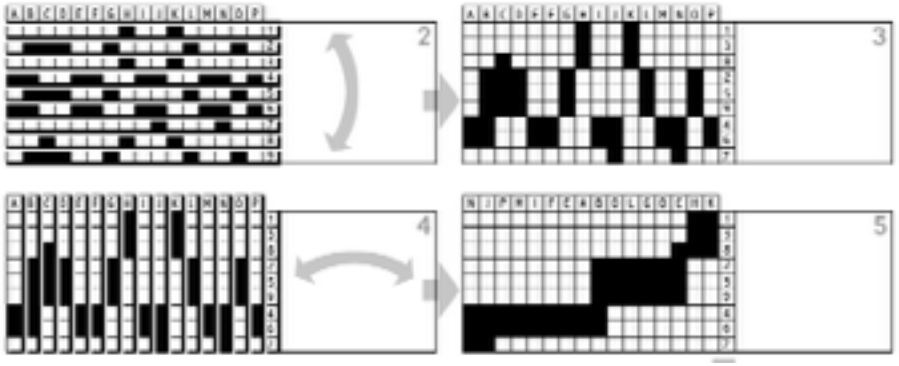
Interaction

Information Visualization 2015-2016

Pierre Dragicevic, Inria



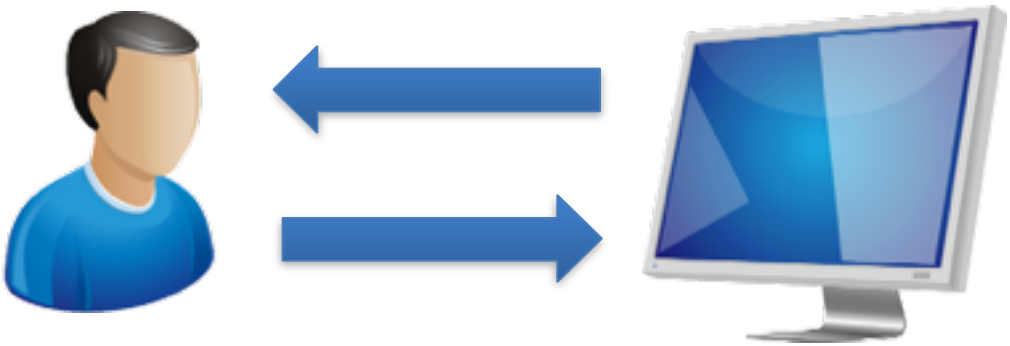
Thanks to **Jean-Daniel Fekete**, **John Stasko** and **Yvonne Jansen** for sharing some slides

Interaction

- This is the topic of this Master!

Interaction

- This is the topic of this Master!

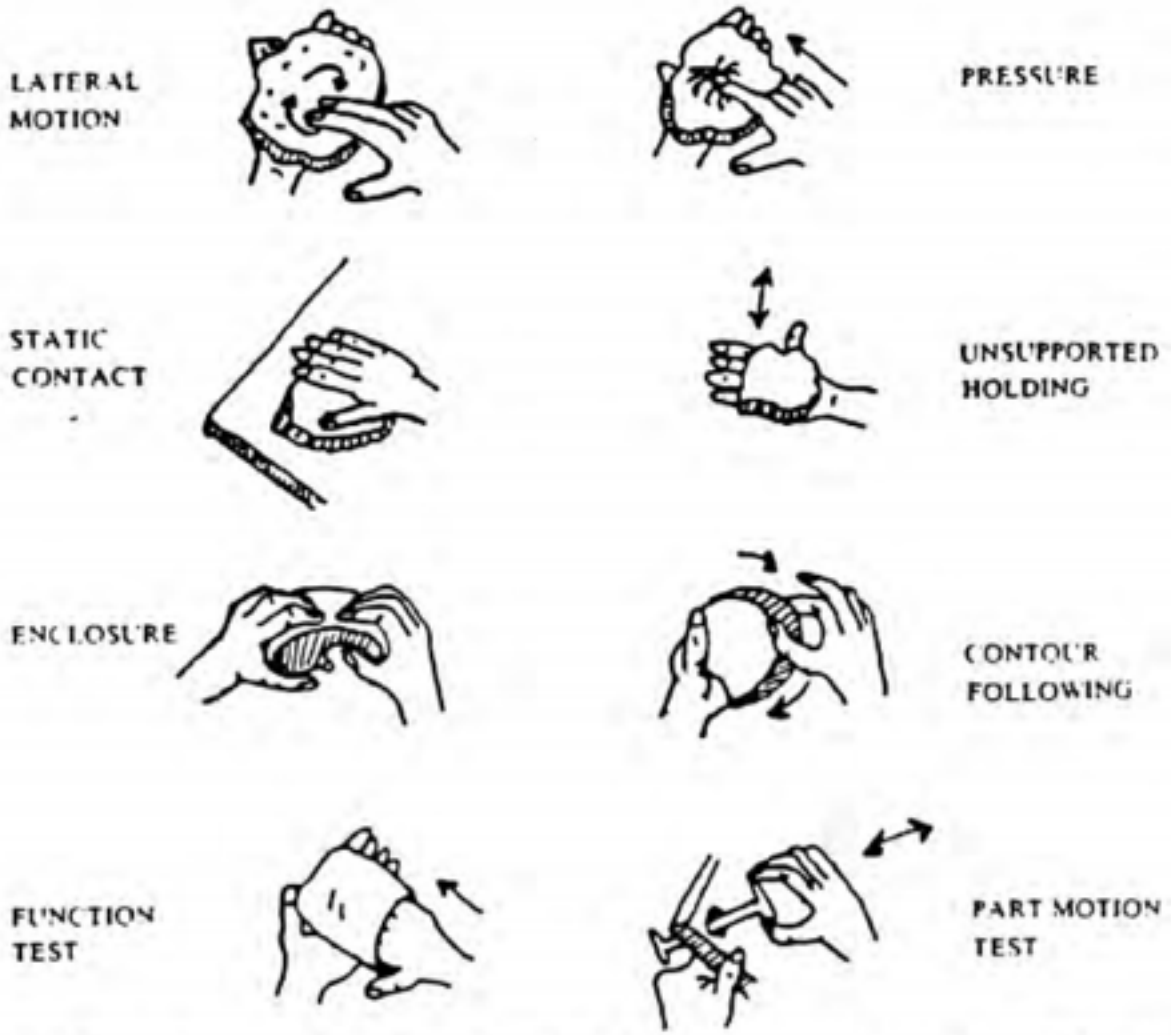


- HCI mostly focuses on input
  - Output for affordances & feedback
- Infovis mostly focuses on output
  - Input for steering output

Active Perception

Active Perception

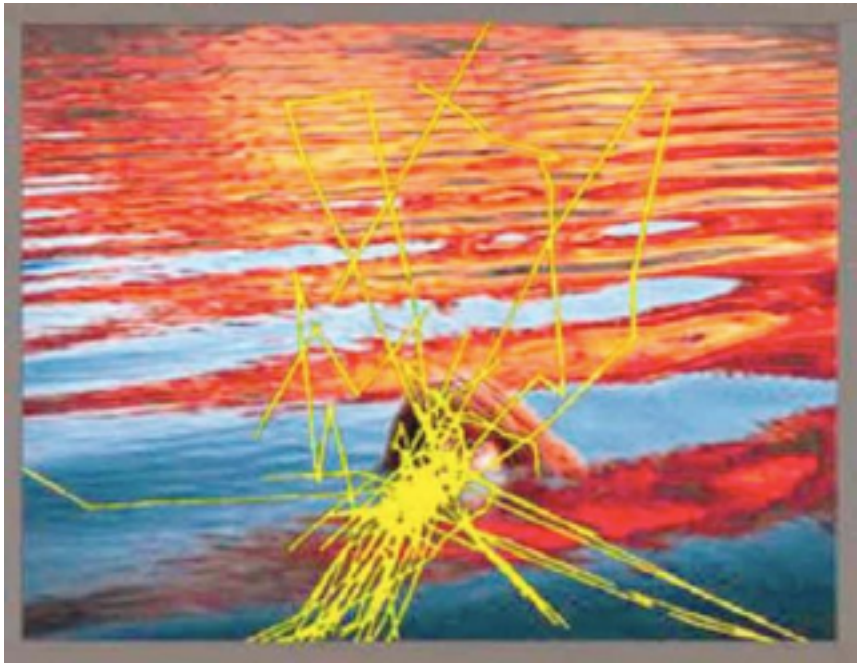
- Perception requires action



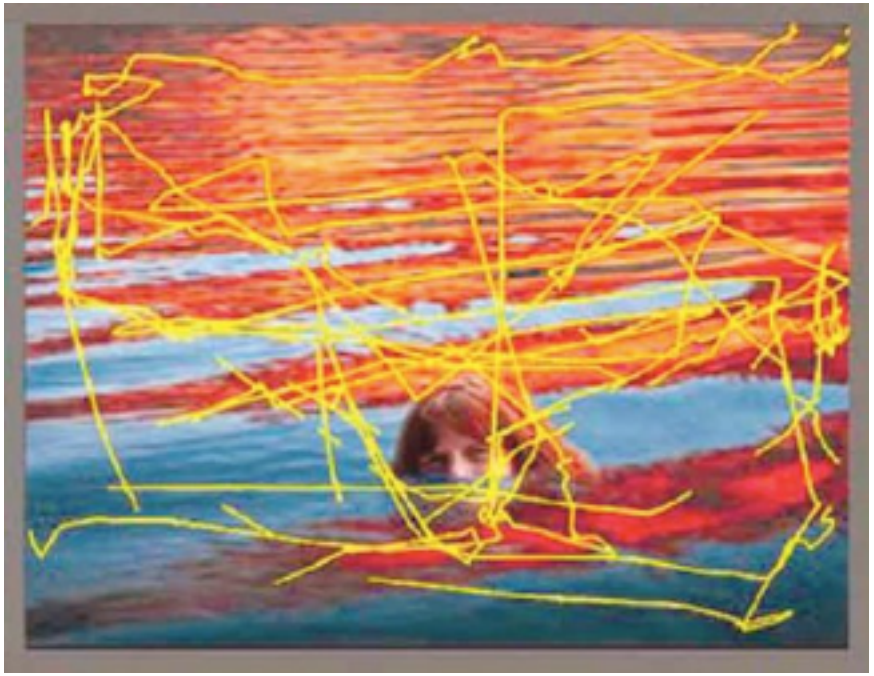
Lederman and Klatzky, 1987 (link)

Active Perception

- Perception requires action



Eye movements of a layperson



Eye movements of an artist

Vogt and Magnussen 2007 (link)

Active Perception

- Perception requires action

Valdis Krebs (link)

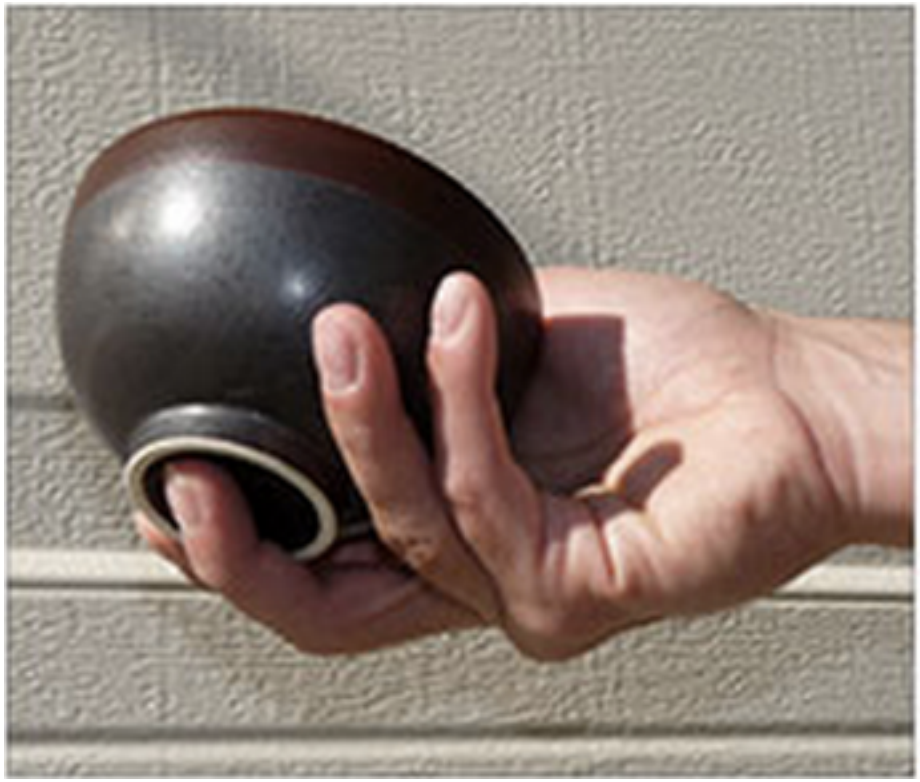
Active Perception

- Perception requires action

Photo appaloosa (link)

Active Perception

- Perception requires action



Bret Victor (link)

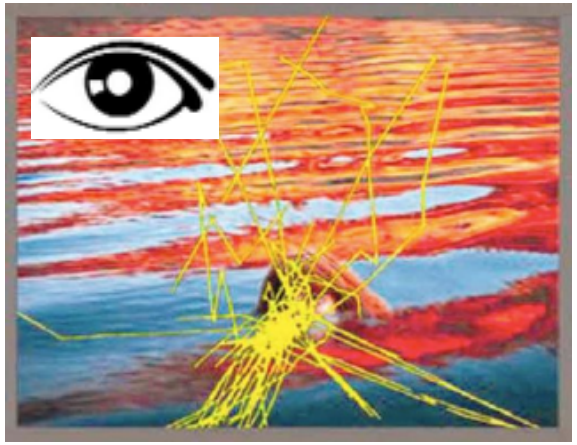
Active Perception

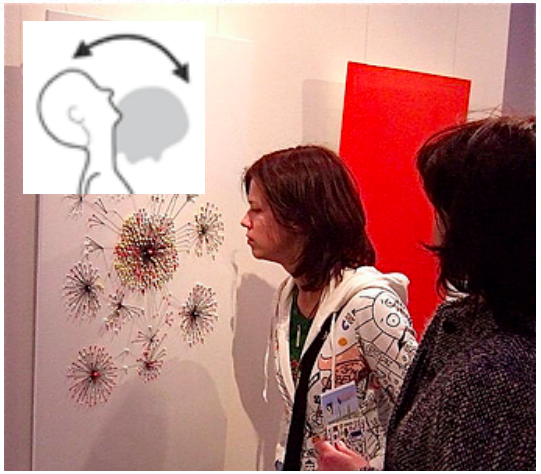
- Perception requires action

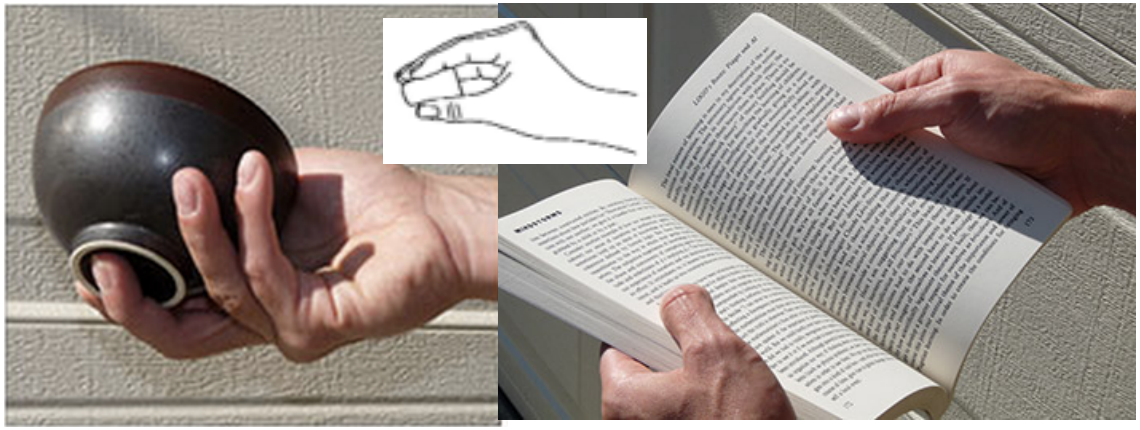
Bret Victor (link)

Active Perception

- Where is the person interacting?







A Definition of interaction

- Static content

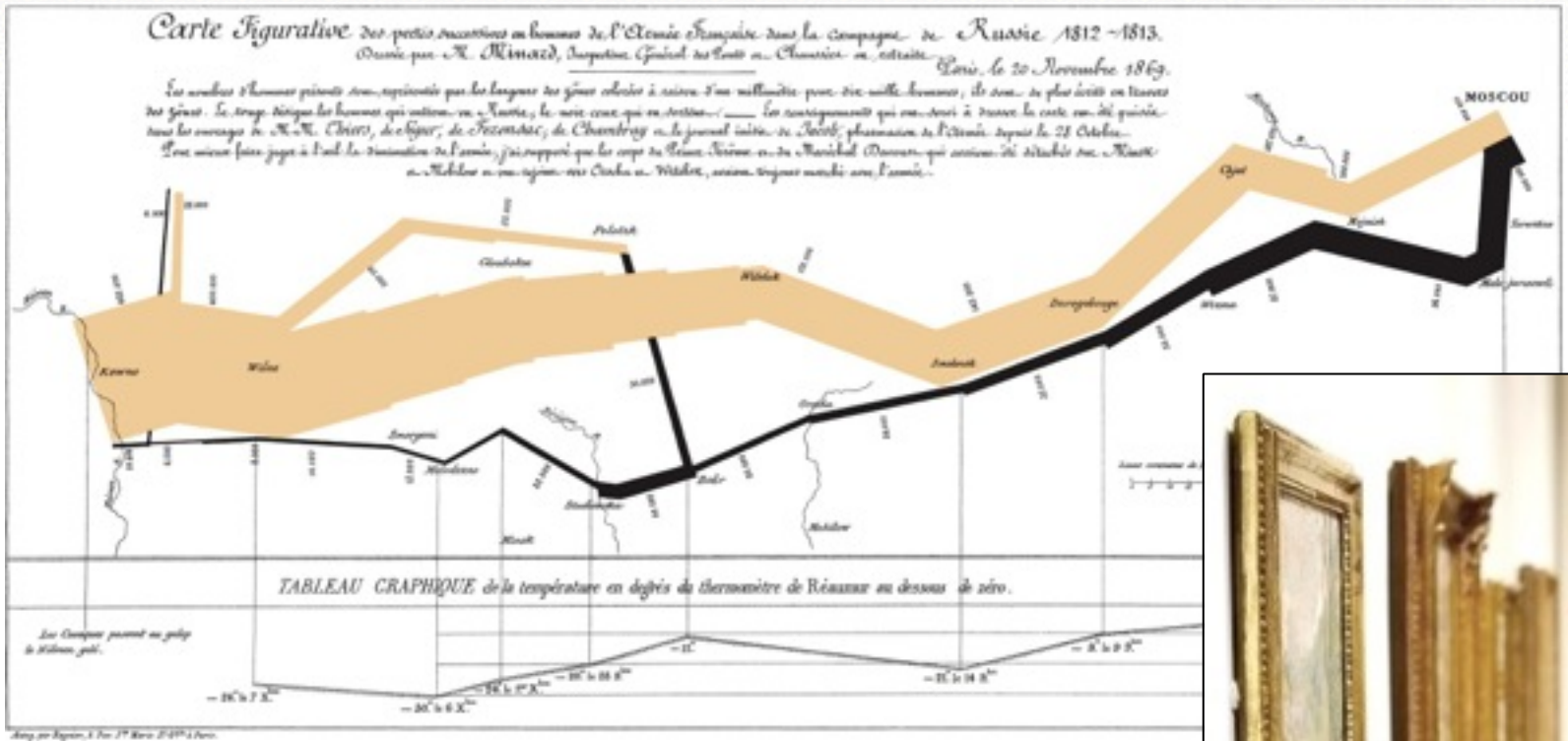
  Does not change

- Dynamic content

  - Animated content
    Changes independently from the user

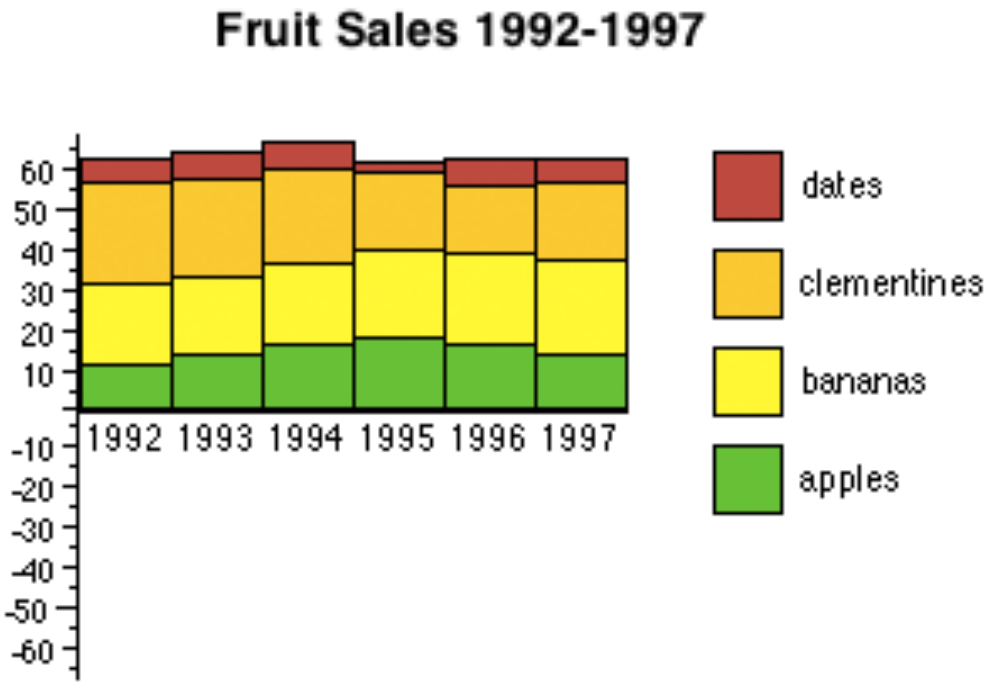
  - Interactive content
    Changes as a result of user actions

Why use computer interaction?



Why use computer interaction?

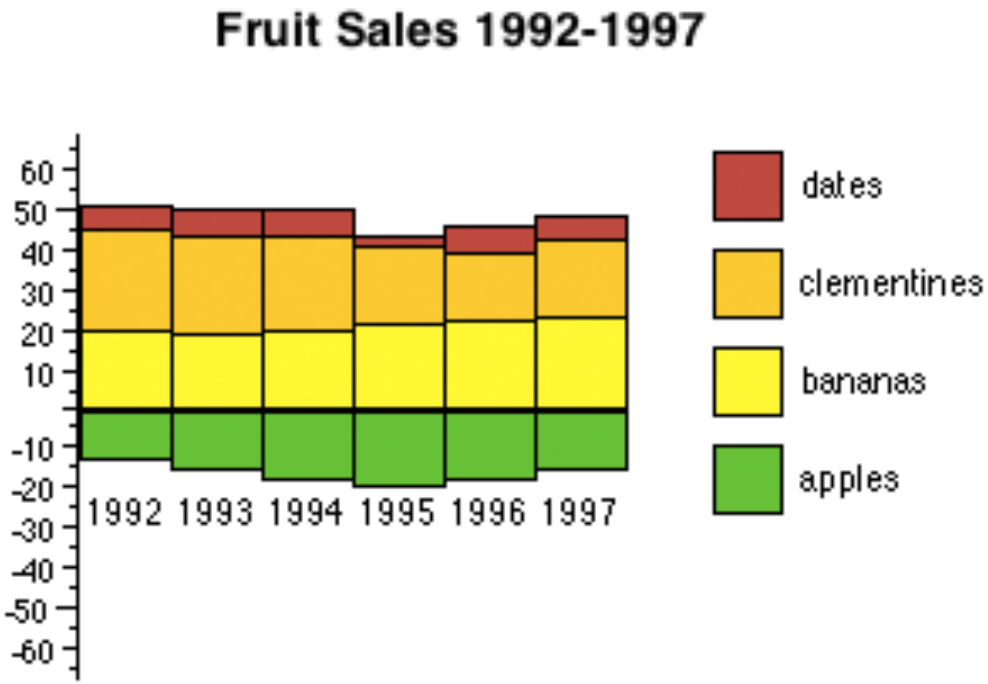
- Evolution of apple sales? Of bananas?



Dix and Ellis, 1998

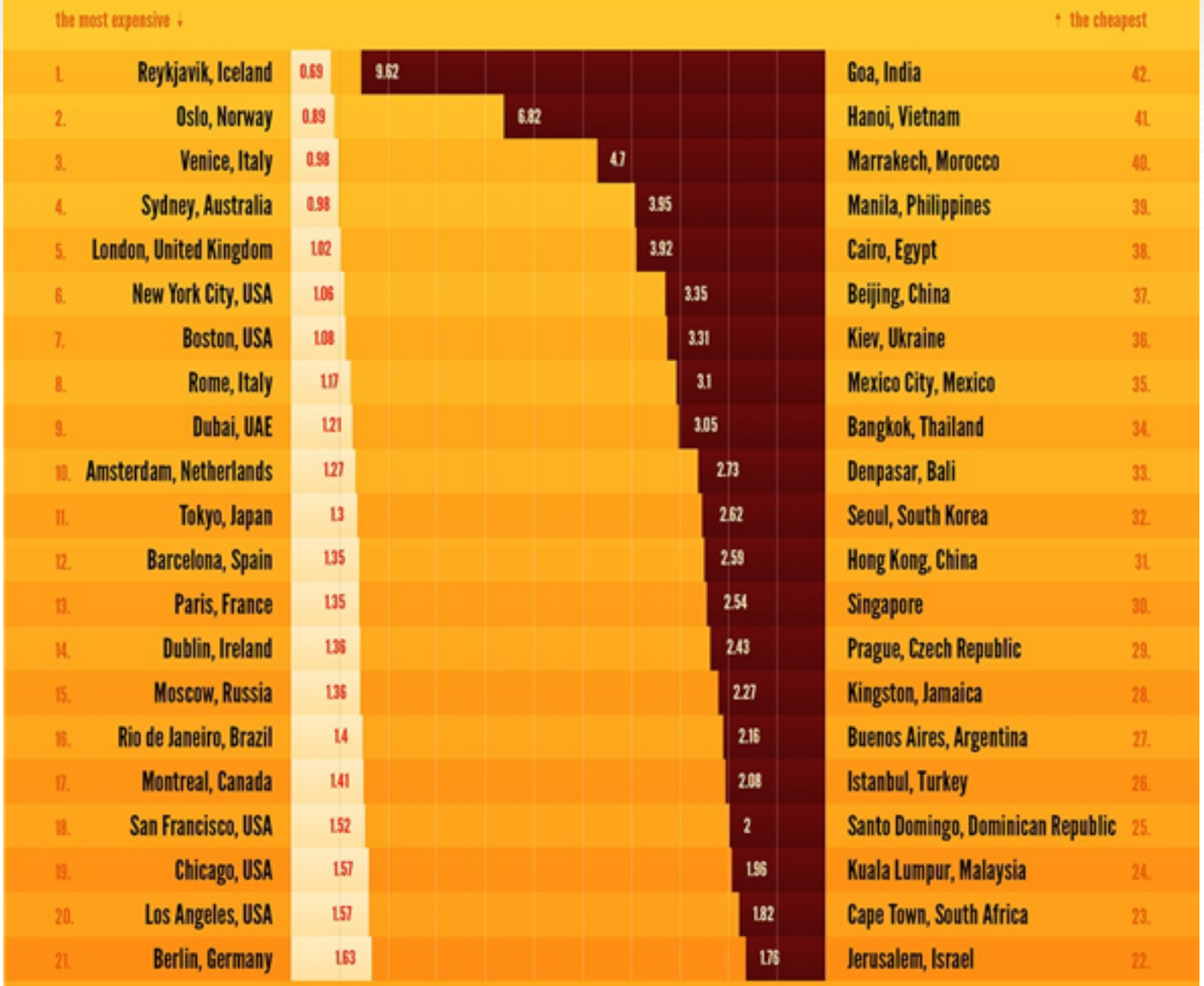
Why use computer interaction?

- Evolution of apple sales? Of bananas?



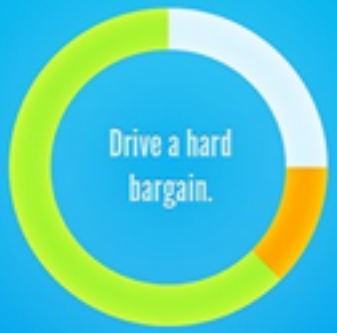
Dix and Ellis, 1998

DAYS YOU CAN STAY FOR $100



: travel guide 2012

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
REYKJAVIK
0.69 DAYS
MOSCOW
1.36 DAYS
TOKYO
1.3 DAYS
NEW YORK CITY
1.06 DAYS
HONG KONG
2.59 DAYS
LONDON
1.02 DAYS
PARIS
1.35 DAYS
SAN FRANCISCO
1.52 DAYS
RIO DE JANEIRO
1.4 DAYS
DUBAI
1.21 DAYS
GOA
9.62 DAYS
CAPE TOWN
1.82 DAYS
SYDNEY
0.98 DAYS

Why use computer interaction?

- There is too much to be shown
- There are many ways to show it

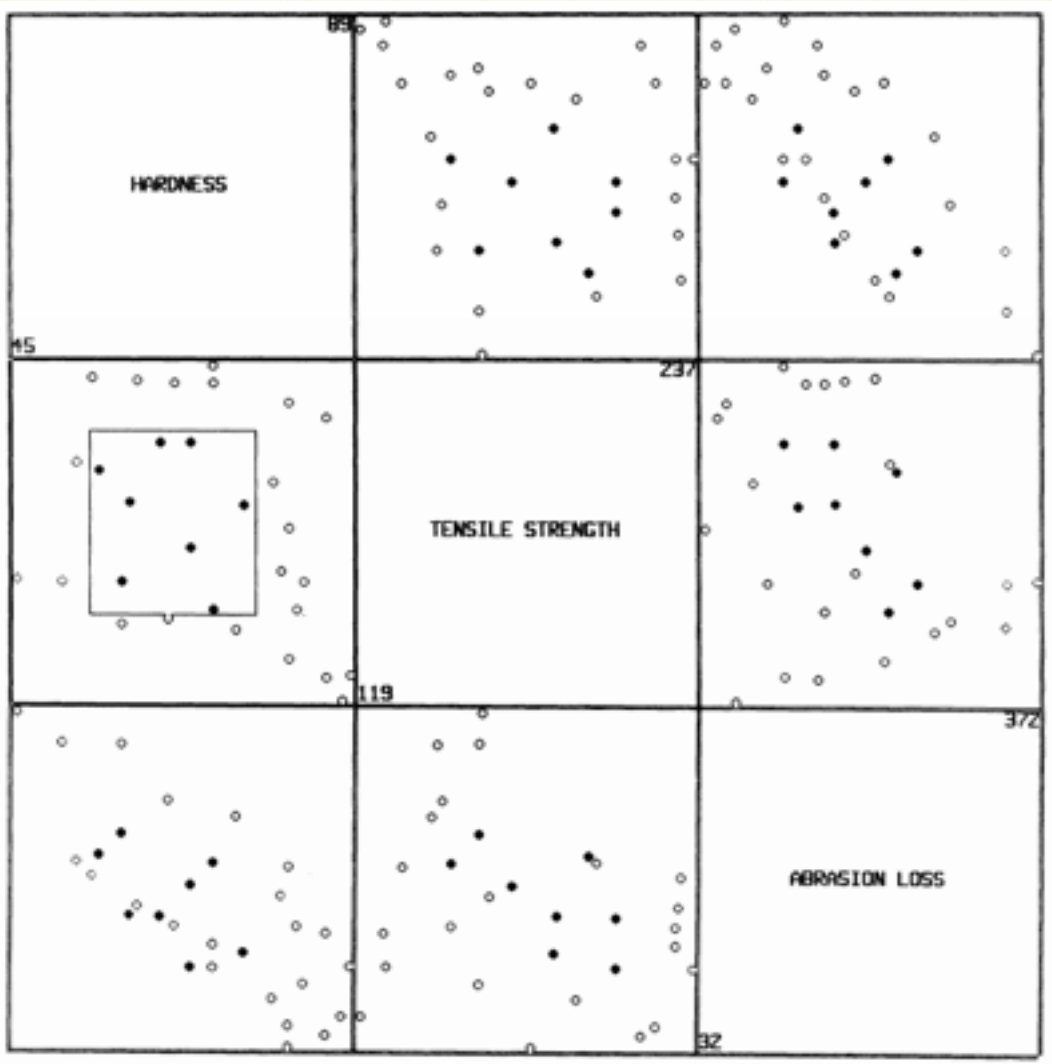
→ Let the user dynamically control what to show and how

Why use computer interaction?

- There is too much to be shown
- There are many ways to show it

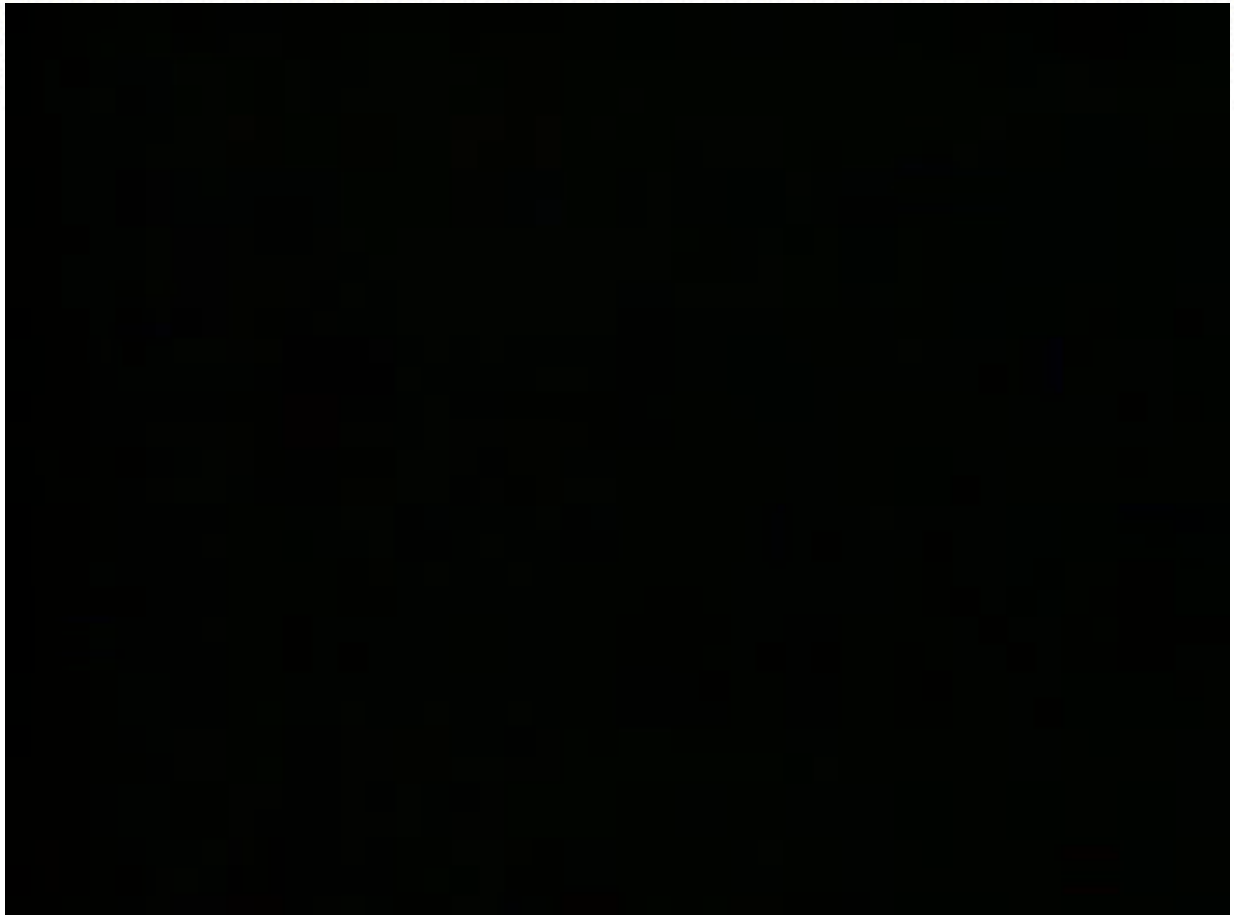
→ Let the user dynamically control what to show and how

Example 1: Brushing



Beker and Cleveland, 1987

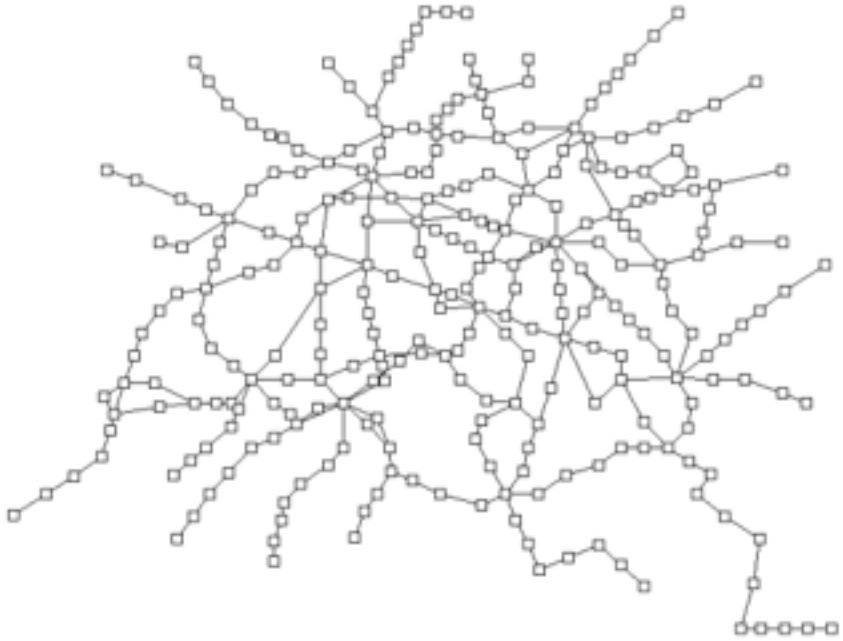
Example 1: Brushing

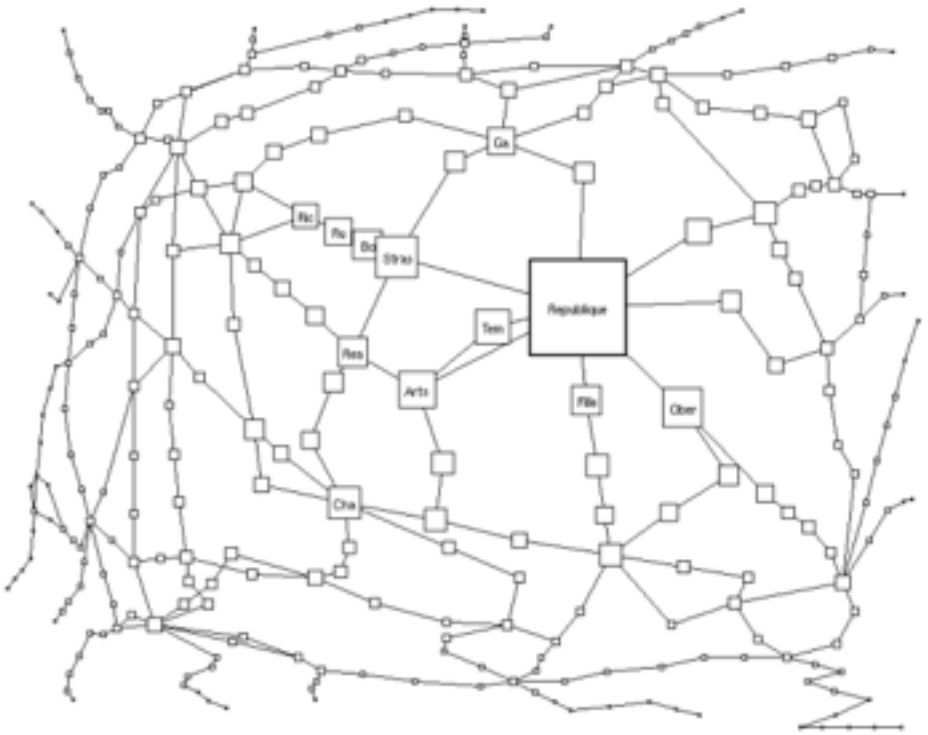


17:50

Beker and Cleveland, 1987

Example 2: Fisheye Views





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

Example 2: Fisheye Views

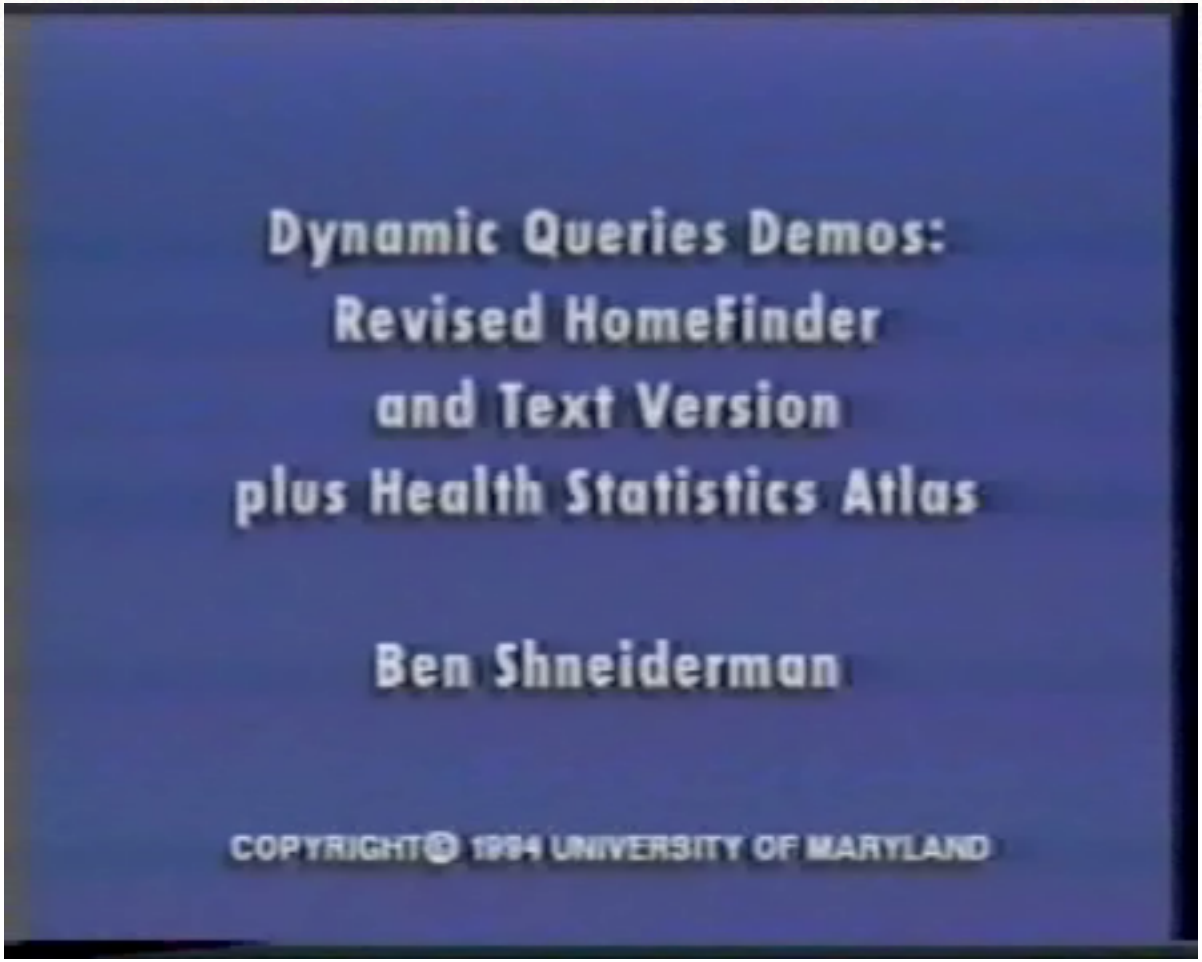
1:08

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 interactions techniques

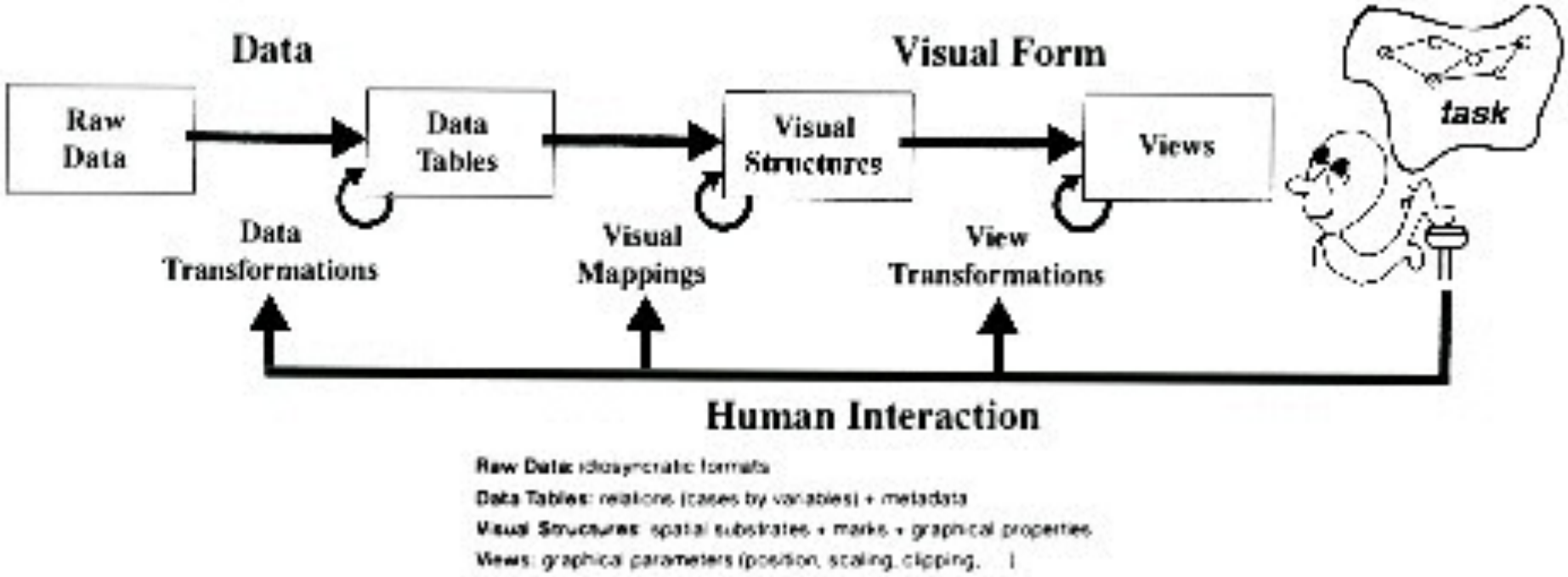
Taxonomies of interaction

- What?
  - What is the user doing?
- Why?
  - Why is the user doing it?
- How?
  - How is the user doing it?

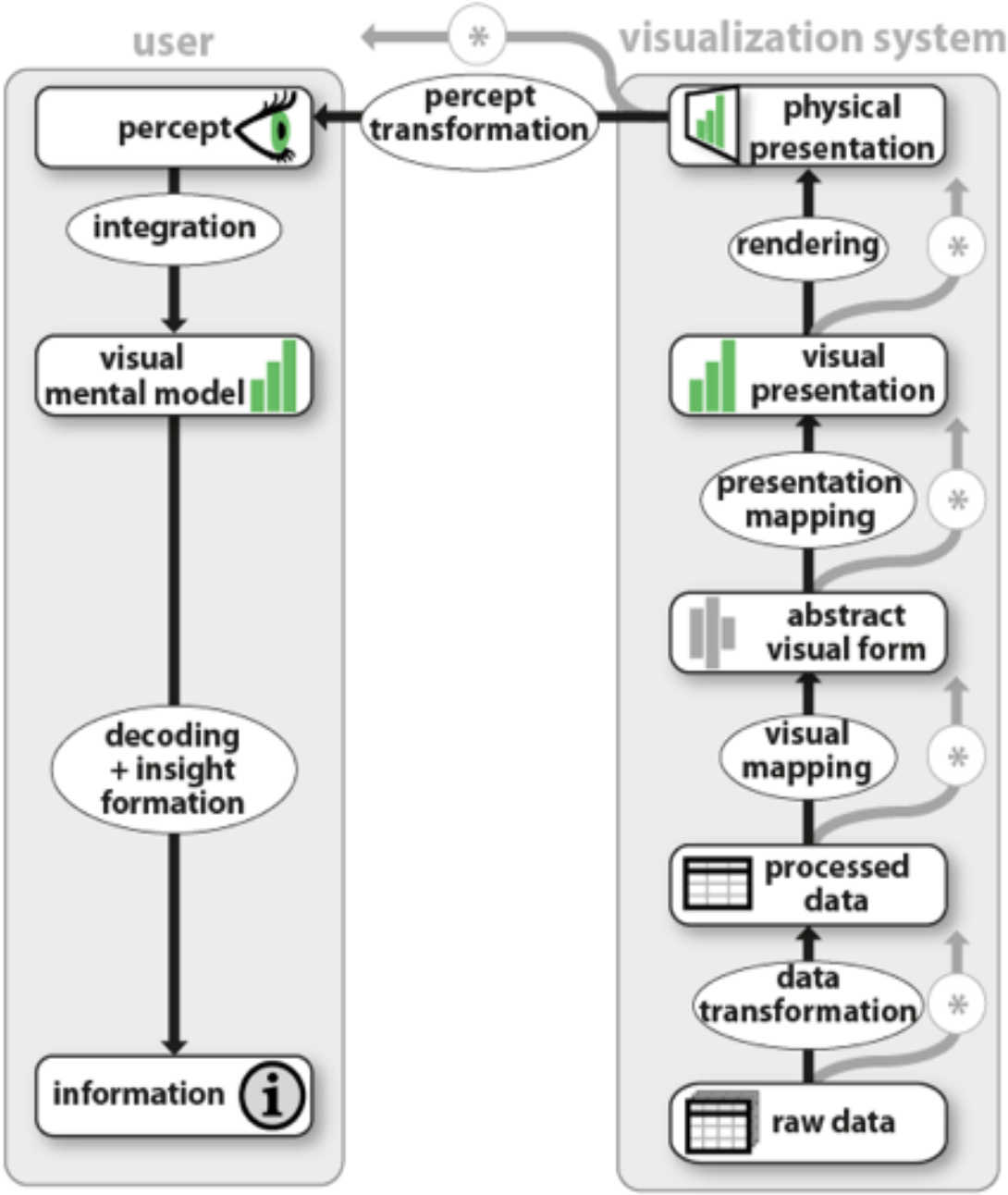
Taxonomies of interaction

- What?
  - What is the user doing?
- Why?
  - Why is the user doing it?
- How?
  - How is the user doing it?

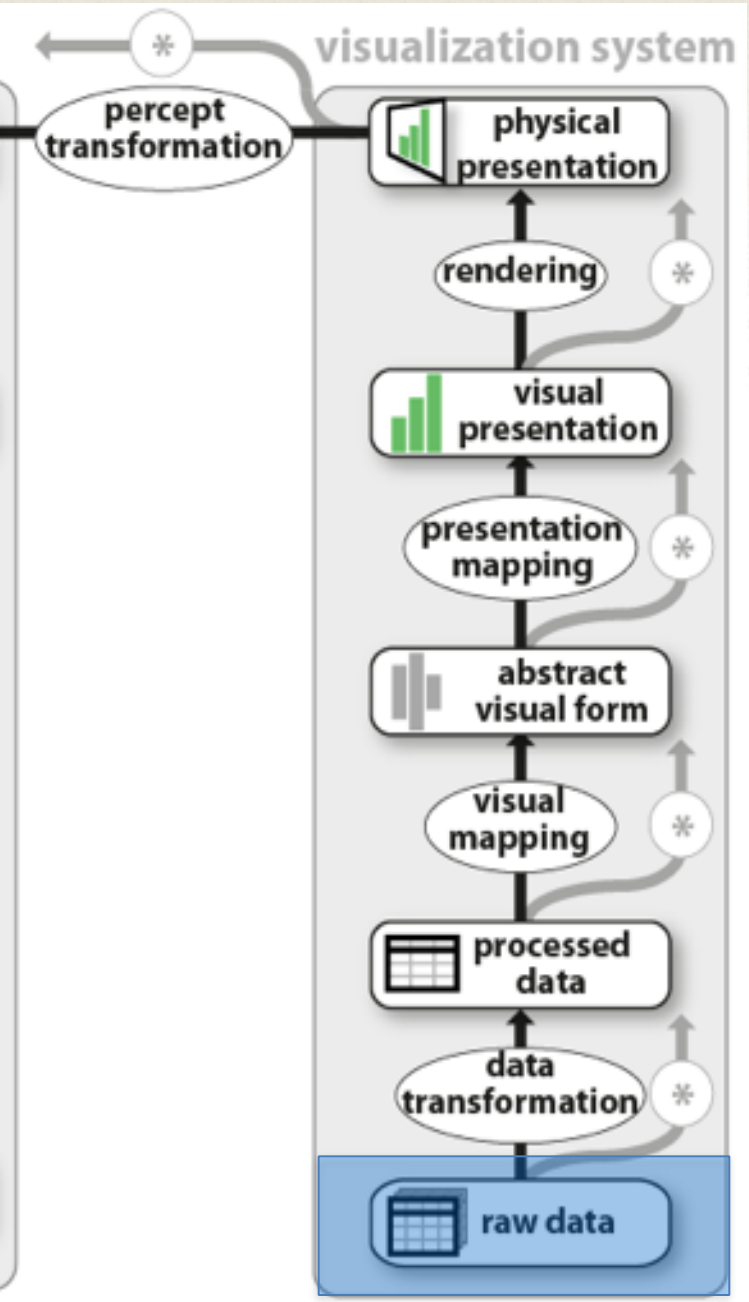
The Visualization Pipeline



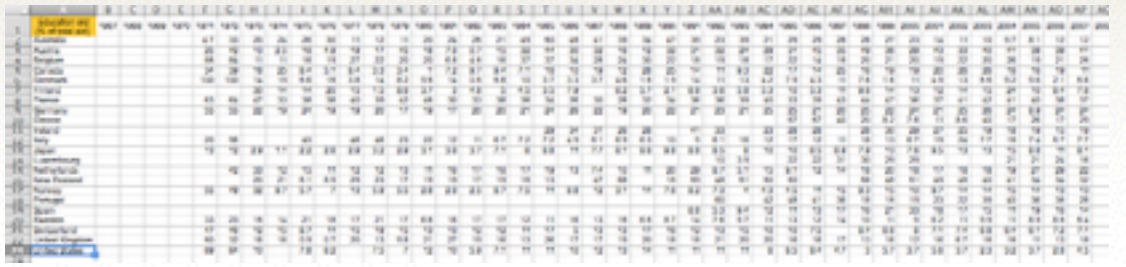
[Card, Mackinlay, Shneiderman, Readings in Information Visualization: Using Vision to Think, 1999]



Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

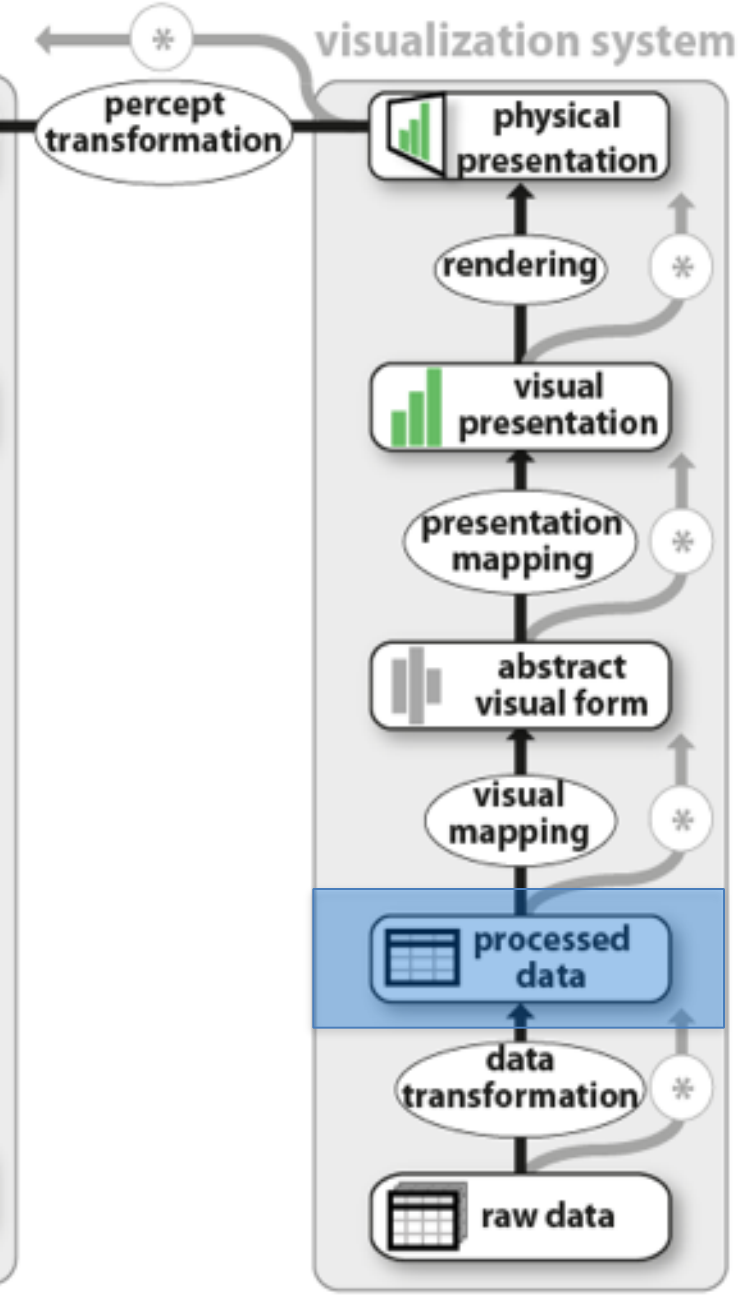


GAPMINDER for a fact-based world view



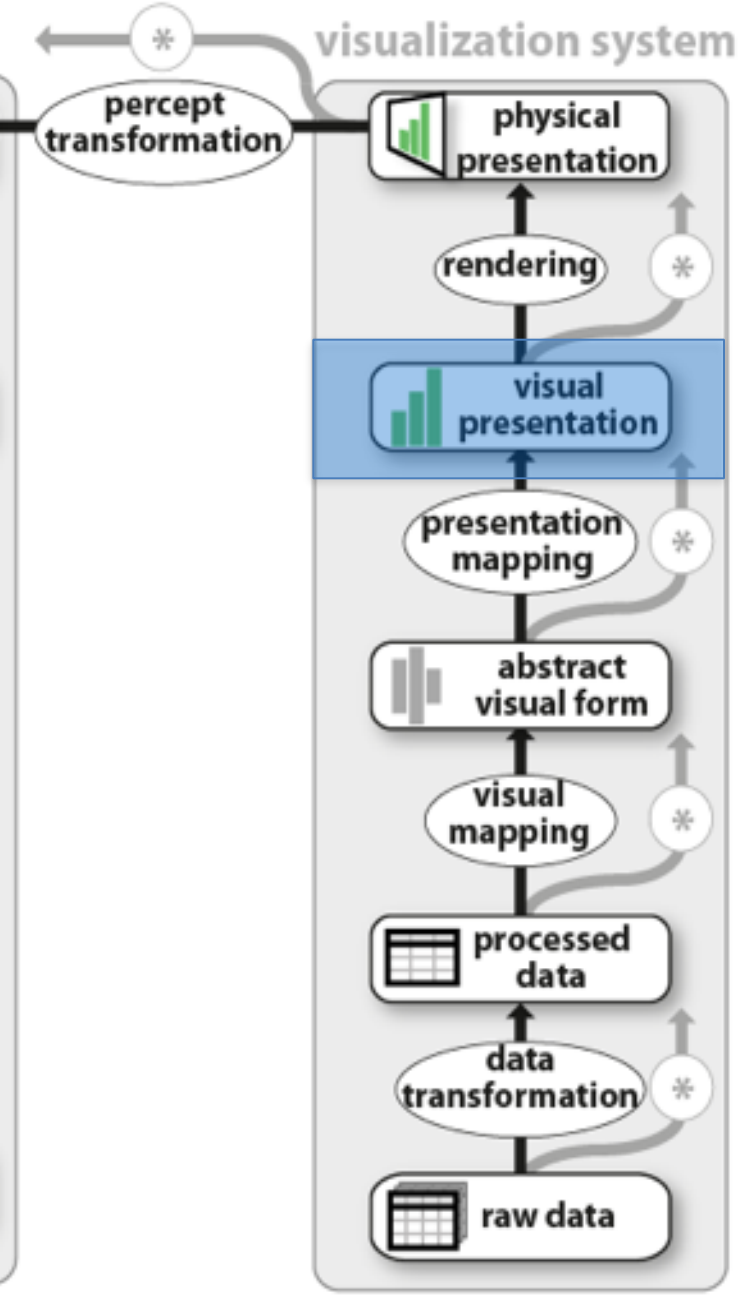
	A	B	C	D	E	F	G	H	I	J	K
1	Education aid (% of total aid)	1967	1968	1969	1970	1971	1972	1973	1974	1975	197
2	Australia					4.75	33.2	19.7	23.7	26.3	30.
3	Austria					24.7	42.3	13.5	2.52	15.9	4.8
4	Belgium					84.5	83.7	11	11.4	15.9	18.
5	Canada					33.7	38.6	18	25.3	8.41	5.1
6	Denmark					100	100	13.7	19	5.6	15.
7	Finland							29.6	13.5	14.1	20.
8	France					62.9	63.7	46.8	33.4	38.2	38.
9	Germany					54.6	54.8	21.7	18.8	23.6	18.
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.
21	Switzerland					47	46	12	15	8.7	11.
22	United Kingdom					49.8	32.4	15.9	16.2	0.91	0.
23	United States					69.3	64	9.97		7.76	6.1
24											

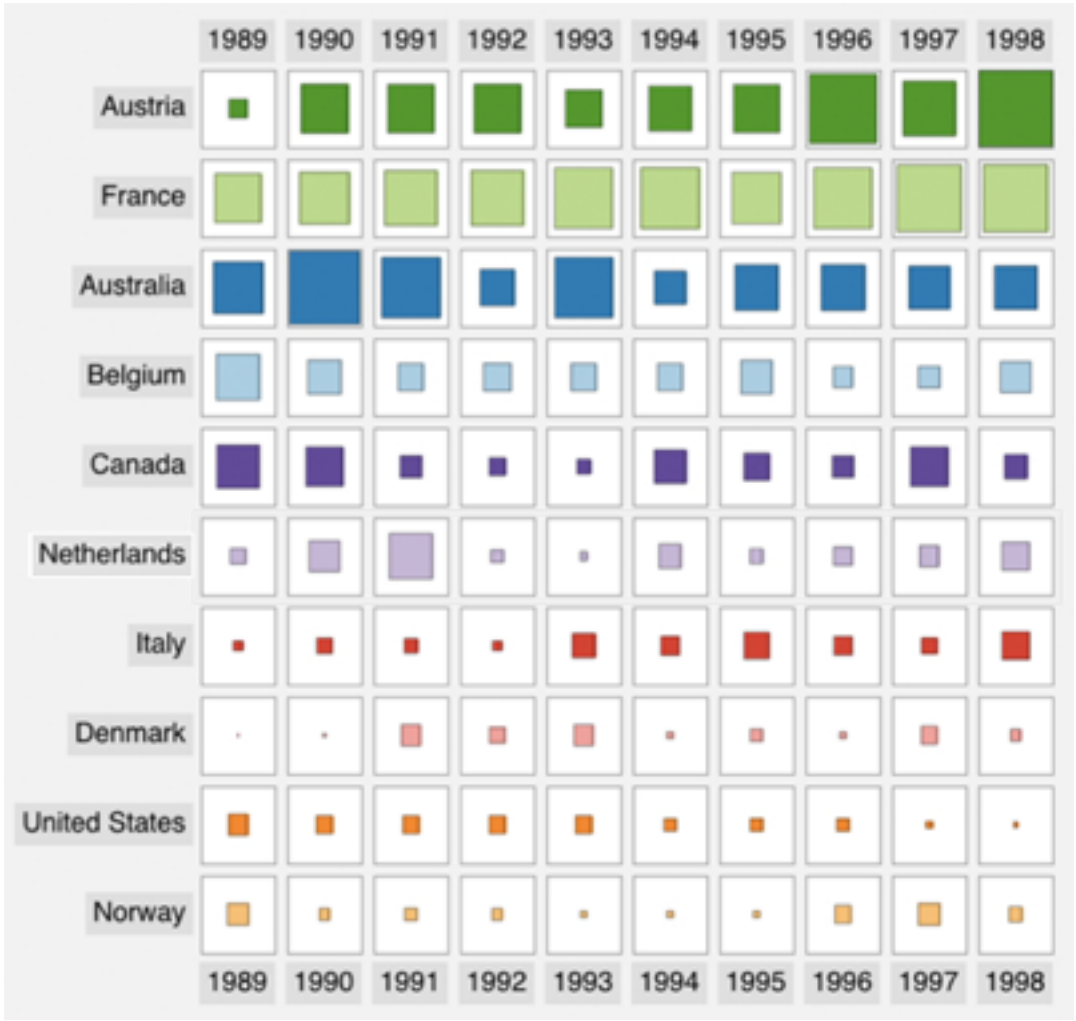
Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



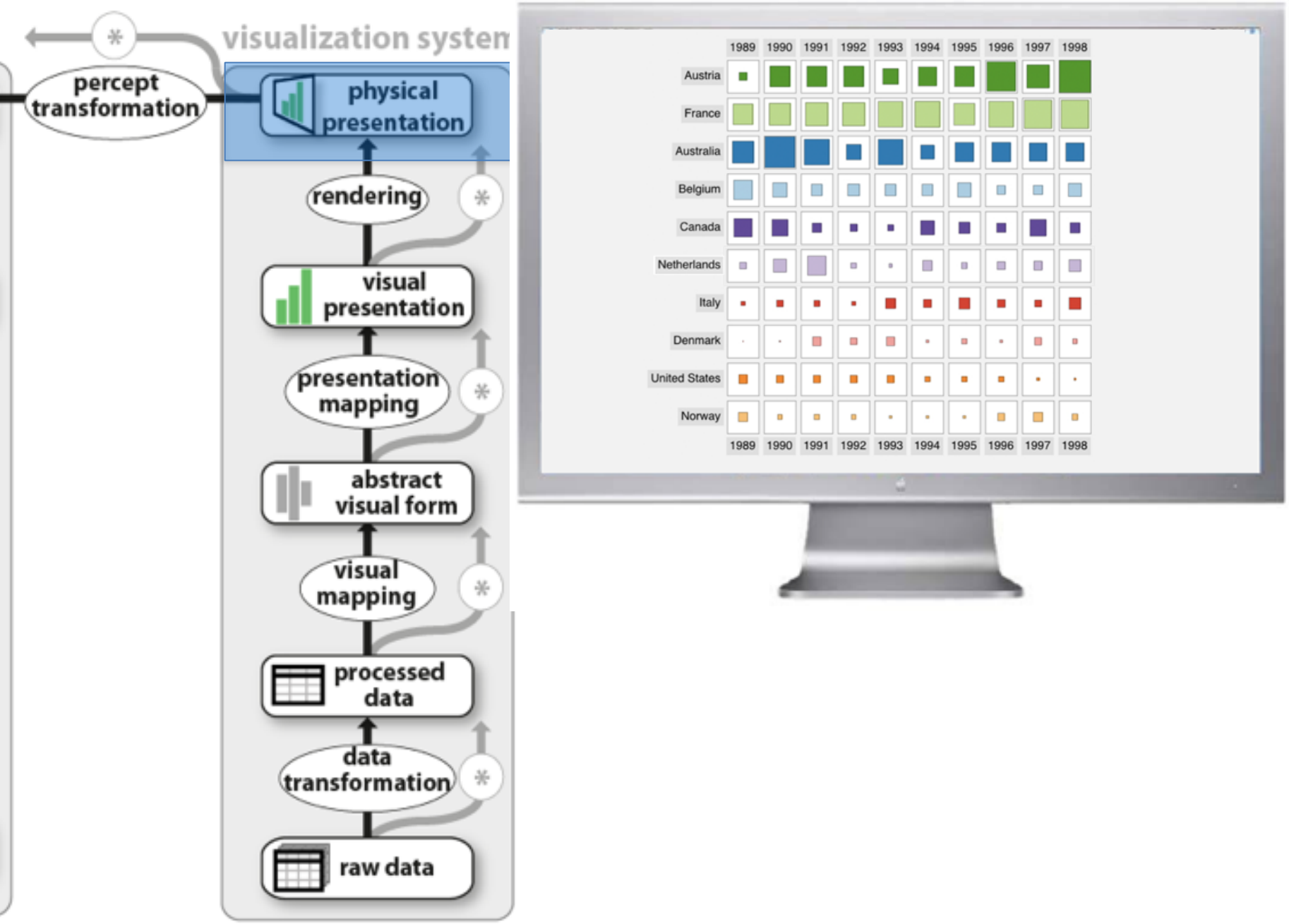
	A	B	C	D	E	F	G	H	I	J	K
1		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	Austria	12.23	31.86	31.07	31.57	24.02	28.61	30.52	44.99	35.41	48.95
3	France	31.87	34.18	35.95	36.06	38.78	40.18	32.68	39.26	43.15	43.9
4	Australia	33.57	46.93	39.24	23.18	38.94	21.38	29.1	29.43	27.97	28.32
5	Belgium	29.93	22.13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

Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

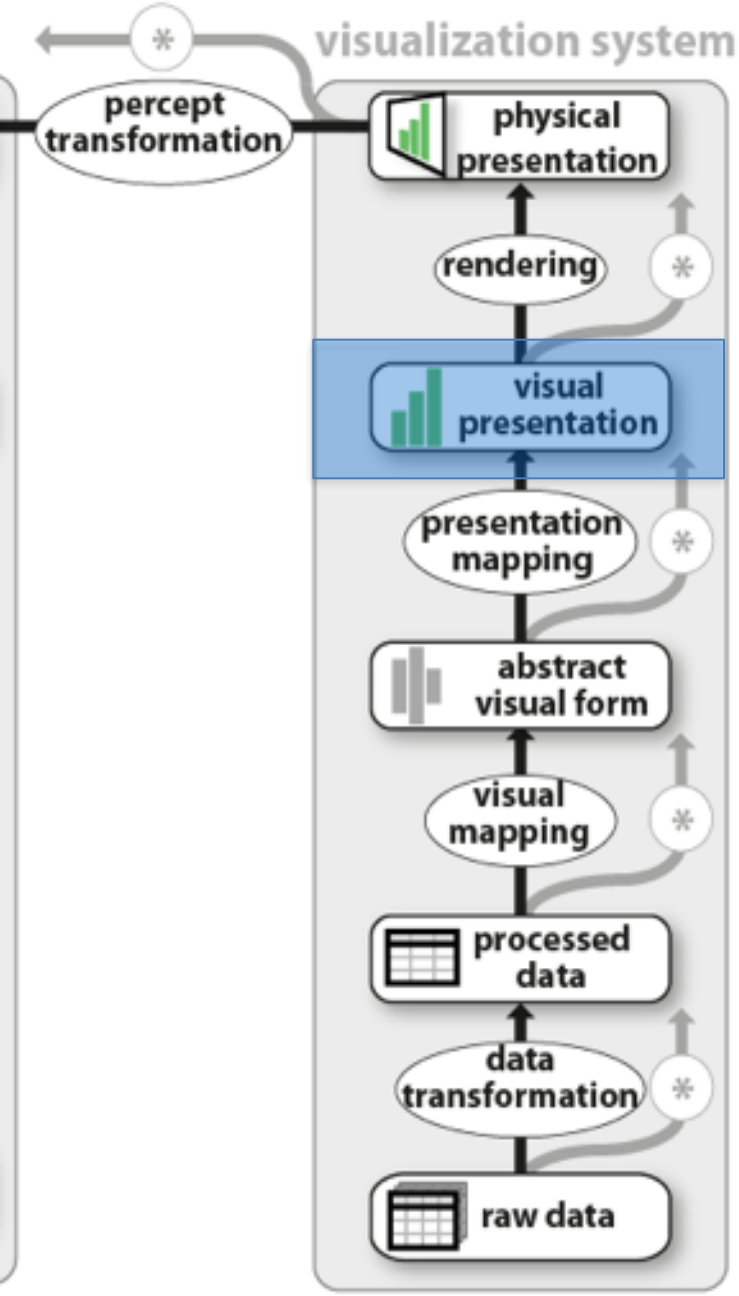


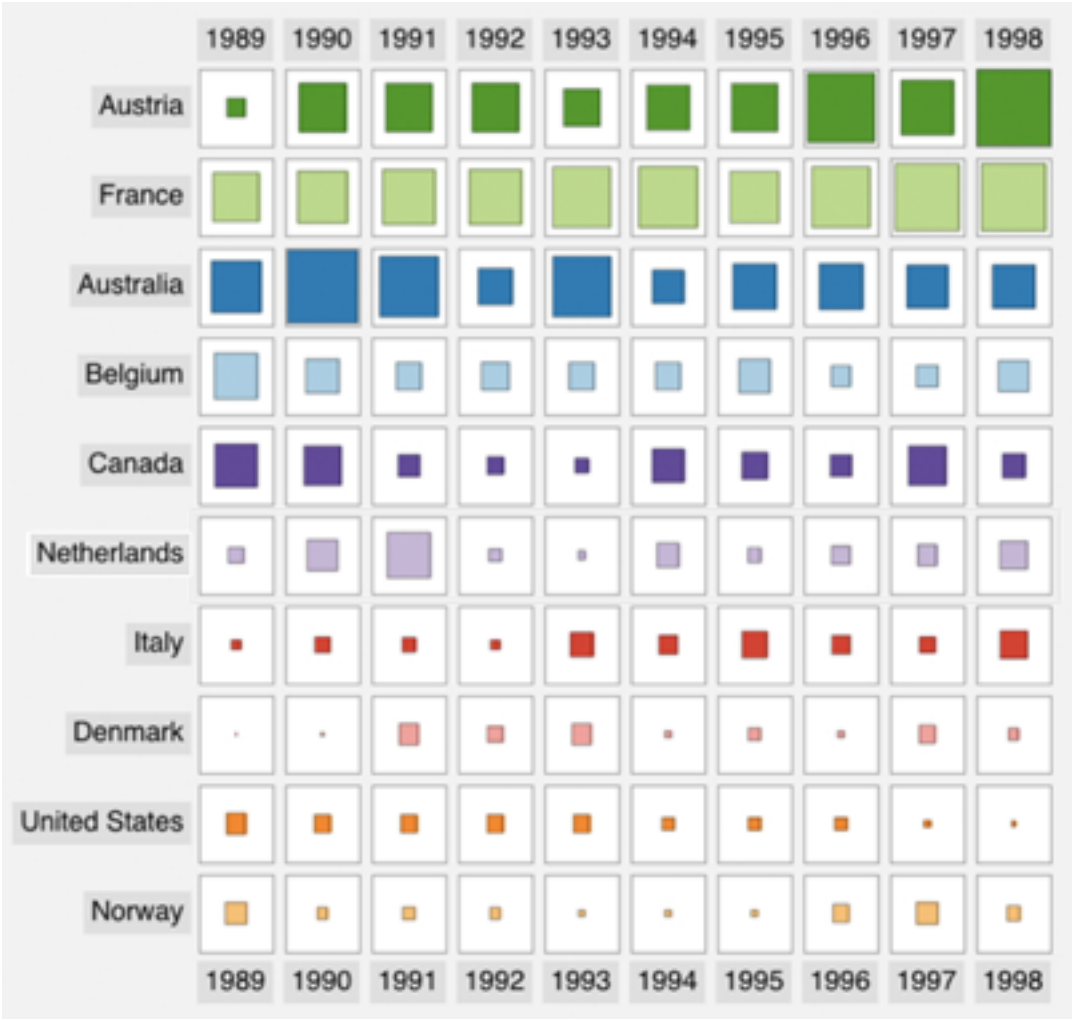


Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

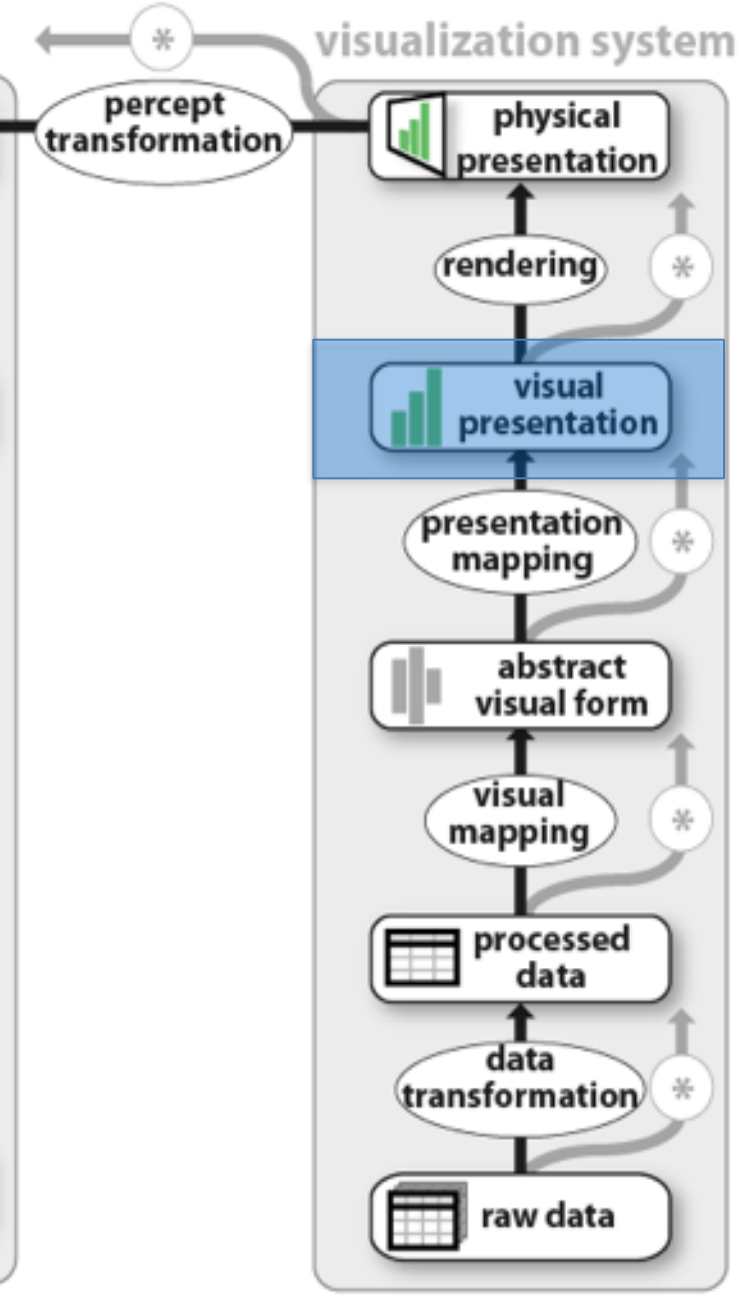


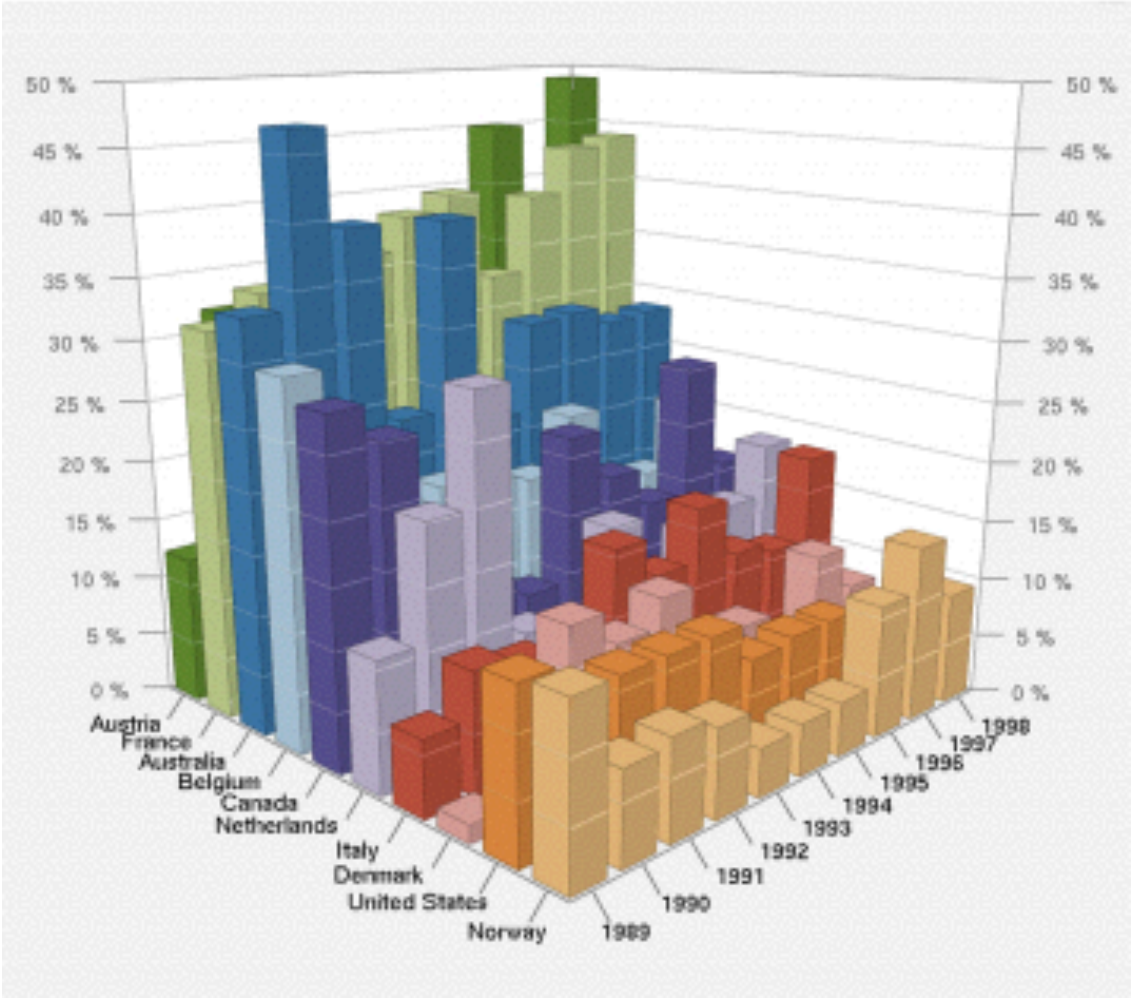
Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



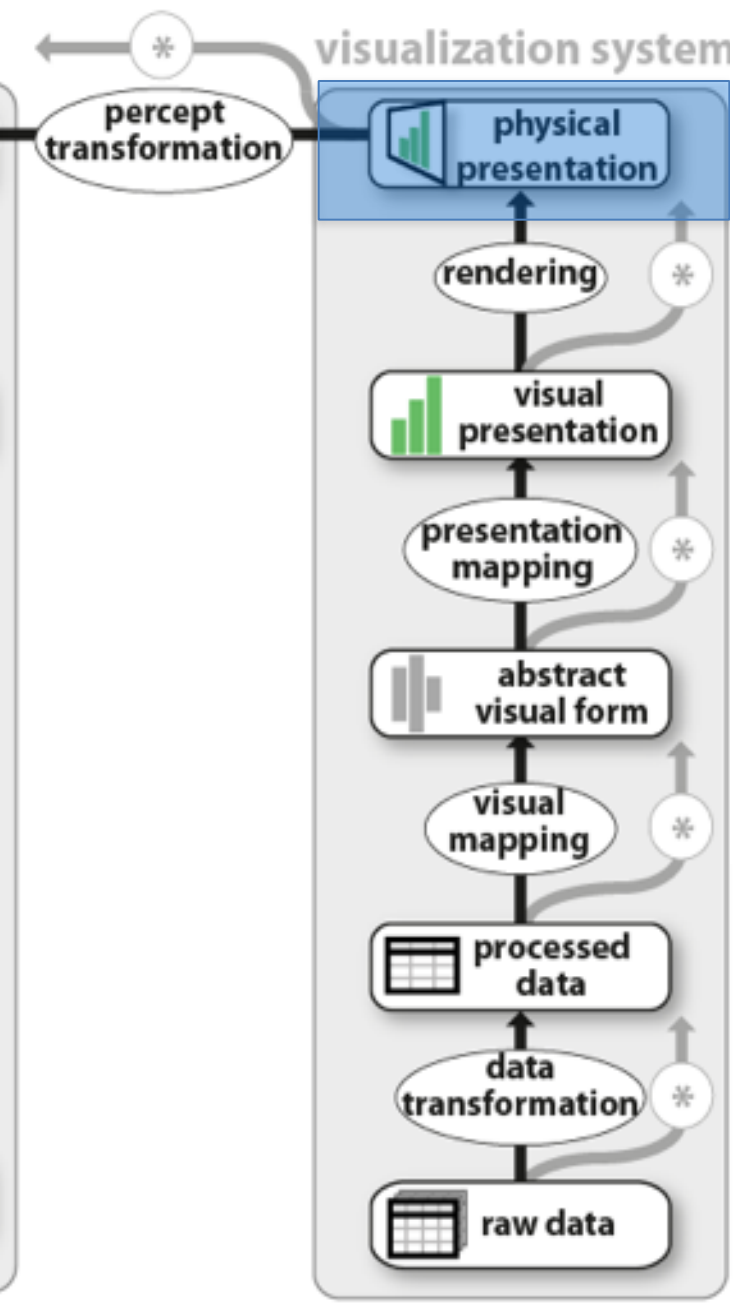


Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

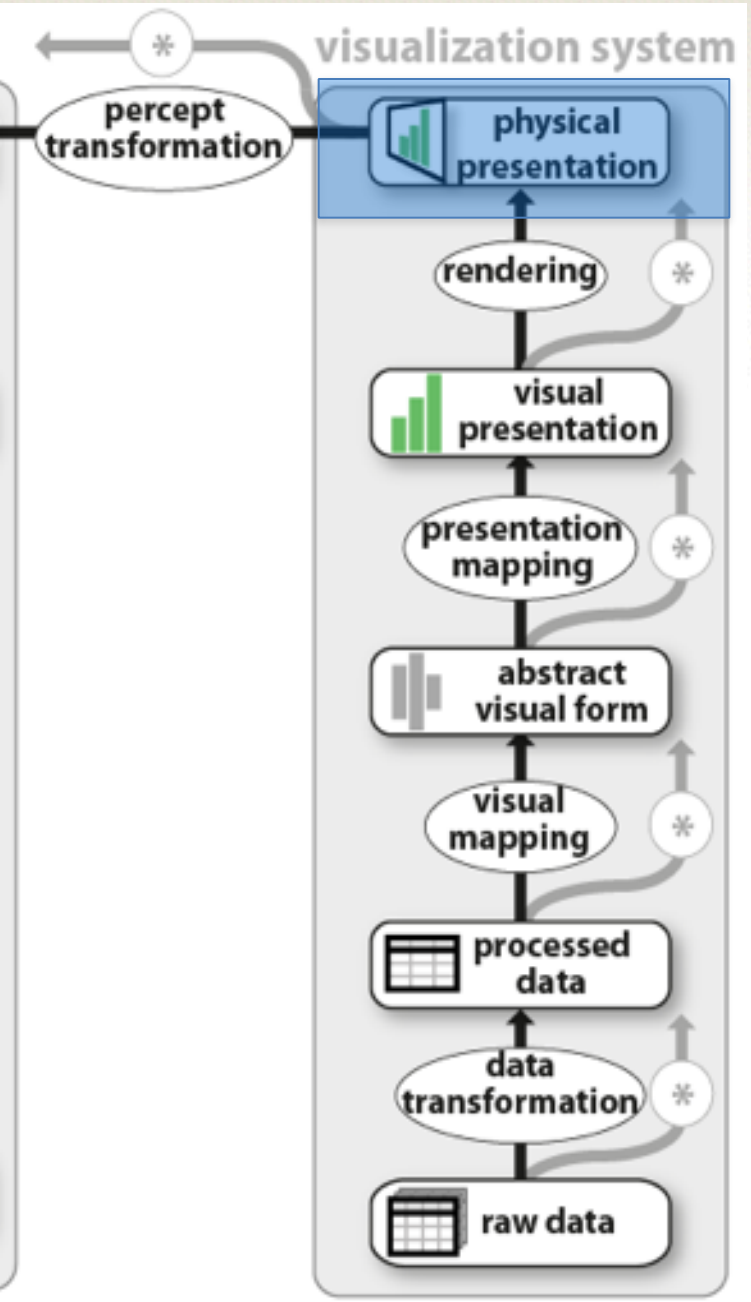




Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

Taxonomies of interaction

- What?
  - What is the user doing?
- Why?
  - Why is the user doing it?
- How?
  - How is the user doing it?

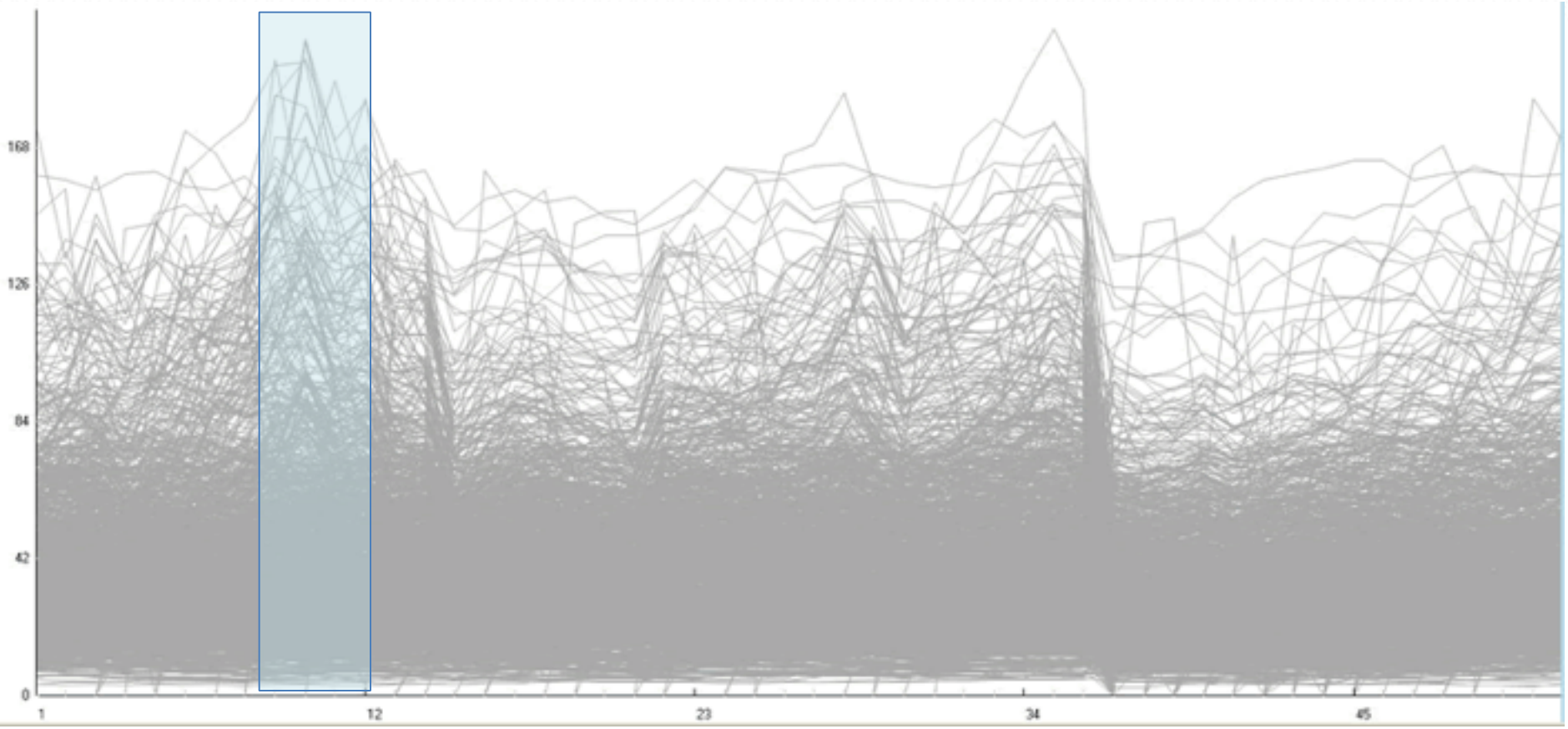
Task Taxonomies

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

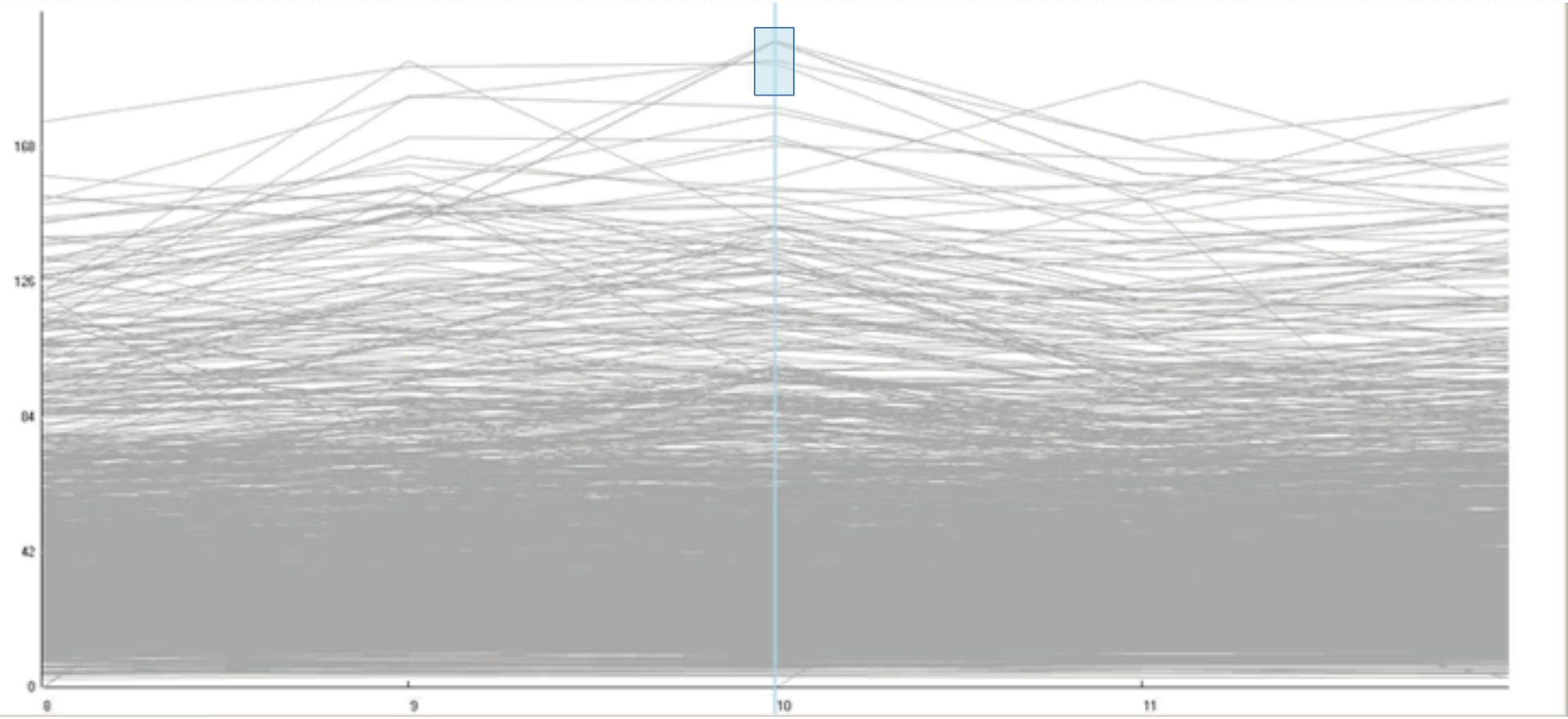


Stephen Few, 2006 (link)

Software: TimeSearcher 2

Analytical Tasks

2. Zoom

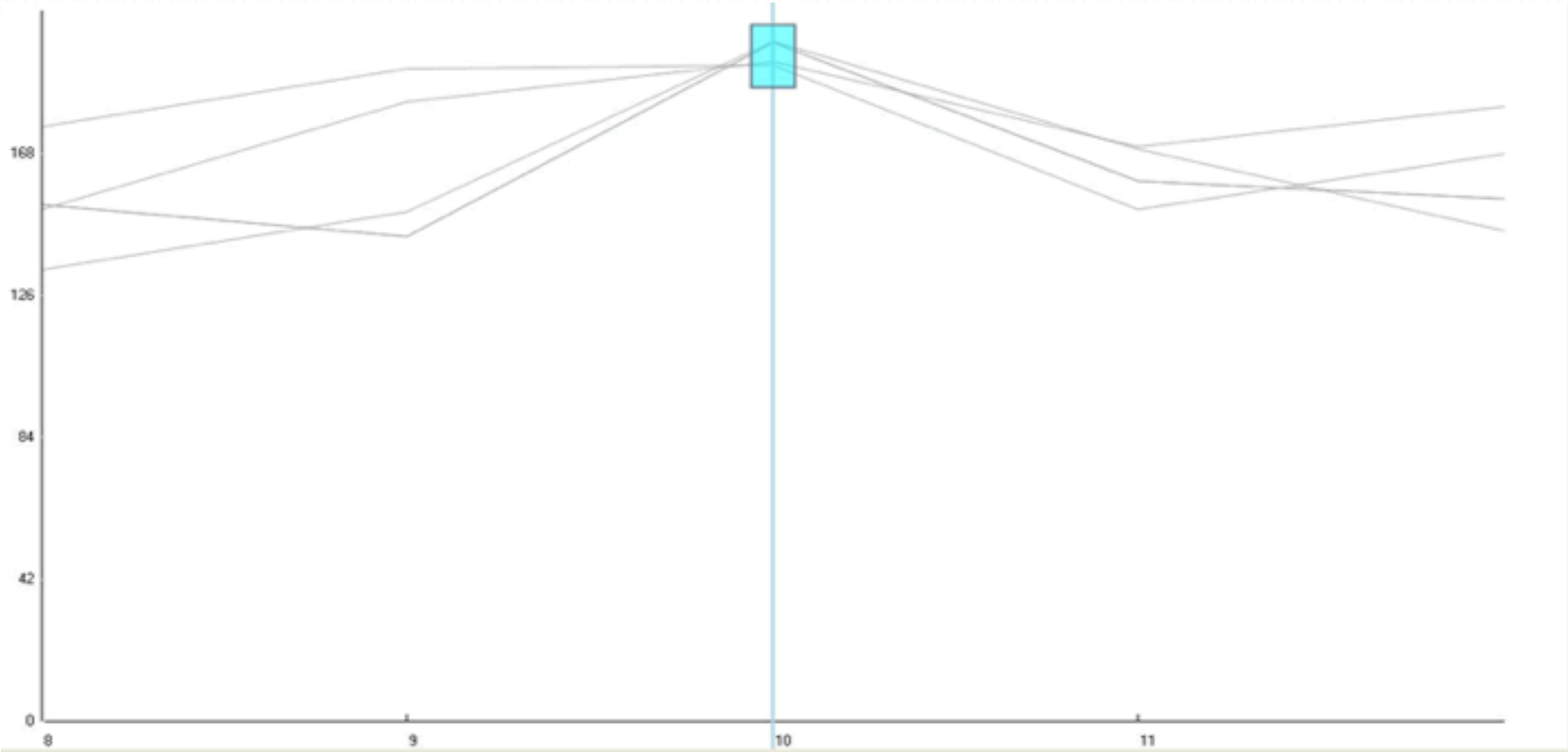


Stephen Few, 2006 (link)

Software: TimeSearcher 2

Analytical Tasks

3. Filter

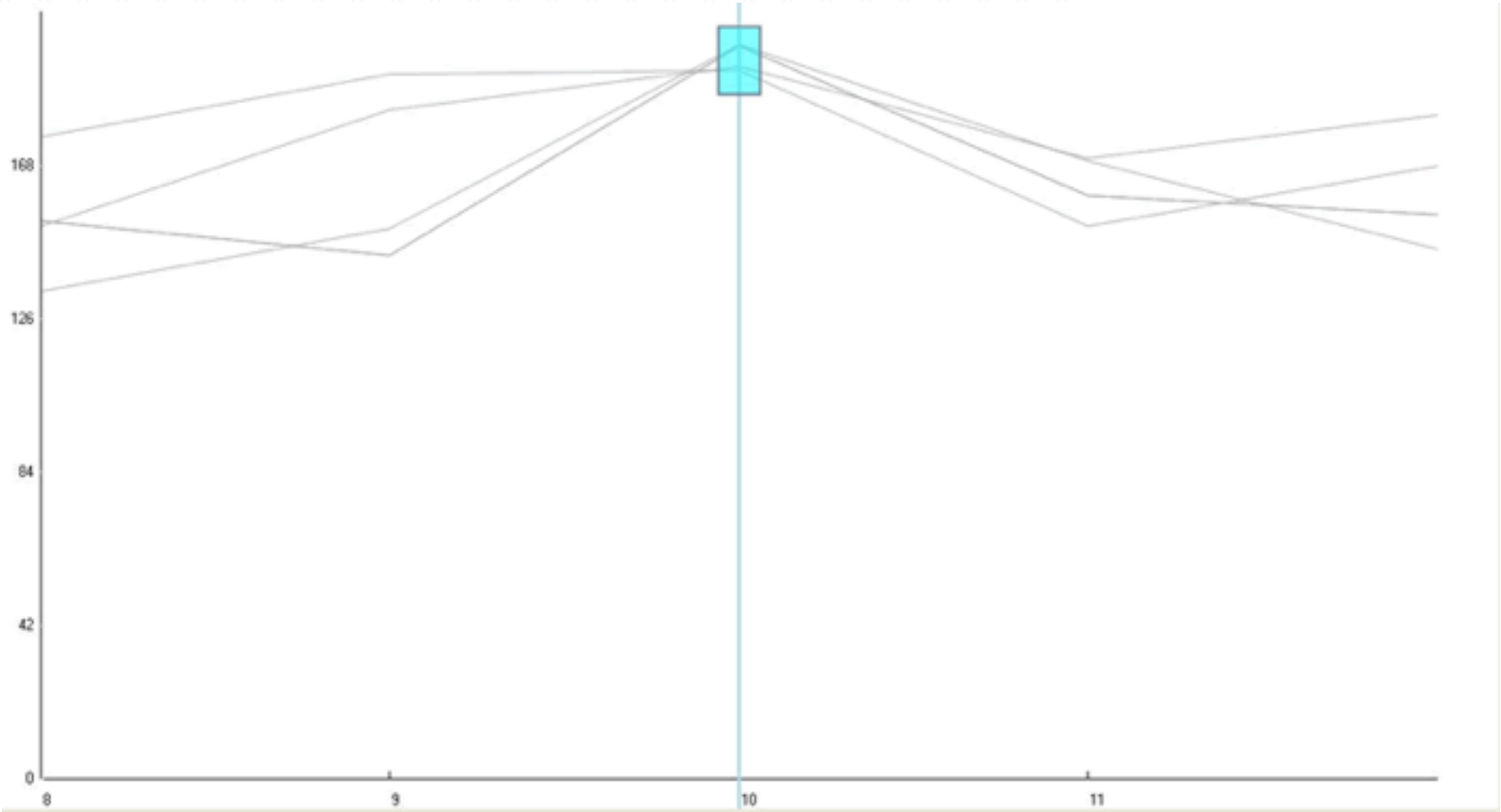


Stephen Few, 2006 (link)

Software: TimeSearcher 2

Analytical Tasks

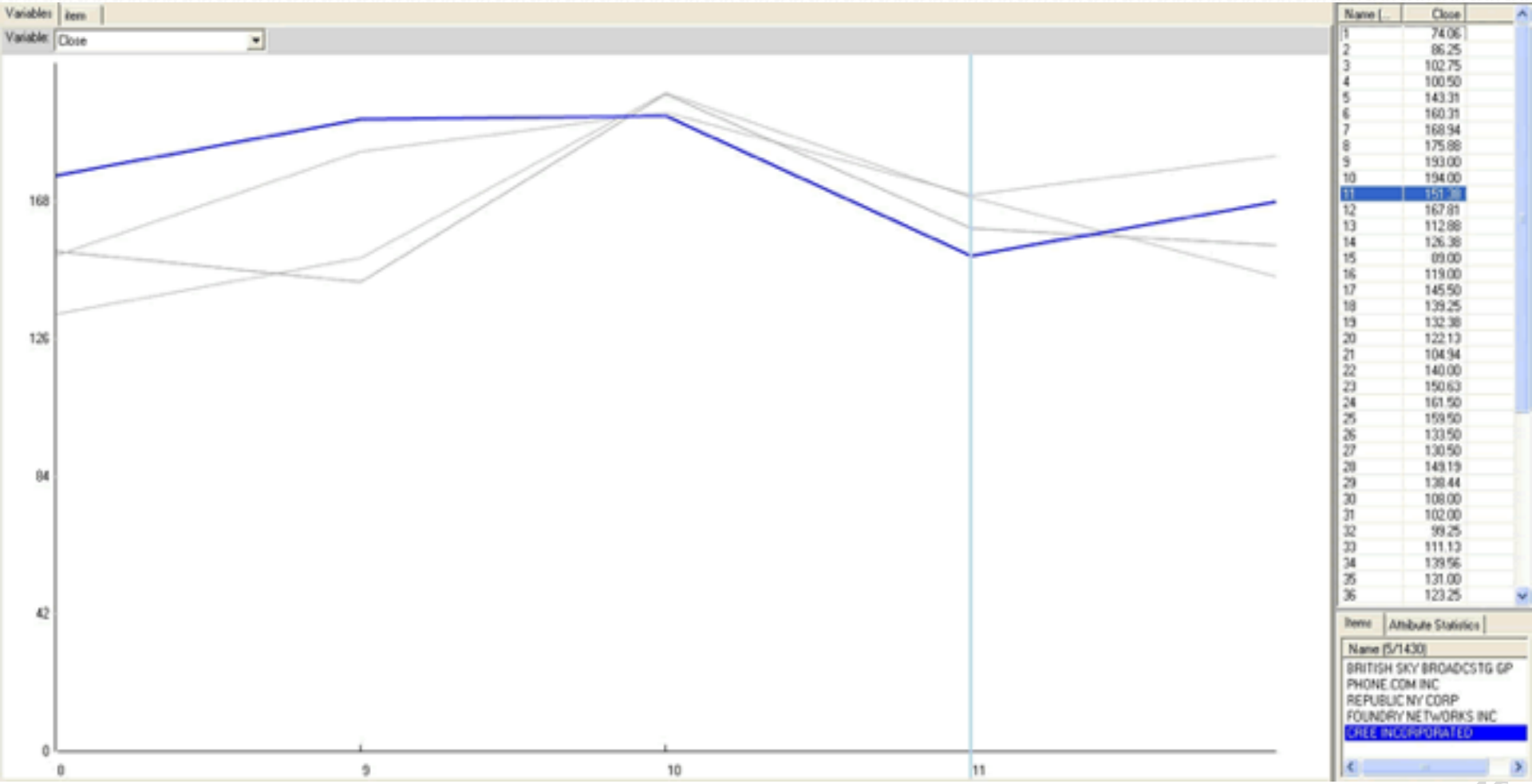
3. Filter



Stephen Few, 2006 (link) Software: TimeSearcher 2

Analytical Tasks

4. Details on demand



Stephen Few, 2006 (link) Software: TimeSearcher 2

Analytical Tasks

- **Visual Information Seeking Mantra (Shneiderman, 1996)**

Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then details on demand
Overview first, zoom and filter, then 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**

1. **Select:** mark something as interesting
2. **Explore:** show me something else
3. **Reconfigure:** show me a different arrangement
4. **Encode:** show me a different representation
5. **Abstract/Elaborate:** show me more or less detail
6. **Filter:** show me something conditionally
7. **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"
    (Tucker, 2004)

- **Types of interaction techniques**
  - **Input**: mouse, touch, keyboard, speech,...
  - Shneiderman: **Command-line interfaces vs. Direct manipulation interfaces**

Interaction Styles

- 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 Styles

- (In)direct manipulation

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"
    (Tucker, 2004)

- **Types of interaction techniques**
  - **Input**: mouse, touch, keyboard, speech,...
  - Shneiderman: **Command-line interfaces vs. Direct manipulation interfaces**
  - Beaudouin-Lafon: **Instruments** with different degrees of **directness**

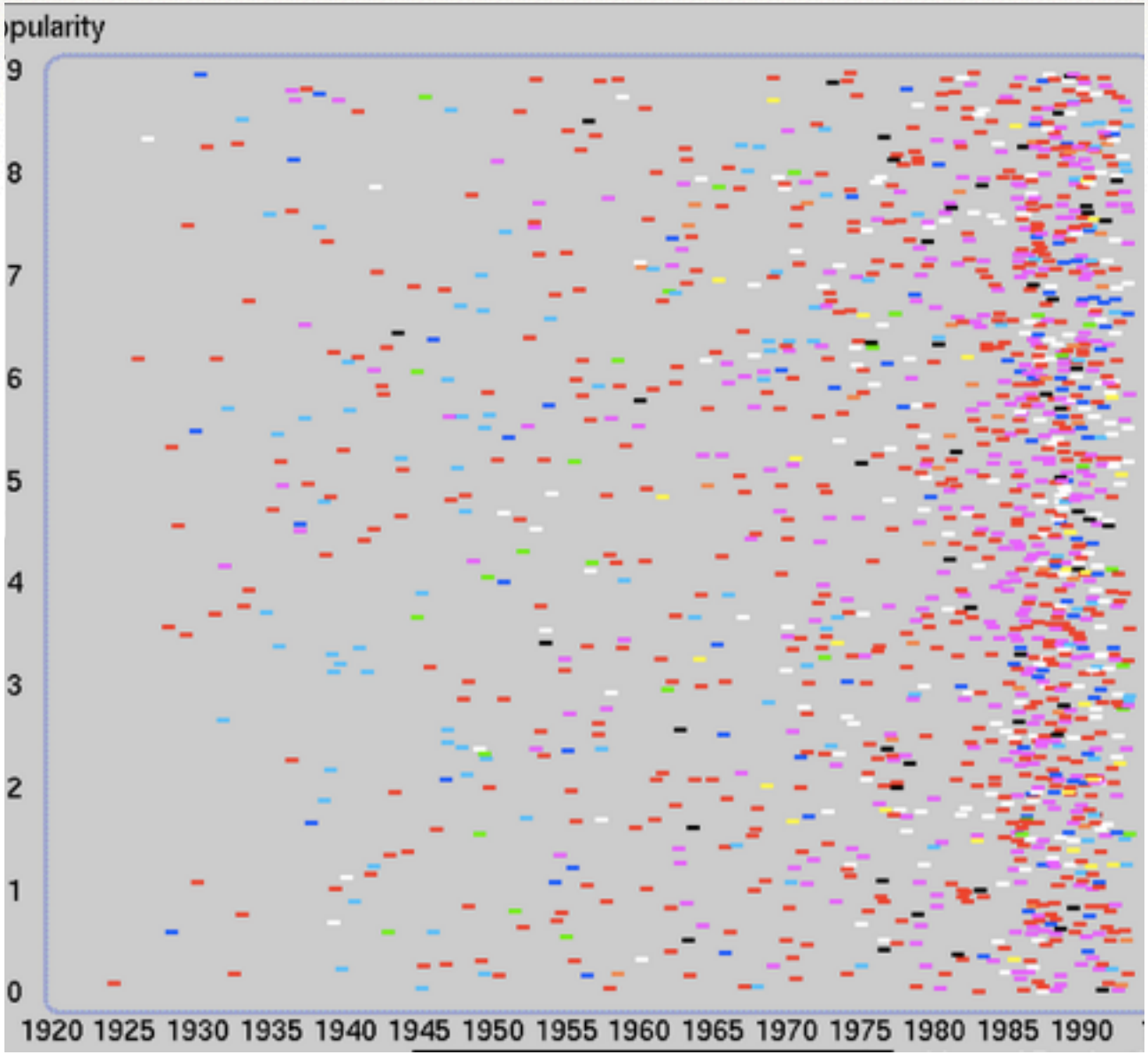
Taxonomies of interaction

- What?
  - What is the user doing?
- Why?
  - Why is the user doing it?
- How?
  - How is the user doing it?

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

Problem



FilmFinder, HCIL

Families of infovis interaction techniques

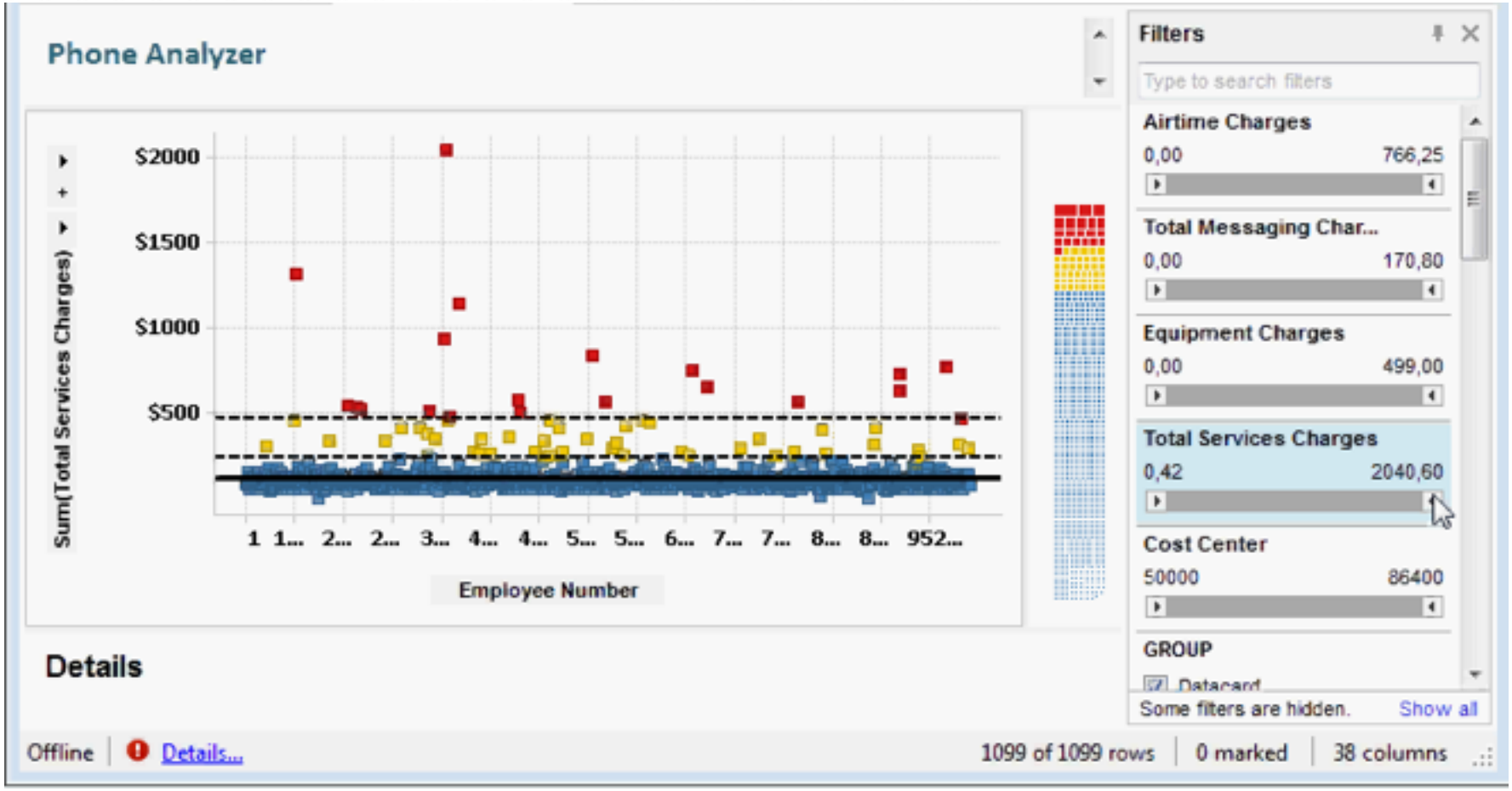
- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

Filtering Techniques

- Dynamic Queries

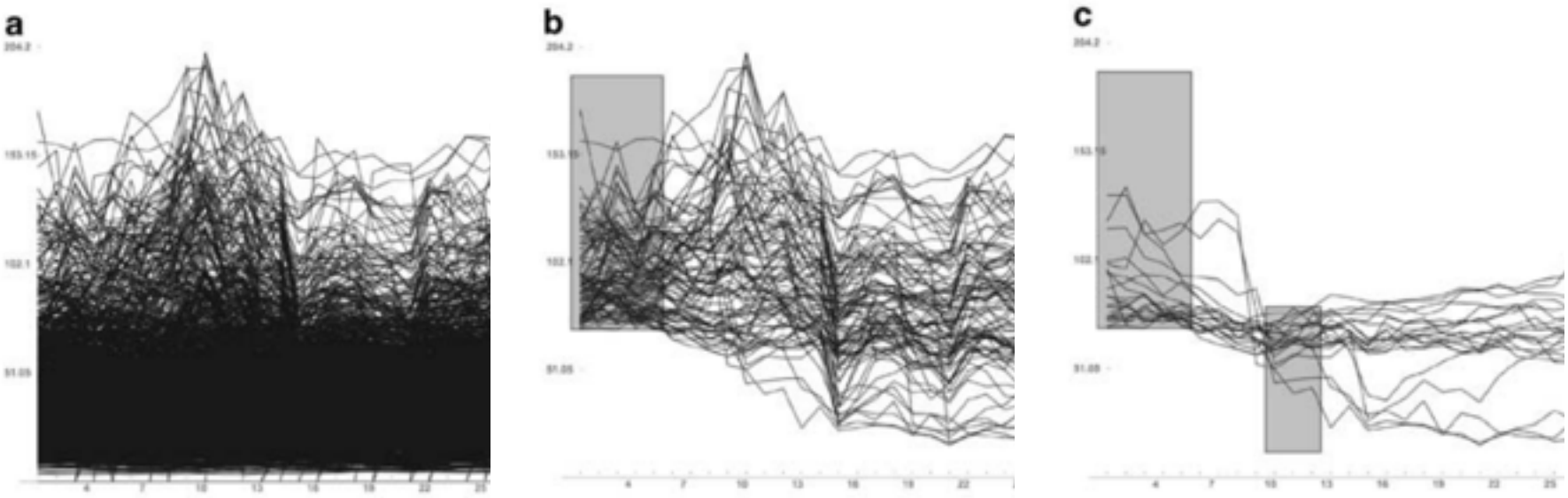
Filtering Techniques

- Dynamic Queries + Rescaling



Filtering Techniques

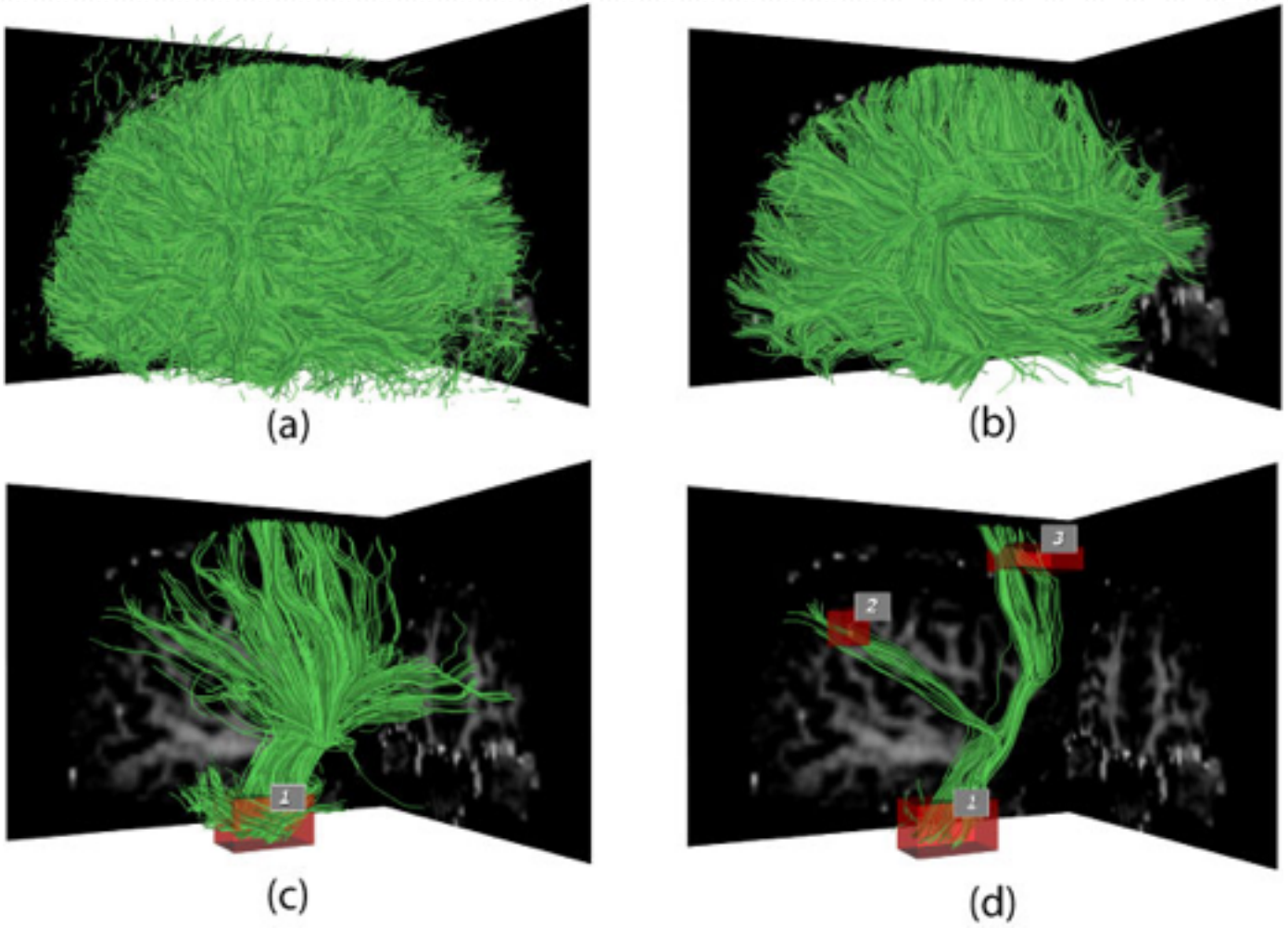
- Dynamic Queries Specified Visually



Time Searcher (Hocheiser, 2003)

Filtering Techniques

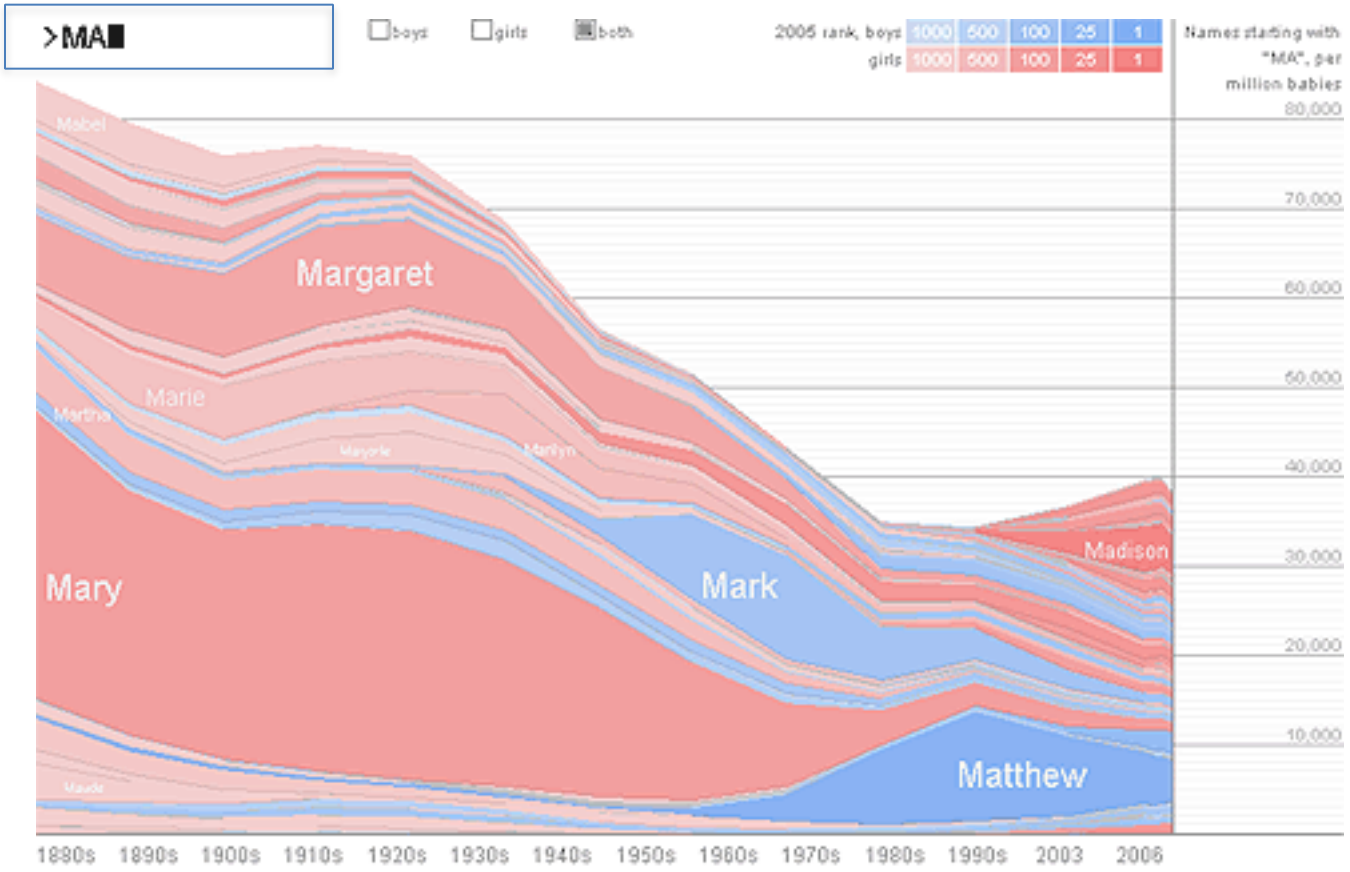
- Dynamic Queries for Volumetric Data



Sherbondy et al, 2004

Filtering Techniques

- Incremental Text Search



Name Voyager (Wattenberg, 2005)

www.babynamewizard.com

Families of infovis interaction techniques

- Filtering techniques 
- Navigation techniques
- Multiple views
- Rearrangement

Problem


Cergy
Taverny
Domont
Goussainville
Saint-Soupplets
Jouy-le-Moutier
Conflans-Sainte-Honorine
Sarcelles
Monthyon
Les Mureaux
Andresy
Mitry-Mory
Aubergenville
Achères
Garges-lès-Gonesse
Meaux
Triport
Guerville
Argenteuil
Saint-Denis
Aulnay-sous-Bois
Claye-Souilly
Poissy
Asnières-sur-Seine
Bobigny
Maule
Nanterre
Quincy-Voisins
Chelles
Lagny-sur-Marne
Beynes
Paris
Montreuil
Torcy
Crécy-la-Chapelle
Auteuil
Nogent-sur-Marne
Garancières
Le Chesnay
Plaisir
Ivry-sur-Seine
Guérard
La Queue-les-Yvelines
Pontchartrain
Versailles
Clamart
Pontault-Combault
Mortcerf
Mérè
Montfort-l'Amaury
Trappes
Robinson
Créteil
Antony
Ozoir-la-Ferrière
Coignières
Orly
Gretz-Armainvilliers
Massy
Saint-Léger-en-Yvelines
Palaiseau
Athis-Mons
Presles-en-Brie
Le Perray-en-Yvelines
Gif-sur-Yvette
Brie-Comte-Robert
Les Ulis
Savigny-sur-Orge
Rozay-en-Brie
Coubert

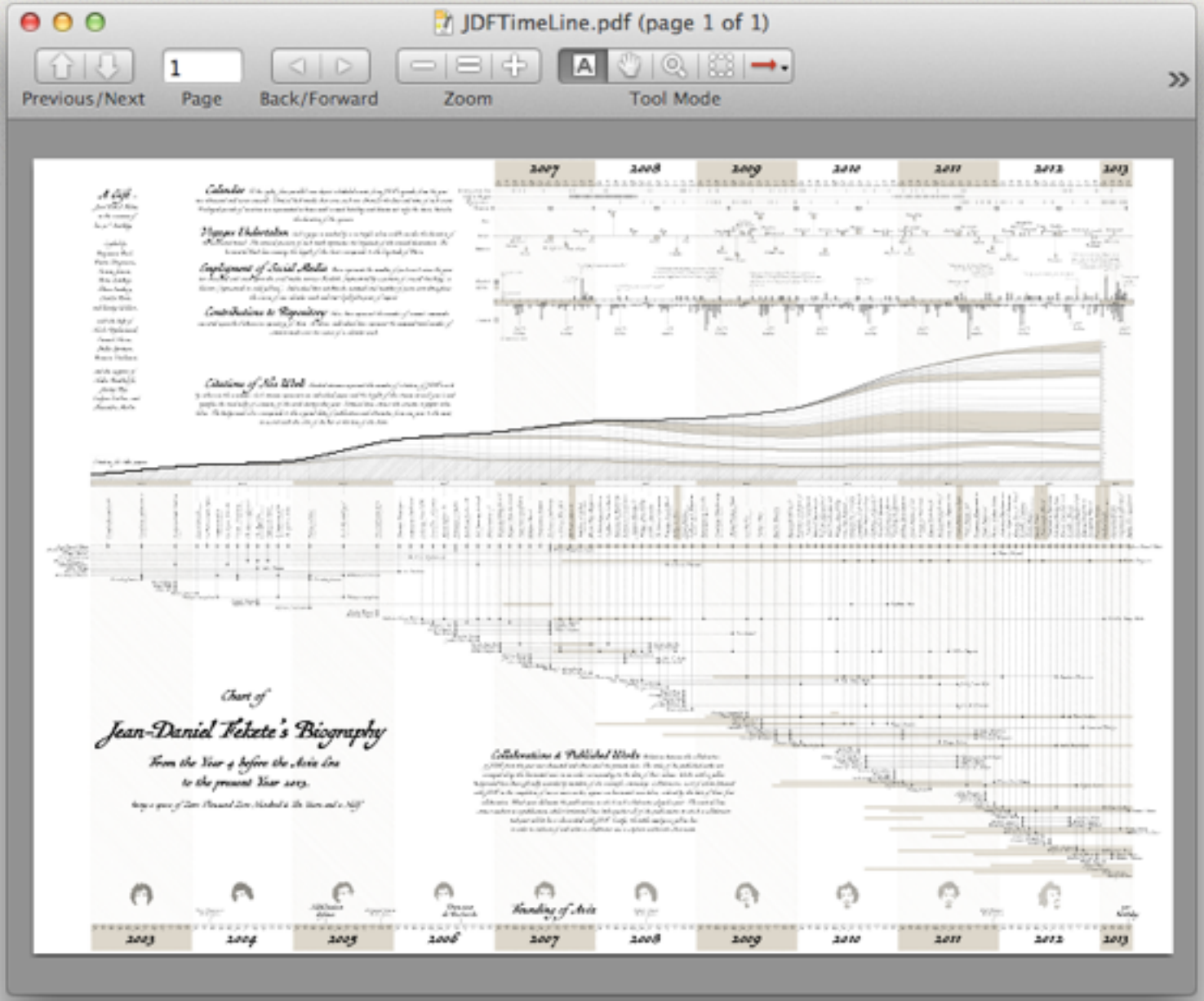
Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

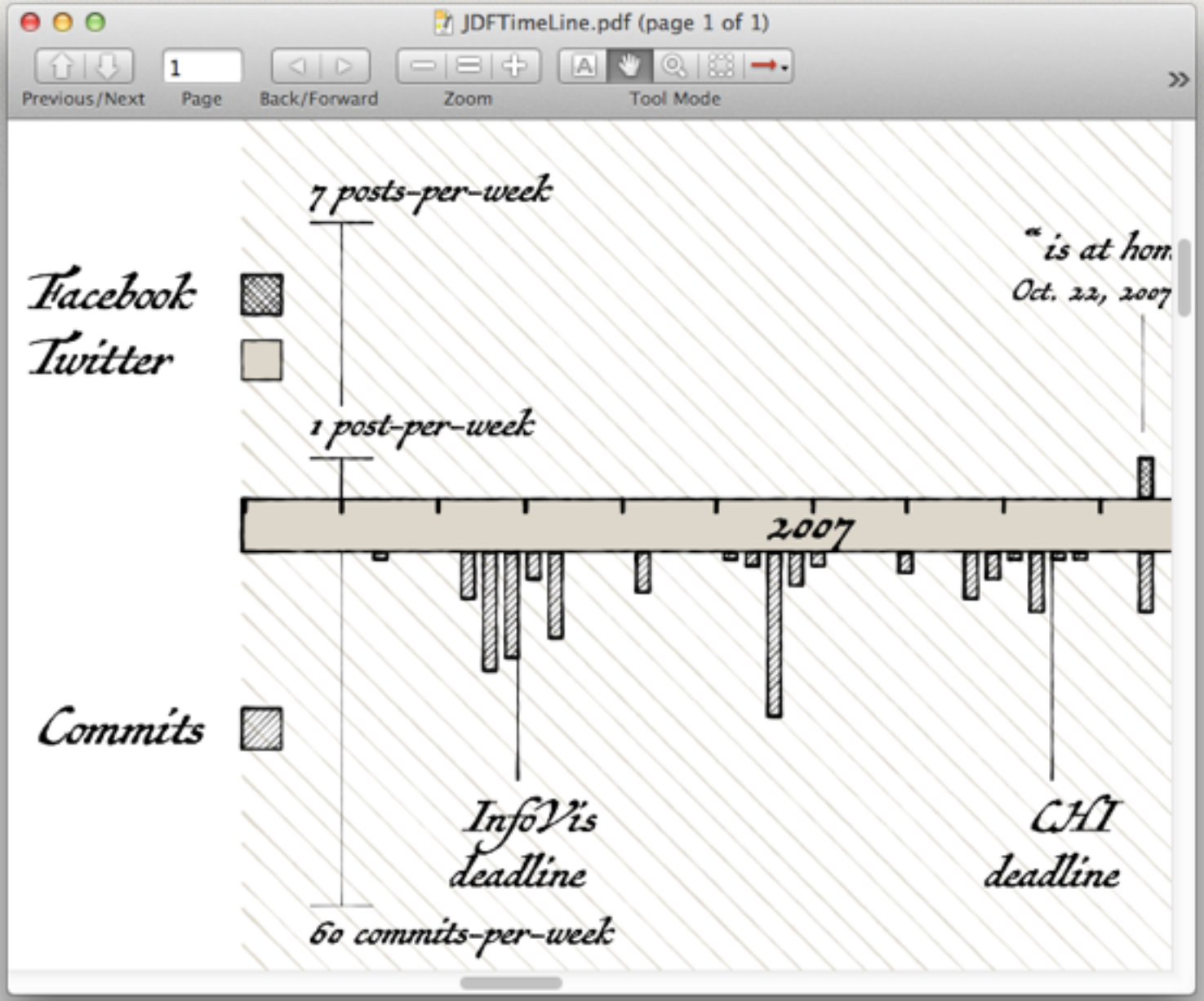
Navigation Techniques

- Pan & Zoom
- Focus + Context

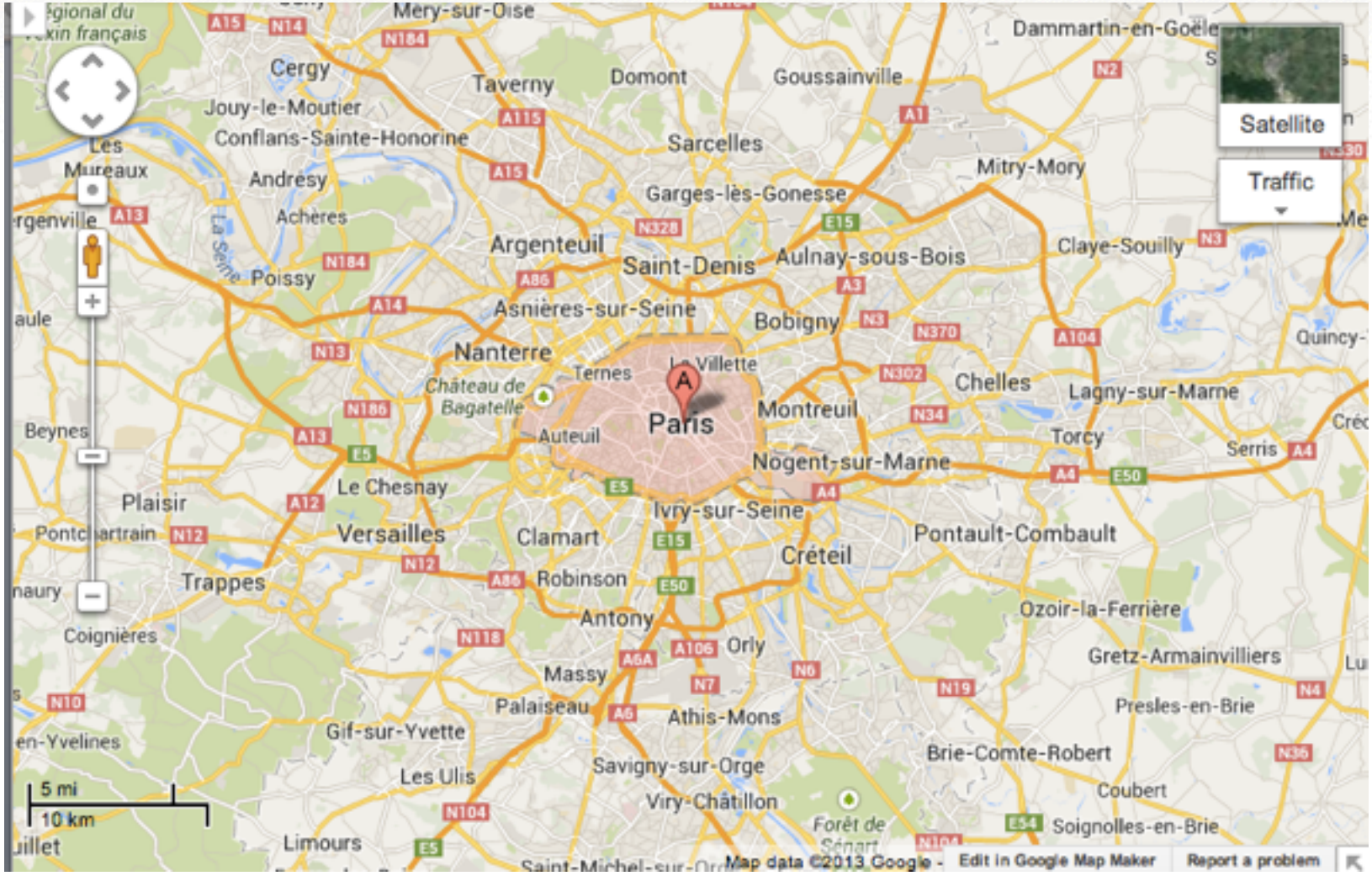
Pan & Zoom


JDFTimeLine.pdf (page 1 of 1)
Previous/Next
Page
Back/Forward
Zoom
Tool Mode
Chart of
Jean-Daniel Fekete's Biography
From the Year 4 before the Axis Era
to the present Year 2013.
Calendar
Employment of Social Media
Contributions to Repository
Citations of his Work
Collaborations & Published Works
Founding of Axis
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013

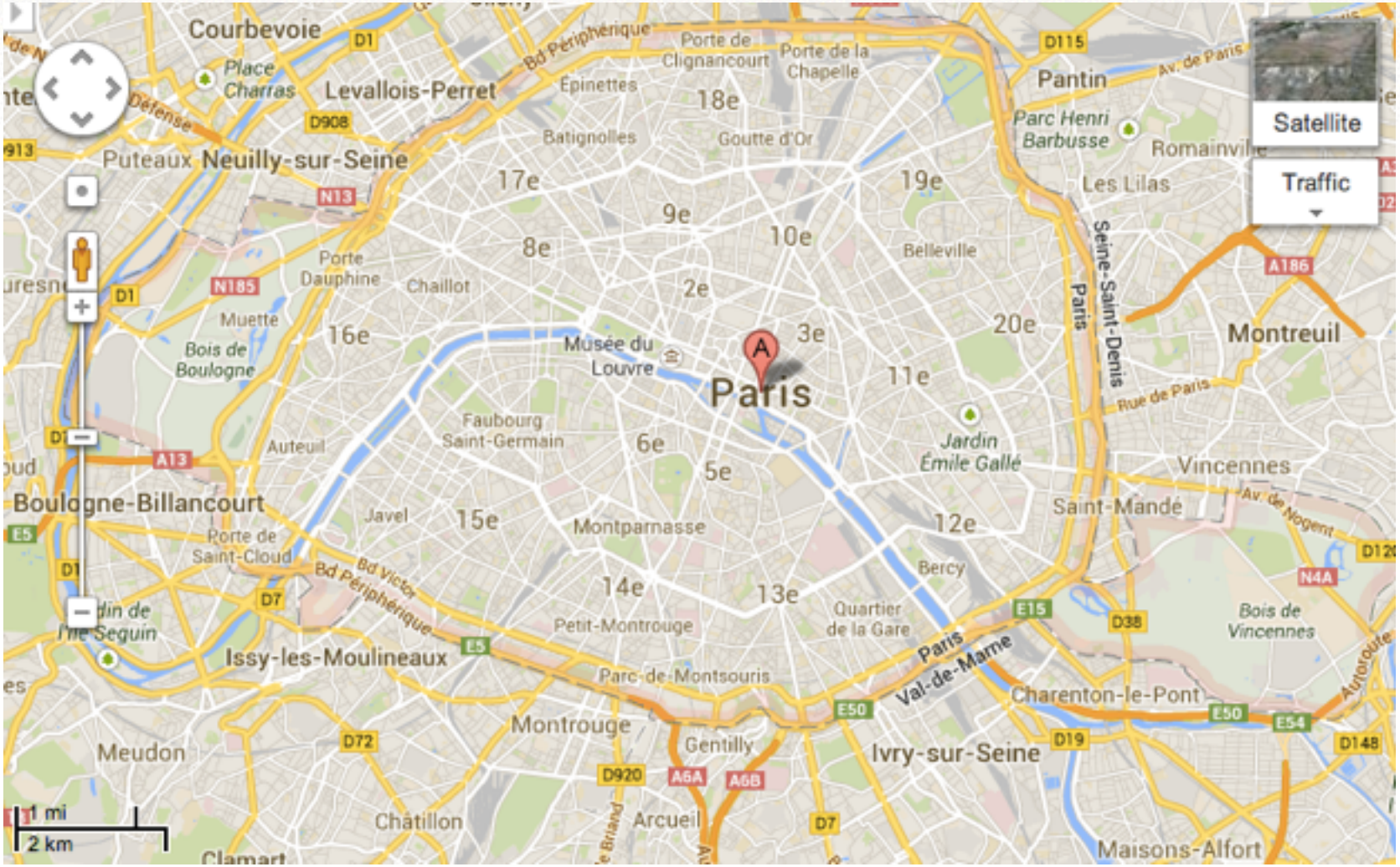
Pan & Zoom


JDFTimeLine.pdf (page 1 of 1)
Previous/Next
1
Page
Back/Forward
Zoom
Tool Mode
7 posts-per-week
Facebook
Twitter
1 post-per-week
" is at hom
Oct. 22, 2007
2007
Commits
InfoVis
deadline
CHI
deadline
60 commits-per-week

Pan & Zoom


Satellite
Traffic
Paris
Nanterre
Argenteuil
Saint-Denis
Versailles
Boulogne-Billancourt
Montreuil
Ivry-sur-Seine
Créteil
Clamart
Antony
Massy
Palaiseau
Asnières-sur-Seine
Bobigny
Aulnay-sous-Bois
Sarcelles
Garges-lès-Gonesse
Taverny
Cergy
Poissy
Chelles
Lagny-sur-Marne
Nogent-sur-Marne
Pontault-Combault
Ozoir-la-Ferrière
Gretz-Armainvilliers
Presles-en-Brie
Brie-Comte-Robert
Coubert
Soignolles-en-Brie
Athis-Mons
Orly
Robinson
Trappes
Le Chesnay
Plaisir
Coignières
Gif-sur-Yvette
Les Ulis
Limours
Savigny-sur-Orge
Viry-Châtillon
Forêt de Sénart
Auteuil
Ternes
La Villette
Château de Bagatelle
Beynes
Achères
Andrésy
Conflans-Sainte-Honorine
Jouy-le-Moutier
Taverny
Domont
Goussainville
Dammartin-en-Goële
Mitry-Mory
Claye-Souilly
Quincy-
Torcy
Serris
5 mi
10 km
Map data ©2013 Google -
Edit in Google Map Maker
Report a problem

Pan & Zoom

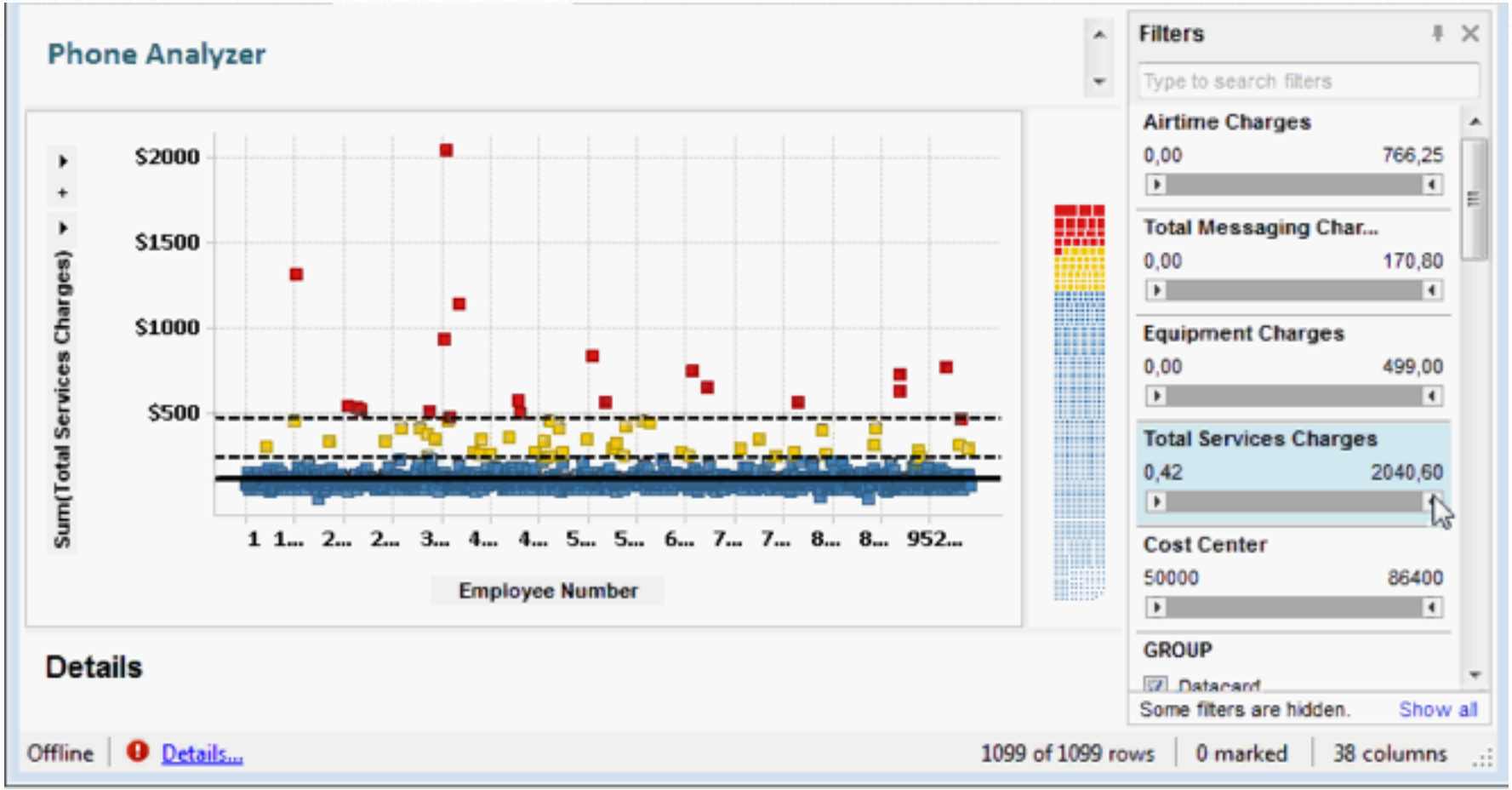

Courbevoie
Place Charras
Levallois-Perret
Bd Périphérique
Porte de Clignancourt
Porte de la Chapelle
Pantin
Parc Henri Barbusse
Romainville
Les Lilas
Satellite
Traffic
Puteaux
Neuilly-sur-Seine
Épinettes
Batignolles
Goutte d'Or
18e
17e
19e
9e
10e
8e
Belleville
Porte Dauphine
Chaillot
2e
Seine-Saint-Denis
Paris
Montreuil
Muette
Bois de Boulogne
16e
Musée du Louvre
3e
20e
Paris
11e
Rue de Paris
Faubourg Saint-Germain
Auteuil
6e
5e
Jardin Émile Gallé
Vincennes
Boulogne-Billancourt
Javel
15e
Montparnasse
12e
Saint-Mandé
Av. de Nogent
Porte de Saint-Cloud
Bd Périphérique
Bercy
14e
13e
Quartier de la Gare
Petit-Montrouge
Bois de Vincennes
Issy-les-Moulineaux
Parc-de-Montsouris
Paris Val-de-Marne
Charenton-le-Pont
Montrouge
Meudon
Gentilly
Ivry-sur-Seine
Châtillon
Arcueil
Maisons-Alfort
1 mi
2 km

Pan & Zoom

- Semantic Zoom

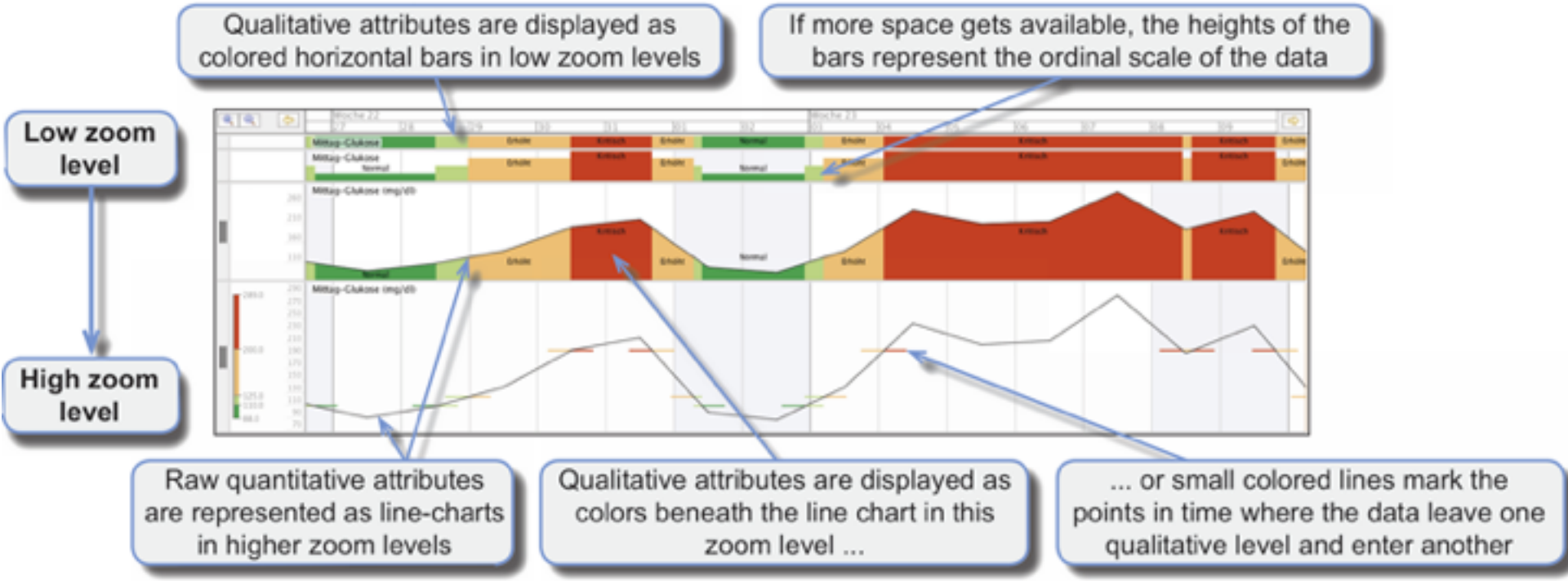
Pan & Zoom

- 1-D Zoom



Pan & Zoom

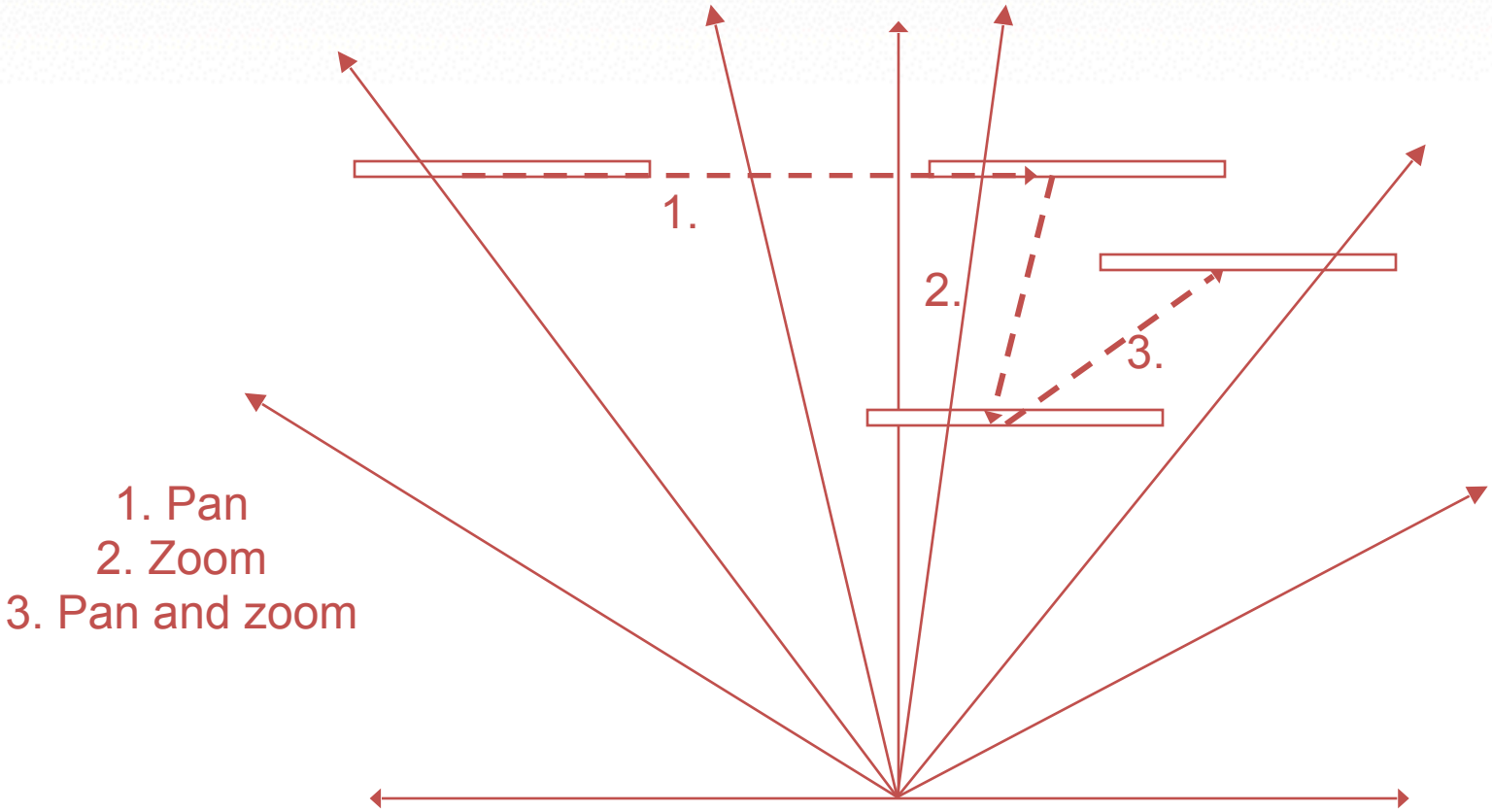
- 1-D Semantic Zoom



Bade et al, 2004 - MIDGAARD (link)

Pan & Zoom

- Space-Scale Diagrams



Furnas and Bederson, 1995
Space-Scale Diagrams: Understanding Multiscale Interfaces (link)

Problem

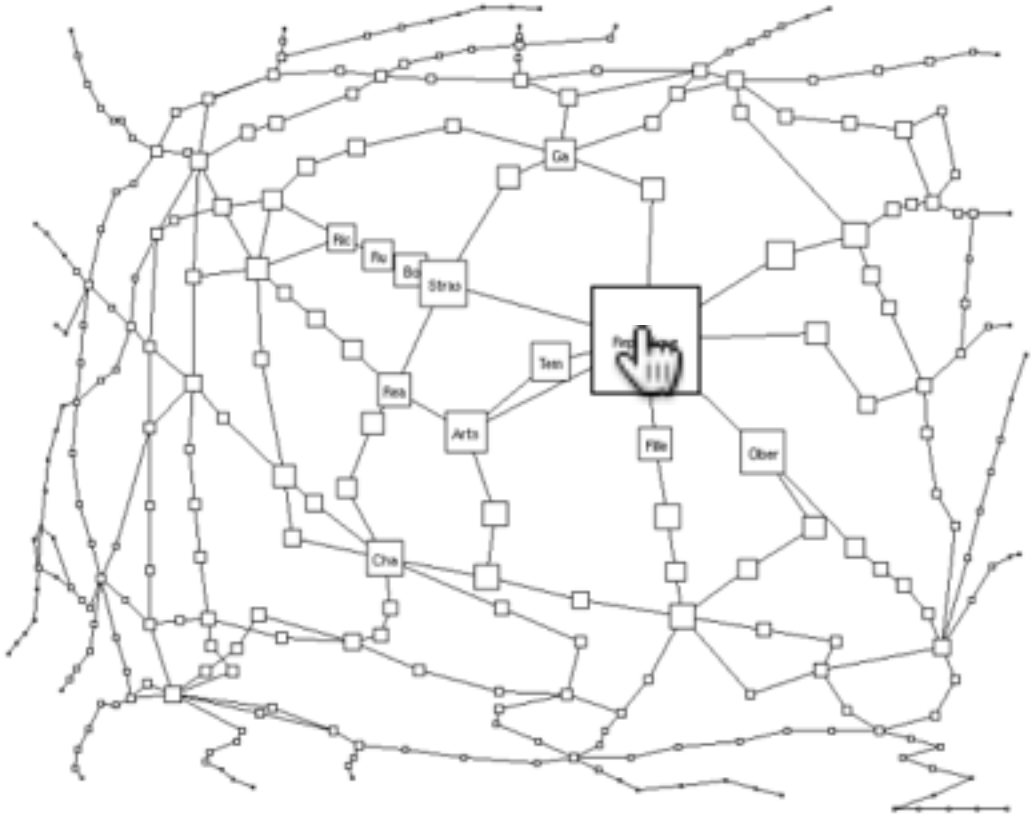
Where am I?

Navigation Techniques

- Pan & Zoom
- Focus + Context

Focus + Context

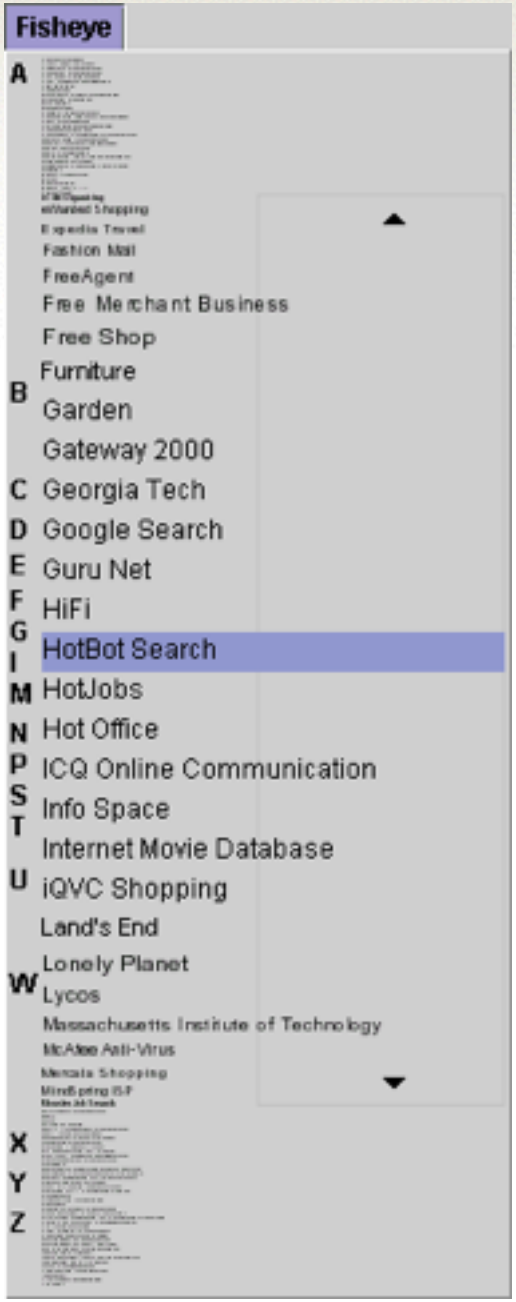
- Space Distorsion



Sarkar and Brown, 1992

Focus + Context

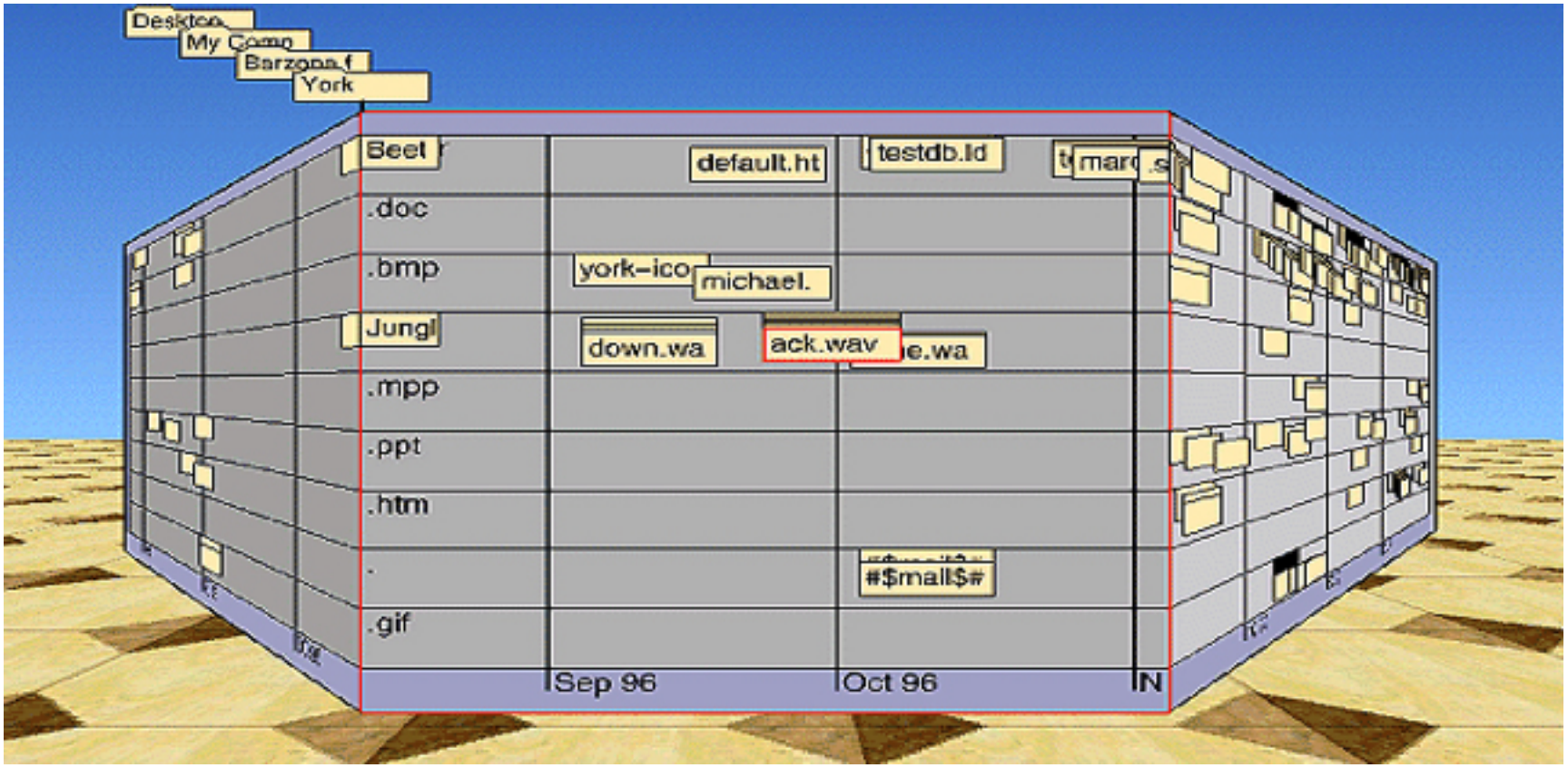
- Space Distorsion



Bederson, 2000

Focus + Context

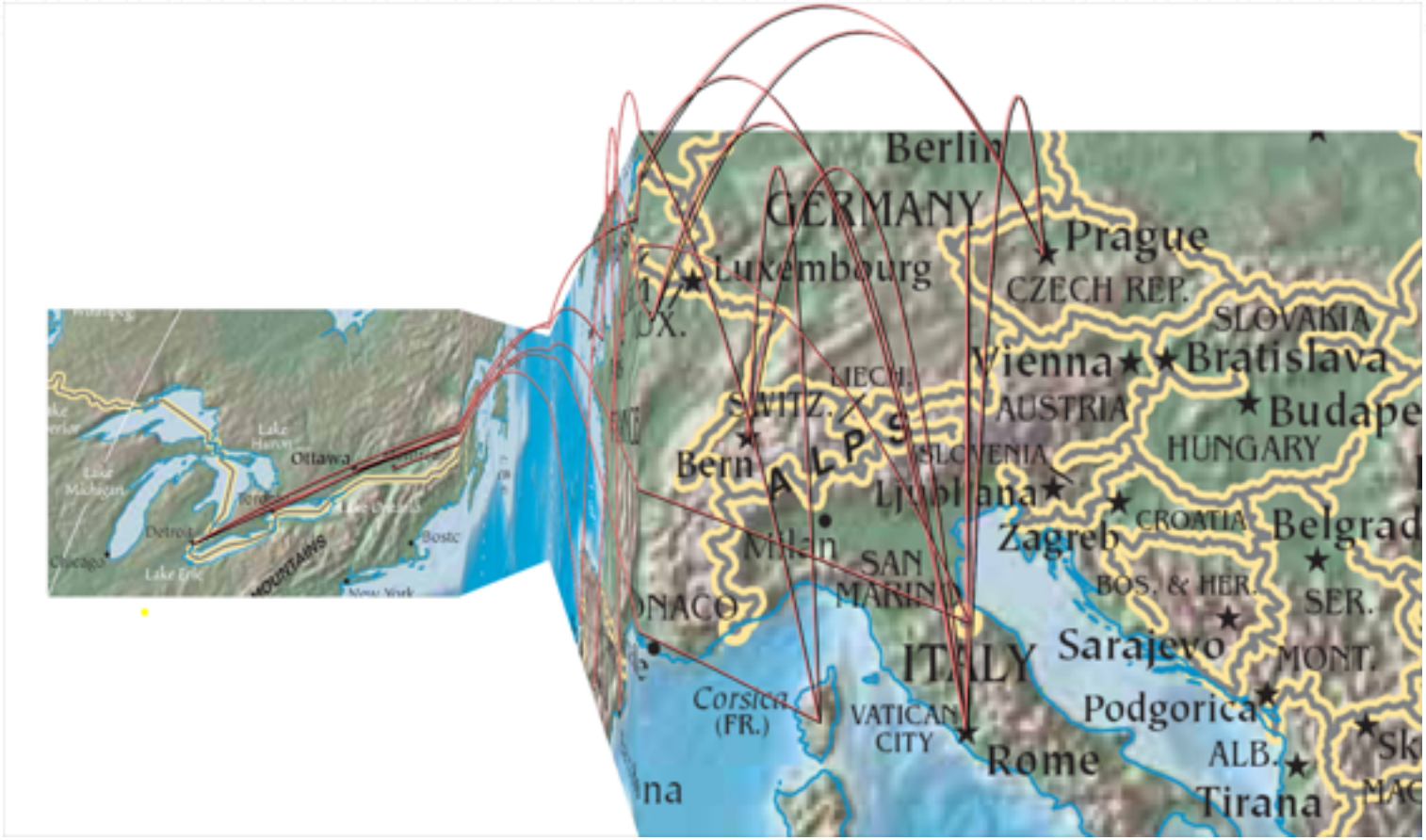
- Space Distorsion



Mackinlay, Roberston and Card, 1991

Focus + Context

- Space Distorsion



Elmqvist et al, 2010

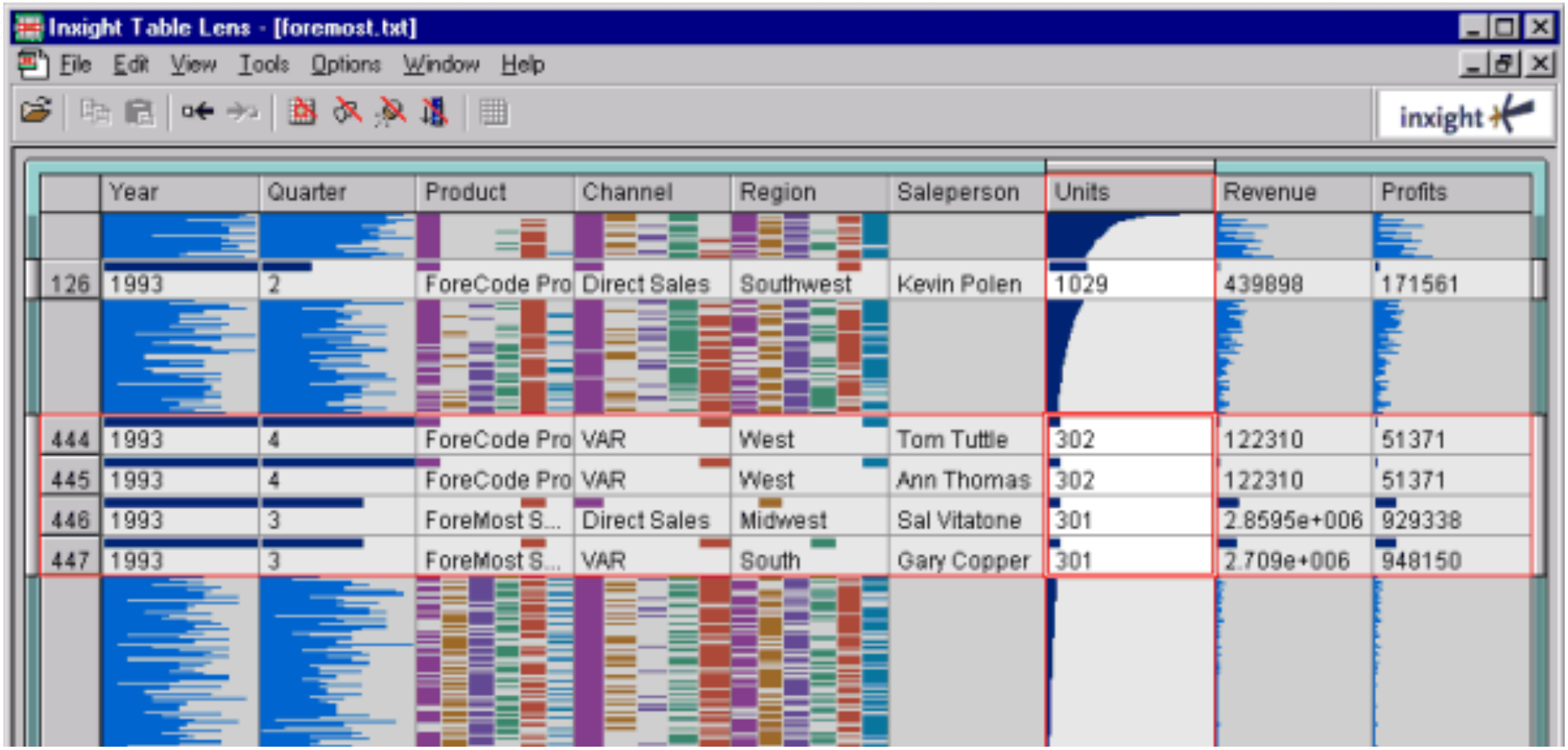
Focus + Context

- Space Distorsion

Brosz, Carpendale and Nacenta, 2011

Focus + Context

- Table Lens



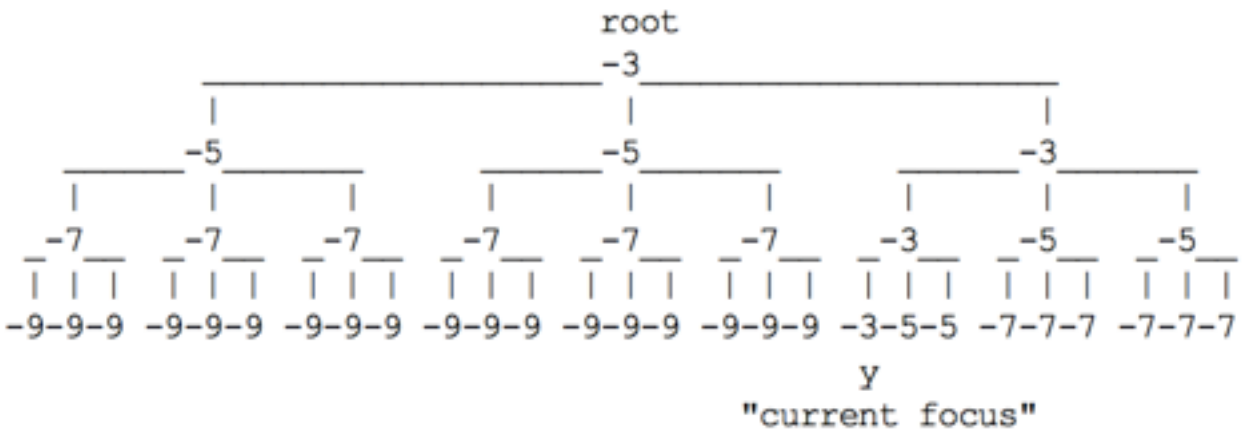
Rao and Card, 1994

Focus + Context

- Generalized Fisheye Views

(c) The Fisheye DOI:

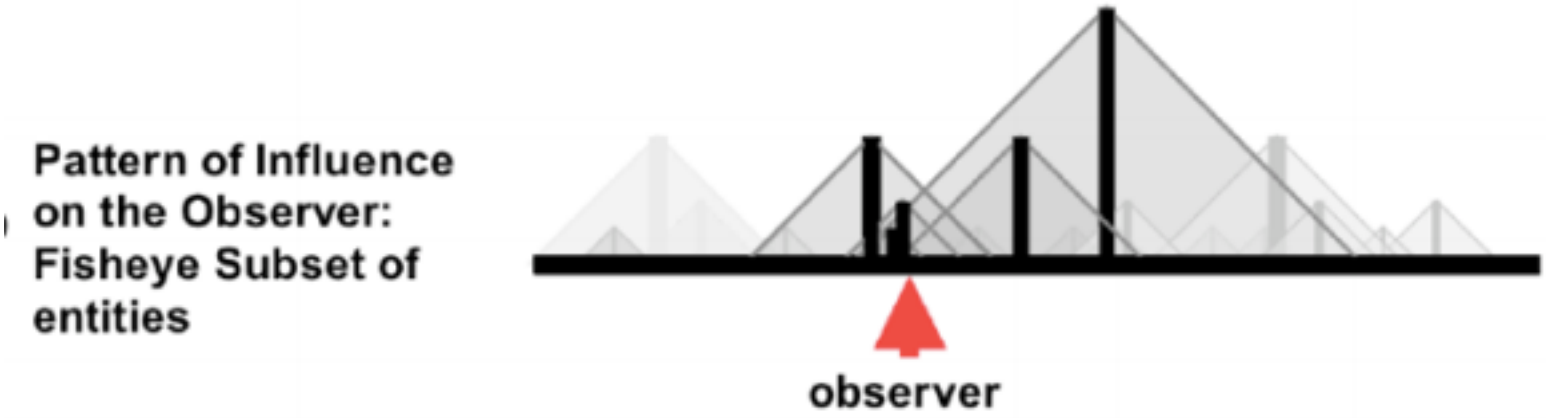
$$DOI_{fisheye(tree)}(x|.=y) = API(x) - D(x,y)$$
$$= -(d_{tree}(x,y) + d_{tree}(x,root))$$



Furnas, 1986
Generalized Fisheye Views

Focus + Context

- Generalized Fisheye Views

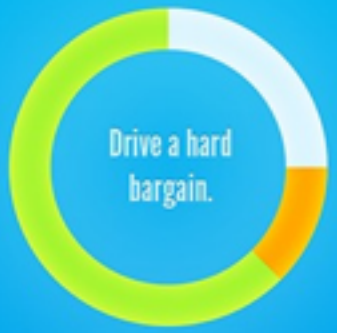


Furnas, 2010
A Fisheye Follow-Up: Further Reflections on Focus + Context

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques 
- Multiple views
- Rearrangement

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

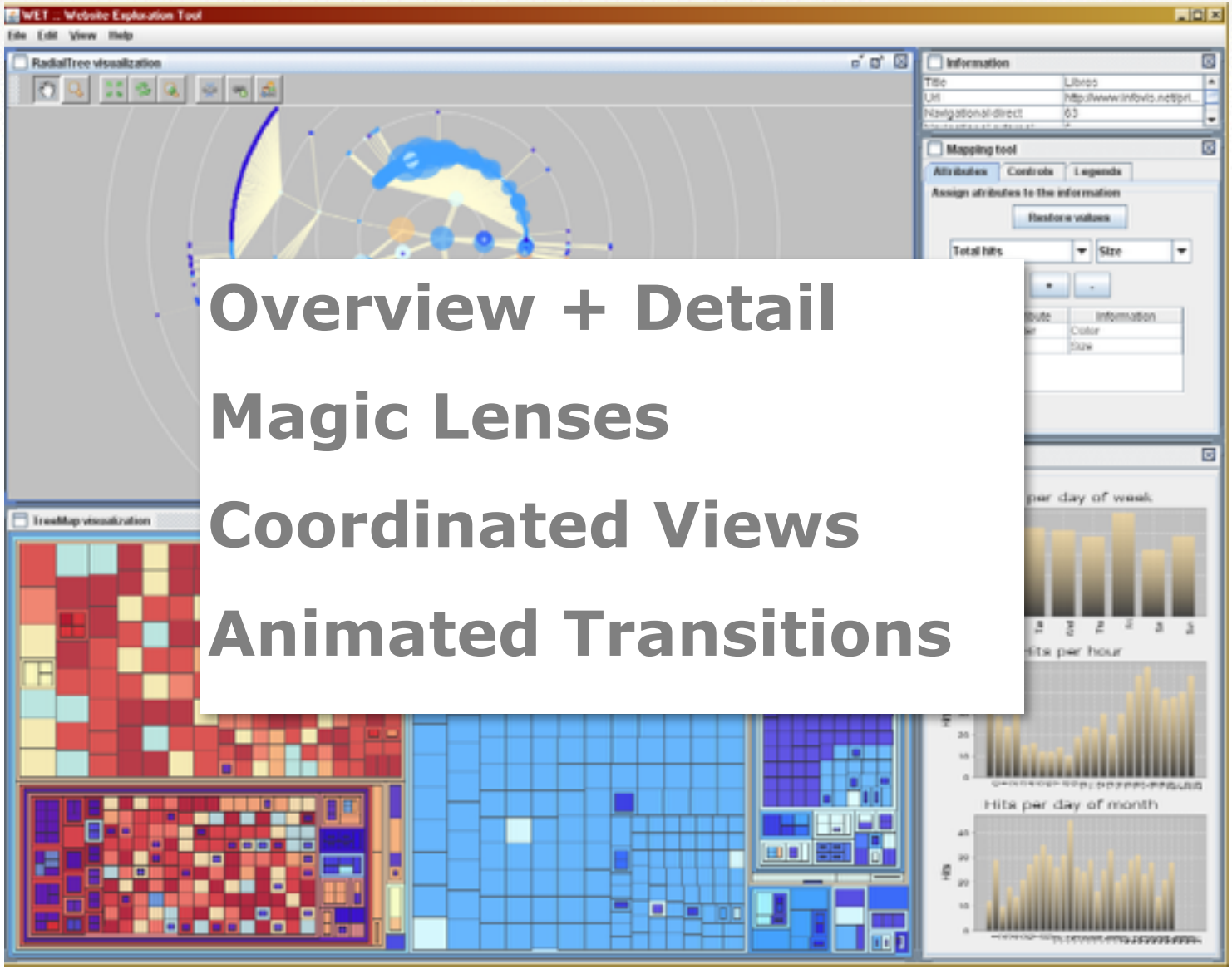
Venice

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

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

Multiple Views

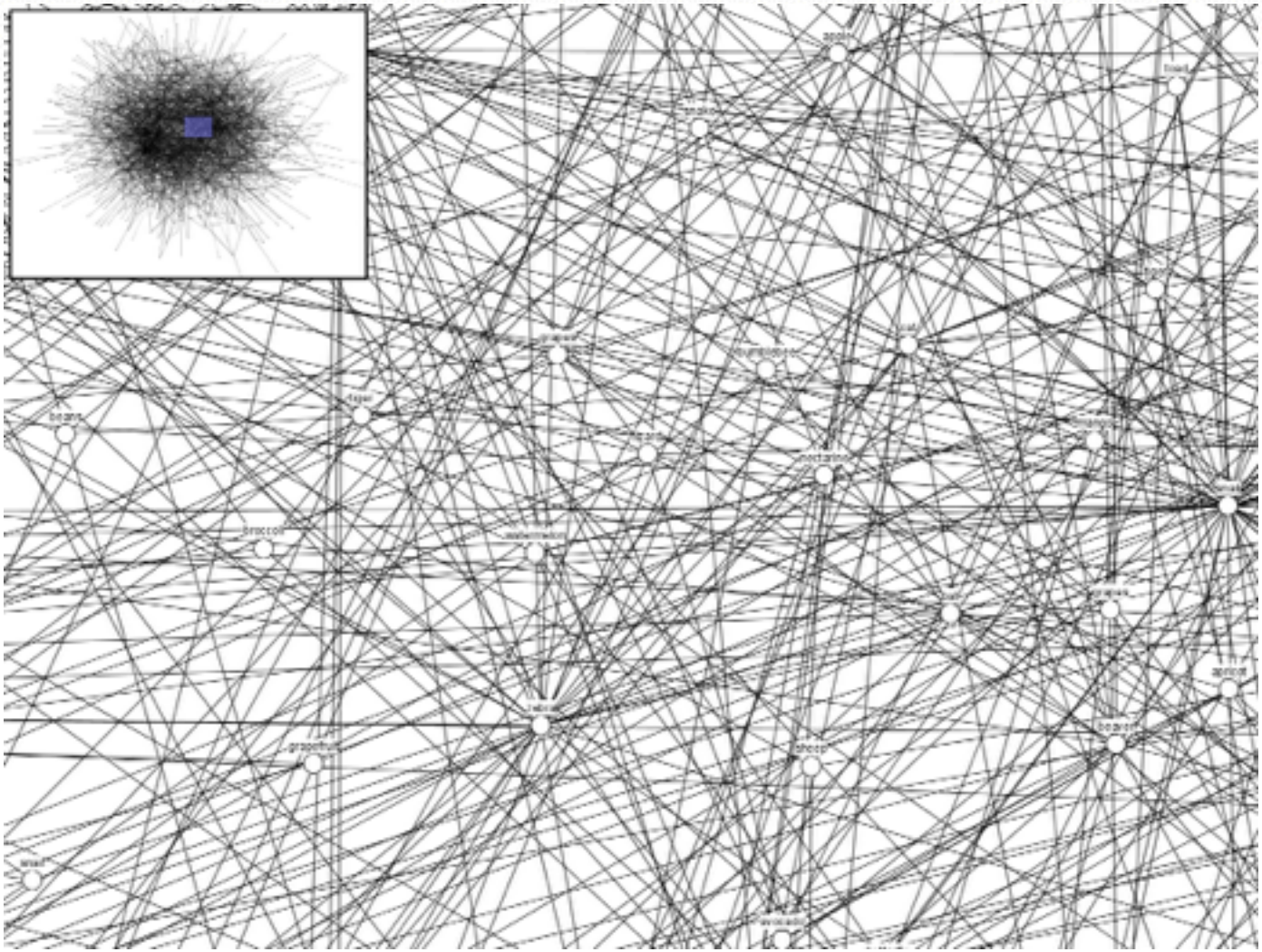


Problem

Where am I?

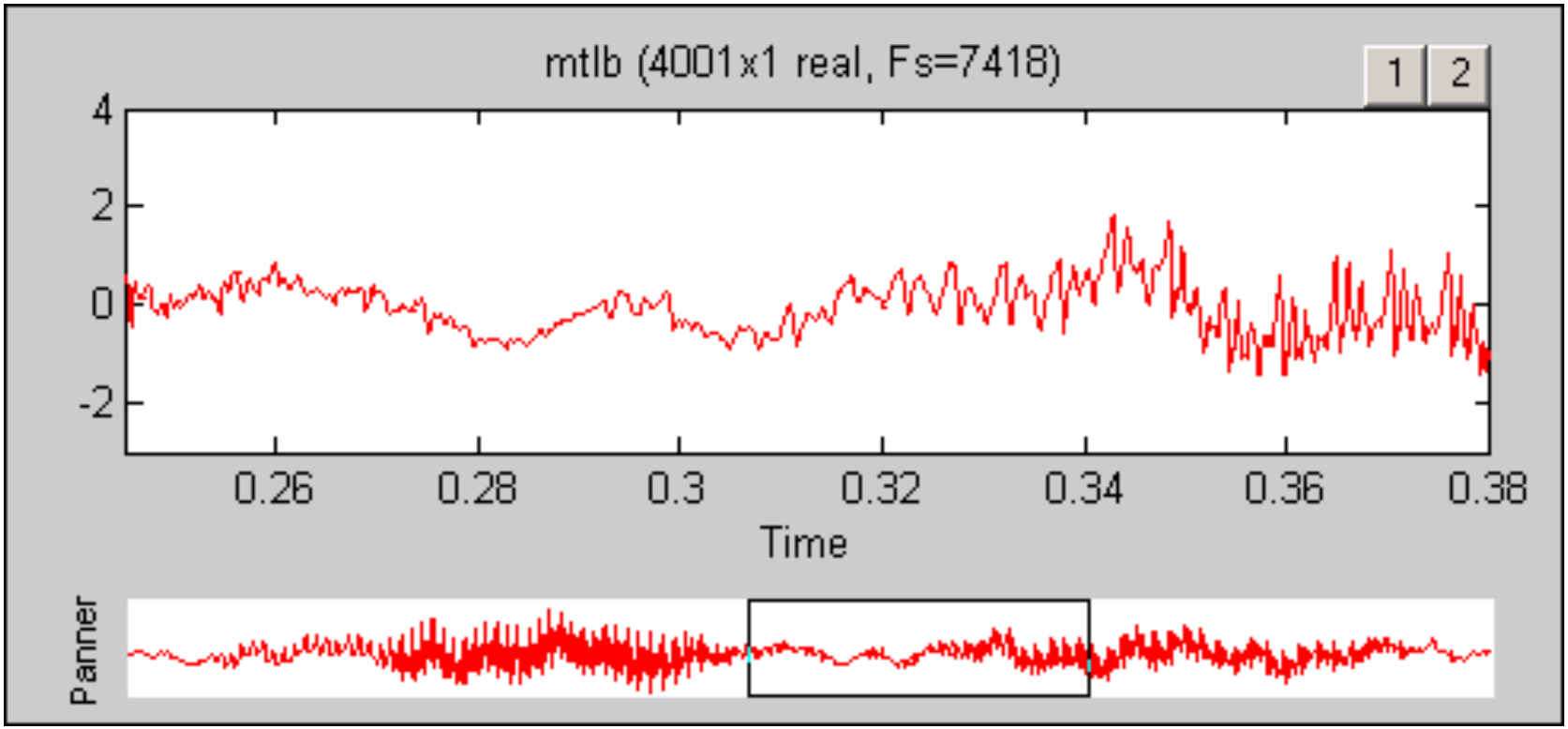
Overview + Detail

Panning a large graph



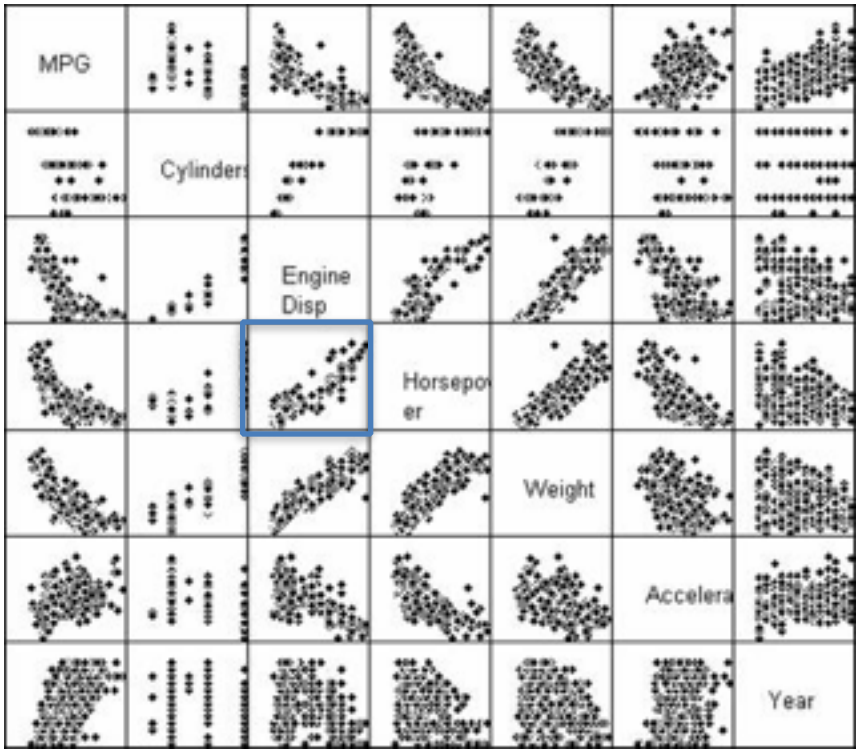
Overview + Detail

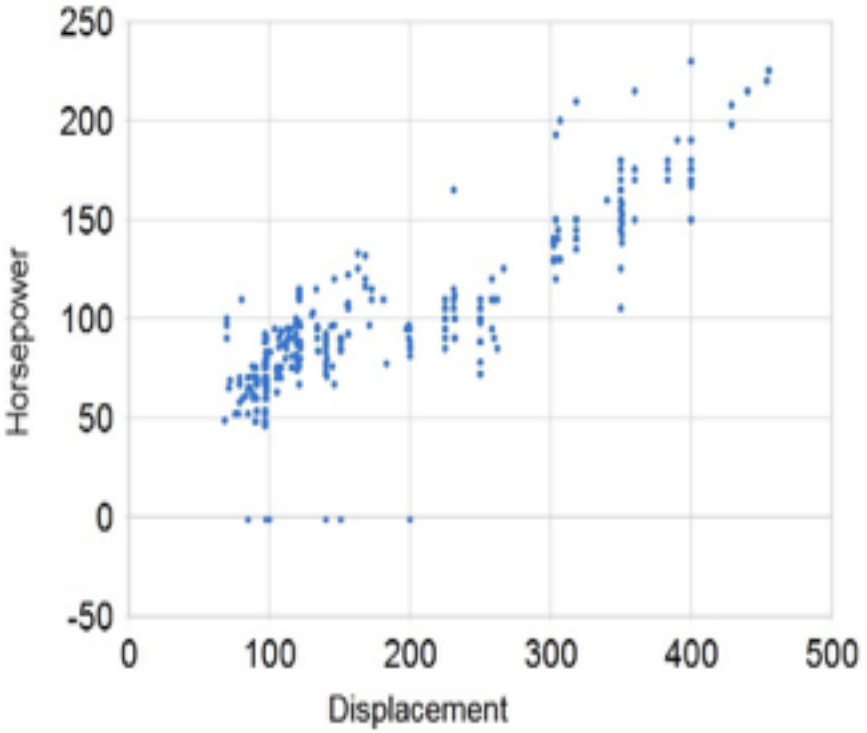
Panning a line chart



Overview + Detail

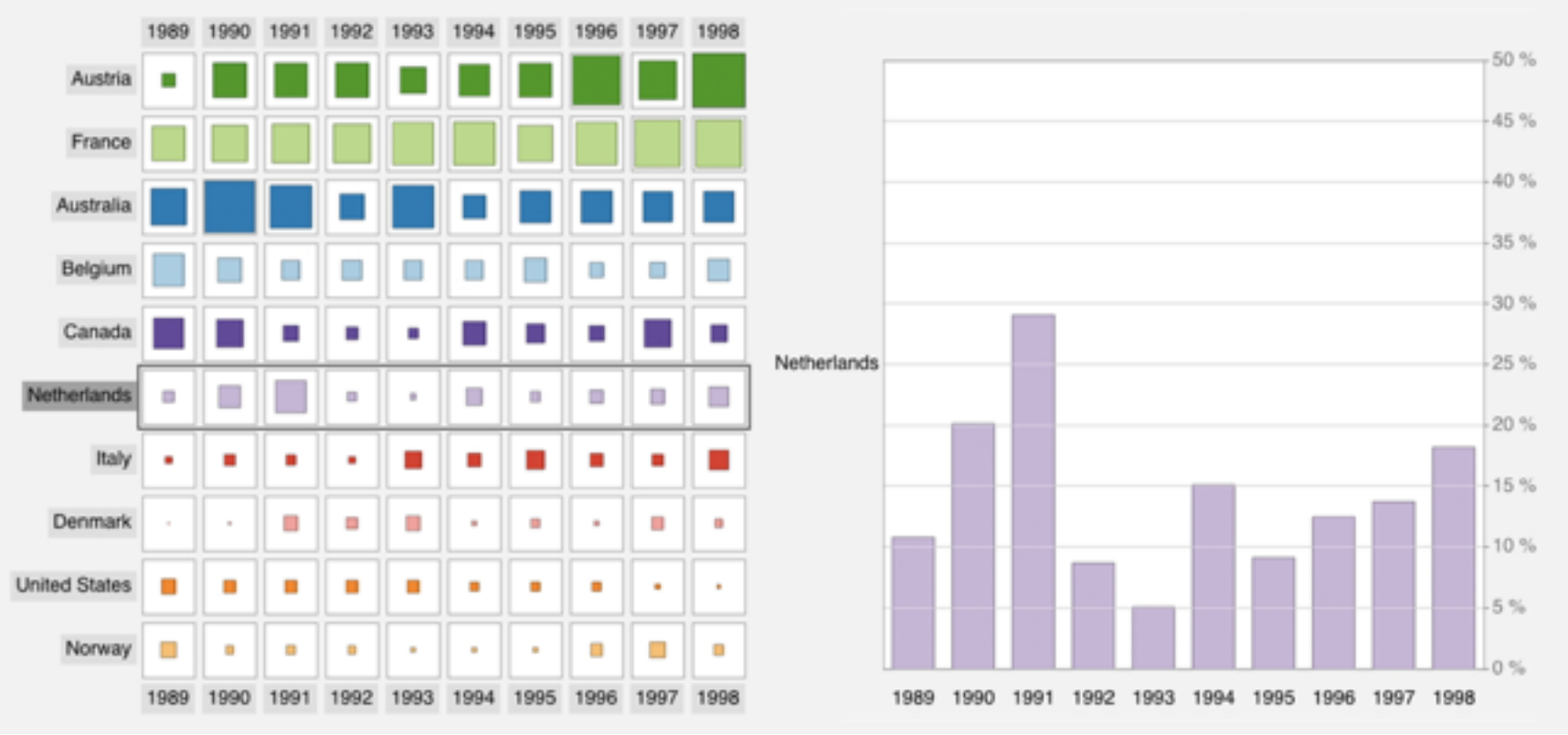
Browsing Multiple Views





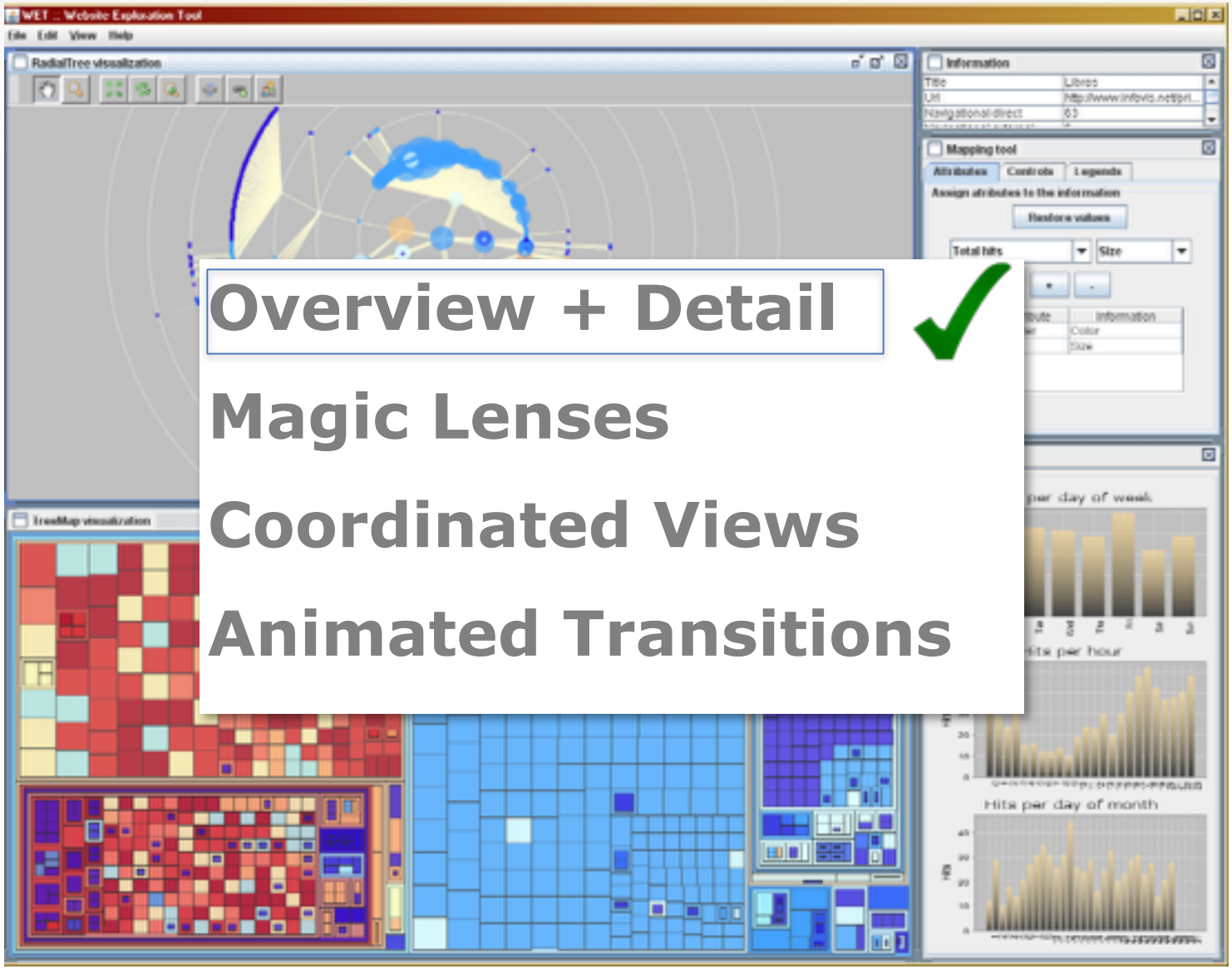
Overview + Detail

Browsing Multiple Views

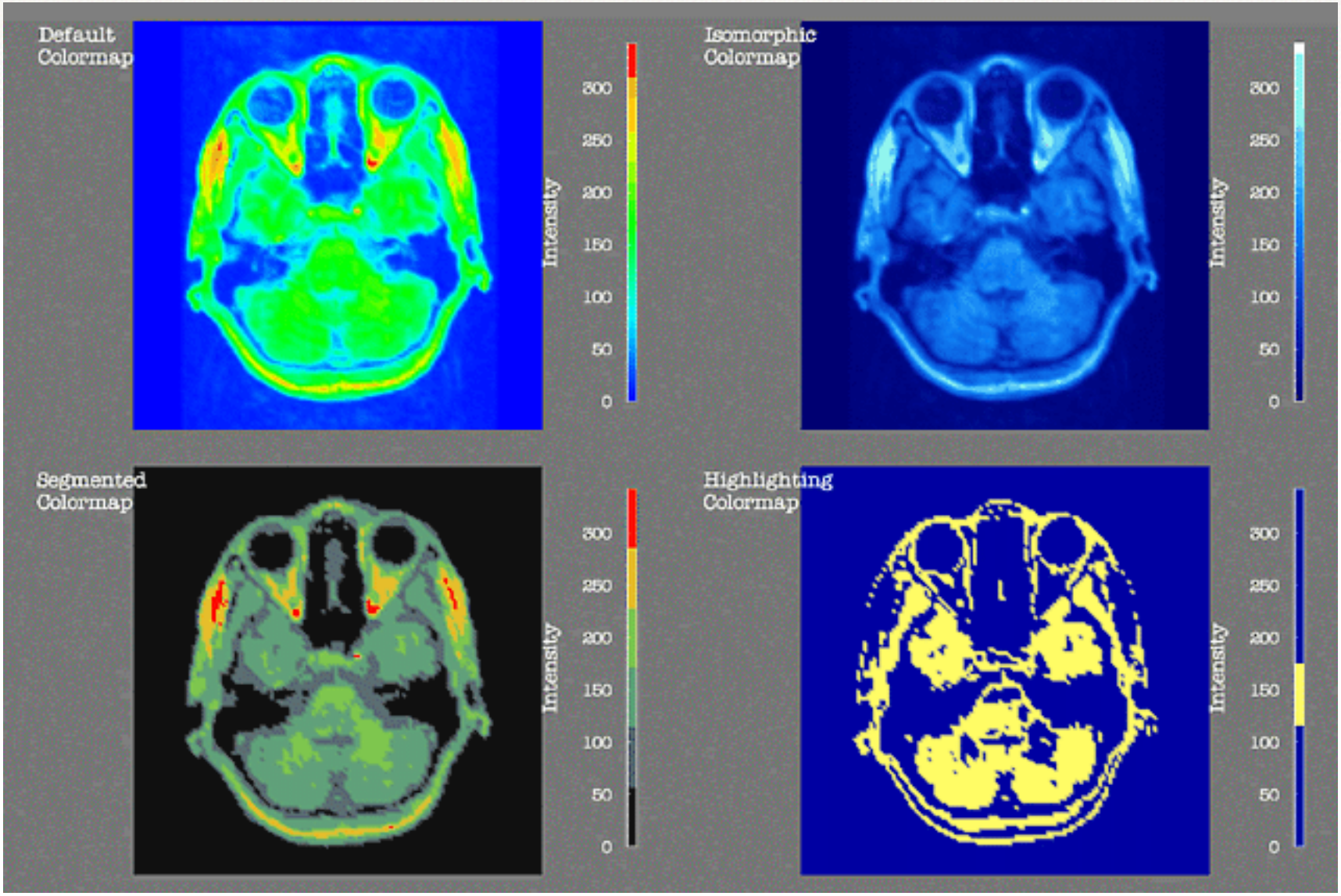


Jansen et al, 2013

Multiple Views

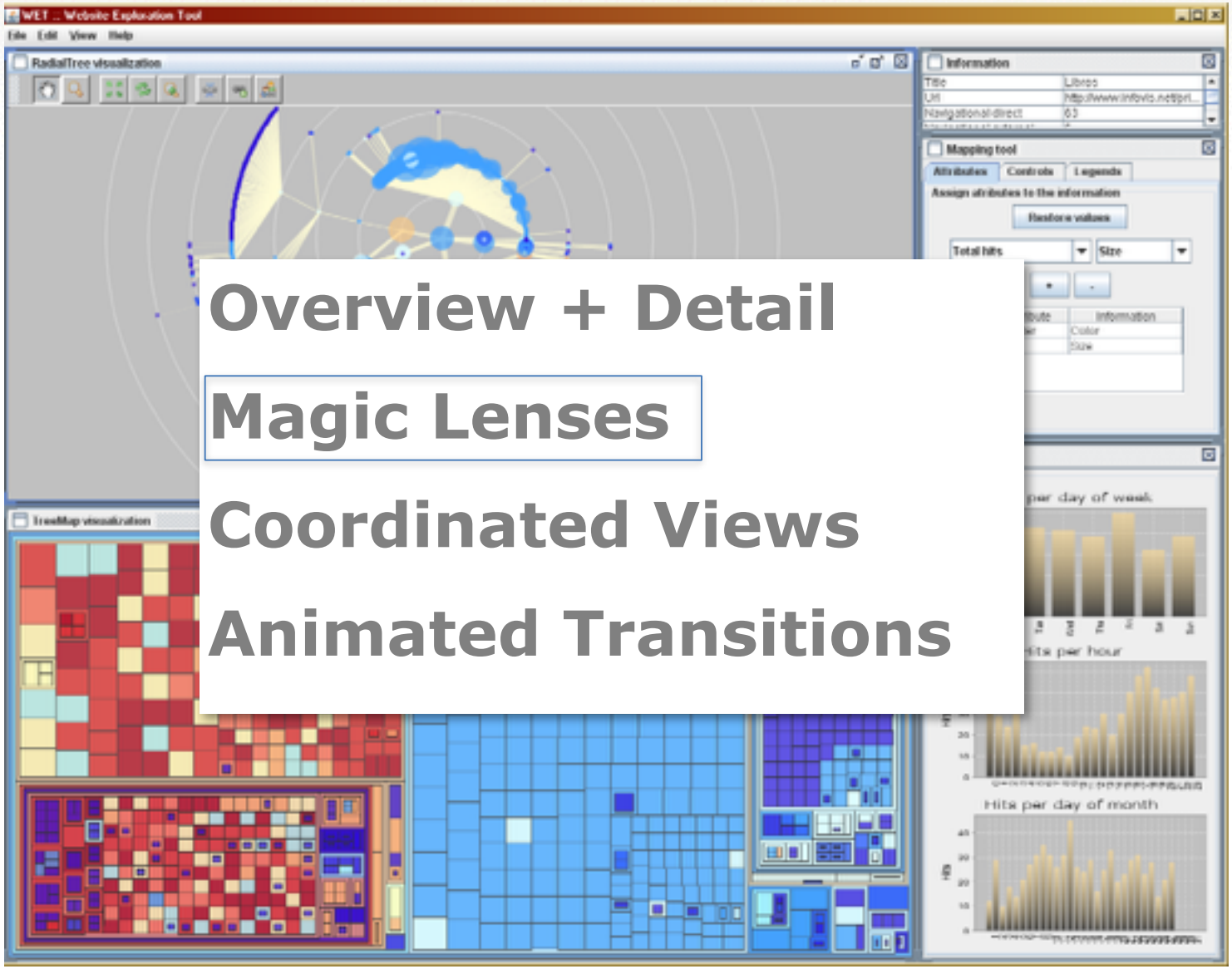


Problem



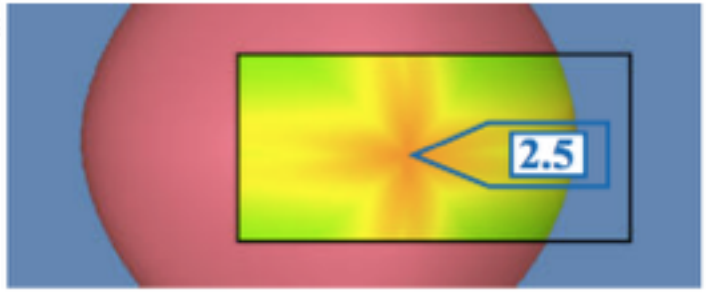
Rogowitz and Treinish, 1995

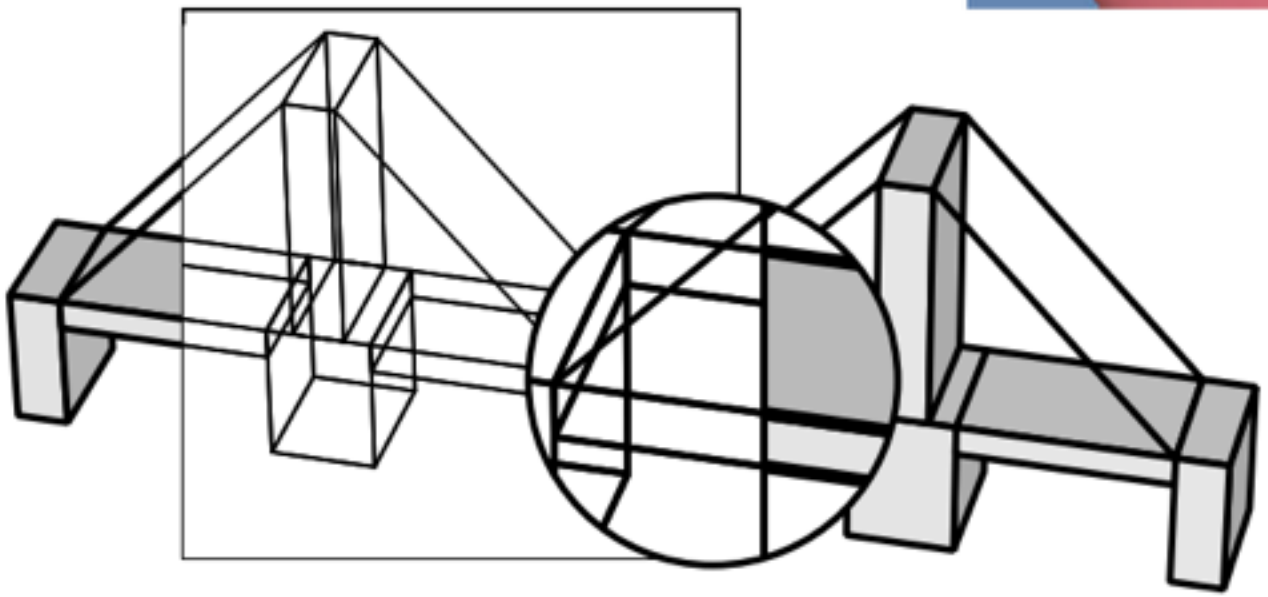
Multiple Views



Magic Lenses

(Xia & Karlen's Presentation)

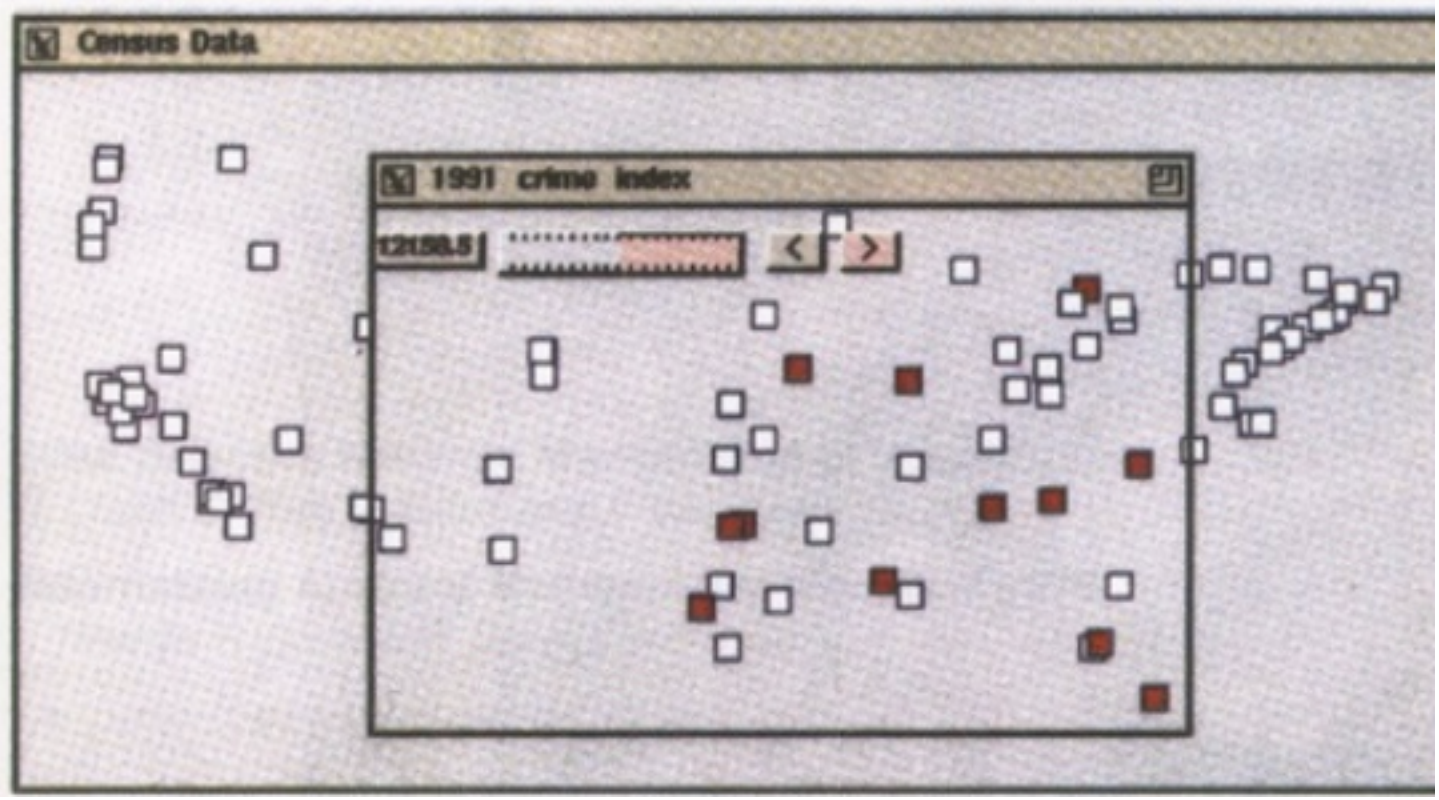




Bier et al, 1993

Magic Lenses

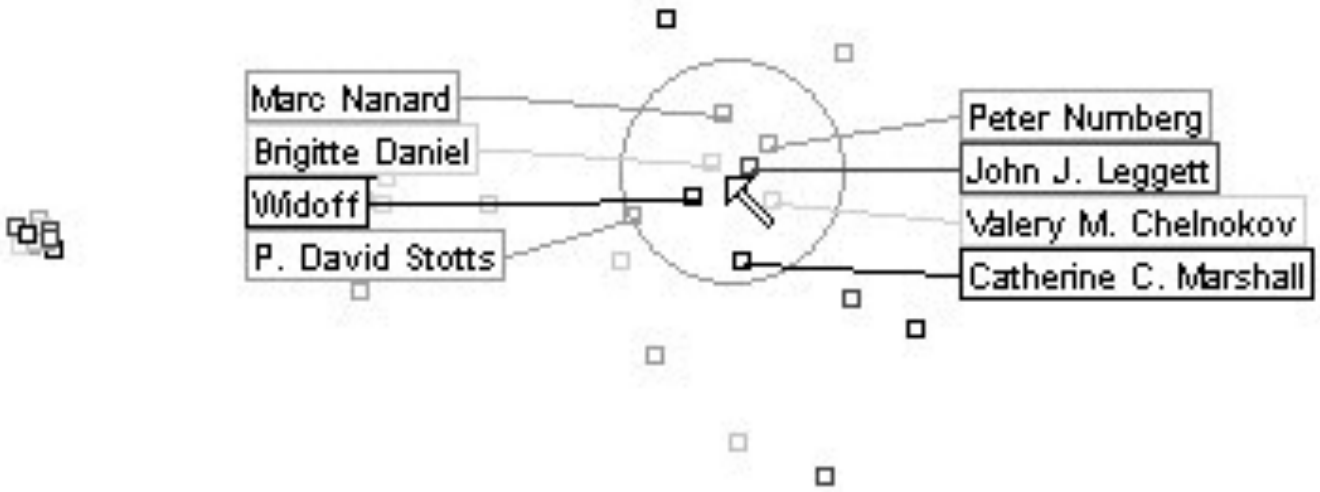
Movable filters for dynamic queries



Fishkin and Stone, 1995

Magic Lenses

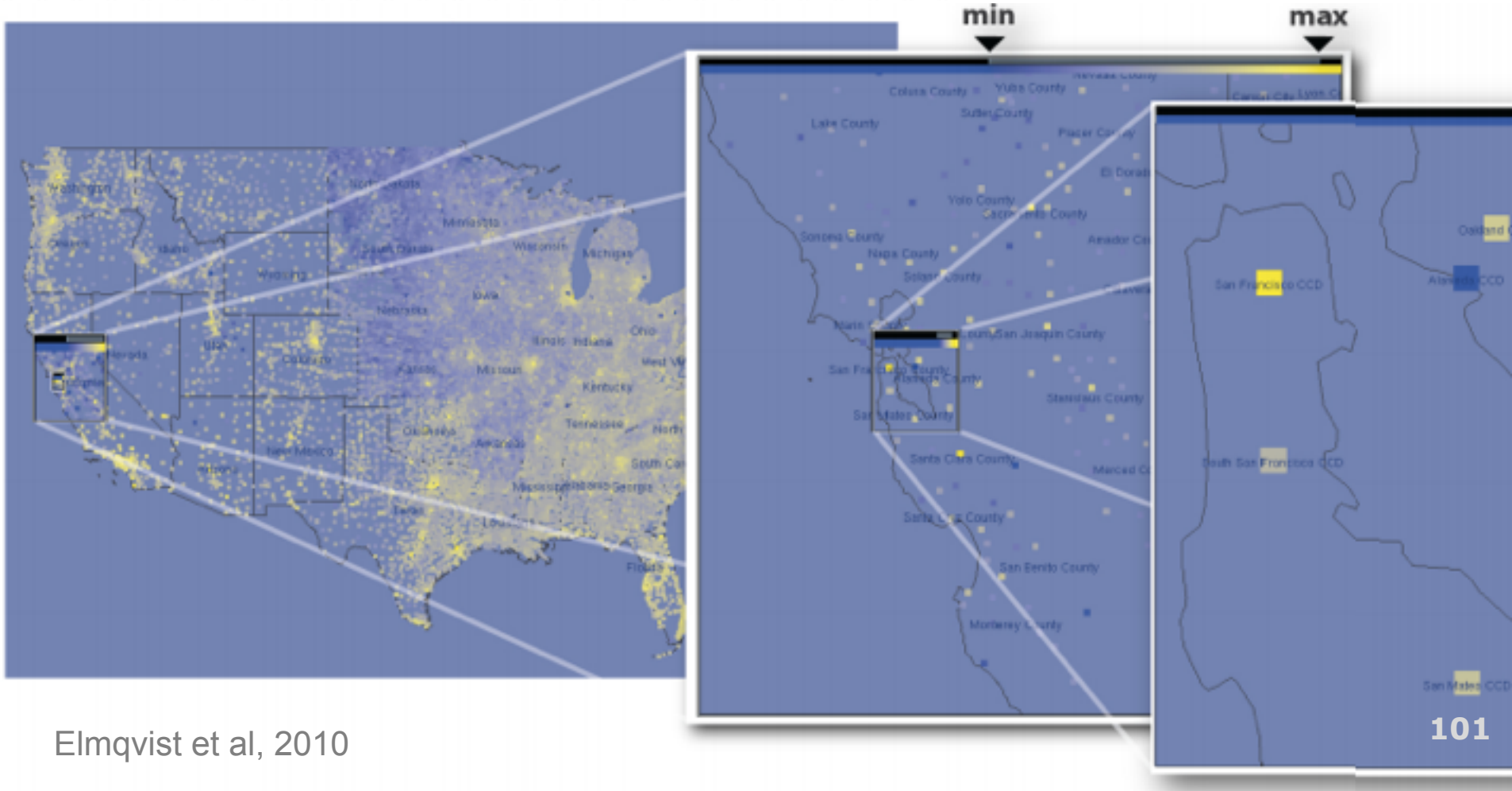
Excentric Labeling



Fekete and Plaisant, 1999

Magic Lenses

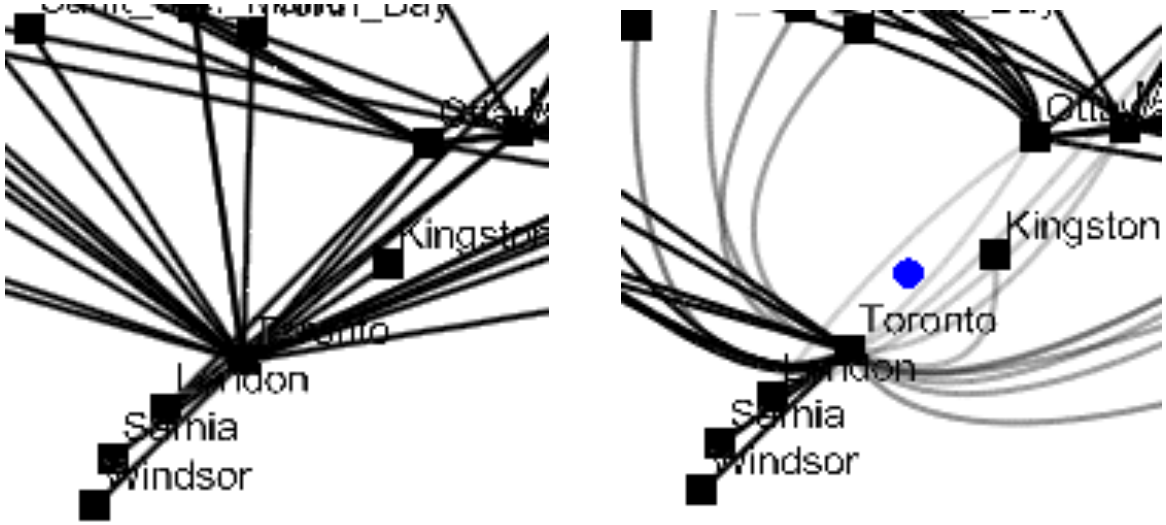
Color lenses



Elmqvist et al, 2010

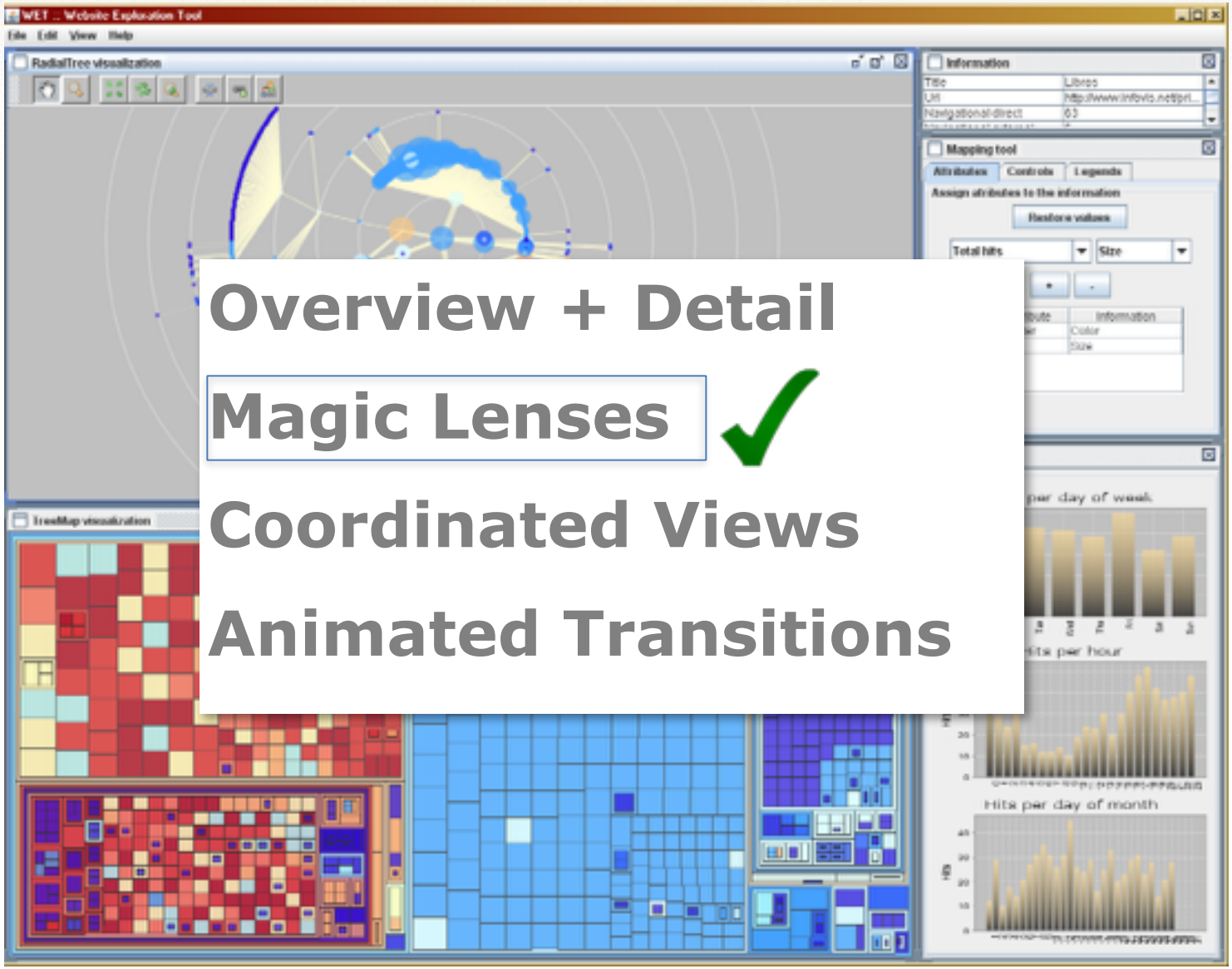
Magic Lenses

Edge lenses

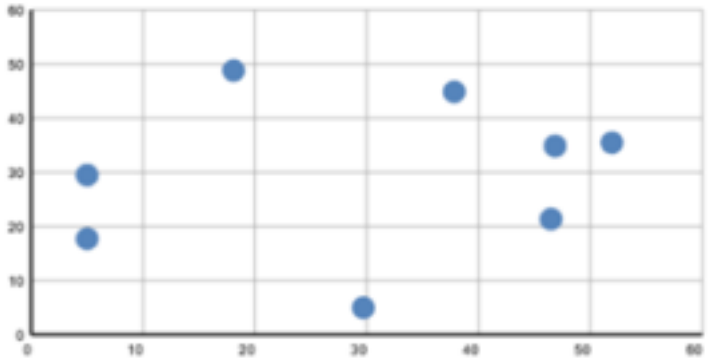


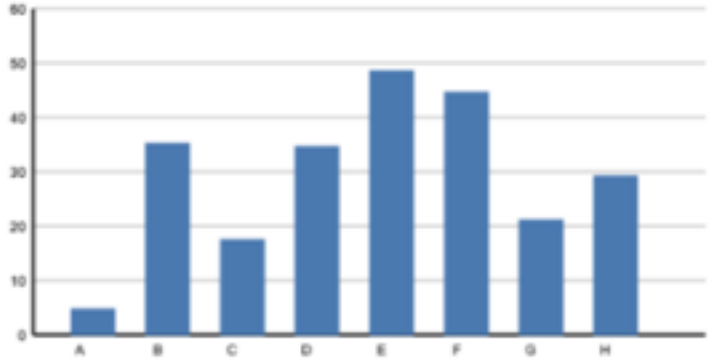
Wong, Carpendale and Greenberg,

Multiple Views



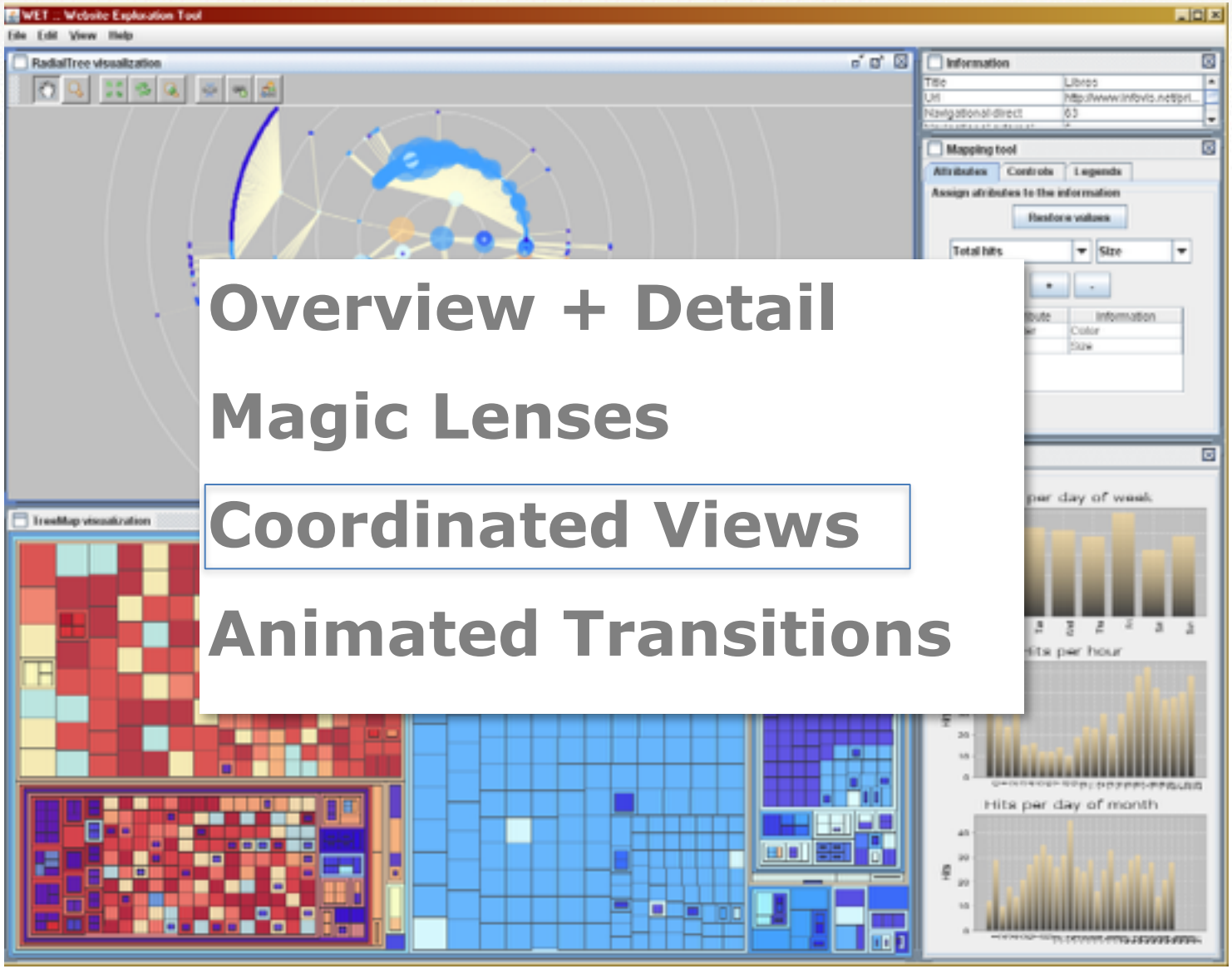
Problem





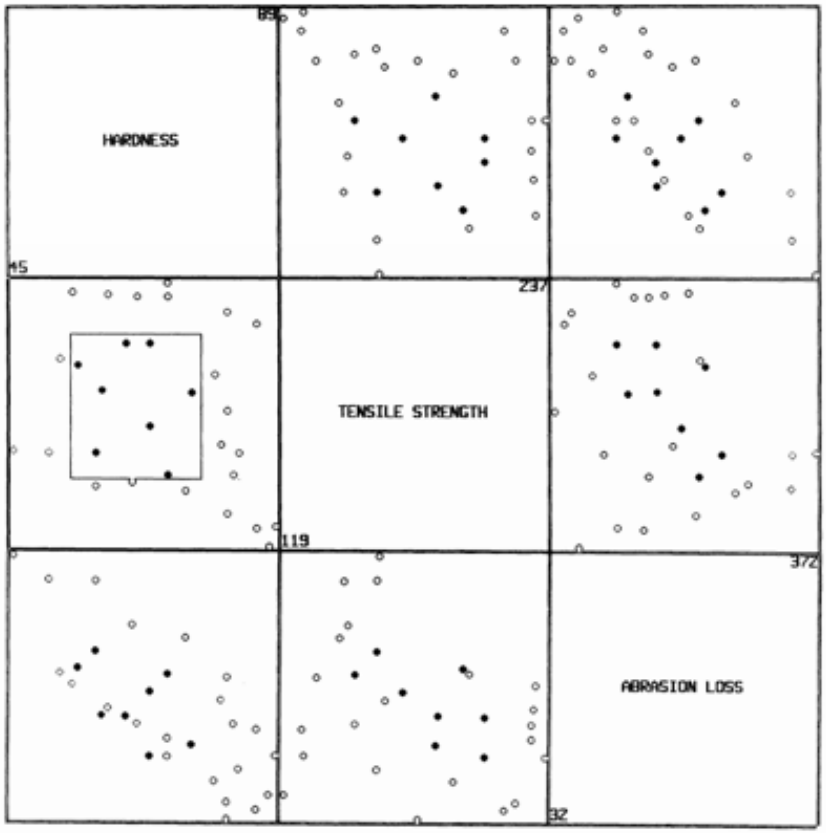
Heer and Roberston, 2007

Multiple Views

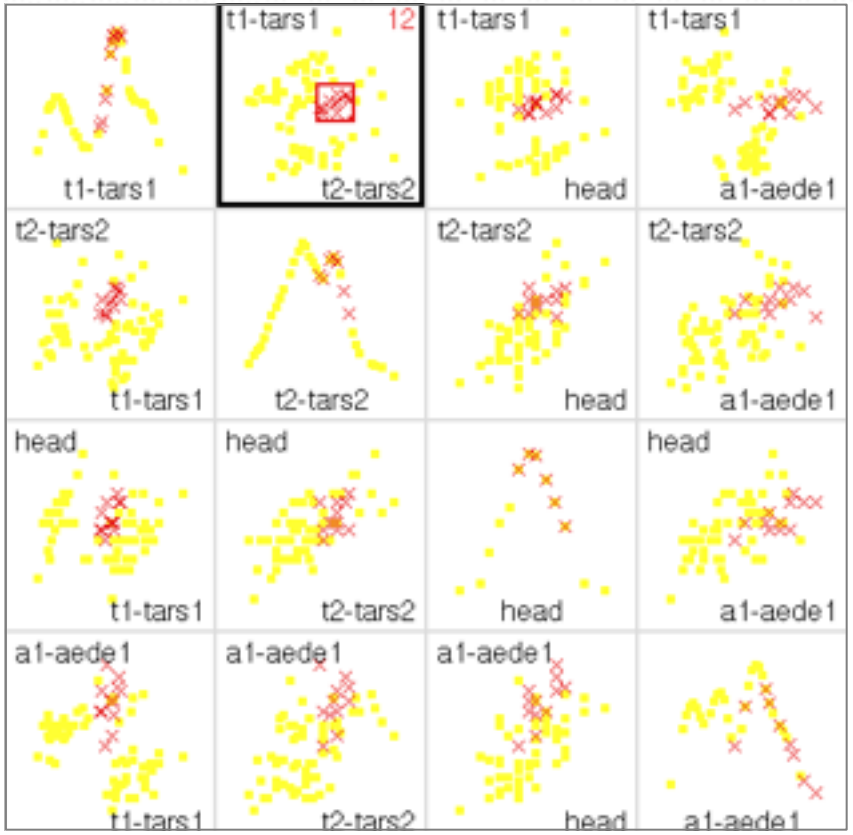


Coordinated Views

Brushing & Linking Scatterplots



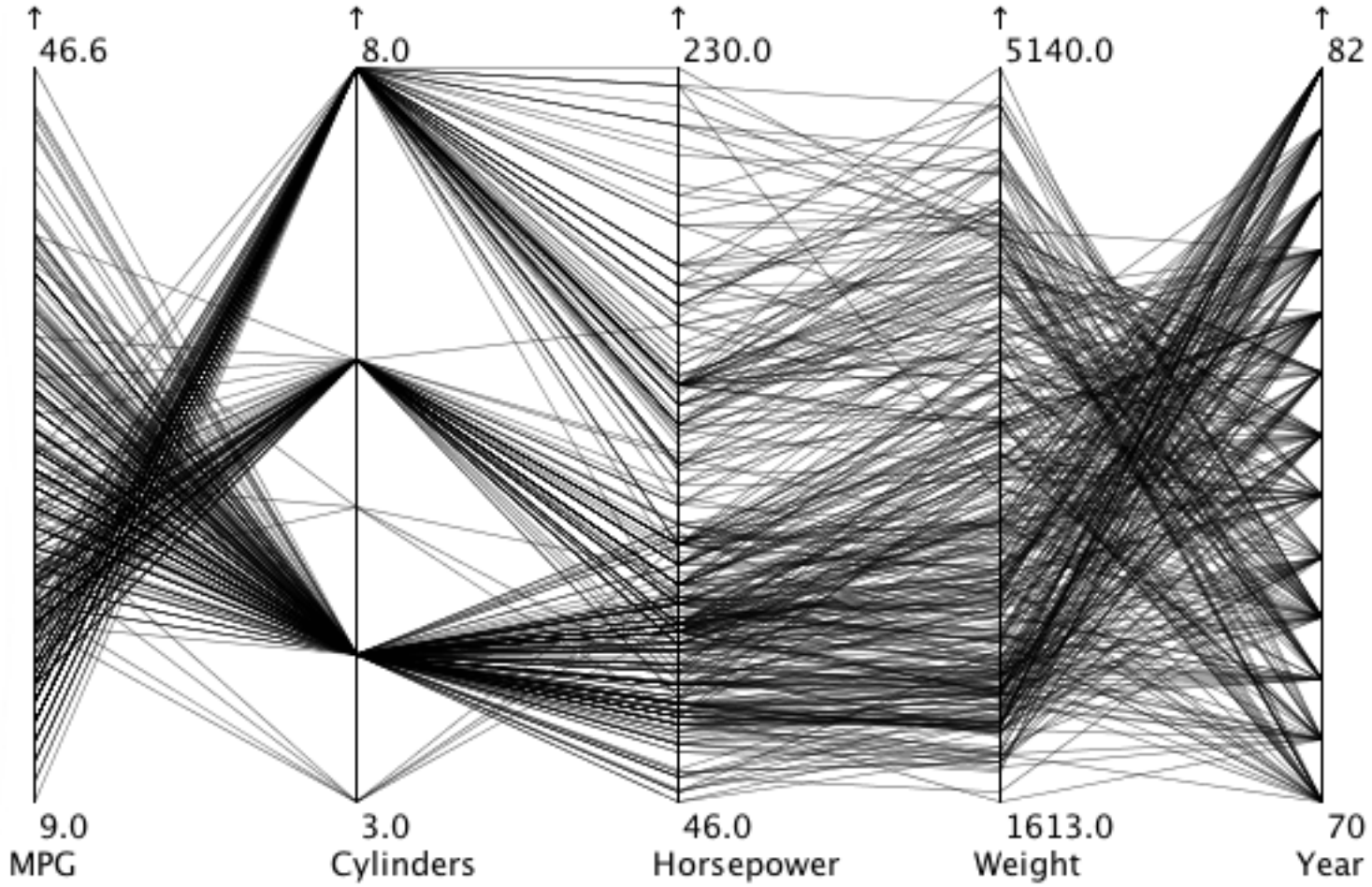
Beker and Cleveland, 1987



Voigt, 2002

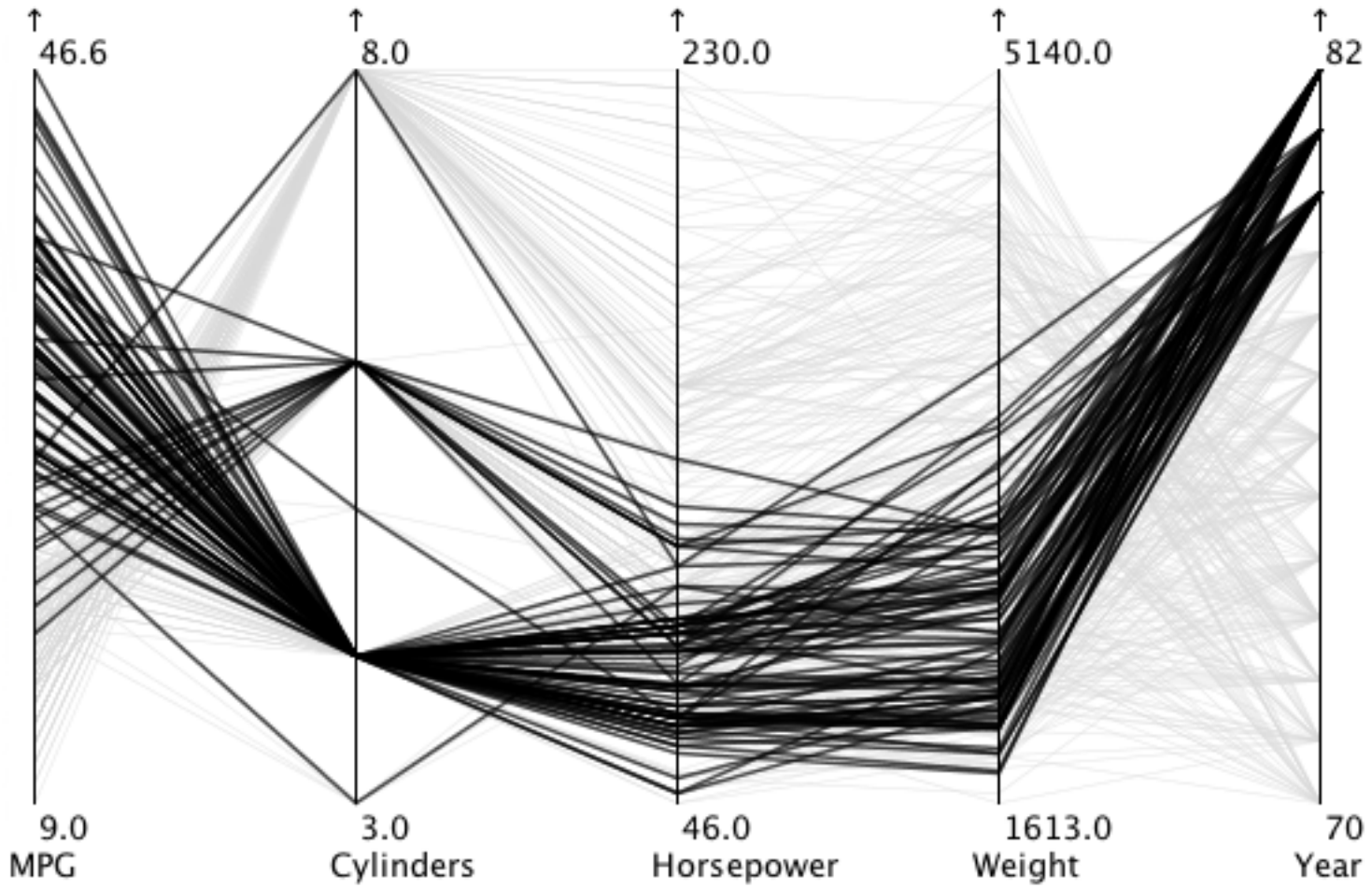
Coordinated Views

Brushing Parallel Coordinates



Coordinated Views

Brushing Parallel Coordinates



Coordinated Views

Brushing & Linking Histograms

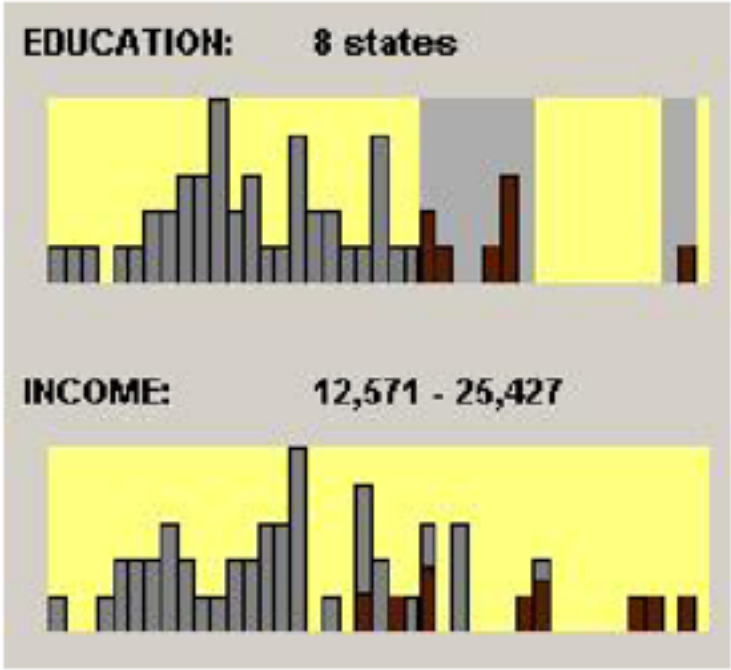
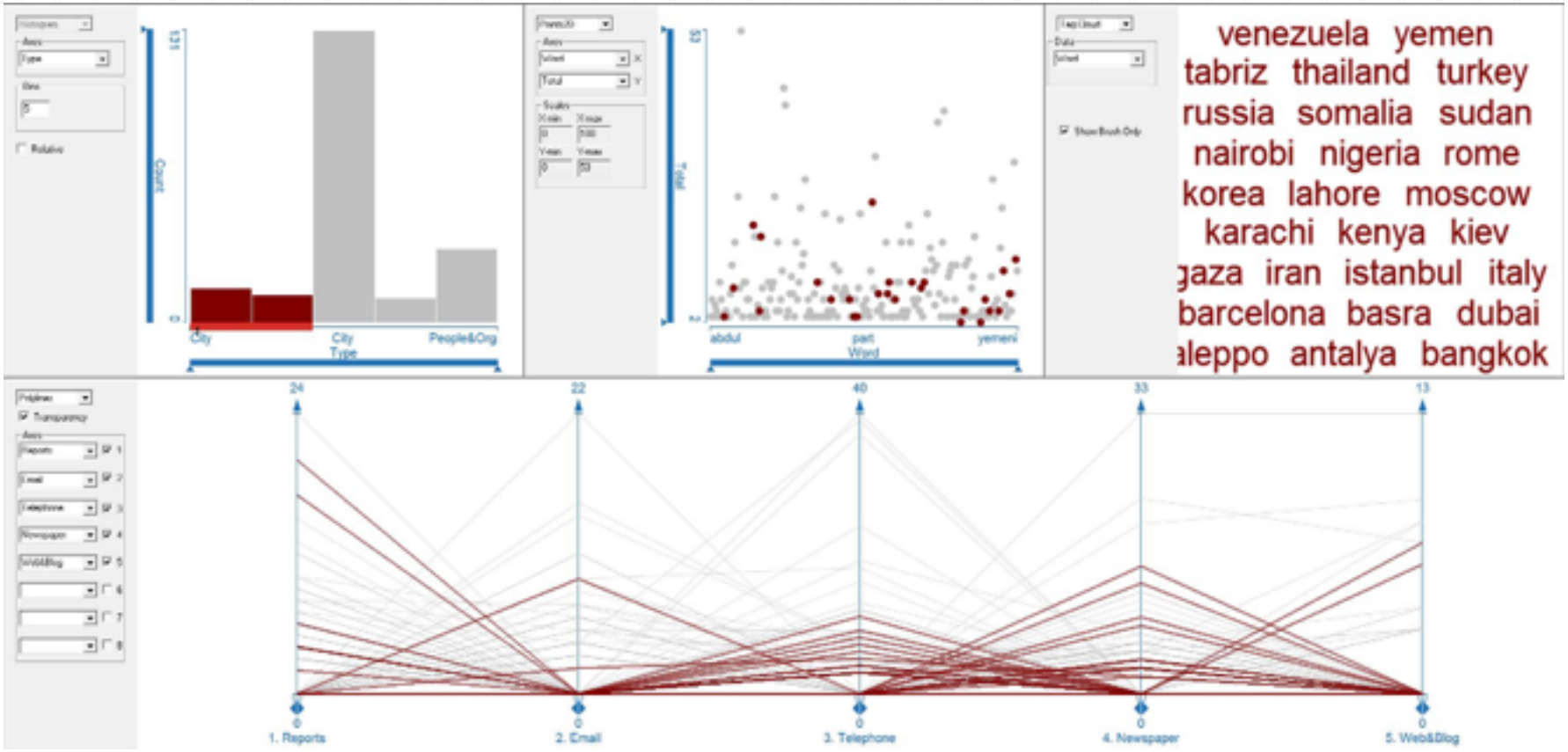


Figure 8: Brushing Histograms

Coordinated Views

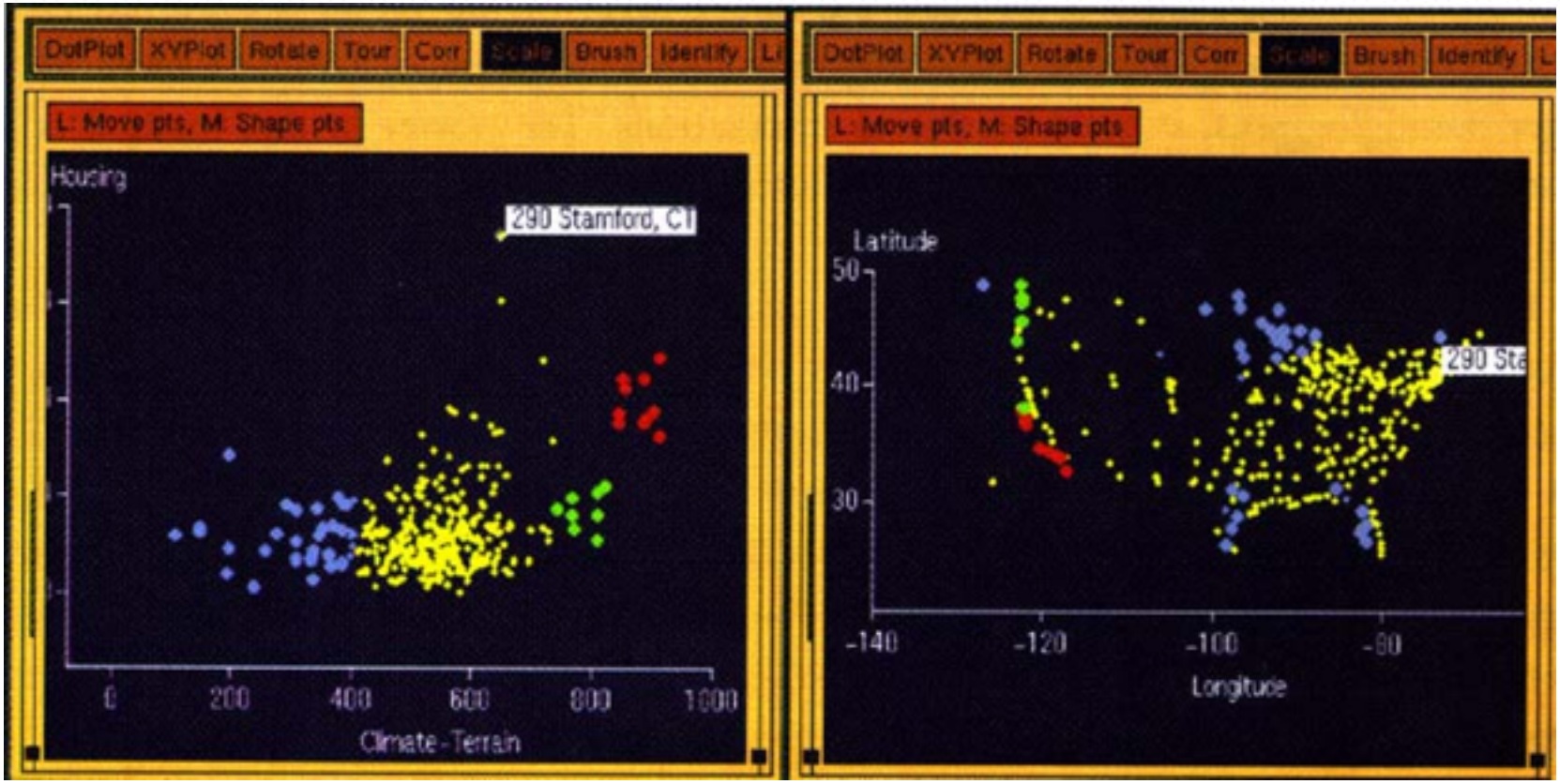
Brushing & Linking Everything



Turkay et al, 2010

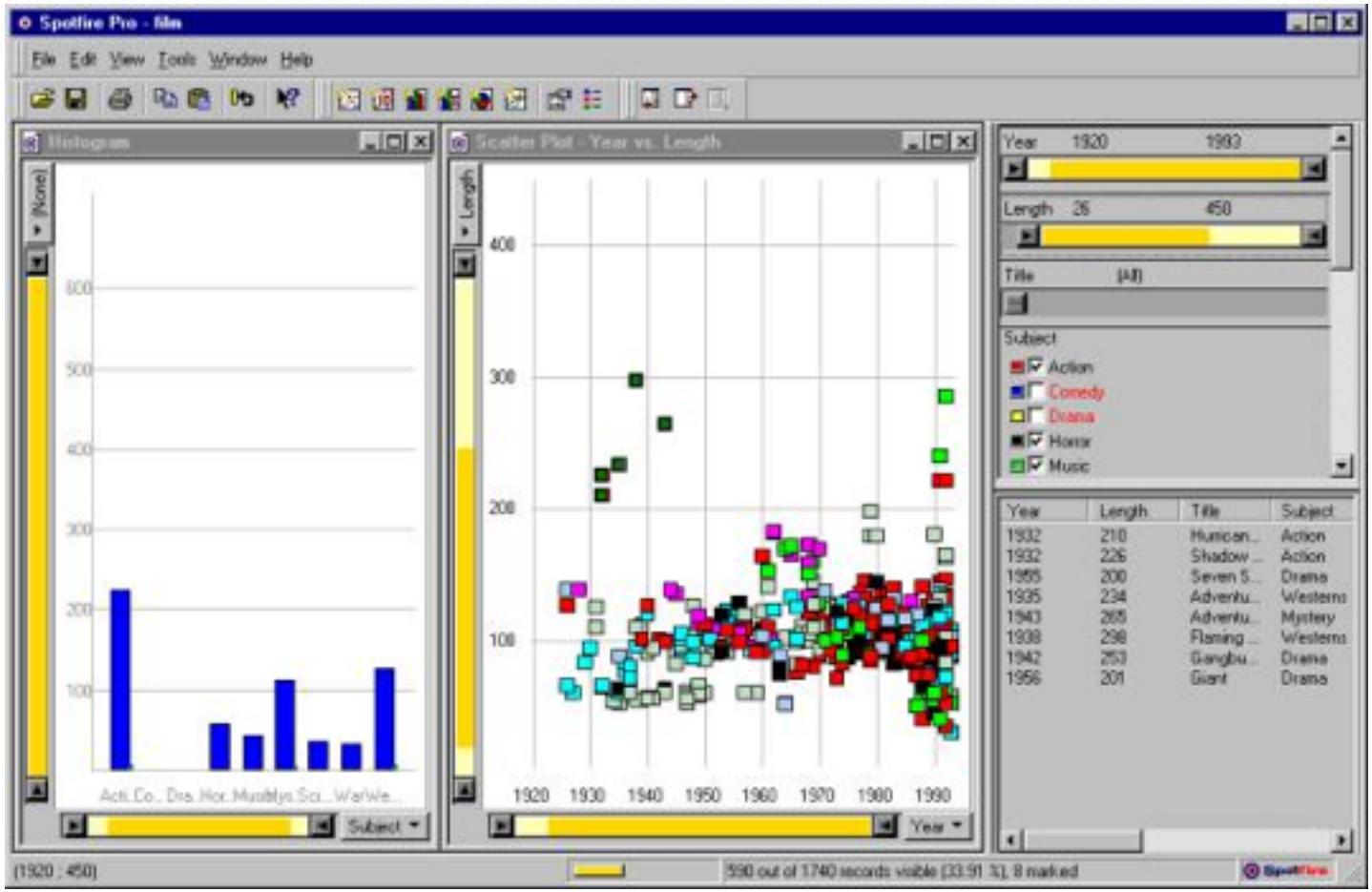
Coordinated Views

Colored Brushing & Linking

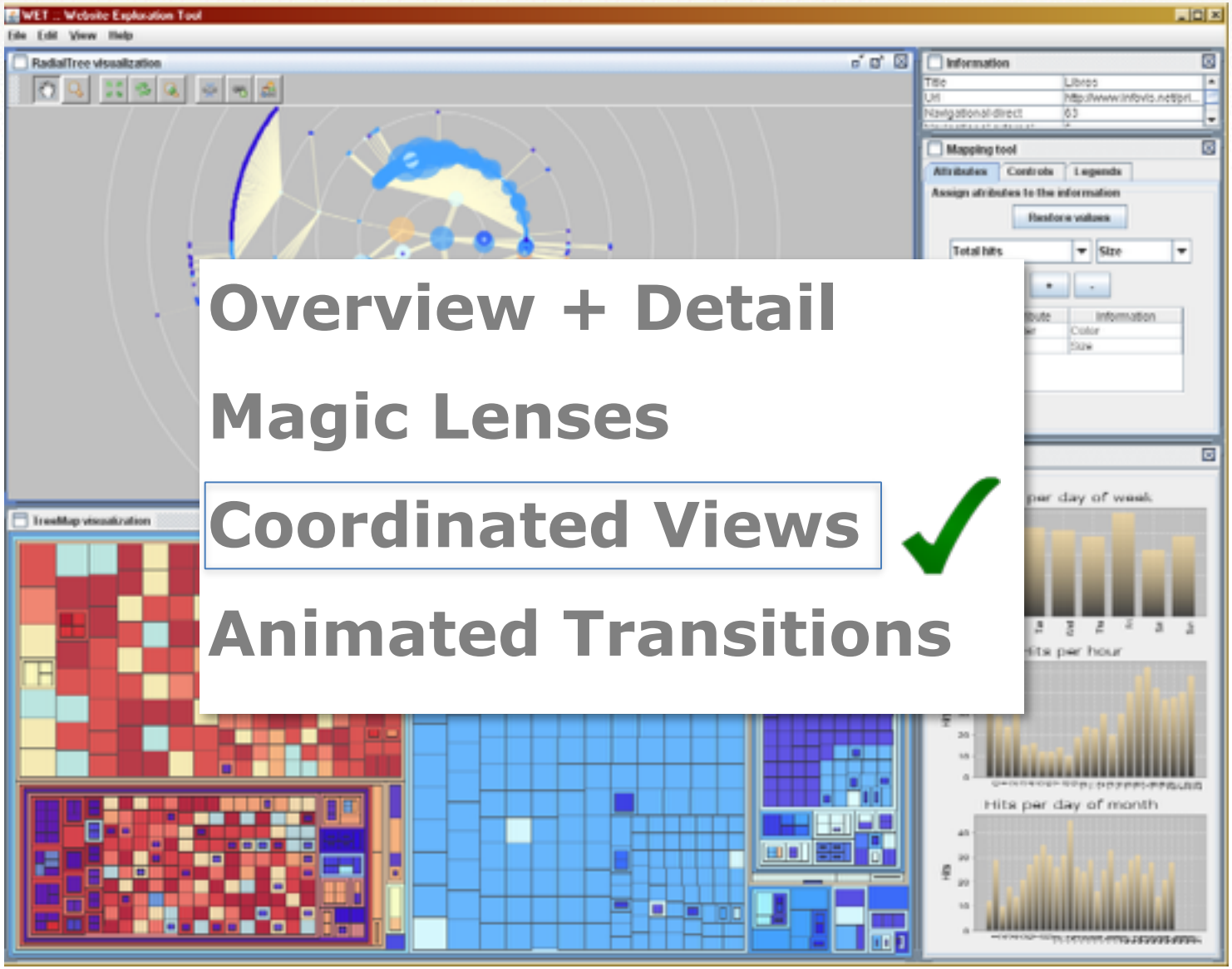


Coordinated Views

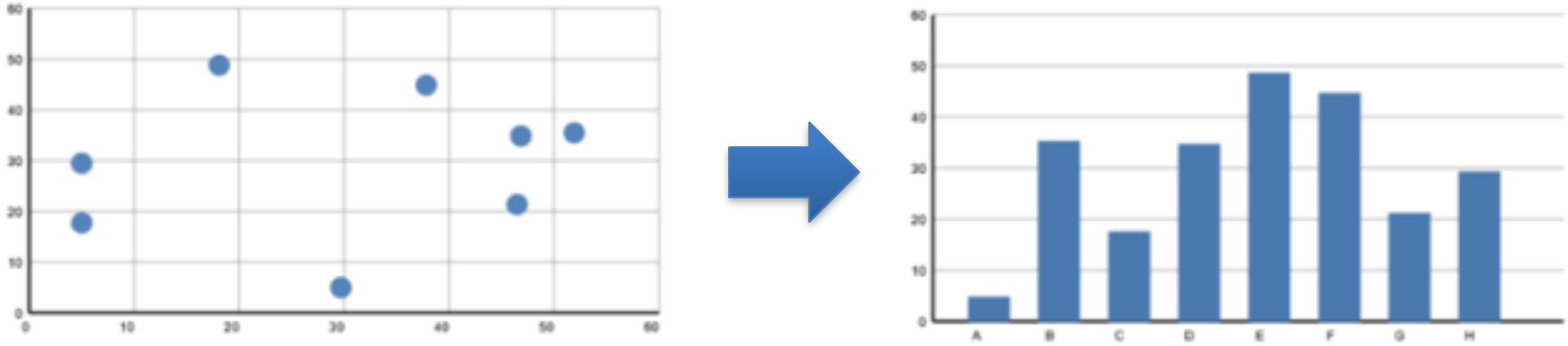
Linking with Dynamic Queries



Multiple Views

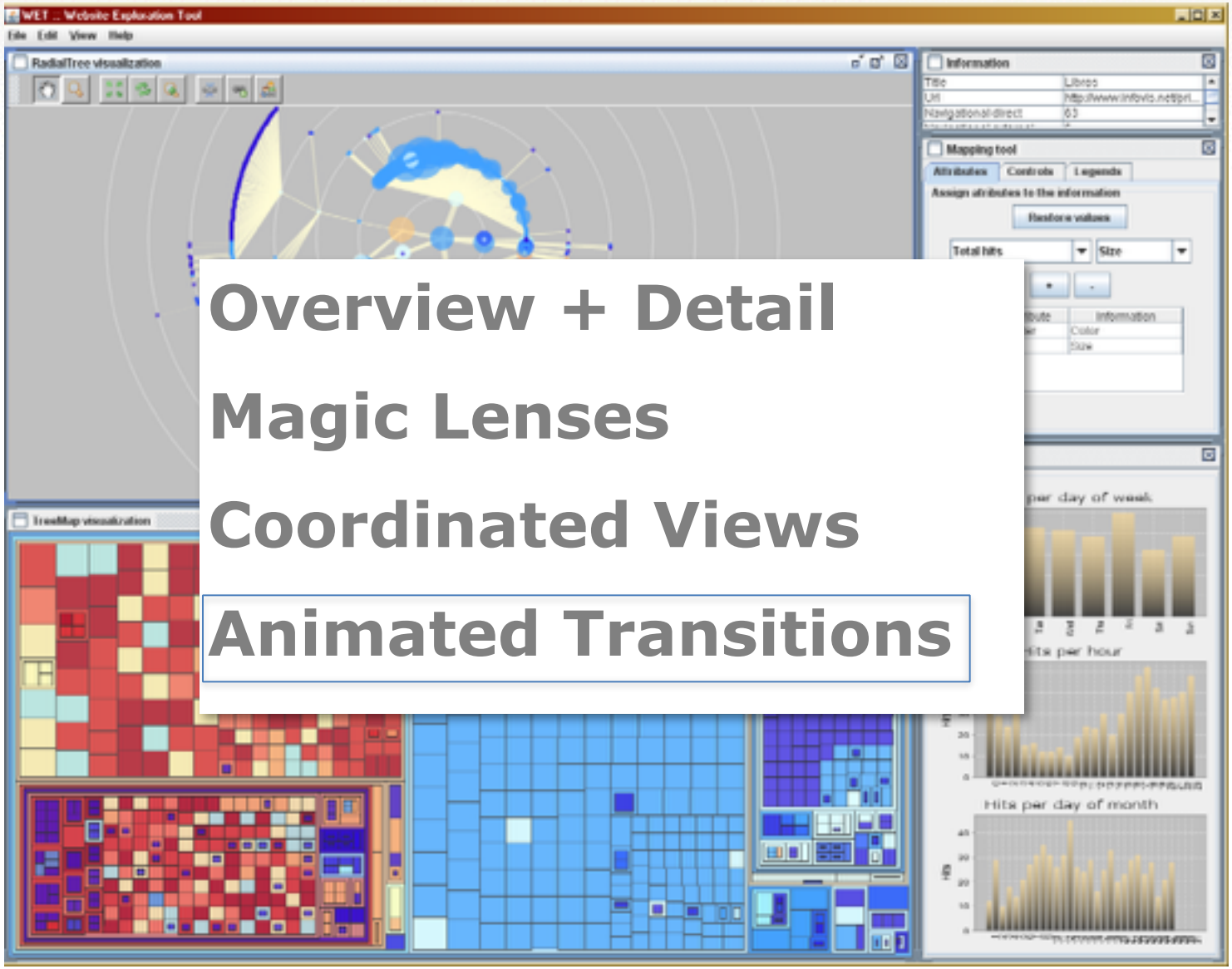


Problem



Heer and Roberston, 2007

Multiple Views



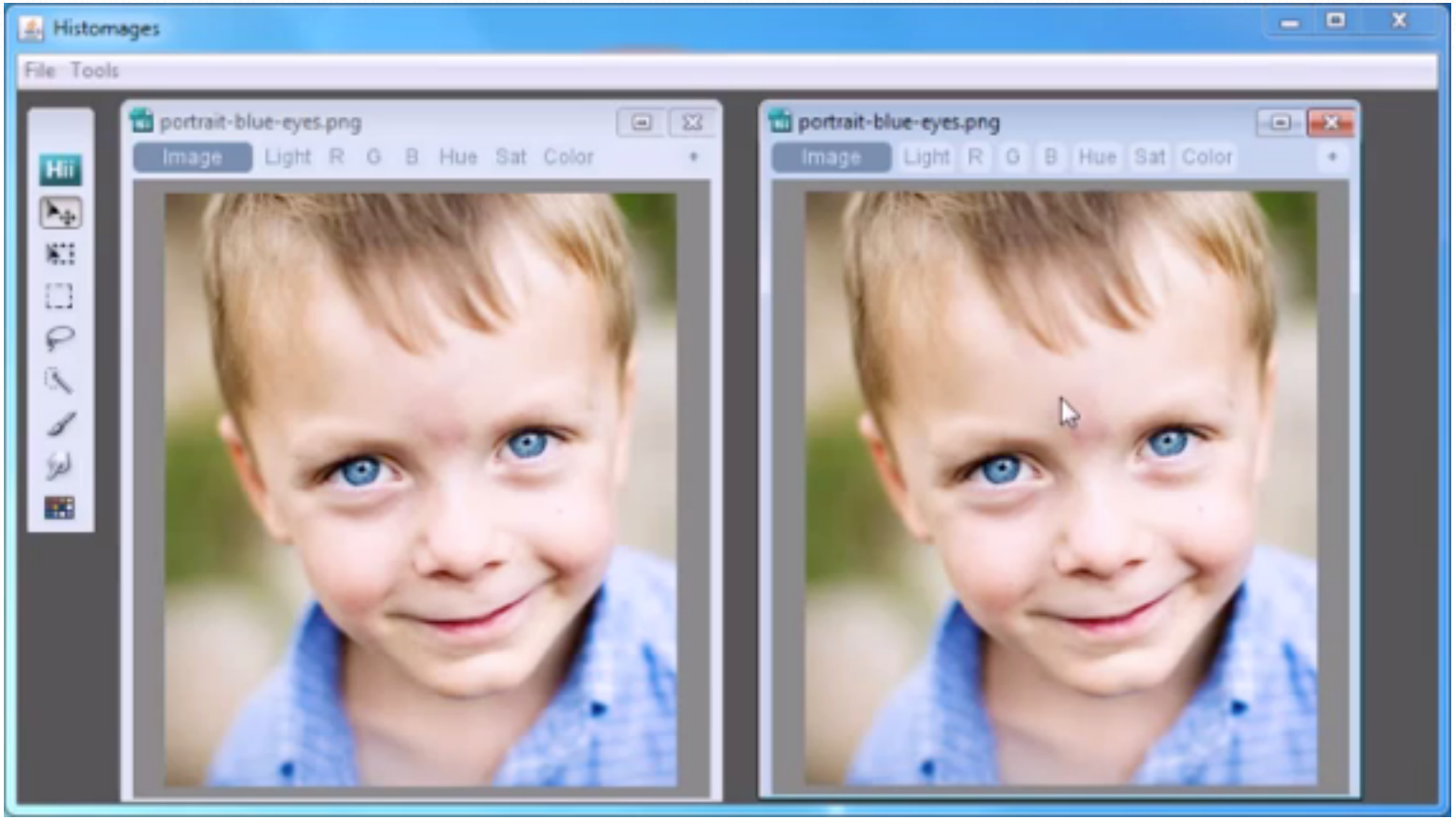
Animated Transitions

00:19

Heer and Roberston, 2007

Animated Transitions

With coordinated views



Histomages (Chevalier et al, 2012)

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

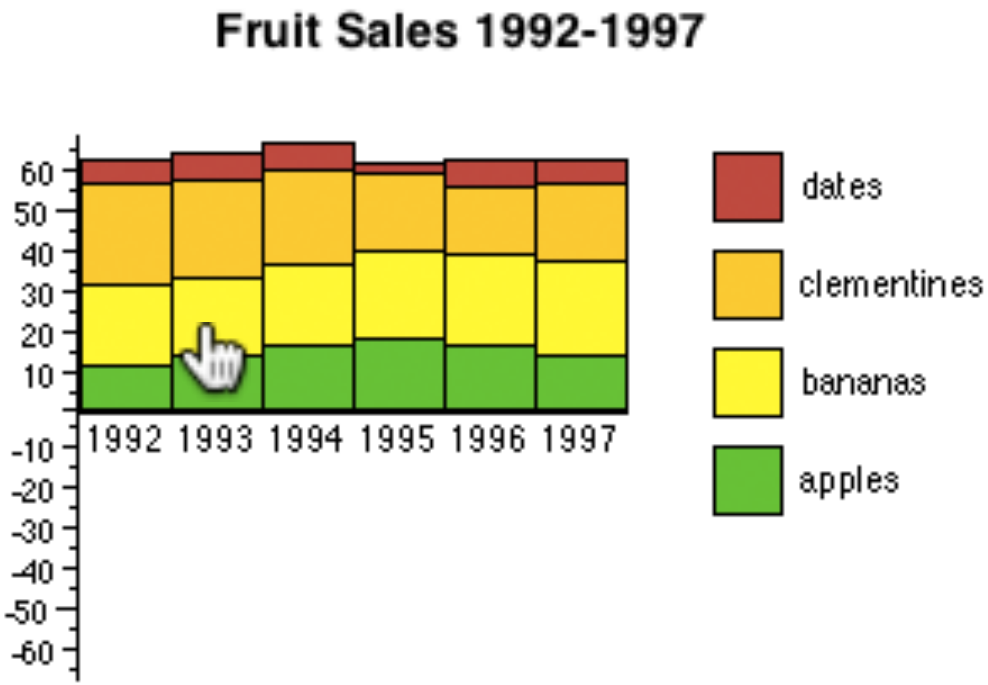
- Overview + Detail
- Magic Lenses
- Coordinated Views
- Animated Transitions

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

Rearrangement

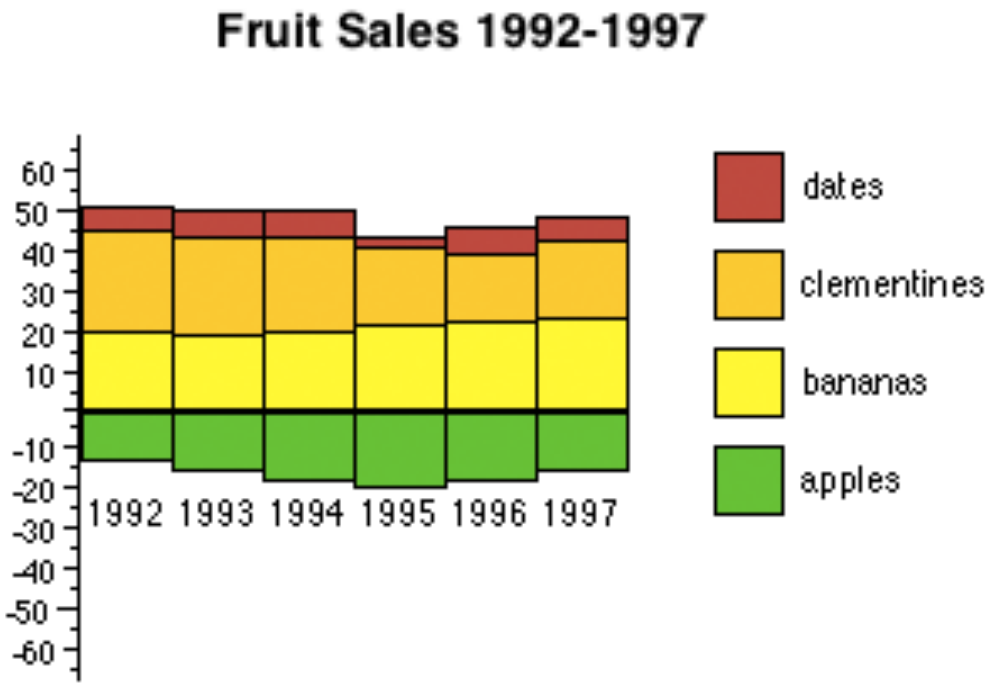
Interactive Stacked Histograms



Dix and Ellis, 1998

Rearrangement

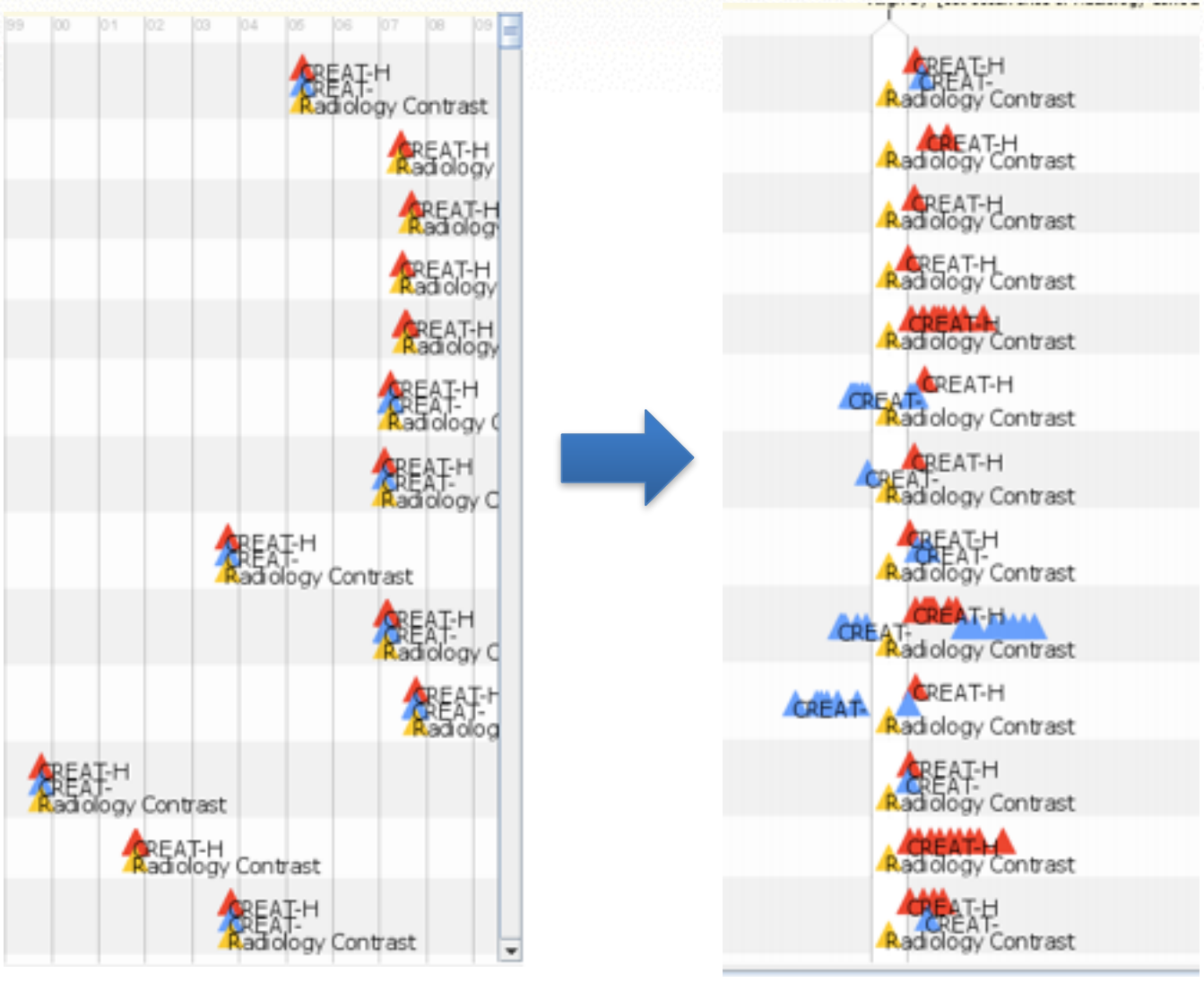
Interactive Stacked Histograms



Dix and Ellis, 1998

Rearrangement

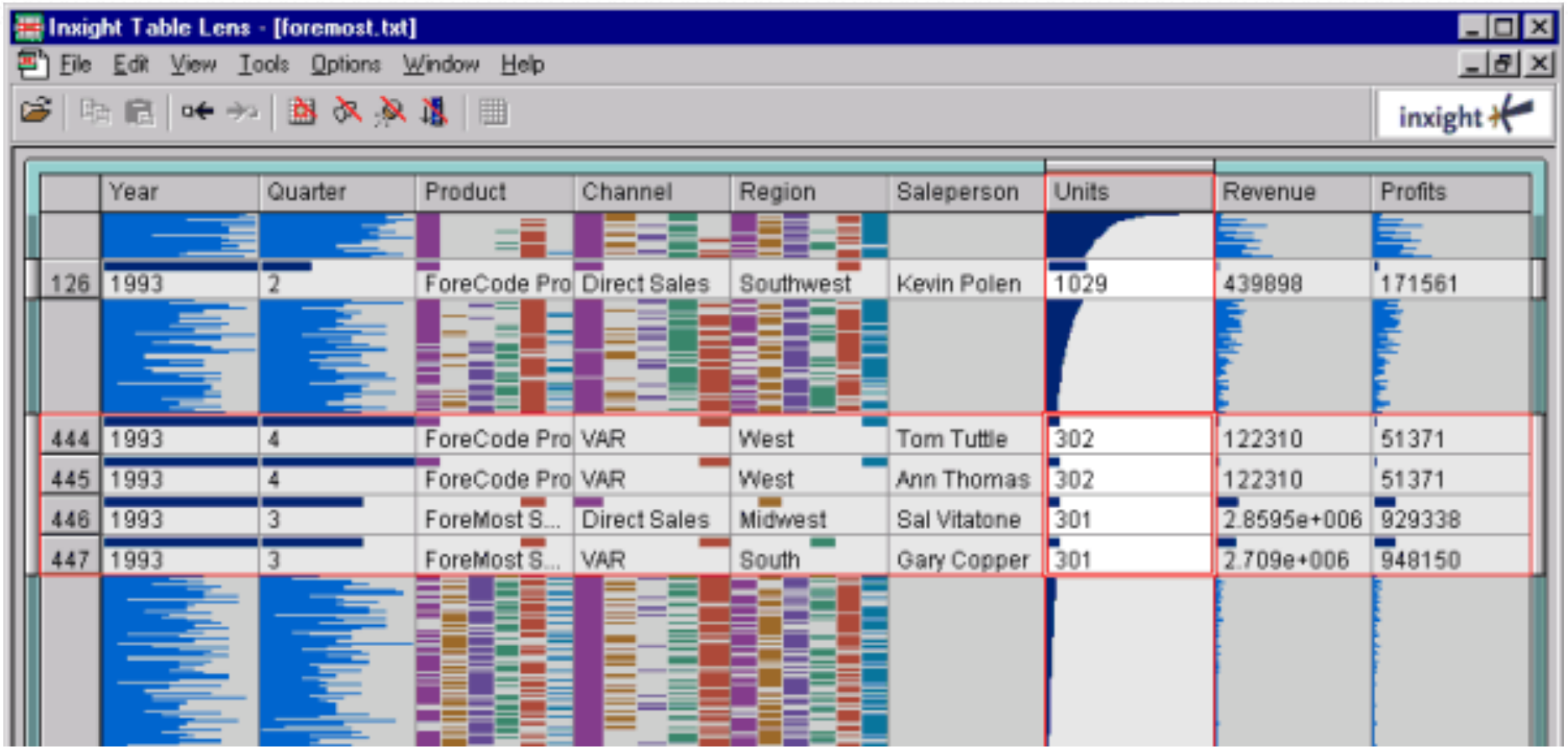
Time-Series Alignment



Lifelines 2 (Wang et al, 2008)

Rearrangement

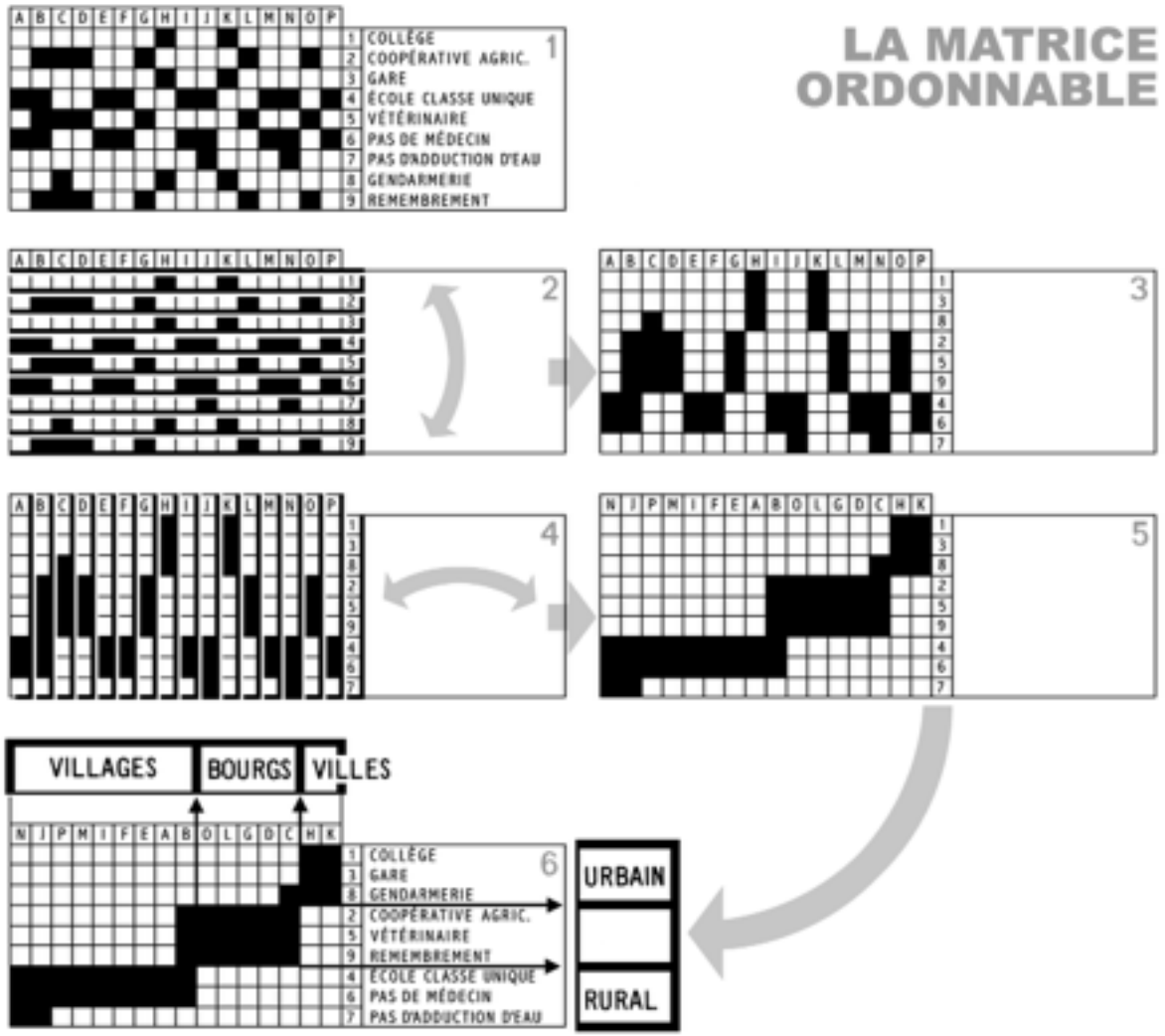
Sorting



Rao and Card, 1994

Rearrangement

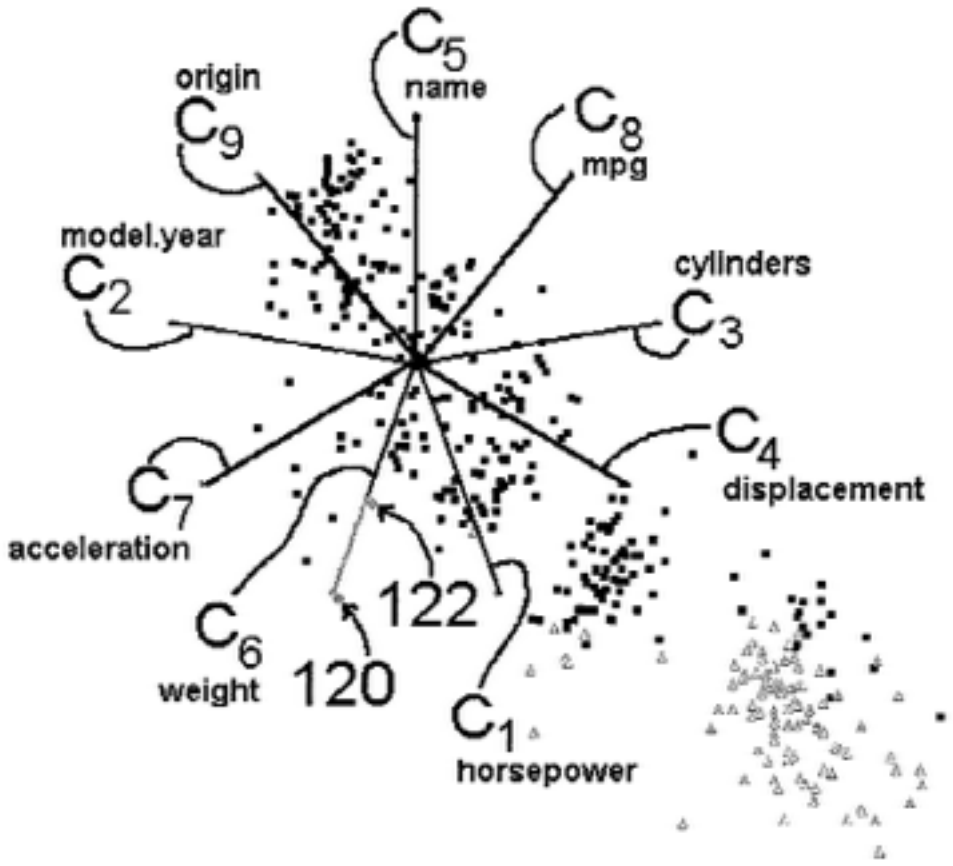
Matrix Reordering



Bertin, 1977

Rearrangement

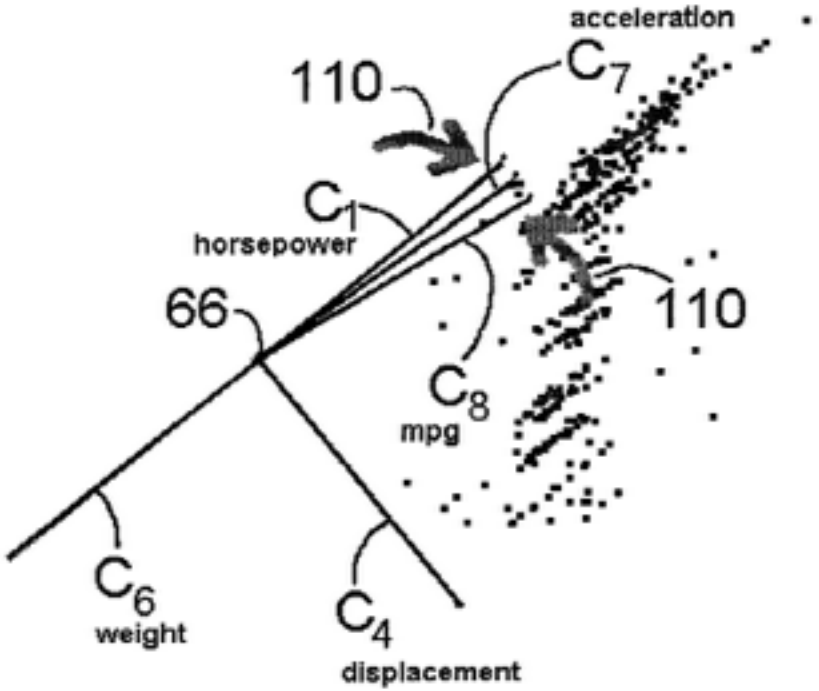
Star Coordinates



Kandogan, 1992

Rearrangement

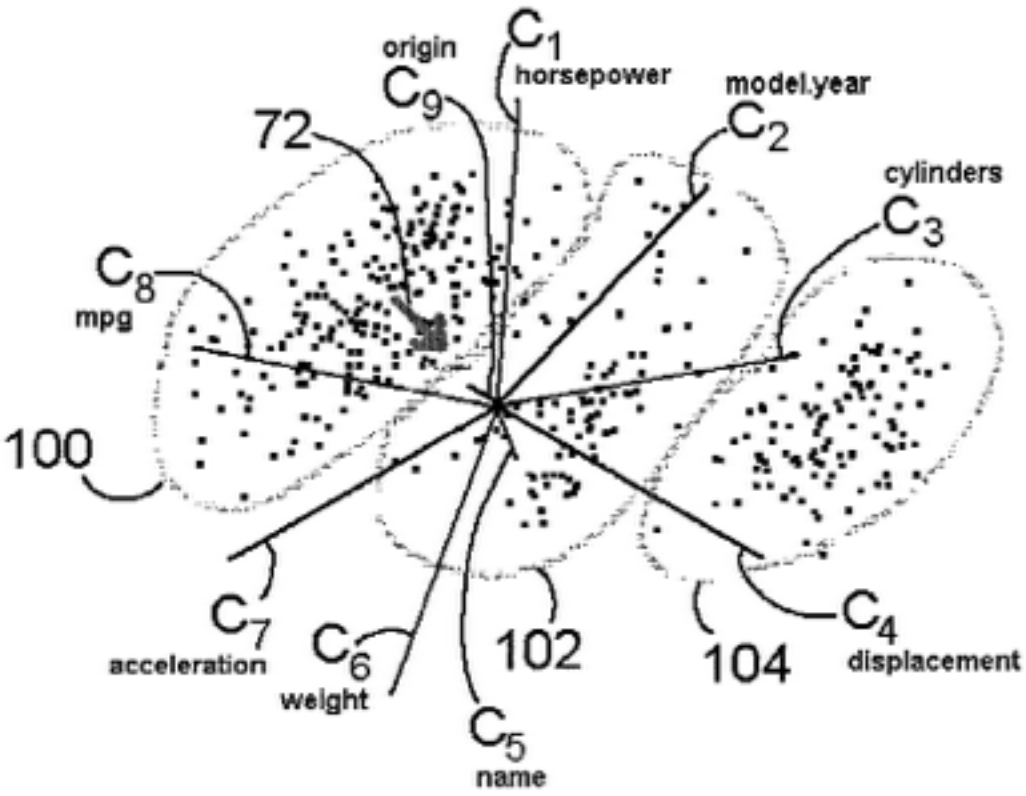
Star Coordinates



Kandogan, 1992

Rearrangement

Star Coordinates

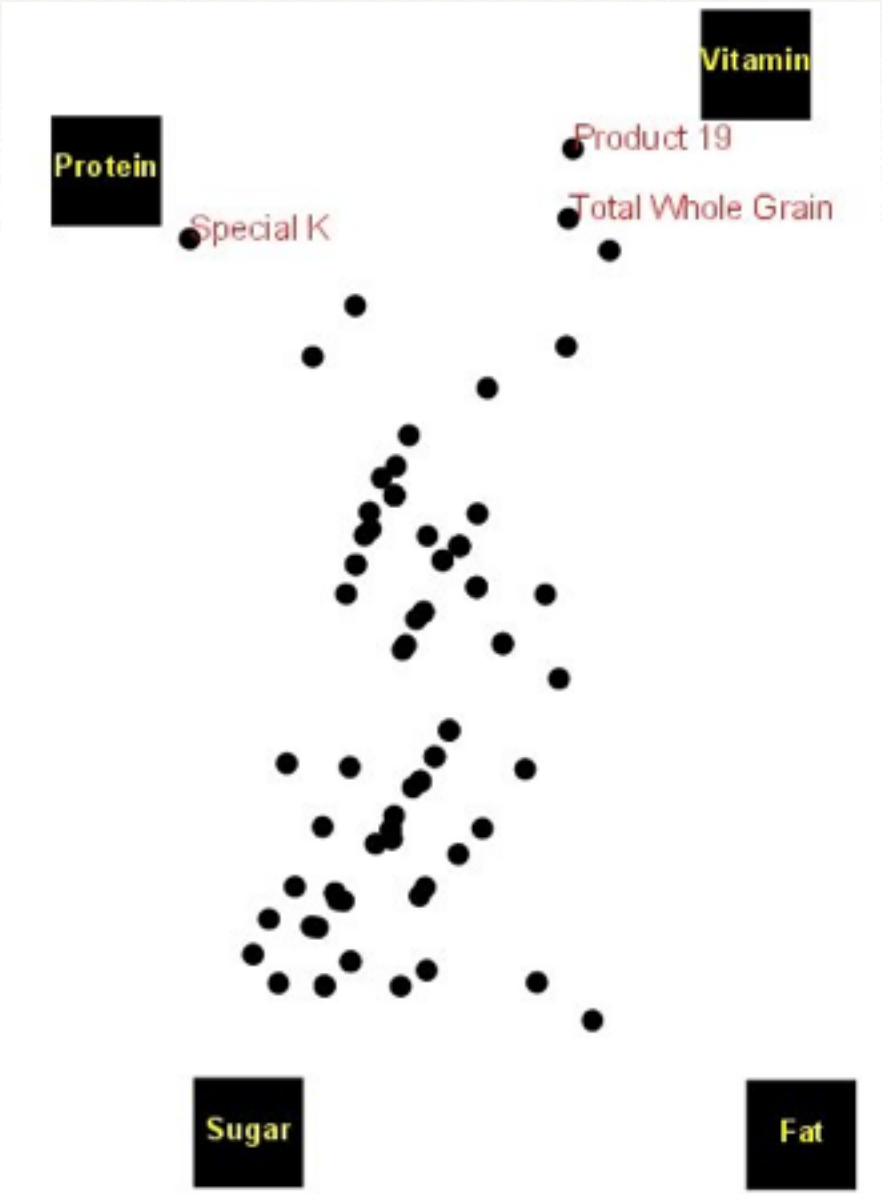


Kandogan, 1992

Rearrangement

Dust & Magnet

(unsassigned)



Yi et al, 2005

Rearrangement

01:46

Yi et al, 2005

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement 

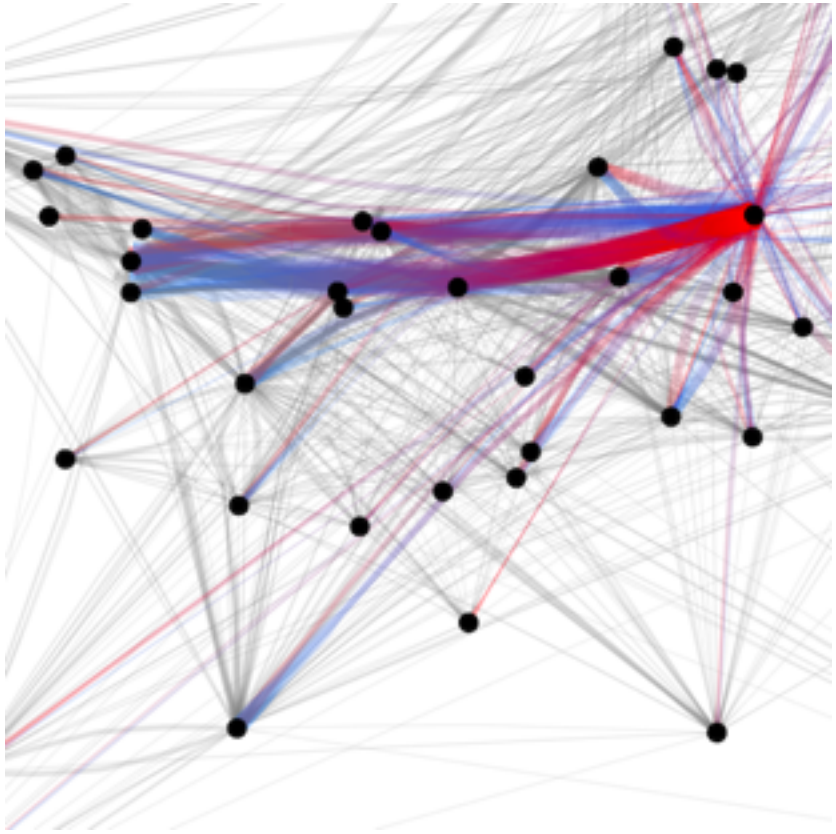
Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

- Pitfalls
- Beyond the desktop

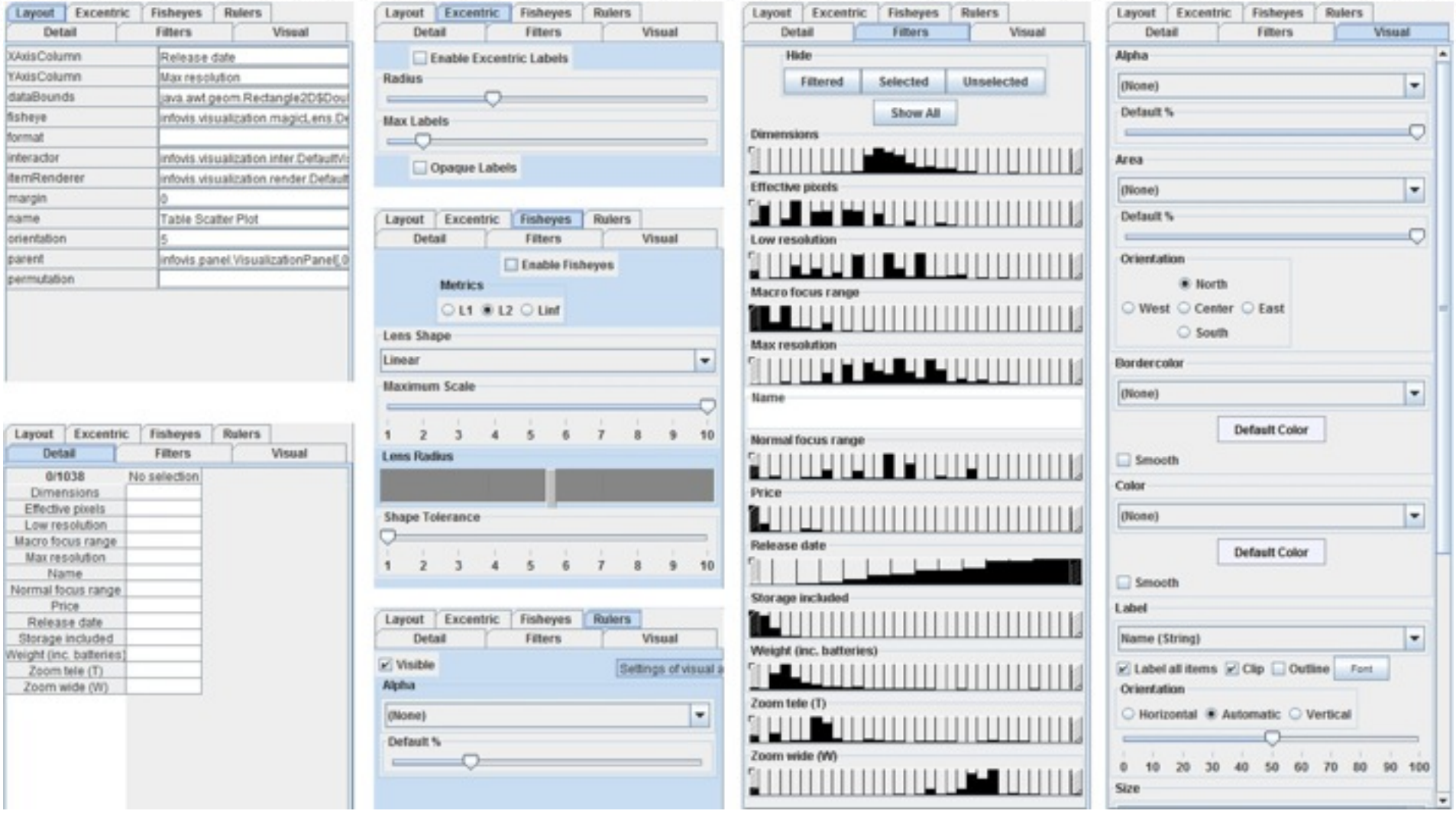
Pitfalls

#1 - Interaction cannot fix bad visualizations



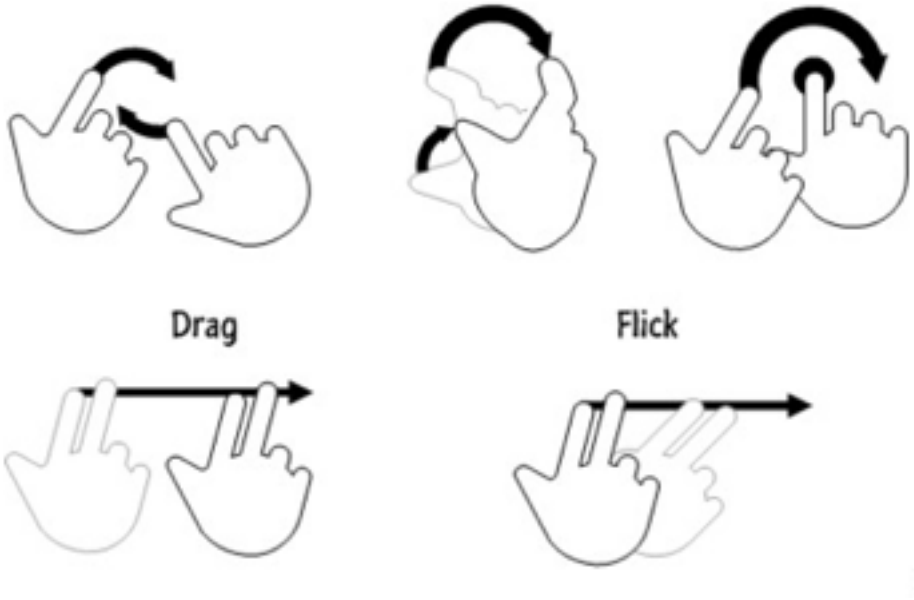
Pitfalls

#2 - Controls take screen real-estate

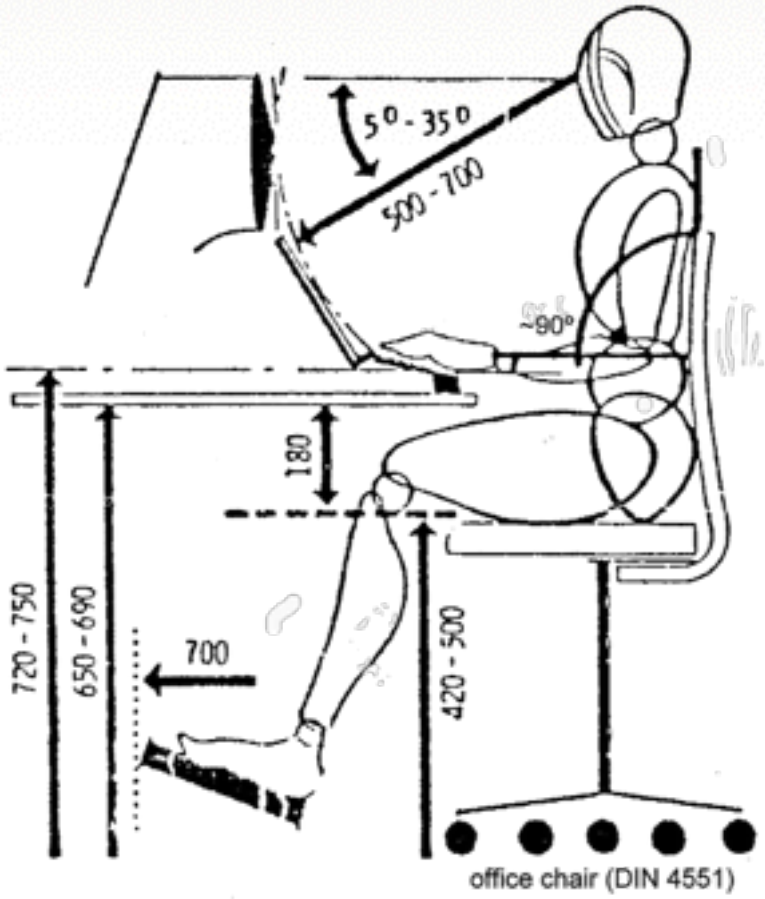


Pitfalls

#3 - Direct manipulation and gestures are rarely not self-explanatory

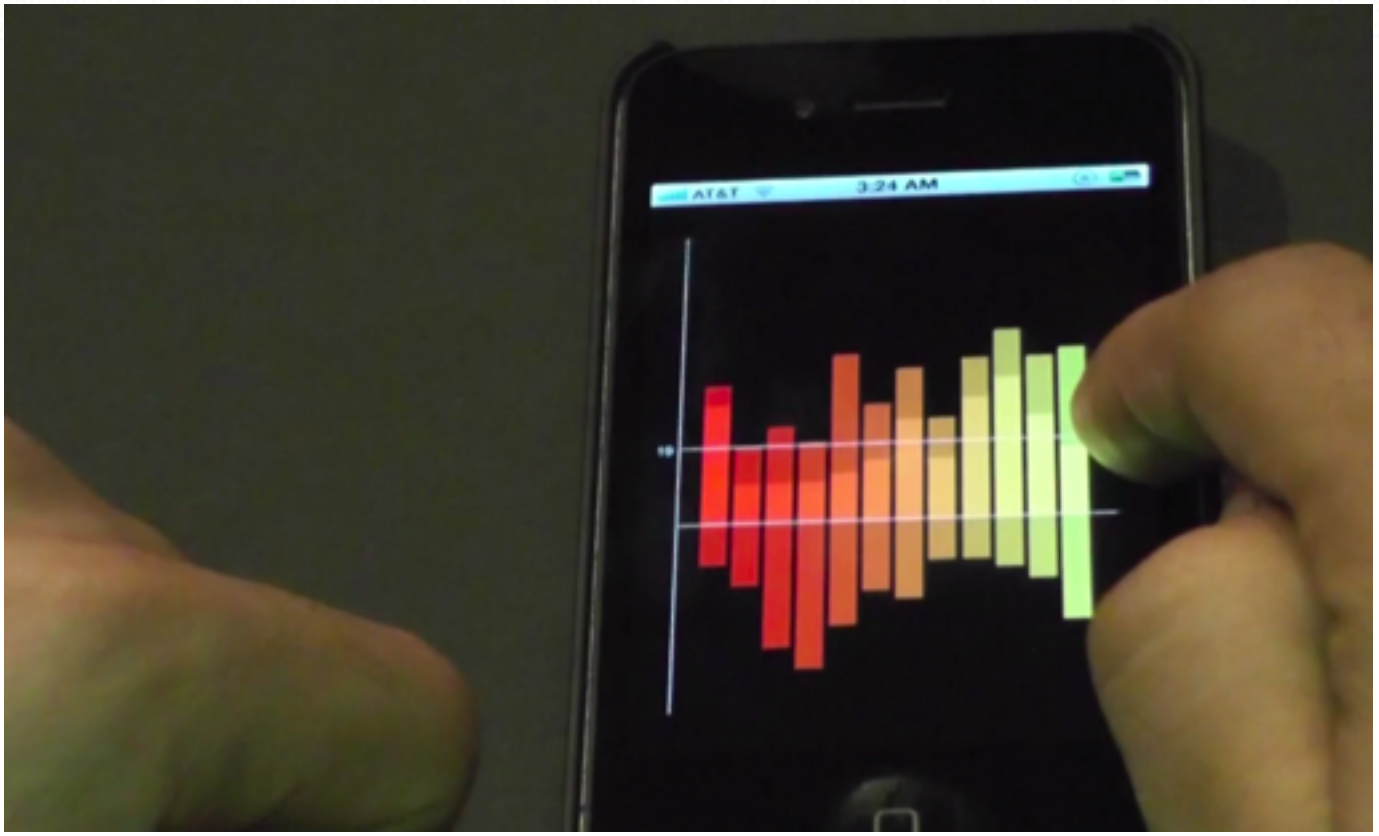


Beyond the Desktop



(Yang & Lu's presentation)

Touch Devices



Sadana and Stasko, 2013

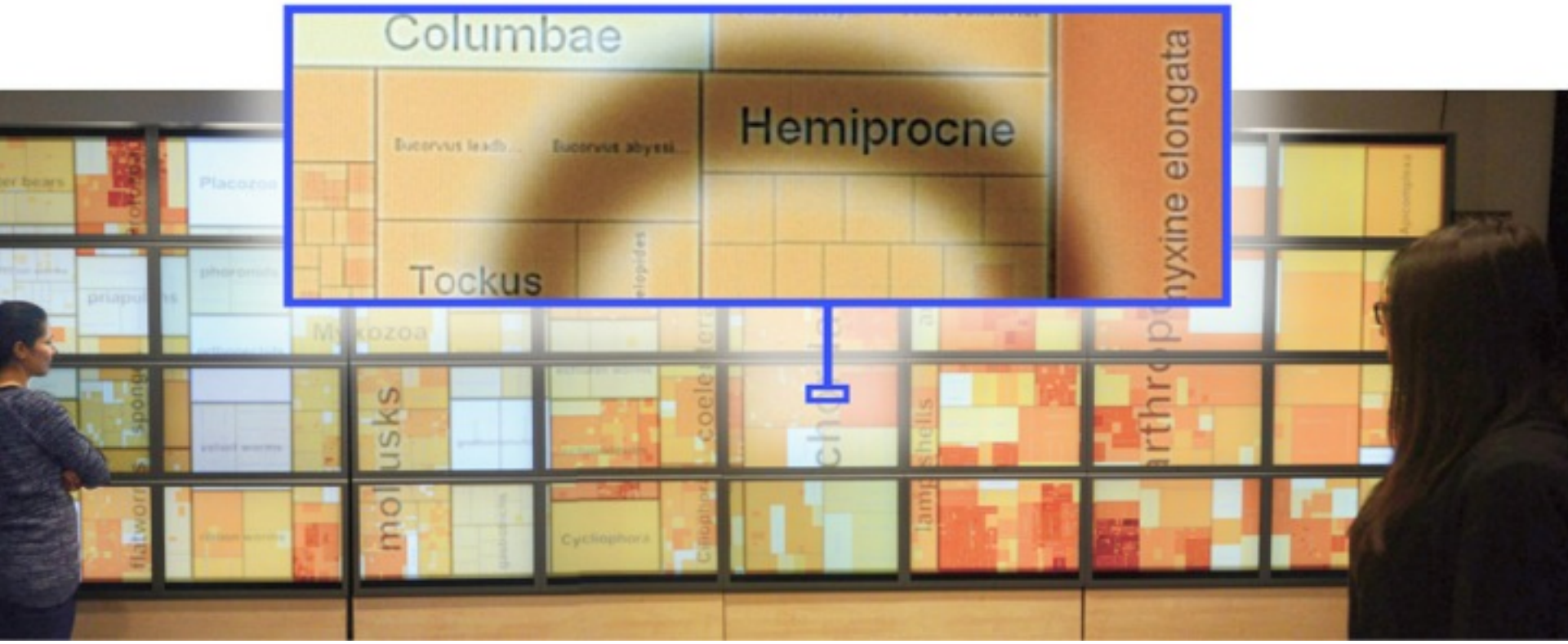
Tabletop Devices

Isenberg and Carpendale, 2008

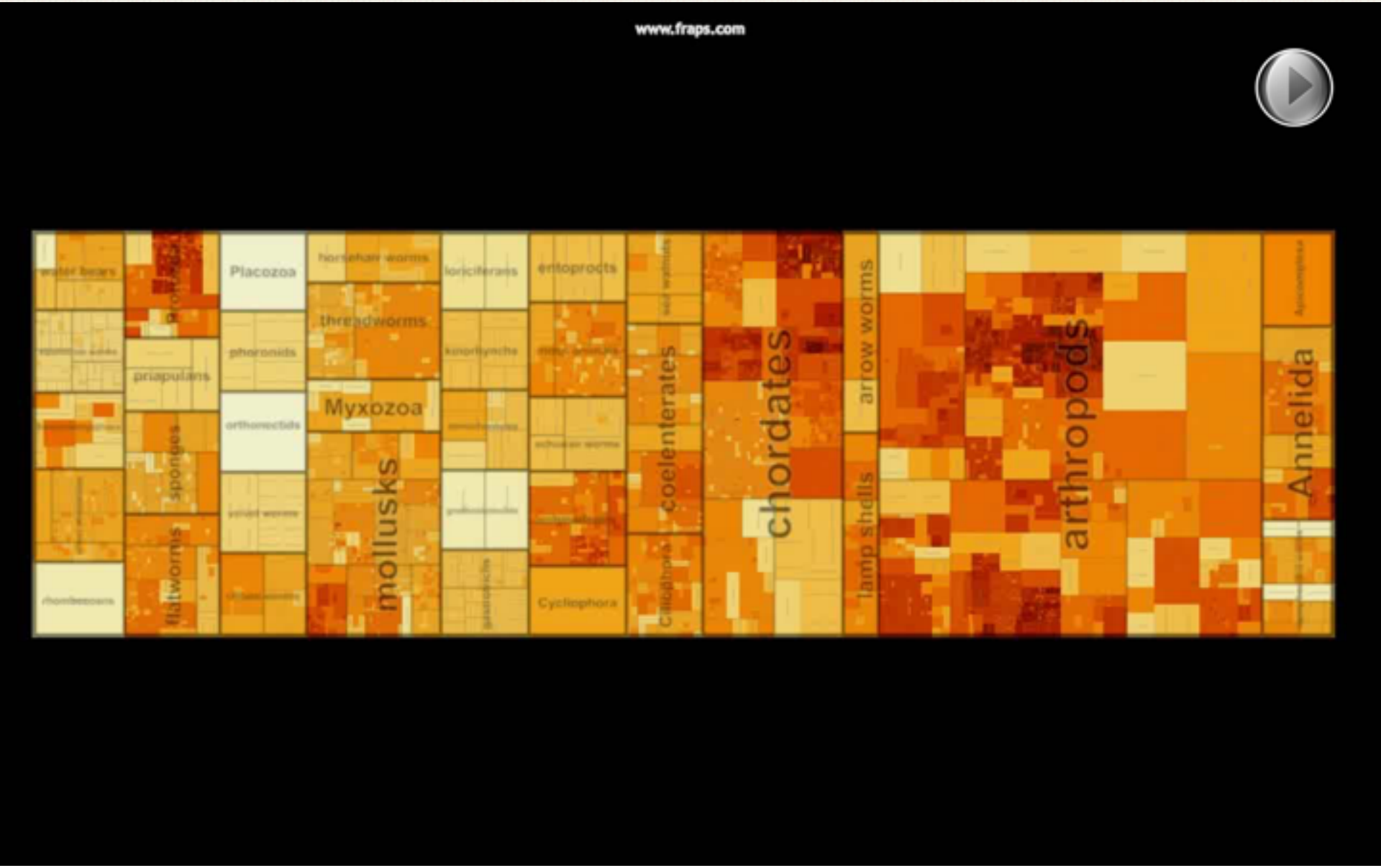
Wall-Sized Displays

WILD Display - Digiscope

Wall-Sized Displays

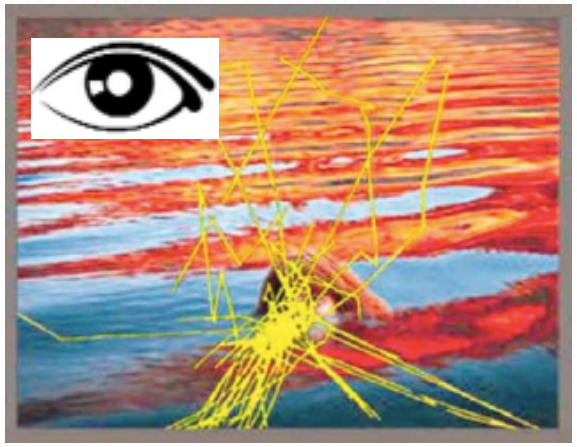


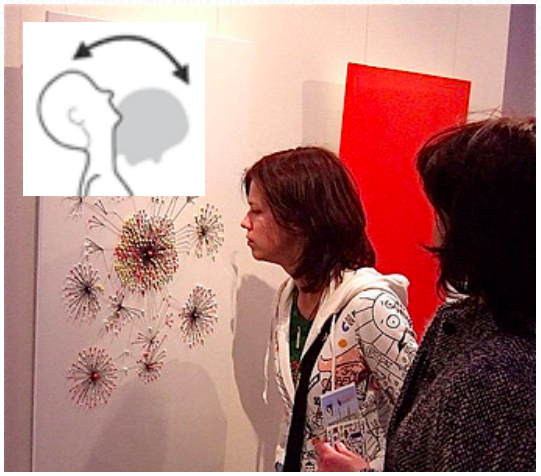
[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis'13]



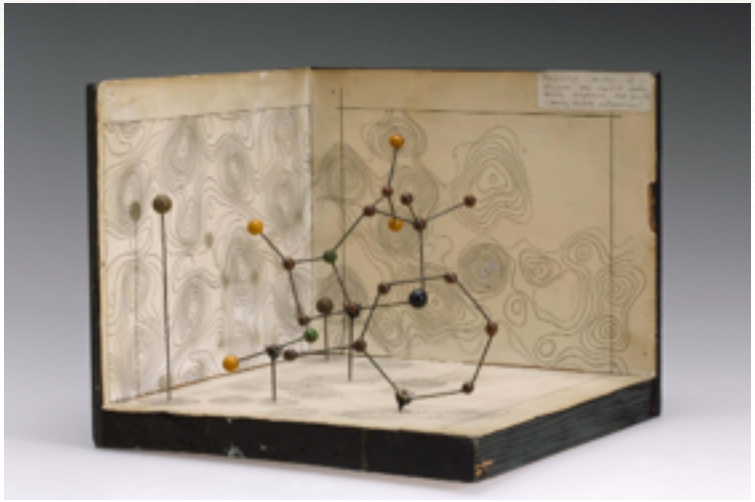
[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis'13]

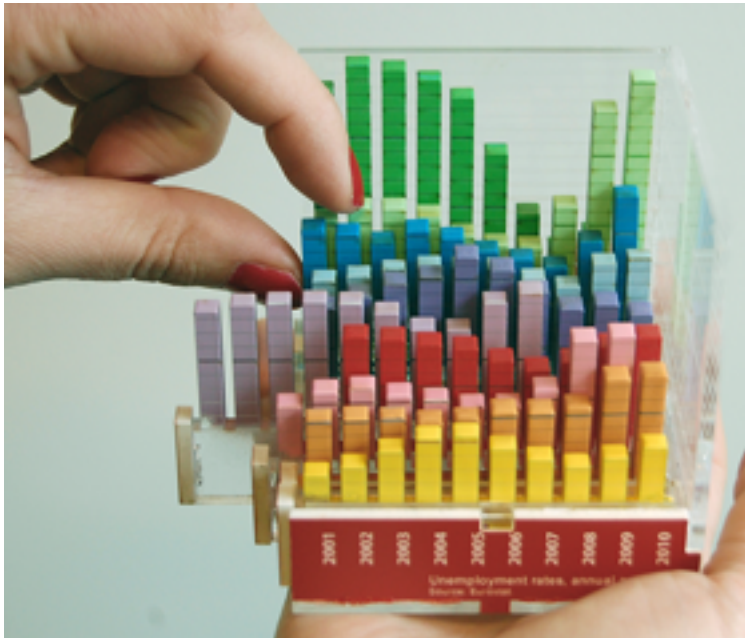
Interaction with the Physical World





Physical Visualizations

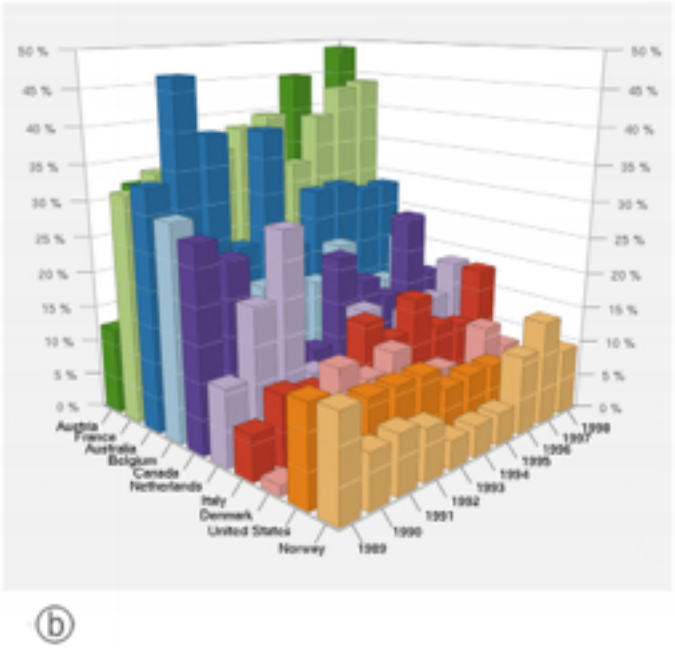


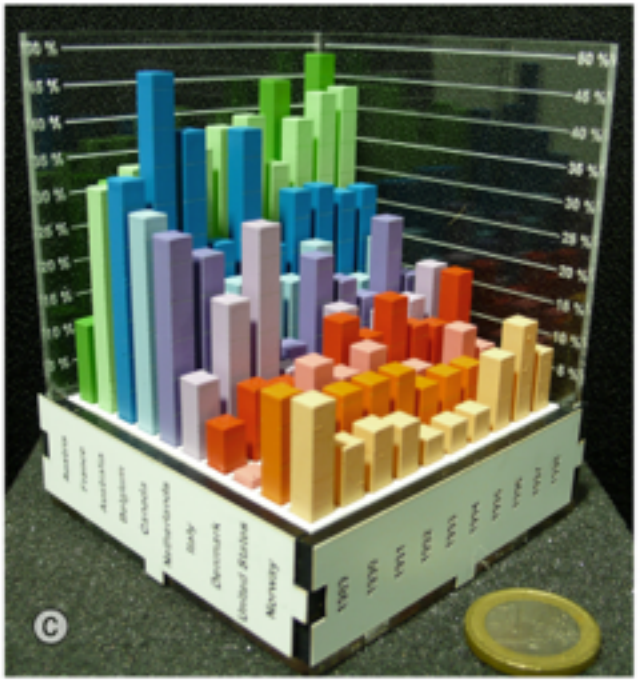


Physical Visualizations

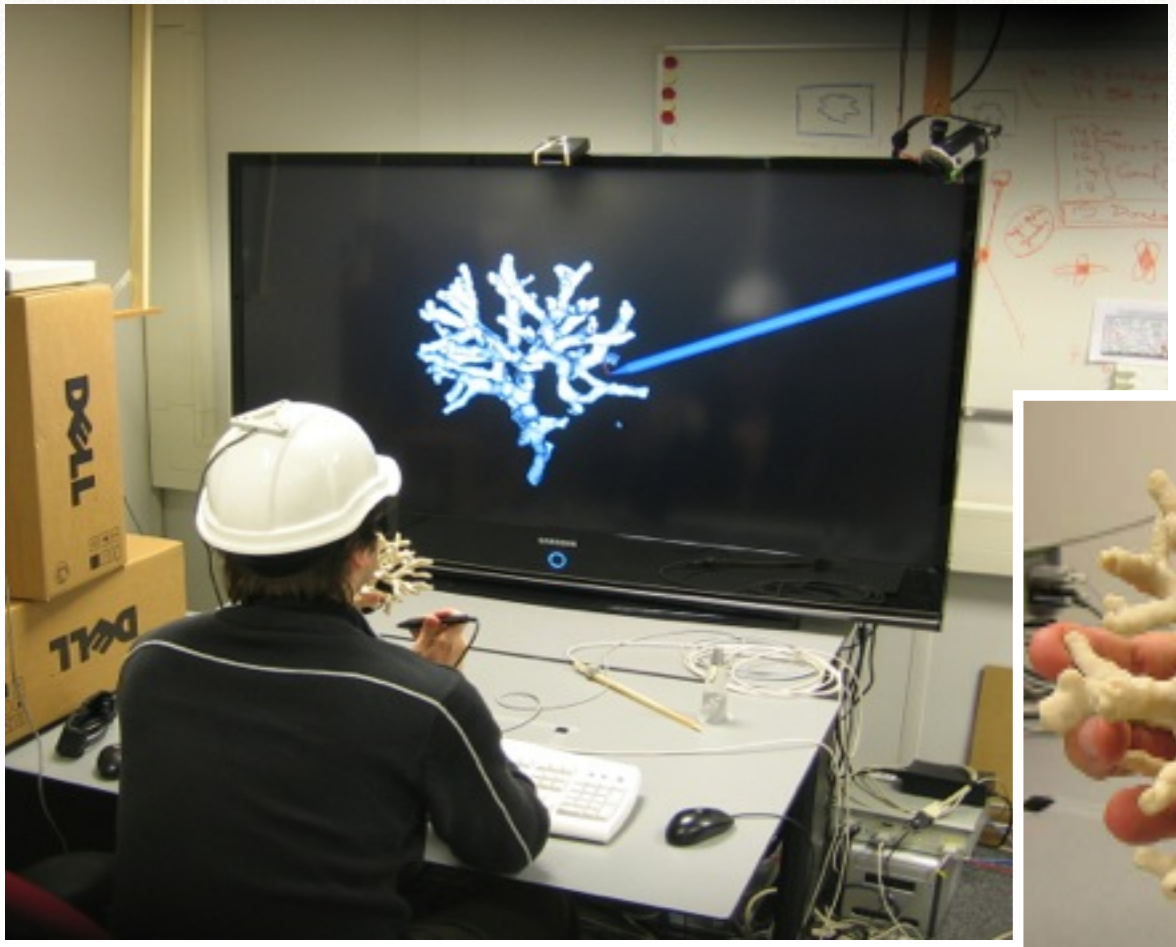
- Physical can outperform virtual

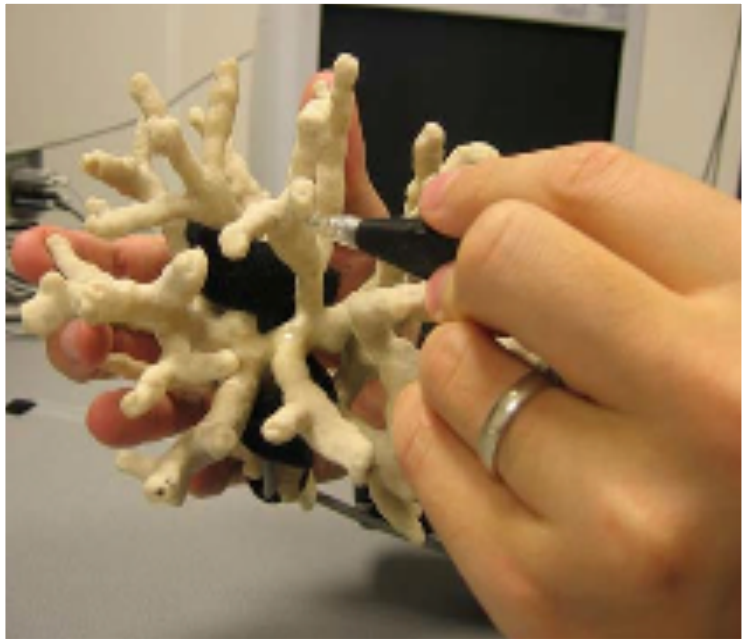
(Giang & Vitale's presentation)





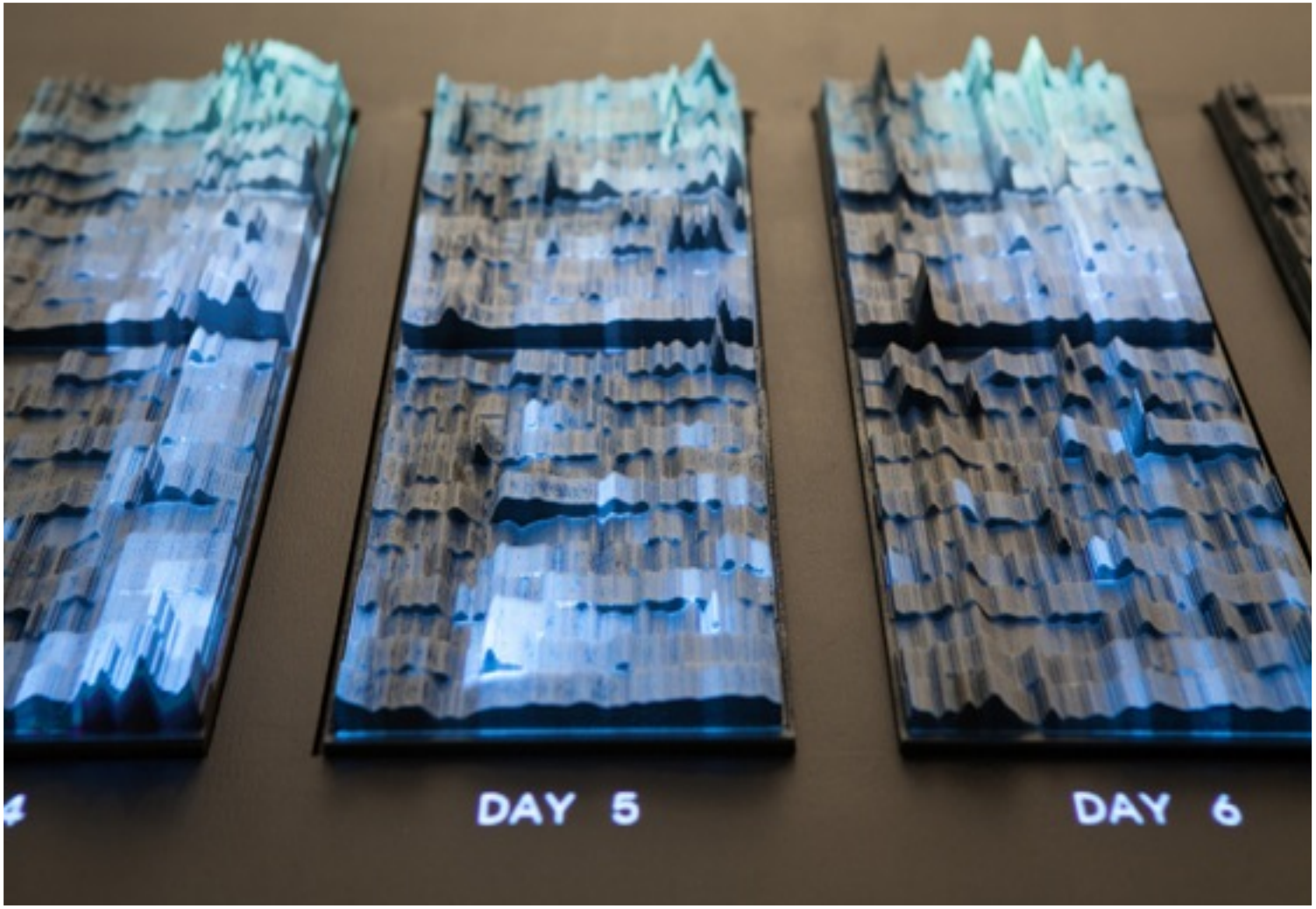
Hybrid Systems





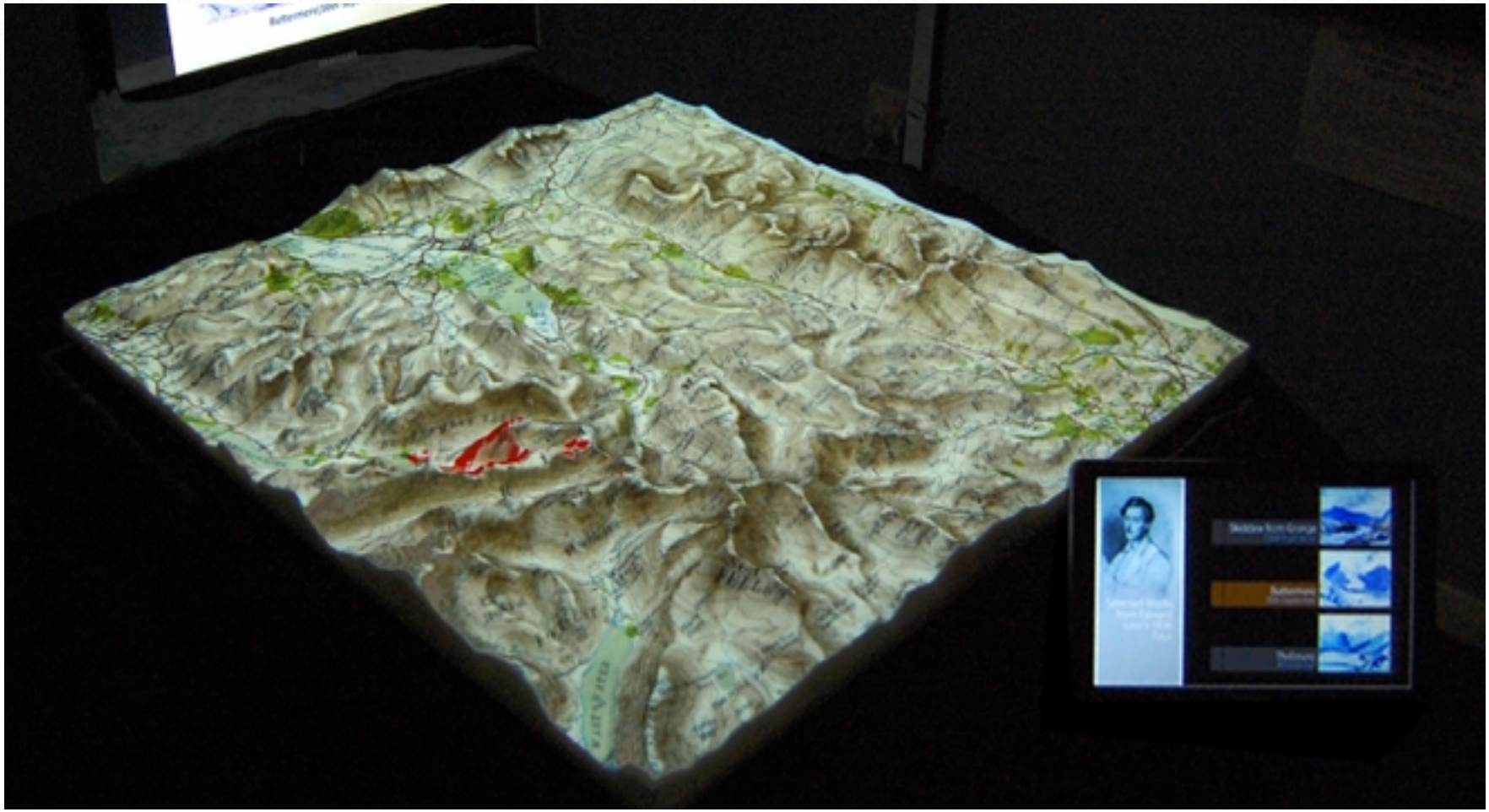
[Kruszynski & van Liere, Tangible Props for Scientific Visualization, Virtual Reality 13 (4) 2009]

Hybrid Systems



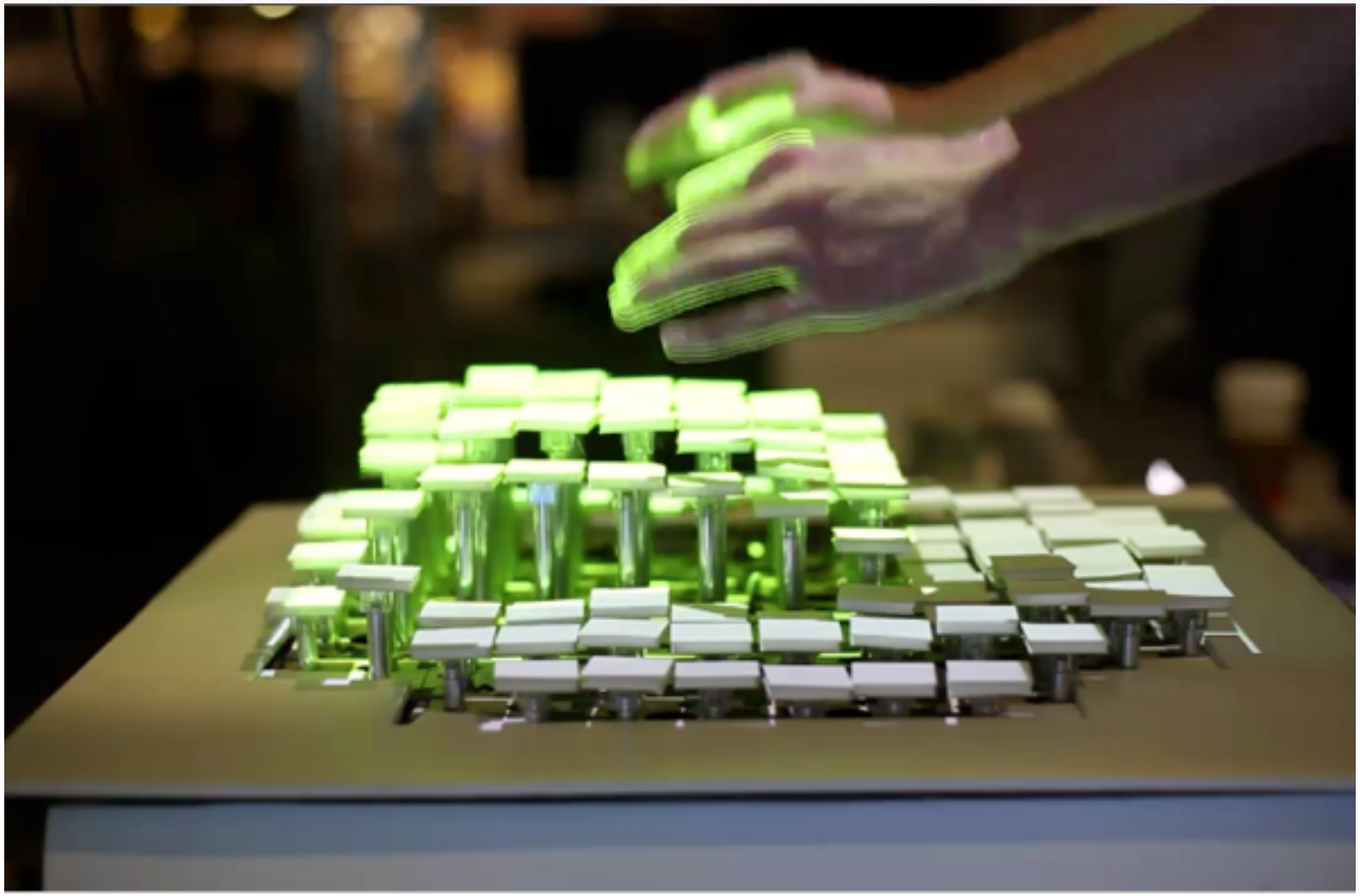
[Stefaner & Hemmert, emoto data sculpture, http://www.nand.io/visualisation/emoto-installation]

Hybrid Systems



[PARM: Projected Augmented Relief Models, University of Nottingham, 2012]

Hybrid Systems

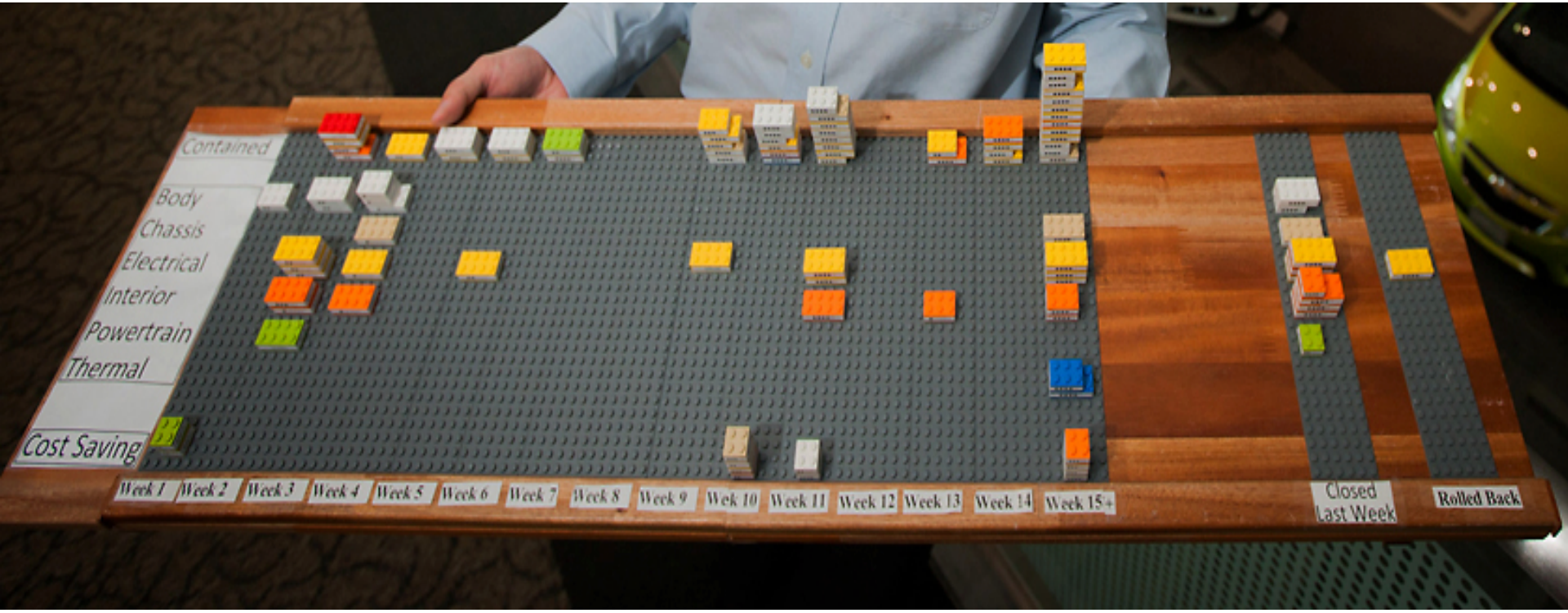


Relief (Leithinger et al, 2009)

Hybrid Systems

Data Physicalization

dataphys.org/list



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