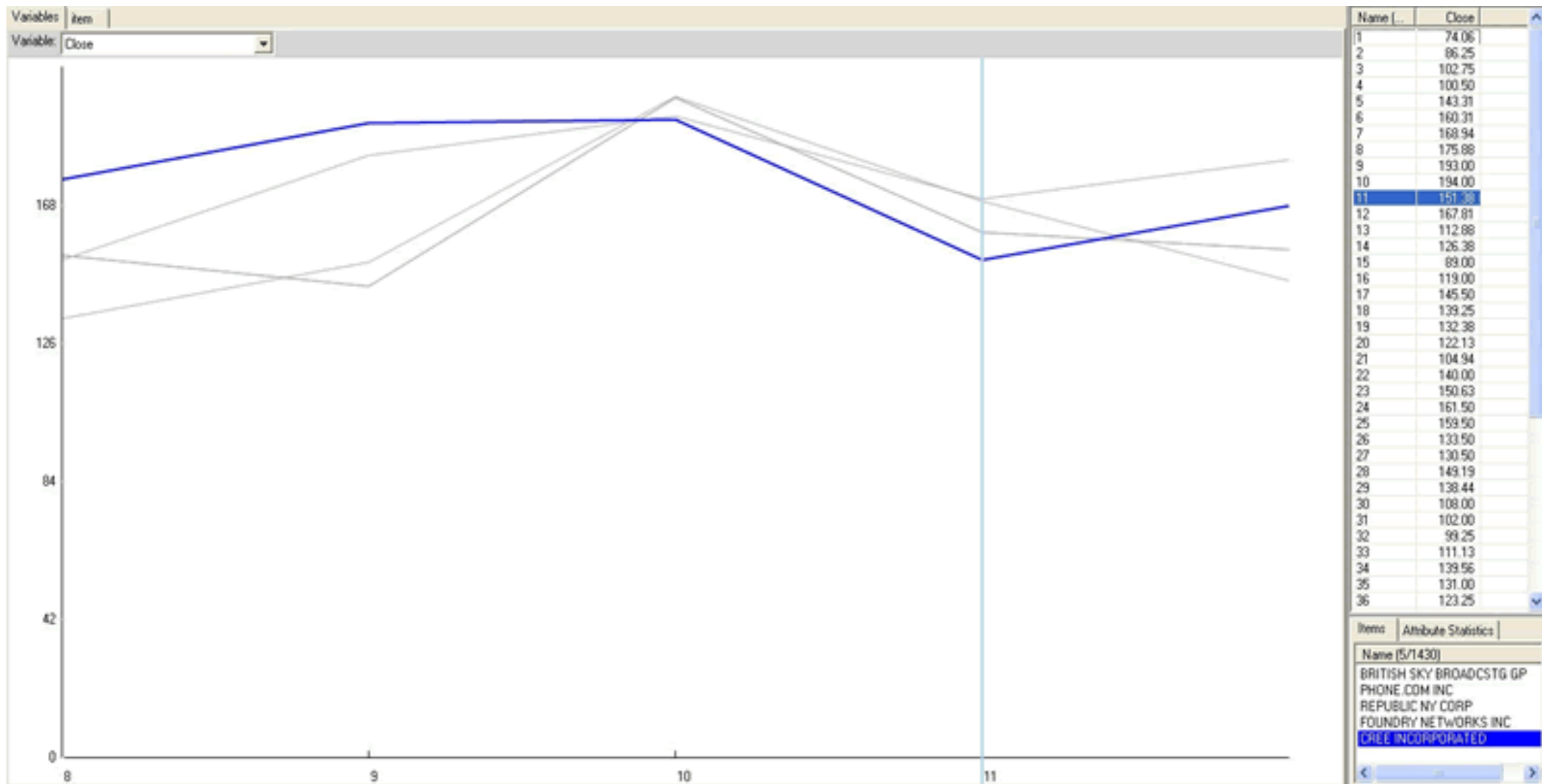
ANALYTICAL TASKS

3. Filter



ANALYTICAL TASKS

4. Details on demand



ANALYTICAL TASKS

Amar, Eagan and Stasko, 2005

- Retrieve value
- Filter
- Compute Derived Value
- Find Extremum
- Sort
- Determine Range
- Characterize Distribution
- Find Anomalies
- Cluster

ANALYTICAL TASKS

Yi et al., 2007

- **Select**: mark something as interesting
- **Explore**: show me something else
- **Reconfigure**: show me a different arrangement
- **Encode**: show me a different representation
- **Abstract/Elaborate**: show me more or less details
- **Filter**: show me something conditionally
- **Connect**: show me related items

TAXONOMIES OF INTERACTION

What?

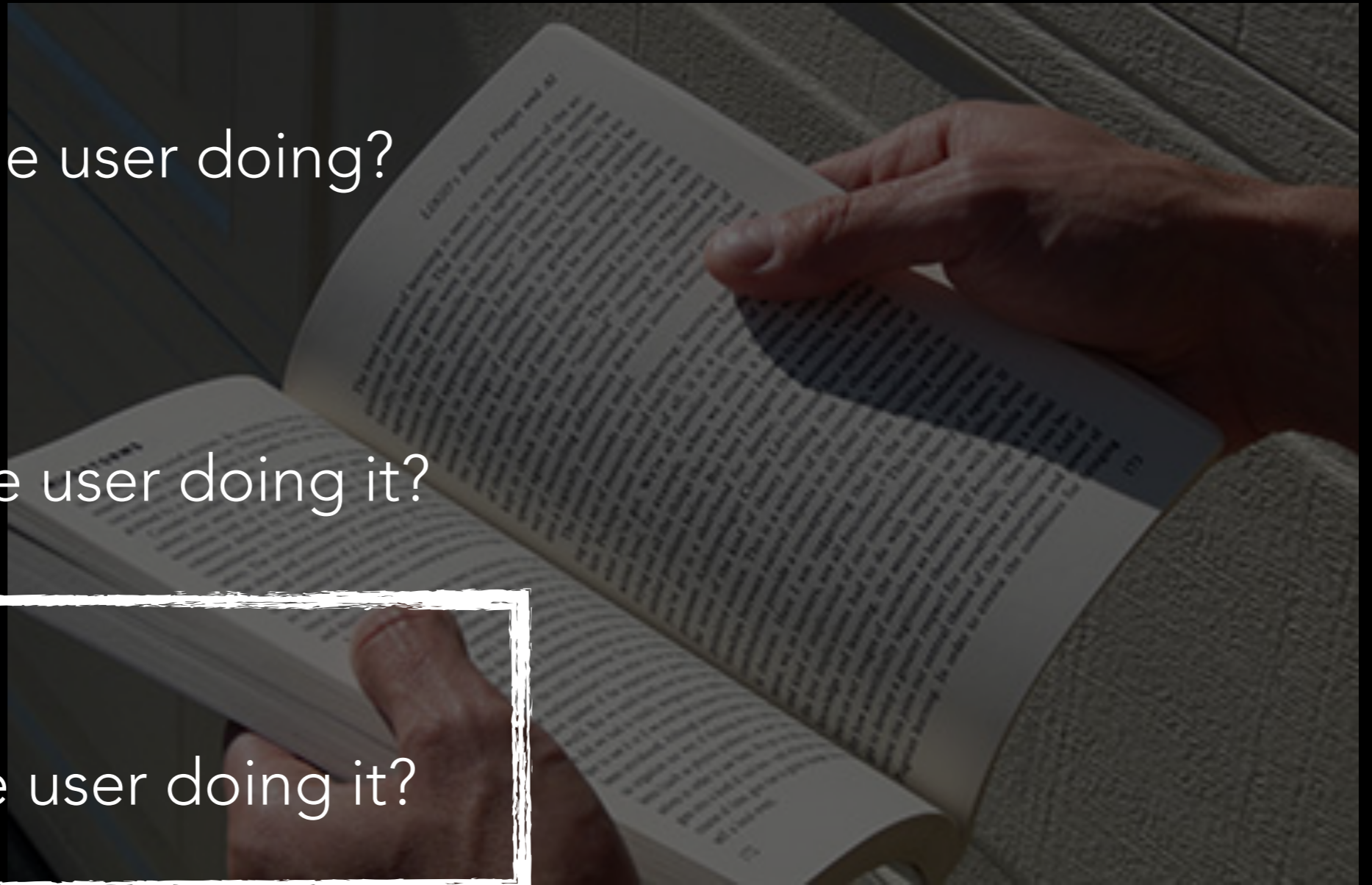
What is the user doing?

Why?

Why is the user doing it?

How?

How is the user doing it?



HOW?

Interaction technique

"An interaction technique is the fusion of **input** and **output**, consisting of all **software** and **hardware** elements, that provides a way for the user to accomplish a task"

Types of interaction techniques

Input: mouse, touch, keyboard, speech, ...

Shneiderman: **command-line** interfaces vs. **direct manipulation** interfaces

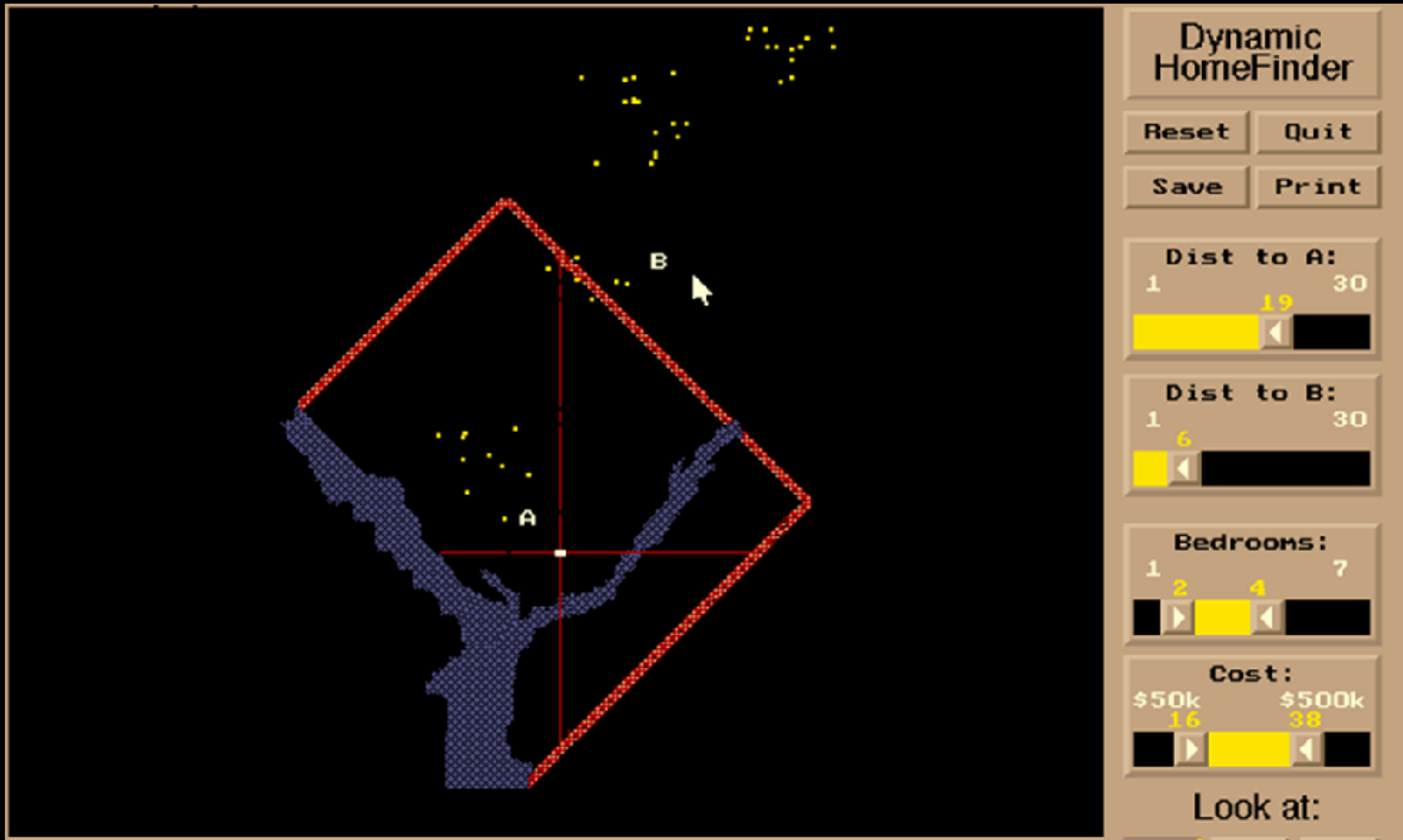
INTERACTION STYLE

Command-line interface

```
Select house-address  
      From atl-realty-db  
Where price >= 200,000 and  
      price <= 400,000 and  
      bathrooms >= 3 and  
      garage == 2 and  
      bedrooms >= 4
```

INTERACTION STYLE

(In)direct manipulation



FAMILIES OF INFOVIS INTERACTION TECHNIQUES

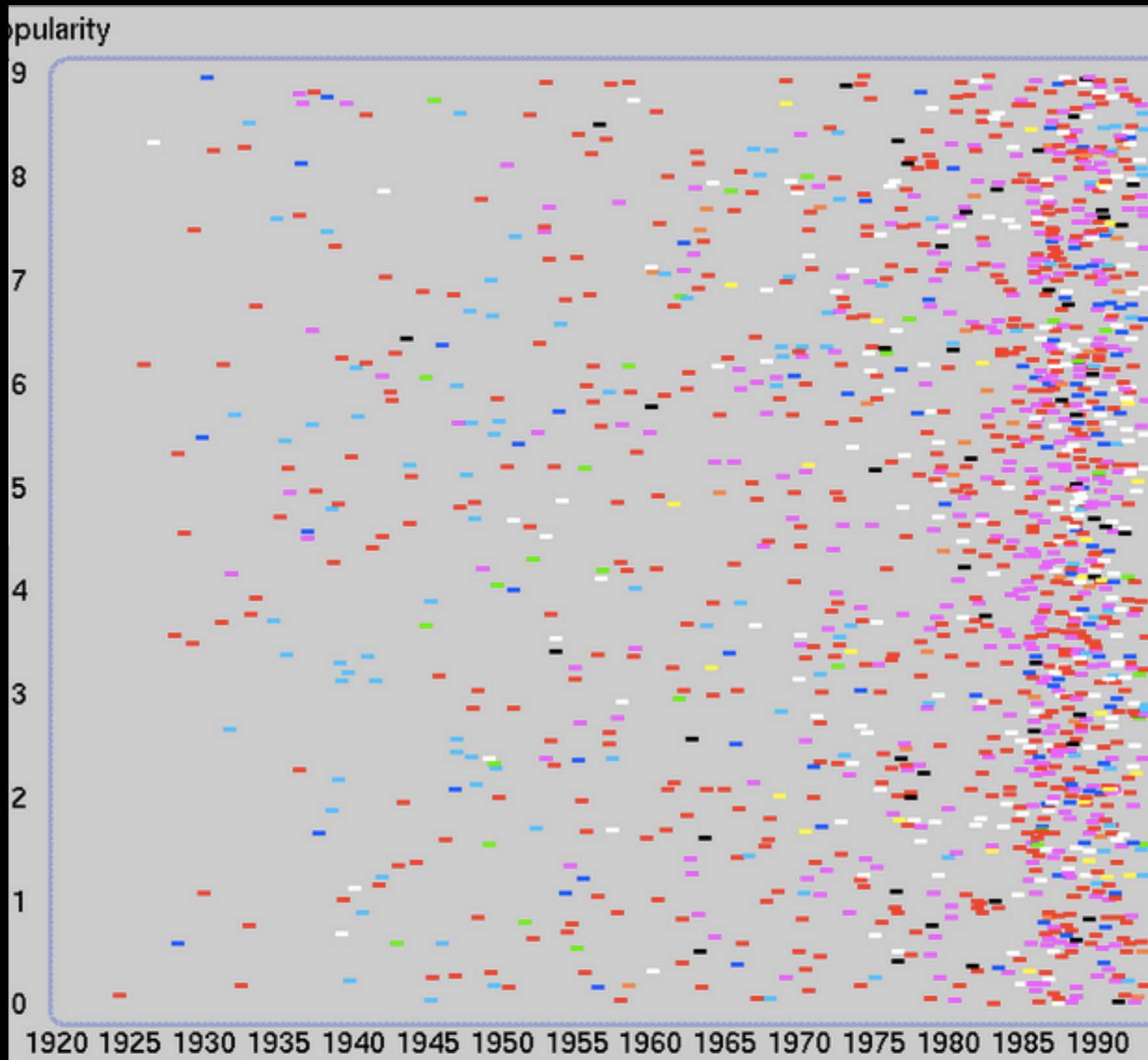
Filtering techniques

Navigation techniques

Multiple views

Rearrangement

PROBLEM



FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

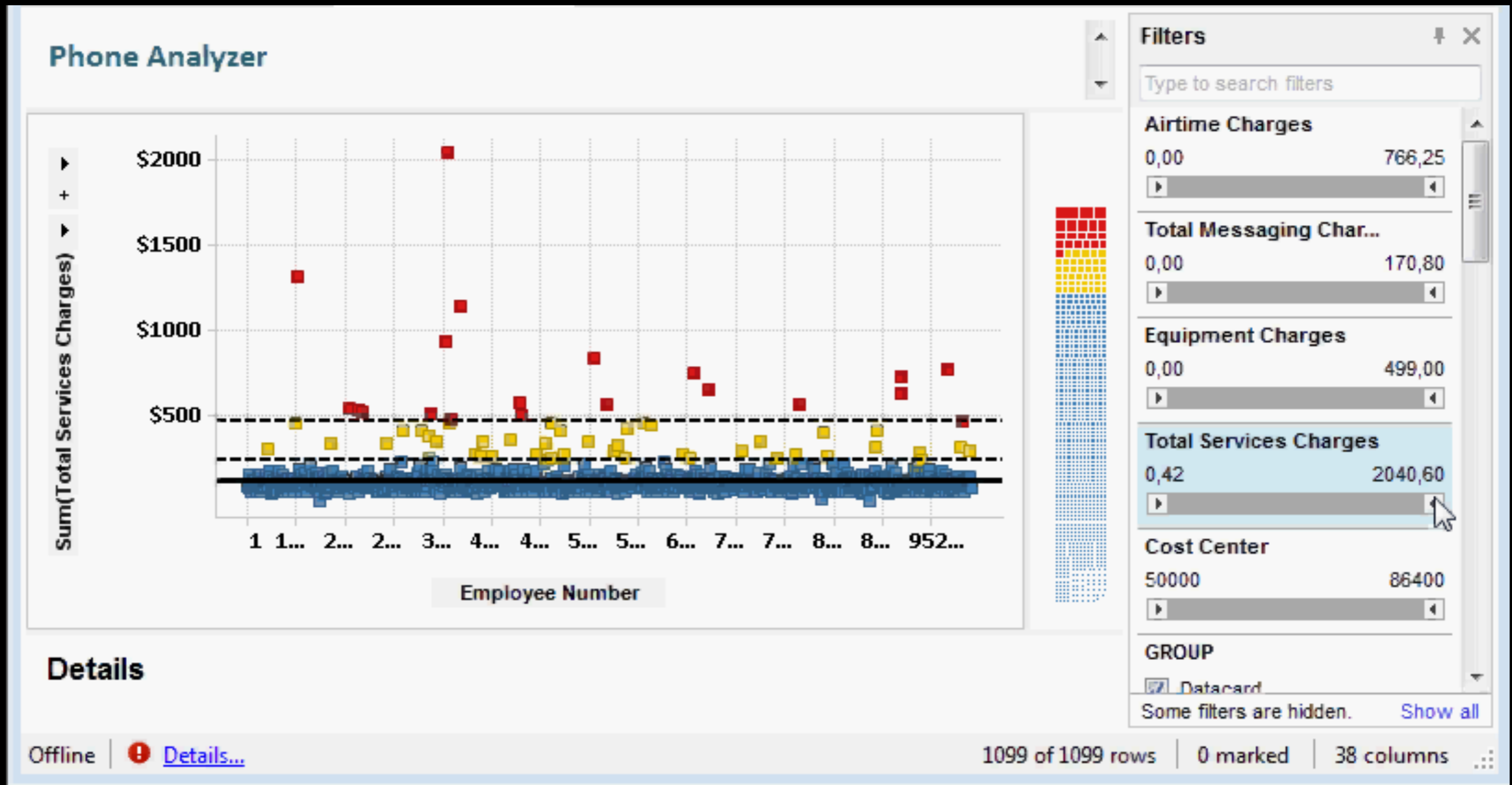
Multiple views

Rearrangement

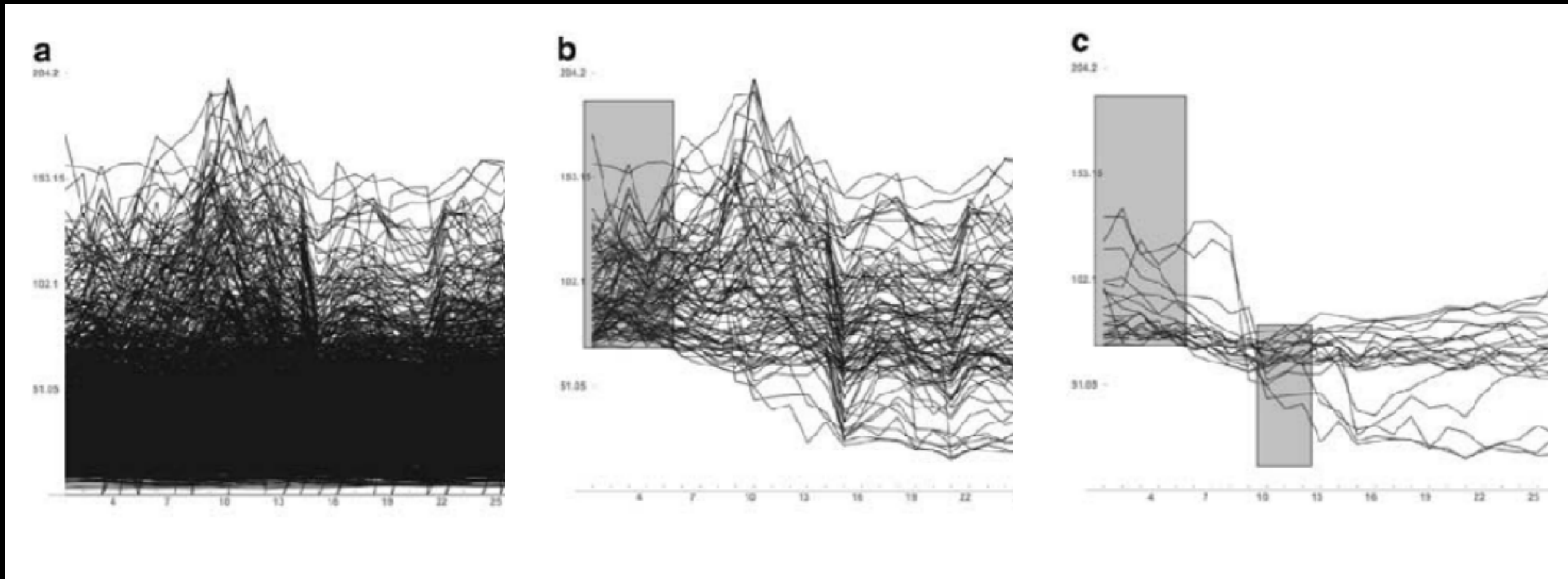
DYNAMIC QUERIES



DYNAMIC QUERIES + RESCALING

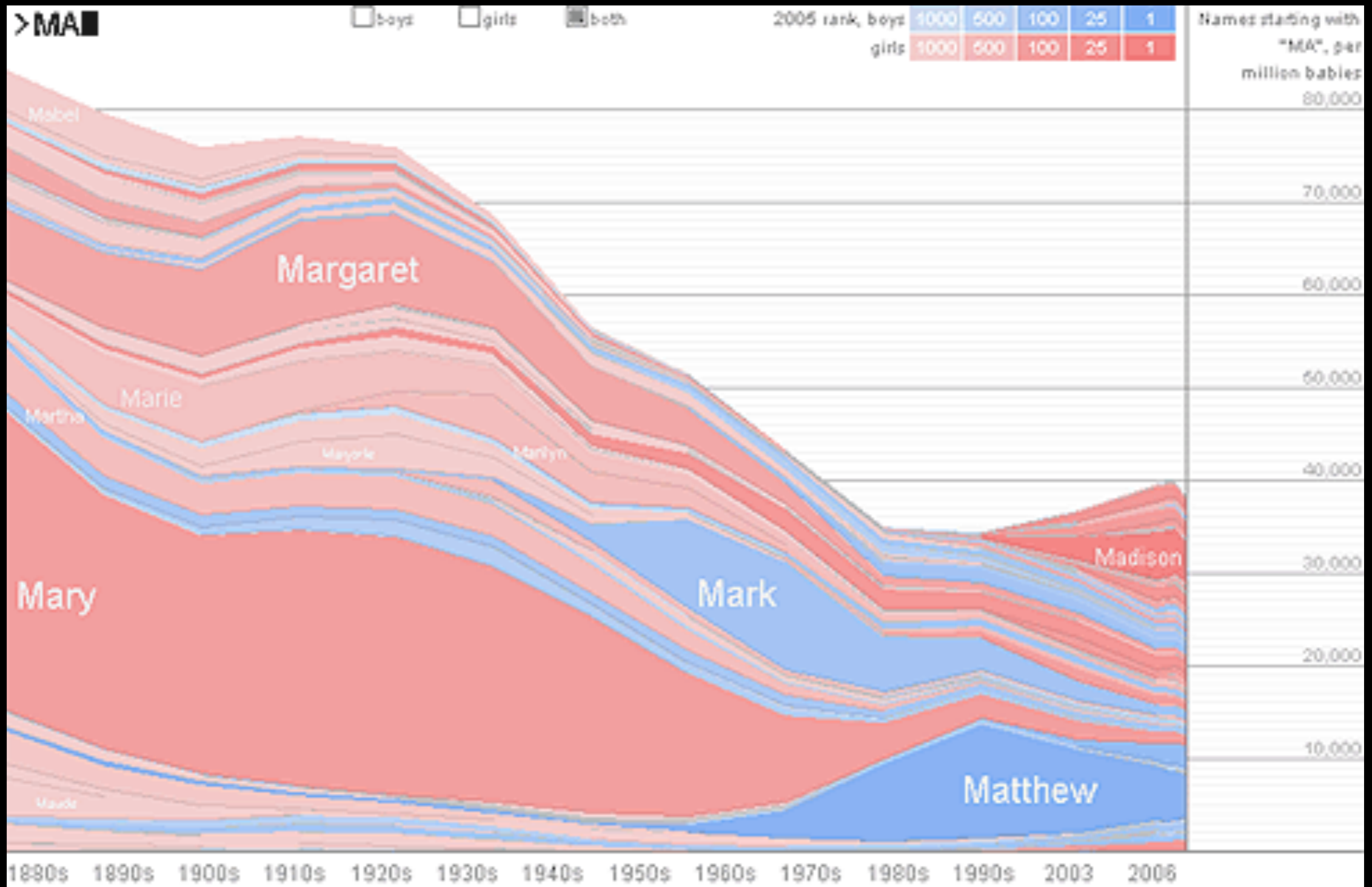


DYNAMIC QUERIES SPECIFIED VISUALLY



Time Searcher (Hocheiser, 2003)

INCREMENTAL TEXT SEARCH



www.babynamewizard.com

Name Voyager (Wattenberg, 2005)

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

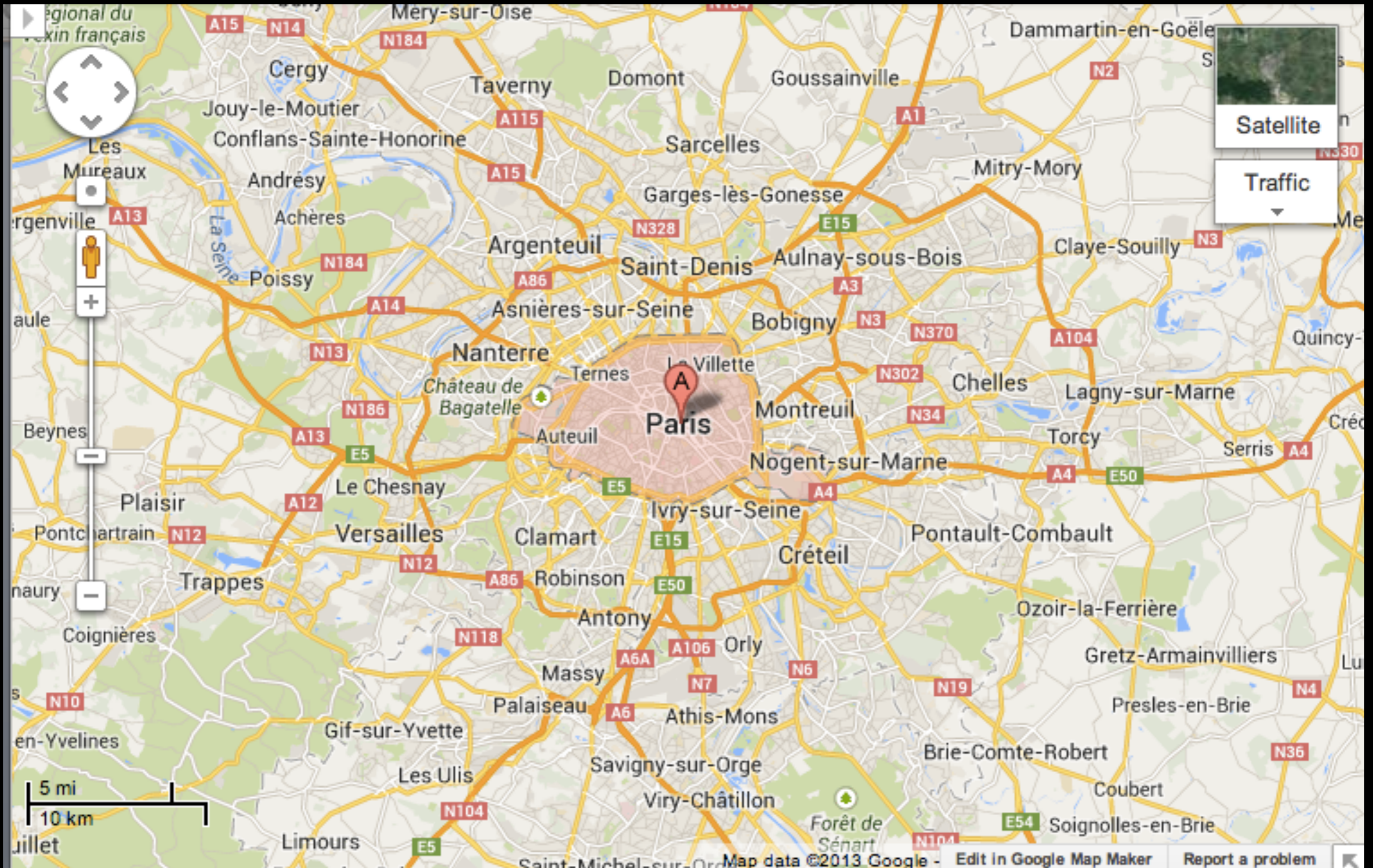
Multiple views

Rearrangement

PROBLEM



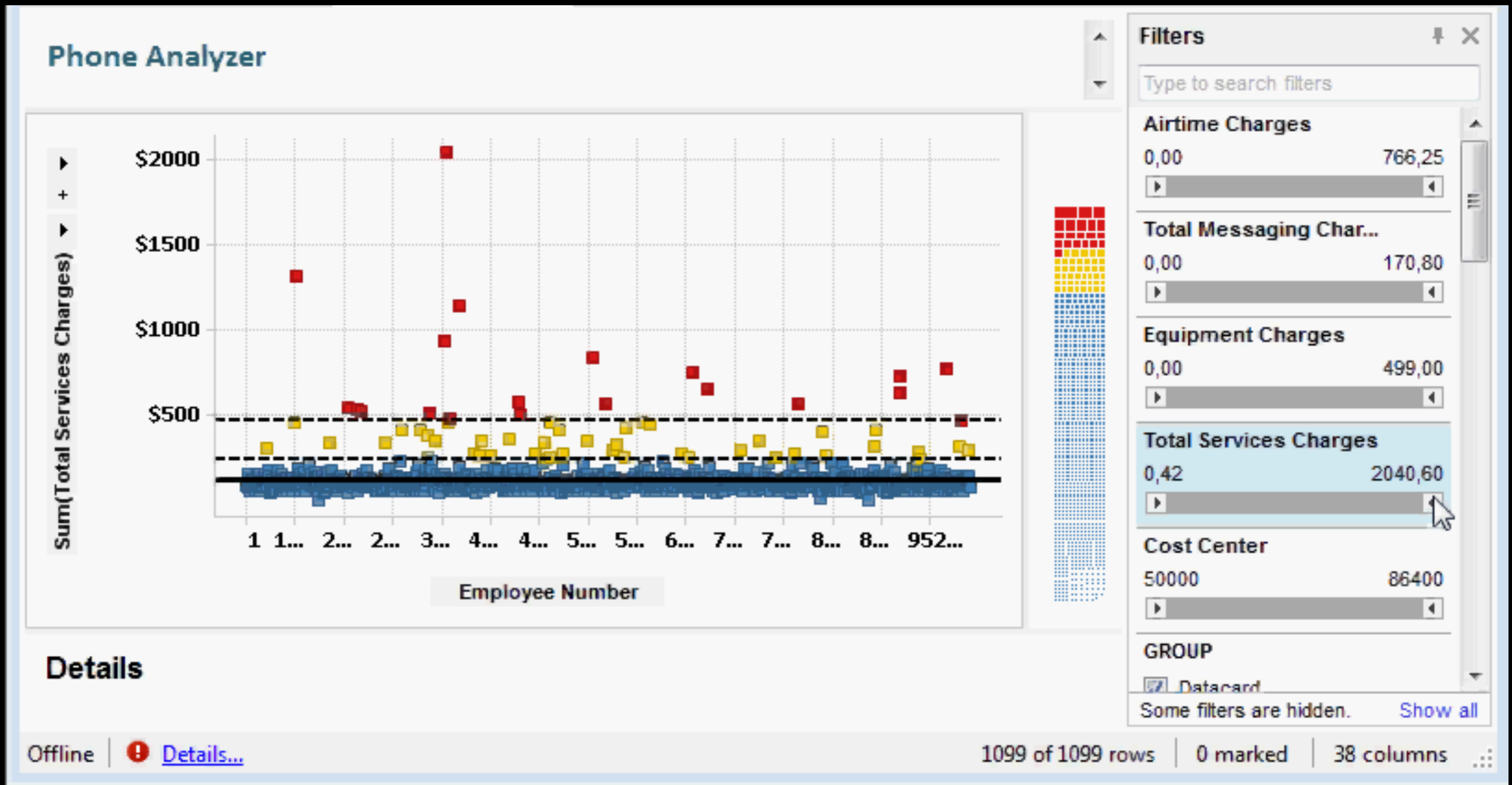
PAN & ZOOM



PAN & ZOOM



PAN & ZOOM: 1D-ZOOM

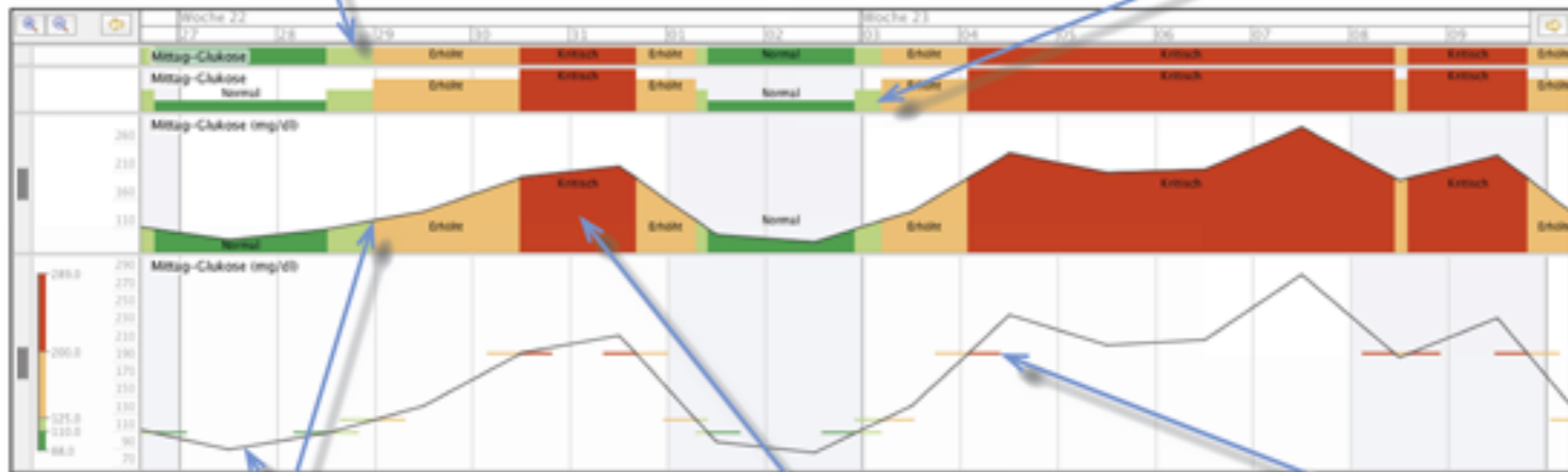


SEMANTIC ZOOM

Qualitative attributes are displayed as colored horizontal bars in low zoom levels

If more space gets available, the heights of the bars represent the ordinal scale of the data

Low zoom level



High zoom level

Raw quantitative attributes are represented as line-charts in higher zoom levels

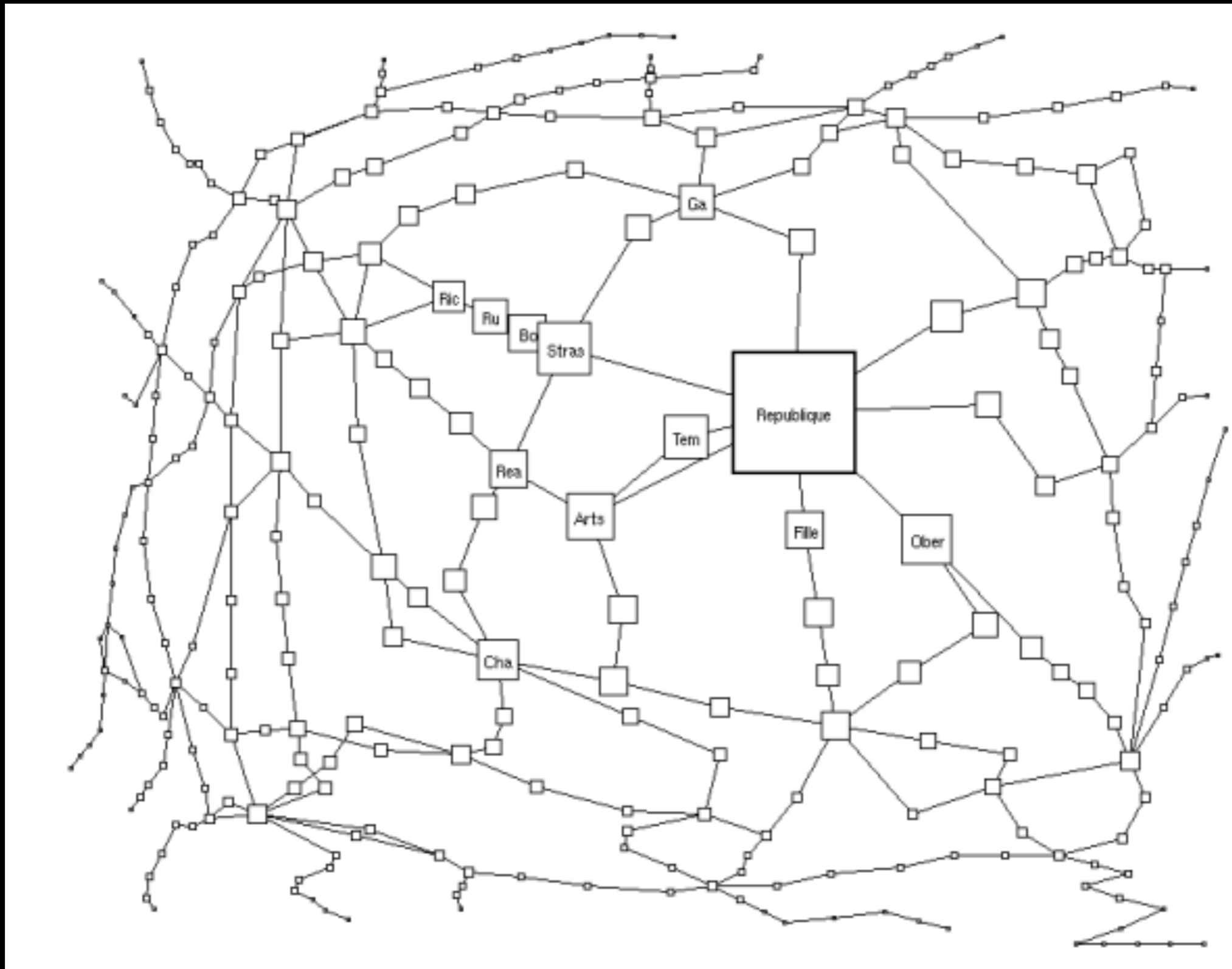
Qualitative attributes are displayed as colors beneath the line chart in this zoom level ...

... or small colored lines mark the points in time where the data leave one qualitative level and enter another

PROBLEM: WHERE AM I?

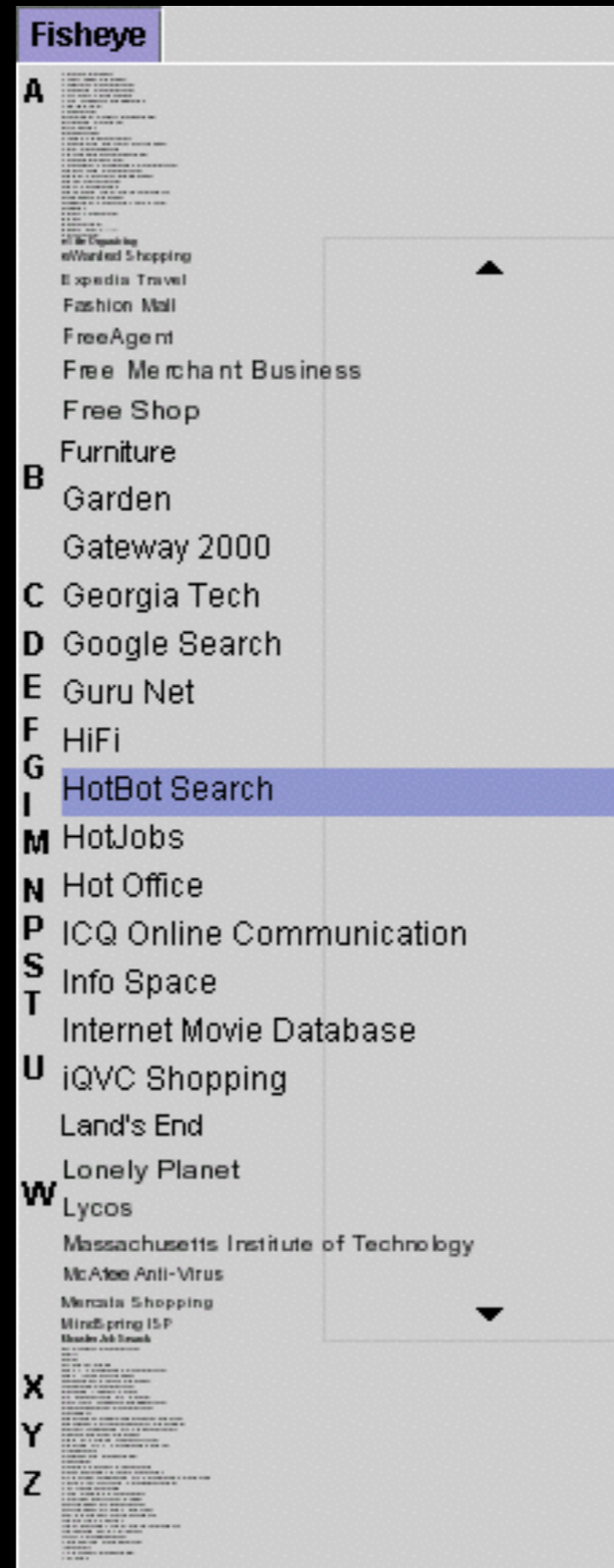


FOCUS+CONTEXT: SPACE DISTORTION

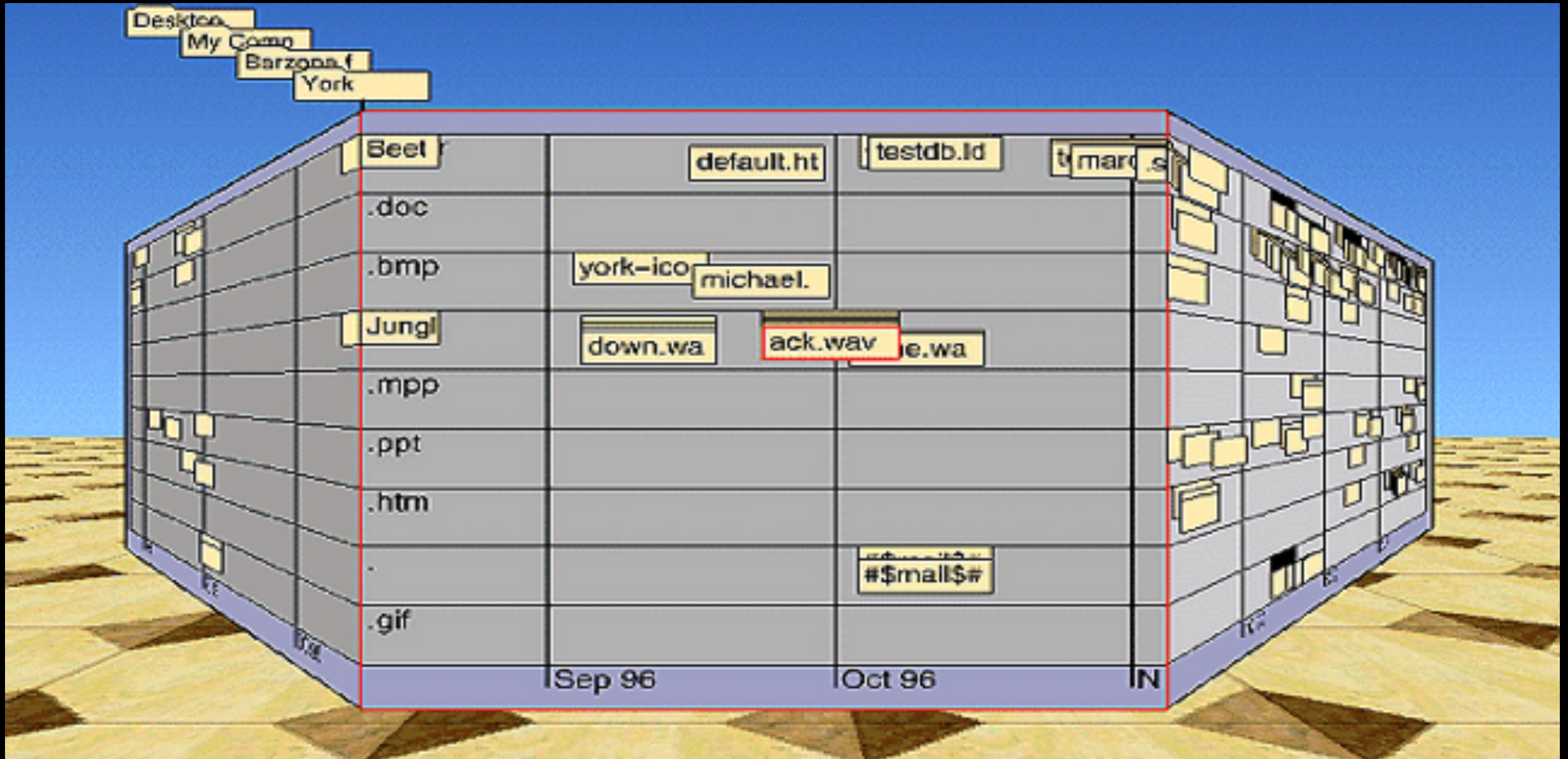


Sarkar and Brown, 1992

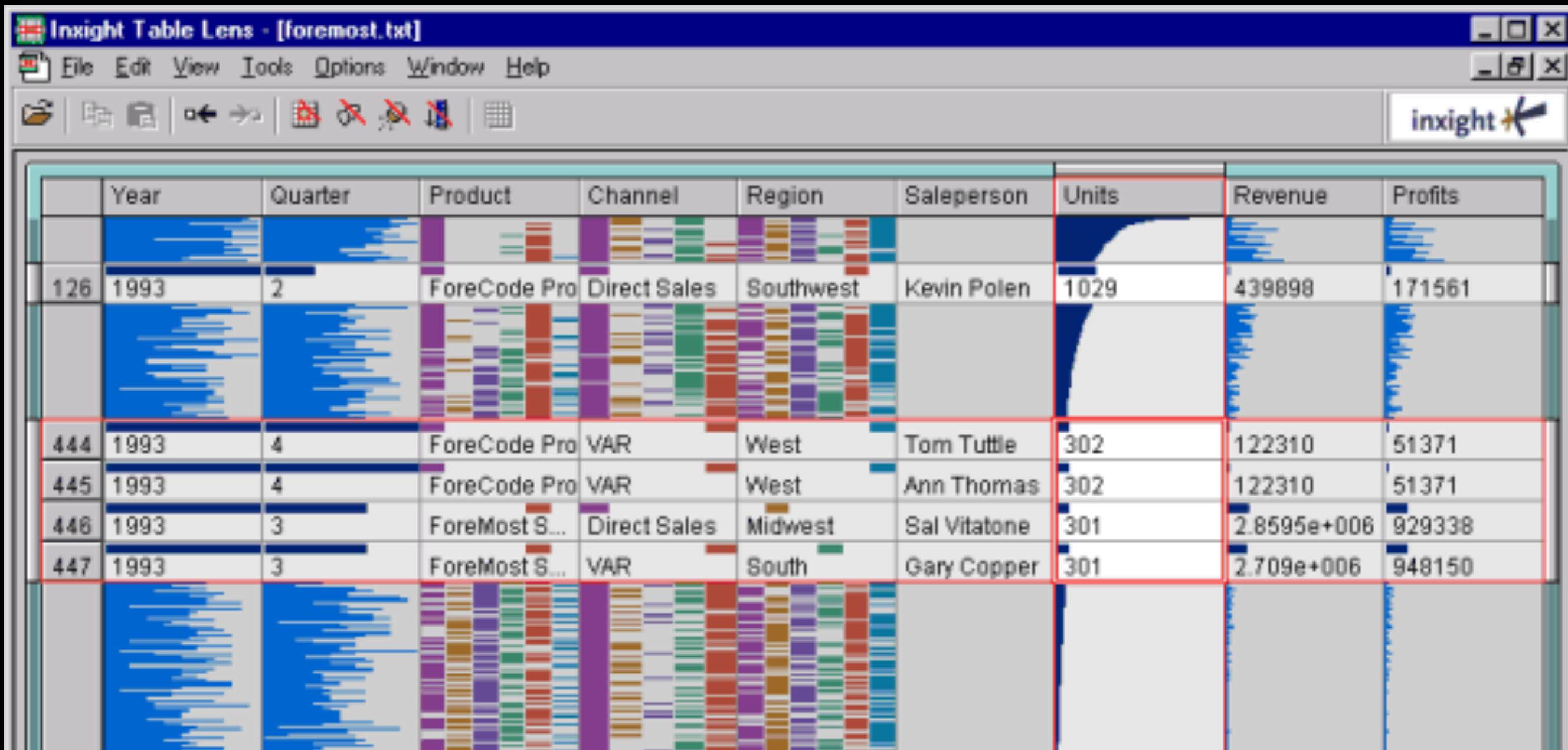
FOCUS+CONTEXT: SPACE DISTORTION



FOCUS+CONTEXT: SPACE DISTORTION



FOCUS+CONTEXT: TABLE LENS



	Year	Quarter	Product	Channel	Region	Saleperson	Units	Revenue	Profits
126	1993	2	ForeCode Pro	Direct Sales	Southwest	Kevin Polen	1029	439898	171561
444	1993	4	ForeCode Pro	VAR	West	Tom Tuttle	302	122310	51371
445	1993	4	ForeCode Pro	VAR	West	Ann Thomas	302	122310	51371
446	1993	3	ForeMost S...	Direct Sales	Midwest	Sal Vitatone	301	2.8595e+006	929338
447	1993	3	ForeMost S...	VAR	South	Gary Copper	301	2.709e+006	948150

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

Multiple views

Rearrangement

MULTIPLE VIEWS

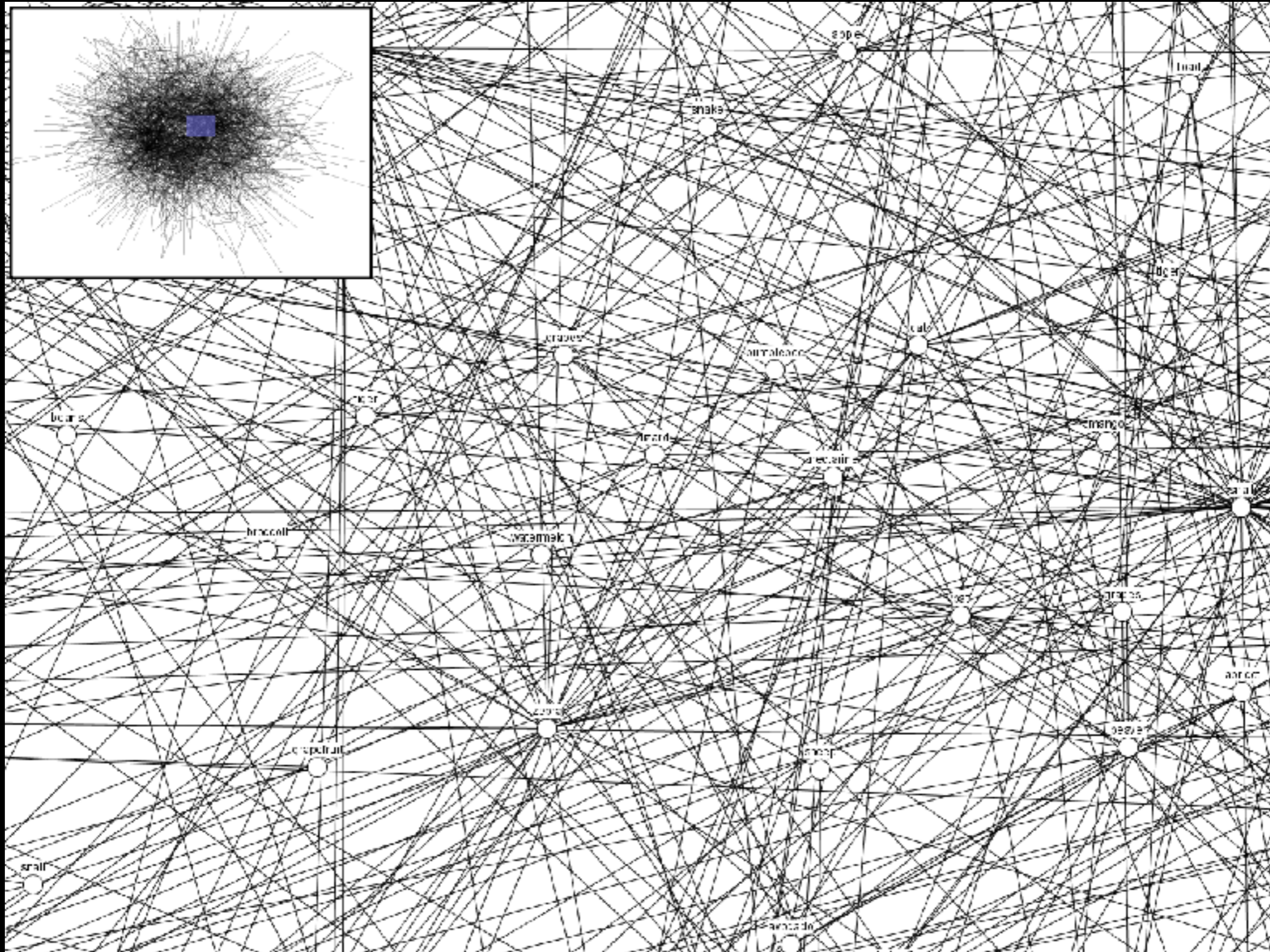
The screenshot displays the WCT Website Exploration Tool interface. It features a main window with a menu bar (File, Edit, View, Help) and a toolbar. The main area is divided into several panels:

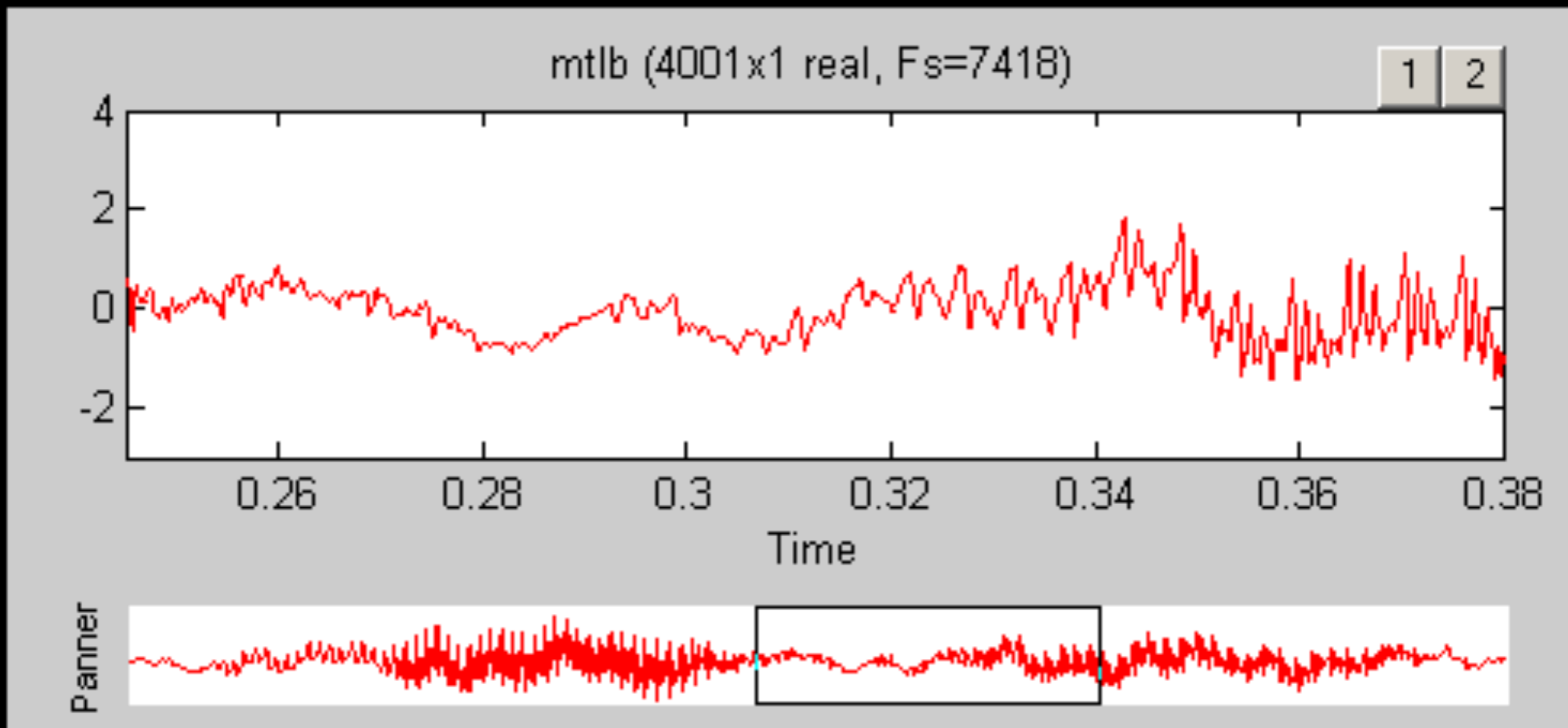
- RadialTree visualization:** A large area showing a hierarchical tree structure of website pages.
- Information panel:** A panel on the right displaying metadata for the selected page, including Title, URL, and Navigation information.
- Treemap visualization:** A large area at the bottom left showing a color-coded treemap of website pages.
- Charts:** Several charts on the right side showing hits per day of week, hits per hour, and hits per day of month.

Overlaid on the center of the screenshot is a white box containing the following text:

Overview + Detail
Magic Lenses
Coordinated Views
Animated Transitions

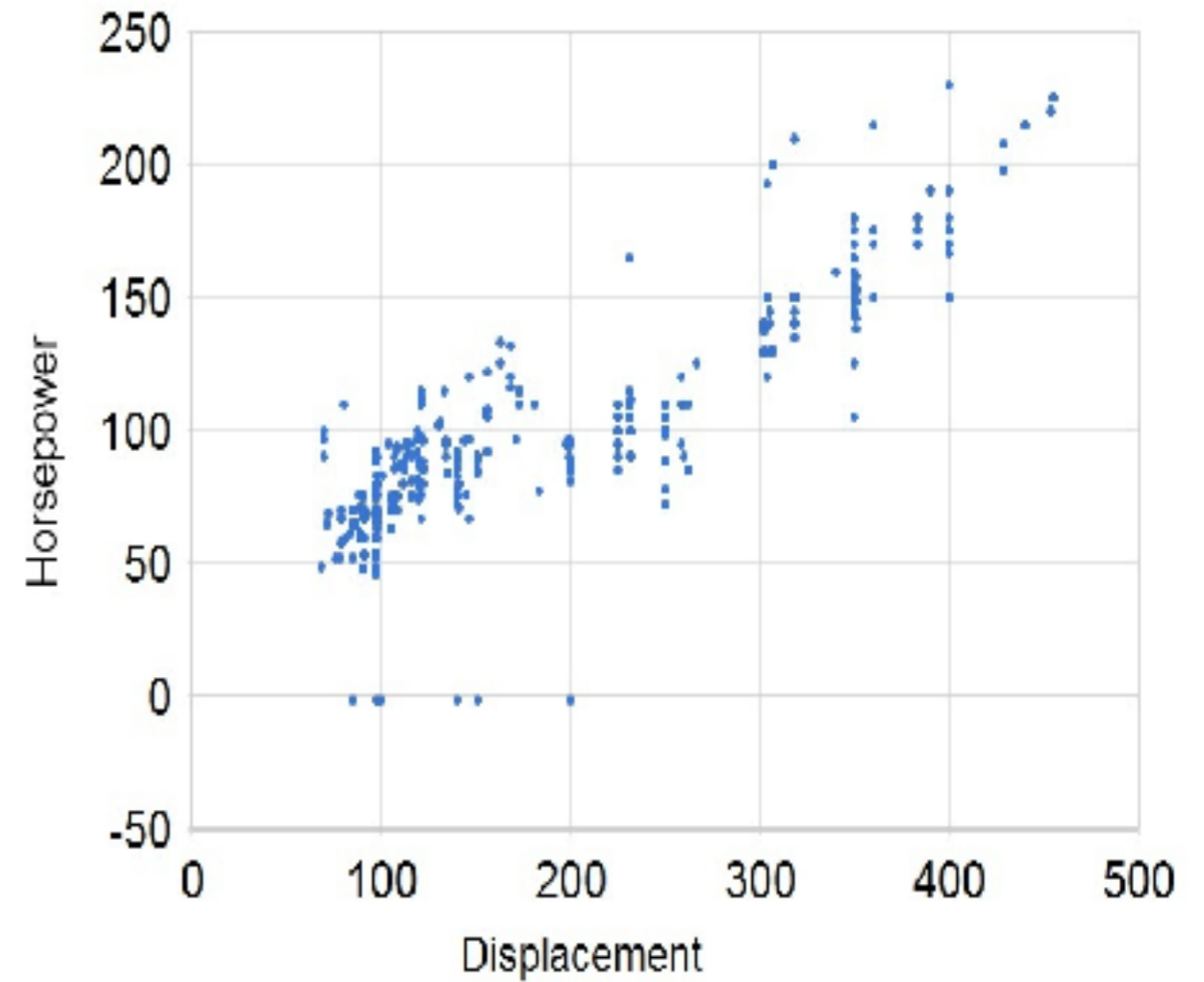
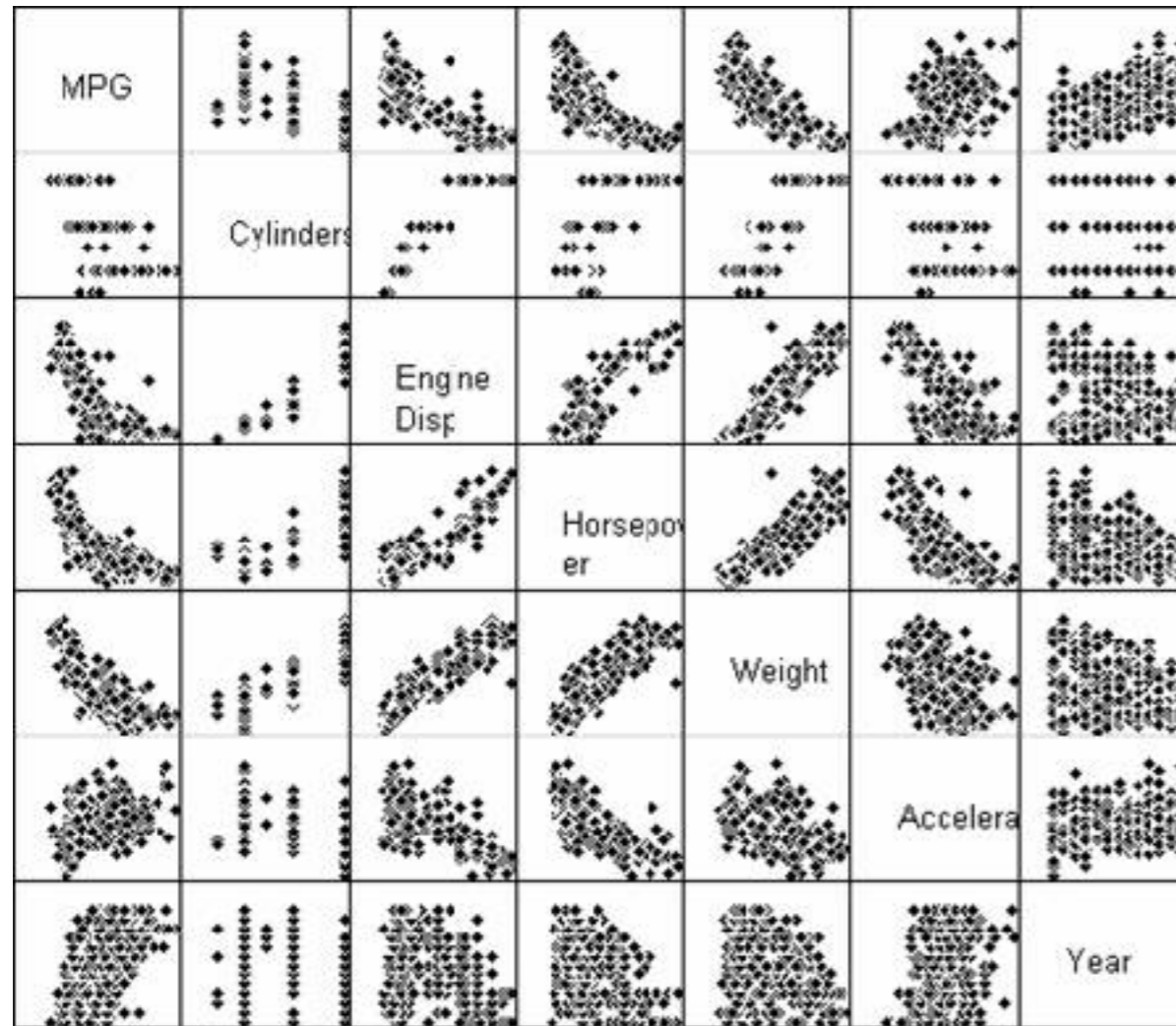
OVERVIEW+DETAILS PANNING A LARGE GRAPH





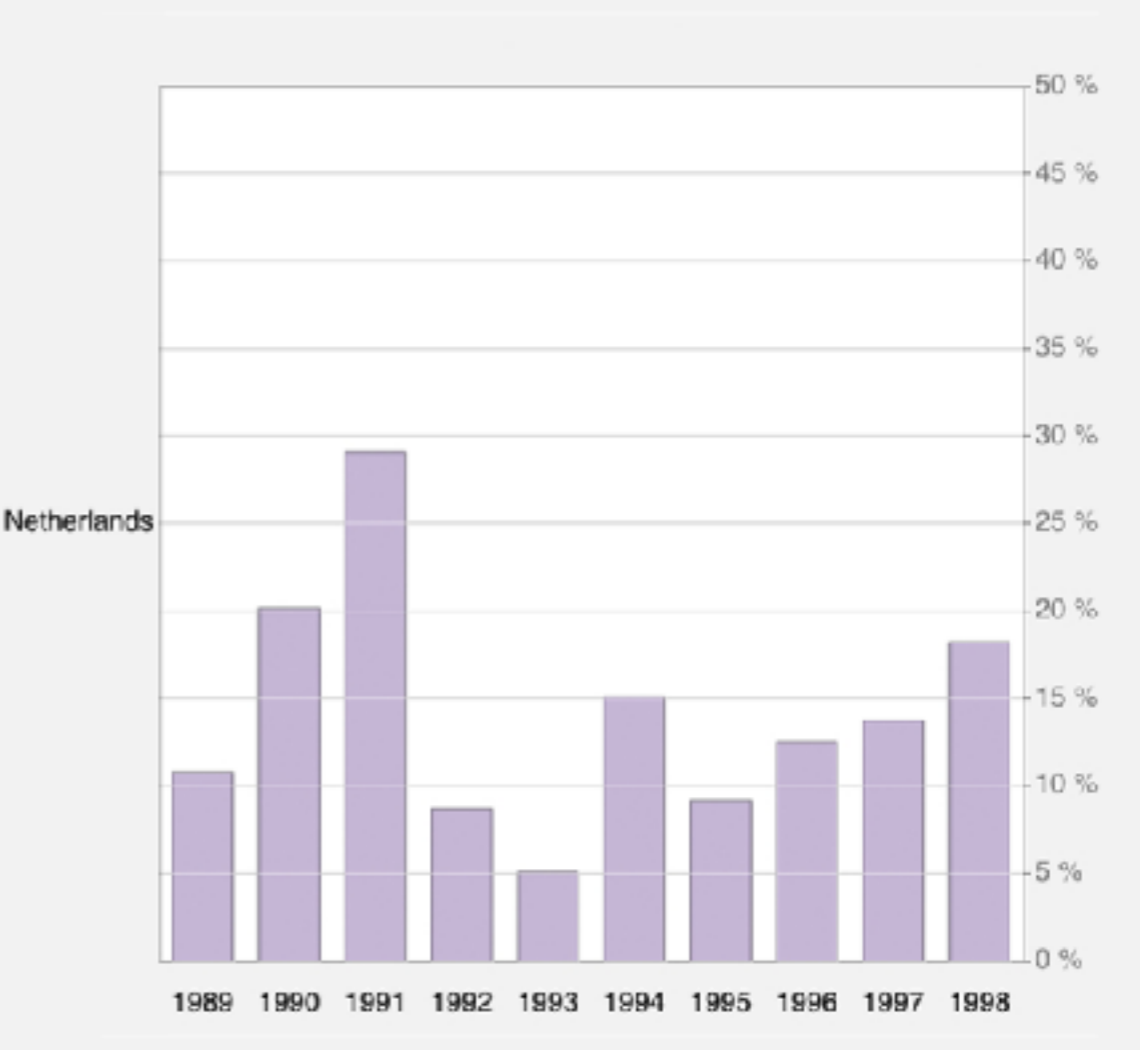
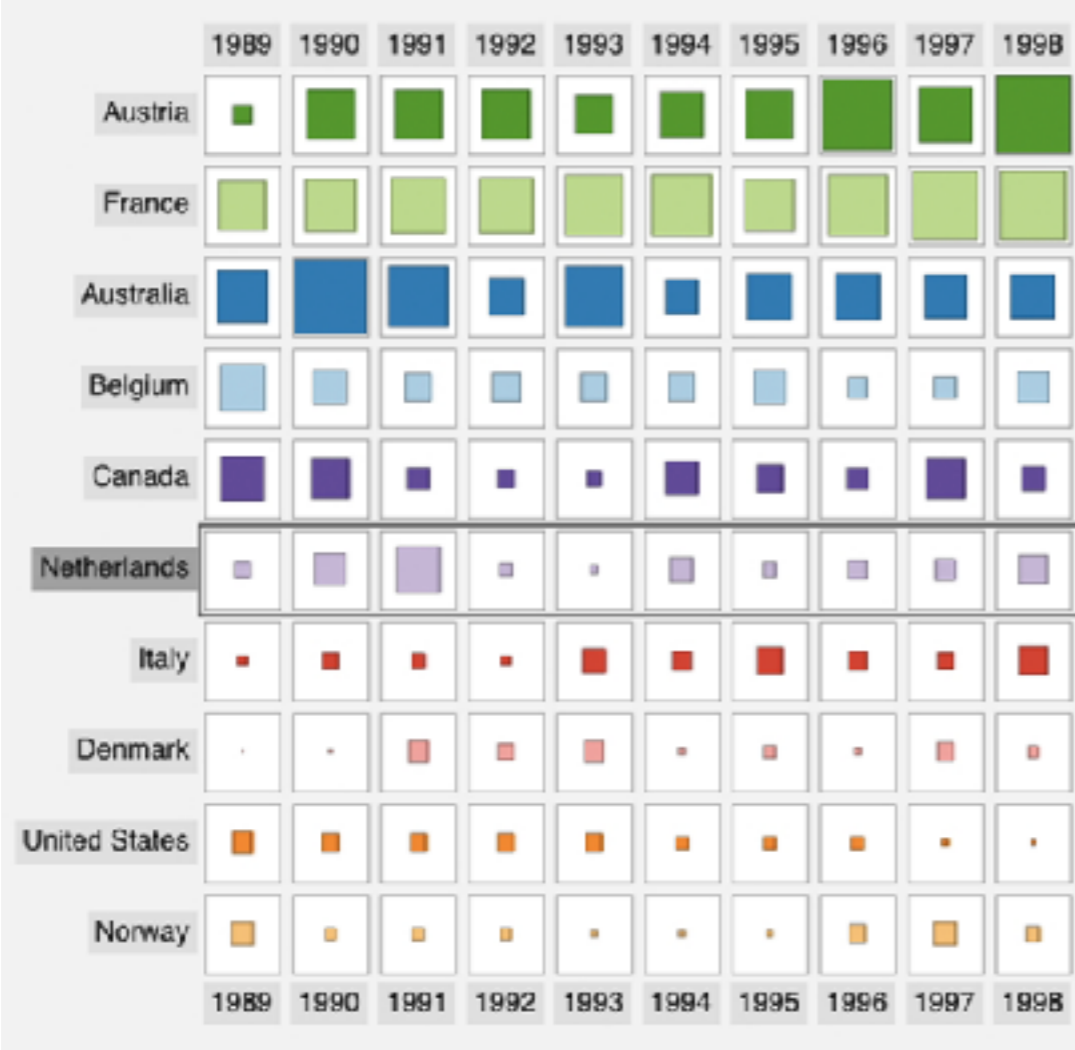
OVERVIEW+DETAILS

BROWSING MULTIPLE VIEWS

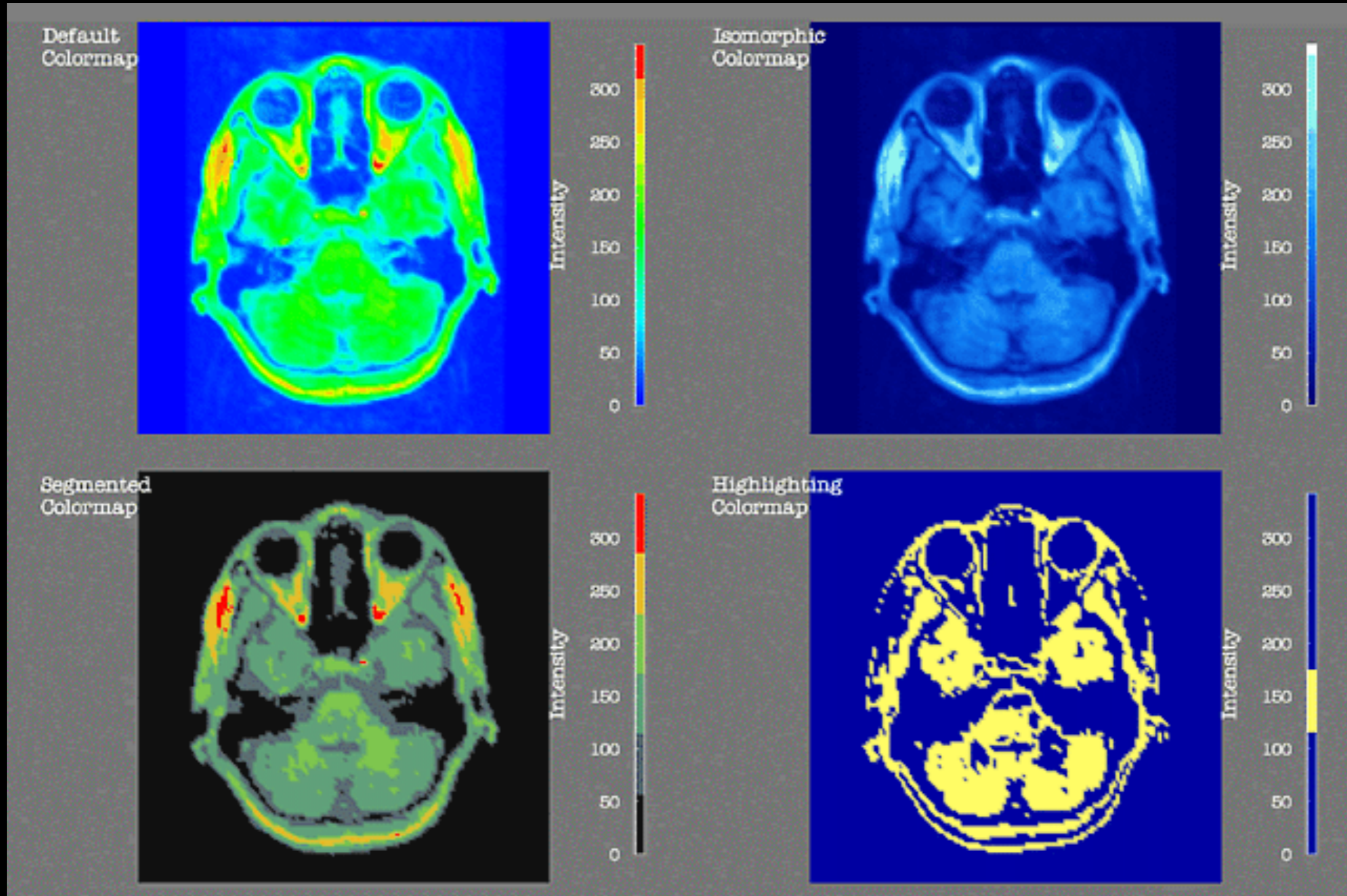


OVERVIEW+DETAILS

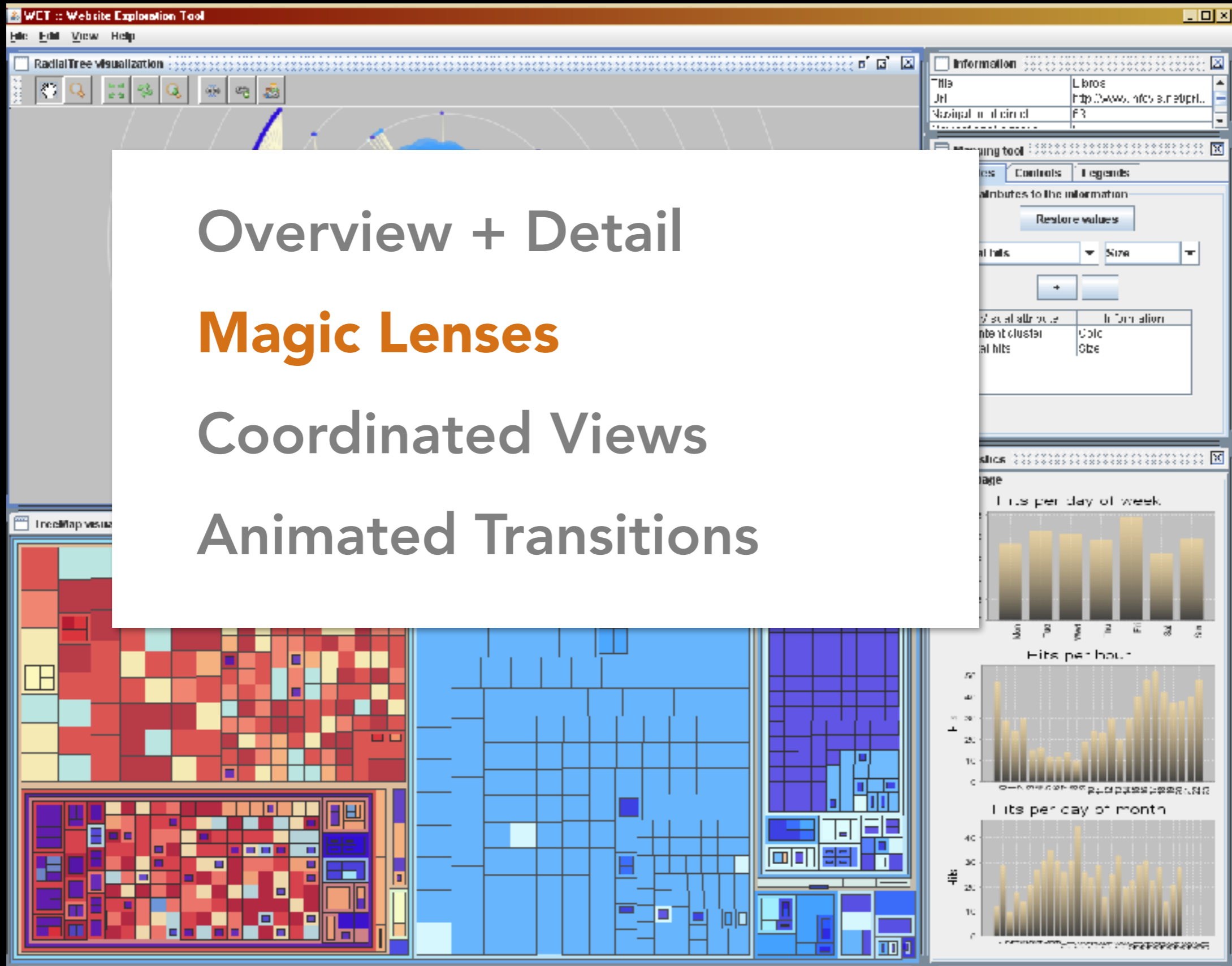
BROWSING MULTIPLE VIEWS



PROBLEM

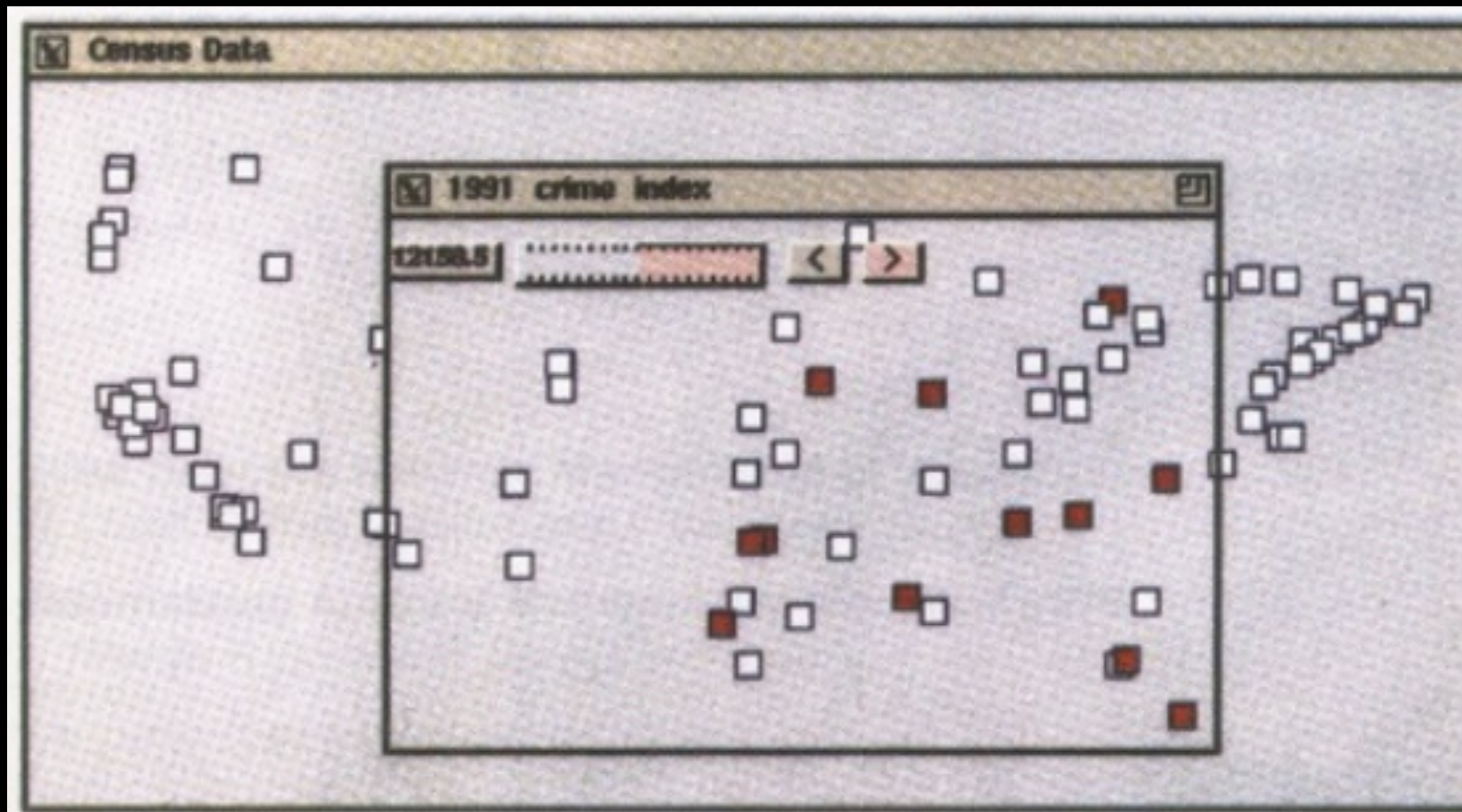


MULTIPLE VIEWS



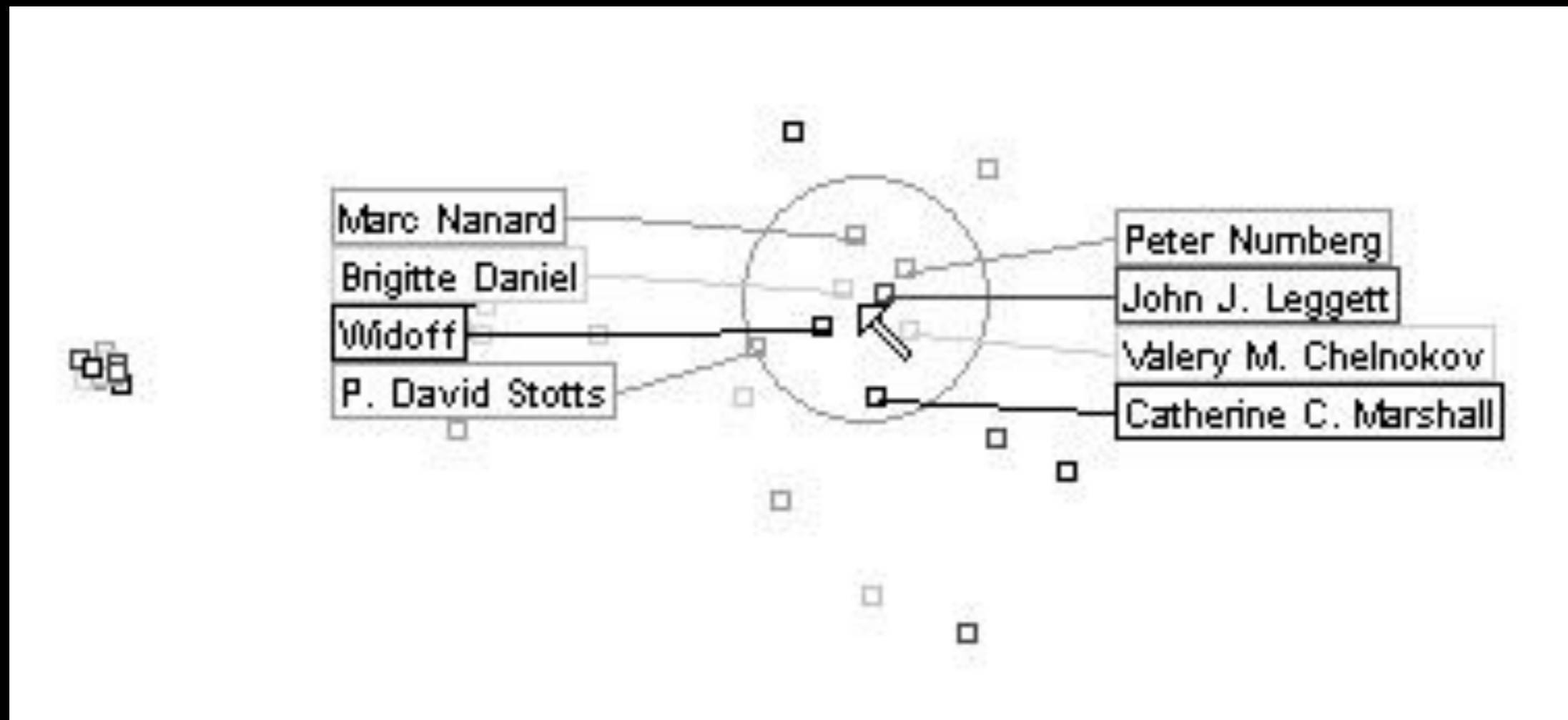
MAGIC LENSES

Movable filters for dynamic queries



MAGIC LENSES

Excentric labeling



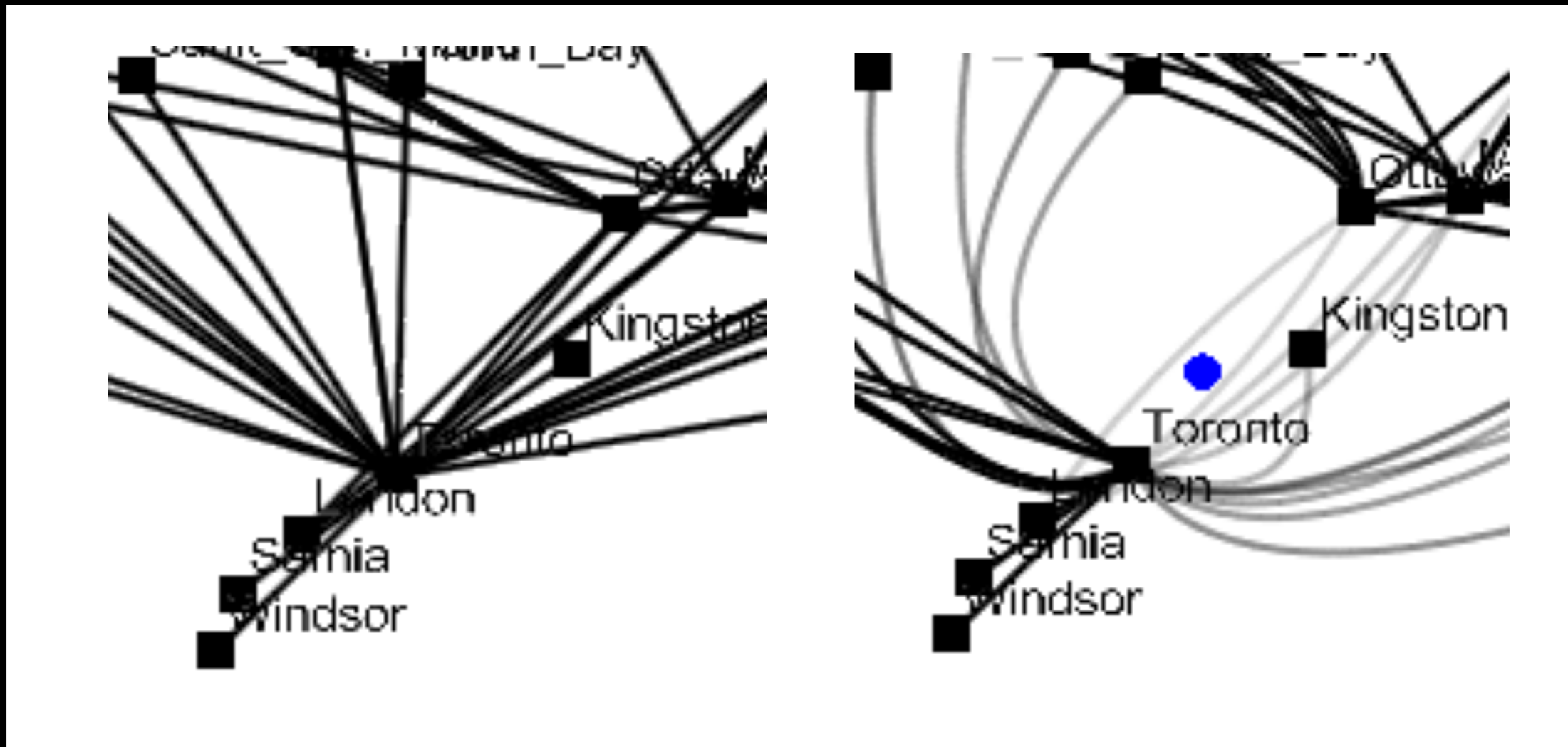
MAGIC LENSES

Color lenses

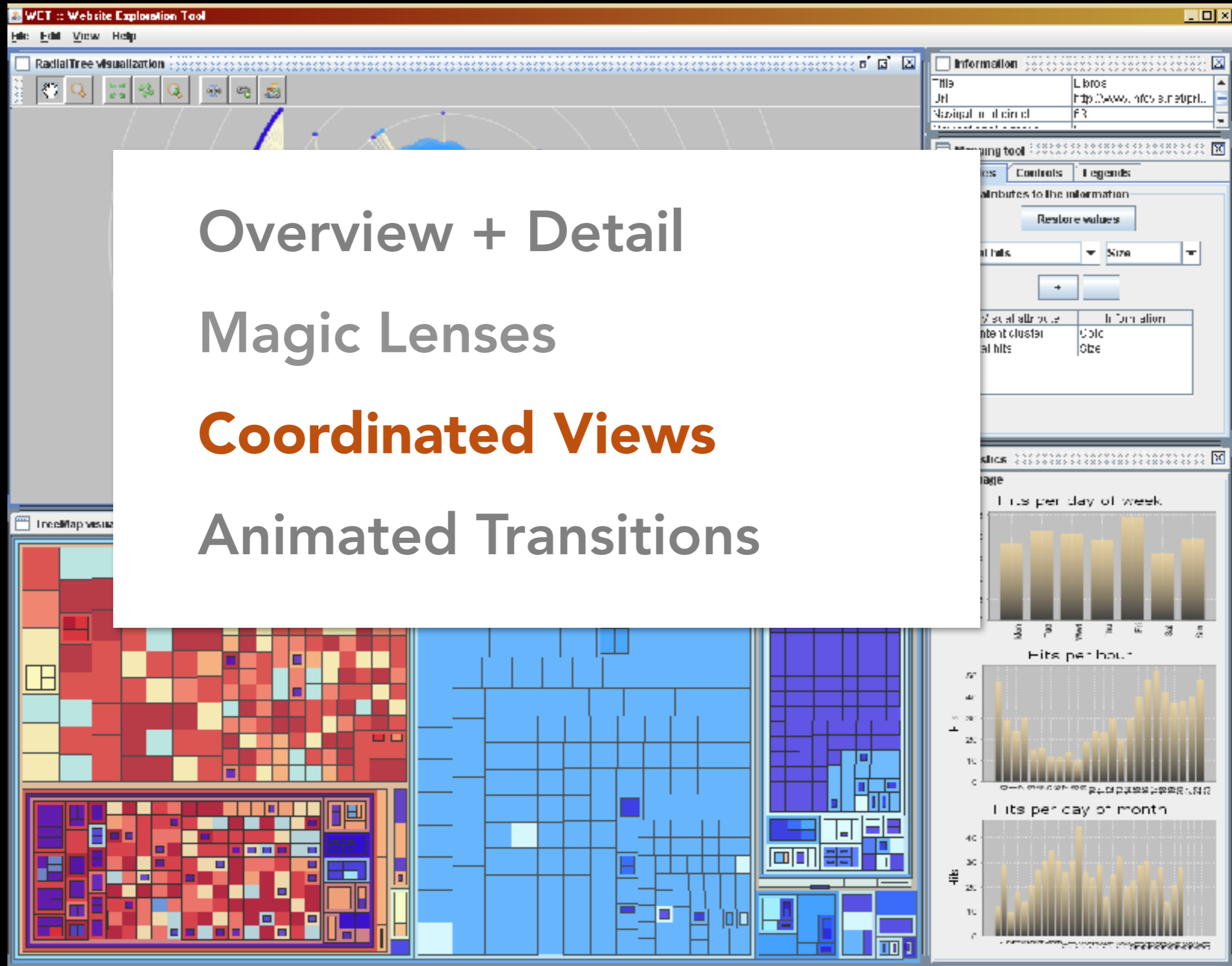


MAGIC LENSES

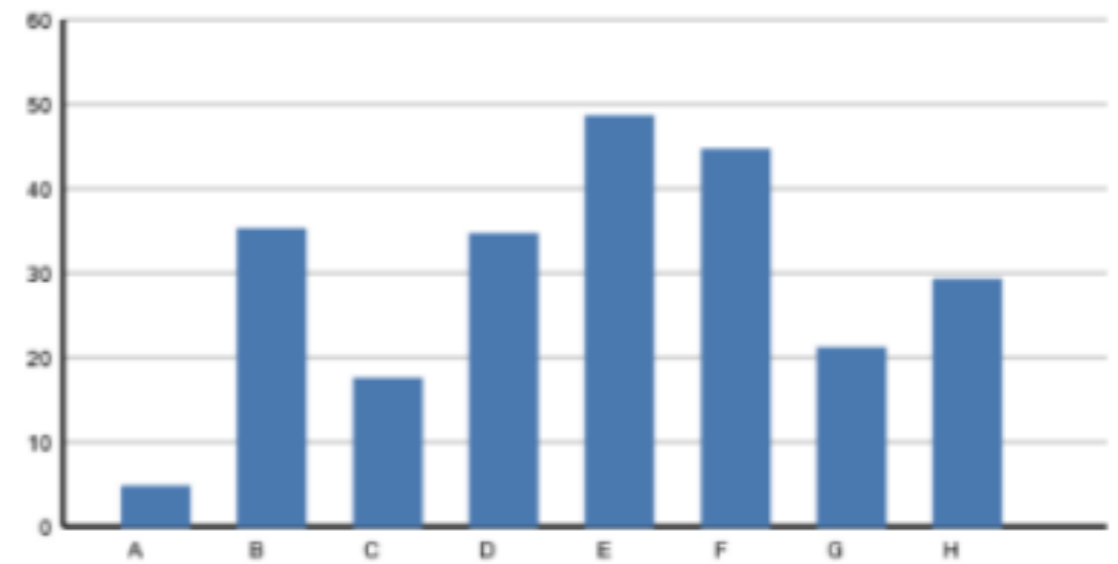
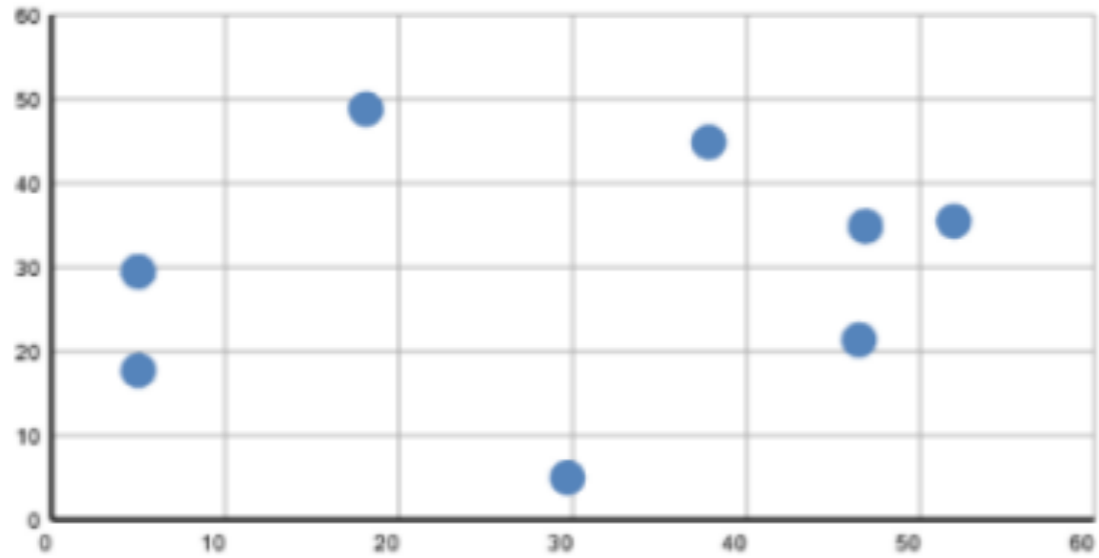
Edge lenses



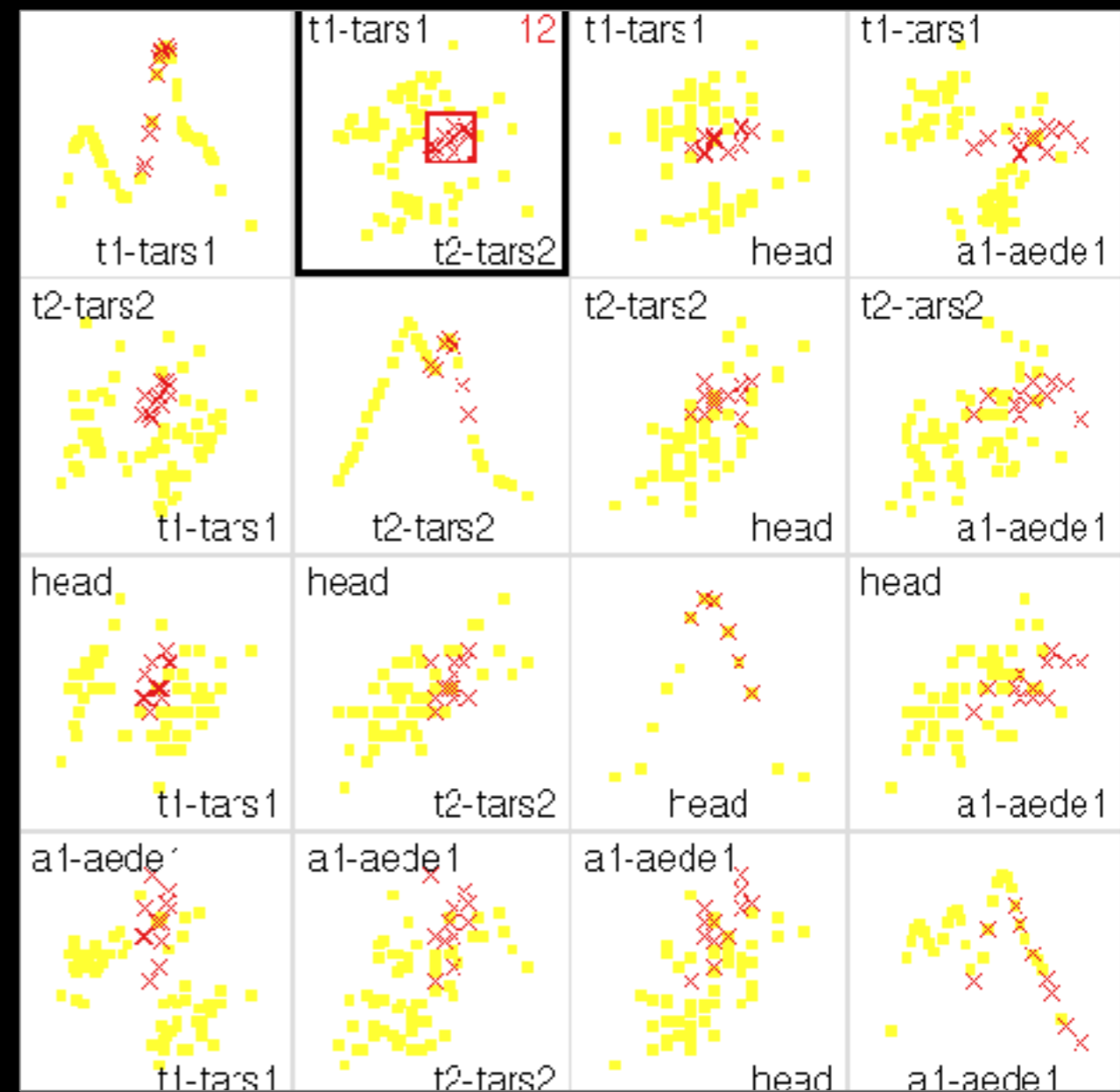
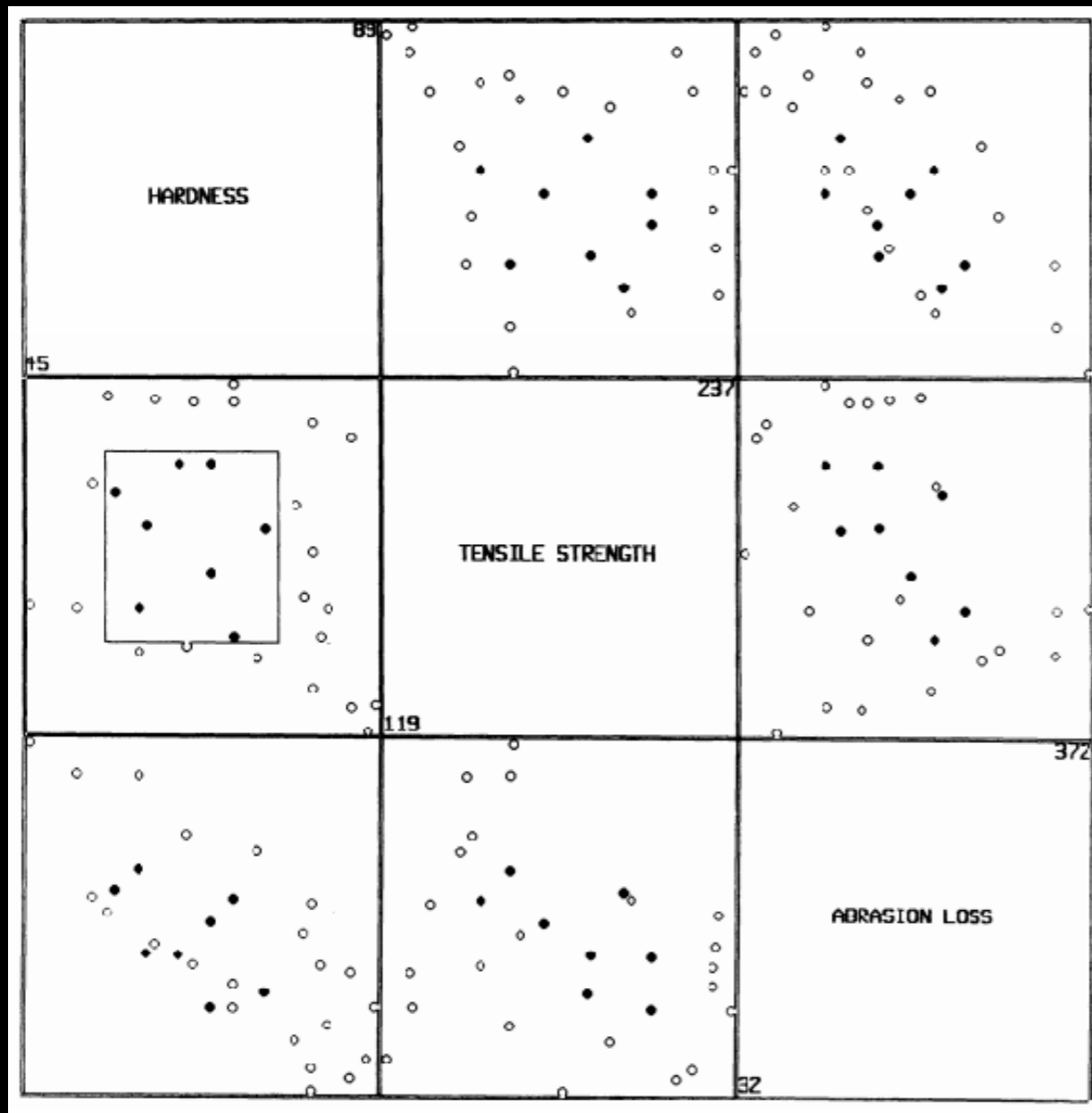
MULTIPLE VIEWS



PROBLEM



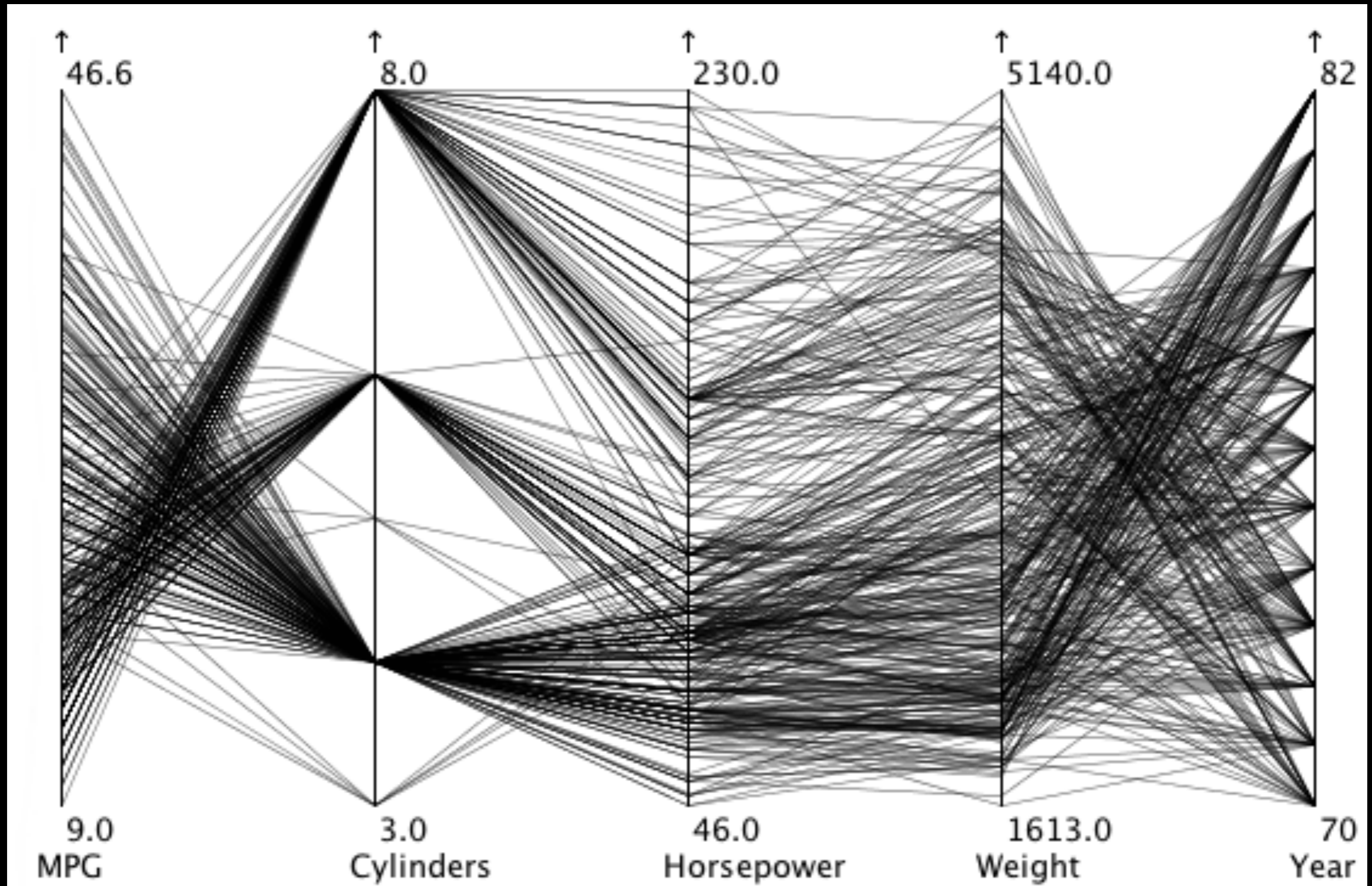
BRUSHING & LINKING SCATTERPLOTS



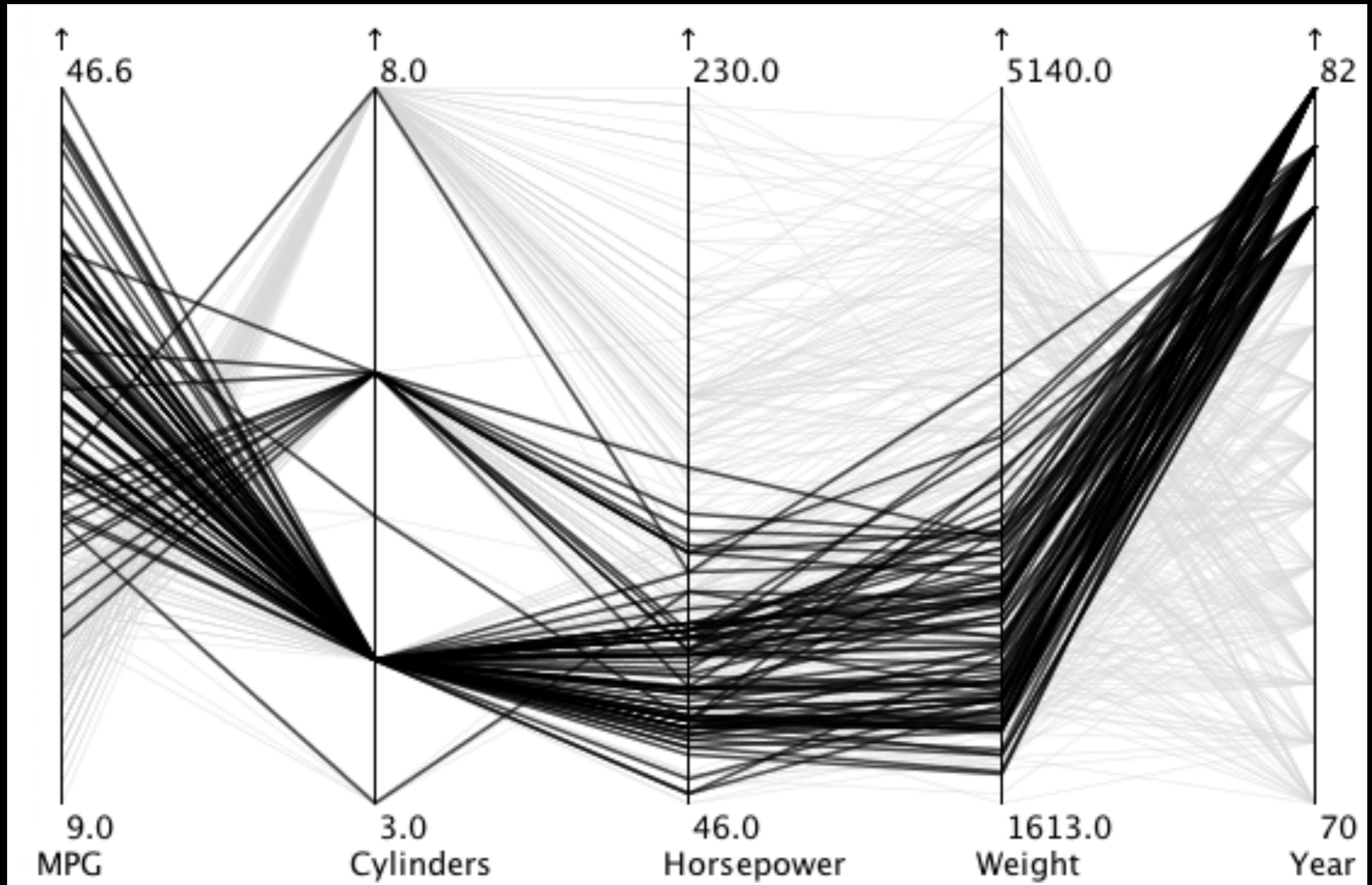
Beker and Cleveland, 1987

Voigt, 2002

BRUSHING PARALLEL COORDINATES



BRUSHING PARALLEL COORDINATES



BRUSHING & LINKING HISTOGRAMS

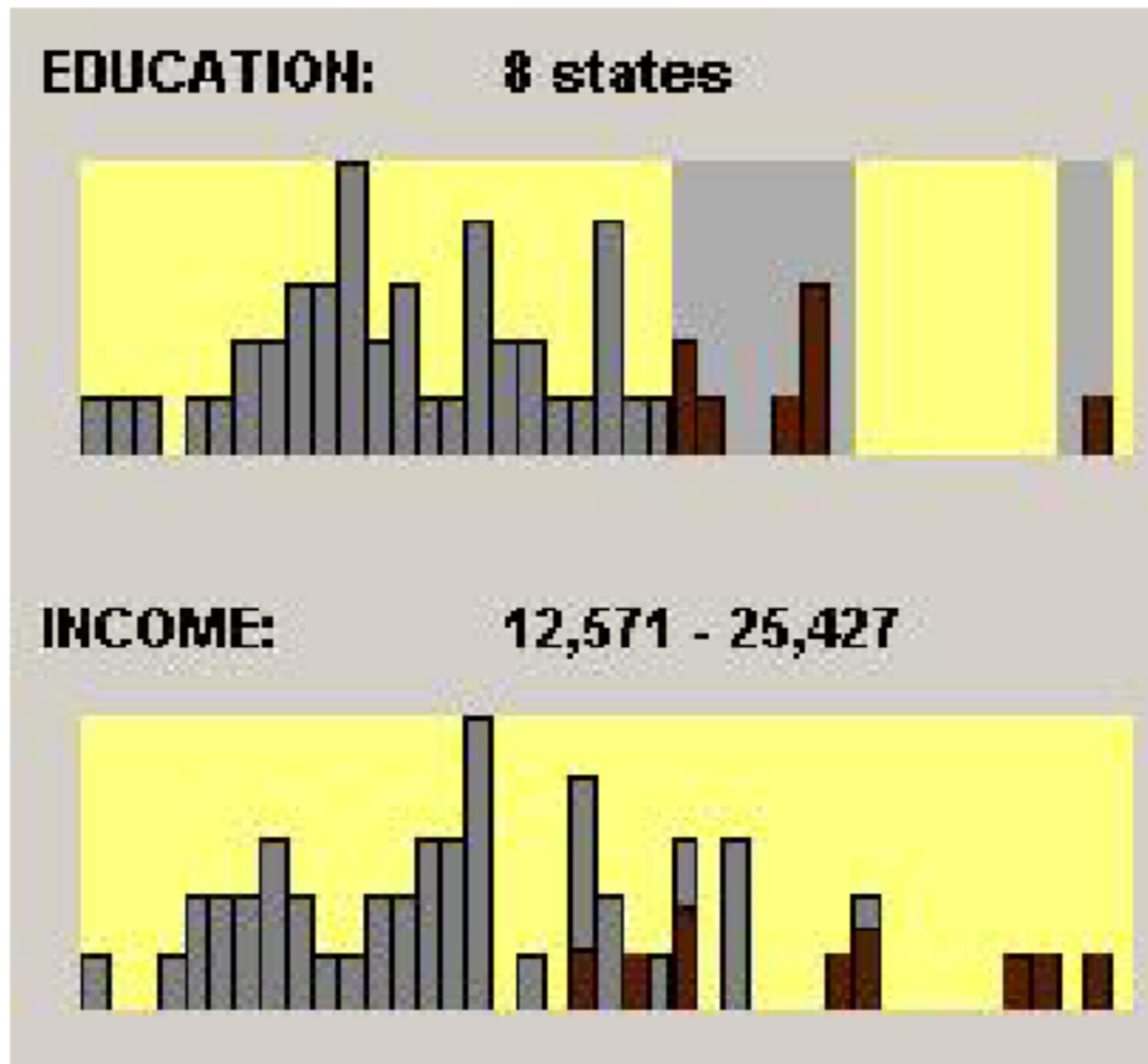
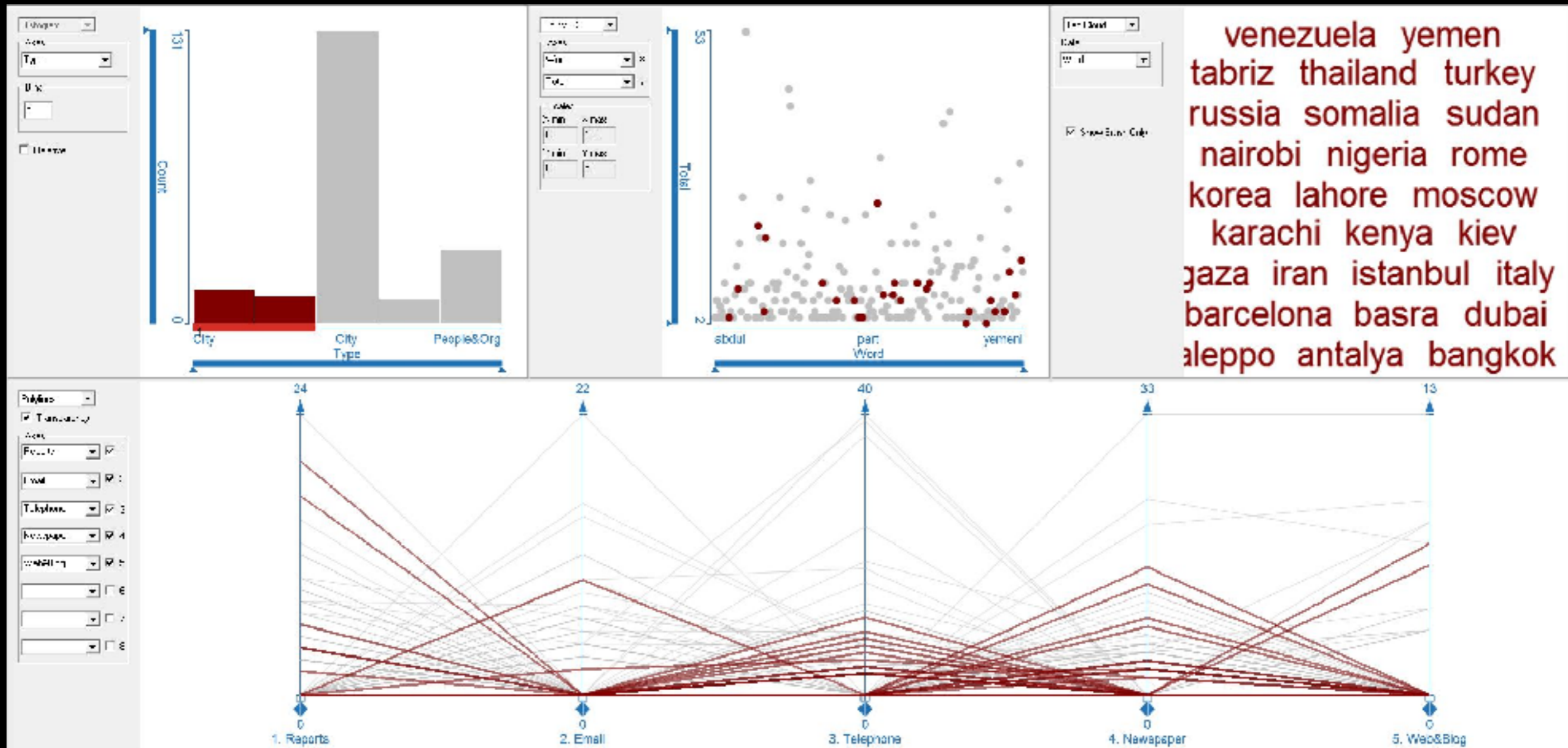
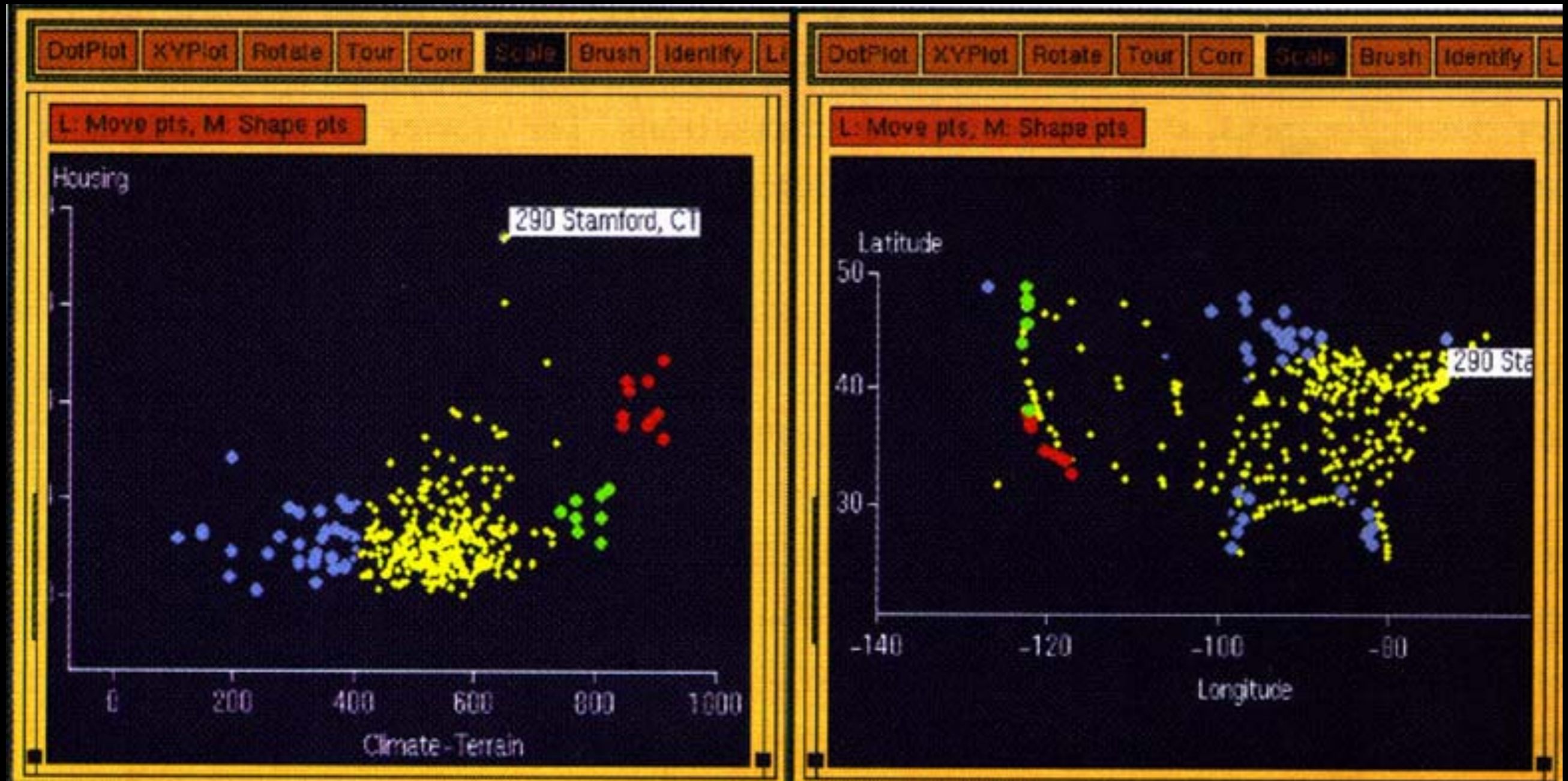


Figure 8: Brushing Histograms

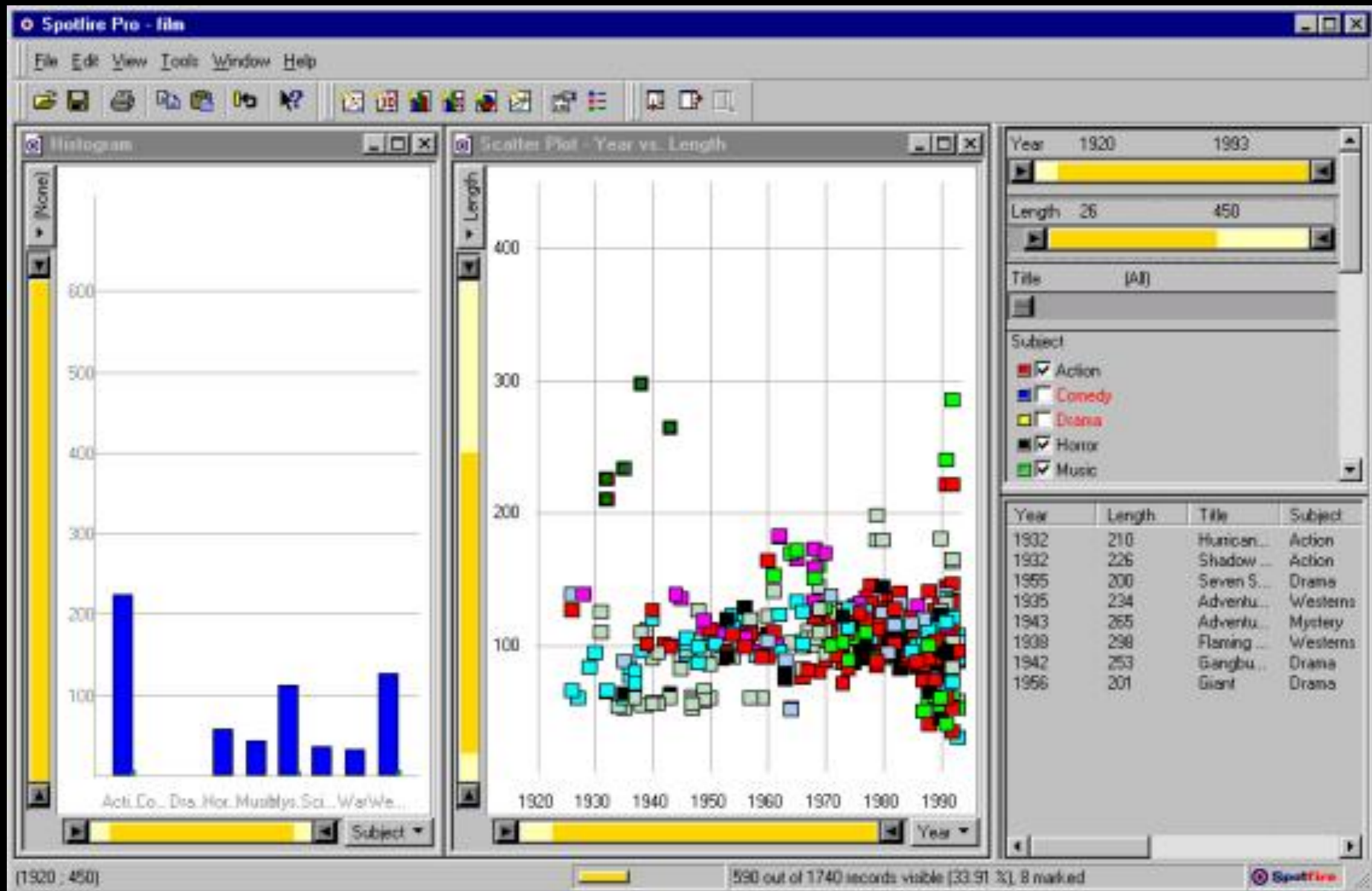
BRUSHING & LINKING EVERYTHING



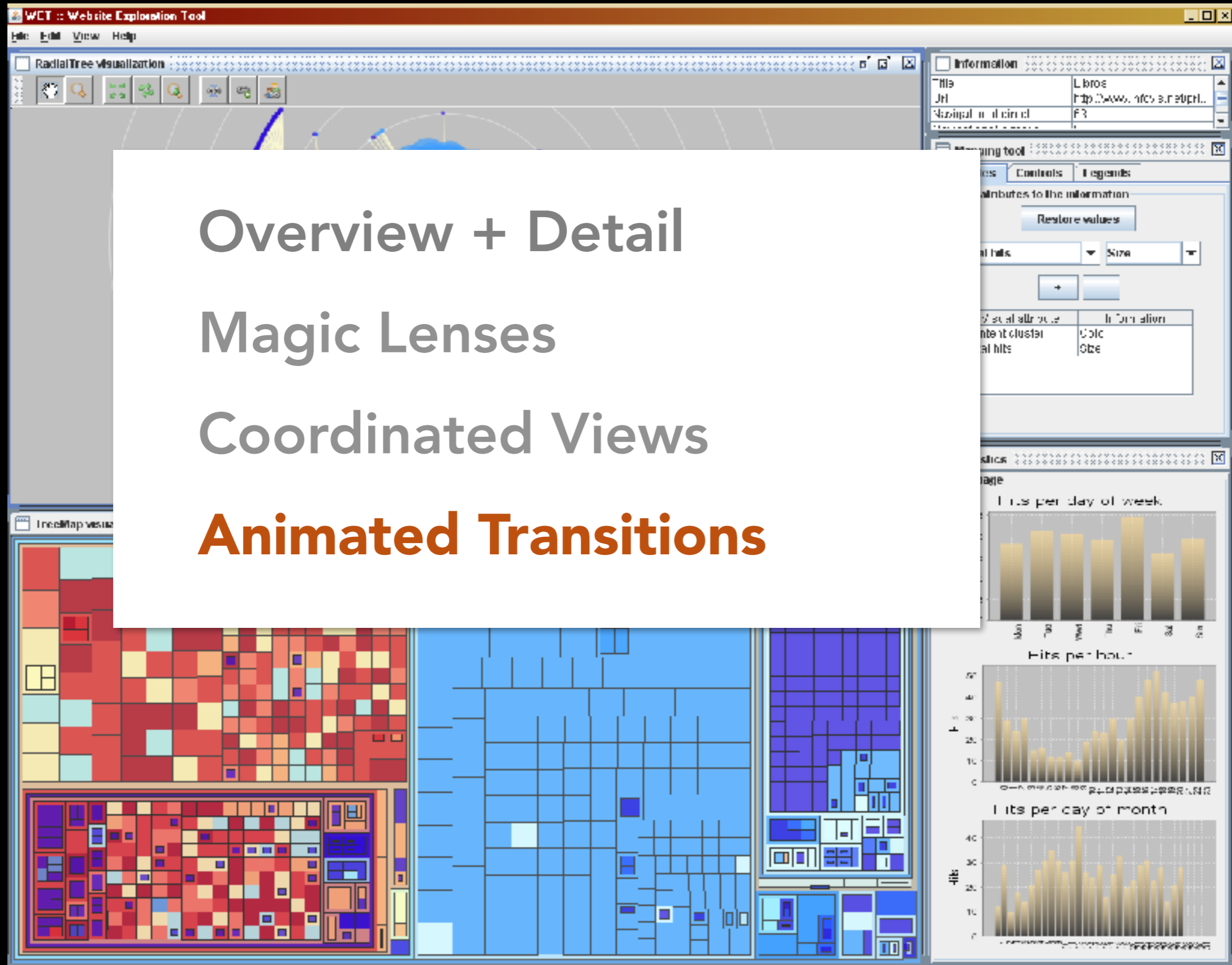
COLOURED BRUSHING & LINKING



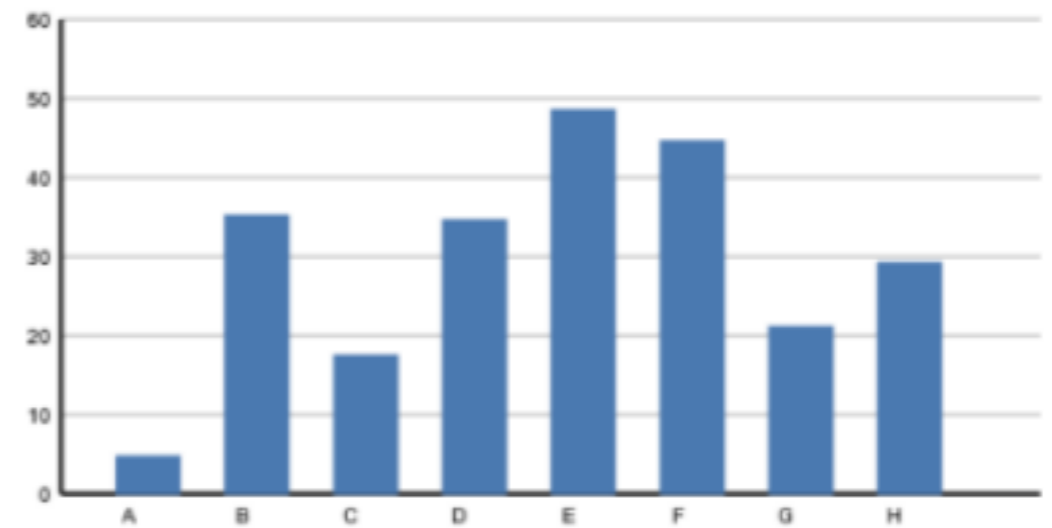
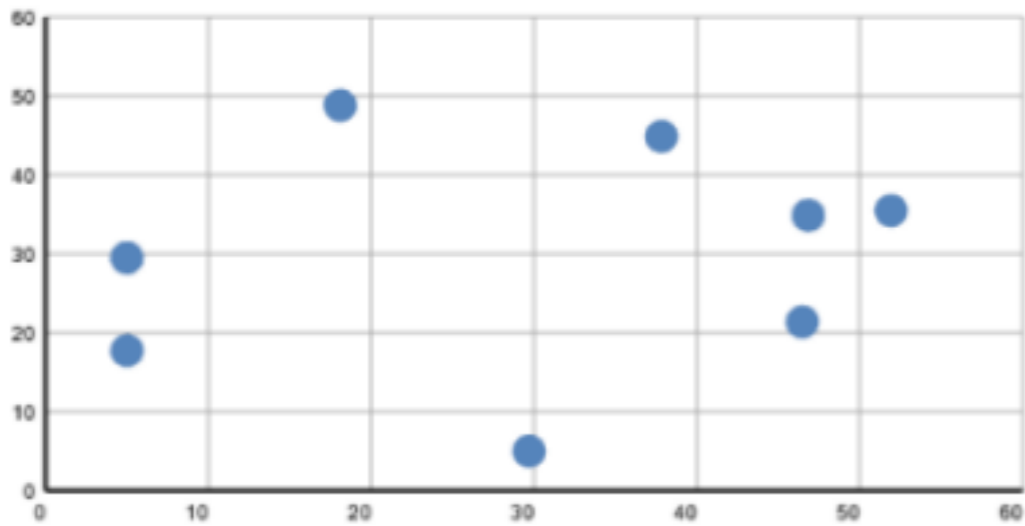
LINKING WITH DYNAMIC QUERIES



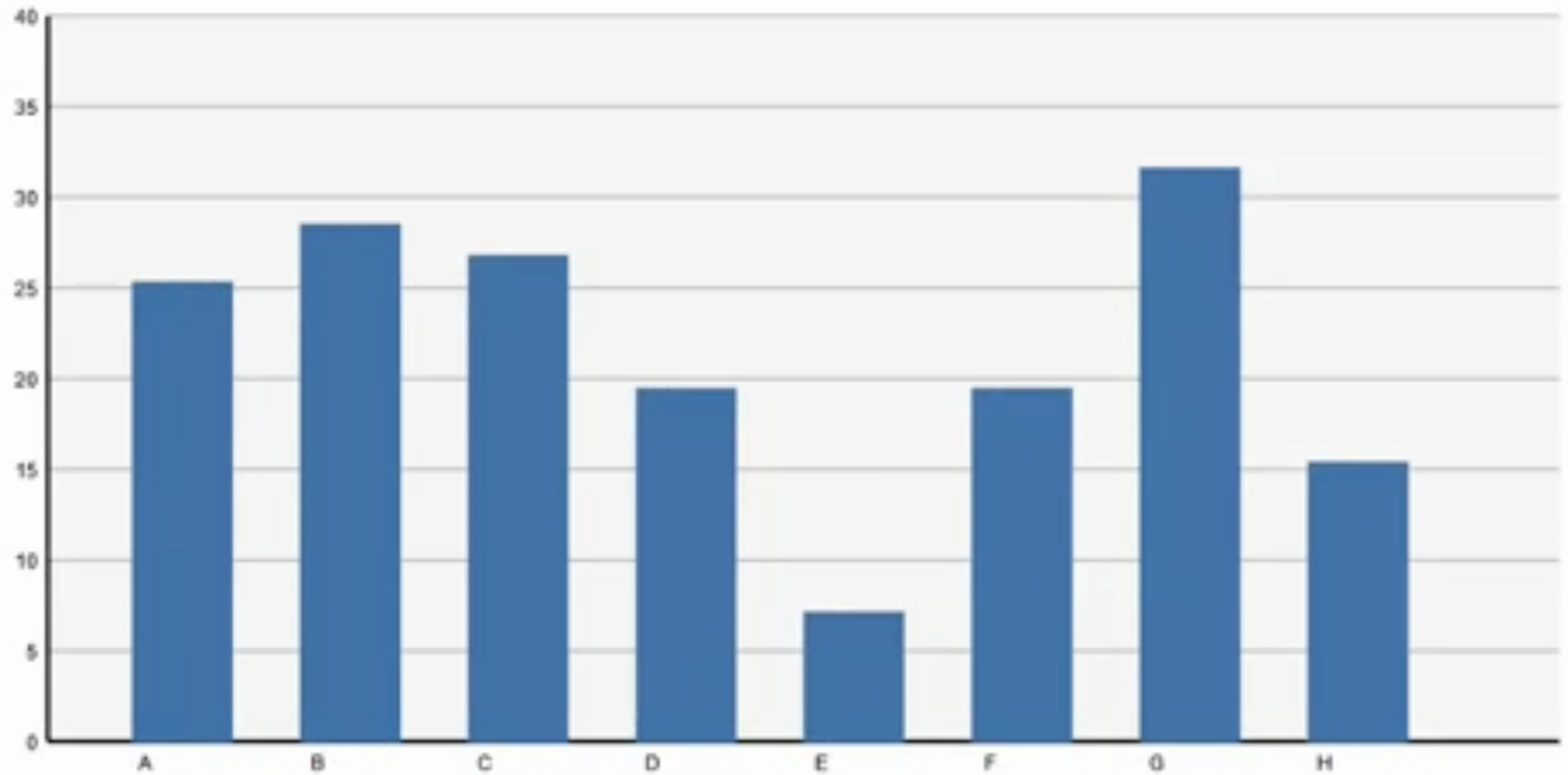
MULTIPLE VIEWS



PROBLEM

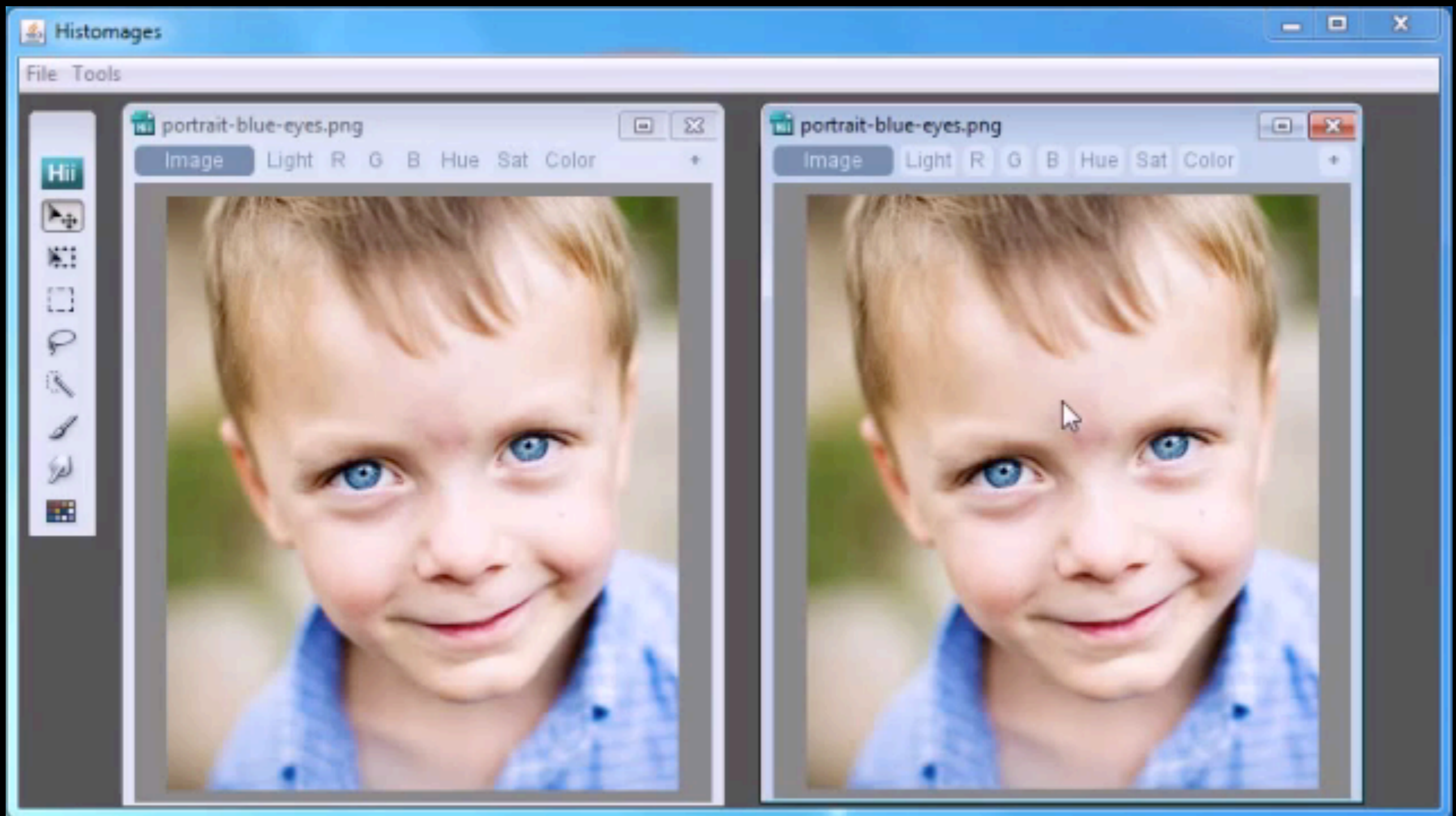


ANIMATED TRANSITIONS



Heer and Roberston, 2007

ANIMATED TRANSITIONS + COORDINATED VIEWS



Histomages (Chevalier et al, 2012)

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

Multiple views

Rearrangement

```
graph LR; A[Multiple views] --> B[Overview + Detail<br/>Magic Lenses<br/>Coordinated Views<br/>Animated Transitions];
```

Overview + Detail
Magic Lenses
Coordinated Views
Animated Transitions

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

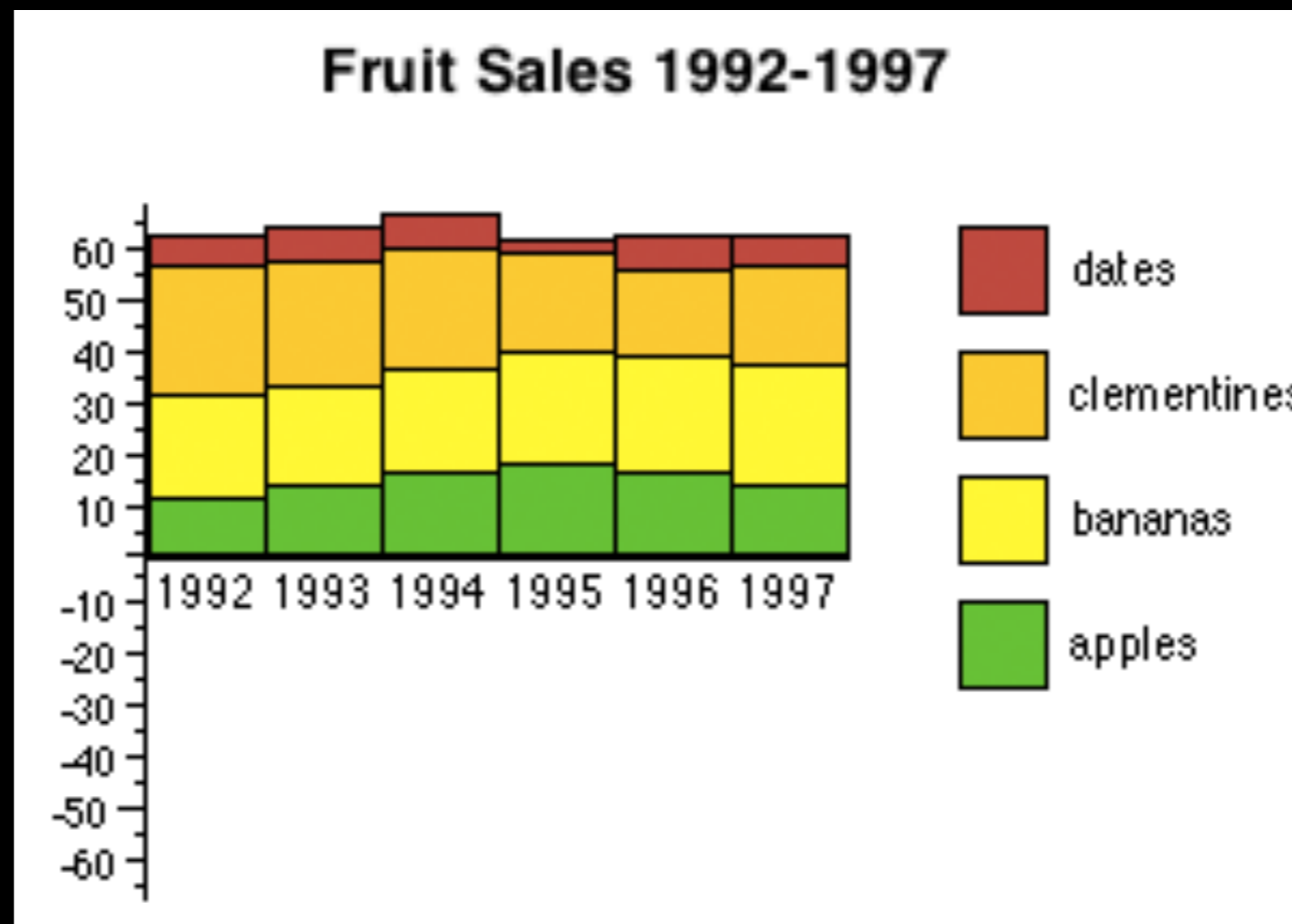
Multiple views

Rearrangement

REARRANGEMENT

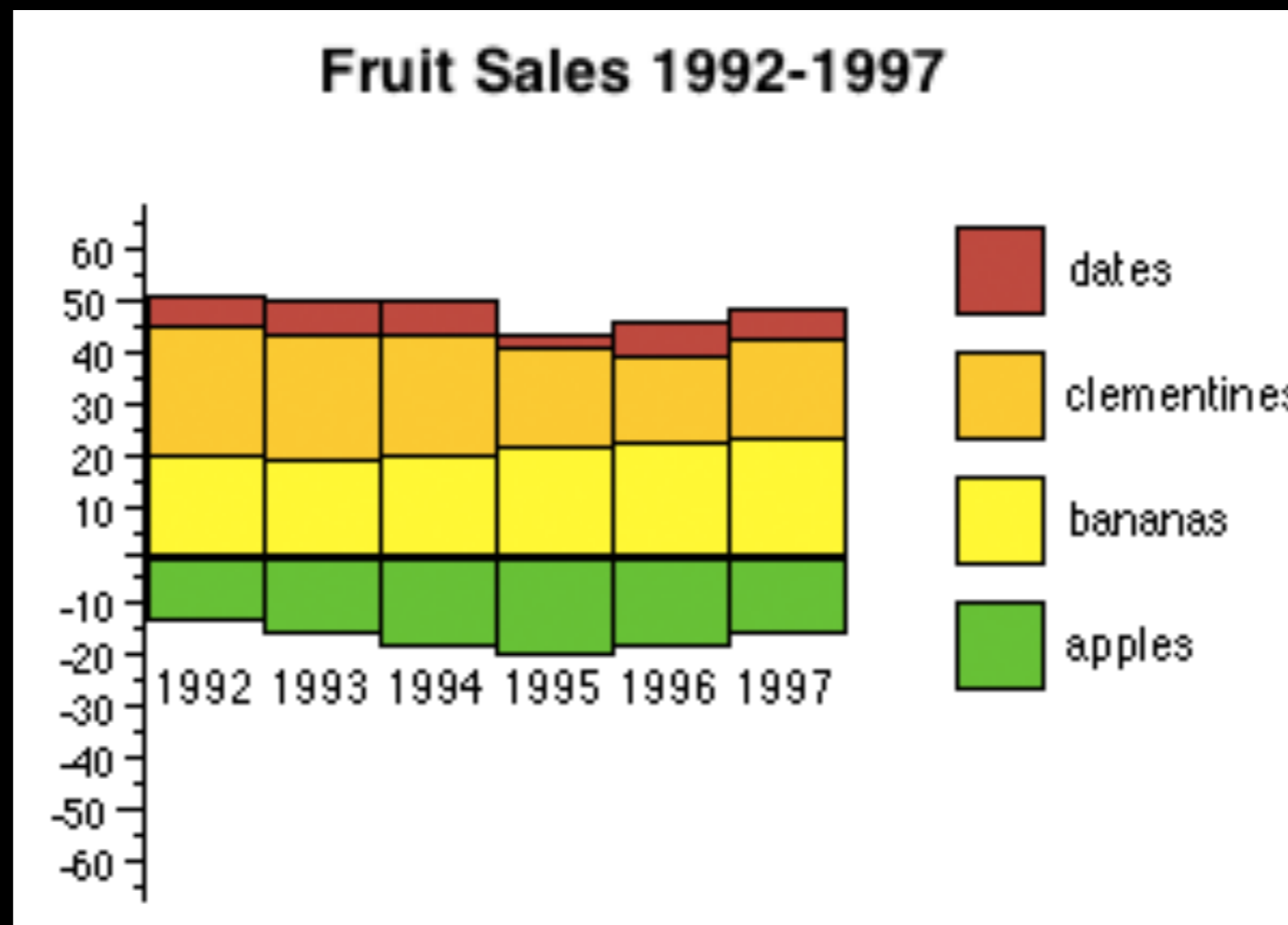
REARRANGEMENT

interactive stacked histogram



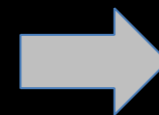
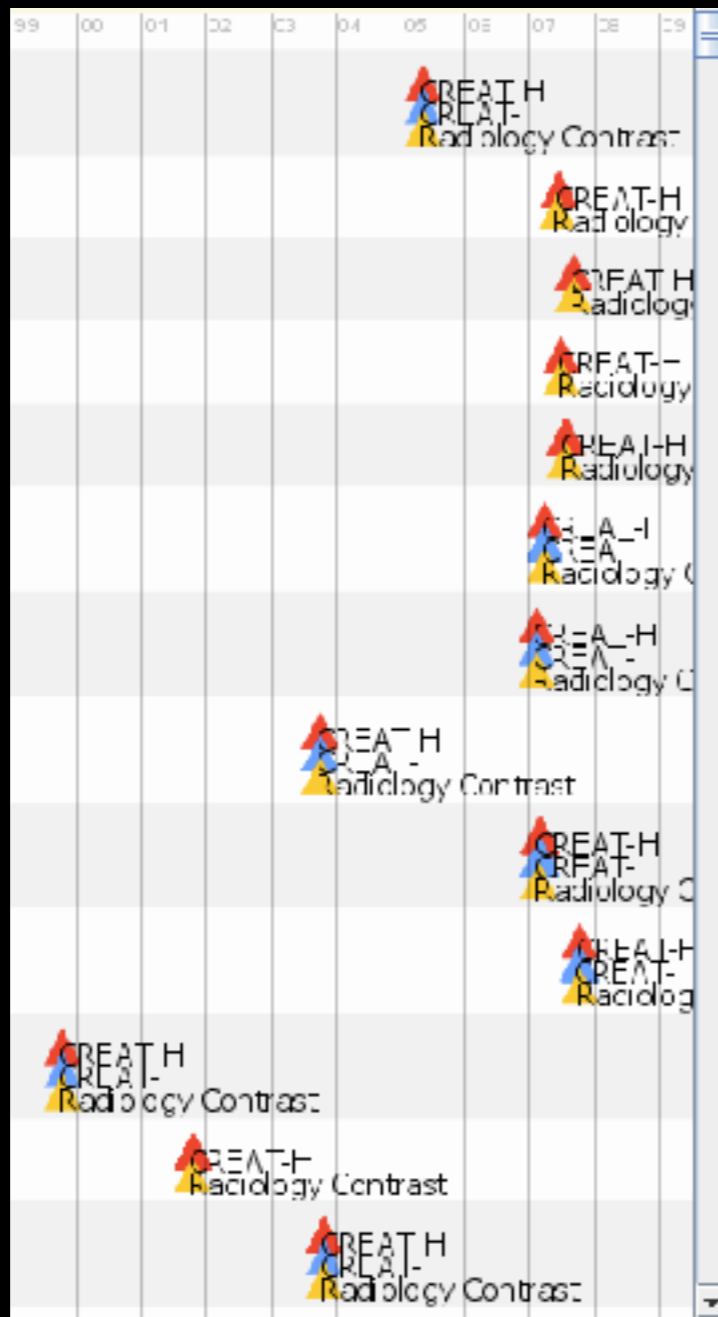
REARRANGEMENT

interactive stacked histogram



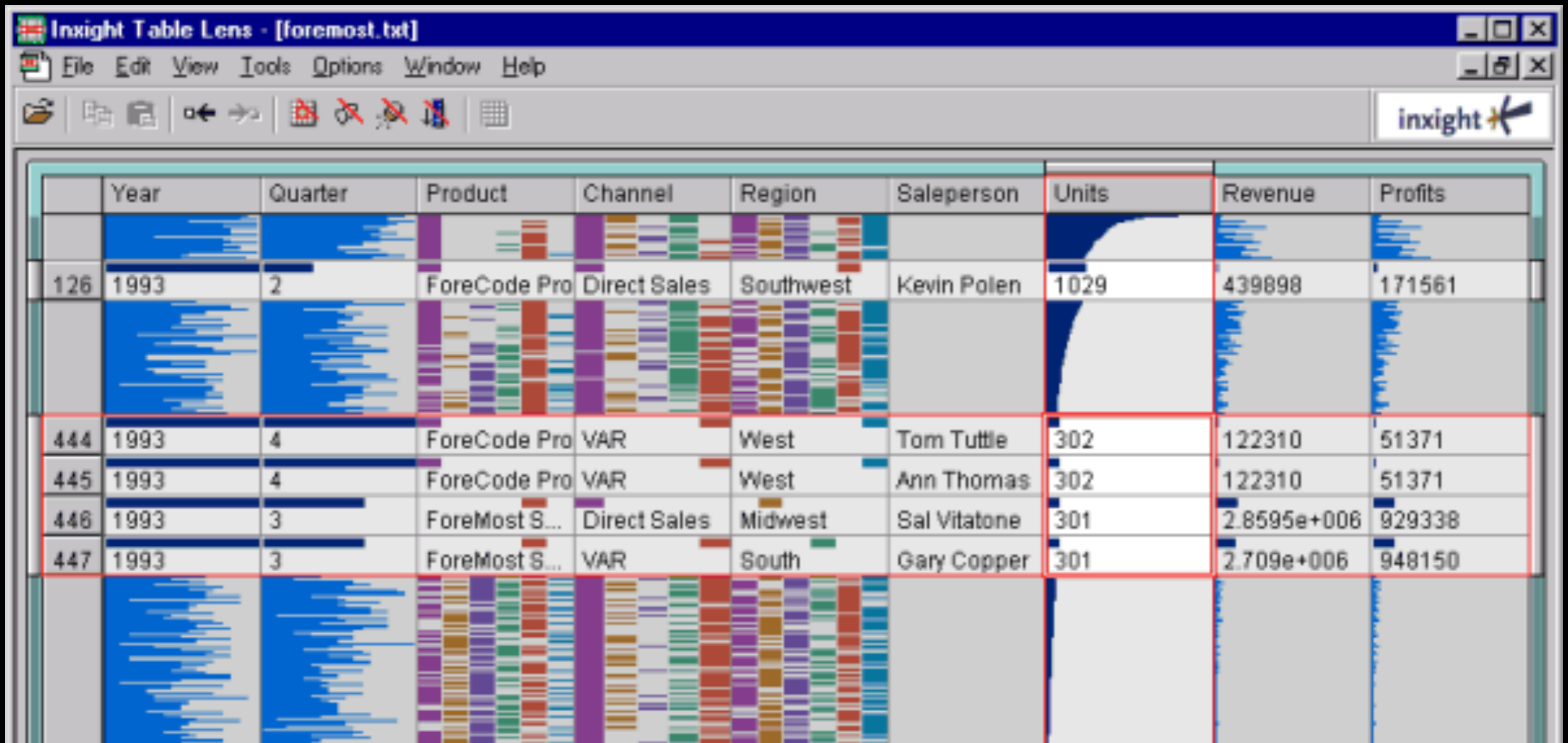
REARRANGEMENT

time-series alignment



REARRANGEMENT

Sorting



The screenshot shows the Inxight Table Lens application window. The title bar reads "Inxight Table Lens - [foremost.txt]". The menu bar includes "File", "Edit", "View", "Tools", "Options", "Window", and "Help". The toolbar contains various icons for file operations and data manipulation. The main window displays a data table with columns: Year, Quarter, Product, Channel, Region, Salesperson, Units, Revenue, and Profits. The table is sorted by Units in descending order. A red box highlights a subset of rows, including the top row (126) and rows 444 through 447. The data in the highlighted rows is as follows:

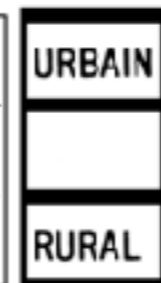
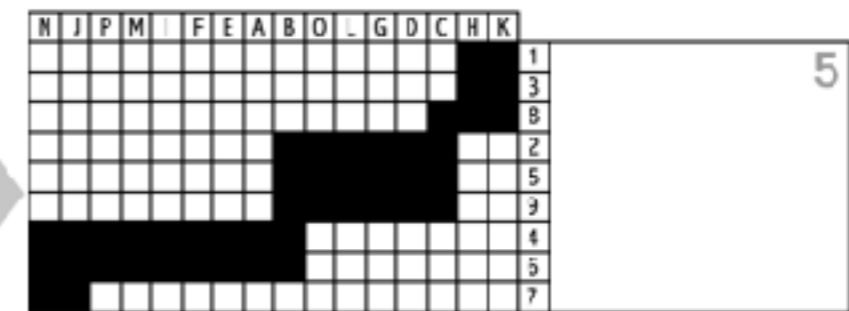
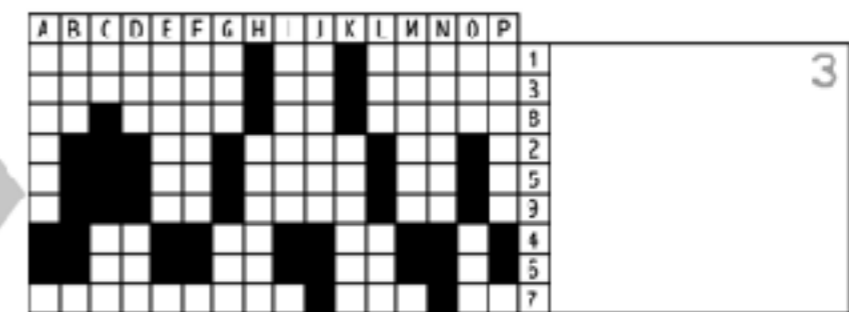
	Year	Quarter	Product	Channel	Region	Salesperson	Units	Revenue	Profits
126	1993	2	ForeCode Pro	Direct Sales	Southwest	Kevin Polen	1029	439898	171561
444	1993	4	ForeCode Pro	VAR	West	Tom Tuttle	302	122310	51371
445	1993	4	ForeCode Pro	VAR	West	Ann Thomas	302	122310	51371
446	1993	3	ForeMost S...	Direct Sales	Midwest	Sal Vitatone	301	2.8595e+006	929338
447	1993	3	ForeMost S...	VAR	South	Gary Copper	301	2.709e+006	948150

REARRANGEMENT

Matrix Reordering

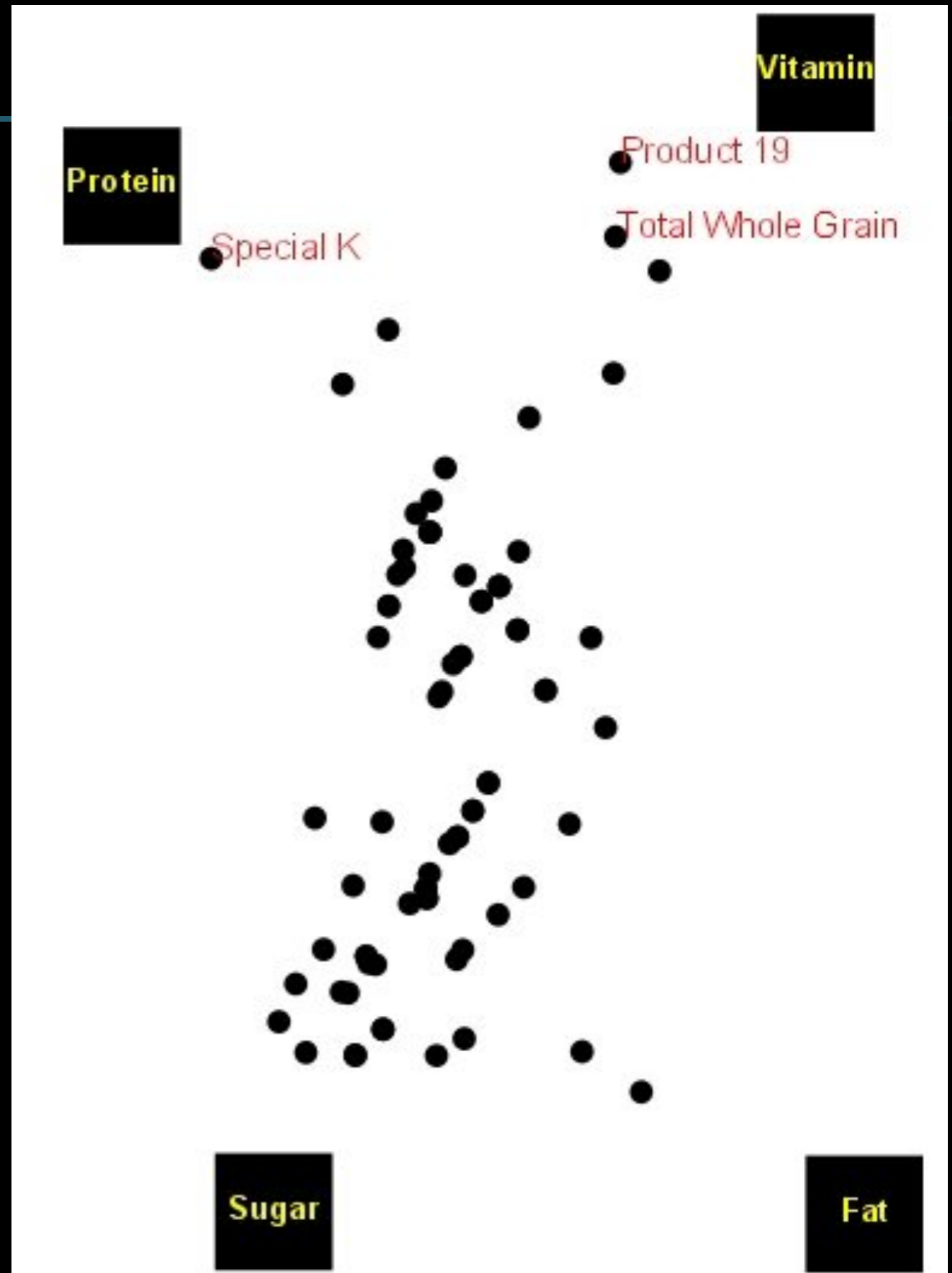


LA MATRICE ORDONNABLE

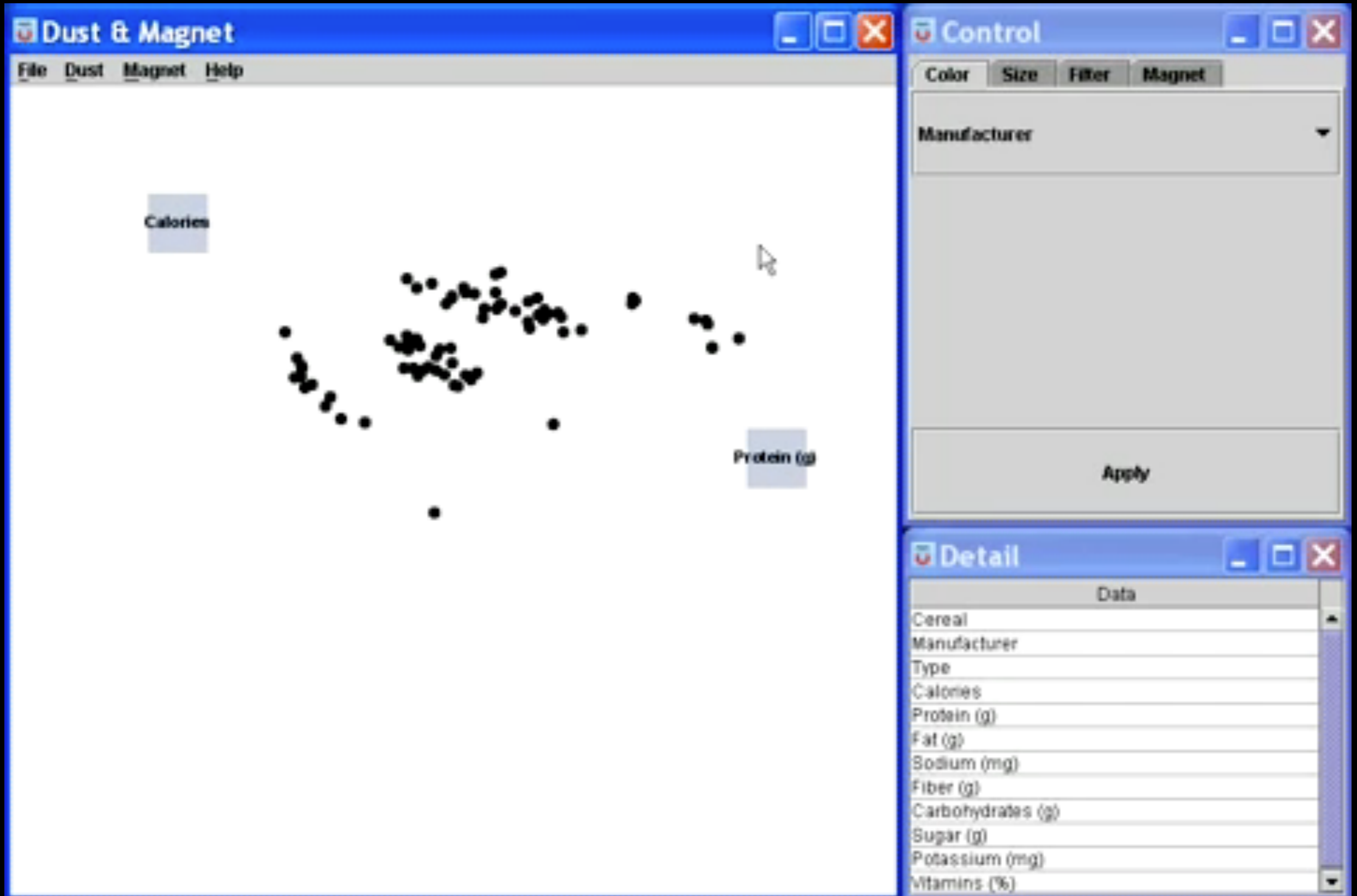


REARRANGEMENT

Dust and Magnet

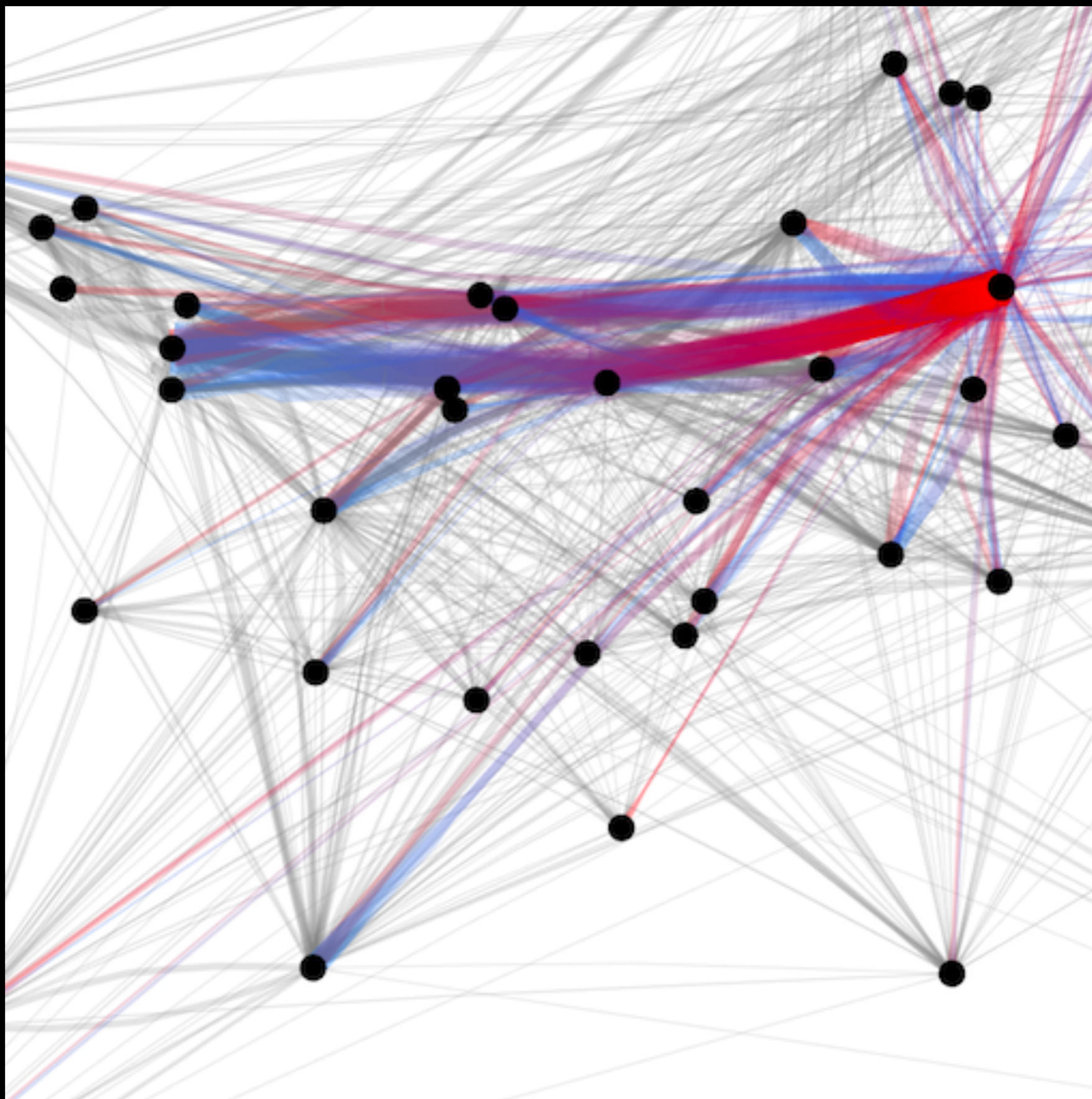


REARRANGEMENT



PITFALLS

#1. INTERACTION CANNOT FIX BAD VISUALIZATIONS

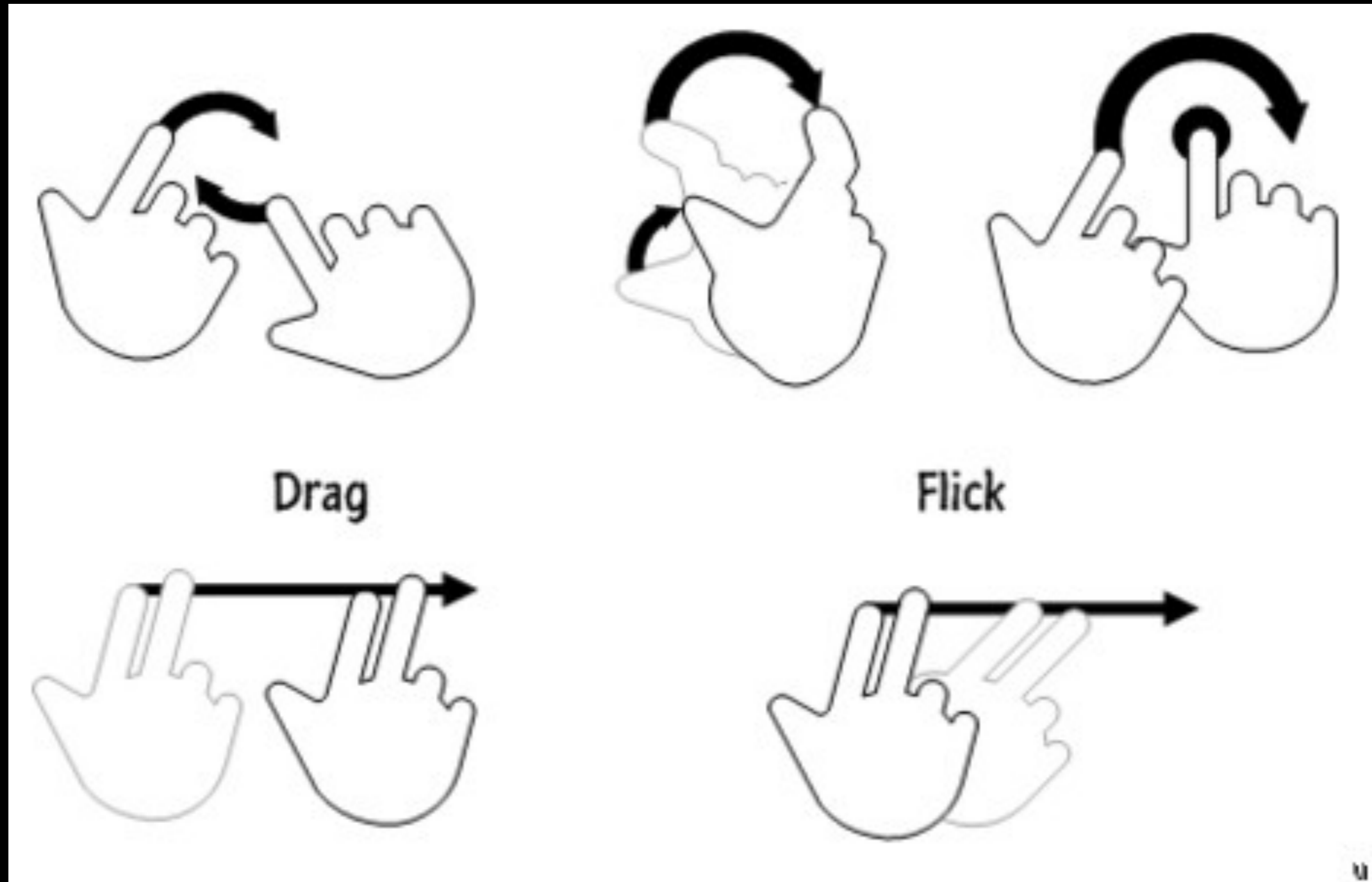


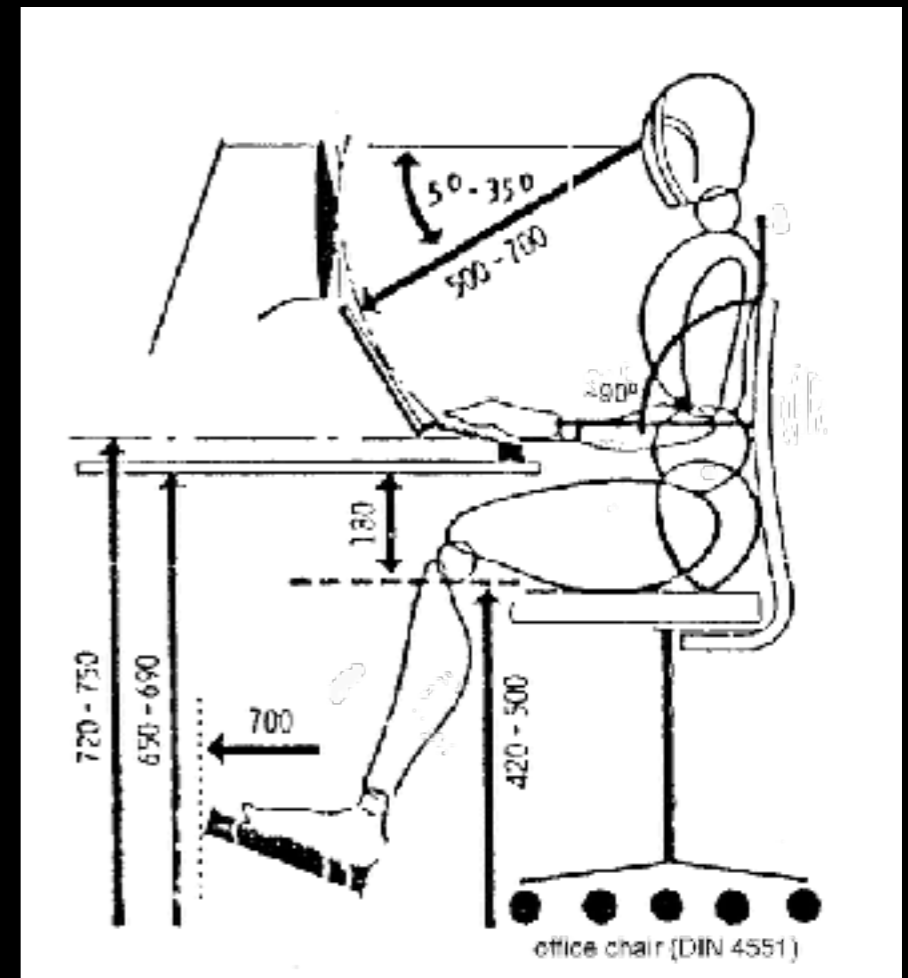
#2. CONTROLS TAKE SCREEN REAL-ESTATE

The image displays five screenshots of a software interface, illustrating the complexity of controls and their impact on screen real estate. The interface is divided into several panels:

- Top Left:** A table listing various properties and their values, such as XAxisColumn (Release date), YAxisColumn (Max resolution), and dataBounds (java.awt.geom.Rectangle2D\$Dou).
- Top Middle:** A control panel for the 'Excentric' tool, featuring a checkbox for 'Enable Excentric Labels', a 'Radius' slider, a 'Max Labels' slider, and a checkbox for 'Opaque Labels'.
- Top Right:** A control panel for the 'Fisheyes' tool, including a 'Metrics' section with radio buttons for 'L1', 'L2', and 'Linf', a 'Lens Shape' dropdown menu set to 'Linear', a 'Maximum Scale' slider, and a 'Lens Radius' slider.
- Bottom Left:** A control panel for the 'Rulers' tool, showing a 'Visible' checkbox, an 'Alpha' dropdown menu, and a 'Default %' slider.
- Bottom Middle:** A control panel for the 'Filters' tool, featuring a 'HDD' section with 'Filtered', 'Selected', and 'Unselected' buttons, a 'Show All' button, and a list of dimensions (Dimensions, Effective pixels, Low resolution, Macro focus range, Max resolution, Name, Normal focus range, Price, Release date, Storage included, Weight (inc. batteries), Zoom tele (T), Zoom wide (W)) each with a corresponding histogram.
- Bottom Right:** A control panel for the 'Visual' tool, including an 'Alpha' dropdown menu, a 'Default %' slider, an 'Area' dropdown menu, an 'Orientation' section with radio buttons for 'North', 'West', 'Center', 'East', and 'South', a 'Bordercolor' dropdown menu, a 'Default Color' button, a 'Smooth' checkbox, a 'Color' dropdown menu, another 'Default Color' button, another 'Smooth' checkbox, a 'Label' section with a 'Name (String)' dropdown menu, a 'Label all items' checkbox, 'Clip' and 'Outline' checkboxes, a 'Font' button, an 'Orientation' section with radio buttons for 'Horizontal', 'Automatic', and 'Vertical', a 'Size' slider, and a 'Size' dropdown menu.

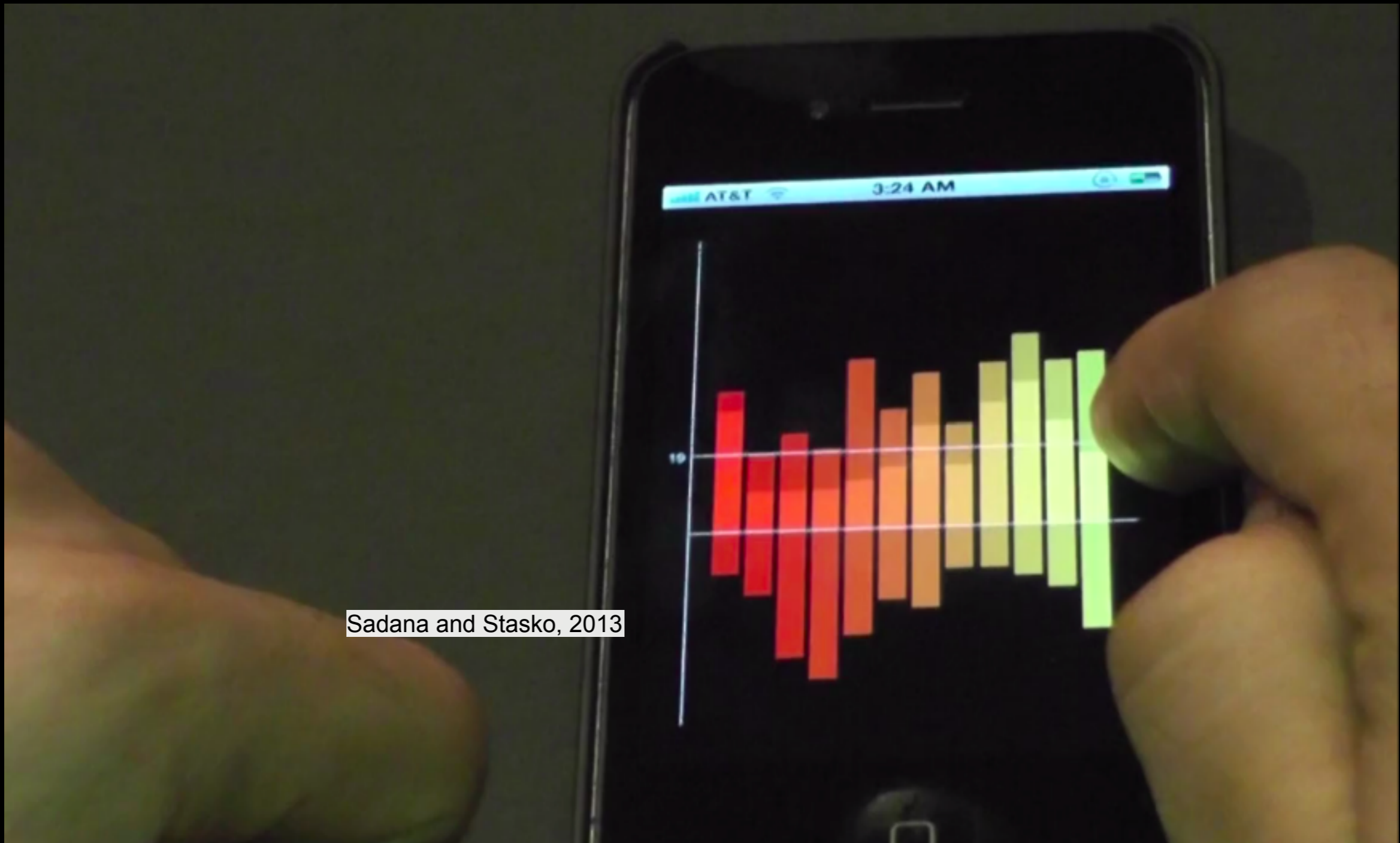
#3. DIRECT MANIPULATION AND GESTURES ARE RARELY SELF-EXPLANATORY





BEYOND THE DESKTOP

TOUCH DEVICES



Sadana and Stasko, 2013

TABLETOP DEVICES



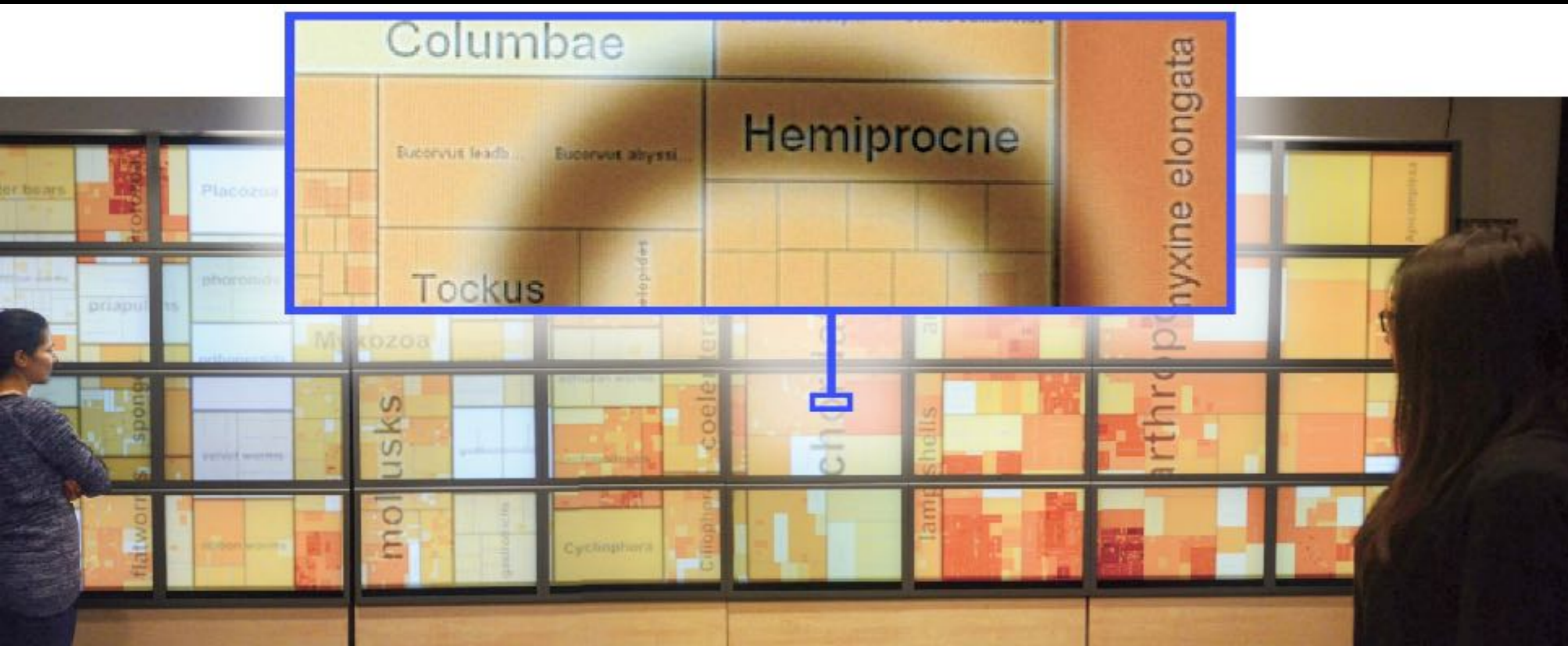
Isenberg and Carpendale, 2008

WALL-SIZED DISPLAYS

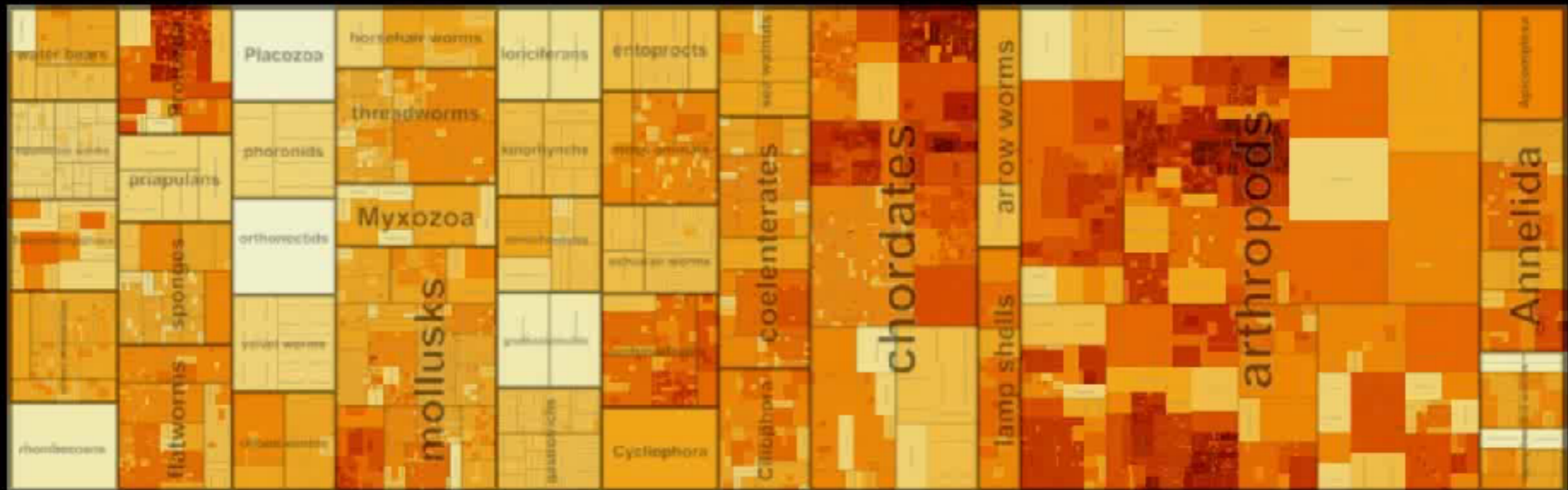


WILD Display - Digiscope

WALL-SIZED DISPLAYS

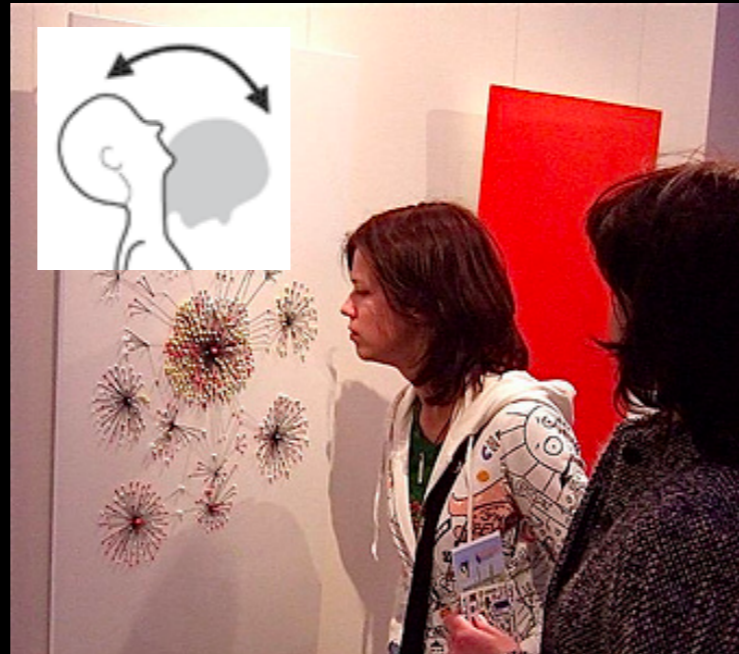


[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis'13]

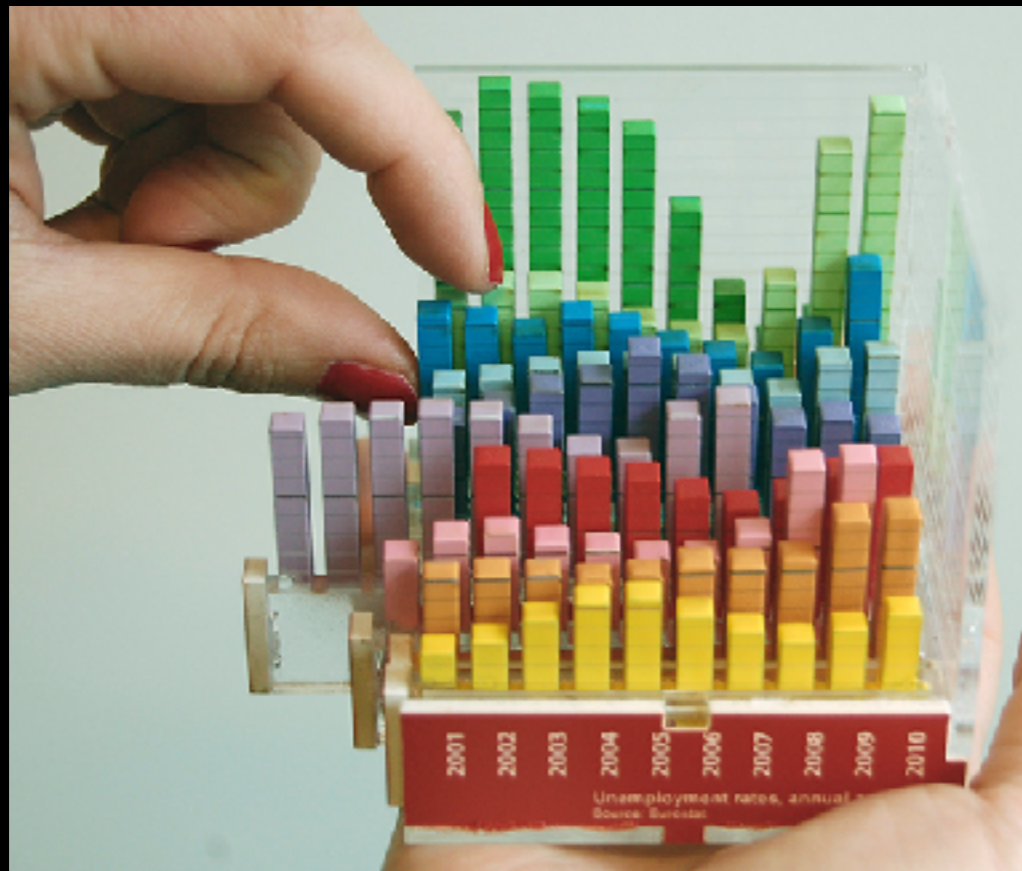
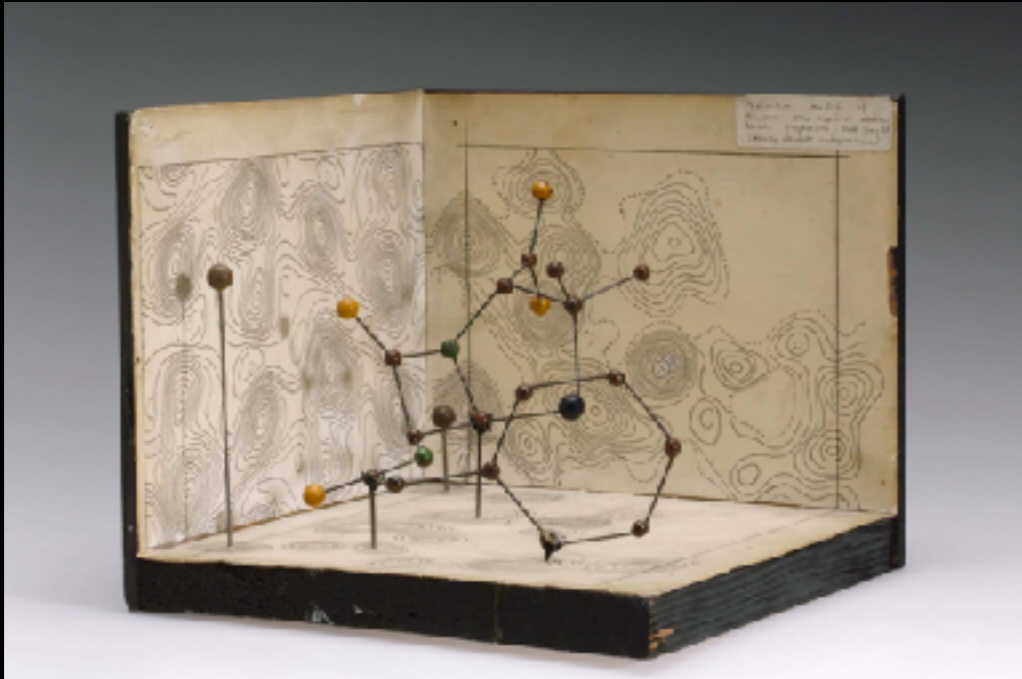


[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis'13]

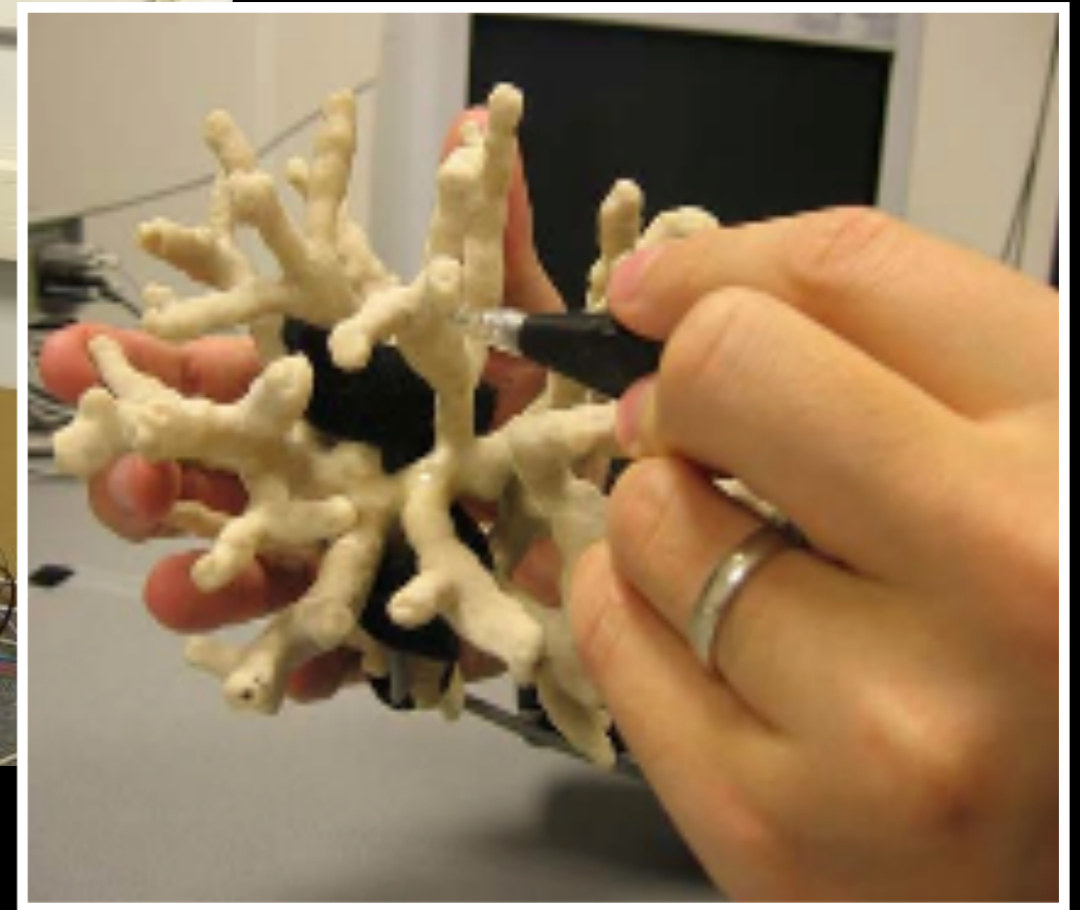
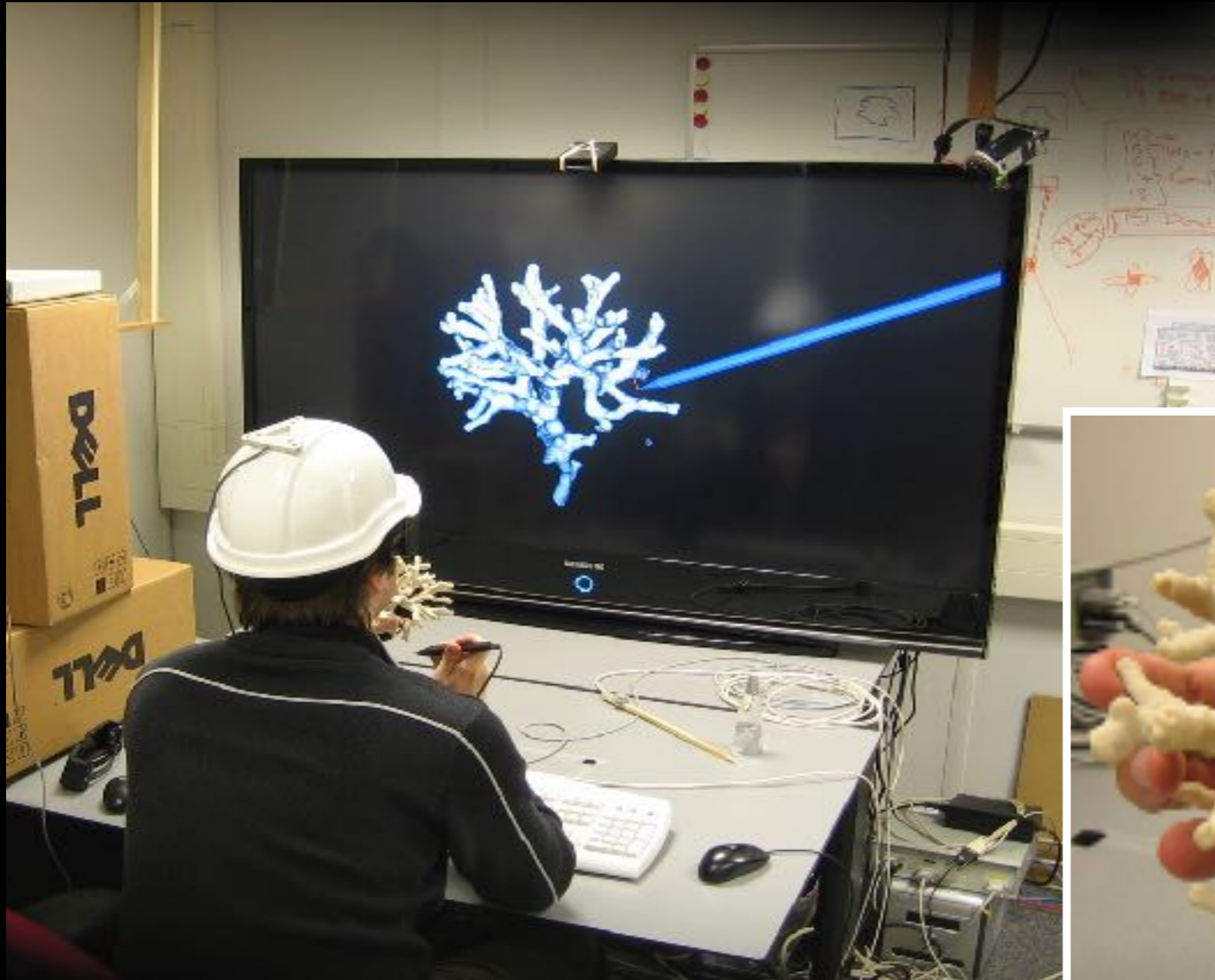
INTERACTION WITH THE PHYSICAL WORLD



PHYSICAL VISUALIZATIONS



HYBRID SYSTEMS



[Kruszynski & van Liere, Tangible Props for Scientific Visualization, Virtual Reality 13 (4) 2009]

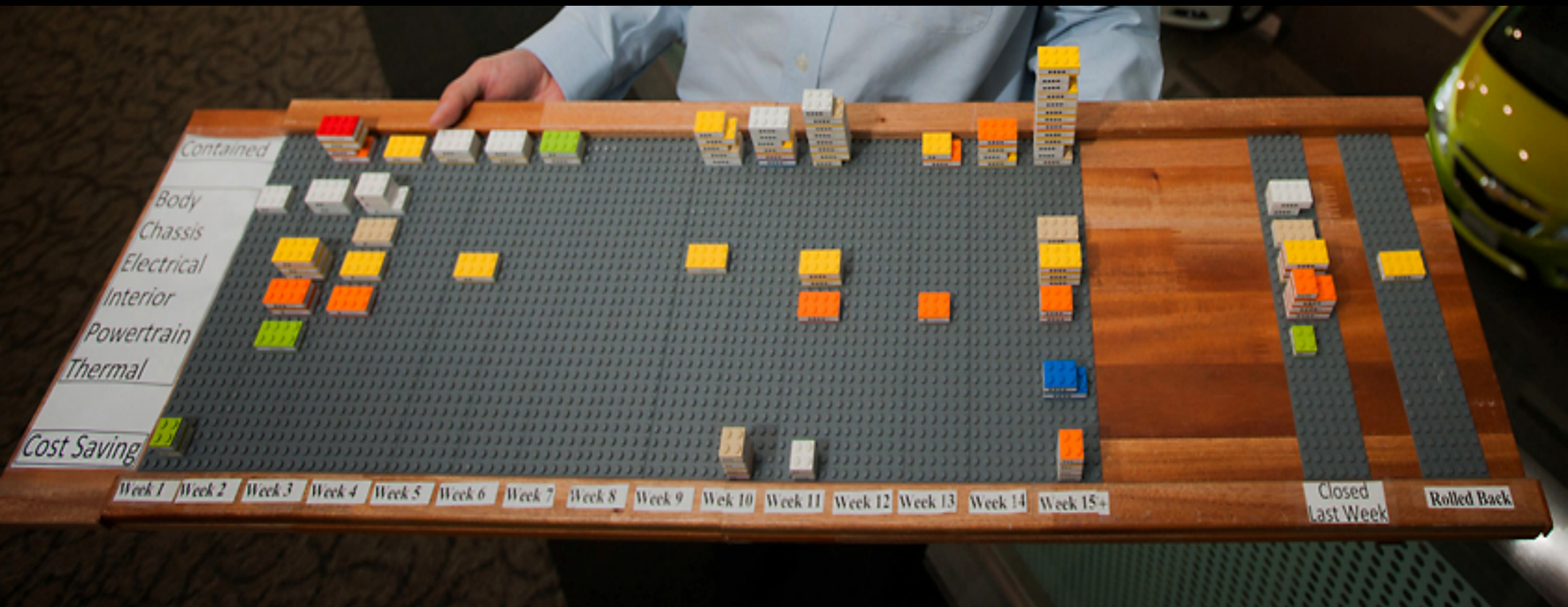
HYBRID SYSTEMS



Inform (Leithinger et al., 2013)

DATA PHYSICALISATION

dataphys.org/list



[Mark Wilson. How GM is saving cash using legos as a data viz tool. April 2012]