

# Interaction



CS 4460 – Intro. to Information Visualization  
October 18, 2017  
John Stasko

## Learning Objectives



- Understand how interaction can be used to address fundamental challenges in infovis that cannot be handled through representation
- List and give examples from 7 interaction categories of Yi's framework
  - Explain how each is employed for analytic benefit
- Describe the following types of interaction and how each is used
  - Drill down, Details on demand, Filtering, Brushing histograms
- Explain what dynamic queries are, and list their benefits as well as their limitations/weaknesses
- Explain what brushing & linking is
- Describe different ways that animation is used for benefit
- Give examples of systems/techniques where interaction is fundamental and vital to the technique
- Understand challenges in moving from keyboard/mouse to finger/pen touch interaction

# Main Components



“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

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## “Little Brother”



- Two main components in an infovis
  - Representation
  - Interaction



- Representation gets all the attention
- Interaction is where the action is (no pun intended)

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# Research Focus



- Very challenging to come up with innovative, new visual representations
- But can do interesting work with how user interacts 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

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# Electronics



- This is now a **NO** laptops/cellphones class
- Exceptions will be noted (labs, etc)
- Note-takers, see me



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# Fundamentally



- For larger data, there is simply too much to show in a coherent manner
- Interaction helps us address that challenge

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# Interaction



- How do you define “interactive”?

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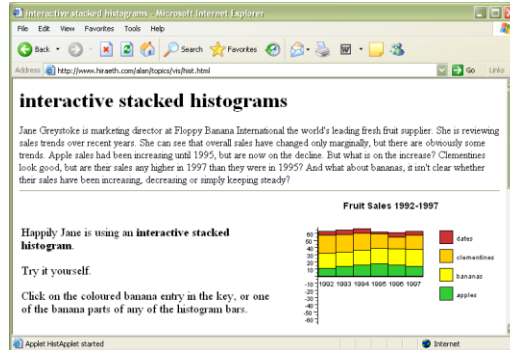
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# Example



Even simple interaction can be quite powerful



Stacked histogram

<http://www.hiraeth.com/alan/topics/vis/hist.html>

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# Pause



- Mini-exercise in pairs:
  - List the different "categories" of interaction in information visualization

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# Interactions

(from class)



- Selection
- Explore
- Zoom
- Filter
- Comparing
- Connect
- Reorder
- Abstract
- Panning
- Saving/exporting
- Min/maximizing
- dragging
- Highlighting
- Hover
- Undo/redo
- Scrolling
- Stacking
- Searching

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# 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

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# Interaction Types



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

# Another Taxonomy



- Operator
  - navigation, selection, manipulation, distortion, filtering
- Space of interaction
  - screen, data value, data structure, attribute, object, visualization structure
- Parameters of the interaction operator
  - focus, extents, transformation, blender

# 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...
  - User-centered versus system-centered characterizations



## 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

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*IEEE TVCG* 13(6), '07

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## 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

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# Focus Emerged



## User intent

“What a user wants to achieve through a specific interaction technique”

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## 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

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# Results



## 7 categories

Select

Explore

Reconfigure

Encode

Abstract/Elaborate

Filter

Connect

## 1. Select



“Mark something as interesting”

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

Examples?

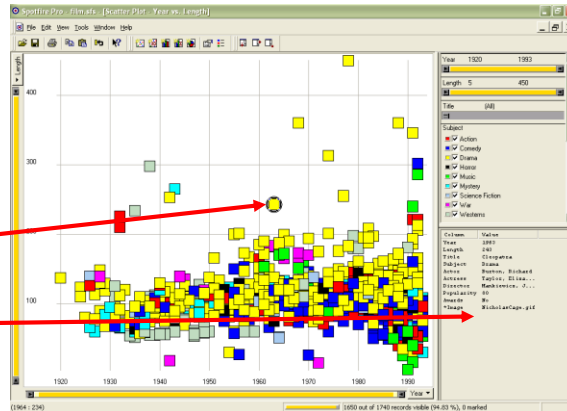
# Mouse Selection



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

Selected item

Attributes



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## 2. Explore



“Show me something different”

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

Examples?

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# Direct Walk



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

The screenshot shows a web browser window with the URL <https://www.cs.gatech.edu/~starke/cs4460/sched>. The page title is "Introduction to Information Visualization [CS 4460]". Below the header, there is a navigation menu with links for Home, Schedule, Assignments, Instructor, TA, Related courses, and Resources. The main content is a "Schedule" table with columns for Date, Session, Topic, Prep Material, Resources, and HW.

Date	Session	Topic	Prep Material	Resources	HW
<b>Week 1</b>					
Aug 21	Lecture	Introduction	<a href="#">Tufte intro</a>	<a href="#">Link</a>	
Aug 23	Lecture	InfoVis Overview	<a href="#">CNS news chapter</a>	<a href="#">Link</a>	
Aug 25	Design	The Basics			
<b>Week 2</b>					
Aug 29	Lecture	Multivariate Data & Tables	<a href="#">Data Table</a>	<a href="#">Link</a>	HW.1
Aug 30	Lecture	Graphs & Charts	<a href="#">Eva article</a>	<a href="#">Link</a>	
Sep 1	Lab	HTML & CSS	<a href="#">Murray on HTML &amp; CSS</a>	<a href="#">Link</a>	
<b>Week 3</b>					
Labor Day Holiday					
Sep 4					
Sep 6	Design	CSV data			HW.2
Sep 8	Lab	JavaScript	<a href="#">Murray on JavaScript</a>	<a href="#">Link</a>	
<b>Week 4</b>					
Sep 11		Hurricane Irma			
Sep 13	Lecture	Visual Perception	<a href="#">Shane article on color</a>	<a href="#">Link</a>	
Sep 15	Lecture	Case Study: Jigsaw	<a href="#">Jigsaw file: video1, video2</a>	<a href="#">Link</a>	HW.3
<b>Week 5</b>					
Sep 18	Lecture	Multivariate Visual Repr. 1	<a href="#">Table Lens, EUC2008: InfoVis08 videos</a>	<a href="#">Link</a>	
Sep 19	Lecture	Multivariate Visual Repr. 2	<a href="#">Cook &amp; Shneiderman</a>	<a href="#">Link</a>	
Sep 22	Lab	SVG	<a href="#">Murray on SVG</a>	<a href="#">Shneiderman article</a>	<a href="#">Link</a>
<b>Week 6</b>					

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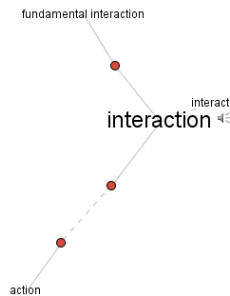
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<http://www.visualthesaurus.com>

# Example



Visual Thesaurus



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## 3. Reconfigure



“Show me a different arrangement”

- Provide different perspectives by changing the spatial arrangement of representation

Examples?

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## Rearrange View



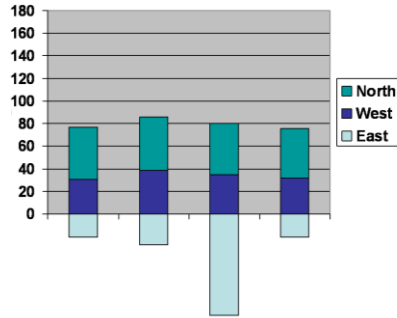
- Keep same fundamental representation and what data is being shown, but rearrange elements
  - Alter positioning
  - Sort

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# Example



Stacked Histogram

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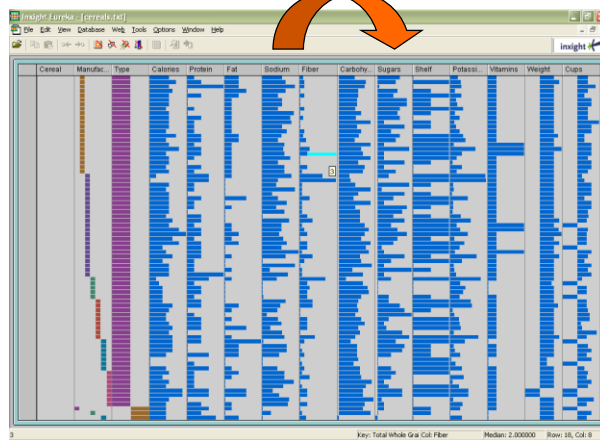
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# Rearrange



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



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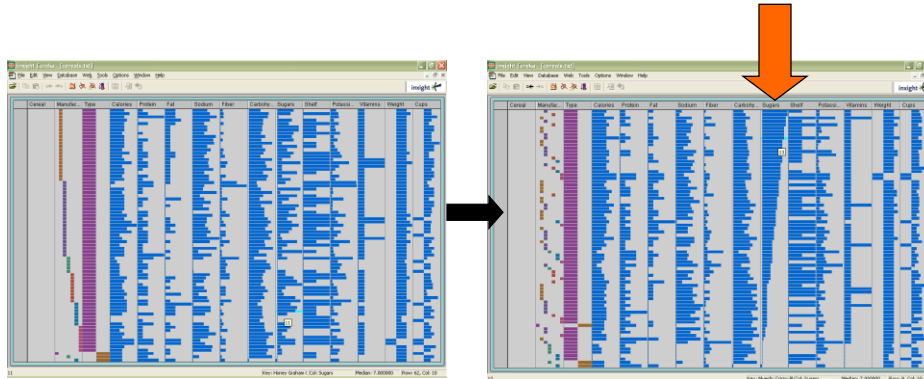
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# Sorting



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



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## 4. Encode



“Show me a different representation”

- Change visual appearances

Examples?

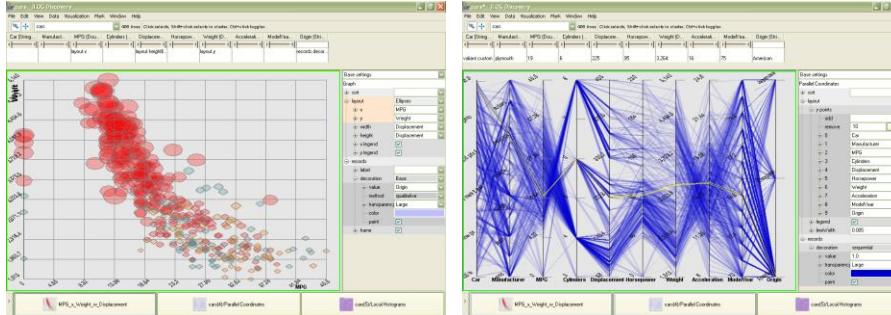
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# Example



Selecting different representation from options at bottom

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## 5. Abstract/Elaborate



“Show me more or less detail”

- Adjust the level of abstraction (overview and details)

Examples?

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# 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

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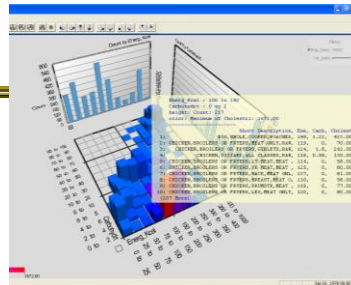
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## Examples



Google Earth



SeeIT

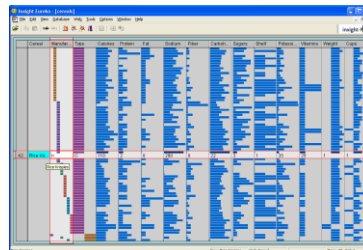


Table Lens

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## 6. Filter



“Show me something conditionally”

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

Examples?

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## Filtering/Limiting



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

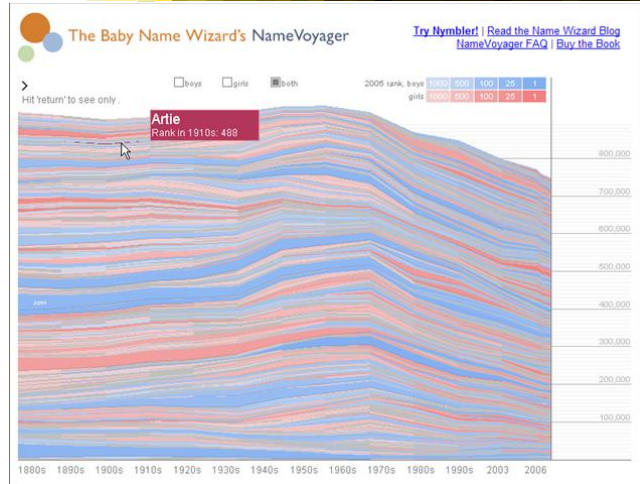
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# Example

NameVoyager



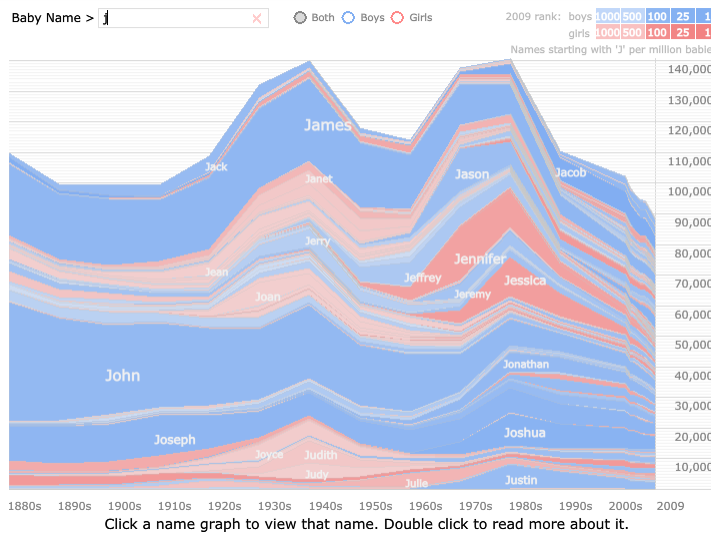
<http://www.babynamewizard.com/namevoyager.html/>

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# Filtering



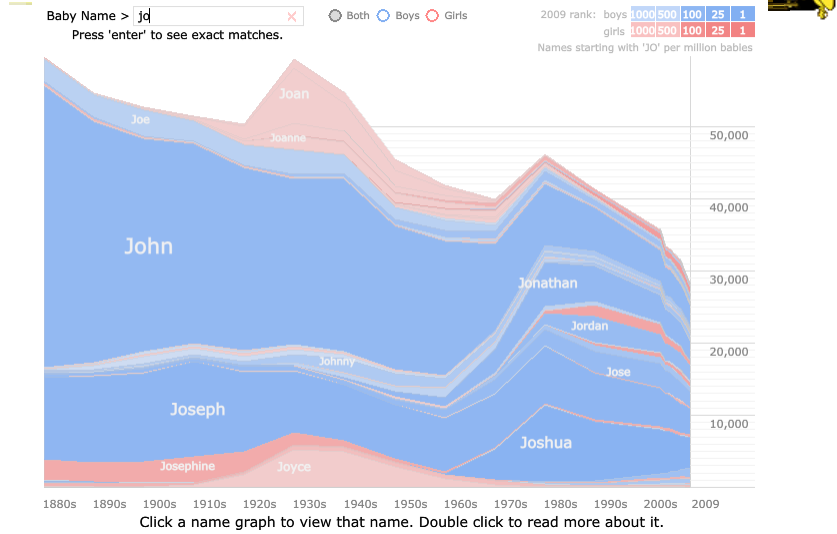
Click a name graph to view that name. Double click to read more about it.

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# Filtering

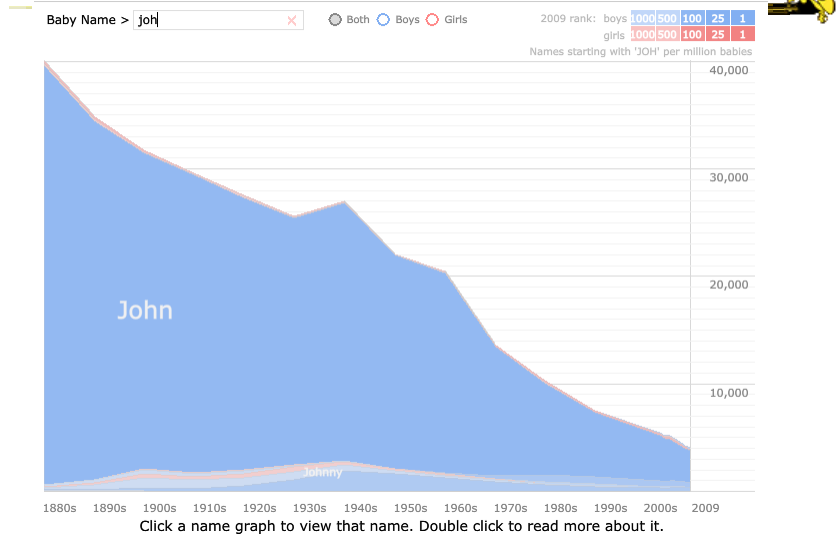


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# Filtering



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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  $\geq$  200,000 **and**  
price  $\leq$  400,000 **and**  
bathrooms  $\geq$  3 **and**  
garage == 2 **and**  
bedrooms  $\geq$  4

# DB Queries



- Pros?
  - Powerful, flexible
- Cons?

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# Typical Query Response



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

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## 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
  - Timesharing vs. batch

# 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

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# 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

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# DQ Examples



- HomeFinder - Univ. of Maryland



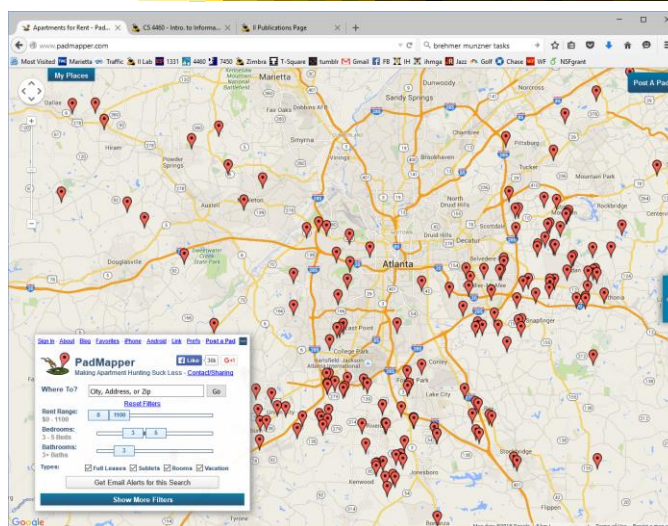
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<http://www.padmapper.com>

# PadMapper



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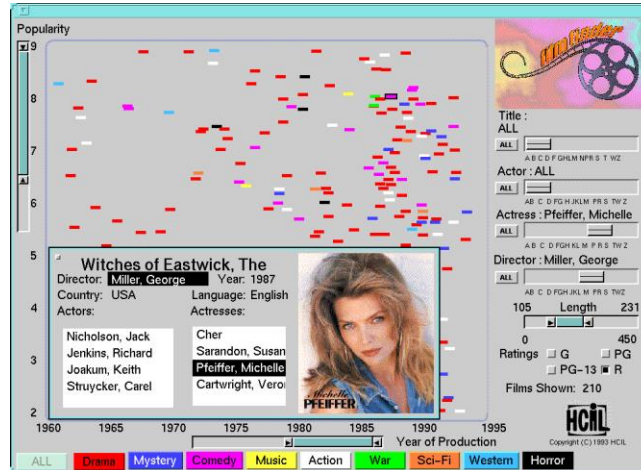
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# FilmFinder



C. Ahlberg  
Maryland

Video



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# Query Controls



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

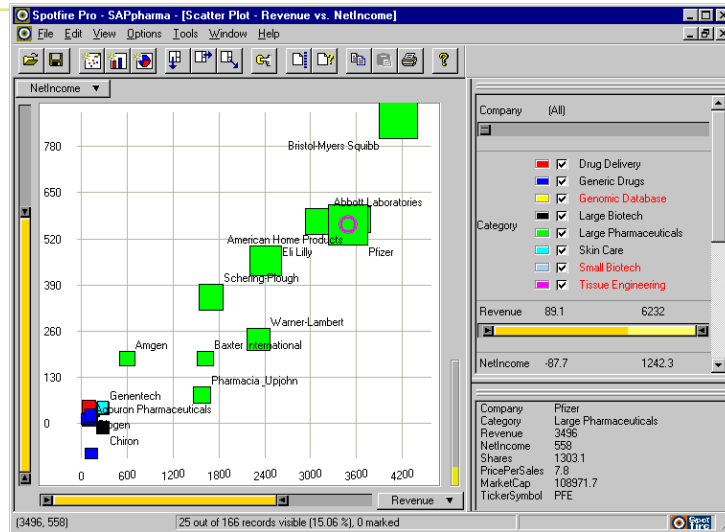
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# Spotfire

(old version)



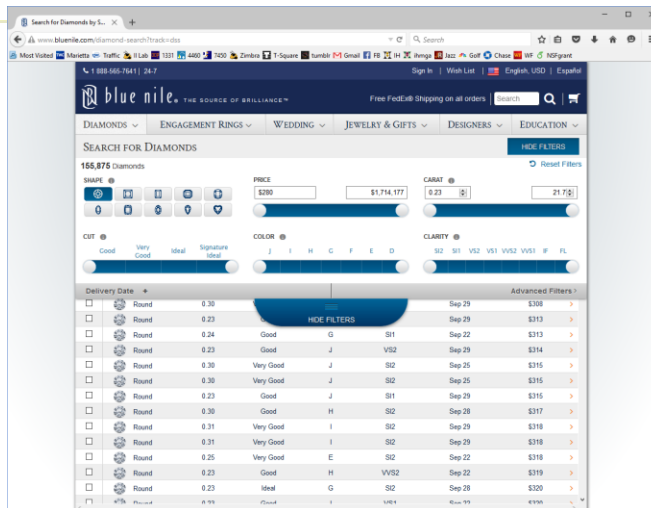
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# An Example

Note quite DQ though



<http://www.bluenile.com/diamond-search?track=dss>

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## DQ Pros



- ?

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## DQ Pros



- Work is faster
- Promote reversing, undo, exploration
- Very natural interaction
- Shows the data

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## DQ Cons



- ?

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## DQ Cons



- Operations are fundamentally conjunctive
- Can you formulate an arbitrary boolean expression?
  - $\neg(A1 \vee A2) \wedge A3 \vee (A4 \vee A5 \wedge A6) \vee \dots$
- But do people really do this often?

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## DQ Cons



- Controls are global in scope
  - They affect everything
- Controls must be fixed in advance

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## DQ Cons



- Controls take space!
  - How much in Spotfire?
- Put data in controls...

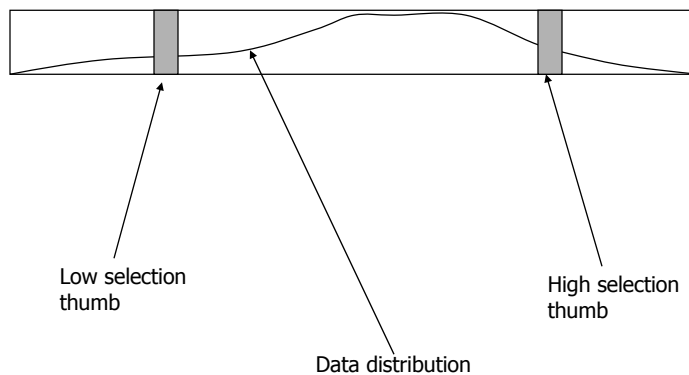
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# Data Visualization Sliders



Eick  
UIST '94

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## 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

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## 7. Connect

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“Show me related items”

- Highlight associations and relationships
- Show hidden data items that are relevant to a specified item

Examples?

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## Highlighting Connections

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- Viewer may wish to examine different attributes of a data case simultaneously
- Alternatively, viewer may wish to view data case under different perspectives or representations
  
- But need to keep straight where the data case is

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# Brushing



- Applies when you have multiple views of the same data
- Selecting or highlighting a case in one view generates highlighting the case in the other views
- Very common technique in InfoVis

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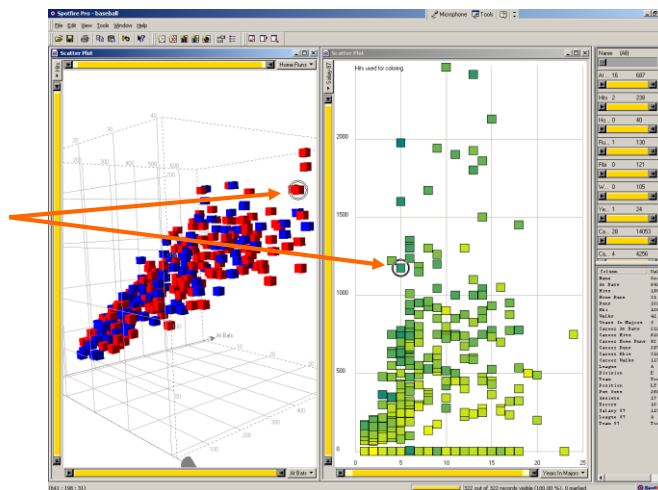
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# Brushing



Same item

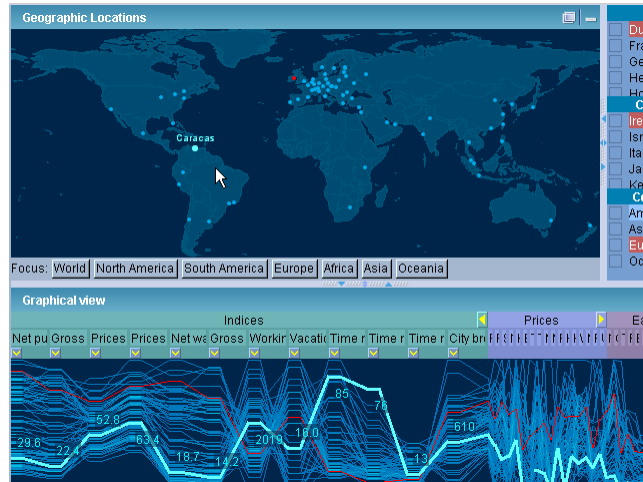


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# Example



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InfoScope

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# Brushing Histograms



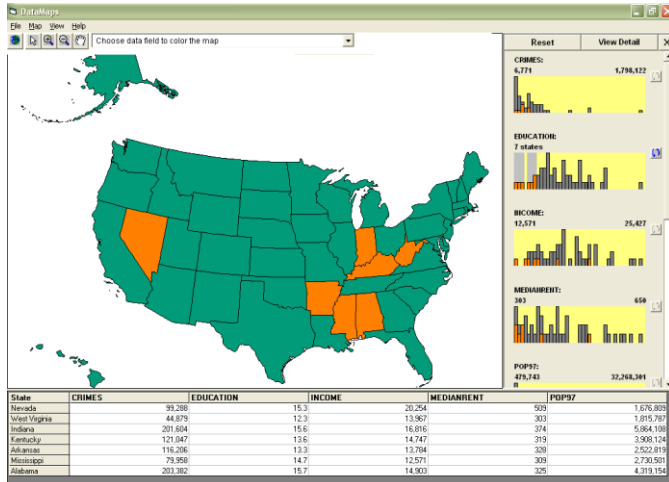
- Special case of brushing
- Data values represented in histograms that can be clicked on and selected (controls region)
- When items selected there, the corresponding item(s) are highlighted in main view windows

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# BH Example



DataMaps

Maryland  
&  
Va Tech

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# Another Kind of Interaction



Animation

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# Animation for Transitions



- Principles
  - Animation can help “soften the blow” when a view changes
  - Preserve context, allow the viewer to track where things went
- Project overview
  - Developed variety of different transitions and applications
  - Performed experiments to see how these are perceived

Heer & Robertson  
*TVCG (InfoVis) '07*

Video

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## OK



- Let's take a step back and think about representation & interaction again

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# Supporting Representation



- Interaction in many cases is vital to representation
  - Provides useful perspective
    - Many, many examples:
      - Parallel coords, InfoZoom, anything 3D
  - Necessary for clarifying representation
    - ???
    - Dust & Magnet
    - OnSet

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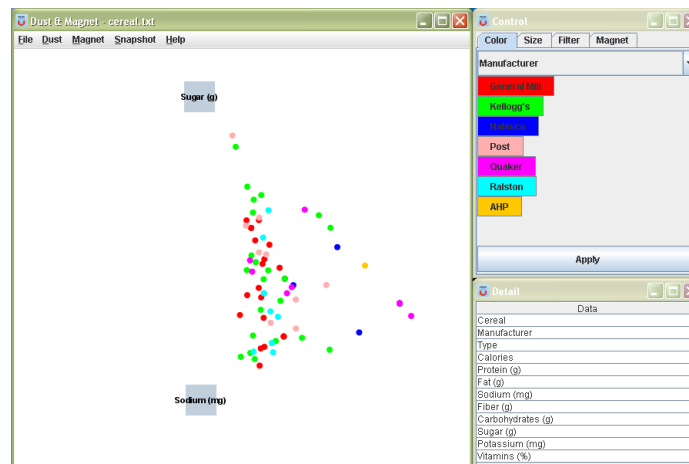
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## Dust & Magnet

Must interact to gain any value



Demo



Yi et al  
*Information Visualization '05*

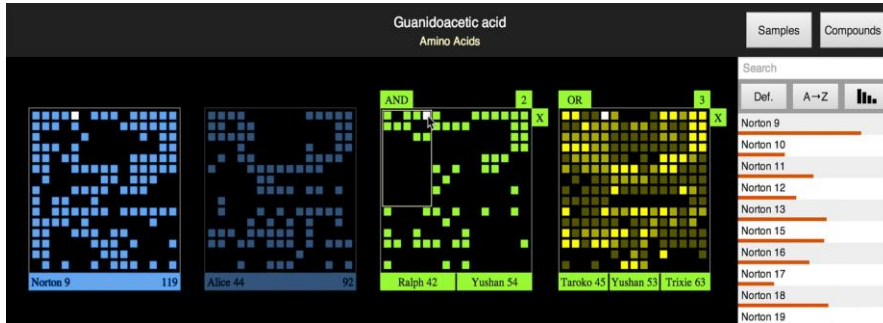
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# OnSet

Perform union & intersection  
via interaction



Represent set as a box, elements are spots in that box  
Use interaction to do set union, intersection

Sadana, Major, Dove & Stasko  
*TVCG (InfoVis) '14*

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## Moving Past WIMP



- 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.

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## Multi-touch InfoVis



- What will it be like to interact with visualizations on a (touch) tablet computer?
  - Lots of UI controls in vis applications
  - Lots of small data objects to manipulate
- Many touch gestures possible, but what are the right ones?

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## Constraints

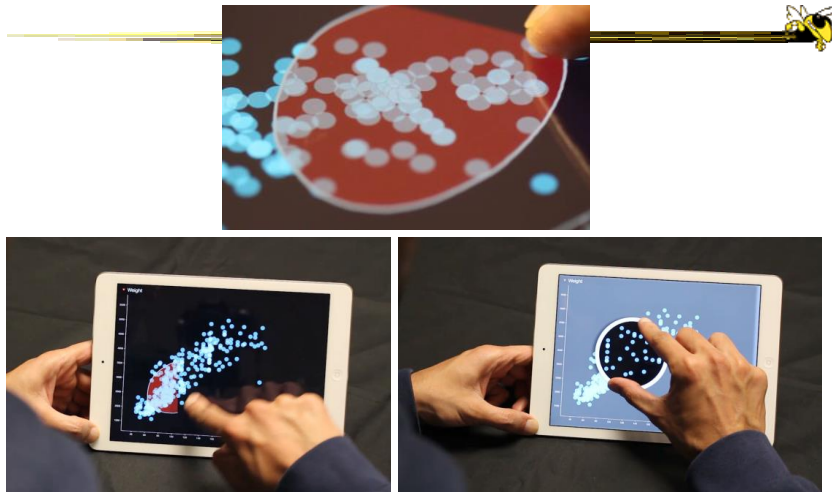


- One hand holding the tablet
- Not much screen real estate
- Fat finger problem
- Hover is gone
- Simpler gestures (1 or 2 finger) probably better
- Leverage gestures from other applications

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Video

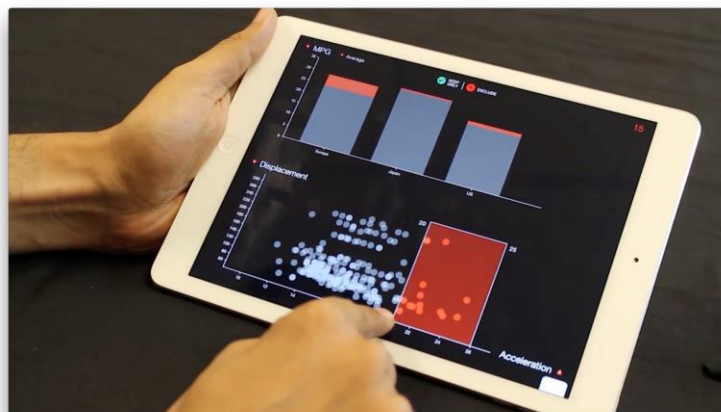
Sadana & Stasko  
AVI '14

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## Multi-Coordinated Views



Video

Sadana & Stasko  
*Computer Graphics Forum (EuroVis) '16*

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# Key Points



- 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

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# Learning Objectives



- Understand how interaction can be used to address fundamental challenges in infovis that cannot be handled through representation
- List and give examples from 7 interaction categories of Yi's framework
  - Explain how each is employed for analytic benefit
- Describe the following types of interaction and how each is used
  - Drill down, Details on demand, Filtering, Brushing histograms
- Explain what dynamic queries are, and list their benefits as well as their limitations/weaknesses
- Explain what brushing & linking is
- Describe different ways that animation is used for benefit
- Give examples of systems/techniques where interaction is fundamental and vital to the technique
- Understand challenges in moving from keyboard/mouse to finger/pen touch interaction

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# Upcoming



- D3: Selections and Grouping
  - Prep: "How selections work" by Bostock
- Tufte's Design Principles
  - Prep: Most Misleading Charts of 2015 & WTF Vizes
- Storytelling & Communication