VISUALIZATION

Tasks & Interactions

Tasks

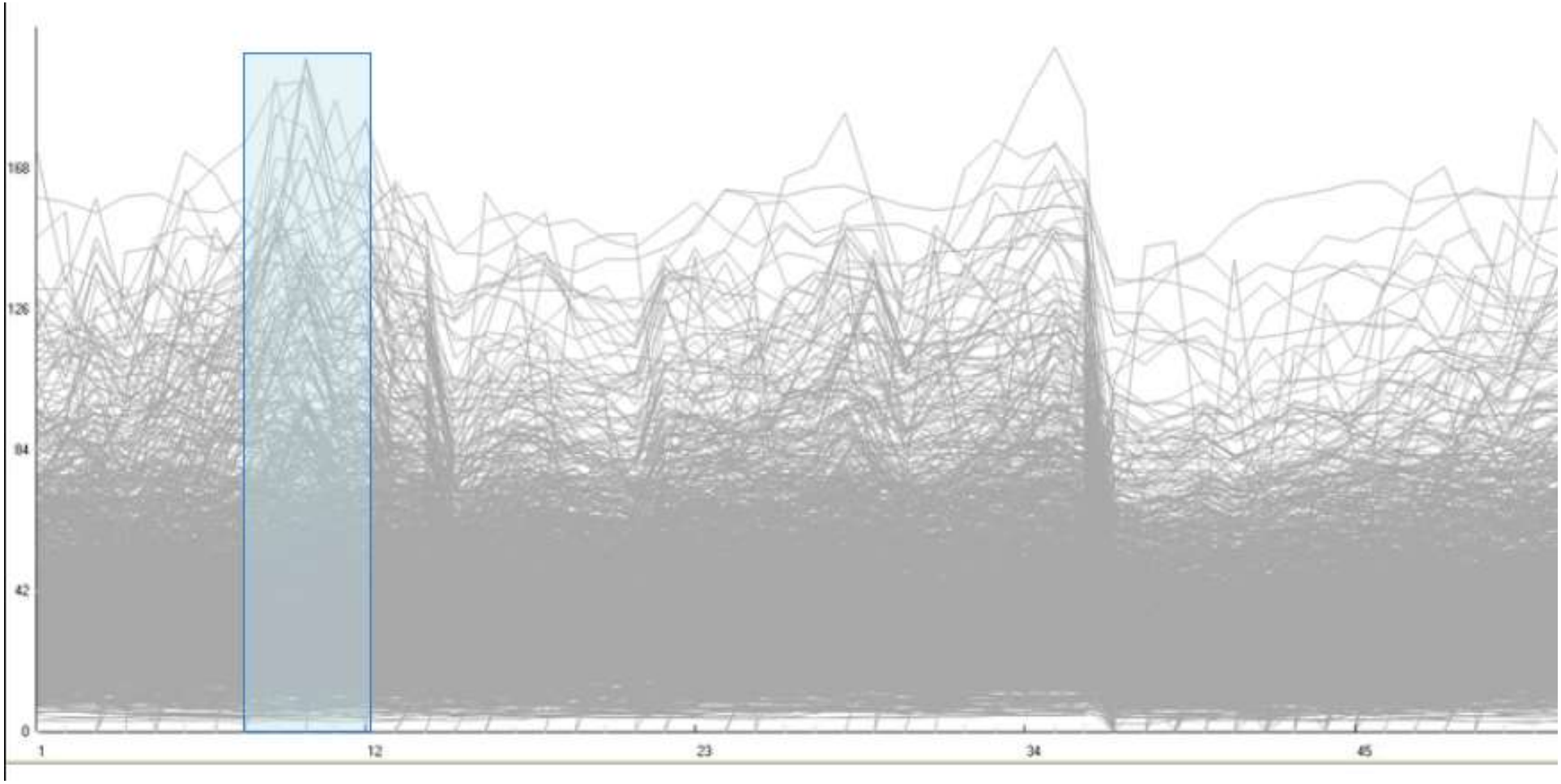
- In order to build better visualizations, we need to understand what people might use them for.
- What tasks do they want to accomplish?

Analytical Tasks

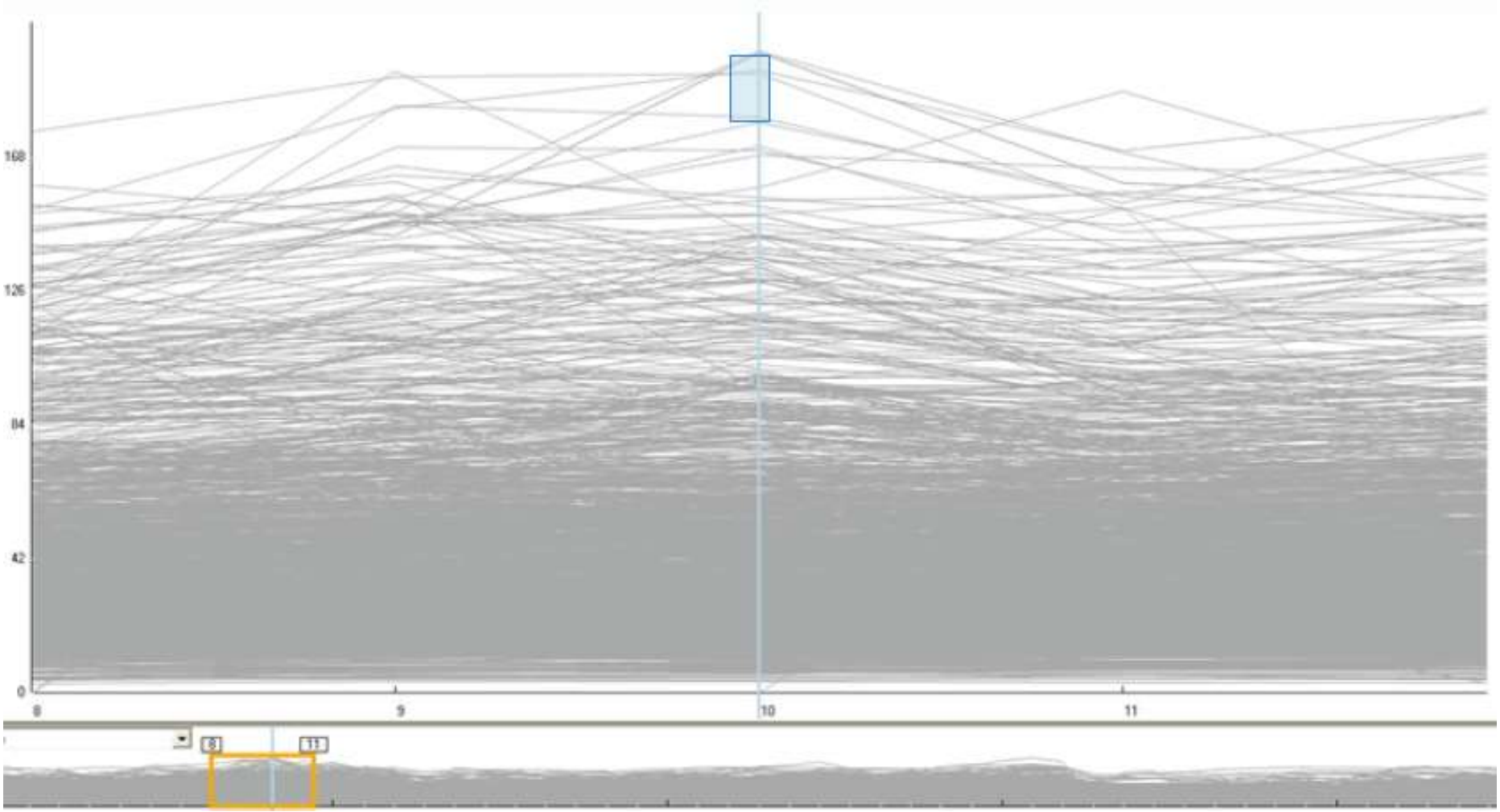
1. **Overview:** Gain an overview of the entire collection
2. **Zoom :** Zoom in on items of interest
3. **Filter:** Filter out uninteresting items
4. **Details-on-demand:** Select an item or group and get details when needed
5. **Relate:** View relationships among items
6. **History:** Keep a history of actions to support undo, replay, and progressive refinement
7. **Extract:** Allow extraction of sub-collections and of the query parameters

- Shneiderman, 1996
-

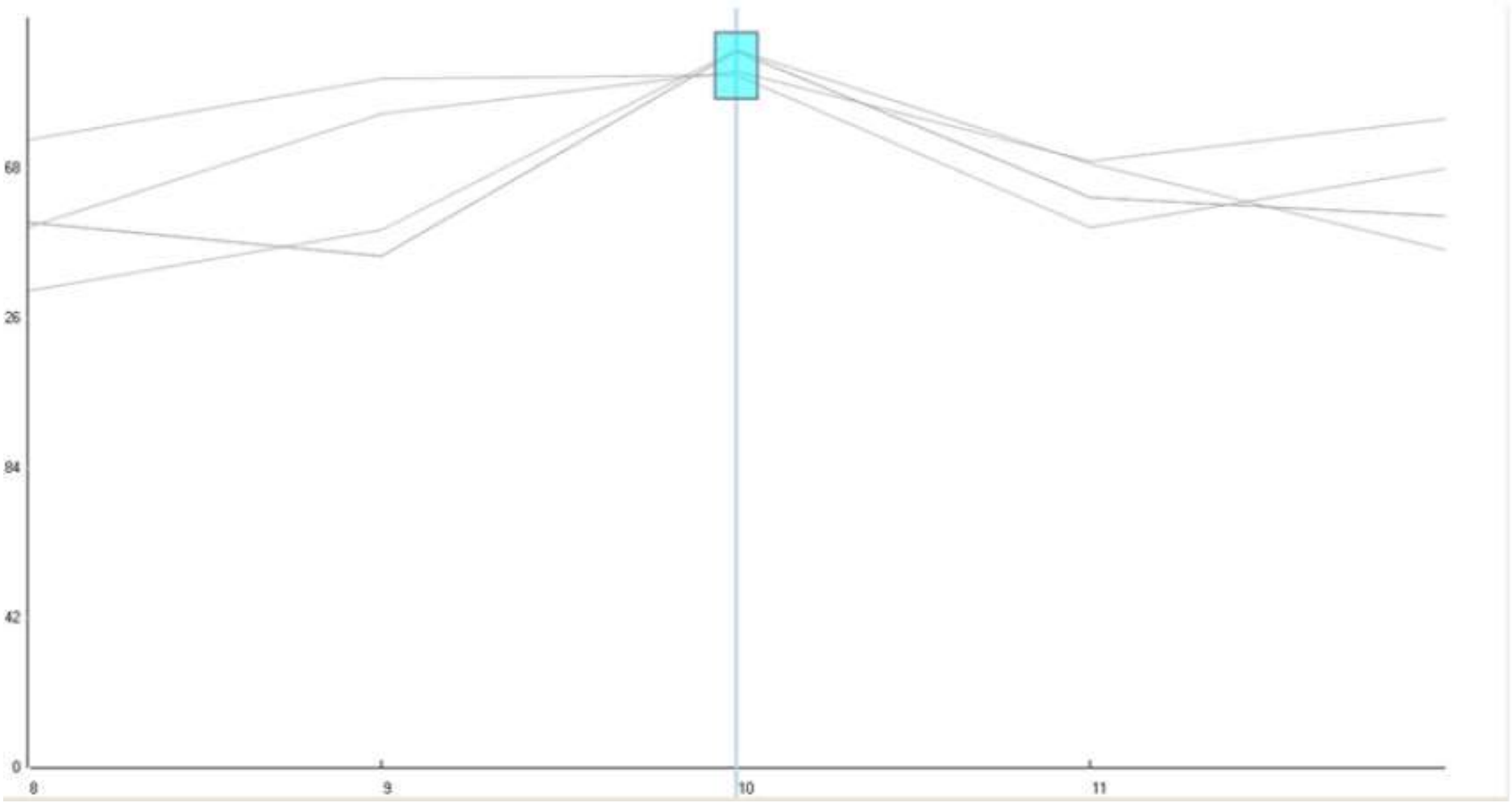
Overview



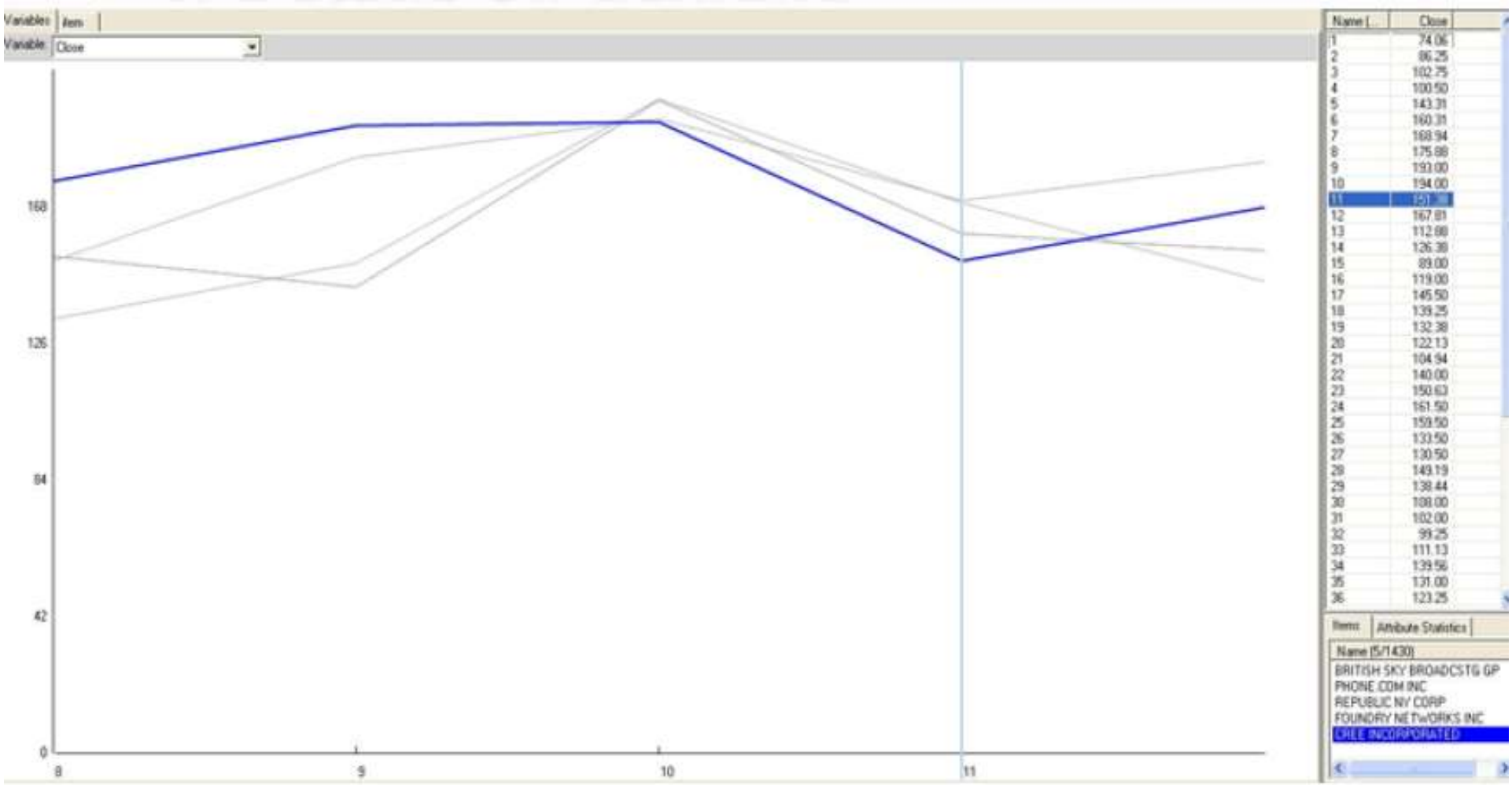
Zoom & Filter



Zoom & Filter



Details on Demand



Analytical Tasks

1. **Retrieve Value**
2. **Filter**
3. **Compute Derived Value**
4. **Find Extremum**
5. **Sort**
6. **Determine Range**
7. **Characterize Distribution**
8. **Find Anomalies**
9. **Cluster**
10. **Correlate**

- Amar, Eagan and Stasko, 2005

Retrieve Value

- General Description: Given a set of specific cases, find attributes of those cases.

- Examples:
  - What is the mileage per gallon of the Audi TT?
  - How long is the movie Gone with the Wind?

Filter

- General Description: Given some concrete conditions on attribute values, find data cases satisfying those conditions.

- Examples:
  - What Kellogg's cereals have high fiber?
  - What comedies have won awards?
  - Which funds underperformed the last one year?

Compute Derived Value

- General Description: Given a set of data cases, compute an aggregate numeric representation of those data cases.

- Examples:
  - What is the gross income of all stores combined?
  - How many manufacturers of cars are there?
  - What is the average calorie content of Post cereals?

Find Extremum

- General Description: Find data cases possessing an extreme value of an attribute over its range within the data set.

- Examples:
  - What is the car with the highest MPG?
  - What director/film has won the most awards?
  - What Robin Williams film has the most recent release date?

Sort

- General Description: Given a set of data cases, rank them according to some ordinal metric.

- Examples:
  - Order the cars by weight.
  - Rank the cereals by calories.

Determine Range

- General Description: Given a set of data cases and an attribute of interest, find the span of values within the set.

- Examples:
  - What is the range of film lengths?
  - What is the range of car horsepowers?
  - What actresses are in the data set?

Characterize Distribution

- General Description: Given a set of data cases and a quantitative attribute of interest, characterize the distribution of that attribute's values over the set.

- Examples:
  - What is the distribution of carbohydrates in cereals?
  - What is the age distribution of shoppers?

Find Anomalies

- General Description: Identify any anomalies within a given set of data cases with respect to a given relationship or expectation, e.g. statistical outliers.

- Examples:
  - Are there any outliers in protein?
  - Are there exceptions to the relationship between horsepower and acceleration?

Cluster

- General Description: Given a set of data cases, find clusters of similar attribute values.

- Examples:
  - Are there groups of cereals w/ similar fat/calories/sugar?
  - Is there a cluster of typical film lengths?

Correlate

- General Description: Given a set of data cases and two attributes, determine useful relationships between the values of those attributes.

- Examples:
  - Is there a correlation between carbohydrates and fat?
  - Is there a correlation between country of origin and MPG?
  - Do different genders have a preferred payment method?
  - Is there a trend of increasing film length over the years?

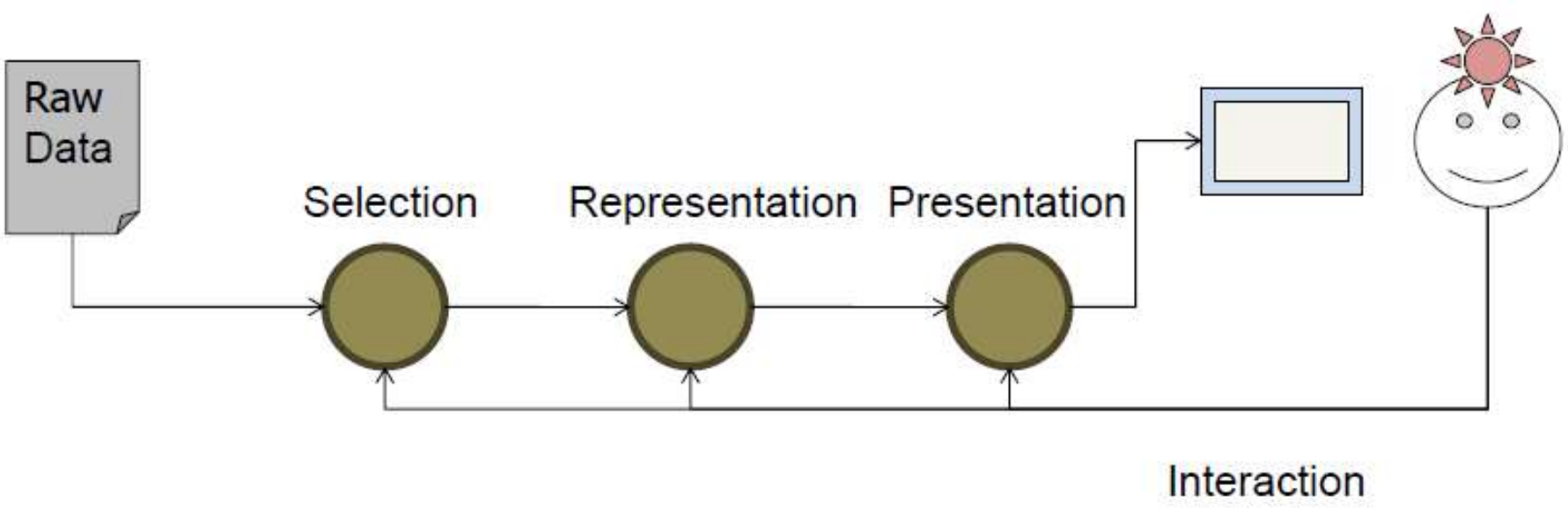
Interactions

- "The effectiveness of information visualization hinges on two things: its ability to clearly and accurately represent information and our ability to interact with it to figure out what the information means."
  - S. Few Now You See It, p. 55

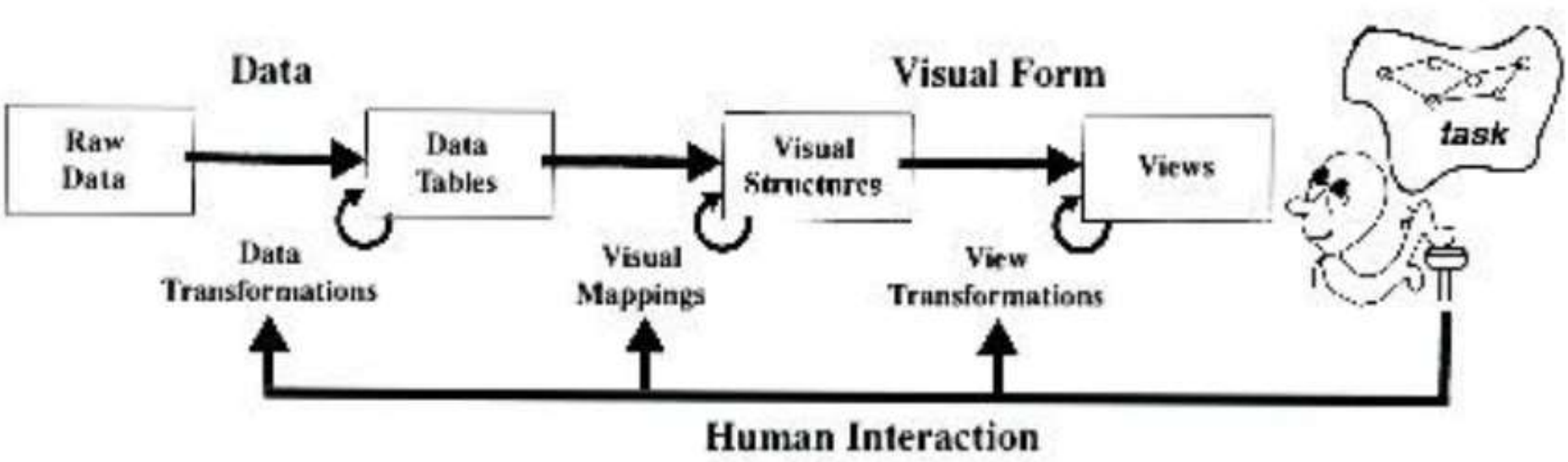
- What is Interaction?
  - "The communication between user and the system" [Dix et al., 1998]
  - "Direct manipulation and instantaneous change" [Becker et al., 1987]

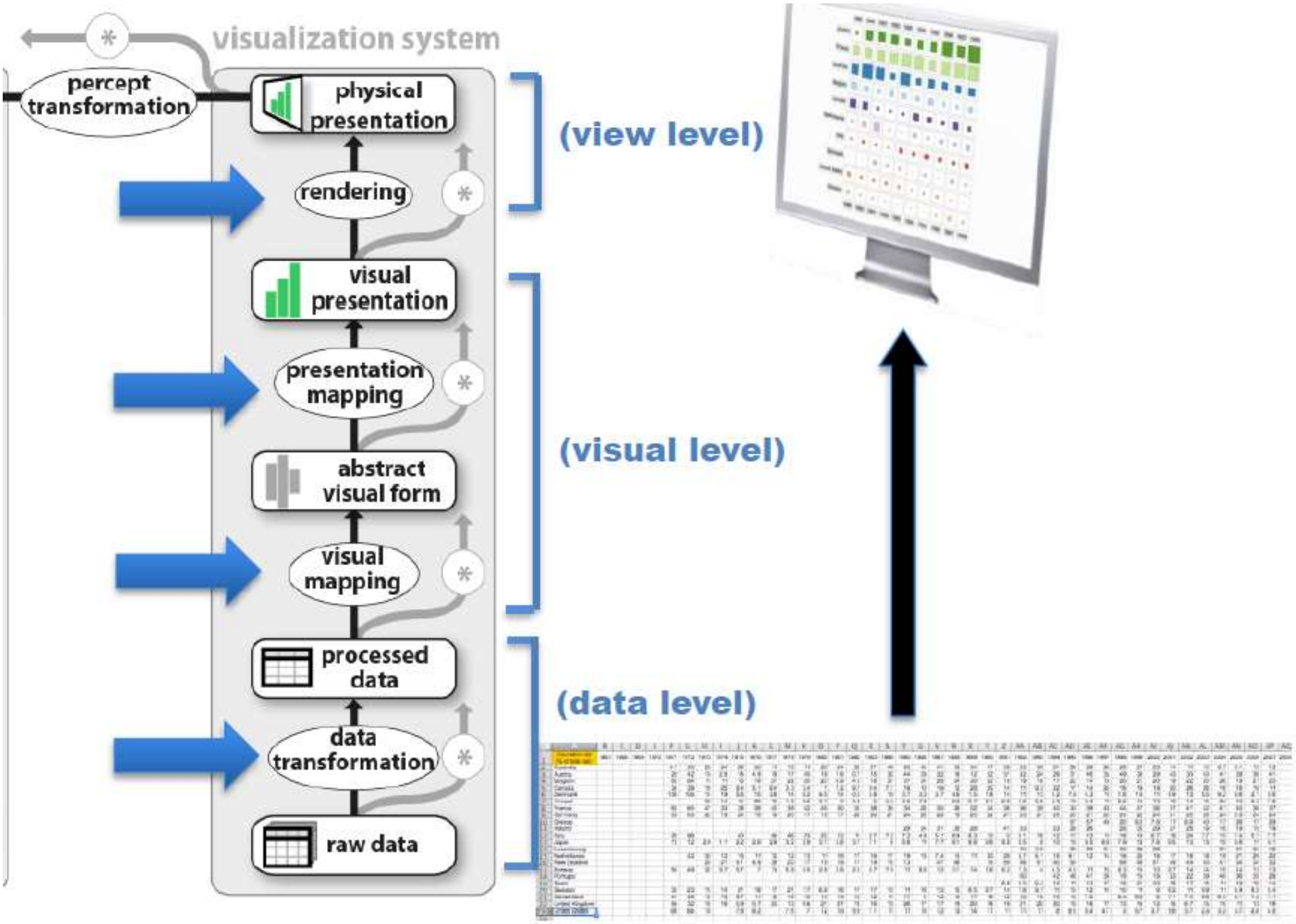
- There is too much to be shown
- There are many ways to show it
  - **Let the user dynamically control what to show and how to show it**

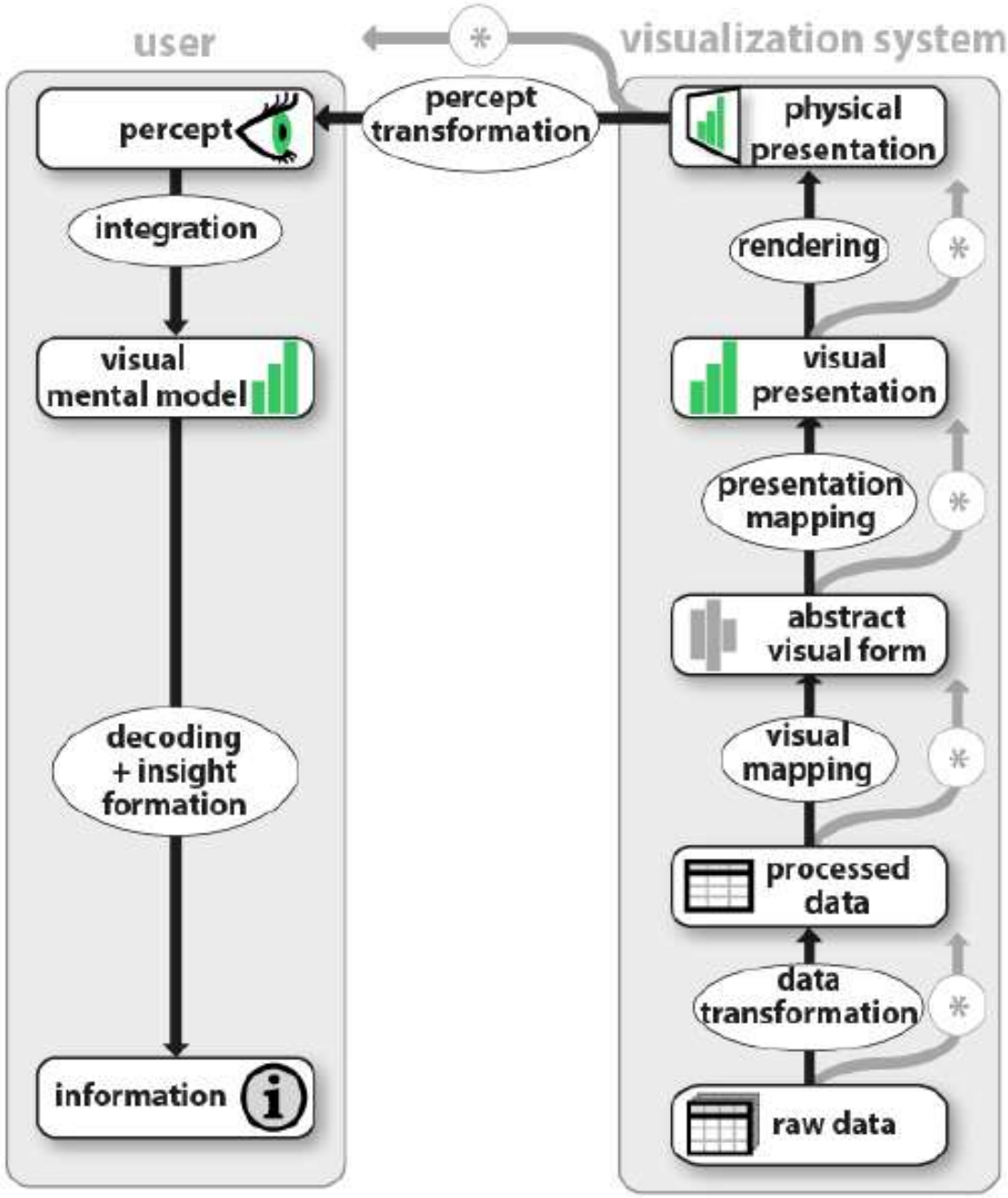
The Visualization Pipeline



The Visualization Pipeline




visualization system
percept transformation
physical presentation
rendering
visual presentation
presentation mapping
abstract visual form
visual mapping
processed data
data transformation
raw data
(view level)
(visual level)
(data level)



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

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
  - **Command-line interfaces**
  - **Input**: mouse, touch, keyboard, speech,...
  - Direct manipulation interfaces

Families of Infovis Interaction Techniques

- Selection
- Rearrangement
- Filtering techniques
- Navigation techniques
- Multiple views

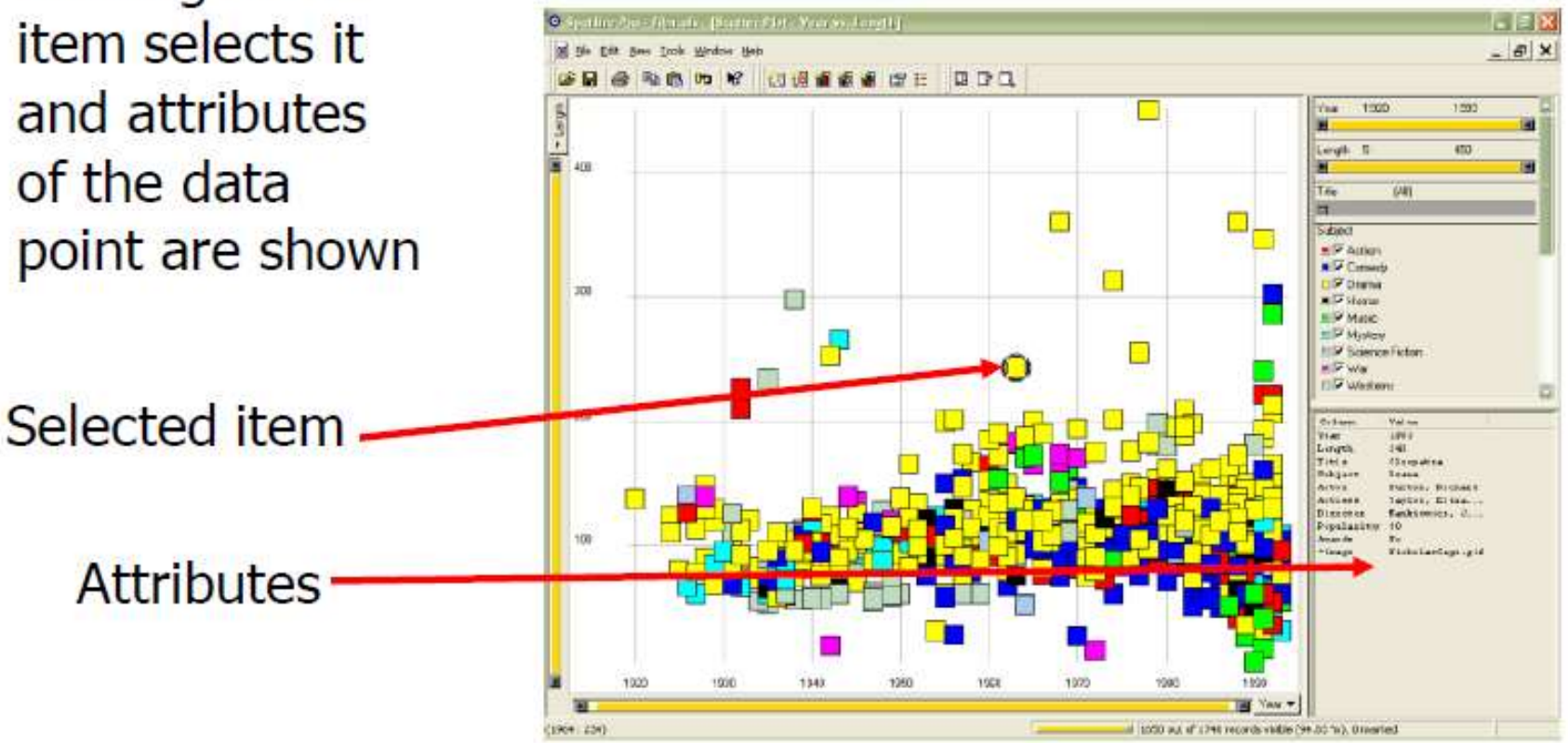
Select

- “Mark something as interesting”
- Mark items of interest to keep track
- Seems to often work as a preceding action to subsequent operations.

- Example
  - Selecting a placemark in Google Map

Mouse Selection

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

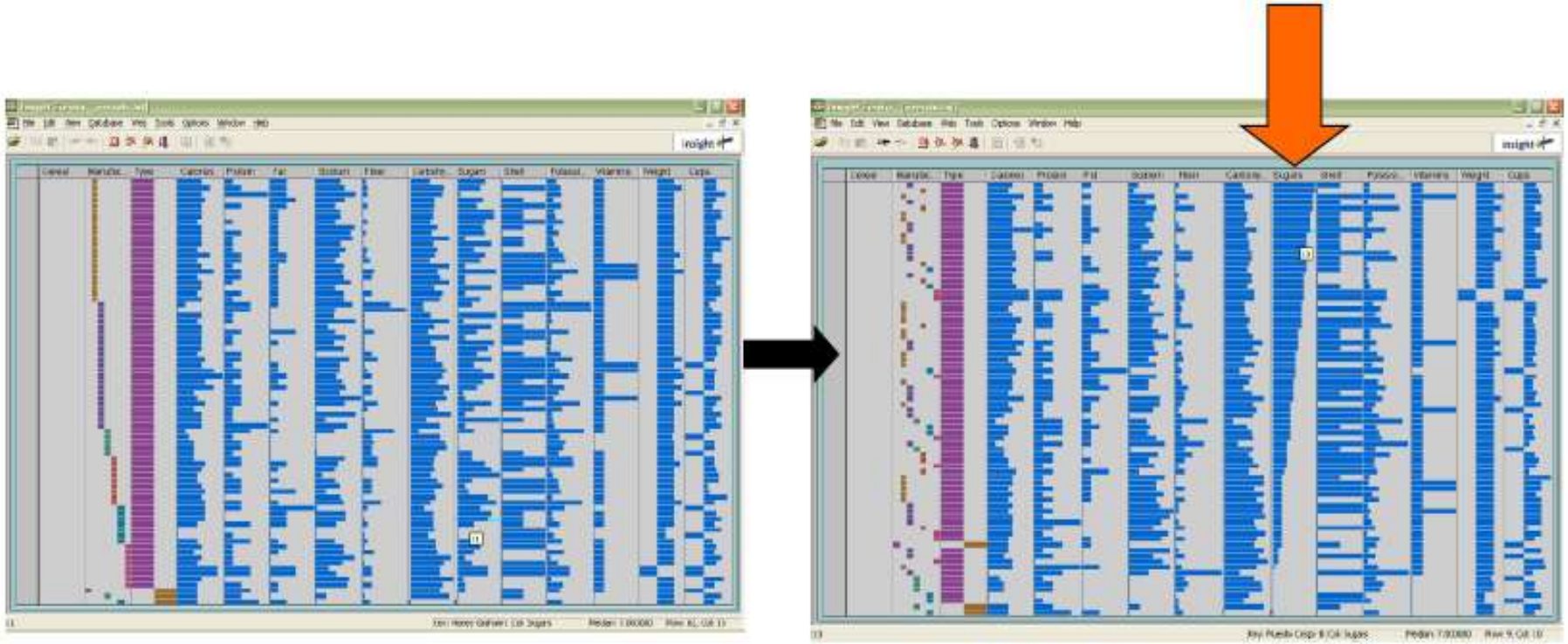


Rearrangement

- “Show me a different arrangement”
- Provide different perspectives by changing the spatial arrangement of representation

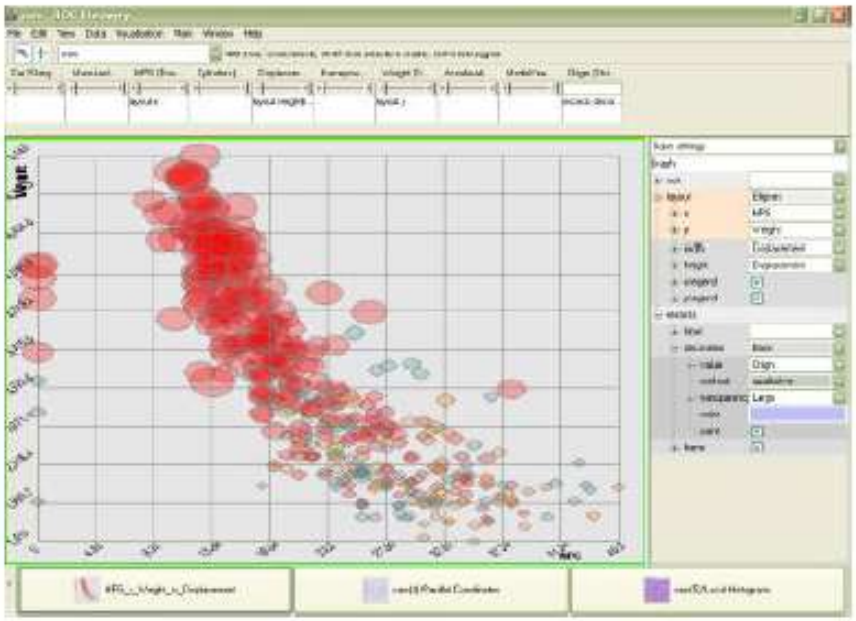
- Example
  - Sorting and rearranging columns in TableLens
  - Changing the attributes in a scatter plot
  - Changing data representation

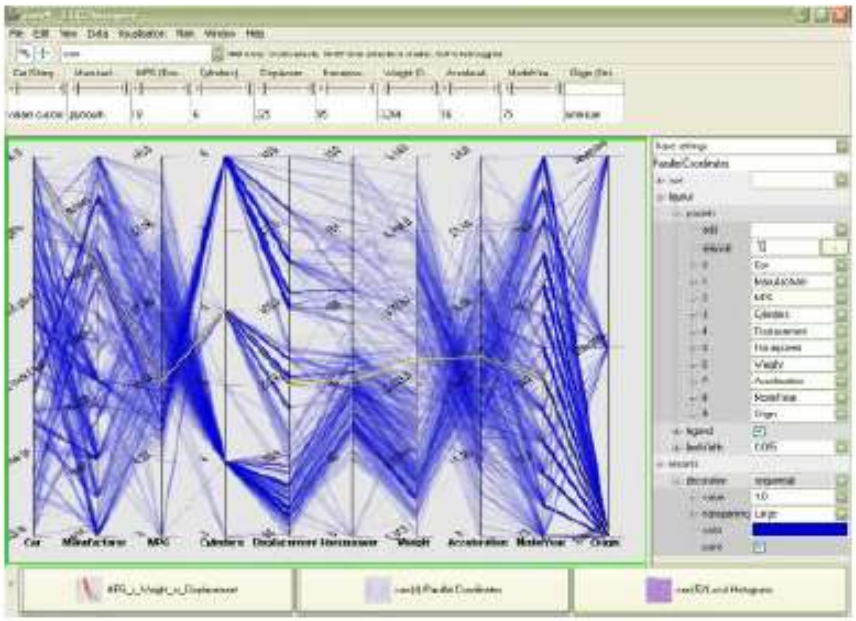
Sorting



Changing Representation

- May interactively change entire data representation
  - Looking for new perspective
  - Limited real estate may force change





Families of Infovis Interaction Techniques

- Selection
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Filtering

- “Show me something conditionally”
- Change the set of data items being presented based on some specific conditions.

- Example
  - Dynamic query

Faceted metadata

- Attributes of datasets are grouped into multiple orthogonal categories
- Selecting a value from one filters on that value and updates the items in other categories
- User explores data collection by series of selections

Database Queries

- Pros
  - Powerful, flexible
- Cons
  - Must learn language
  - Only shows exact matches
  - Don’t know magnitude of results
  - No helpful context is shown
  - Reformulating to a new query can be slow

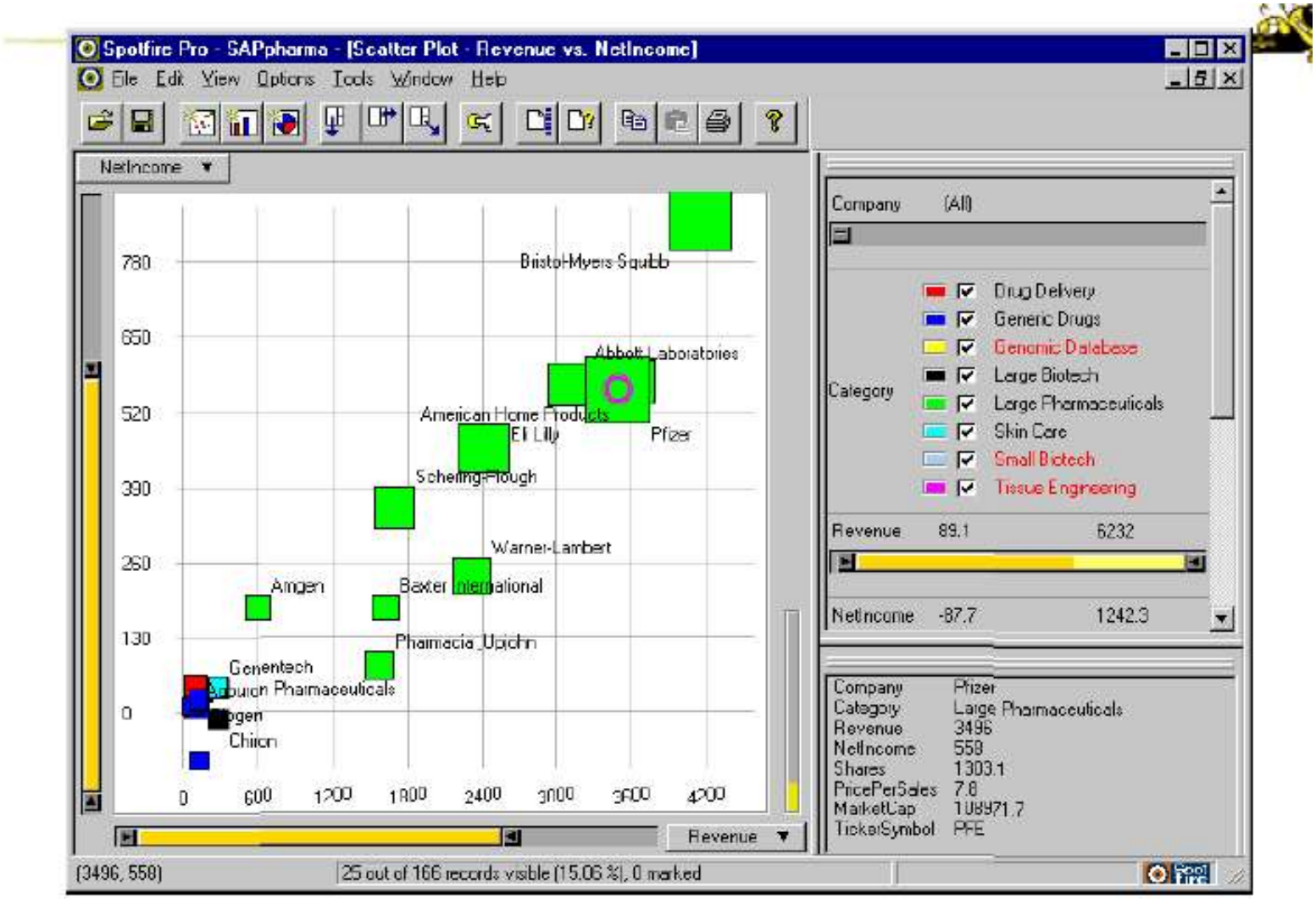
Dynamic Queries

- Probably best-known and one of most useful infovis techniques (Shneiderman IEEE Software ’94)
- Visual representation of world of action including both the objects and actions
- •Rapid, incremental and reversible actions
- •Selection by pointing (not typing)
- •Immediate and continuous display of results

Dynamic Query - Example

- HomeFinder - Univ. of Maryland

Dynamic Query - Example



Spotfire

Families of Infovis Interaction Techniques

- Selection
- Rearrangement
- Filtering techniques
- Navigation techniques
  - Pan + Zoom
  - Focus + Context
- Multiple views

Incremental Exploration and Navigation

- For very large datasets
- Small portion displayed
- Other parts displayed as needed
- Displayed visualization small

⇒Layout and interaction times may be small

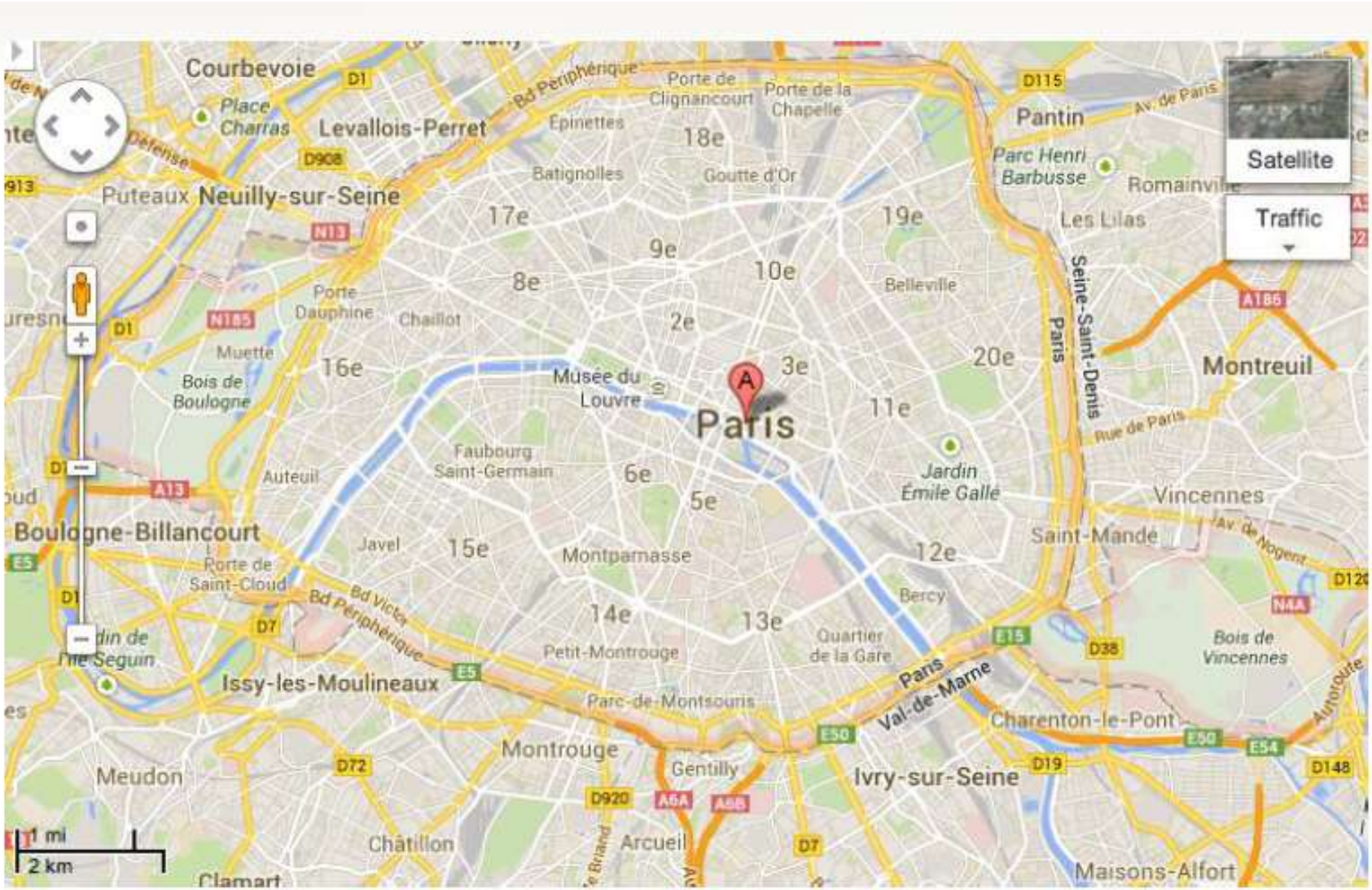
Pan & Zoom

- Zoom and Pan
  - Zoom for graphs exact, not pixel-based (adjustment of screen transformations)
- Geometric Zooming
  - Simple blow-up
- Semantic Zooming
  - Content changes
  - Clustering

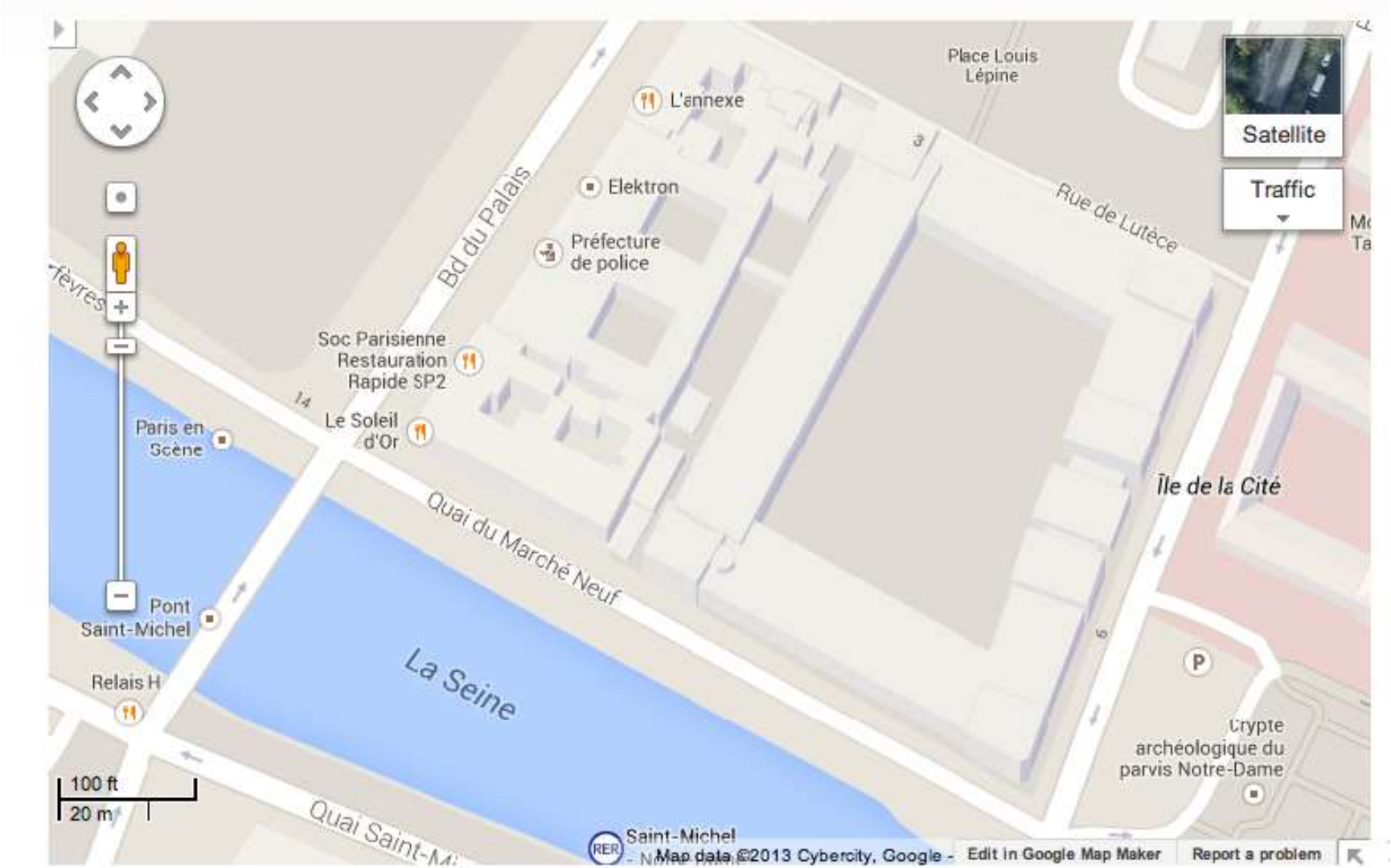
Pan & Zoom


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

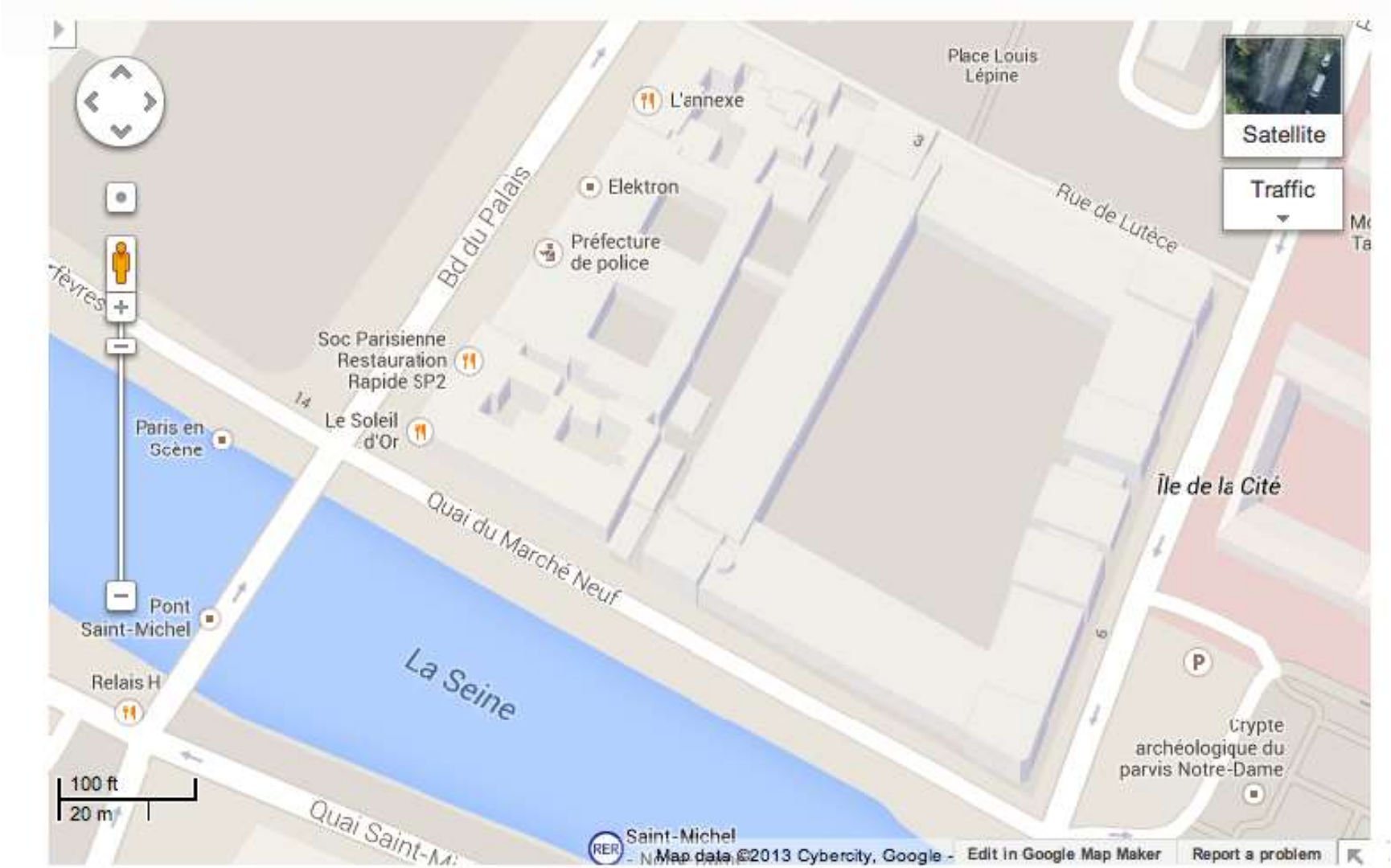
Pan & Zoom


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

Pan & Zoom

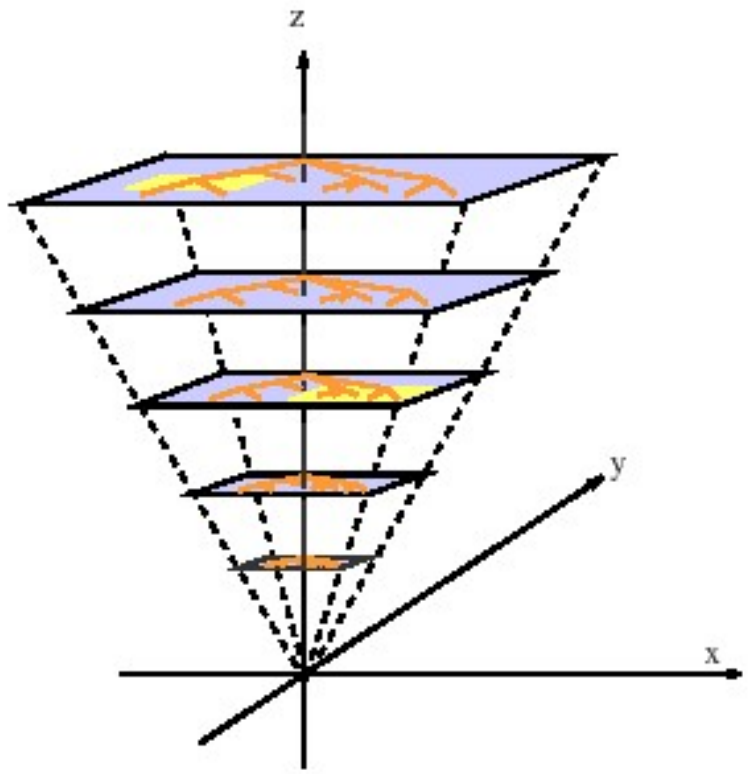

Place Louis Lépine
L'annexe
Satellite
Traffic
Elektron
Bd du Palais
Rue de Lutèce
Préfecture de police
Soc Parisienne Restauration Rapide SP2
Le Soleil d'Or
Paris en Scène
Île de la Cité
Quai du Marché Neuf
Pont Saint-Michel
La Seine
Relais H
Crypte archéologique du parvis Notre-Dame
100 ft
20 m
Saint-Michel
Map data ©2013 Cybercity, Google -
Edit in Google Map Maker
Report a problem

Problem – Where am I?



Problem with Combination of Zoom and Pan

- Assume zoom and pan independent
- Objects may temporarily move away
- Semantic Zoom: Picture differs for each level



Focus + Context Techniques

- Zooming looses contextual information
- Focus + Context keeps context
- Example: Fisheye Distortion

Real-world Example

Degree of Interest

- Concept introduced in classic paper : “Generalized fisheye views” George Furnas, 1986

- Definition :
- $DOI_{fisheye}(x|y) = API(x) – D(x,y)$
  - x is any node
  - y is current point of focus
  - API(x) is the global A Priori Importance
  - D(x,y) is the Distance between x and the current point y

Example – C program

```
28                t[0] = (t[0] + 10000)
29                     - x[0];
30                for(i=1;i<k;i++){
31                     t[i] = (t[i] + 10000)
32                          - x[i]
33                          - (1 - t[i-1]/10000);
34                     t[i-1] %= 10000;
35                }
36                t[k-1] %= 10000;
37                break;
38           case 'e':
>39                for(i=0;i<k;i++) t[i] = x[i];
40                break;
41           case 'q':
42                exit(0);
43           default:
44                noprint = 1;
45                break;
46      }
47      if(!noprint){
48           for(i=k - 1;t[i] <= 0 && i > 0;i--);
49           printf("%d",t[i]);
50           if(i > 0) {
```

STANDARD

```
   1 #define DIG 40
   2 #include <stdio.h>
...4 main()
   5 {
   6      int c, i, x[DIG/4], t[DIG/4], k = DIG/4, noprint = 0;
...8      while((c=getchar()) != EOF){
   9           if(c >= '0' && c <= '9'){
..16           } else {
  17                switch(c){
  18                     case '+':
..27                     case '-':
..38                     case 'e':
>>39                          for(i=0;i<k;i++) t[i] = x[i];
  40                          break;
  41                     case 'q':
..43                     default:
..46                }
  47                if(!noprint){
..57                }
  58           }
  59           noprint = 0;
  60      }
  61 }
```

FISH-EYE

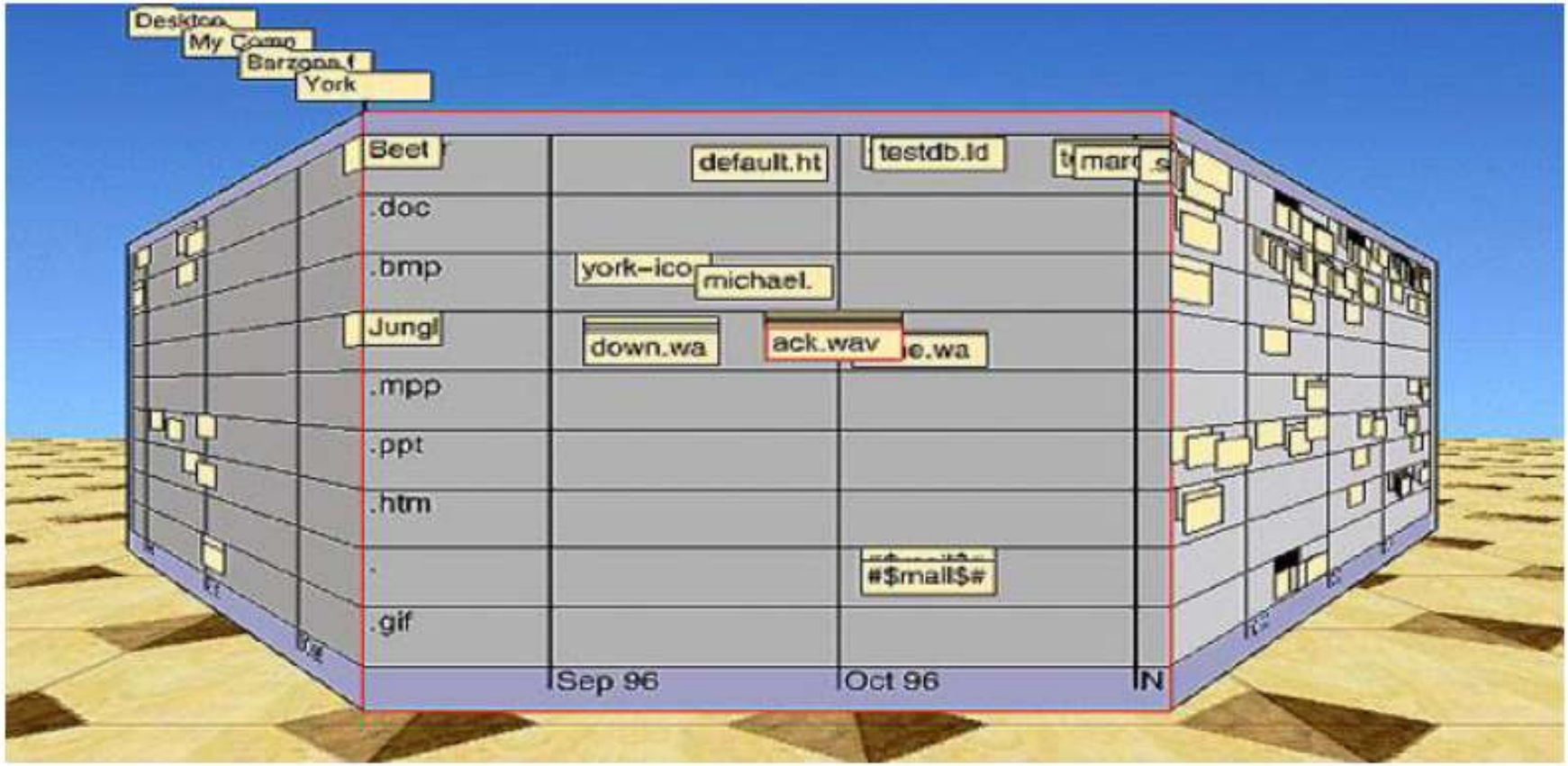
Focus + Context

- Space Distorsion
  - Fisheye Menus

Bederson, 2000

Perspective Wall

Focus+Context View of Calendars



Mackinlay, Roberston and Card, 1991

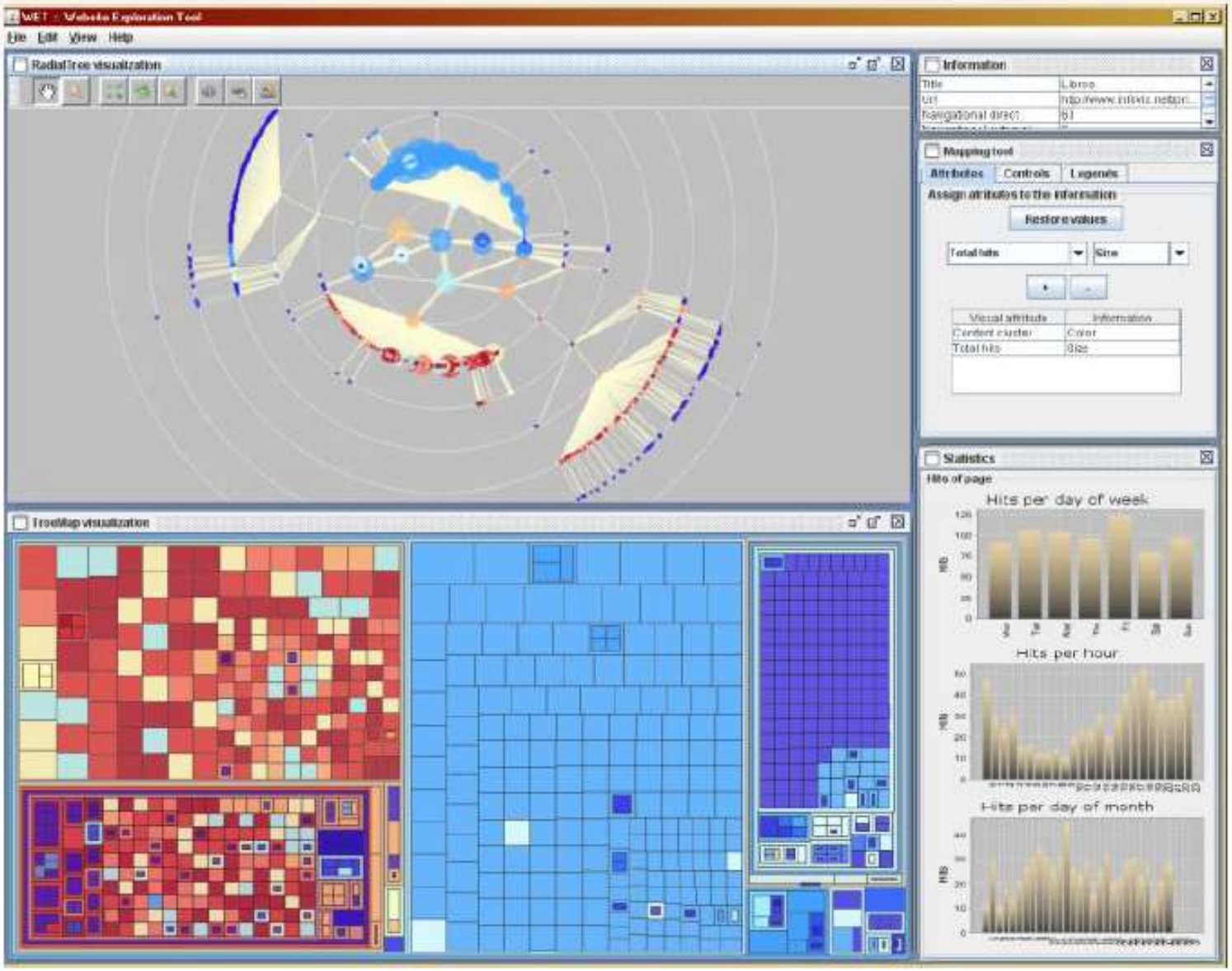
Problems with Fish-eye Views

- Distortion can be annoying
- Can be very difficult to implement
- Any change in focal point potentially requires recalculation of DoI for all objects and hence rerendering of all objects affects performance.

Families of Infovis Interaction Techniques

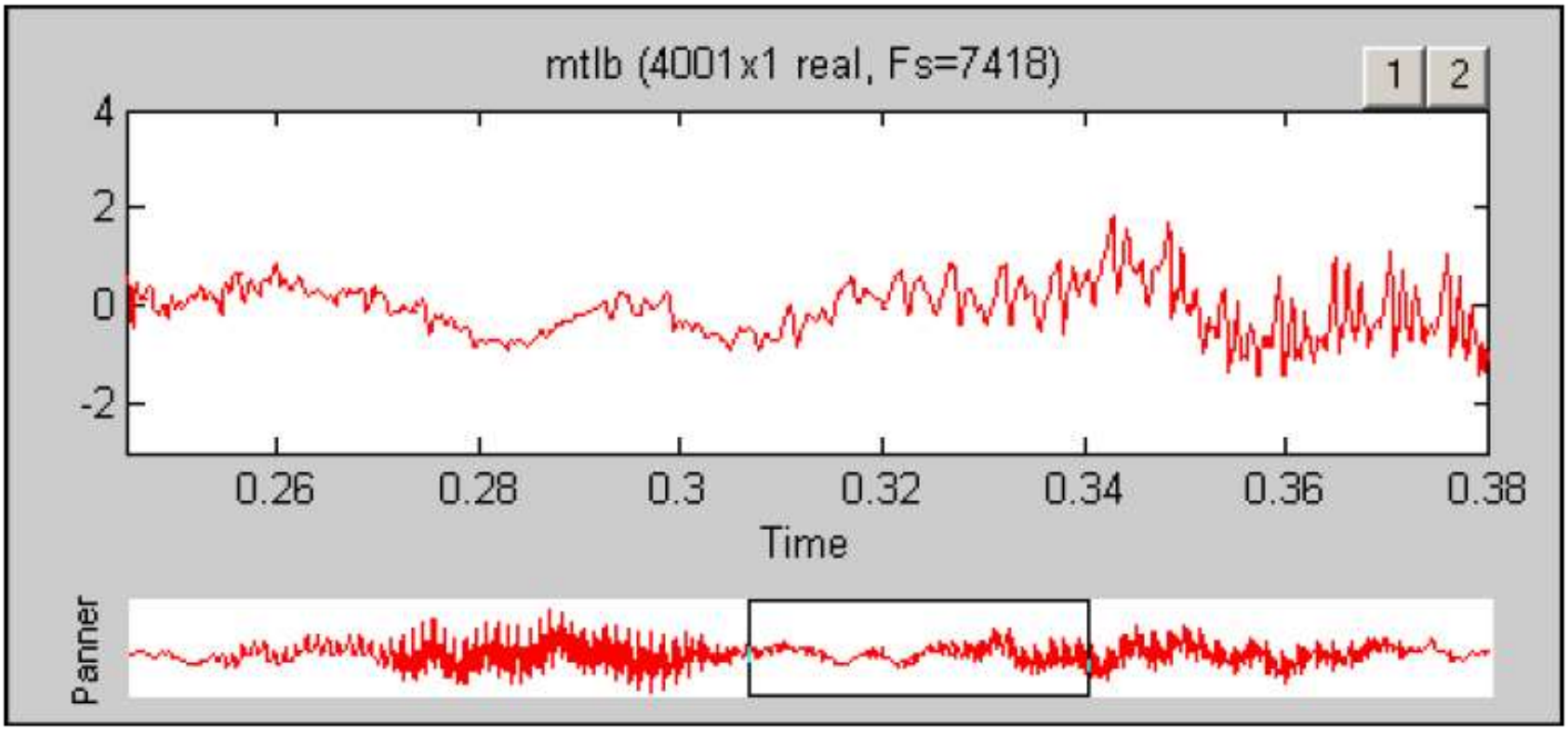
- Selection
- Rearrangement
- Filtering techniques
- Navigation techniques
- Multiple views
  - Overview + Detail
  - Magic Lens
  - Coordinated Views

Multiple Views

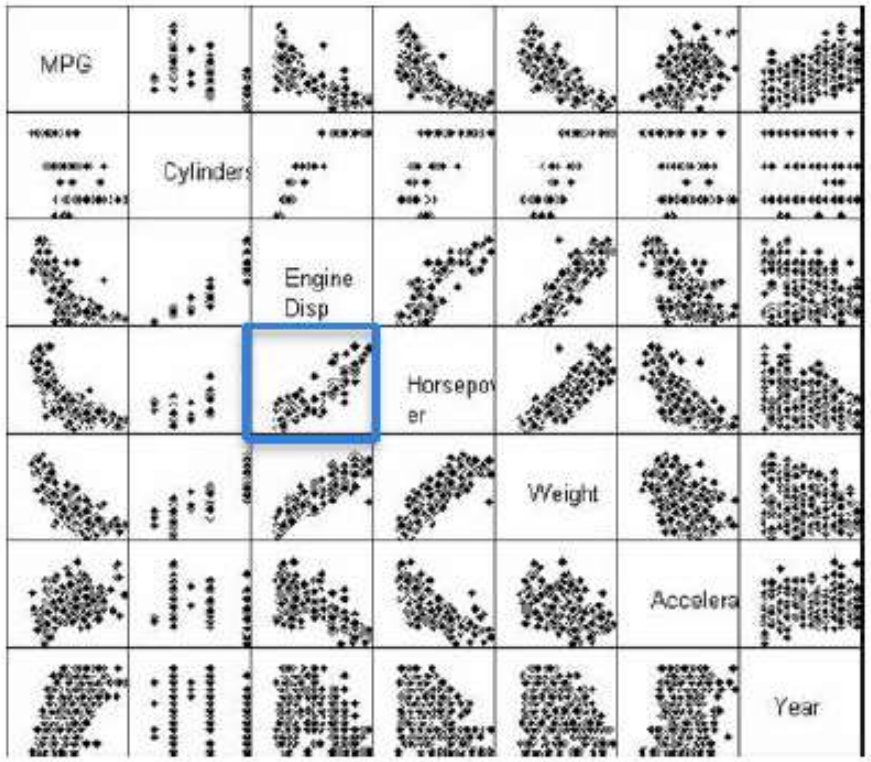


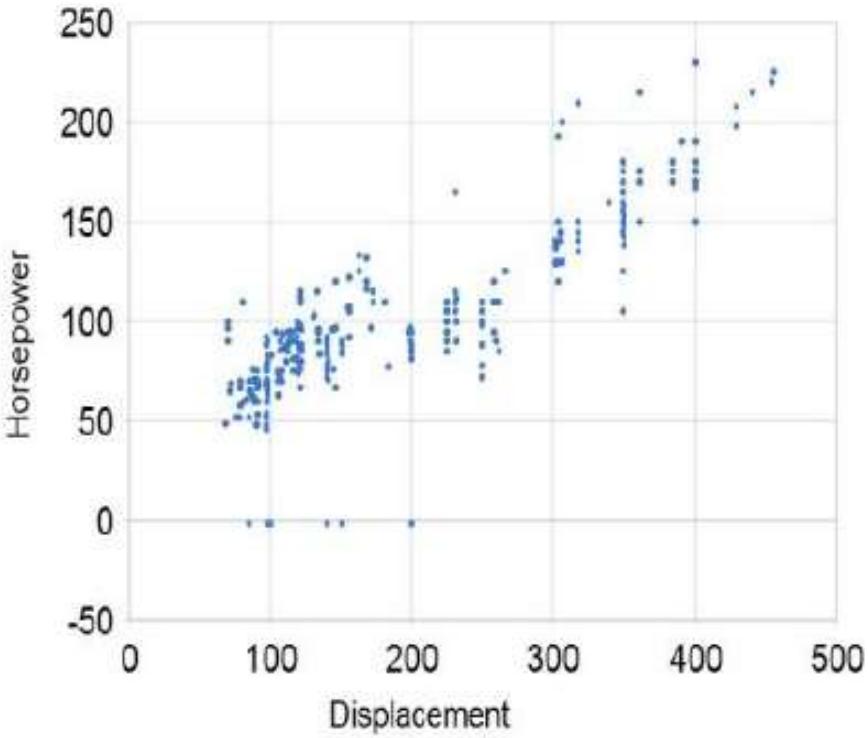
Overview + Detail

Panning a line chart



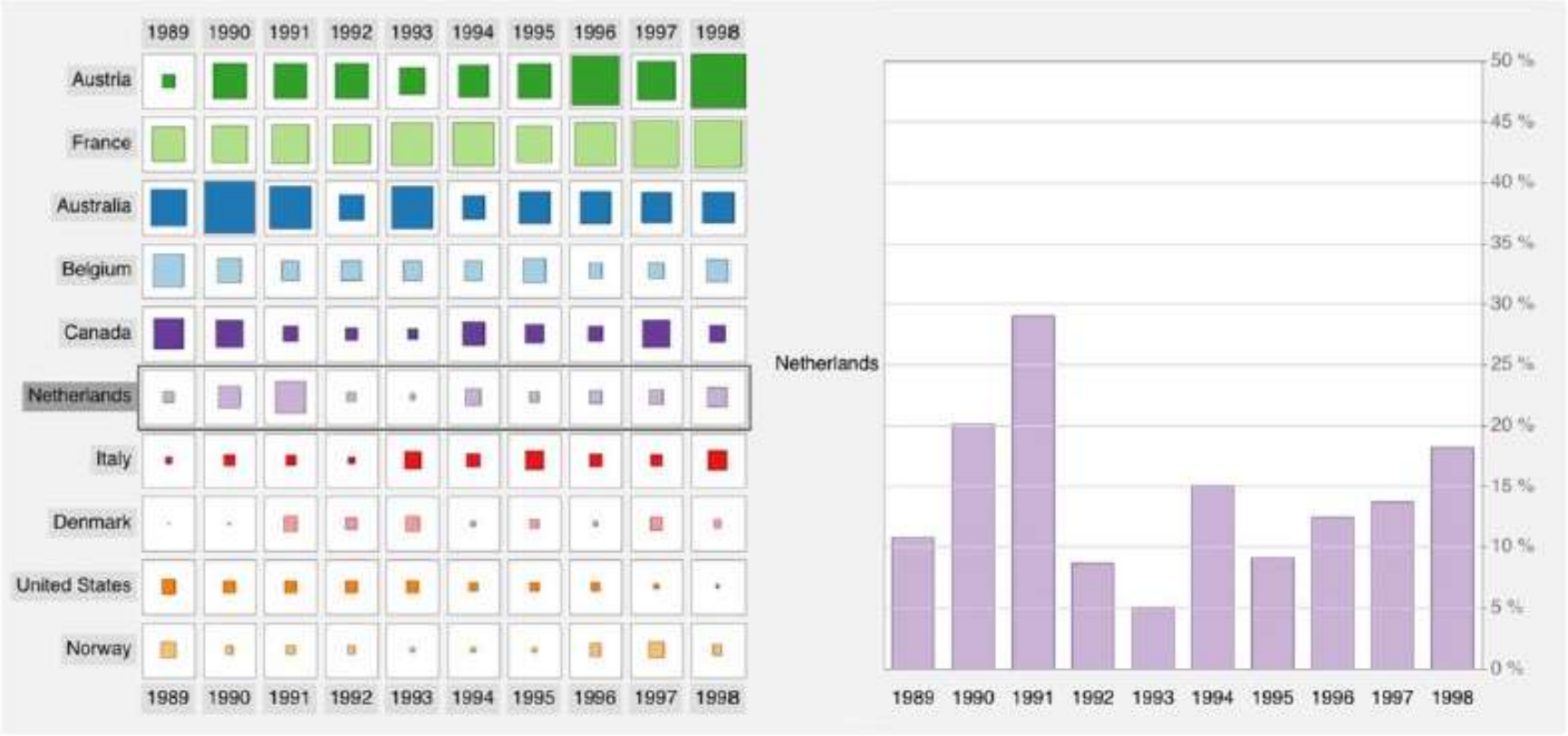
Browsing Multiple Views





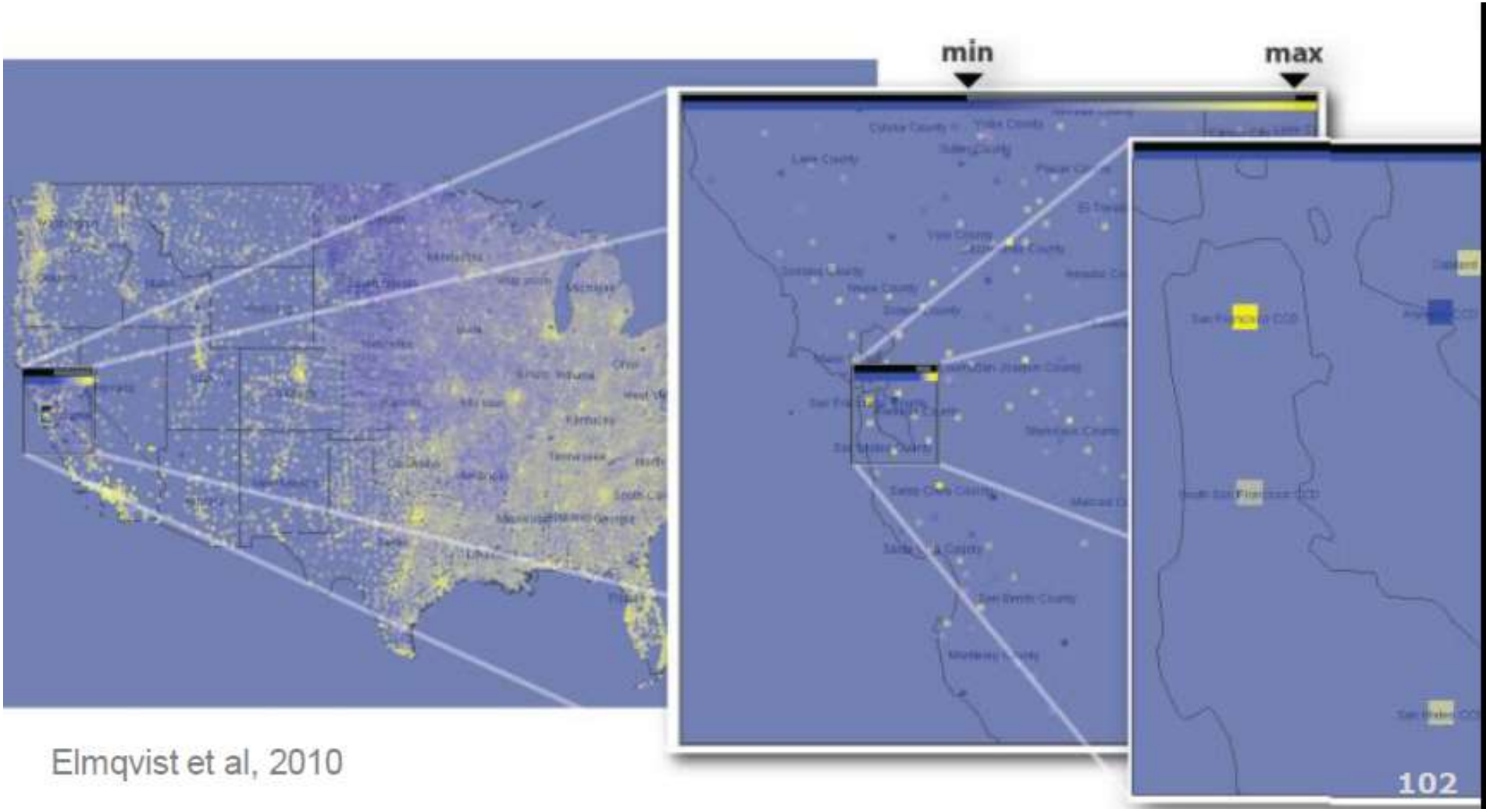
Overview + Detail

Browsing Multiple Views



Jansen et al, 2013

Magic Lens



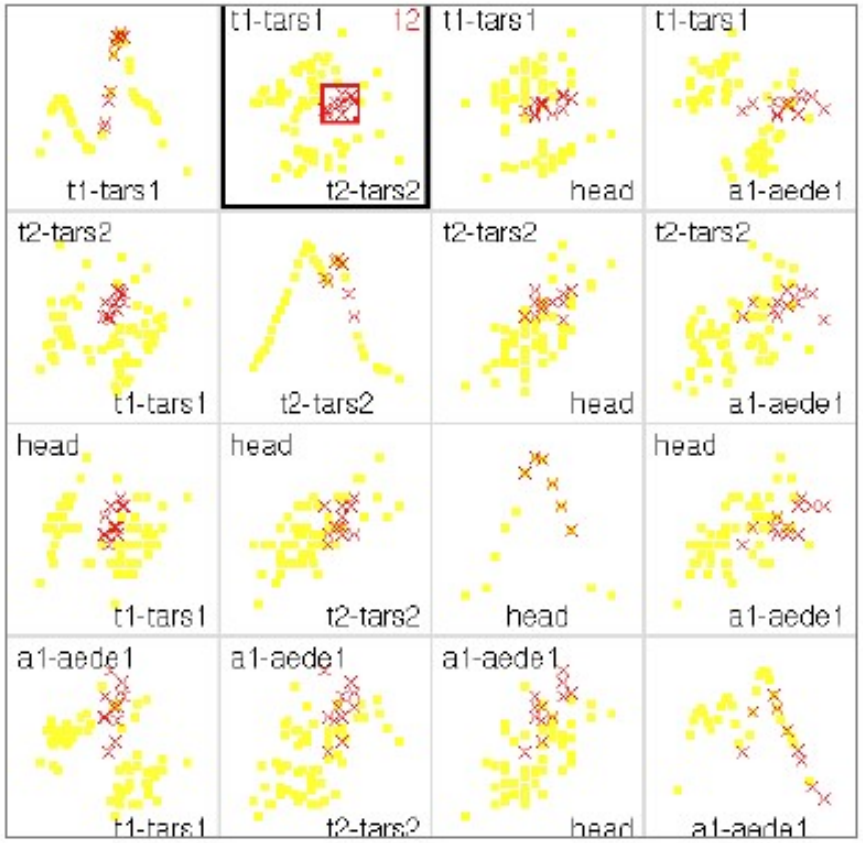
Elmqvist et al, 2010

Coordinated Views

- "Show me related items in different views"
  - Highlight associations and relationships
  - Show hidden data items that are relevant to a specified item

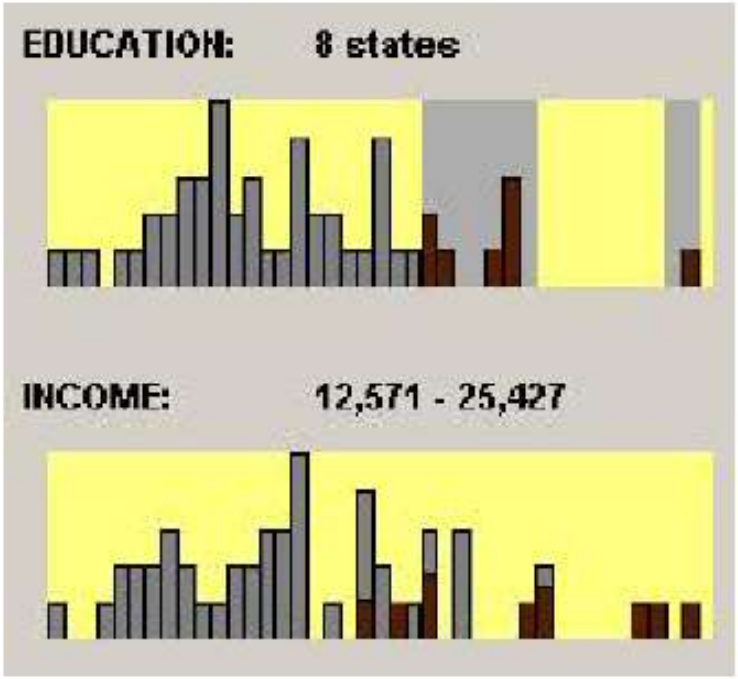
- Brushing
  - Selecting or highlighting a case in one view generates highlighting the case in the other views
  - Very common technique in InfoVis

Brushing & Linking Scatterplots

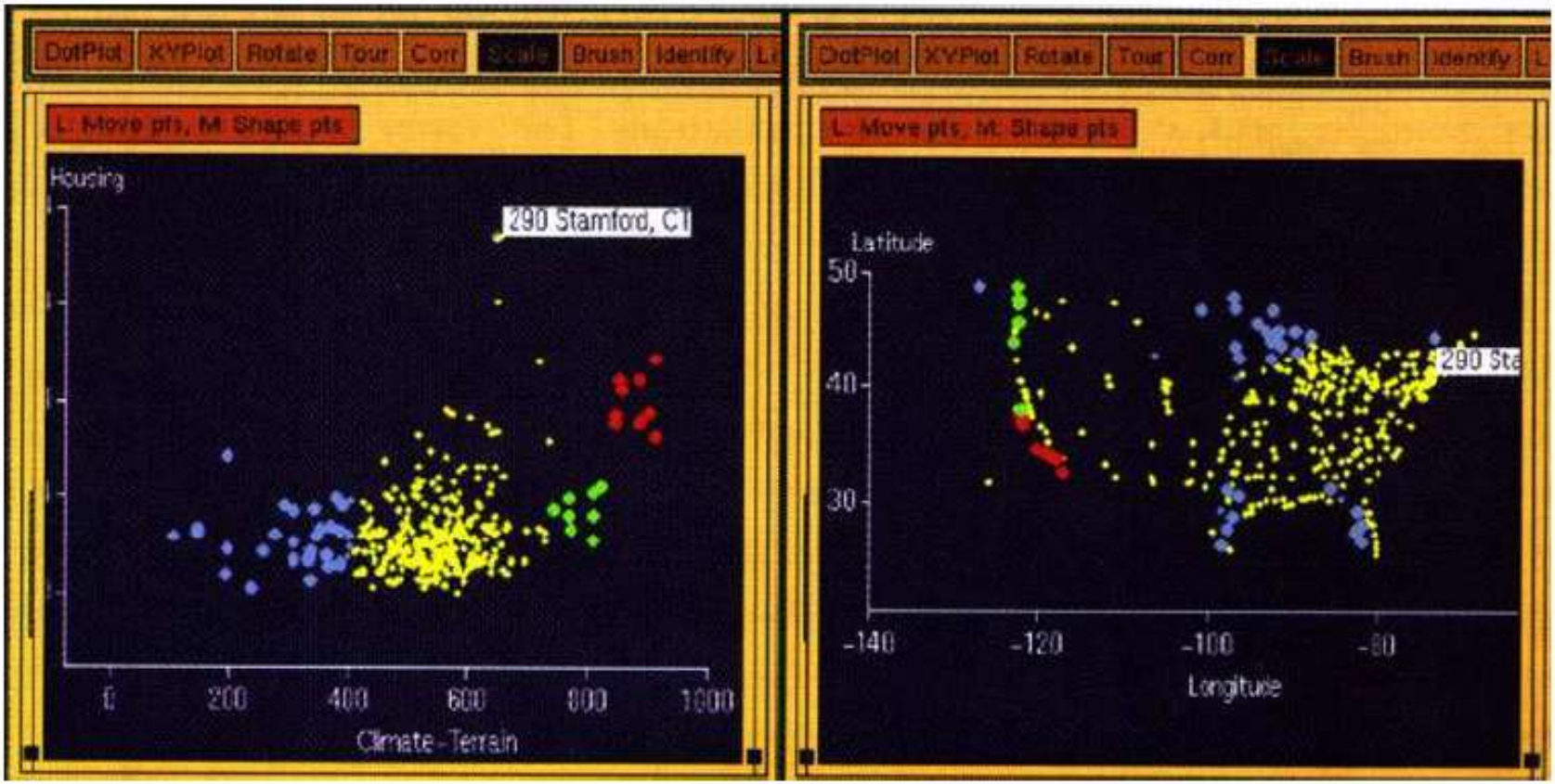


Voigt, 2002

Brushing & Linking Histograms

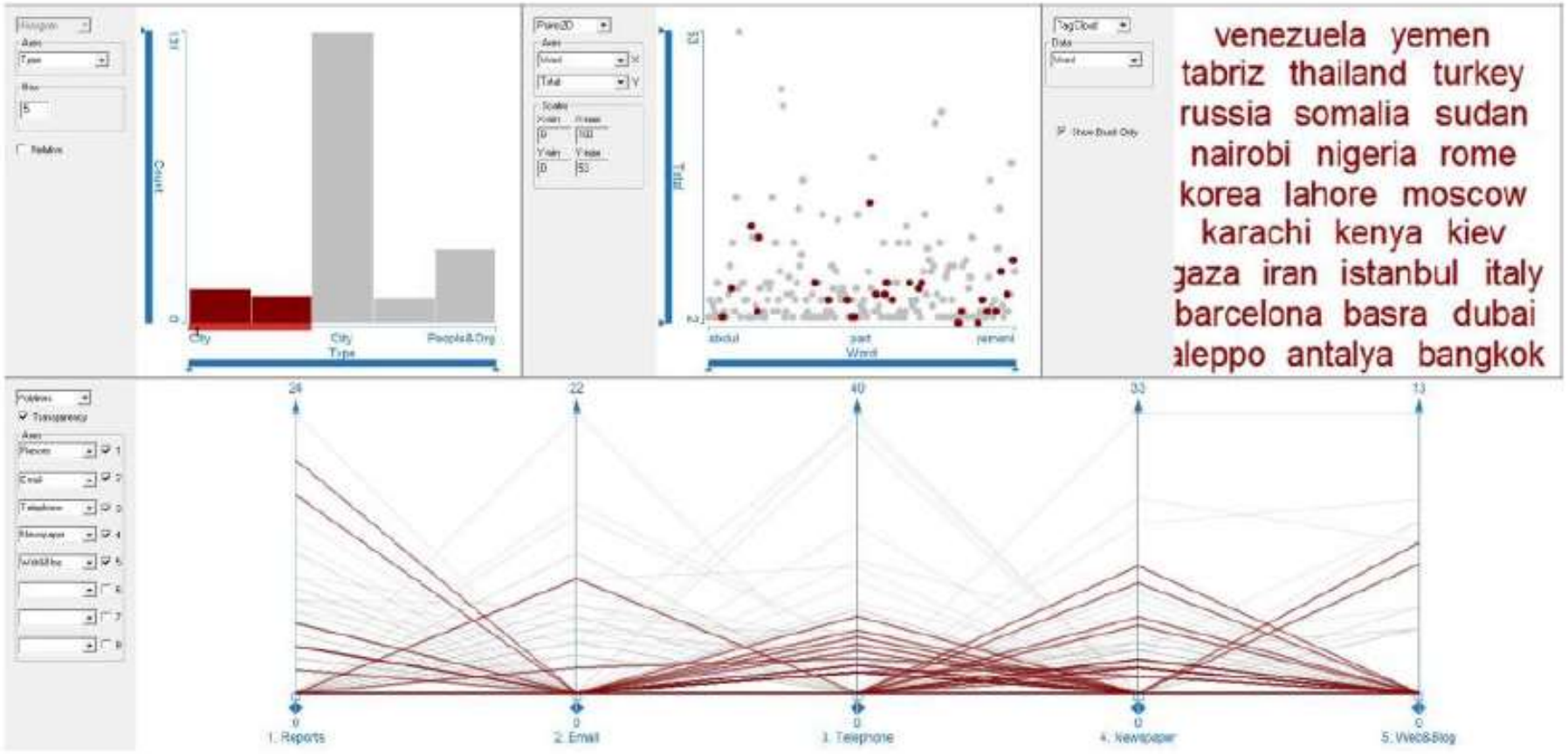


Colored Brushing & Linking



Chris North, 2001

Brushing & Linking Everything



Turkay et al, 2010

Moving beyond WIMP

- In human–computer interaction **WIMP** stands for "windows, icons, menus, pointer“
- WIMP metaphor on desktop machines assumes certain input devices
  - Keyboard and mouse centric
- How does interaction change when we move to a more mobile platform - Tablet, phone, etc.?
- What will it be like to interact with visualizations on a (touch) device?
- Lots of UI controls in vis applications
- Lots of small data objects to manipulate
- Many touch gestures possible, but what are the right ones?

Reading

- Christopher Ahlberg, Christopher Williamson and Ben Shneiderman. “Dynamic Queries for Information Exploration: An Implementation and Evaluation”, *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (ACM CHI)1992.* https://www.cs.umd.edu/users/ben/papers/Ahlberg1992Dynamic.pdf

- George Furnas. “Generalized Fisheye Views”, *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (ACM CHI) 1986. https://dl.acm.org/doi/abs/10.1145/22339.22342*