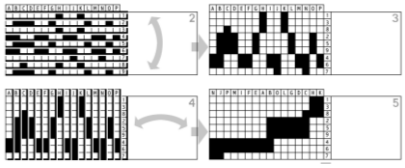
Interaction For Visualization

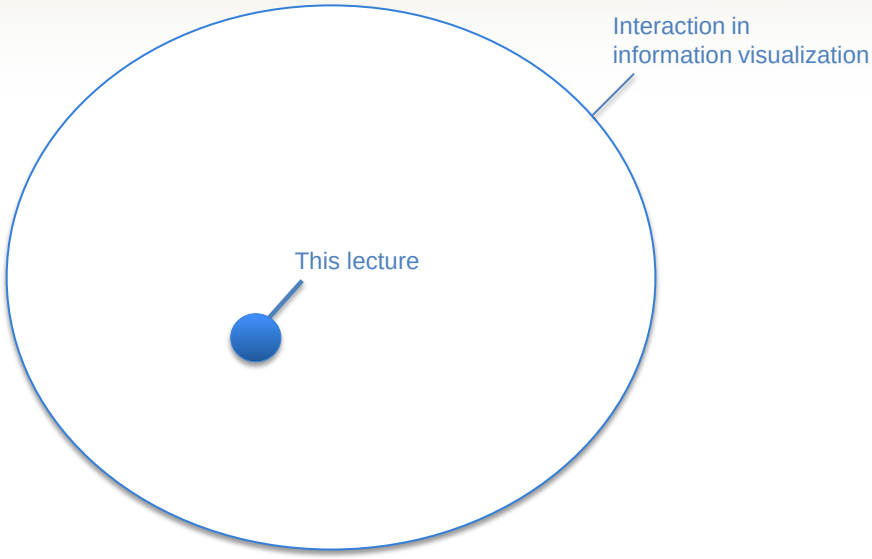
Harvard, 2015



Jean-Daniel Fekete
INRIA

Thanks to **Pierre Dragicevic**, **John Stasko** and **Yvonne Jansen** for sharing some slides

Coverage of this Lecture



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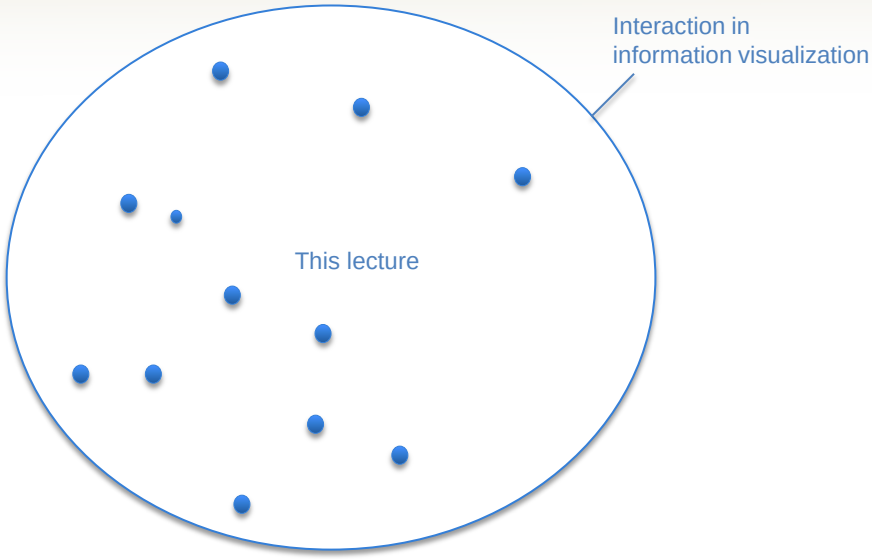
Coverage of this Lecture



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Why interact?

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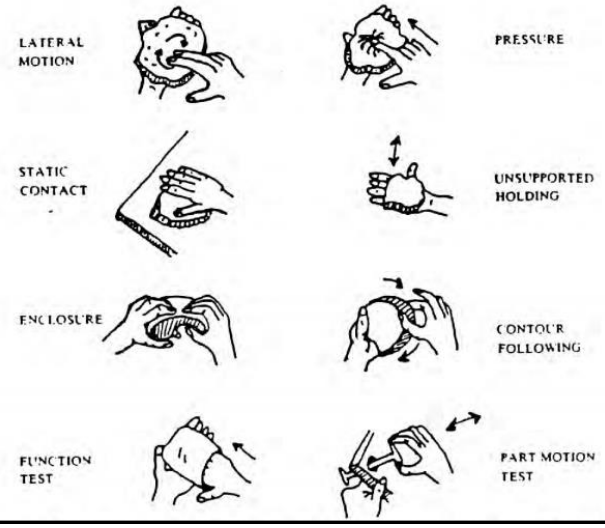
Why interact?

- Perception requires action



Lederman and Klatzky, 1987 (link)

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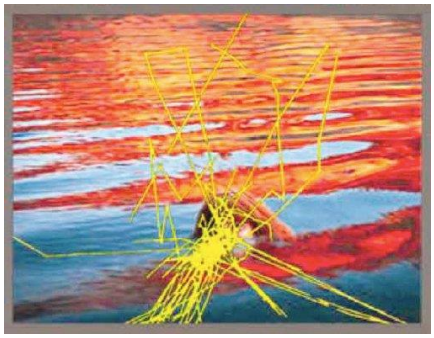
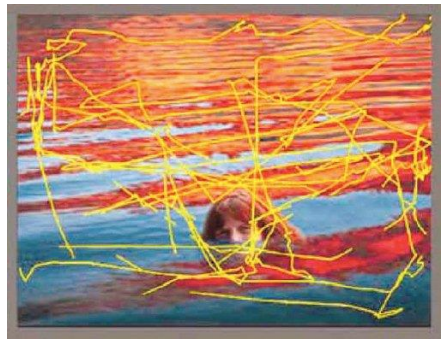
Why interact?

- Perception requires action



Eye movements of a layperson



Eye movements of an artist

Vogt and Magnussen 2007 (link)

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Why interact?

- Perception requires action

Valdis Krebs (link)

8

Why interact?

- Perception requires action

Photo appaloosa (link)

9

Why interact?

- Perception requires action

Bret Victor (link)

10

Why interact?

- Perception requires action

Bret Victor (link)

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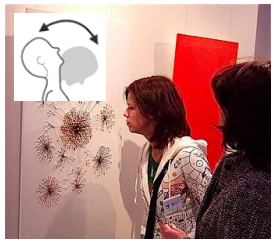
Why interact?

- Is this interacting?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Definition of interaction

- Static content
- Dynamic content
  - Animated content
    Change independently from the user
  - Interactive content
    Change as a result of user actions

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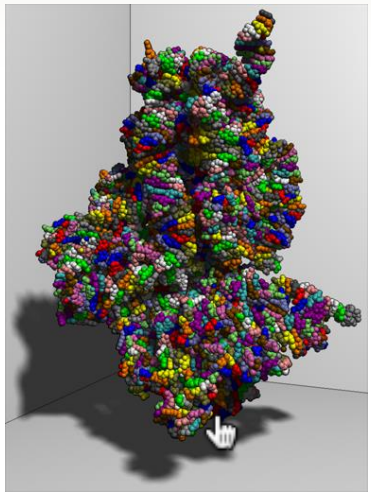
Definition of interaction



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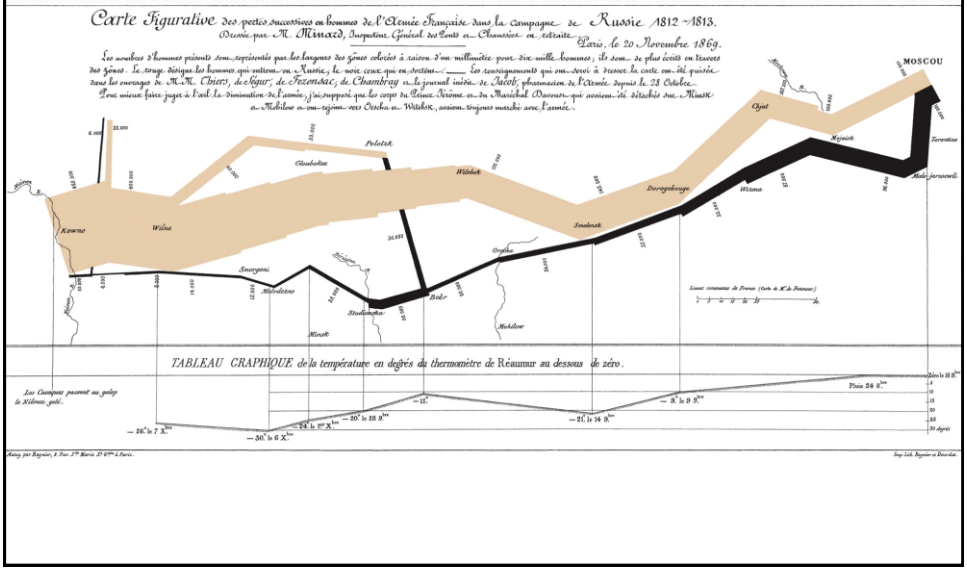
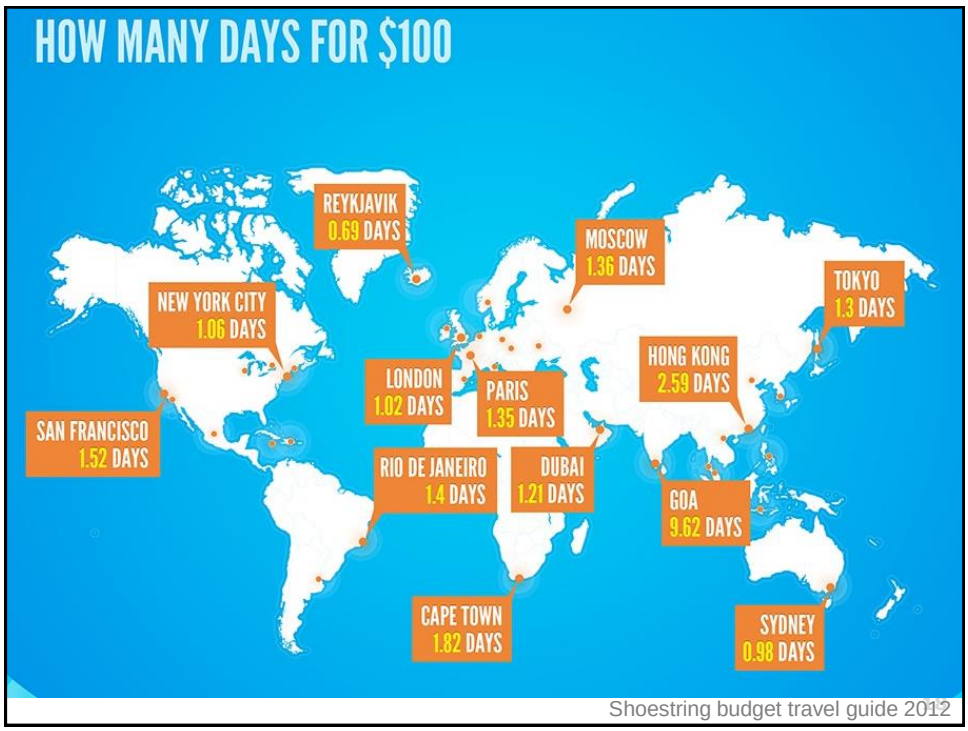
Why interact with a computer?




DAYS YOU CAN STAY FOR $100
the most expensive
the cheapest
1. Reykjavik, Iceland 0.69
2. Oslo, Norway 0.89
3. Venice, Italy 0.98
4. Sydney, Australia 0.98
5. London, United Kingdom 1.02
6. New York City, USA 1.06
7. Boston, USA 1.08
8. Rome, Italy 1.17
9. Dubai, UAE 1.21
10. Amsterdam, Netherlands 1.27
11. Tokyo, Japan 1.3
12. Barcelona, Spain 1.35
13. Paris, France 1.35
14. Dublin, Ireland 1.36
15. Moscow, Russia 1.36
16. Rio de Janeiro, Brazil 1.4
17. Montreal, Canada 1.41
18. San Francisco, USA 1.52
19. Chicago, USA 1.57
20. Los Angeles, USA 1.57
21. Berlin, Germany 1.63
9.62
6.82
4.7
3.95
3.92
3.35
3.31
3.1
3.05
2.73
2.62
2.59
2.54
2.43
2.27
2.16
2.08
2
1.96
1.82
1.76
Goa, India 42.
Hanoi, Vietnam 41.
Marrakech, Morocco 40.
Manila, Philippines 39.
Cairo, Egypt 38.
Beijing, China 37.
Kiev, Ukraine 36.
Mexico City, Mexico 35.
Bangkok, Thailand 34.
Denpasar, Bali 33.
Seoul, South Korea 32.
Hong Kong, China 31.
Singapore 30.
Prague, Czech Republic 29.
Kingston, Jamaica 28.
Buenos Aires, Argentina 27.
Istanbul, Turkey 26.
Santo Domingo, Dominican Republic 25.
Kuala Lumpur, Malaysia 24.
Cape Town, South Africa 23.
Jerusalem, Israel 22.
Shoestring budget travel guide 2012


The cheapest
Drive a hard bargain.
Goa
Bed $2.69
Goa State Museum (free)
Transport $0.90
Food $6.74
Eat on the cheap. Eat the local fare. Delicious.
Hanoi
Bed $4.80
Ho Chi Minh Mausoleum (free)
Transport $1.20
Food $8.64
Don't look for cheap alcohol. It's a forlorn hope.
Marrakech
Bed $6.19
El Bahia Palace $1.13
Transport $1.69
Food $12.38
The most expensive
Get the best hot dogs in the world.
Reykjavik
Bed $26.71
Blue Lagoon $46.74
Transport $40.90
Food $30.05
Forget about the city, explore the nature.
Oslo
Bed $37.14
Viking Ship Museum $10.13
Transport $12.66
Food $52.33
Visit in the off-season and beat the crowds.
Venice
Bed $24.72
Venice museum pass $22.25
Transport $24.72
Food $30.90
Shoestring budget travel guide 2012
17



Why interact with a computer?

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

→ Let the user dynamically control what to show and how to show it

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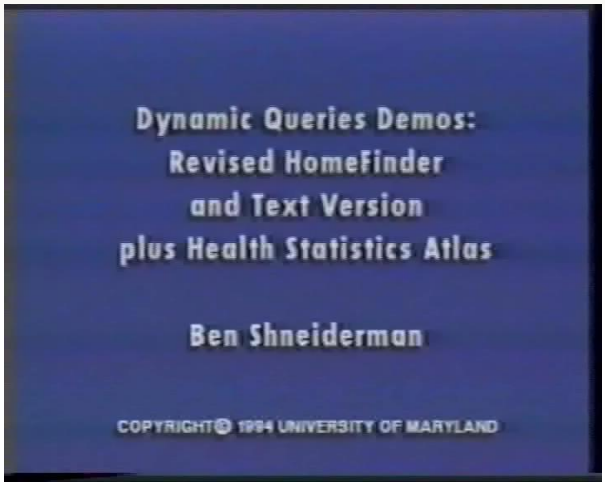
Example 1: Dynamic Queries

Williamson and Shneiderman, 1992

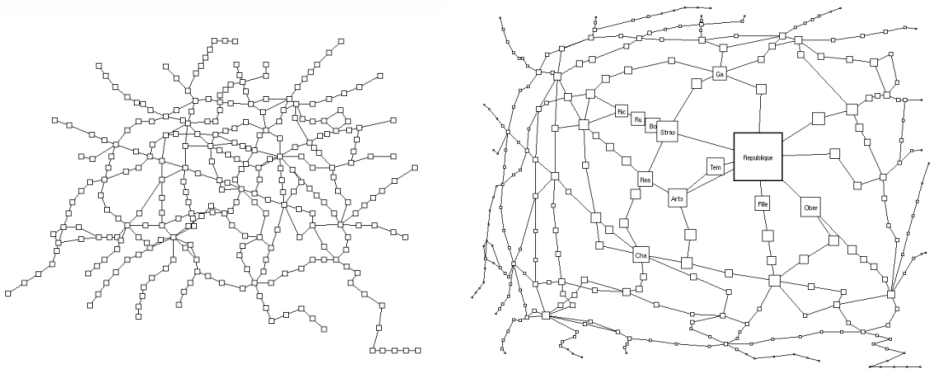
Example 1: Dynamic Queries



1:29

Williamson and Shneiderman, 1992

Example 2: Fisheye Views



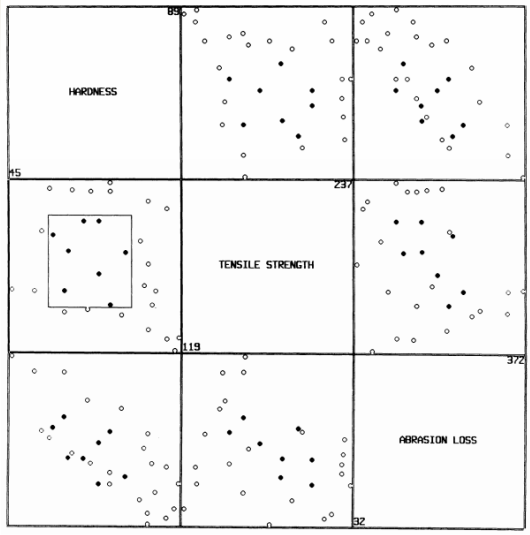
Sarkar and Brown, 1992

Example 2: Fisheye Views

1:08

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

Example 3: Brushing



Beker and Cleveland, 1987

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Example 3: Brushing

17:50

Beker and Cleveland, 1987

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Taxonomies of interaction

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

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The Visualization Pipeline

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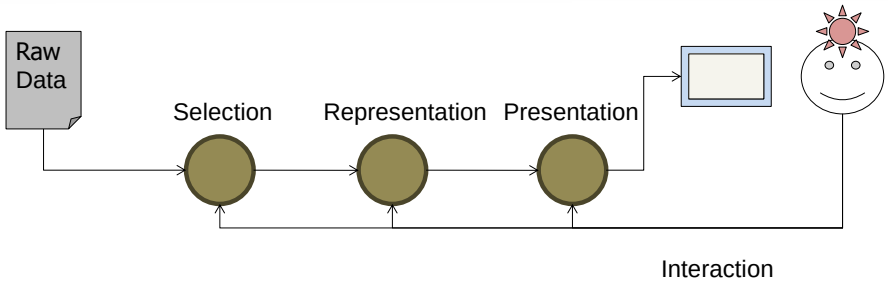
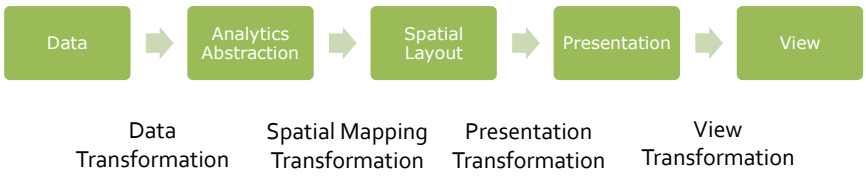
The Visualization Pipeline



The Visualization Pipeline

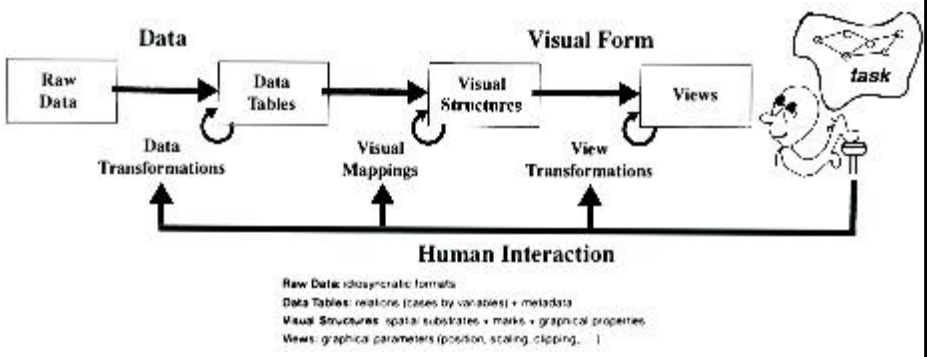
From [Spence, 2000

The Visualization Pipeline



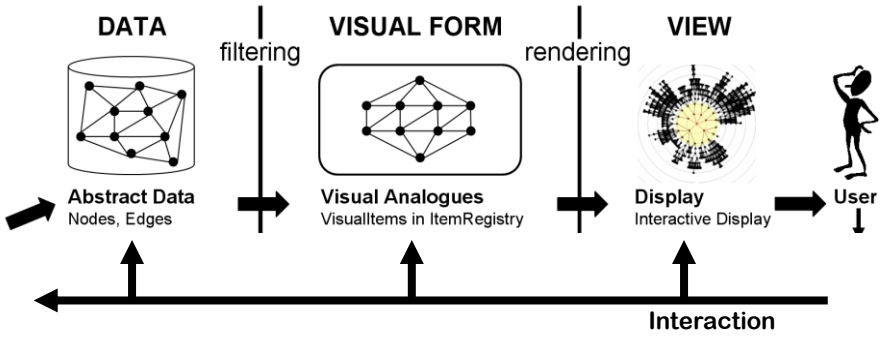
From [Card et al., Readings in Information Visualization]

The Visualization Pipeline

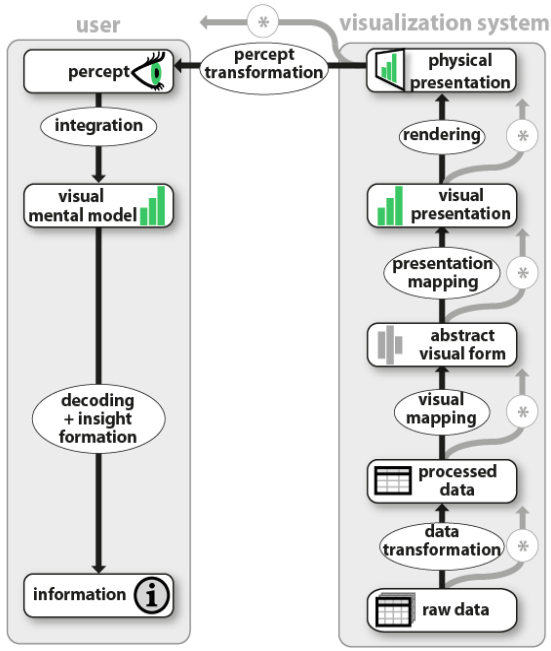


[Card, Mackinlay, Shneiderman, Readings in Information Visualization: Using Vision to Think, 1999]

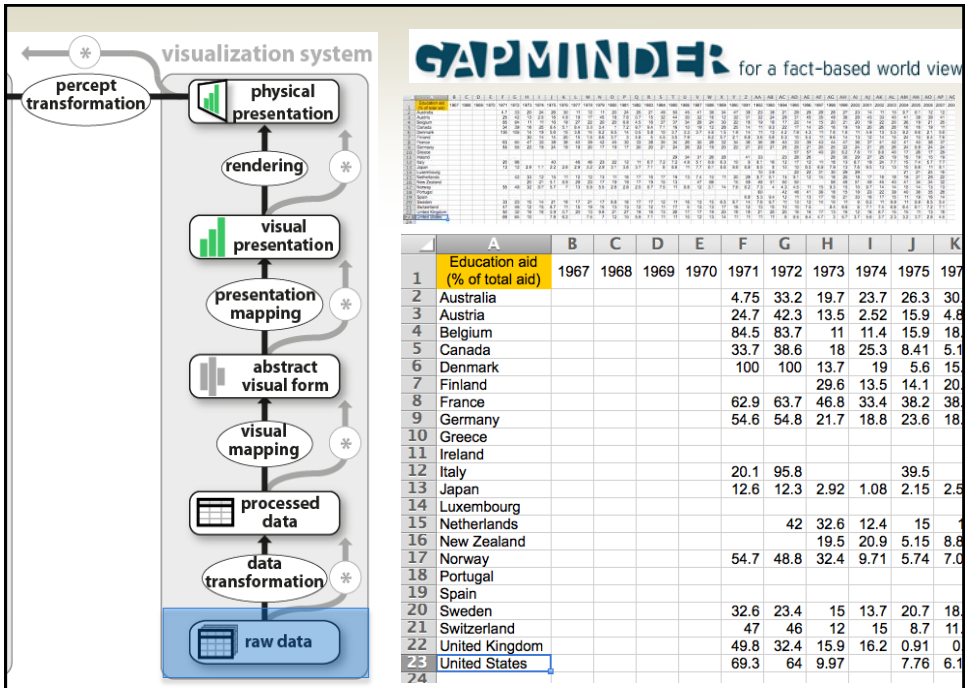
The Visualization Pipeline



From Ed CHI
Illustration de J. Heer

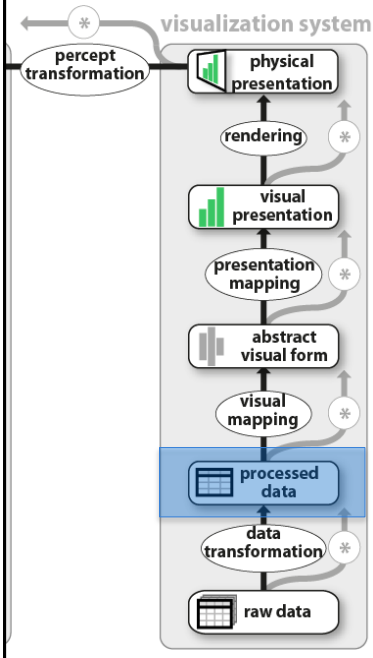


Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



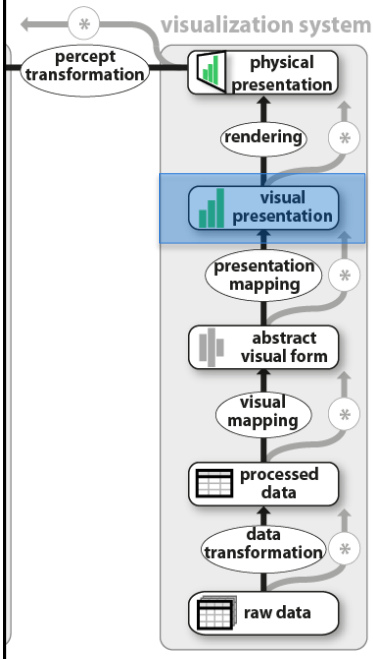
	A	B	C	D	E	F	G	H	I	J	K
1	Education aid (% of total aid)	1967	1968	1969	1970	1971	1972	1973	1974	1975	197
2	Australia					4.75	33.2	19.7	23.7	26.3	30.
3	Austria					24.7	42.3	13.5	2.52	15.9	4.8
4	Belgium					84.5	83.7	11	11.4	15.9	18.
5	Canada					33.7	38.6	18	25.3	8.41	5.1
6	Denmark					100	100	13.7	19	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											

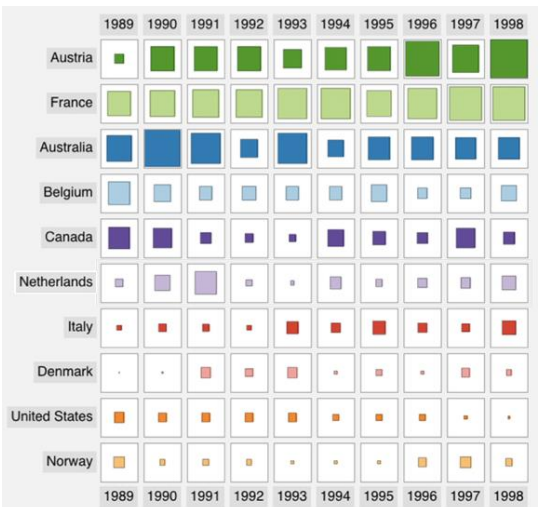
Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



	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)





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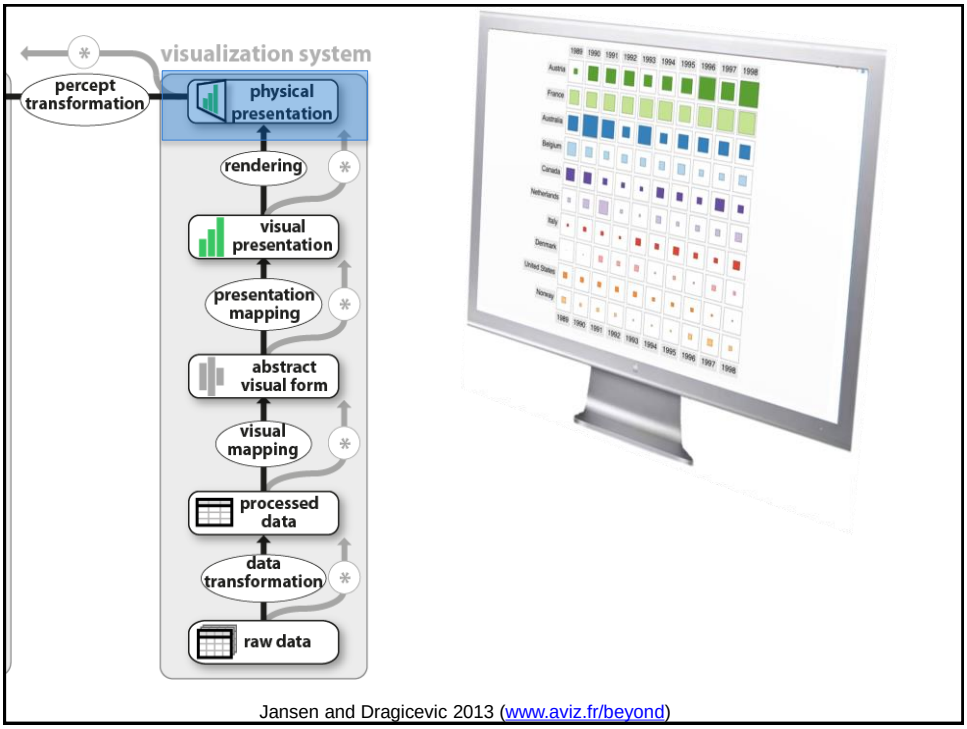

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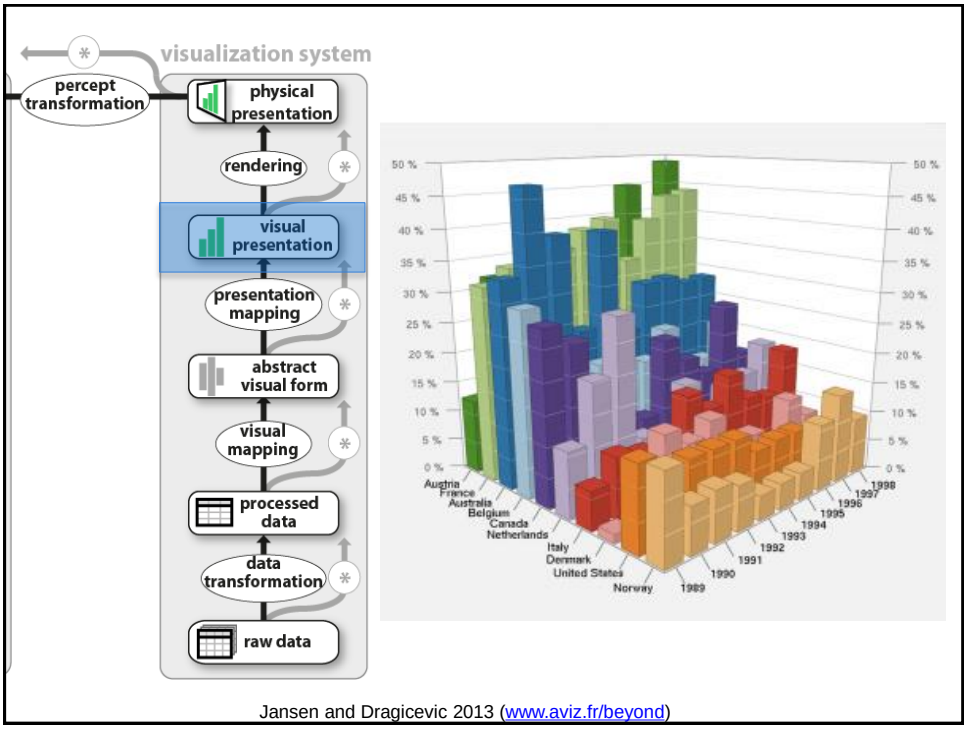

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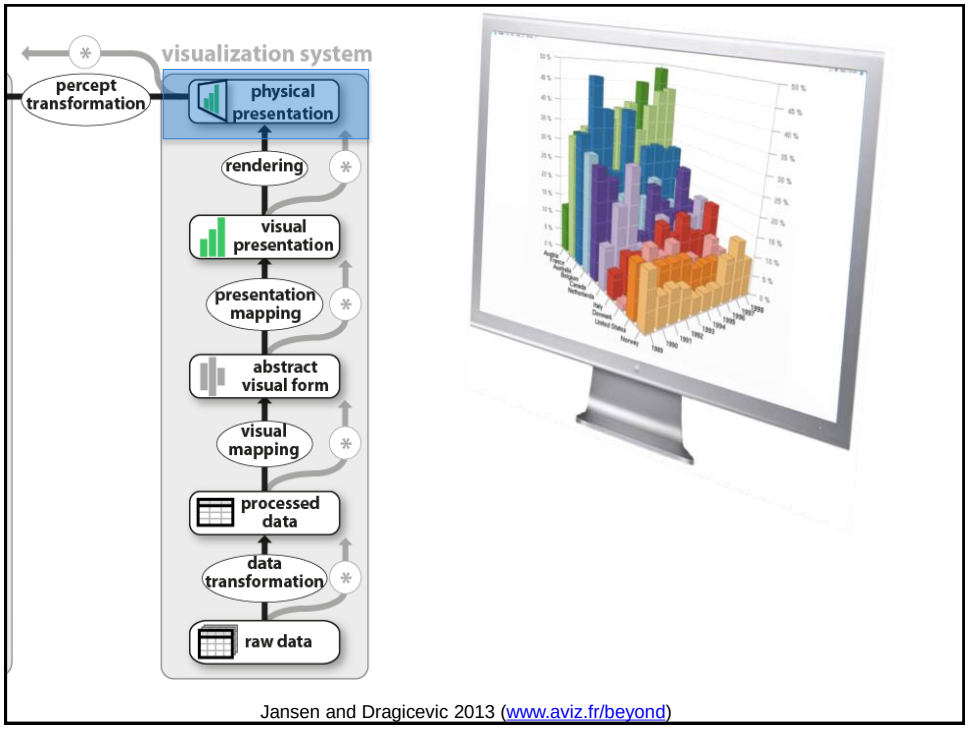

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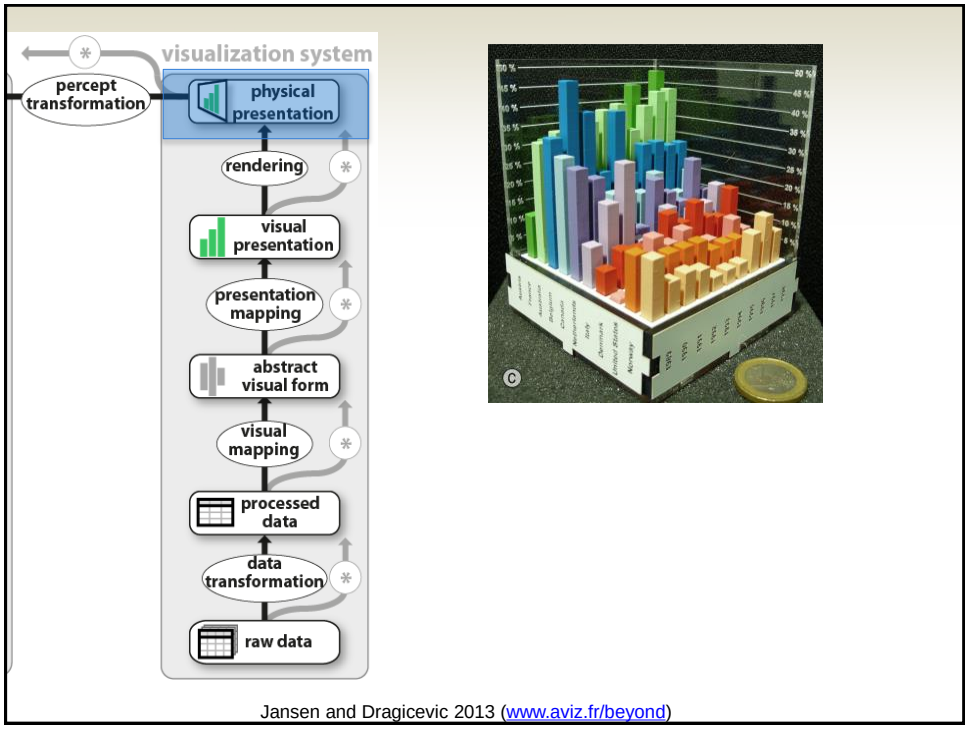

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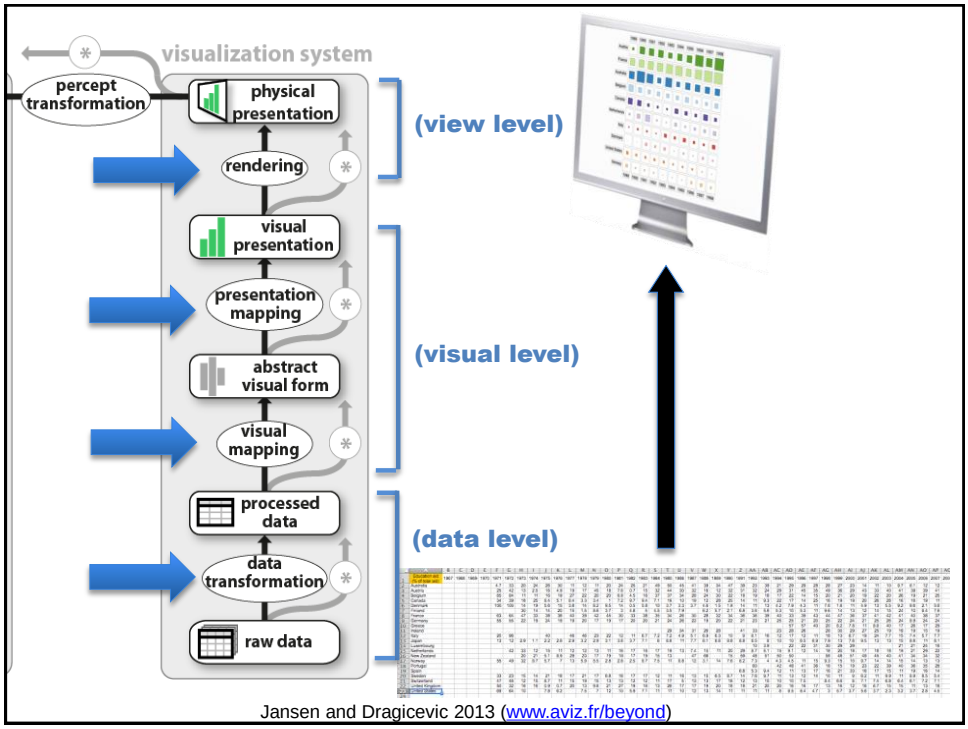

Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

Taxonomies of interaction

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

Tasks

- How?
  - How is the user doing it?

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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

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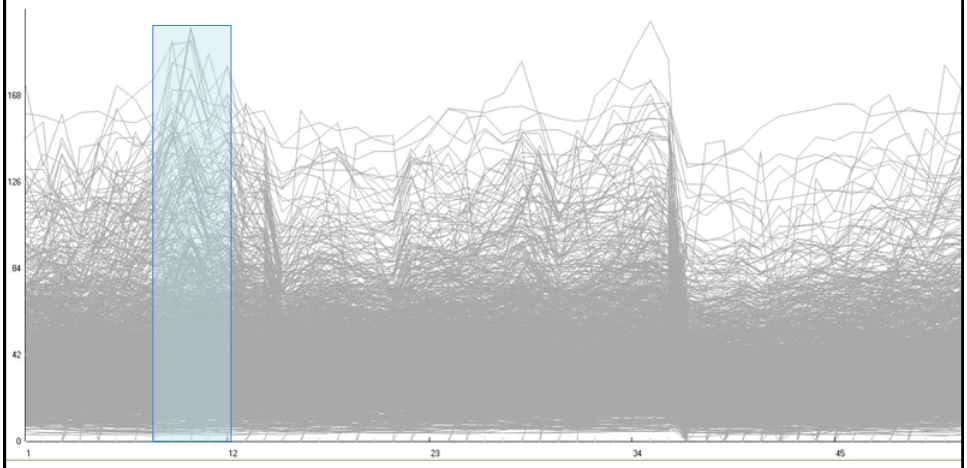
Analytical Tasks

1. Overview



Stephen Few, 2006 (link) Software: TimeSearcher 2

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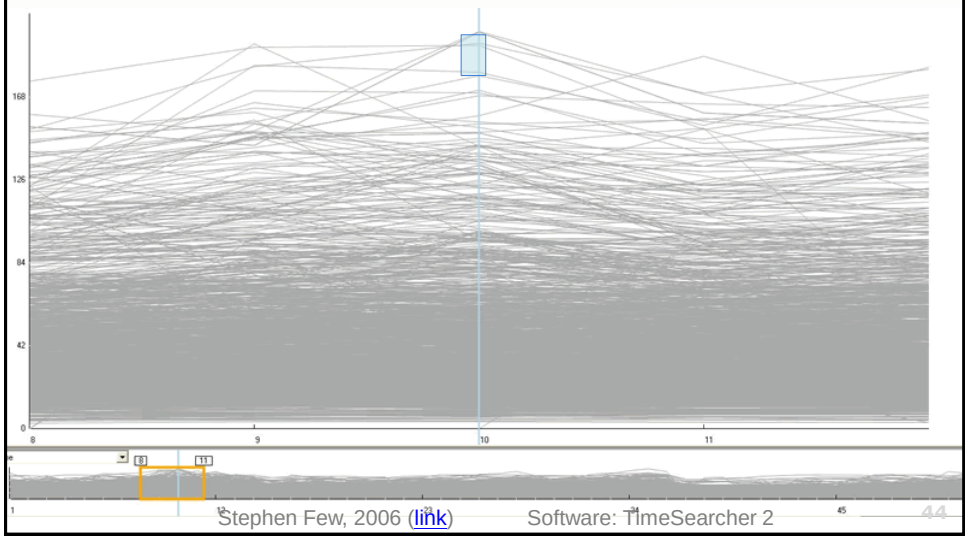
Analytical Tasks

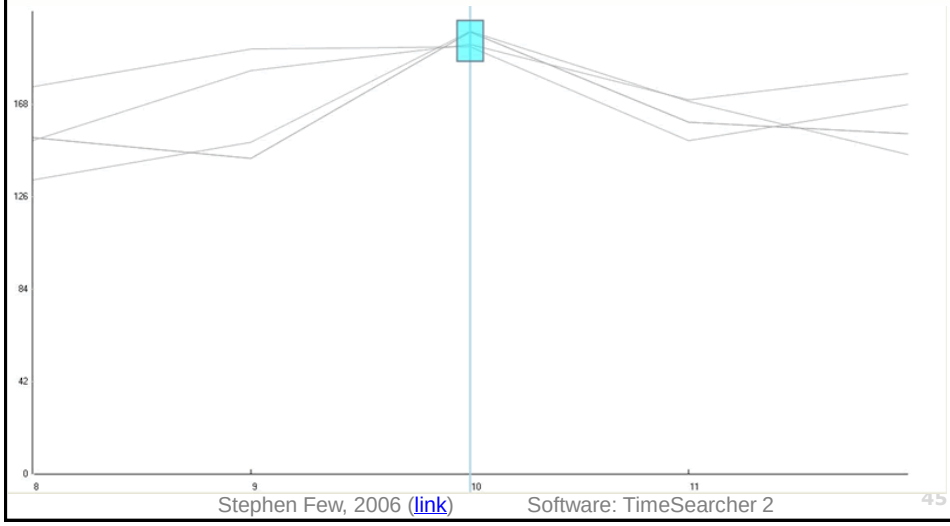
2-3. Zoom and Filter



Stephen Few, 2006 (link) Software: TimeSearcher 2

Analytical Tasks

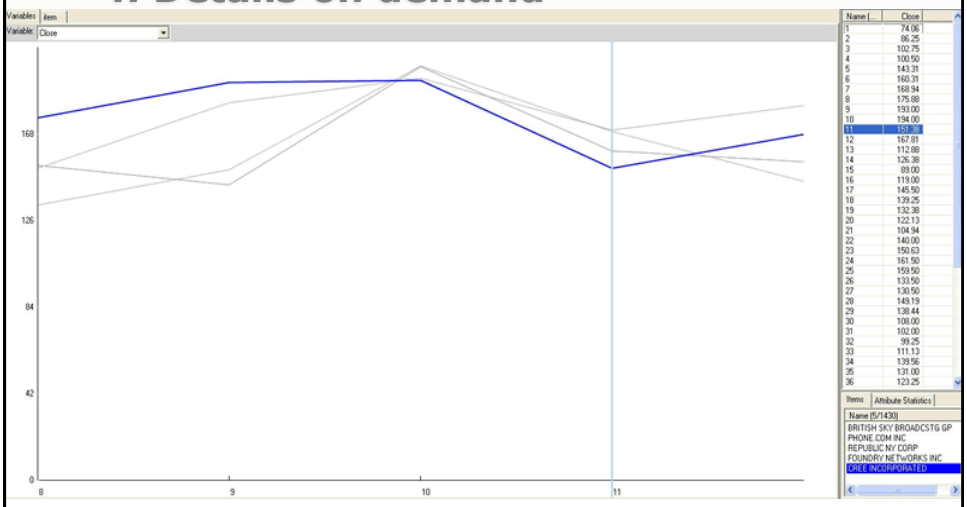
2-3. Zoom and Filter



Stephen Few, 2006 (link) Software: TimeSearcher 2

Analytical Tasks

4. Details on demand



Stephen Few, 2006 (link) Software: TimeSearcher 2

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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

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Analytical Tasks

- Amar, Eagan and Stasko, 2005
  - Retrieve Value
  - Filter
  - Compute Derived Value
  - Find Extremum
  - Sort
  - Determine Range
  - Characterize Distribution
  - Find Anomalies
  - Cluster
  - Correlate

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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

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Taxonomies of interaction

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

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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**

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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
```

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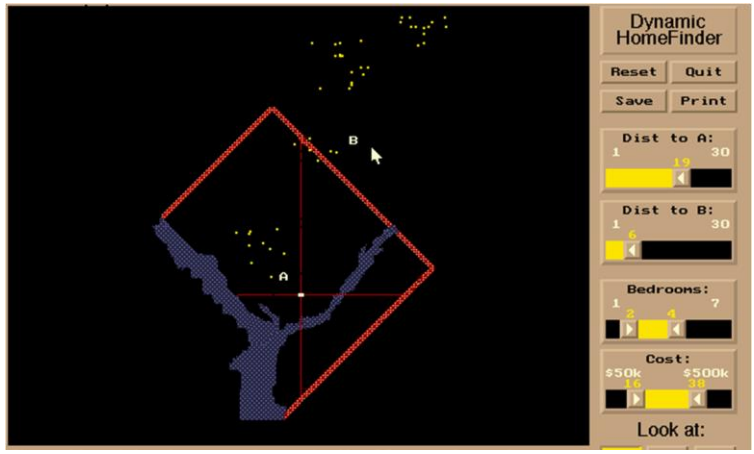
Interaction Styles

- (In)Direct manipulation



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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**

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Taxonomies of interaction

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

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Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

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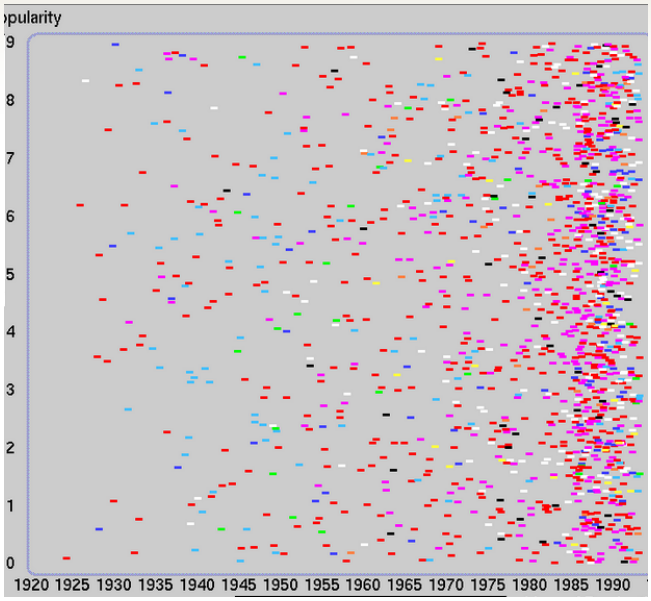
Problem



FilmFinder, HCIL

57

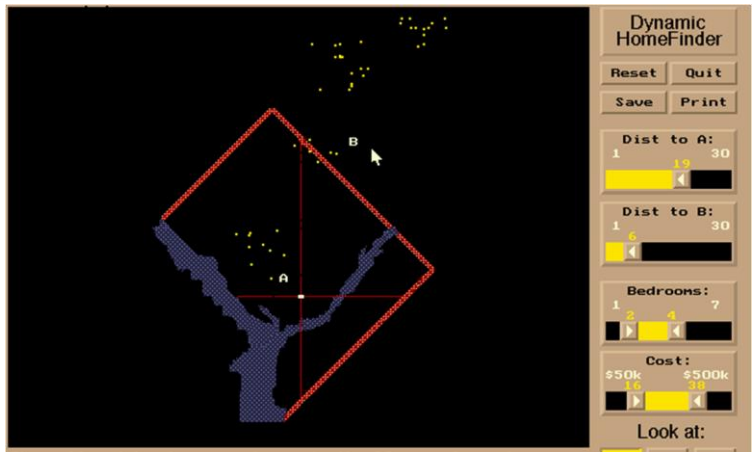
Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

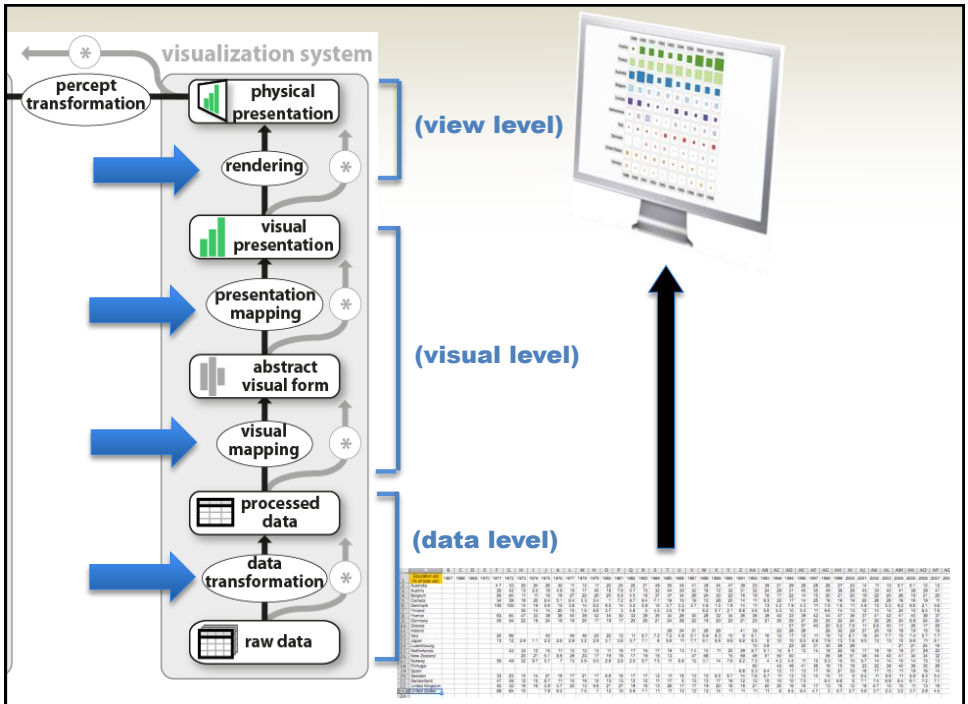
58

Filtering Techniques

- Dynamic Queries



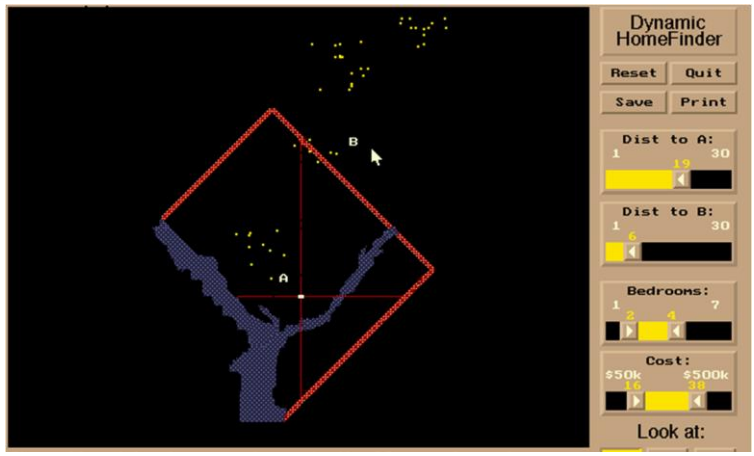
59



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

Filtering Techniques

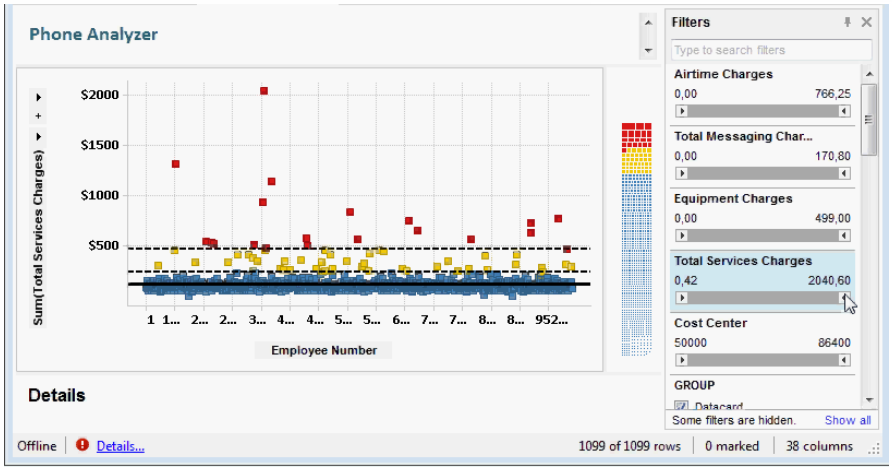
- Visual-Level Dynamic Queries



61

Filtering Techniques

- Dynamic Queries + Zooming

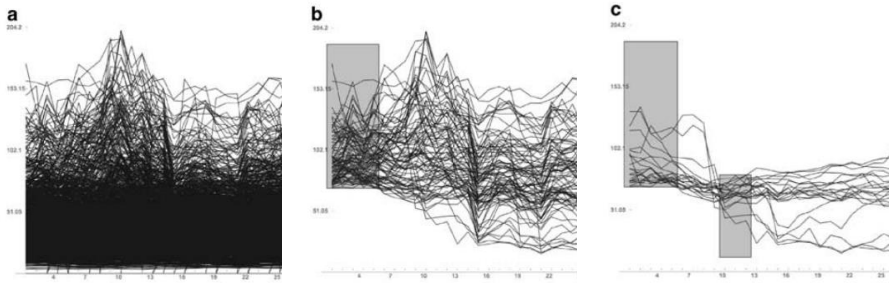


Spotfire Software

62

Filtering Techniques

- Dynamic Queries Specified Visually

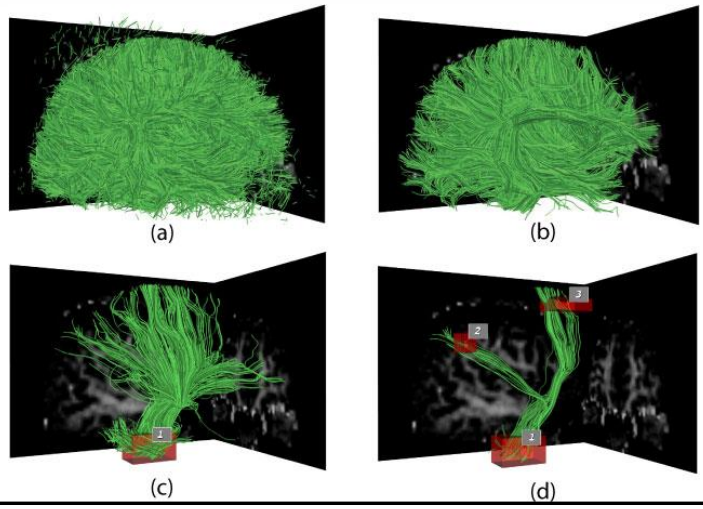


Time Searcher (Hocheiser, 2003)

63

Filtering Techniques

- Dynamic Queries for Volumetric Data

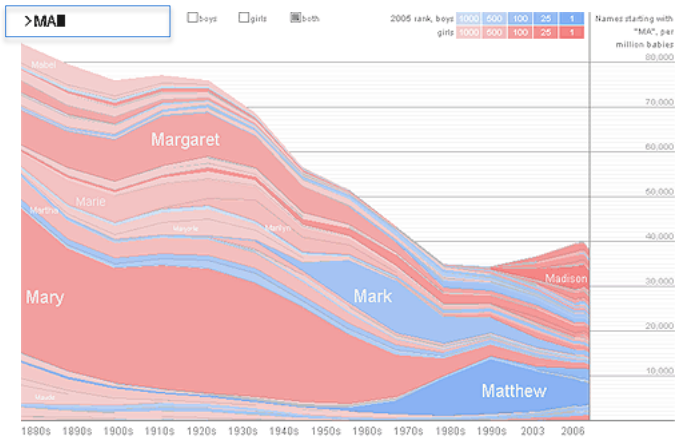


Sherbondy et al, 2004

64

Filtering Techniques

- Incremental Text Search



Name Voyager (Wattenberg, 2005)

65

Problem

66

Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

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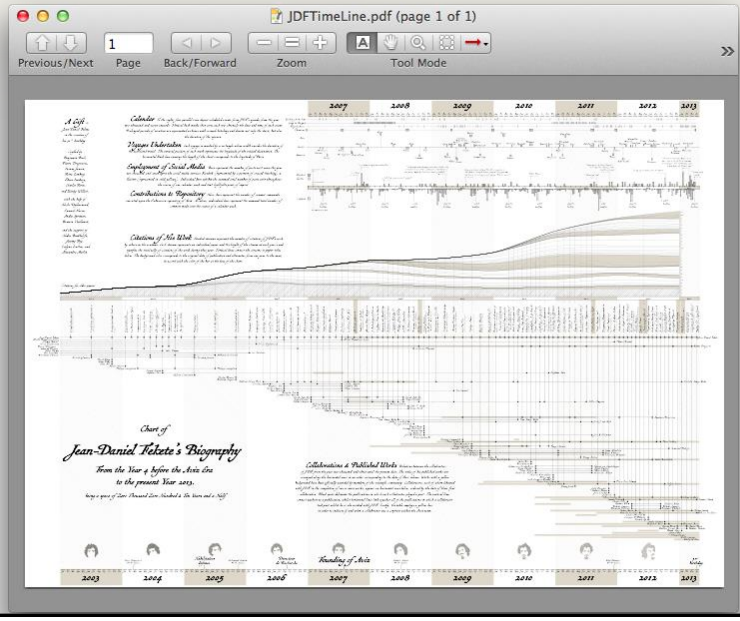
Navigation Techniques

- Pan & Zoom
- Focus + Context

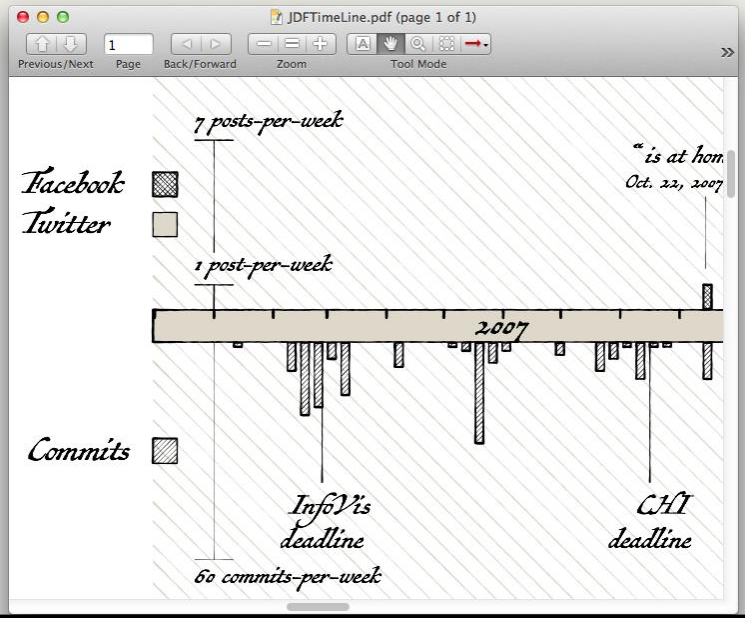
68

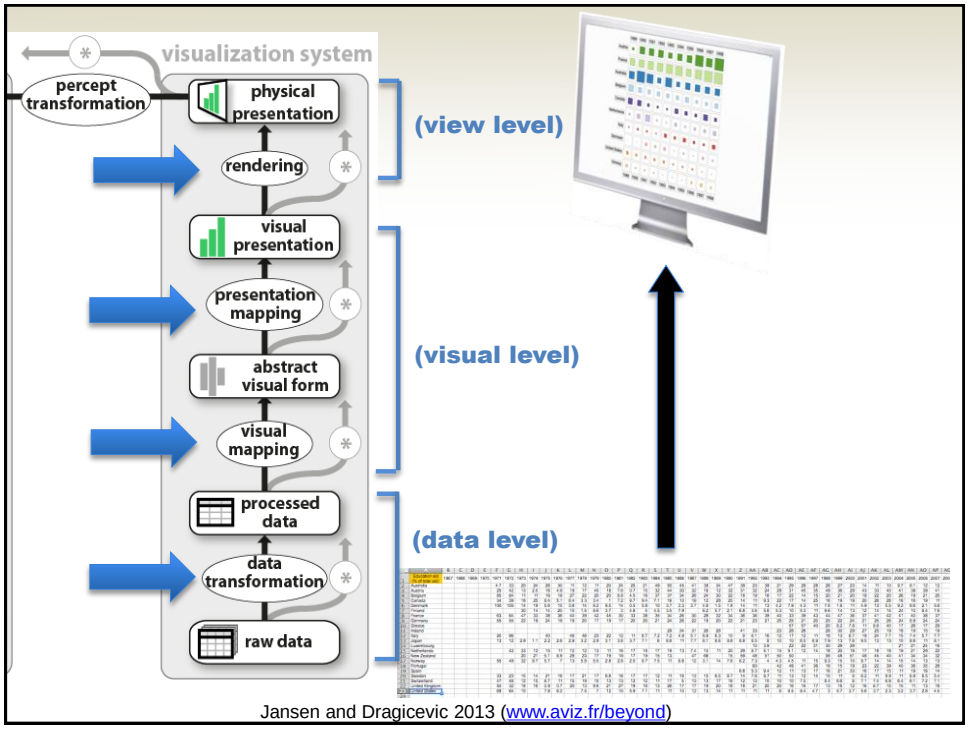
Pan & Zoom



69

Pan & Zoom



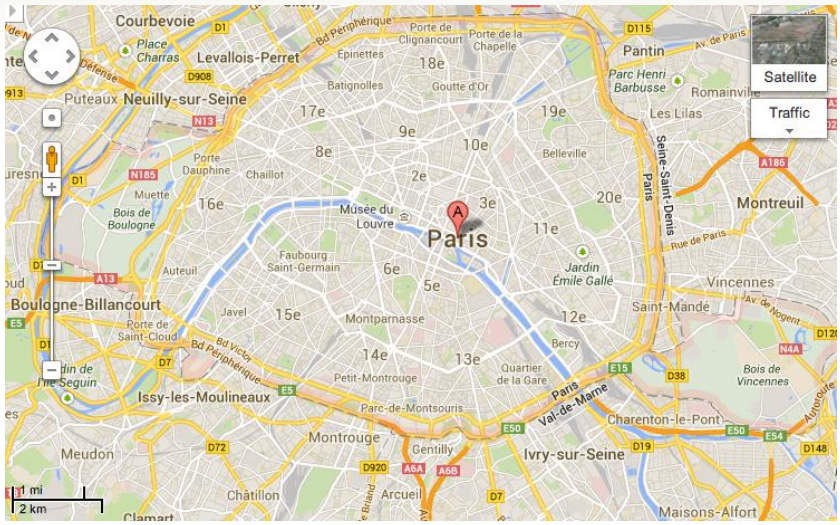


Jansen and Dragicevic 2013 (www.aviz.fr/beyond)

Pan & Zoom

72

Pan & Zoom



73

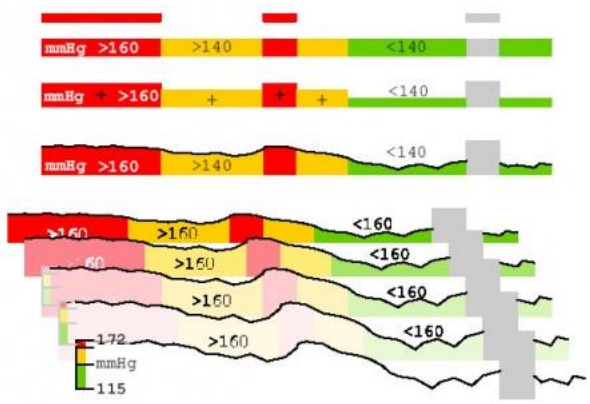
Pan & Zoom

- Semantic Zoom

74

Pan & Zoom

- Semantic Zoom

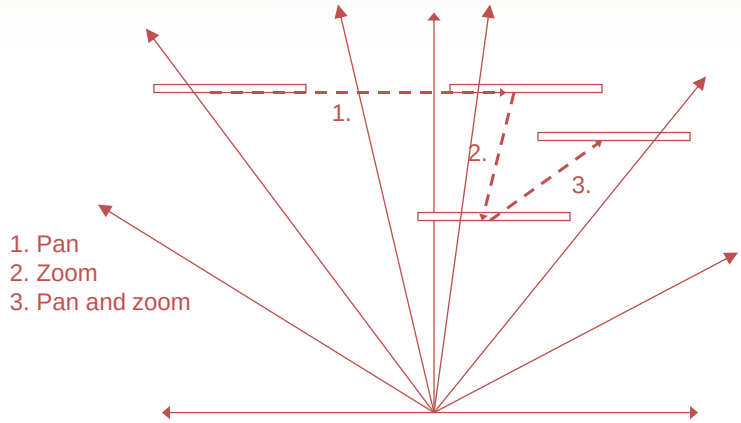


Bade et al, 2004 (link)

75

Pan & Zoom

- Space-Scale Diagrams



1. Pan
2. Zoom
3. Pan and zoom

Furnas and Bederson, 1995

Space-Scale Diagrams: Understanding Multiscale Interfaces (link)

Problem

Where am I?

Navigation Techniques

- Pan & Zoom
- Focus + Context

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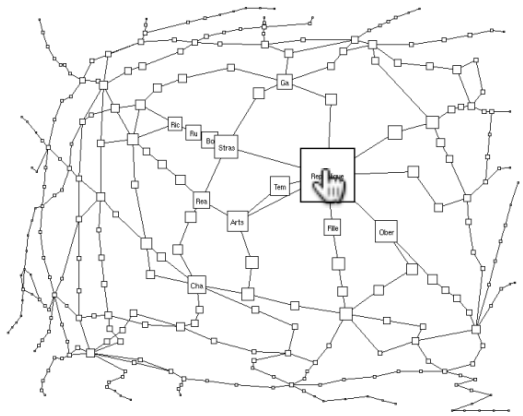
Focus + Context

- Space Distorsion
  - Fisheye Views of Graphs

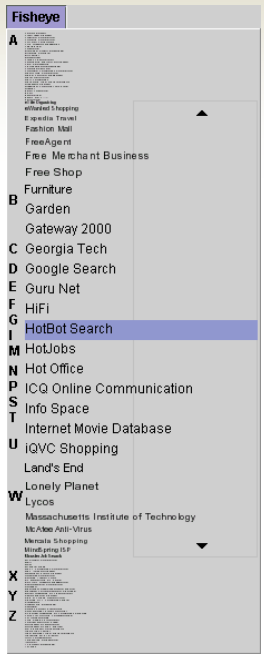


Sarkar and Brown, 1992

79

Focus + Context

- Space Distorsion
  - Fisheye Menus

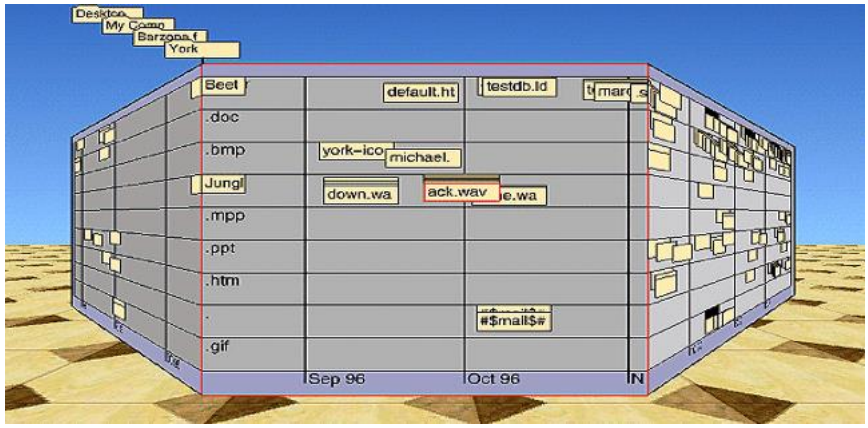


Bederson, 2000

80

Focus + Context

- Space Distorsion
  - Perspective Wall

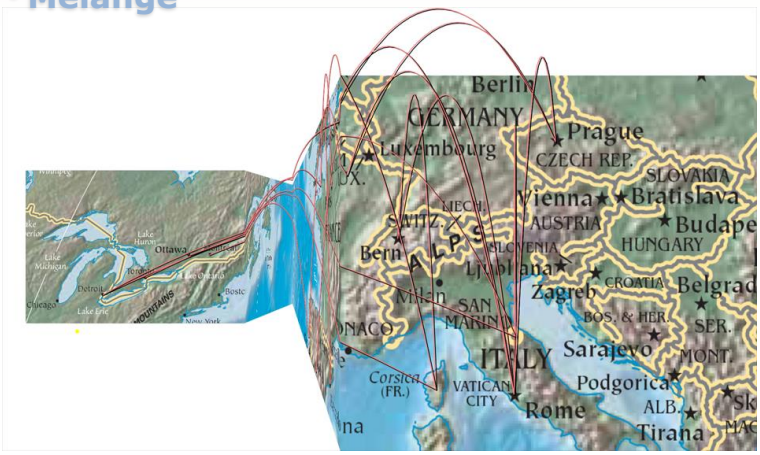


Mackinlay, Roberston and Card, 1991

81

Focus + Context

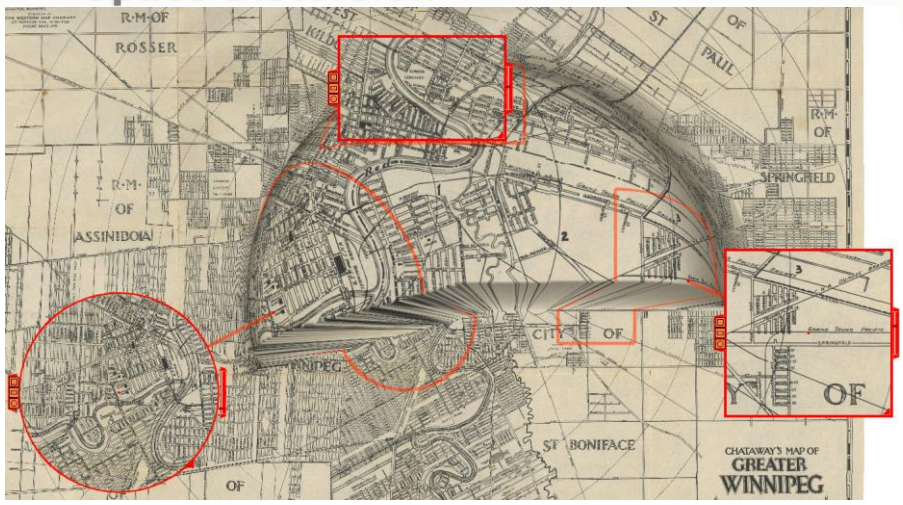
- Space Distorsion
  - Melange



Elmqvist et al, 2010

Focus + Context

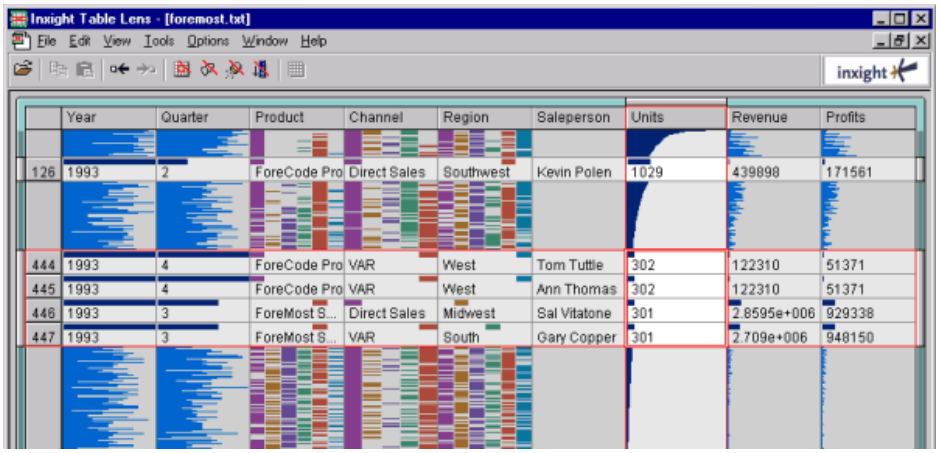
- Space Distorsion



Brosz, Carpendale and Nacenta, 2011

Focus + Context

- Table Lens



Rao and Card, 1994

84

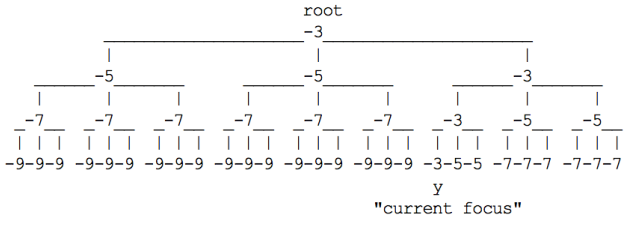
Focus + Context

- Generalized Fisheye Views

(c) The Fisheye DOI:

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

$= -(d_{tree}(x,y) + d_{tree}(x,root))$

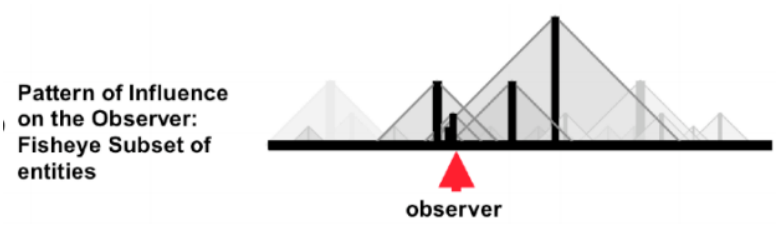


Furnas, 1986
Generalized Fisheye Views

85

Focus + Context

- Generalized Fisheye Views



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

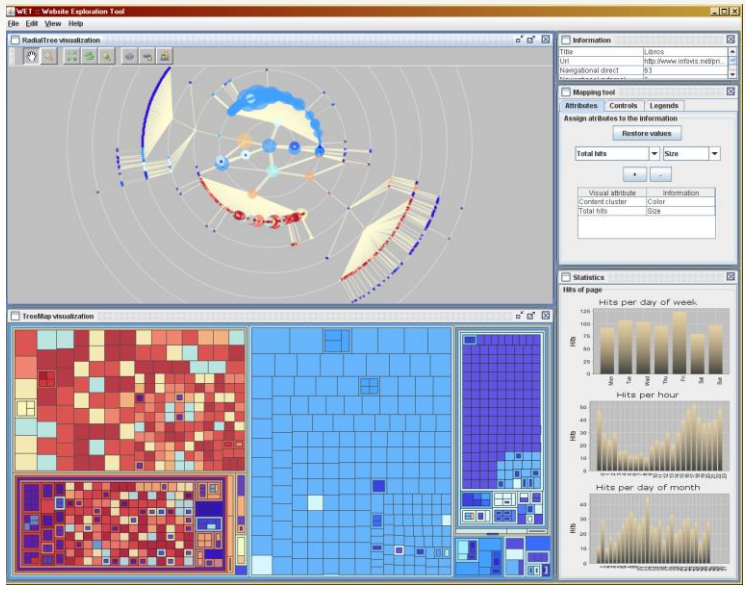
86

Families of infovis interaction techniques

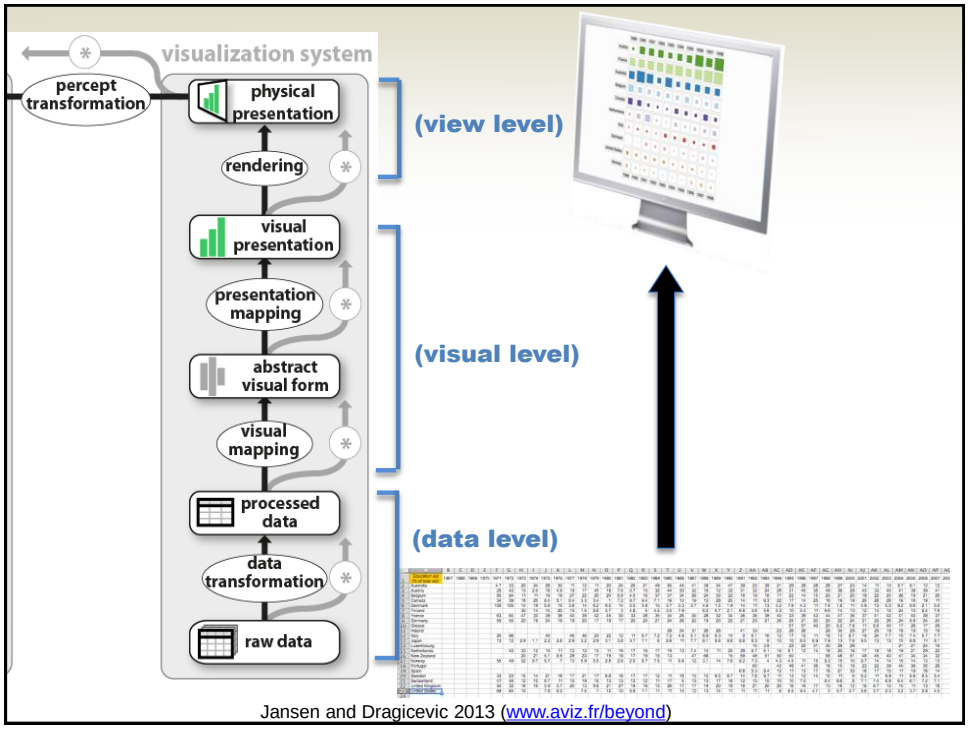
- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

87

Multiple Views

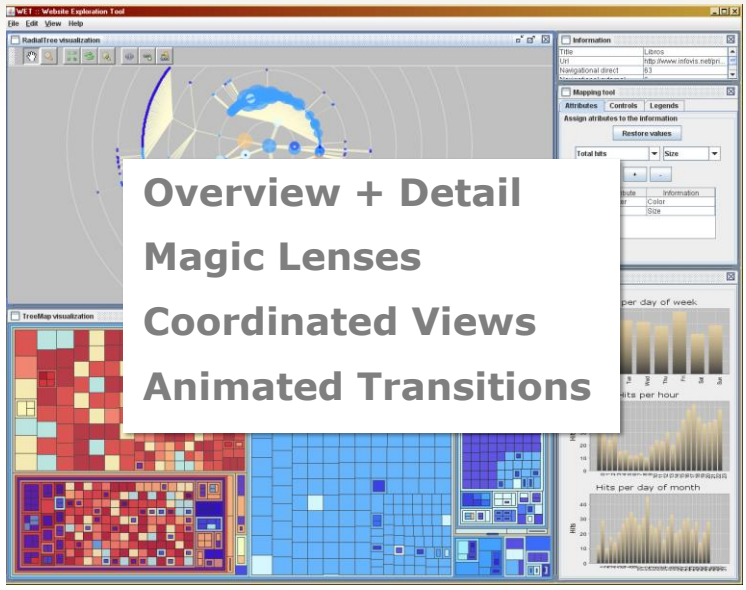


88



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

Multiple Views



90

Problem

Where am I?

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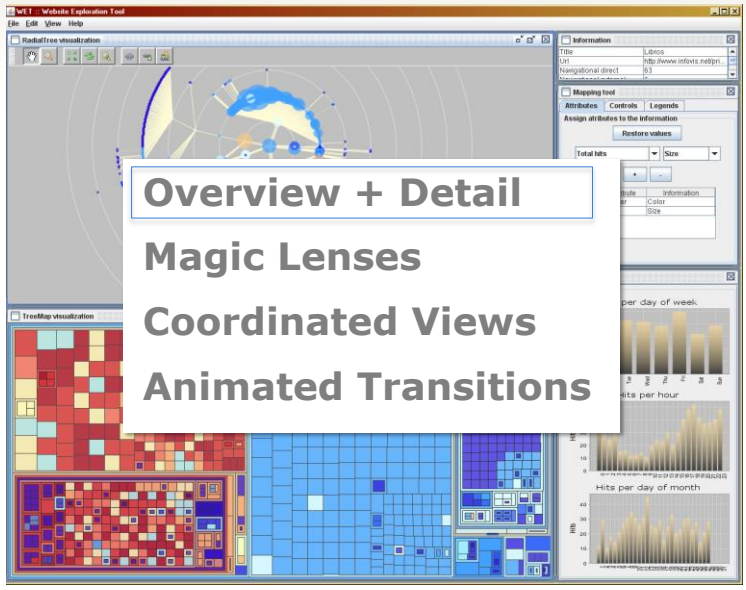
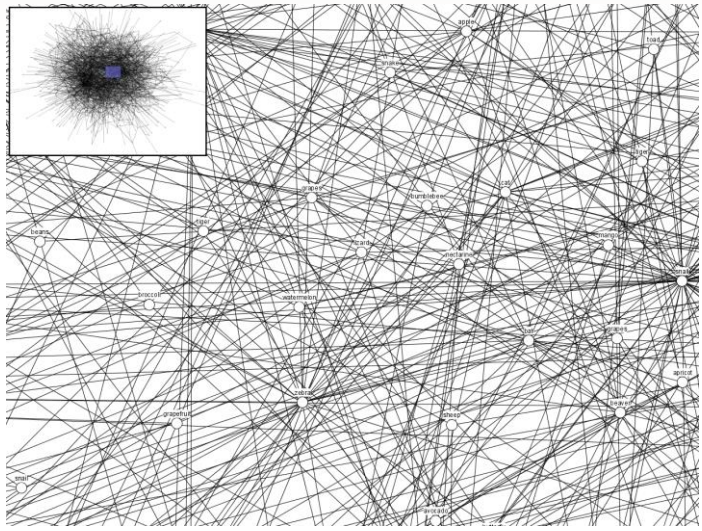
Multiple Views



92

Overview + Detail

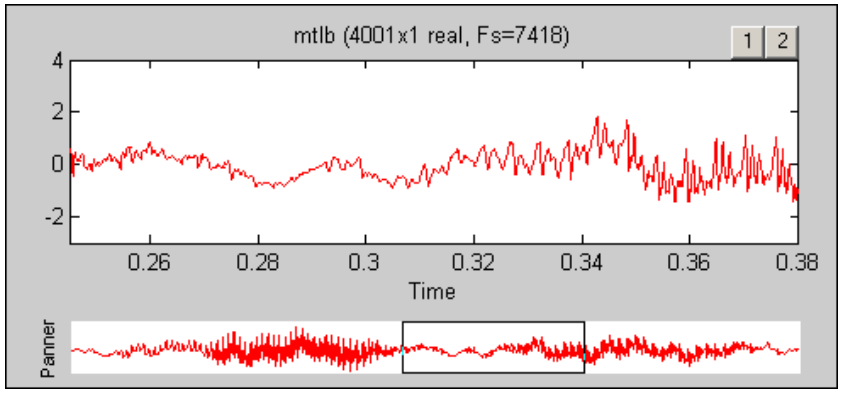
Panning a large graph



93

Overview + Detail

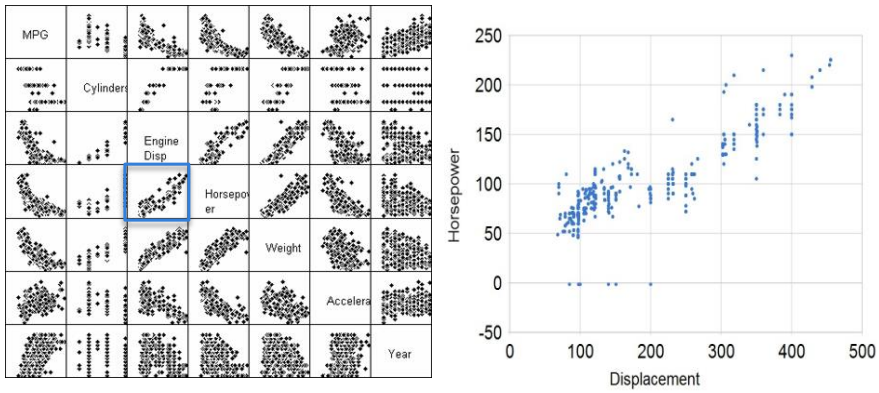
Panning a line chart



94

Overview + Detail

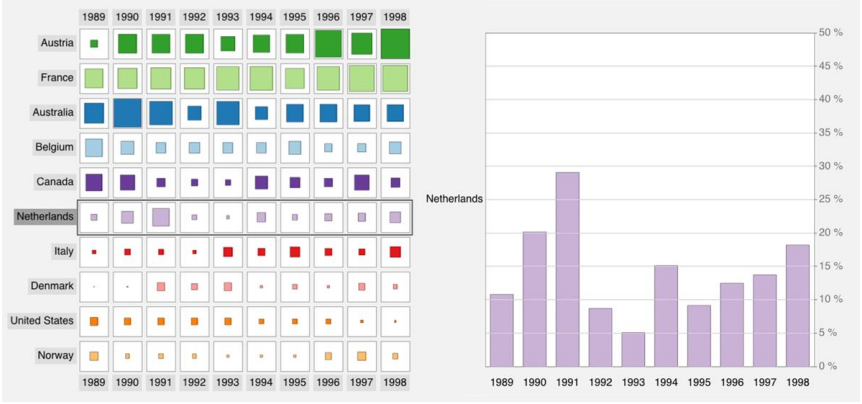
Browsing Multiple Views



95

Overview + Detail

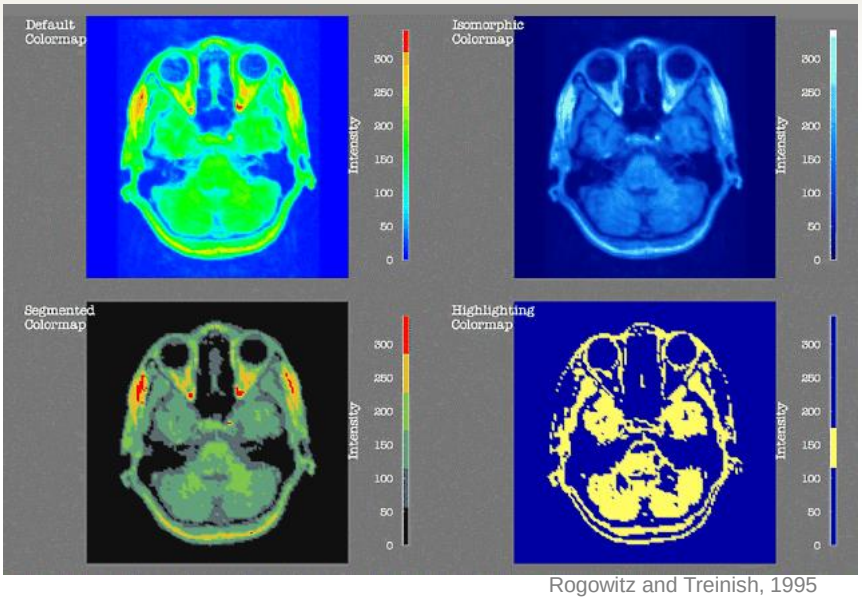
Browsing Multiple Views



Jansen et al, 2013

96

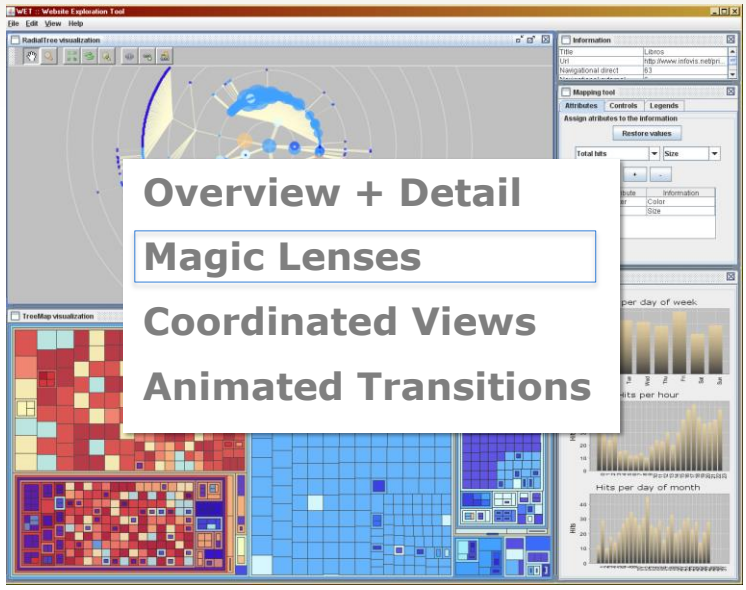
Problem



Rogowitz and Treinish, 1995

97

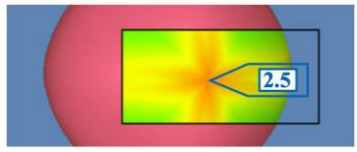
Multiple Views

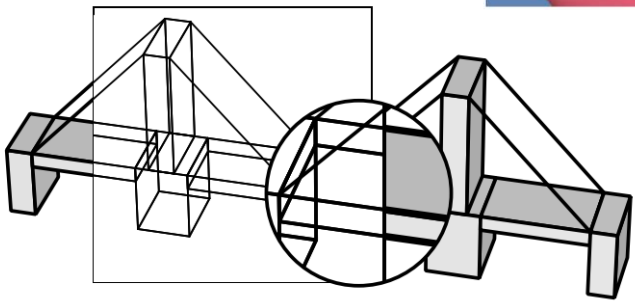


98

Magic Lenses

(Manfred's Talk)



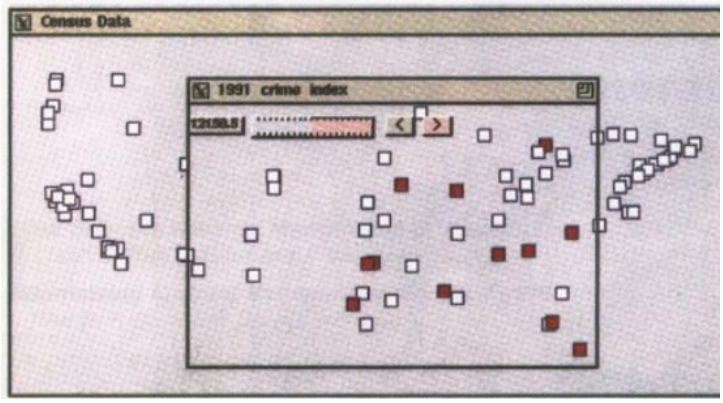


Bier et al, 1993

99

Magic Lenses

Movable filters for dynamic queries

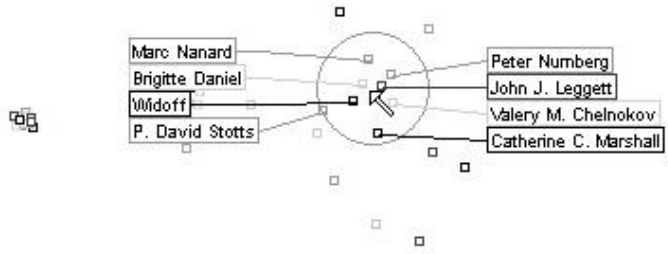


Fishkin and Stone, 1995

100

Magic Lenses

Exentric Labeling

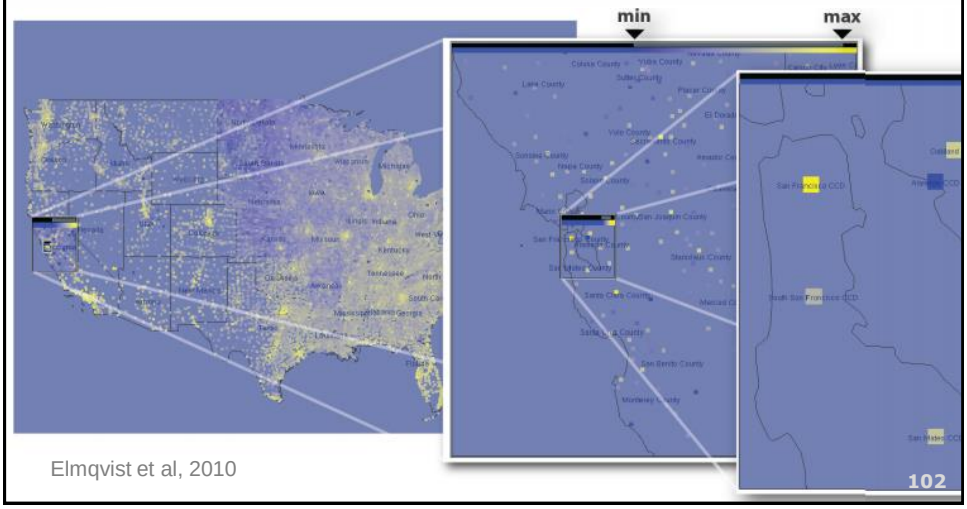


Fekete and Plaisant, 1999

101

Magic Lenses

Color lenses

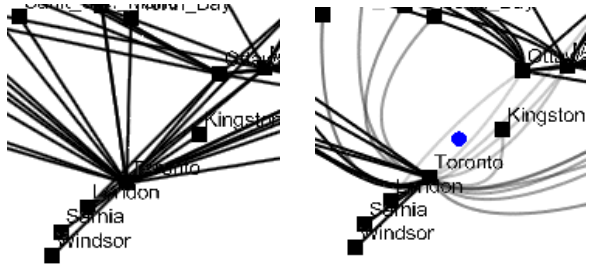


Elmqvist et al, 2010

102

Magic Lenses

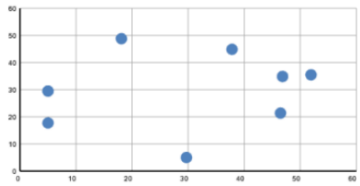
Edge lenses

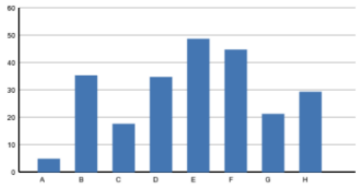


Wong, Carpendale and Greenberg,

103

Problem

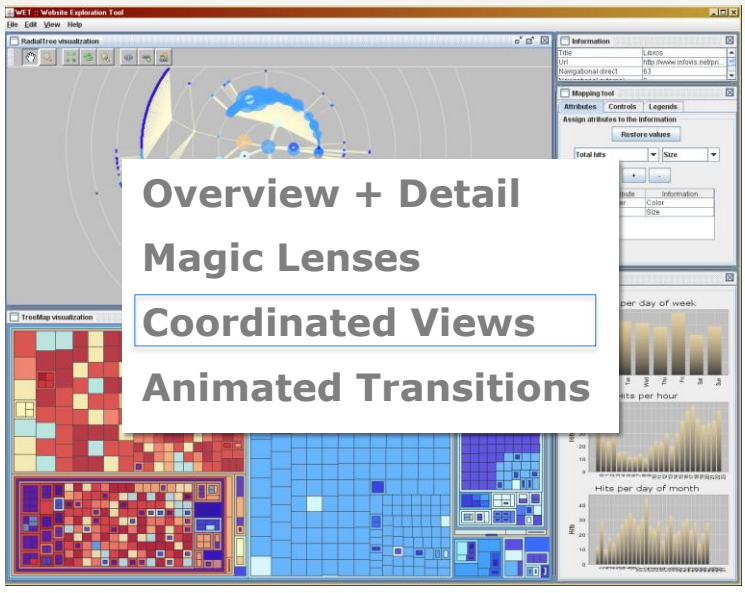




Heer and Roberston, 2007

104

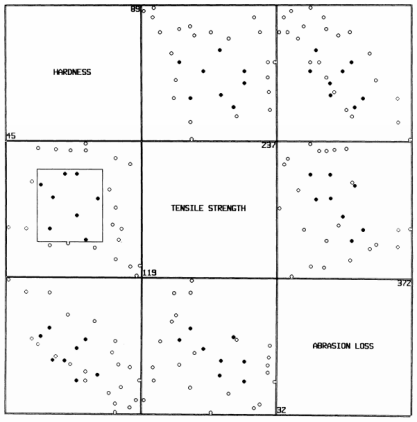
Multiple Views



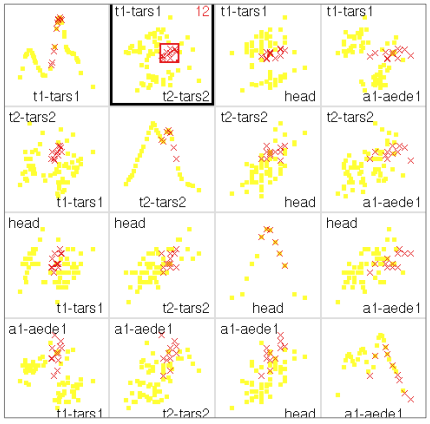
105

Coordinated Views

Brushing & Linking Scatterplots



Beker and Cleveland, 1987

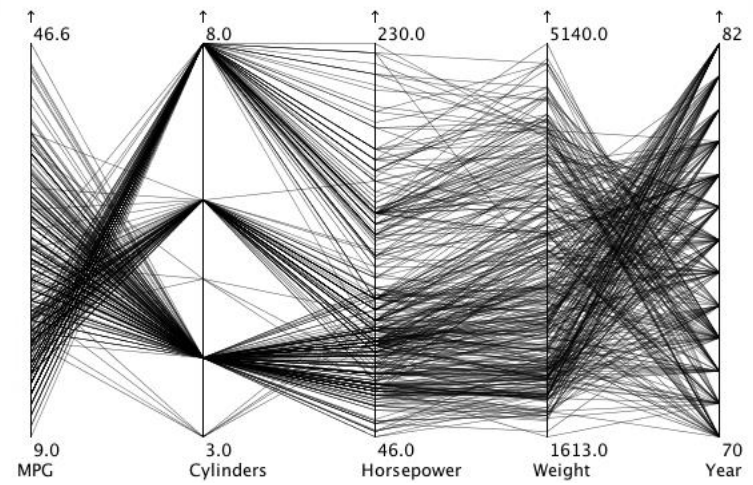


Voigt, 2002

106

Coordinated Views

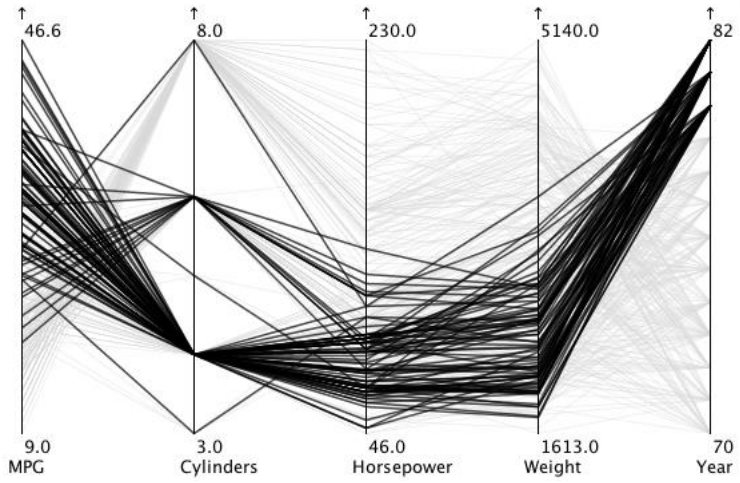
Brushing Parallel Coordinates



107

Coordinated Views

Brushing Parallel Coordinates



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Coordinated Views

Brushing & Linking Histograms

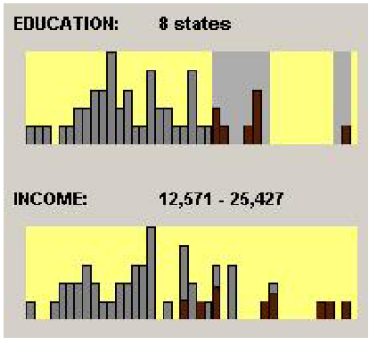


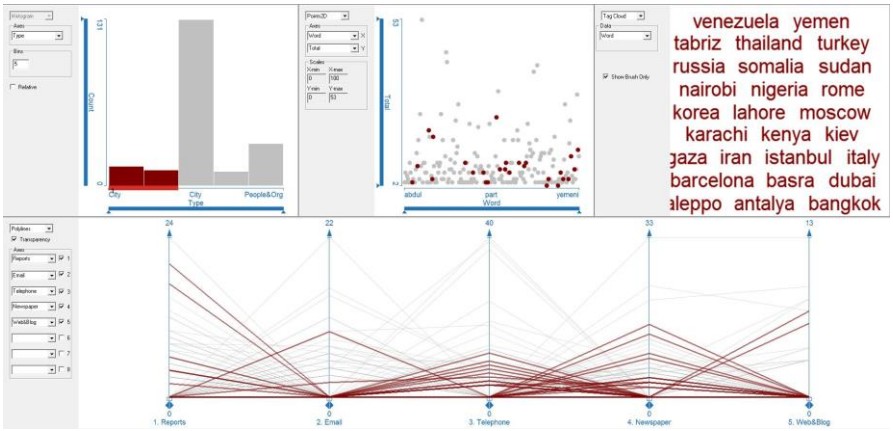
Figure 8: Brushing Histograms

Chris North, 2001

109

Coordinated Views

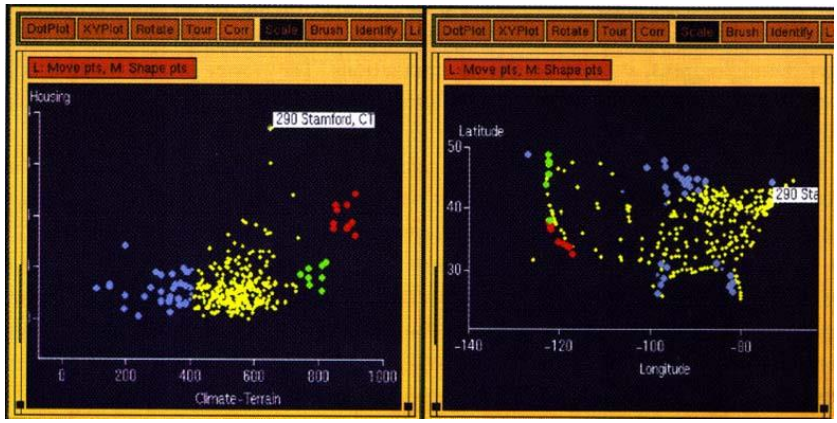
Brushing & Linking Everything



Turkay et al, 2010

Coordinated Views

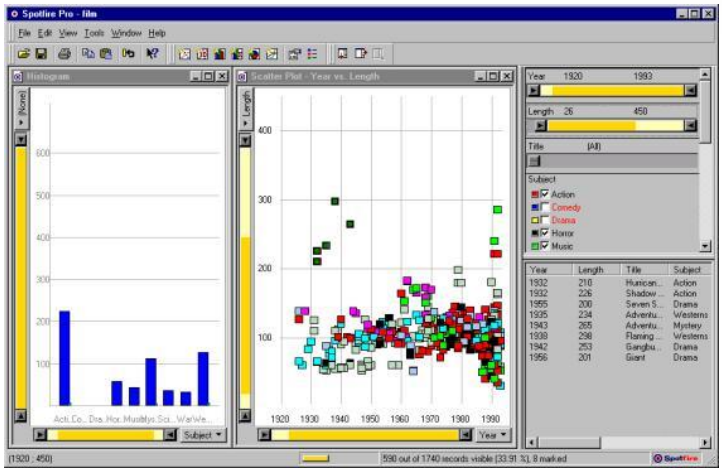
Colored Brushing & Linking



Chris North, 2001

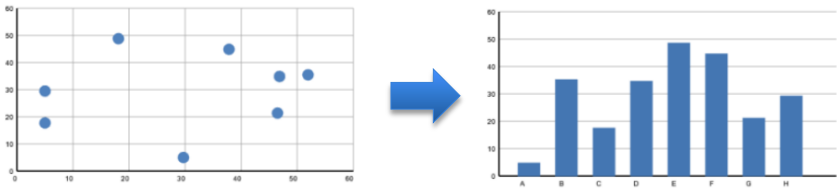
Coordinated Views

Linking with Dynamic Queries



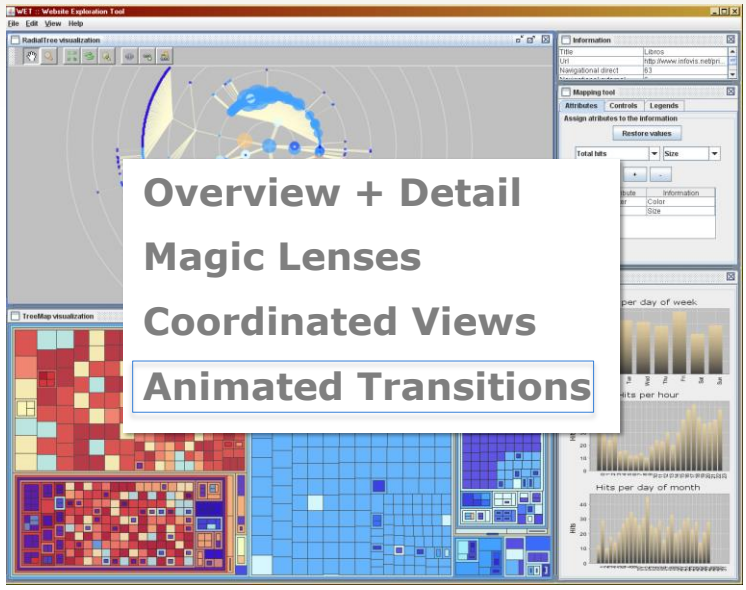
Spotfire Software

Problem



Heer and Roberston, 2007

Multiple Views



114

Animated Transitions

00:19

Heer and Roberston, 2007

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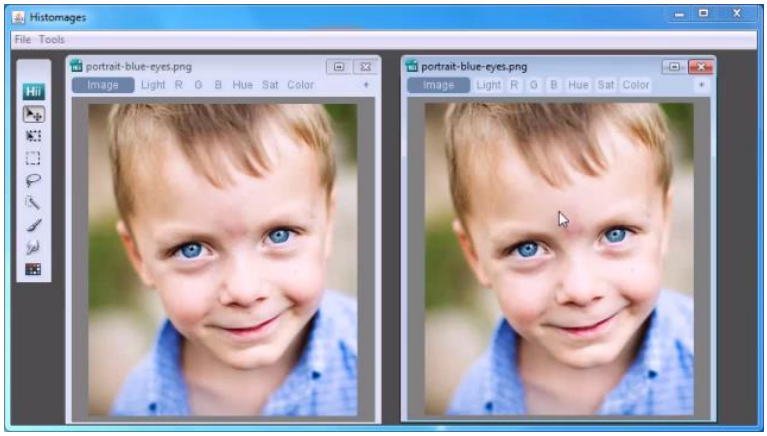
Animated Transitions

With coordinated selection and edition



Histomages (Chevalier et al, 2012)

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Families of infovis interaction techniques

- Filtering techniques
- Navigation techniques
- Multiple views
- Rearrangement

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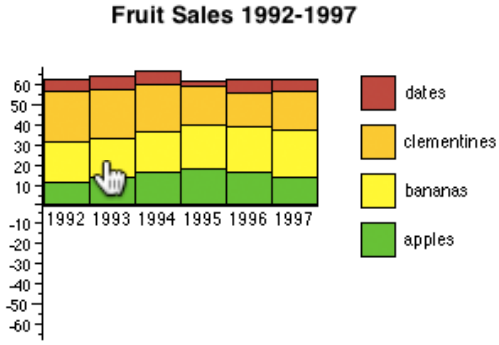
Rearrangement

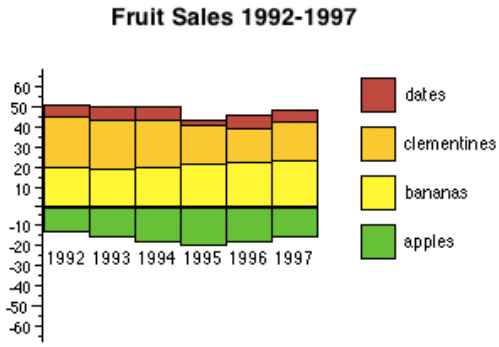
Interactive Stacked Histograms



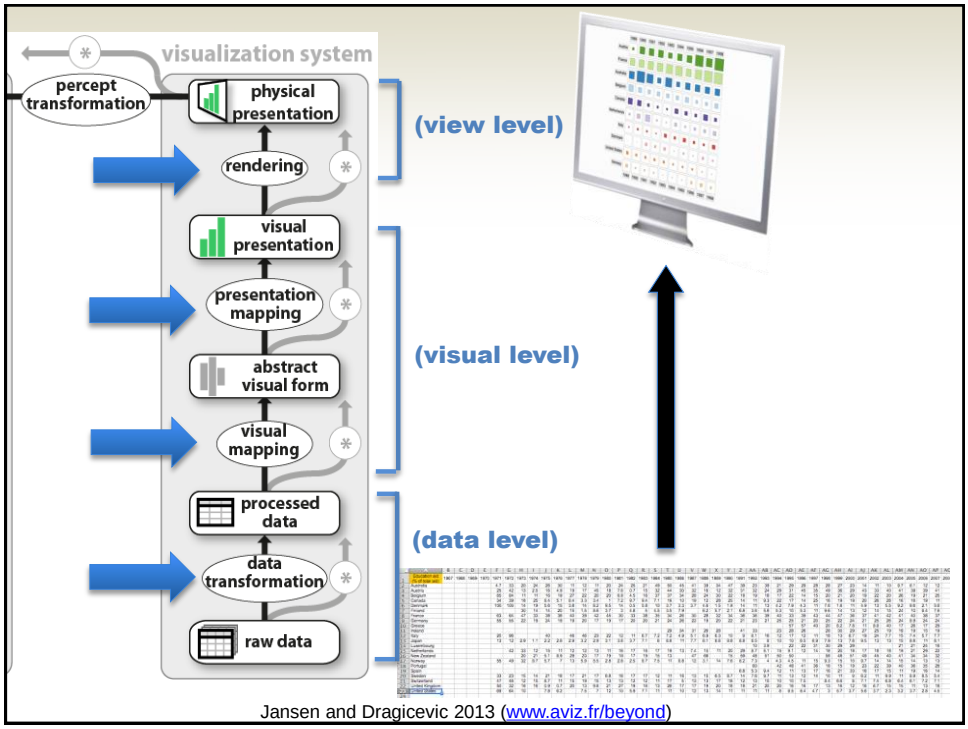
Dix and Ellis, 1998

Rearrangement

Interactive Stacked Histograms



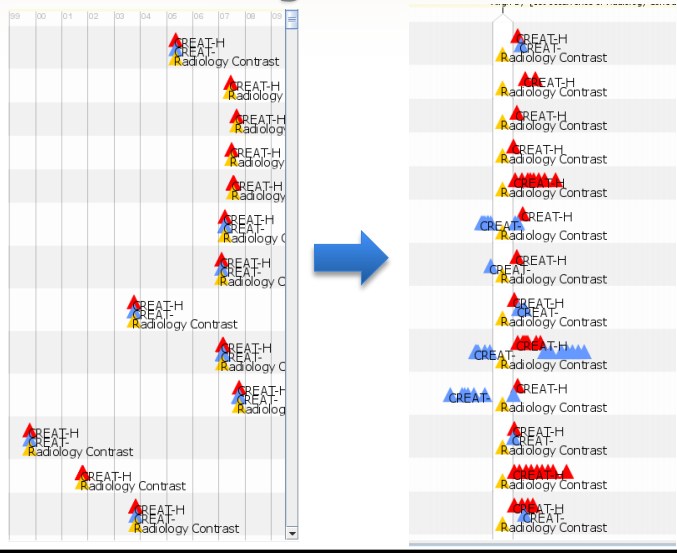
Dix and Ellis, 1998



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

Rearrangement

Time-Series Alignment



Lifelines 2 (Wang et al, 2008)

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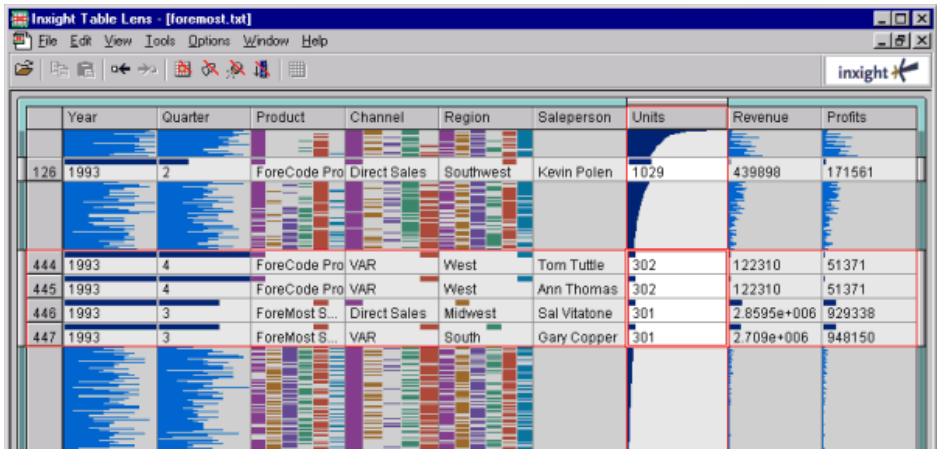
Rearrangement

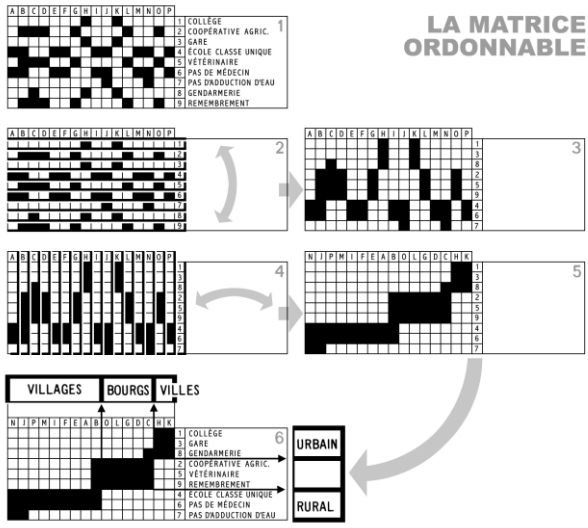
Sorting



Rao and Card, 1994

Rearrangement

Matrix Reordering



Bertin, 1977

Rearrangement

Star Coordinates

Candogan, 1992. Video from Lehman and Theisel, 2013.

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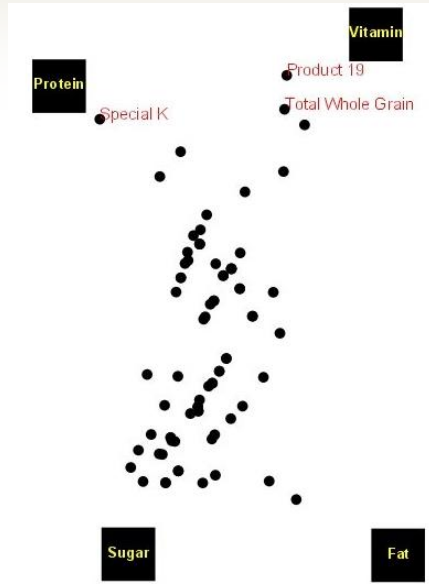
Rearrangement

Dust & Magnet



Yi and al, 2005

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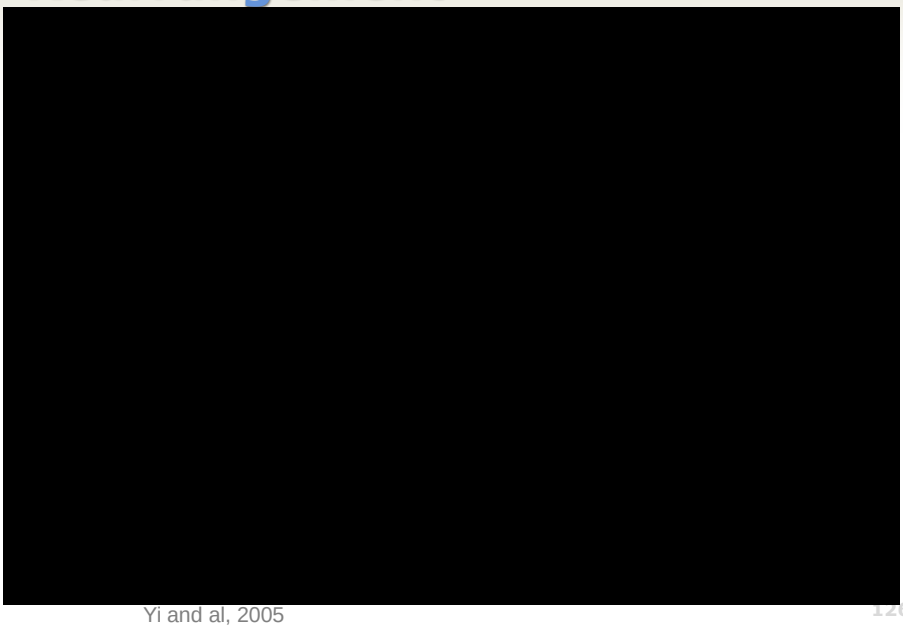
Rearrangement

01:46



Yi and 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

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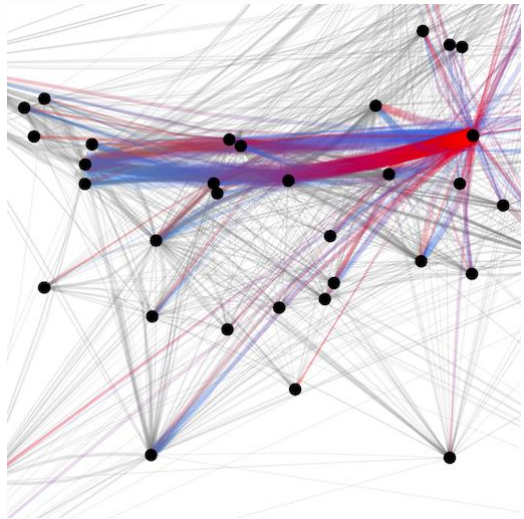
Pitfalls

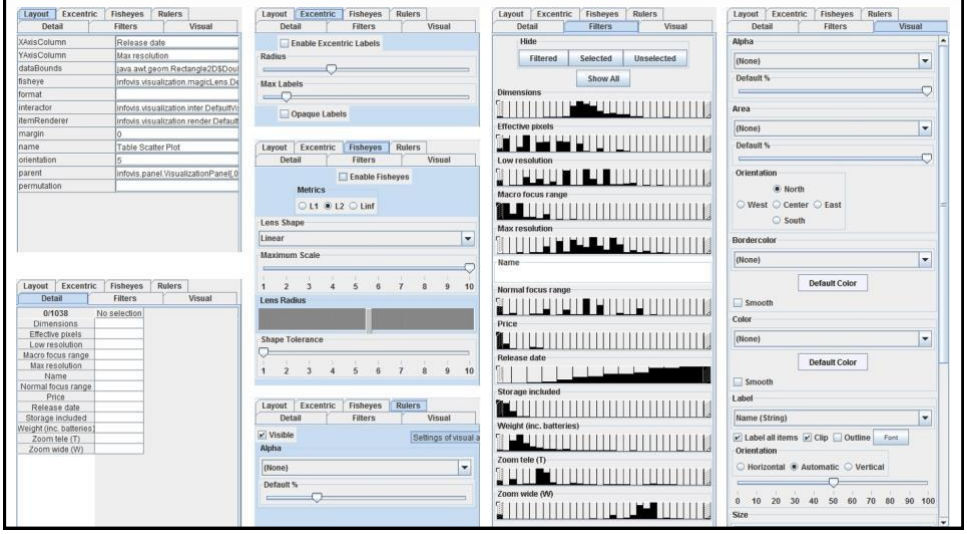
#1 - Interaction has a cost



129

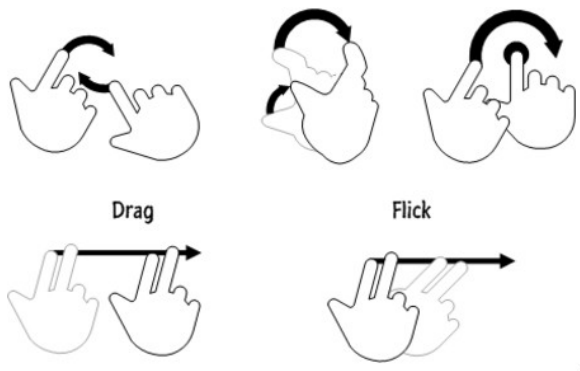
Pitfalls

#2 - Controls take screen real-estate



Pitfalls

#3 - Few other techniques are self-explanatory



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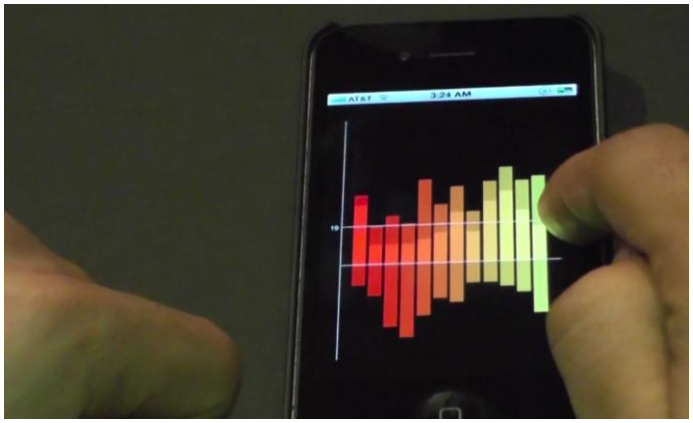
touch devices



132

Sadana and Stasko, 2013

tabletop devices

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Isenberg and Carpendale, 2008

wall-sized displays

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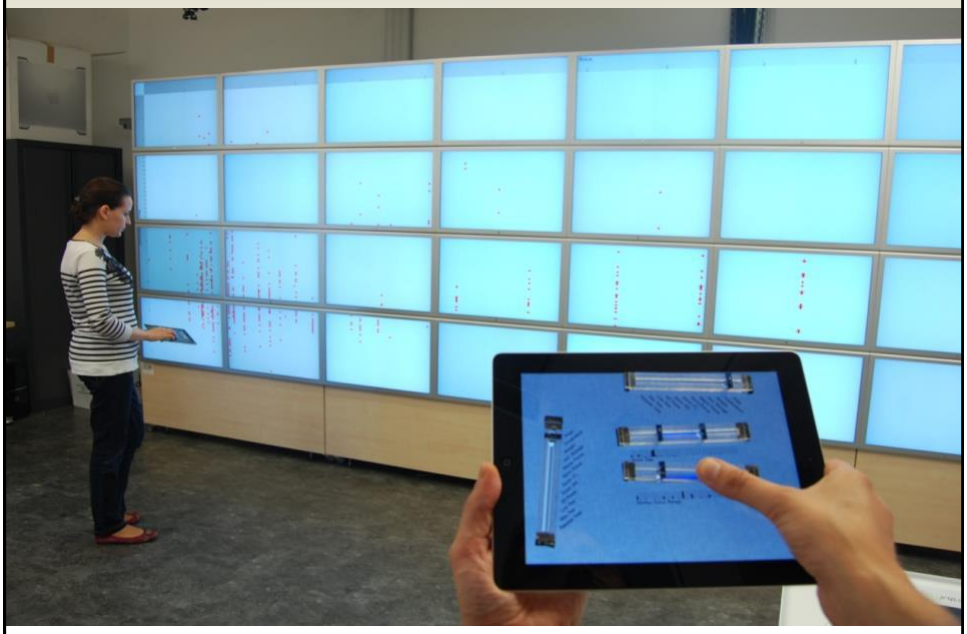

[Jansen et al., Tangible Remote Controller for Wall-sized Displays. CHI' 12]

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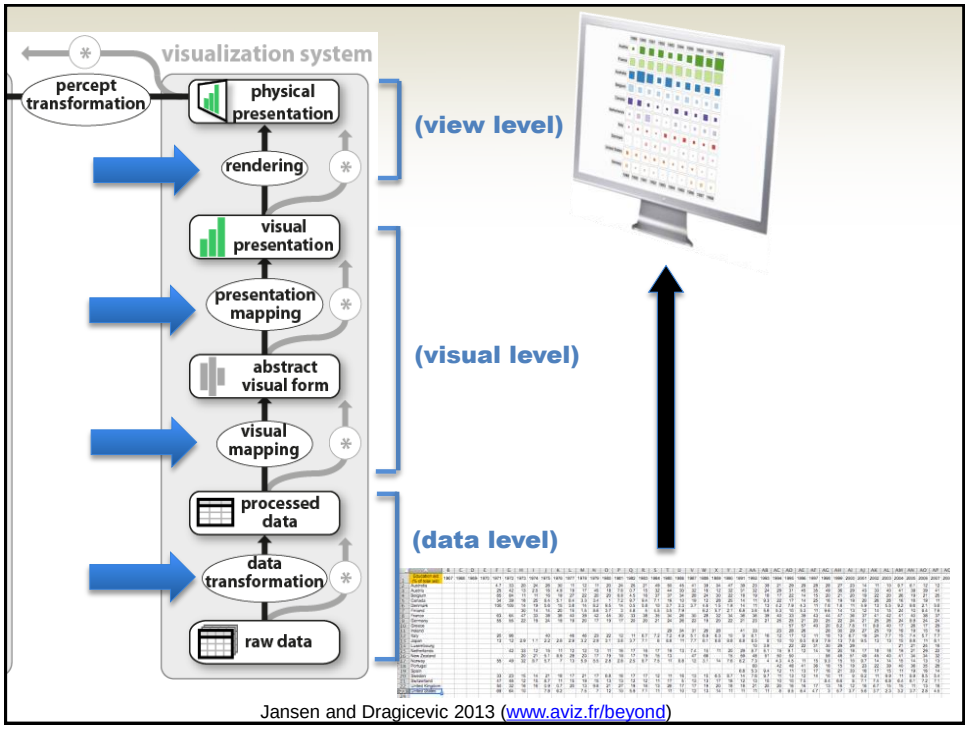
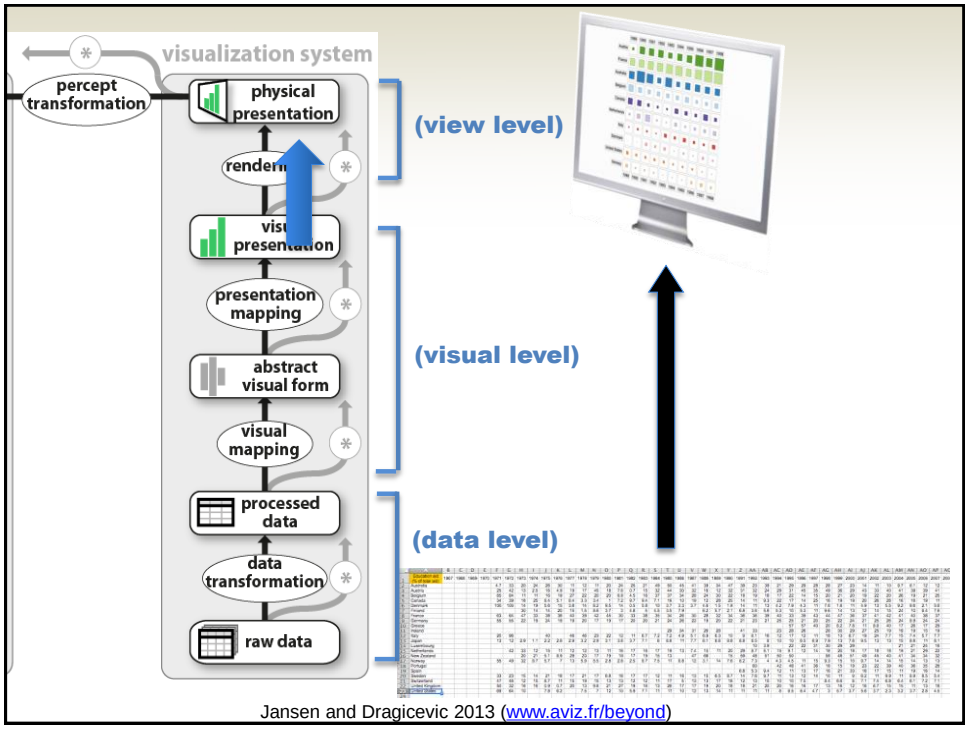
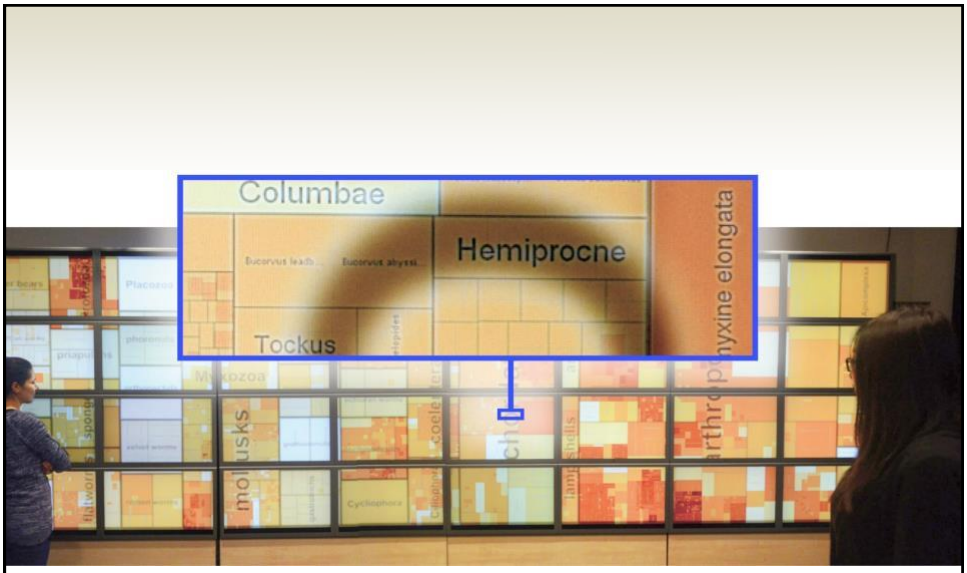


Jansen and Dragicevic 2013 (www.aviz.fr/beyond)



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



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

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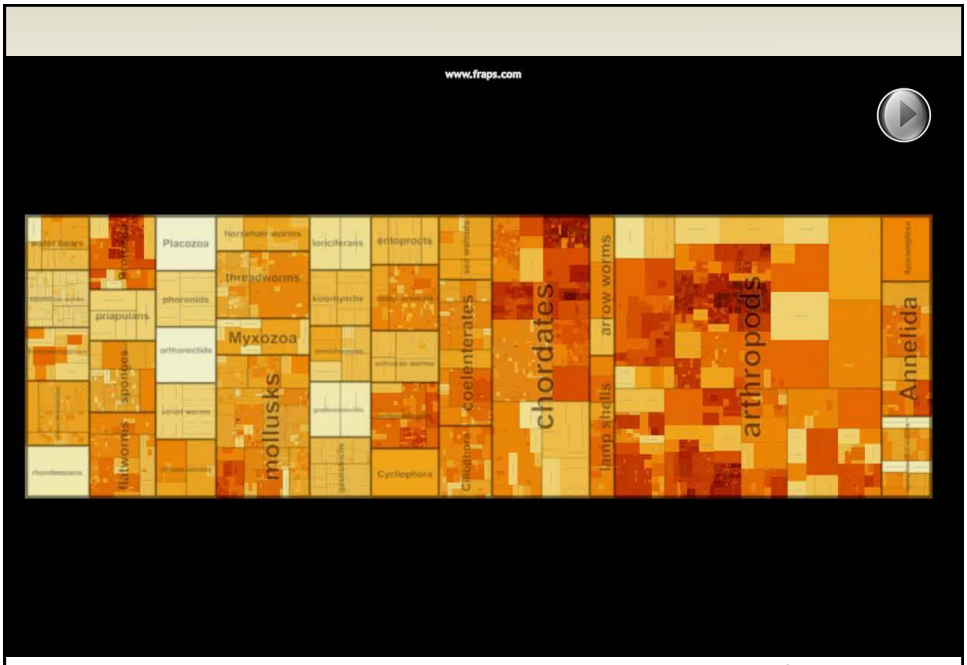
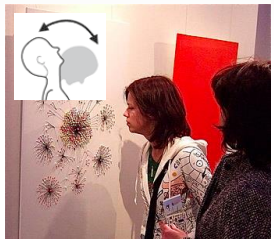


[Isenberg et al. , Hybrid Images for Large Viewing Environments, InfoVis' 13]

- Interaction with the physical world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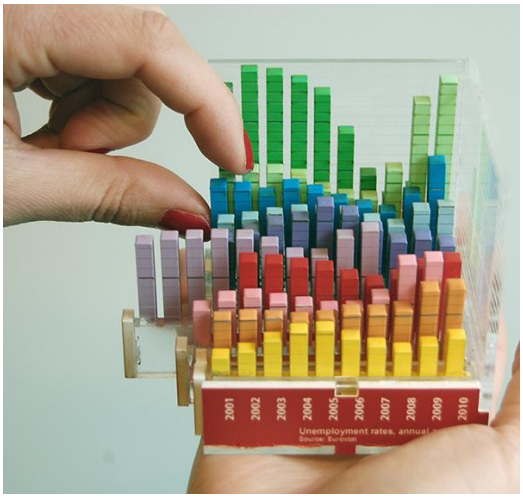
physical visualizations



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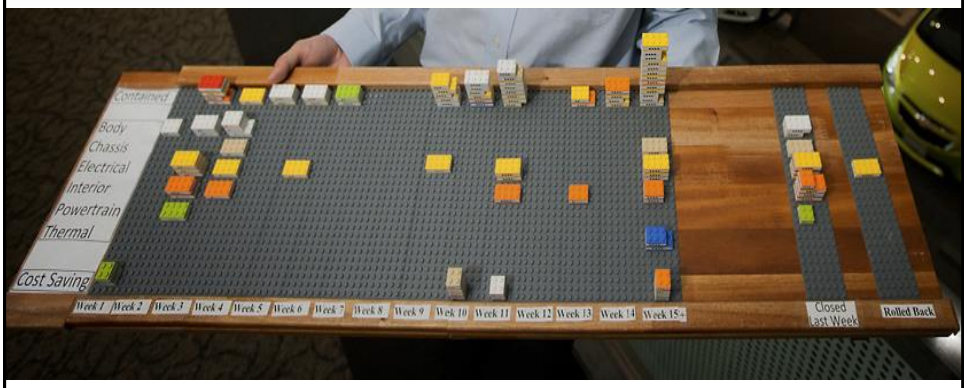
tinyurl.com/physvis



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

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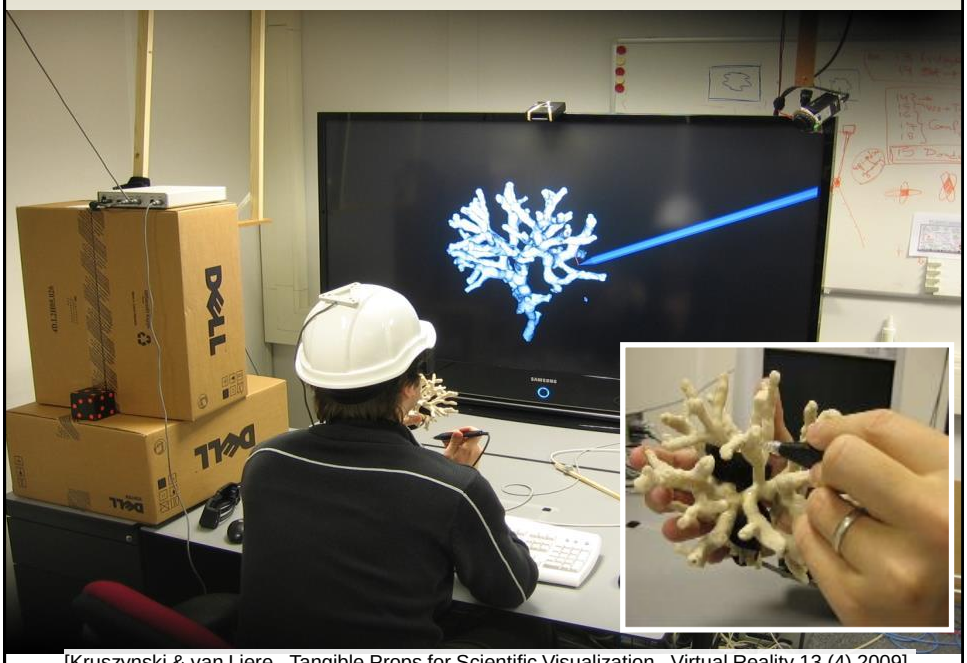
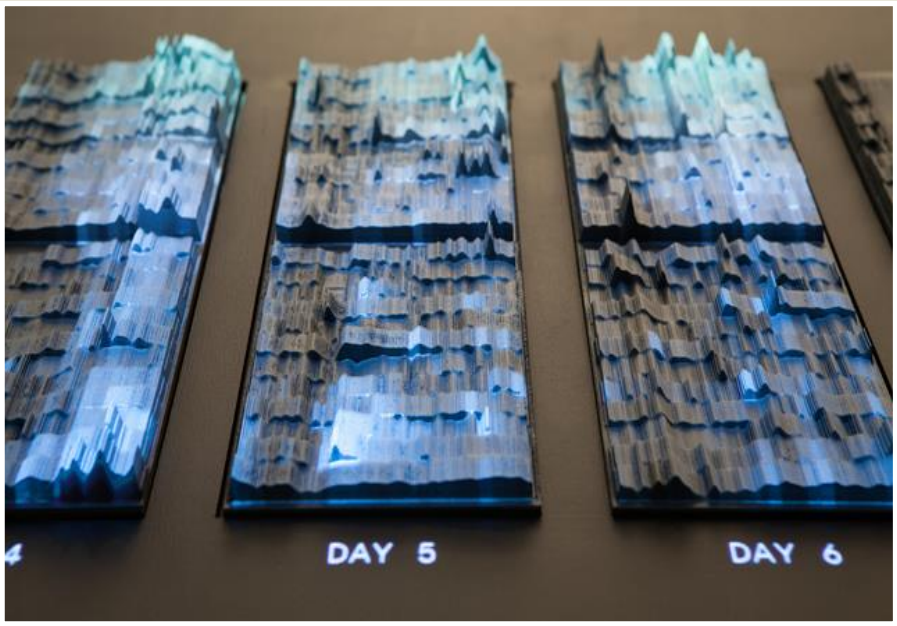


[Kruszynski & van Liere, Tangible Props for Scientific Visualization, Virtual Reality 13 (4) 2009]



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

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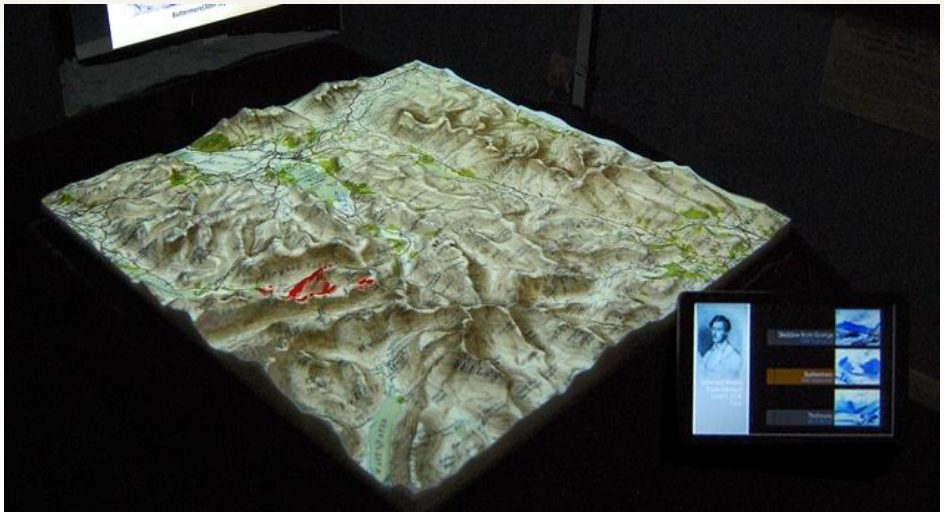

[PARM: Projected Augmented Relief Models, University of Nottingham, 2012]

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Relief (Leithinger et al, 2009)

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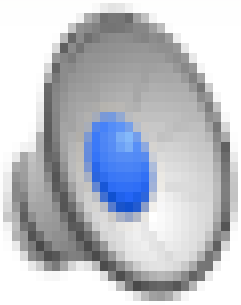

Relief (Leithinger et al, 2009)

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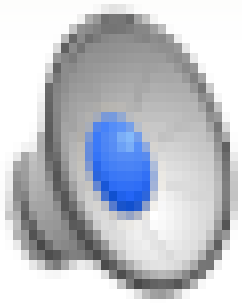

Inform (Leithinger et al, 2013)

1.47

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