

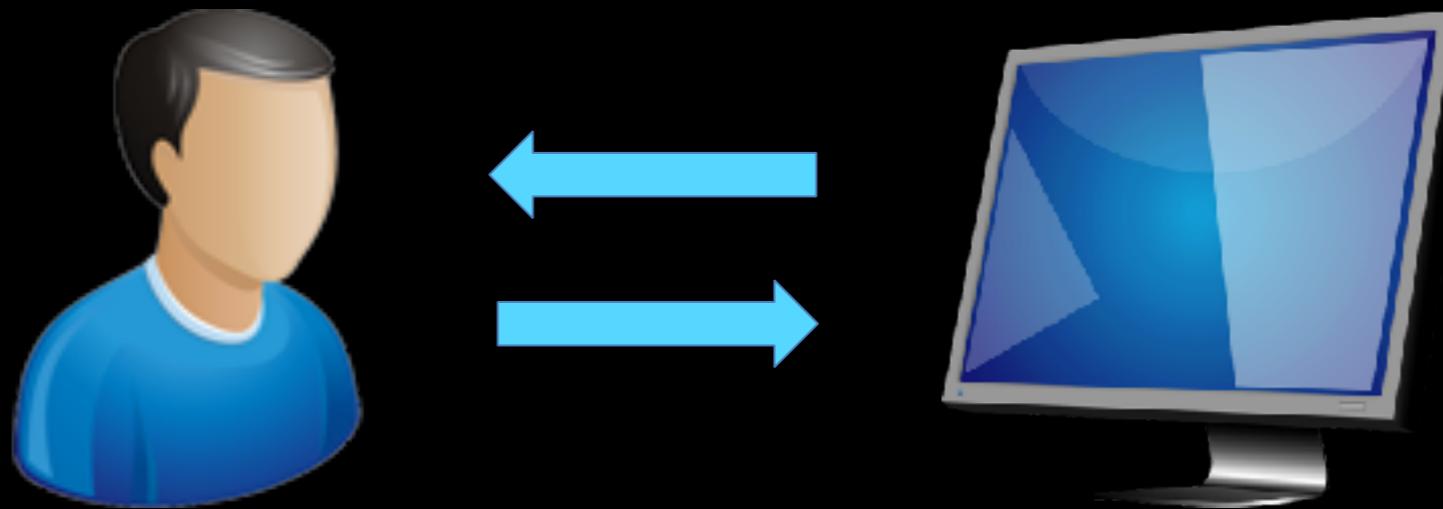
CSC2537 / STA2555 - INFORMATION VISUALIZATION INTERACTION

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

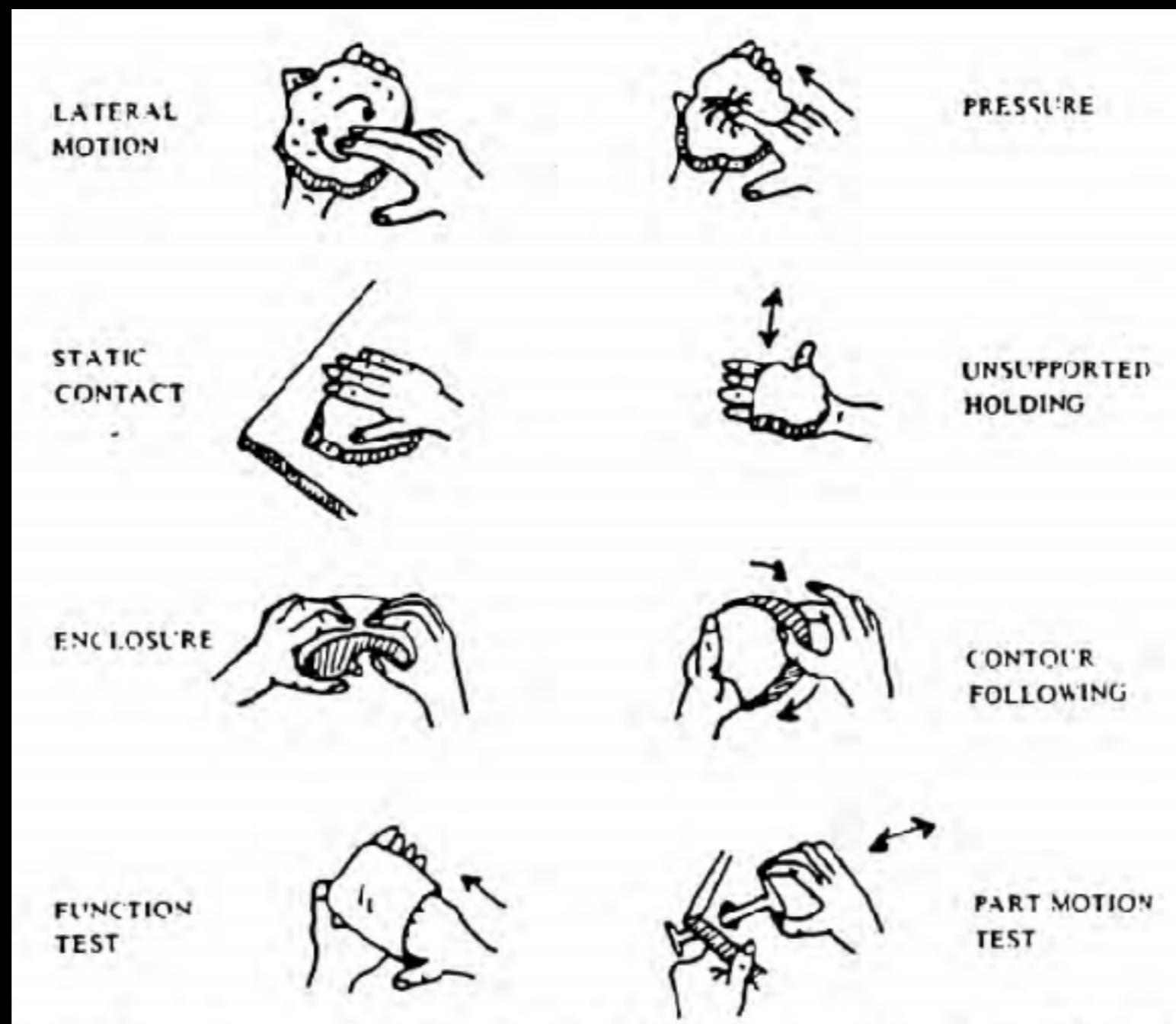
- output for affordances & feedback

Infovis research mostly focuses on output

- input for steering output

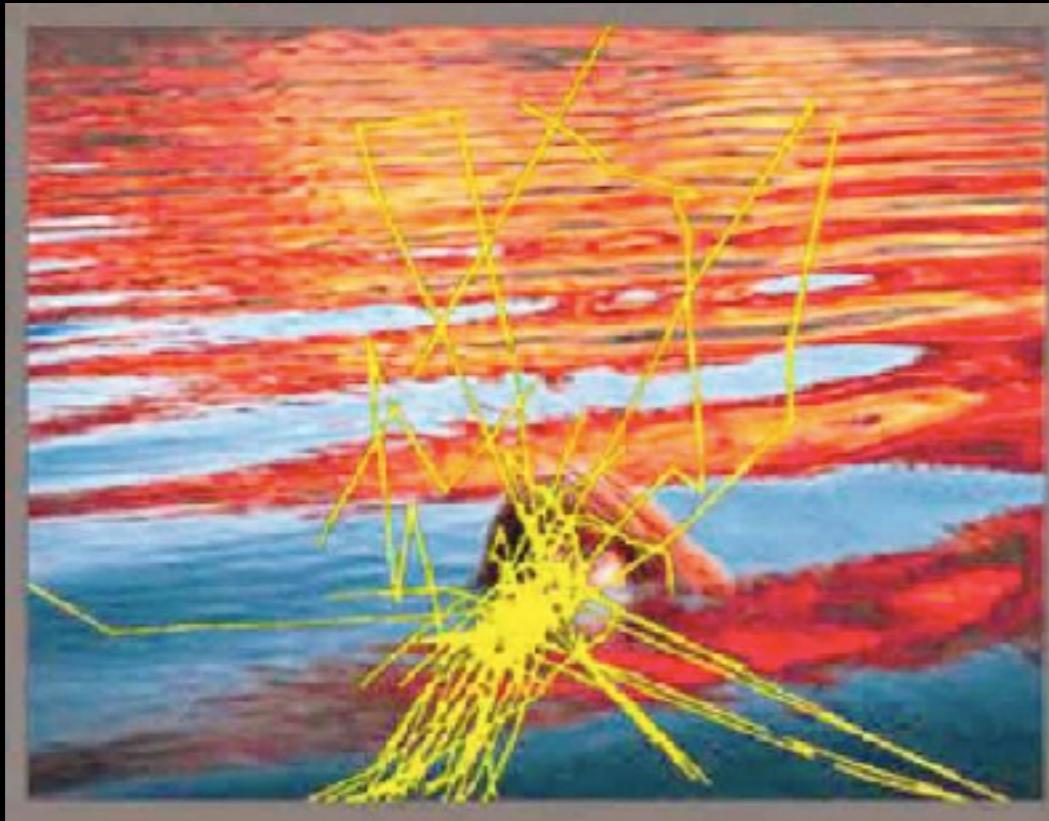
ACTIVE PERCEPTION

Perception requires action



ACTIVE PERCEPTION

Perception requires action



Eye movement of a layperson



Eye movement of an artist

Vogt and Magnussen 2007 ([link](#))

ACTIVE PERCEPTION

Perception requires action



ACTIVE PERCEPTION

Perception requires action



Bret Victor ([link](#))

ACTIVE PERCEPTION

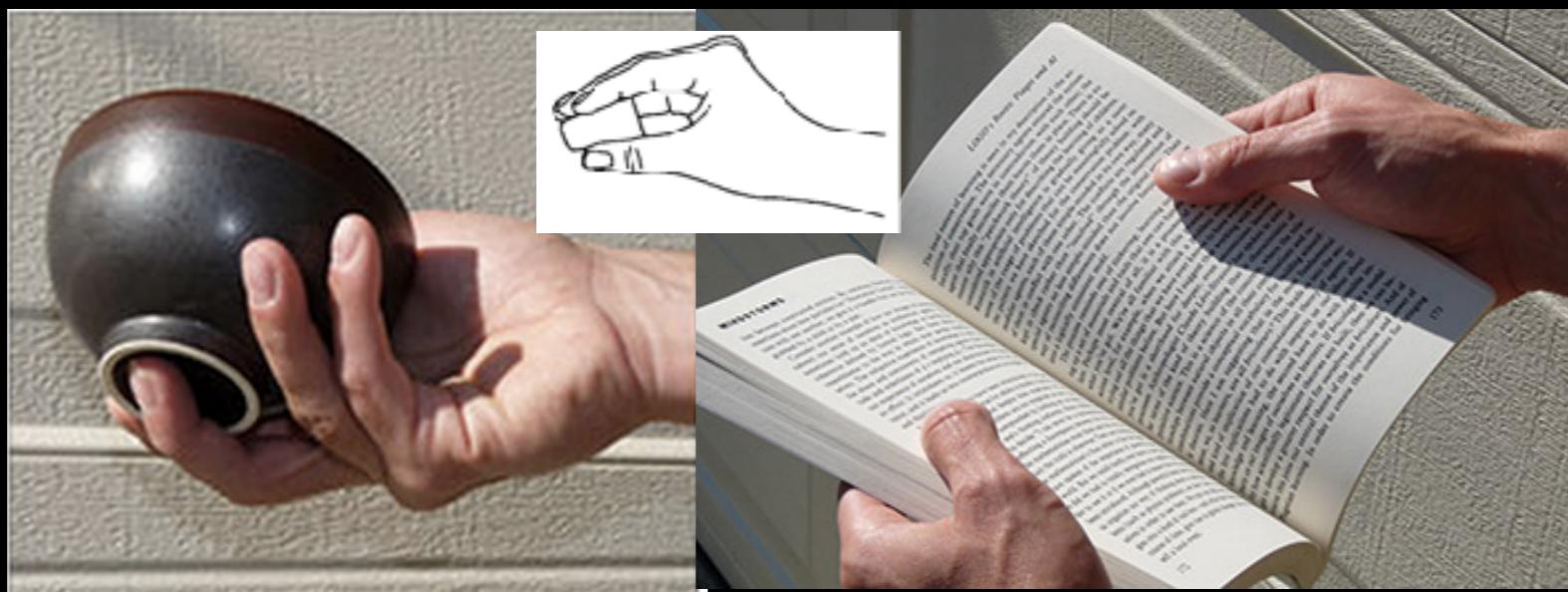
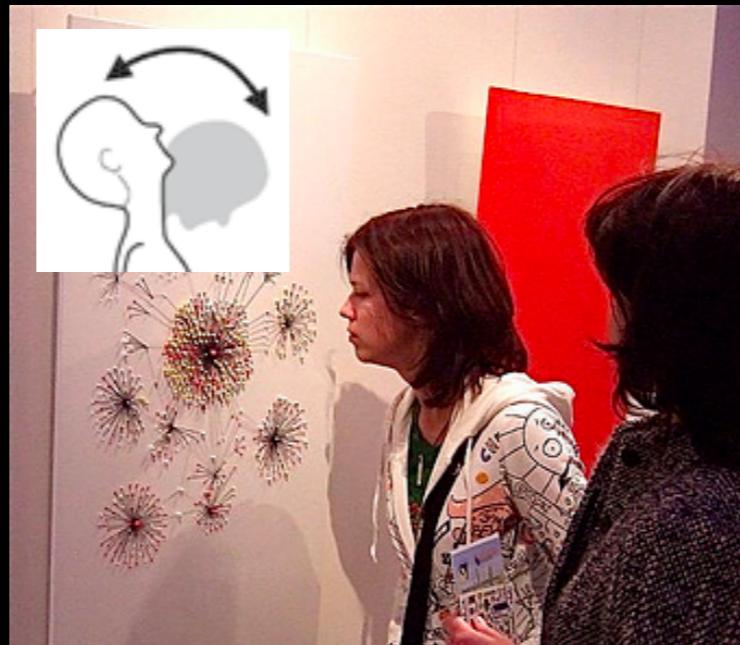
Perception requires action



Bret Victor ([link](#))

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

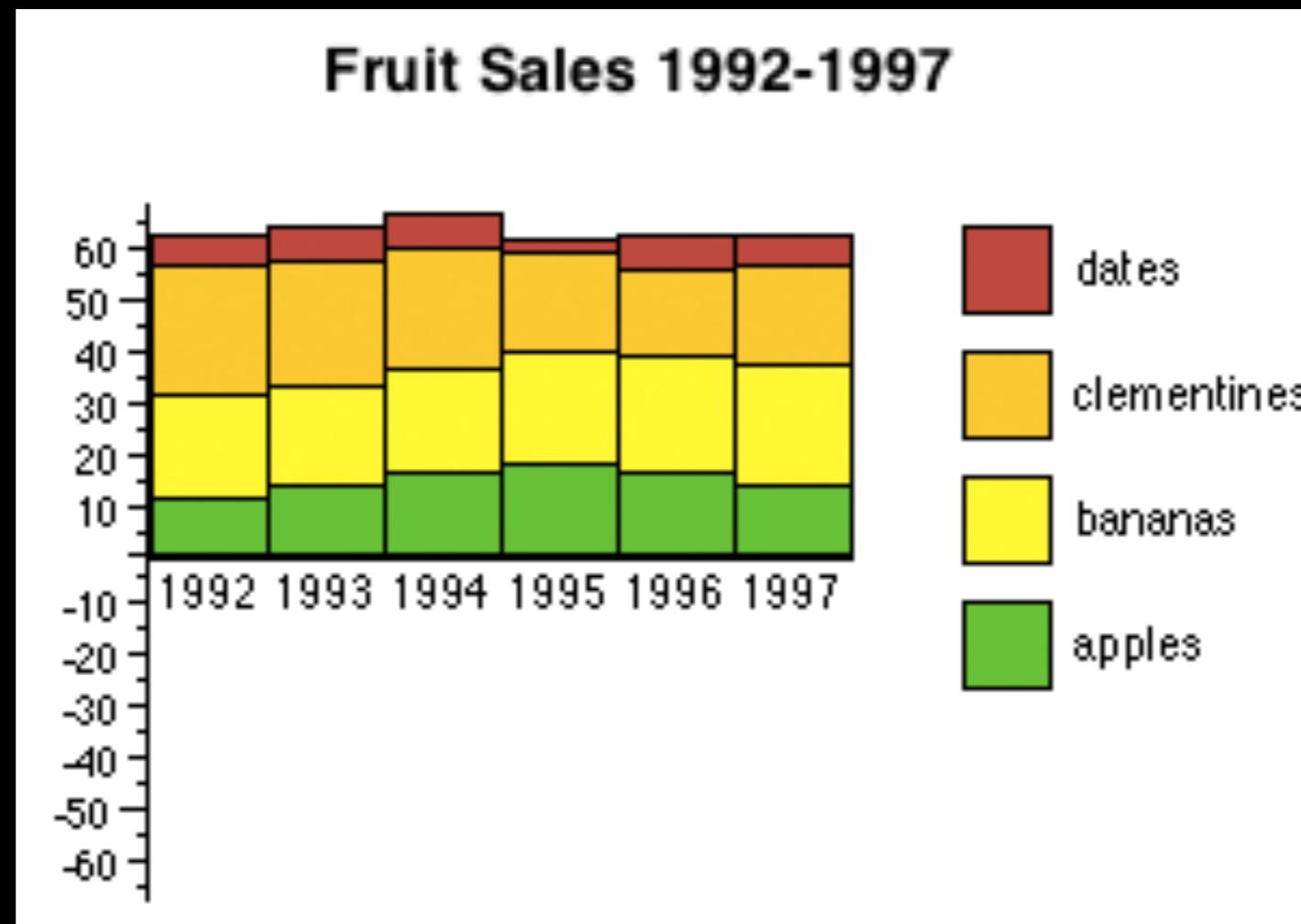
Changes as a result of user actions

WHY USE COMPUTER INTERACTION?



WHY USE COMPUTER INTERACTION?

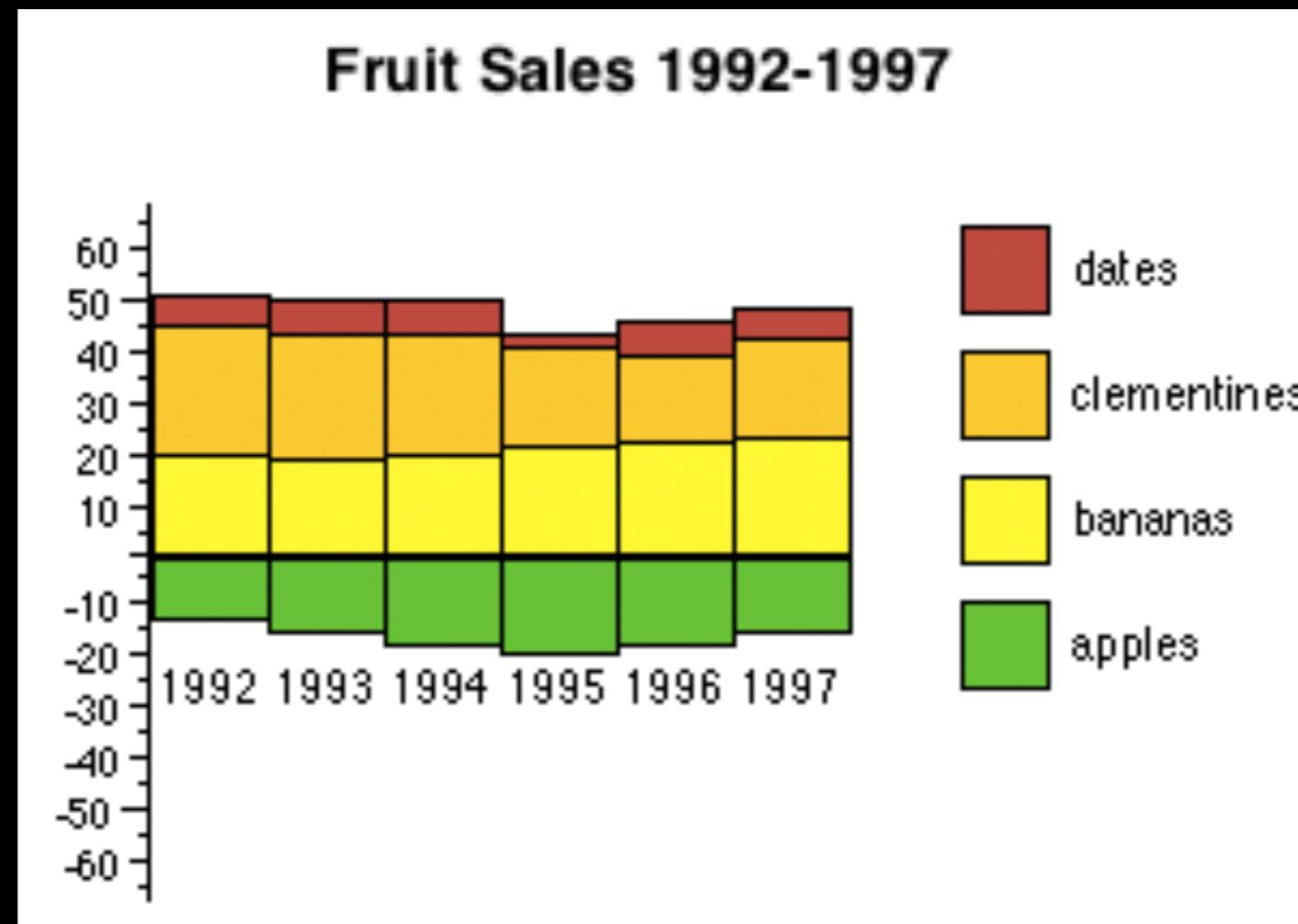
Evolution of apple sales? Of bananas?



Dix and Ellis, 1998

WHY USE COMPUTER INTERACTION?

Evolution of apple sales? Of bananas?



Dix and Ellis, 1998

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	0.98			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	1.63				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



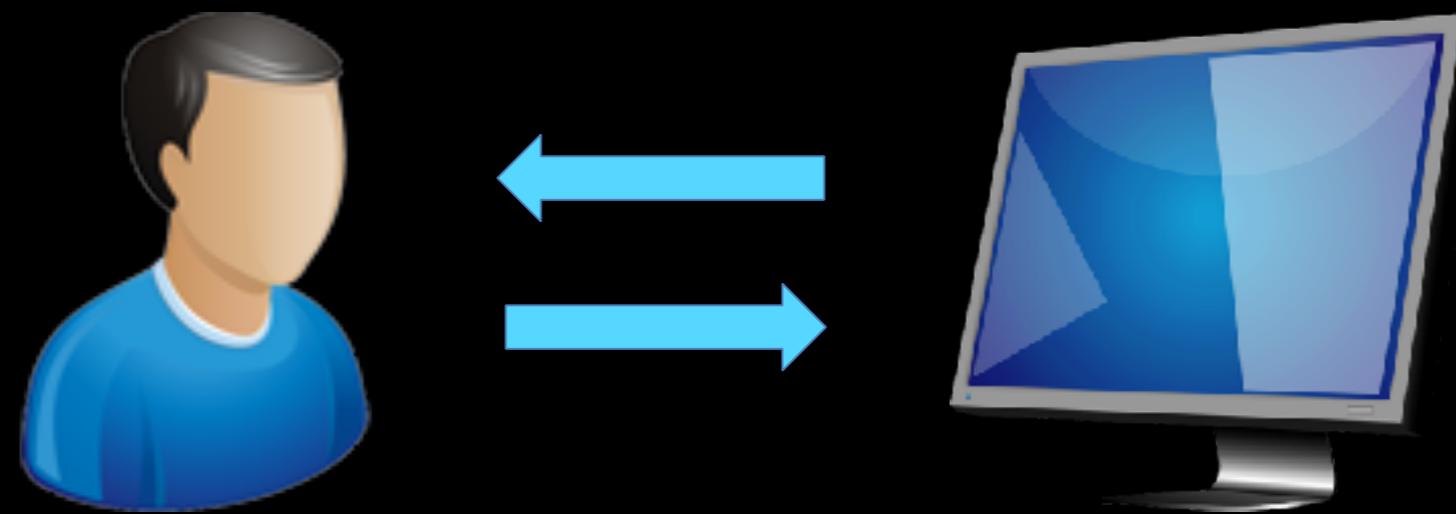
Venice

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

HOW MANY DAYS FOR \$100

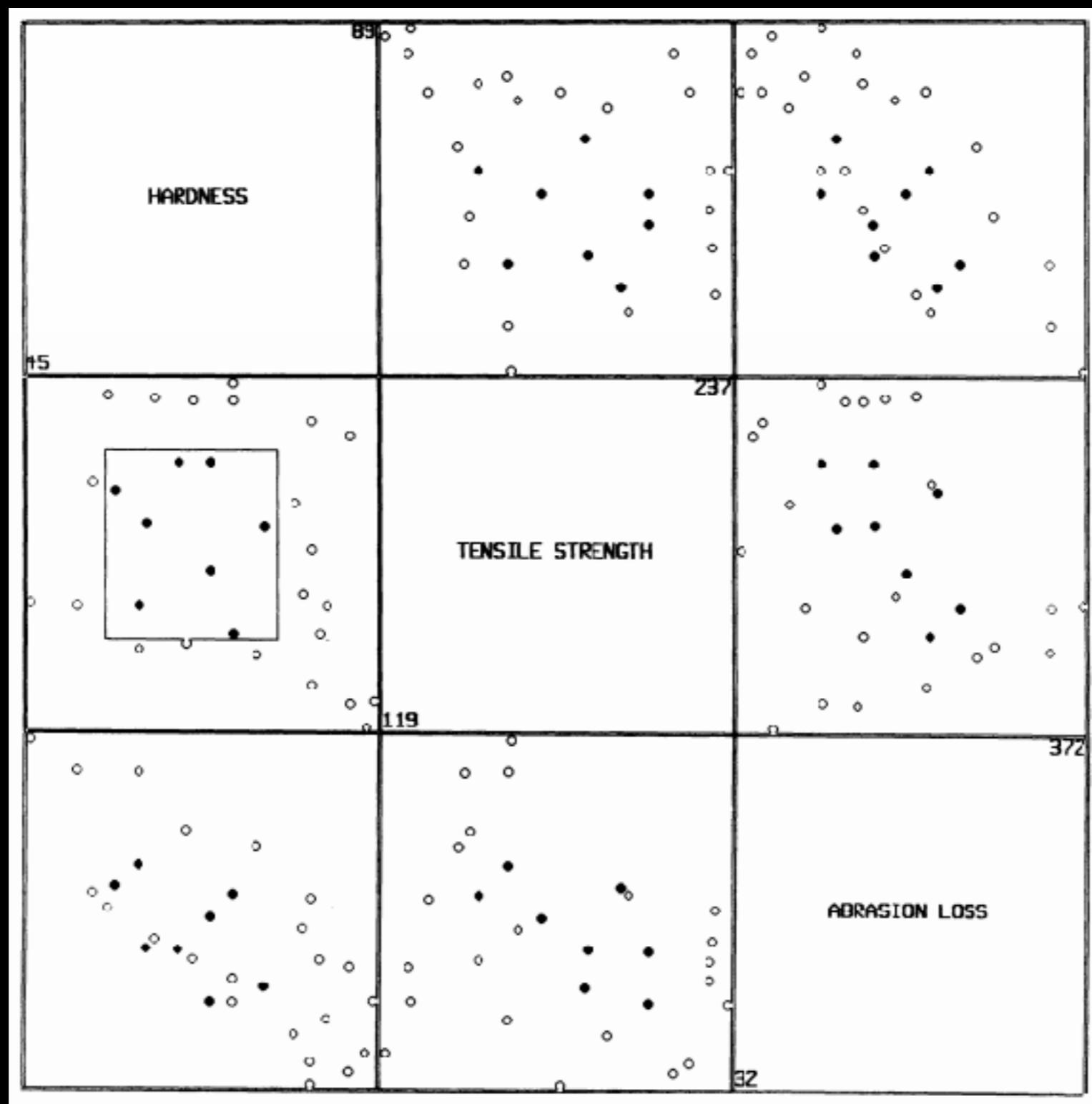


WHY USE COMPUTER INTERACTION?



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



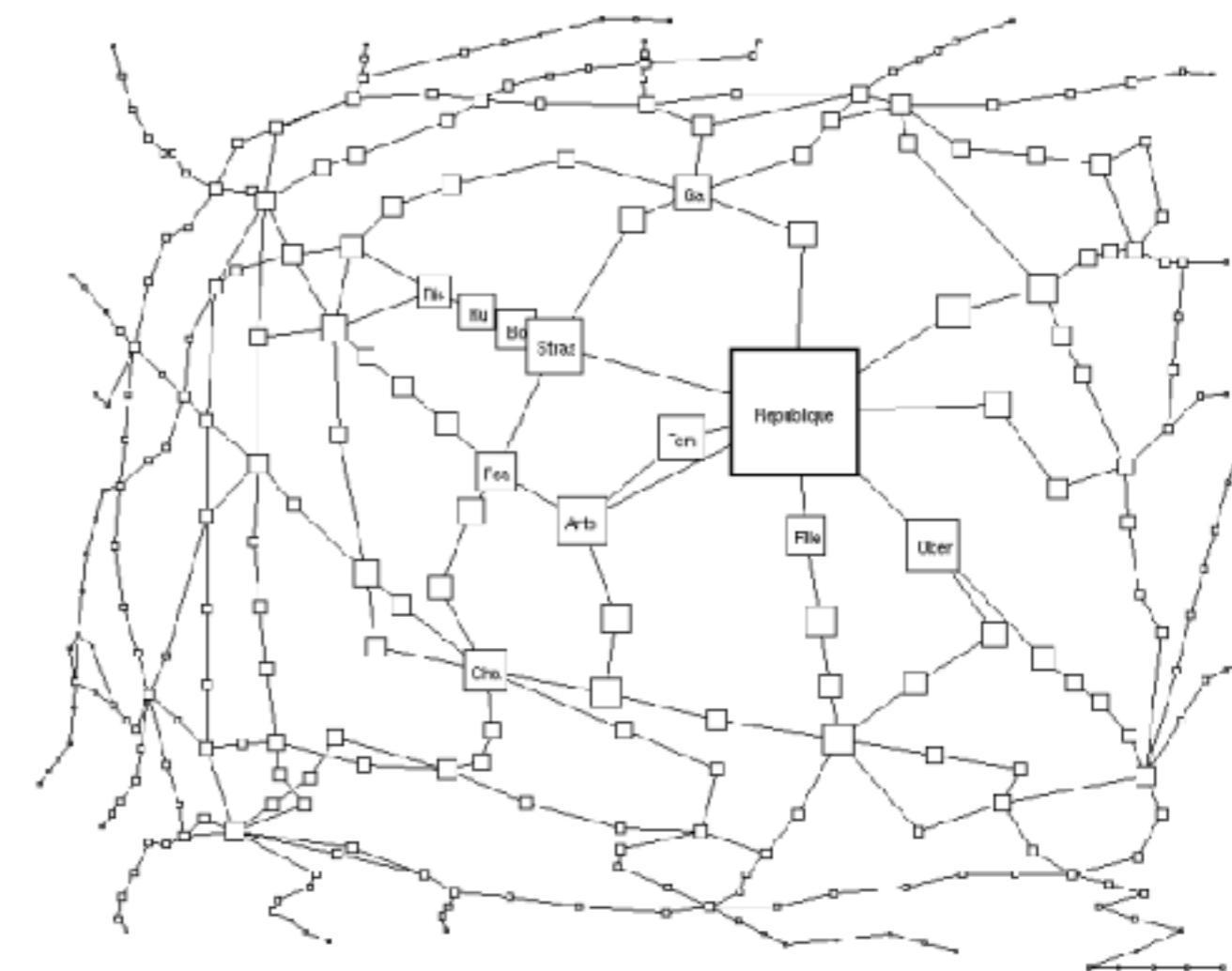
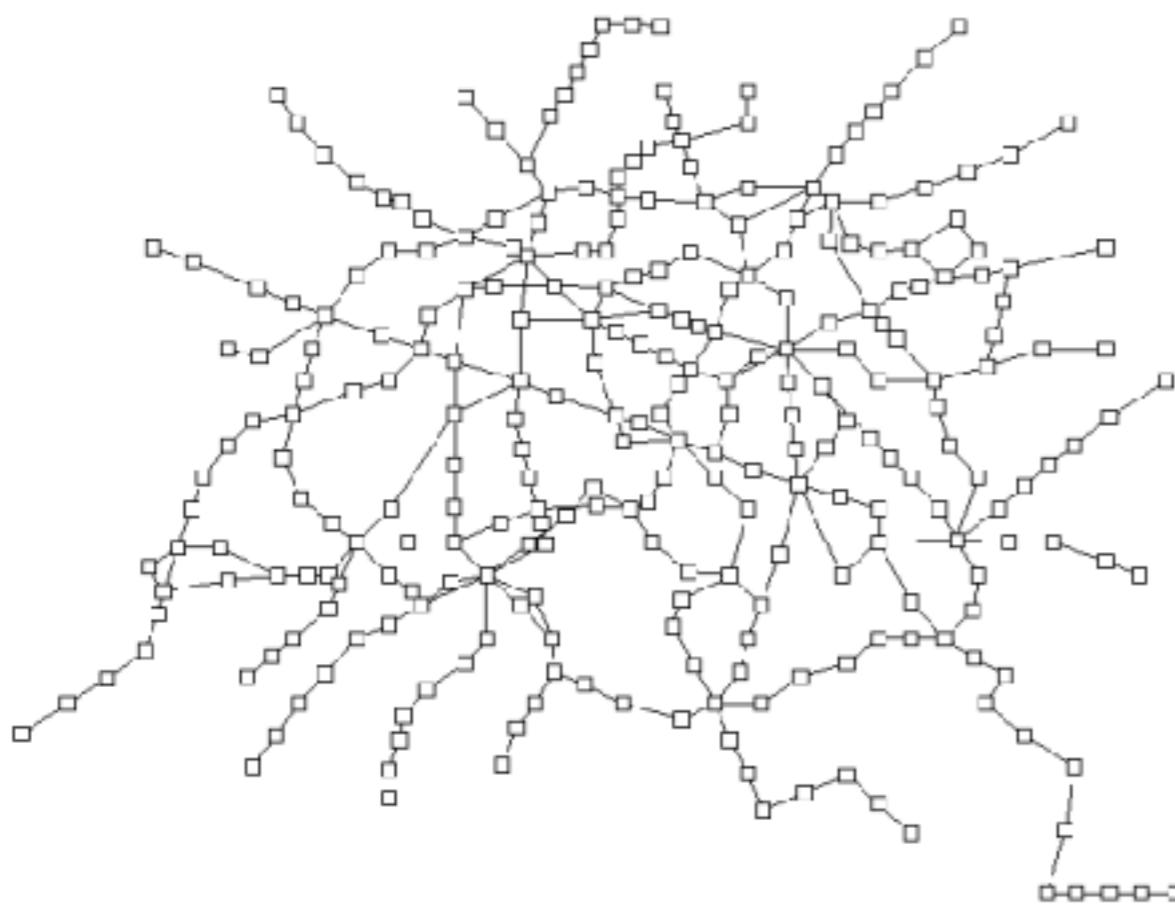
Beker and Cleveland, 1987

EXAMPLE 1: BRUSHING



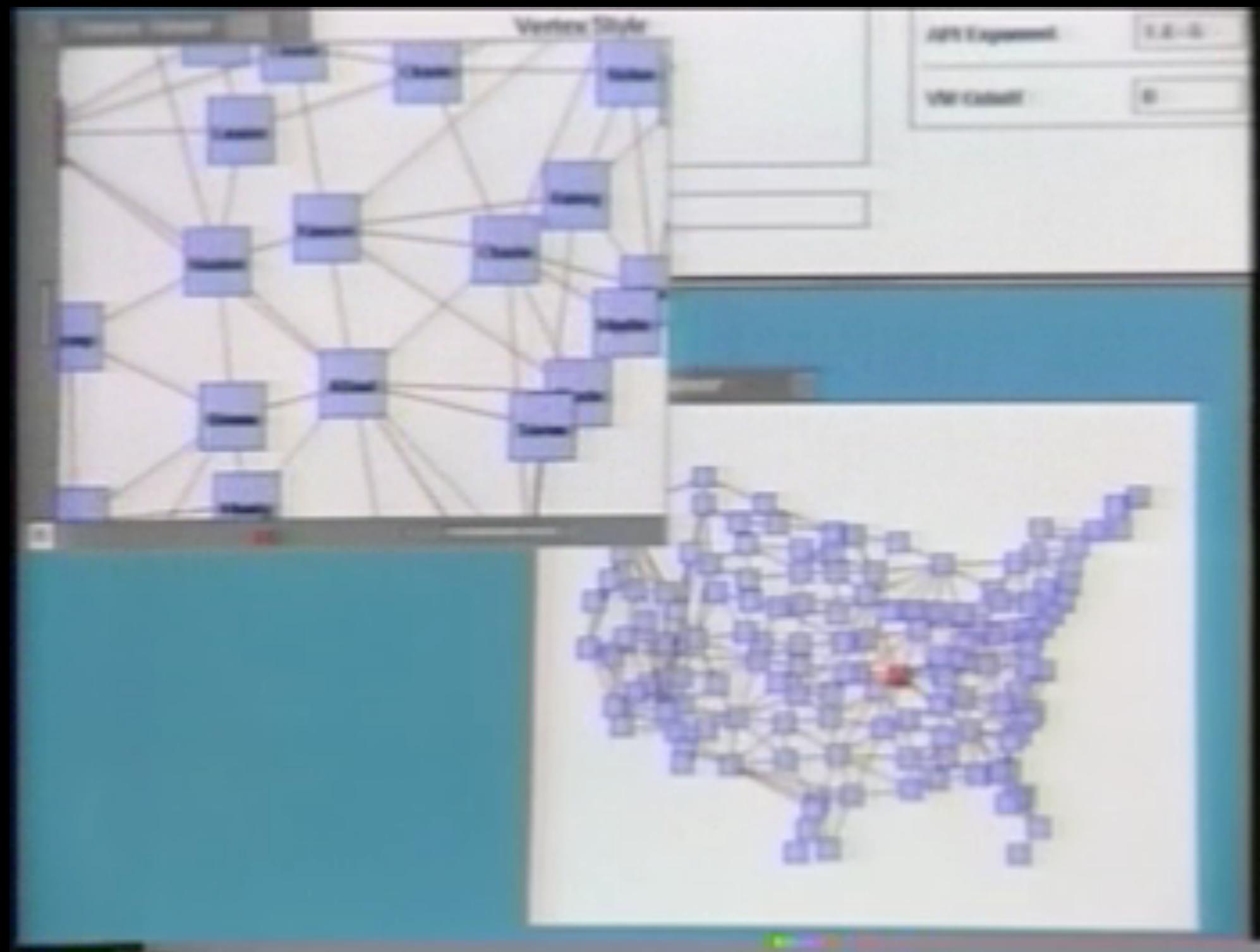
Beker and Cleveland, 1987

EXAMPLE 2: FISHEYE VIEWS



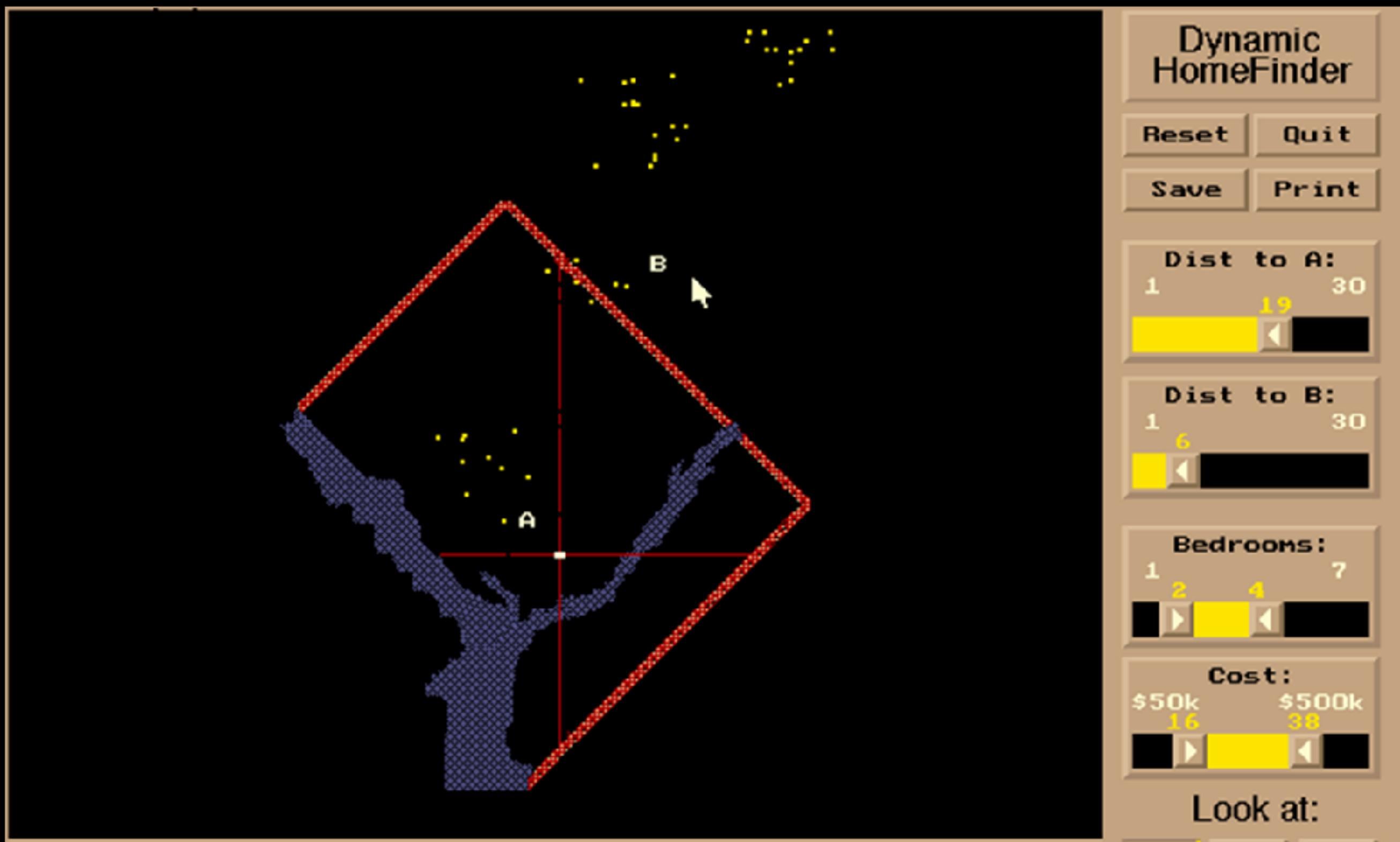
Sarkar and Brown, 1992 (see also Furnas, 1986)

EXAMPLE 2: FISHEYE VIEWS



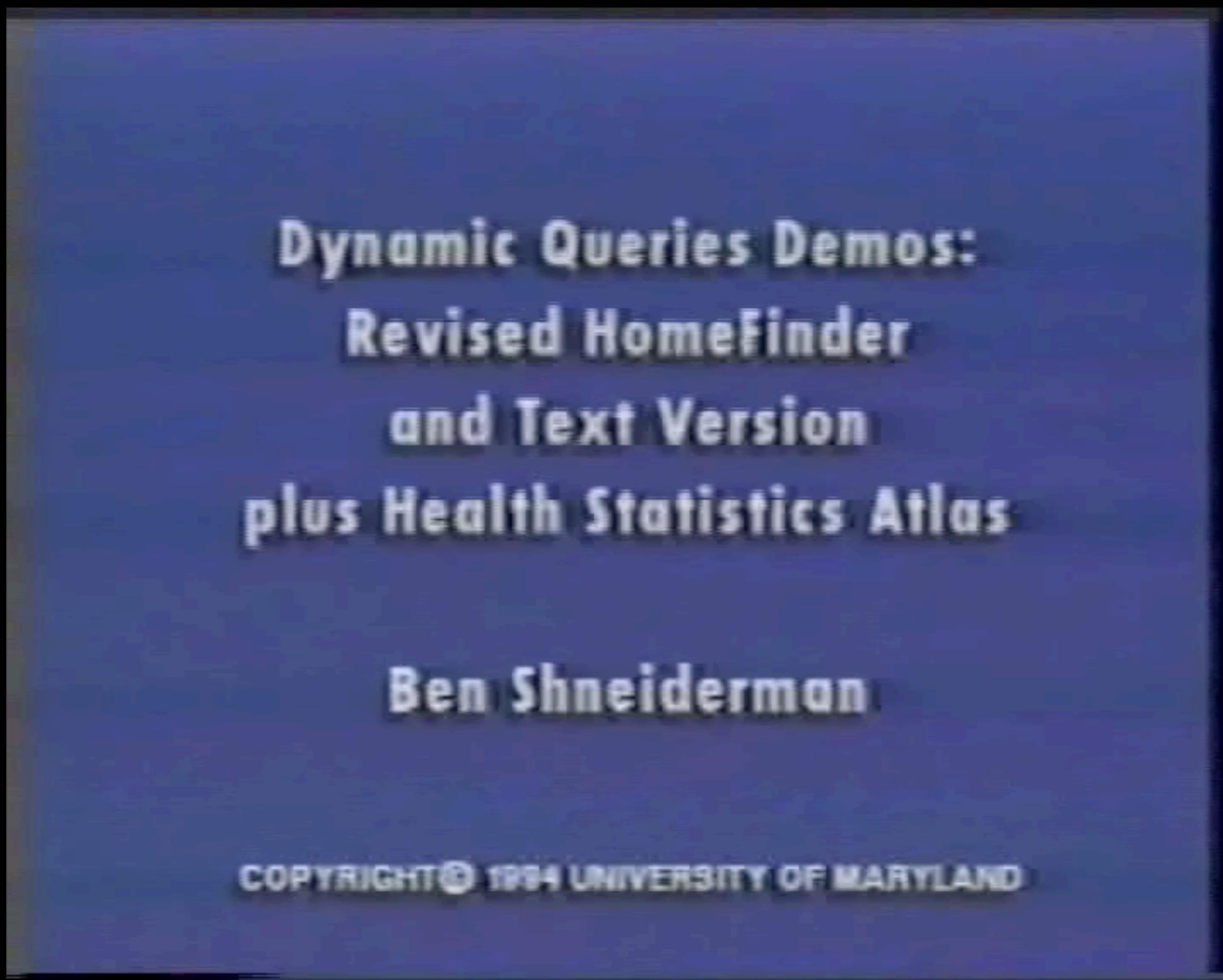
Sarkar and Brown, 1992 (see also Furnas, 1986)

EXAMPLE 3: DYNAMIC QUERIES



Williamson and Shneiderman, 1992

EXAMPLE 3: DYNAMIC QUERIES



1:29

Williamson and Shneiderman, 1992

MANY INTERACTION TECHNIQUES



TAXONOMIES OF INTERACTION

What?

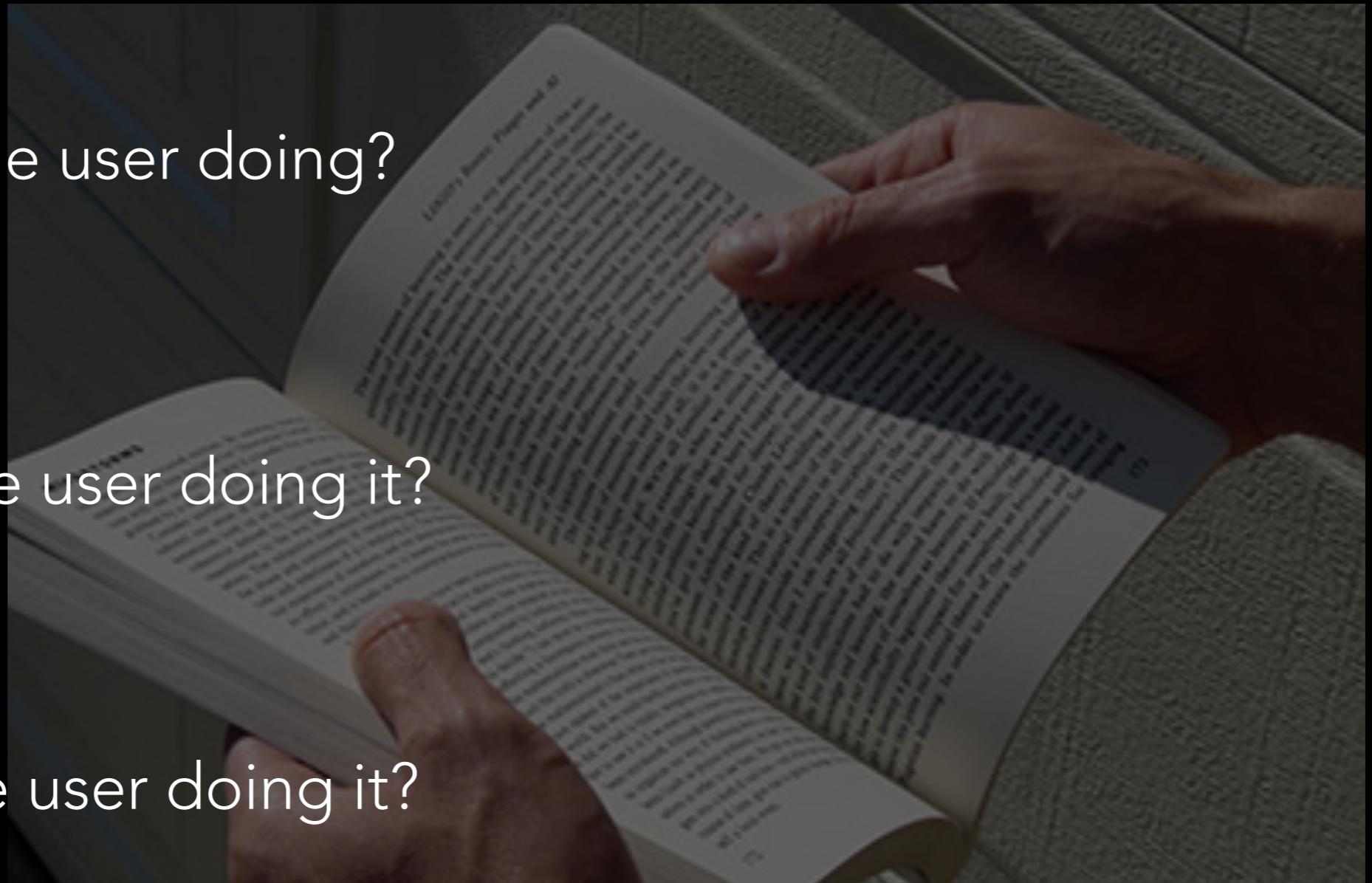
What is the user doing?

Why?

Why is the user doing it?

How?

How is the user doing it?



TAXONOMIES OF INTERACTION

What?

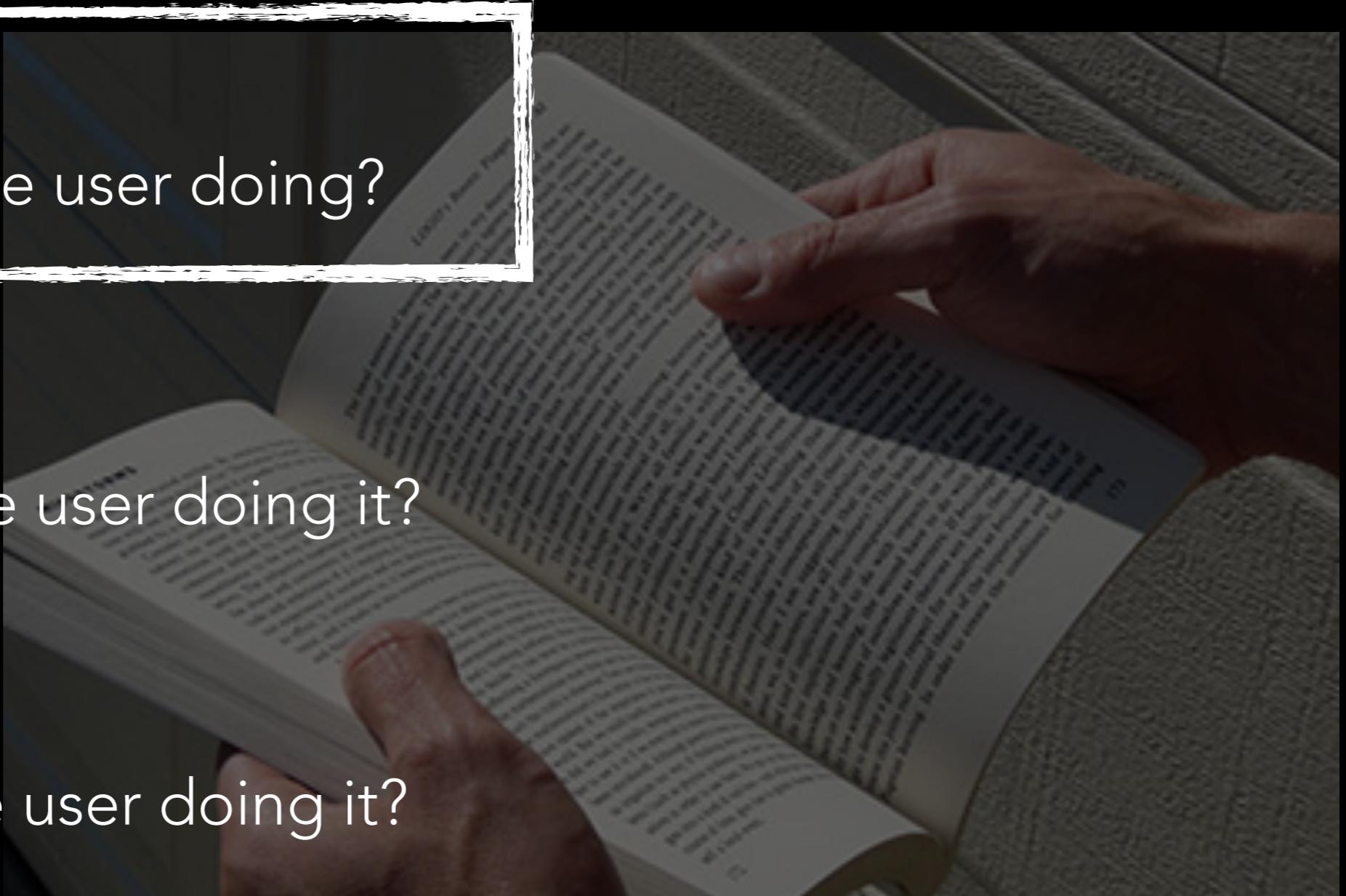
What is the user doing?

Why?

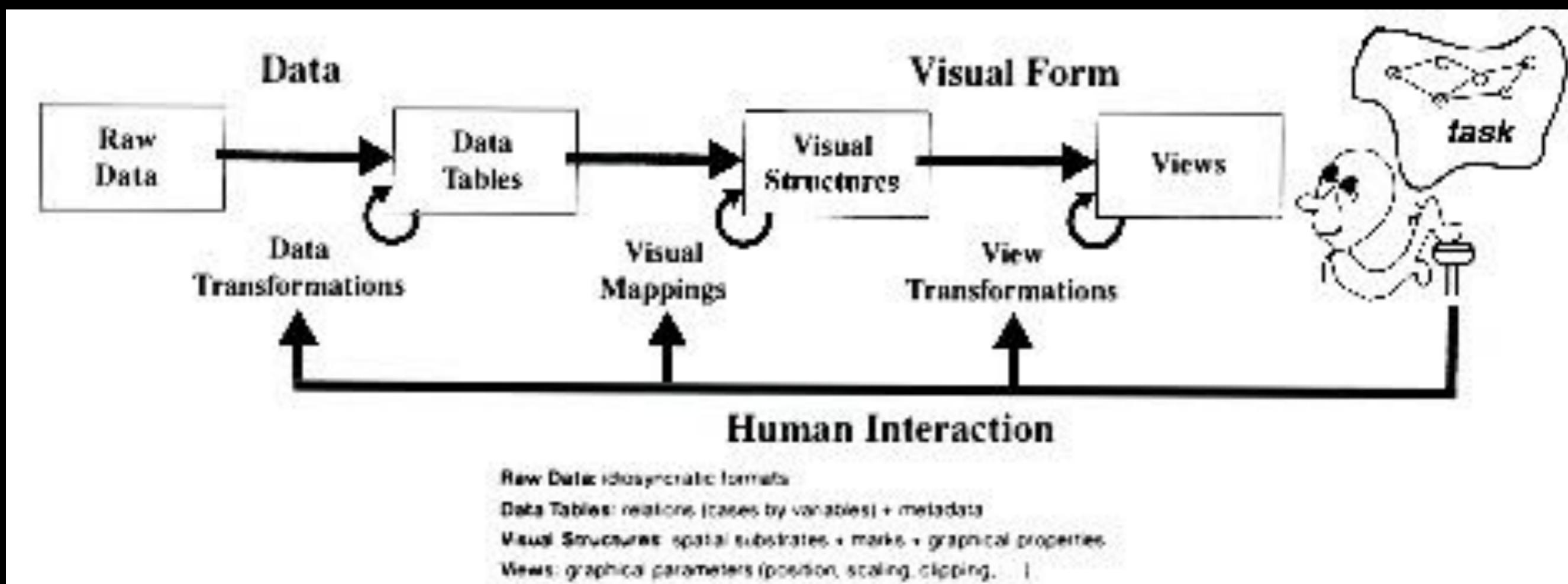
Why is the user doing it?

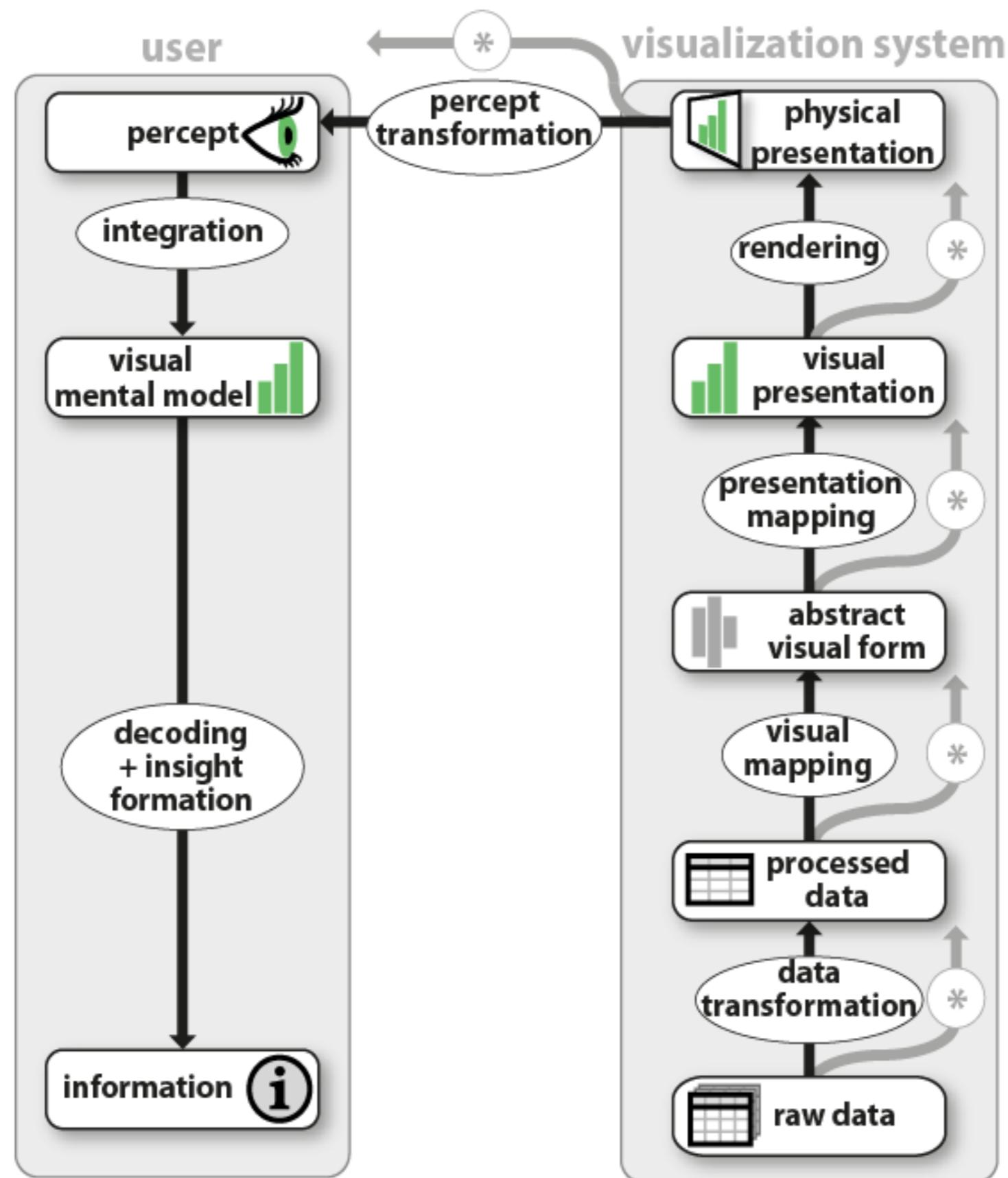
How?

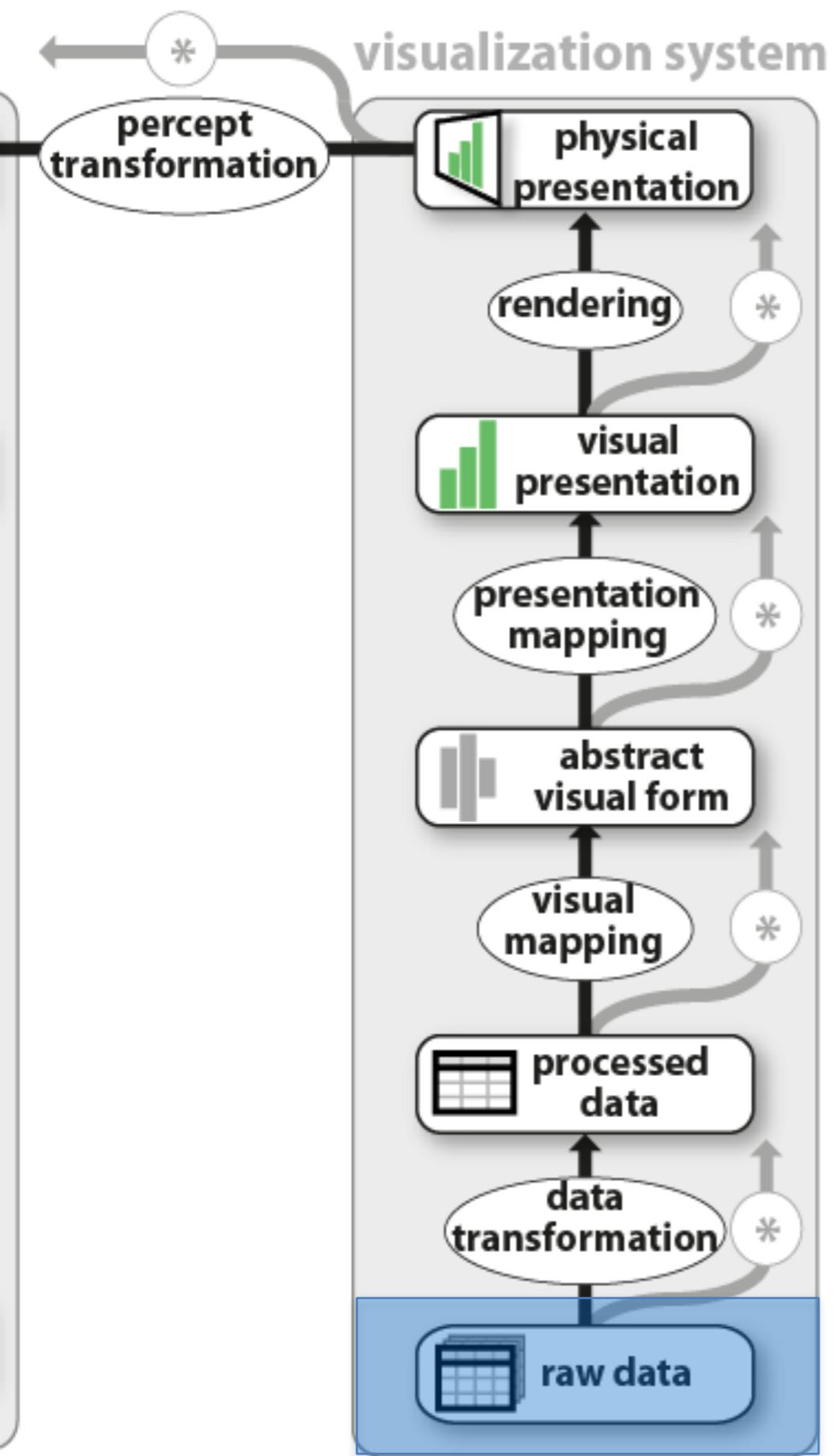
How is the user doing it?



THE VISUALIZATION PIPELINE



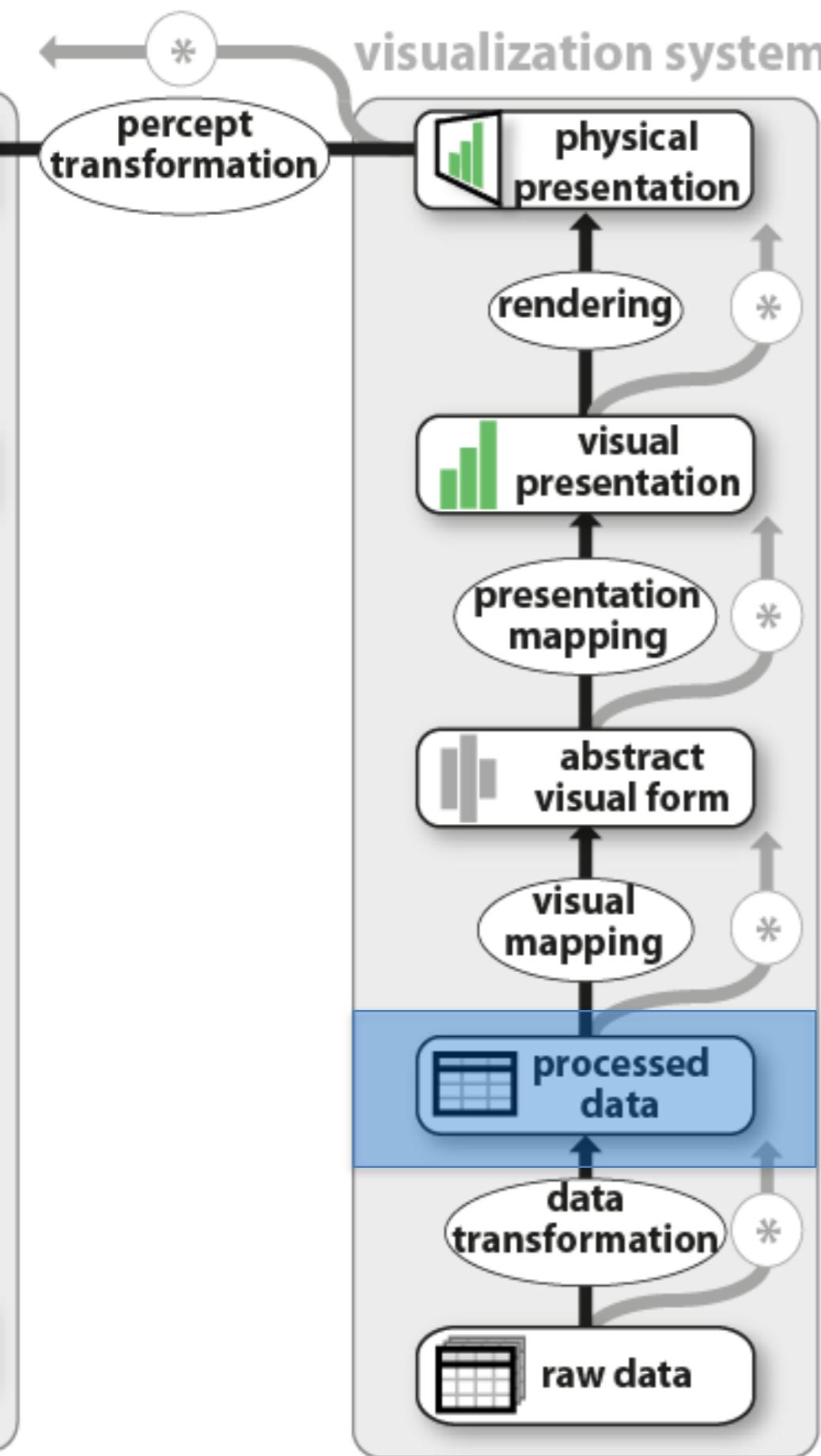




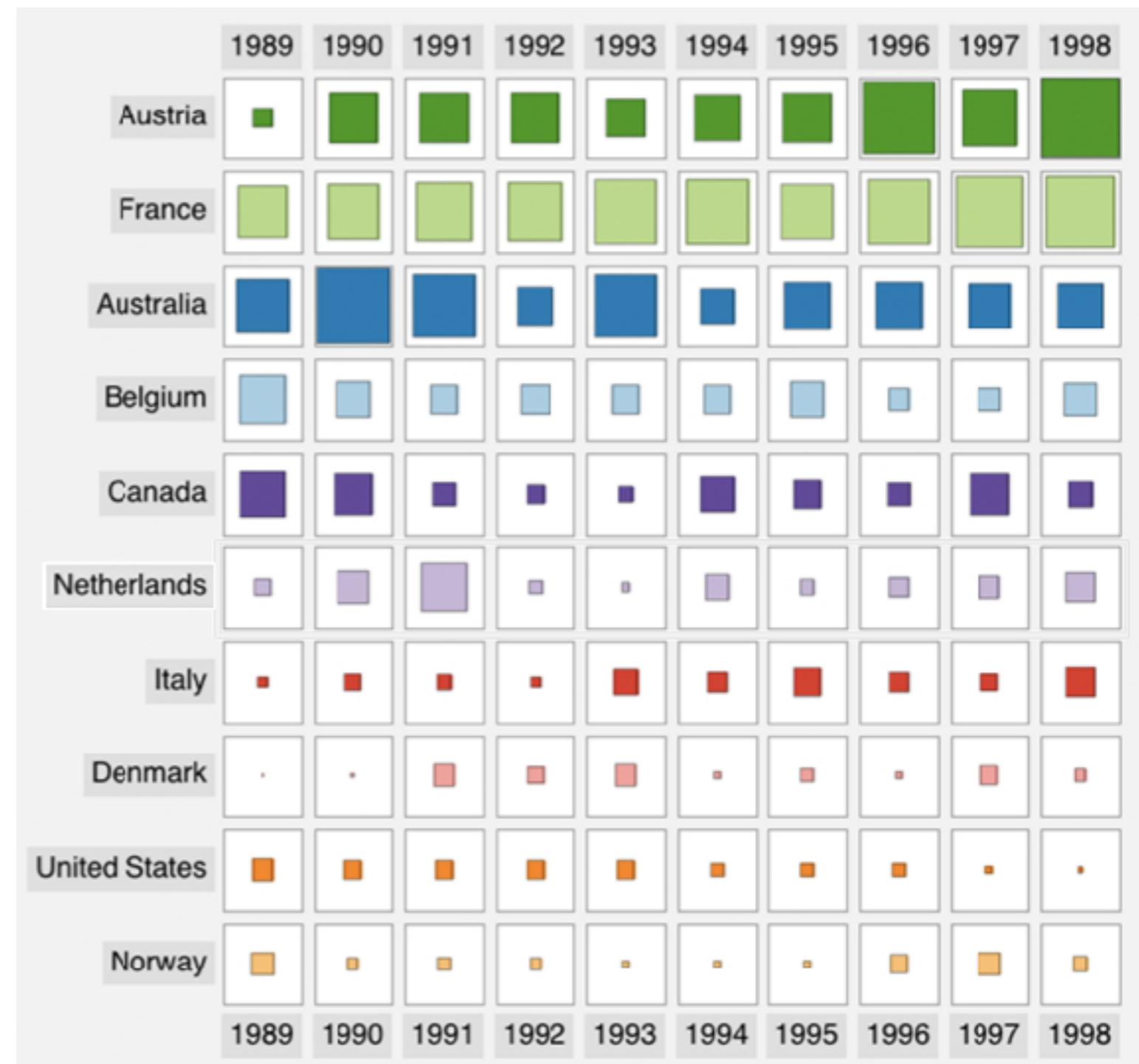
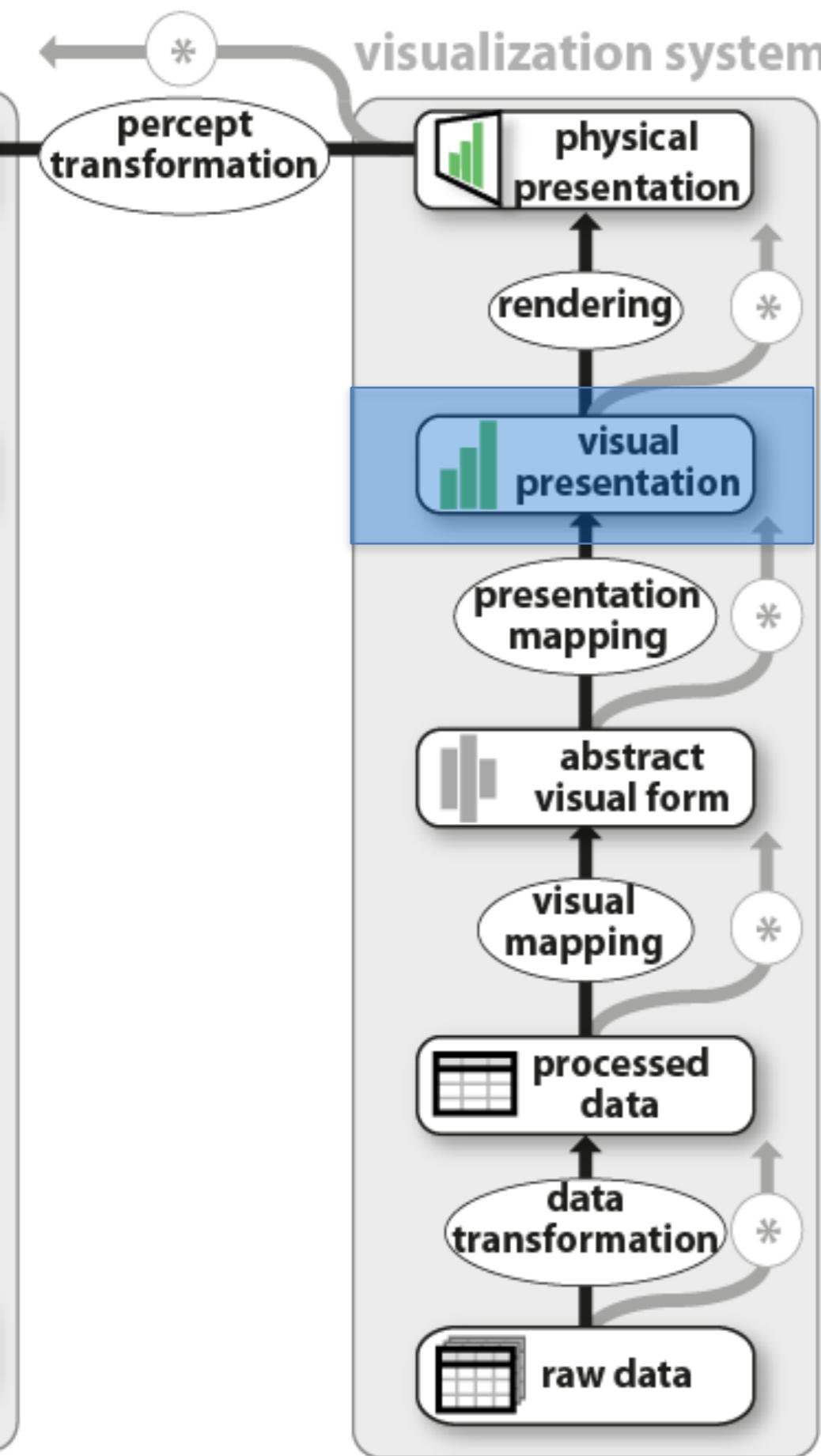
GAPMINDER for a fact-based world view

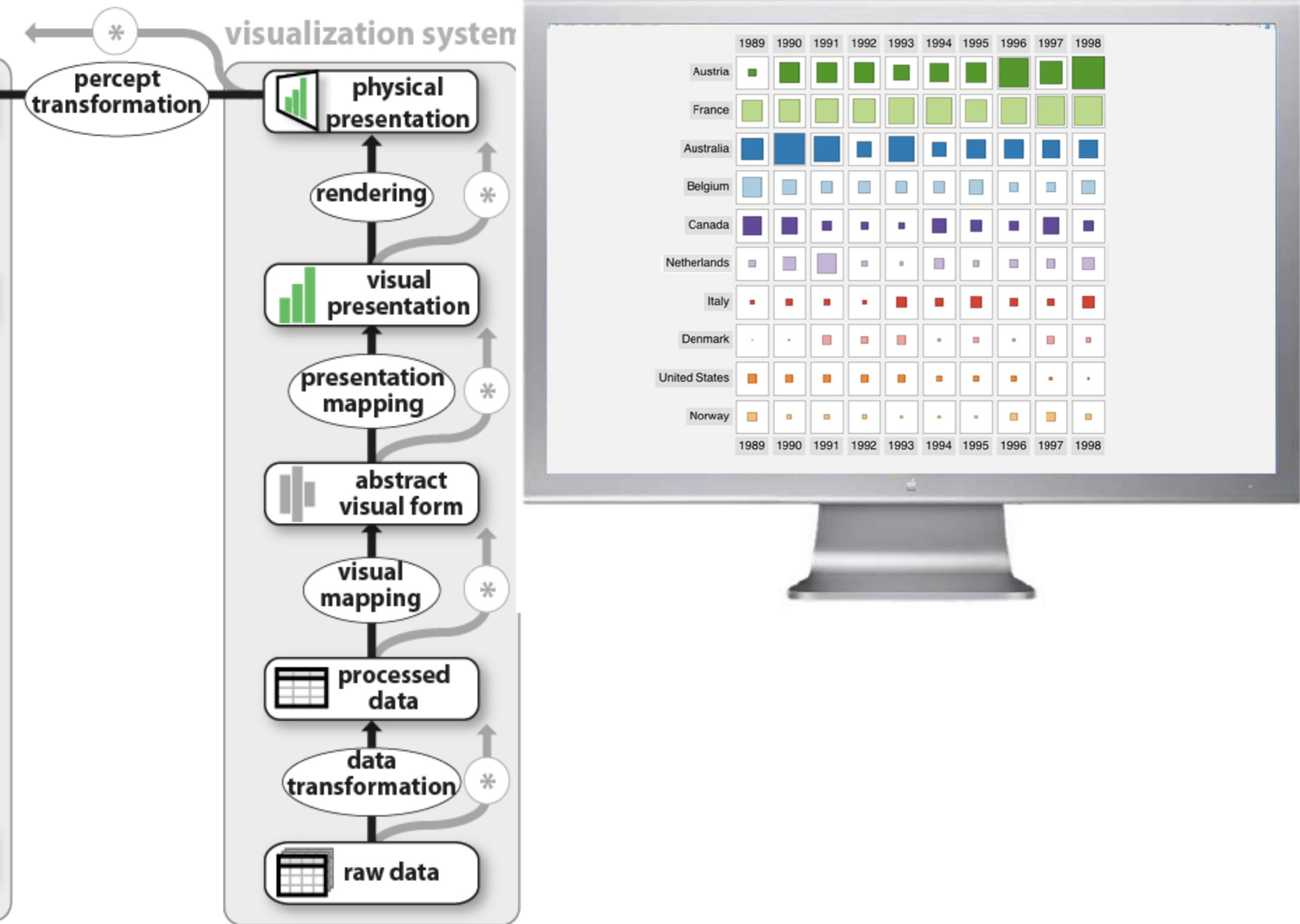
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

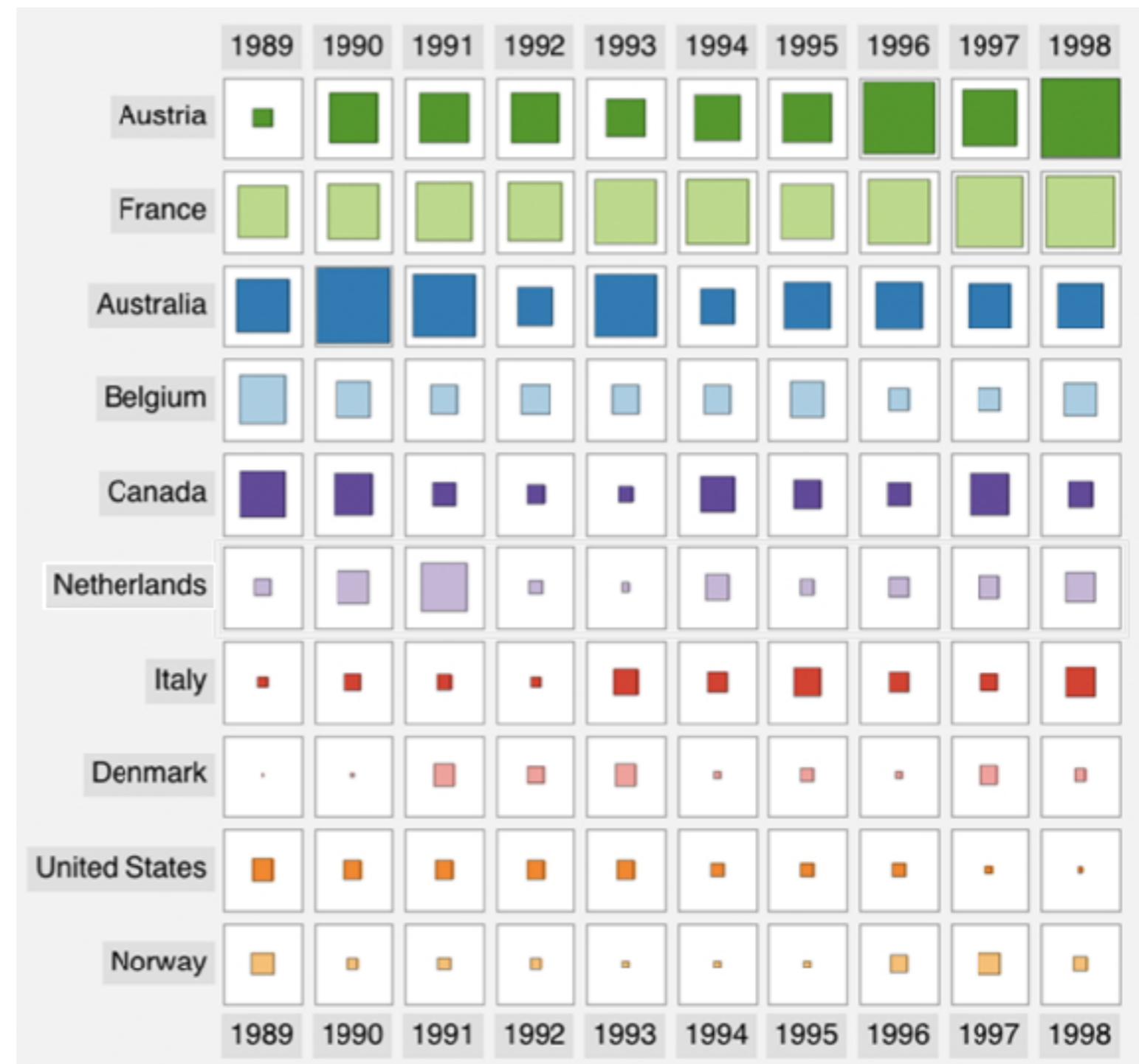
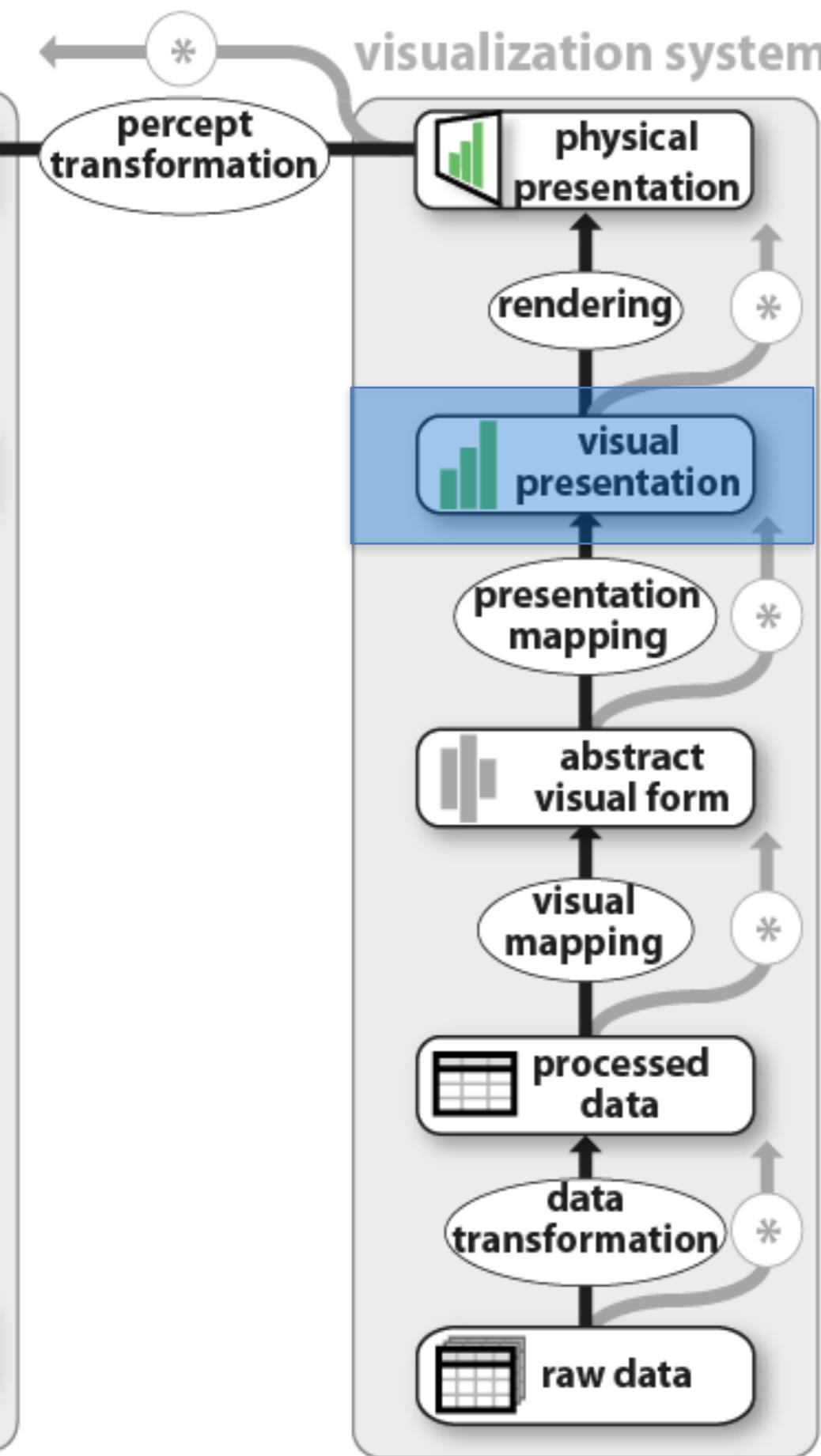
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	Education aid (% of total aid)	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	
2	Australia																									
3	Austria																									
4	Belgium																									
5	Canada																									
6	Denmark																									
7	Finland																									
8	France																									
9	Germany																									
10	Greece																									
11	Ireland																									
12	Italy																									
13	Japan																									
14	Luxembourg																									
15	Netherlands																									
16	New Zealand																									
17	Norway																									
18	Portugal																									
19	Spain																									
20	Sweden																									
21	Switzerland																									
22	United Kingdom																									
23	United States																									
24																										

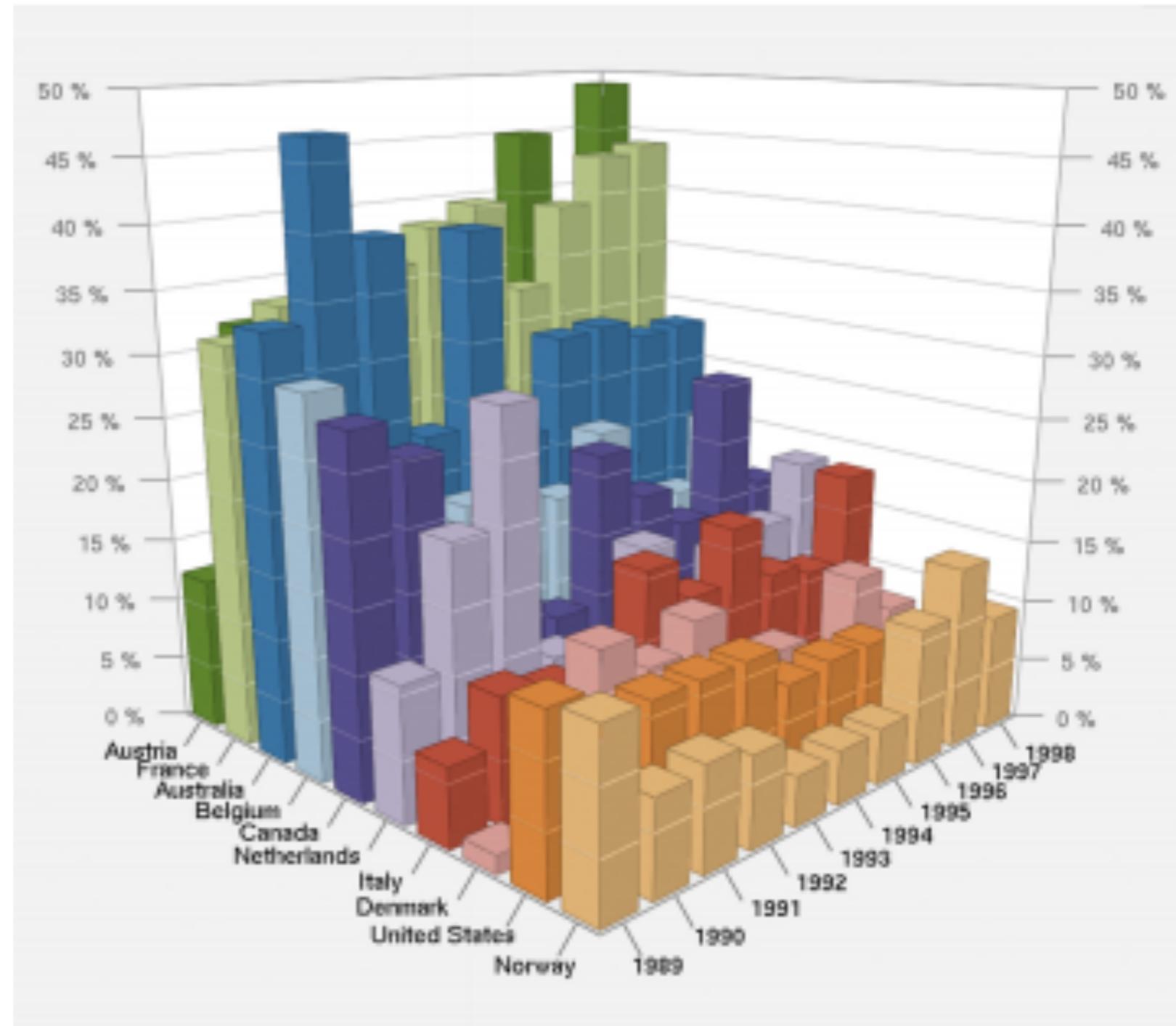
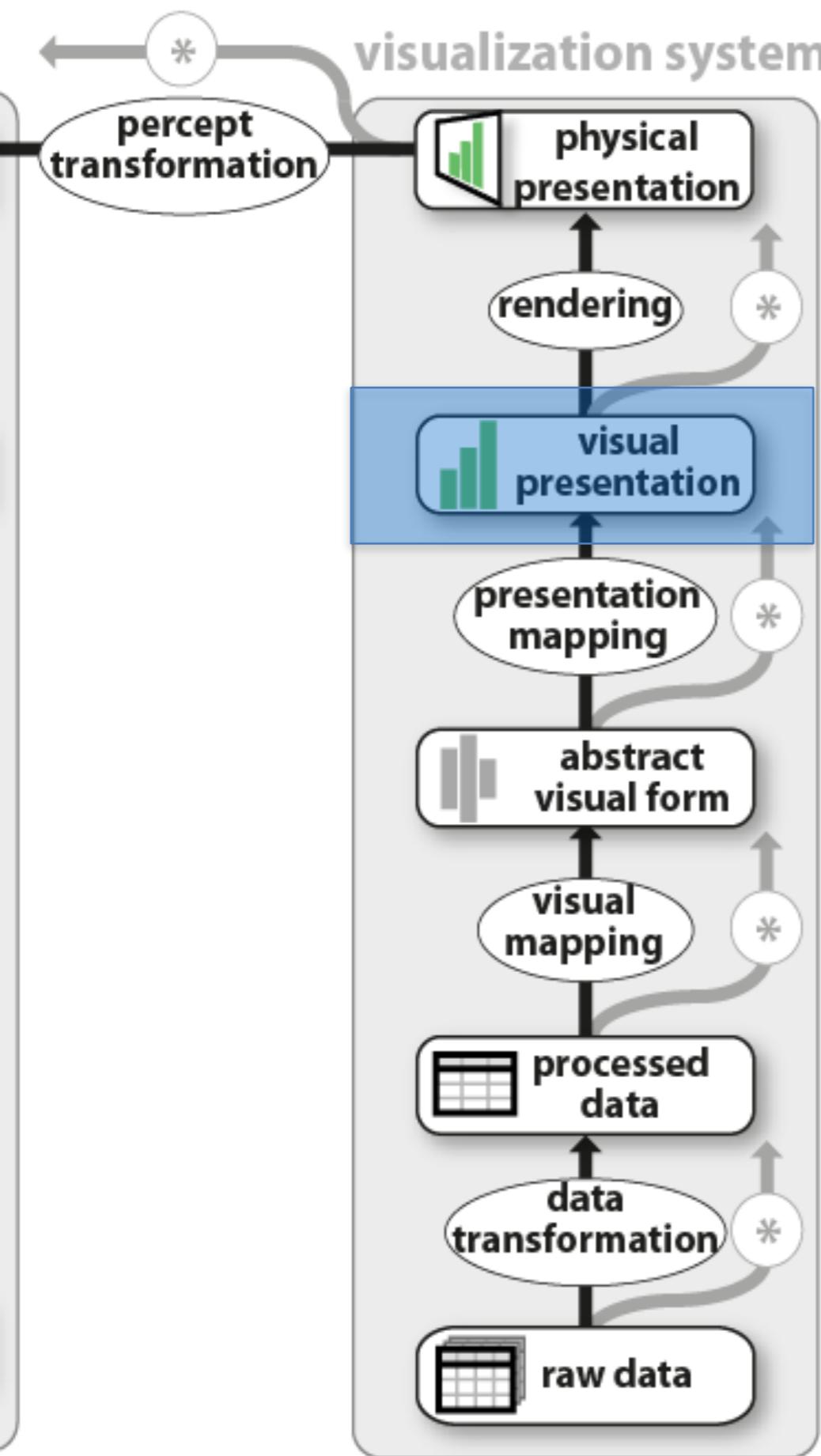


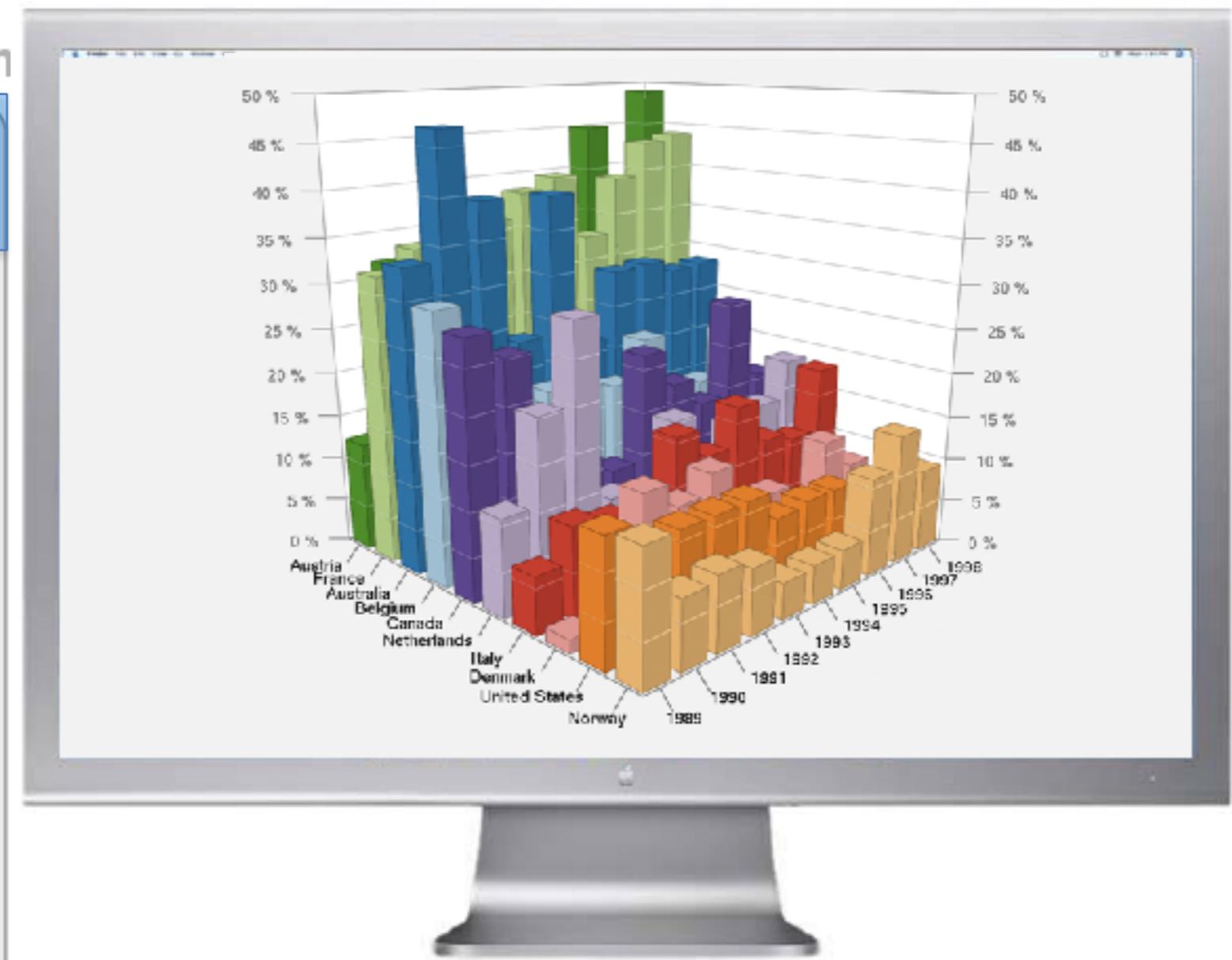
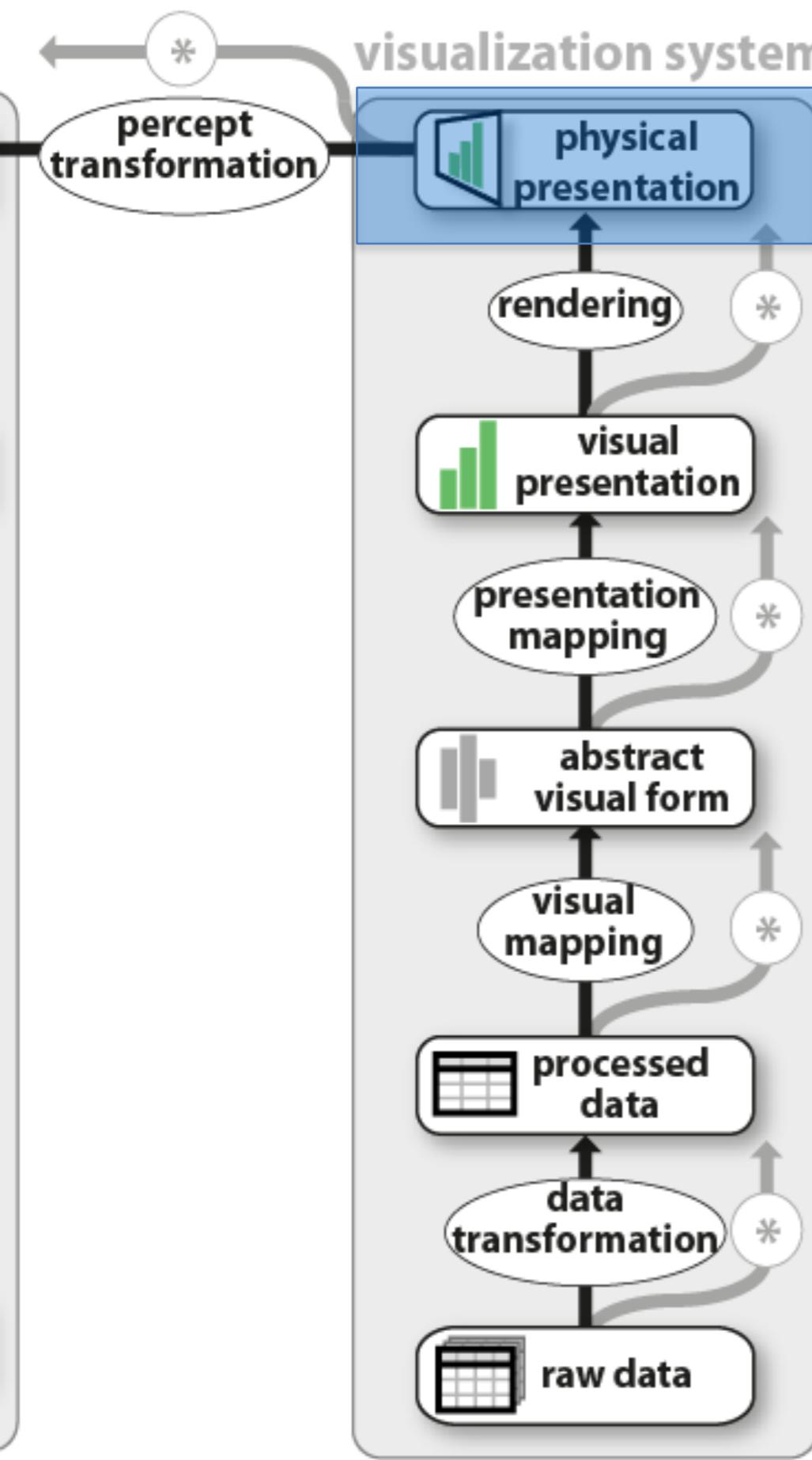
	A	B	C	D	E	F	G	H	I	J	K
1		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	Austria	12.23	31.86	31.07	31.57	24.02	28.61	30.52	44.99	35.41	48.95
3	France	31.87	34.18	35.95	36.06	38.78	40.18	32.68	39.26	43.15	43.9
4	Australia	33.57	46.93	39.24	23.18	38.94	21.38	29.1	29.43	27.97	28.32
5	Belgium	29.93	22.13	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	12.25	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

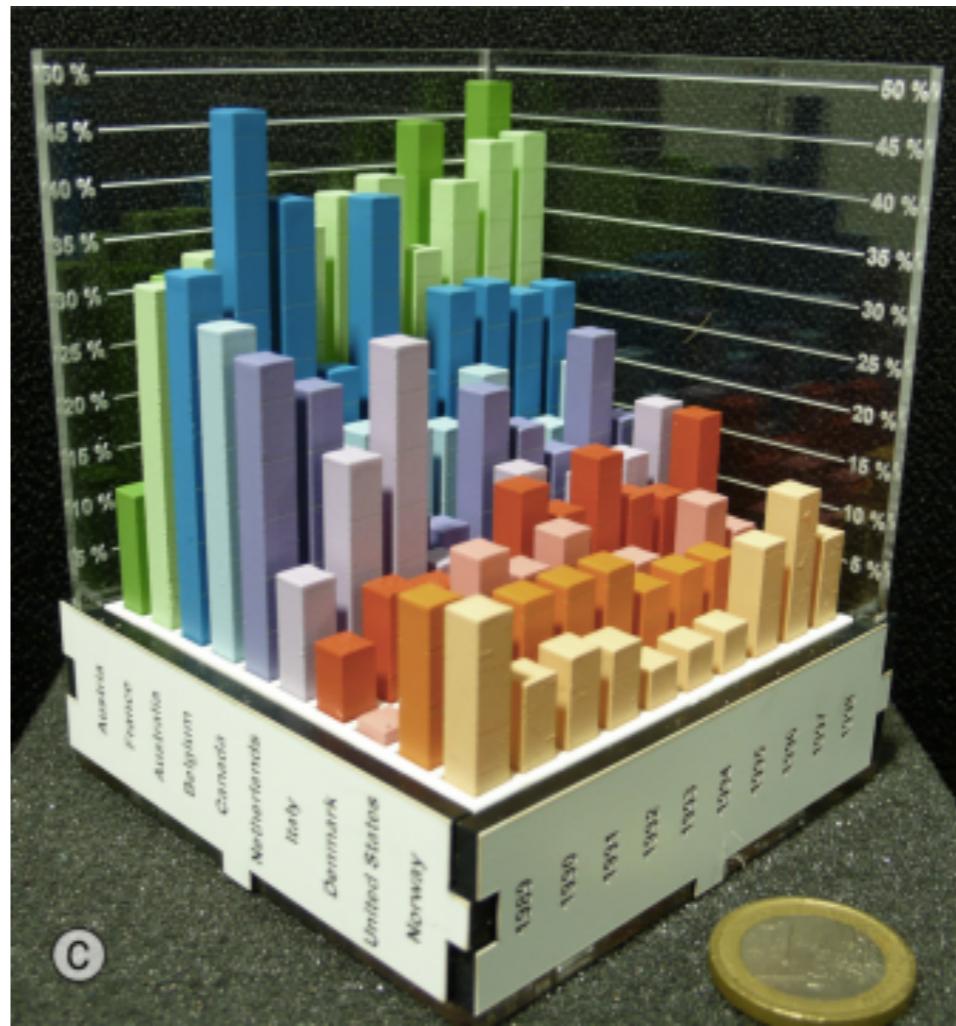
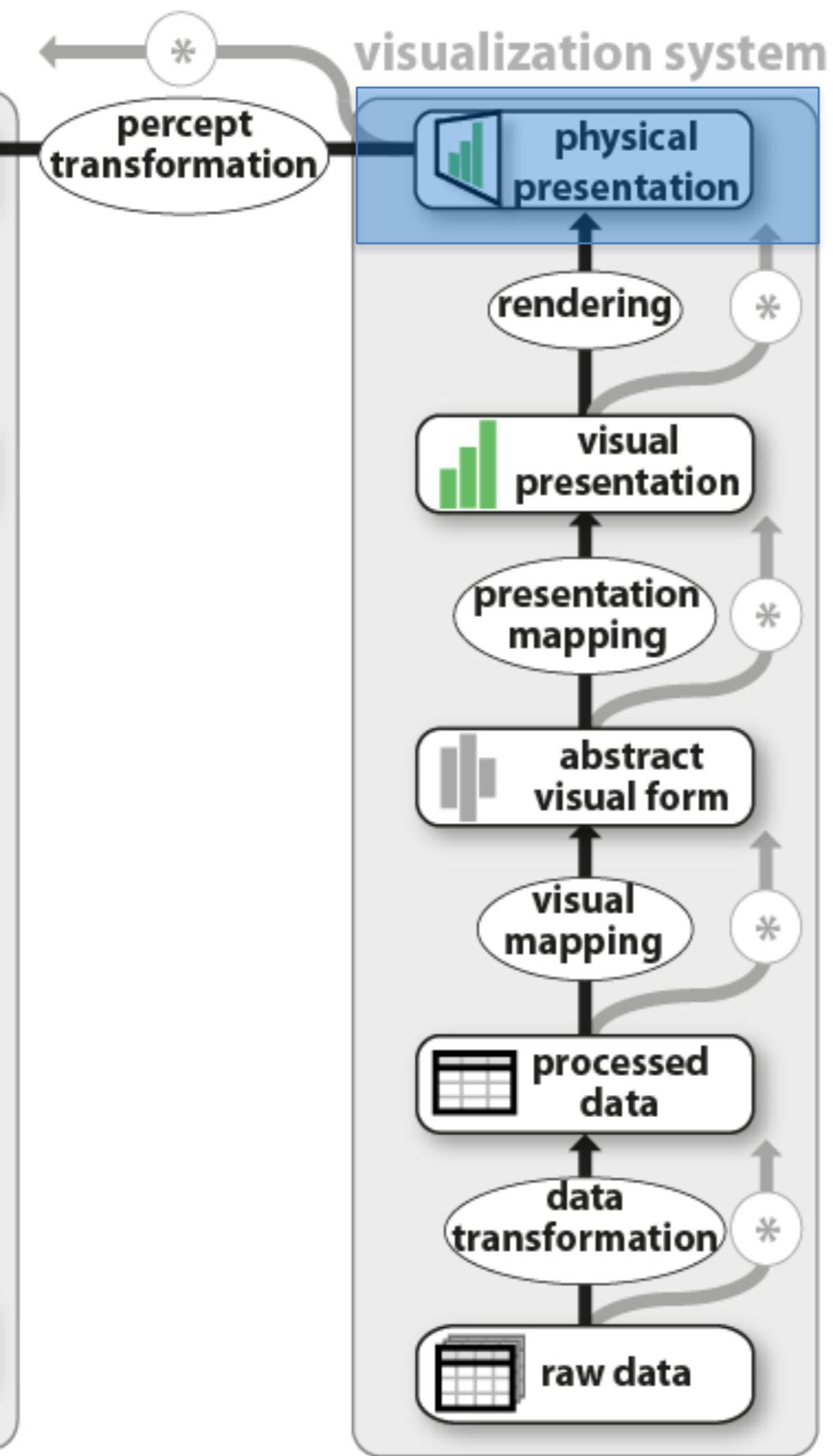












TAXONOMIES OF INTERACTION

What?

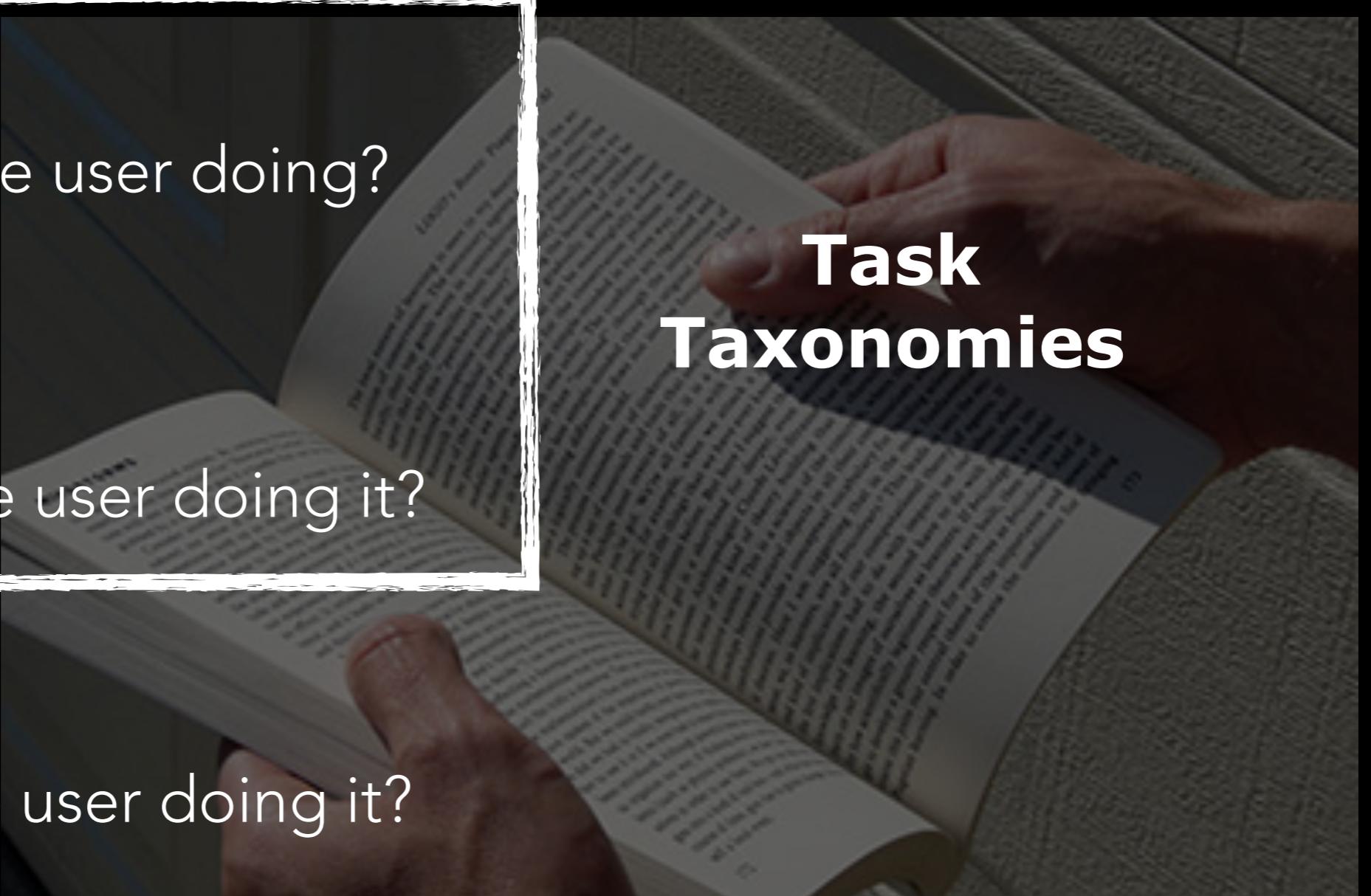
What is the user doing?

Why?

Why is the user doing it?

How?

How is the user doing it?



**Task
Taxonomies**

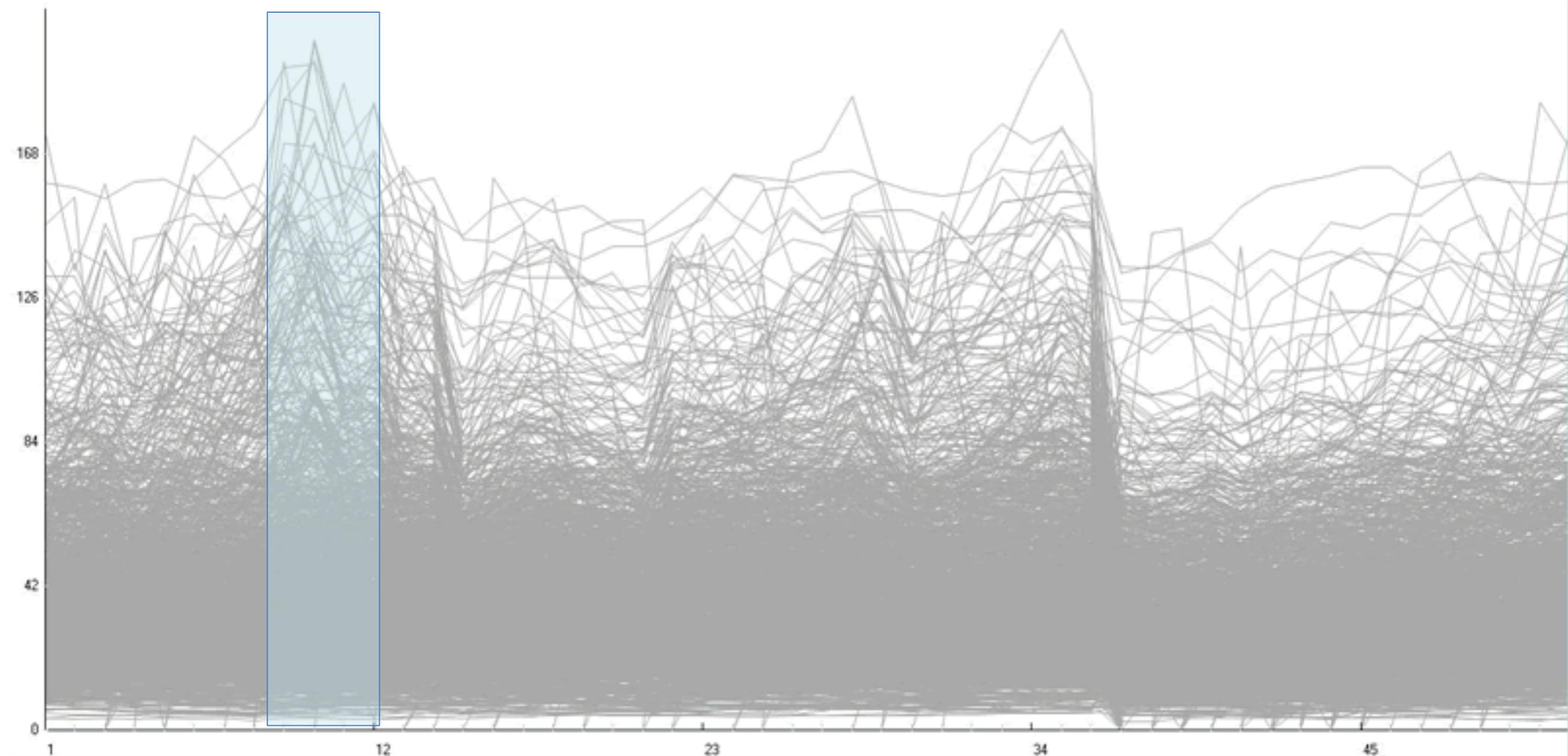
ANALYTICAL TASKS

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

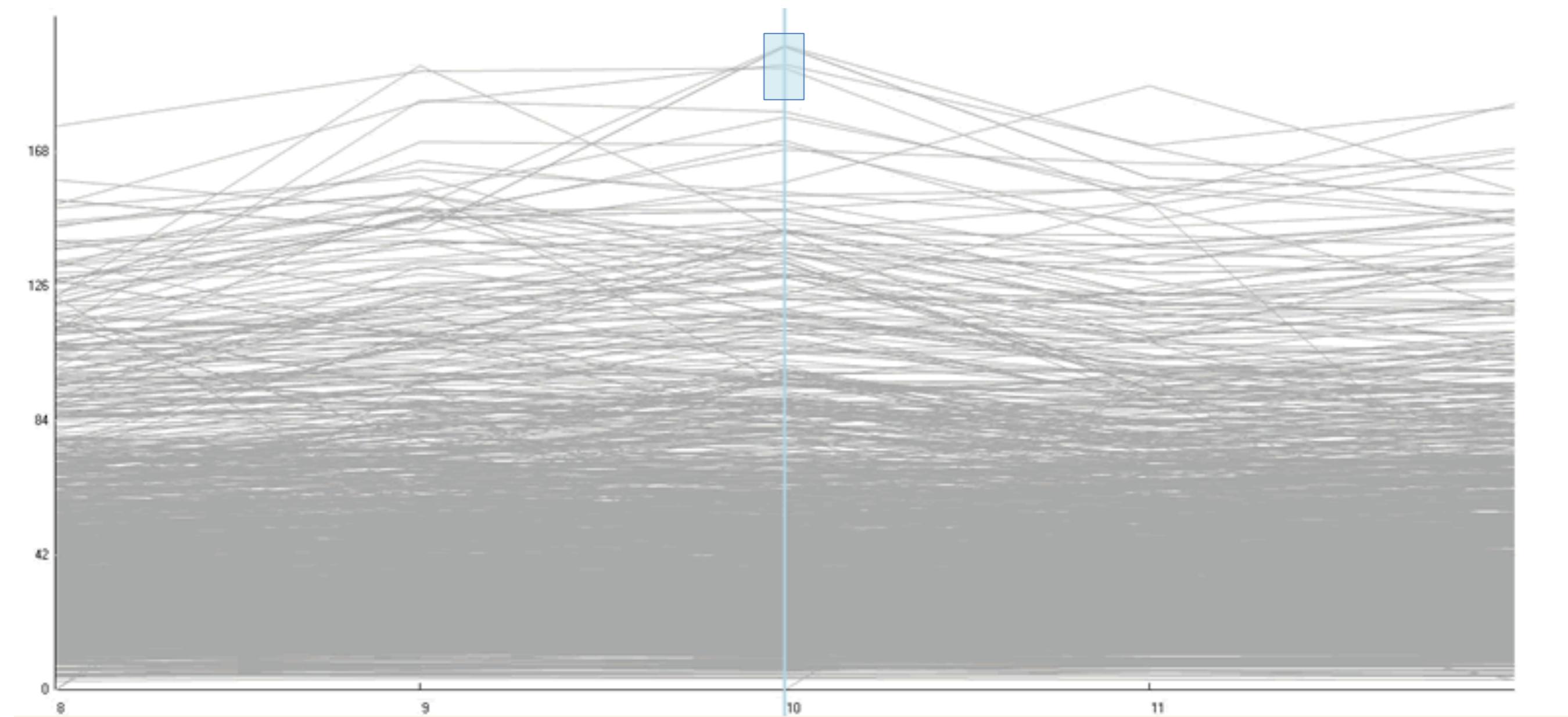
ANALYTICAL TASKS

1. Overview



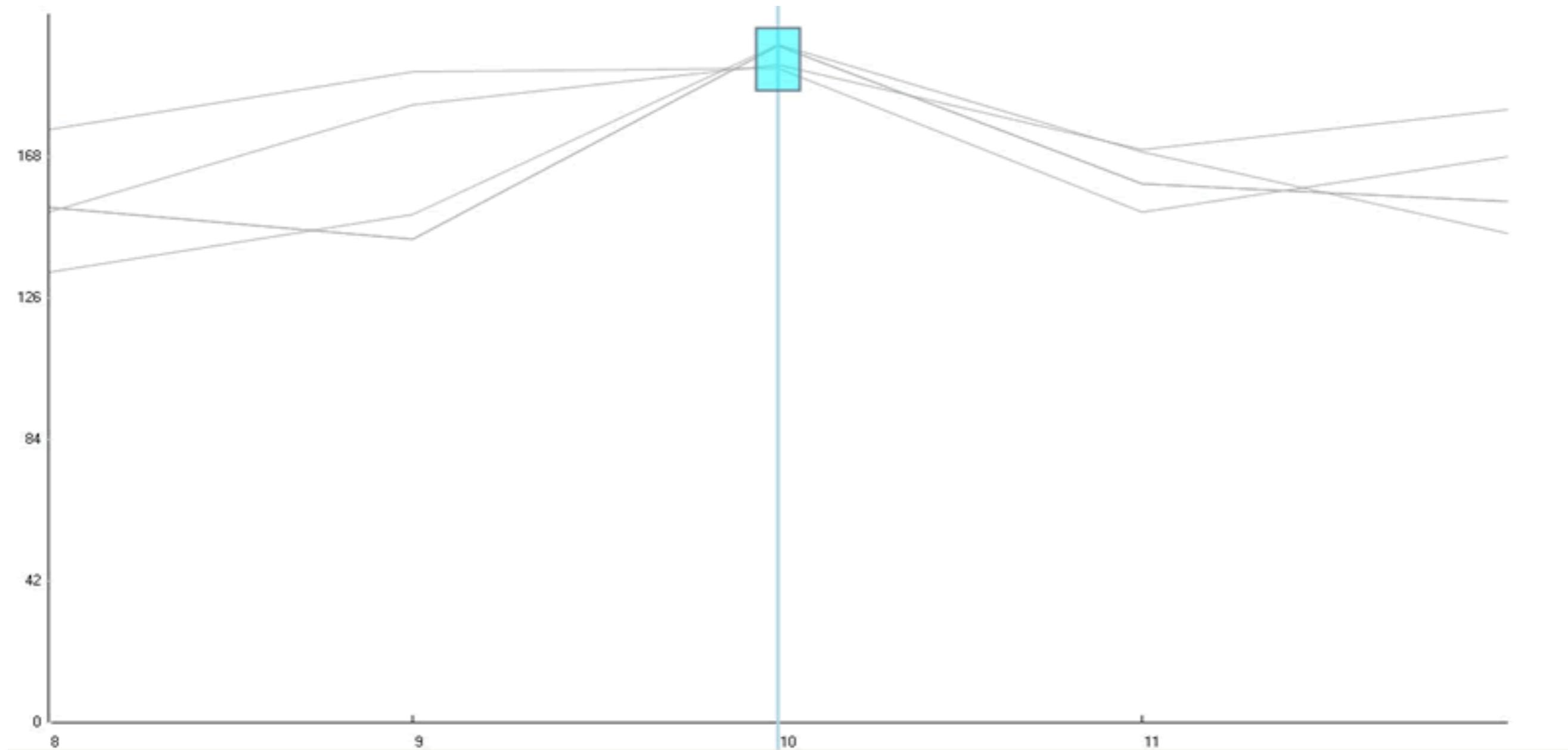
ANALYTICAL TASKS

2. Zoom



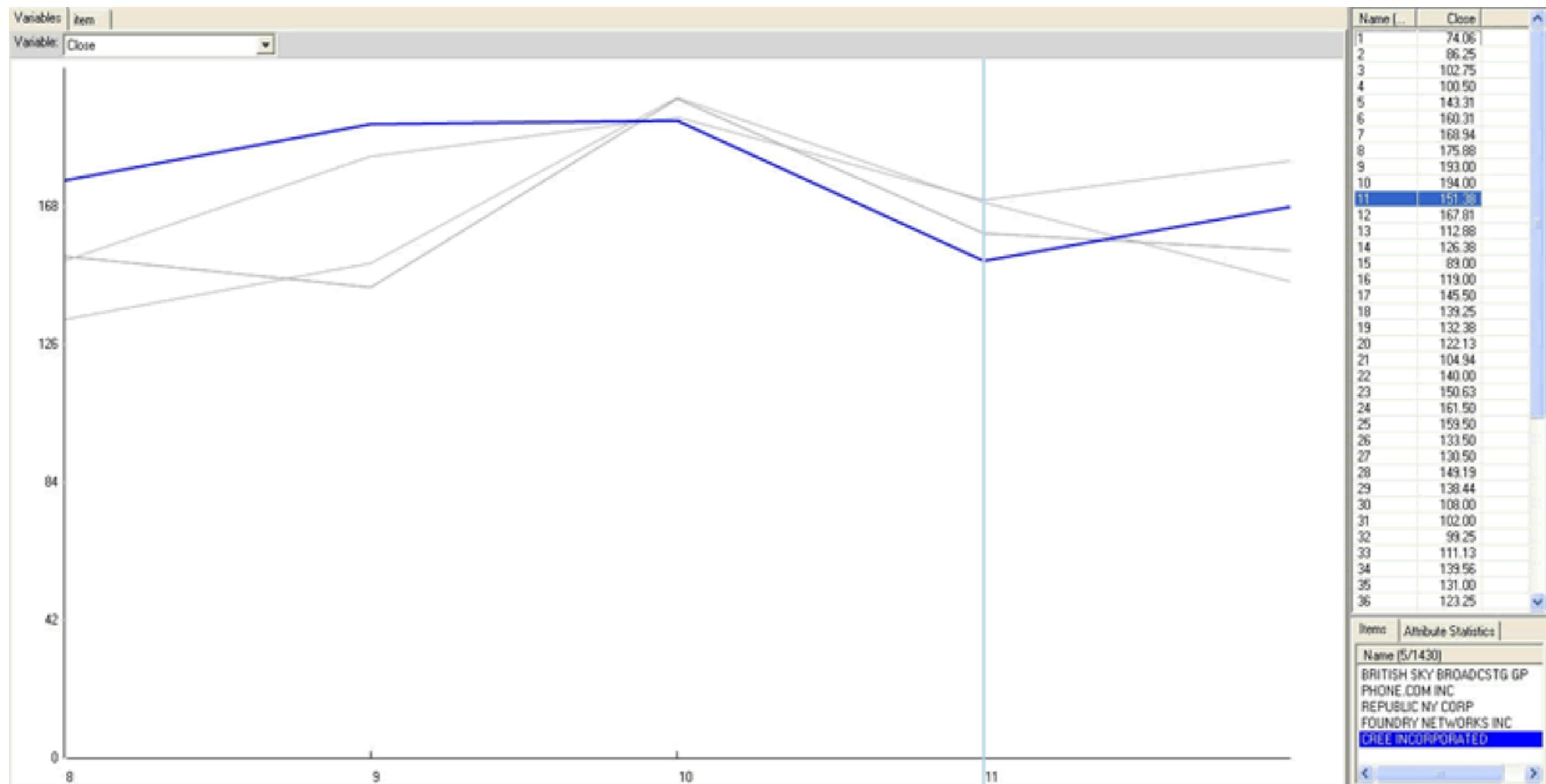
ANALYTICAL TASKS

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?

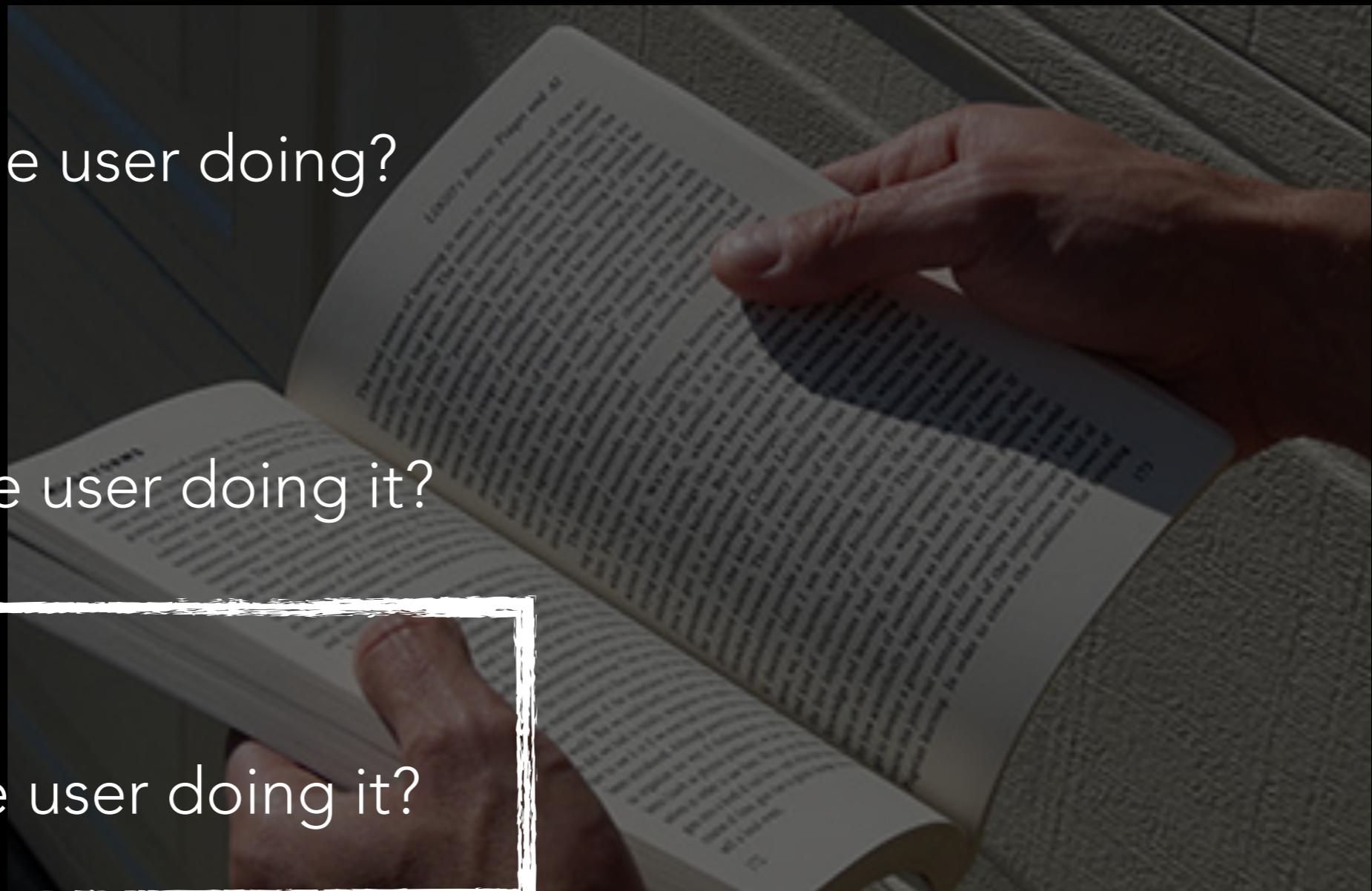
What is the user doing?

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

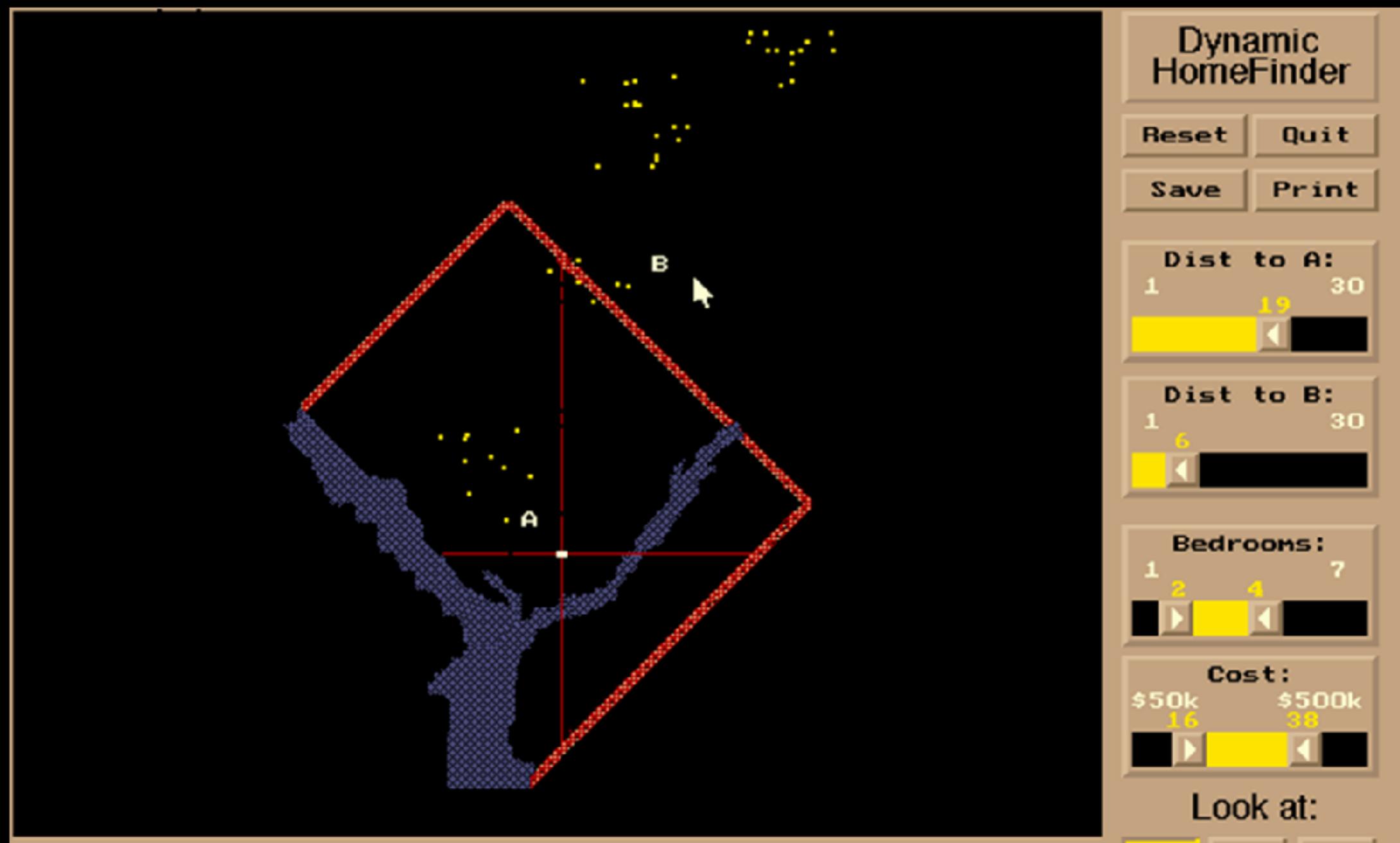
INTERACTION STYLE

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

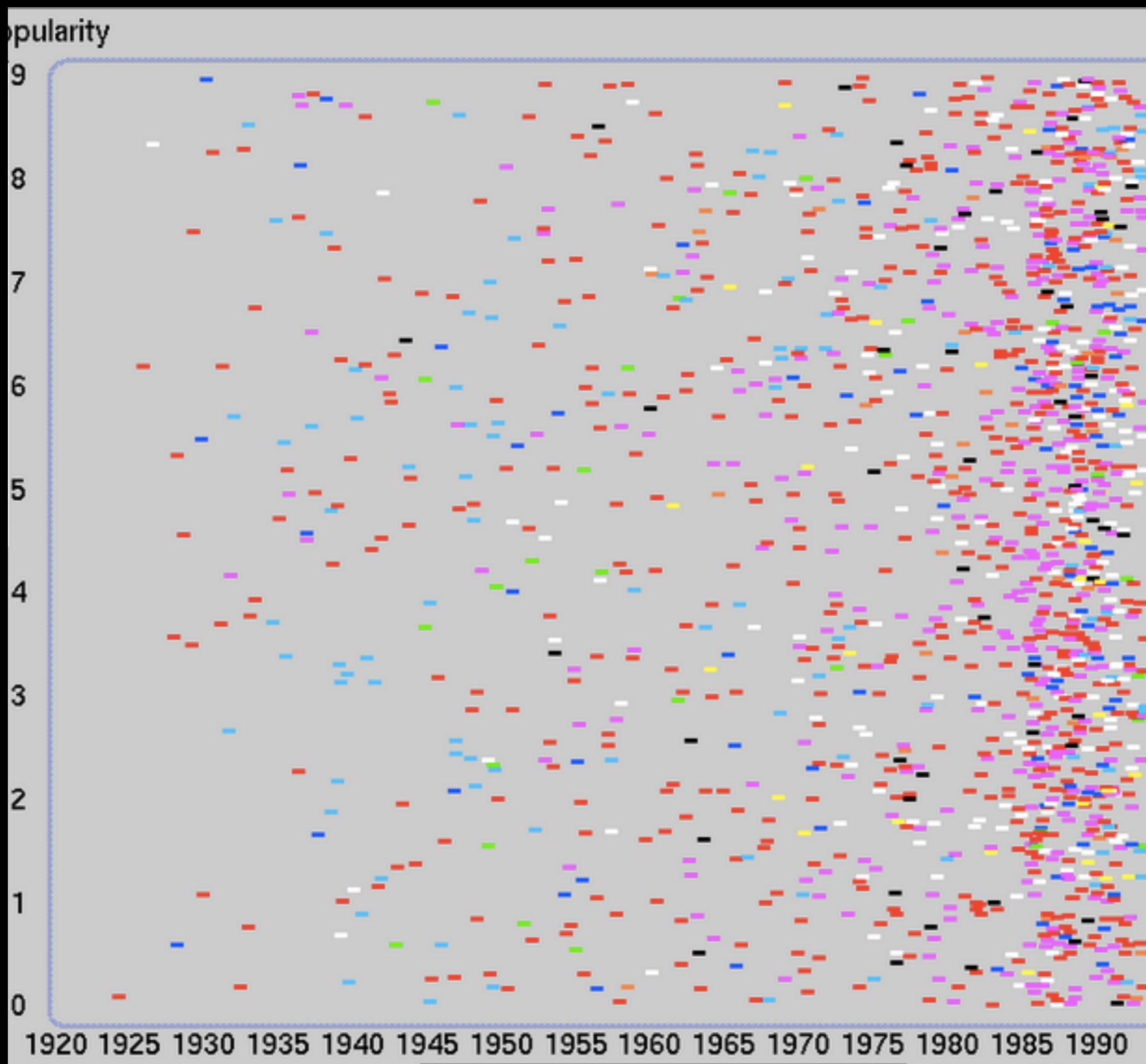
Filtering techniques

Navigation techniques

Multiple views

Rearrangement

PROBLEM



FAMILIES OF INFOVIS INTERACTION TECHNIQUES

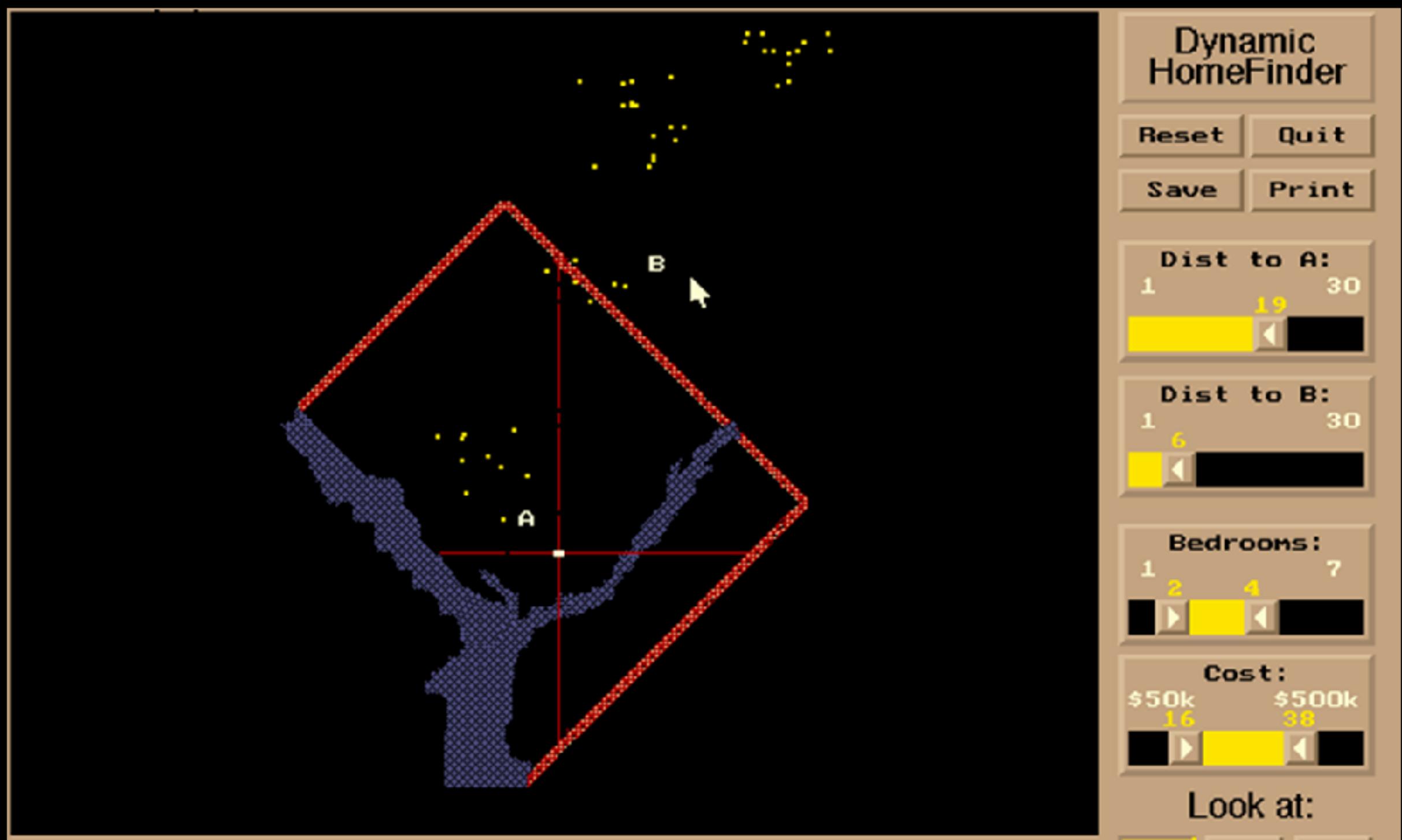
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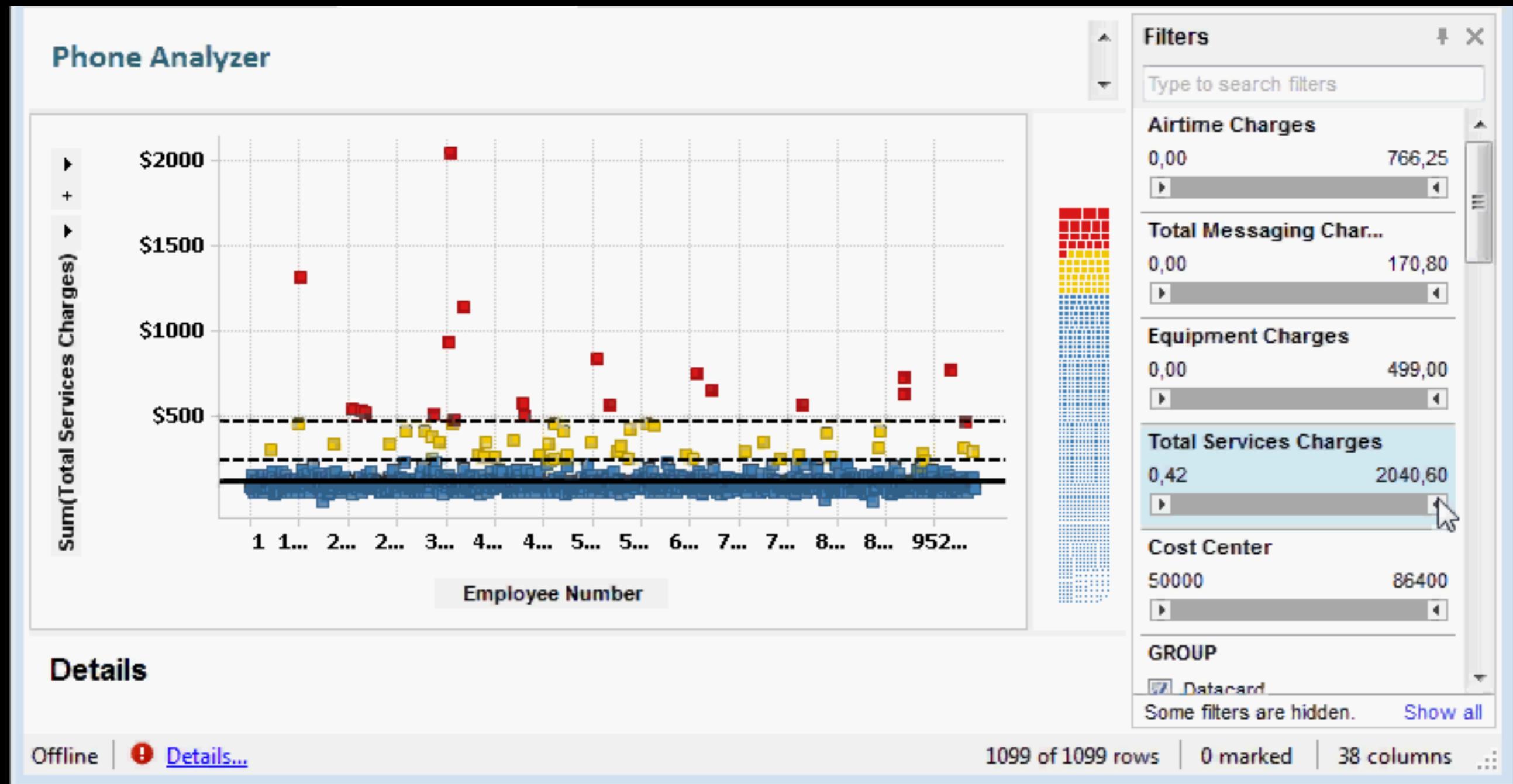
Multiple views

Rearrangement

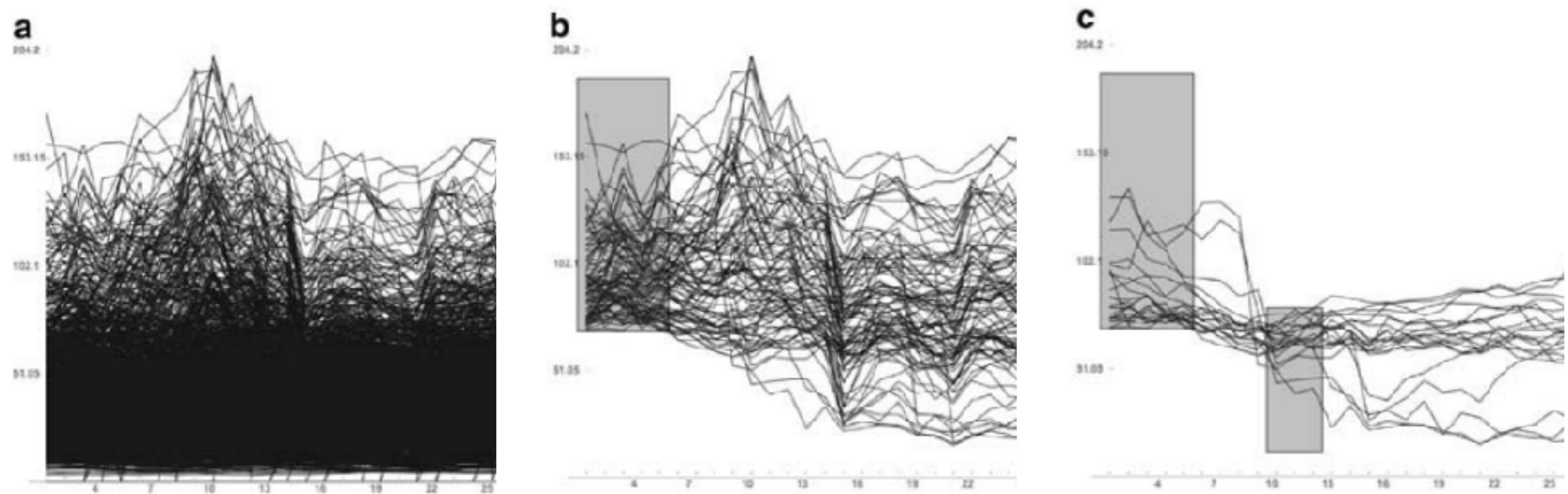
DYNAMIC QUERIES



DYNAMIC QUERIES + RESCALING

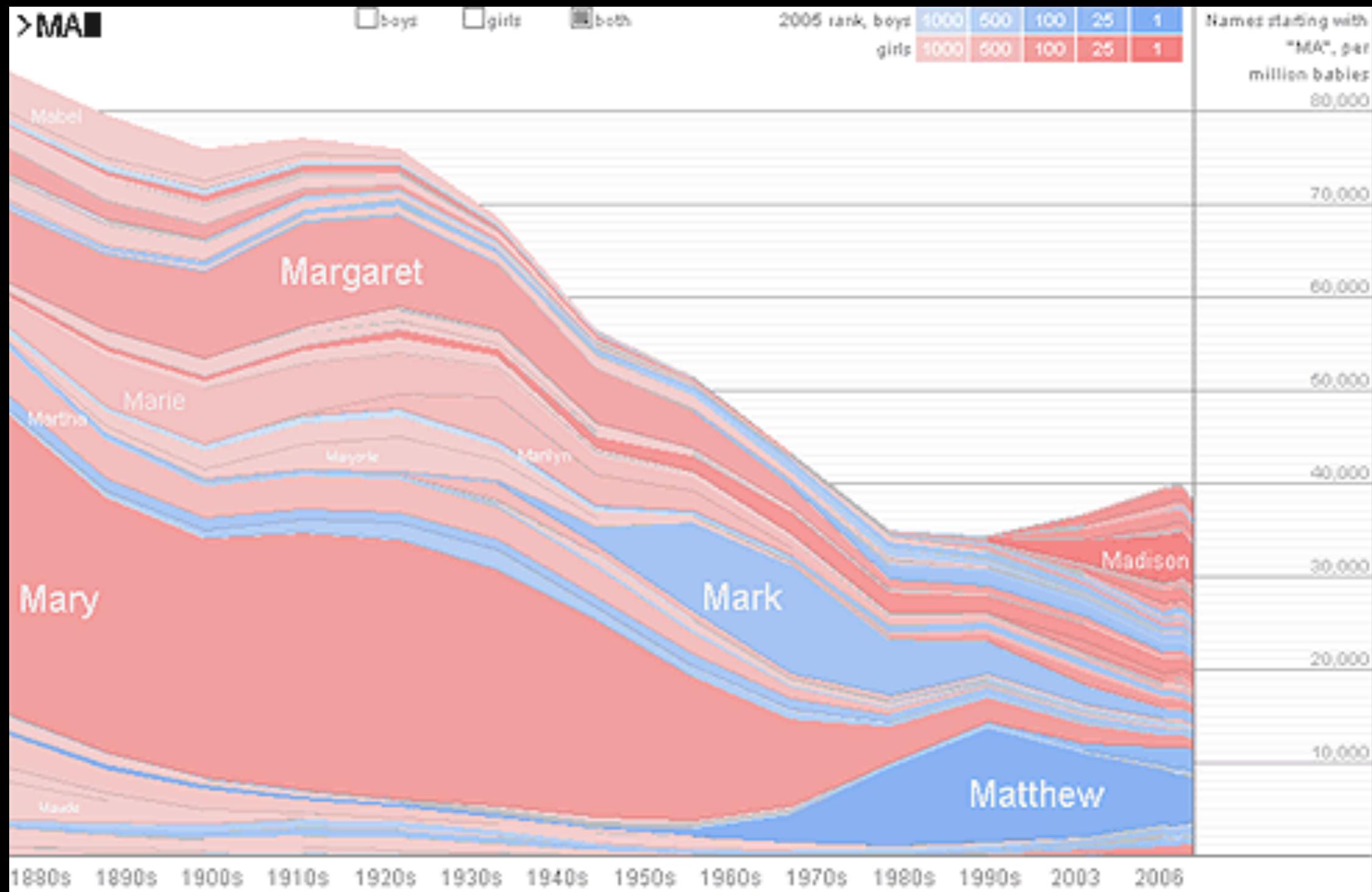


DYNAMIC QUERIES SPECIFIED VISUALLY



Time Searcher (Hocheiser, 2003)

INCREMENTAL TEXT SEARCH



www.babynamewizard.com

Name Voyager (Wattenberg, 2005)

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

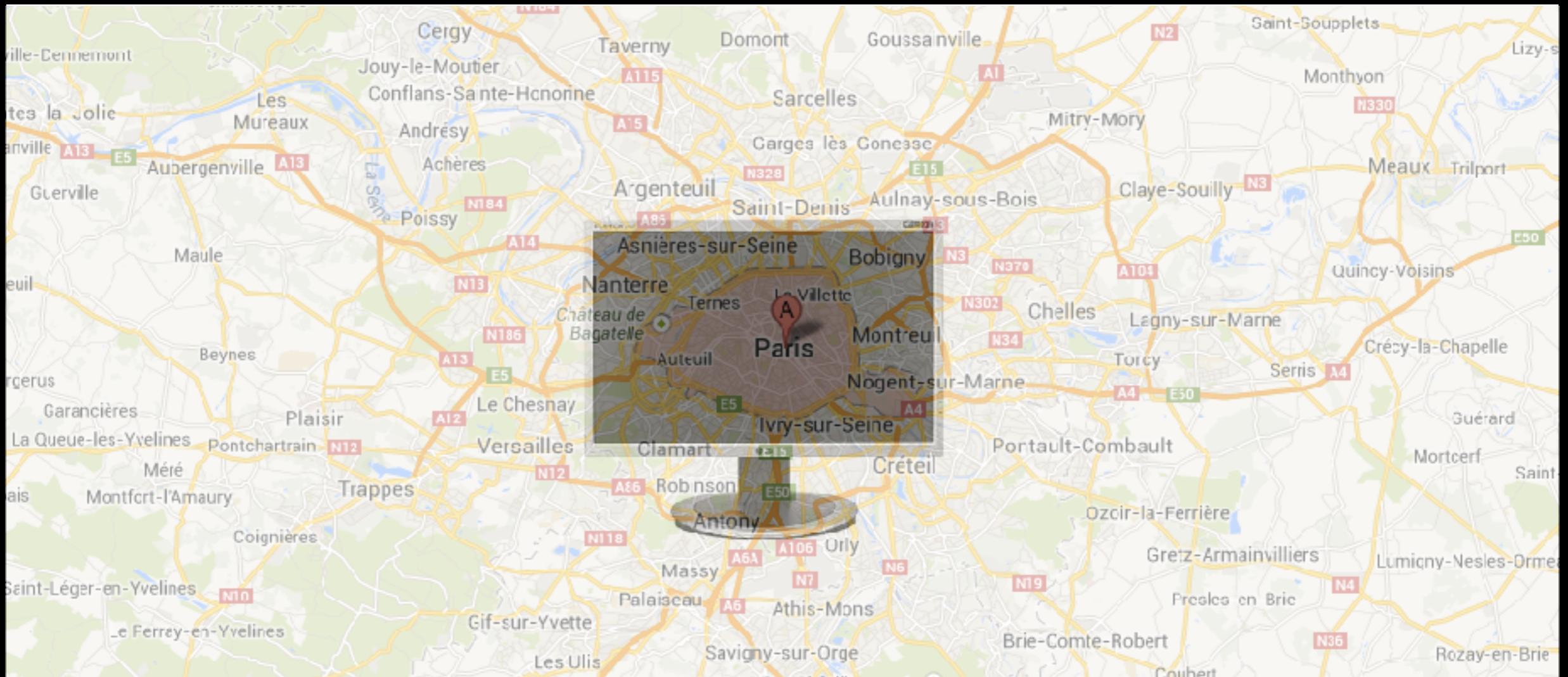
Filtering techniques

Navigation techniques

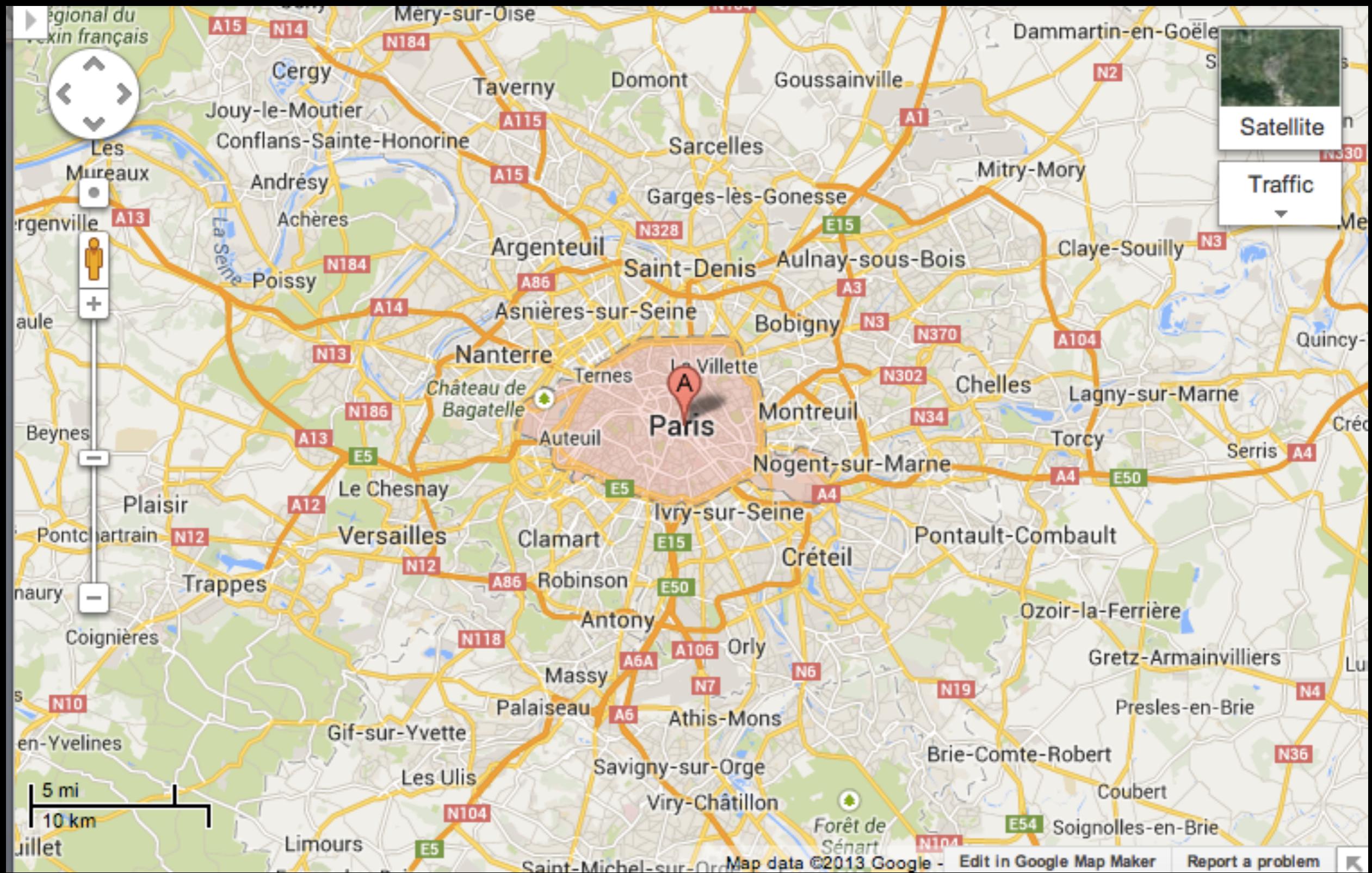
Multiple views

Rearrangement

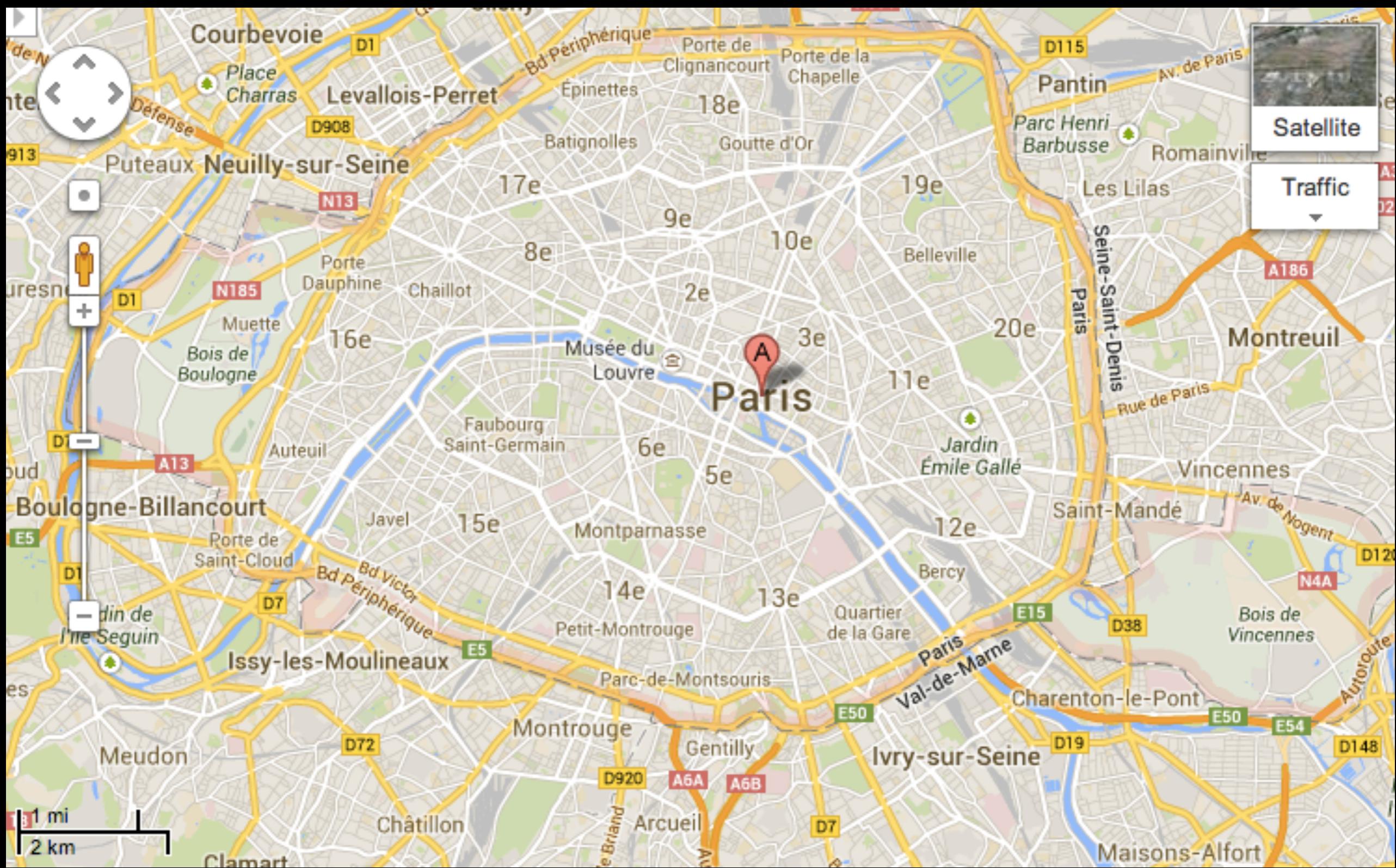
PROBLEM



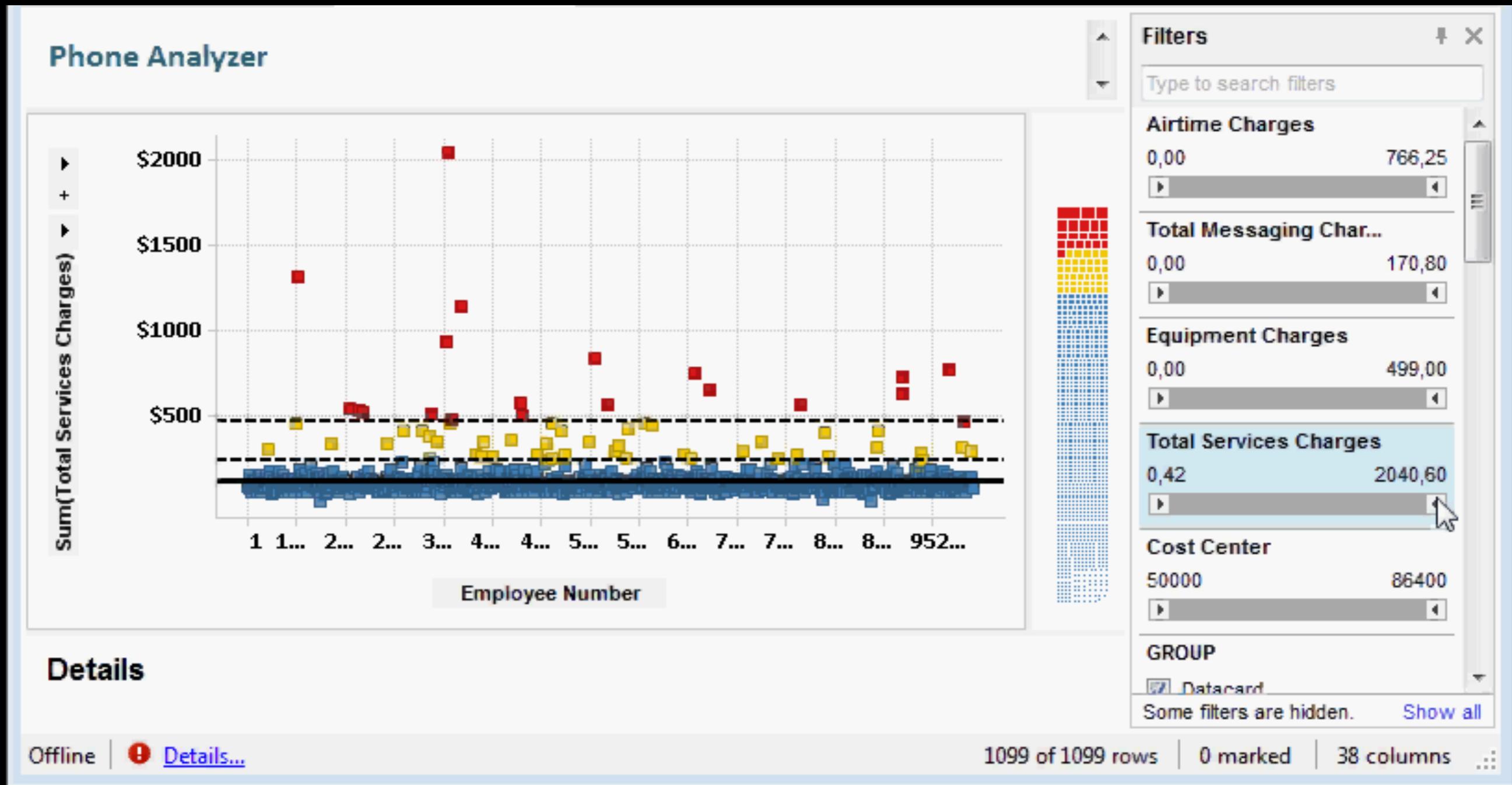
PAN & ZOOM



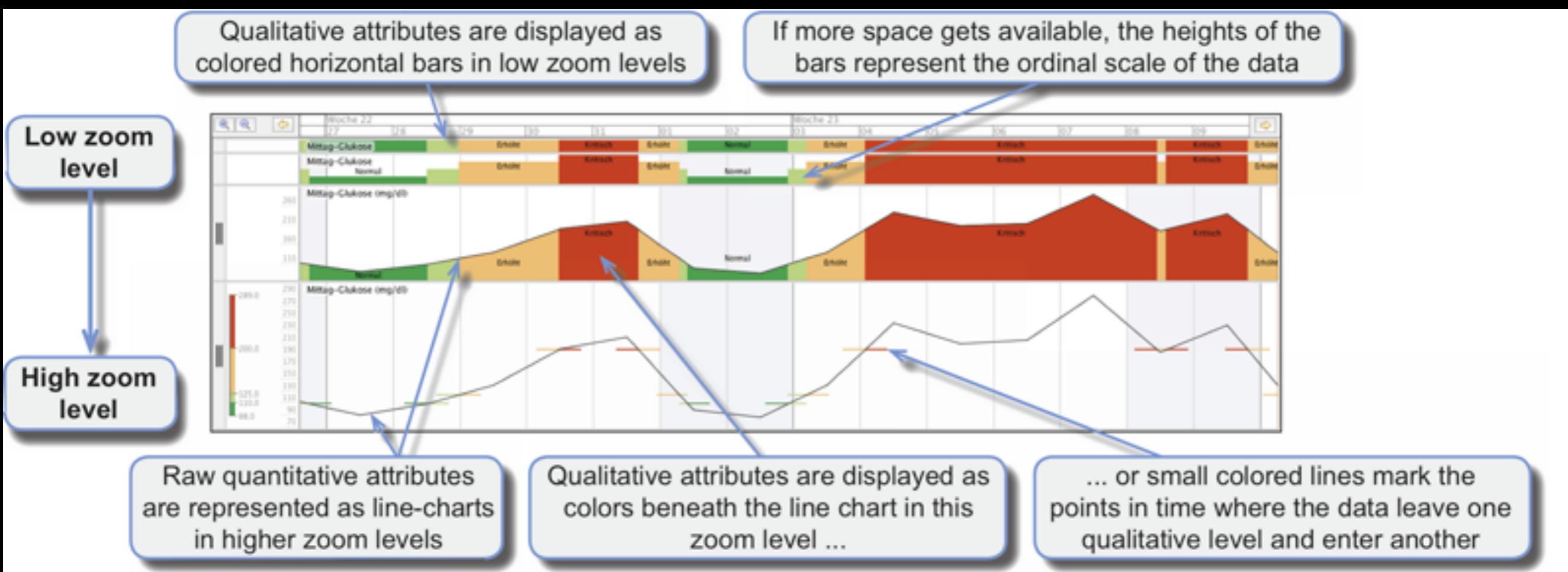
PAN & ZOOM



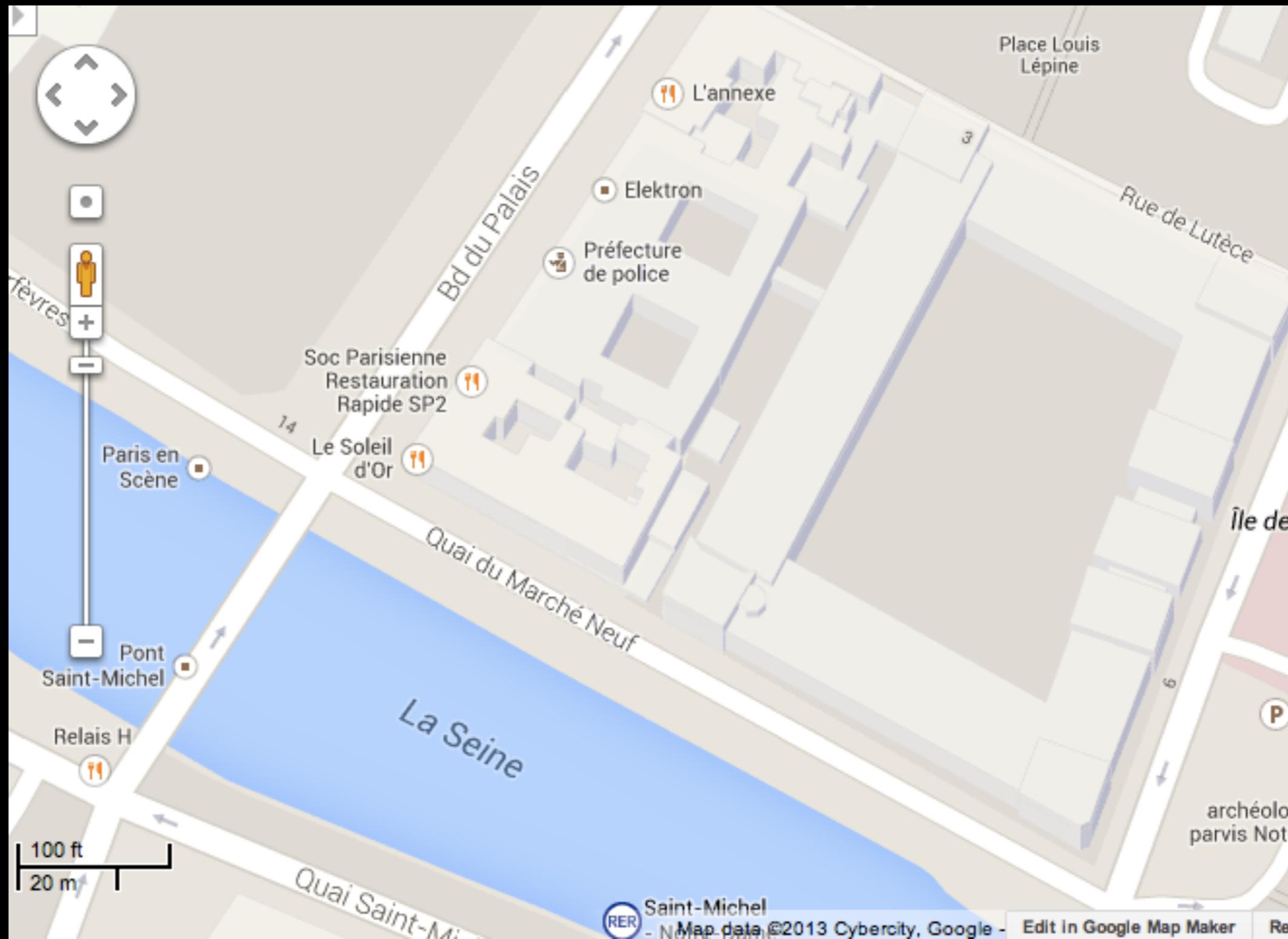
PAN & ZOOM: 1D-ZOOM



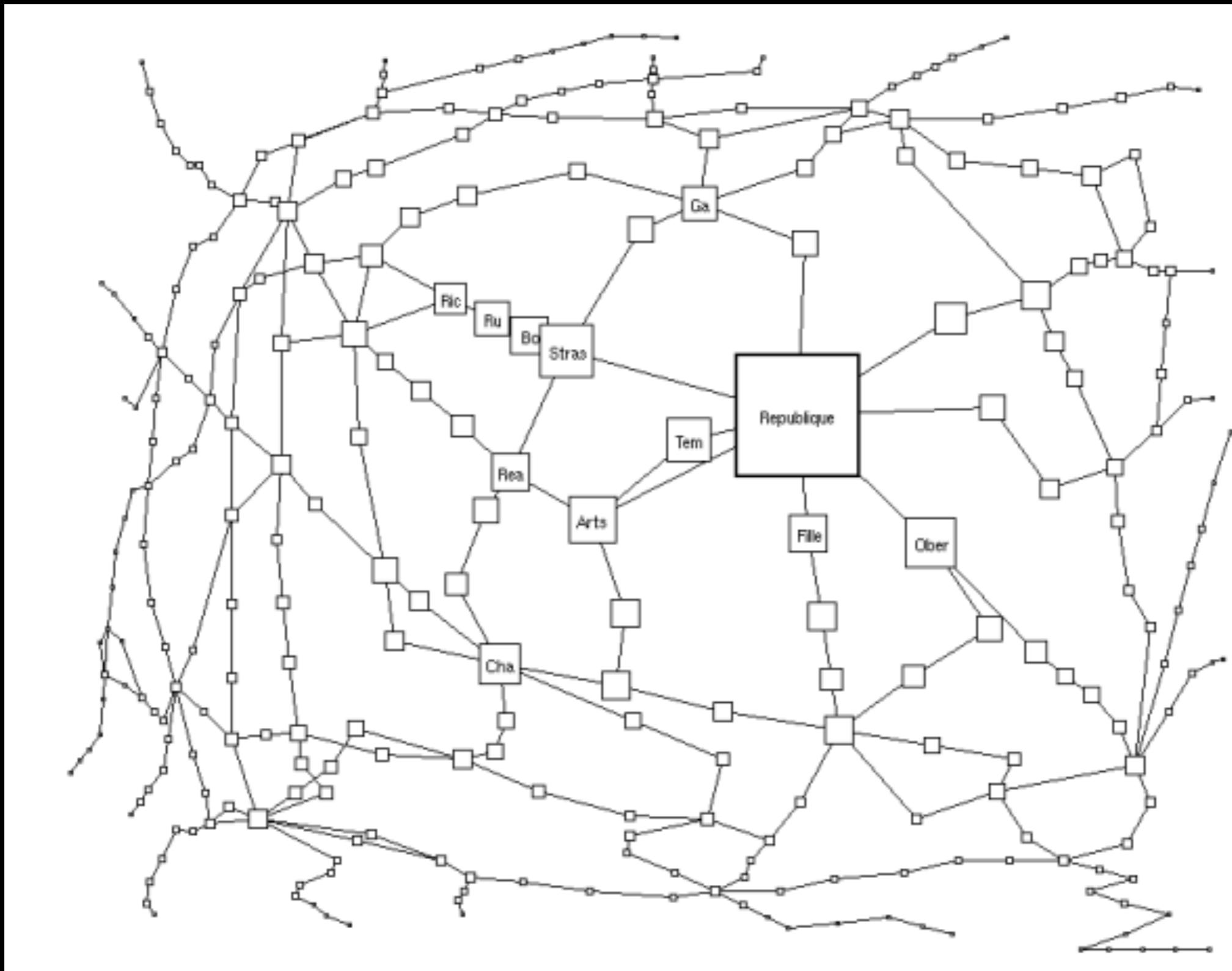
SEMANTIC ZOOM



PROBLEM: WHERE AM I?

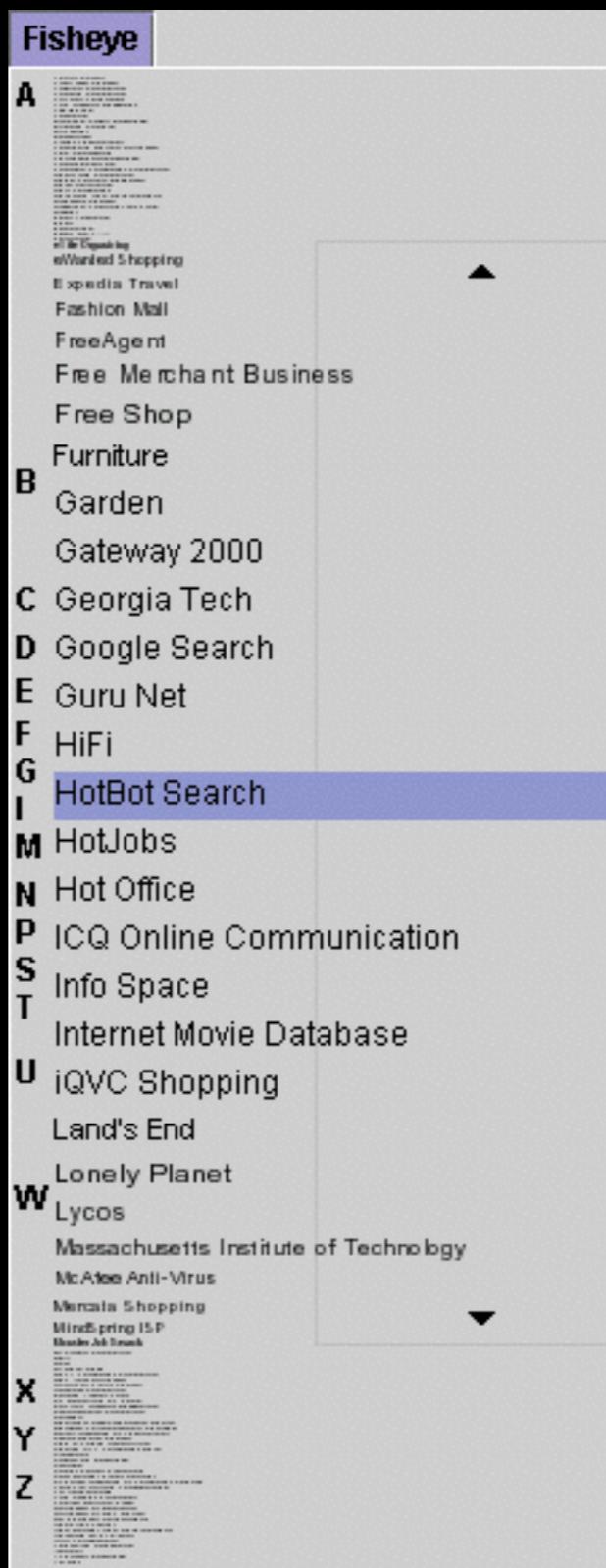


FOCUS+CONTEXT: SPACE DISTORTION



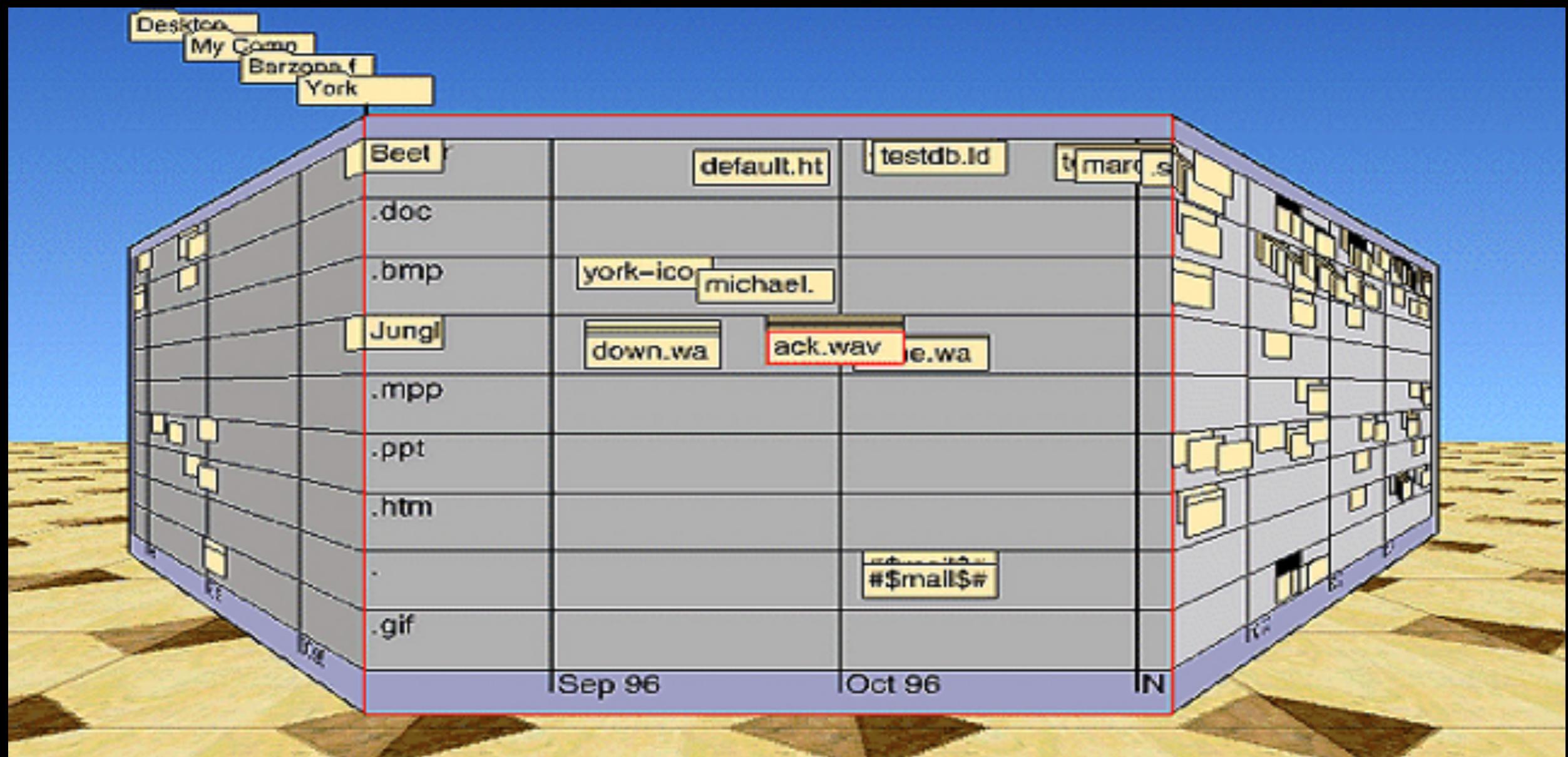
Sarkar and Brown, 1992

FOCUS+CONTEXT: SPACE DISTORTION



Bederson, 2000

FOCUS+CONTEXT: SPACE DISTORTION



Mackinlay, Roberston and Card, 1991

FOCUS+CONTEXT: TABLE LENS

Inxight Table Lens - [foremost.txt]

File Edit View Tools Options Window Help

Inxight

	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

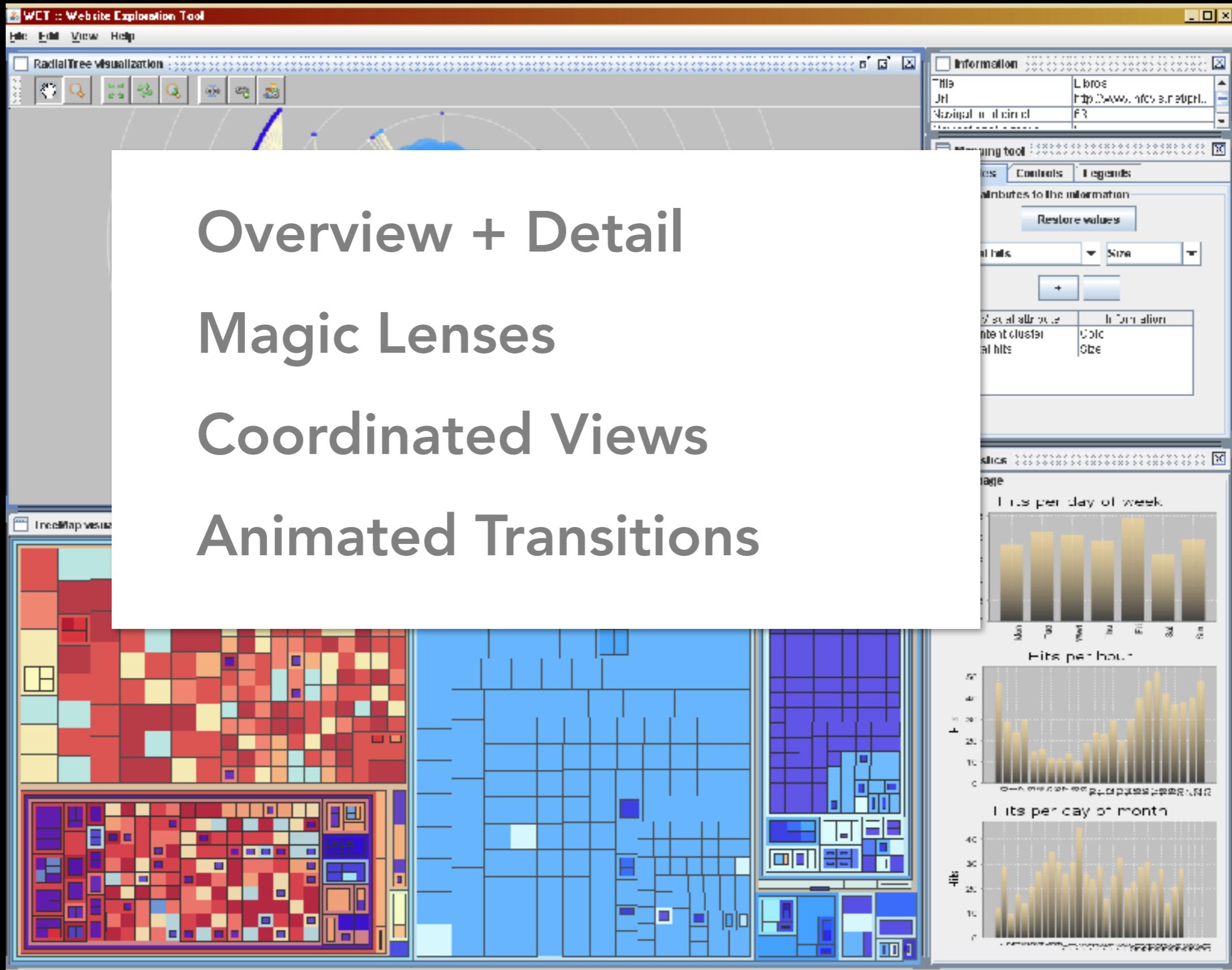
Navigation techniques

Multiple views

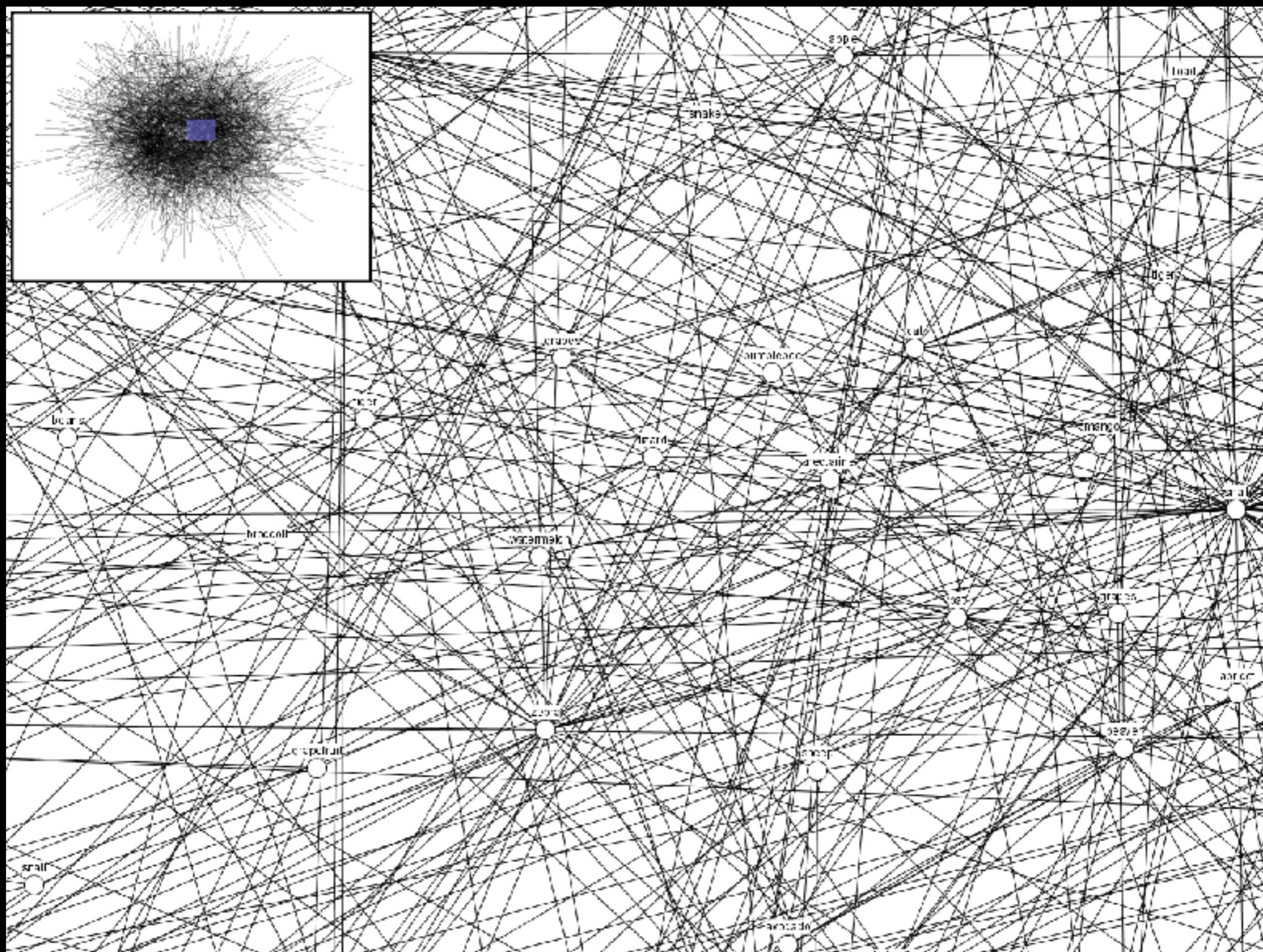
Rearrangement

MULTIPLE VIEWS

Overview + Detail
Magic Lenses
Coordinated Views
Animated Transitions

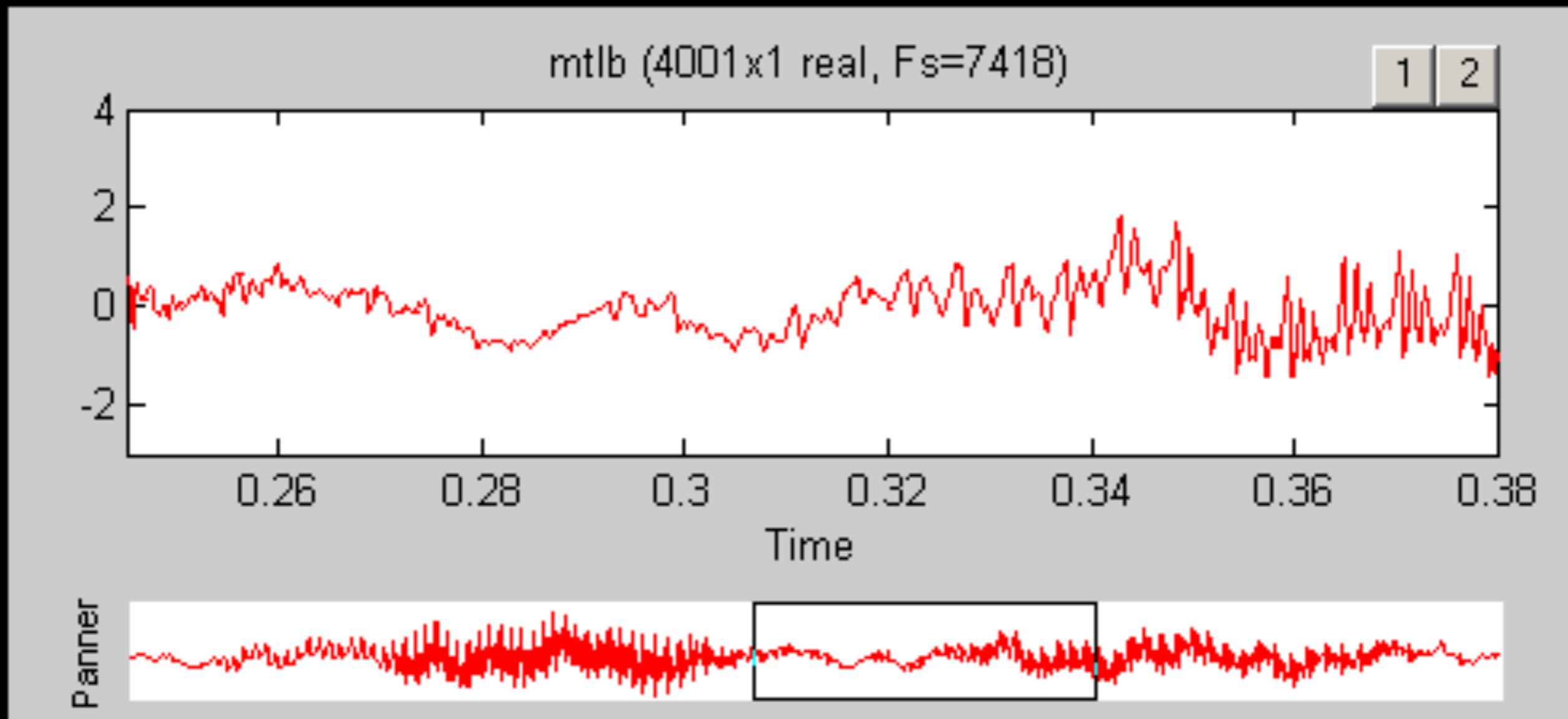


OVERVIEW+DETAILS PANNING A LARGE GRAPH



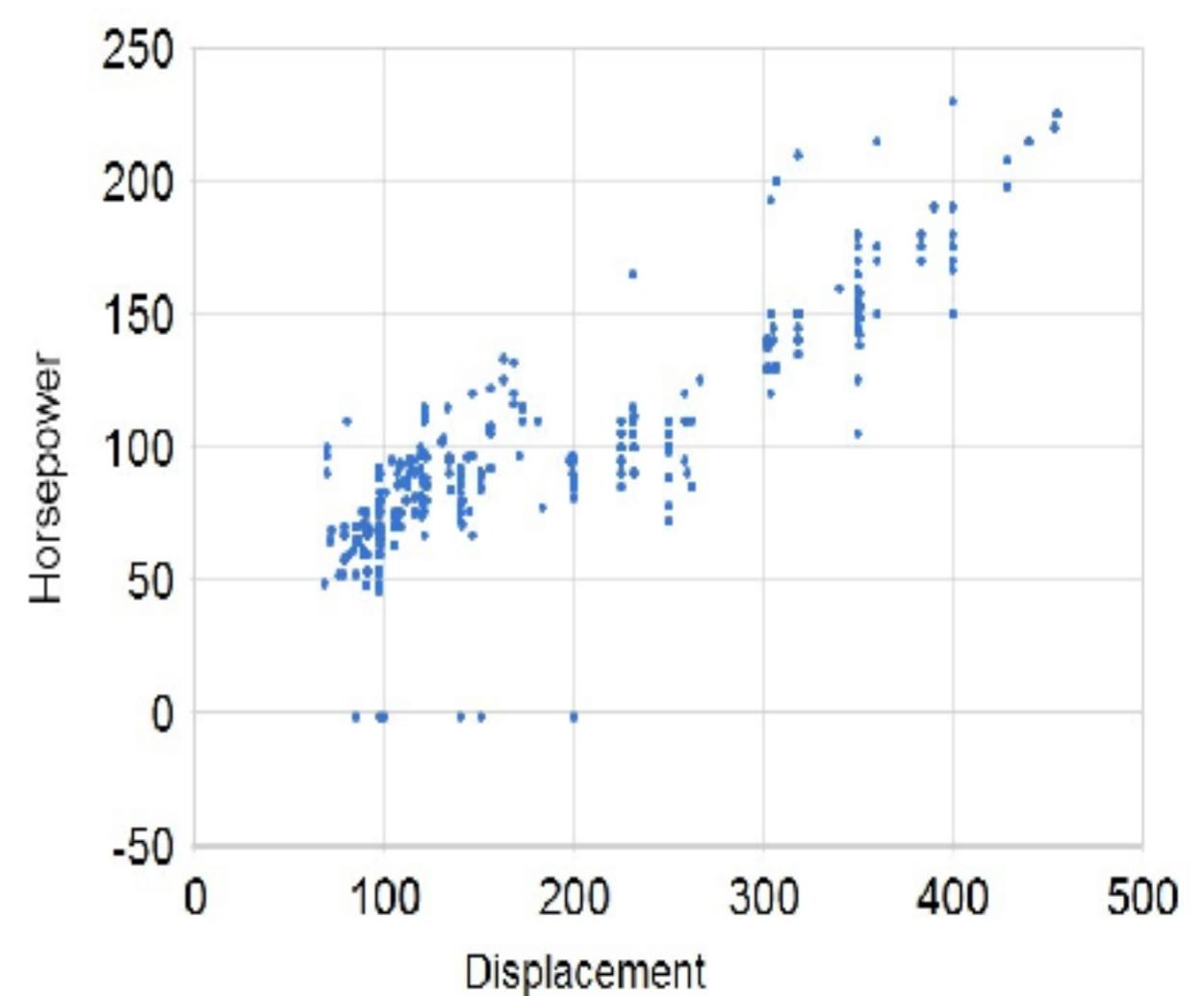
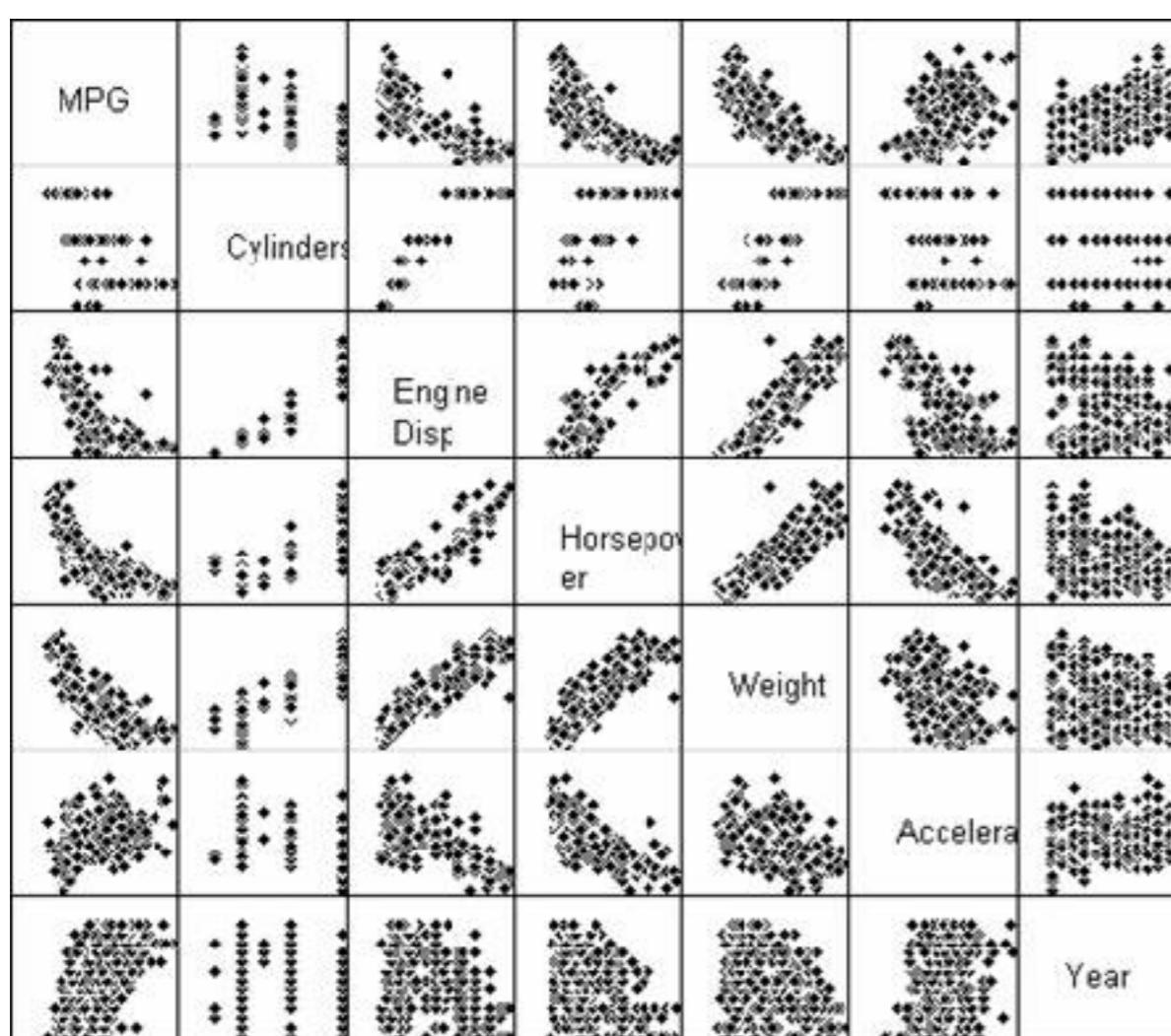
OVERVIEW+DETAILS

PANNING A LINE CHART



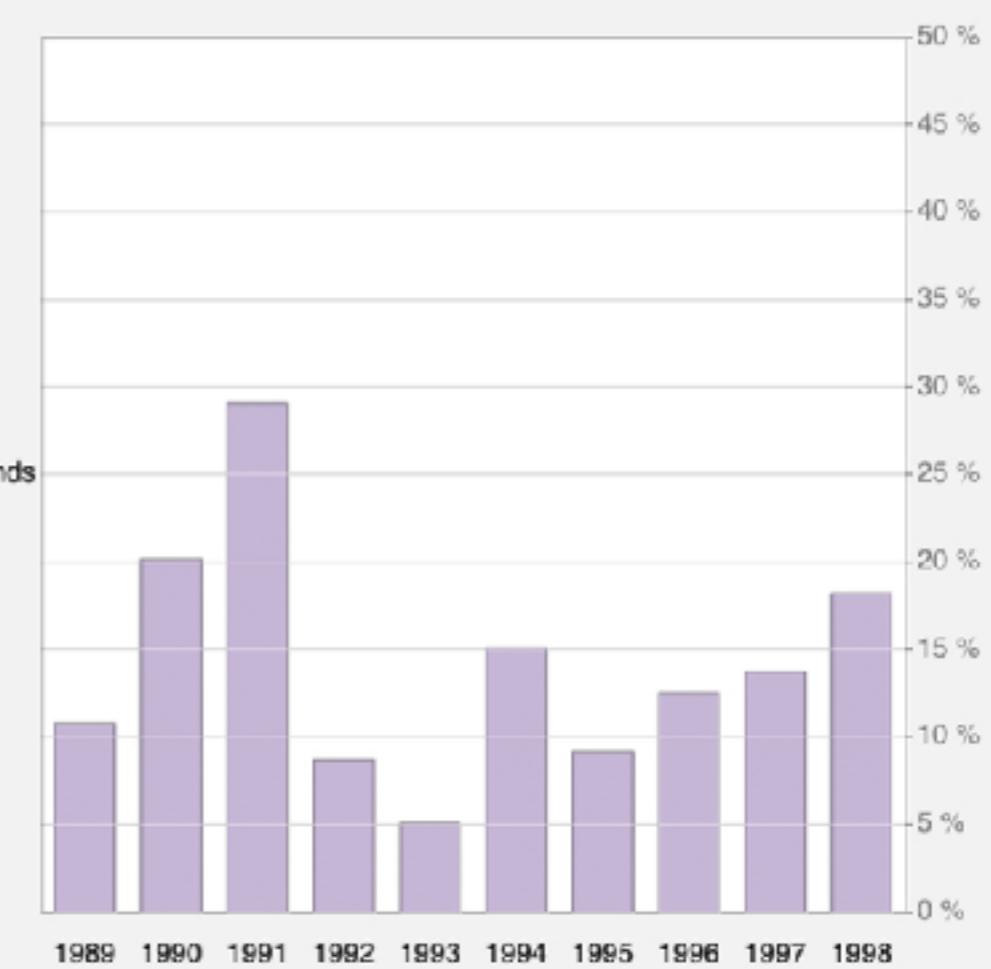
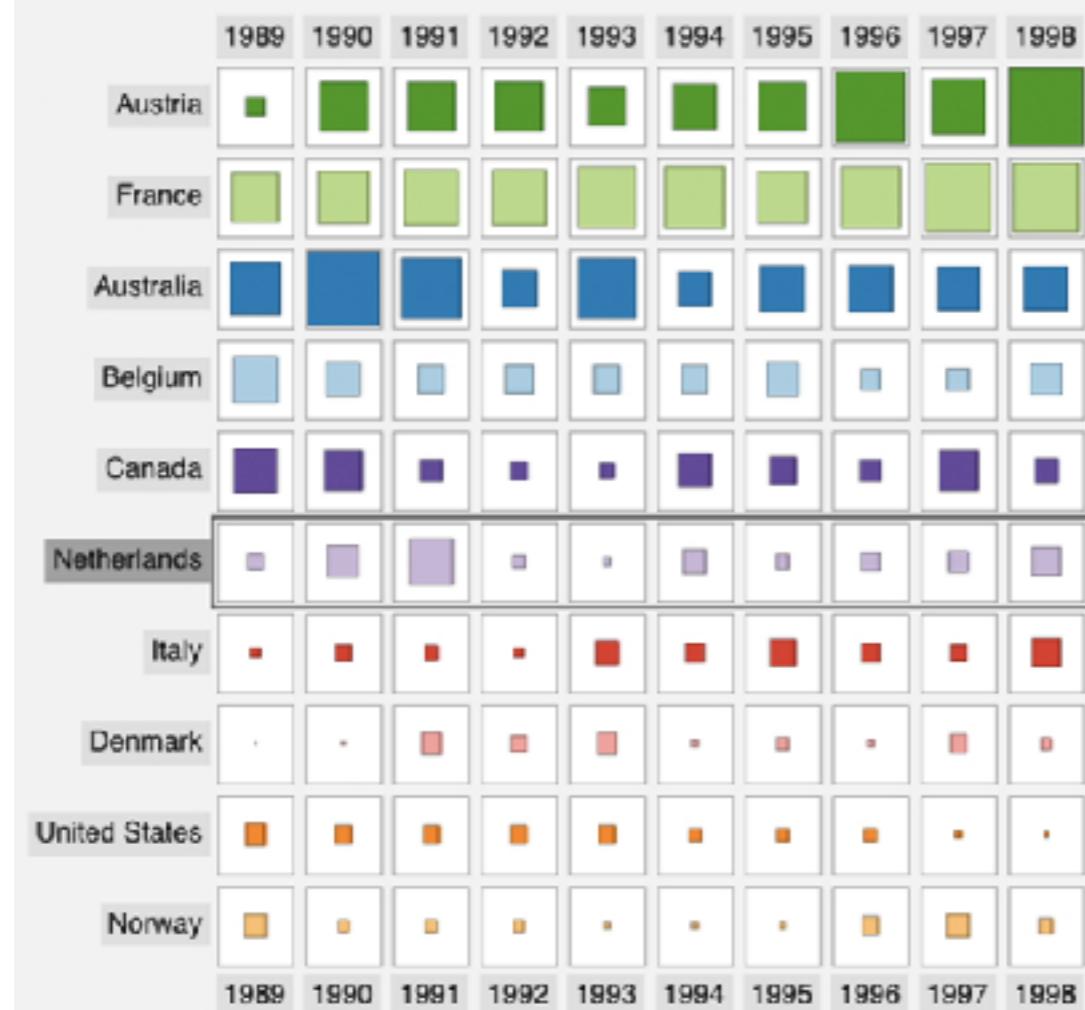
OVERVIEW+DETAILS

BROWSING MULTIPLE VIEWS

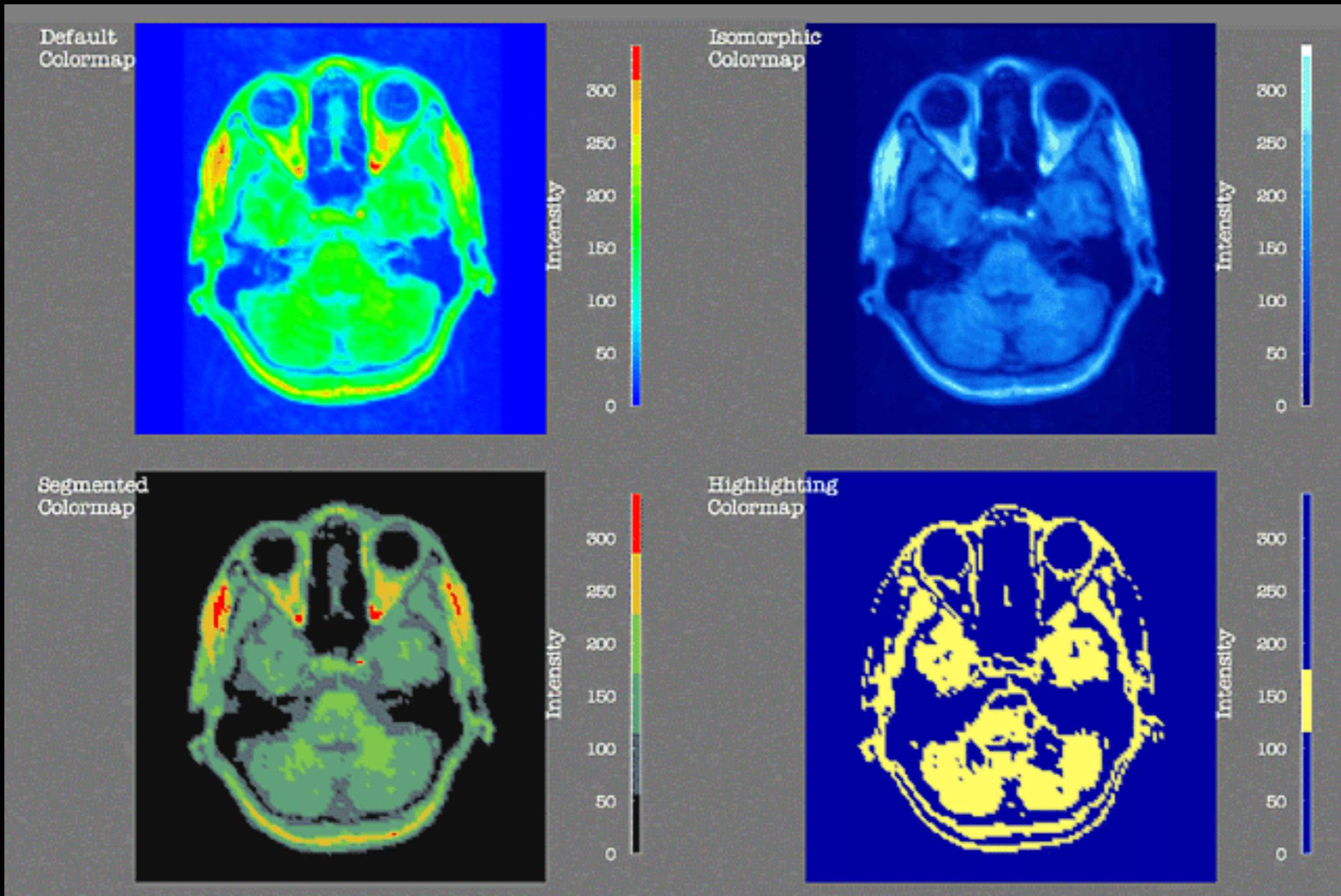


OVERVIEW+DETAILS

BROWSING MULTIPLE VIEWS



PROBLEM



Rogowitz and Treinish, 1995

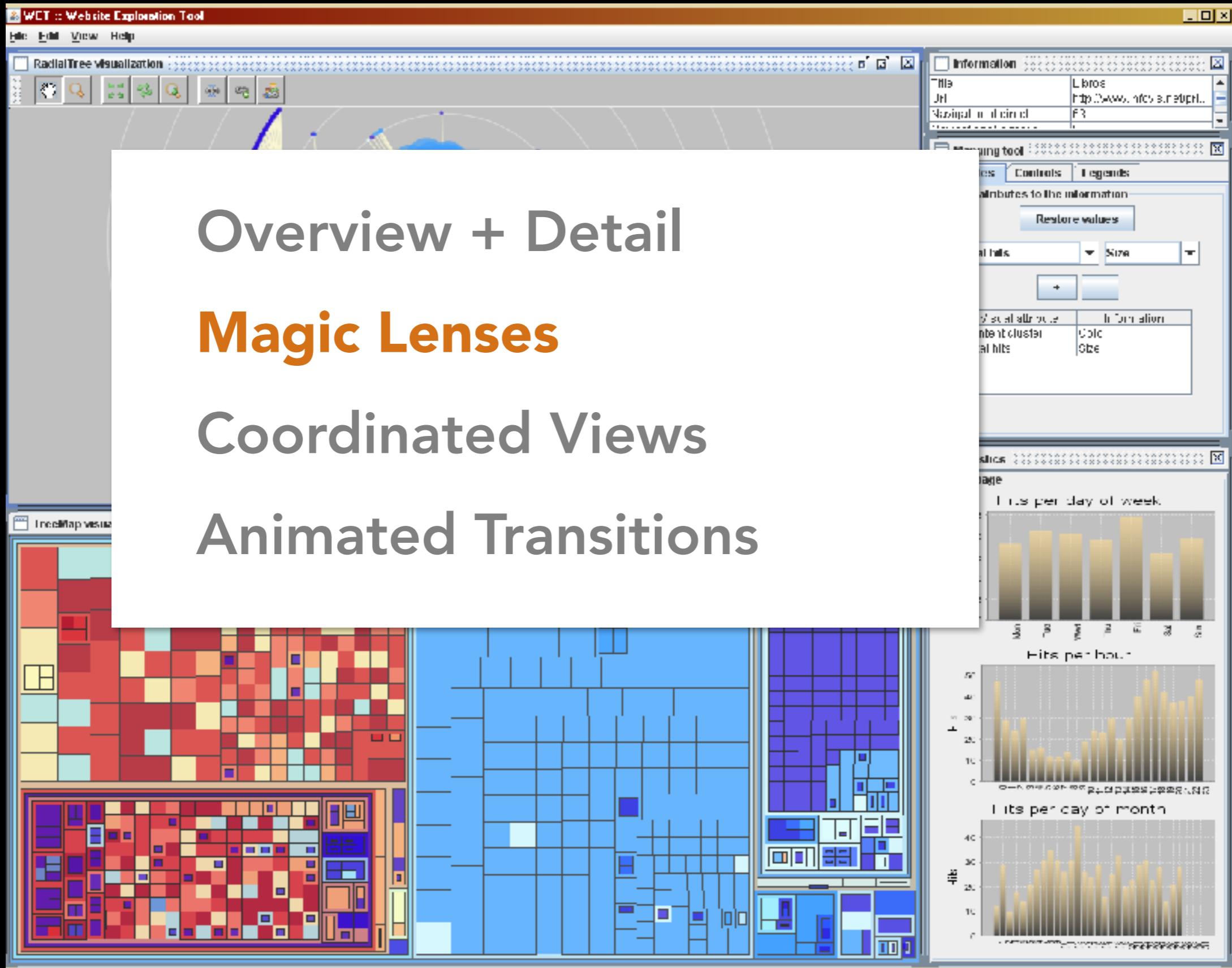
MULTIPLE VIEWS

Overview + Detail

Magic Lenses

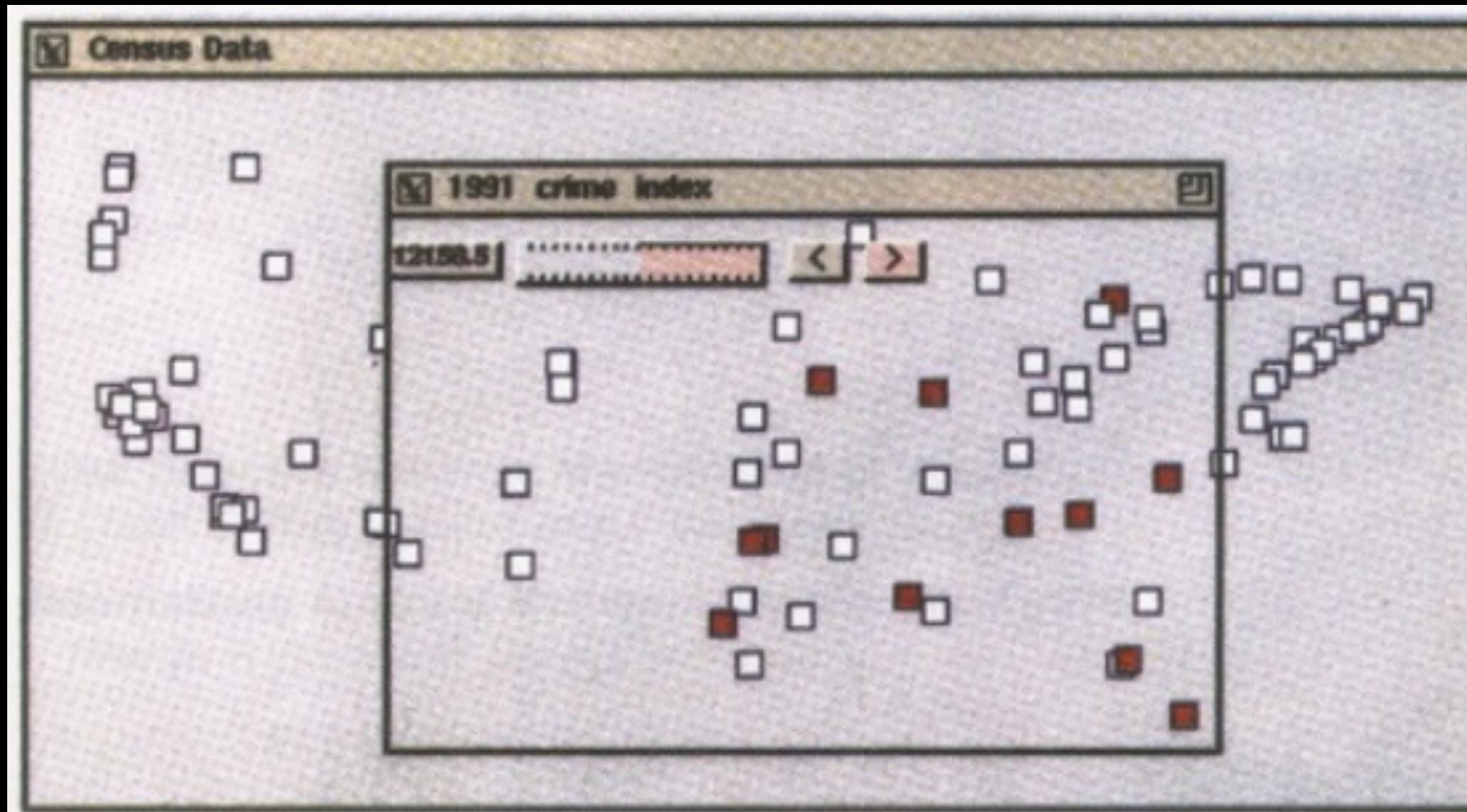
Coordinated Views

Animated Transitions



MAGIC LENSES

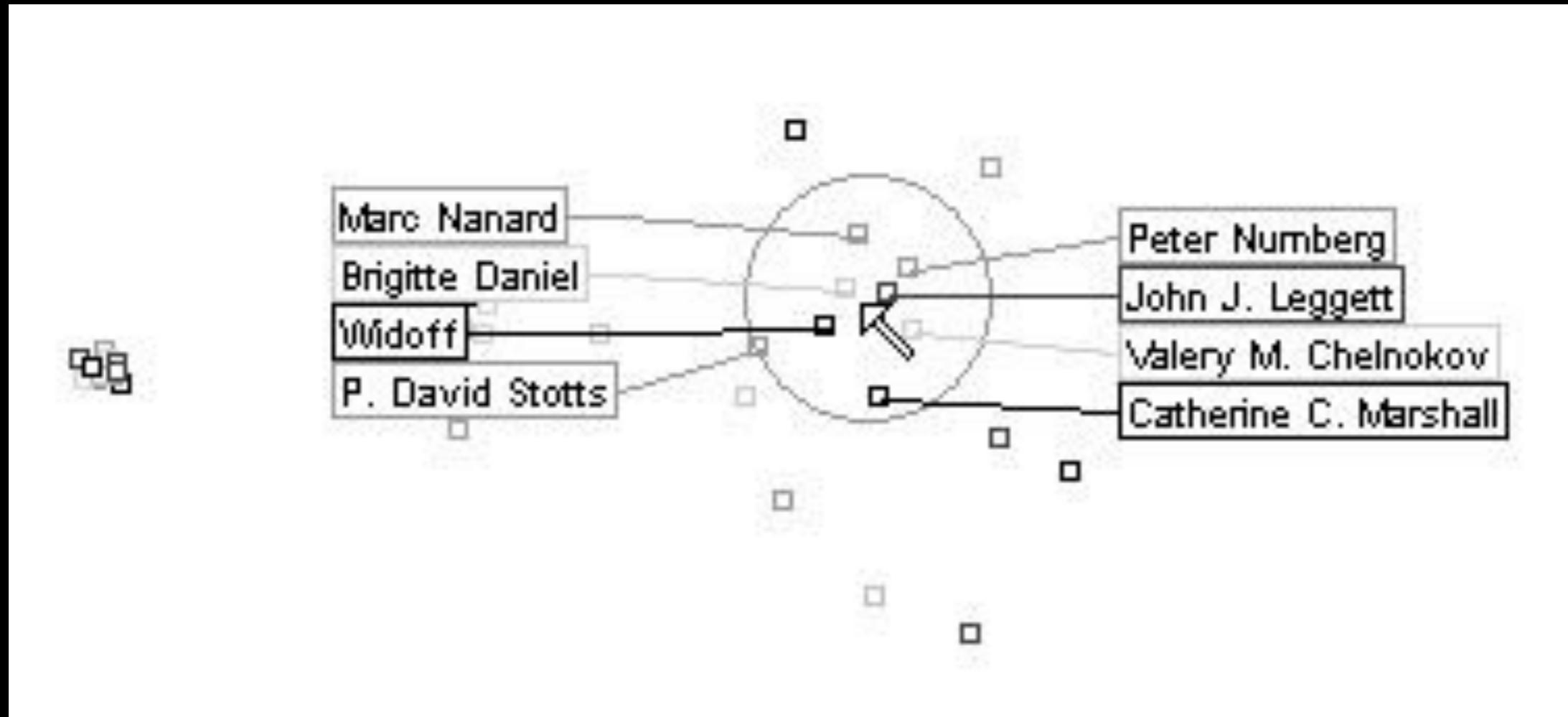
Movable filters for dynamic queries



Fishkin and Stone, 1995

MAGIC LENSES

Excentric labeling



MAGIC LENSES

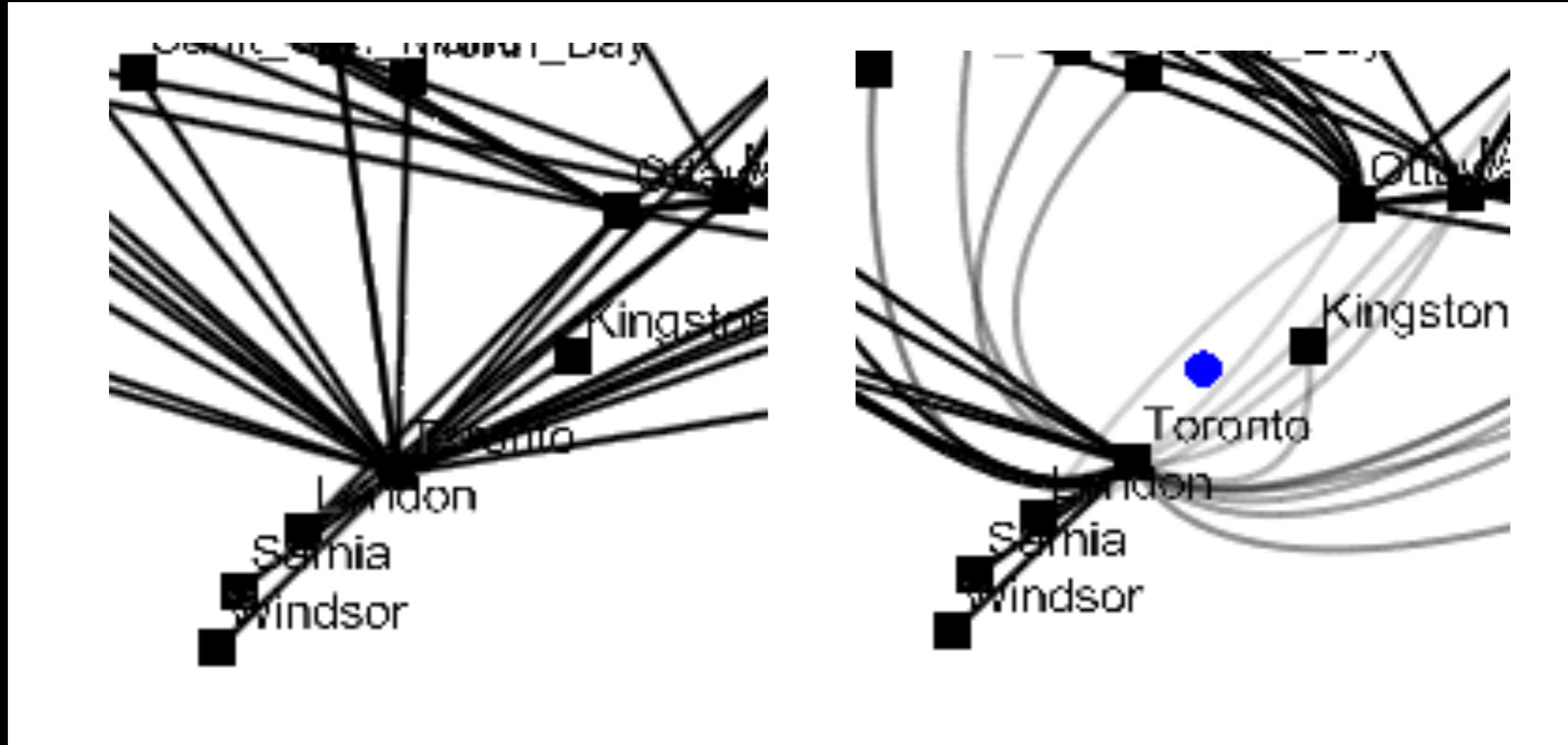
Color lenses



Elmqvist et al, 2010

MAGIC LENSES

Edge lenses



Wong, Carpendale and Greenberg,

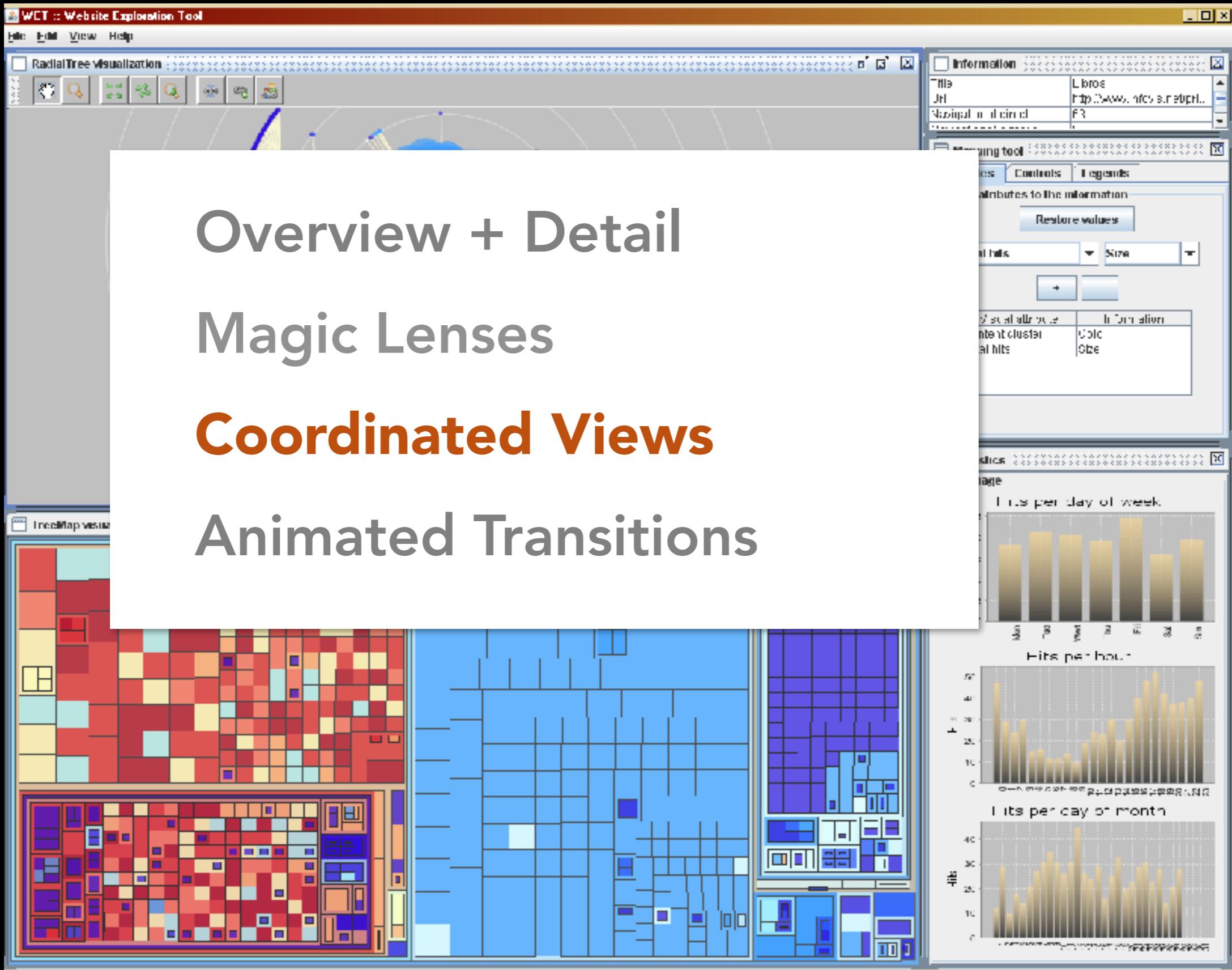
MULTIPLE VIEWS

Overview + Detail

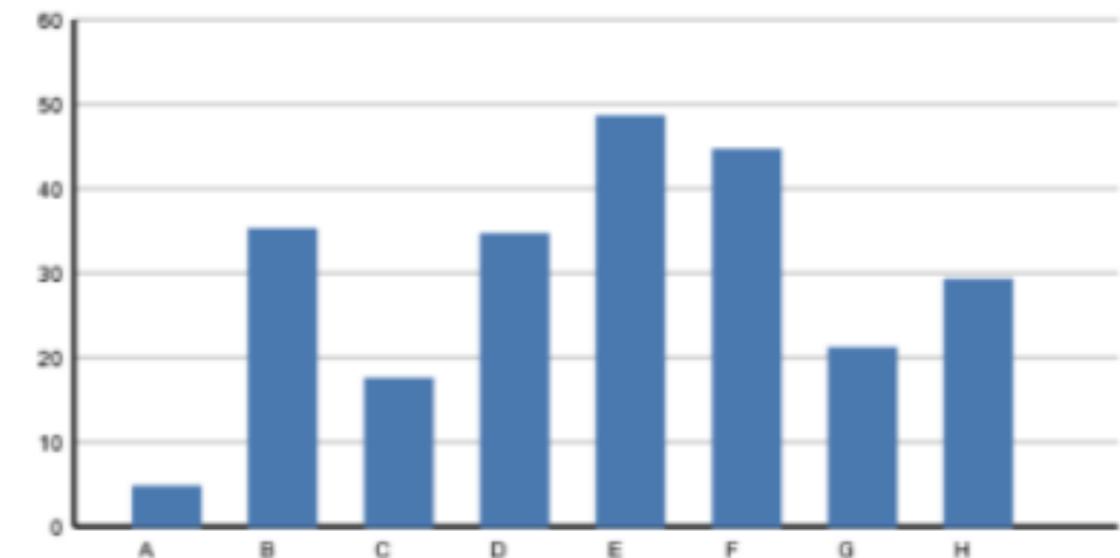
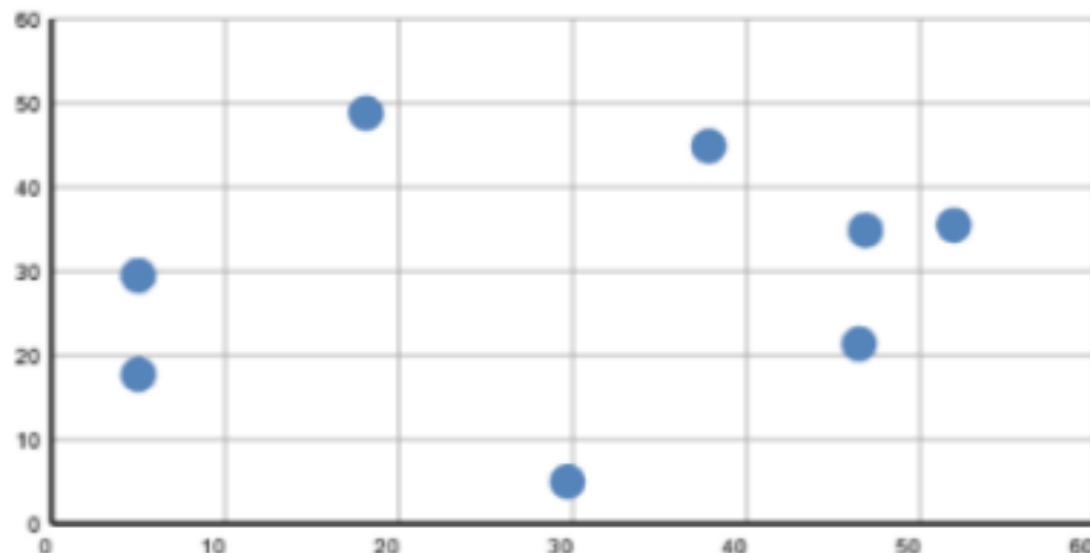
Magic Lenses

Coordinated Views

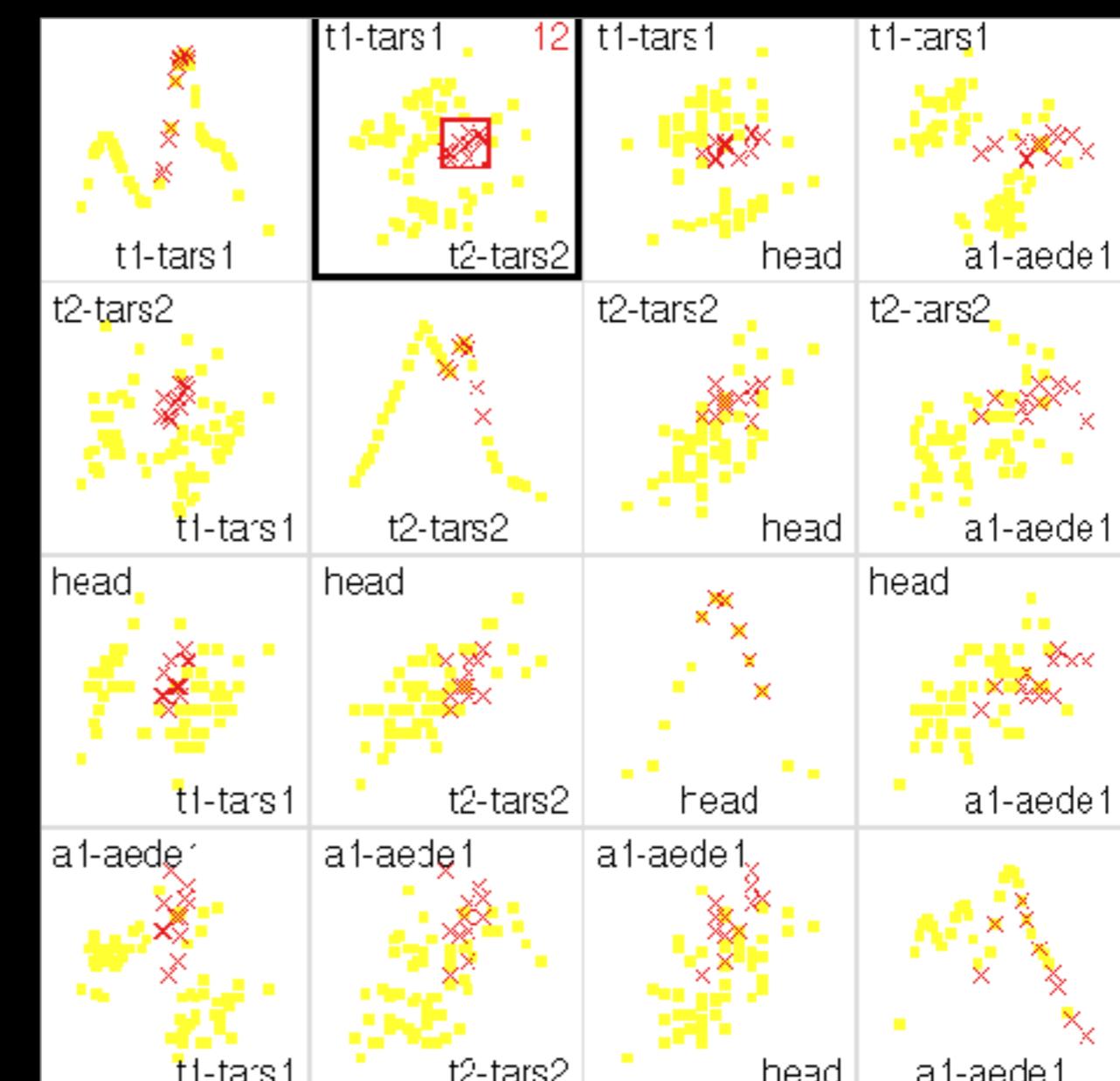
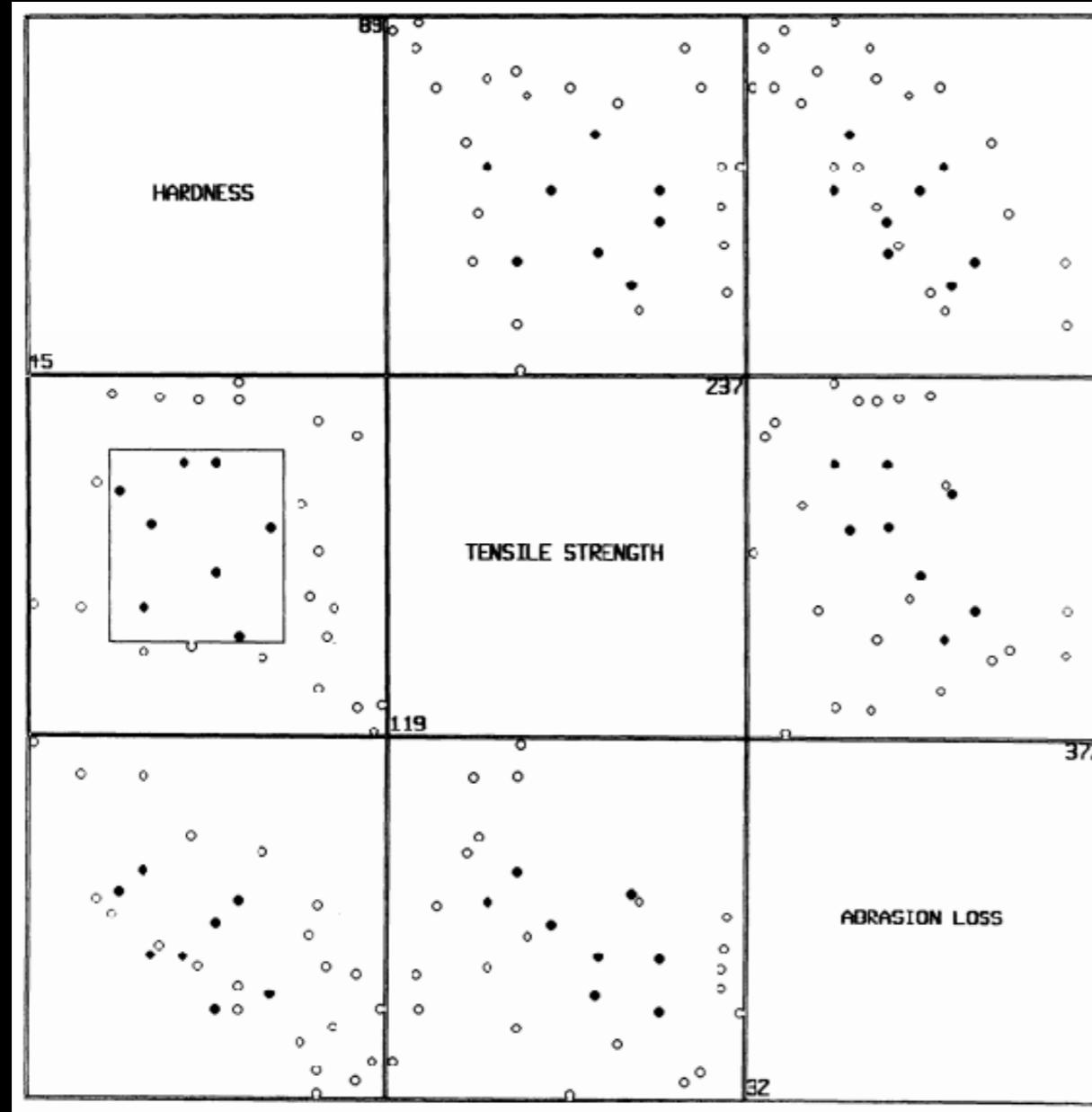
Animated Transitions



PROBLEM



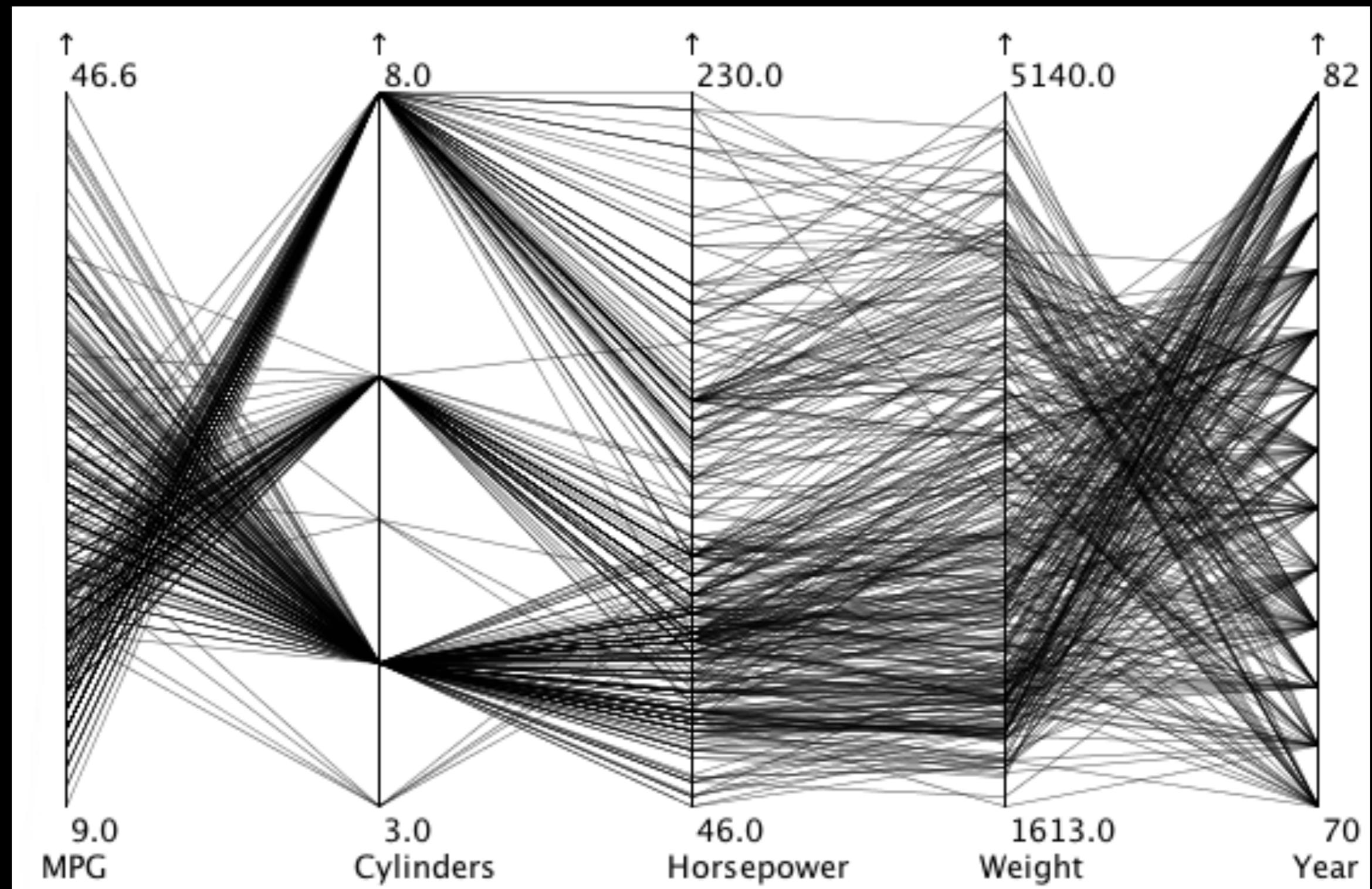
BRUSHING & LINKING SCATTERPLOTS



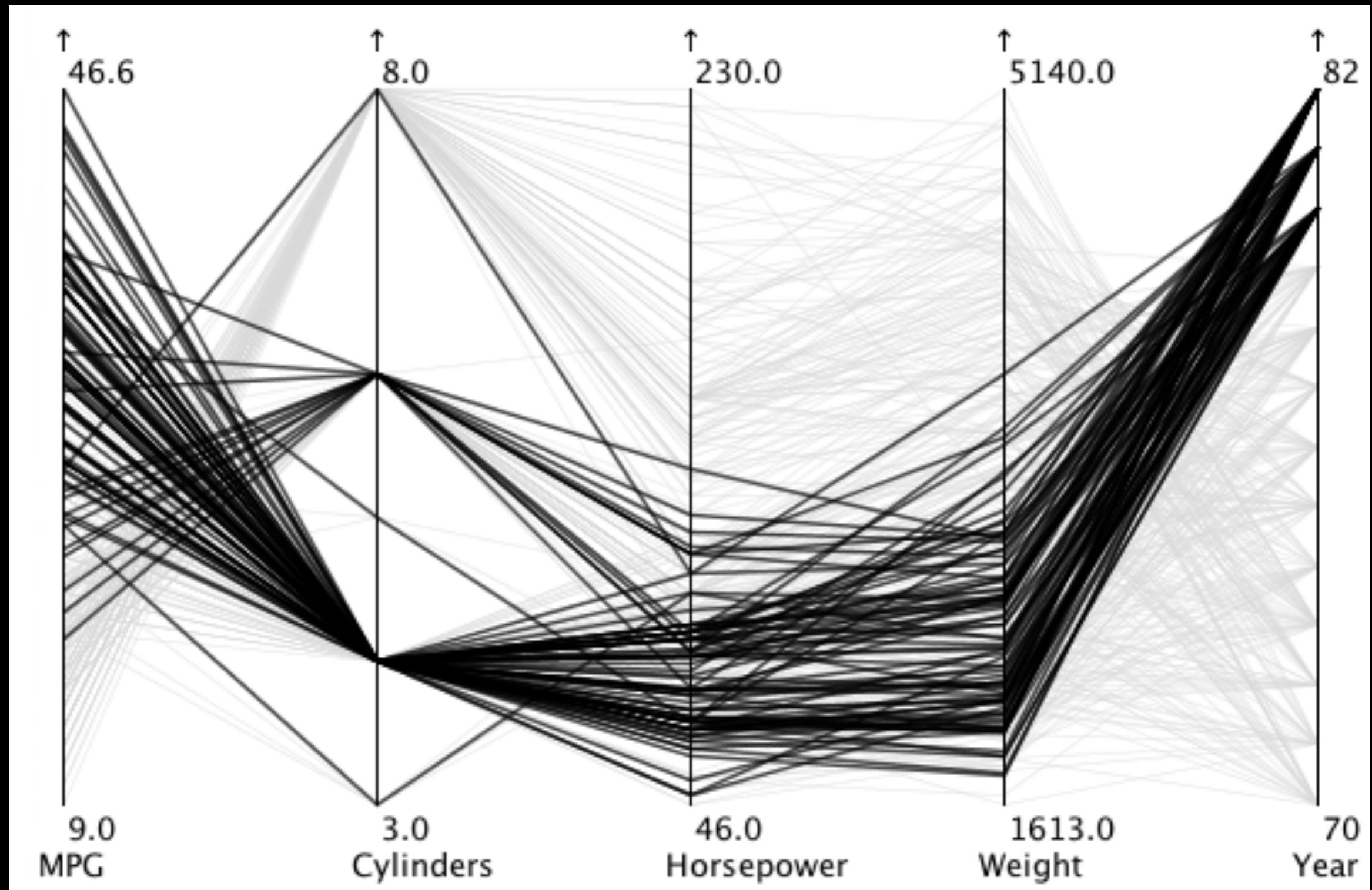
Beker and Cleveland, 1987

Voigt, 2002

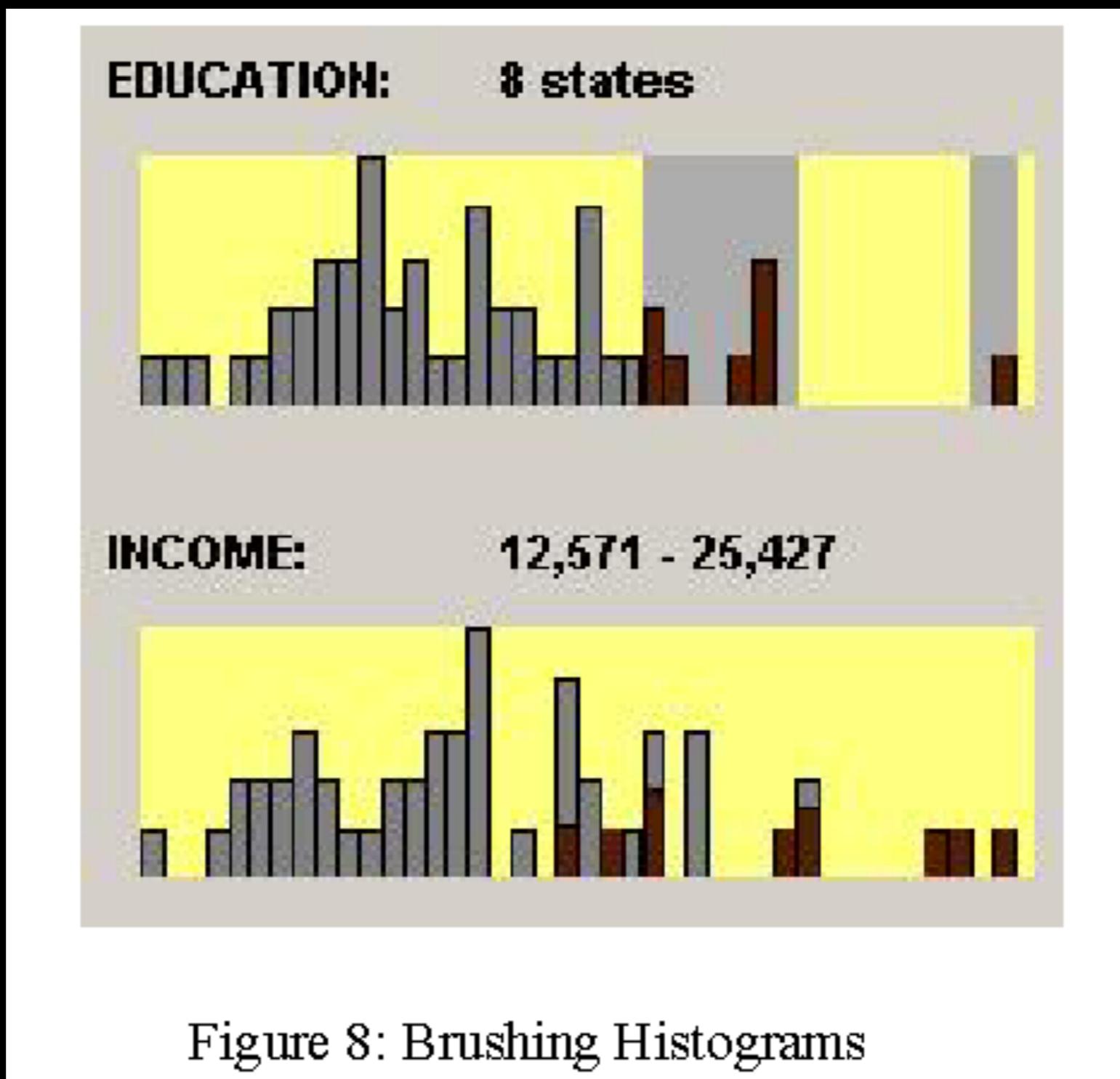
BRUSHING PARALLEL COORDINATES



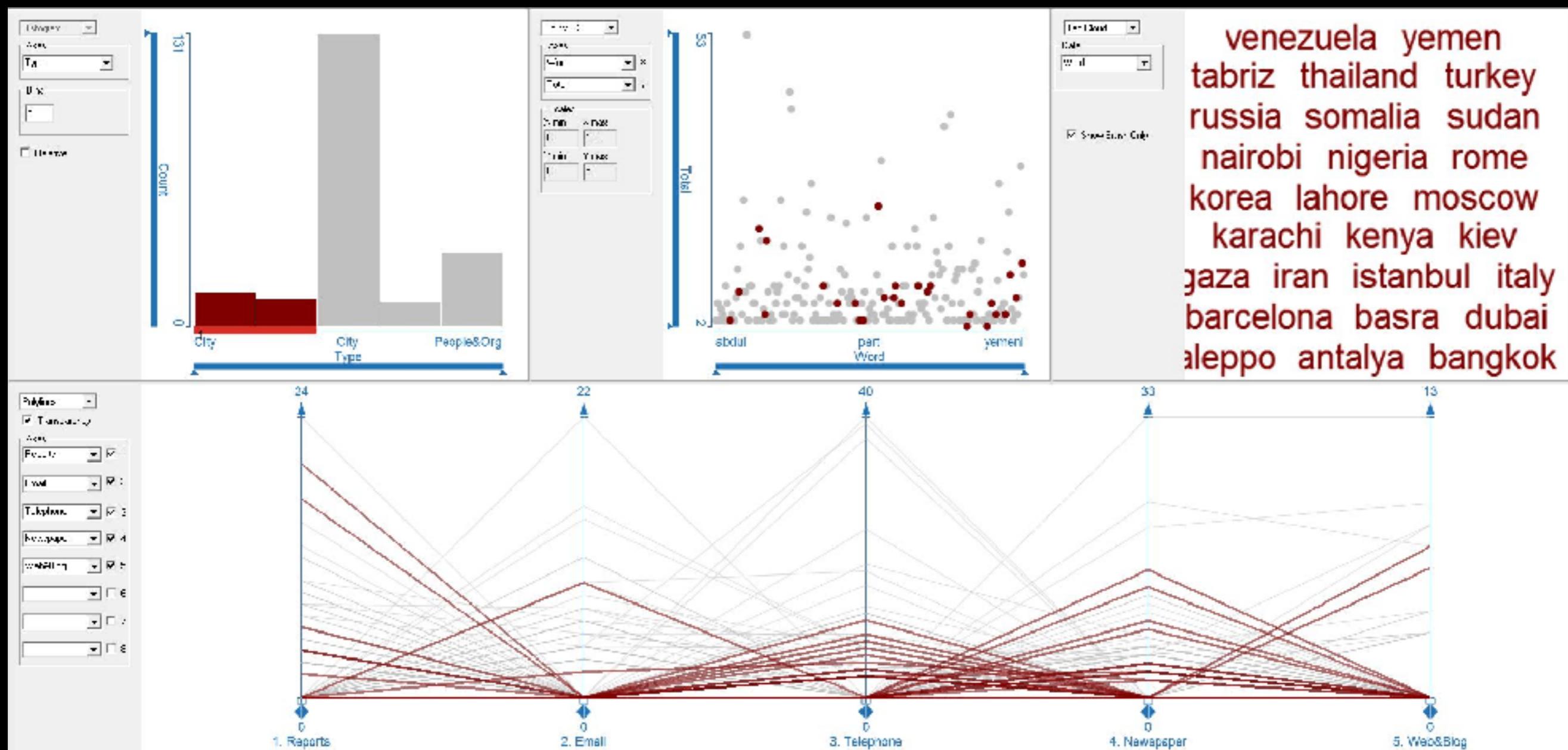
BRUSHING PARALLEL COORDINATES



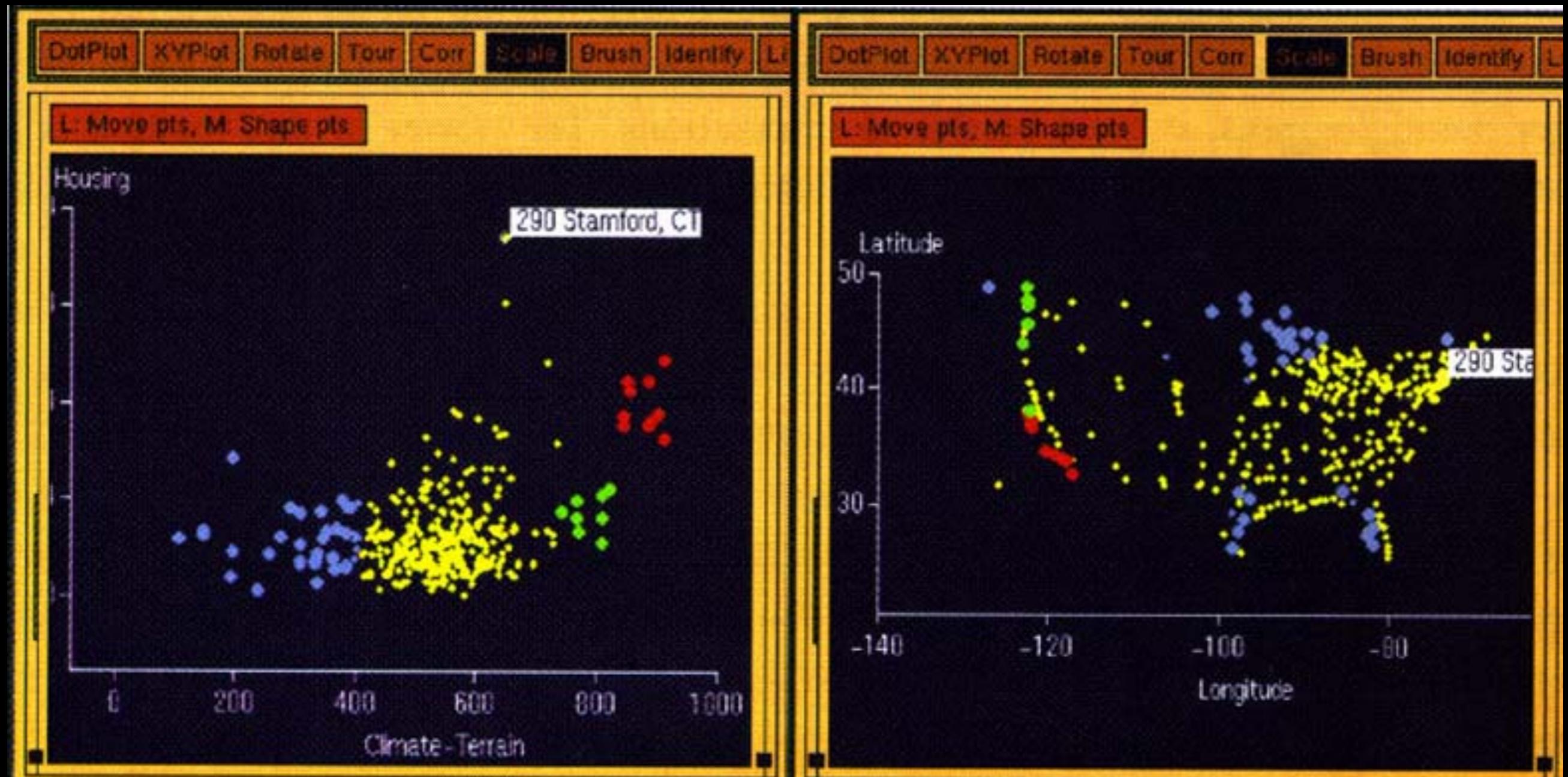
BRUSHING & LINKING HISTOGRAMS



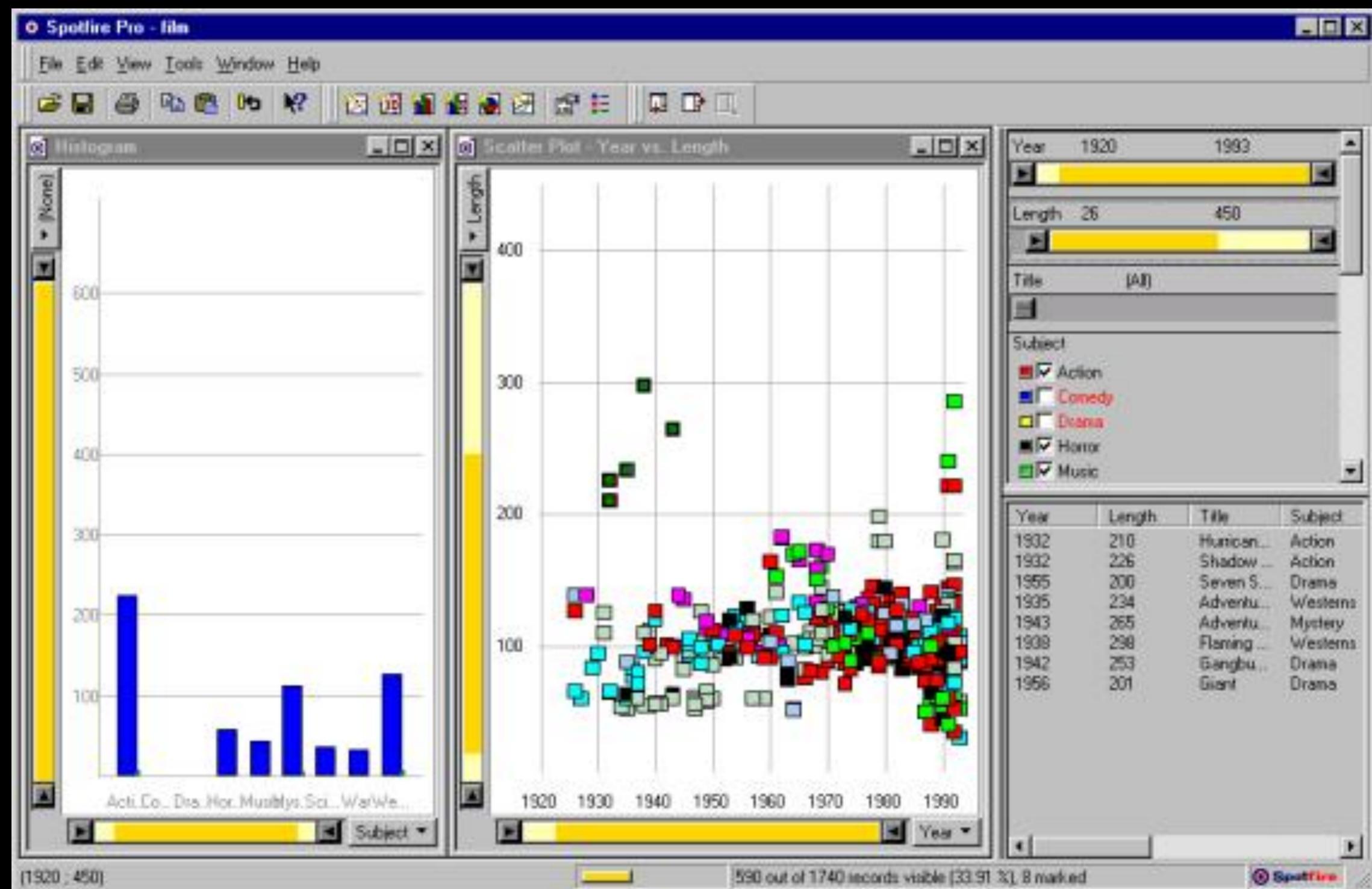
BRUSHING & LINKING EVERYTHING



COLOURED BRUSHING & LINKING



LINKING WITH DYNAMIC QUERIES



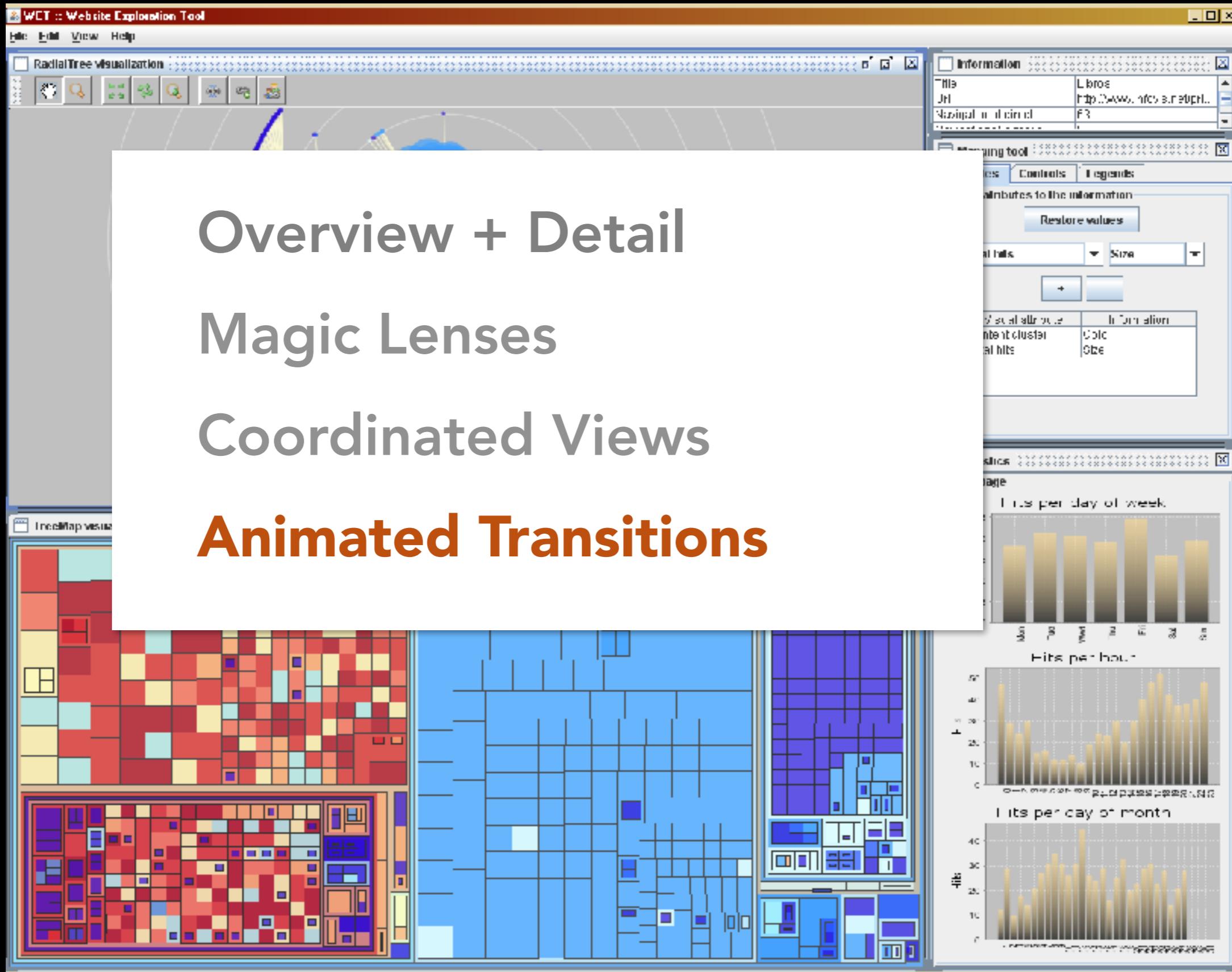
MULTIPLE VIEWS

Overview + Detail

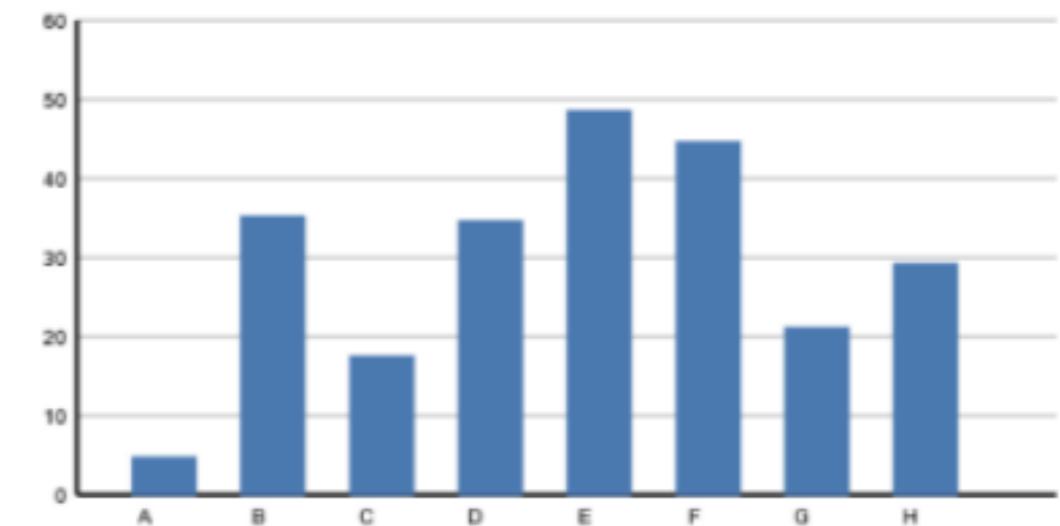
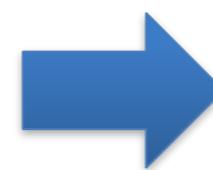
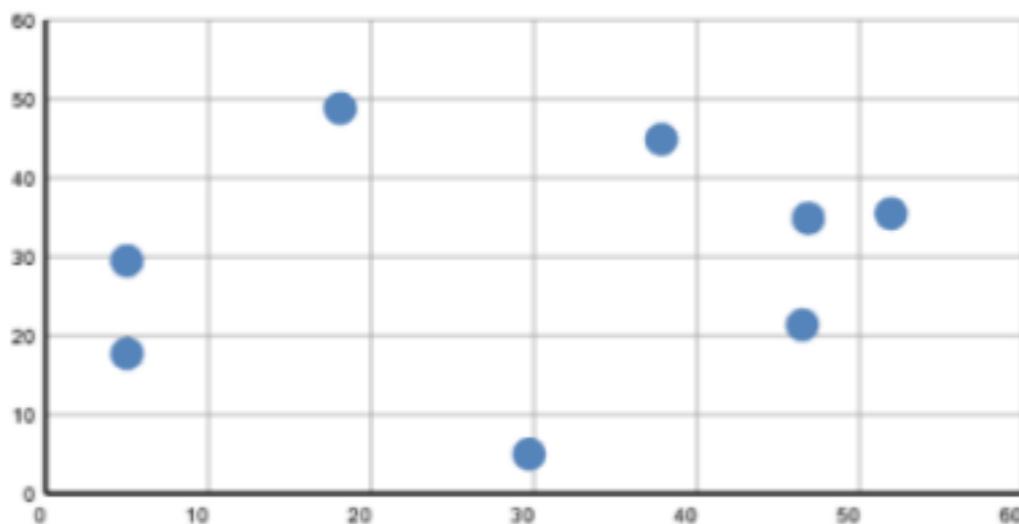
Magic Lenses

Coordinated Views

Animated Transitions

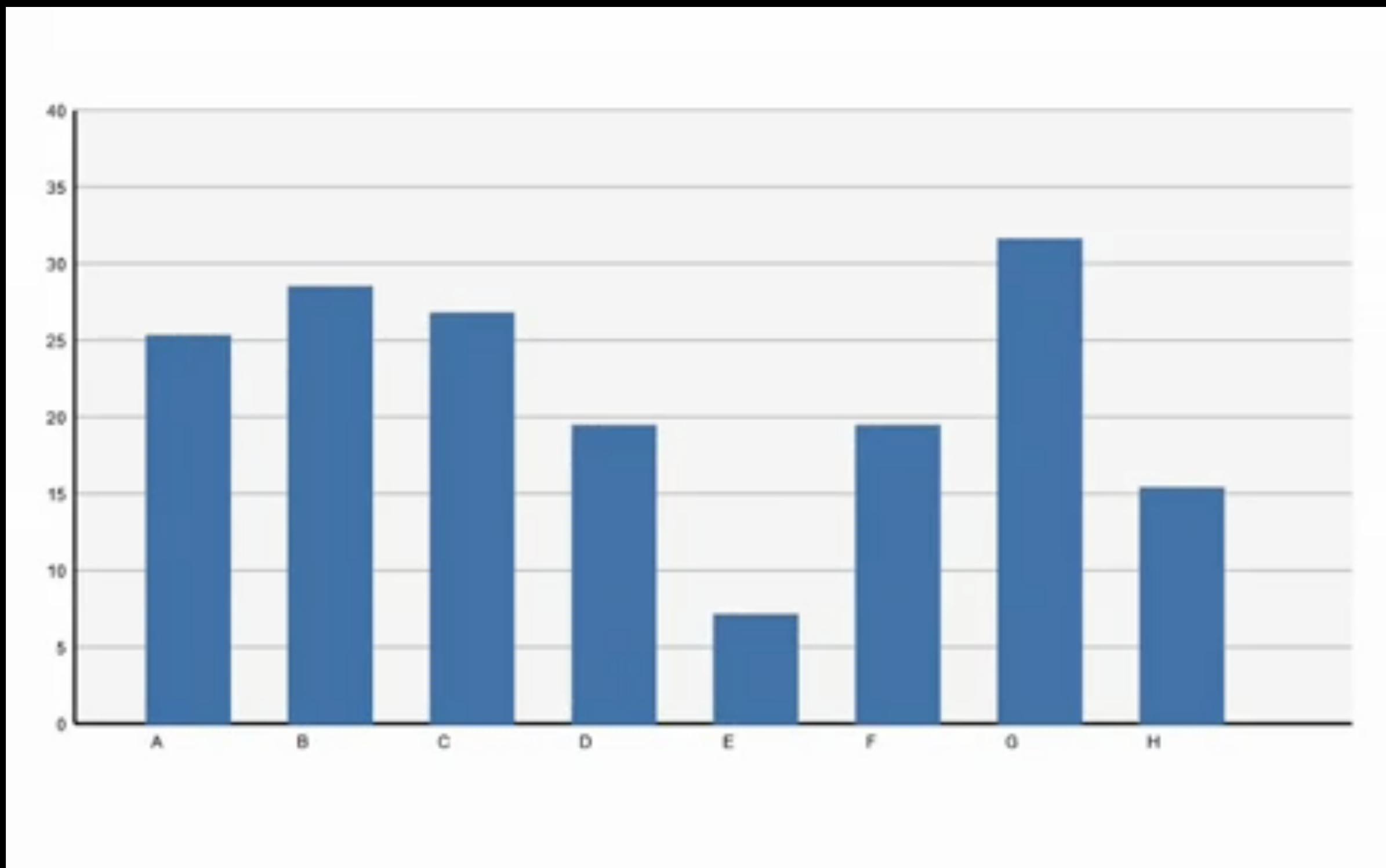


PROBLEM



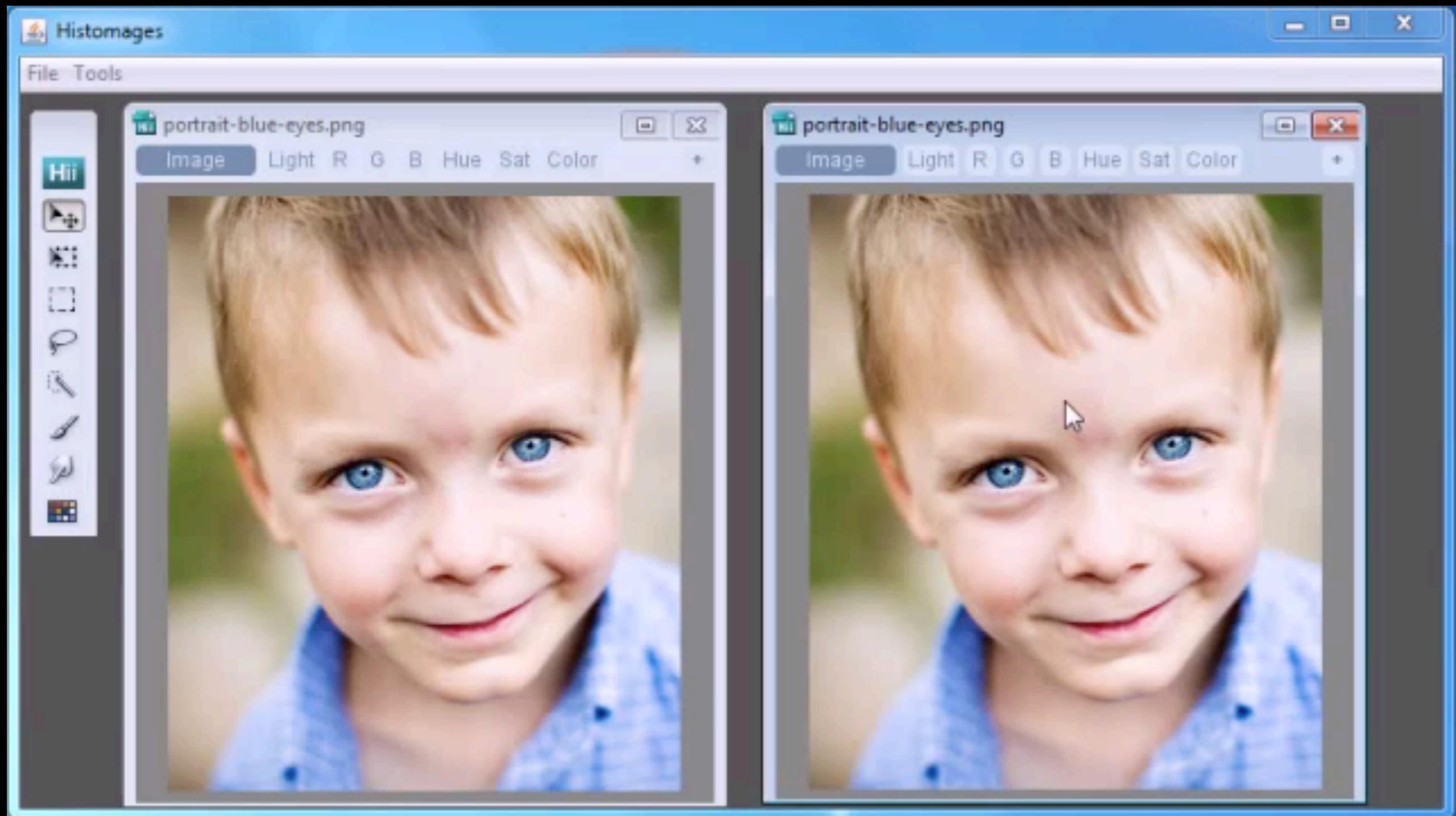
Heer and Roberston, 2007

ANIMATED TRANSITIONS



Heer and Roberston, 2007

ANIMATED TRANSITIONS + COORDINATED VIEWS



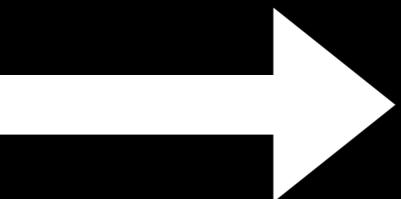
Histomages (Chevalier et al, 2012)

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

Multiple views



Overview + Detail
Magic Lenses
Coordinated Views
Animated Transitions

Rearrangement

FAMILIES OF INFOVIS INTERACTION TECHNIQUES

Filtering techniques

Navigation techniques

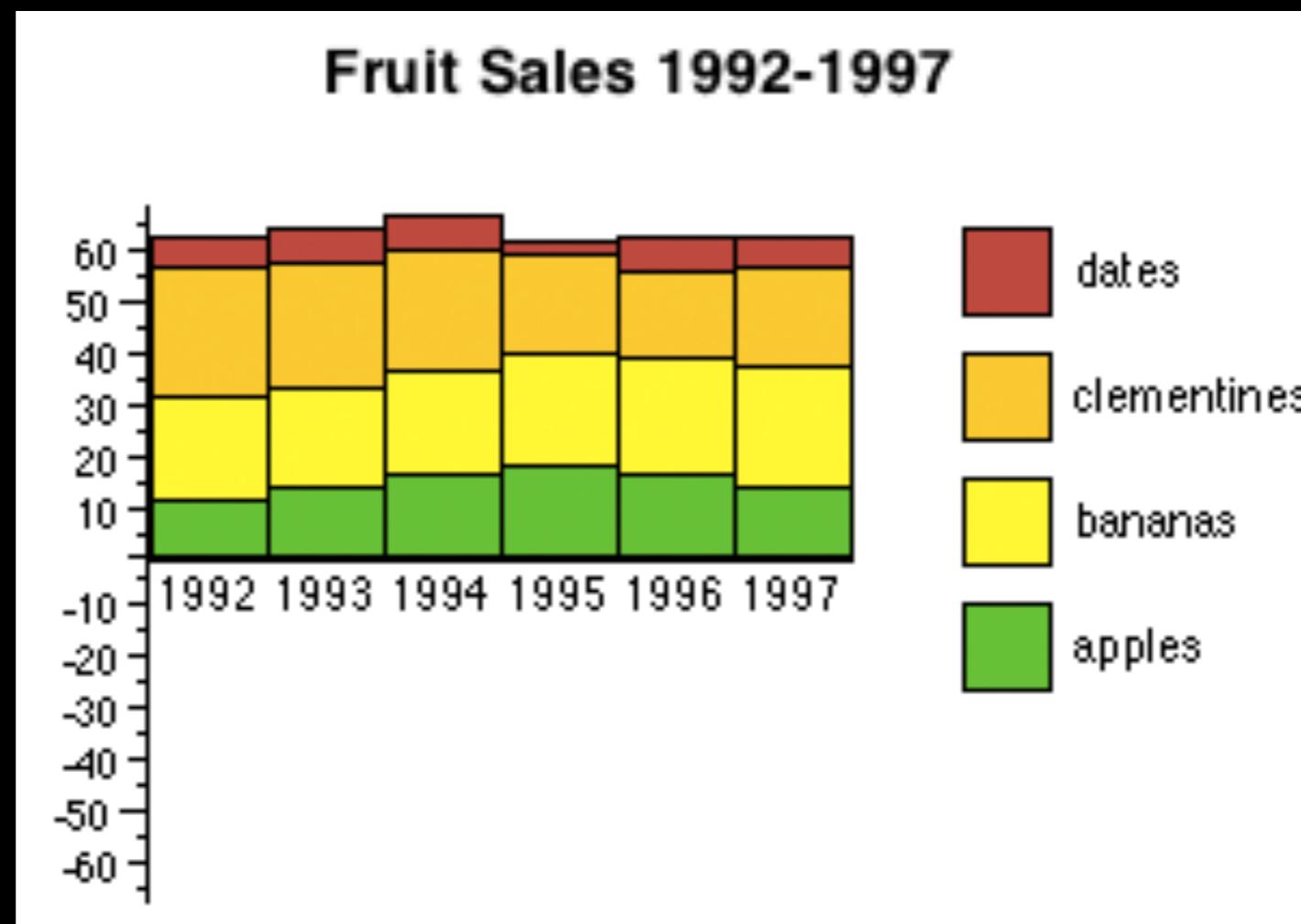
Multiple views

Rearrangement

REARRANGEMENT

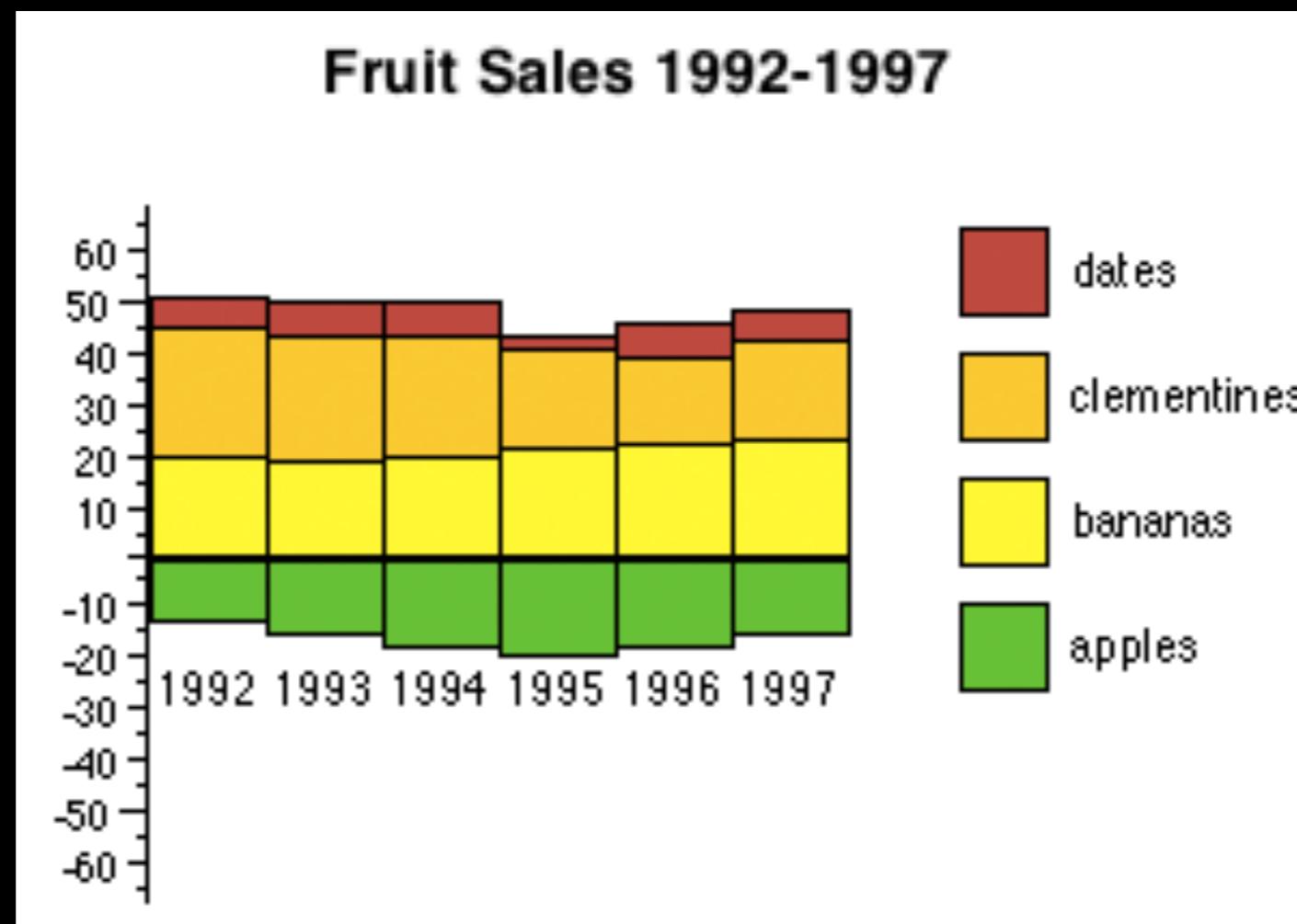
REARRANGEMENT

interactive stacked histogram



REARRANGEMENT

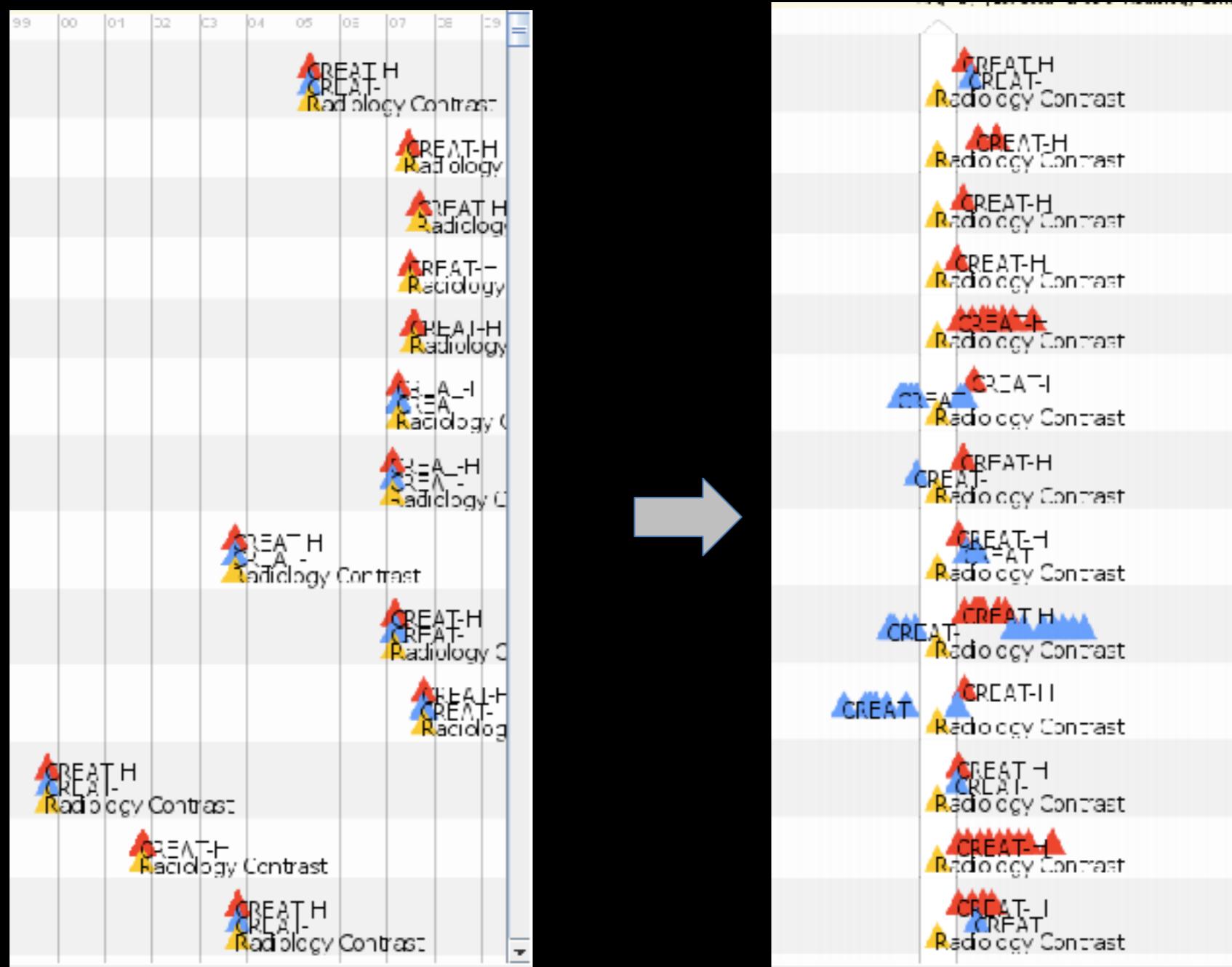
interactive stacked histogram



Dix and Ellis, 1998

REARRANGEMENT

time-series alignment



REARRANGEMENT

Sorting

Inxight Table Lens - [foremost.txt]

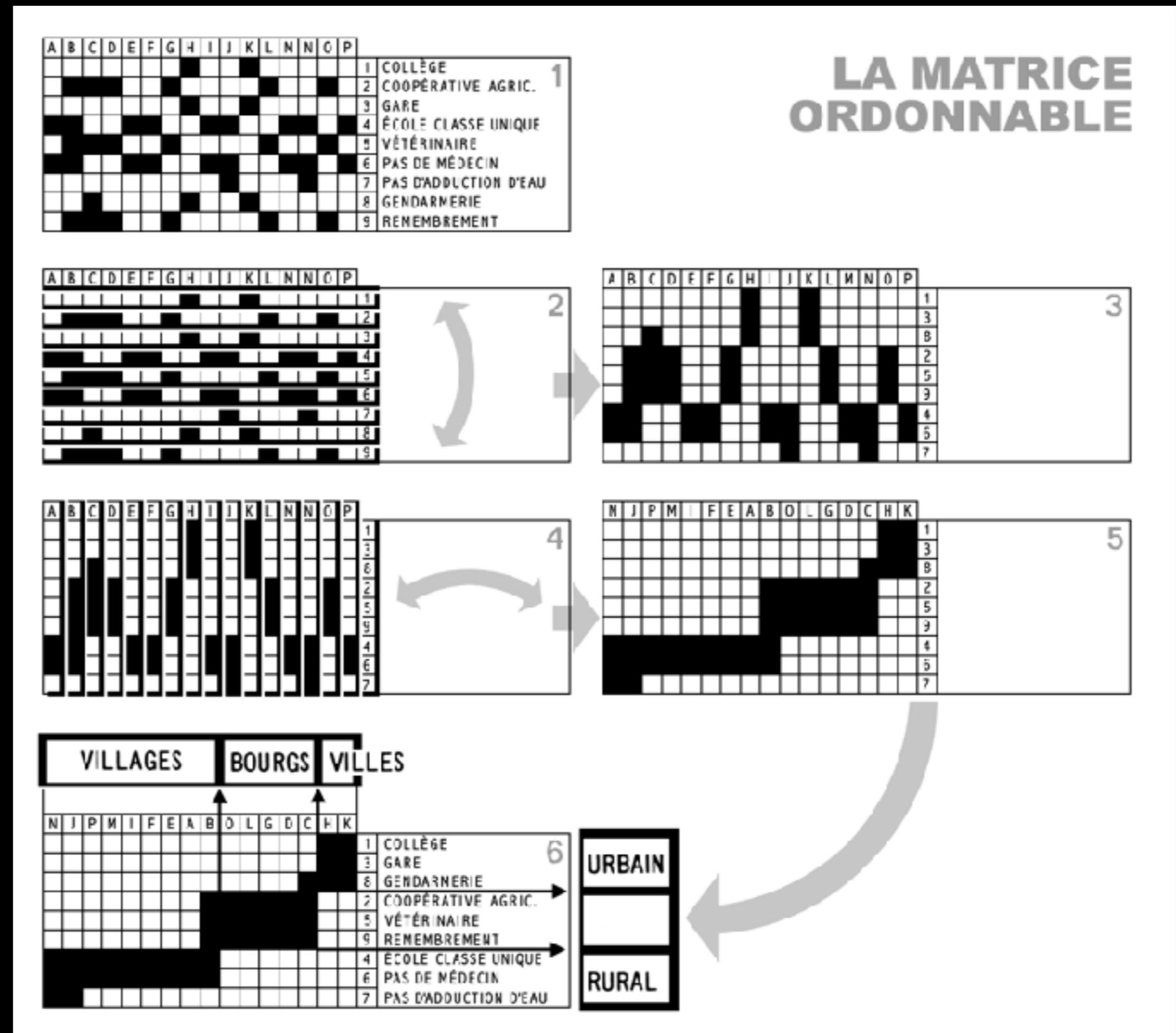
File Edit View Tools Options Window Help

inxight

	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

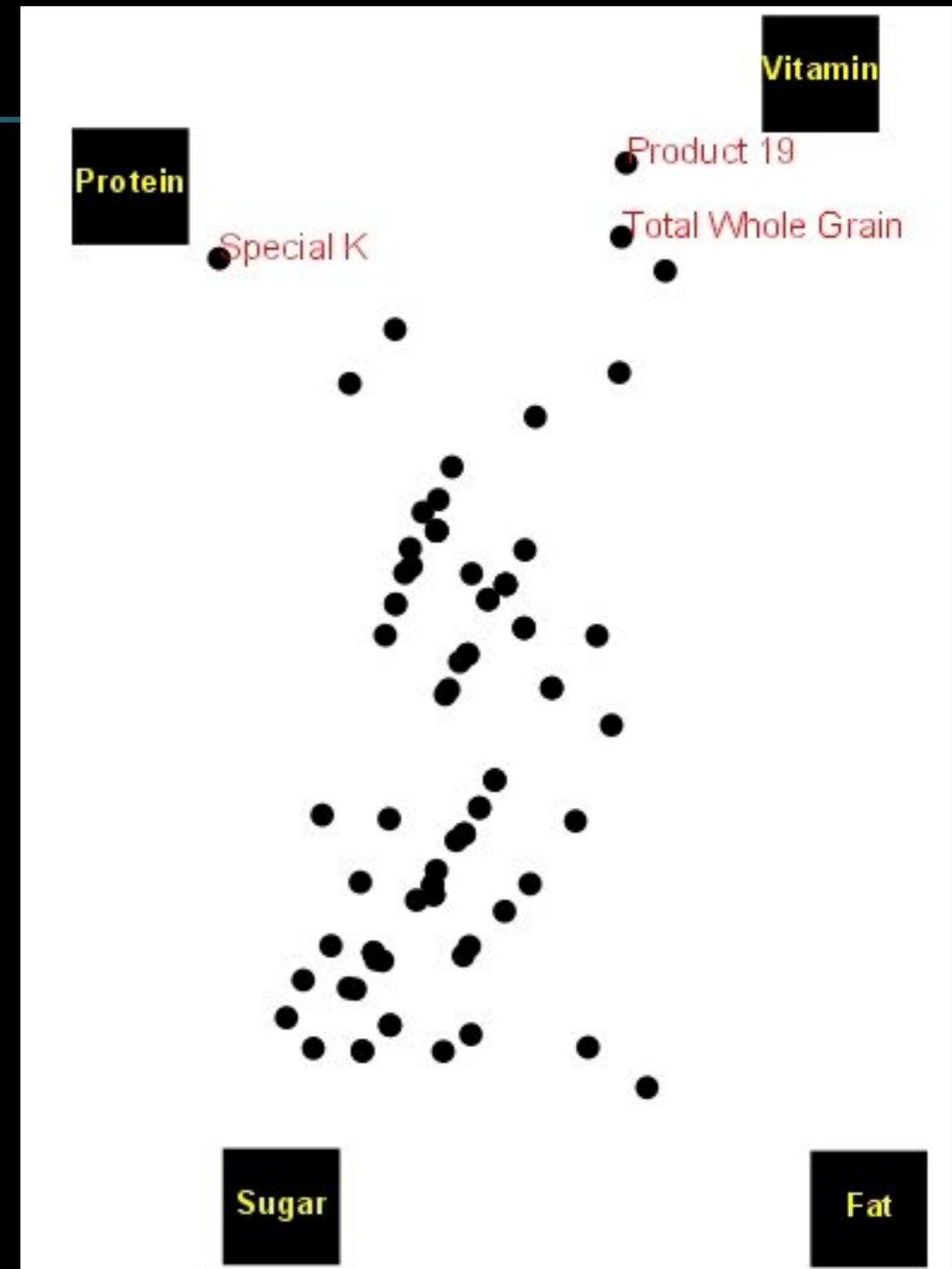
REARRANGEMENT

Matrix Reordering



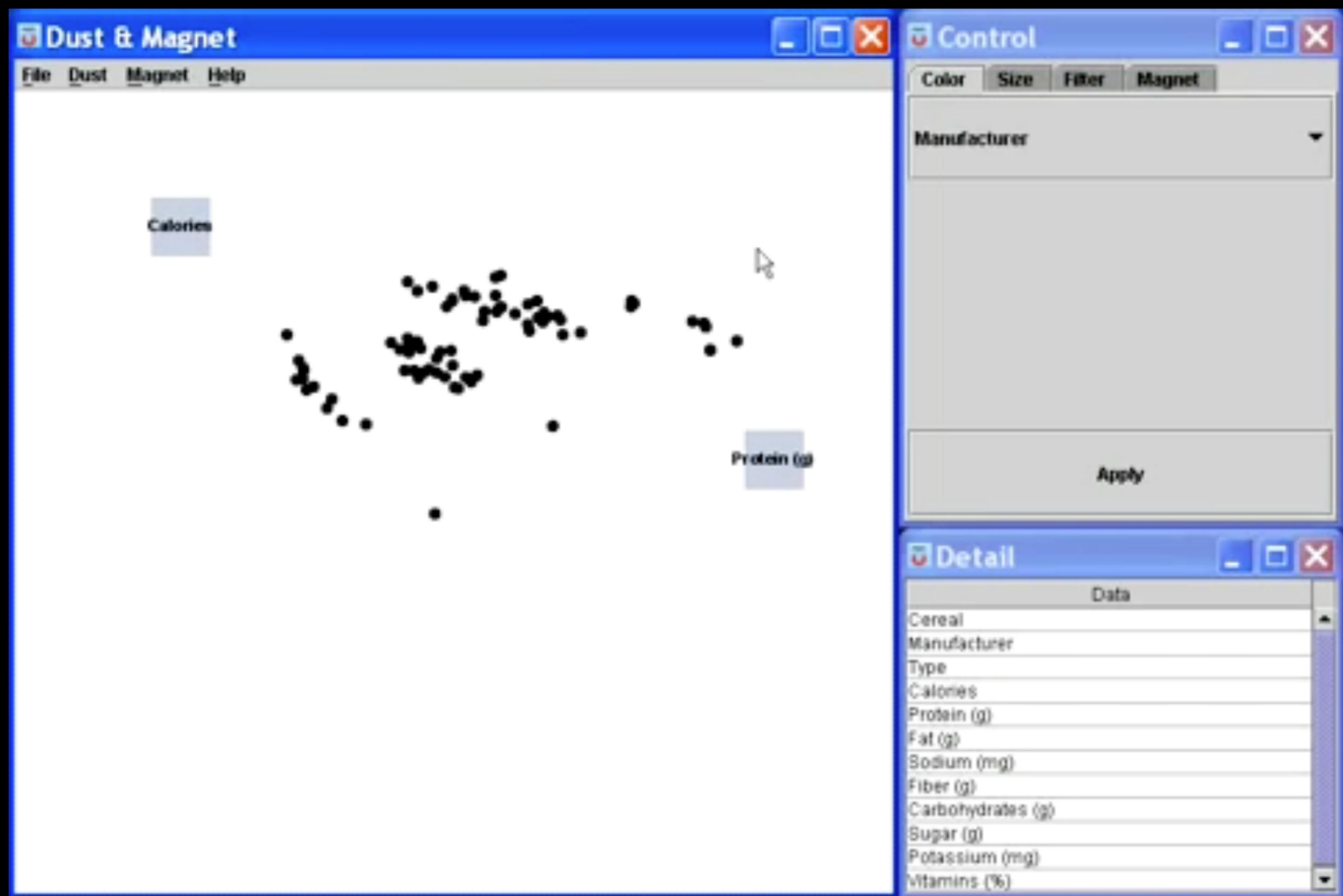
REARRANGEMENT

Dust and Magnet



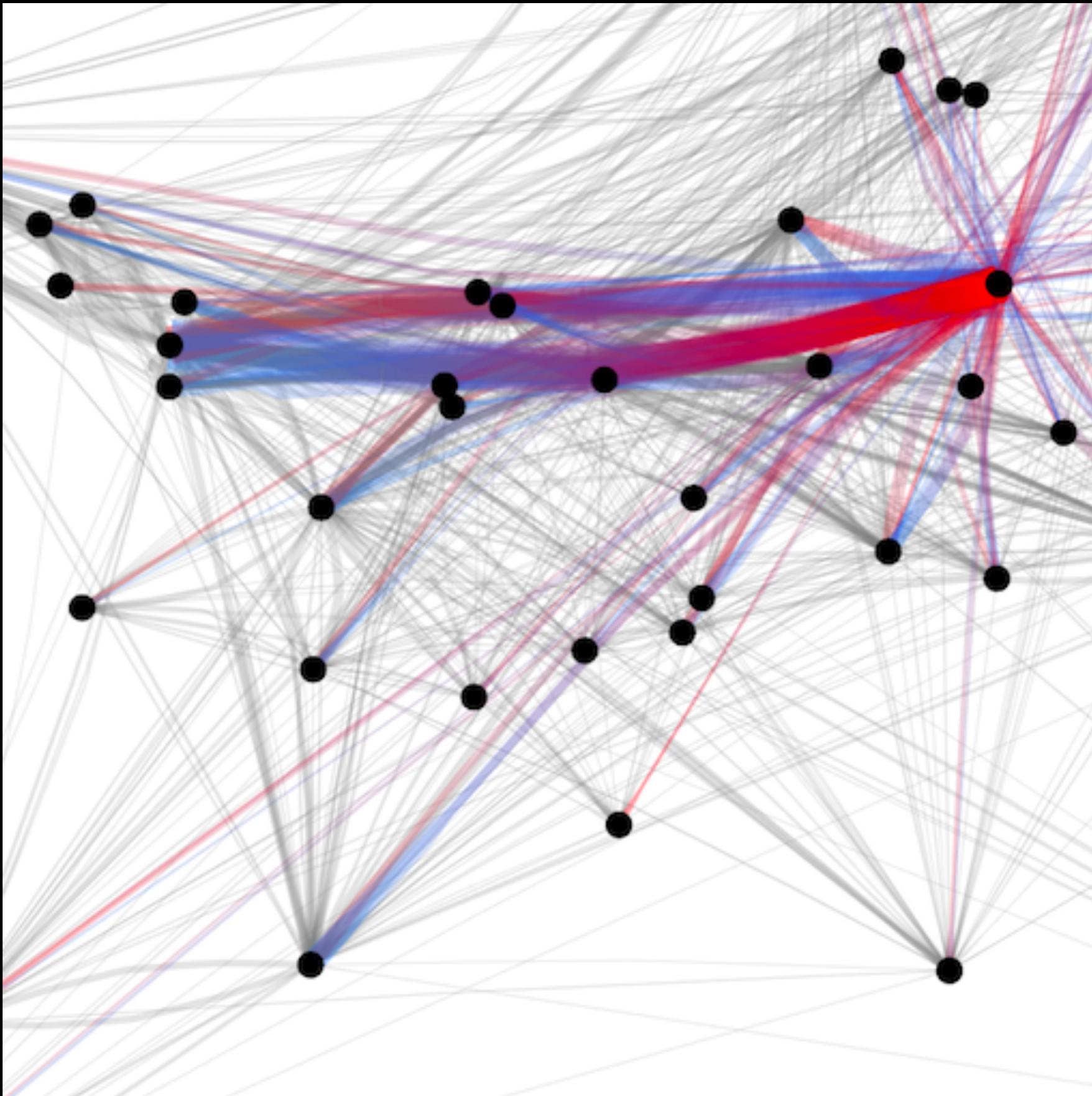
Yi et al, 2005

REARRANGEMENT



PITFALLS

#1. INTERACTION CANNOT FIX BAD VISUALIZATIONS

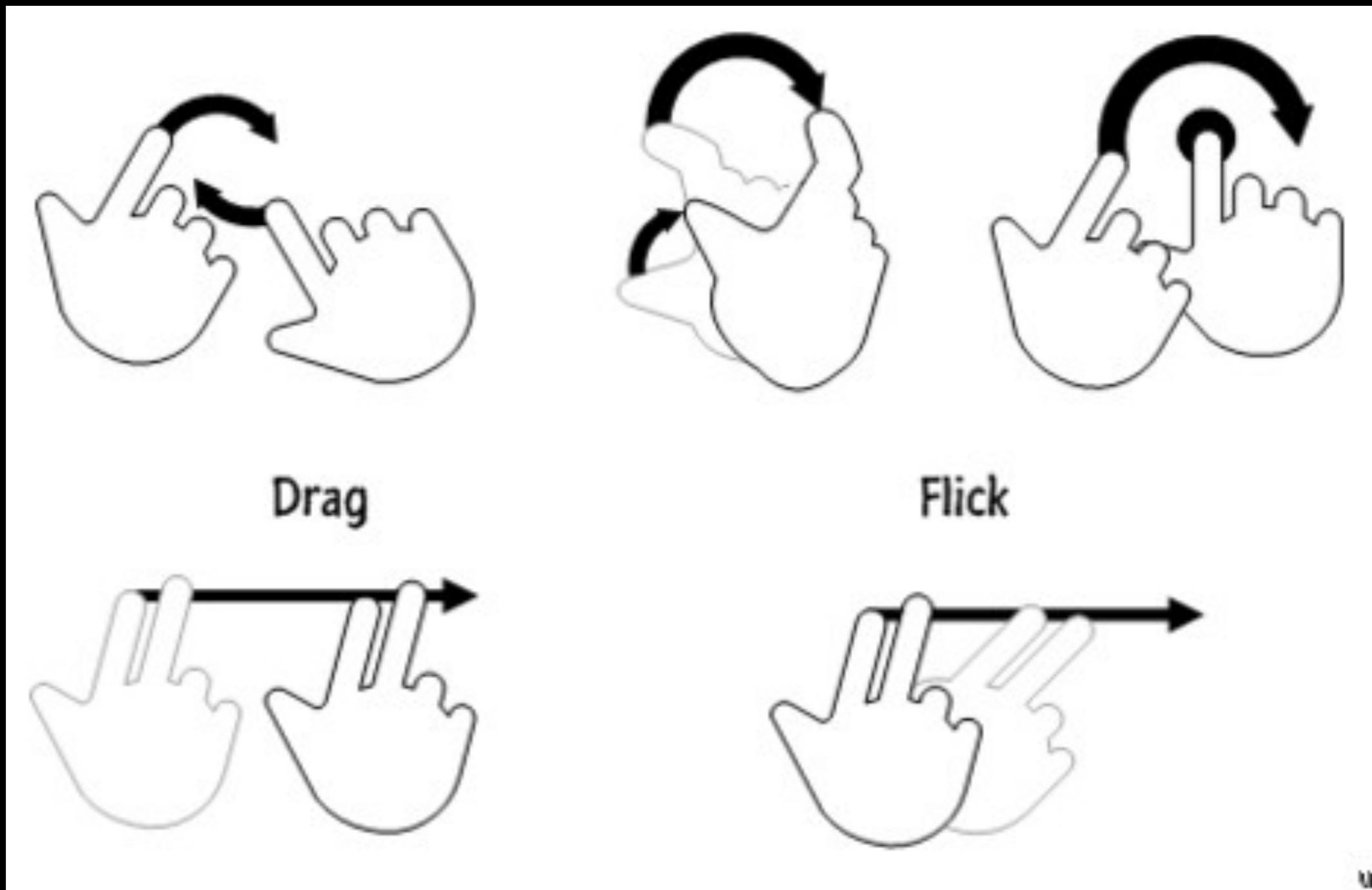


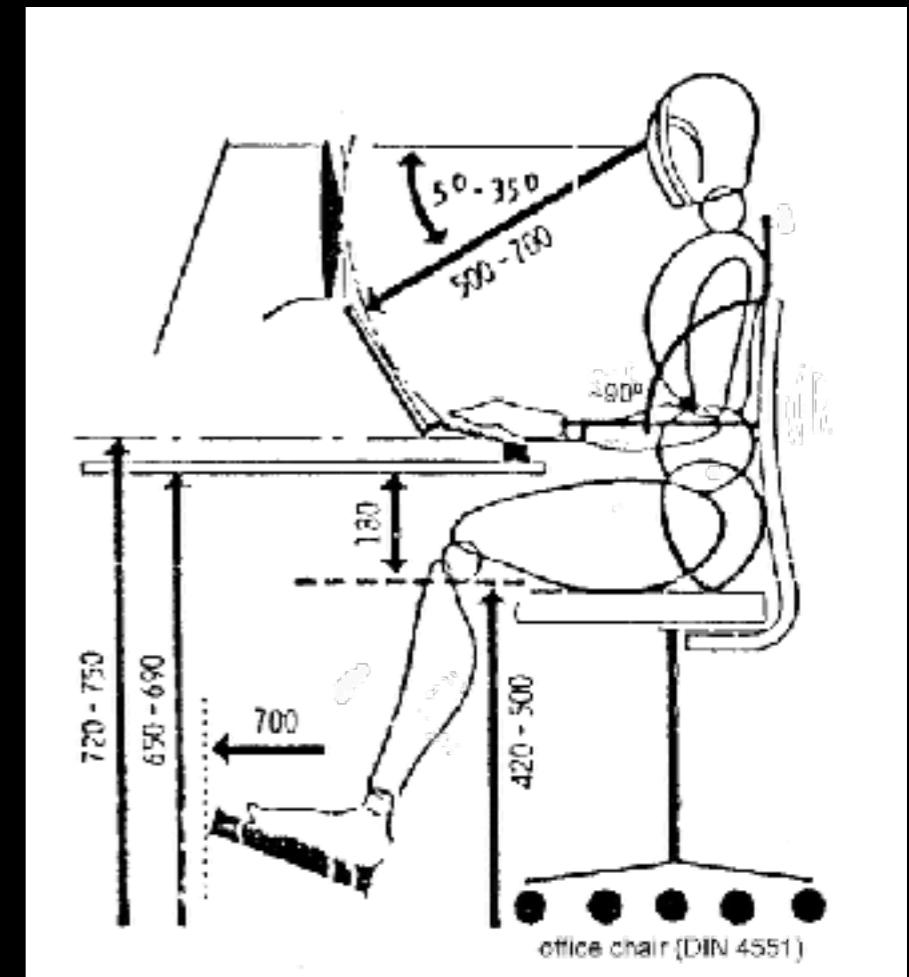
#2. CONTROLS TAKE SCREEN REAL-ESTATE

The image displays six screenshots of software interfaces, likely from a visualization or data analysis tool, arranged in a 2x3 grid. Each interface shows a complex set of controls, including dropdown menus, checkboxes, sliders, and lists, which occupy a significant portion of the screen.

- Top Row:**
 - Left:** A table of properties with tabs for Layout, Excentric, Fisheyes, Rulers, and Visual. The Visual tab is active, showing fields for XAxisColumn, YAxisColumn, dataBounds, fisheye, format, interactor, itemRenderer, margin, name, orientation, parent, and permutation.
 - Middle Left:** A panel with tabs for Layout, Excentric, Fisheyes, and Rulers. The Excentric tab is active, containing sections for Radius (with a slider), Max Labels (with a slider), and checkboxes for Enable Excentric Labels and Opaque Labels.
 - Middle Right:** A panel with tabs for Layout, Excentric, Fisheyes, Rulers, and Visual. The Visual tab is active, showing a 'HDC' section with tabs for Filtered, Selected, and Unselected, and a 'Show All' button. Below are sections for Dimensions, Effective pixels, Low resolution, Macro focus range, Max resolution, and Name, each with a corresponding histogram-like visualization.
 - Right:** A panel with tabs for Layout, Excentric, Fisheyes, Rulers, and Visual. The Visual tab is active, showing sections for Alpha (dropdown), Default % (slider), Area (dropdown), Default % (slider), Orientation (radio buttons for North, West, Center, East, South), Rendercolor (dropdown), and a 'Default Color' button. It also includes Smooth (checkbox), Color (dropdown), and another 'Default Color' button.
- Bottom Row:**
 - Left:** A panel with tabs for Layout, Excentric, Fisheyes, Rulers, and Visual. The Visual tab is active, showing a 'Rulers' section with a 'No selection' message and fields for Lens Radius (slider) and Shape Tolerance (slider).
 - Middle:** A panel with tabs for Layout, Excentric, Fisheyes, and Rulers. The Rulers tab is active, showing a 'Visible' checkbox, an Alpha dropdown (set to (None)), and a Default % slider.
 - Right:** A panel with tabs for Layout, Excentric, Fisheyes, Rulers, and Visual. The Visual tab is active, showing sections for Weight (inc. batteries), Zoom tele (T), and Zoom wide (W), each with a histogram-like visualization.

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





BEYOND THE DESKTOP

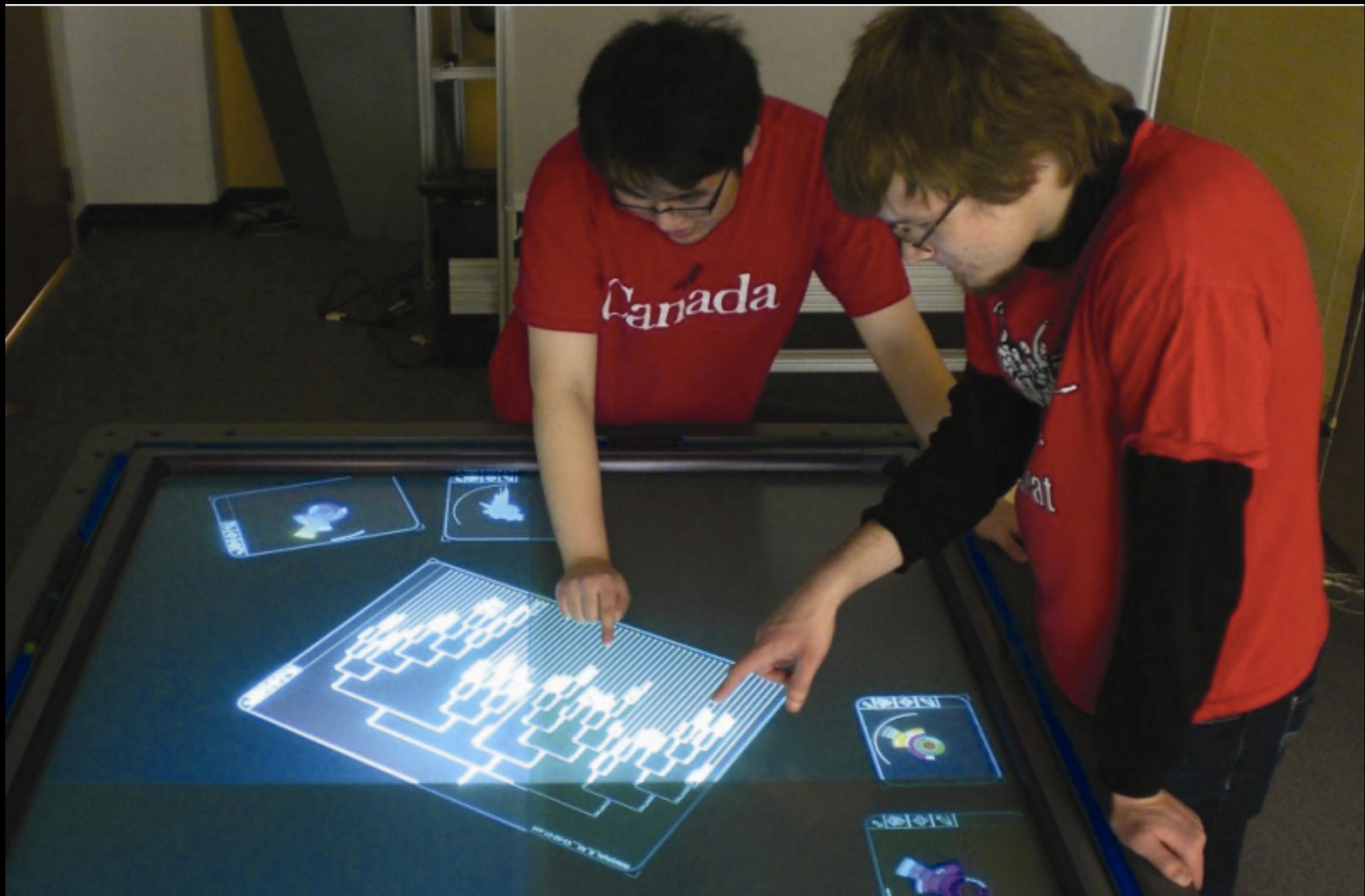
TOUCH DEVICES



Sadana and Stasko, 2013

Sadana and Stasko, 2013

TABLETOP DEVICES



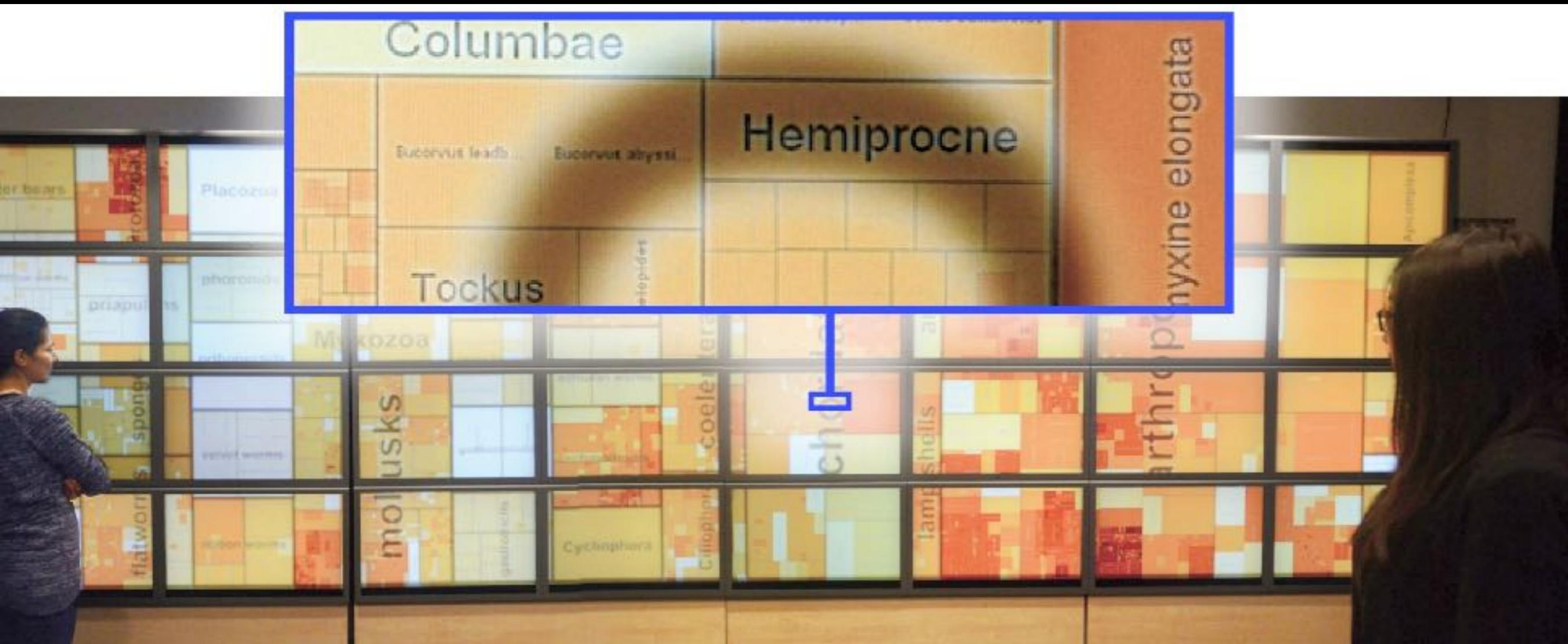
Isenberg and Carpendale, 2008

WALL-SIZED DISPLAYS

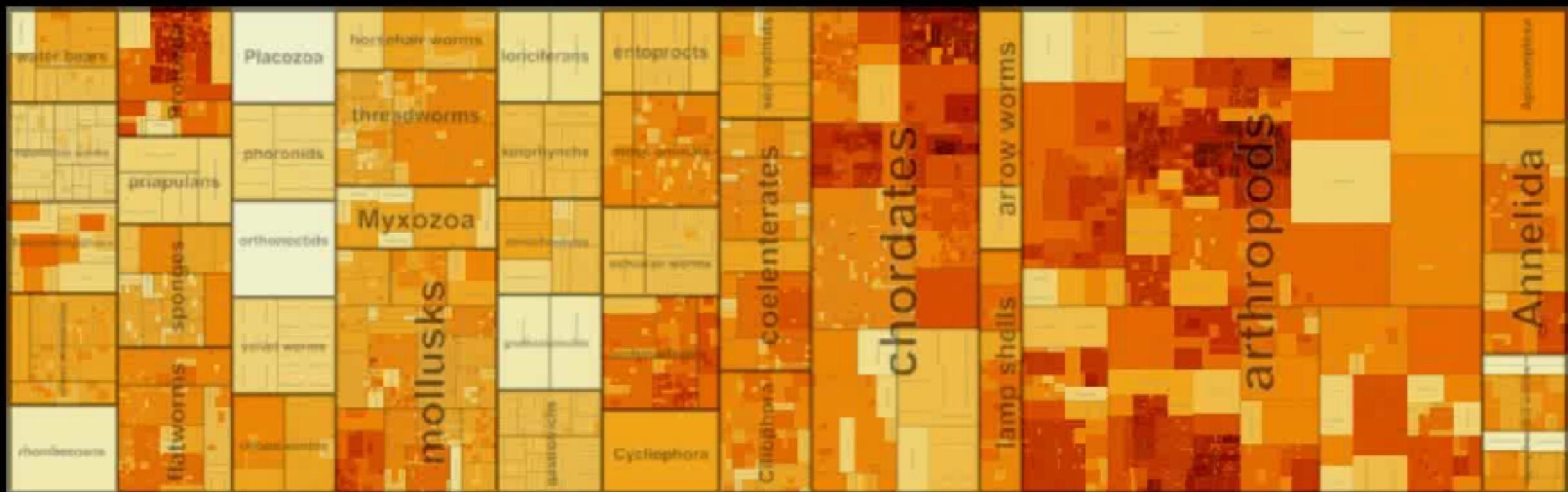


WILD Display - Digiscope

WALL-SIZED DISPLAYS

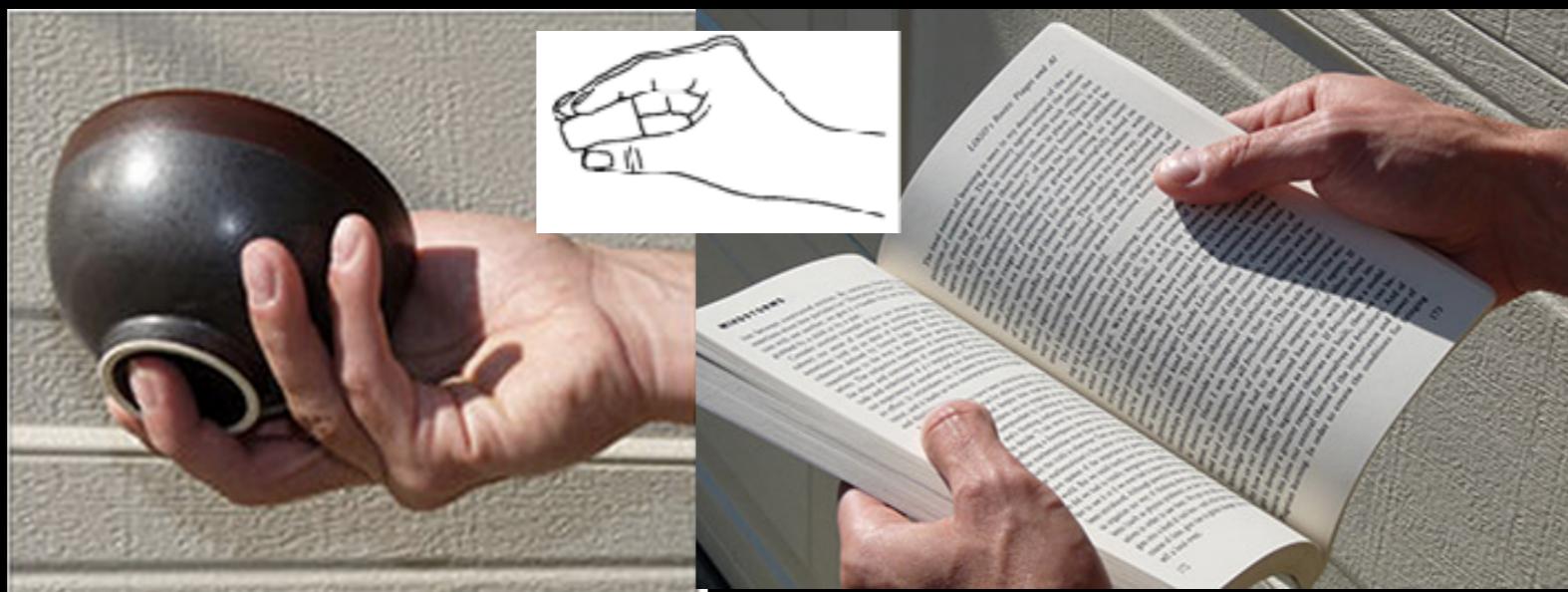
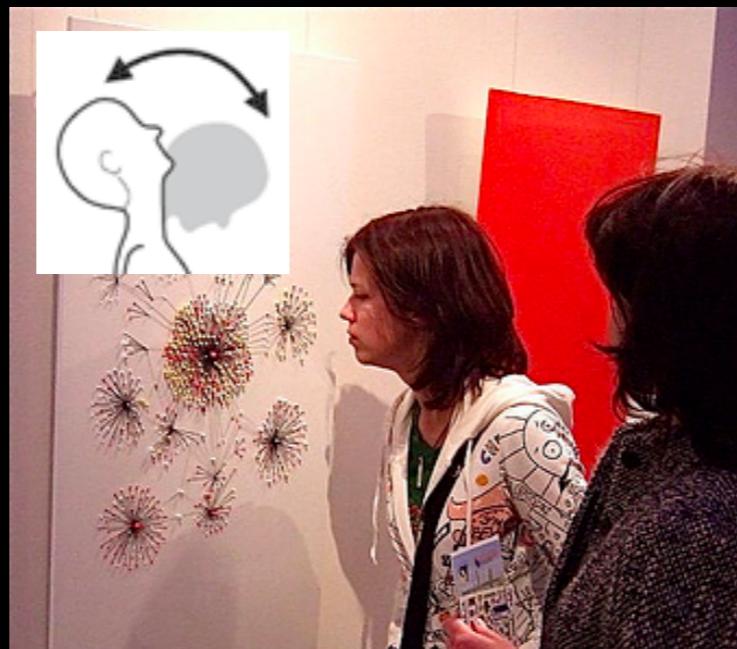


[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis'13]

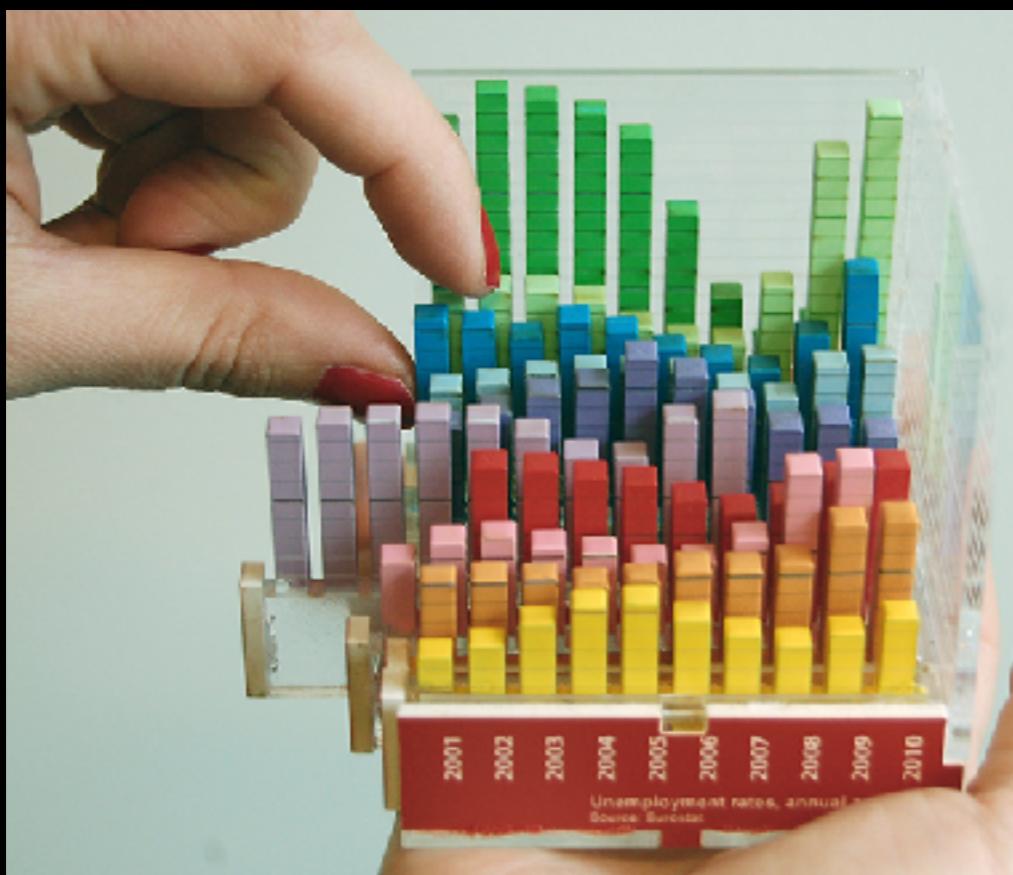
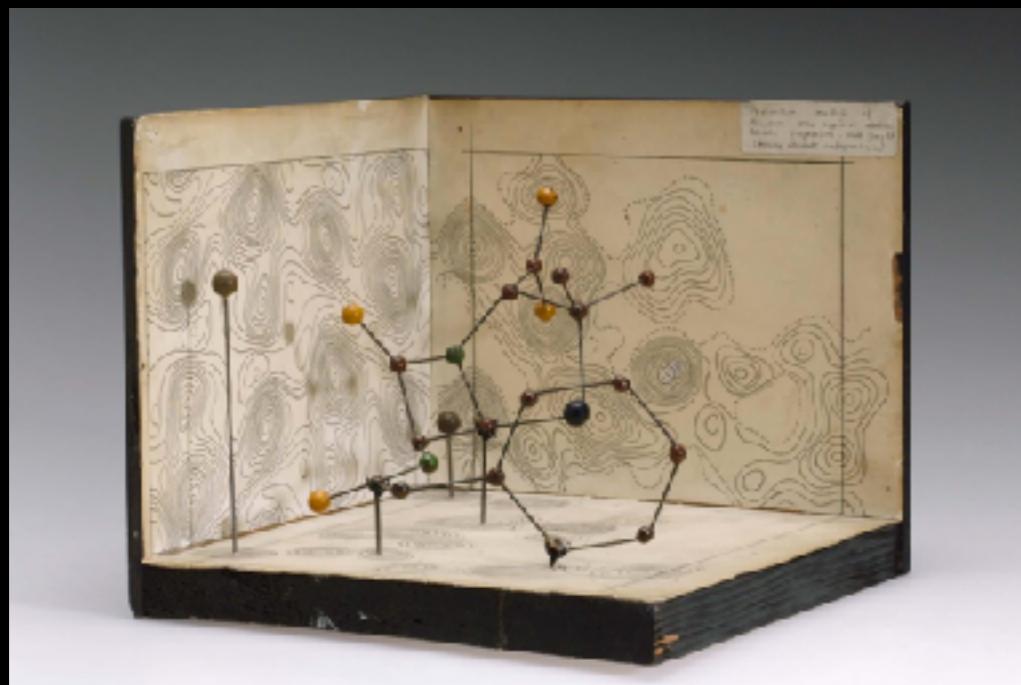


[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis'13]

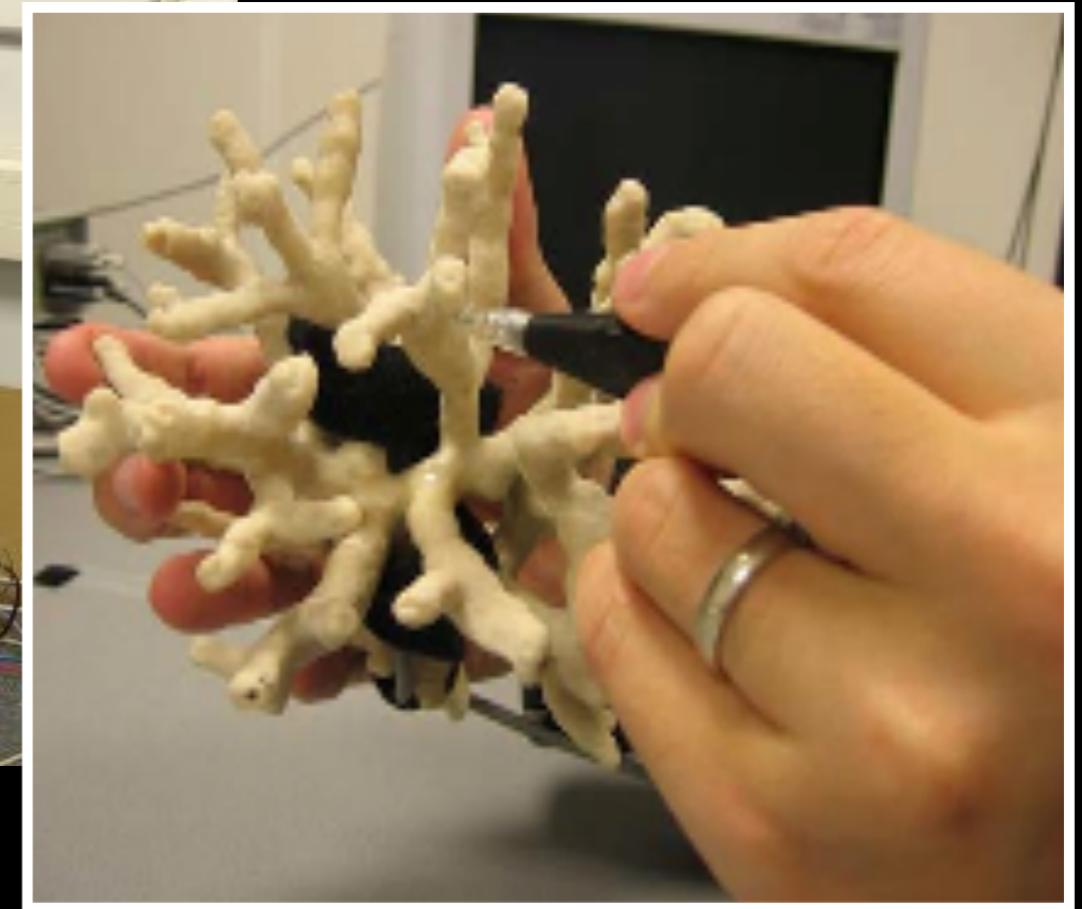
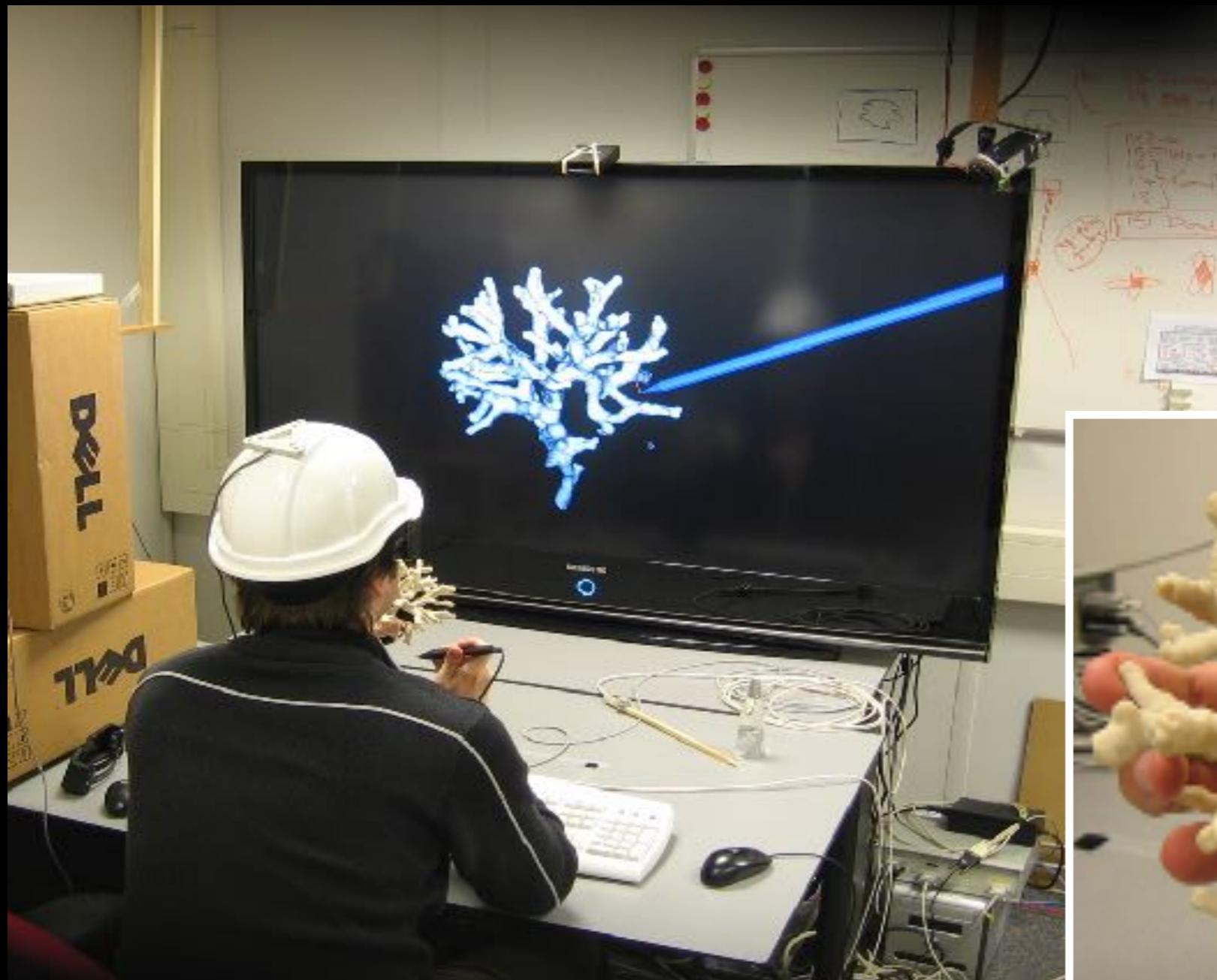
INTERACTION WITH THE PHYSICAL WORLD



PHYSICAL VISUALIZATIONS



HYBRID SYSTEMS



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

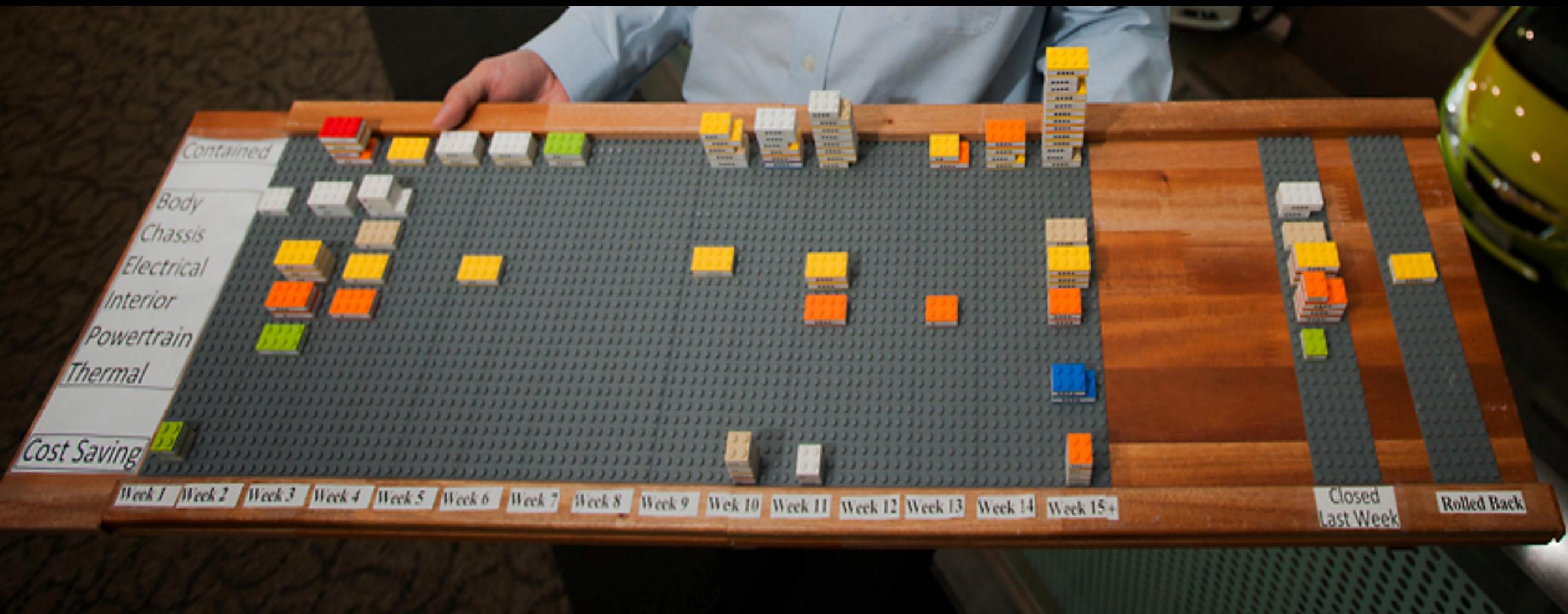
HYBRID SYSTEMS



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]