User Interaction 1

CS 4460 - Information Visualization

Spring, 2019

Alex Endert

Semester update

- Assignments shifting to more programming
- After user interaction, lectures will become more dataset-specific (text, graphs, …)

Semester update

- You should know basics of static graphical charts now
  - Perception, Design, Best Practices, visual encodings/marks
- You should understand the importance of user tasks (low and high level)
- Next talk about User Interaction
  - Next 2 lectures

today

- define interaction - what is it?
- Talk about taxonomies for interaction (focusing one 1 main one, the one you read in the reading for today)
- Discuss examples for types of interaction
- (finish next time)

Interaction?

- What do we mean by “interaction”?

Background

- Interaction (HCI)

  = “The communication between user and the system” [Dix et al., 1998]

  = “Direct manipulation and instantaneous change” [Becker et al., 1987]

instantaneous include the idea that changes should happen immediately after user manipulation.

“HCI research is far from having solid (and falsifiable) theories of interaction”
[Beaudouin-Lafon, 2004]

Main Components

The meaning of the data cannot be accurately accessed without interaction.

"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

Interaction is often "Little Brother" of InfoVis

- Two main components in an infovis
  - Representation
  - Interaction
- Representation gets all the attention
- Interaction is where the action is
  - (no pun intended)

Research Focus

Analysis is a process: a continuous process of understanding new information, asking new questions, seeking no understandings and so on and so forth.

- Very challenging to come up with innovative, new visual representations
- But can do interesting work with how users interact with the view or views
  - It's what distinguishes infovis from static visual representations on paper
- Analysis is a process, often iterative with branches and side bars
  - remember what we said about sensemaking. Need interaction for analytic process.

Taxonomies of User Interaction Types

Interaction Types

- Dix and Ellis (AVI ’98) propose
  - Highlighting and focus
  - Accessing extra info – drill down and hyperlinks
  - Overview and context – zooming and fisheyes
  - Same representation, changing parameters
  - Linking representations – temporal fusion

Interaction Types

- Keim’s taxonomy (TVCG ’02) includes
  - Projection
  - Filtering
  - Zooming
  - Distortion
  - Linking and brushing

Few's Principles

- Especially useful ways of interacting with data

Comparing
Sorting
Adding variables
Filtering
Highlighting
Aggregating
Re-expressing
Re-visualizing
Zooming and panning
Re-scaling
Accessing details on demand
Annotating
Bookmarking

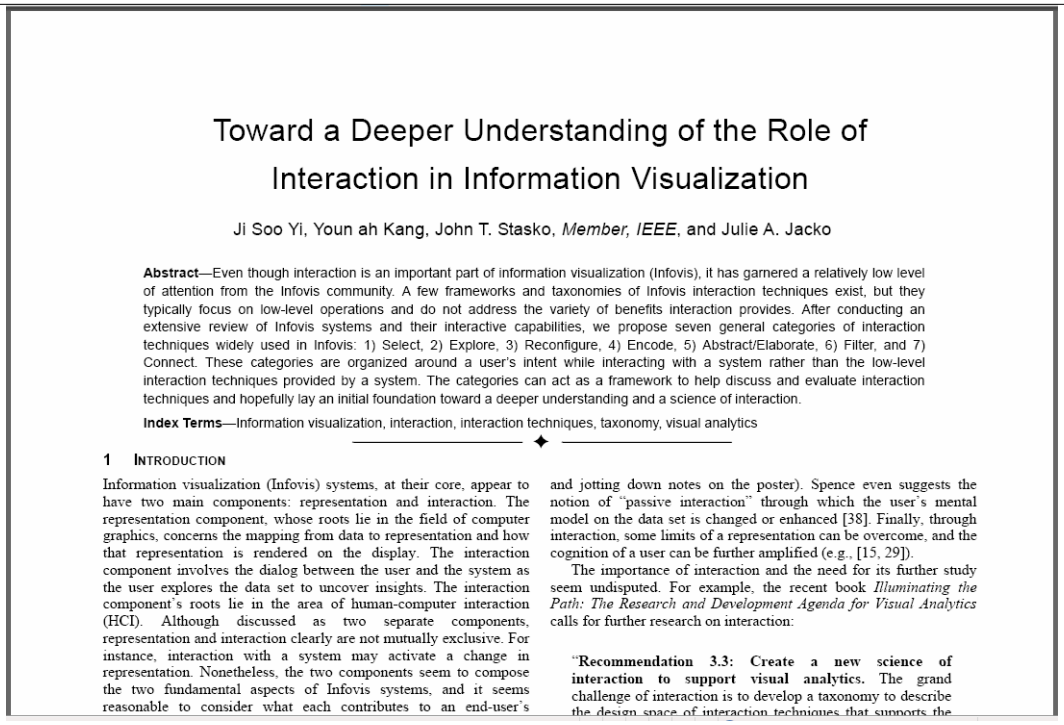
Now You See It
Chapter 4

Challenging

- Interaction seems to be a difficult thing to pin down and characterize
- Let's go back to the user trying to solve problems, get insight, explore data…
  - User-centered versus system-centered characterizations

See interaction as a user-centered way to elicit information from data

Another take



Toward a Deeper Understanding of the Role of Interaction in Information Visualization

Ji Soo Yi, Youn ah Kang, John T. Stasko, *Member, IEEE*, and Julie A. Jacko

Abstract—Even though interaction is an important part of information visualization (Infovis), it has garnered a relatively low level of attention from the Infovis community. A few frameworks and taxonomies of Infovis interaction techniques exist, but they typically focus on low-level operations and do not address the variety of benefits interaction provides. After conducting an extensive review of Infovis systems and their interactive capabilities, we propose seven general categories of interaction techniques widely used in Infovis: 1) Select, 2) Explore, 3) Reconfigure, 4) Encode, 5) Abstract/Elaborate, 6) Filter, and 7) Connect. These categories are organized around a user's intent while interacting with a system rather than the low-level interaction techniques provided by a system. The categories can act as a framework to help discuss and evaluate interaction techniques and hopefully lay an initial foundation toward a deeper understanding and a science of interaction.

Index Terms—Information visualization, interaction, interaction techniques, taxonomy, visual analytics

1 Introduction

Information visualization (Infovis) systems, at their core, appear to have two main components: representation and interaction. The representation component, whose roots lie in the field of computer graphics, concerns the mapping from data to representation and how that representation is rendered on the display. The interaction component involves the dialog between the user and the system as the user explores the data set to uncover insights. The interaction component's roots lie in the area of human-computer interaction (HCI). Although discussed as two separate components, representation and interaction clearly are not mutually exclusive. For instance, interaction with a system may activate a change in representation. Nonetheless, the two components seem to compose the two fundamental aspects of Infovis systems, and it seems reasonable to consider what each contributes to an end-user's and jotting down notes on the poster). Spence even suggests the notion of "passive interaction" through which the user's mental model on the data set is changed or enhanced [38]. Finally, through interaction, some limits of a representation can be overcome, and the cognition of a user can be further amplified (e.g., [15, 29]).

The importance of interaction and the need for its further study seem undisputed. For example, the recent book *Illuminating the Path: The Research and Development Agenda for Visual Analytics* calls for further research on interaction:

"**Recommendation 3.3: Create a new science of interaction to support visual analytics.** The grand challenge of interaction is to develop a taxonomy to describe the design space of interaction techniques that supports the

IEEE TVCG 13(6), '07

Study Methodology

- Survey
  - 59 papers

    Papers introducing new interaction systems

    Well-known papers in subareas of Infovis
  - 51 systems

    Commercial Infovis Systems (SeeIT, Spotfire, TableLens, InfoZoom, etc.)
  - Collected 311 individual interaction techniques
- Affinity Diagram Method

Focus Emerged

User intent

"What a user wants to achieve through a specific interaction technique"

Main Idea

- Don't focus so much on particular interactive operations and how they work
- Interaction is ultimately being done by a person **for a purpose**
  - Seeking more information, solving a problem
  - Fundamental aspect of exploratory, analytic discourse

Results

7 categories
Select
Explore
Reconfigure
Encode
Abstract/Elaborate
Filter
Connect

When you categorize interaction types by user intent, the user's intent is usually the task they are trying to perform.

1. Select

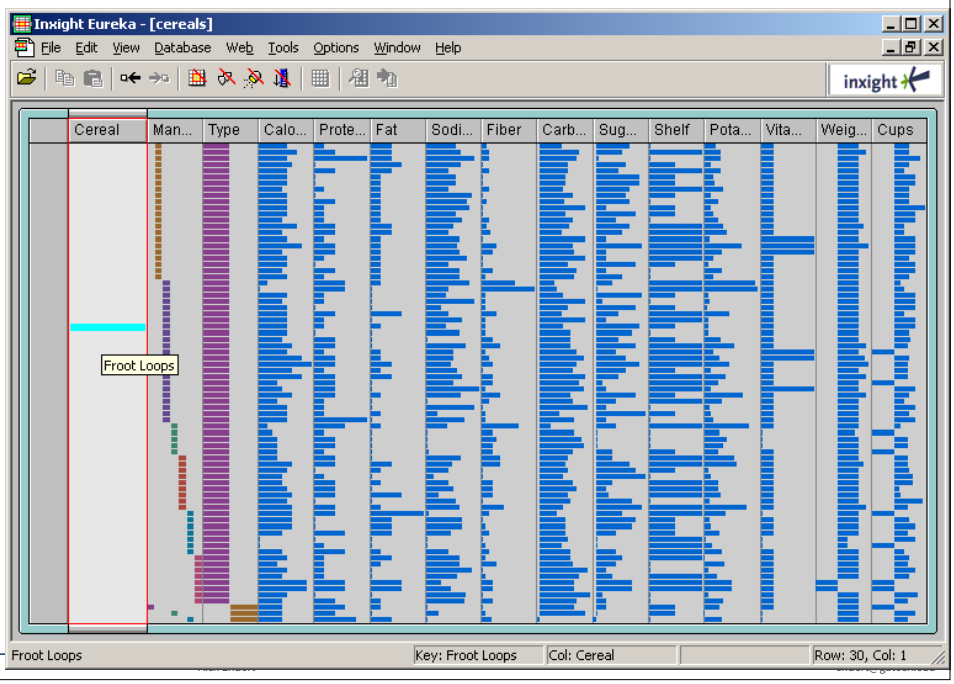
"**Mark something as interesting**"

- Mark items of interest to keep track
- Often as a preceding action to subsequent operations.

e.g.,
- Selecting a placemark in Google Maps
- The Focus feature in TableLens

Pop-up tooltips

- Hovering mouse cursor brings up details of item

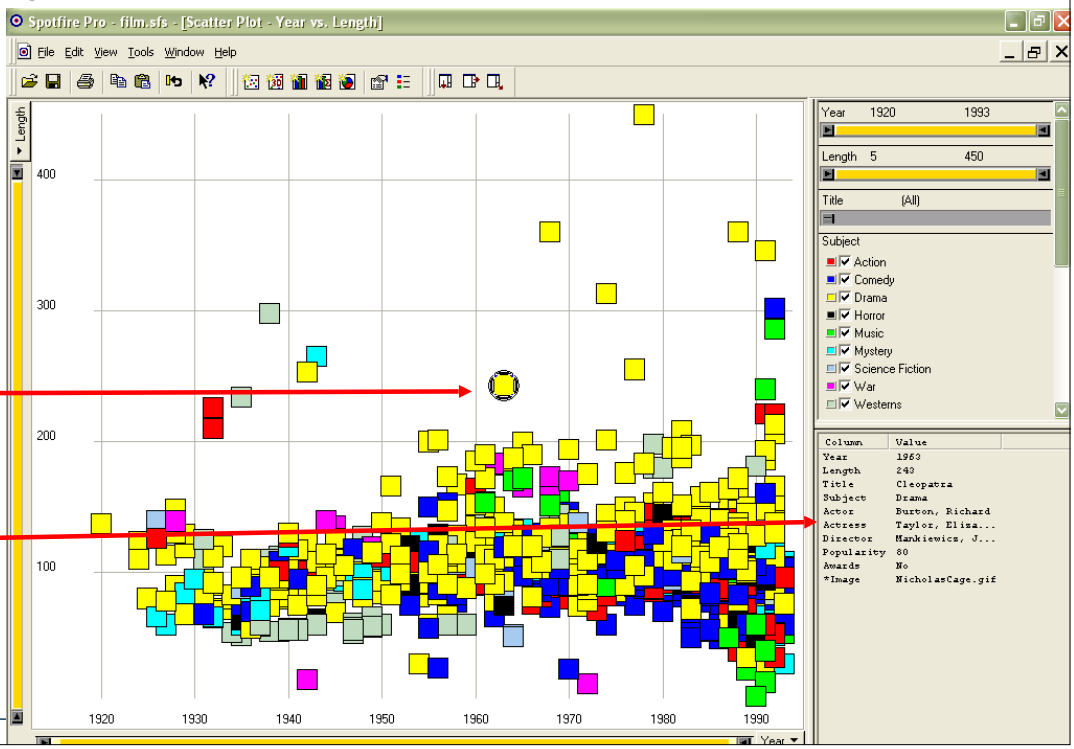


Mouse Selection

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

Selected item

Attributes



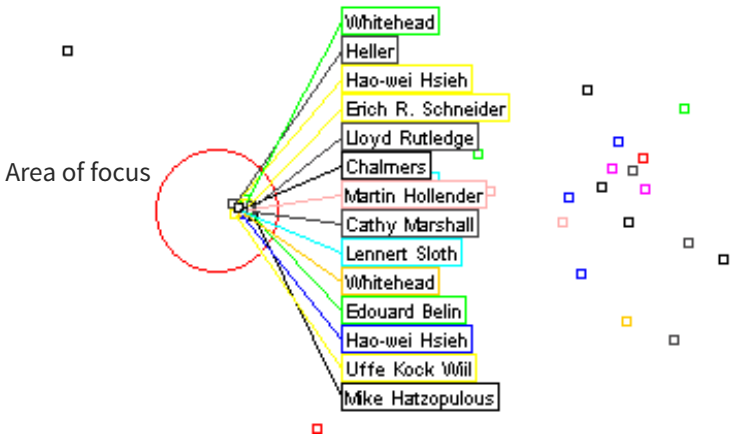
Challenge

- Where are the labels?
  - Labeling is difficult to do when so many entities exist

When you select multiple objects, where to place all the information in a way that makes sense.

Excentric Labeling

Description boxes containing the name of the data point



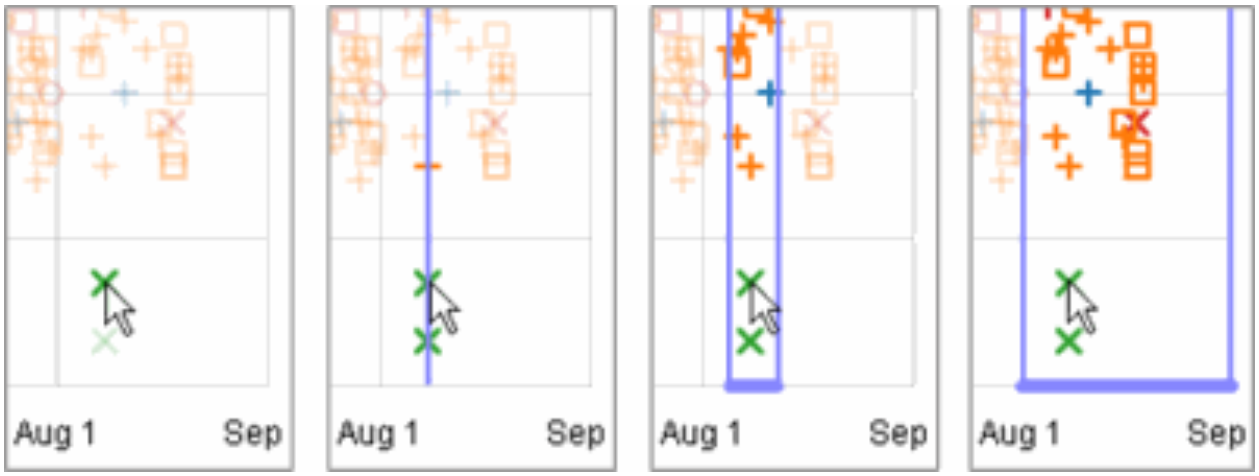
Line and box color match the color of the data point

Fekete and Plaisant CHI '99

Generalized Selection

- When you click on an item in a visualization, can we generalize the selection off the precise item?
  - Maybe you want to select items matching some attribute(s) of that item
  - Maybe you wanted items that are nearby your selection?

Query Relaxation



As you dwell on your mouse click, the selection criteria broaden and you can choose sets of items

Heer, Agrawala, Willett
CHI '08

Video at: http://vis.berkeley.edu/papers/generalized_selection/

2. Explore

"**Show me something different**"

- Enable users to examine a different subset of data
- Overcome the limitation of display size

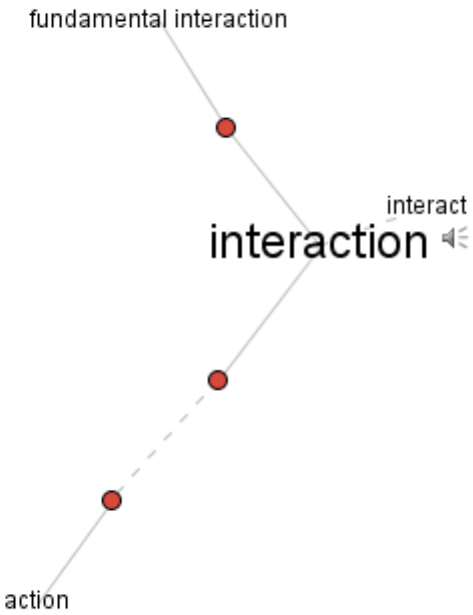
e.g.,
- Panning in Google Earth
- Direct Walking in graphs (e.g., Visual Thesaurus)

Direct Walk

- Linkages between cases
- Exploring one may lead to another
- Example:
  - Following hyperlinks on web pages

Example

Visual Thesaurus http://www.visualthesaurus.com



much more on this when we talk about graphs later

3. Reconfigure

"**Show me a different arrangement**"

- Provide different perspectives by changing the spatial arrangement of representation

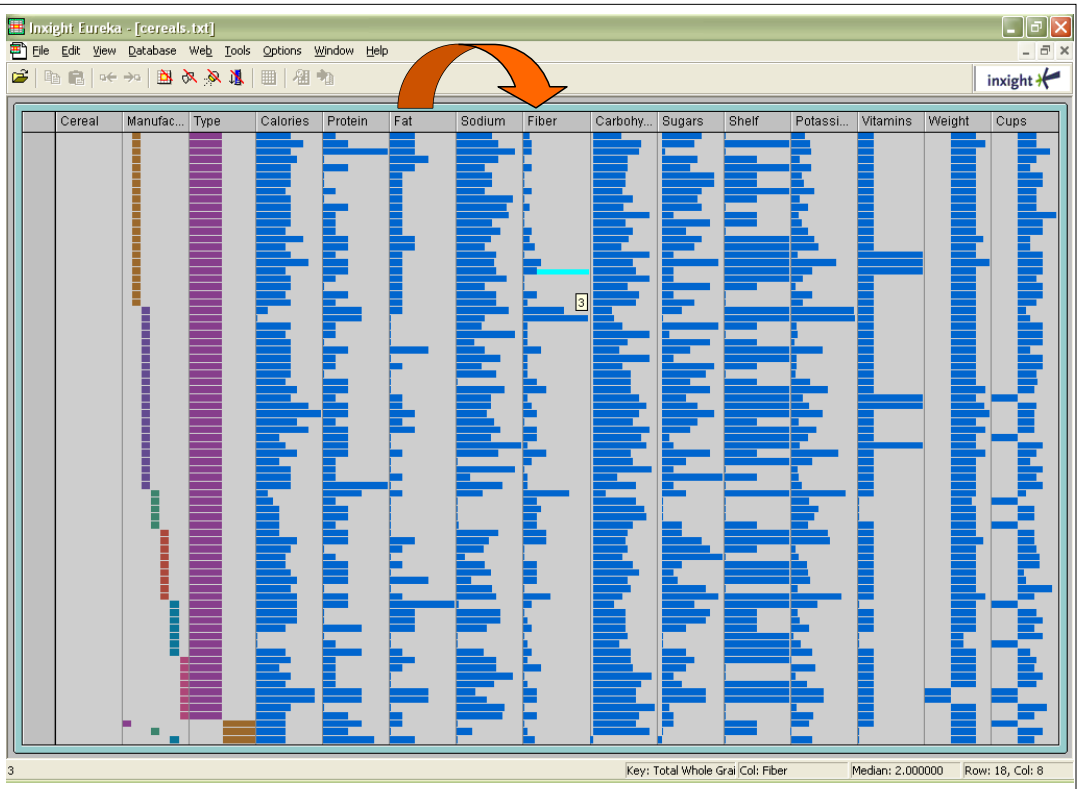
e.g.,
- Sorting and rearranging columns in TableLens
- Changing the attributes in a scatter plot
- The baseline adjustment feature in Stacked Histogram
- The "Spread Dust" feature in Dust & Magnet

Rearrange View

- Keep same fundamental representation and what data is being shown, but rearrange elements
  - Alter positioning
  - Sort

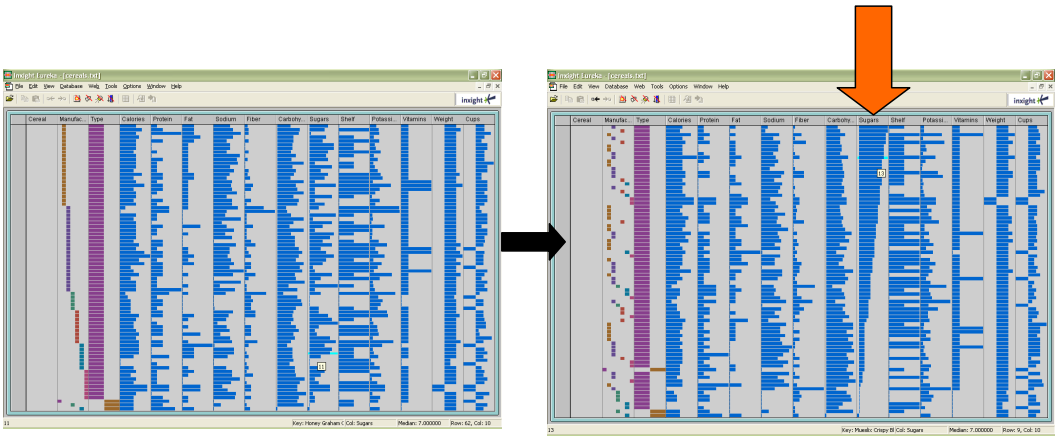
Rearrange

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



Sorting

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



4. Encode

"**Show me a different representation**"

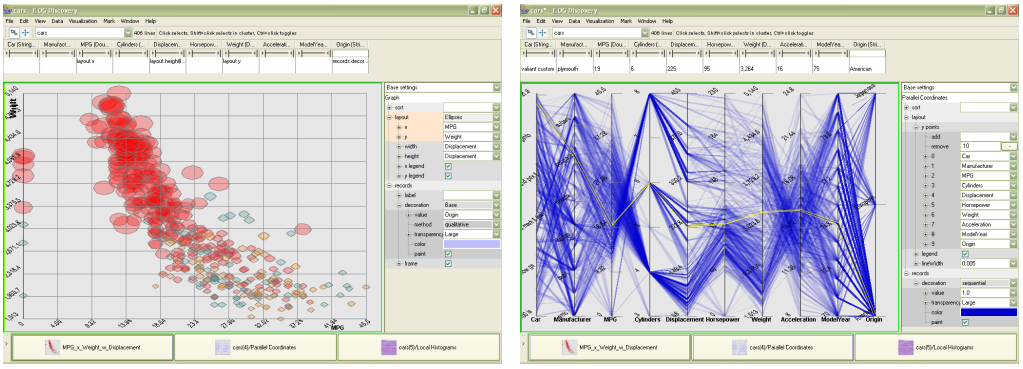
- Change visual appearances

e.g.,
- Changing color encoding
- Changing size
- Changing orientation
- Changing font
- Changing shape

Changing Representation

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

Example



Selecting different representation from options at bottom

5. Abstract/Elaborate

"**Show me more or less detail**"

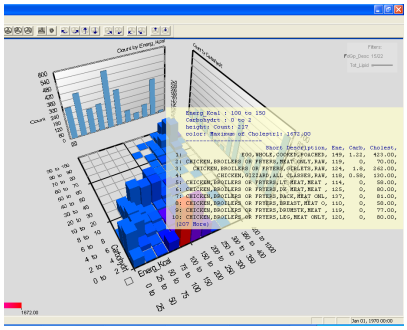
- Adjust the level of abstraction (overview and details)

e.g.,
- Unfolding sub-categories in an interactive pie chart
- Drill-down in Treemap
- Details-on-demand in Sunburst
- The tool-tip operation in SeeIT
- Zooming (geometric zooming)

Details-on-Demand

- Term used in infovis when providing viewer with more information/details about data case or cases
- May just be more info about a case
- May be moving from aggregation view to individual view
  - May not be showing all the data due to scale problem
  - May be showing some abstraction of groups of elements
  - Expand set of data to show more details, perhaps individual cases

Examples



SeeIT

Google Earth

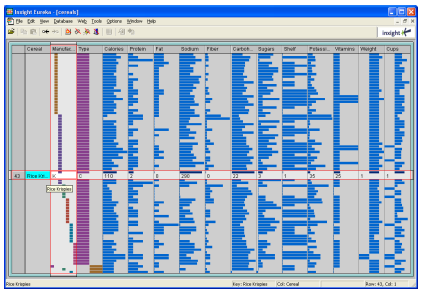
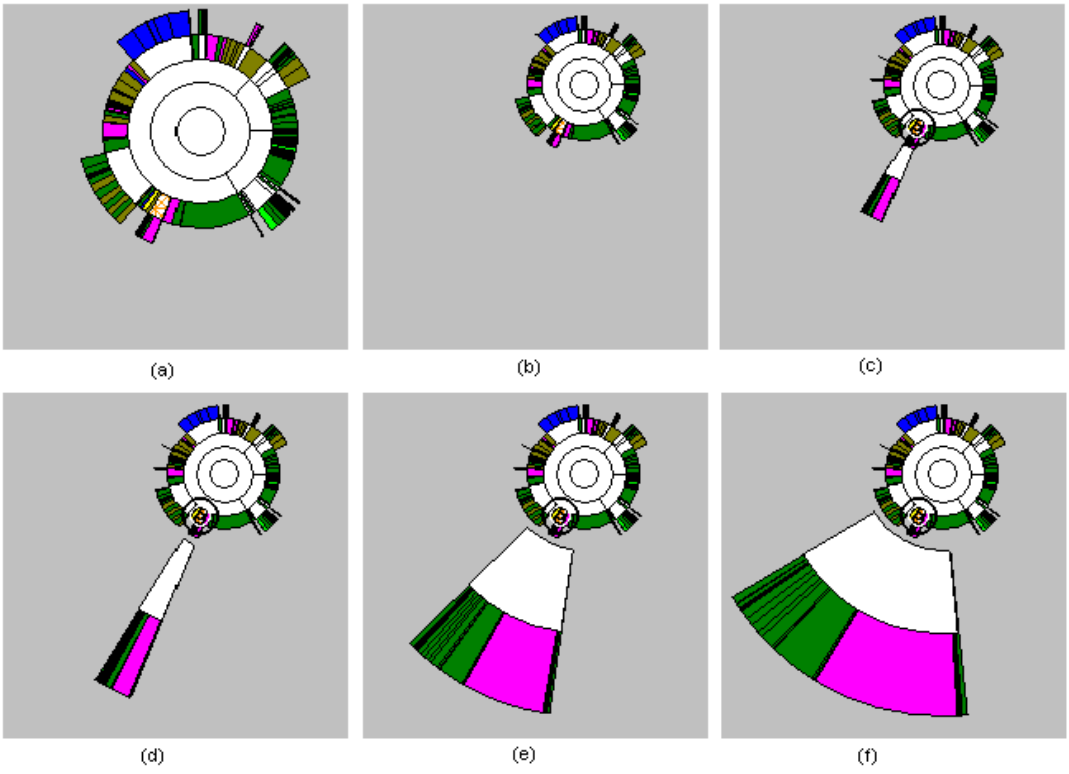


Table Lens

Example

Animated SunBurst



6. Filter

"**Show me something conditionally**"

- Change the set of data items being presented based on some specific conditions.

e.g.,

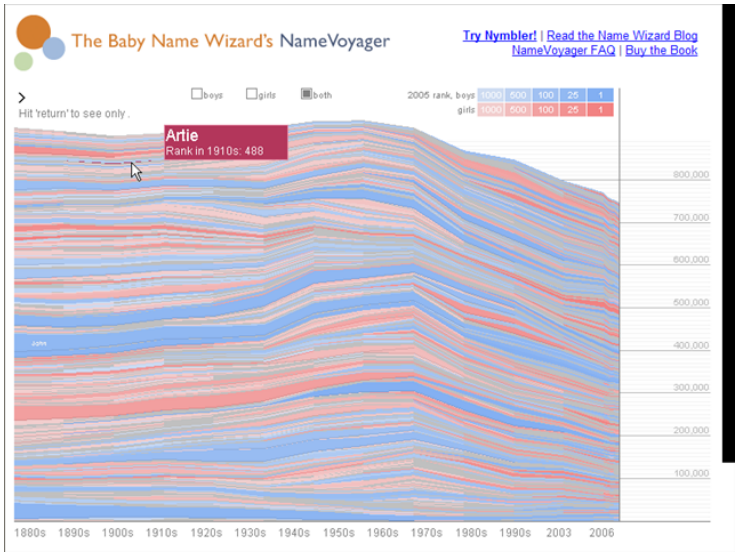
- Dynamic query
- Attribute Explorer
- Keystoke based filtering in NameVoyager
- QuerySketch

Filtering/Limiting

- Fundamental interactive operation in infovis is changing the set of data cases being presented
  - Focusing
  - Narrowing/widening

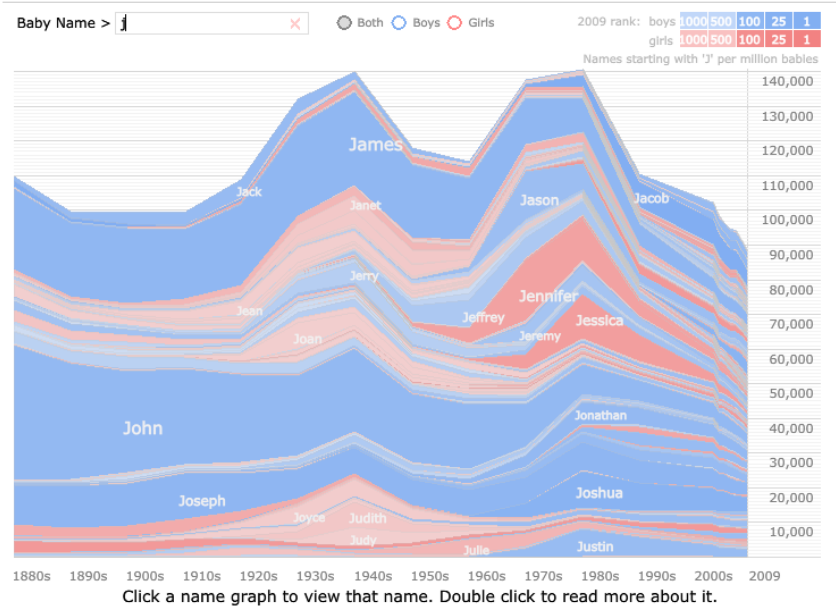
Example

NameVoyager



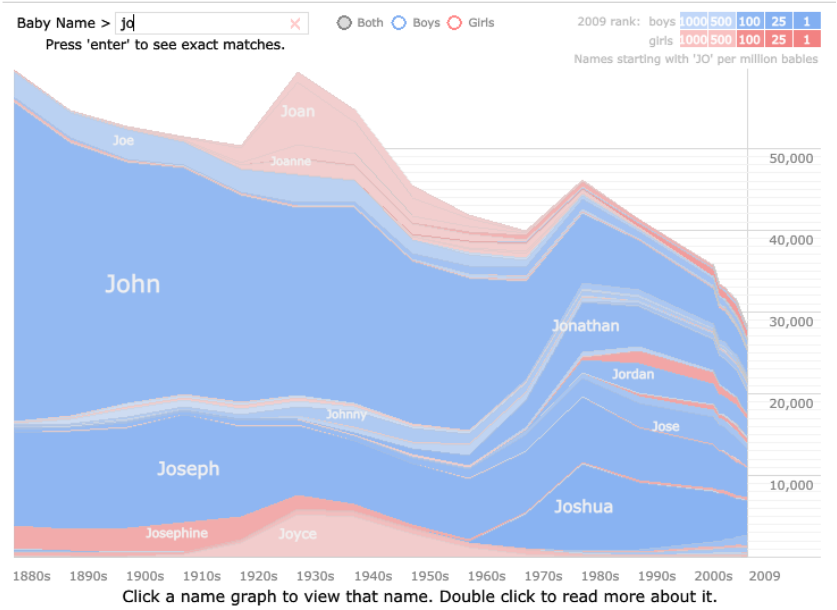
http://www.babynamewizard.com/namevoyager.html/

Filtering



Click a name graph to view that name. Double click to read more about it.

Filtering



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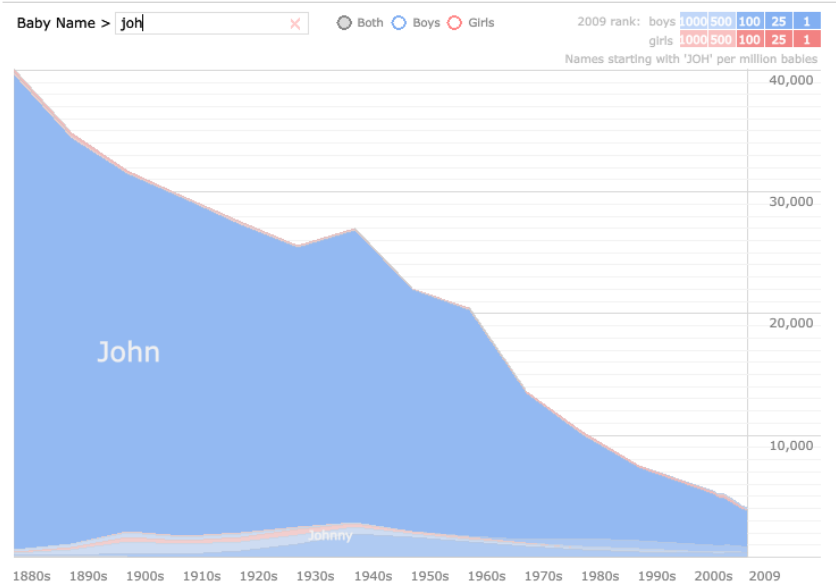

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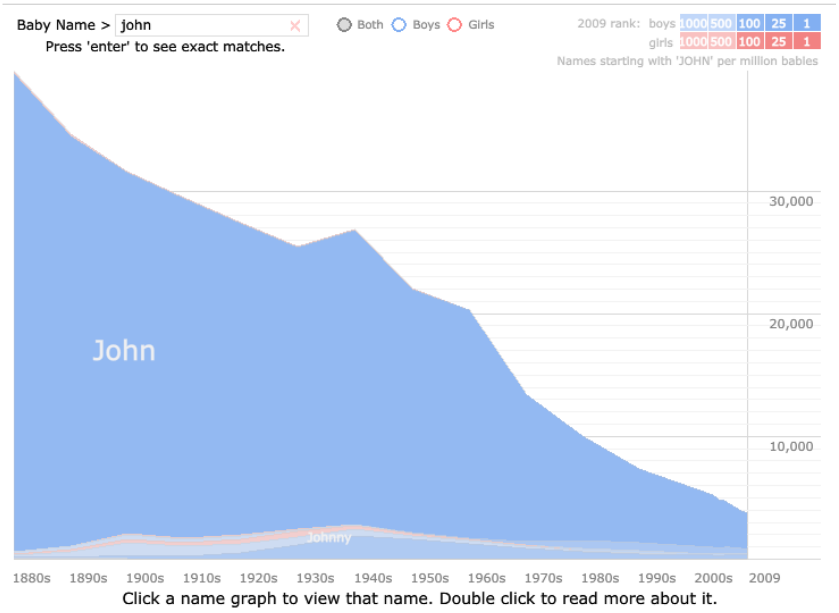


Dynamic Query

- Probably best-known and one of most useful infovis techniques
- Let's explore more details...

DB Queries

- Query language
  - Select house-address
    From atl-realty-db
    Where price >= 200,000 and
        price <= 400,000 and
        bathrooms >= 3 and
        garage == 2 and
        bedrooms >= 4

DB Queries

- Pros?
  - Powerful, flexible
- Cons?

DB Queries

- Pros?
  - Powerful, flexible
- Cons?
  - one at a time
  - difficult to construct

Typical Query Response

- 124 hits found
  - 1. 748 Oak St. - a beautiful …
  - 2. 623 Pine Ave. -
  - …
- 0 hits found

Further 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 Query

- Specifying a query brings immediate display of results
- Responsive interaction (< .1 sec) with data, concurrent presentation of solution
- “Fly through the data”, promote exploration, make it a much more “live” experience

Dynamic Query Constituents

- 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

Shneiderman
IEEE Software ’94

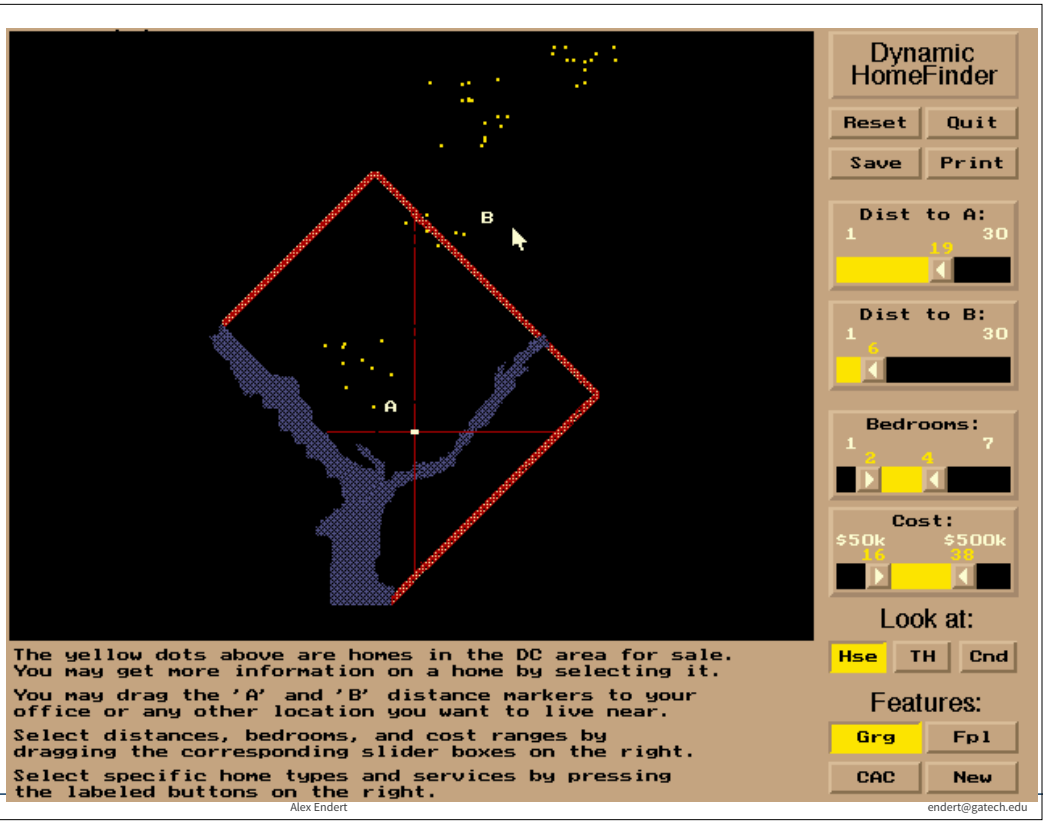
Ahlberg & Shneiderman
CHI ‘94

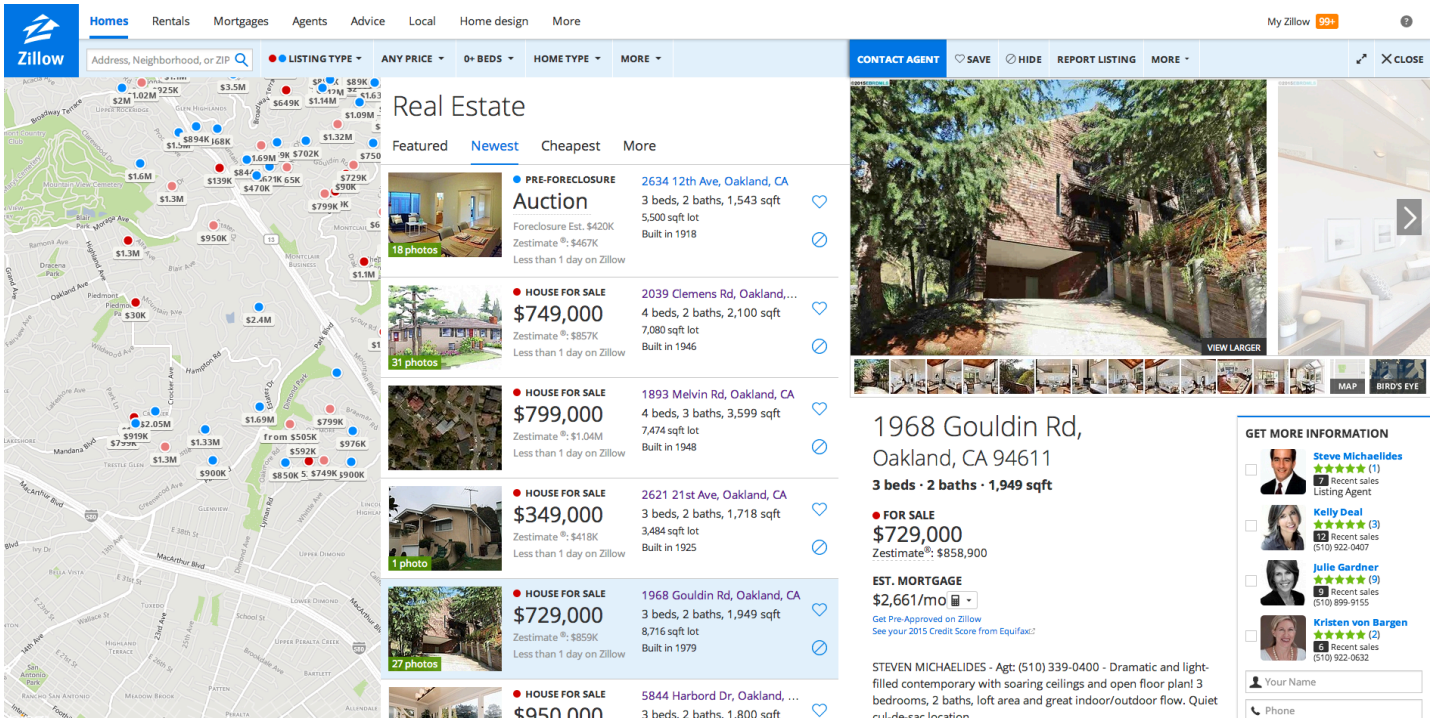
Imperfection

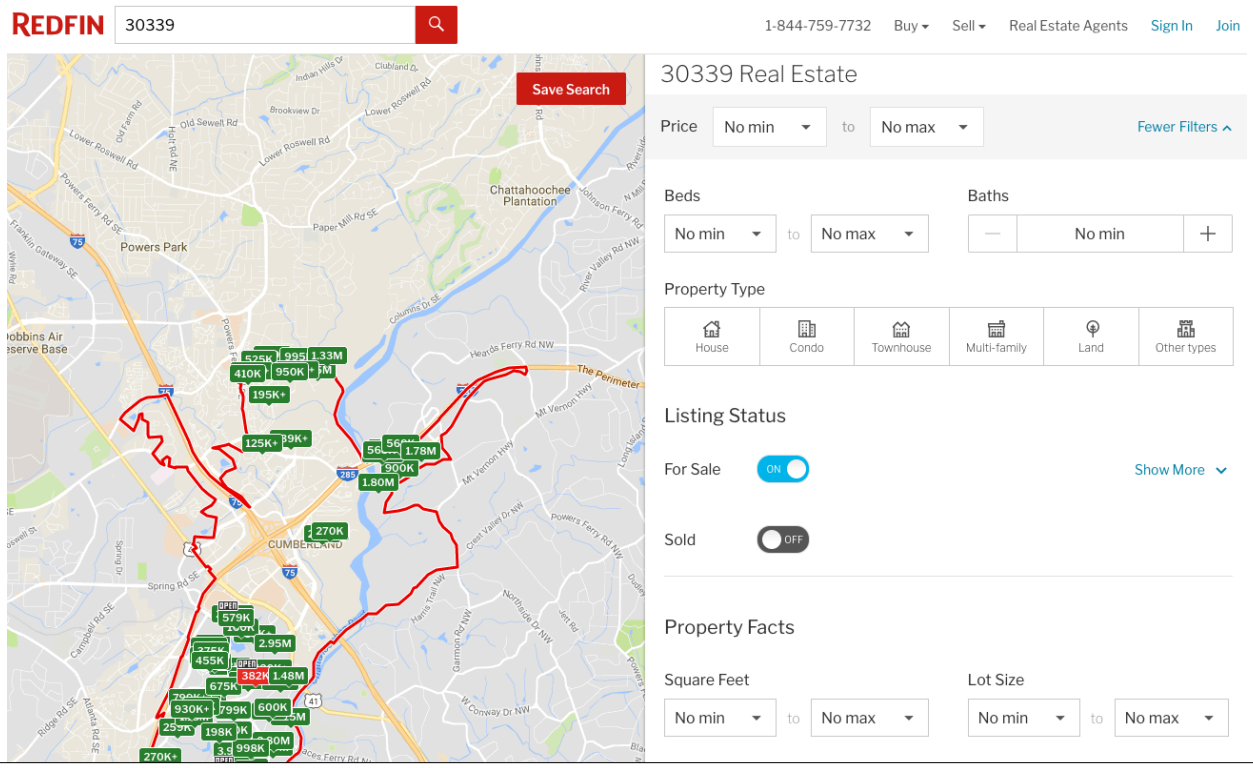
- Idea at heart of Dynamic Query
  - There often simply isn’t one perfect response to a query
  - Want to understand a set of tradeoffs and choose some “best” compromise
  - You may learn more about your problem as you explore

DQ Examples

- HomeFinder - Univ. of Maryland



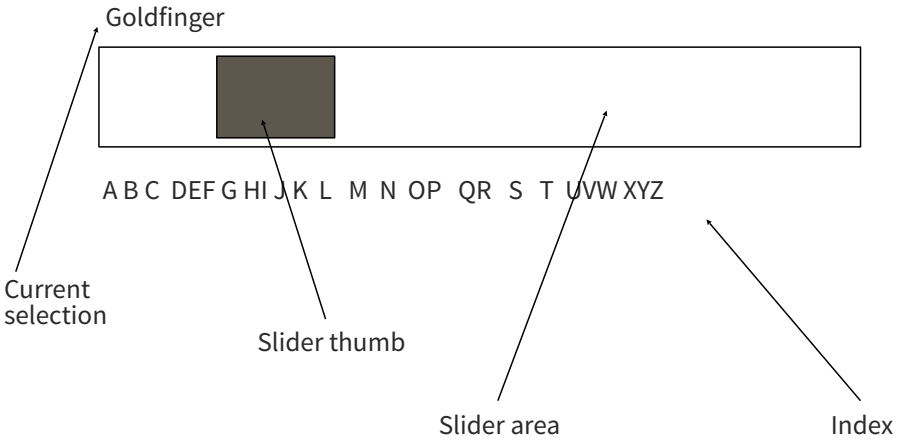




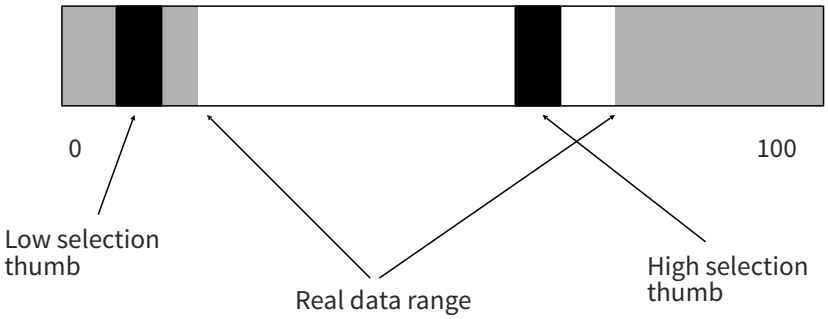
Query Controls

- Variable types
  - Binary nominal - Buttons
  - Nominal with low cardinality - Radio buttons
  - Ordinal, quantitative - sliders

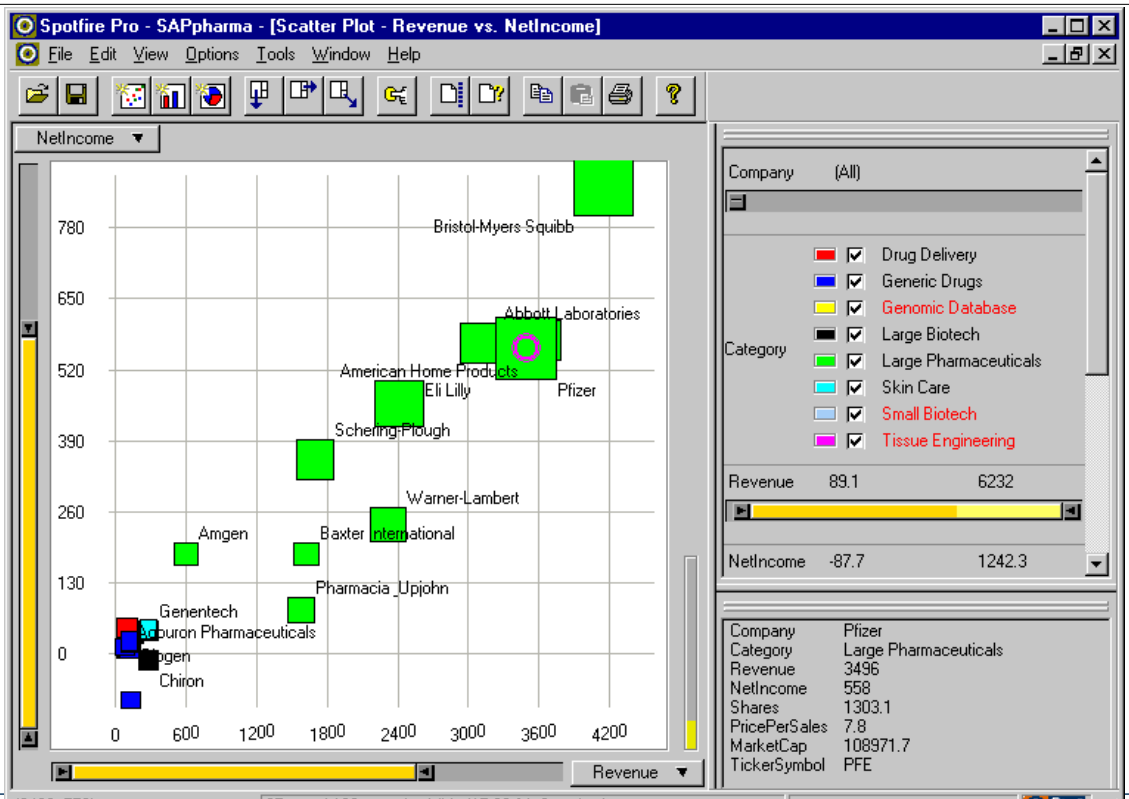
Alphaslider



Rangeslider



Spotfire

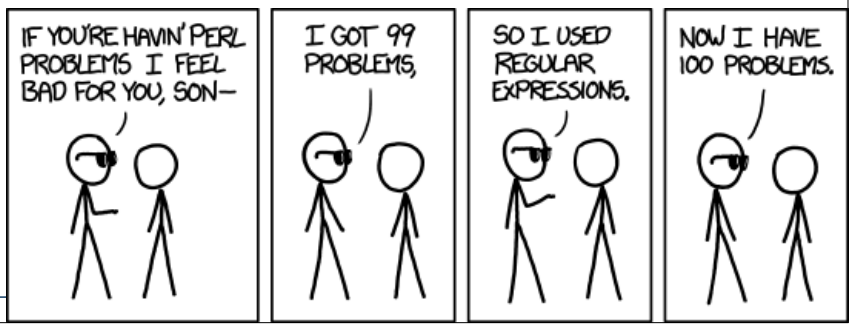


DQ Pros

- ?

DQ Pros

- Work is faster
- Promote reversing, undo, exploration
- Very natural interaction
- Shows the data
- Easier than complex queries



DQ Cons

- Operations are fundamentally conjunctive
- Controls are global in scope
  - They affect everything
- Controls must be fixed in advance
  - you have to program what each slider controls

DQ Cons

- Controls take space!
  - How much in Spotfire?

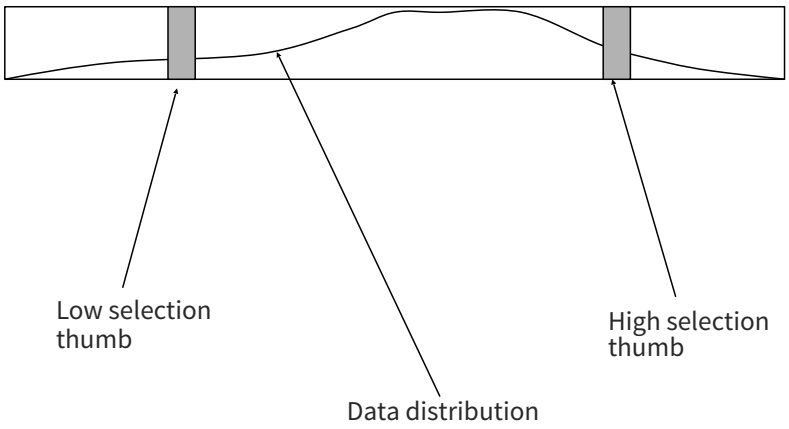
"Interaction Junk"
Endert and North, BELIV 2012

How many space is taken up by interaction tools rather than vis.

- Put data in controls?
- Put controls in the vis? Why vis and controls are separate

Data Visualization Sliders

- Data in the controls…



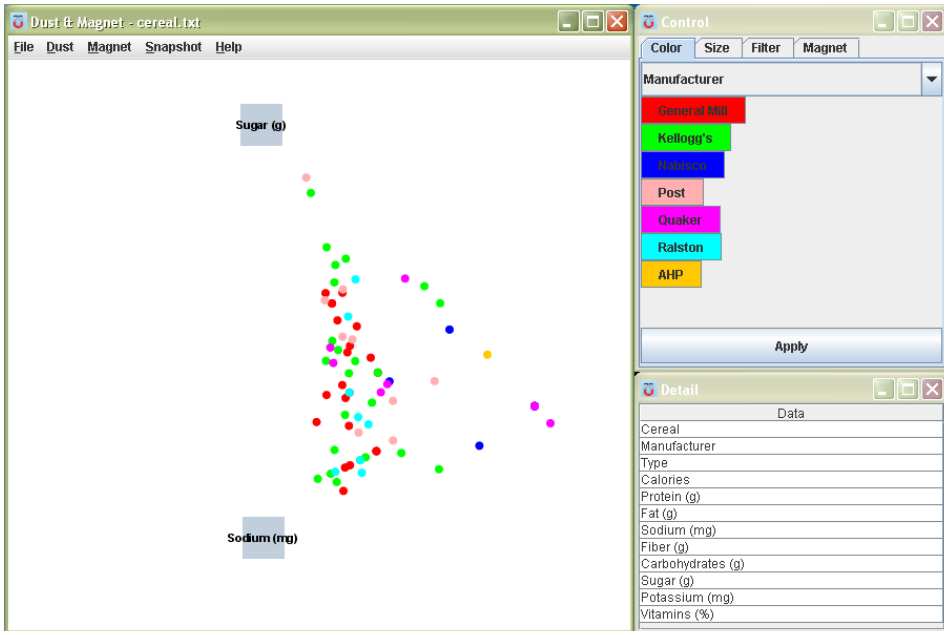
Eick
UIST '94

Not completely separate the area users use to control the vis and the area for showing the data.

Dust & Magnet

- Control in the visualization…

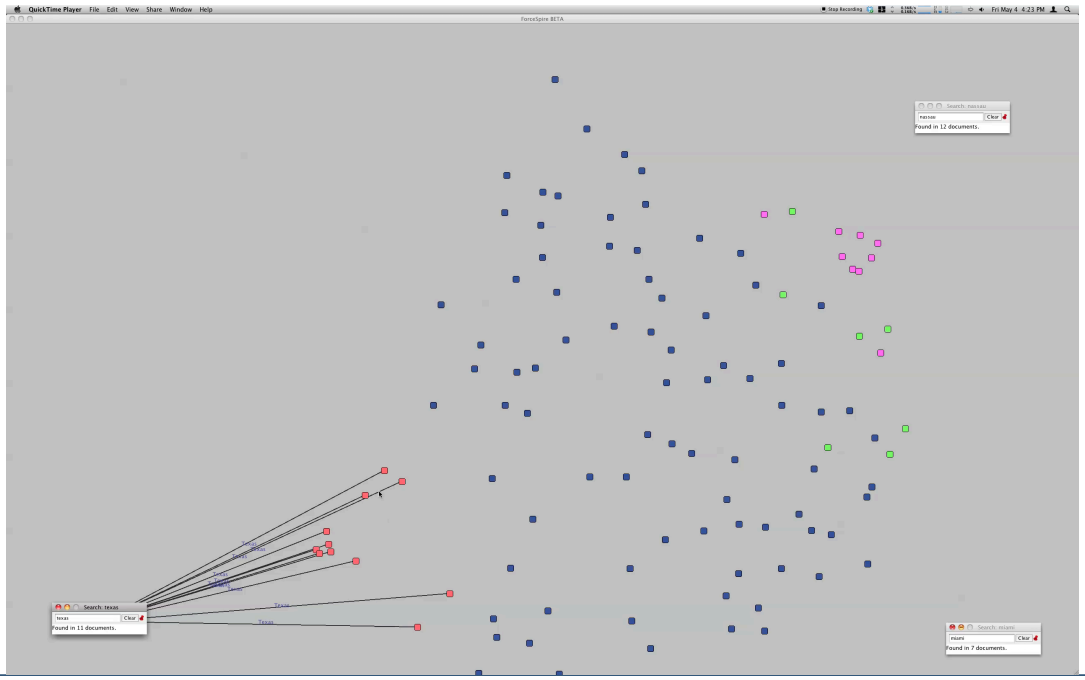
Demo



Yi et al
Information Visualization '05

Semantic Interaction

- Control in the visualization…



DQ Cons

- As data set gets larger, real-time interaction becomes increasingly difficult
- Storage - Data structures
  - linear array
  - grid file
  - quad, k-d trees
  - bit vectors

Tanin et al
InfoVis '97

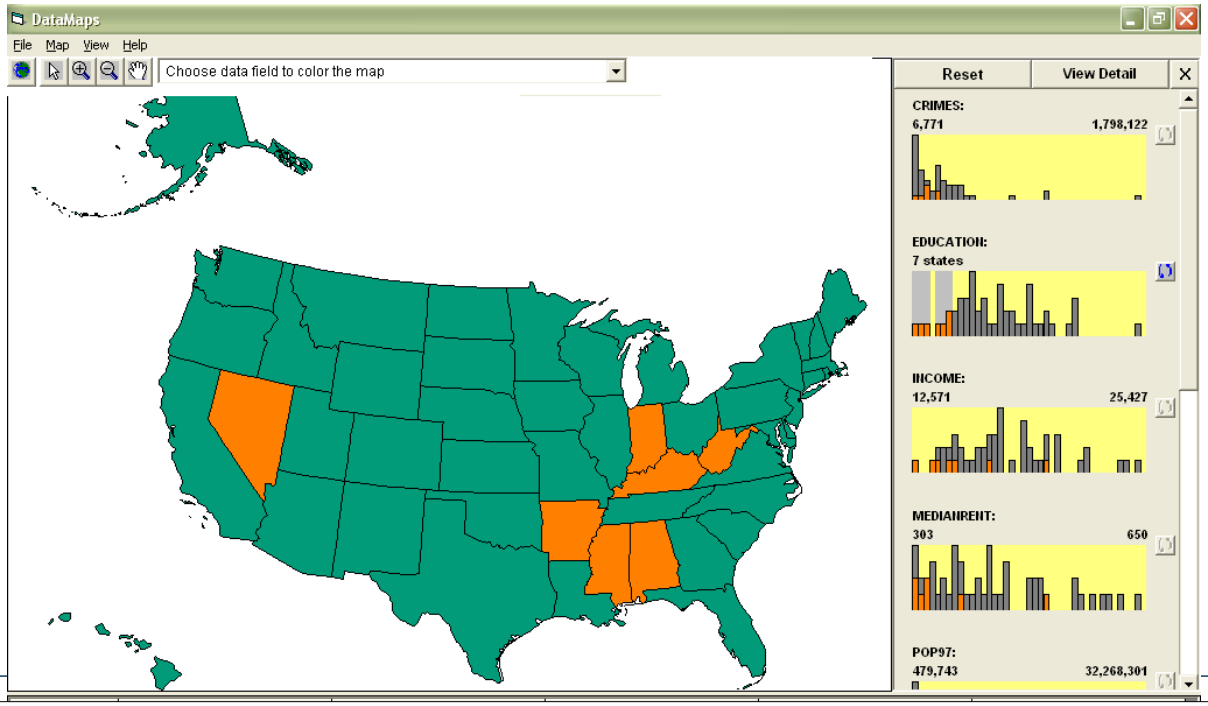
Brushing Histograms

- Special case of brushing
- Data values represented in histograms that can be clicked on and selected (controls region)
- When items selected there, the corresponding item(s) are highlighted in main view windows

BH Example

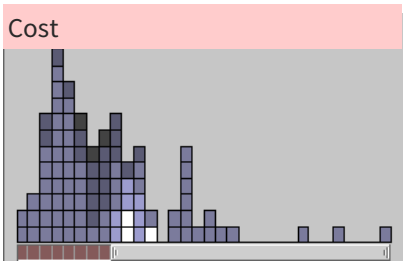
DataMaps

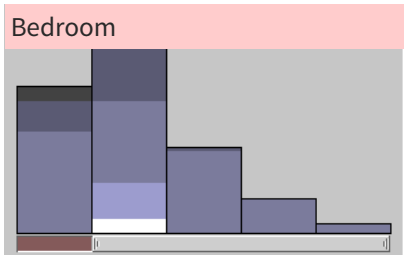
Maryland
&
Va Tech

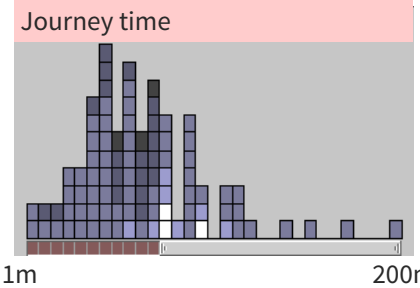


Attribute Explorer

Spence & Tweedie
Inter w Computers '98







Attribute histogram
All objects on all attribute scales
Interaction with attributes limits
Brushing across views
Color-encoded sensitivity

DQ Disadvantage

- Operations are global in scope
- Can we do something to fix that…?

Key Points from Today

Further: speech-based interaction -> speak to the visualization system

- Interaction facilitates a dialog between the user and the visualization system
- Multiple views amplify importance of interaction
- Interaction often helps when you just can't show everything you want