Information Visualization

User tasks and infovis techniques

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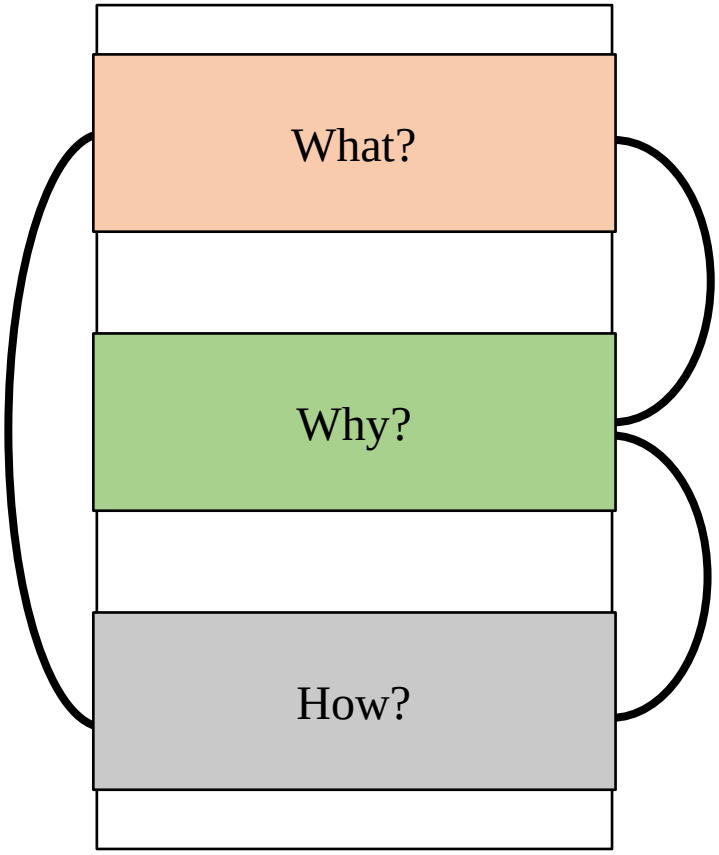
User tasks

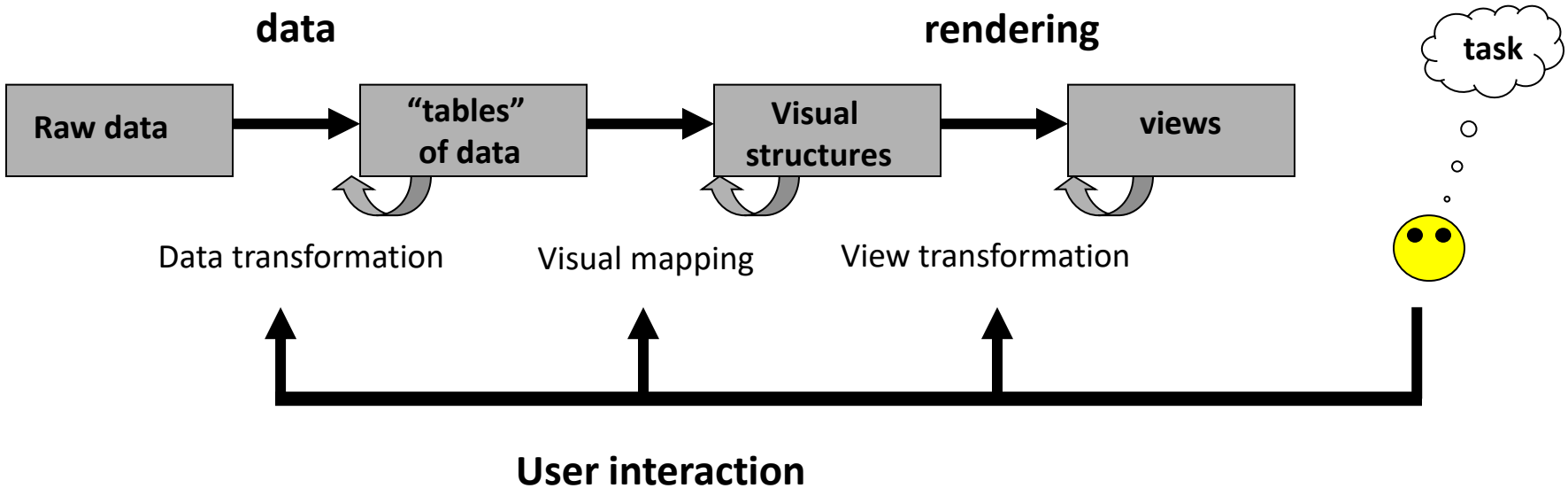
Approach “what-why-how”



- It is a way to analyze visualization techniques using three questions:
- What
  - Which data are represented
- Why
  - Why users are using the visualization technique
- How
  - Which are the visual codification and which are the interaction techniques implemented

Munzner, Tamara *Visualization Analysis and Design*. Boca Raton, FL:Taylor & Francis, 2014

Standard visualization model



Ward, M., Grinstein, G. and Keim, Daniel *Interactive Data Visualization*. Natick, MA: A.K. Peters Ltd. 2010

Foundations

- Data characterization
- **Interaction and user tasks**
- Perception

Interaction

- Changing the display
  - Selection
  - Navigation
  - Reorder/reorganize
  - Changing the visual coding
  - Remove/include elements using filtering, clustering, etc
- Latency
- Feedback
- Costs
  - Time and user attention

User tasks

Keller & Keller (1994)

- Identify
- Localize
- Distinguish
- Categorize
- *Cluster*
- Order
- Compare
- Associate
- Correlate

Keller, P. e Keller, M. *Visual Cues: Practical Data Visualization*. IEEE Computer Society Press, 1994

Shneiderman (1996)

- Overview
- “Zoom”
- Filtering
- Details on demand
- Relate
- History
- Export (data)

Shneiderman, Ben *The Eyes Have it: A Task by Data Type Taxonomy for Information Visualization*. 1996 IEEE Symposium on Visual Language, pp336-343

User tasks

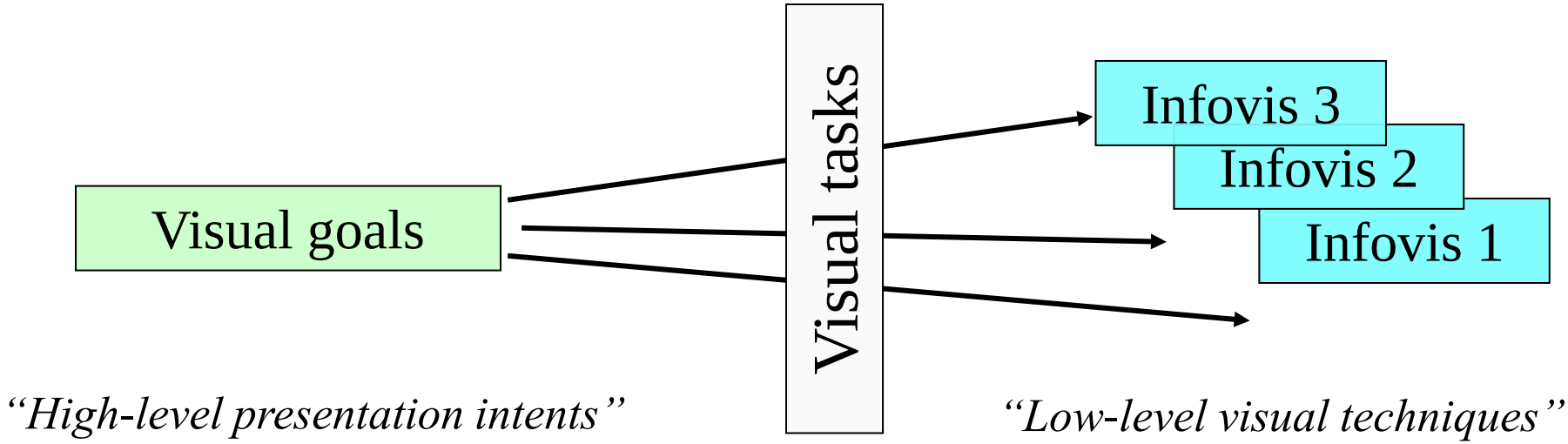
- Wehrend and Lewis, 1990
- Springmeyer, 1990
- Shneiderman, 1996
- Zhou and Feiner, 1998
- Morse et al., 2000
- Amar and Stasko, 2004
- **Amar et al., 2005**
- Valiati et al., 2006

Low level analytical tasks

- Find value
- Filter data
- Compute value
- Find limits
- Classify/order
- Determine threshold
- Characterize distribution
- Find anomalies
- Cluster
- Correlate

Visual strategies for user tasks

- Two levels of abstraction to explain the relationship between user tasks and interaction with infovis techniques



Zhou, Muchelle e Feiner, Steven. *Visual Task Characterization for Automated Discourse Synthesis.* In: Proc. CHI'98, Los Angeles, USA. pp 392-399, 1998

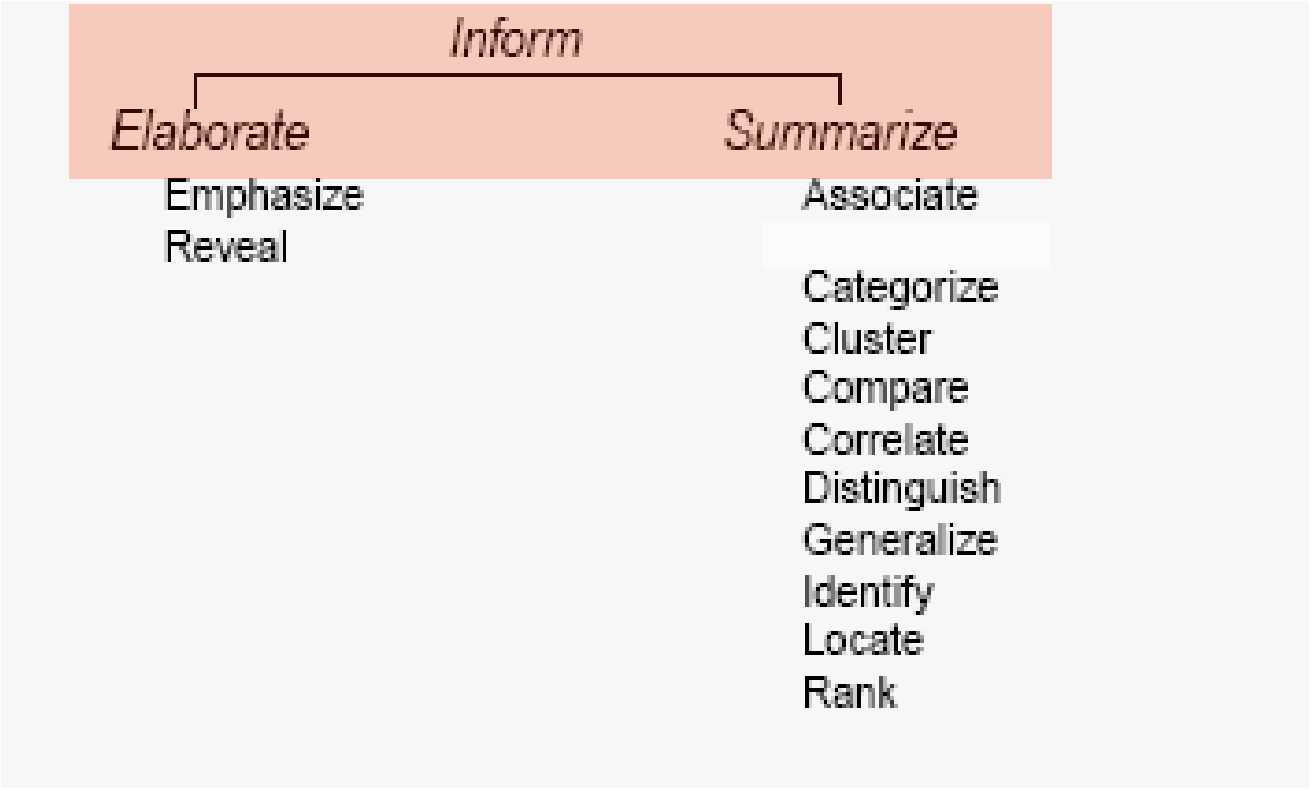
Visual tasks

- Are characterized by two dimensions

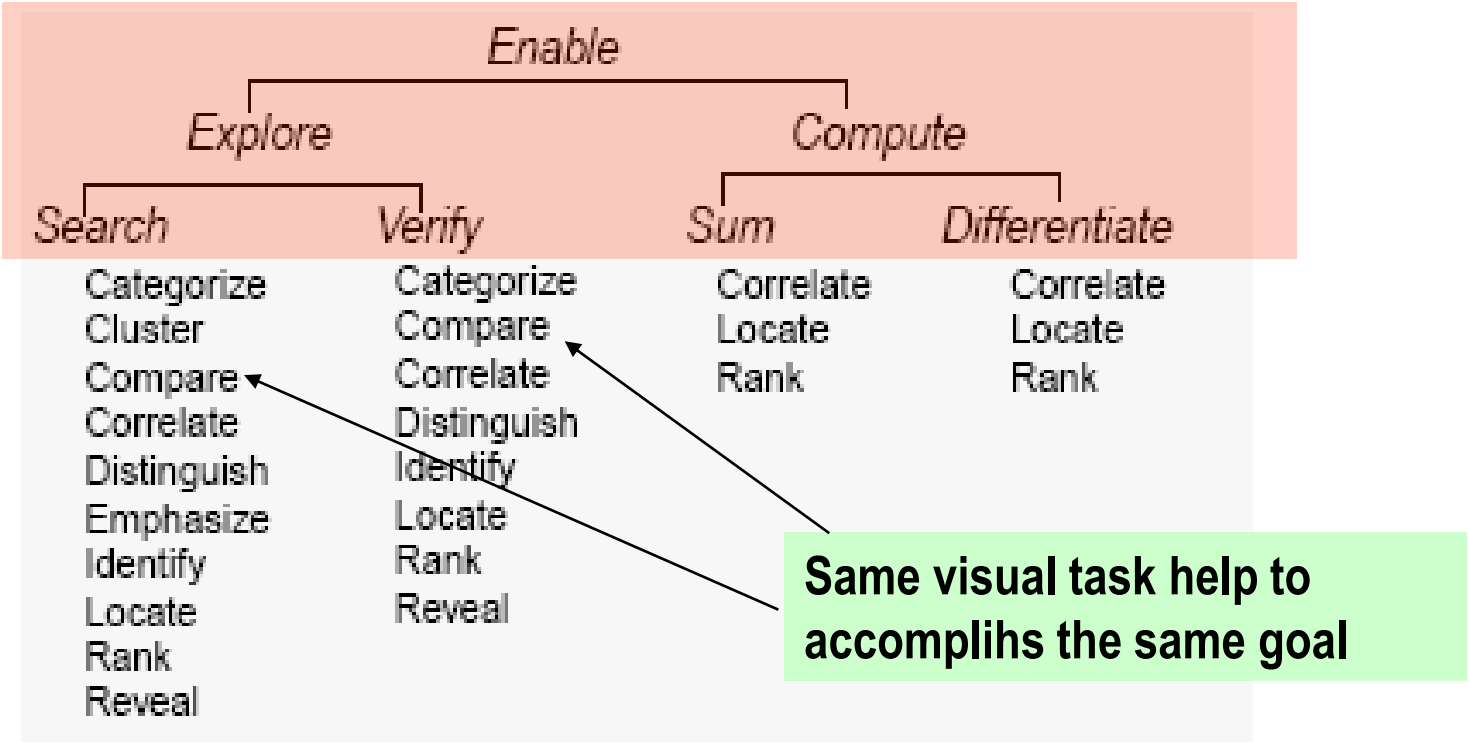
- Visual goals)
  - Goals that should be accomplished with the infovis technique

- Visual implications
  - The visual actions the infovis technique implements

Visual goals & visual tasks



Visual goal and visual tasks



Why people are using vis in terms of actions and targets

Actions

- **Analyze**
  - Consume
    - *Discover*
    - *Present*
    - *Enjoy*
  - Produce
    - *Annotate*
    - *Record*
    - *Derive*
- **Search**

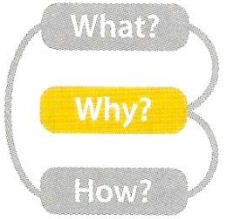
	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

- **Query**
  - Identify
  - Compare
  - Summarize

Targets

- **All Data**
  - Trends
  - Outliers
  - Features
- **Attributes**
  - One
    - *Distribution*
    - *Extremes*
  - Many
    - *Dependency*
    - *Correlation*
    - *Similarity*
- **Network Data**
  - Topology
  - *Paths*
- **Spatial Data**
  - Shape

Munzner, 2014

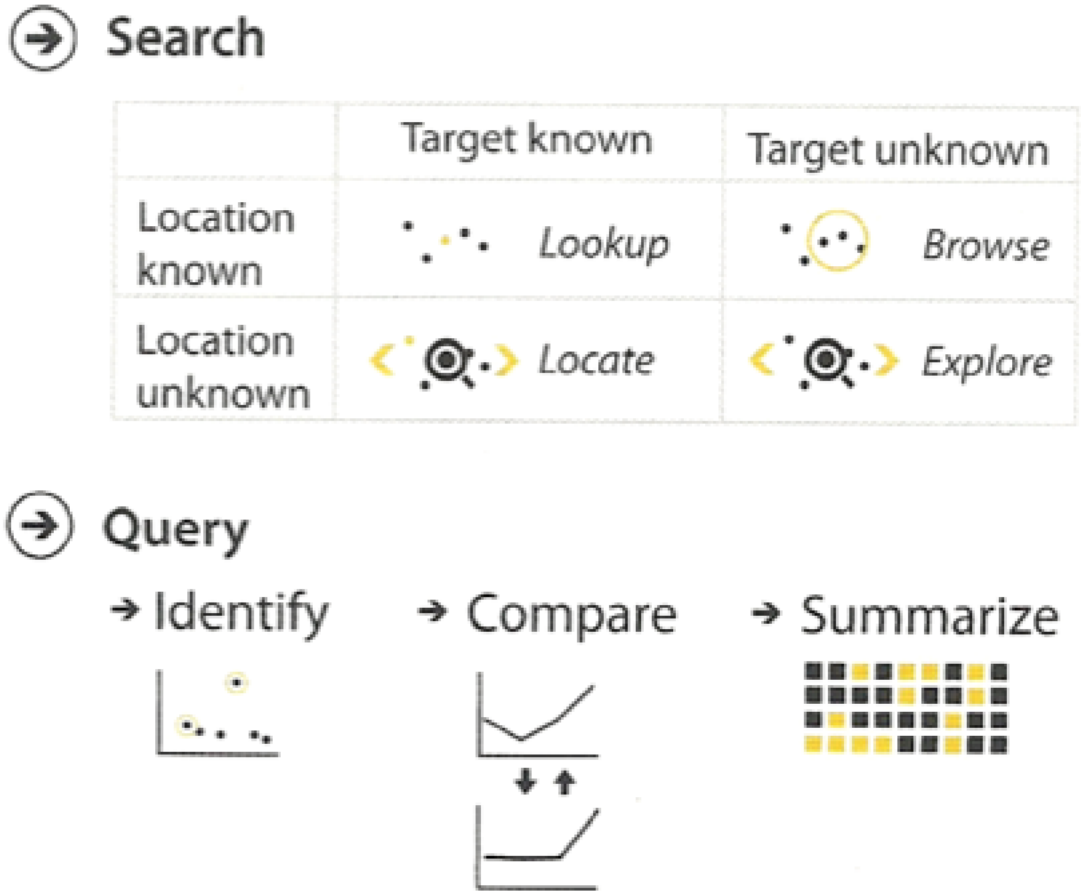


High-level actions: Analyze

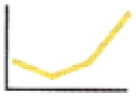
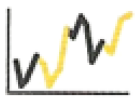
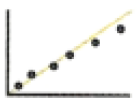
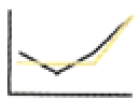
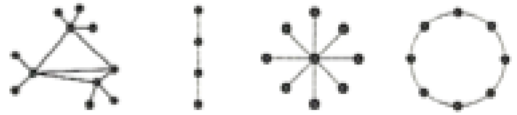
- Consume
  - Discover vs Present
    - classical split
    - explore vs explain
  - Enjoy
    - newcomer
    - casual, social
- Produce
  - Annotate, Record
  - Derive
    - crucial design choice

Actions: Mid-level search, low-level query

- what does user know?
  - target, location
- how much of the data matters?
  - one, some, all



Why: Targets

- **All Data**
  - Trends 
  - Outliers 
  - Features 
- **Attributes**
  - One
    - *Distribution* 
    - *Extremes* 
  - Many
    - *Dependency* 
    - *Correlation* 
    - *Similarity* 
- **Network Data**
  - Topology 
  - *Paths* 
- **Spatial Data**
  - Shape 

Interaction

- Distinguishes infovis from static paper visualizations.
- Analysis is a process, often iterative, with branches and sideways paths.

Acceptable Response Times

- .1 second
  - Animation, visual continuity, sliders
- 1 second
  - System response, pause in conversation
- 10 seconds
  - Cognitive response

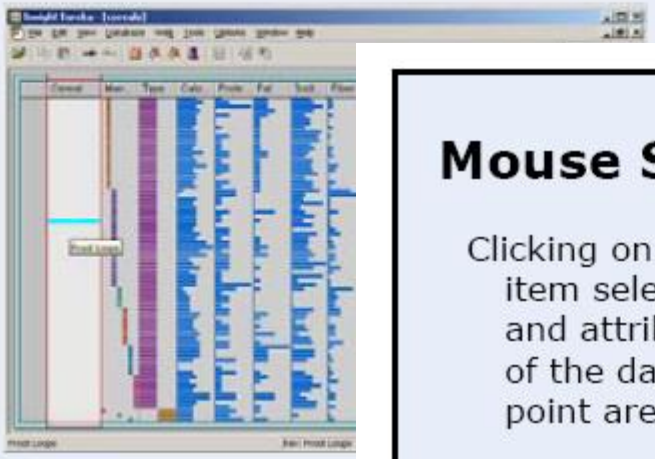
Basic Interaction Techniques

- Selecting
  - Mouse click
  - Mouseover / hover / tooltip
  - Lasso / drag
- Rearrange
  - Move
  - Sort
  - Delete

Selecting

Pop-up tooltips

Hovering mouse cursor brings up details of item



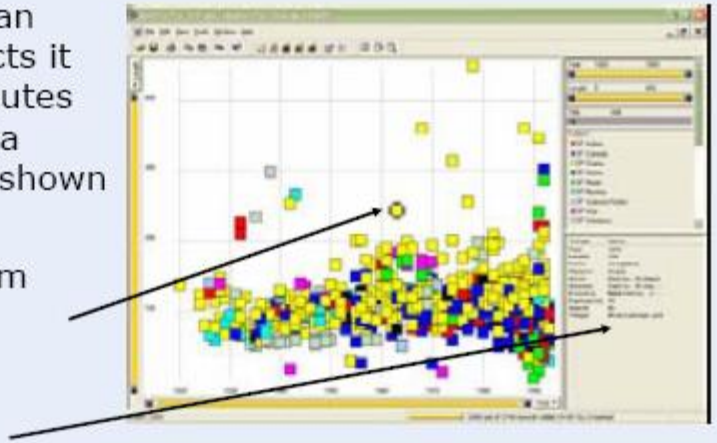
Slide adapted from John Stasko

Mouse Selection

Clicking on an item selects it and attributes of the data point are shown

Selected item

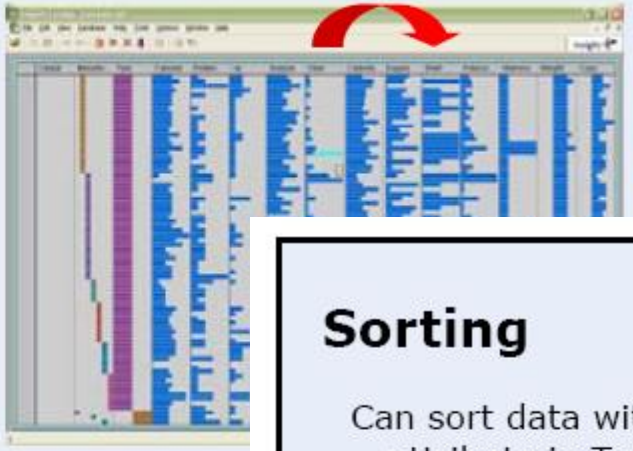
Attributes



Slide adapted from John Stasko

Rearrange

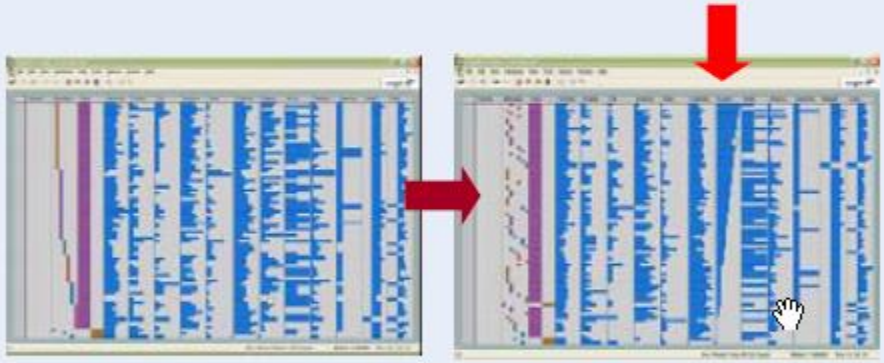
In TableLens you can move columns (attributes) left and right



Slide adapted from John Stasko

Sorting

Can sort data with respect to a particular attribute in Table Lens



Slide adapted from John Stasko

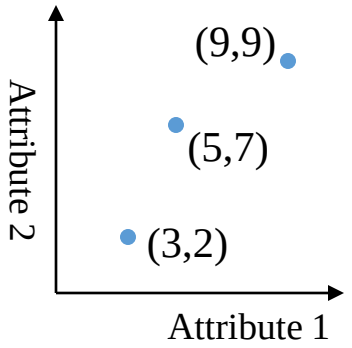
Strategies for interactive visualization

- How to exhibit large data sets?

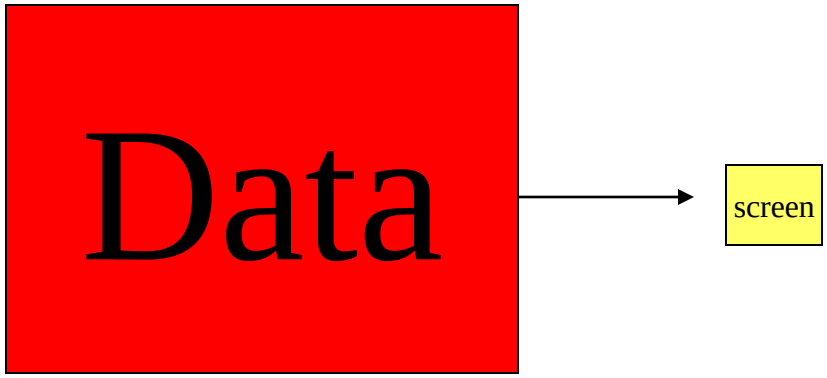
details zoom O+D F+C transformation

How to ensure overview: by scalability

- Small datasets are easy
  - “Just show everything”
- Large datasets…
  - What to exhibit?



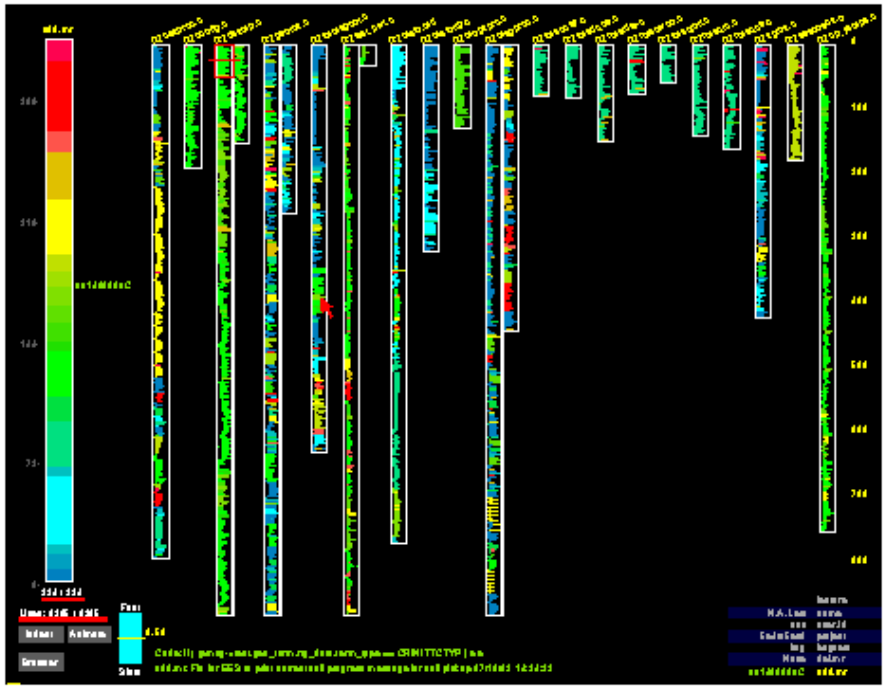
Strategies for scalability



- Compress information
  - Reduce size (geometric zoom)
- Reduce amount of information
  - Compress without losing data (semantic zoom)
  - Increase density

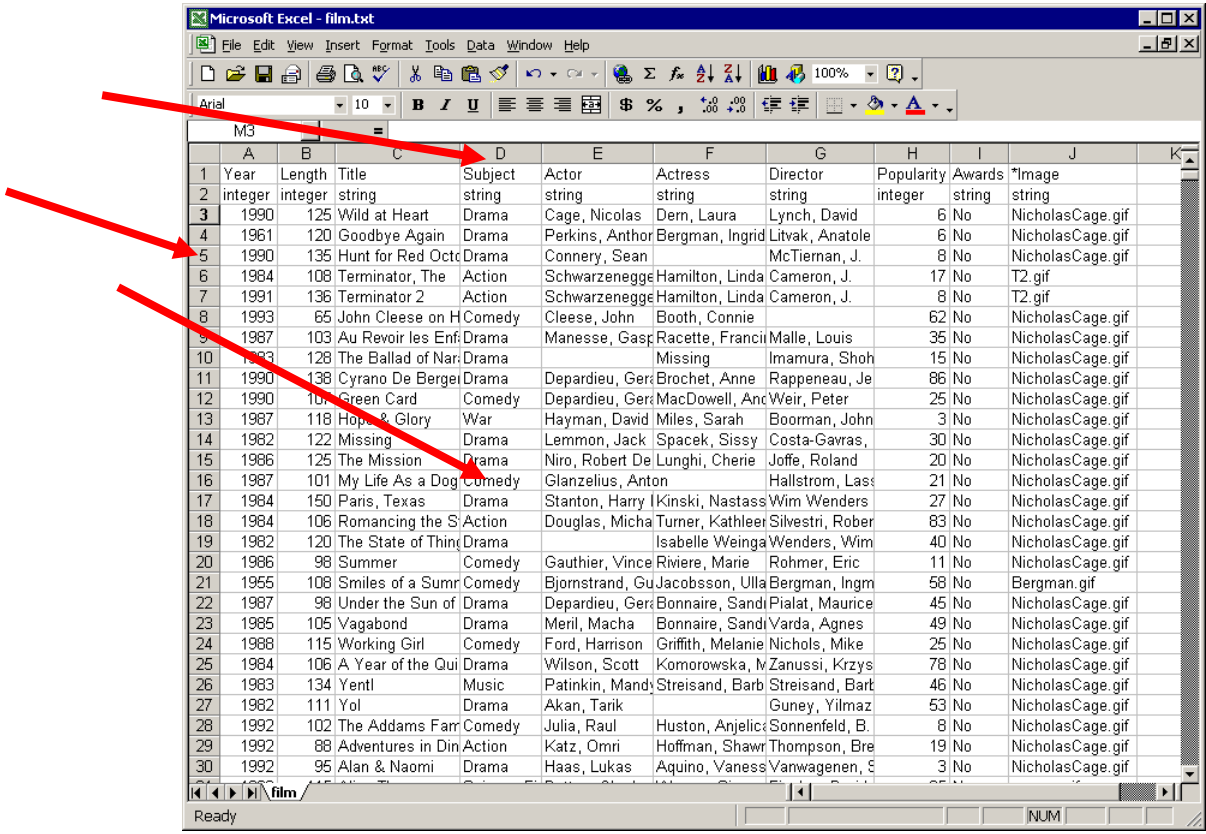
Example: SeeSoft

- 1 pixel line per line of code

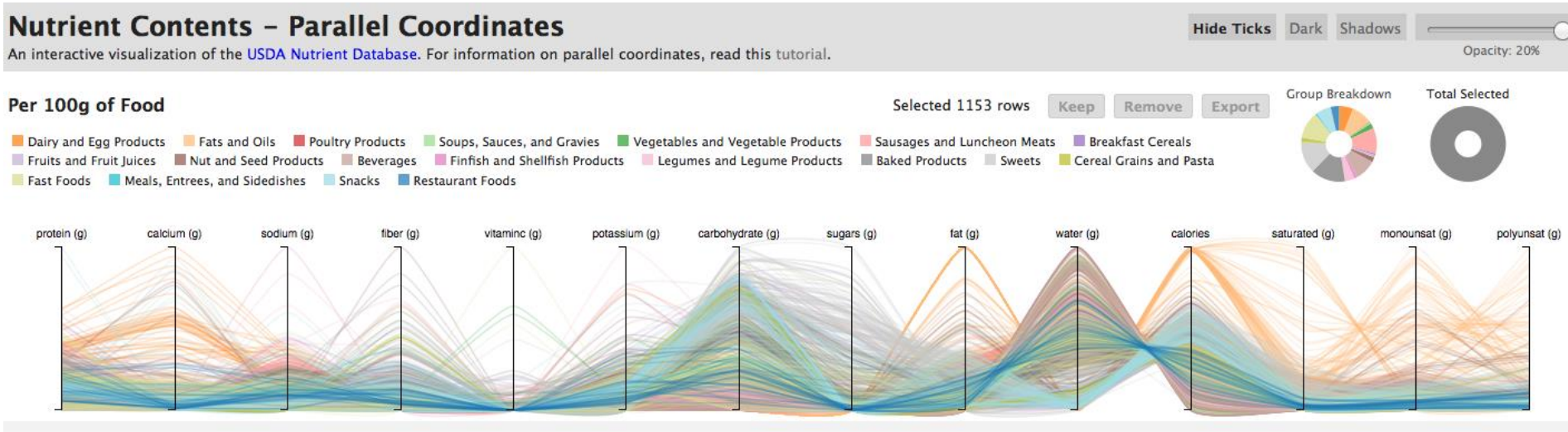


Reduce the amount of data

- Example
  - Reduce # attributes
  - Reduce # items
  - Reduce range of values
- Two ways
  - Remove
  - Grouping



	A	B	C	D	E	F	G	H	I	J
1	Year	Length	Title	Subject	Actor	Actress	Director	Popularity	Awards	*Image
2	integer	integer	string	string	string	string	string	integer	string	string
3	1990	125	Wild at Heart	Drama	Cage, Nicolas	Dern, Laura	Lynch, David	6	No	NicholasCage.gif
4	1961	120	Goodbye Again	Drama	Perkins, Anthor	Bergman, Ingrid	Litvak, Anatole	6	No	NicholasCage.gif
5	1990	135	Hunt for Red Octo	Drama	Connery, Sean		McTiernan, J.	8	No	NicholasCage.gif
6	1984	108	Terminator, The	Action	Schwarzenegge	Hamilton, Linda	Cameron, J.	17	No	T2.gif
7	1991	136	Terminator 2	Action	Schwarzenegge	Hamilton, Linda	Cameron, J.	8	No	T2.gif
8	1993	65	John Cleese on H	Comedy	Cleese, John	Booth, Connie		62	No	NicholasCage.gif
9	1987	103	Au Revoir les Enf	Drama	Manesse, Gasp	Racette, Francii	Malle, Louis	35	No	NicholasCage.gif
10	1983	128	The Ballad of Nar	Drama		Missing	Imamura, Shoh	15	No	NicholasCage.gif
11	1990	138	Cyrano De Berger	Drama	Depardieu, Ger	Brochet, Anne	Rappeneau, Je	86	No	NicholasCage.gif
12	1990	108	Green Card	Comedy	Depardieu, Ger	MacDowell, And	Weir, Peter	25	No	NicholasCage.gif
13	1987	118	Hope & Glory	War	Hayman, David	Miles, Sarah	Boorman, John	3	No	NicholasCage.gif
14	1982	122	Missing	Drama	Lemmon, Jack	Spacek, Sissy	Costa-Gavras,	30	No	NicholasCage.gif
15	1986	125	The Mission	Drama	Niro, Robert De	Lunghi, Cherie	Joffe, Roland	20	No	NicholasCage.gif
16	1987	101	My Life As a Dog	Comedy	Glanzelius, Anton		Hallstrom, Lass	21	No	NicholasCage.gif
17	1984	150	Paris, Texas	Drama	Stanton, Harry I	Kinski, Nastass	Wim Wenders	27	No	NicholasCage.gif
18	1984	106	Romancing the S	Action	Douglas, Micha	Turner, Kathleer	Silvestri, Rober	83	No	NicholasCage.gif
19	1982	120	The State of Thin	Drama		Isabelle Weinga	Wenders, Wim	40	No	NicholasCage.gif
20	1986	98	Summer	Comedy	Gauthier, Vince	Riviere, Marie	Rohmer, Eric	11	No	NicholasCage.gif
21	1955	108	Smiles of a Sumr	Comedy	Bjornstrand, Gu	Jacobsson, Ulla	Bergman, Ingm	58	No	Bergman.gif
22	1987	98	Under the Sun of	Drama	Depardieu, Ger	Bonnaire, Sandi	Pialat, Maurice	45	No	NicholasCage.gif
23	1985	105	Vagabond	Drama	Meril, Macha	Bonnaire, Sandi	Varda, Agnes	49	No	NicholasCage.gif
24	1988	115	Working Girl	Comedy	Ford, Harrison	Griffith, Melanie	Nichols, Mike	25	No	NicholasCage.gif
25	1984	106	A Year of the Qui	Drama	Wilson, Scott	Komorowska, M	Zanussi, Krzys	78	No	NicholasCage.gif
26	1983	134	Yentl	Music	Patinkin, Mandy	Streisand, Barb	Streisand, Barb	46	No	NicholasCage.gif
27	1982	111	Yol	Drama	Akan, Tarik		Guney, Yilmaz	53	No	NicholasCage.gif
28	1992	102	The Addams Fam	Comedy	Julia, Raul	Huston, Anjelica	Sonnenfeld, B.	8	No	NicholasCage.gif
29	1992	88	Adventures in Din	Action	Katz, Omri	Hoffman, Shawr	Thompson, Bre	19	No	NicholasCage.gif
30	1992	95	Alan & Naomi	Drama	Haas, Lukas	Aquino, Vaness	Vanwagenen, S	3	No	NicholasCage.gif

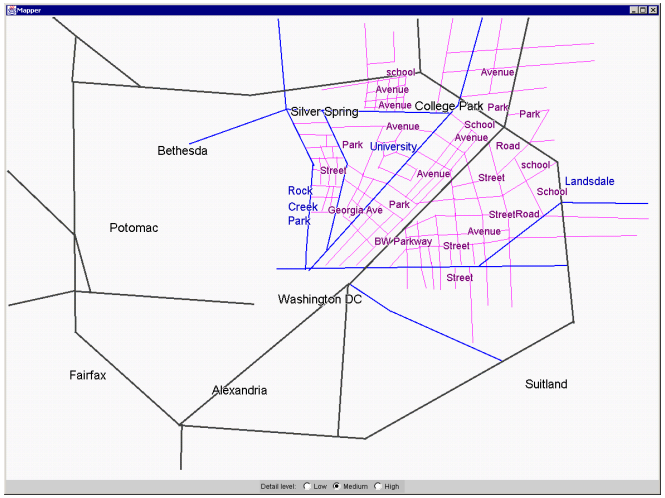


name	group	protein (g)	calcium ...	sodium ...	fiber (g)	vitaminc...	potassiu...	carbohy...	sugars (g)	fat (g)	water (g)	calories	satu
utter oil, anhydrous	Dairy and Egg Products	0.28	0.004	0.002		0	0.005			99.48	0.24	876	61.92
utter, salted	Dairy and Egg Products	0.85	0.024	0.714		0	0.024	0.06	0.06	81.11	15.87	717	51.36
heese fondue	Dairy and Egg Products	14.23	0.476	0.132		0	0.105	3.77		13.47	61.61	229	8.721
heese food, cold pack, american	Dairy and Egg Products	19.66	0.497	0.966		0	0.363	8.32		24.46	43.12	331	15.35
heese food, pasteurized process, swiss	Dairy and Egg Products	21.92	0.723	1.552		0	0.284	4.5		24.14	43.67	323	15.48
heese spread, cream cheese base	Dairy and Egg Products	7.1	0.071	0.673		0	0.112	3.5	3.5	28.6	58.5	295	18.02

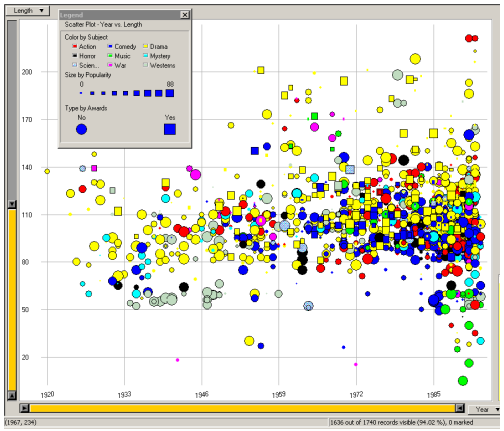
http://exposedata.com/parallel/

Remove= cut/ prunning

- Remove items



- Remove attributes
  - Scatterplots:
    - Select 2 or 3 attributes, ignore the others
  - Spotfire:
    - Use the query to select attributes
    - And show details on demand

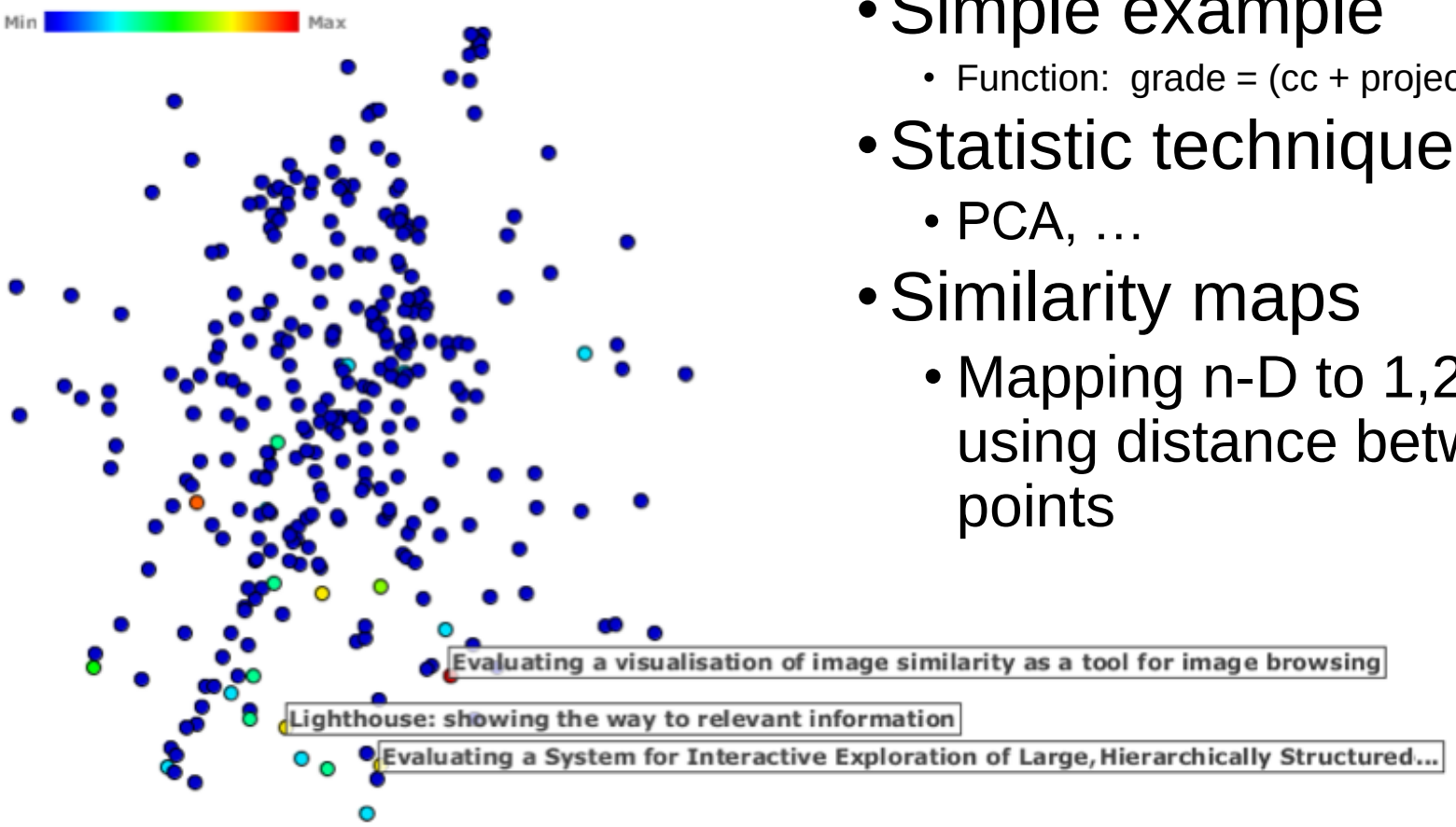


- Problem: loosing information

Grouping= clustering

- Clustering (grouping many items in a one entity)
  - What to group?
    - By category (SQL “group by”)
    - Spatial (TableLens)
    - By algorithm (clustering)
    - Defined by the user (“folders”)
  - What are the values associated to a group?
    - Mathematic functions (SQL “group by”)
      - Counting, average, min, max
    - Semantic abstraction
  - Grouping many levels = trees
  - Navigation:
    - Parallel visualizations
    - Semantic zooming

Clustering



- Grouping attributes
  - Simple example
    - Function: grade = (cc + project) / 2
  - Statistic techniques
    - PCA, …
  - Similarity maps
    - Mapping n-D to 1,2,3-D using distance between points

InfoVis articles (1995-2008). By Eler (2011)

Advanced Interaction Techniques

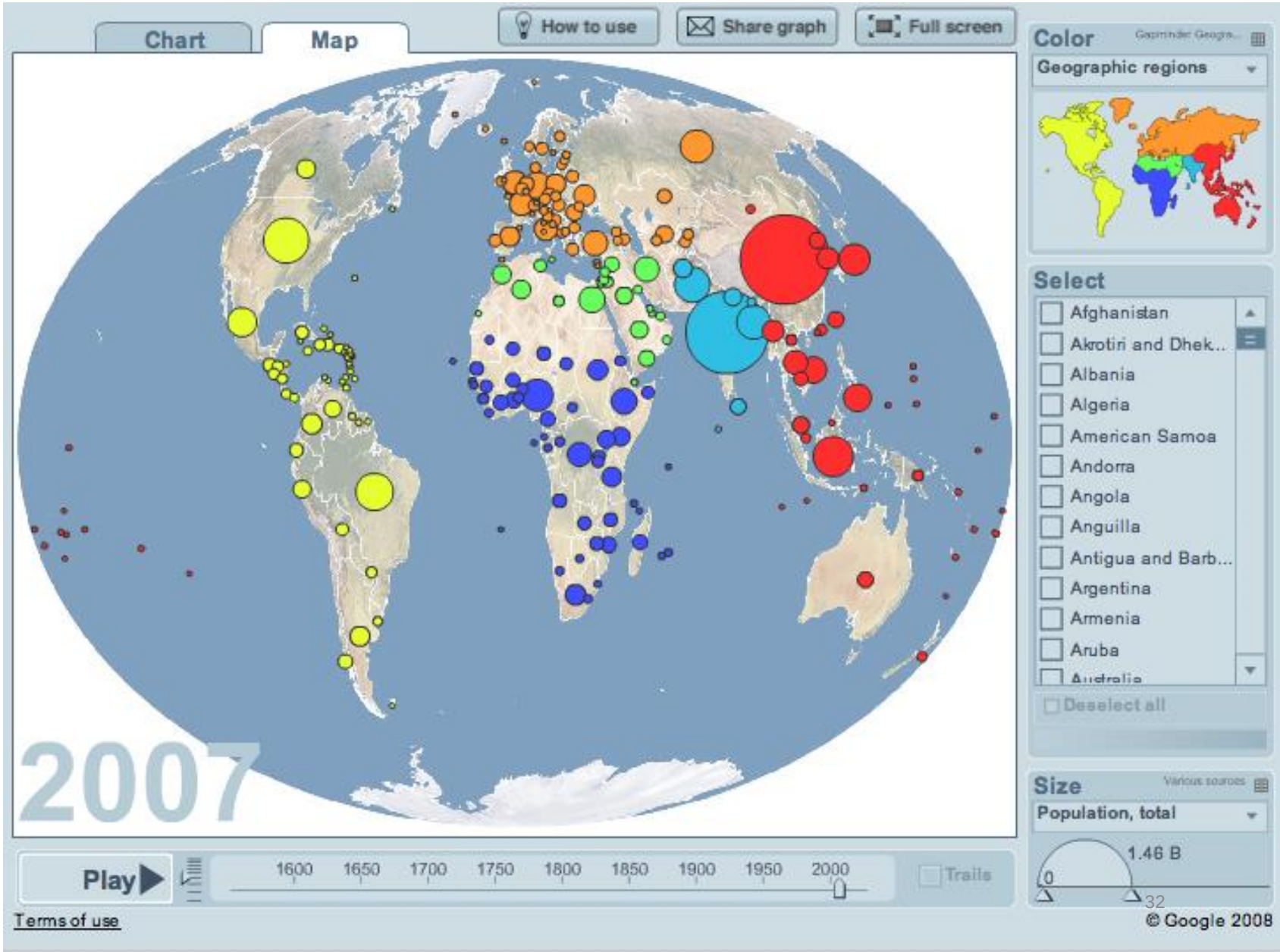
- Overview + Detail (O+D)
- Focus + Context (F+C)
- Brushing and Linking
- Zoom: Panning and Zooming
- Transformation: distortion-based Views

Overview + Details

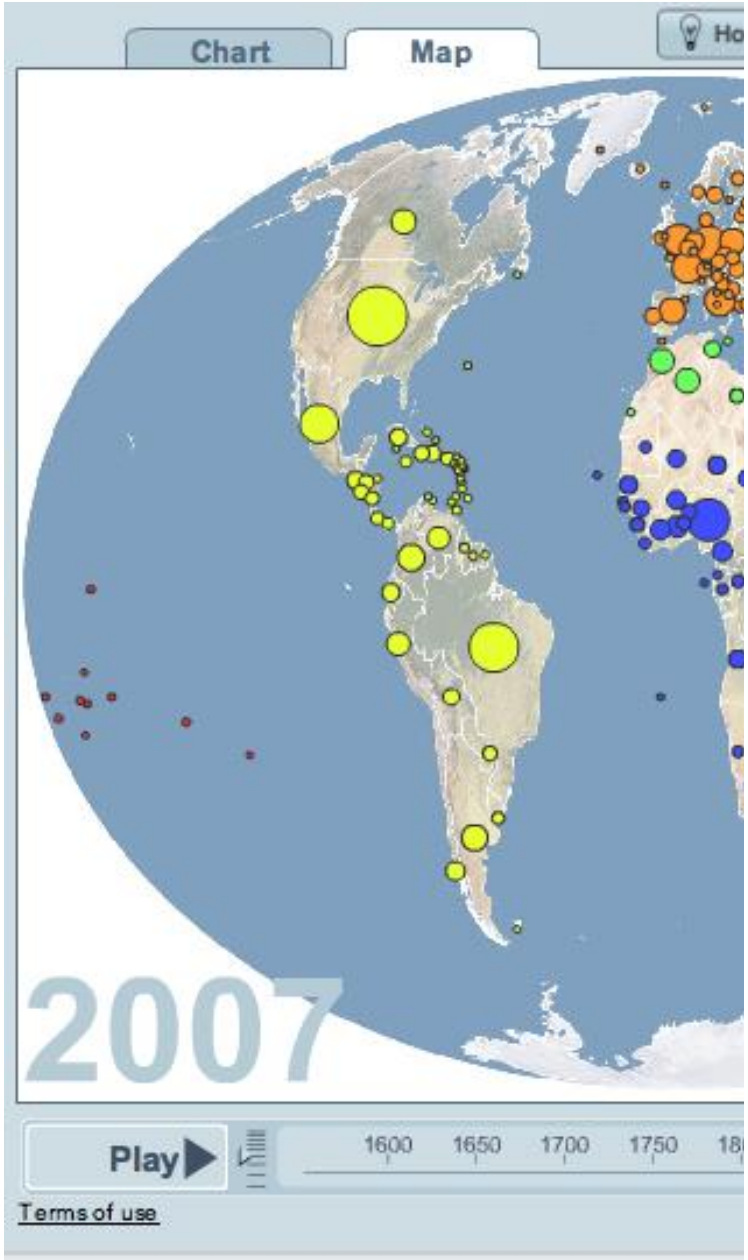
- Separate views
  - No distortion
  - Shows both overview and details simultaneously
  - Drawback: requires the viewer to consciously shift there focus of attention.

Overview

http://www.gapminder.org/

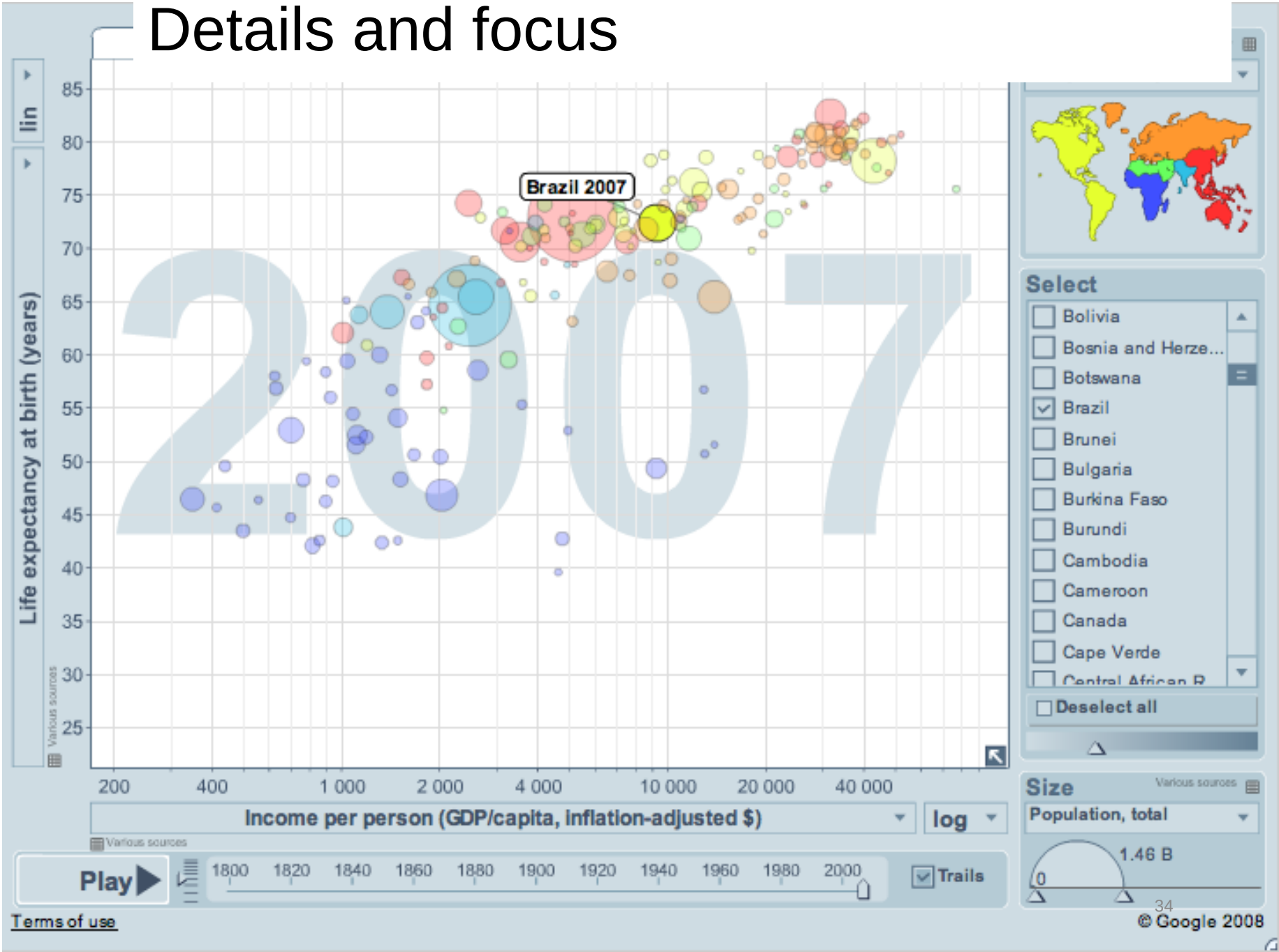


Overview

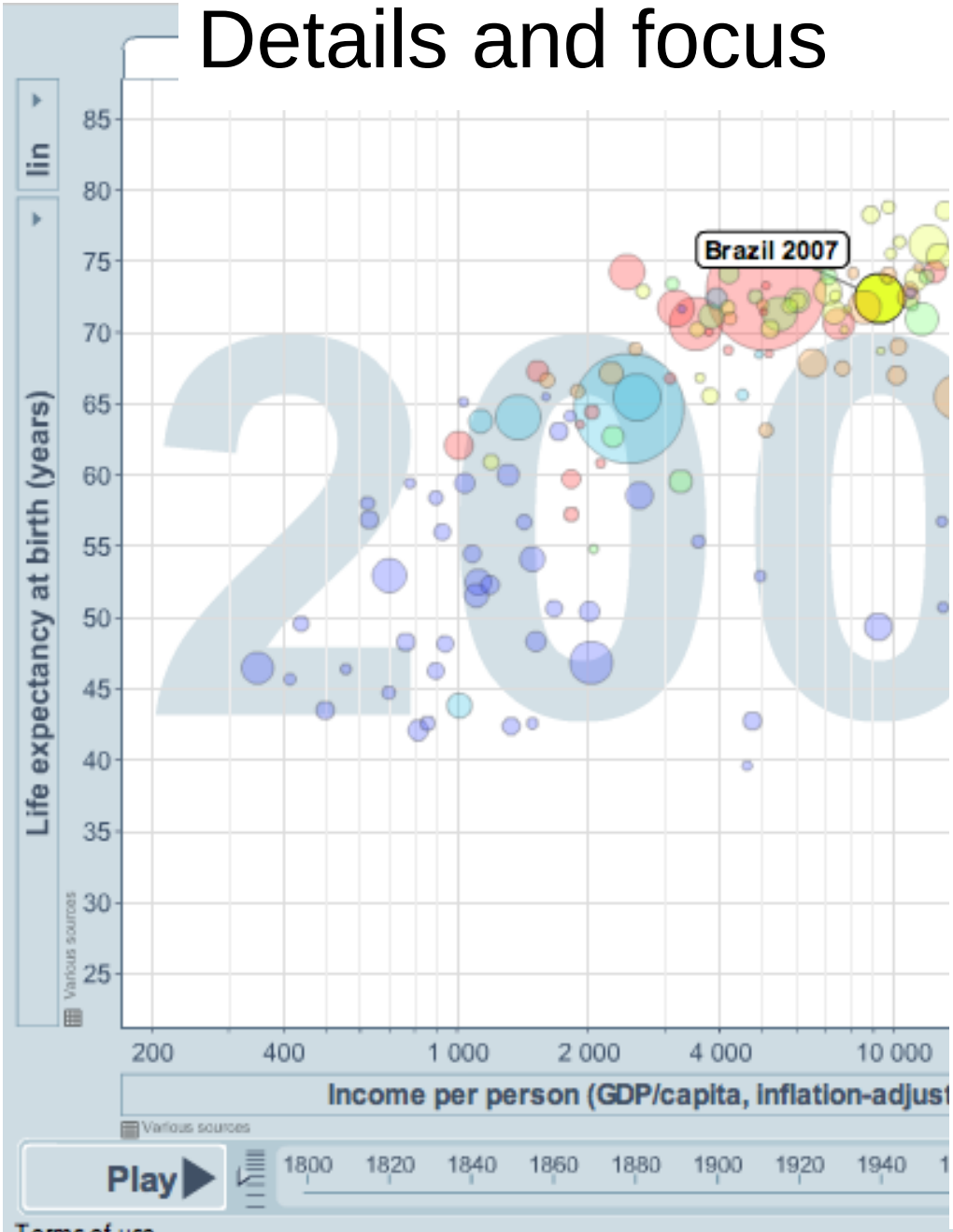


- It provides
  - Maps, spatial orientation
  - Contextual information, relationships
  - Which information is (or not) present in the display
- Detection of patterns
- Direct access
- Reduce searching process
- Enforce exploration, help to select the next move
- HCI metric – improve user performance, time of learning and satisfaction

Details and focus



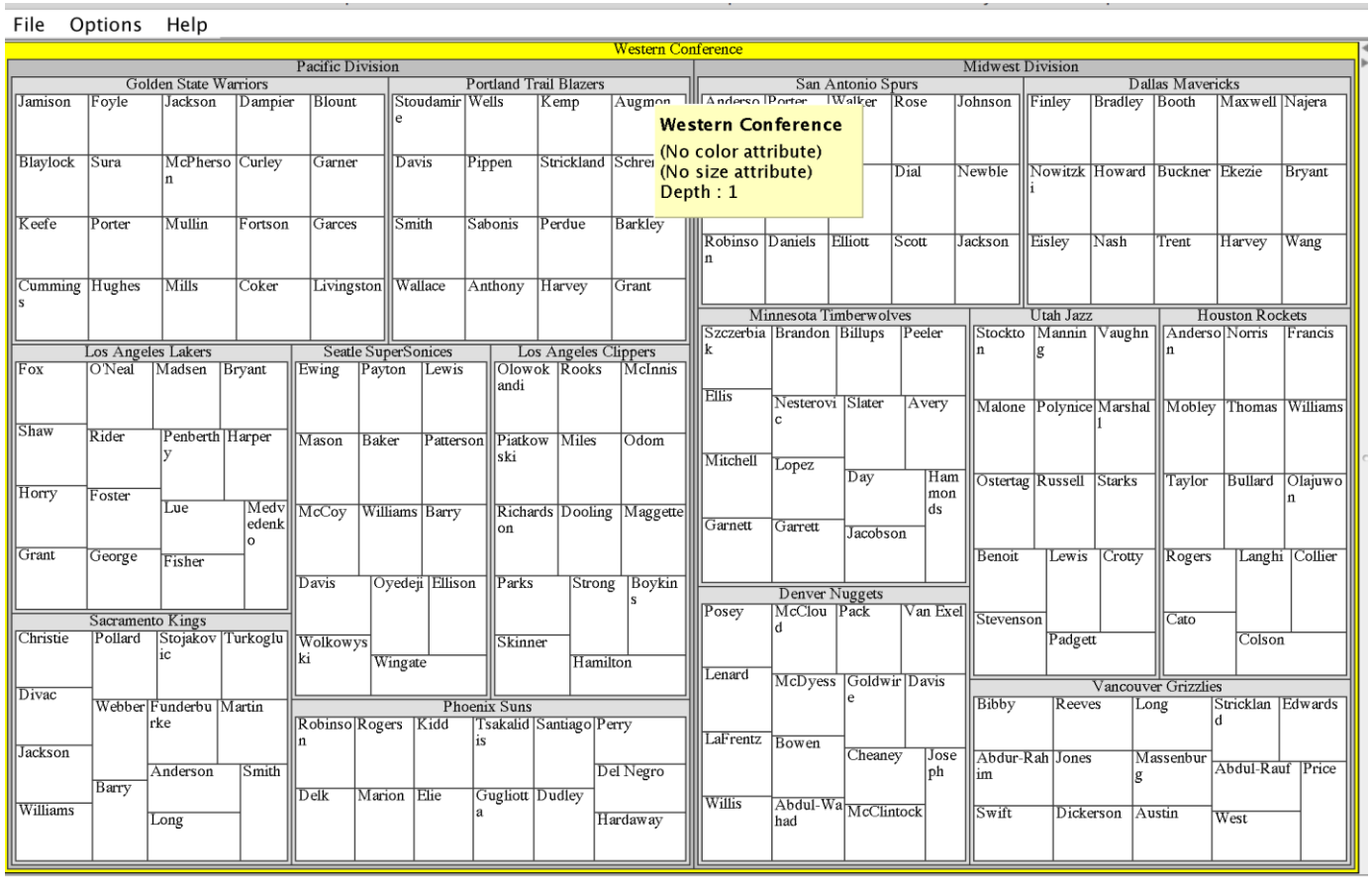
Details and focus



- It is the result of a cleaning data process (data that are of the scope/focus)
- It provides details about part of data
- Semantic zooming

Overview+Detail: Treemaps

- Treemaps: overview + detail (time separation)



Overview+Detail: Seesoft

- Spatial separation

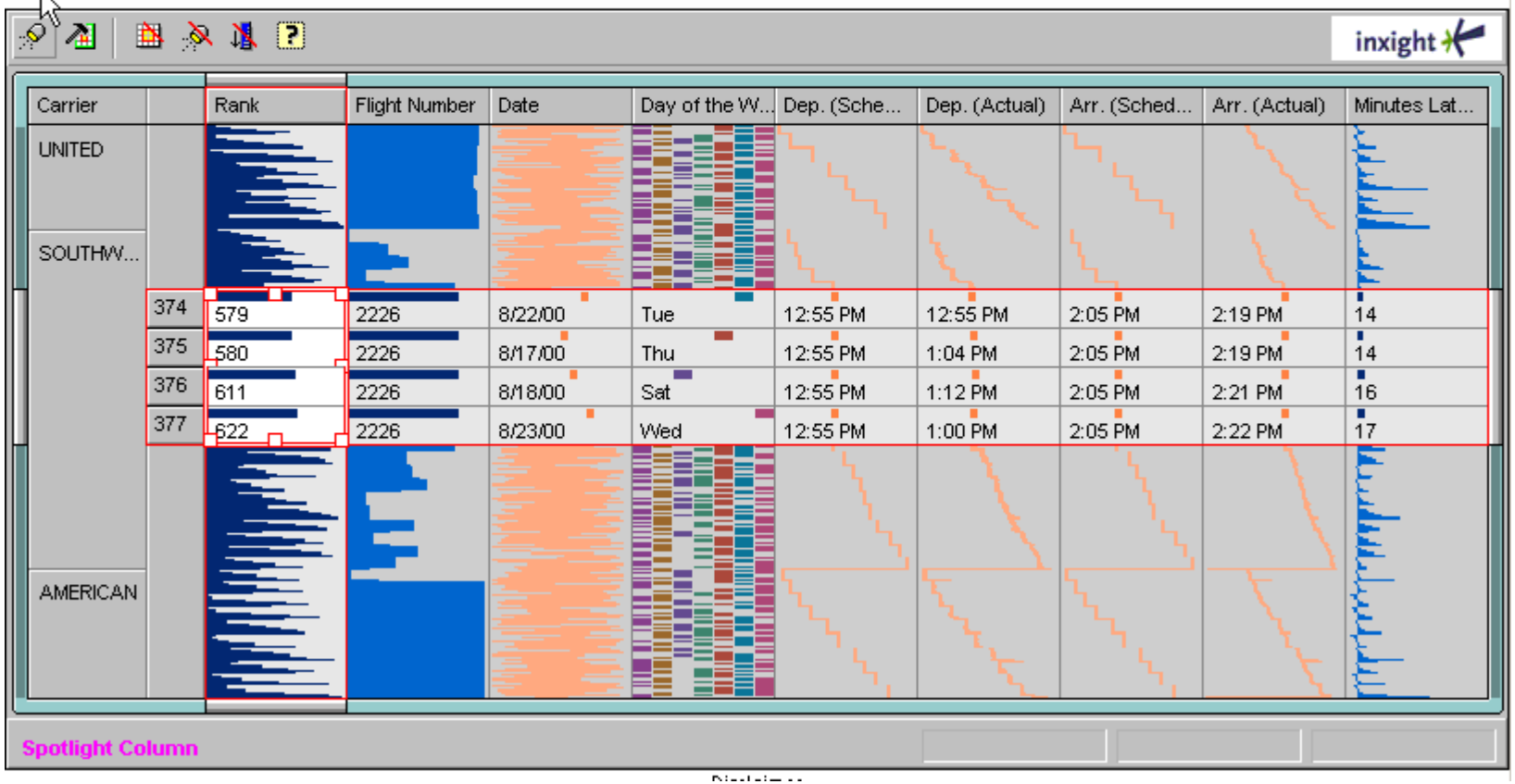
Focus + Context

- A single view shows information in context
  - Contextual info is near to focal poin
  - Distortion may make some parts hard to interpret
  - Distortion may obscure structure in data
    - We'll have a lecture on distortion later

- Examples from Xerox PARC:
  - TableLens
  - Perspective Wall
  - Hyperbolic Tree Browser

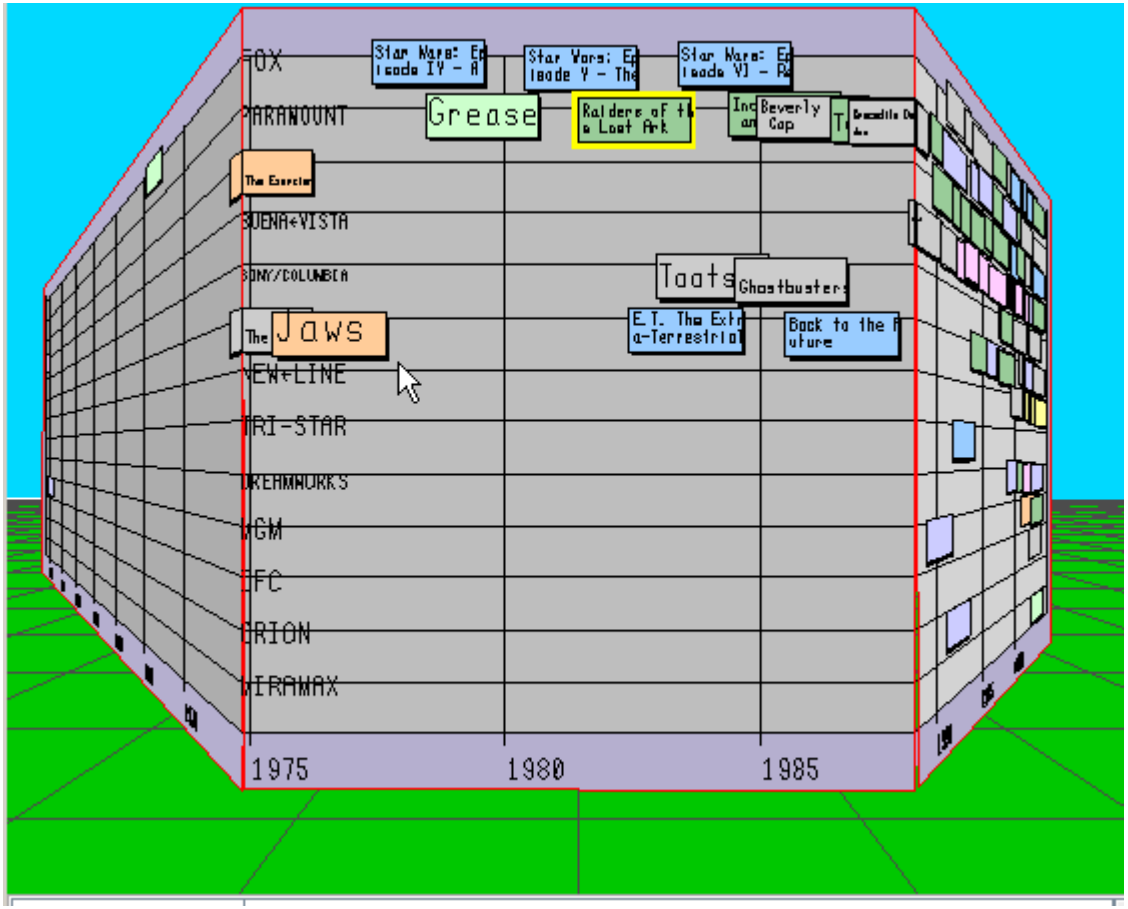
Focus + Context:
TableLens from PARC/Inxight

3) Can you see that United flights tended to get later and later as the day went on?



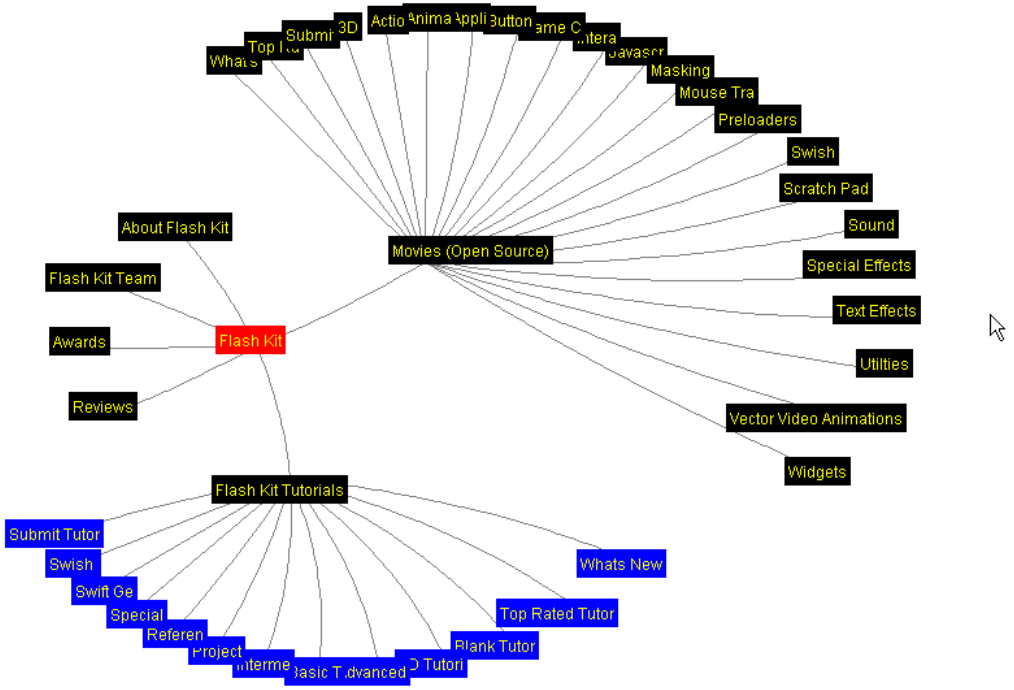
http://www.inxight.com/products/sdks/tl/
http://www.inxight.com/demos/tl_calcrisis/tl_calcrisis.html

Focus + Context (+ Distortion): Perspective Wall from PARC/Inxight



http://www.inxight.com/demos/timewall_demos

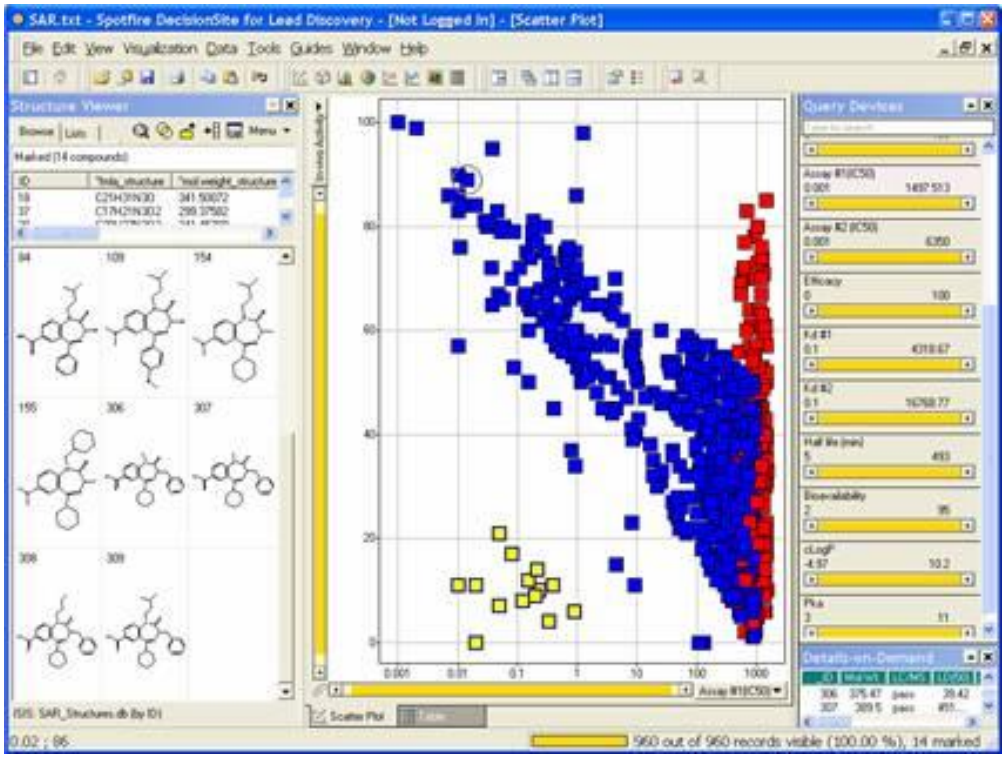
Focus + Context:
Hyperbolic Tree from PARC/Inxight



http://inxight.com/products/sdks/st/

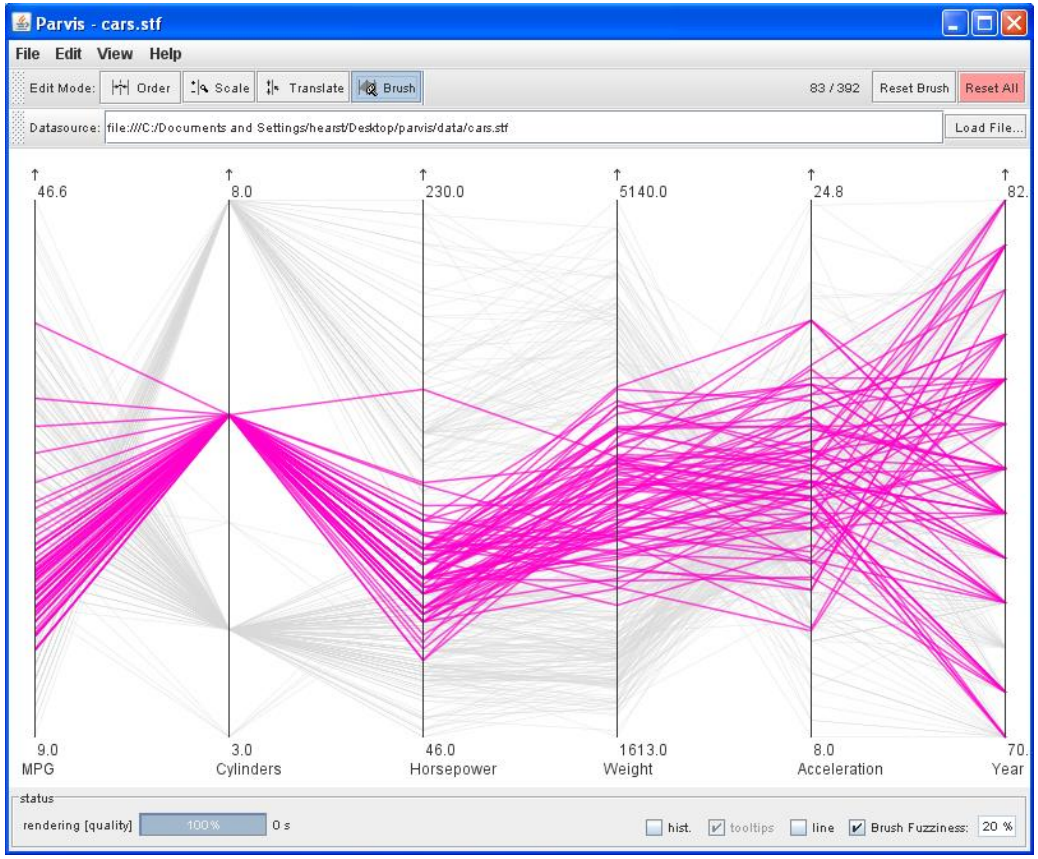
Highlighting / Brushing and Linking / Dynamic Queries

- Spotfire, by Ahlberg & Shneiderman
  - http://hcil.cs.umd.edu/video/1994/1994_visualinfo.mpg
  - Now a very sophisticated product:
    - http://spotfire.tibco.com/products/gallery.cfm



Highlighting and Brushing: Parallel Coordinates by Inselberg

- Free implementation: Parvis by Ledermen
  - http://home.subnet.at/flo/mv/parvis/



Pan and Zoom

How to show a lot of information in a small space?

- Multiple Levels of Resolution
  - The view changes depending on the “distance” from the viewer to the objects
- Distortion-based techniques
  - Keep a steady overview, make some objects larger while simultaneously shrinking others

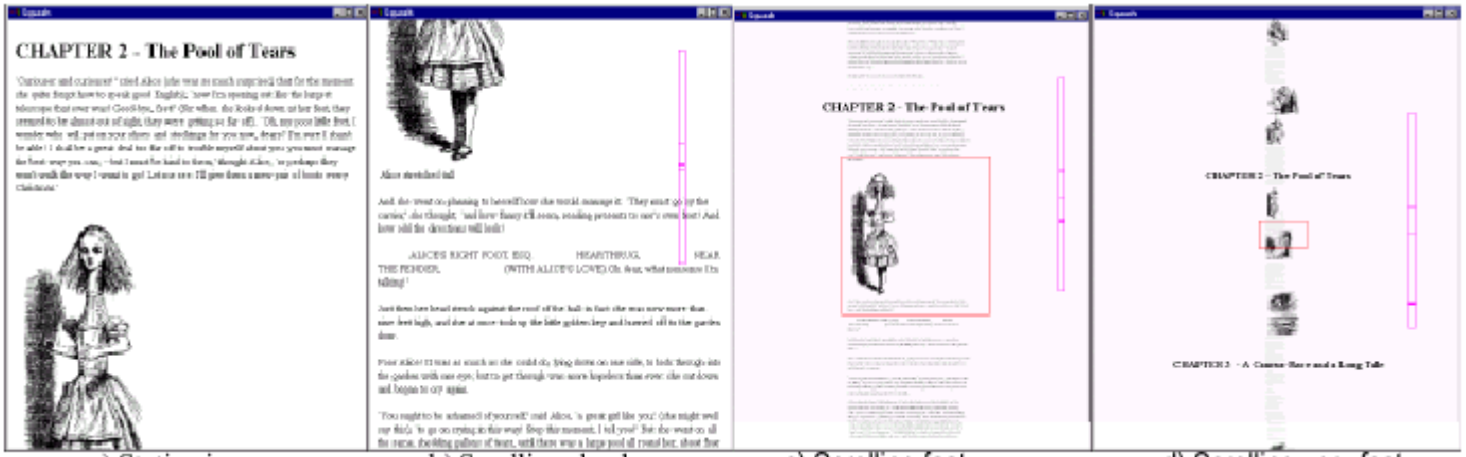
Zooming

- Standard Zooming
  - Get close in to see information in more detail
  - Example: Google earth zooming in

- Intelligent Zooming
  - Show semantically relevant information out of proportion
  - Smart speed up and slow down
  - Example: speed-dependent zooming, Igarishi & Hinkley

- Semantic Zooming
  - A *semantic zoom* control allows the user to zoom between two different semantic views of the same data set
  - Zooming can be conceptual as opposed to simply reducing pixels
  - Example tool: Pad++ and Piccolo projects
    - http://hcil.cs.umd.edu/video/1998/1998_pad.mpg

Speed-dependent Zooming
by Igarashi & Hinkley 2000



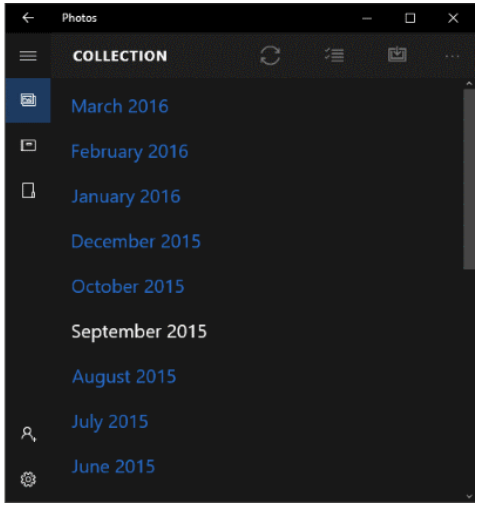
a) Static view b) Scrolling slowly c) Scrolling fast d) Scrolling very fast

http://www-ui.is.s.u-tokyo.ac.jp/~takeo/video/autozoom.mov
http://www-ui.is.s.u-tokyo.ac.jp/~takeo/java/autozoom/autozoom.htm

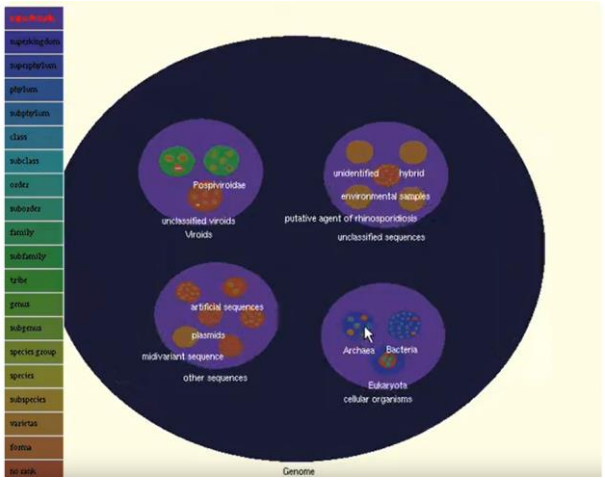
Standard vs. Semantic Zooming

- Geometric (standard) zooming:
  - The view depends on the physical properties of what is being viewed
- Semantic Zooming:
  - When zooming away, instead of seeing a scaled-down version of an object, see a different representation
  - The representation shown depends on the meaning to be imparted.

Examples of Semantic Zoom

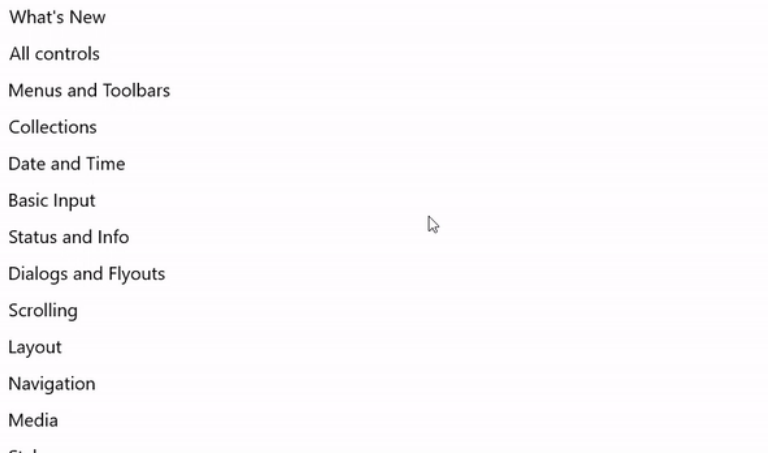


- Other examples
- Zoom into restaurant:
  - see the interior
  - see what is served there
- maybe zoom based on price instead!
  - see expensive restaurants first
  - keep zooming till you get to your price range



https://www.youtube.com/watch?v=d2xWEKtVv3s

WinUI Gallery



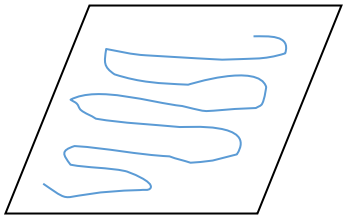
Examples of Semantic Zoom

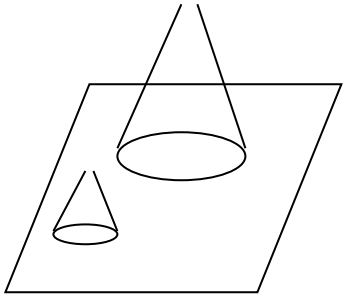
- Infinitely scalable painting program
  - close in, see flecks of paint
  - farther away, see paint strokes
  - farther still, see the holistic impression of the painting
  - farther still, see the artist sitting at the easel

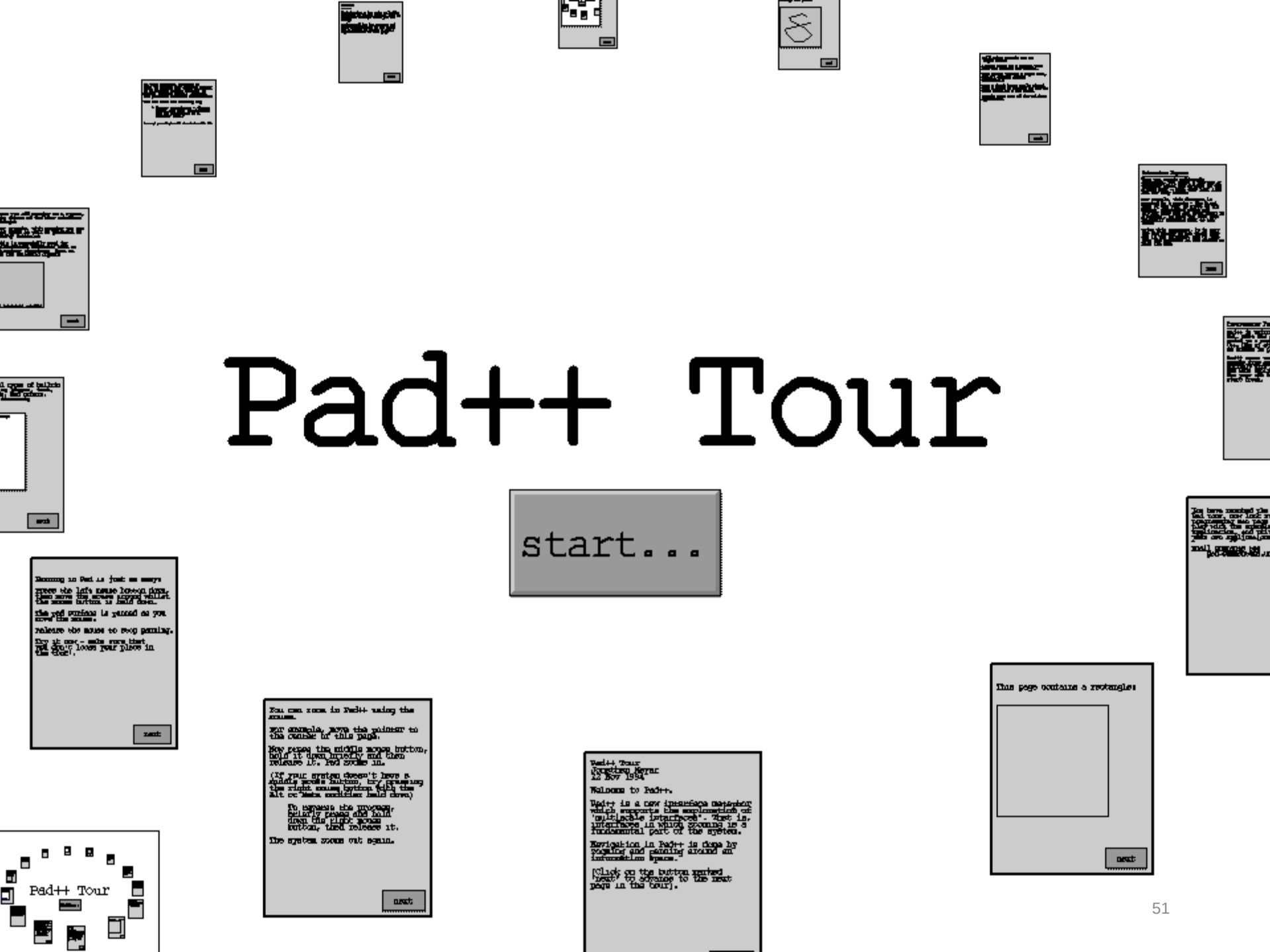
Pad++

- An infinite 2D plane
- Can get infinitely close to the surface too
- Navigate by panning and zooming
- Pan:
  - move around on the plane
- Zoom:
  - move closer to and farther

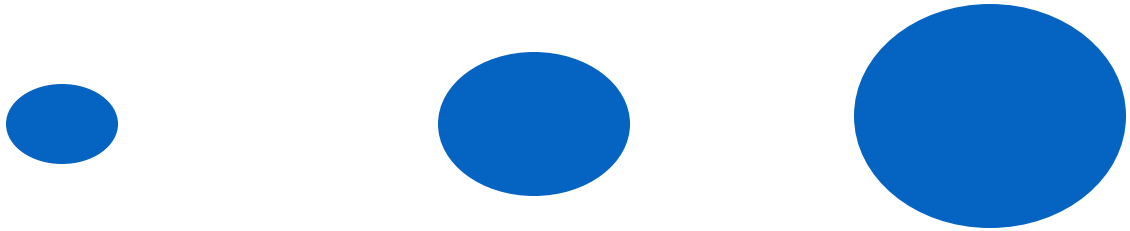
  from the plane
  - http://hcil.cs.umd.edu/video/1998/1998_pad.mpg



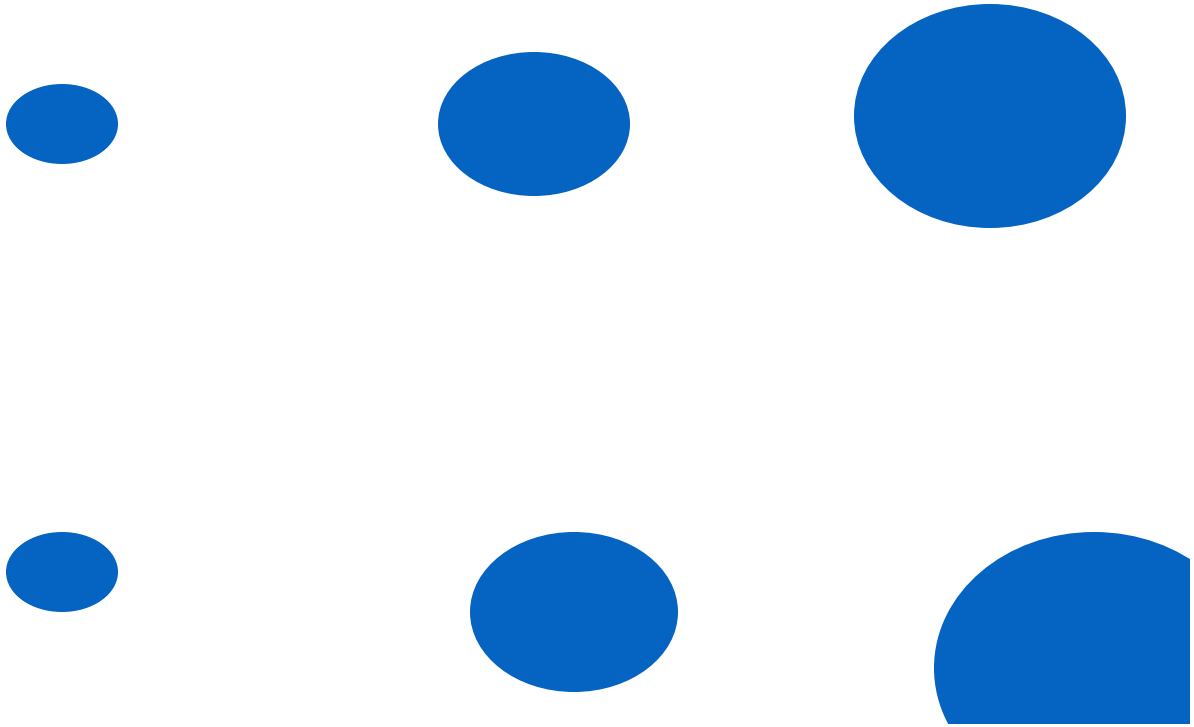



Pad++ Tour
start...
Pad++ Tour
This page contains a rectangle:
next
You can zoom in Pad++ using the mouse.
next
Pad++ Tour
Welcome to Pad++.
next

How to Pan While Zooming?

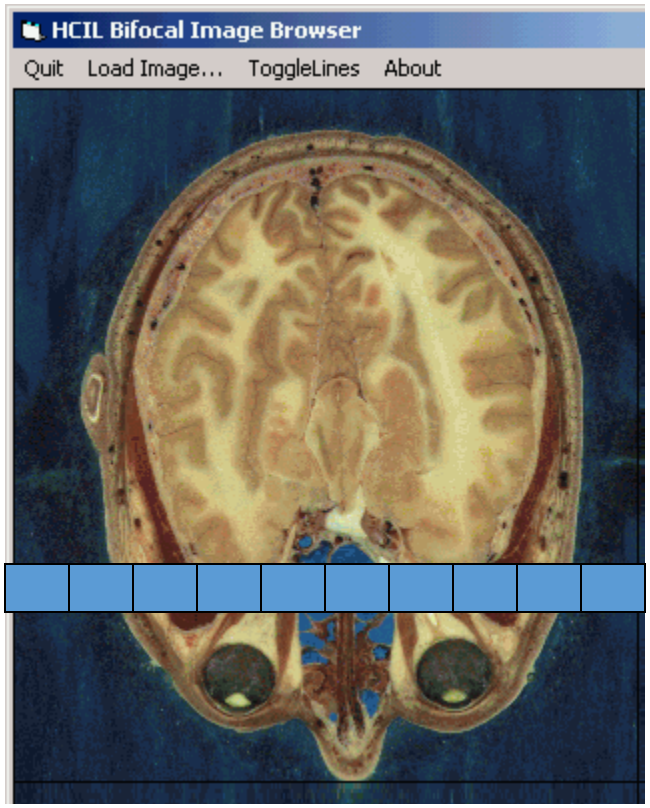


How to Pan While Zooming?

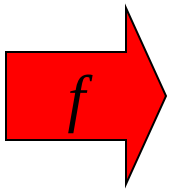


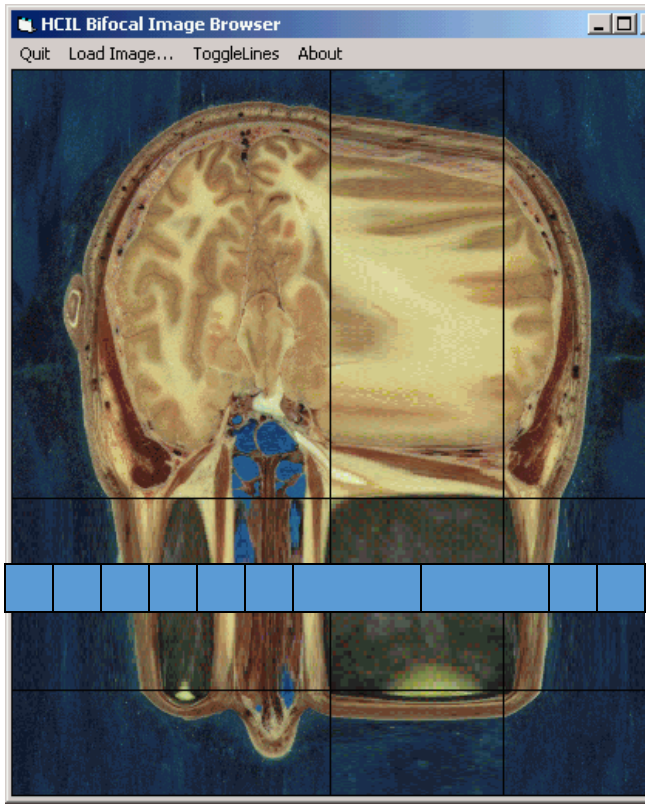
Distortion

- Mapping the information to a surface of exhibition



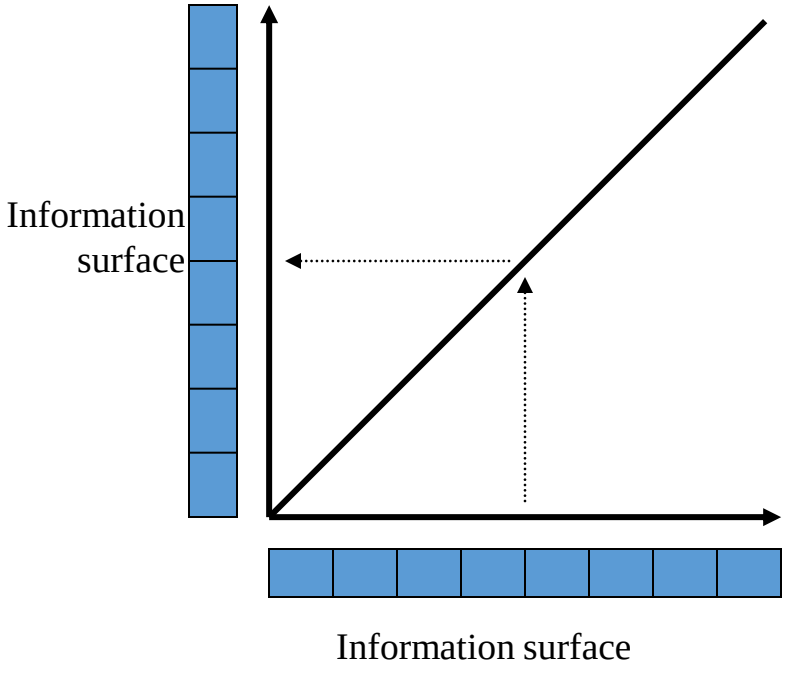
Information surface

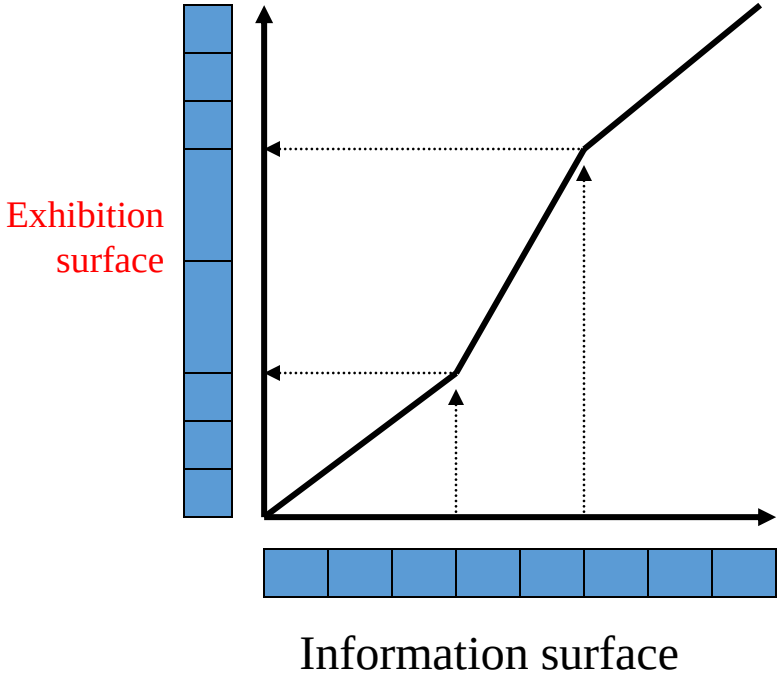




Exhibition surface

Mapping function



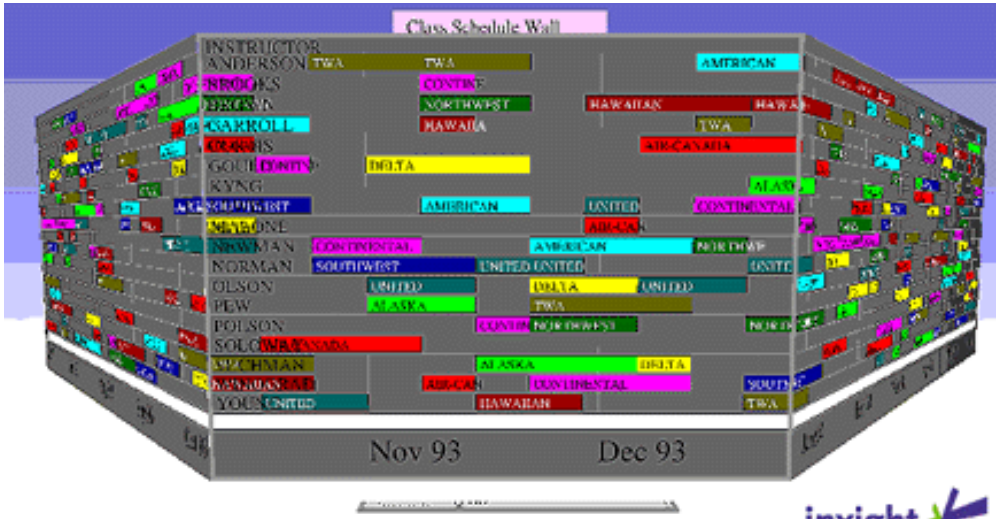


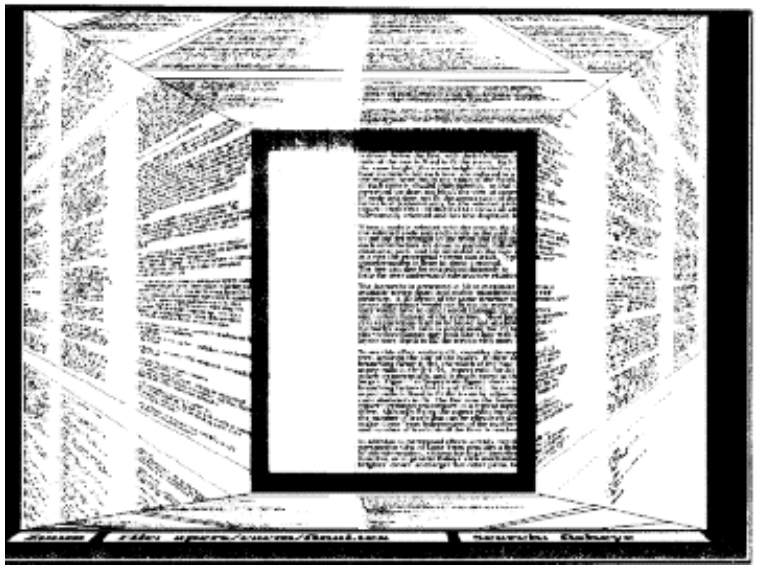
Identity function = normal overview

Bifocal

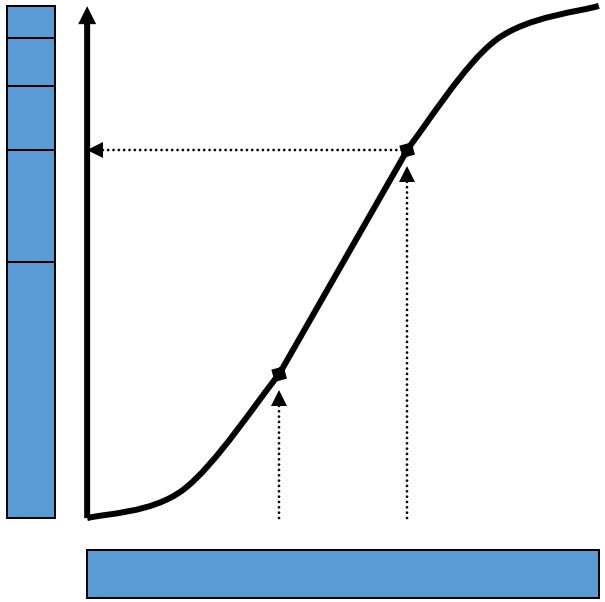
Perspective Wall / Document Lens

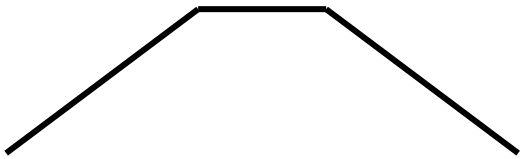
Contexto diminui gradualmente





inxight

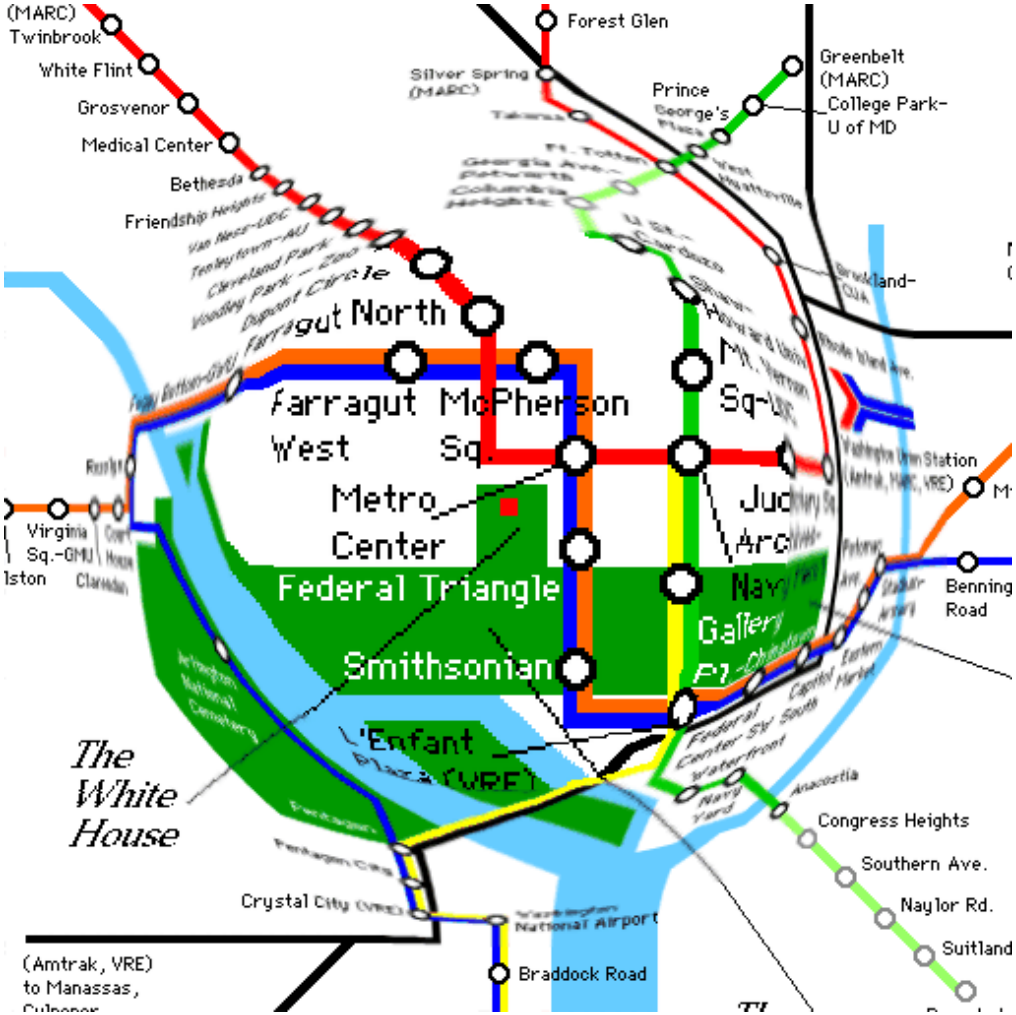


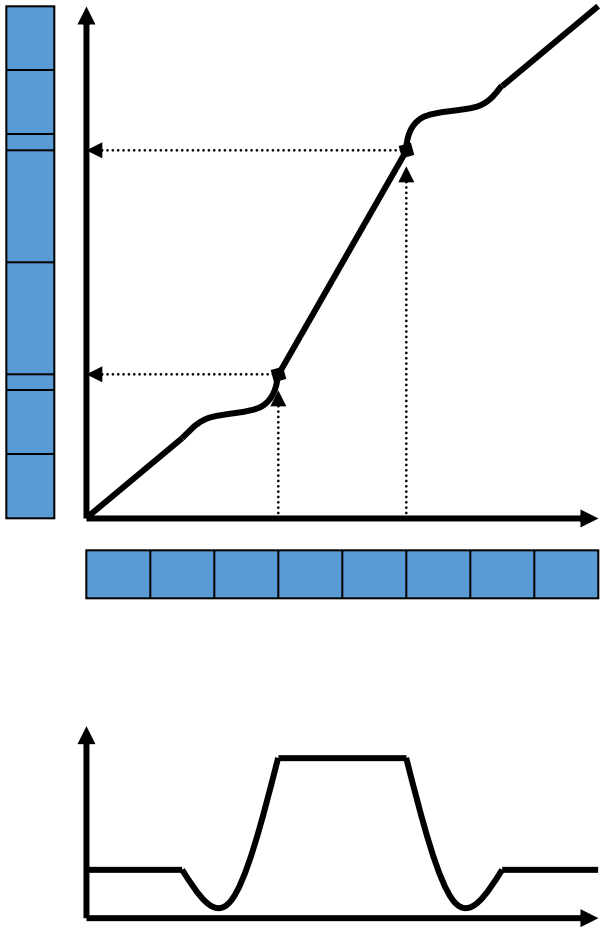


Perspective

“Bubble”

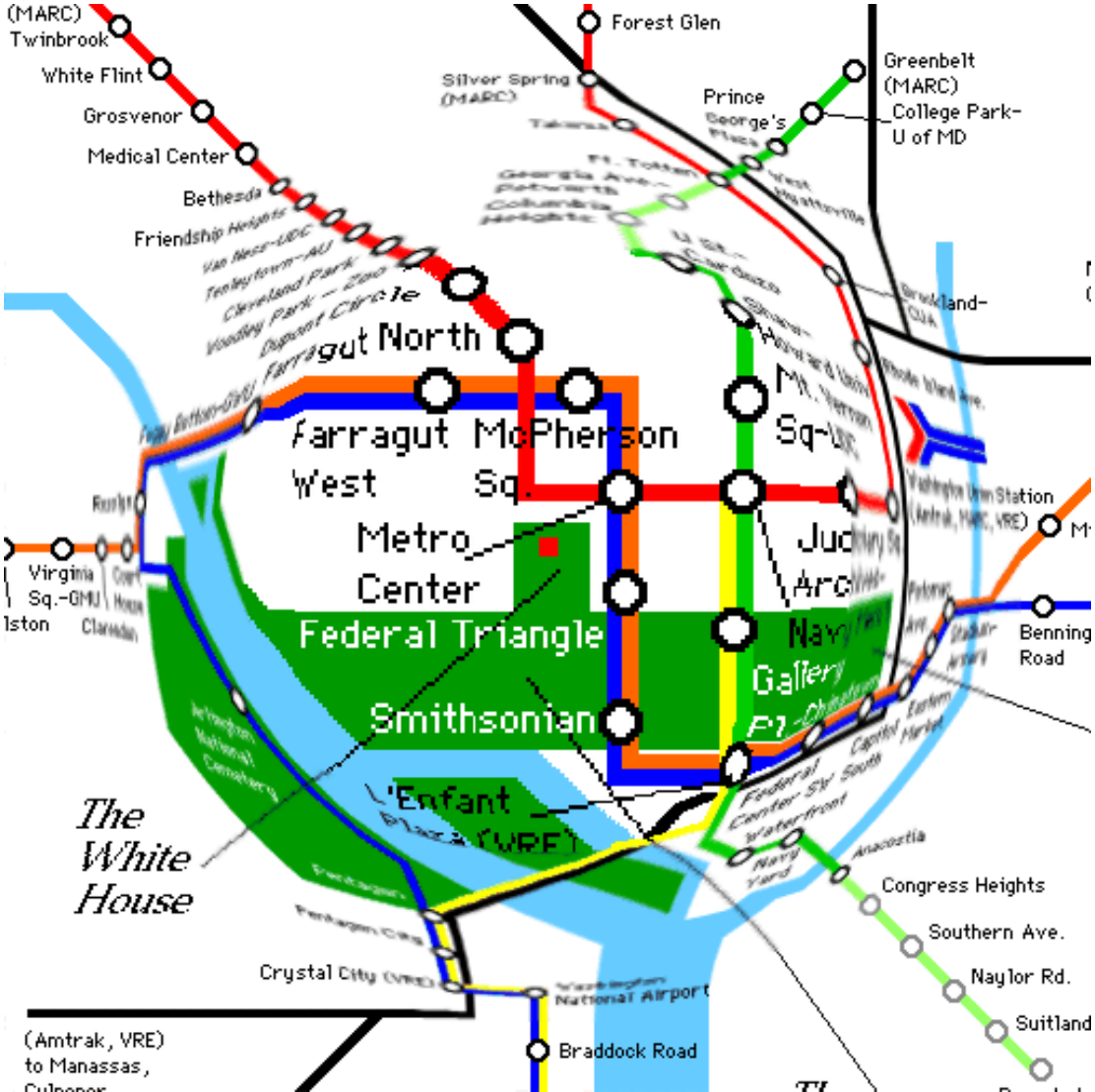
Inconvenient: local context is smaller

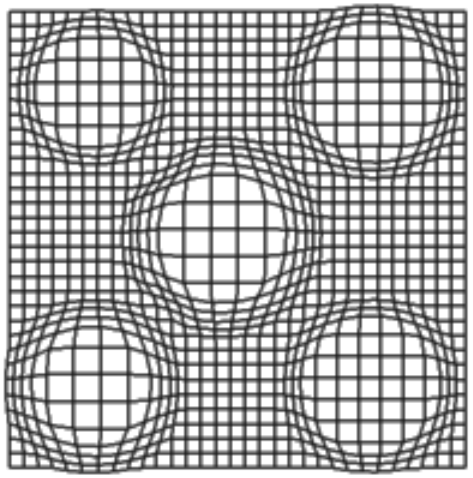




Bubble

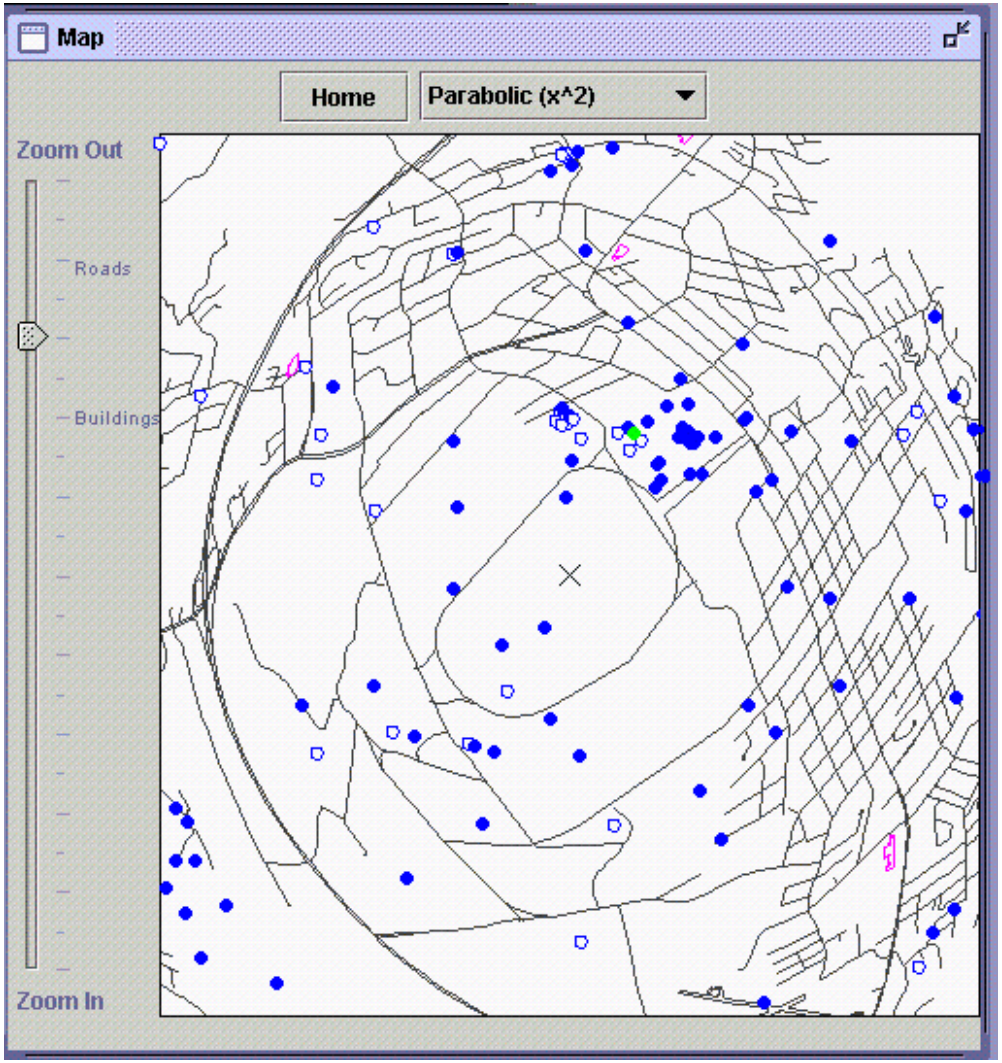
Non linear

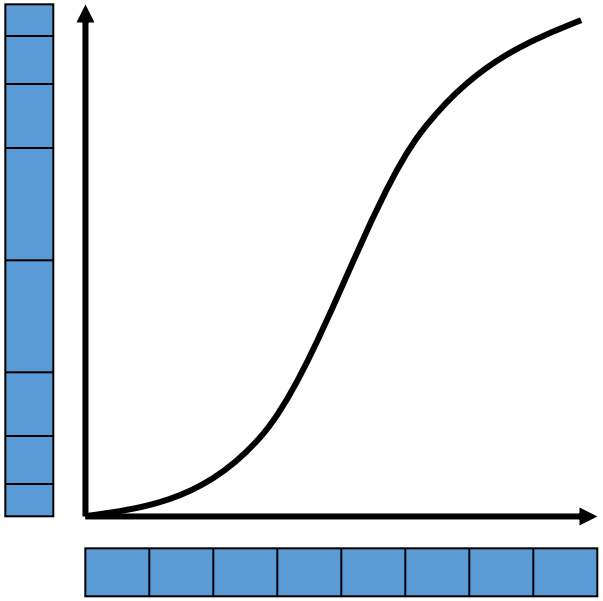

(MARC)
Twinbrook
White Flint
Grosvenor
Medical Center
Bethesda
Friendship Heights
Forest Glen
Silver Spring
(MARC)
Takoma
Prince
George's
Plaza
Greenbelt
(MARC)
College Park-
U of MD
Farragut North
Farragut
West
McPherson
Sq.
Metro
Center
Federal Triangle
Smithsonian
Gallery
Pl-Chinatown
Virginia
Sq.-GMU
Ballston
Clarendon
Benning
Road
The
White
House
L'Enfant
Plaza (VRE)
Navy
Yard
Anacostia
Congress Heights
Southern Ave.
Naylor Rd.
Suitland
Crystal City (VRE)
National Airport
Braddock Road
(Amtrak, VRE)
to Manassas,

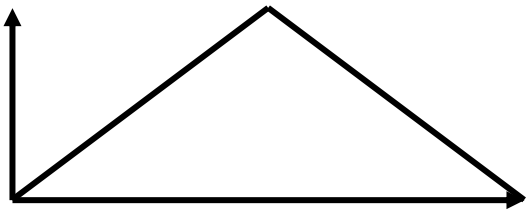


“Fisheye”, “wide-angle lens”

Inconvenient: don’t have a plain area



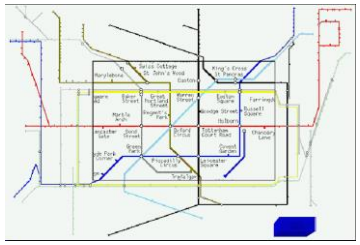


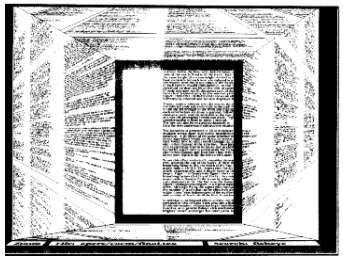


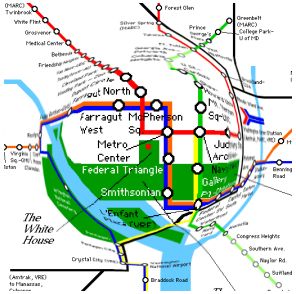
degree

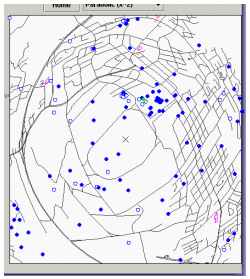
Summary

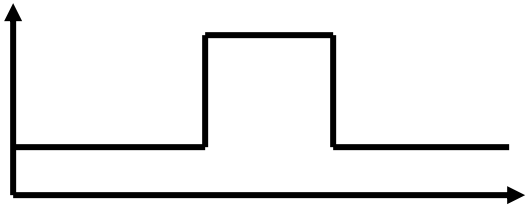
- Bifocal
- Perspective
- Bubble
- Wide-angle

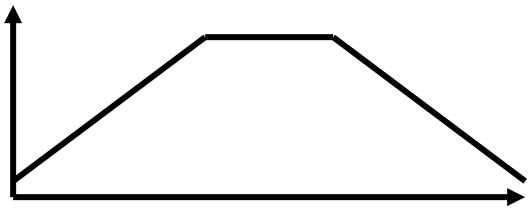


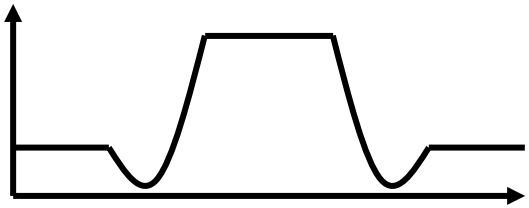


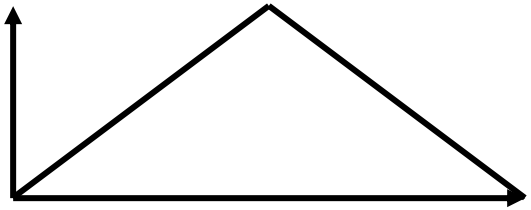












Shneiderman's Taxonomy of Information Visualization Data Types

- **1-D Linear** Document Lens, SeeSoft
- **2-D Map** GIS, Medical imagery
- **3-D World** CAD, Medical, Molecules, Architecture
- **Multi-Dim** Parallel Coordinates, Spotfire, Influence Explorer, TableLens
- **Temporal** Perspective Wall, LifeLines, Lifestreams
- **Tree** Cone/Cam/Hyperbolic, TreeBrowser, Treemap
- **Network** Netmap, netViz, Multi-trees

Shneiderman's Taxonomy of Information Visualization Tasks

- Overview: see overall patterns, trends
- Zoom: see a smaller subset of the data
- Filter: see a subset based on values, etc.
- Details on demand: see values of objects when interactively selected
- Relate: see relationships, compare values
- History: keep track of actions and insights
- Extract: mark and capture data

Shneiderman's Visualization Mantra

- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand
- Overview, zoom & filter, details on demand