

# Information Visualization

User tasks and infovis techniques  
2020

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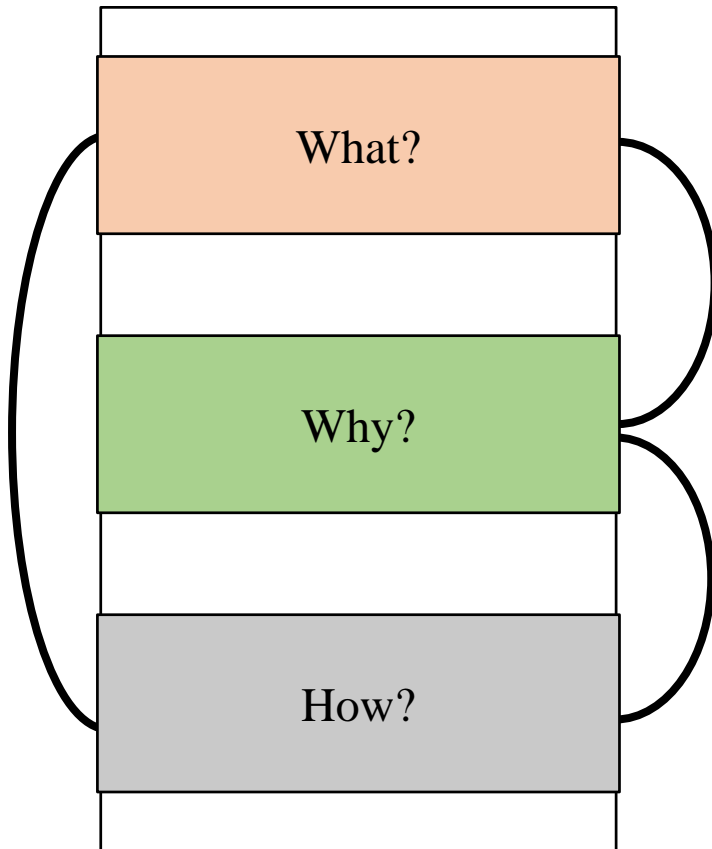
winckler@unice.fr

<http://www.i3s.unice.fr/~winckler/>



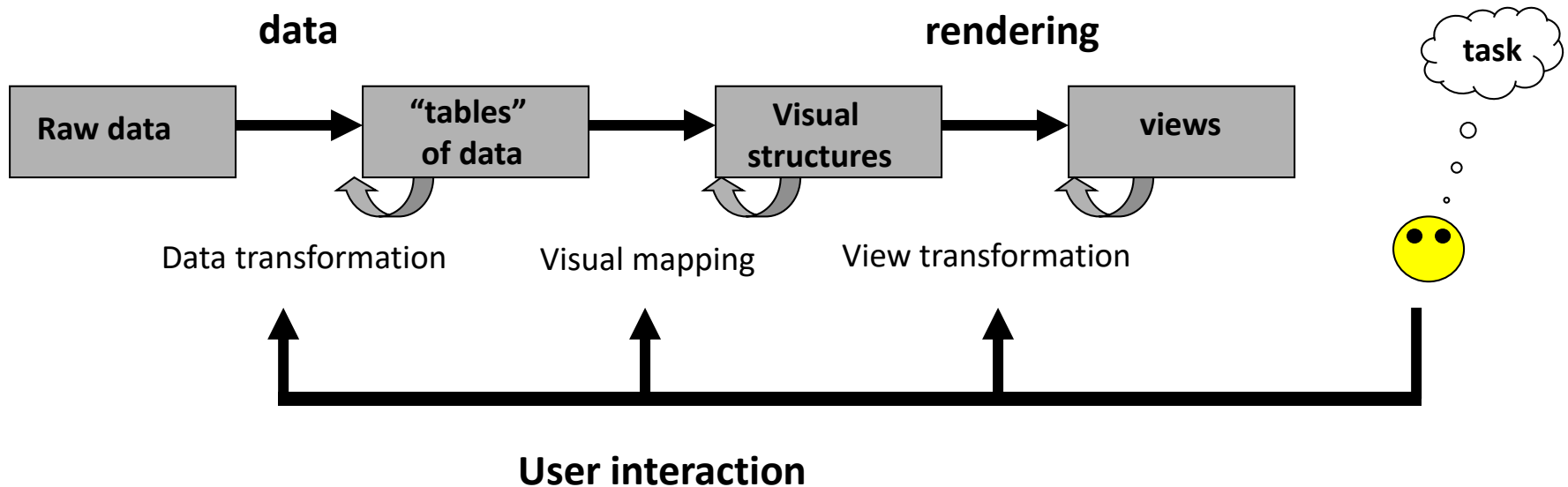
# User tasks

# 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

# Standard visualization model



# 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

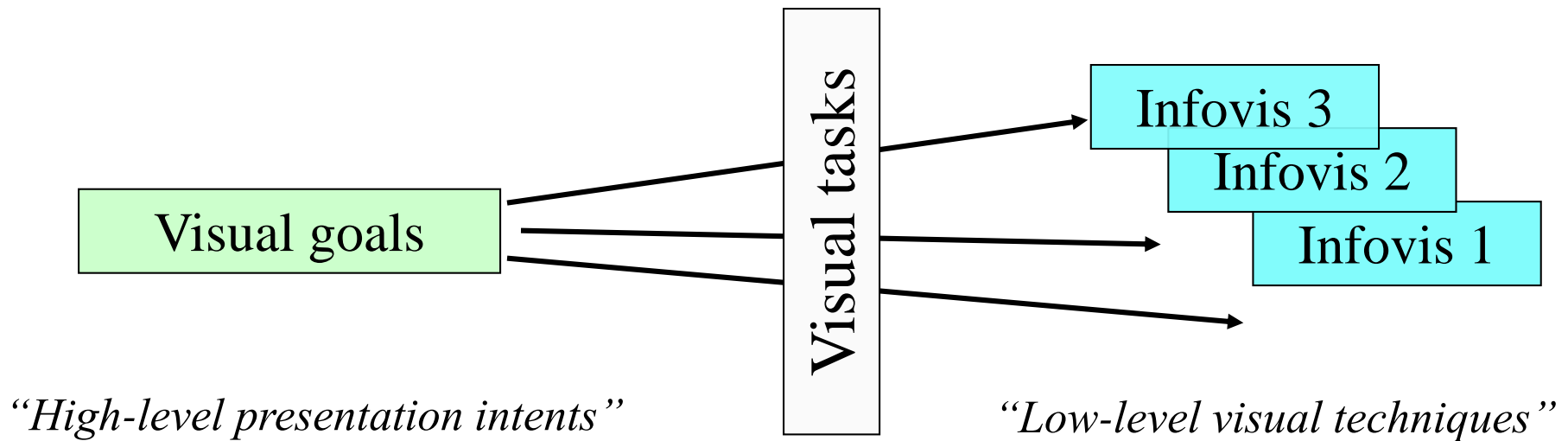
- Wehrend and Lewis, 1990
- Springmeyer, 1990
- Shneiderman, 1996
- Zhou and Feiner, 1998
- Morse et al., 2000
- Amar and Stasko, 2004
- **Amar et al., 2005**
- Valiati et al., 2006

## 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





# Visual tasks

- Are characterized by two dimensions

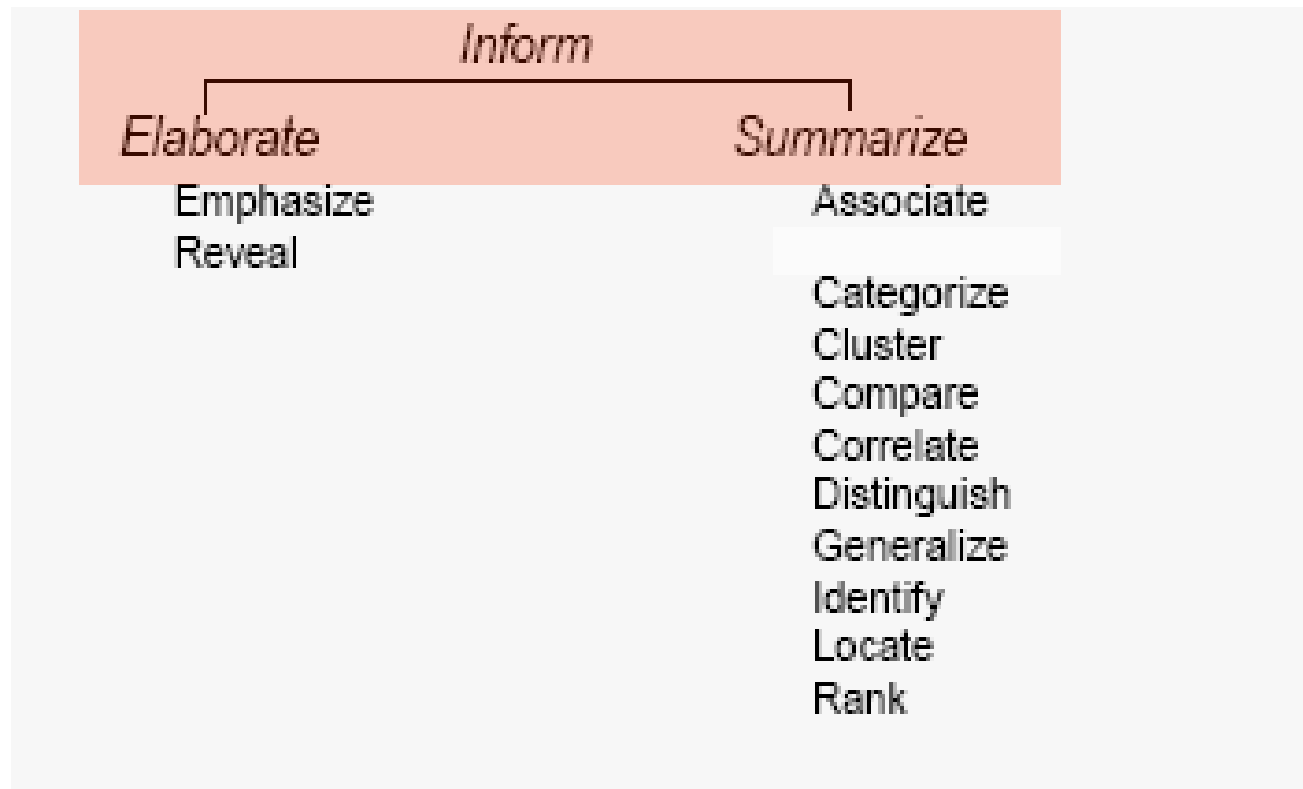
- Visual goals )

- Goals that should be accomplished with the infovis technique

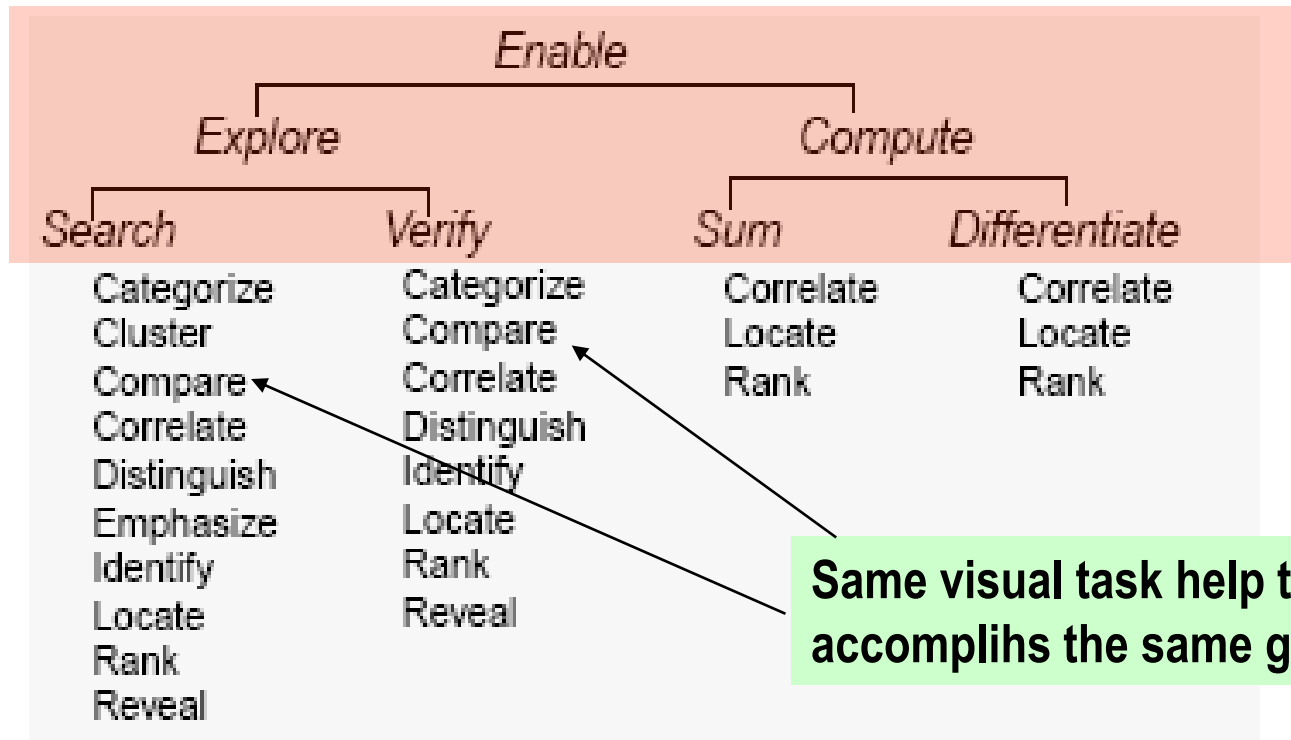
- Visual implications

- The visual actions the infovis technique implements

# Visual goals & visual tasks



# Visual goal and visual tasks



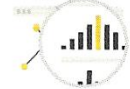
# Why people are using vis in terms of actions and targets

## Actions

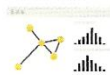
### → Analyze

→ 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

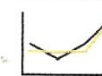
→ Dependency



→ Correlation



→ Similarity



### → Network Data

→ Topology



→ Paths

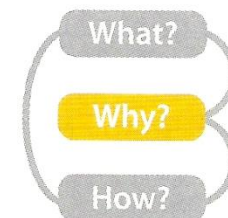


### → Spatial Data

→ 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

## ➔ Search

	Target known	Target unknown
Location known	 <i>Lookup</i>	 <i>Browse</i>
Location unknown	 <i>Locate</i>	 <i>Explore</i>

## ➔ Query

➔ Identify



➔ Compare



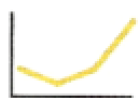
➔ Summarize



# 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



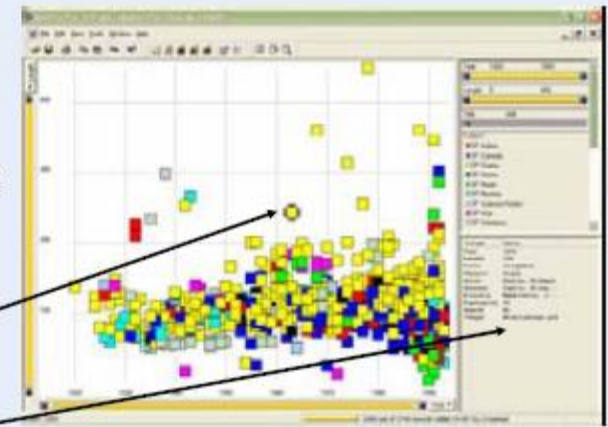
Slide adapted from John Stasko

## Mouse Selection

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

Selected item

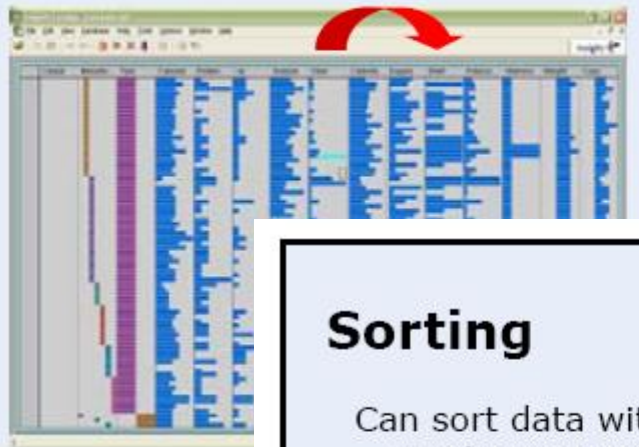
### Attributes



Slide adapted from John Stasko

## Rearrange

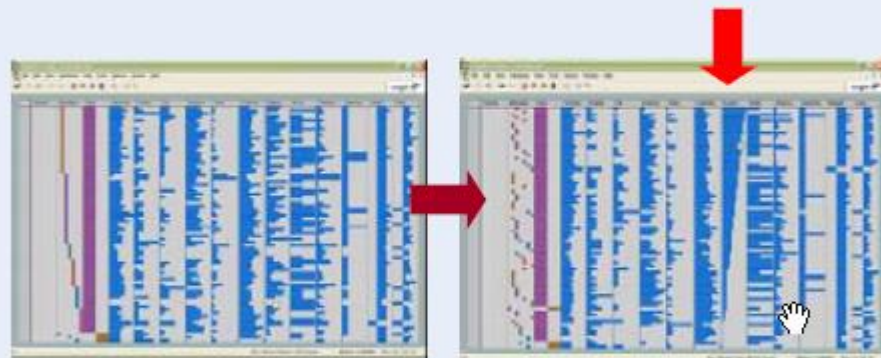
In TableLens  
you can move  
columns  
(attributes)  
left and right



Slide adapted from John Stasko

## Sorting

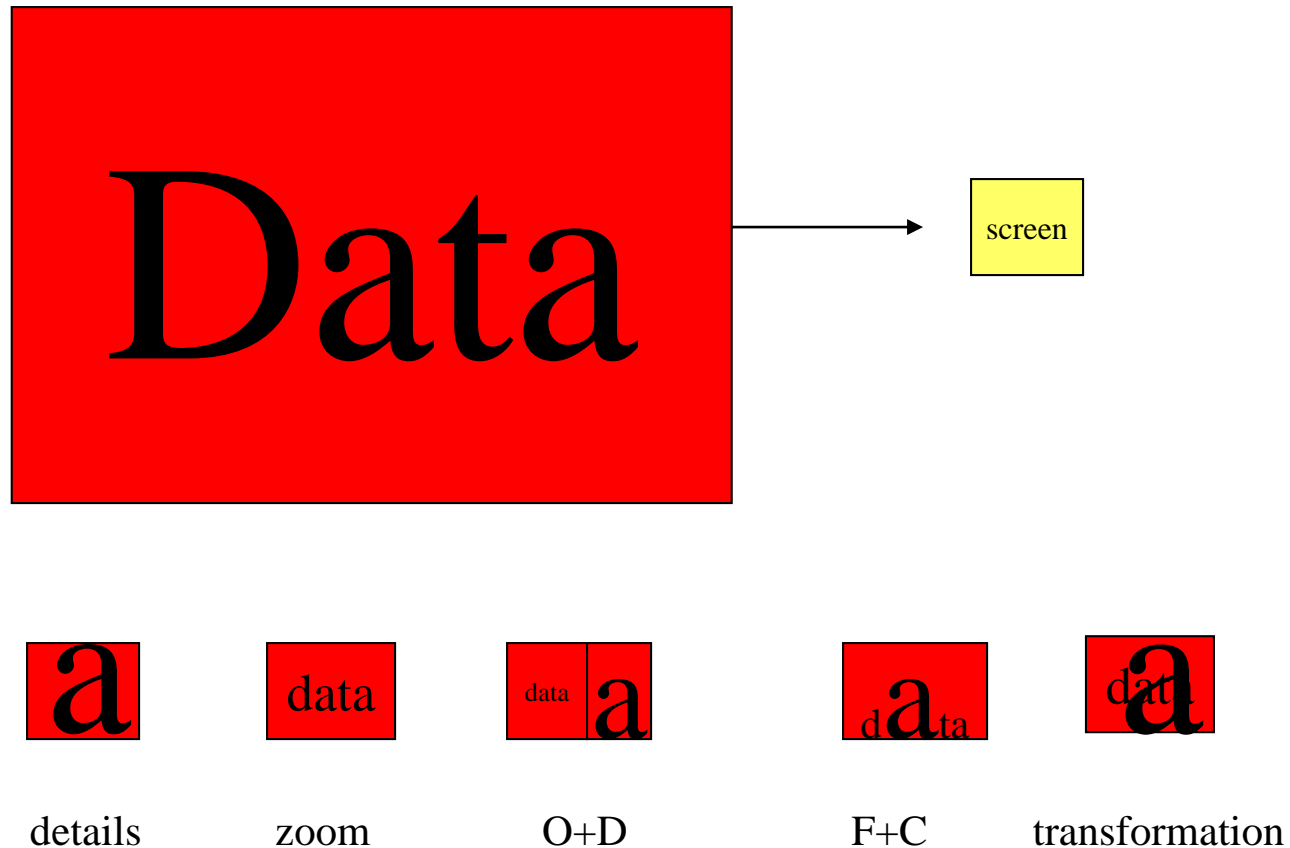
Can sort data with respect to a particular  
attribute in Table Lens



Slide adapted from John Stasko

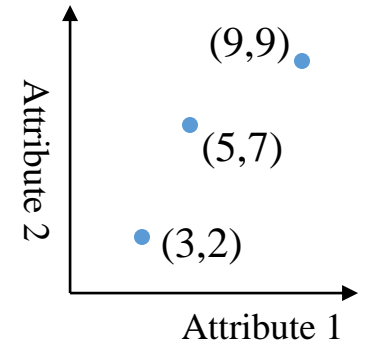
# Strategies for interactive visualization

- How to exhibit large data sets?

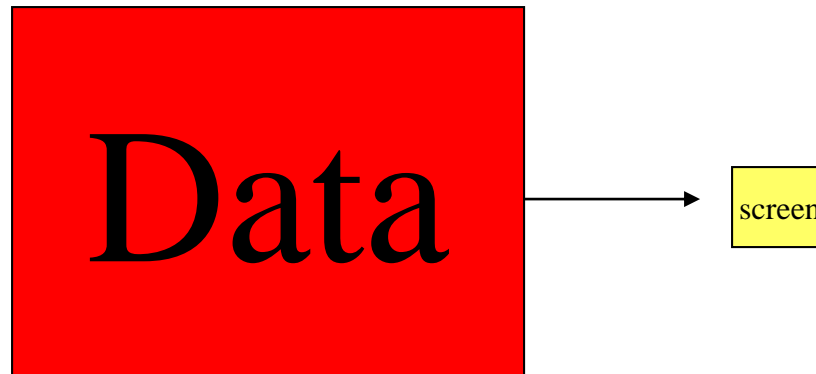


# How to ensure overview: by scalability

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



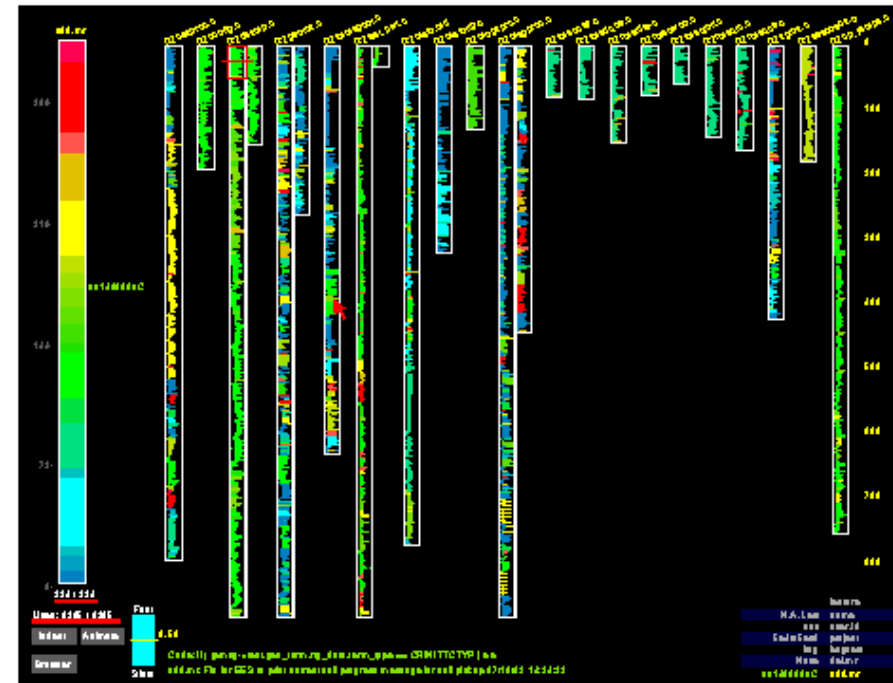
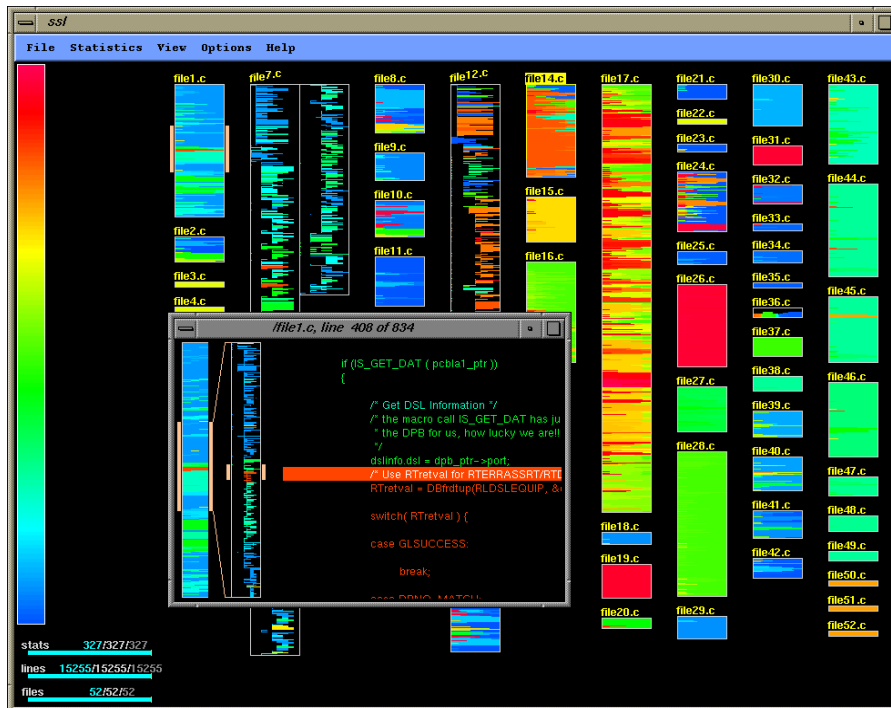
# Strategies for scalability



- 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





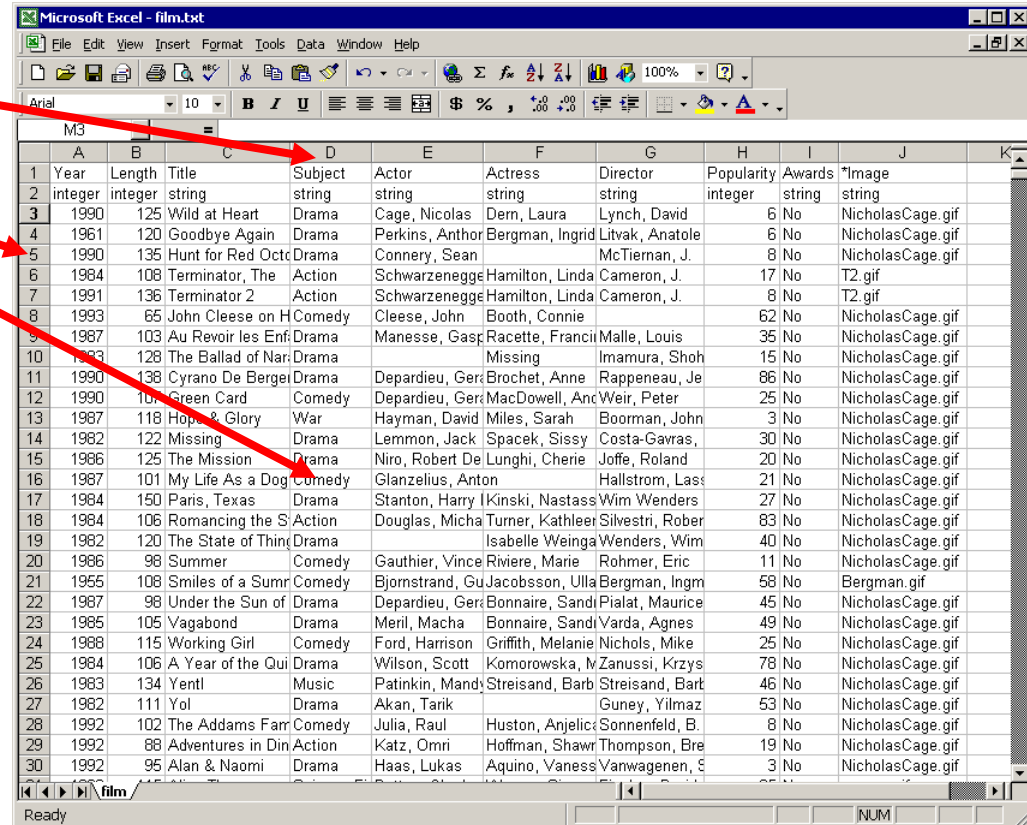
# Reduce the amount of data

- Example

- Reduce # attributes
- Reduce # items
- Reduce range of values

- Two ways

- Remove
- Grouping



Microsoft Excel - film.txt

	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, Francis	Malle, Louis	35	No	NicholasCage.gif
10	1983	128	The Ballad of Nar	Drama		Missing	Imamura, Sho	15	No	NicholasCage.gif
11	1990	138	Cyrano De Berget	Drama	Depardieu, Geri	Brochet, Anne	Rappeneau, Je	86	No	NicholasCage.gif
12	1990	104	Green Card	Comedy	Depardieu, Geri	MacDowell, Anc	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, Lasse	21	No	NicholasCage.gif
17	1984	150	Paris, Texas	Drama	Stanton, Harry	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, Ingma	58	No	Bergman.gif
22	1987	98	Under the Sun of	Drama	Depardieu, Geri	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, Mand	Streisand, Barb	Streisand, Bar	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, Anjelic	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, Vanessa	Vanwagenen, S	3	No	NicholasCage.gif

## Nutrient Contents – Parallel Coordinates

An interactive visualization of the [USDA Nutrient Database](#). For information on parallel coordinates, read this [tutorial](#).

Hide Ticks

Dark

Shadows

Opacity: 20%

### Per 100g of Food

Selected 1153 rows

Keep

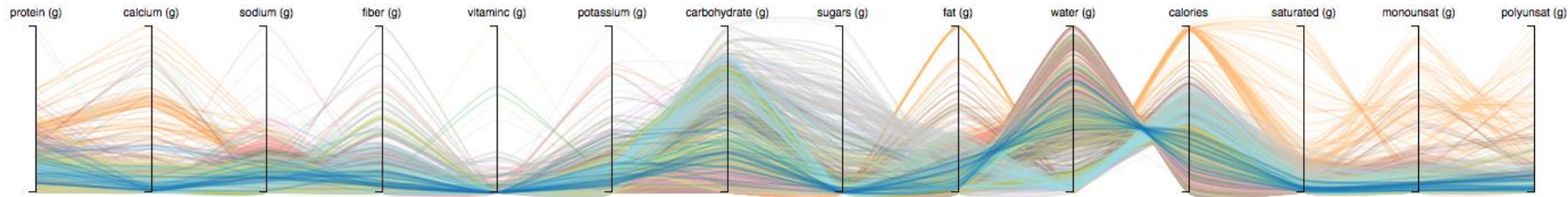
Remove

Export

Group Breakdown

Total Selected

Dairy and Egg Products Fats and Oils Poultry Products Soups, Sauces, and Gravies Vegetables and Vegetable Products Sausages and Luncheon Meats Breakfast Cereals  
Fruits and Fruit Juices Nut and Seed Products Beverages Finfish and Shellfish Products Legumes and Legume Products Baked Products Sweets Cereal Grains and Pasta  
Fast Foods Meals, Entrees, and Sidedishes Snacks Restaurant Foods

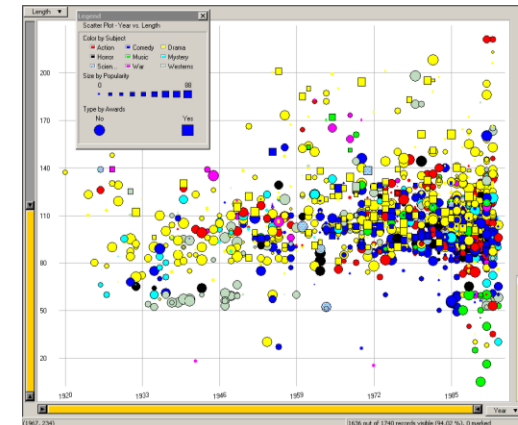
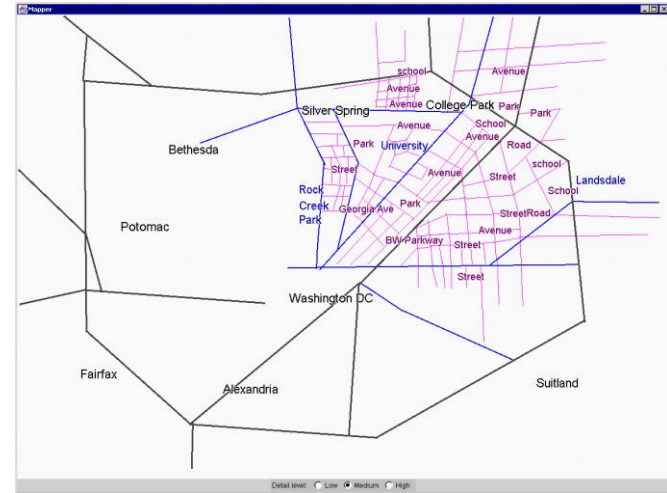


name	group	protein (g)	calcium ...	sodium ...	fiber (g)	vitaminc...	potassiu...	carbohy...	sugars (g)	fat (g)	water (g)	calories	satur...
utter oil, anhydrous	Dairy and Egg Products	0.28	0.004	0.002		0	0.005			99.48	0.24	876	61.92
utter, salted	Dairy and Egg Products	0.85	0.024	0.714		0	0.024	0.06	0.06	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/ pruning

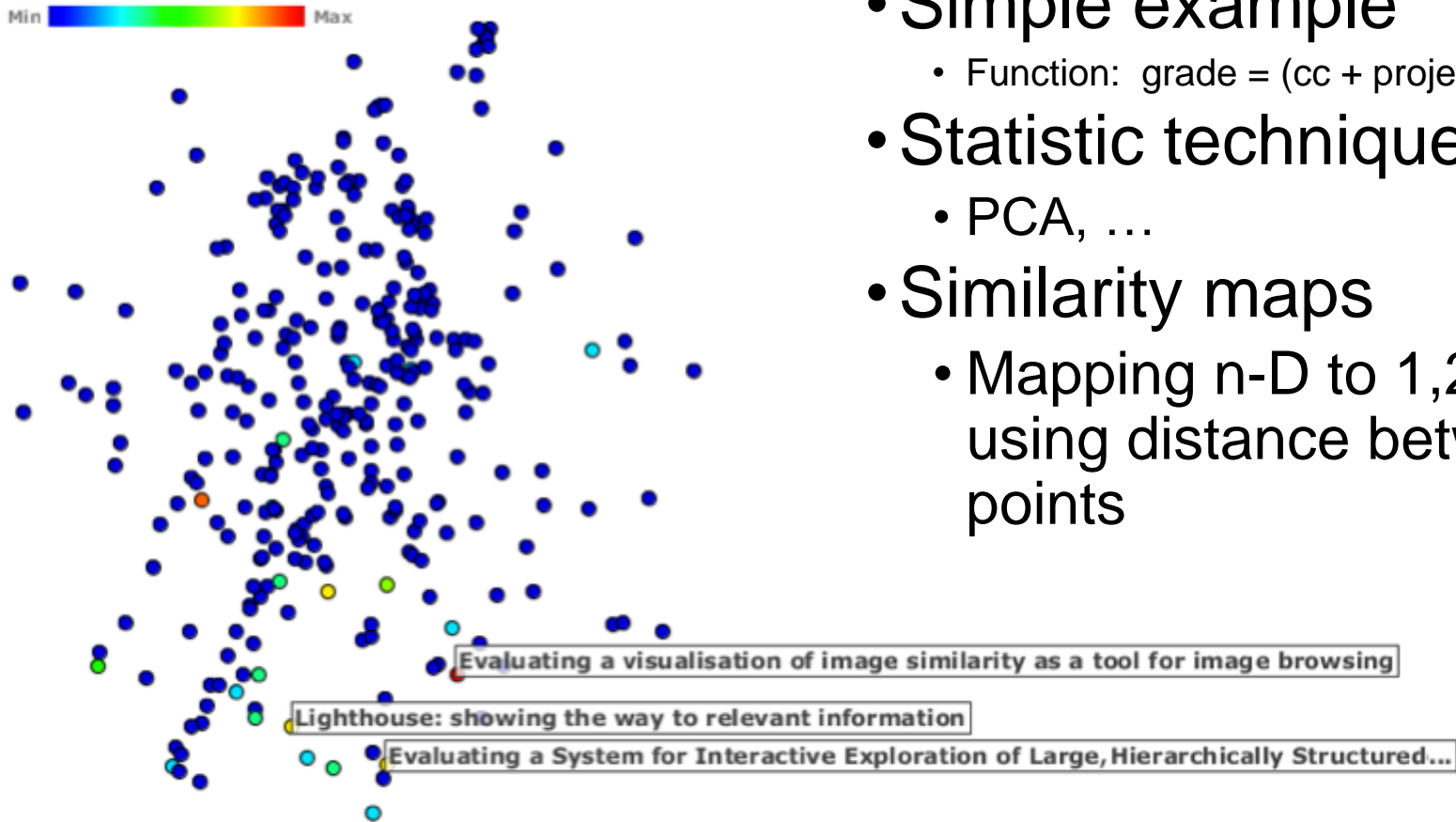
- Remove items
- Remove attributes
  - Scatterplots:
    - Select 2 or 3 attributes, ignore the others
  - Spotfire:
    - Use the query to select attributes
    - And show details on demand
- Problem: losing information



# 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:  $\text{grade} = (\text{cc} + \text{project}) / 2$
  - Statistic techniques
    - PCA, ...
  - Similarity maps
    - Mapping n-D to 1,2,3-D using distance between points

# Advanced Interaction Techniques

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

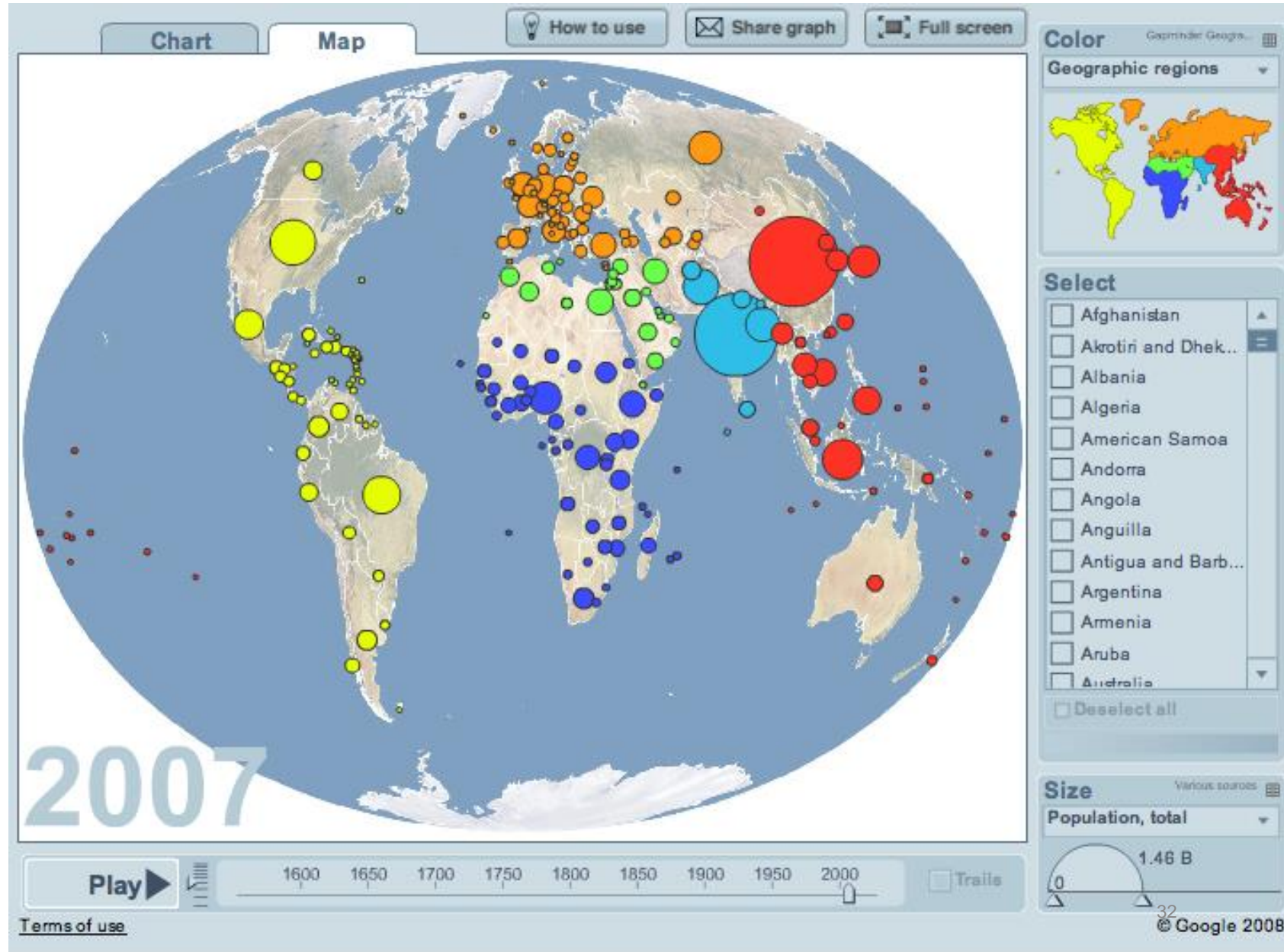
# Overview + Details

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



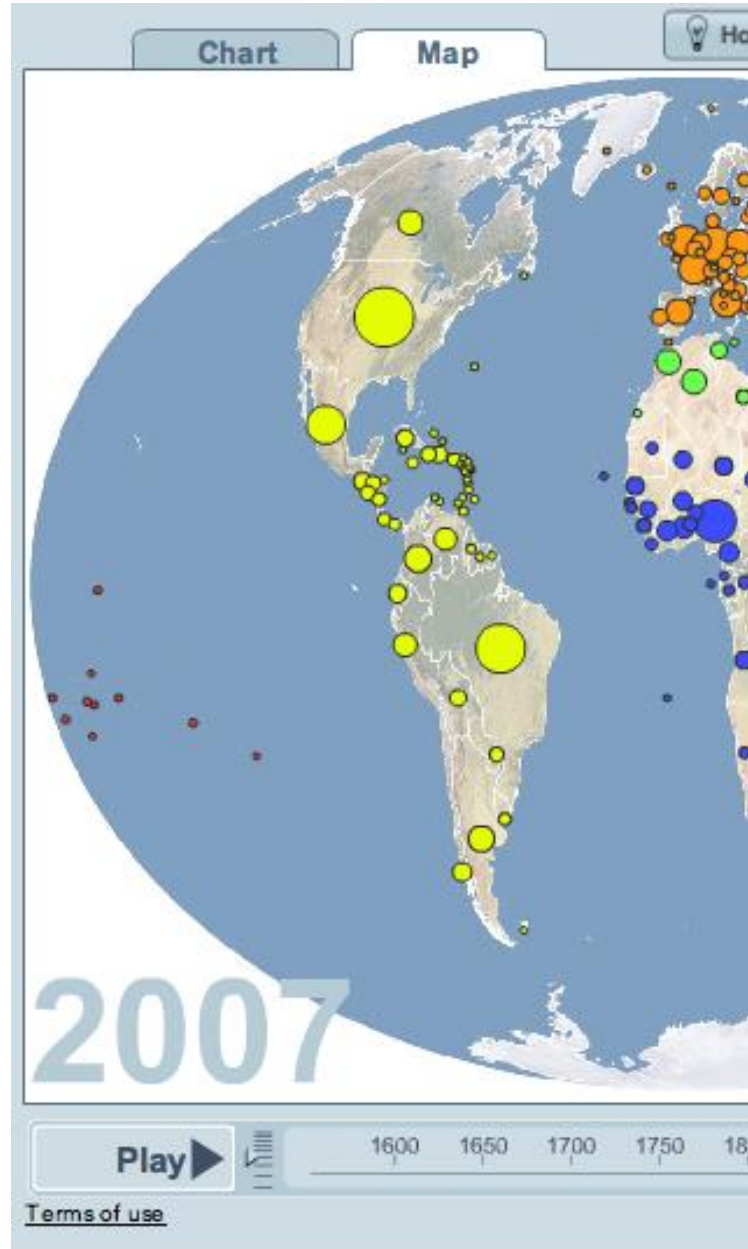
# Overview

<http://www.gapminder.org/>



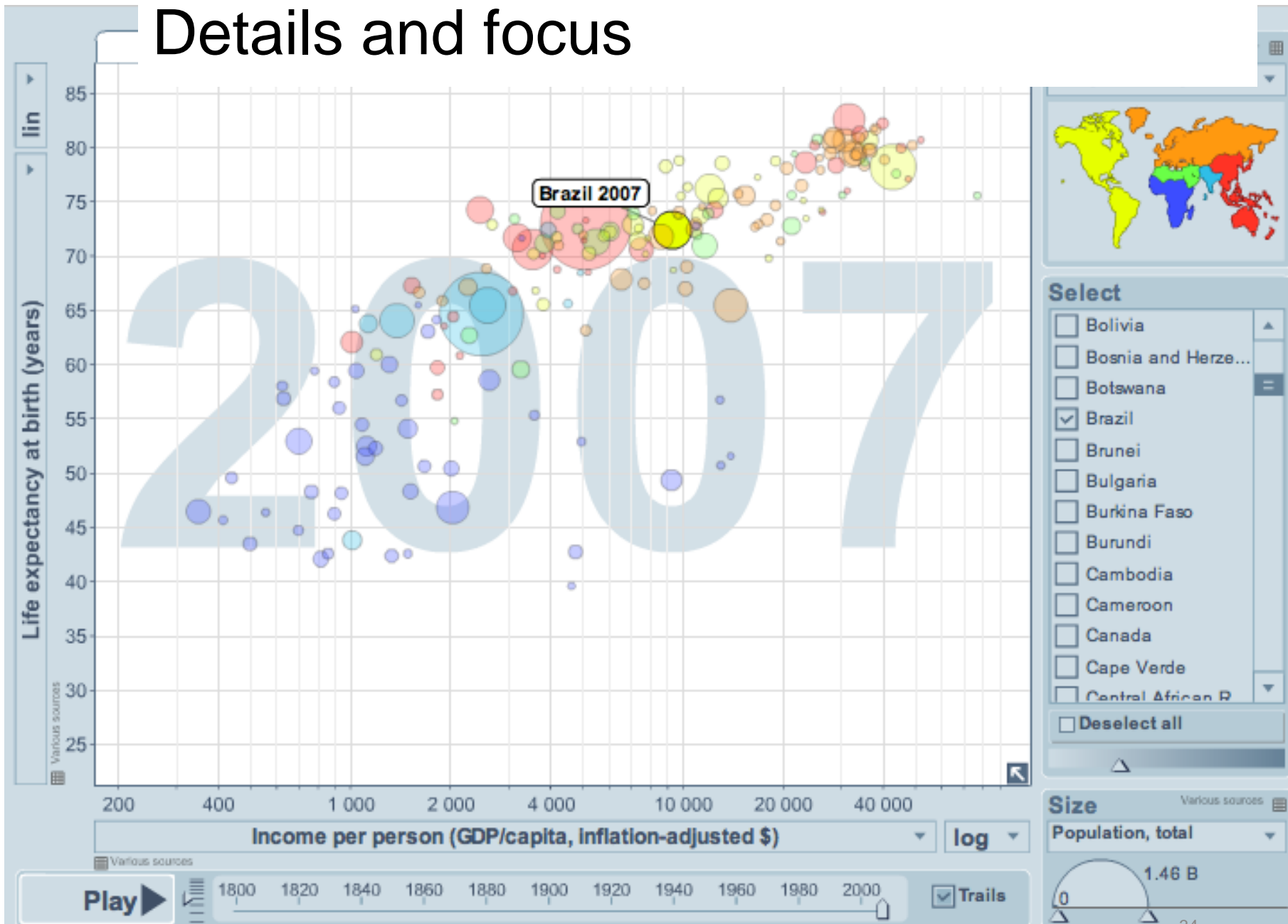


# Overview

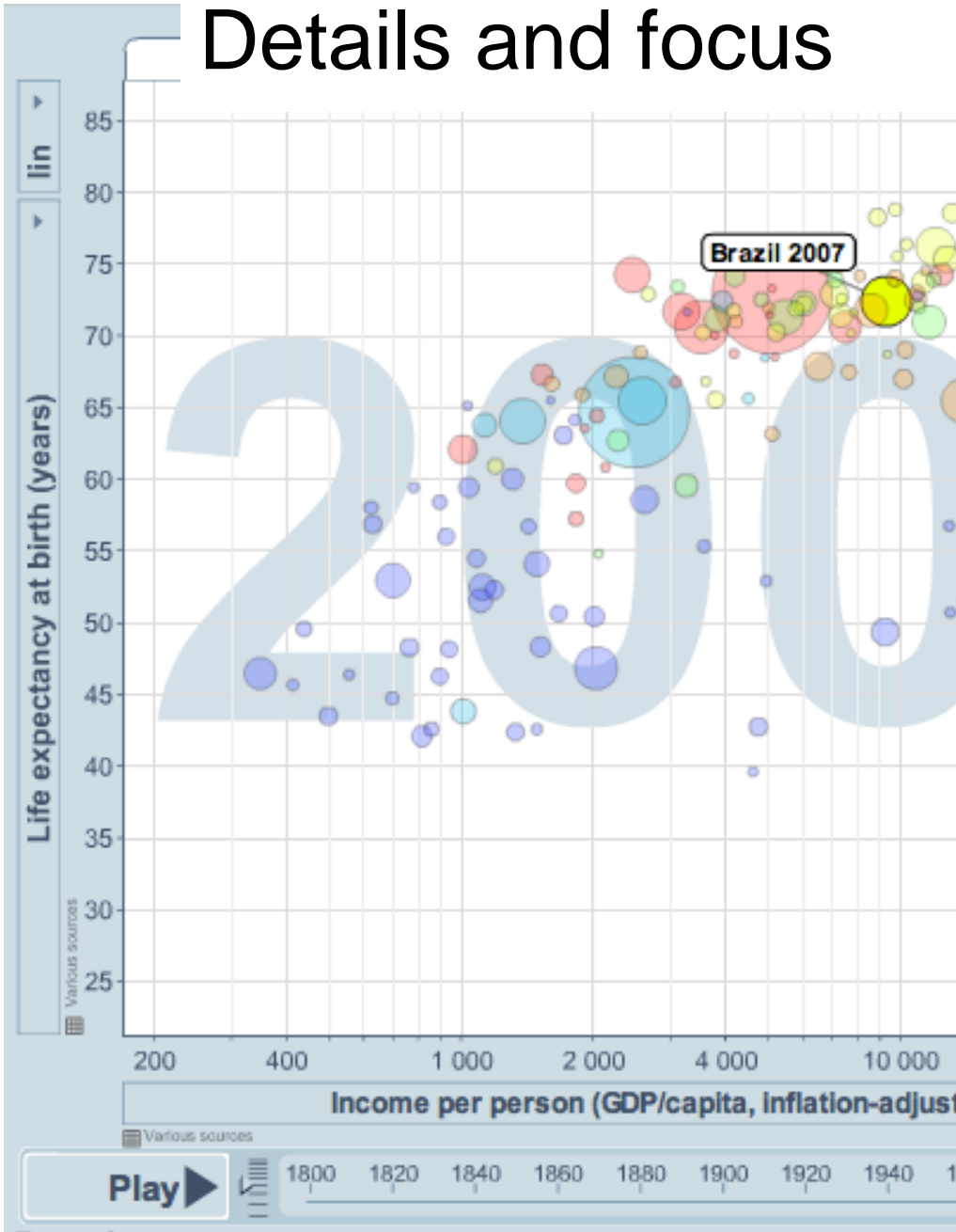


- It provides
  - Maps, spatial orientation
  - Contextual information, relationships
  - Which information is (or not) present in the display
- Detection of patterns
- Direct access
- Reduce searching process
- Enforce exploration, help to select the next move
- HCI metric – improve user performance,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

# Details and focus



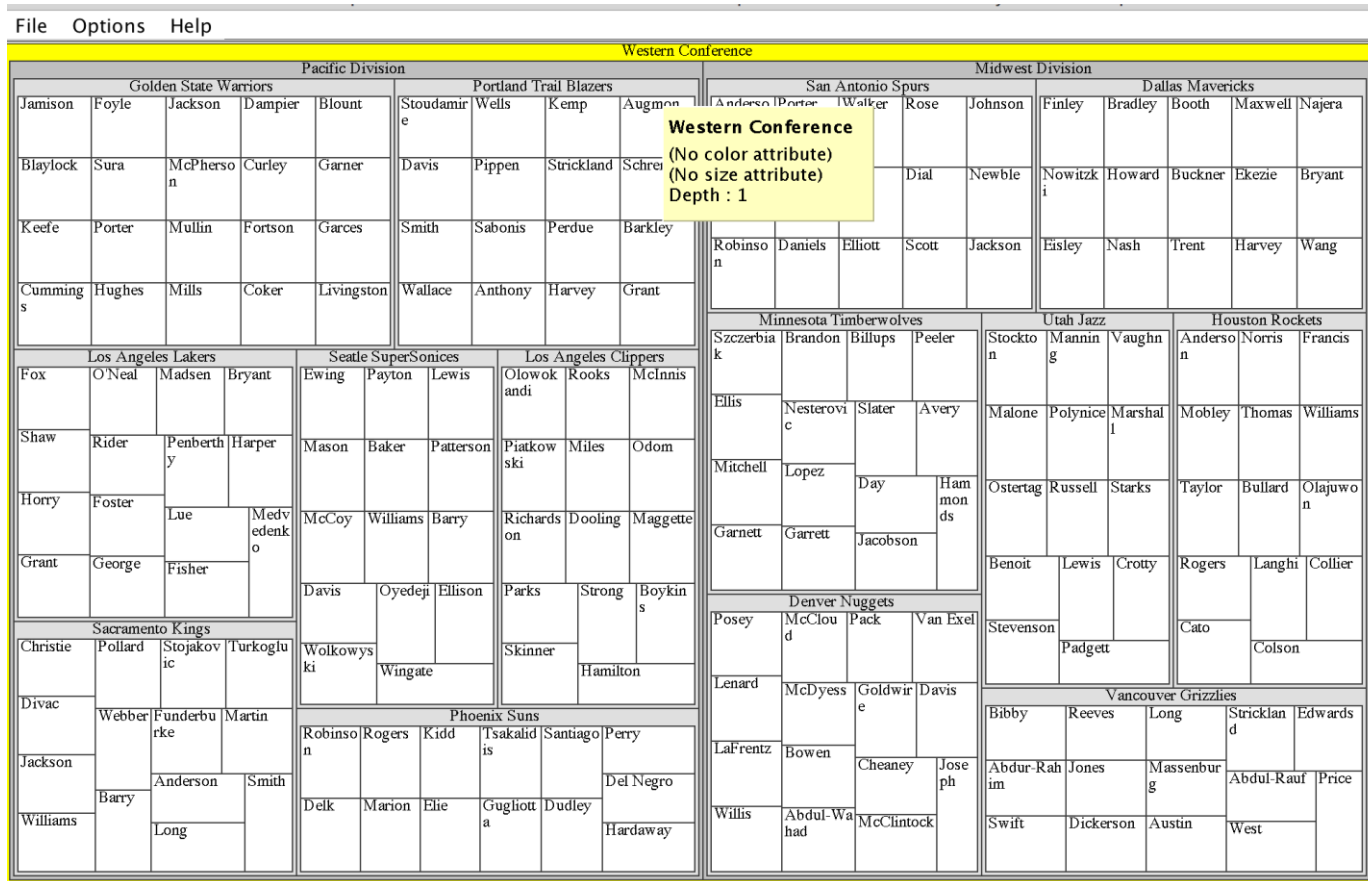
# Details and focus



- 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

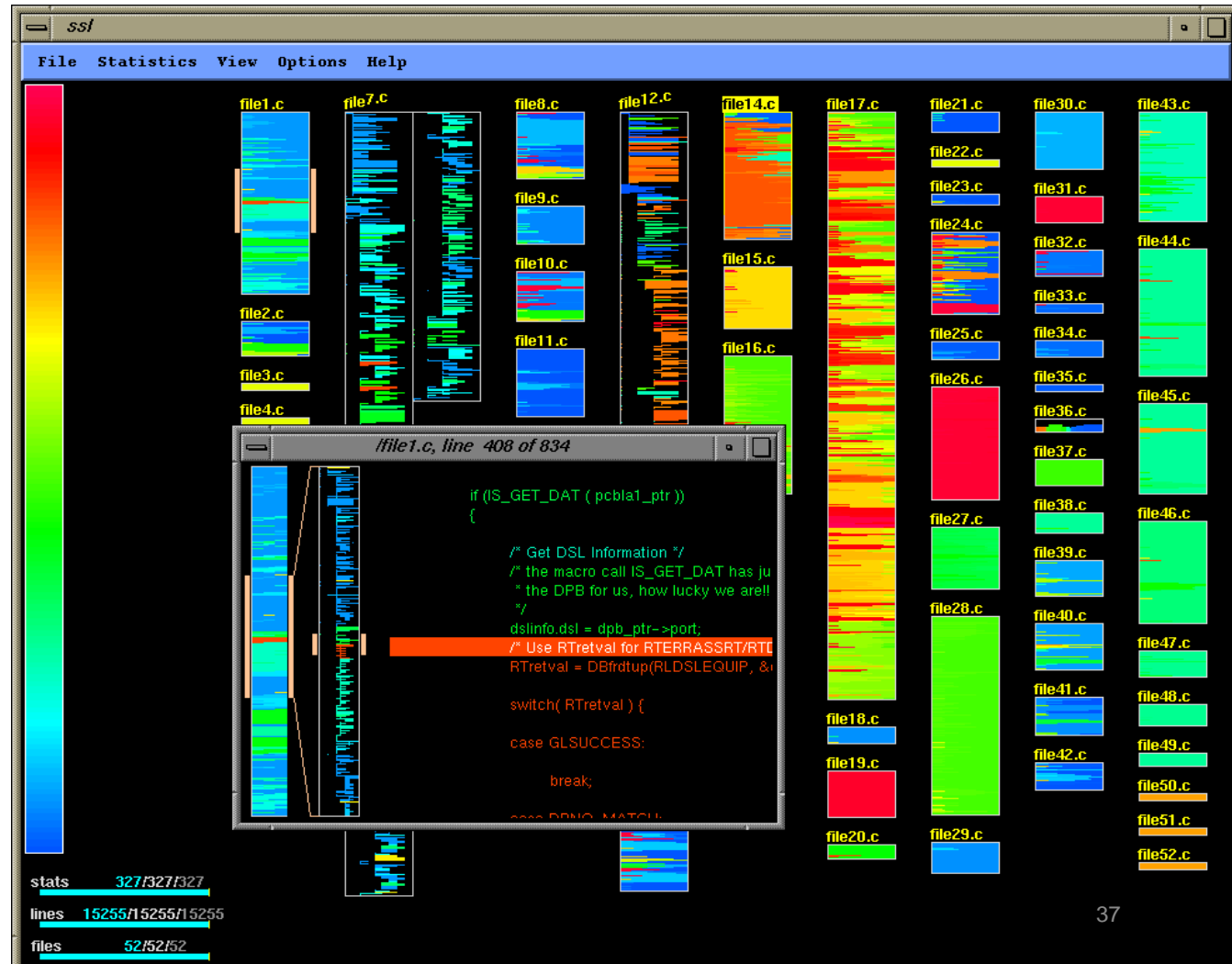
# Overview+Detail: Treemaps

- Treemaps: overview + detail (time separation)



# Overview+Detail: Seesoft

- Spatial separation



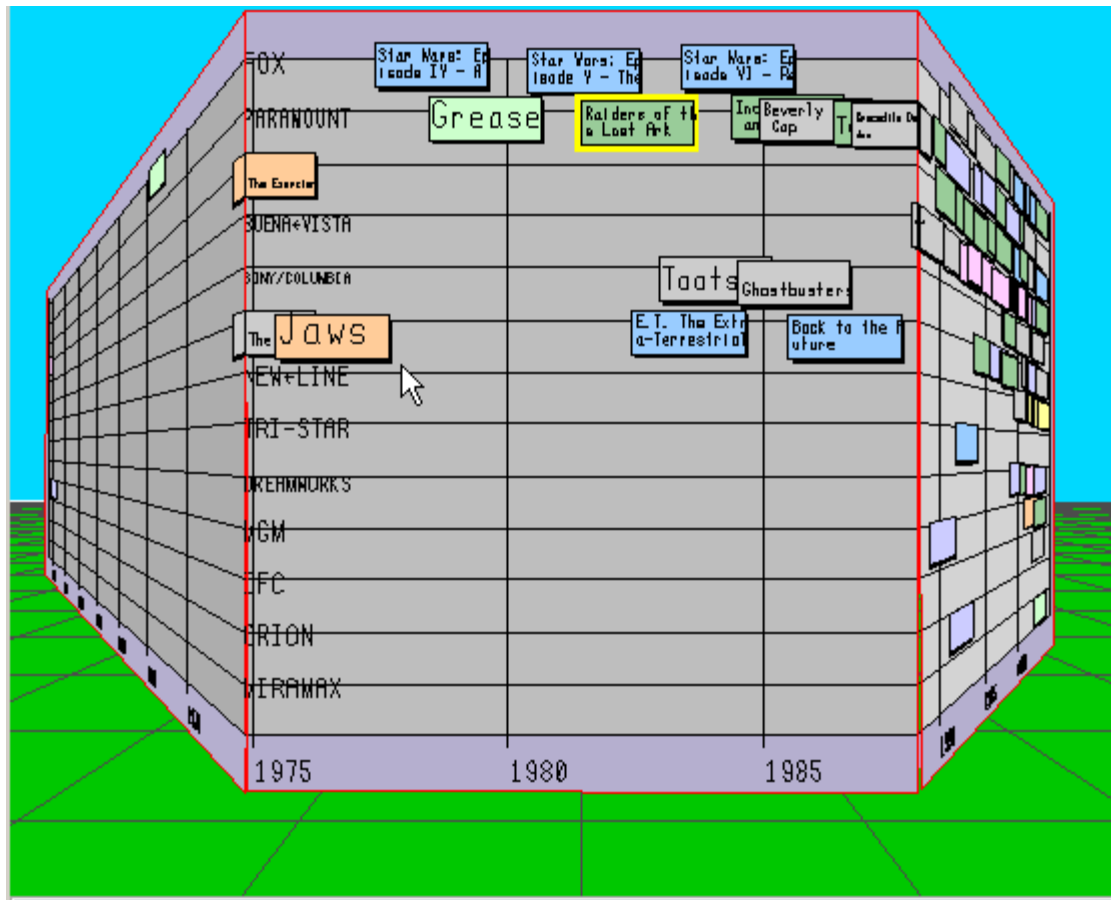
# Focus + Context

- A single view shows information in context
  - Contextual info is near to focal point
  - 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

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

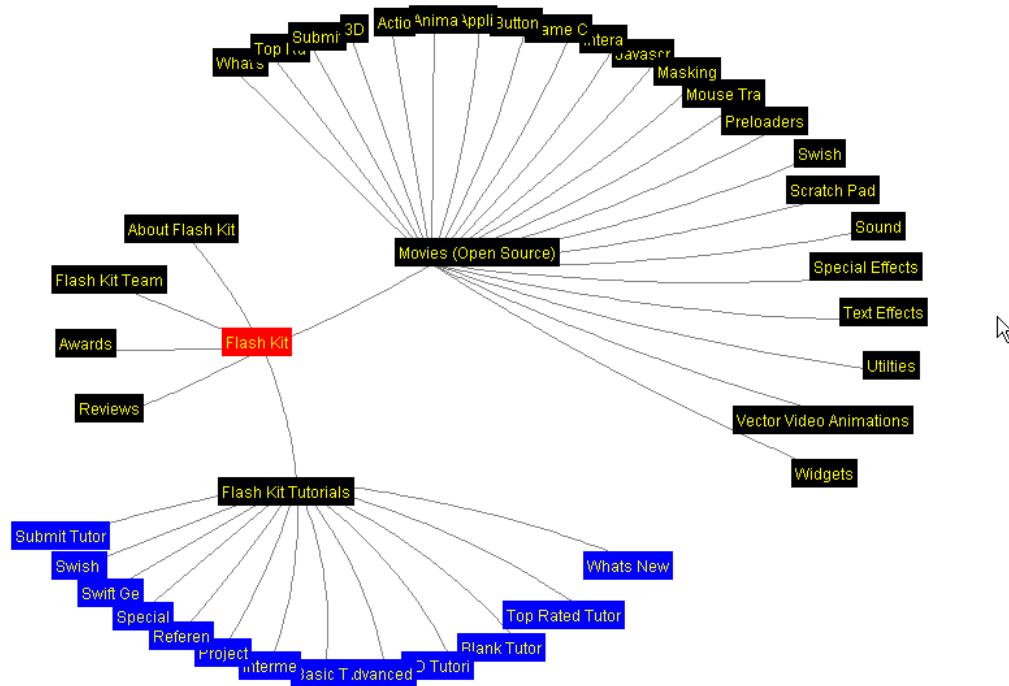


# Focus + Context (+ Distortion): Perspective Wall from PARC/Inxight





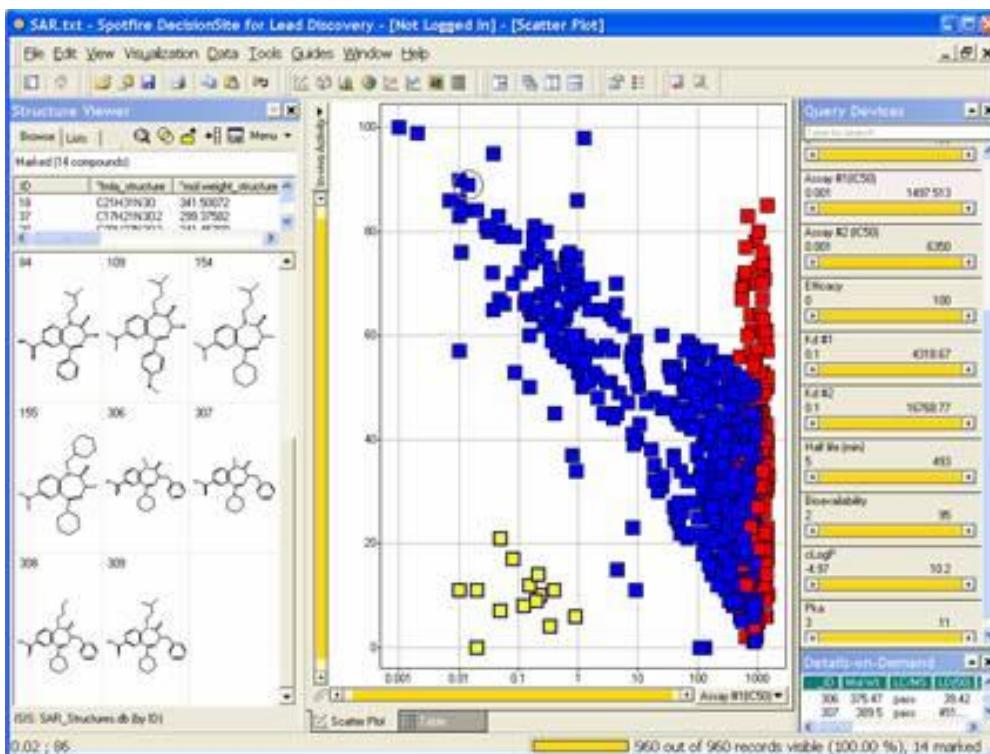
# Focus + Context: Hyperbolic Tree from PARC/Inxight



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

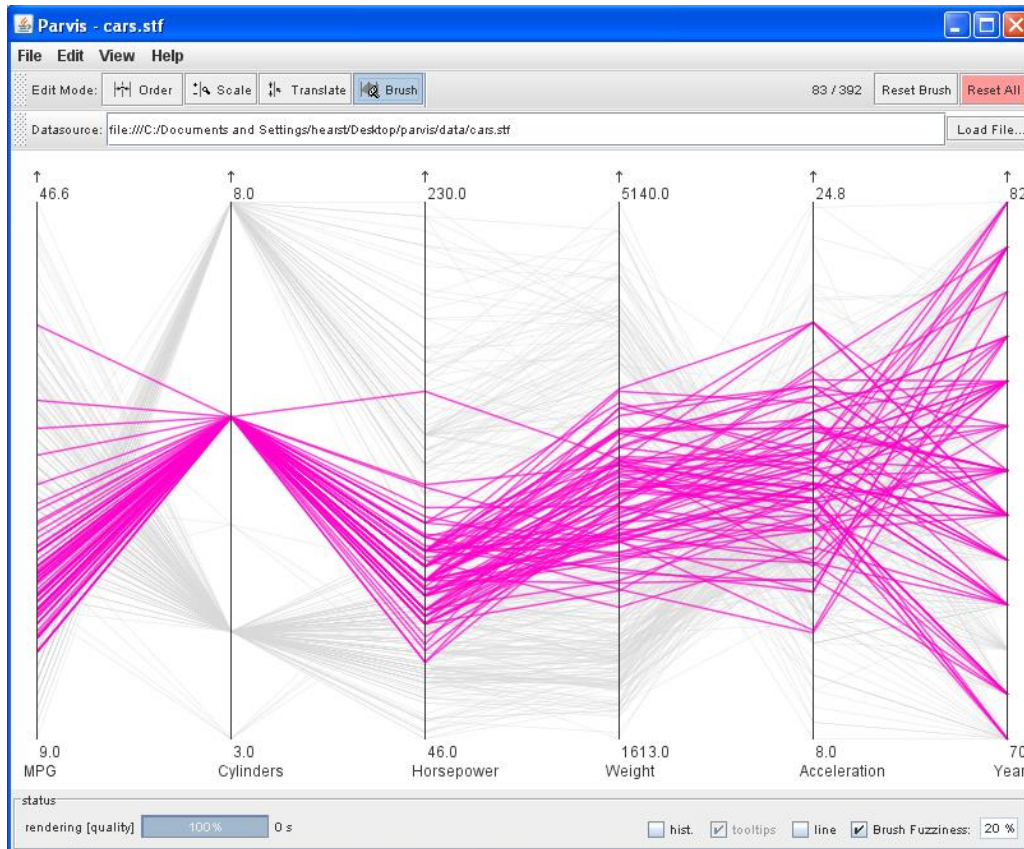
# Highlighting / Brushing and Linking / Dynamic Queries

- Spotfire, by Ahlberg & Shneiderman
  - [http://hcil.cs.umd.edu/video/1994/1994\\_visualinfo.mpg](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?

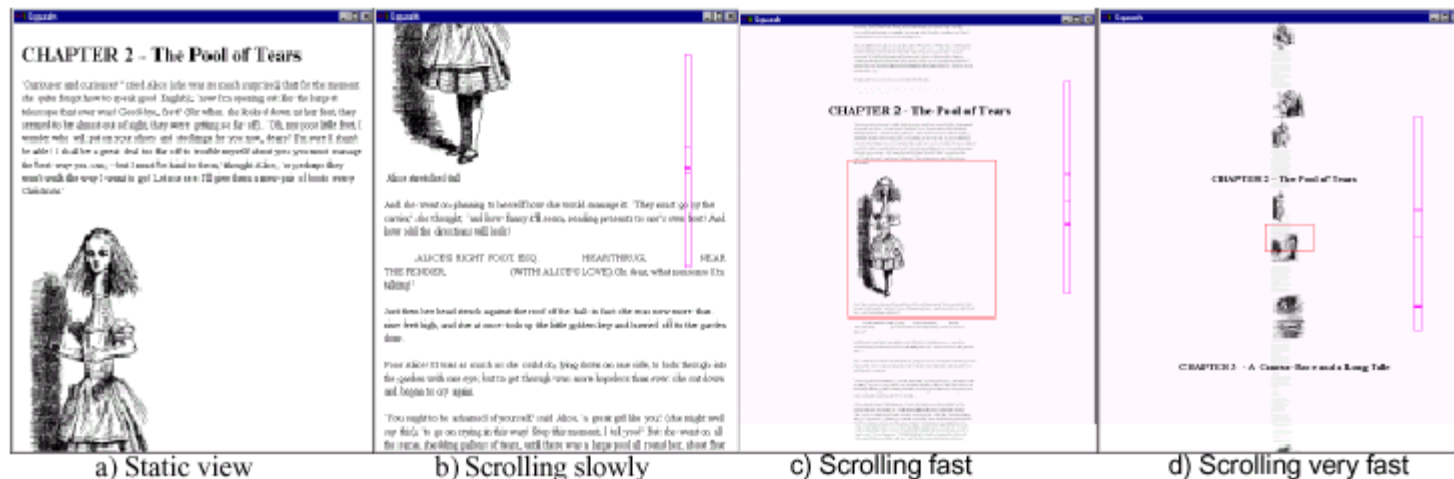
- Multiple Levels of Resolution
  - The view changes depending on the “distance” from the viewer to the objects
- Distortion-based techniques
  - Keep a steady overview, make some objects larger while simultaneously shrinking others

# 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
  - 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](http://hcil.cs.umd.edu/video/1998/1998_pad.mpg)

# Speed-dependent Zooming

by Igarashi & Hinkley 2000



<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

- Information Maps
  - 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
- Browsing an information service
  - Charge user successively higher rates for successively more detailed information

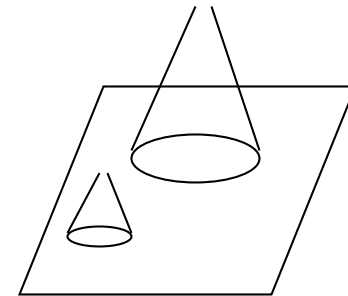
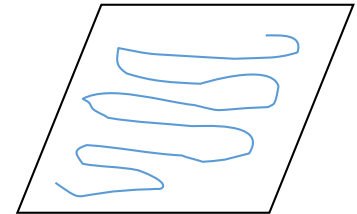


# Examples of Semantic Zoom

- 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](http://hcil.cs.umd.edu/video/1998/1998_pad.mpg)



# Pad++ Tour

start...

Zooming in Pad++ is just as easy as zooming out. Press the left mouse button down, then move the mouse around whilst the mouse button is held down. The red pointer is placed as you move the mouse. Release the mouse to stop panning. Try it now - make sure that you know where your place is in the tour.

You can zoom in Pad++ using the mouse. For example, move the pointer to the centre of this page. Now press the middle mouse button, hold it down briefly and then release it. You zoom in. (If your system doesn't have a middle mouse button, try pressing the right mouse button with the Alt or Meta modifier held down.) To unzoom the program, briefly press and hold down this middle mouse button, then release it. The system zooms out again.

Pad++ Tour  
Jonathan Meyer  
12 Nov 1994  
Welcome to Pad++.  
Pad++ is a new interactive metaphor which supports the implementation of "multiple interfaces". That is, interfaces in which zooming is a fundamental part of the system. Navigation in Pad++ is done by panning and zooming around an information space.  
(Click on the button marked "next" to continue to the next page in the tour).

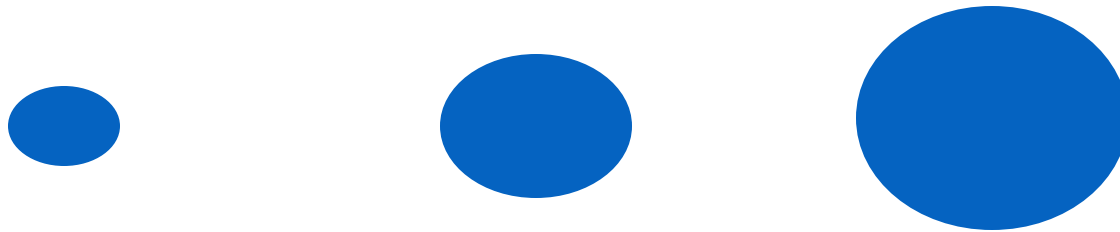
This page contains a rectangle:



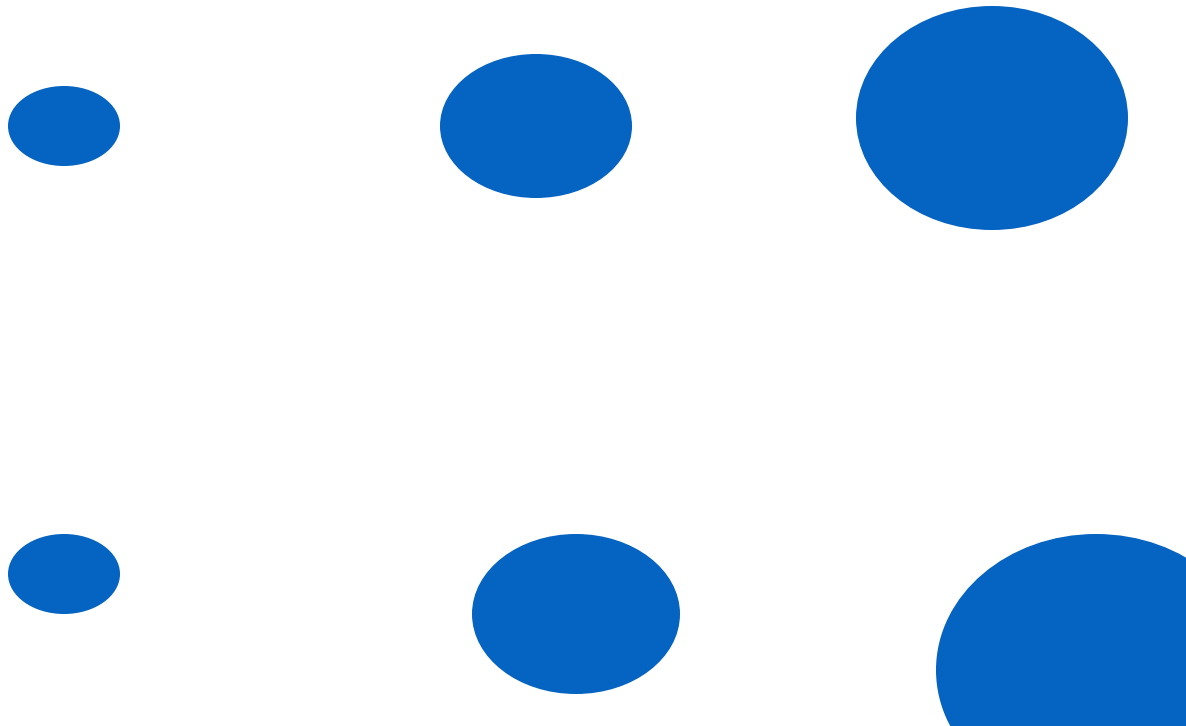
next

Pad++ Tour

# How to Pan While Zooming?

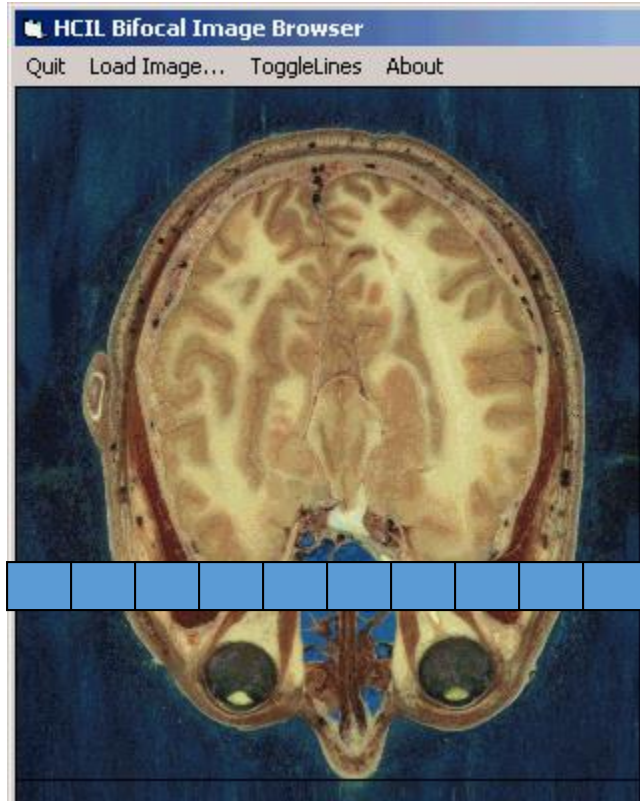


# How to Pan While Zooming?

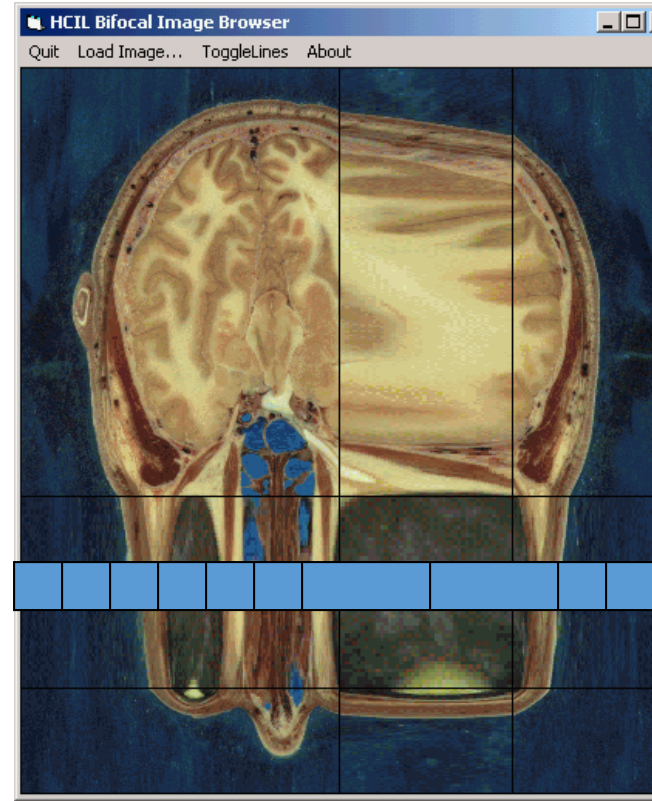
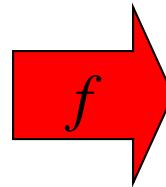


# Distortion

- Mapping the information to a surface of exhibition

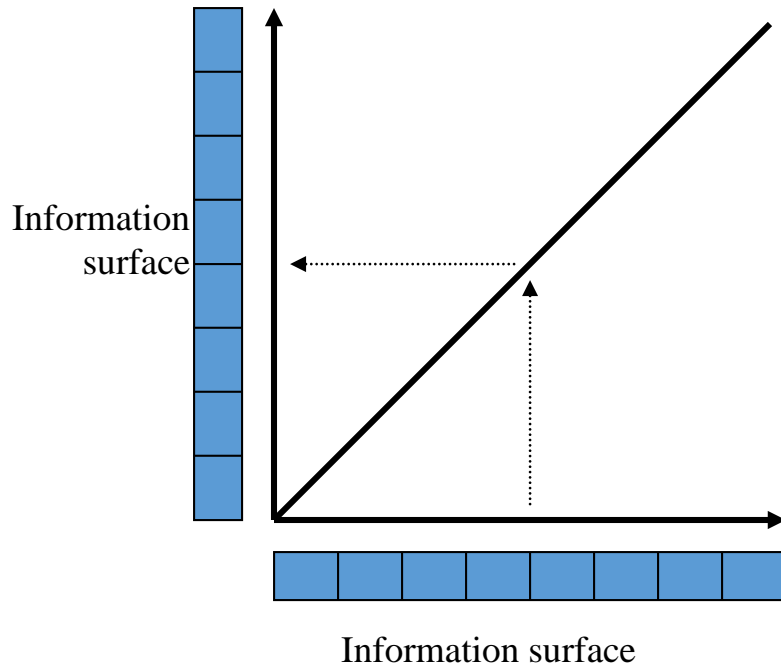


Information surface

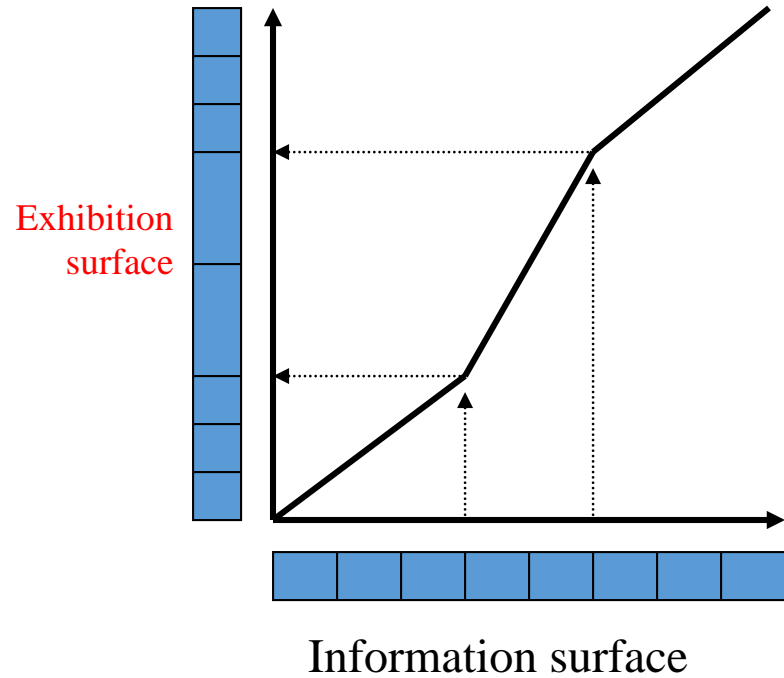


Exhibition surface

# Mapping function



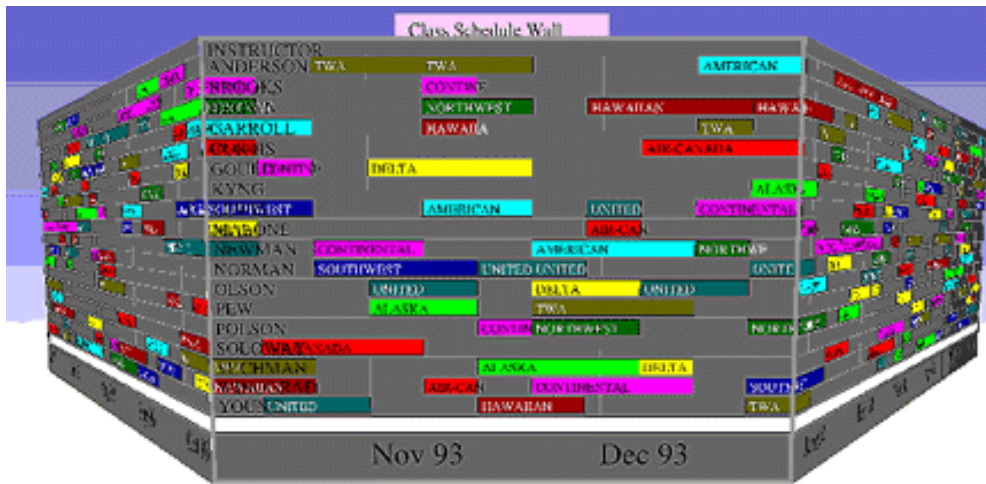
Identity function =  
normal overview



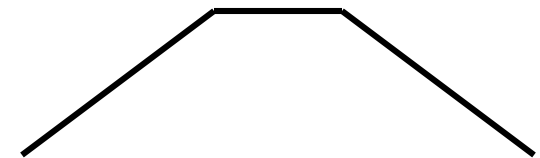
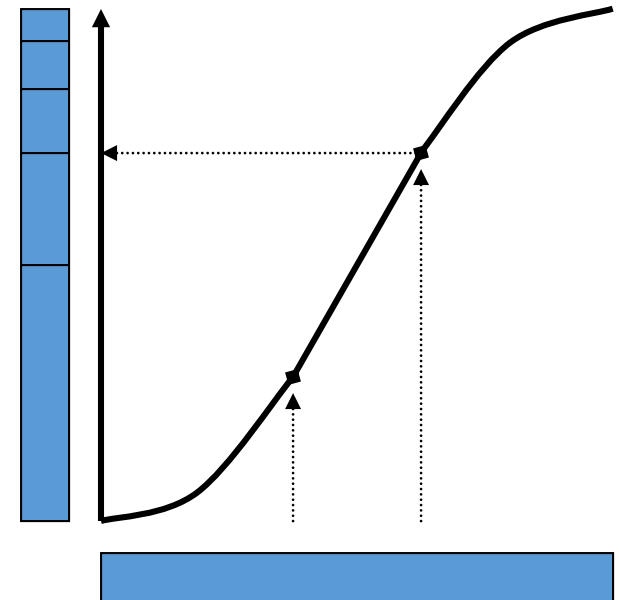
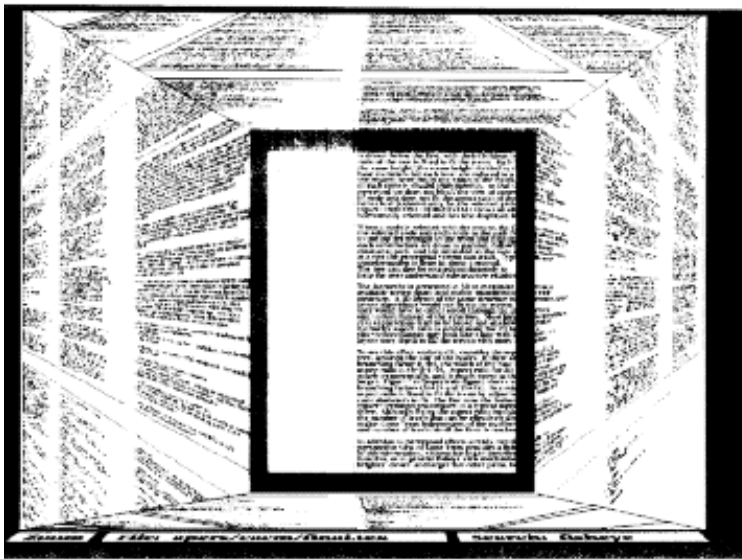
Bifocal

# Perspective Wall / Document Lens

Contexto diminuir gradualmente



inlight

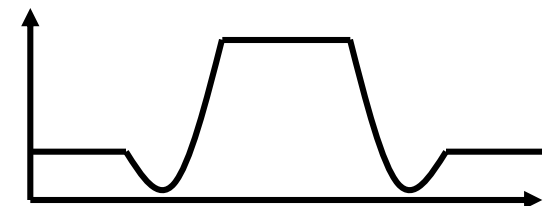
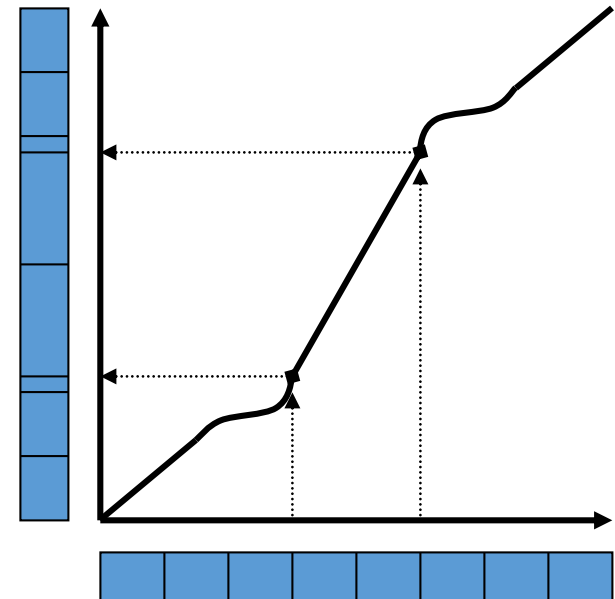
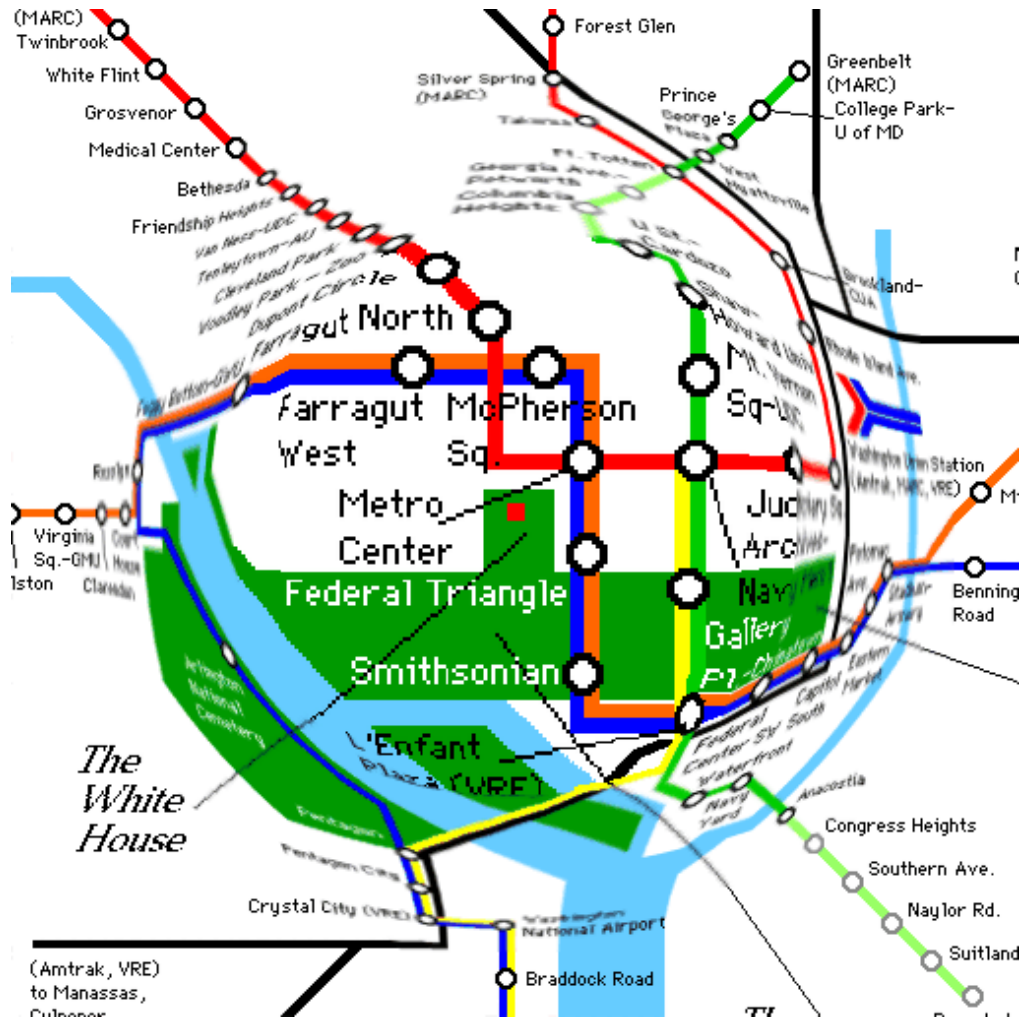


Perspective



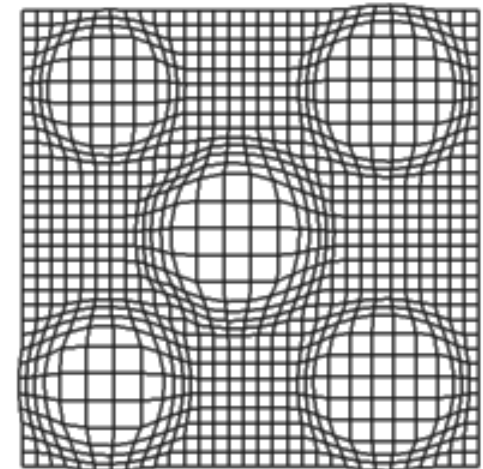
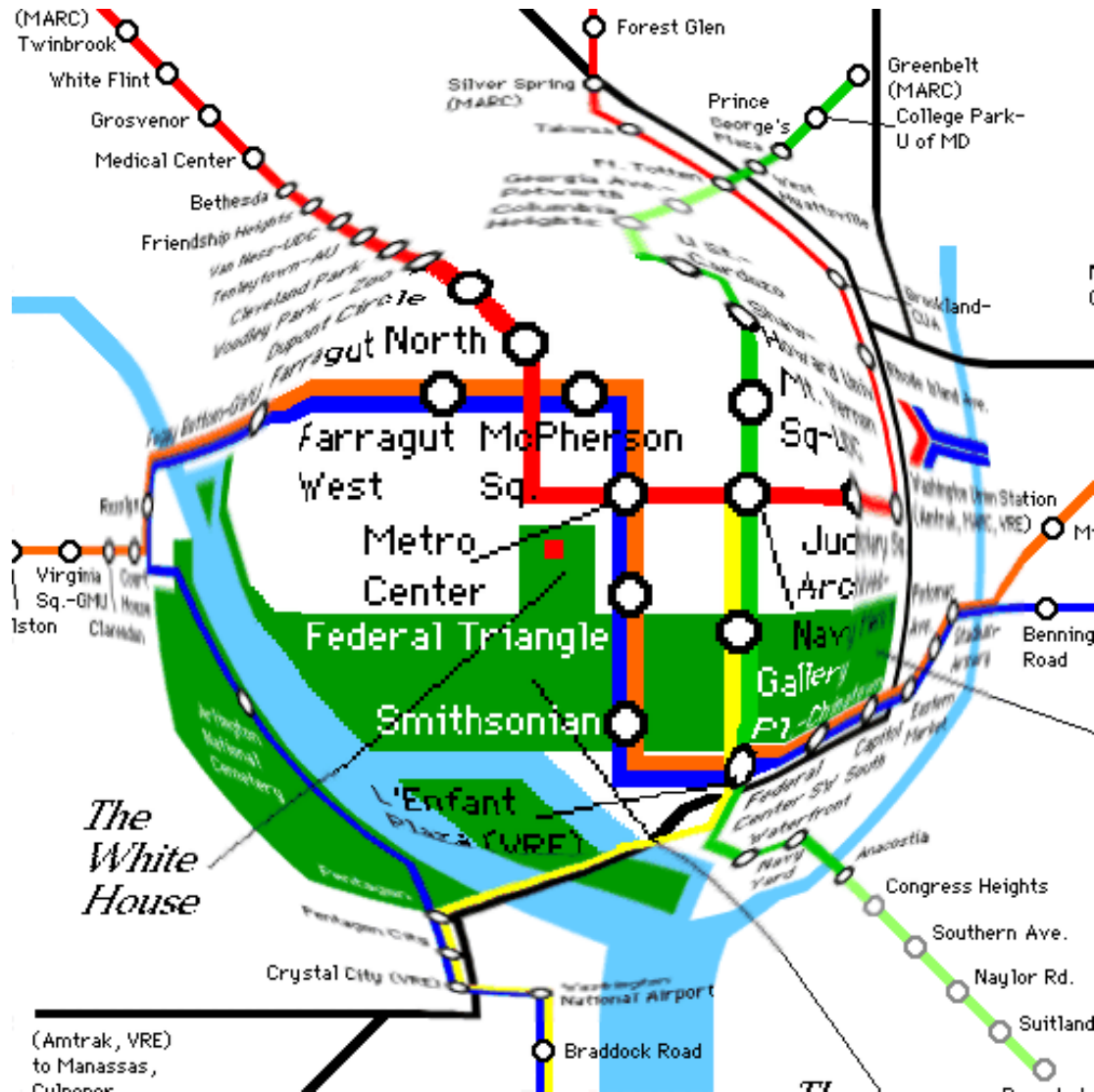
# “Bubble”

Inconvenient: local context is smaller



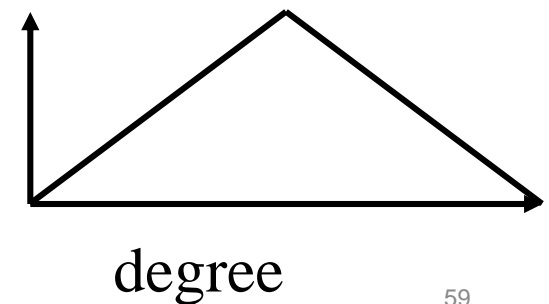
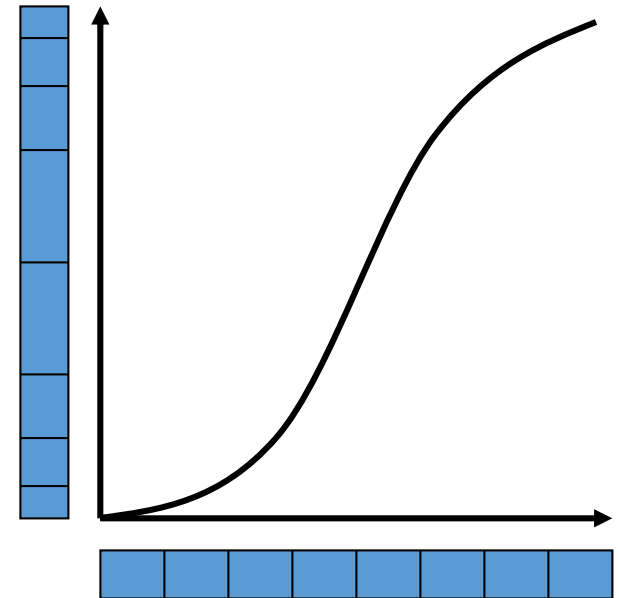
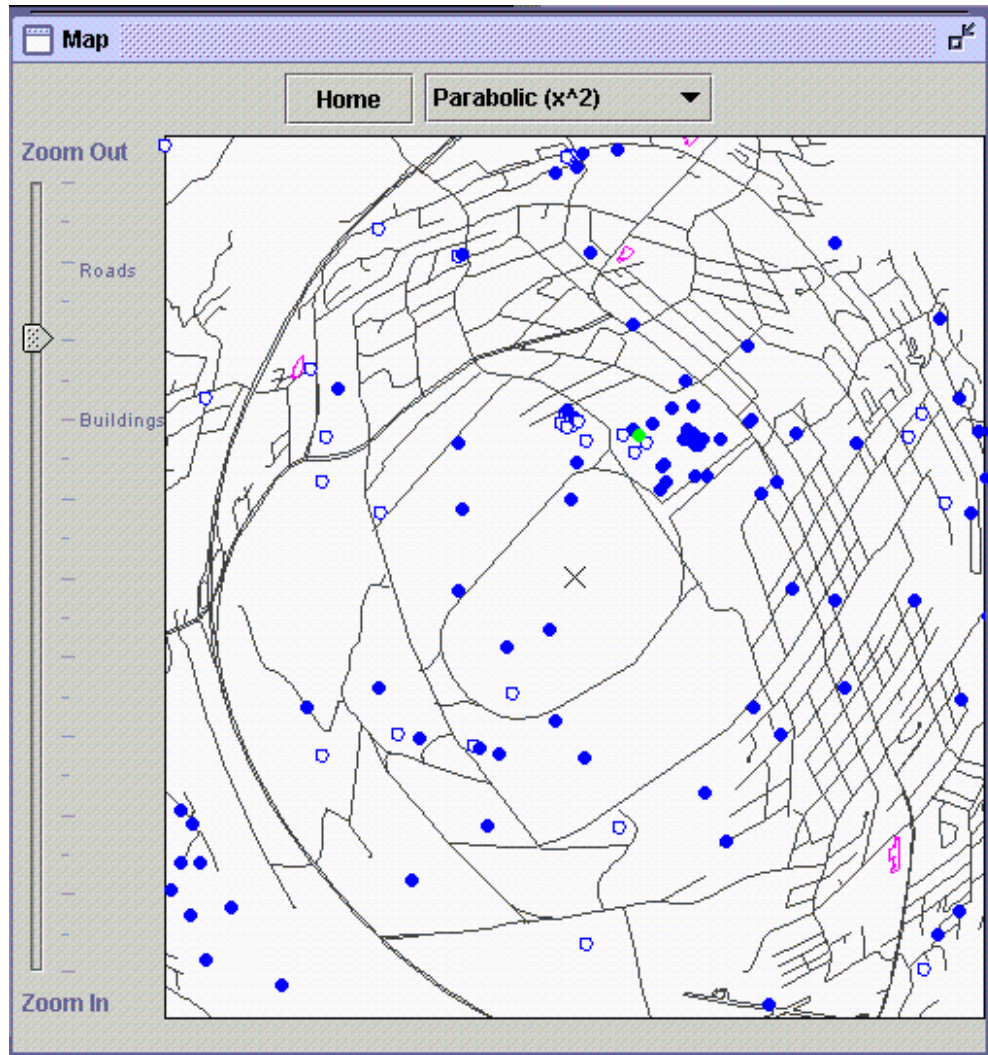
Bubble

# Non linear



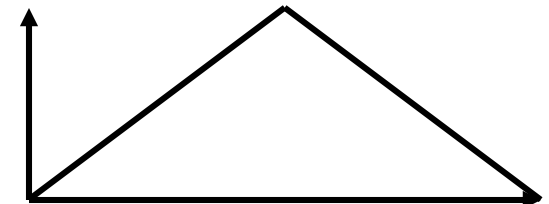
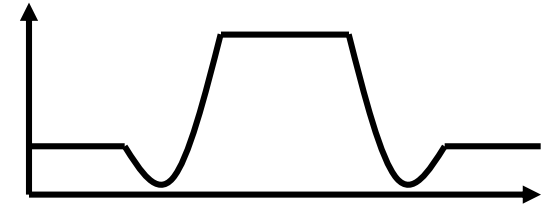
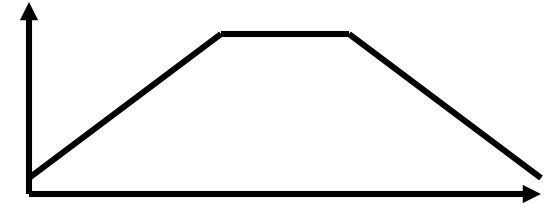
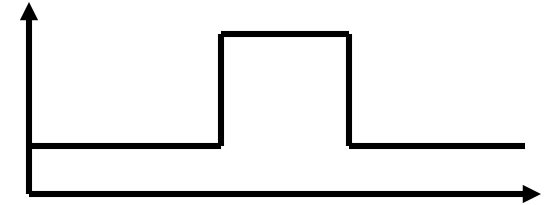
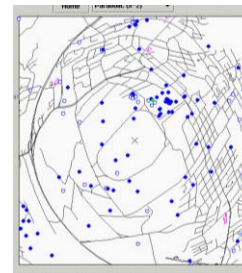
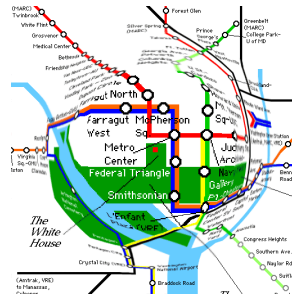
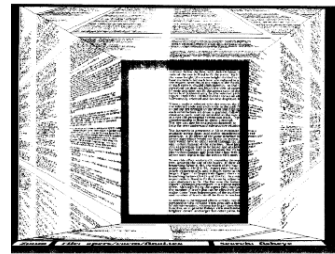
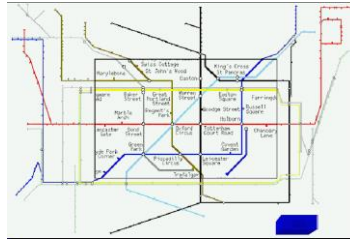
# “Fisheye”, “wide-angle lens”

Inconvenient: don't have a plain area



# 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
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