Interaction

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

“Little Brother”

- Two main components in an infovis
  - Representation
  - Interaction

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

Electronics

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

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

Interaction

• How do you define “interactive”? 
Example

Even simple interaction can be quite powerful

Stacked histogram

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

Pause

• Mini-exercise in pairs:
  – List the different "categories" of interaction in information visualization
Interactions
(from class)

- Selection
- Explore
- Zoom
- Filter
- Comparing
- Connect
- Reorder
- Abstract
- Panning

- Saving/exporting
- Min/maximizing
- Dragging
- Highlighting
- Hover
- Undo/redo
- Scrolling
- Stacking
- Searching

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

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

Ward, Grinstein, & Keim 2010, chapter 10
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

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
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

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

2. Explore

“Show me something different”

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

Examples?
Direct Walk

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

Example

http://www.visualthesaurus.com

Visual Thesaurus
3. Reconfigure

“Show me a different arrangement”

- Provide different perspectives by changing the spatial arrangement of representation

Examples?

Rearrange View

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

Stacked Histogram

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

Examples?
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)

Examples?
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

Google Earth

Table Lens
6. Filter

“Show me something conditionally”

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

Examples?

Filtering/Limiting

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

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

Filtering

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

Baby Name: John

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

Press 'enter' to see exact matches.

Example

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

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
  - 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

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

![HomeFinder Image]

PadMapper

![PadMapper Image]

http://www.padmapper.com
Query Controls

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

Note quite DQ though
DQ Pros

• Work is faster
• Promote reversing, undo, exploration
• Very natural interaction
• Shows the data
DQ Cons

• Operations are fundamentally conjunctive
• Can you formulate an arbitrary boolean expression?
  – !(A1 V A2) ^ A3 V (A4 V A5 ^ A6) V ...

• But do people really do this often?
DQ Cons

• Controls are global in scope
  – They affect everything

• Controls must be fixed in advance

DQ Cons

• Controls take space!
  – How much in Spotfire?

• Put data in controls...
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
7. Connect

“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

- 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
**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
**Example**

![Example Image](image_url)

**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

Another Kind of Interaction

Animation
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

**Fall 2017 CS 4460**

Heer & Robertson  
TVCG (InfoVis) ’07

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**OK**

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

Dust & Magnet

Must interact to gain any value

Yi et al
Information Visualization ’05
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.
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?

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
Multi-Coordinated Views
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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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